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Autumn 1992 Volume 23 Number 12 $7.95

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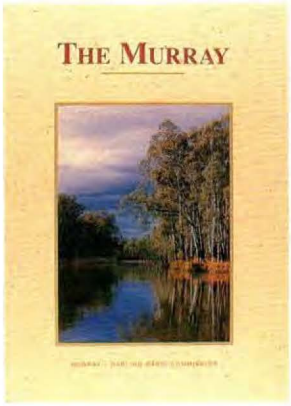

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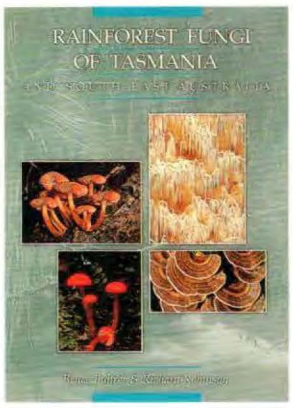

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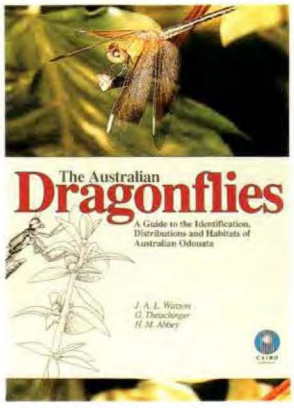

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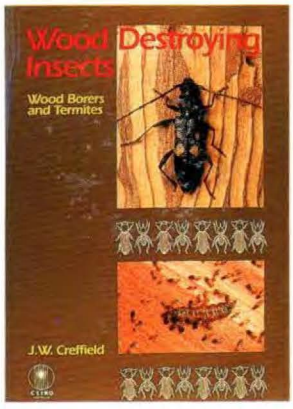

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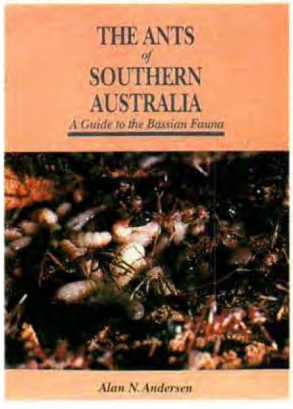

The Ants of Southern Australia: A Guide to the Bassian Fauna
Alan Andersen, CSIRO Division of Wildlife and Ecology
1991, 70 pp, illustrated, paperback, 247 x 174mm
ISBN 0 643 05152 X $20.00
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Front Cover

Closeup of the specialised stinging hairs of a stinging nettle. Do stinging nettles produce more of these when grazed by animals? See the article in Quips, Quotes & Curios. Photo by Keith Wheeler.

SCIENCE PRIZES

BY FIONA DOIG

MANAGING EDITOR

CELEBRATING OUR NATIONAL ACHIEVEments is important but Australians are more likely to worship sporting heroes than intellectual achievers. Look at how we celebrated winning the America's Cup yacht race and Kay Cottee's triumphant solo voyage. The Wallabies World Cup Football win last year earned them a ticker-tape parade.

Meanwhile, back in the lab, humble Dr Scientist, who has just made a significant breakthrough in identifying an important agent that could replenish Australia's degraded soil, indulges his success with a glass or two of champagne at an informal press function. His discovery rates a two-column spiel in the local paper; the story is picked up by a couple of other papers and . . . soon forgotten.

Many very clever people are making significant contributions to Australia. Some are working hard to ensure this country doesn't fall apart through land degradation or agricultural problems; others are making medical breakthroughs or finding efficient means of energy production. Many devote entire lifetimes to improving the future. Our future.

These people need to be acknowledged. Incentives are in order.

The Nobel Prize has to be the most esteemed prize. Winning this would be the pinnacle of anyone's career. Carrots like this one dangle heavily for any dedicated academic. Such an acknowledgment is highly regarded around the world. And its impact is certainly longer lasting than a two-column newspaper article or a mention on the evening news.

But with international prizes, competition is fierce and too many of our leading scientists have gone largely unrecognised.

Fortunately there are Australian prizes offered to scientists that recognise their special achievements.

The Eureka Prize is awarded in several categories. The Pol Prize for Environmental Research was won last year by Professor Martin Green of the University of New South Wales' School of Electrical Engineering for his outstanding contribution to the development of high-efficiency photovoltaic solar cells. The Australian Museum Prize for Industry was shared by BHP Pty Ltd and Biotech International.

It is great to see corporations getting involved in recognising environmental achievements. The IBM Conservation Award is a joint venture of IBM Australia Ltd and the Zoological Parks Board of New South Wales. Recognition of outstanding contribution to nature conservation is central to this award.

But it is not only eminent scientists that need recognition. Encouraging budding young scientists is also important. A number of science prizes are being offered to students to encourage the pursuit of science as a career.

The Earthworm Environmental Awards for Schools are a joint initiative of several organisations, including the Australian Museum. A variety of prizes are presented and winners are chosen by a panel of experts in science education and communication. One of last year's winners did a survey of domestic garbage and created a manual outlining the main components, with suggested strategies to reduce or recycle various waste products. Such information could be immensely useful to councils and town planners . . . and this project was done by a ten-year-old!

Prizes are a means of enabling people to be recognised and have their worth to society acknowledged. They provide a valuable way for Australians—individuals and organisations alike—to reach out and say 'thanks'. ■

Earthworm Award-winning students from Parramatta State School, Cairns, with their prize: an IBM computer.

RIC BOLZAN / AUSTRALIAN MUSEUM

IN THIS ISSUE

BY GEORGINA HICKEY
SCIENTIFIC EDITOR

LIFE AT LARGE? THIS IS THE THEME OF TWO OF THE articles in this issue. The first deals with the appropriately named Megamouth Shark—a giant known only from six specimens. Megamouth VI made headline news in 1990 when it was captured alive off California, filmed under water and released with a radio-transmitter. The person who brings you this story is Western Australian Museum's Barry Hutchins. He was also instrumental in the retrieval of Megamouth III, which was washed ashore two years earlier on a beach 50 kilometres south of Perth.

Our next article is about the world's largest living reptiles, Leatherback Turtles, which are capable of withstanding very cold temperatures. Two American scientists, Frank Paladino and James Spotila, have spent the last few years measuring the metabolic rates of these giants in an attempt to elucidate how other large and rather more famous reptiles—the dinosaurs—fared in similarly cold environments.

Other articles in this issue deal with tektites—mysterious blobs of natural glass found only in certain areas of the world, Australasia being one. The authors, Alex Bevan and Ken McNamara (pictured) of the Western Australian Museum, unravel the contentious story of their origin. We also learn how New Zealand's venerable reptile, the Tuatara, is shedding its fossil image; how stinging nettles react when eaten (their special stinging hairs are shown on the cover); and how prehistoric ghosts come back to haunt the living. Our poster this issue is a 19th-century illustration of a seahorse.

Alex Bevan (right) and Ken McNamara.

Articles

Regular Features

FROM THE ARCHIVES

THE ACCIDENTAL ANTHROPOLOGIST

Ian Hogbin had planned his career as a schoolteacher but, in his final year of study, made a radical jump-shift to social anthropology, becoming a key figure in the historical development of the discipline. When he died in 1989, this 'accidental anthropologist' left behind a wealth of articles, books and photographs depicting life in five very different Melanesian societies.

BY ALEXANDRA SZALAY

RARE & ENDANGERED

THE PEDDER GALAXIAS

Despite predictions to the contrary, the damming of Tasmania's Gordon, Serpentine and Huon Rivers in 1972 had the effect of immediately boosting Lake Pedder's native galaxias species. Ten years later, however, the picture is very different. One of the species has had a drastic nosedive towards extinction, making this fish perhaps the most endangered vertebrate species in Tasmania.

BY PREMEK HAMR

WILD FOODS

THE TUCKER STATE

Wallaby rissoles, baked possum, wattlebird stew and seaweed are just some of the items you might find on a Tasmanian menu. In this 'Bush Tucker State', the bush-pioneer mentality is alive and strong.

BY TIM LOW

PROFILE

DAVID ATTENBOROUGH

Courteousness, scientific accuracy, excellence in broadcasting and a deep commitment to his audience and to public service . . . we present Sir David Attenborough.

BY ROBYN WILLIAMS

PHOTOART

ORIGINAL AUSTRALIA

Wild and remote images from Tasmania.

BY CHRIS BELL

VIEWS FROM THE FOURTH DIMENSION

PALAEONTOLOGICAL POLTERGEISTS

Most of us were taught in school that the form of a structure reflects its function. But it's not always this simple. Sometimes spooks from the past can distort the relationship between modern form and function.

BY MICHAEL ARCHER

THE LAST WORD

THE POLITICS OF HARMONY

All human societies—whether black, white or brindle—have an impact on their environment. Thus to claim that traditional Aboriginal society was in harmony with the environment is to deny that society fundamental human qualities.

BY MICHAEL HERMES

Columns

LETTERS

Common Name, Common Sense; Pensioner's Plea; Population Bomb; Greening our Population; Love me, Love my Mag!; Armchair Travellers; Poster pictures; Teacher's Pet; ANH Forum.

QUIPS, QUOTES & CURIOS

Death Deferred; Stinging Lessons; Grooming Gives Monkeys a High; In Search of the Oldest Spider; Mice and Monarchs; Doing it Tough; Mantis Ears; Mystery of the Mima Mounds; Moas and NZ Plants; Sea-hare Ink; Drop us a Vine.

QUESTIONS & ANSWERS

Galah Relatives; Ant-iques; Trash or Treasure.

REVIEWS

The Gaia Atlas of First Peoples; The Fifth Essence: The Search for Dark Matter in the Universe; Taken for Granted: The Bushland of Sydney and its Suburbs; Native Plants of the Sydney District: An Identification Guide; Flora of New South Wales Volume 1; The Ants of Southern Australia: A Guide to the Bassian Fauna; Beyond the Reach: Cradle Mountain-Lake St Clair National Park; Continent in Crisis; Binna Burra Mountain Lodge, Lamington National Park; Coconut Beach Resort, Cape Tribulation; Whale-watching & Fraser Island; Sea Acres, Port Macquarie.

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Subject and author listings for Volume 23.

LETTERS

Comments, criticisms and congratulations from concerned correspondents. Readers are invited to air their views.

Common Name, Common Sense

I wonder if the scientific community has ever considered the relationship between a species name and its chances of survival?

For members of the general public to sympathise with the plight of threatened wildlife, familiarity with the species in question is essential. A 'Save the Koala' campaign can have wide public support because every Australian has been made aware of the existence of the Koala at an early age. The reason for that is at least in part that is has a simple and distinctive name.

But what if the 'Black-footed Tree-rat' was threatened? In its own way it is just as unique and deserving of preservation as the Koala but it would not receive the same public support. First, the name is too detailed. People may cynically wonder "What about the White-footed Ground-rat or the Yellow-throated Water-rat?" In other words, the name implies that it is just one of numerous similar species. Second, the word 'rat' gives it the connotation of being disease-carrying vermin. Finally the name is just too complicated to stick in people's minds. If people aren't aware of the existence of a species, they will not be concerned about its demise.

This last point I have been made clearly aware of as a primary schoolteacher studying birds that frequent the school grounds. Possibly the most appealing of them all is the Blue-faced Honeyeater, yet this is the bird of which the children are the least aware simply because they have not heard the bird's name referred to or have heard it and not retained it. (Adults too would be entitled to switch off at the word 'honeyeater' as there are some 133 listed bird names, including synonyms, containing the word.)

On this basis, two examples spring to mind readily; one I consider a success and the other a failure. The Bilby, which a few years ago was unheard of by the general public, is now creeping into our consciousness. Would it have done so if it was referred to as the Rabbit-eared Bandicoot? The failure I consider to be the renaming of the Jabiru as the Black-necked Stork. In the Northern Territory almost everyone is familiar with the Jabiru but only a handful of people would recognise the term Black-necked Stork.

The education of the public on conservation issues is vital to its success. Surely the scientific community must take account of their responsibility in this area and work towards making the public aware of as many species as possible through helping to standardise names that are distinctive and easy to remember.

—B. Swain
Katherine, NT

Will the renamed Jabiru be ignored now?

PETER COOK / AUSCAPE INTERNATIONAL

Pensioner's Plea

Can't you reduce the price of subscriptions to pensioners? It seems silly to me that The Australian Museum Society offers a discount price but ANH does not. What about students? Surely a better deal here would win some potential lifelong subscribers for ANH. I have been subscribing for 35 years (my family for much longer) and am sure many students of natural history, given an incentive, would also be avid devotees. In my younger days I found ANH extremely useful in setting the agenda for my career, in part due to its availability and economy of scale when I was but a lad at school. I have spent 30 years as a research scientist and have thoroughly enjoyed it!

—Richard McBray
Drummoyne, NSW

It is the Australian Museum's policy not to give discounts on ANH subscriptions. The price is set to cover production, staffing and mailing costs. Other magazines (such as Geo *and* Australian Geographic*) do not offer such discounts. The Australian Museum Society is an independent body to the Australian Museum and formulates its own policies. A TAMS pensioner membership is still more than the cost of an ANH subscription. —Ed.*

Population Bomb

We always kid ourselves that the world population problem is one that is 'out there' and doesn't directly affect Australians (see ANH vol. 23, no. 10, 1991).

Although I disagree with some points made by Dr Flannery (for example, surely a reduced population would lead to less government income and therefore less teachers, not smaller class sizes), I think he is most brave in his confrontation of this serious issue. This also applies to Flannery's earlier heroic finger-pointing at the Pope's responsibility in maintaining overpopulation in the world (see ANH vol. 23, no. 2, 1989). I am glad to see ANH doesn't steer clear of such controversy. Science is controversial, so keep diving in!

I only hope politicians read this article and have enough sense to take a stand and produce a population policy for Australia; something that is clearly lacking.

—Vladimir Rasmussen
Darlinghurst, NSW

Greening our Population

I have been an ANH subscriber for several years and was particularly interested in two earlier issues on the "Plague in the Pacific" (see ANH vol. 23, no. 1, 1989) and "A Vaccine for the Plague" (see ANH vol. 23, no. 2, 1989). Now Dr Flannery has pointed out that the problem of overpopulation needs to be addressed in Australia (ANH vol. 23, no. 10, 1991). I see controlling population as more important than the many efforts to 'green' our environment, all of which would be overturned by the necessities of coping with the effects and needs of population growth.

—K. Frey
Darwin, NT

Love me, Love my Mag!

I really enjoy ANH because it reminds me what a beautiful and unique place Australia is and how lucky I am to live here. I always look forward to receiving the next issue. With so many negative issues on the conservation and natural history fields, your positive articles help to revive the spirit and give some confidence for the future of our natural world.

My copy of ANH is taken on all my camping weekends so that at least eight people argue, discuss and enjoy nearly every issue. The photos and short articles are my favourites for this. What an absorbing publication!

Australia's population problem exposed.

—N. Creedie
Hobart, Tas.

Armchair Travellers

My wife and I are lucky enough to live on a farm, with unspoilt bushland and a large garden. When we were young we travelled extensively. Now I am content to remain at home and do my travelling in a comfy armchair with an ANH on my lap and a cup of tea in hand. We have travelled around all States by caravan and often meet 'old friends' in the pages of ANH. This is the magazine I wait for and enjoy most, then keep to read again next year.

—Neville Rogerson
Canowindra, NSW

ANH makes great armchair travel!

Poster Pictures

How about a return to the old type of poster; that of photographs of Australian wildlife? The current series, while interesting, simply does not have the visual impact of say, a wild Cassowary on its nest. I am sure many schools used these posters to interest students in environmental issues, whereas I doubt the current posters are as useful. Or why not alternate between the two poster series?

Your magazine is an excellent one, particularly since the change to the new format a couple of years ago. I always look forward to the next issue.

—T.M. Mazzer
Mildura, Vic.

Teacher's Pet

As a science teacher I have found ANH to be an excellent resource for Year 11 and 12 students and should be mandatory reading in all science classes. So why isn't it getting into schools on recommended reading or text lists? I would like to see it distributed to all schools so articles could be discussed in the classroom to acquaint students with the latest in natural history in our part of the world.

My only regret with ANH is that it still remains quarterly and doesn't come out more often! Even the writers I disagree with give my students and myself something to think about, which is good. It makes for good discussions and encourages them to think.

Without magazines like this to disseminate knowledge, the world would be a poorer place. Every library at every school I ever work in will subscribe to it!

—K. Debsworth
Fyshwick, ACT

ANH Forum

I would appreciate suggestions on how businesses can demonstrate their support and concern for the environment (and not just profits!). Let's face it, most of us are in one business or another that has a greater or lesser impact on the environment. How can we bring about change if we don't know how?

How about including an ideas corner in the letters page? Some readers may be able to offer some great suggestions that have worked for them. Action starts with ideas, but ideas need to be heard.

—G. Gargan
St Kilda, Vic.

Readers are always welcome to send such suggestions for possible publication in this column. Please keep letters brief so that as many as possible can be included. —*Ed.*

CARL BENTO / AUSTRALIAN MUSEUM

QUIPS, QUOTES & CURIOS

COMPILED BY GEORGINA HICKEY

SCIENTIFIC EDITOR

Death Deferred

John Adams and Thomas Jefferson, second and third presidents of the USA, both died on 4 July 1826—50 years after the Declaration of Independence. Coincidence? Not, it would seem, according to Jefferson's last words: "Is it the fourth?" he asked on his death bed, to which the doctor replied "It soon will be." And not according to recent studies in the United States.

Similar stories have been told of apparent postponements of death until after important occasions. These might be personal, such as a child's wedding or a birthday, or an important religious event. To test this idea empirically, sociologists David Phillips and Elliot King, from the University of California at San Diego, had to show that the number of deaths just before an important event dipped, and the number just after it peaked. But first they had to come up with an event that met two special criteria: it had to be important to one group of people, and not to other (control) groups; and its timing could not be fixed (to eliminate the effects, if any, of the months or season). One such event is Passover—the Jewish festival of freedom that celebrates the Israelites' exodus from Egypt. Over 75 per cent of American Jews celebrate Passover with a family meal at the beginning of the holiday. During this meal, males of the family carry out specific rituals, and the eldest male recites the exodus story. The actual dates of Passover vary annually by about four weeks (between March and April).

Phillips and King obtained their experimental and control groups by poring through the death certificates of those people that had died in California around the time of Passover (1966–1984). For their major control group (non-Jewish) they selected only Japanese and Chinese people. Getting a Jewish group together, however, proved more difficult because in America a decedent's religion is not noted on the death certificate. Phillips and King therefore had to use only those names that passed a rigorous test: with the aid of *A dictionary of Jewish names and their history* (1977), only those names that originated from central and eastern Europe (origin of most American Jews), that were sufficiently common to warrant discussion in at least two places in the dictionary, and that were also one of ten or more of the same name in the central Los Angeles (home of most Californian Jews) telephone directory were used.

Of the 1,919 Jewish deaths, 8.1 per cent more occurred in the week after Passover than before (*The Lancet* 24 September 1988: 728–732). For the control groups, the average number of deaths before and after Passover was the same. These results, although consistent with the idea of postponement of death until after the event, are not terribly convincing so, on the basis that Passover is likely to be less important for women (the central ceremonial role is assumed by males, and a high ratio of intermarriage in California means that many women with Jewish surnames are not in fact Jewish), they decided to split the Jewish group up according to sex. Much to their surprise they found an overwhelming increase (25.8 per cent) in male deaths after Passover than before, but no difference for women. Hence this so-called Passover effect is only apparent in the Jewish male population.

Apparently people can postpone death until after an important event.

RICHARD NOWITZ

Passover is made up of religious and social components. Although the religious side is the same year to year, when Passover falls on a weekend the social side is more important because the family gathering can be larger. One would thus also expect the Passover effect to be more pronounced in those years; and indeed it was. For weekend Passovers, 61.4 per cent more deaths occurred after Passover than before. By comparison, the equivalent figure for weekday Passovers, although still significant, was much smaller (13.7 per cent).

Other explanations that have been proffered for the Passover or dip/peak effect include stress or overeating associated with the holiday (but this doesn't explain the dip before the holiday); fixed monthly or seasonal mortality pattern (the decision to study an event that is not fixed overrules this argument); and postponement of life-threatening surgery (but the dip/peak effect was found to still be present for those who did not have surgery prior to death). The best explanation, therefore, is that death is postponed until after the important event.

Three years later Phillips and colleagues were able to replicate the dip/peak results of the Passover experiment using a different cultural group, a different season and a different genetic stock (*J. Amer. Med. Assoc.* 263: 1947–1951; 1991). This time they concentrated on the Chinese Harvest Moon Festival, which is also celebrated with a family feast, but whose central ceremonial role, in contrast to Passover, is played by senior women (over 75 years). The death rate of old Chinese women was shown to dip significantly during the week before the festival and to peak significantly in the week after. Again this mortality pattern is best explained by the ability to postpone death until after an important event.

—G.H.

Stinging Lessons

Animals won't waste valuable energy running from predators that aren't there. Perhaps the same principle applies to plants.

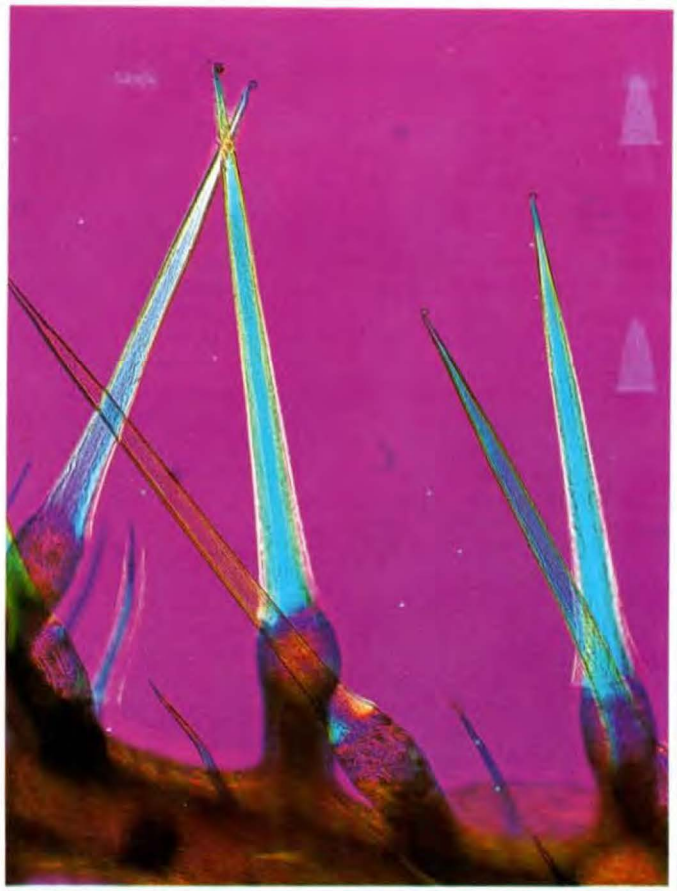
While plants, of course, don't have the option of mobility, many have developed effective defences against being eaten. But these defences often come at a cost to leaf, root or flower growth. The possibility that a plant could behave judiciously and only increase its level of defence when warranted—that is, in response to herbivore damage—is a controversial idea.

Biologists Andrew Pullin and Julie Gilbert, now at the Universities of Keele and Reading (UK) respectively, have fuelled the controversy with investigations into how the stinging nettle *Urtica dioica* responds to grazing pressure (*Oikos* 54: 275–280; 1989).

The sting of *Urtica* is physiologically complex and presumably energetically expensive. It is contained in a specialised hair known as a trichome. Pullin and Gilbert compared the trichome densities in plants from heavily grazed fields with those from ungrazed wastelands and found that nettles from fields subjected to regular grazing pressure had higher trichome densities.

This could have simply been an example of selection at work; nettles with naturally lower trichome densities being culled from grazed fields but surviving where there was no herbivore pressure. There seems, however, to be more to it. Pullin and Gilbert simulated grazing in the field and in glasshouses by cutting plants. The regrowth from cut plants at both locations had higher trichome densities than initial growth. The researchers also found that shoots from the centre of grazed nettle patches had lower densities of trichomes than the edge shoots that were more exposed to grazing. These results lend weight to the idea that, at least in this species of nettle, grazing pressure does increase the number of stinging hairs.

—K.McG.



KEITH WHEELER

Do stinging nettles increase the number of trichomes (stinging hairs) in response to herbivore grazing?

Grooming Gives Monkeys a High

Scientists have found that mutual grooming in monkeys stimulates the production of opioid chemicals in the brain. These chemicals, called endorphins, activate the same receptors as the opiate narcotics morphine and heroin. Studies by Eric B. Keverne and colleagues at the University of Cambridge, UK, show that in African Talapoin Monkeys *(Miopithecus talapoin)* there is a correlation between the amount of mutual grooming a monkey takes part in and the level of beta-endorphin in its cerebrospinal fluid *(Psychoneuroendocrinology* 14: 155; 1989).

Grooming interactions are a familiar and normal part of the behavioural repertoire of primates. They occur in different social situations, strengthening bonds and giving comfort to the participants. Mutual grooming has been found to be particularly common during and following copulation, in cementing social relationships (especially between mother and infants), in maintaining peace and cohesion in primate societies, and following aggressive outbursts.

In Keverne *et al.*'s studies, levels of endorphin were found to significantly increase following mutual grooming in previously isolated monkeys, strongly suggesting that social behaviours have an action on the brain's opioid system. The researchers also found that low doses of morphine caused a decline in grooming behaviour, again indicating that grooming and opioids form an important part of social reward.

Monkeys were also given the drug naloxone, which blocks opiate receptors. The animals groomed and sought grooming far more often, as if showing an enhanced need for social contact.

The researchers conclude that the rewards for social contact appear to be mediated by the brain's endorphins and believe the result to be particularly interesting in the light of the increase in both the breakdown of social relationships and opiate abuse in today's society. Artificially induced euphoria, via opiate narcotics, negates the need for social contact. In this sense at least such drugs can be considered truly antisocial.

—S.H.

Mutual grooming gives monkeys a high by stimulating the production of endorphins in the brain.

JEAN-PAUL FERRERO / AUSCAPE INTERNATIONAL

Dr Suzanne Hand, a biologist at the University of NSW, and Karen McGhee, a freelance science writer living in Newcastle, are regular contributors to QQC.

In Search of the Oldest Spider

What makes a spider a spider? Luckily for those of us who study them, that question is rather easy to answer. First of all, their jointed legs and chitinous exoskeleton mark them as arthropods, the dominant phylum of animals on Earth. As they lack antennae and have four pairs of legs, they can be classed as arachnids, along with ticks, mites, harvestmen and several other more obscure groups. However, the essence of 'spiderness' is surely the spinnerets. These are highly modified limbs located either midway (in primitive forms) or at the very end of the abdomen, the back half of the spider's body. Their function reflects the essential primary adaptation of spiders: the production of silk. While a number of other arthropods produce silk as well, only spiders have the glands for making the silk in the abdomen, and extrude it from specialised abdominal appendages. The silk actually issues from small, modified hairs called spigots, each producing a single line that may work alone or be combined with other lines to fulfil a variety of the spider's requirements.

As a student of spider systematics, I am naturally interested in the evolution of this extraordinary group of animals. However, it is an unfortunate fact that fossils of spiders are among the rarest known, and that the further back one goes in the record of the rocks, the rarer they become.

Exquisitely preserved fossils of spiders in ambers of various ages are perhaps the most abundant. A few of the very oldest amber spiders are from the Cretaceous Period (65–144 million years ago) of Australia. I recently examined these, and it seems there are not many differences between spiders that spun their webs in this Age of Dinosaurs and those we see in our gardens today.

Spiders preserved as impression fossils in fine-grained rocks show less detail. Some 220-million-year-old specimens from Spain look a bit different from modern forms, but they cannot quite be placed in our classification scheme.

As we go back through time, we encounter a great gap in the fossil record of spiders, spanning the entire Permian Period (248–286 million years ago). However, when we emerge on the other side of this gap, spiders look different indeed. Nearly all of the spiders from the Carboniferous Period (286–360 million years ago) are marked by having the abdomen divided into separate segments, a characteristic found only in the most primitive spiders of tropical Asia. At least we think these fossils are of spiders—only a handful show that quintessential spider character, the spinnerets.

Finally, our trip back through time finds us in the Devonian Period (360–408 million years ago). By the mid-1980s, only two possible spider fossils were known from the Devonian: *Palaeocteniza crassipes* from Scotland, and *Archaeometa devonica* from Germany. However, few details—and no spinnerets—were visible on either of these poorly preserved fossils, and they told us little about spider evolution.

Since 1983, with various coworkers, I have been studying remarkable fossils from the region of Gilboa, New York State, USA. These fossils are intact bits of arthropods, which can be removed from their rock matrix with strong acids. The age of the deposit is Middle Devonian, about 380 million years old, somewhat younger than the two Devonian spider fossils just mentioned. My colleague Paul Selden and I isolated and set aside a series of fragments, including legs and jaws, which we could not make fit any of the already reconstructed animals from the collection. The fragments had a characteristic pattern on the cuticle, or exoskeleton.

Perhaps the most important discovery at Gilboa came in 1987 when Patricia Bonamo, who discovered the site, sent me a new group of fossils on microscope slides, including one that was immediately identifiable as a spider spinneret! The spinneret, although isolated, torn and folded, was beautifully preserved, including about 20 spigots and numerous tiny sense organs. This was unequivocal evidence of the presence of spiders in the Devonian Period. But before going any further, I resolved to study in detail the two other Devonian fossil spiders. The German example turned out to be so poorly preserved that it seemed unlikely even to be of an animal. It resembles a fish coprolite (fossilised faeces). The Scottish fossil was minute, less than a millimetre long, and badly crumpled and folded. Utilising optical sectioning and computer reconstruction, I was unable to find any of the defining characteristics of spiders. This fossil is probably a very small specimen of another kind of arachnid common at the site. Thus our spinneret from Gilboa became the oldest verifiable spider fossil.

After analysing the characters visible on the fossil spinneret, we concluded that the structure was primitive and unlike that belonging to any living spider (*Science* 246: 479–481; 1989). Paul Selden then pointed out that the enigmatic 'puzzle parts' we had previously saved from the deposit had the same cuticular pattern as the spinneret and may have come from the spider. Sure enough we identified among them spider jaws and legs, the form of which was such that we were sure we had found the remains of an entirely new kind of spider, one fully capable of making silk, but which had much less specialised legs and jaws than any others known.

Based on these characters, we speculate that our ancient spider probably lived in a tubular retreat or burrow that it lined with silk (perhaps the original function of silk). Did it make a web? And, if so, what did it catch? Winged insects do not appear in the fossil record until nearly 50 million years later. Clearly there is a great deal more to be learned about the earliest spiders and their world.

—William A. Shear
Hampden-Sydney College
Virginia, USA

Fossil spinneret: at 380 million years old it is the oldest verifiable spider fossil in the world.

W. PERRY CONWAY

***Peromyscus melanotis* is unique in its ability to avoid the toxic effects of a Monarch meal.**

Mice and Monarchs

An opportunistic mouse in Mexico thrives on a food source for which few other creatures dare compete. *Peromyscus melanotis* is one of five species of mice that live together on the mountain sides in central Mexico where, each year, Monarch Butterflies *(Danaus plexippus)* overwinter in densities of up to ten million per hectare. Rich in fats and easy prey because of lethargy induced by low temperatures, the butterfly aggregations are potential energy bonanzas. But a free lunch is rare in the animal kingdom. The insects store toxic compounds (cardenolides and alkaloids) in their body tissues, making them foul-tasting and deadly to most vertebrates.

Despite this, a four-year study by John Glendinning and Lincoln Brower, from the University of Florida, has shown that *P. melanotis* (particularly females) set up residency inside the Monarch aggregations and feed exclusively on the butterflies. In fact, they exploit the energy source so well that they are able to breed intensively during winter, unlike the other local mouse species *(J. Anim. Ecol.* 59: 1091–1112; 1990).

Exactly how *P. melanotis* escapes the effects of the Monarch's chemical defences is not fully understood. Glendinning and Brower noticed the mouse did not seem to metabolise the butterfly toxins and tended to eat only the soft tissues of the insects, avoiding the cuticles where most of the toxins are concentrated. Whichever way it does it, exploiting a resource that few other vertebrates would touch appears to have paid off for *P. melanotis:* it is the most successful mouse species in the area.

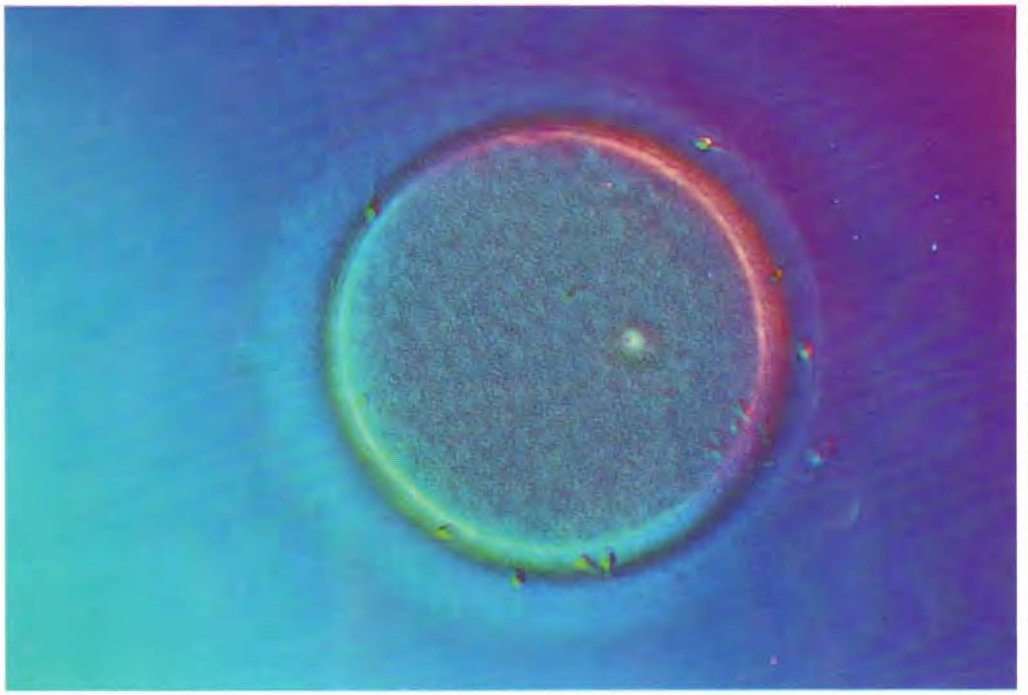
—K.McG.

Doing it Tough

Mammalian sperm undergoes a rigorous test of fitness even before it reaches the trials of the female reproductive tract. To enter the race for the ovum it must first survive ejaculation! Human sperm, for example, travels at 500 centimetres per second as it is catapulted along the combined 50-centimetre length of the vas deferens and urethra. And during the journey it confronts potentially lethal forces in the fluid in which it is propelled. Recent work by Jay Baltz, Oneeka Williams and Richard Cone at the Johns Hopkins University in Baltimore, Maryland, suggests how mammalian sperm design may help it survive ejaculation (*Biol. Reprod.* 43: 485–491; 1990).

Baltz and his co-workers measured the maximum force that each type of sperm could withstand without being harmed. This provided comparative measurements of sperm strength. They tested, and found support for, the theory that shorter sperm (from animals such as bulls and humans) are more robust than longer sperm (from animals such as rodents). However, they found that longer sperm were not quite as fragile as theoretical predictions anticipated. It was expected, for example, that if sperm from one species were twice as long as from another species, it would be four times as fragile. This was not true.

In an attempt to elucidate this discrepancy, Baltz and his team turned their attentions to the structure of the sperm tail. In mammalian sperm the tail invariably consists of a central axoneme (made up of several microtubules) surrounded by nine dense fibres. The size of the fibres varies from species to species. The researchers found that additional sperm strength not anticipated by the previous theory correlated well with the size of the fibres. It appears that these fibres provide the protection that mammalian sperm needs to survive ejaculation. **—K.McG.**



Before getting to the egg, sperm must first withstand the forces of ejaculation. How do they achieve this?

J. FRAZIER/ANT PHOTO LIBRARY

Cross-section of the sperm tail of a rat, showing the nine dense outer fibres.

RONNIE HARDING

Comparison of male (left) and female ears of the praying mantis *Ameles heldreichi*. The male ear is much larger than the female's. This correlates well with the fact that the male is fully winged and capable of flight, whereas the female has only short wings.

COURTESY DAVID YAGER

Mantis Ears

The mantis ear—a single and midline structure located between the last pair of legs—is unique among insects. It was first reported in 1986 by Cornell University scientists David Yager and Ronald Hoy who suspected its function was to detect the ultrasonic emissions of echolocating bats (see ANH vol. 22, no. 3, 1986–87). An alternative theory suggests that ultrasound may play a role in mantis courtship.

More recent work by Yager has shown that variations in the structure of male and female ears is widespread in praying mantis genera. Of the 183 genera he examined, 34 per cent showed evidence of auditory sexual dimorphism (*J. Zool.* 221: 517–537; 1990). There was also a strong correlation between auditory sensitivity and the ability to fly. Mantises with functional wings (males) tended to have sensitive ultrasonic hearing, while those with short wings (females) didn't. Although this would appear to lend further support to the bat defence theory, the evidence is not conclusive. The mantis ear is located on the same body segment as the hind wings, so it is possible that the ear structure has changed simply as an adaptive response to changes within that body segment.

The discovery of auditory sexual dimorphism within mantises, however, does cast doubt on the use by mantises of acoustic signals during courtship. It suggests that, in many instances, signalling would be a one-way affair from female to male. Importantly, Yager points out, the male would not be able to use acoustic signals to identify himself as a mate, rather than a meal, to the generally larger, highly predatory female.

—K.McG.

Mystery of the Mima Mounds

'Mima mounds' is a geological term given to smooth rounded piles of fine sediment that range in size from 2.5 to 15 metres in diameter and up to 2.5 metres in height. They are found in many parts of the world and typically form over any flat hard surface, be it rock, hardpan or bedded gravel. Although also referred to as prairie mounds, pimple mounds or, simply, mounds, the term 'Mima mounds' reflects the locality of their first published sighting, in 1841, on the Mima Prairie in Washington State, USA.

Since their original discovery, when they were thought to be Indian burial grounds, a large number of theories have been proposed to explain their origin. These range from formation by gophers, freeze-thaw processes, wind or water erosion, various depositional processes, and the latest (and also mine) – formation by seismic activity. In fact, Mima mounds have probably generated more hypotheses about their origin than any other geological feature.

The gopher theory has perhaps drawn the greatest number of published papers. Gophers are alleged to mine and translocate large volumes of soil to form the mounds. However, the theory fails because mounds are absent from vast expanses of gopher habitat, and are present in areas with no gophers at all.

According to the freeze-thaw hypothesis, prehistoric ground froze into polygonal shapes, the corners of which were later washed away with meltwater. But freeze-thaw processes place a climatic restriction on mounds, which are abundant in areas that now lack such climates, or have lacked them in the past.

Other ideas suggest that depressions fill with water and in turn trap sediments followed by vegetation, which collects more sediment, eventually forming the mounds. Advocates of erosional hypotheses believe mounds are topographic highs left after wind or water erosion. Other scientists favour erosion in concert with vegetation anchoring, such as with tree roots, as probable causes. And still others believe Mima mounds may originate as gilgai – mounds formed through the shrinking and expansion of clayey soils, well-described for Australia but also present elsewhere.

The seismic hypothesis suggests their formation is due to vibrations from earthquake activity (*Geology* 18: 281–284; 1990). I first became interested in this idea when I noticed the behaviour of a thin layer of fine sediment on a sheet of plywood subjected to hammer blows from beneath. The sediment immediately formed into micromounds that were miniature replicas of those observed in the field. This experimental evidence is supported by the fact that mounds, wherever noted around the world, are close to areas of past or present seismic activity. The seismic hypothesis explains the geometric pattern usually observed for mounds, and also fits well with the fact that mounds are always found on a rigid or semi-rigid subsurface (other hypotheses do not rely on rigid substrata). It also resolves the problem of their occurrence in a variety of climatic locales.

The existence of megamounds, up to five times larger than the ones usually encountered, are suggested to cast doubt on all of the possible theories. It would appear, though, that the only limitation on mound size, according to the seismic hypothesis, is the intensity of the shock waves and the thickness of the sediment layer acted upon. That earthquakes can produce enough energy for the formation of megamounds is not disputed.

Some writers have suggested there may be more than one way to form a mound but to me, at least, their morphological similarity wherever encountered suggests the probability of a single formational cause. One thing we do know for sure is that the 150-year-old mystery will be with us for a while longer.

—Andrew W. Berg
US Bureau of Mines
Spokane, Washington, USA

COURTESY ANDREW BERG

Gophers, erosion or earthquakes: how do Mima mounds form?

Moas and NZ Plants

Botanists are looking to a relationship that ended 600 years ago to explain a peculiar growth habit common among New Zealand plants.

In other parts of the world, divarication (branching at a wide angle) is a rare adaptive response to herbivore grazing. In New Zealand it occurs in ten per cent of all native woody plants—that is, in 53 species across at least 17 families, apparently evolving repeatedly. Characteristics of divaricating plants include difficult-to-break interlacing branches, tough stems, and the placement of more leaves towards the interior with fewer and smaller leaves on the accessible exterior.

Divarication has proved to be of some deterrent value against the herbivorous mammals introduced by Europeans during the past two centuries. But New Zealand had no native herbivorous mammals. So what widespread selective pressure would have caused divarication in New Zealand plants? Ian Atkinson and Michael Greenwood, from New Zealand's Department of Scientific and Industrial Research in Lower Hutt, have been looking to moas for the answer (*N.Z. J. Ecol.* 12: 67–96; 1989).

Moas may have been responsible for a peculiar growth pattern in New Zealand plants.

CHARLES R. KNIGHT / COURTESY, FIELD MUSEUM OF NATIONAL HISTORY, *CK32T, USA

Divaricate branching in plants may have developed in response to browsing from moas.

A. HAMILTON / *C73 NATIONAL MUSEUM OF NEW ZEALAND, WELLINGTON, N.Z.

There were about 11 species of these herbivorous flightless birds common throughout New Zealand before the arrival of the Maoris 1,000 years ago. Weighing from 20 to 200 kilograms and with heavy horny bills, they were capable of devouring a seedling in one bite. Deterrents to browsing such as spines found in plants from other parts of the world may have been less effective against moas. Atkinson and Greenwood believe that divarication developed as a direct result of browsing pressure from moas.

To support their theory, Atkinson and Greenwood refer to the fossil record. Moas appear to have been concentrated in the lowlands where fertile alluvial soils are most widespread. They were not found on offshore islands, were less common in the alpine zone and could not have climbed cliffs or trees. The distribution of divaricating plants matches well. And it is significant that several species that divaricate on the mainland do not do so on offshore islands. Further support for the theory comes from the fact that there are nine plant species that display divarication as juveniles but lose the peculiar growth habit when their height exceeds three metres. That the height of the largest moas was not far short of three metres is, according to the researchers, no coincidence. **—K.McG.**

Sea-hare Ink

What you see—or rather, don't see—in the marine environment is not always what it seems. Take, for example, the phenomenon of 'inking'. Octopuses do it and so do squid, superbly obscuring their escapes from predators.

Sea-hares, *Aplysia* spp., also release ink. And, despite the fact that they move too slowly for the ink to act as a shield for a getaway, it has long been assumed that they too ink to repel predators. But it is an assumption based on little in the way of scientific evidence.

There have been very few reports of sea-hares being predated upon in their natural habitats or even in laboratory aquaria and, so, little evidence of what the animal actually does when confronted by a potential predator. In fact, it seems that few animals actually bother to confront the sea-hare as a prospective meal.

The opportunity to observe the response of sea-hares as prey arose when Ethel Tobach and Andrea Zaferes from the American Museum of Natural History in New York found evidence of potential sea-hare predators—an anemone species and the Blue Crab—during field work off the Puerto Rican coast in 1987.

In a series of experiments in laboratory aquaria sea-hares were presented to anemone species and Blue Crabs. The crabs did not eat the sea-hares, even though contact was made in some instances, and the sea-hares did not ink. In the case of the anemones, the results were varied. Of the sea-hares eaten, some inked, some didn't. And of the sea-hares untouched, some also inked and some didn't. The researchers therefore concluded that inking is not a direct response to being ingested by, or a means of escape from, anemones.

So why do sea-hares produce ink? The substance may play a role in colouring and camouflaging the animals against background vegetation. The ink could simply be a reservoir for storing pigments from the algae eaten by the animal. These pigments are found in the body wall of the animal and may enable it to match its skin tone to that of its food. Seahares tend to be green if fed green algae and turn pink if fed red algae.

—K.McG.

The sea-hare *Aplysia dactylomela*.

JIRI LOCHMAN / LOCHMAN TRANSPARENCIES

JEAN-PAUL FERRERO / AUSCAPE INTERNATIONAL

Swinging through the jungle can be a hazardous pursuit for one of the world's largest tree-dwelling mammals.

Drop us a Vine

With females weighing up to 40 kilograms and males up to twice that, Orang-utans (*Pogo pygmaeus*) are the largest mammals that travel extensively through the forest canopy. In the course of their daily travels they suspend themselves hundreds of times from lianas (woody vines). A weak vine can mean plummeting to a serious injury or even death. The ability to identify weak vines could, therefore, have a bearing on survival and, in theory, should be more important for heavier individuals.

John Cant, an anatomist from the University of Puerto Rico, and his team of researchers travelled to northern Sumatra to measure the risks associated with the Orang-utan's arboreal lifestyle (*Amer. J. Phys. Anthrop.* 81: 203; 1990). The researchers' main *modus operandi* involved simulating the actions of Orang-utans, that is, hanging on the vines themselves to find the weights at which they broke. Varying weights were achieved by wearing backpacks full of rocks.

A total of 99 lianas from 30 different species varying from 1.2 to 3.4 centimetres in diameter were tested. The failure rate of vines tended to increase as thickness of the vine decreased, although some lianas less than two centimetres thick withstood the maximum stress test of 132 kilograms.

While only three per cent of the vines tested were found to break at the adult female Orang-utan weight of 40 kilograms, 19 per cent failed at the adult male weight. And, as a 19 per cent failure rate would be more than enough to induce daily falls and probably serious injuries if lianas were simply selected at random, the researchers believe that Orang-utans must somehow first be able to identify reliable vines.

—K.McG.

"There has probably never been a fledgling anthropologist more unprepared for field work than he was upon his arrival at Rennell."

THE ACCIDENTAL ANTHROPOLOGIST

BY ALEXANDRA SZALAY

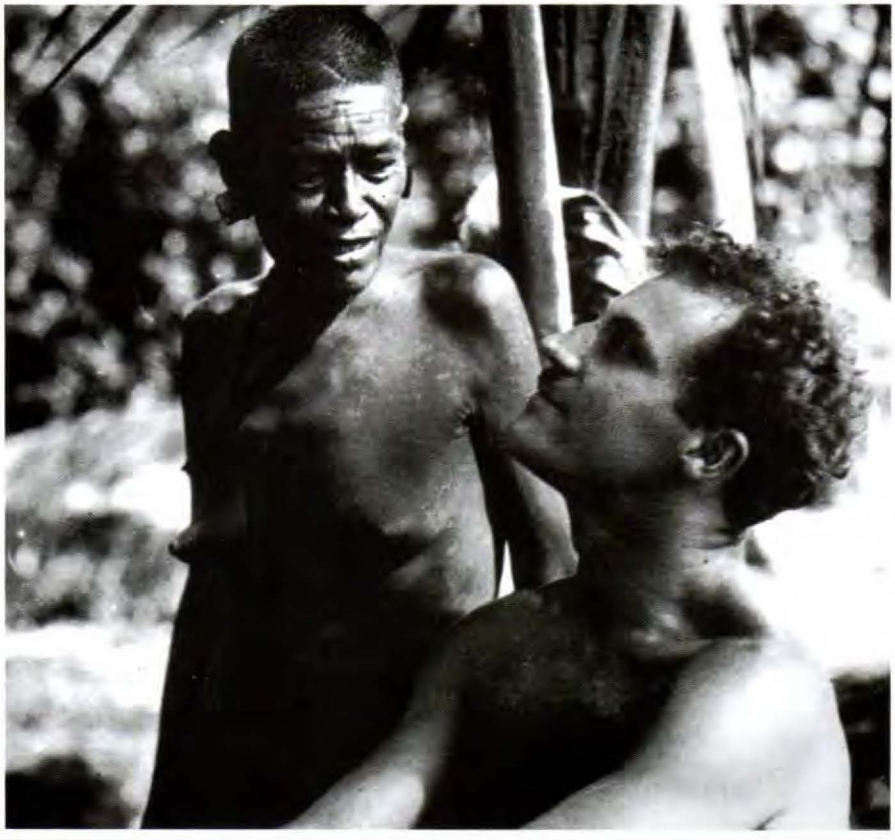
AUSTRALIAN MUSEUM

IAN HOGBIN HAD PLANNED A CAREER AS A schoolteacher. .Instead, as an early student of two of the principal founders of social anthropology, A.R. Radcliffe-Brown and Bronislaw Malinowski, he became a key figure in the historical development of the discipline. In a career that spanned more than 50 years, Hogbin established an unparalleled record of field work, working with five very different societies in Melanesia, each with its own unique language and culture. From this work flowed a series of articles and books, distinguished equally for their remarkable insight and elegant prose. Of these, *The island of menstruating men*, an account of the male cult of Wogeo, New Guinea is a recognised classic.

The Australian Museum holds Hogbin's collection of fieldwork photographs, some 750 images, in addition to the ethnographic material he collected during his field research. Surprisingly – since anthropologists are not usually known for their hunting and trapping prowess – the Museum also holds biological specimens collected by Hogbin. These include two holotypes of previously undescribed species of fish and flying-fox.

In August 1927, a few months before his twenty-third birthday, Ian Hogbin arrived at Rennell Island, a Polynesian outlier in the Solomon Islands, to begin anthropological field work. In his memoirs – a series of interviews recorded with Sydney University anthropologist Jeremy Beckett published just before Hogbin's death – Hogbin remarked that there has probably never been a fledgling anthropologist more unprepared for field work than he was upon his arrival at Rennell. He had had just six months of formal training in anthropology, and all that was known of Rennell society at that time was that the two previous visitors to the island, a pair of missionaries, had been killed and eaten.

Ian Hogbin, aged 22, with one of his informants.



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Educated at Sydney's Fort Street High School, Hogbin had oriented his university studies towards a career as a schoolmaster. In his final year at Sydney University, he was required to choose a course to complete his postgraduate Diploma in Education. He selected anthropology, then a relatively new addition to the curriculum. A.R. Radcliffe-Brown, one of the principal founders of social anthropology, had just arrived to take up the inaugural Chair in Anthropology at the University. Radcliffe-Brown had attracted a great deal of funding from the Rockefeller Foundation for anthropological research, and was interested in getting workers into the field as soon as possible. Hogbin performed well in his course, and one afternoon Radcliffe-Brown asked him if he was interested in becoming a professional anthropologist. Disenchanted by his five weeks of practice teaching, Hogbin answered "Yes". It was in this way that Hogbin, in his own words, "accidentally became an anthropologist".

Hogbin travelled to Rennell Island with an Australian geological expedition led by G.A.V. Stanley, who hoped to find the island rich in phosphates. As it happened, Rennell proved to be not at all rich in phosphates and, after two months, the expedition was withdrawn. For Hogbin, too, the expedition was not a success.

Owing to the unfortunate demise of the last two Europeans to visit the island, the British Protectorate administration had insisted on assigning a police force of 15 Solomon Islanders and a white overseer, complete with bayonets, to protect Hogbin and the geological party during their stay on the island. Such an arrangement was clearly not inspiring of local confidence, and Hogbin was obliged to abandon any hope of getting to know the local people and understanding their culture. In his memoirs, Hogbin notes that he and Stanley subsequently discovered that the missionaries, although killed, had not been eaten. Their deaths were attributed to villagers' envy of their stores, particularly their steel tools. Some time after Hogbin's visit, a Swedish anthropologist went to the island to undertake field work. He wrote to Hogbin, telling him he had learned that the local people had been already making plans to kill him and the geological party too, despite the 15 police.

From Rennell Hogbin sailed on to Ontong Java, another Polynesian outlier, situated to the north of the Solomons chain. Here, there was nothing to hinder his efforts to participate in and observe the local culture and he established a

strong rapport with the villagers, remaining there until the early months of 1929.

One aspect of Hogbin's research in Ontong Java was a consideration of local burial practices. He found that traditional cemeteries in Ontong Java were not unlike European churchyards. They were places set apart, the graves divided into rows, and each row was occupied by the extended family. Each grave was marked with a headstone carved out of coral rock. The villagers told Hogbin that a European trader had recently died on the island and, as he hadn't any relatives, they had buried him in the bush with a simple stake marking the place. Some time later, when Hogbin succumbed to a particularly severe attack of malaria, he was visited by his friends from the village, expressing their condolences and best wishes for a speedy recovery. One of them told him, "I hope you're not worried about where you're going to be buried should you die, because of course we wouldn't bury you in the bush like that other European. I've already arranged for a place for you in my row".

Following his field work in Ontong Java, Hogbin returned to Sydney to complete his Masters degree, then travelled to England to do his Ph.D. at the London School of Economics under Bronislaw Malinowski. He returned to field work in 1933 to the Solomon Islands, where he worked in both Guadalcanal and Malaita.

At this time much of Island Melanesia was still relatively free from European encroachment, and it was not unusual for several months to pass without contact with another European. In his memoirs, Hogbin recalls meeting a missionary who had dropped anchor off the coast of the village in Malaita where he had been working for some time: "I sent off a note to this missionary's schooner saying that if there was anyone aboard would he come and have dinner with me that night. It was, as I say, a missionary, and he was so hideously ugly that I was ashamed to look at him. His eyes were too close together, he had a nose like a hatchet, no lips at all. He was really an ogre, a monster. You couldn't look at him. And it wasn't until two or three days later I was shaving and caught sight of my own face in the mirror and realised he was just an ordinary European, with characteristic European features which I had become so unused to because I was so taken up with Melanesian features."

In the early days of Hogbin's field work, the few anthropologists who were working in the Pacific tended to be regarded by their fellow Europeans – mainly traders and administrators – as peculiar individuals for their close association with the natives and apparent lack of any sense of white prestige. Hogbin's ethnographies are as much about religion and politics in small-scale societies on the brink of profound social change, as they are about encounters with individuals. Often his informants were also close friends, and in his later years Hogbin returned to visit all the societies he had previously studied. His last trip was in 1974 when he returned to Wogeo Island, where he had lived and worked 40 years ago, at the invitation of the grandson of one of his informants.

Wherever he went for his field work, in the Solomon Islands and New Guinea, Hogbin took with him his quarterplate camera and tripod. The camera was heavy and cumbersome to use and the film notoriously slow. Nonetheless, his use of the camera was skilled and the resulting images enhance significantly our understanding of the rituals and daily activities described in his ethnographies. Hogbin frequently refers to his informants by name in his work, recording anecdotes and verbatim accounts that lend an invaluable insight into the culture he is describing. Through his photographs, we are able to put faces to names, visual images to written events.

Hogbin's work displays a remarkable ease and depth of understanding of other cultures and other lives. At the end of his life, Hogbin resisted the rites of his own culture, stating that he did not wish to be given a funeral, and requesting that his body be sent to the Anatomy Department at the University of Sydney where medical students could be given the opportunity to study his remains.

Ian Hogbin died in Sydney on 1 August 1989. Two years later, on a bright September afternoon in 1991, I visited the Sydney University Anatomy Department to assist with the sorting and identification of the Department's large collection of mammal skulls. While there, I recalled Hogbin's specific request regarding his remains, and inquired if it had been carried out. I was assured by the Department that it had. In fact, Hogbin had been cremated only a few weeks prior to my visit. A small ceremony had been held for him. ■

Suggested Reading

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Alexandra Szalay is a graduate in anthropology and European literature. She first became acquainted with Hogbin's field photographs in 1986 while working on a major project to document the Museum's Pacific Anthropology collections. She now works as a research assistant in the Mammal Section, while pursuing postgraduate studies in social anthropology at the University of Sydney.

"We are hopeful that the 'Passion Pond' will live up to its reputation and produce a brand new generation of Pedder Galaxias."

THE PEDDER GALAXIAS

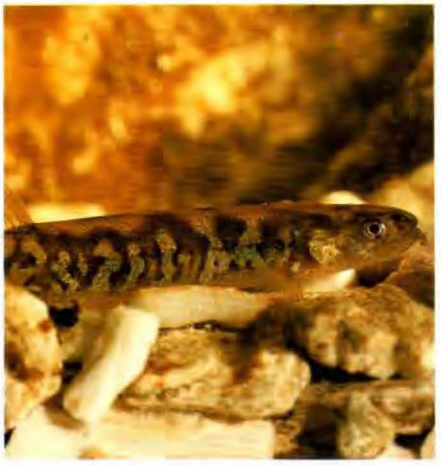
BY PREMEK HAMR

INLAND FISHERIES COMMISSION, HOBART

THE ORIGINAL LAKE PEDDER IN SOUTH-western Tasmania was inhabited by two species of native galaxiid fishes: the Pedder Galaxias *(Galaxias pedderensis)* and the Swamp Galaxias *(Galaxias parvus)*. Both species were native to the lake and the adjoining streams such as Maria Creek, Stillwater Rivulet and the Serpentine River. In 1972 the lake was inundated following the completion of the hydro-electric scheme, which involved the damming of the Gordon, Serpentine and Huon Rivers.

Contrary to numerous initial predictions from conservationists and scientists that the native fish species would disappear from the lake, there was a large population explosion of galaxiids in the new lake. Large schools were observed until the late 1970s but then in the early 1980s their numbers in the lake appeared to decline rapidly. Recent investigations of the status of Tasmanian threatened and endangered fishes by the Inland Fisheries Commission have shown that, although the numbers of the little Swamp Galaxias remain high in the Pedder region, populations of the Pedder Galaxias have undergone a dramatic decline in the new lake as well as surrounding streams. Electrofishing surveys, during which fish are attracted to and temporarily stunned by an electric current, revealed that few Pedder Galaxias remained. The species was absent in the new lake and was found in small numbers in four creeks only. This represents a drastic reduction in the original range and population numbers as reported by investigators prior to, and immediately after, flooding.

The cause of this recent decline is not clear, however the loss of most of the species' original lowland habitat and the introduction of Brown Trout *(Salmo trutta)*, a large predator as well as a possible competitor for food, may be at least partly responsible. Additionally, and perhaps more importantly, the new lake and the adjoining streams have been invaded by another potential aggressive competitor and predator, the Climbing Galaxias *(Galaxias brevipinnis)*. This species was not formerly reported from the area immediately adjacent to the old lake but is now very abundant throughout the Pedder and Gordon drainages and appears to have replaced the Pedder Galaxias in most of the streams running into the lake. As a result, the Pedder Galaxias has been placed on the Australian endangered species list and has become perhaps the most endangered vertebrate species in Tasmania.



Since the flooding of Lake Pedder, competition with other fish species has drastically reduced the number of Pedder Galaxias.

A recent intensive study of the Pedder Galaxias has shown that only two populations remain in the wild. After assessing the present status of these remaining populations it is clear that the number of fish is low and they are vulnerable to competition and predation from both Brown Trout and the Climbing Galaxias, which are present within the two streams. Since February 1990, only 49 Pedder Galaxias have been found and the total number of fish remaining is estimated to be as low as 200. Furthermore, Pedder Galaxias are only present in the lower, well-shaded, meandering sections of the streams, while the shallower and faster-flowing upper reaches have been completely taken over by the Climbing Galaxias.

Little is known about the biology of the Pedder Galaxias but recent findings show that spawning takes place in the spring when water temperatures begin to rise. Females deposit between 150 and 1,200 relatively large eggs onto gravel or vegetation on the stream bottom. The diet consists mainly of terrestrial insects and aquatic insect larvae.

The existing wild populations of the Pedder Galaxias are difficult to protect, due to continued access of Brown Trout and Climbing Galaxias. The construction of a barrier to these species is not considered a practical option because of the topography of the streams and the inability of any such barrier to stop the invasion of the Climbing Galaxias. Additionally, it appears likely that the Pedder Galaxias itself may require a migration between lake and stream to complete its life cycle. Any barrier would inhibit this migration.

These findings highlight the urgent need for careful management of the Pedder Galaxias. Presently there are two main management strategies being pursued. The first is the translocation of the Pedder Galaxias to a new secure habitat, while the second is to breed the species in captivity in order to increase the existing number of fish. To this end Lake Oberon in the South West National Park has been chosen as a potential translocation site and a large spawning tank dubbed the 'Passion Pond' was constructed at the Commission's Salmon Ponds hatchery compound where captive breeding trials are presently under way.

Although the future of the species certainly appears precarious, it is felt that if a portion of the existing populations is relocated without delay to a safe, remote lake where it will be free from human interference, this rare little fish can once again flourish. We are also hopeful that the 'Passion Pond' will live up to its reputation and our captive fish will breed this spring and produce a brand new generation of Pedder Galaxias, which we can then use to strengthen this new population. ■

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Dr Premek Hamr is a scientific officer with the Inland Fisheries Commission, Tasmania. In addition to working on the conservation of the Pedder Galaxias he is studying the life histories of several other galaxiid fishes as well as advising on the management of the freshwater crayfish fishery in Tasmania.

RON MAWBEY

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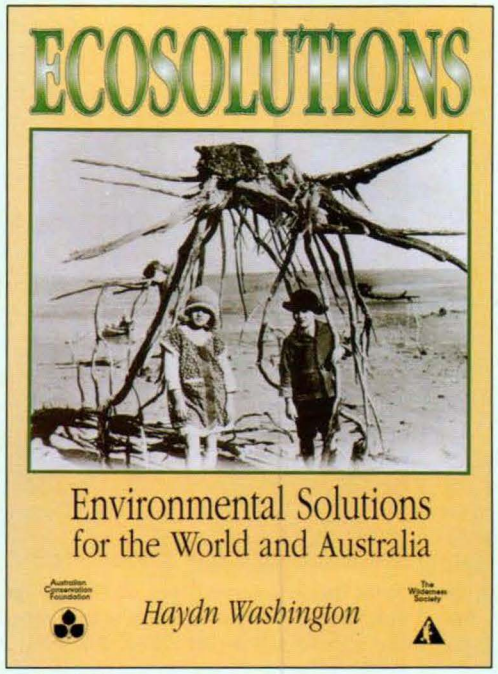

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"The trick to softening the Native Hen was to boil it with a boot, and to eat the boot and throw away the bird!"

THE TUCKER STATE

BY TIM LOW

NATURE WRITER

Some Tasmanians remember, as children, grubbing up roots of ground orchids to eat as snacks. The scented Sun Orchid *(Thelymitra nuda)* was probably one of the species used, as its starchy tubers are tasty.

THERE IS A GUIDEBOOK TO CHEAP travel in Tasmania so helpful it even suggests proper topics of conversation for the hitchhiker. Unless you want to be thrown from a fast-moving car, it advises against talking about Aboriginal land rights, Bob Brown, the Greens, or conservation. The list of suitable topics is headed by "Huntin', shootin', and fishin'".

On a recent trip to Tasmania I found the people to be not at all the rednecks these comments imply. But I was amazed at the popularity of "huntin', shootin', and fishin'". In Tasmania the bush-pioneer mentality is alive and strong. Wallaby meat is enormously popular, and many older folk remember eating parrot pie and currawongs. When hitching around the State I always broached the subject of hunting, not to avoid being hurled from cars, but to elicit information about pioneer life. Some of the responses amazed me.

Dave Dowlman, who gave me a lift into Launceston, told me how to remove the eucalyptus taint from the Common Brushtail Possum *(Trichosurus vulpecula)*: "You skin them while still warm, wrap them in muslin, and bury them for three of four days". Damp sandy soil is best. Before baking, Dave recommended coating them in clay, four to five centimetres thick, to cook them in their own juices.

At Triabunna on the east coast, a teacher told me the locals were heavily into 'shook', the local term for poaching. Apart from keeping freezers full of venison and wallaby meat, the people were taking Sooty Shearwaters *(Puffinus griseus)*, Yellow-tailed Black Cockatoos *(Calyptorhynchus funereus)*, Blackbirds *(Turdus merula)*, Black Swans *(Cygnus atratus)* and Yellow Wattlebirds *(Anthochaera paradoxa)*, the last of which is very sweet. Wattlebird season is August, when the birds are plump. They are cooked up in stews and the fat floating on top is skimmed off and kept as butter.

This information astounded me. I knew that wattlebirds were popular in colonial times in New South Wales, Victoria, and Tasmania. John Gould wrote of the Yellow Wattlebird that "hundreds are annually sent to the markets of Hobart Town for the purposes of the table. It is highly prized as an article of food, and in winter becomes excessively fat". How surprising that Tasmanians still eat these birds, illegally I might add.

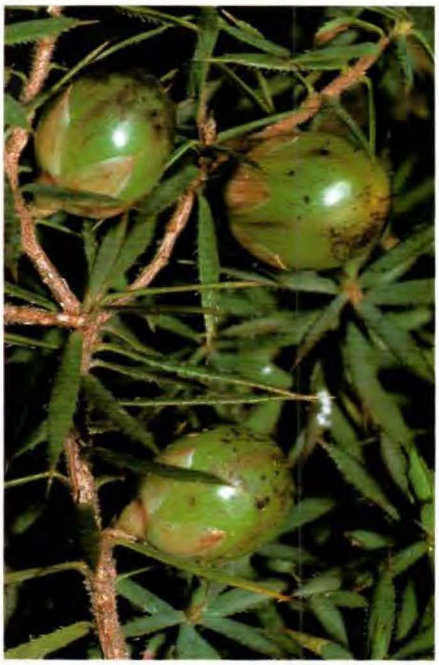
The Tasmanian Native Hen *(Tribonyx mortierii)* was another widely eaten bird, but is considered tough eating. Ruth Bakker, 47, remembered her mother boiling the horribly tough blue-grey meat for two days over a wood stove. So nasty was the smell that she hated venturing into the kitchen. Other informants told me that the trick to softening the Native Hen was to boil it with a boot, and to eat the boot and throw away the bird!

The Sooty Shearwater is also disliked by some, although others love the oily, fishy taste. In Tasmania you can buy the fried birds from fast food outlets, or from Coles on special for $3.75. Other game birds, at least in past times, included snipe and 'Black Jays' (a local name for the Black Currawong, *Strepera fuliginosa*).

The most popular game animal by far is

Of Bennett's Wallaby, John Gould reported that "many thousands are killed annually for the sake of its flesh, which is very generally eaten and highly esteemed, being delicate, juicy and well-flavoured".

PHOTOS: TIM LOW



Native Cranberries taste like apples but are no larger than peas. The ripe fruits are greenish or white, often with purple spots or stripes, and are found on a prickly ground-hugging shrub.

Bennett's Wallaby *(Macropus rufogriseus rufogriseus)*, the local subspecies of Red-necked Wallaby. It is abundant and in no danger of overharvesting. The meat is usually made into rissoles, but makes excellent tender roast, without a gamey taste.

Tasmanians obviously like their game, but they were also forthcoming about wild plant foods. Several people told me of eating Native Cranberries *(Astroloma humifusum)*, Native Cherries *(Exocarpos cupressiformis)*, cooked Bull Kelp *(Durvillea potatorum)*, the white bases of Sag (Longleaf Matrush, *Lomandra longifolia)* and wild mushrooms.

Longleaf Matrush, known in Tasmania as Sag, is a well-known bush food. Tufts of leaves are pulled from the clump and the white inner bases chewed. Matrush is common in paddocks and along streams in eastern Australia.

Marie Howard, 49, originally from Holwall, ate bracken 'roots' and orchid tubers as a child. John Gough, from Fingal, remembered during the depression digging up 'tater yams', tiny tubers almost certainly from an orchid. These memories provide a fascinating link with the colonial era. The Sydney botanist Joseph Maiden wrote in 1898 that "There is hardly a country boy who has not eaten so-called Yams, which are the tubers of numerous kinds of terrestrial or ground-growing orchids".

Apart from all this talk about bush foods, some old-timers regaled me with intriguing tales about possum snaring (for the skins), tanbark gathering, early farm life, and (everyone's favourite topic) Tasmanian Tigers, which still exist, at least in many minds.

Thanks to isolation and a sluggish economy, pioneer living seems but a memory of yesterday in Tasmania. The lifestyle reflects this. The cities are so small that everyone lives near the bush, and many people own weekend country shacks. Both city and country folk know their timbers, grow vegetables, stew their own jams, and gather mushrooms and blackberries.

I was invited to Tasmania to speak at a wild foods seminar organised by Adult Education and the Launceston College of TAFE. Among the audience were entrepreneurs hoping to make money from the bush tucker boom. My advice to them now, after six weeks touring this remarkable island, is to market Tasmania as the Bush Tucker State. It's a legitimate claim to make. Nowhere else in white Australia is the eating of marsupial meat an entrenched part of the culture, nor the shooting of so many different game birds, nor the gathering of wild fruits, roots and seaweeds. The Tasmanian Development Authority should encourage the development of bush tucker restaurants serving venison and wallaby meat with Mountain Pepper *(Tasmannia lanceolata)* sauce, and blackberry pies with Cider Gum *(Eucalyptus gunnii)* syrup. Some food writers dismiss the bush tucker boom of the 1990s as mere gimickry, but I ate enough wallaby rissoles in Tasmania to know it's the real thing down there. ■

Suggested Reading

Gould, J., 1865. *Handbook to the birds of Australia.* Author: London.

Maiden, J., 1898. Some plant-foods of the Aborigines. *Agric. Gaz. NSW* 9(4): 349–354.

Tim Low is a full-time nature writer living in Brisbane. He is the author of four books about plant use, the most recent of which are Bush tucker *and* Bush medicine *(Angus & Robertson).*

"Sir David represents the splendid British tradition of cataloguing life."

DAVID ATTENBOROUGH

BY ROBYN WILLIAMS

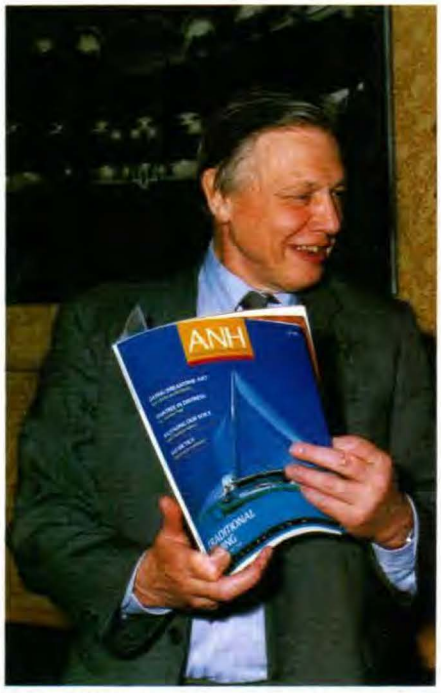
ABC RADIO SCIENCE SHOW

MOST OF US HAVE BEEN WATCHING David Attenborough on the box for as long as we can remember. During the decades he hasn't appeared to age, still boyishly waving his arms with biological enthusiasm from every mountain top, valley, beach or forest on Earth. Yet he's the same age as Margaret Thatcher and to many of us, far more beguiling.

When he came to the Australian Museum to lecture as part of the Super Science Series many could see, face to face, that Sir David is indeed well out of his teens. He also confessed to being somewhat less lithe than he once was: he told us that during the famous sequence in program four of the "Trials of Life" series, when he was seen running with the chimpanzee hunt chasing monkeys, the BBC executives later looking at the footage asked "Why did someone chuck a bucket of water over David?" He had to explain that he was drenched with sweat. His breathlessness was also obvious; but then who wouldn't be out of puff after two hours of charging through the jungle with a pack of rampaging killer chimps, with the only pause being having to talk to the camera, impromptu, about what's going on?

That particular film ended with remarkable and perhaps disturbing pictures of the chimpanzees, mouths smeared with blood, consuming their captured monkey. Sir David, presuming the viewers' discomfort, asked why we should be shocked when we ourselves also kill, often with less reason than for survival.

This question, together with other implications in the scripts of his series on animal behaviour, led some to ask whether Sir David was being too sociobiological. Was he implying that there is some kind of killer-instinct that our ape flesh is heir to and that we battle to suppress? Some ethnologists such as Konrad Lorenz have made much of this, as have writers like Robert Ardrey, who draw on examples of animal behaviour to comment on the flaws in our 'human nature'. Was Sir David right to make so much of the dramatic killing sequences in his series, not only of chimps, but Killer Whales and others?



Sir David Attenborough preparing for one of his Australian lectures.

KATE LOWE / AUSTRALIAN MUSEUM

It's this type of inquiry that David Attenborough finds most uncongenial. He prefers to seek out some phenomenon in nature and to describe it, to display what animals do as fairly as possible (without interfering with the naturalness of what's going on) and then to leave us to make what we will of it. He will most assuredly provide facts to augment our understanding, but he won't want to add any philosophical analysis or intellectual baggage. It's not his style.

That is what he said to the huge audience at the Museum lecture and they were satisfied. Except for a small number who persisted and who were hissed for their pains. The trouble is, it seems to me, that any film about natural history, however free you think it is of wider implications, must carry them, if only by exclusion. Are we to assume from Sir David's series that *all* animals are basically eating, breeding and fighting machines with little flexibility? Are we to assume that we too are part of this rigid continuum?

I'm sure he'd be horrified that the infinite displays of variety and subtlety he has brought to our screens should be considered in any way 'narrow'. But we might ask him, on his next visit to Australia, why he has not chosen to explore any of the famous issues in his field: the role of instinct, the reasons for territoriality, the extent of altruism and cooperation. Eventually, who knows, maybe he'd even like to tackle the cosmic question of the animal nature of *Homo sapiens sapiens* and what it means.

So far, most of Sir David's great series ("Life on Earth", "The Living Planet", "Trials of Life") have been lists, superb ones, but nonetheless summaries of what there is. Now we might ask him whether he fancies doing some films on "Why it is so".

I suspect he'd rather not. At 65 it may not be very tempting to embark on a whole new sequence of documentaries, let alone a new style of presentation. To me Sir David represents the splendid British tradition of cataloguing life. It flourished in the 19th century and gave the basis for most of the zoology and botany degrees in Britain and indeed Australia until about the end of the 1960s. Much of this tradition is the backbone of what museums do. Little wonder then that Sir David has served on the Trusts the British Museum and of the Science Museum in London.

The point of cataloguing is that you cannot begin to answer questions about the nature of life or the resilience of the environment until you know what's there. That his task is not remotely done is demonstrated by Professor Bob May's remark that there are about 1.5 million species named today but up to 30 million still out there waiting to be discovered. (Professor Bob May, an Australian scientist based at Oxford, has recently spoken at the Australian Museum.)

At the end of Sir David's talk he received a standing ovation from the thousands present. And although we had arranged a small cocktail party for Sir David to follow, he couldn't get away from those who had him sign his books for two hours non-stop! Of all the tributes paid to him –the courteousness, the scientific accuracy, the excellence in broadcasting– there's one that's not often mentioned. Sir David has an incredibly deep commitment to his audience and to public service. It's this that explains something of the films he makes and how he makes them. It is also a model that museums could bear in mind. ■

As Executive Producer of the ABC Radio Science Show, Robyn Williams has the opportunity to interview many interesting people in science.

You can learn a lot about the history of Macquarie Street just by looking at the pavement.

Macquarie Street's Sydney Hospital hasn't always enjoyed such an established and conservative title.

Last century, the site was occupied by a hospital which was named after the preferred liquor of the day, namely, Rum.

In 1810, three Sydney businessmen built the city a magnificent hospital in exchange for the coveted monopoly over the city's Rum trade.

This became the Rum Hospital, and stood complete until 1876, when the central block was demolished to build the present Sydney Hospital.

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In 1826, before anybody had even heard of 'Feminism,' the colony ran short of servants.

Accordingly, the ladies of the colony set up the Female School of Industry in order to teach their lesser sisters "every branch of household work." The site is more appropriately occupied now by the Mitchell Library.

The fact is, Macquarie Street is more than just another city street.

It is Sydney's, if not Australia's, most interesting thoroughfare.

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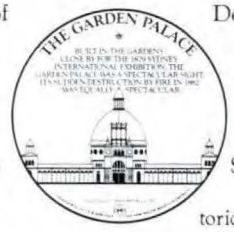

So if you want to find out what Sydney was really like in the early days, look out for the Caltex Commemorative Plaques on your next stroll down Macquarie Street.

You could learn a lot simply by watching where you walk.

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"In all of his 16 years as a commercial fisherman, he had never seen anything like it before, shark-like but with the head of a baby whale."

MEGAMOUTH: GENTLE GIANT OF THE DEEP

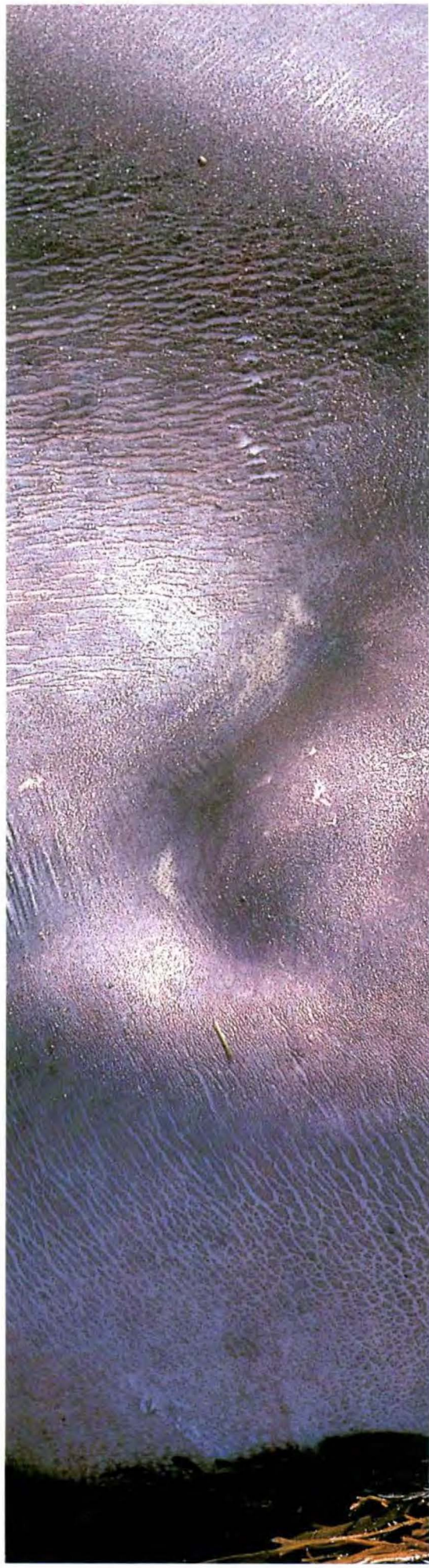
BY BARRY HUTCHINS

DEPARTMENT OF AQUATIC VERTEBRATES, WESTERN AUSTRALIAN MUSEUM

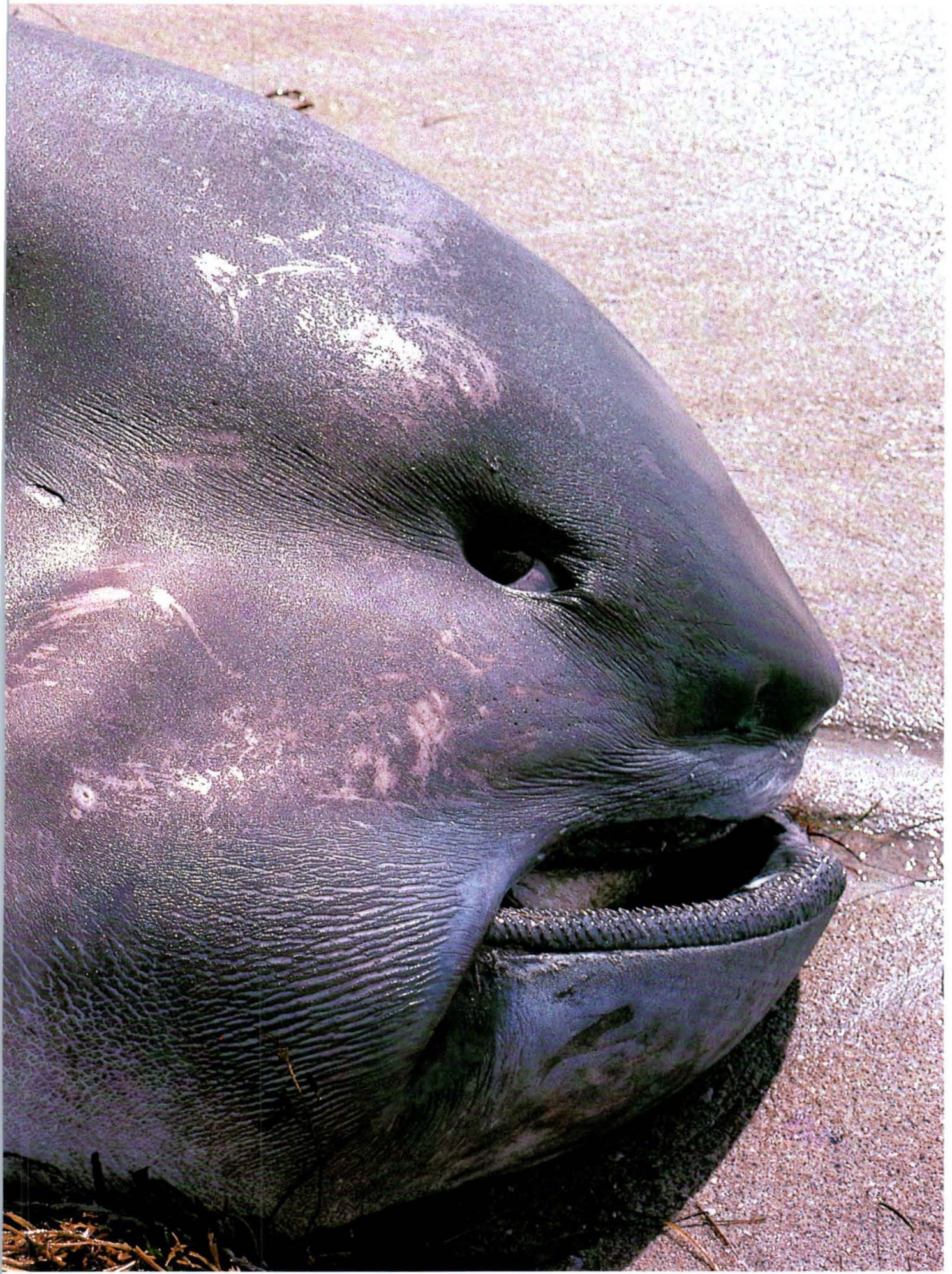
"THERE'S THIS LARGE CREATURE ON the beach," the telephone caller said. "I've never seen anything like it before–it appears to be a cross between a shark and a whale." The speaker was Derek Blackman from Western Australia's Fisheries Department, an inspector who I knew from previous experience had a good knowledge of aquatic animals. "You had better come down and see this beast before it gets carted off to the tip."

The last thing I needed that August morning in 1988 was a wild goose chase to Mandurah, 50 kilometres south of Perth. More than likely it would turn out to be the rotting carcass of a shark or small whale. However, Derek was insistent and, as I was puzzled by some aspects of the description he had given me, I decided to check the animal out.

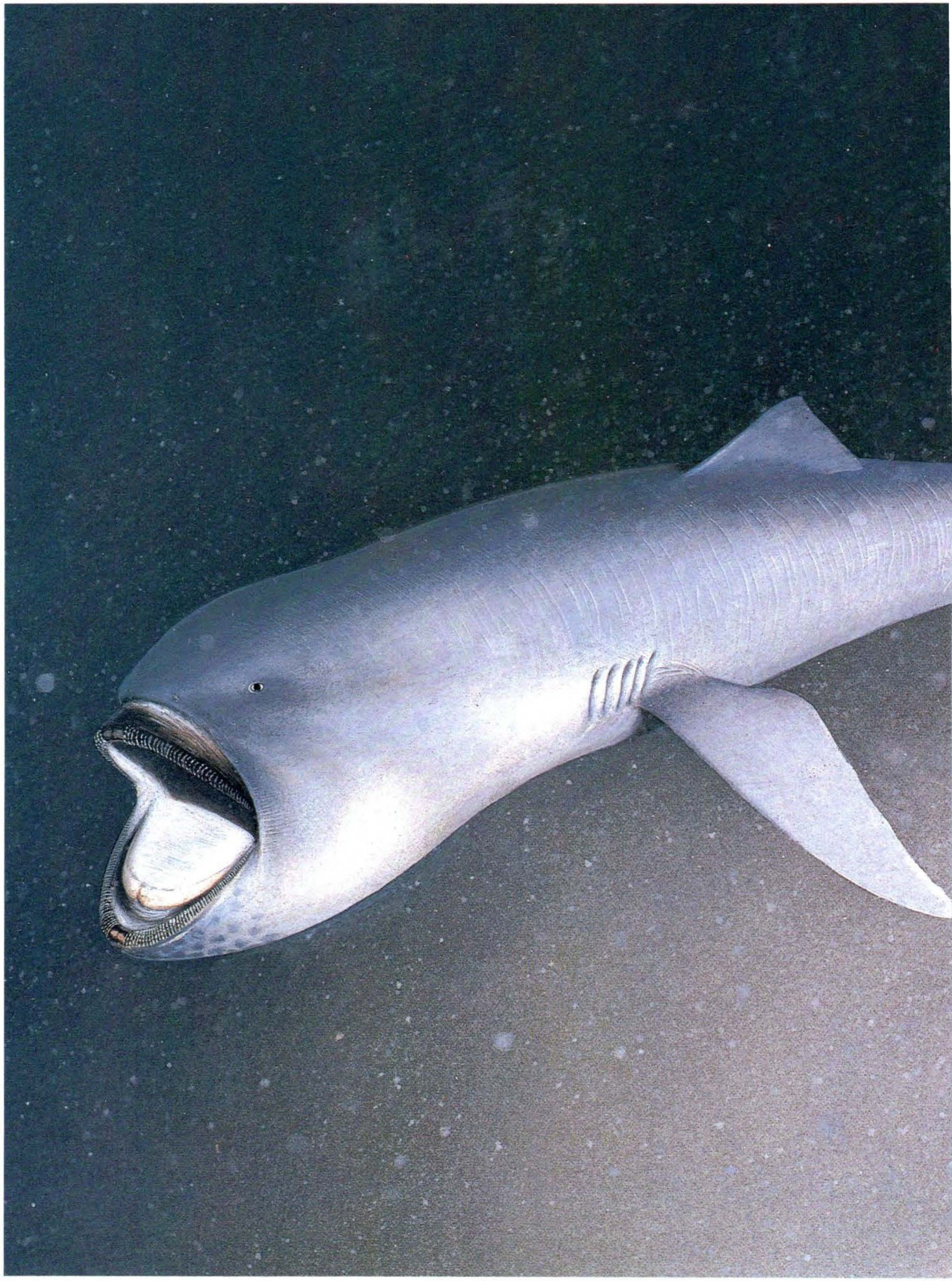
Soon afterwards, Western Australian Museum Technical Officer Nick Haig and I were on our way to Mandurah armed with several identification books on marine creatures. Thumbing through one of these, I happened on a description of the Megamouth Shark, a rare deep-sea animal that was known only from two individuals caught in the central and eastern Pacific. An illustration of the shark showed some similarities to the descrip-



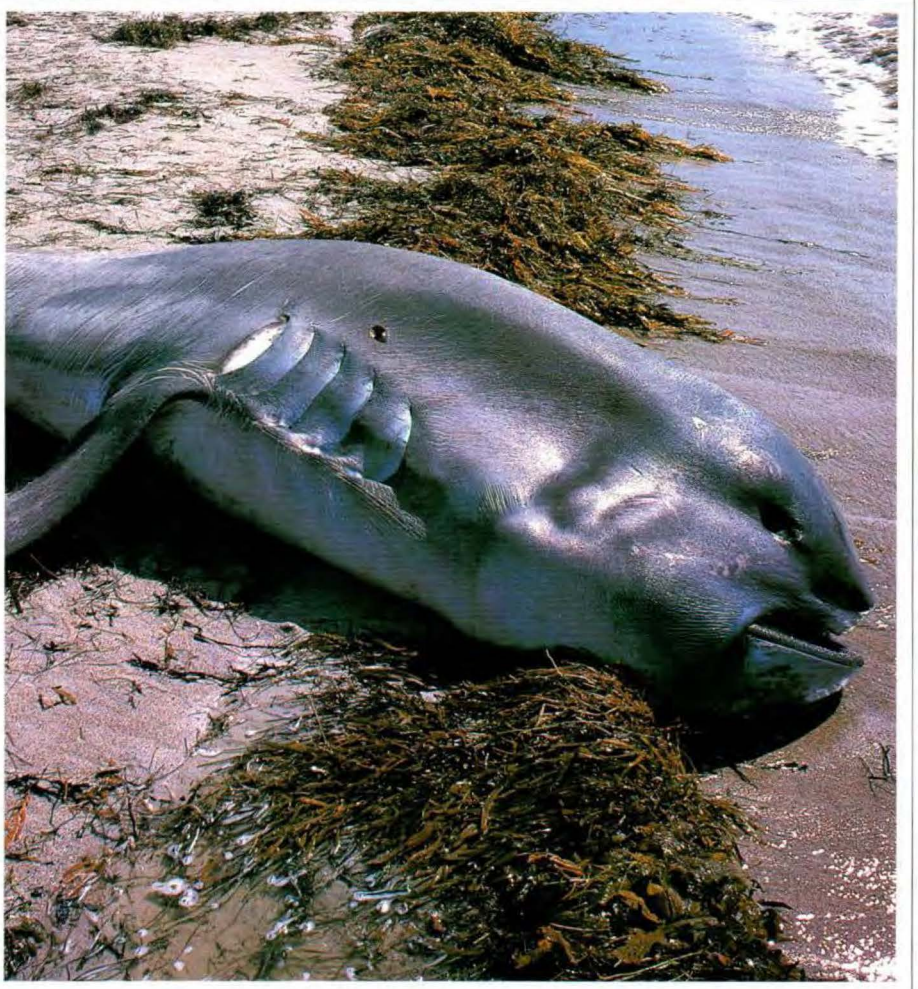
The third Megamouth Shark ever found (Megamouth III) was washed ashore on the beach at Mandurah, Western Australia, in 1988. The shark gets its name from its huge mouth designed for feeding on plankton.



BARRY HUTCHINS



ROGER SWAINSTON / IKAN



Megamouth III, on the beach at Mandurah. The wound above the gills was probably made by the Cookiecutter Shark, a small midwater oceanic species that preys on large, slow-swimming marine animals.

tion given by Derek. Could the Mandurah beast be a third specimen of Megamouth? My curiosity was now whetted.

After meeting up with Derek Blackman, we were driven to the northern side of the ocean entrance to Mandurah inlet. Quite a crowd had gathered, no doubt attracted by the television news helicopter that had landed on the beach. From the midst of a knot of people at the water's edge, a long grey tale protruded. As our party approached, the huddle parted to reveal an astonishing sight. A large shark-like animal lay forlornly on the beach. At almost 5.2 metres in length, the creature was certainly much larger than I had expected. It had the fins and gill slits normally expected of a shark, but a short, almost pug-like snout that gave it the appearance of a baby whale. Other notable features were its wide mouth designed for feeding on plankton, a bathtub-shaped lower jaw for gulping in large volumes of water, and a silvery to silvery black lining to its mouth. Furthermore, in contrast to the triangular-shaped teeth of the more familiar species of sharks, this creature had rows of minute teeth presumably used to prevent larger food items like jellyfish from falling out of its mouth. There was no mistaking this animal–it was indeed a fine example of the Megamouth Shark, scientifically known as *Megachasma pelagios*.

An illustration of Megamouth, showing how it uses its bathtub-shaped lower jaw for gulping in large volumes of water.

BARRY HUTCHINS

UNTIL THE FIRST SPECIMEN WAS DISCOvered in November 1976, scientists would never have dreamed that such a large unknown shark was roaming the seas. Megamouth had probably been encountered before by fishermen, but often such large sharks are returned immediately to the sea by their captors because of the difficulty in handling them. This first recorded capture made worldwide news. The 4.5-metre shark had become entangled in a parachute sea anchor being used by a United States Navy research vessel off Hawaii. The drogue was set at a depth of 165 metres and the shark had apparently blundered into it. With its small sharp teeth snagged in the parachute's fabric, Megamouth had been unable to escape. The shark was discovered when the sea anchor was retrieved. It was recognised as something different and brought back to Honolulu. Megamouth was formally introduced to science when a scientific description was published in 1983. The shark was so unusual that, in addition to being described as a new genus and species, it was placed in a new family of sharks, the Megachasmidae.

Megamouth III was rolled onto a piece of steel mesh to support its huge bulk while being moved.

BARRY HUTCHINS

Eight years later, in November 1984, a second individual of Megamouth was found. A fisheries observer on board a commercial driftnet fishing boat operating off the Californian coast near Santa Catalina Island was surprised to see a strange shark come to the surface entangled in the boat's gill net. The shark was still alive and making a feeble attempt to escape. A nearby fisheries research vessel was contacted and a biologist on board (Dennis Bedford) confirmed the shark's identity and rarity. This specimen was also 4.5 metres in length but it had been captured at a depth of only 38 metres. Megamouth II was taken to Los Angeles and preserved at the Natural History Museum, where it is now on display.

The finding of the Mandurah Megamouth again caused a flurry of interest worldwide. News media from North America, Europe and across Australia were quickly on the phone to the Western Australian Museum wanting information on the capture of Megamouth III. From talking with bystanders at the site of the stranding, I had managed to piece together some of the events that led to the shark's death. Megamouth had apparently been sighted by surfboard riders the previous day. As it seemed intent on beaching itself, the surfers had tried to coax it into deeper water. Their efforts were obviously unsuccessful as it was found the next morning stranded on the beach and, although still alive, died a short while later.

Mandurah Shire Council was enthusiastic about the possibility of preserving Megamouth and quickly provided a front-end loader, a truck, and the necessary manpower. A ditch was dug adjacent to the shark, lined with concrete reinforcing mesh, upon which Megamouth was then rolled. Slings were placed around the wire mesh, attached to the scoop of the front-end loader, and the 700-kilogram shark was then lifted onto the back of the truck for the trip to a deep freezer in Perth.

Public interest was sufficiently high to warrant a special showing of Megamouth that weekend. The frozen specimen was placed on a flat-bed trailer and viewed by almost 4,000 people over several hours in a congested Museum car park. It was subsequently preserved in formalin and is presently being held in a temporary container awaiting a permanent display tank.

In quick succession, three further Megamouths were discovered. Megamouth IV was washed ashore at Hamamatsu City, Japan, in January 1989. The dead, four-metre-long male individual was photographed but, before it could be retrieved, waves washed it back out to sea. The fifth Megamouth was also found in Japan, being netted alive off Suruga Bay in June of the same year. The 4.9-metre individual was released alive. The sensational capture of Megamouth VI, however, turned the scientific world on its head—it had been taken alive, filmed underwater, and subsequently released with two implanted radio-transmitters to track its movements. Now we would learn more about this mysterious animal.

THE SIXTH MEGAMOUTH WAS CAPTURED about ten kilometres off Dana Point, near Los Angeles in California. While

retrieving his drift swordfish nets just past midnight of 21 October 1990, fisherman Otto Elliot noticed that something large was entangled at a depth of about 23 metres. In all of his 16 years as a commercial fisherman, he had never seen anything like it before, shark-like but with the head of a baby whale, and very much alive. Otto felt someone who was an authority on marine creatures should see it.

The sluggish five-metre animal was easily released from the net and tied by its tail to the stern of Otto's boat. So as not to hurt it further, the creature was towed to the Dana Point harbour at idling speed, a trip that took eight hours. Even though it was a Sunday morning, news soon reached Dr Bob Lavenberg of the Natural History Museum in Los Angeles, the home of Megamouth II.

On reaching Otto Elliot's boat, Lavenberg was amazed to find a perfectly healthy Megamouth Shark resting quietly on the sea bottom 4.5 metres below the boat and seemingly none the worse for wear after being towed backwards. (Many sharks, particularly the dangerous species, must continue to swim forwards in order to pass water through the gills; they drown quickly if prevented from doing so.) Here was the opportunity to study a live Megamouth, but where could it be kept? Phone calls were made to various marine sea-life parks but none could provide the necessary facilities. Lavenberg therefore decided that the shark should be released after first subjecting it to a close scrutiny. To test a theory of his that Megamouth is a vertical migrator (that is, able to move from deep water into relatively shallow water and back again), Lavenberg also organised for an ultrasonic transmitter and depth sensor to be attached to the shark so that its movements could be followed.

The following morning, Megamouth was again towed back out to sea by Otto Elliot's boat. The trip took six hours and, during the last two hours, it had swum strongly against the tension of the rope, impatient to be free. When the line was removed from its tail, the shark immediately dived for the bottom 43 metres below. After swimming around for ten minutes just above the bottom, apparently to get its bearings, Megamouth began to swim offshore at a speed of about one kilometre per hour. The research vessel that was monitoring the ultrasonic signals being emitted from the attached transmitters was not far behind. For 50 hours the shark was tracked, by which time sufficient data had been gathered to show that the shark was indeed a vertical migrator. It had spent the daylight hours at a depth of about 170 metres, and at dusk had ascended to around 12 metres below the surface where it remained throughout the night. This vertical migration is obviously triggered by light changes, but may also be a response to the movement of the planktonic animals on which it feeds. The euphausiid shrimps that make up part of Megamouth's diet are known to migrate daily from deep waters to the surface. One thing remains unclear: if the shark is a regular vertical migrator, why haven't more been caught by offshore net fishermen working at night? Perhaps there have been. Following the news reports of the capture of Megamouth III, the Western Australian Museum received additional accounts of Megamouth-like creatures from Australian fishermen. Most said that the animals were released because of their large size. However, it was not possible to verify these encounters. One so-called Megamouth, for example, was described as being covered with white spots, a feature characteristic of the Whale Shark *(Rhincodon typus)*.

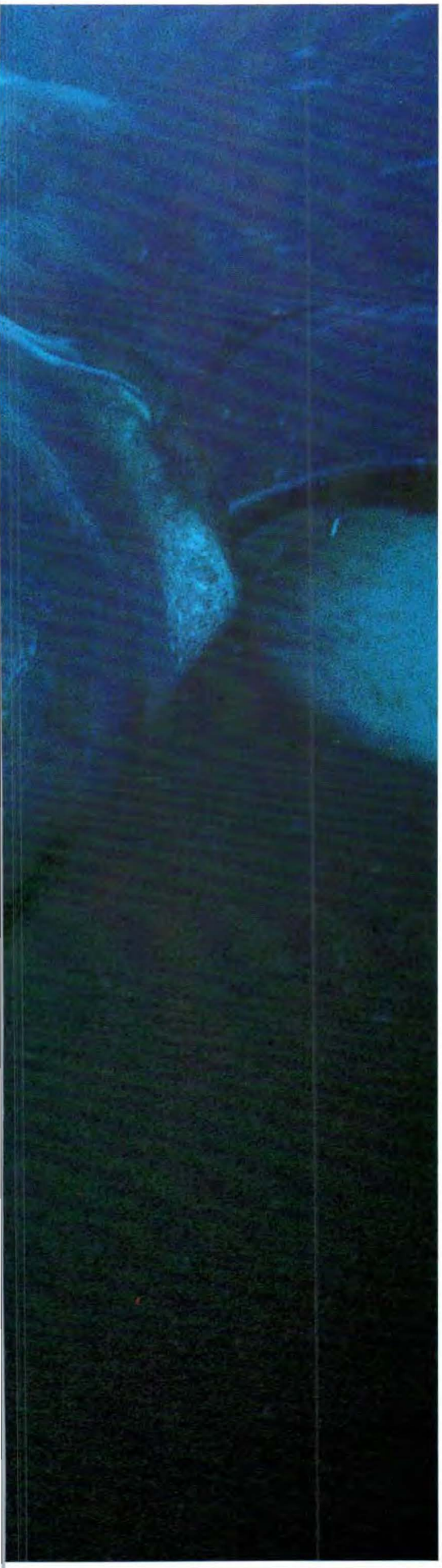
All Megamouths found to date have been males with the possible exception of Megamouth V. Photographs of the latter taken before its release show no sign of the characteristic claspers of a male. Bob Lavenberg believes that the capture of Megamouths I, II and VI in the central and eastern North Pacific at the same time of the year (October to November) may indicate that this is the mating season for Megamouth Sharks in this region. Furthermore, Megamouths II and VI showed evidence of recent matings. The claspers of Megamouth II were oozing spermatophores and those of the sixth individual were abraded and bleeding, a common occurrence in sharks that have just mated. Furthermore, the latter had a fresh wound on the lower jaw, a feature found in other sharks that grasp one another's mouths during mating.

Other wounds were found on the bodies of both Megamouths I and III. These were circular and crater-like, and are believed to have been caused by the Cookiecutter Shark *(Isistius brasiliensis)*, a small midwater oceanic animal that

It took a front-end loader to lift Megamouth III onto the back of a truck bound for a deep freeze in Perth.

BARRY HUTCHINS

THOMAS E. HAIGHT



Megamouth, despite appearances, is a gentle giant.

attaches to its prey with the help of suctorial lips and a modified pharynx. With a twist of its body, the large saw-like teeth of the lower jaw then easily remove a conical plug of flesh. The slow-swimming Megamouth would be easy prey for the active Cookiecutter Shark.

When Megamouth was first described, it was placed in the new family Megachasmidae. However, a subsequent study has suggested it might better be placed in the same family as the Basking Shark *(Cetorhinus maximus)*, the Cetorhinidae. Both are large filter-feeding inhabitants of oceanic waters that also share certain unique conditions of the jaws and teeth. Furthermore, the investigation implied that these sharks might be the two most primitive members of the order Lamniformes. There is some evidence that Megamouth, or at least a close ancestor, may have inhabited the waters along the western coast of North America 26 million years ago. Lavenberg compared the teeth of a modern Megamouth with some fossil teeth of an as-yet-unidentified shark from the early Miocene or late Oligocene and found some similarities.

Further studies are needed to examine more closely the anatomy of this rare shark so that a more thorough evaluation of its relationships can be made. Unfortunately, this means that additional Megamouth specimens are needed for the necessary dissections. Perhaps more dead or dying individuals will be found washed ashore so that all those netted can be released, as happened with Megamouths V and VI. It seems a pity to have to kill such a harmless shark just so that we can learn more about it. Still, on the present trend of encounters, there is little doubt that Megamouth VII will soon be adding more to the unfolding story of this fascinating sea creature. ■

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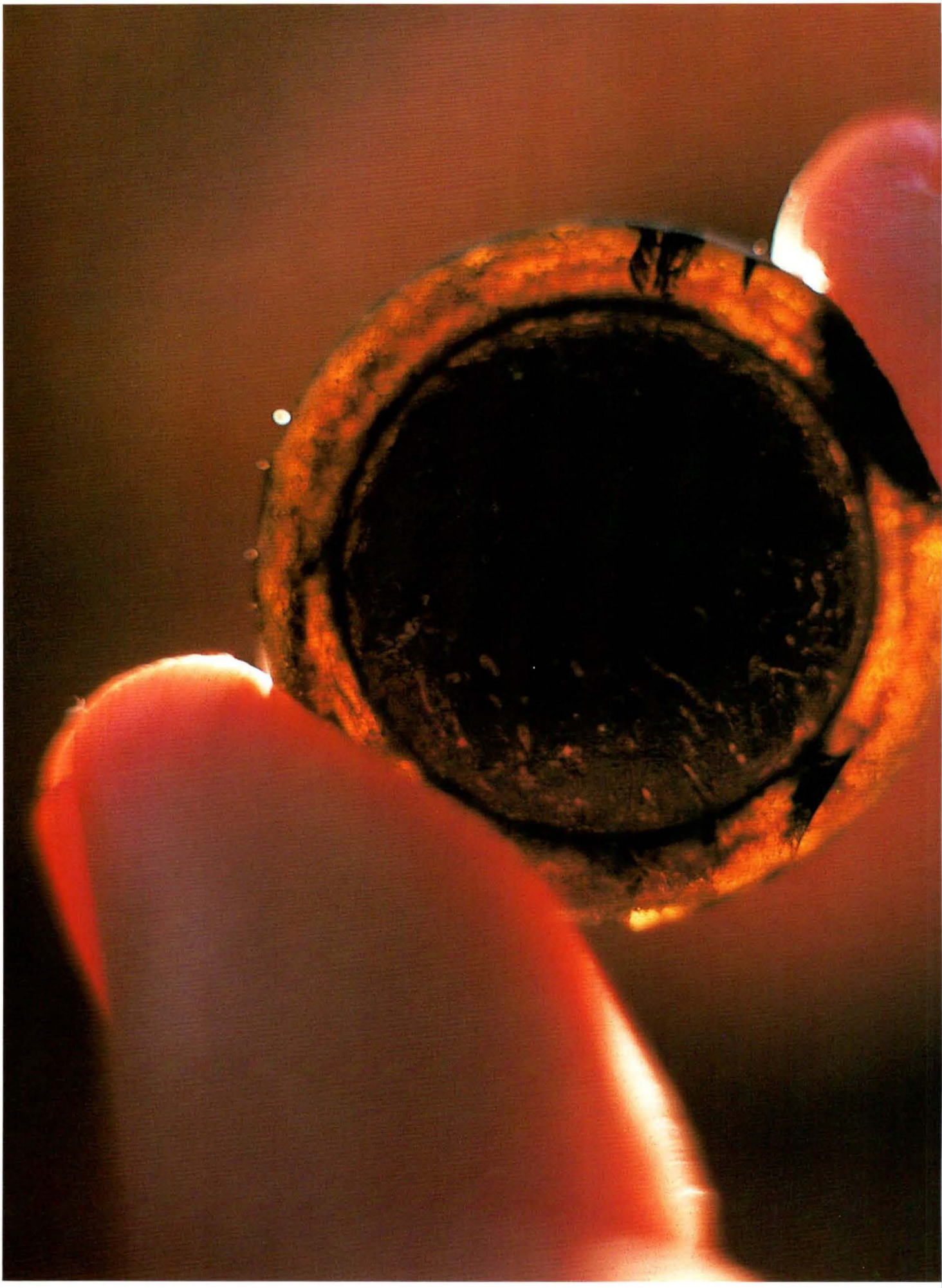
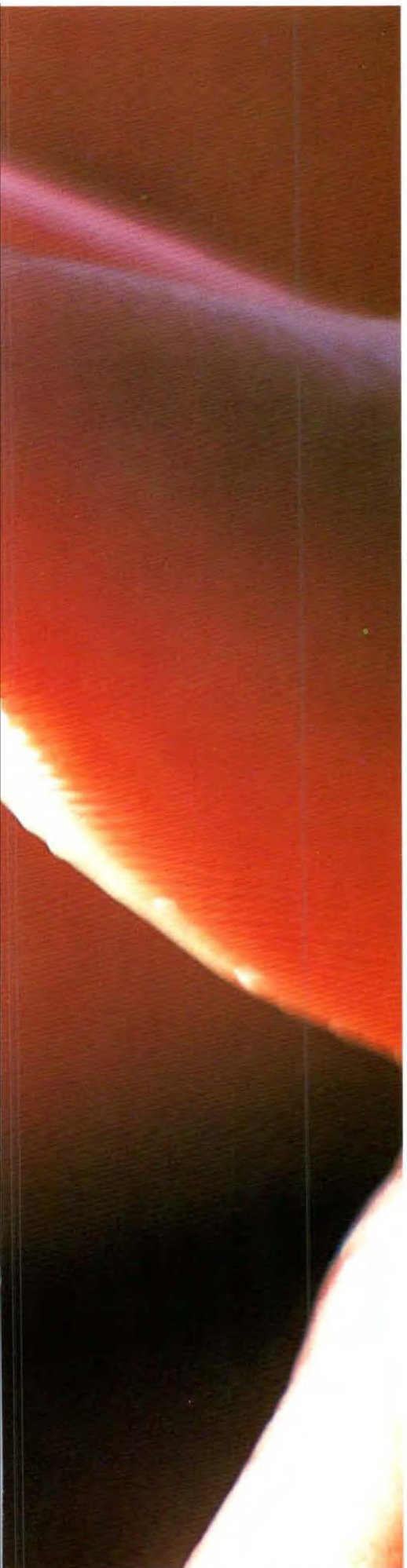
Dr Barry Hutchins is a curator in the Department of Aquatic Vertebrates at the Western Australian Museum. His main interests are in the classification, evolution and ecology of leatherjackets and clingfishes. He has written several popular books on Australian fishes, including a comprehensive field guide to the marine species inhabiting Australia's southern half. Much of the information on Megamouth VI was generously provided by Dr Bob Lavenberg of the Natural History Museum of Los Angeles County.



ALEX BEVAN



"Just how these blobs of natural glass became launched into the atmosphere has only relatively recently been revealed. Its unveiling has been a classic exercise in scientific deduction."

THE DAY IT RAINED GLASS

BY ALEX BEVAN & KEN McNAMARA

WESTERN AUSTRALIAN MUSEUM

IMAGINE A SCENE MANY THOUsands of years ago. It is late afternoon. A group of Aborigines is sitting under the shade of a wattle tree fashioning stone tools when one of them spots a shiny black pebble at his feet. Picking it up he dashes it with his knapping tool, sending a shower of razor-sharp glass shards flying everywhere. One slices through his finger and while the blood flows freely from the clean wound he curses loudly. Yet it may have been by such an imaginary painful discovery that the source of sharp tools and 'medicinal' stones treasured by generations of his descendants was first revealed. Little could these

Australian tektites (or australites) come in a variety of shapes, the most familiar, although not the most common, being the flanged 'button'. The shapes of these blobs of glass lend clues to their origin.

Map showing the four tektite-strewn fields: Czechoslovakia (moldavites), Ivory Coast, North America (bediasites from Texas, georgiaites from Georgia), and South-East Asia–Australia (indochinites, philippinites, javaites and australites), and the Haitian tektite occurrence.

Two tektites as they were found at Khon Khaen, north-eastern Thailand. The tektites from this area are about 800,000 years old.

KEN McNAMARA

A tektite from Czechoslovakia. Called moldavites, these earliest recorded tektites were originally mistaken for man-made glass, but were actually formed 14.7 million years ago.

early discoverers have realised that these self-same black pebbles were to be used many thousands of years later by NASA scientists as models for the design of the Apollo re-entry module that would return astronauts to Earth from their exploration of the Moon.

What are these enigmatic objects? Since 1900, when the Austrian geologist F.E. Suess first proposed the name, we have called them 'tektites'. Derived from the Greek *tektos*, meaning 'molten', the word reflects the fact that they formed from molten blobs of glass. But how and when they were melted, and from where tektites came in the first place, have been subjects of intense scientific debate for the last 150 years. Scientists have long agreed that their aerodynamically sculpted shapes resulted from high-speed flight through the atmosphere during an early stage in their formation. Just how these blobs of natural glass became launched into the atmosphere, however, has only relatively recently been revealed. Its unveiling has been a classic exercise in scientific deduction. By sifting through the accumulated evidence scientists have tracked down how tektites originated.

ABUNDANT TEKTITES OF DIFFERENT AGES have been found in four main areas in the world—South-East Asia and Australia, the Ivory Coast in Africa, Czechoslovakia, and North America—and are restricted to certain geographical areas, known as 'strewn fields'. Up until recently, the oldest tektites, dated at around 35 million years old, were known from the southern United States, but tiny 'fossil' tektites dated around 64.5 million years old have since been discovered on the Caribbean island of Haiti; those from the Ivory Coast are much younger at about 1.3 million years old. The largest and youngest strewn field extends from China, Vietnam, Laos, Cambodia and Thailand through the Philippines, Malaysia and Java, and across most of Australia, and may include tiny spheres of glass, called microtektites, found in deep-sea sediments south and west of Australia. Tektites from these regions have all been dated at around 800,000 years suggesting that, whatever their origin, they were probably formed in one major event.

The first recorded tektites, known as 'moldavites' (now 'vltavins'), were found in the late 18th century in Czechoslovakia. Unfortunately, early attempts to decipher the origin of tektites were made on these beautiful, translucent green examples found in Bohemia, a famous Czechoslovakian glass-making region. Not surprisingly, they were originally thought to be fragments of man-made glass. However, moldavites contain bubbles of atmospheric gas with a pressure equivalent to an altitude of 32 kilometres, and dating of the glass in recent times has revealed they were formed 14.7 million years ago! Because of the similarity of most tektites to natural, black volcanic glass, called obsidian, popular opinion in

the 18th century was that they were unusual forms that had been shot into the atmosphere by violent volcanic eruptions. However, the compositions of tektites are very different from volcanic rocks and, during the 20th century, most theories revolved around an extraterrestrial origin: either directly from the Moon, or indirectly from the effects of huge meteorites hitting the Earth.

Tektites come in many shapes and sizes. One colossal chunk of layered glass found in Indochina weighed 12.8 kilograms. These so call 'Muong Nong' tektites are exceptional; most aerodynamically shaped tektites rarely exceed a few hundred grams in weight, and the majority weigh only a few grams. The largest tektite recorded in Australia is a 437-gram specimen from Western Australia. Of all the tektites, the Australian tektites, known as 'australites', show the greatest variety of shapes, and nearly 30 different forms are known with a range of descriptive names from 'buttons', 'boats' and 'canoes' to 'dumbbells', 'lenses', 'ovals' and 'teardrops'. These bizarre shapes suggest that the australites we find today have been through at least three stages: original solidification from molten glass; aerodynamic sculpting during high-speed flight; and, finally, damage caused by weathering and erosion during their long exposure on the Earth's surface.

During their early flight through the atmosphere, the molten blobs of glass solidified into a number of primary shapes depending on whether or not they were rotating, and their speed of rotation. Spheres did not rotate but, with increasing rates of rotation, the molten glass solidified into spheroids, ellipsoids and, in rare cases, dumbbells. Some of the most rapidly rotating dumbbells were drawn apart, like soft toffee, producing two teardrop-shaped objects call 'apioids'. After attaining their initial shape, many australites stabilised in flight and were then partly remelted by frictional heating as they hurtled at hypersonic velocities through the atmosphere. Their frontal surfaces melted and successive layers of molten material were stripped away by a process known as ablation. In the case of many small extensively ablated australites, the molten material that reached the leading edge was caught in eddy currents and solidified in the protective shadow of the cool rear surface, forming complex, rolled features called 'flanges'. When tektites slowed sufficiently in the atmosphere ablation ceased and, for larger less ablated tektites, the frontal layer cooled, contracted and broke away. These tektites, known as 'cores', have a rim marking the rearward limit of the detached frontal layer and are by far the most common forms of australite found.

Since falling to Earth, tektites have undergone the ravages of time. Generally, they have become pitted and grooved by slightly acidic rain. Many have been transported, eroded and dispersed by flowing water. Others have been washed into

Australites, shown here at just under half their natural size, come in a variety of shapes.

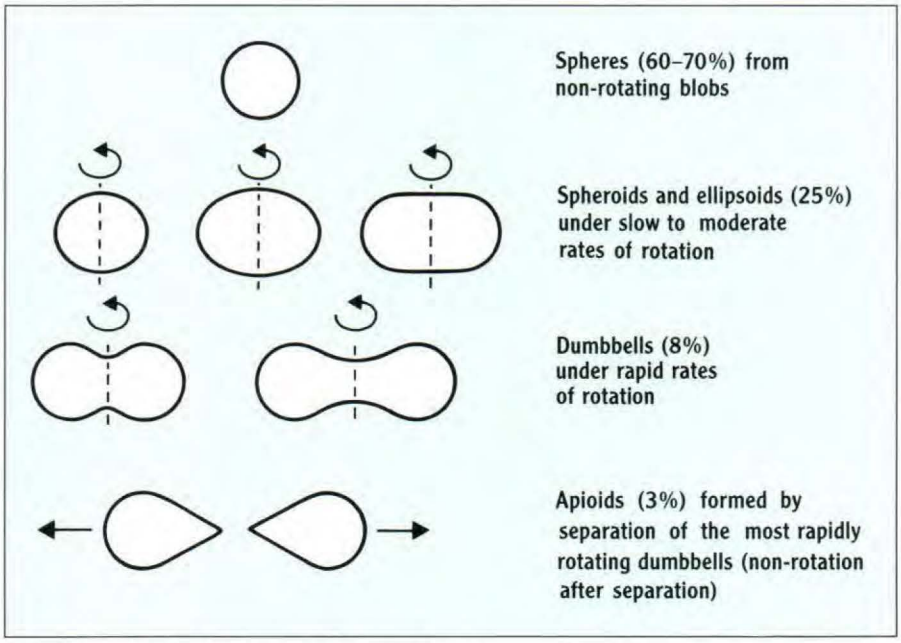


Diagram showing the development of primary shapes.

KEN McNAMARA

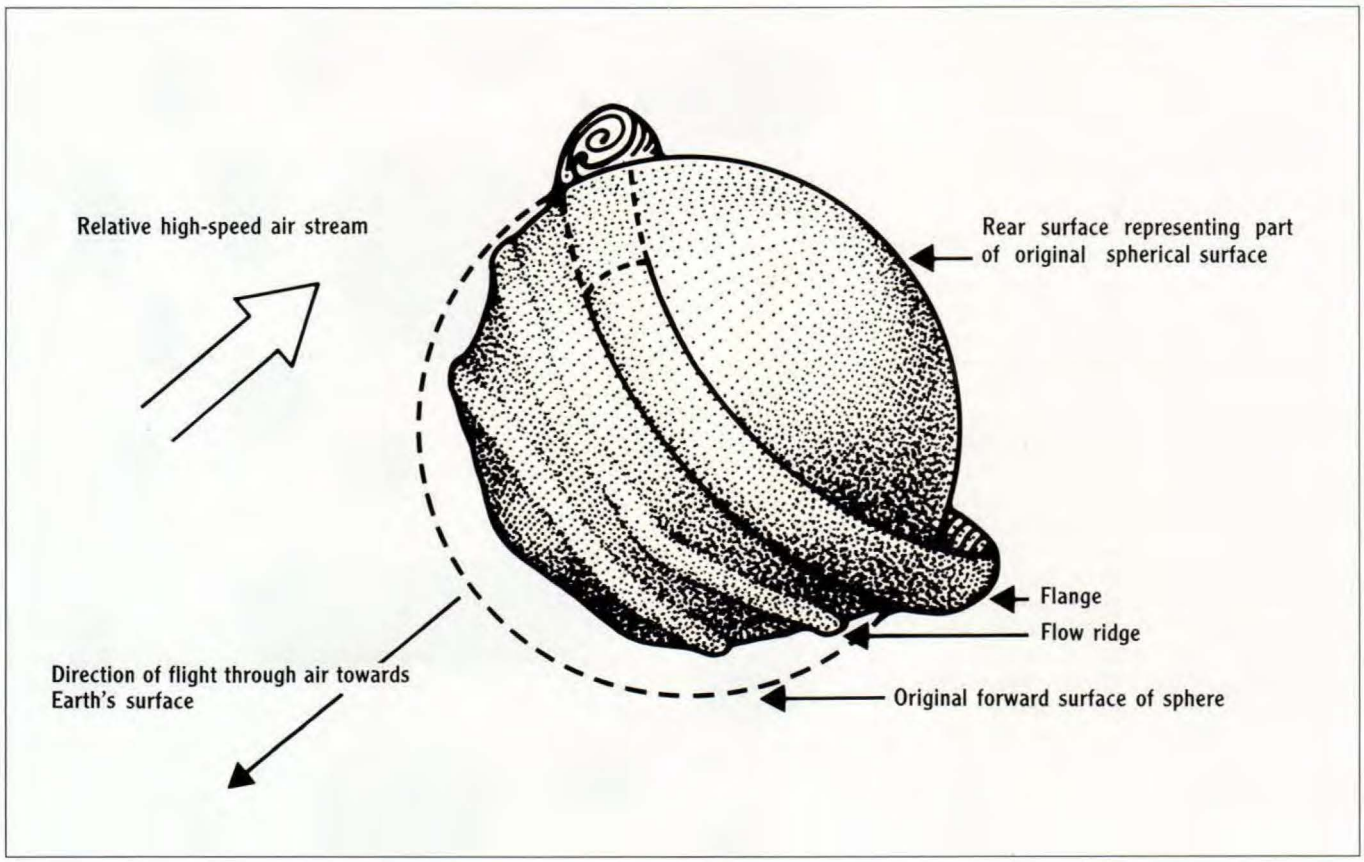


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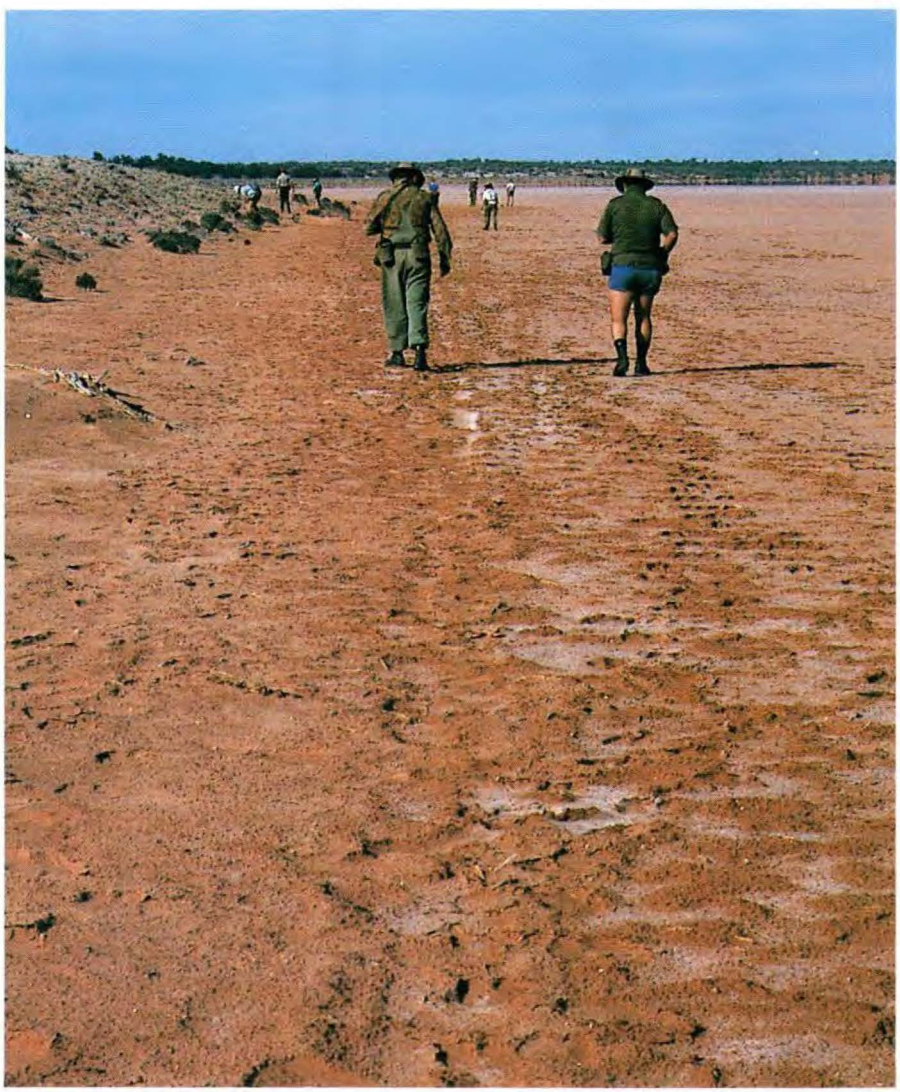
Diagram showing how a 'button' australite is formed.



ALEX BEVAN

Collecting tektites on the Nullarbor.

lakes and concentrated. At one site, Lake Yindarlgooda in Western Australia, more than 22,000 australites have been found.

Although the shapes of tektites tell us much about their history and have even found a practical application in space engineering, they do not tell us from what tektites were made. We can only deduce this from their chemical composition. The compositions of tektites are very similar to quartz-rich sedimentary rocks (such as sandstones and siltstones) that are common on the surface of the Earth. Tektite glass has a high content of silica, but also contains some aluminium, iron, magnesium, calcium, potassium, sodium, titanium and manganese. A few tektites contain tiny spheres of iron-nickel metal, iron sulphide and, rarely, iron-nickel phosphide, and these exotic inclusions provide us with our first major clue to the origin of tektites as they are all minerals characteristic of meteorites. So, are tektites meteorites? As we shall show later the answer is no, however other tell-tale foreign particles in tektites not only give us an idea from what tektites were made, but also how they were made. Occasionally tektites contain shred-like filaments of pure silica glass, called 'lechatelierite', and specks of the mineral coesite. The silica glass is thought to have formed from quartz grains that have been instantaneously fused, whereas coesite is a high-pressure form of quartz. Significantly, both substances are commonly found in

the pulverised sandy rocks in some of the world's large meteorite craters.

In 1933 L.J. Spencer, then Keeper of Minerals at the British Museum (Natural History), noted the strong similarity between tektites and melt glasses found at some meteorite craters. He therefore proposed that tektites were the result of instantaneous fusion of Earth rocks during large-scale, meteorite impacts. However, this was met by scepticism, and many of his scientific colleagues still believed that tektites were either meteorites, or that they had come from the Moon.

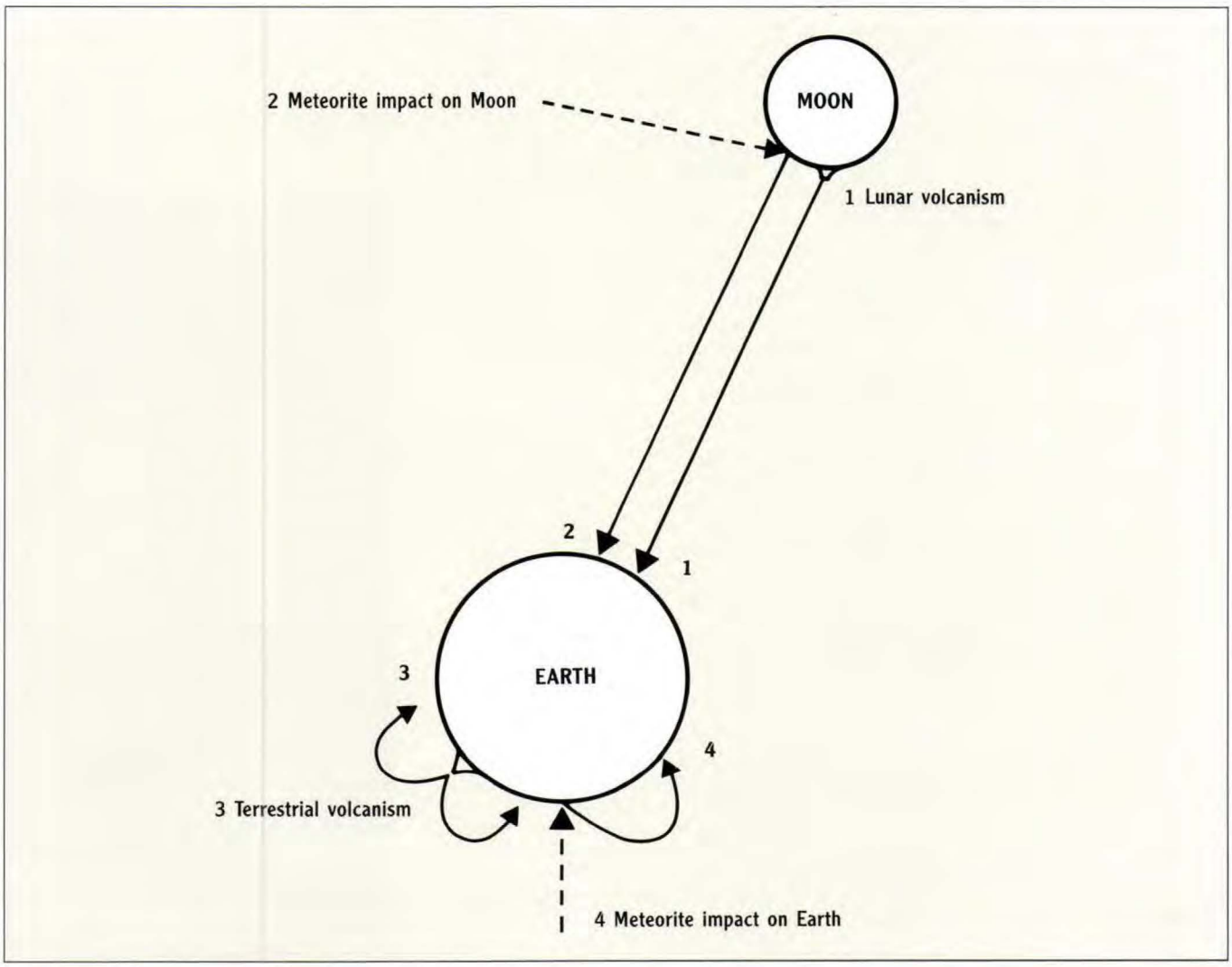
Over the next 30 years, painstaking research gradually eliminated many theories of tektite origin, including their direct derivation from meteorites or comets. Apart from the distinct chemical differences between meteorites and tektites, meteorites possess a weak background radioactivity that they acquired from long and intense bombardment by high-energy cosmic rays in space. Tektites lack this type of radioactivity and so could not have been in space for any length of time. This damning piece of evidence clearly favoured a terrestrial origin for tektites, but was not sufficient to eliminate a lunar origin completely.

The tektite debate raged intensely during the ten years prior to the first landing on the Moon. By that time, the main protagonists in the field had separated into two main camps: those who believed they formed from cometary or meteorite impact on terrestrial rocks; and those who thought they had been derived either by impact or volcanism from the Moon. Ironically, the return of the first rocks from the Moon in 1969 (a feat the humble tektite had helped make possible!) provided evidence that tektites had not come from there. The chemistry of lunar rocks, which are predominantly basalts, proved to be very different from tektites. Badly mauled, the few remaining champions of the lunar origin suggested that the parental material of tektites might have come from deep within the Moon, still believing that it would have been impossible to launch tektites from the surface of such a large planet as Earth.

It was not until 1982 that the final nail was driven into the coffin of a lunar origin for tektites. Until then, the dating techniques that had been applied to tektites had only revealed when they had formed as molten glass. By analysing the differences in the isotopes of the rare elements samarium (Sm) and neodymium (Nd), and the elements rubidium (Rb) and strontium (Sr), Henry Shaw and Gerry Wasserburg of the Californian Institute of Technology showed that their ratios in tektites are similar to those in the ancient crust of the Earth. This matched the chemical data that indicated a close similarity in composition between tektites and some sedimentary rocks, especially 'dirty' sandstones, called greywackes, that contain other minerals such as feldspar, mica and clays. Since the Sm–Nd ratio is relatively undisturbed by processes such as weathering, sedimentation, heating and melting, the Sm–Nd radiometric age of a tektite should represent the time of formation of the original Earth's crust from which sedimentary rocks and ultimately tektites were derived. The Sm–Nd ages obtained from North American, European, Ivory Coast and Australasian tektites are 650, 900, 1,900 and 1,150 million years respectively, proving conclusively that tektites could not have been made from lunar rocks, the youngest of which are around 3,200 million years old.

THE ORIGIN OF TEKTITES BY TERRESTRIAL impact of comets or asteroids is no less exotic a mechanism than lunar vulcanism, but in the famous words of Sherlock Holmes, "When you have ex-

Diagram showing the four principal theories of tektite formation: 1) lunar volcanism; 2) lunar meteorite impact; 3) terrestrial volcanism; 4) terrestrial meteorite impact.



KEN McNAMARA

KEN McNAMARA

An Aboriginal artefact made from an australite.

ABORIGINES AND TEKTITES

Tektites have played a long and important role in Aboriginal culture, the earliest record being a tektite from an archaeological site at Miriwun, in the Kimberley, dated at 18,000 years old. Many different Aboriginal groups believed tektites to have particular powers. In some parts of central Australia they were much sought after simply because they were thought to be 'lucky' stones. In most of Western Australia they are called Maban, which is a word used for any object thought to be 'magic'.

Tektites have been used by some Aboriginal tribes as healing stones to cure wounds, sickness and disease. Their 'magic' properties were guarded by medicine men who would 'extract' a tektite from the patient, taking the illness with it. In some parts of south-western Australia, tektites were thought to keep illness at bay. Other tribes thought that tektites had destructive powers. There are also records of tektites having been used as 'death pointers', firstly by causing illness, then death. The 'death pointer' ritual sometimes involved throwing the tektite at the offender. In areas of Gippsland, even to touch a tektite was thought to be enough to cause death.

Some south-western Australian tribes used tektites in rain-making ceremonies. By other tribes they were used to make the sun shine, or the wind stop, or to make game more bountiful. Two tektites from Mt Magnet in Western Australia were used in the psychic transmission of messages. Often carried about in the beards of 'medicine men', tektites were said to possess the power, by transmission through the navel of the wearer, to receive and transmit long-distance messages.

Commonly, tektite glass has been prized as a source of high-quality implements. Percussion flakes made from tektites are very sharp and have been used as knives, points, arrow heads, or as ceremonial knives in certain rituals.

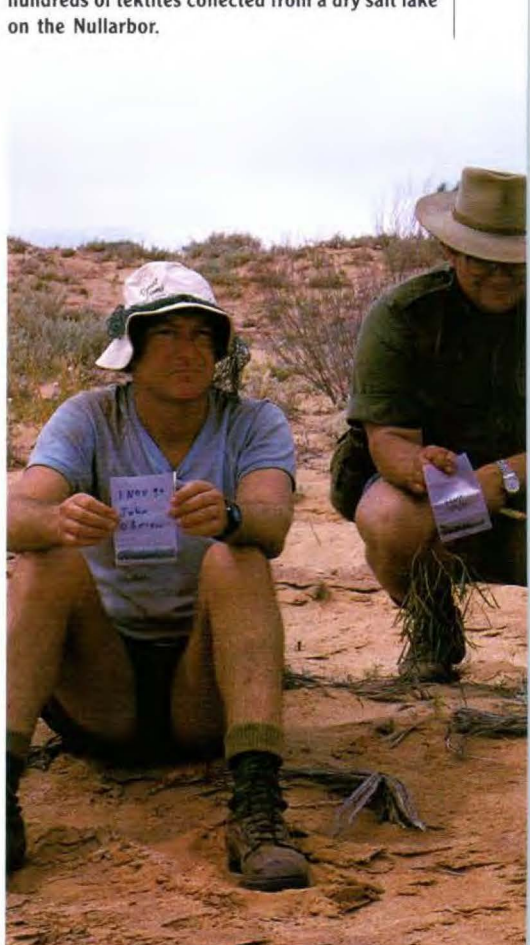
One quite common use of tektites was in the hunting of Emus. One hunting method involved binding a tektite in a number of Emu feathers. The Emus, on investigating the object, removed the tektite and swallowed it as a gizzard stone. While doing this the birds were speared.

In some regions tektites are known as 'Emu-stones'; in others as 'Emu-eyes'. The reason for the latter name is said to be that the tektites represent 'eyes' that Emus lost while wandering around, searching for food. The Aboriginal name 'Emu-stones' may simply have arisen from the observation of their use as gizzard stones. Indeed, Aborigines have been known actively to search for dead Emus in order to extract tektites from their gizzards.

cluded the impossible, whatever remains, however improbable, must be the truth". Having established beyond reasonable doubt how, from what and when tektites formed, efforts have concentrated on the search for the impact sites from where they were launched. The Czechoslovakian tektites were probably blasted from a 24-kilometre-wide impact crater at Ries in nearby Germany, which contains sediments with similar isotopic ratios and compositions to those in moldavites. Additionally, ancient crustal rocks in the area of the crater are 900 million years old, agreeing well with the Sm–Nd ages of moldavites. For similar reasons, it has long been suggested that the Bosumtwi Crater in Ghana (north-west Africa) was the source of the Ivory Coast tektites. To date, the North American tektites have no known source crater. The age of their source rocks (650 million years) rules out the more ancient North American Precambrian Shield.

The source crater of the Australasian strewn field has also proved elusive. The most likely region for the origin of Australasian tektites is Indochina, close to the site of the giant 'Muong Nong' tektites. These huge lumps of glass almost

Soldiers from the Perth Logistic Battalion with hundreds of tektites collected from a dry salt lake on the Nullarbor.



certainly never left the ground, but formed as puddles of molten glass near the impact site. Recently, a crater-like lake in Cambodia, called Tonle Sap (Grand Lake), has been targeted by Jack Hartung of the University of Vienna as a possible source. Tonle Sap is a huge gash in the Earth's surface measuring 100 kilometres long and 35 kilometres wide. The lake is aligned north-west to south-east and its shape, like two cigars laid end-to-end, is characteristic of a very low-angle impact.

Understanding the dynamics of low-angle impacts may eventually explain some of the unusual features of the Australasian tektite strewn field and how thousands of tonnes of glass could be hurled high above the Earth, and several thousand kilometres at hypersonic speeds. Theoretical studies of the effects of large impacts suggest that the projectiles and parts of the target material vaporise, and that plumes of vapour are likely to expand outwards at speeds much higher than the original impact. These high-speed vapour clouds could accelerate impact debris beyond the escape velocity (the speed needed to overcome gravity) of a large planet like Earth, and the vapour itself might condense to form microtektites.

One puzzling feature remains: why should most tektites have formed only during the last 35 million years, especially

COURTESY GLEN A. IZETT

A corroded, 64.5 million-year-old tektite enclosed in a shell of iron-rich clay, found in deposits on the Caribbean island of Haiti.

ALEX BEVAN

as there are many known examples of giant impacts stretching back more than 1,500 million years in the geological record? It has been suggested that one or more large comets or asteroids collided with the Earth about 65 million years ago at the end of the geological period known as the Cretaceous, and that this event directly, or indirectly, led to the extinction of many groups of animals, including the dinosaurs and ammonites. A recent exciting discovery of relic tektites in Cretaceous–Tertiary boundary marine sedimentary rocks on Haiti lends strong support to the impact theory, and also explains why there are no ancient tektites. The remains of the Haitian tektites are found in a thin bed of fine sediment that contains numerous rounded clay pellets. Inside a few of the pellets are deeply corroded tektites, surrounded by a shell of iron-rich clay that formed by weathering and alteration of the glass. Thus the most plausible explanation for the lack of very *ancient* tektites is that, under most conditions, they have simply become unrecognisably altered with great geological time.

We still have much to learn about tektites. Maybe the only way we will find out exactly how tektites form is if a colossal meteorite impact causes another tektite shower to rain upon the Earth tomorrow. Although it might mark the end of our civilisation, a shower of millions of incandescent glass marbles cascading over thousands of kilometres really would be a sight to see! ■

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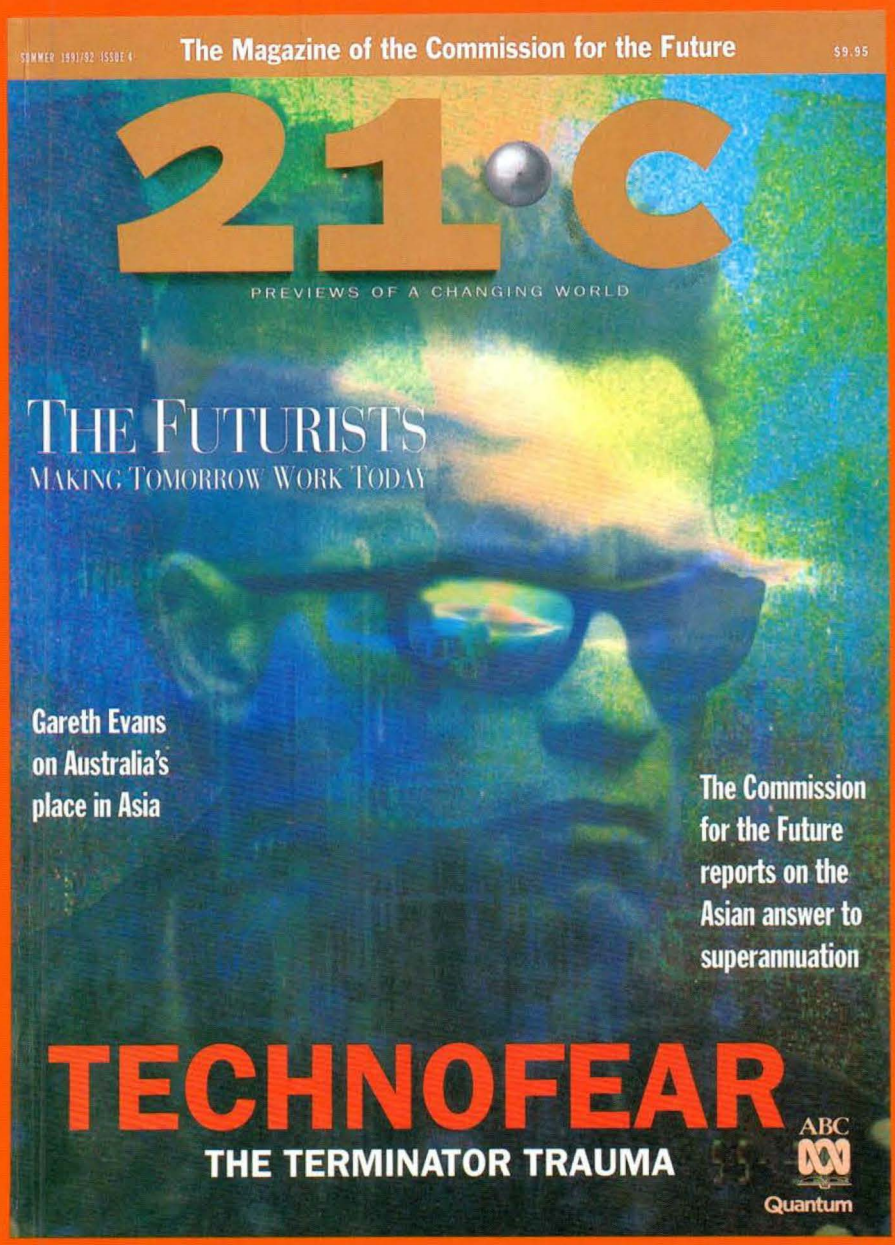

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"The concept of living fossil is not useful, at least as far as Tuatara are concerned."

LIVING A LIE: NEW ZEALAND'S TUATARA

BY MICHAEL THOMPSON & CHARLES DAUGHERTY

SCHOOL OF BIOLOGICAL SCIENCES, UNIVERSITY OF SYDNEY
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IN 1867, BRITISH MUSEUM CURATOR Albert Günther recognised that the Tuatara *(Sphenodon punctatus)* of New Zealand is not a lizard as was previously thought; instead he placed it into a primitive order of otherwise extinct reptiles known as Rhynchocephalia. Rhynchocephalians are named for the overhang in the upper jaw, Greek *rhynchos* meaning beak and *kephale* meaning head, and are in fact sometimes referred to as 'beak heads'. This is a distinctive feature in many extinct rhynchocephalians, but only slightly developed in Tuatara. Modern analysis of a suite of skeletal morphologies, including the smaller beak, has since raised the status of the ryhnchocephalian family Sphenodontidae, to which the Tuatara belongs and which has a fossil record of 225 million years, to the level of an order, the Sphenodontida.

The diversity of the sphenodontidans peaked in the late Triassic and Jurassic (180 to 220 million years ago), by which time they were found throughout the Northern Hemisphere and, as fossils in Africa and their modern presence in New Zealand suggests, much of the Southern Hemisphere too. At the end of the Cretaceous (about 60 million years ago), they died out everywhere except on the geographically isolated islands of New Zealand.

Sphenodon is very similar to 210-million-year-old *Clevosaurus*, a sphenodontidan from the Triassic–Jurassic of England. This, and its position as the only living member of this ancient group of reptiles, earned it the name of 'living fossil'. So-called living fossils are species that are morphologically similar to very ancient, and phylogenetically important, species, and include the famous coelacanth fish, and the invertebrate peripatus (see ANH vol. 22, no. 12, 1989). In addition, rhynchocephalians, which at the time included *Sphenodon*, were regarded as close to the ancestral reptilian stock, the so-called stem reptiles from which all other major reptilian groups, and therefore birds and mammals, arose. Consequently, biologists from Europe and America collected hundreds of specimens.

Probably already confined to small coastal islands at the time of European settlement, the government recognised

Research on the Tuatara has shown that their primitive 'living fossil' image is inappropriate. Their modern behaviour and physiology are perfectly adapted to their harsh environment. Shown here are a male (top) and female. The female is smaller, has less well-developed crest and a subtly different head shape.

BEN CROPP PHOTO

that overcollecting placed New Zealand's most prominent vertebrate in danger. As such, in 1895, the Tuatara became one of the world's first reptiles to be protected by law. Just three years later the eggs of Tuatara were also protected. So protective was the Government that little research on Tuatara occurred for 50 years. However, restricted access to most of the islands on which Tuatara occurred had the desired effect of providing sanctuary to many populations of Tuatara.

In 1949, Bill Dawbin of Victoria University of Wellington (affectionately known as Vic), and later of the University of Sydney, began the first intensive study of Tuatara this century. The main focus of his research was Stephens Island—a cool, wet, windy island in Cook Strait between the North and South Islands—where he marked and recaptured Tuatara over a period of 30 years. He showed that Tuatara are similar to many turtles in their extreme longevity and age to sexual maturity, and not to the lizards they superficially resemble. He estimated they took 15 years to reach sexual maturity, grew for 30 years and lived at least 60 years. But 60 years is probably an underestimate; one can still go to Stephens Island and capture animals with Dawbin's markings. Although Dawbin's conclusions have been refined during the last decade, his data still provide a good summary of the life of Tuatara on Stephens Island.

Surveys in the 1970s by Ian Crook of the New Zealand Wildlife Service (now part of the Department of Conservation) showed Tuatara to occur on about 30 small islands in two geographically separated localities in the north-east of New Zealand, and in Cook Strait. More importantly, Crook's survey implied that the distribution of Tuatara had been limited to these islands by introduced mammalian predators, particularly the Pacific Rat *(Rattus exulans)*.

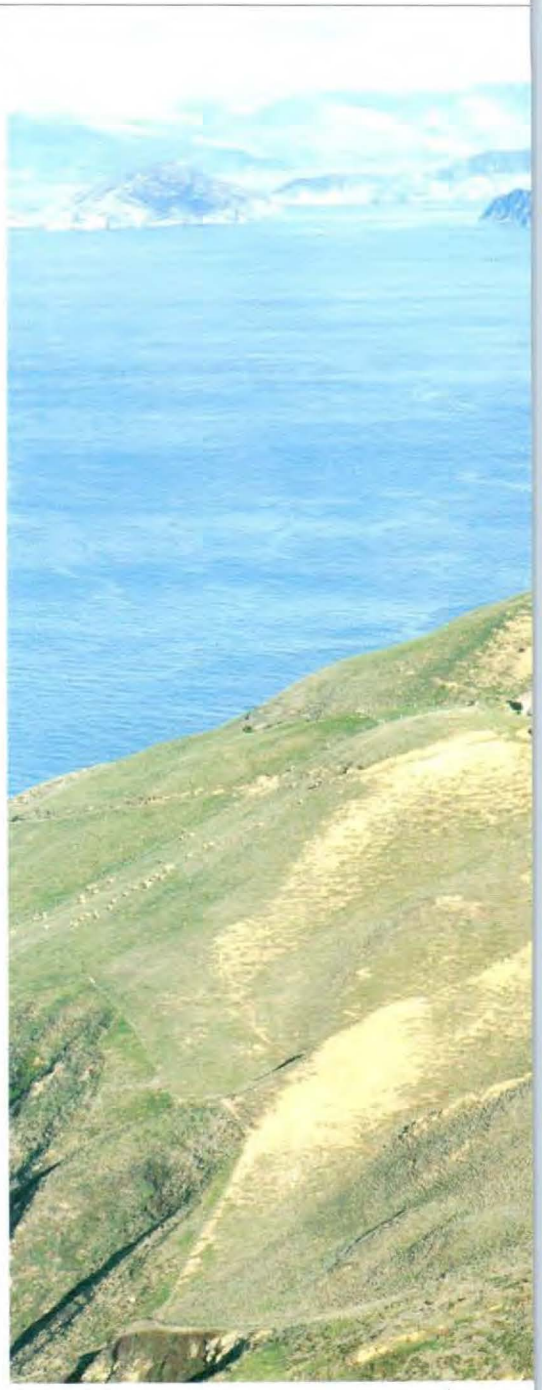
The original Maori settlers of New Zealand probably brought the Pacific Rat with them as a source of food. These rats eat the young and probably the eggs of Tuatara, and may be largely responsible for the extinction of Tuatara from mainland New Zealand. The effect of subsequent European introductions of mammals to New Zealand can be gauged from the complete extermination of Tuatara from Whenuakura Island within a period of three years after the introduction of the Brown Rat *(Rattus norvegicus)* between 1981 and 1984.

Concern over such extinctions, and the need for basic information on biology for the formulation of management strategies, led directly to our study of the nesting ecology and egg physiology of Tuatara. The project was initiated in the autumn of 1985 and has expanded to include studies of behaviour, hormonal cycles, aspects of autecology (such as diet, activity cycles etc.), genetics and physiology, utilising staff and three postdoctoral fellows at Vic, and researchers from New Zealand, Australia and the USA.

We chose Stephens Island as the focus of our studies for several reasons: it has a long history of research, it contains the largest population of Tuatara, and it is well serviced by the New Zealand Lighthouse Service. Prior to construction of the lighthouse in the 1890s, Stephens Island was totally covered with tall forest. However, with the lighthouse came houses, vegetable gardens, pasture, sheep, cattle, cats and a railway line. Initial gaps created in the forest soon led to destruction of tall forest by strong winds, sea spray and stock. Today, about a third of the island is covered in pasture and, surprisingly, it is this exposed land that is important for the successful nesting of Tuatara.

MICHAEL THOMPSON

Tuatara nests and rookeries were located by attaching spools of cotton to pregnant females. As the exact nesting period was unknown, some had to be tracked daily for two months before they nested.



Our first trip to Stephens Island was four days of excitement. Access to Stephens is difficult, so we went by helicopter, the first of many such trips. When we landed at about noon, we were anxious to see a Tuatara. Believing they were nocturnal, we were amazed to see one almost immediately at the forest edge near the field station. Then we saw another, and another, and another. They seemed to be common and active during the day.

Don Newman, of the New Zealand

About a third of Stephens Island is pasture, which is separated from the forest by fences to exclude stock. Tuatara move from the forest to sparsely vegetated 'rookeries' in the pasture to nest.

MICHAEL THOMPSON

Wildlife Service and host of our first trip, told us not to try catching Tuatara during the day because they are very fast. He was correct. We had dinner and waited for nightfall. As it got dark, we got more and more impatient about going out to observe and catch the 'nocturnal' Tuatara. Don tried to tell us not to hurry, we were sure to see plenty. And sure enough we did. Before going three metres from the door, and before even reaching the edge of the concrete patio, we caught three adult Tuatara! Unlike during the day, Tuatara are easy to catch at night. At this point we knew all our research plans could come to fruition.

The next three days were spent observing Tuatara in all habitats, learning how to catch them and brainstorming about the possibilities of research. Additionally, we managed to take blood samples from about 30 adult Tuatara. Those blood samples were the beginnings of probably the most exciting Tuatara story to come from the whole program, but we weren't to know that at the time.

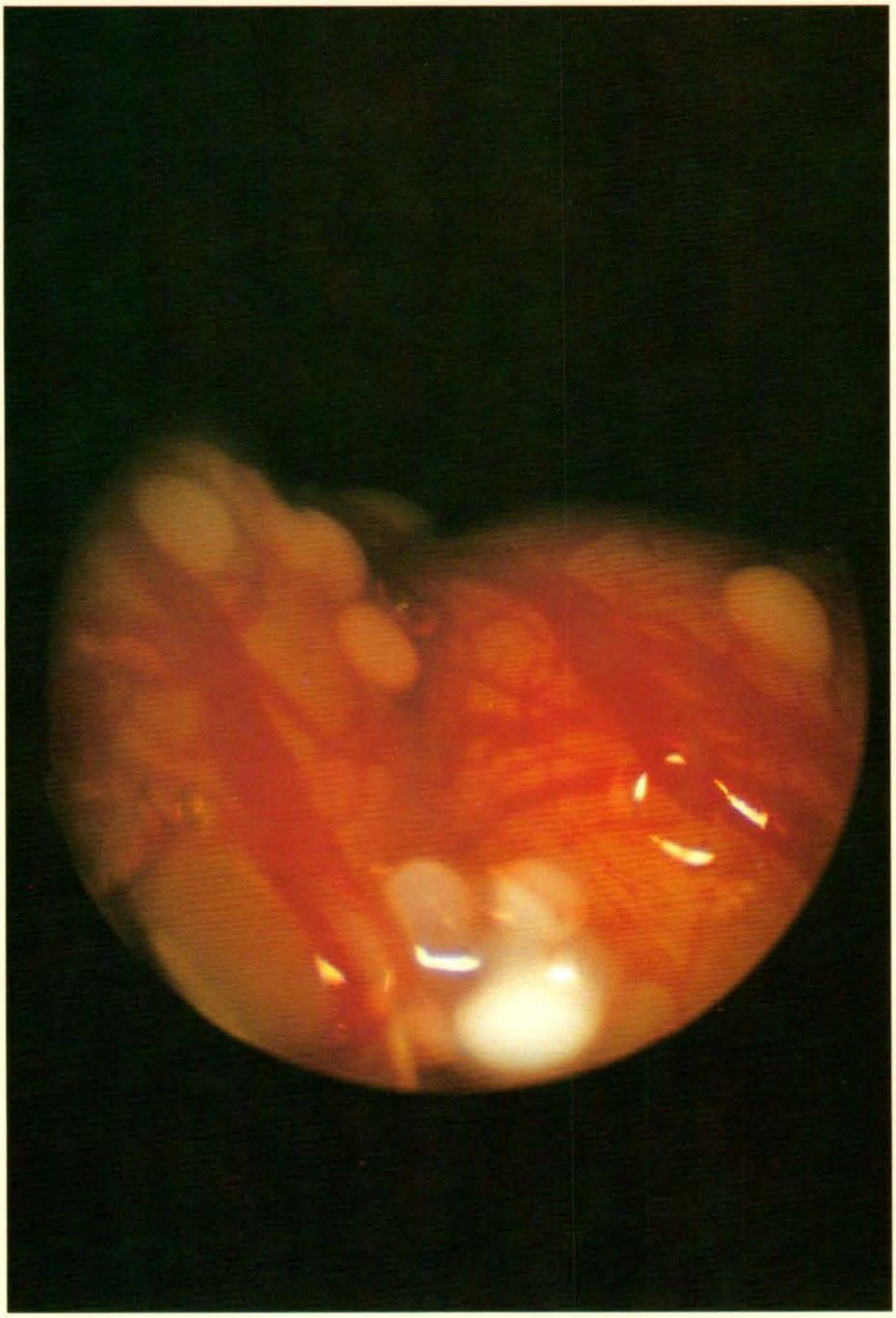
SINCE MAY 1985, A TREMENDOUS AMOUNT has been learnt about Tuatara biology, much of which is specifically relevant to the species' conservation and management. Very early in the program we began to see that, although anatomically very similar to that of 210-million-year-old fossils, the 'primitive' living fossil has a modern behaviour and physiology that is extremely well adapted to its present environment. This supports similar conclusions made by Dawbin and implies evolutionary adaptation, which means that the physiology and behaviour of modern Tuatara may be different from that of their ancient relatives. Hence the concept of living fossil is not useful, at least as far as Tuatara are concerned.

An example of the adaptation of Tuatara to present conditions is their activity at night when conditions might be considered least favourable for reptiles. They are most active on wet summer nights, and some Tuatara can be seen out at temperatures as low as 6°C – not very reptilian, but well adapted to the cold, wet, windswept conditions on Stephens Island. Over the 60 million years or more that Tuatara and their ancestors have been in New Zealand, the environment has not always been similar to modern conditions. Yet they are adapted to modern conditions, so they must have changed during that time.

Blood is an amazingly informative biological material. When we collected blood samples from Tuatara, we not only used them for the genetic analyses mentioned in the text; we also analysed the plasma (liquid part of blood) for sex hormones. This enabled us to discover some amazing facts about the Tuatara's unique reproductive cycle.

Most egg-laying lizards nest at least once a year; a few may nest at intervals of up to once every two to four years. As far as we know, the ovaries of such lizards in non-nesting years are inactive (contain no yolked follicles). This is not the case in female Tuatara, which nest on average about once every four years on Stephens Island. Surprisingly, female Tuatara take an average of just over three years to make enough yolk for a single clutch of eggs. The process of yolk formation is thus more than three times as long as reported for any other reptile, including long-lived crocodiles and turtles. This is not the only unusual feature about the female Tuatara's reproductive cycle. She also spends an inordinately long time (about eight months) shelling the fertilised eggs in her oviducts—again, a process more than three times as long as known in other reptiles.

This unusual reproductive strategy was partly discovered using laparoscopy, a minor surgical procedure that allows us to view the ovaries of live females under local anaesthesia. Hormonal analyses helped complete the tale. Like other female reptiles, female Tuatara have increasing levels of the hormone oestradiol during yolk formation, which is not surprising as this hormone is known to stimulate yolk production. Peak levels of oestradiol occur around the time of mating (nine to ten months before nesting), and probably help stimulate sexual behaviour. A rise in progesterone marks the time of ovulation (eight months before nesting). Very high levels of the sex hormones oestradiol, progesterone and also testosterone are seen only in the mating–ovulatory period. These hormonal profiles suggest that female Tuatara may be sexually receptive only in the year that they nest, but because Tuatara are so infrequently seen mating this has never been confirmed.



ALISON CREE

Part of an ovary of a female Tuatara, close to ovulating a clutch of eggs, as seen down a laparoscope.

Although female Tuatara seem to nest around once every four years on Stephens Island, the nesting frequency may vary quite a lot among females and also in each individual during her lifetime. We know of some females that nested two years apart, whereas another nested only once in five years. We don't understand what factors influence nesting frequency, but age and food supply are likely to be important. It also seems probable that nesting frequency varies between islands, depending on how factors such as temperature and the presence of introduced rats influence food supply.

Unlike female Tuatara, males potentially breed each year on Stephens Island. As in male lizards, they have an annual cycle in sperm and hormone (testosterone) production at the testes. However, there are some unusual features compared with male lizards. Unlike the testes of male lizards from non-tropical climates, those of the Tuatara are not known to show any distinct period of seasonal inactivity. Sperm production seems to continue at a low level throughout winter and then increases during summer, in readiness for the late-summer to autumn mating period. Testosterone profiles in the plasma match this pattern of sperm production. It is not known whether the reproductive cycles of male Tuatara differ between islands, but some geographic variation in timing seems likely.

Although in the past some scientists have suggested that unusual physiological features of Tuatara reflect their 'primitiveness', we prefer a different explanation. Longer reproductive cycles in Tuatara can be viewed as extraordinary adaptations for life at cool temperatures. Only when we have studied the reproductive cycles of New Zealand lizards living in the same cool environments will we know whether long reproductive cycles are unique to Tuatara or are a common feature of reptiles living in constantly cool climates.

—Alison Cree
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New Zealand's reptilian fauna consists of skinks, geckos and the Tuatara. All, except for one skink and the Tuatara, give birth to live young. This immediately tells us that there is something unusual about Tuatara. Although there were no good descriptions of Tuatara nests, we knew they nested in late spring and early summer and, being apparently 'primitive', we expected Tuatara to nest somewhere within their home ranges. Our working hypothesis was that Tuatara construct a shallow hole near their residence burrow, deposit eggs in it and backfill the hole, all within a short period of time. Many lizards have similar nesting behaviour.

To locate the nests we attached small spools of cotton to the tails of female Tuatara that we knew to be pregnant from X-ray analysis, and followed their daily movements for many weeks. But the working hypothesis could not have been more wrong! Female Tuatara do not move far from their home burrows (maximum of five metres) until they are almost ready to nest. Then, they move comparatively long distances (180 metres was the maximum recorded) from their home burrows to congregate with other Tuatara to nest in rookeries. Construction of the nest chamber usually takes many days, although egg laying usually occurs on one night only. Backfilling and camouflaging the nest can take several days and then the female sits over the nest every night for a week or more to protect it from destruction by other females looking for a spot to lay eggs.

Thus the so-called primitive living fossil has one of the more elaborate nesting behaviours in the reptilian world. At this point we were joined by Professor Gary and Dr Kathy Packard of Colorado State University, and Dr Alison Cree, a postdoctoral fellow who was part of the team by this time, to investigate the physiological basis of the unusual nesting behaviour. We located 63 nests and measured the moisture content and temperature of 28 of these throughout the incubation period. Instead of taking 13 months to hatch, as had previously been inferred, we found eggs of Tuatara to take between 10 and 16 months to hatch, depending on the temperature of the nest. This is one of the longest incubation periods known in reptiles.

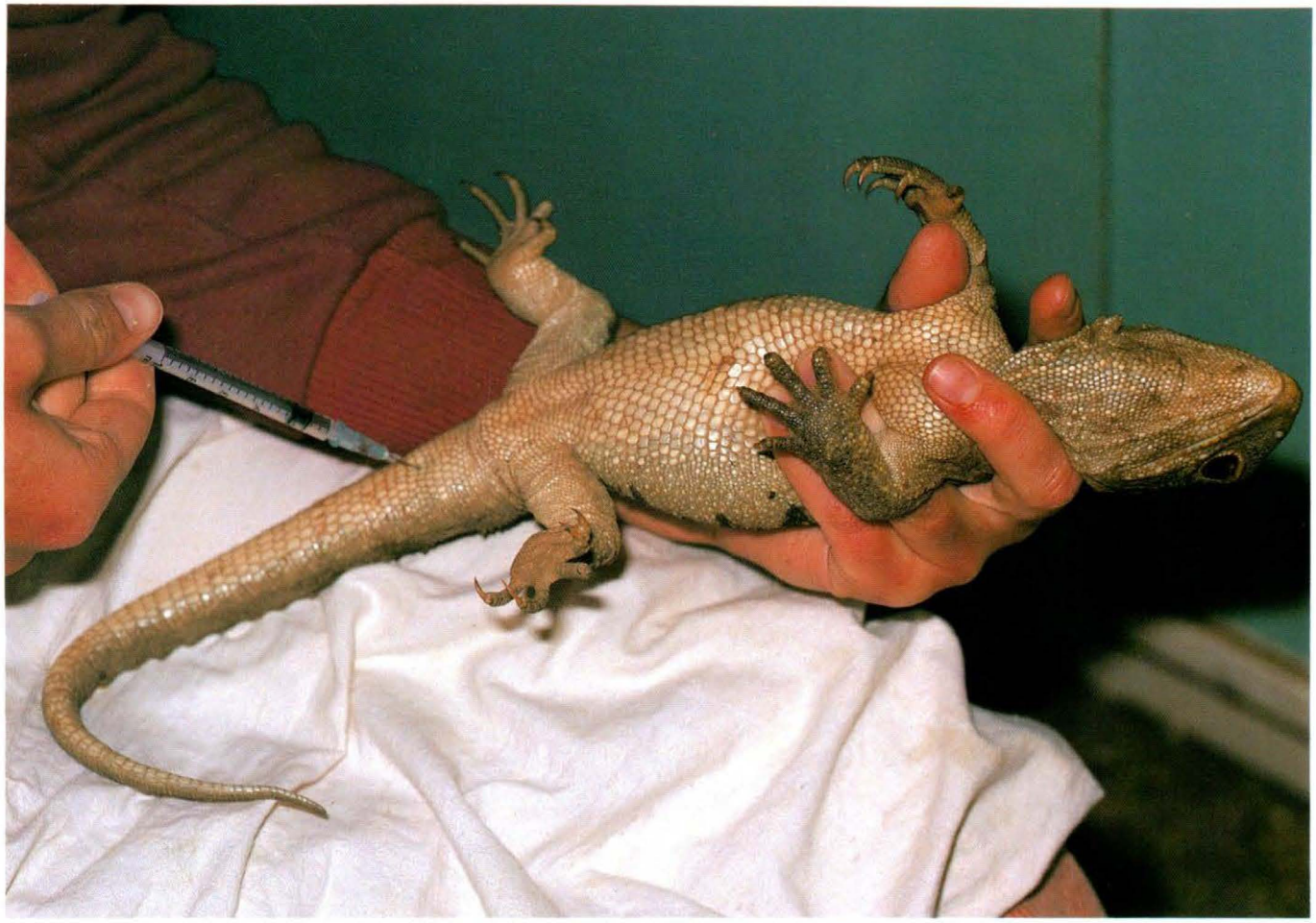
Although Tuatara prefer forest habitats (up to 2,000 per hectare live there compared to 400 per hectare in open pasture), no nests were ever located in the forest. All nests were in open areas, predominantly sheep pasture. Our studies indicate that soil temperatures in the forest are too low to support incubation, thus the driving force behind females not nesting in the forest. The pasture, it seems, provides an important nesting environment for Tuatara.

But, how do they select their nest sites? Of the 60 or so nests we located, their only common feature was that they were not heavily shaded by vegetation. No other characteristic, such as slope,

Special probes were placed in Tuatara nests to measure their temperature and moisture content. After 12 months incubation, the nests were excavated to assess their success. In successful nests like this, the eggs have swelled and any spaces between them have been taken up by soil and roots.

During nest construction the females dig with their front feet, however they assume this characteristic 'head out' pose when laying eggs.

MICHAEL THOMPSON



Blood was taken from many Tuatara from separate island populations to assess their genetic variation.

Eggs were hatched in the laboratory to investigate Tuatara physiology and help interpret field observations. Methods developed to incubate eggs of Tuatara from Stephens Island are now being applied to the North Brother Island species *Sphenodon guntheri*. Note the caruncle, or egg breaker, on the nose of the hatchling. Tuatara share this fundamental feature with turtles and crocodiles, but not lizards, which they superficially resemble.

R. ROBERTSON / VUW

aspect or soil type, can be used to predict where nesting will occur, yet the nests are highly clumped. Identification of all the requirements for nesting would be useful in determining management practices for Tuatara, especially on Stephens Island.

Most islands with Tuatara do not have pasture and, indeed, neither did Stephens prior to erection of the lighthouse in 1894. Our data, together with early descriptions by overseas researchers and lighthouse keepers, indicate that, historically, Tuatara nested on the cliff tops and faces where vegetation was sparse. Tuatara rapidly took advantage of clearings, including lighthouse keepers' vegetable gardens, in which to nest. This suggests that the complicated nesting behaviour of Tuatara is a response to rarity of suitable (that is, open) nesting sites. On Stephens Island now, the behaviour is merely a

historical hangover because of the presence of the man-made pasture.

The apparent rapid rate of increase in the population of Tuatara on Stephens Island suggests that the presence of pasture has greatly increased the availablity of good-quality nesting sites. However, this is a double-edged sword because one of the major causes of egg mortality was found to be desiccation in the dry pasture soils.

OUR INITIAL INTEREST IN TUATARA BLOOD was in the hope of using it to paternity-test young animals. That proved impossible with the limited techniques available to us, but the samples (now over 400) formed the basis of a larger study of genetic variation in Tuatara. In the 1800s there had been various attempts to split Tuatara into a number of taxa, but New Zealand legislation recognised only one species. With genetic analysis of blood samples from 27 separate island populations (many collected by Alison Cree and an assistant at Vic, Jennie Hay) we confirmed that the early recognition of three distinct Tuatara groups was correct, and that one was in fact a second species, *Sphenodon guntheri*.

Sphenodon guntheri is confined to one island only, North Brother Island in Cook Strait. The adult population is no more than 400 and the entire island is only four hectares. Obviously, this is a species of great concern, requiring special management effort. Presently, we assume that most aspects of its biology are similar to those of *S. punctatus* on Stephens Island, but that is only an assumption and is being checked now with field and laboratory studies. *Sphenodon guntheri* is smaller than the Stephens Island Tuatara and somewhat different in colour. Using techniques developed with eggs of Stephens Island Tuatara, artificial incubation of *S. guntheri* eggs is being used to set up a captive colony of this animal. In this way its gene pool will be at least partially protected in the case of a natural disaster on North Brother Island, such as the accidental introduction of rats.

Clearly, we still have a lot to learn about Tuatara, and the research effort is ongoing. However, we now have basic information on their reproductive biology, behaviour, ecology, physiology and eggs, upon which we can base management decisions. What is more, we have learned some lessons along the way. First, we have found that some of the early taxonomic assessments of Tuatara, subsequently neglected, were correct; and second, Tuatara are not 'living fossils' but animals beautifully adapted to a special and very demanding environment.■

Suggested Reading

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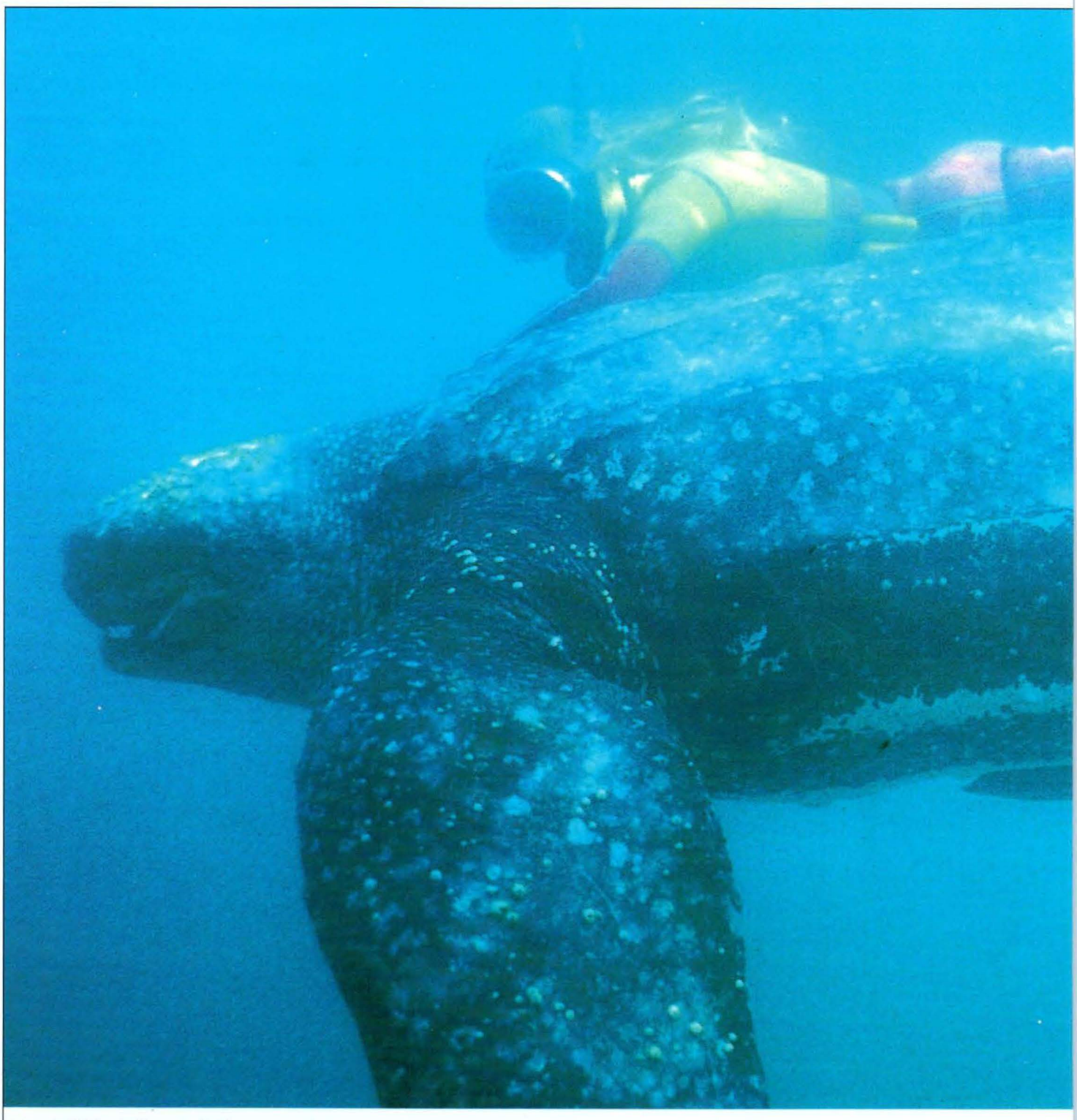
Dr Michael Thompson is a lecturer in animal biology at the University of Sydney's School of Biological Sciences. His interests include nesting biology and egg physiology in reptiles and he is currently conducting research similar to the Tuatara study on the Eastern Water Dragon in New South Wales. Dr Charles Daugherty is a senior lecturer in the School of Biological Sciences at Victoria University of Wellington. His interests include genetic variation within and among populations of New Zealand animals, and the taxonomy of reptiles and birds in New Zealand.



RON & VALERIE TAYLOR/ANT PICTURE LIBRARY

For a 'cold-blooded' animal, Leatherback Turtles have demonstrated an amazing ability to regulate body temperature, and can raise it while the surrounding temperature drops. They are the subject of intense thermoregulatory studies, which may provide clues about the temperature regulation patterns of extinct giants like dinosaurs.

"Use of cliches such as 'active, warm-blooded mammals' and 'slow, sluggish reptiles' reflects mammalian chauvinism and is counterproductive for understanding dinosaurian ecology and reptilian evolution."

IT WAS THREE O'CLOCK IN THE MORNING, Costa Rican time. Our parkas provided little protection from the downpour. We were exhausted, having patrolled the four-kilometre stretch of beach all night for signs of Leatherback Turtles coming in to nest. Not one had been sighted. But just when we were ready to call it quits, the rain eased up and a large, dark figure appeared in the surf less than ten metres away. The black volcanic sand and overcast sky made it difficult to tell what it was at first. So we both sat, motionless, hoping the dark form was indeed a Leatherback and not another large tree trunk being washed ashore. Slowly and methodically the shape made its way through the surf and began to plod up the beach toward the high-tide mark. We continued to watch as this behemoth crawled right past us, seemingly oblivious to our presence.

Leatherback Turtles (*Dermochelys coriacea*) are the largest (over 900 kilograms) living reptiles in the world. They can withstand a wide range of temperatures and consequently are found from the tropics to north of the Arctic Circle. Leatherbacks have been captured in cold

DINOSAURS AND LEATHERBACKS: STANDING UP TO THE COLD

BY FRANK V. PALADINO & JAMES R. SPOTILA

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COURTESY FRANK PALADINO

Tortuguero Beach, Costa Rica: Leatherback Turtles come ashore to nest in the black volcanic sand above the high-tide mark.

(7° C) North Atlantic seas that would cause the death of a human in less than ten minutes, yet have been found to have body temperatures over 25° C! And in more temperate climes (26.2° C), one turtle was recorded raising its body temperature on land by half a degree (from 29.6° to 30.1° C) while the surrounding temperature dropped 4.4°. These are amazing feats for a reptile that is commonly described as 'cold-blooded' or ectothermic and have resulted in intense interest in the species' thermoregulatory abilities.

THE CLASSIC DEFINITION OF AN *ECTOtherm* is an animal that requires heat from the environment to maintain body temperatures different from the ambient or surrounding temperature. Ectotherms are typically *bradymetabolic*; that is, they have a low basal (resting) metabolic rate. 'Warm-blooded' *homeothermic endotherms*, on the other hand, are defined as animals that maintain constant high body temperatures despite low environmental temperatures and obtain the heat necessary to maintain high body temperatures from internal sources. The term *homeotherm* refers to an animal that maintains a constant body temperature while a *poikilotherm* is an animal that varies body temperatures. Endotherms are typically described as *tachymetabolic* with a high basal metabolism similar to the pattern seen in current-day mammals and birds. What our research over the past few years has demonstrated is that, as animals become larger, the ectotherm–endotherm thermoregulatory definitions become increasingly less descriptive of their true physiology. Indeed, large animals like the Leatherback appear to exhibit a unique and different pattern of metabolic heat production and temperature regulation that we have called *gigantothermy*. Gigantothermy is the maintenance of high body temperatures by means of large body size, low metabolic rates (bradymetabolism), and use of peripheral tissues as insulation. This pattern of thermoregulatory–metabolic physiology should give us some insights into the possible palaeobiology of large dinosaurs.

There has been a controversy raging in the popular science literature about whether or not dinosaurs were 'warm-blooded' tachymetabolic endotherms like current-day mammals and birds. This brouhaha was instigated and has been perpetuated by the popular science writings of Robert Bakker ('adjunct curator' at the University Museum, Boulder, Colorado) and his flock of dinosaurologists. The ideas presented by this group are that, because dinosaurs were active, had complex and diverse behaviour, and were found to exist in colder polar regions, they must have been tachymetabolic endotherms. But these arguments are strongly disputed by all the published evidence and observations so far. For example, current-day ectothermic reptiles have very complex behaviours and are quite active in the environments in which they are found. On the polar arguments, Australian palaeontologists Thomas Rich (Museum of Victoria) and Patricia Rich (Monash University) have found the fossils of chicken-sized hypsilophodontid dinosaurs from Dinosaur Cove, Victoria; they be-

Leatherback Turtles lay about 100 'leathery' eggs the size of tennis balls. Out of every four nests constructed, only one or two eggs will survive to adulthood.

JANY SAUVANET / AUSCAPE INTERNATIONAL

A portable tripod, hoist and scale were used to weigh these giants on the beach.

lieve that, if the temperatures were cold and hostile enough, these animals were probably small enough to hibernate in a hole for the winter (as many of today's reptiles do in colder polar environments). Additionally, if the polar temperatures were more reasonable, as is indicated by the palaeobotanical studies of Jack Wolf (US Geological Survey in Denver), then the eyes and brain space of these small hypsilophodontid dinosaurs would allow for efficient activity in the continual darkness or twilight of these milder polar winters. For the large hadrosaur fossils found by William A. Clemens and colleagues (University of California, Berkeley) along the Colville River in Alaska, these animals were fully capable of migrating from these northern environments if the climate became too hostile; and, according to the evidence reported recently by Michael Parish (University of Colorado at Boulder) and colleagues, hadrosaurs probably did migrate.

To further substantiate our views on the temperature regulation patterns and metabolic capabilities of large animals, we have measured the metabolic rates of elephants and found that, true to the pattern and data obtained by renowned physiologists Max Kleiber (University of California at Davis) and Francis G. Benedict (Carnegie Institution, Washington) back in the 1920s and '30s, the larger a tachymetabolic animal gets, the lower the basal heat produced per gram of body tissue. This relationship has been described as the 'mouse to elephant' curve and basically illustrates that, if large tachymetabolic animals produced heat at the same rate as a mouse, they would in all probability overheat very quickly and might actually cook themselves.

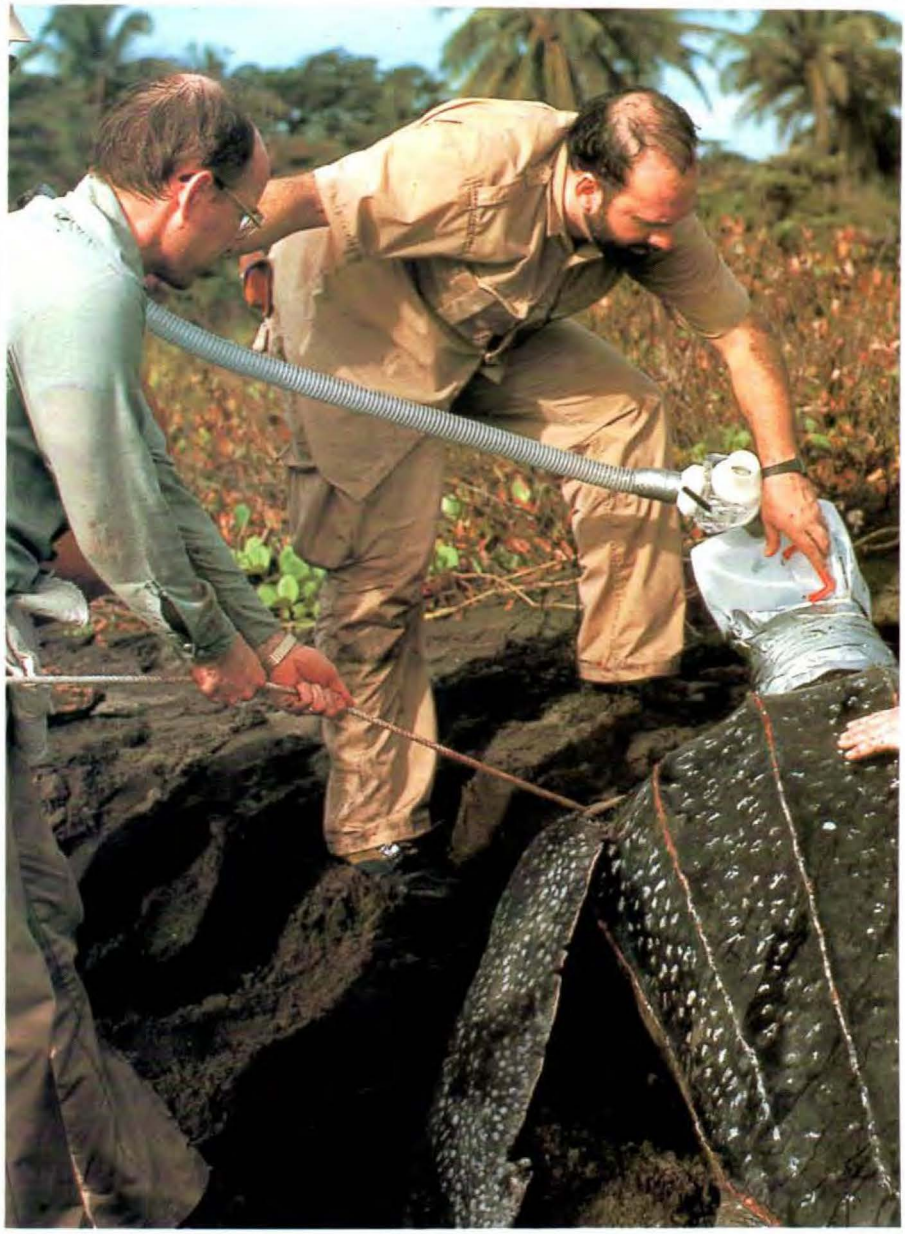
We therefore felt it was time to provide some empirical data on a reptile that comes as close as we could find to a dinosaur. Leatherbacks are large—indeed, they are the largest living reptile; and they live in a very conductive and cold medium. The metabolic and thermoregulatory patterns they demonstrate should thus provide us with insights into the abilities of large reptiles to adapt and operate in these conditions. However, because they are so rare and difficult to capture and handle, and because they live by wandering throughout the entire ocean system of the world, coming to shore only to nest on remote isolated beaches where precise physiological laboratory work is difficult, they have never had their metabolism measured. We hoped that our plans and portable instruments would allow us to work on these animals while they were on the beach and give us the opportunity to collect many of the data required to answer some of the questions on large reptile/dinosaur thermoregulation and metabolism.

THIS NIGHT WE WERE LUCKY. IT WAS AN impressive looking specimen weighing in at 430 kilograms. She quickly slipped past us and started building her nest above the berm (the horizontal section of the beach beyond high-tide mark). With her rear flippers she took about 20 minutes to scoop out a metre-deep by 30-centimetre-wide hole in the sand in which she laid about 100 eggs that looked like leathery tennis balls. After she had finished laying, she was caught, restrained in a cargo net, and weighed with a large tripod, hoist and scale. She calmed down after several minutes of restraint and 30 minutes later we placed a sealed mask over her head and collected her respiratory gases in large meteorological balloons. These gas collections were then analysed for total volume, and percentages of oxygen and carbon dioxide and, together with the animal's mass, were used to calculate the turtle's resting metabolic rate.

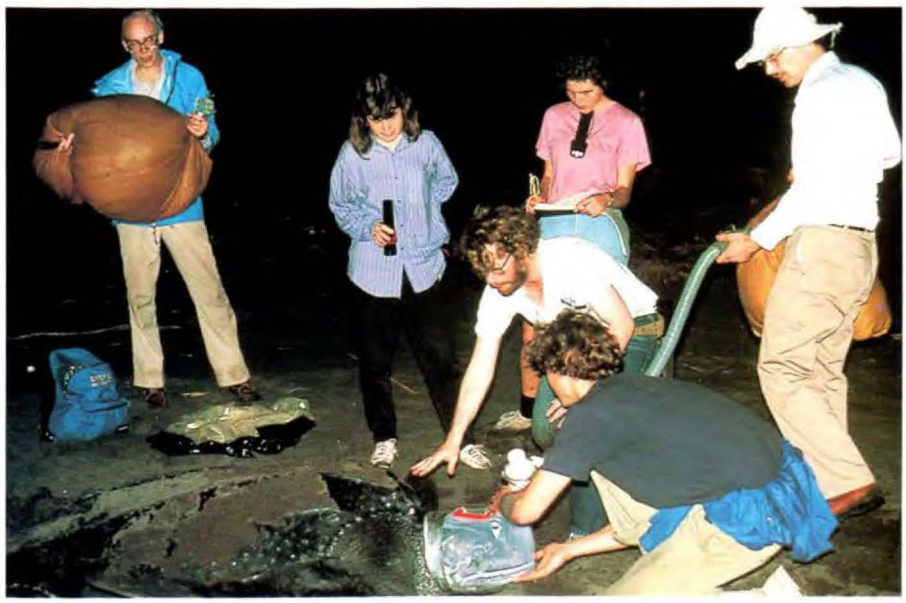
The metabolic rate is a measure of the amount of energy used by an animal to operate in any environment and is reported in terms of joules per second (watts) per kilogram of body weight (W kg^{-1}). Resting metabolism is the minimal amount of energy needed to maintain an animal under the least stressful conditions, which are usually in the dark during the normal rest period of an animal's daily cycle. The closest we could come to approximating these conditions for Leatherbacks on land was to have them resting as quietly as possible in a net after two hours. We had held Leatherbacks for over 24 hours and measured their metabolism continuously over that time period, but

A respitory mask was attached to the head of the turtle after nesting.

COURTESY FRANK PALADINO



Collection of respiratory gases while the turtle climbs over a metre-high berm. Frank Paladino (centre) holds the respiratory mask, accompanied by James Spotila holding the rope.



Respiratory gases are collected while the turtle vigorously throws sand to cover her nest cavity. The inflated balloons contain turtle gases ready for analysis.

COURTESY FRANK PALADINO

the oxygen consumption was minimal at about two hours after capture and never changed much after that. We used that cut-off time as a standard so as not to hold the animals too long and to handle them as little as possible. The procedure was repeated while the turtle was active – as she walked and as she vigorously covered her eggs with sand.

Altogether we have measured the resting and active metabolic rates of over 20 Leatherbacks ranging in size from 250–430 kilograms from both the Atlantic and Pacific Oceans. On average, the resting metabolism of these turtles was 0.35 W kg^{-1}. This is higher than that of a bradymetabolic Green Turtle (*Chelonia mydas*) scaled up to the size of a Leatherback, but less than half the value predicted for a tachymetabolic mammal or bird the same size. Still their body temperatures were on average over 31° C. For Leatherbacks, their ectothermic metabolic rates were more than sufficient to maintain high body temperatures and high activity levels in even the cold, highly conductive waters of the Arctic. From this empirical evidence we conclude that larger polar ectothermic dinosaurs were physiologically capable of maintaining elevated body temperatures and demonstrating complex behaviours without the need for fur or feathers or a tachymetabolic physiology, as speculated by the dinosaurologists. And just as the Leatherback can travel from the Arctic to the tropics, dinosaurs would also have been capable of great migrations to find food and avoid environments that became too harsh.

Examination of the biophysical and physiological aspects of thermoregulation leads to the conclusion that larger animals, be they reptiles or mammals, are less dependent on the radiative environment (that is, sunshine for warming and the clear night sky for cooling), are less affected by convection (because of their thicker boundary or insulative layer), and have a larger thermal inertia (that is, take longer to heat up and cool down) than smaller animals. Thus, the same amount of heat supplied or removed at an animal's surface will result in a smaller and less rapid change in the body temperature of the larger animal. Large body size effectively 'isolates' animals from their environment, stabilises internal temperatures, and reduces thermoregulatory demands on metabolism. Large *homeothermic* animals are selected for low metabolic rates because, as our data indicate, large animals do not need great amounts of heat to maintain high constant body temperatures. With a high metabolic rate they would also have a lot of difficulty dissipating their internal heat because of their relatively lower surface area to volume ratio. To maintain high constant body temperatures, large animals may alter their insulation thickness by changing blood flow. We are currently investigating the circulation patterns of the Leatherback to understand how changes in blood flow into

the flippers and other portions of the body are used to tightly regulate body temperatures in cold and warm waters as well as on land.

Small mammals and birds combine elevated metabolic rates, high-quality insulation and precise neural control to regulate body temperatures between 35 and 42° C. There are large differences between the metabolic, insulative and neural capacities of small birds or mammals when compared to small reptiles, making it appropriate to use terms such as 'endothermic homeotherm' and 'ectothermic poikilotherm' to describe their respective thermoregulatory patterns. However, for large reptiles and mammals with similar mass, many of the differences in insulative and metabolic abilities disappear. This is why we proposed a new term 'gigantothermy' to describe this convergence of thermoregulatory adaptations in large animals. Large size obviates the need for a high metabolic rate.

The discussions of dinosaur thermoregulatory capacities by Bakker and other dinosaurologists failed to consider, or misinterpreted, the biophysical constraints of large body size on energy exchange, and ignored studies that indicated large dinosaurs were not endothermic. Use of cliches such as 'active, warm-blooded mammals' and 'slow, sluggish reptiles' reflects mammalian chauvinism and is counterproductive for understanding dinosaurian ecology and reptilian evolution. Our experimental data and models suggest that gigantothermy would have allowed large dinosaurs to be 'active, warm-blooded reptiles', exhibiting complex behaviour patterns like migration, and to be capable of surviving in a variety of habitats, including the polar regions of the late Cretaceous, without a mammalian, endothermic metabolism or undue thermoregulatory stress. As we have seen in the Leatherback, bradymetabolic reptiles can even live and thrive in Arctic seas where many endothermic, tachymetabolic mammals cannot. We also know that living reptiles have active and complex lifestyles that are readily supported by reptilian physiologies (including the gigantothermy of Leatherbacks, regional elevated temperatures of Green Turtles, and behavioural thermoregulation of small reptiles). There is thus no need to postulate that dinosaurs had different physiologies or metabolic capabilities than their current-day reptilian relatives. The thermoregulatory challenge overcome by Leatherbacks in the cold North Atlantic would be equal to or greater than the conditions faced by large dinosaurs in Cretaceous polar climates. ■

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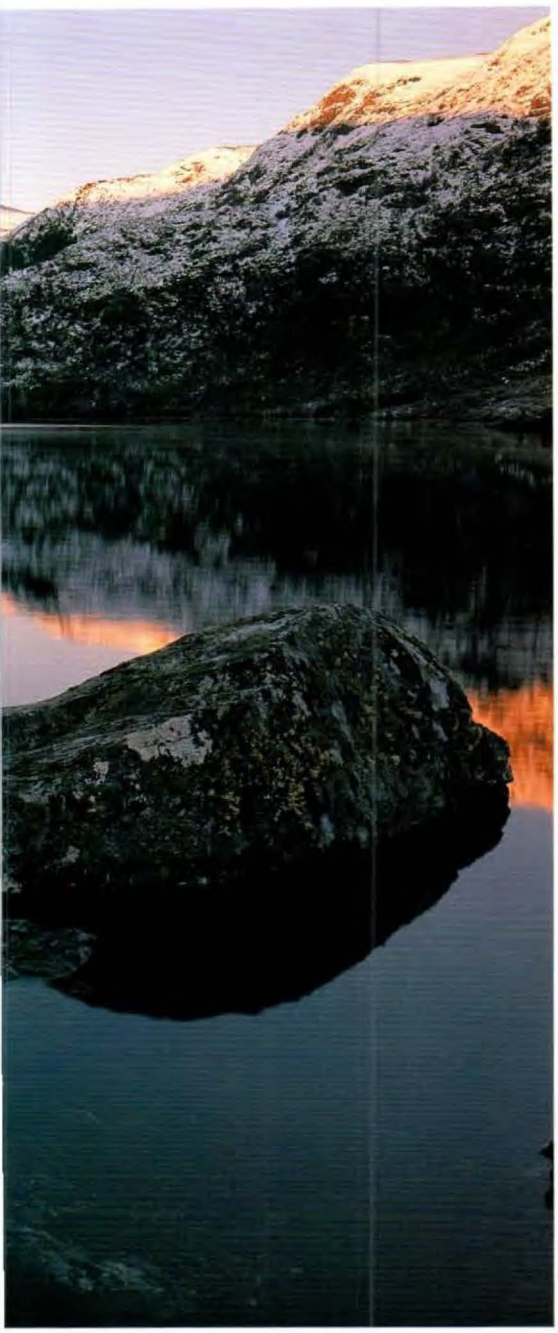
The research described here was supported and funded in part by the Caribbean Conservation Corporation, Department of Energy, and the Purdue Research Foundation.

Frost detail, Lake Windemere.



Cradle Mountain and Dove Lake at sunrise.

Ewartia meredithae.

ORIGINAL AUSTRALIA

BY CHRIS BELL

NATURE PHOTOGRAPHER

"Introduce an individual to the beauty of a wild landscape through a photograph and the area's future becomes half secured", maintains Chris Bell, a nature photographer based in Hobart, Tasmania. Chris believes photographs serve as a catalyst in re-establishing our links with nature and, hence, our concern. "Australians' increasing awarness—and love—of their landscape", he insists, "is due largely to the photographic image".

Bell specialises in wild, remote locations, particularly temperate Tasmania, with which he is most familiar. He urges us, through his art form, to take zealous care of what little remains of 'Original Australia'.

The images reproduced here are from his latest book *Beyond the reach* (reviewed in this issue). The theme: Tasmania's World Heritage Cradle Mountain–Lake St Clair National Park.

Mount Geryon in a snowstorm.

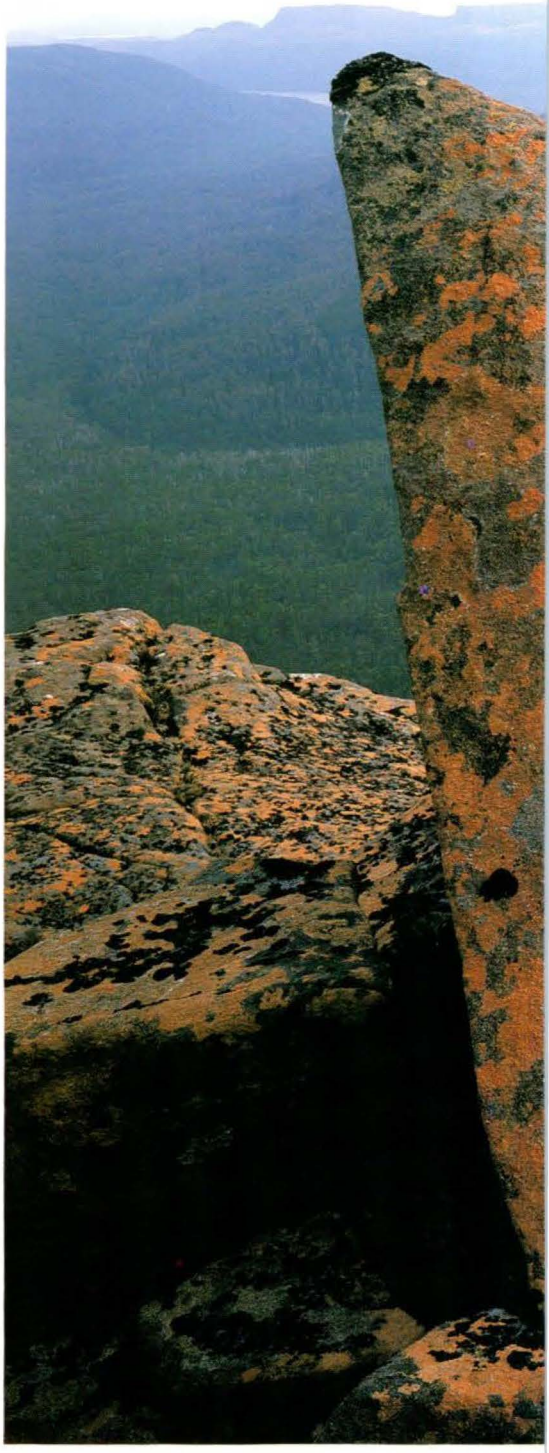
Mountain Rocket, Milligania Lily and sunlit Pencil Pine.

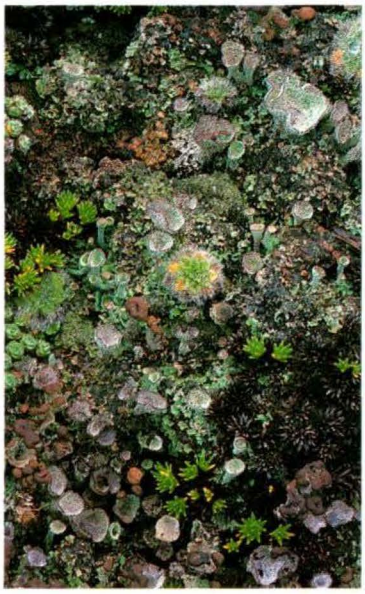
Autumn fruiting fungi, Cradle Mountain.

ORIGINAL AUSTRALIA

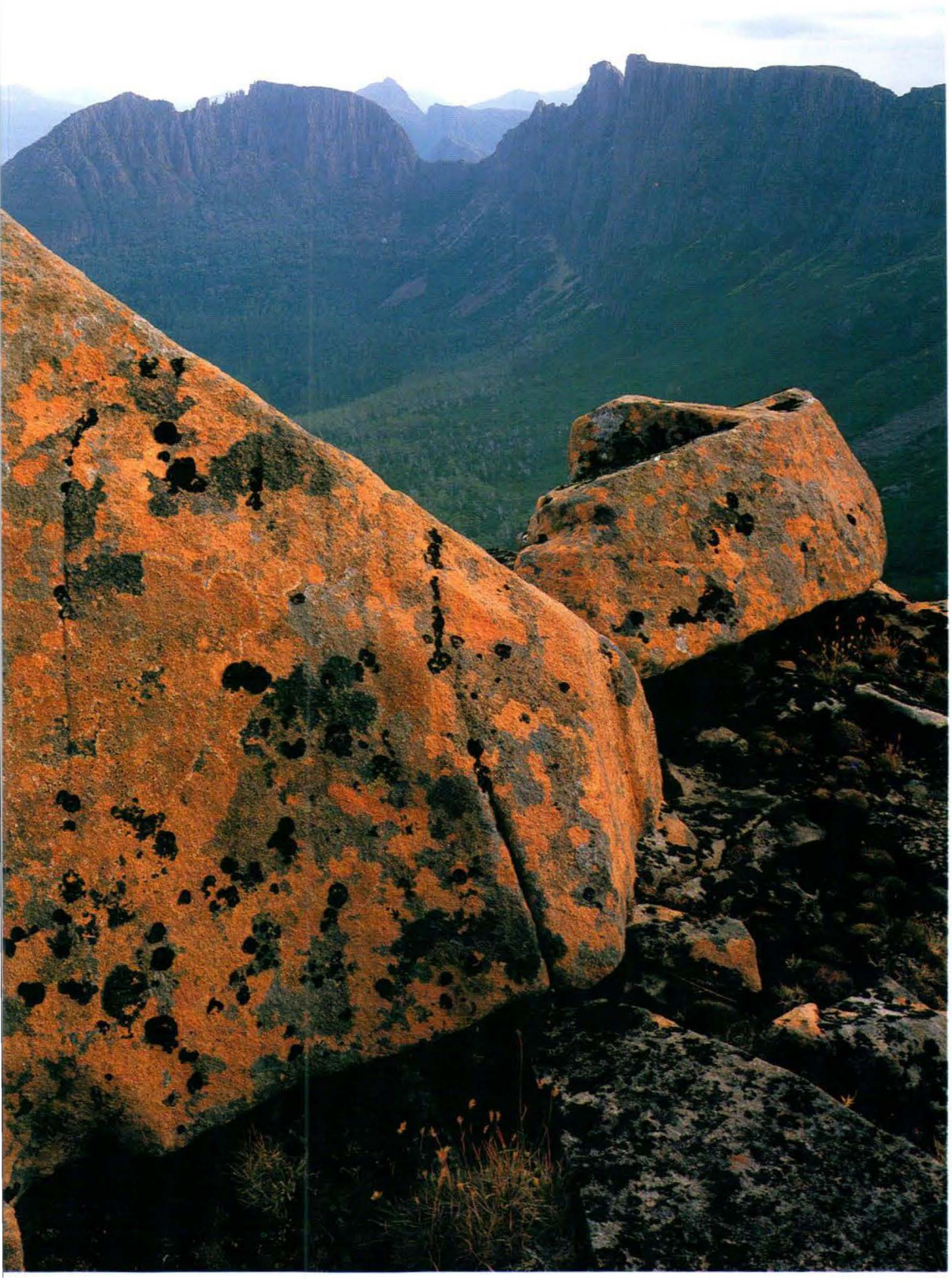
ORIGINAL AUSTRALIA

Hard Water Fern, ***Blechnum wattsii.***





Lichen garden, Mount Inglis.



Dolerite boulders, Du Cane Range.

"Libraries of invisible prehistory lurk behind the shape of even the smallest toenail, or simplest behaviour."

PALAEONTOLOGICAL POLTERGEISTS

BY MICHAEL ARCHER

SCHOOL OF BIOLOGICAL SCIENCE, UNIVERSITY OF NEW SOUTH WALES

ONE OF THE MOST REMARKABLE EXPeriences I had during my undergraduate years was a series of lectures in evolutionary theory given by Professor Egbert Leigh. 'Bert' was a most remarkable teacher. For days I watched in awe as blackboard after blackboard filled with calculations of laminar flow, counter currents, pore diameter and turbulence. As the chalk squawked to a climax, with all of the students clinging to the edge of their seats, he slammed a full stop at the end of the calculation and then lovingly wrote in great big letters "QED!" *(Quad erat demonstrandum*—a smug Latin expression more or less meaning "Told you so!"). He had derived through mathematical deduction a *prediction* of the optimal size of the osculum (mouth) of a barrel sponge—and then revealed that his prediction precisely matched measurements made on living sponges. For the rest of the class, the world may not have stopped turning, but for me it was an eye-popping revelation. He had demonstrated a precise correlation between the demands of the environment and an evolutionary response in the natural world. At that same moment in the crypt at Westminster Abbey, Darwin's crusty face must have broken into a satisfied grin.

It was my first introduction to the common notion that every part of every creature is optimally shaped or adapted for a particular function. But what, I wondered, should the committed adaptationist conclude if field measurements *fail* to produce the values predicted from theory? The usual reaction is that some other rogue factor is upsetting the balance and it has either to be bullied out of hiding by *ad hoc* deduction ("Oh my! Look what happens when we add the gravitational attraction of Venus to the predicted value") or winkled out through hard yakka in the field. One way or another, the form of creatures should be reflected in observable function.

Reasonably convinced that this was the way the wheels of the wild world worked, every paper I subsequently wrote about a fossil mammal included a discussion of presumed function based on differences in structure. If a fossil thylacine had a particularly long cutting crest on its upper molars, I confidently hypothesised that it was more carnivorous than its less well-endowed relatives.

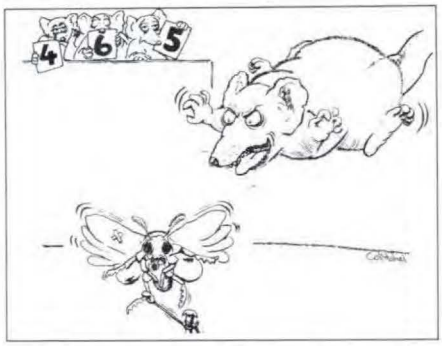
My naivety might have been left intact if it weren't for the urge to apply the sponge-mouth exercise to the mouths of carnivorous marsupials (dasyurids). We decided to test the presumption that differences in the shape of teeth of closely related species reflect differences in the way the teeth are used. I suggested to Honours student Mark Graham that he investigate functional differences between the tooth rows of two living antechinuses, the Brown Antechinus *(Antechinus stuartii)* and the larger Dusky Antechinus *(A. swainsonii)*. I had already published the deduction that the mouthful of dental differences—the Dusky's premolar row is long with slender, spaced-out teeth, while the Brown has a 'chunky' premolar row with wide, crowded, seemingly 'tougher' teeth—probably reflected a significant difference in their choice of munchies.

But when each antechinus was presented with the same smorgasbord of delicacies ranging from spiders and centipedes to beetles, a severe attack of incredulity ensued. No smug QED was to be stamped on this experiment because the results neatly decapitated the prediction—both gobbled up virtually everything on the menu, the only slight difference being that the larger Dusky savaged a few more of the larger beetles. My simplistic presumptions about form and function crumbled somewhere in that chaos of frenzied bug-busting.

Although more work in this area *might* reveal significant form–function correlations that eluded our preliminary investigations, I now can't help but suspect that the unravelling of our expectations may have resulted from palaeontological poltergeists—spooks from the past mucking up what ought to have been a simple demonstration of the functional value of modern form. Considering that virtually all of modern biological form was constructed in the factories of prehistoric ecosystems, and that more than 99 per cent of all species that have ever lived are now extinct, it would be surprising if modern ecosystems and living creatures

DICK WHITFORD

The range of this Dusky Antechinus partly overlaps the habitat of the Brown Antechinus and the two probably compete for food.



COLIN STAHEL

Feeding trials were carried out to discover which foods each antechinus preferred.

were *not* seething with the ghostly scars of abruptly severed relationships.

Studies in Central America have revealed, for example, that the late Pleistocene extinction of giant herbivorous mammals such as elephants, horses and ground sloths left many tree species without efficient means of dispersing their enormous seeds (Janzen and Martin 1982). In New Zealand similar studies have shown that a peculiar growth pattern in many endemic plants less than three metres tall can neatly be explained by the similarly proportioned ghosts of flightless grazing moas (Atkinson and Greenwood 1989; see also QQC this issue).

Do similar ghosts haunt Australia's ecosystems? I spent a hypnotic June afternoon strolling through an ancient Daintree rainforest. In a patch of sunlight on the mossy, leaf-strewn floor were more than 20 brilliantly coloured fruits of the Kuranda Quandong or Nutwood Tree *(Elaeocarpus bancroftii)* looking a lot like small blue dinosaur eggs. On closer examination, they revealed a thin layer of 'flesh' wrapped around an enormous seed. Although slightly bitter to taste and reputedly poisonous to some herbivores, they are known to be swallowed by cassowaries, which defecate the indigestible seeds elsewhere in the forest. Because the characteristics of these seeds are similar to those from Central America, which were evidently dispersed by giant extinct herbivores, it seems at least possible that this and perhaps other Queensland rainforest trees with gob-stopper-sized fruits were also dispersed by the bizarre menagerie of now-extinct giant marsupial herbivores (Jones and Crome 1990).

Returning to our antechinus experiment, the origin and explanation for the differently shaped dentitions of the Brown and Dusky Antechinuses may well have been competition that plagued their ancestors when they first drew territorial lines in the leaf litter of lost worlds millions of years ago. Selection pressure to reduce the competition and enable both to dine on the same forest floor may have led to one becoming a gourmet of gross gooey grubs and the other a *bon vivant* of beetles. If then a favoured prey item tipped over the precipice of extinction or evolved some dastardly chemical cocktail that caused its prime appreciator to wrinkle a whiskered nose in disgust, the hungry dasyurid, replete with now useless dental distinctions devoted to the defunct or inedible delicacy, would once again be cast into competition with its congener, producing the otherwise inexplicable modern situation.

Even if we can demonstrate that a particular form is used for a particular modern function, this is still not the same thing as saying that *that* function is the explanation for the *original* development of the form. Consider the use of cactus spines by the Galapagos Woodpecker Finch *(Cactospiza pallida)* to winkle grubs from rotten wood. If capricious extinctions left us this as the only bird in the world, some ardent adaptationist would undoubtedly have concluded that the reason bird beaks evolved was to more efficiently hold wooden worm-winklers rather than to serve as food-stabbers and pluckers as in all other birds.

Similarly, 'present-o-centric' deductions have led physiologists to conclude that electroreceptors in Platypus bills evolved to improve the efficiency of underwater prey detection (see ANH vol. 23, no. 4, 1990). Most certainly, they do use this 'sixth sense' to capture prey, 'seeing' the electrical outbursts of the escaping prey's contracting muscles. But considering that fossil platypuses are almost invariably found in deposits well-endowed with snaggle-toothed crocs, fish and hooked-beaked turtles that would kill for a piece of 'platypie', isn't it just possible that electroreceptors also evolved as an aid to avoiding becoming someone *else's* dinner?

Libraries of invisible prehistory lurk behind the shape of even the smallest toenail, or simplest behaviour. As creatures and conditions change with time, life's arsenal of prehistoric form becomes fodder for the development of novel function, which in turn drives the evolutionary machinery that overhauls form. Our mistake is to presume that the explanation for the *origin* of form must always be retrievable from the study of *modern* function. ■

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Professor Michael Archer lectures in biology and geology at the University of New South Wales. Most of his non-teaching hours are devoted to the study of the fossil faunas of Riversleigh.

QUESTIONS & ANSWERS

COMPILED BY JENNIFER SAUNDERS

EDITORIAL COORDINATOR

Galah Relatives

Q. We are somewhat confused as to which genus the well-known Galah belongs. At least 14 authors show it as belonging to *Cacatua*, while another five seem to prefer *Eolophus*. Could you tell us which one is now acceptable?

—E.L. & O.P. Hamonet
Speers Point, NSW

A. No-one has questioned that the Galah is most closely related to the white cockatoos of the genus *Cacatua*. The debate is whether it is sufficiently close to be considered in the same genus, or different enough to warrant its own genus, *Eolophus*. The approach to biological classification adopted will be important in determining the answer.

The Galah has a number of characteristics that are unique within the cockatoos: the pink and grey plumage of the adult, the pink down of the nestlings, several features of the skull, and some of its behaviour. Biochemical evidence, however, suggests that the Galah is closer to the Short-billed (Little) Corella *(C. pastinator)* and Slender-billed Corella *(C. tenuirostris)* than to the Sulphur-crested Cockatoo *(C. galerita)* and Major Mitchell's Cockatoo *(C. leadbeateri)*. The interpretation is that the Galah evolved its distinctive characteristics after the first division within the white cockatoos and after it had *itself* separated from the corellas.

Traditional methods of biological classification would recognise the Galah's morphological distinctiveness by placing it in a separate genus. An alternative method of classification uses genealogical relationships (that is, the relative time that each species of cockatoo branched off from the ancestral lineage) rather than overall differences. Therefore, if the Galah's time of divergence was between that of any two species of *Cacatua*, it too must be put in that genus.

Different ornithologists employ these two different approaches to classification, depending on their wish to emphasise morphological distinctness or genealogical relationships. Neither can be said to be right or wrong, even though more than one name may be in use at the same time. Perhaps the more important thing is for the ornithologist to say which approach has been taken and stick to it.

—Walter Boles
Australian Museum

The Galah debate: to which genus should this bird belong?

P.D. MUNCHENBERG / NPIAW

Ant-iques

Q. How long do ants live?

—Alex Dougal
Sussex Inlet, NSW

A. Very little is known regarding the longevity of ants. For a start, such details vary from species to species, and to date there has only been restricted work on a relatively small number of species. Experiments that have been carried out seem to be based on only a few individuals within a laboratory nest. From what is known, it appears that the mother queens live for much longer than the workers in all groups of ants, and that males have a shorter adult life span than either queens or workers. The maximum recorded age of an Australian queen is 21 years for the Sugar Ant, *Camponotus consobrinus*, making these ants one of the most long-lived insects ever recorded. Longevity is also

related to body size and ambient temperature—an ant will live longer the bigger it is and the lower the temperature. In general, if you're a worker ant, once you reach adulthood, you can expect to live for around one to three years, depending on what species you are. That is, of course, if you don't get stepped on first.

—J.S.

Trash or Treasure

Q. I wonder if you could help me with a problem of identification? I recently inherited some items of jewellery, which contain gemstones, from my grandmother. I don't know what the stones are and would be most interested to find out. Can you suggest the best way to have them identified? Also, my son has a number of pebbles he has found while out fossicking and would like to know more about them.

—S. Gardiner
Hornsby, NSW

A. The Australian Museum has a gemstone identification service, which is conducted by Gayle Webb, a qualified gemmologist in the Mineral Section. She will identify rough or cut stones (including pebbles), set in jewellery or loose as the case may be. There is a small charge for the service. You can contact Gayle on (02) 339 8252.

—J.S.

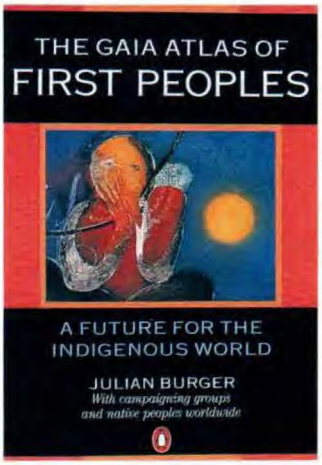
COURTESY ARGYLE DIAMONDS

Find your fortune?

REVIEWS

COMPILED BY JENNIFER SAUNDERS

EDITORIAL COORDINATOR



The Gaia Atlas of First Peoples

By Julian Burger. Penguin, Victoria, 1991, 191pp. $25.00.

Indigenous peoples are often referred to as 'First Peoples' because their ancestors were the original inhabitants of the land. They are also known as 'Fourth World' peoples because they have been forced to marginal areas and live relatively impoverished lives within the industrialised First World, the socialist Second World and the developing Third World. In recent months and years, they have received a great deal of attention in the media so that suddenly we are much more aware of their existence and plights. In Australia, there have been Bicentennial protests, along with demands for land rights, criminal justice and better living conditions. In South America and Siberia, there have been protests over the widespread destruction of the environment. In Canada, demands for participation in constitutional reform and roadblocks to halt out-of-control 'development' have received national and international attention. Elsewhere, popular films such as "Dances with Wolves" or documentaries on cultural genocide practices and the effects of colonialism, decolonisation, multinational corporations, pollution and arcane governmental practices have moved indigenous peoples to centre stage. Some might argue that the collective guilt of many First and Second World peoples is responsible for much of the prominence indigenous peoples receive today, but this is not correct. It is the First Peoples themselves that are at last setting agendas and demanding that they and their cultures be given equal recognition. Julian Burger's *The Gaia atlas of First Peoples* is ample evidence of this.

This book is a welcome volume that summarises the philosophies, histories, concerns and aspirations of the world's 250 million indigenous peoples living in over 70 countries. It was compiled by Burger with the assistance of numerous indigenous peoples and organisations, as well as a large team of contributors and consultants.

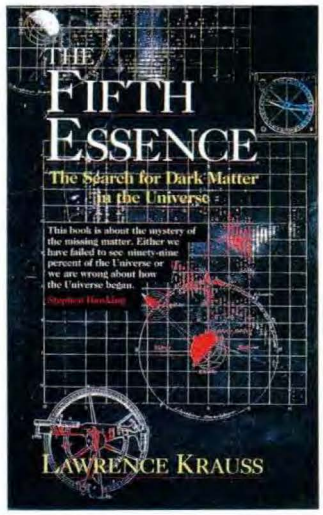
Lavishly illustrated, it provides the reader with numerous quotes and statements from indigenous peoples themselves. This first-hand 'contact' gives those who have not had the chance to 'meet' First Peoples a means of understanding their cultural values. For example, their relationship with the land is made meaningful through statements such as this one by Hayden Burgess, a native Hawaiian: "The Earth is the foundation of Indigenous Peoples, it is the seat of spirituality, the foundation from which our cultures and languages flourish. The Earth is our historian, the keeper of events and the bones of our forefathers. Earth provides us with food, medicine, shelter and clothing. It is the source of our independence, it is our Mother. We do not dominate her; we must harmonise with her."

The book is divided into three main parts. Part one describes their way of life, focusing on the traditional, pre-contact aspects that persist today. Part two outlines the crisis indigenous peoples face today; and part three shows how First Peoples are standing up for themselves as a united front.

The main message of this book is freedom. Burger, perhaps romantically and contrary to much evidence, regards life in indigenous societies as being essentially free. Freedom is also what the future is all about, according to the author, and the book concludes that the world needs to strive for a common humanitarian, environmentally sensitive culture.

There are two main weaknesses in this book. The first is that there are numerous photographs of First Peoples who are not identified. This anomaly only heightens their isolation and alienation. They have names and are individuals just like the rest of us and this is the very point of their protests! The second is that many of the descriptions accompanying illustrations, charts or lists are incomplete, inaccurate or somewhat misleading. For example: the Polar Bear carving on page 29 is not Inuit but rather a prehistoric Dorset Eskimo piece over 900 years of age; on page 18 significant Canadian Indian peoples such as the Ojibwa are omitted; on page 138 the full meaning and history of the Aboriginal flag is not clearly explained; and in the index of resource organisations concerned with indigenous affairs, significant institutions such as the Australian Institute of Aboriginal and Torres Strait Islander Studies have not been included. The book also provides few in-depth reports and gives the reader little help in terms of references to find more. This book is certainly not academic but does serve as a general introduction to indigenous peoples. It would be particularly useful for school children but should also be enlightening for adults who need to broaden their general awareness of contemporary indigenous issues.

—Paul Tacon
Australian Museum



The Fifth Essence: The Search for Dark Matter in the Universe

By Lawrence Krauss. Random Century, Sydney, 1990, 342pp. $29.95.

Any new-agers that are looking for a mystical explanation of cosmology are in for a shock if they pick up this book. *The fifth essence* is a non-mathematical text that combines the standard theory of cosmology with the standard theory of particle physics. This combination of the theory of the very small with the theory of the very large is one of the intellectual triumphs of theoretical physics. However, both theories have problems and the results of their combination still await observational confirmation.

When the light from distant galaxies is put through a spectroscope that displays the intensity of the light as a function of its wavelength, many spectral lines are seen. By knowing the wavelengths of the spectral lines produced by atoms it is possible to identify the same lines in the spectra from the galaxies. However, there is one important difference in that all the spectral lines from the galaxy are shifted to longer wavelengths and this red-shift is proportional to the galactic distance. This is the famous Hubble red-shift that provides the best evidence for the cosmological expansion coming

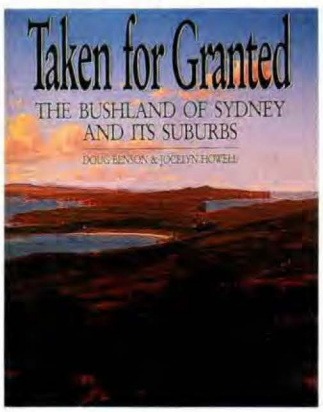
from the Big Bang.

Often, galaxies occur in large groups that are clearly gravitationally bound together. In this case, all the galaxies have the same Hubble red-shift and any differences in red-shift between them are due to their relative velocities. By measuring a large number of these relative velocities and using gravitational theory, the astronomer can estimate the total mass of all the galaxies in the cluster. Since the galaxies consist of stars where the relationship between mass and luminosity is well known, it is possible to get a luminosity mass by measuring the absolute brightness of the galaxies. However, when these masses are compared, it is found that the gravitational mass is often 10 or 100 times larger than the luminosity mass; hence the need for 'dark' matter to make up the deficit. Similar results are obtained by looking at pairs of galaxies or galaxy rotation curves. The mass determined from spectral lines and gravitational theory is always very much larger than the mass derived from luminosities.

The major purpose of Krauss' book is to examine possibilities for this dark matter. He believes that the best candidates are axions, WIMPs or magnetic monopoles. The theory of the strong nuclear force, called quantum chromodynamics, describes the interaction of quarks that combine to form neutrons, protons and many other particles. Some versions of the theory required the existence of a light particle called the axion. Unfortunately, the axion's interaction with ordinary matter is so weak that their detection is almost impossible. In addition, results from Supernovae 1987A confirmed the models for supernovae explosions and thereby made the existence of axions less likely. His second choice, the WIMP (weakly interacting massive particle), also comes from particle theory. The theory of super symmetry predicts that every particle should be accompanied by a partner with the same mass but of opposite spin. Since this is not observed, the super symmetry must be broken and this breaking is associated with the existence of a WIMP that has a mass between 5 and 50 times the mass of the proton. The final candidate considered is the magnetic monopole. In 1931 the brilliant British physicist Paul Dirac pointed out that the existence of one magnetic monopole in the universe could explain why electric charge only comes in integral multiples of the electronic charge (although quarks have fractional charges, they do not exist as isolated objects). Recent work has shown that magnetic monopoles would be extremely massive and so would be an important product of the Big Bang. Indeed, the problem was how to get rid of them. Unfortunately, after many experiments, none of these particles has been seen and the source of the dark matter is still a mystery.

This book is complete in that it adequately introduces all the concepts and objects that are discussed, but be warned—the acceleration is such that only the persistent or knowledgeable reader will maintain the pace. Nevertheless it can still be read at a lower level, by skipping the more complex arguments, to achieve a good understanding of the main thesis that the universe contains more mass in unseen and hence unknown matter than astronomers can observe. This book will appeal to those that not only bought Stephen Hawking's *A brief history of time* (1988), but also read it.

—David Crawford
Sydney University



Taken for Granted. The Bushland of Sydney and its Suburbs
By Doug Benson and Jocelyn Howell. Kangaroo Press, NSW, 1990, 160pp. $35.00.

In the centre of a modern city like Sydney, cliffs, valleys and water courses are largely irrelevant. Tunnels allow us to pass through hills and under busy intersections; concrete overpasses take us high above the ground. Our journeys are determined by timetables and freeways, rather than the lie of the land.

Standing outside the Hilton Hotel in Pitt Street, it is hard to imagine the swamp that once filled this broad basin and fed the colony's first water supply: "From King Street to Bridge Street the Tank Stream appears to have followed a sandstone gully with thickets of mesic shrubs 6–8m high. Here Lillypilly, *Acmena smithii*, Cheese Tree, *Glochidion ferdinandi*, Blueberry Ash, *Elaeocarpus reticulatus* and the small fragrant tree *Synoum glandulosum* probably grew."

Beneath the bitumen and concrete lies a lost world, vividly recreated in a new book by Doug Benson and Jocelyn Howell of the Royal Botanic Gardens.

Drawing on current research and records from the earliest days of the colony, *Taken for granted* describes the natural plant communities of the greater Sydney area. Chapters on geology, climate and soils set the scene, but this is no dry geographical study. The authors have woven the human history of Sydney into the story, and show how this has created the environment we see today. The book tells of the Aboriginal people, and the plants that gave them food, tools and shelter. It tells of Banks, Caley and Cunningham, and the botanists who built on their pioneering work. But, most importantly, it records the gradual disappearance of the natural vegetation.

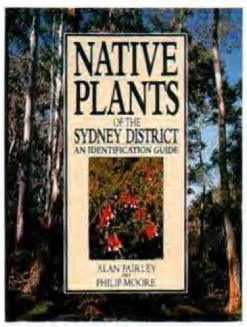
Few commuters on the 481 bus from Ashfield to Annandale would have given a thought to the area's farming potential. In 1827, Peter Cunningham saw the land beside Parramatta Road this way: "On each side of the road is a post and rail fence, while the land is thickly covered with heavy timber and brush, the soil being usually a poor shallow reddish or ironstone clay, the contemplation whereof presents but little pleasure to the agriculturist". Despite Cunningham's assessment, the Turpentine–Ironbark forests that lined the road were soon to be cleared to make way for agricultural estates.

With its comprehensive area-by-area approach, *Taken for granted* is of great interest to those of us who make Sydney our home today. The illustrations show us familiar and surprising views from the last 200 years—black-and-white and colour photographs, maps, landscape paintings by Von Guerard and others, even a tea-set decorated with Sydney wildflower designs. As a recent immigrant to Bondi, I was especially saddened to see the faded image from the 1870s showing the peaceful lagoon lined with *Melaleuca quinquinervia* that nestled behind the dunes.

But *Taken for granted* is more than just a requiem for lost landscapes. The cautionary tales of the past are the springboard for action today. In the final chapter, the authors propose a number of reserves, many in western Sydney, which should be given immediate protection. They also outline the factors that threaten the existing reserves—land clearing, a changed fire regime, and the problems of nutrients and runoff.

Carefully researched and well referenced, this is a book of great interest to anyone who enjoys Sydney's bush and wonders how it used to look. A truly natural history, *Taken for granted* tells a story that began on 29 April 1770 and continues today, all over Australia.

—Peter Wright
National Trust



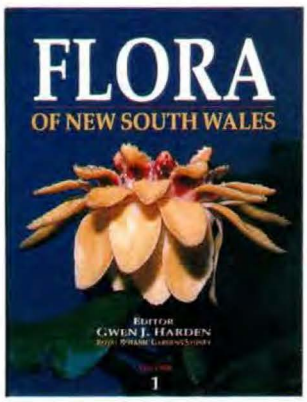
Native Plants of the Sydney District: An Identification Guide
By Alan Fairley and Philip Moore. Kangaroo Press, Sydney, 1989, 432pp. $80.00.

Flora of New South Wales Volume 1
Edited by Gwen J. Harden. NSW University Press, Sydney, 1990, 601pp. $69.95.

It is a truism of plant books that field guides are guides to living plants and floras are guides to dead plants. These two books neatly illustrate the

difference. They are both about New South Wales plants, but could hardly differ more in their approach. *Native plants of the Sydney district*, written by two naturalists for fellow naturalists, is full of colour plates and easy-to-read descriptions; the *Flora of New South Wales*, written by botanists for other botanists, is heavy with keys and technical language.

Native plants of the Sydney district is a marvellous book and a must for the Sydney nature lover. In more than 400 full colour pages it describes and illustrates almost 1,500 of the 2,000 plant species found in the region bounded by Newcastle, Nowra and the Blue Mountains. According to the authors, "Excluded are some of the sedges and grasses which are difficult to distinguish in photographs and which have limited popular appeal. Also excluded are introduced plants, some rarer ferns and orchids, species with



doubtful records and a few plants occurring on the fringes of the area which are atypical of those in the Sydney district".

The plants are presented by family, and the descriptions of the families are especially informative, with the authors discussing such topics as host mimicry among mistletoes and the spread of grasses following Aboriginal burning. Localities are given for many of the plants and there is even a simple family key.

The colour photos show all the common plants, along with a number of obscure species never before illustrated. Combined with *Plants of western New South Wales* by Cunningham, Mulham, Milthorpe and Leigh (Soil Conservation Service of New South Wales, 1981), the two books provide a photographic record of most New South Wales plants (excluding rainforest and alpine species).

My one complaint is that, as an identification guide, this book does not include bushland weeds, nowadays an important component of the Sydney flora. Naturalists often confuse native and introduced plants, and this book does nothing to dispel that confusion.

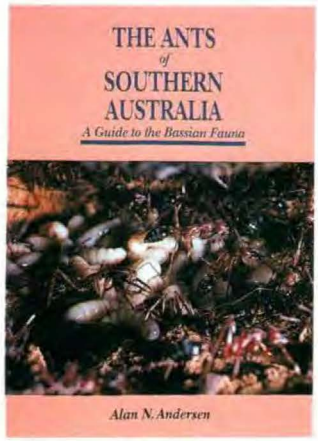
No such complaint can be levelled at Volume 1 of the *Flora of New South Wales*. This hefty tome, covering the ferns, conifers and more primitive angiosperms, features all exotic as well as native species.

This is an impressive flora. The keys and descriptions are detailed and entirely adequate for identification—a great improvement over the keys and cursory descriptions of the *Flora of the Sydney region* (Reed, 1963). The language has been kept as simple as possible, and the glossary, printed on green paper for easy access, seems comprehensive. The design is also very clean and professional. Remarkably, there is a line drawing of every species, mainly of a diagnostic character, presented conveniently beside the main description. There are also numerous colour plates.

This flora has been prepared by botanists at the Royal Botanic Gardens, Sydney. As is usual of floras, the descriptions are written from dried specimens, often by botanists who have never seen the live plant. This is evident in the numerous descriptions that omit obvious features of the live plants, such as flower colour, in favour of characters that preserve well. There is also very little information about habitat. For these reasons, this flora may prove a disappointment to the naturalist, but it will be welcomed by the biologists and agriculturalists who have had to make do without a New South Wales flora since 1893. Hopefully, the remaining three volumes will appear soon, as New South Wales is still well behind South Australia, which has had a complete modern flora since 1986.

In closing, I note with sadness that the quality of these plant books is certainly reflected in their price. The complete flora, when it becomes available, will presumably cost about $300, and *Native plants of the Sydney district* at $80.00 is a hefty slug.

—Tim Low



The Ants of Southern Australia: A Guide to the Bassian Fauna
By Alan N. Anderson. CSIRO Publications, Melbourne, 1991. 70pp. $20.00.

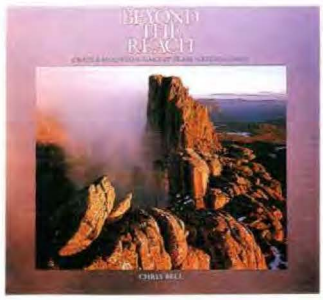
Australia has a truly remarkable ant fauna. It is highly diverse and in some areas up to 150 different species per hectare have been recorded. This continent is also home to the world's most primitive ants—the bull ants and their relatives. Ecologically, ants play a very important role in nutrient recycling, and they are increasingly being used as indicators of habitat disturbance.

Ants are well known for their elaborate social systems. Colonies generally comprise an egg-laying queen, sterile female workers and soldier castes. Because of the unusual sex determination system found in all hymenopterans (wasps, bees and ants), it is relatively easy for the queen to determine the sex of her offspring—fertilised eggs produce females and unfertilised eggs produce males. Thus, males are only produced to coincide with mating flights and new colony formation. Otherwise, only sterile females are generated in large numbers to forage for food, care for the young and maintain the colony. Here the sisterhood is indeed powerful.

Anderson provides the reader with clear, well-illustrated keys to the major ant genera and common species of south-eastern Australia. I grabbed a few wandering ants and had little difficulty using the keys. Also, the problems relating to generic definition and difficult groups of species are clearly addressed rather than ignored, as often occurs in many guides. What I like most about this book is the discussion given for each genus. Here, the author gives tips and information on species recognition, foraging habits, nest structure, and other items of natural history that help make the groups familiar. Such knowledge is usually gained only by personal experience, and rarely passed on except by word of mouth. Technical texts often omit this kind of information, but Anderson has written it down, bringing life to the text.

This guide is an excellent introduction to those species that characterise the distinct biogeographical zone of cool and wet southern Australia: the Bassian ant fauna. It is, however, also useful along the coasts and ranges from central New South Wales through Victoria and Tasmania. With this fine little book in hand, the inhabitants of Australia's southern corner can now obey Solomon's famous injunction, "Go to the ant, thou sluggard".

—Daniel Bickel
Australian Museum



Beyond the Reach: Cradle Mountain–Lake St Clair National Park
By Chris Bell. Laurel Press, Tasmania, 1991, 95pp. $49.95. Also available by post from Laurel Press, PO Box 132, Sandy Bay, Tasmania 7005.

Beyond the reach is essentially a picture book; an amazing portfolio of images from Cradle Mountain–Lake St Clair National Park. The limited dialogue is only included as background information to increase the appreciation and understanding of the spectacular photography. The text briefly covers the history of the area, the geology, and its flora and fauna, as well as emphasising the importance of wilderness and its personal impact on the author.

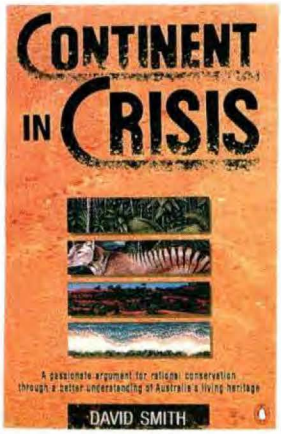
Chris Bell is drawn to this region and as a dedicated conservationist states, "I have deliberately not disclosed the specific locations of some of the photos . . . I wish to avoid the trap of enticing people to secluded or fragile areas, or of raising their expectations." This is probably a wise decision as you cannot help being tantalised by this special place.

"Wilderness endures, wealth is ephemeral, and always will be" is perhaps the underlying philosophy of the book. Bell challenges our consciousness as to the value of wilderness for its own sake and its benefit in understanding ourselves. Some may regard his attitude concerning the environment as supersensitive; however, considering the limited amount of wilderness remaining in the world, his message is vital.

The photography is spectacular, capturing the intrinsic beauty of the intricate grandeur of the mountain ranges and rock formations. The ever-changing colours and moods are revealed as the seasons change. The lighting effects are skilfully captured at dawn and dusk, adding to the presentation.

Looking at this beautifully presented book, you cannot fail to be captivated by the quality of the images and the enthusiasm of the author. A visual masterpiece!

—Fiona Mackillop
Australian Museum



Continent in Crisis
By David Smith. Penguin, Melbourne, 1991, 201pp. $14.99.

Continent in crisis provides a thumbnail sketch of the development of the Australian continent and its flora and fauna. The chapters take the reader on a trip through time, by dealing with topics such as continental drift and its effect on the Australian climate; the development of mammals; Australia's geological history; the influence of the Aborigines; and the impacts experienced with and since the arrival of Europeans. These early chapters provide the background to the real reason for the book – a discussion of the future of sustainable development in Australia.

The task that the author has adopted is immense and presents a considerable challenge: to provide sufficient information on each subject so that the reader is able to make informed decisions. Unfortunately, in his attempt to do this, too many topics are discussed, resulting in a disjointed picture of a very complex subject.

Apart from the superficial treatment of such an involved subject, the book has a number of other weaknesses. The author presents theories as if they are generally agreed interpretations of past history. Statements are made that seem to have no relevance to the matter under discussion and the loose ends of the discussion are not brought to a conclusion.

The diagrams in the book also leave a lot to be desired. For a reader not accustomed to the Australian fauna, the diagrams would be extremely misleading as there is no indication of scale; a planigale, for example, is drawn to the same size as a Dingo. Added to this is the failure to acknowledge the source for the diagrams, and the incorrect labelling of the bat diagram.

Overall, this book provides a good grounding in the long-standing theories that attempt to explain the uniqueness of the Australian flora and fauna. However, readers who are excited by this book will need to refer to the relevant scientific journals to gain an up-to-date understanding of the subject matter.

—Elizabeth Telford

TRAVEL REVIEWS

EAST COAST RAINFORESTS

Binna Burra Mountain Lodge Lamington National Park

Nature Australia Limited, Binna Burra Lodge, Beechmont, Qld 4211. Reservations (008) 074 260; administration (075) 333 622; fax (075) 333 647.

Perched atop a mountain with 360-degree views, Binna Burra is a bushwalker's paradise. Its style is a cross between a private ski lodge and a hotel, with large, comfortable rooms and a friendly atmosphere. The timber and shingle cabins were built by intrepid pioneers in the 1930s and have since been enjoyed by three generations of dedicated bushwalkers. I arrived after a severe bout of bronchitis and a few days in the cool, crisp mountain air gave my poor tired lungs a new lease on life.

All guests are encouraged to sit together at meals, of which there are no less than seven, beginning with early morning breakfast at 6:30am and ending with supper around 9:00pm. One thing is certain: I never went hungry at Binna Burra, and they cater for every taste. Breakfasts offered not only a huge selection of cereals but also every kind of milk from full-cream, to skim and soy, plus an array of fruit and hot breakfasts. This is something I have never come across before and I was certainly impressed. All meals offered this variety and the food was scrumptious.

To work off these copious meals, there are myriad walking trails through Lamington's beautiful rainforest. They vary from easy one-hour jaunts to full-day trips, and Binna Burra offers many guided walks, information and maps of walking trails, day packs and even umbrellas when necessary, plus an enormous packed lunch.

Given all the inclusions, Binna Burra is excellent value for a holiday. I suggest a week's stay to really appreciate what this resort has to offer, and there are a number of special-interest weeks throughout the year, including photography, watercolour, adventure, running and even murder-mystery weekends.

I recommend it for solo travellers and families alike. There is a nearby bunkhouse available for school groups (run by the Lamington Natural History Association) and Binna Burra also runs the adjacent campsite. It's a comfortable hour-and-a-half drive from Brisbane (or a bus ride from Brisbane, Surfers Paradise or Coolangatta).

Binna Burra cabins.

FIONA DOIG/AUSTRALIAN MUSEUM

Coconut Beach Resort.

Tariffs include all meals and start from $98 per person for a Casuarina room to $133 for an Acacia room. Mid-week specials are from $450–$610 and a full week from $637–$868. Children under three years old are free and 3 to under-15 year olds are half adult tariff. Rates are based on shared occupancy.

Coconut Beach Resort Cape Tribulation

PO Box 6903, Cairns, Qld 4870. Reservations (070) 98 0033; administration (070) 52 1311; fax (070) 51 6432.

Just a few kilometres south of Cape Tribulation and 150 kilometres north of Cairns, Coconut Beach leaves behind the ritzy resorts of an unfashionable high-rise past and prefers instead to echo its surroundings. Situated in the heart of the World Heritage-listed Daintree region, where the rainforest meets the reef, it forms the perfect setting to escape the rat-race.

I was surprised to learn it was fully occupied when I arrived as there seemed to be very few people around. The rooms are large, well-appointed and designed for tropical living. I also encountered more wildlife around my room than in the rainforest itself, with visits from Australian Brush Turkeys, a monitor lizard and a feral piglet (pigs are an enormous problem in the Daintree). I was gently advised that the melomys are to be tolerated if they decide to pay your room a visit (these charming little native rats have a fondness for chewing through flyscreens). On the palm-fringed beach, huge bright blue and black Ulysses Butterflies (*Papilio ulysses*) flit above the rainforest.

Although secluded, the resort offers lots of optional excursions. I found the guided rainforest walk at night fascinating (you have to keep your eyes out for stinging bushes—the pain from touching one is, I'm told, mind-bending and can last for months). There is also an outer reef trip on a dive-boat, which I could not pass up.

The ultimate means of experiencing the reef is to surround yourself in it and scuba diving here is a magical experience, although snorkelling is almost as good. The boat is equipped to do both and non-divers can do a resort course on board. We anchored off a lesser-known sand cay, where we encountered dozens of giant clams with velvety lips, schools of brilliantly coloured fish that inspected us with idle curiosity, and enormous corals rising up from the sea floor. I also saw nudibranchs, starfish, beche de mer and pretty fan worms.

I spent another day on the Bloomfield Track Safari, a four-wheel-drive and boat trip up the Bloomfield River. This river boasts some of the most spectacular mangroves I've seen, and of course crocodile spotting is a favoured pastime.

Other trips the resort offers include guided horse rides, Daintree River photo and fishing safaris, mountain bike rid-

ing, scenic flights, sea kayaking, Cooper Creek cruise and other outer reef cruises.

Further developments for the resort are planned, including exclusive 'tree houses' for optimum privacy, an environmental conference centre, canopy walkway and budget lodge-style accommodation for special-interest and school groups.

Rates for 1992 (per night, per person) are $165 single, and $115 double plus $35 per additional adult or child. These rates include a tropical continental breakfast. Other meals can be bought at the restaurant, picnic hampers are available, and there is a small resort store. Coconut Beach Resort is also offering a free half-day guided walk with accommodation booked by ANH readers.

Whale-Watching & Fraser Island

TraveLearn, Continuing Education Department, University of Queensland, St Lucia, Qld 4067. Reservations and administration (07) 365 7000; fax (07) 365 7099.

For many years I've been wanting to return to Fraser Island, the world's largest sand island, for I'd left with many unanswered questions. How can an island of sand support such a magnificent rainforest? Why is the water so clear and pure? Why are the numerous lakes different colours?

On TraveLearn's trips, nothing goes unanswered. Leading our tour were Cliff Thompson, formerly a CSIRO soil scientist whose knowledge of local sand-dune systems is immense, and John Sinclair, sometimes referred to as 'Mr Fraser Island', a dedicated conservationist who has cleared the path to Fraser's impending World Heritage Listing application.

The two balanced each other well; at first Cliff's lectures were a little daunting as we grappled with podsols and macrozamias. John's style was less technical and more wide-ranging. Once out in the field, with Cliff and John showing us what they had talked about, it all came together neatly. We were shown how plants obtain their nourishment and colonise dunes and how systems of dunes are gradually formed. We saw the birds that had just migrated from Siberia and we tasted the pure water. Most importantly we realised how significant Fraser Island is.

The curious colours of the lakes, which vary from clear dark tea, to yellow, orange-red, sapphire blue and lime green, intrigued me. The difference depends on whether or not any organic material leaches through the sand into the water. Brilliant blue results from clear water; yellow, orange and red-brown lakes contain varying amounts of organic material; and green results from algae. One thing is certain, they are all great to swim in—even the cola-coloured swimming hole at Dilli Village, where we stayed—and diving into lime green Lake Wabby from a steep sand-dune is something not to be missed!

Our daily jaunts in 'convertible' four-wheel-drive buses (remarkably comfortable) led us along the beach to the coloured sands, Maheno shipwreck and across to the western coast. Our jovial drivers, Noel and Paul, added some light entertainment. We went as far north as Indian Head to watch dolphins, fish and a turtle in the water from one of only three rock formations on the island. Walking through the rainforest from Pile Valley to Central Station held everyone in awe and the creeks on Fraser Island are so clear you can't see the water without looking twice!

This is indeed a painless and fun way to learn, and I have found that I remember so much more than had I studied books instead.

After five days on Fraser Island, we crossed Hervey Bay to join the whale-watching program.

Oceanographer Bob Morris gave such good lectures on whales they almost out-rated the sightings. I understand the plight of whales more now than ever before. The boat itself, however, was rather ricketty for the long trips into Hervey Bay. TraveLearn has addressed this problem and will be using a high-speed catamaran for its 1992 trips and, I am pleased to announce, is making special provisions for handicapped people, with facilities for wheelchair access.

Our first sighting was a Humpback breaching towards the horizon. It leapt completely out of the water; then again, showing its tail. As we neared, two whales surfaced. One startled us all, suddenly spouting behind the boat when we were all looking the other way. There was a 4.00am wake-up the next day for another whale-watch and it was a rather weary bunch of new-found friends that returned to Brisbane that evening.

TraveLearn is running a number of whale-watching and Fraser Island trips throughout the September 1992 whale-watching season. Weekend whale-watch trips are $395; new three-and five-day whale-watching trips with a day on Fraser Island have been added into the program (price to be advised). Two modified options on the trip reviewed here include a choice of a longer trip (13–20 September; $1,330) or a shorter one (5–11 September; price to be advised). Both are accommodated on Fraser Island at Eurong Resort (not far from Dilli Village). All the above (except weekend trips) are ex-Brisbane. Careful planning on TraveLearn's part has enabled many short and long trips to be appended together, so check out their excellent program. But if you plan on visiting Fraser, remember it is a sand island and expect to get some of it between your toes!

John Sinclair with our TraveLearn group at Indian Head on Fraser Island.

FIONA DOIG / AUSTRALIAN MUSEUM

Sea Acres, Port Macquarie

Sea Acres Rainforest Centre, Pacific Drive, Port Macquarie 2444. Phone (065) 82 3355; fax (065) 82 3330. Entrance fee $8.50 adults; accompanied children free.

Captain John Oxley, in 1813, wrote of Port Macquarie: "Trees thickly embraced with creepers among which a kind of passionflower threw its broad shining leaves, flowers and tendrils, forming a vast canopy. Tree ferns here were twenty feet high and on the forks of the older trees grew stag and elkhorn ferns."

Such a description might well have been written today about Sea Acres Nature Reserve in Port Macquarie, where I spent a fascinating afternoon on my return journey from Queensland.

A wildlife sanctuary since 1913, this 72-hectare pocket of rainforest is now a nature reserve under the New South Wales National Parks and Wildlife Service. Sea Acres was the first coastal landscape to attract a Heritage Listing for the "preservation of an area containing an outstanding remnant of coastal rainforest".

One of the main features of the Sea Acres Rainforest Centre development was the construction of an amazing 1.3-kilometre boardwalk, which meanders through the undisturbed rainforest. You need a good hour or two to really take it all in.

You can either wander along the boardwalk on your own or take a guided tour as I did. The signage around the boardwalk is both entertaining and informative. I spotted numerous Australian Brush Turkeys, some nesting birds and a goanna.

Back in the visitor centre you can see a film in the theatre, spend time in the electronic rainforest display room, browse in the gift shop or have a bite in the cafe.

Sea Acres is open from 9.00am to 4.30pm every day except Christmas day. Sea Acres also provides educational programs for Kindergarten to higher education and environmental groups. It is well worth the slight detour off the Pacific Highway to Port Macquarie, one of the best en route overnight spots between Sydney and Brisbane.

—F.D.

"To claim that Aboriginal society was in harmony with the environment is to deny that society fundamental human qualities."

THE POLITICS OF HARMONY

BY MICHAEL HERMES

ARCHAEOLOGICAL CONSULTANT, DARWIN

LESLEY HEAD'S REMINDER (ANH VOL. 23, no. 6, 1990) of the complex interaction between traditional Aboriginal society and the environment challenges simplistic notions of a society in harmony with nature. To understand Australia's present ecology and biogeography, we would do well to consider the evidence for past environmental and cultural changes.

Interpretations of the nature of traditional Aboriginal society in our popular press almost invariably stress a harmonious and unchanging symbiotic balance. One of the zaniest examples of this view comes from the conservative *Far Eastern Economic Review*, dated 30 August 1990: "Aborigines refrained from butchering koalas for their skins or drilling for oil on the Barrier Reef not because they lacked the technology but because they had more respect for their surroundings and their own future" (p. 24).

Koalas were, in fact, considered a delicacy in many areas by traditional Aboriginal groups and were hunted with comparative ease due to their docile nature and conspicuous habits. It has been argued by Anthony Lee and Roger Martin that the patchy and low densities of Koalas observed by Gould and other naturalists in the first years of European exploration were the result of Aboriginal influences: hunting and associated factors such as the fire regime, and the comparatively recent introduction of the Dingo.

Further north, Peter Johnson has recorded that the older residents of the Cooktown–Daintree district have observed that Bennett's Tree-kangaroo is now more often seen in the northern half of its range, and attribute this to the cessation of Aboriginal and European hunting.

Pinpointing irrefutable cases of traditional Aboriginal over-exploitation resulting in extinctions is, however, a difficult matter. Impacts would generally have been localised and temporary due to the nature of traditional hunting and land management practices. Moreover, palaeontological and early historical records are too sketchy to draw upon. But that does not mean that the environmental impact of traditional Aboriginal society was insignificant.

As Lesley Head has rightly recognised, popular notions of Aboriginal society have blinded us to the impact that Aborigines have had on the environment. By outlining past European perceptions of Aboriginal culture we can demonstrate that present perceptions are borne of contemporary philosophical and political attitudes rather than from 'reality'.

When Aboriginal people first came under close scrutiny from European observers in the late 1700s, their descriptions and portrayals were strongly coloured by Rousseau's ideal of the 'Noble Savage'. The people of Port Jackson were painted with classical Roman features, living a noble and liberated life, which Rousseau and his contemporaries, living in bleak early industrial Europe, saw as a Utopian ideal. This perception faded as it began to conflict with the reality of the displacement and alienation of Aboriginal society.

"European commentators have persisted in cramming Aboriginal society into an assortment of intellectual costumes"

In the latter half of the 19th century, a view emerged that Aboriginal society was doomed. This stemmed partly from Lewis Henry Morgan's application of Darwin's 'survival of the fittest' idea to the field of anthropology. This notion was abandoned when it became clear that the Aborigines would not die out as expected (and perhaps hoped). With the advent of the White Australia Policy, the government had little trouble getting rid of most non-whites by simply sending them home. Since it was clearly impossible to send Aboriginal society home, it was decided that turning them into white Australians was the next best thing. Assimilation then became the catchcry.

In the 1960s and 1970s amidst Flower Power, environmental consciousness, and racial and sexual equality, a neo-Rousseauan renaissance developed. Aboriginal society was again seen as a culture in tune with the world, turning the full cycle to the views of 200 years before.

This latest view is still prevalent in the popular literature. Clyde Holding in 1985, then Minister for Aboriginal Affairs, wrote in an introduction to *Kakadu Man* that "Australia's indigenous people learned to live in harmony with an environment of great variety."

These sentiments glaze over the complex process where the environment swings from balance to imbalance and back again in response to changing Aboriginal technological and cultural practices. The most conspicuous event in the recent past was, perhaps, the introduction of the Dingo around 4,000 years ago, resulting in the mainland extinction of the Thylacine and the Tasmanian Devil. The overall impact of this event on Australia's environment is difficult to assess but cannot have been insignificant.

Over the past 200 years, European commentators have persisted in cramming Aboriginal society into an assortment of intellectual costumes. These were usually ill-fitting, uncomfortable and frequently discarded. Rather than being Flower Power people or khakied land systems managers, Aborigines used the environment to the level of their technological sophistication as other societies do.

All human societies have an impact on their environment. It is only that the magnitude of that impact varies according to a number of factors, technological sophistication being pre-eminent.

To claim that traditional Aboriginal society was in harmony with the environment is to deny that society fundamental human qualities. The environmental halo awarded to Aboriginal society by many is a common trend in our popular literature and one that may have more to do with fantasy than fact. ■

Suggested Reading

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Johnson, P.M., 1983. Bennett's Tree-kangaroo. Pp. 266–267 in *The Australian Museum complete book of Australian mammals*, ed. by R. Strahan. Angus & Robertson: Sydney.

Neidjie, B., Davies, S. & Fox, A., 1985. *Kakadu Man Bill Neidjie*. Allan Fox & Associates: Sydney.

Michael Hermes has worked as an archaeologist and teacher in the Northern Territory for the past six years. Two of those years were spent in eastern Arnhem Land, teaching in remote Aboriginal communities.

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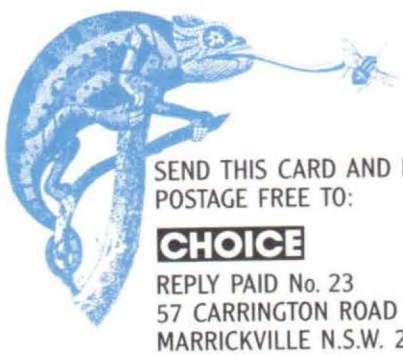

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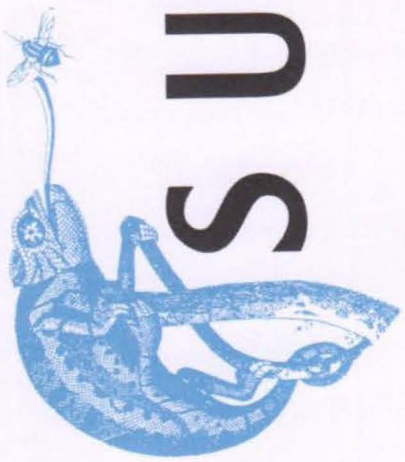

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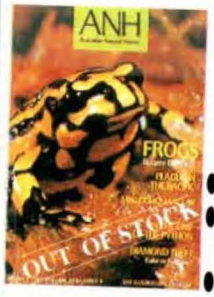

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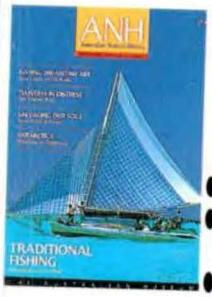

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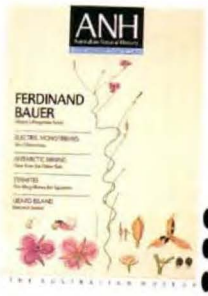

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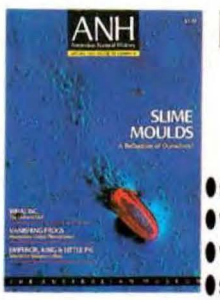

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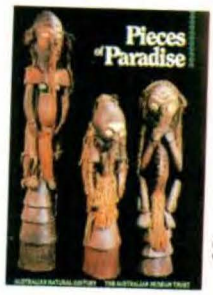

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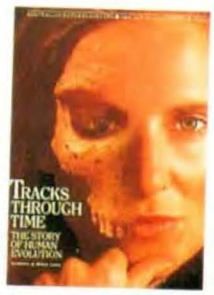

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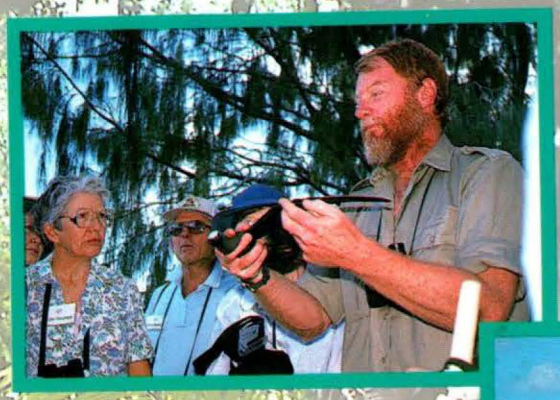

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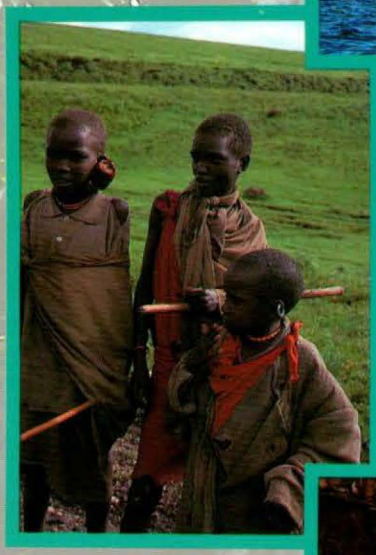

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