ANH
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POMPEIIS IN THE PACIFIC
A Slice Through the Past

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Residue Analysis

BIOLOGICAL CONTROL
and the Cane Toad syndrome

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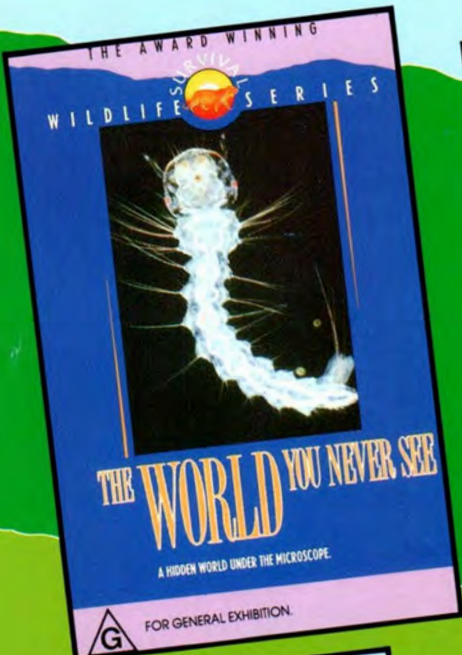

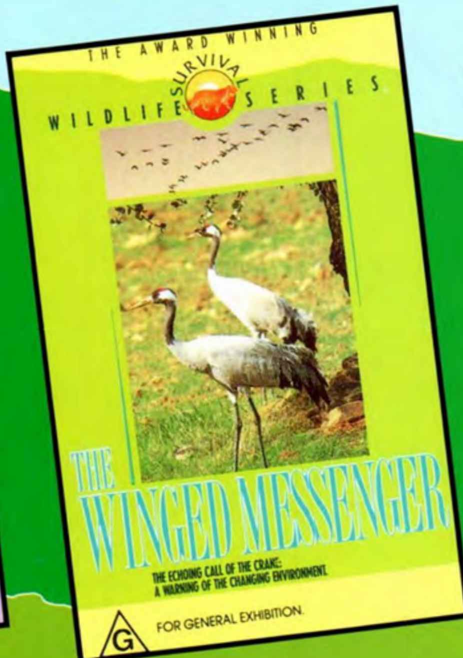

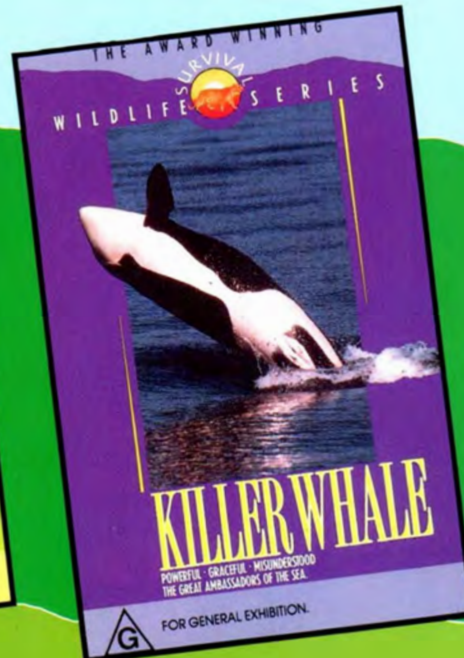

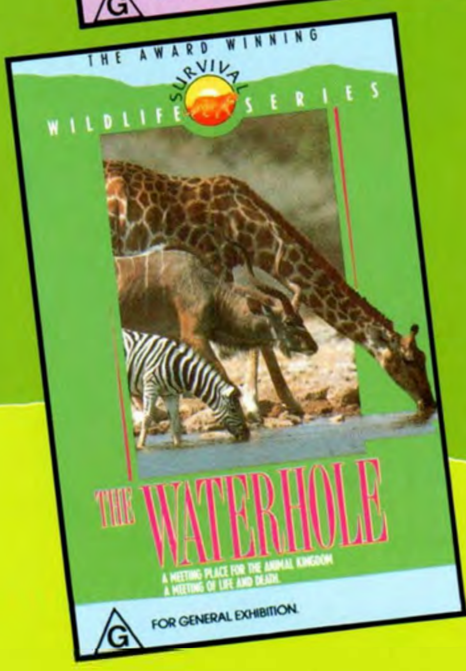

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Front Cover
The Cane Toad is often incorrectly associated with the method of biological pest control. Stringent tests for suitable control agents now ensure that the 'Cane Toad Syndrome' is a thing of the past. Photo: Leo Meier, Weldon Trannies.

E D I T O R I A L

GARBAGE: A GROWING CONCERN

BY FIONA DOIG
EDITOR

I NEVER REALISED HOW MUCH RUBBISH Australians accumulate until I visited East Africa. Things like takeaway food packaging and plastic bags are rare luxuries. Old tyres are custom-made into thongs; children produce imaginative toys from coathangers, bits of string and cans. These people have so much less than us—yet are so much more resourceful.

All bottles in East and Central Africa are reused. I was chased down a street in Tanzania. by an irate shop owner incensed at my gall in removing a soft-drink bottle from the premises. Three burly men came flying at me making sure I never forgot the error of my ways.

This episode made me realise just how dependent we have become on garbage. Imagine going back to deposit bottles. We think we are being 'environmentally sound' by recycling glass. It strikes me as silly to return one glass container only to have it made into another. It might be a step up from throwing it away, but surely it is cheaper and more efficient to wash a bottle than to melt and remould it!

We still have deposit bottles, but only in South Australia. The return rate there is 85 per cent, compared with only 25 per cent in other States. But they are not reused, just recycled. Imagine what a difference a large company like Coca Cola could make if it brought in a worldwide policy that all its bottles are reusable. That's the kind of green image companies *should* be seeking—a genuine commitment to reducing waste, not just unrelated token sponsorships. Large companies have the power to lead the way with such trends and earn themselves genuine green reputations. Image is vital and, as it becomes apparent that the environmental boom is not just a phase, more and more businesses will be struggling to improve their—or sink. It is inevitable that political pressure will force much stricter environmental laws. A company that starts now will be better off financially in the long term. So why aren't they doing it?

We may carefully recycle much of our garbage. But are we generating any less or simply switching from one kind of disposable resource to another less detrimental one? I wonder if it is any more environmentally friendly to keep recycling at the same rate of usage to which we have been accustomed—particulary when much of it ends up in landfill. What do we do with all the environmentally sound rubbish when these are full? And existing sites in Sydney have an estimated life expectancy until only 1997. I can imagine the outcries from residents that don't want the new garbage sites in their suburb. But it is still our rubbish and we are responsible for it!

We aren't given incentives to minimise waste. There is little information and few facilities. A very successful composting collection was set up in Holland that reduced the total garbage content of household waste to such an extent that individual households involved received a large cut in their garbage rates. A remarkably simple and worthwhile scheme. So why aren't *we* doing it? Such a scheme could reduce up to a half of our total domestic waste sent for landfill.

We don't always have to see garbage as waste. Often it can be a useful by-product, an untapped resource. What about all the methane generated by garbage dumps (a good energy source that is used successfully overseas, and here previously)? As methane is a greenhouse gas, we *should* use it: the carbon dioxide its combustion generates is less environmentally detrimental. The New South Wales Waste Management Authority is seeking customers to establish facilities near landfills to utilise this cheap energy source.

The amount of garbage is not our only concern. The damage it does to the environment is critical. Not just directly. It is the energy and resources used to produce material that goes straight in the bin that is the issue. A major concern is plastics, well known to be harmful to sea life—they can entangle and kill dolphins, seals, fish, birds, and even coral. Plastics accumulate and float, and take centuries to break down. Ocean waste is a serious problem: about six billion kilograms of waste are discarded annually by ocean-going vessels and plastic refuse is the most commonly sighted man-made material in the oceans. What is surprising is our attitude to plastic—we have one of the most durable materials known and we make it into disposable goods!

Our society lives and dies by the massive accumulation of waste it produces. We throw away something rather than reuse or return it because to do so is easier. To change, we need the kind of incentives that encourage shop owners to chase people down the street to get their bottles back. Incentives in the waste minimisation campaign are vital. ■

IN THIS ISSUE

BY GEORGINA HICKEY
SCIENTIFIC EDITOR

RICHARD FULLAGAR

ANALYSIS OF PLANT AND ANIMAL RESIDUES on stone tools will permit the resolution of longstanding problems in the current debate about the origins of the Australian Aborigines. ANU's Tom Loy is one of the pioneers in the new and exciting methods of residue analysis (see page 470). Residue analysis has also been used to study the obsidian tools manufactured in West New Britain (PNG) before and after the eruption of Mt Witori 3,500 years ago. Robin Torrence, Jim Specht (pictured sitting down) and Richard Fullagar from the Australian Museum's Division of Anthropology are currently studying the layers of sediment resulting from a series of volcanic eruptions over the last 10,000 years, to find out just how the people's lives there were affected. See their story on page 456.

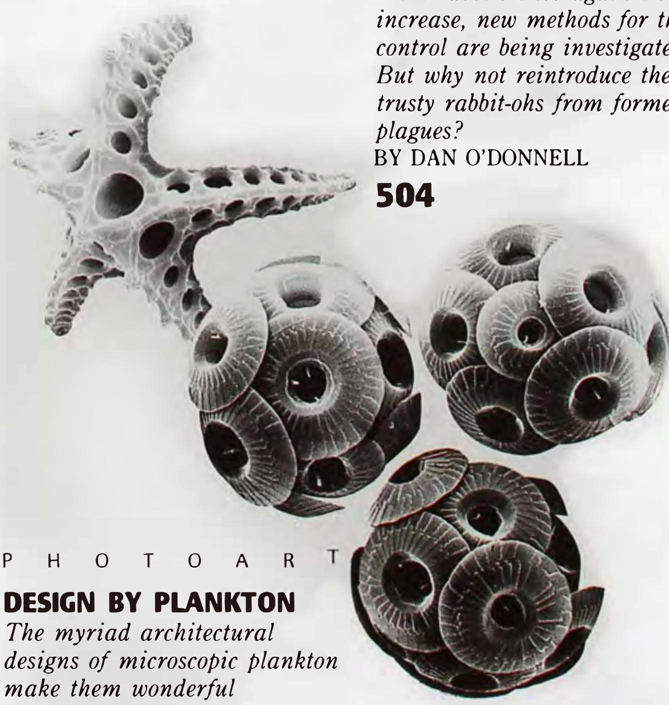
Lesley Head, from Wollongong University, takes a look at the issue of conservation *versus* Aboriginal land rights. Although conservationists are usually supportive of Aboriginal land rights, their interests are not always the same. This is because conservationists are locked into a romanticised view of Aborigines and the way they live in their environment. Perhaps it is time we reassess our expectations of our 'natural' environment.

Other articles in this issue deal with Charles Darwin's personal life (can his constant 'ill health' be explained by a fear of public places?) and the method of biological pest control—it's time people stopped connecting this control method with the disastrous introduction of the Cane Toad.

Our archival section lifts the dust off an extraordinary 120-year-old deformed human skull; Rare & Endangered focuses on a cold-hearted yet most venerable vertebrate; the rabbit-ohs of by-gone days score the Last Word; and our regular writers discuss topics as diverse as the nipples pasted on male chests, the deceptive good looks of the palm-like cycads, the hierarchical levels of the biological world, and why we bother with the study of biology at all. The poster in this issue is a 19th-century painting of a Dingo.

Articles

Regular Features



Columns

FEEDBACK

LETTERS

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

Fragile Forests

After reading the last few issues of ANH I was surprised to read some of Dr Tim Flannery's views. In his review of *The ecology of Australia's wet tropics* (ANH vol. 23, no. 1, 1989) he states: "The view of rainforest that emerges from these studies is not one of an exquisitely sensitive environment that wilts at the touch of man; but of a dynamic, resilient environment that if properly managed may be more capable than most of coping with appropriate human exploitation". He expresses similar views in the Spring 1989 issue (ANH vol. 23, no. 2).

Dr Flannery has spent eight years researching rainforest in Melanesia and obviously must have some knowledge in this field. However, he holds a view about rainforests that is not generally accepted and certainly not the point of view that I previously held. He states that, because of their complexity, rainforests are exceptionally robust. I thought that it was partly because of their complexity that they were *not* robust and I would appreciate an explanation of this statement. One of Flannery's most amazing claims (in the same review) is that "even such gross disturbance as mining. . .can be tremendously advantageous to rainforest, allowing it to spread well beyond its original boundaries". I was under the impression that it would take hundreds of years for rainforest to reach maturity and, therefore, complexity. I would also like to know how Flannery thinks that tropical rainforest can cope with the construction of logging roads, which would be required in order for selective logging to occur. I do not presume so much as to say that he is incorrect, but I thought his different ideas should have been presented to the readers of ANH in an explanatory fashion rather than expecting us to take his point of view as gospel.

I do, however, understand Flannery's opinion on the effects of fire. For many habitats in Australia, fire management is probably required. I know that the Ground Parrot (*Pezoporus wallicus*) of coastal south-eastern Australia requires a particular height of heath and, without occasional fires, the heath would grow too tall for this bird. In the question of fire management, I think each case should be judged on its merits.

I would just like to finish by saying that I enjoy the magazine and look forward to continuing to read the (mostly) high-quality articles presented.

—Michael Todd
Toronto, NSW

My view that complex systems are more stable than simple ones is in part borne out by the history of some Australian habitats. The simple desert ecosystems have been devastated, while there has not been a single documented extinction in rainforest (at least among mammals). Doubtless that some are stable, simple systems but, in a complex system, the individual parts can interact and compensate for disturbance. When commenting upon how mining actually benefited rainforest in one case, I was simply passing on the findings of Messrs Unwin, Stockert and Sanderson of the CSIRO, who published their findings in The ecology of Australia's wet tropics*—the book I reviewed. They conclude that mining disturbed the local fire regime, to the advantage of fire sensitive rainforest.*

—Tim Flannery
Australian Museum

FRITHFOTO

Tin mining in the tropical rainforest at Mt Hartley, near Cooktown, far-northern Queensland.

'Echo' Tourism

In the article "The Daintree Dilemma" (ANH vol. 23, no. 3, 1989), the key word is 'draconian'. If regulations governing access and numbers to delicate areas are not acceptable to park authorities and managers, then those areas are doomed!

The philosophy governing management of national parks in Australia, like it or not, appears to be based upon the economic input from tourism. In the United States, tourist operators are granted licences according to park management plans and in turn the number of tourists is controlled. In only a few cases am I aware that such planning is in operation in our national parks. Do not blame the demon capitalism—blame human greed and a lack of sensible planning!

I speak from 25 years experience as owner of the Chakola Wildlife Refuge in Kangaroo Valley, New South Wales. Since establishing a 40-bed experimental centre there in 1965, the property has been controlled and numbers of visitors have never exceeded 40 (we recommend 35 as a better social grouping). In fact, because the former owners believed in annual burning-off for grazing cattle, the quality of the environment has been enhanced since then. The refuge requires little management—only the people that come there, and they in turn share our concerns for preservation of the surroundings. The local wildlife happily shares our enjoyment.

I add that this is no 'hands-on-heart conservation outfit'. It is simply a carefully managed commercial idea, and a small demonstration that has been seen to work! I have applied similar disciplines towards growth and quality in my special interest tours operations, for we visit areas where I believe a limited number of tourists is an essential responsibility towards the environment and local cultures.

If 'eco-tourism' is to be developed in the Daintree, who will pay? Or will it pay for itself? Will the young world travellers described in the article pay relevant to the service costs? Possibly not. Recently I saw just such a person in the Everest National Park, warming herself in a local tea shop by a fire that burned precious buffer-zone timber carried in by yak train. Her T-shirt proclaimed 'SAVE DAINTREE'.

—Warwick M. M. Deacock
Ausventure, Brighton, Qld

Ant problem? Try Sago!

H. EHMANN

Give Sago A Go

Recently I picked up a book in a shop called *Greenies answer to pests* (or similar). It suggested pouring boiling water down ants' nests or even resorting to petrol! An old way of discouraging ants in the kitchen is quite simple: keep all surfaces clean of food, keep all dishes washed, seal all food stored and place a cup of sago near the invaded area. Within a fortnight ants will not come back. (I suppose sago gives off a scent.) Congratulations on a superb magazine.

—Pamela Reid
Hurstville, NSW

RAOU Office at the Australian Museum

The Royal Australasian Ornithologists Union (RAOU), the largest bird-study organisation in Australia, has carved yet another milestone in its long and varied history—the establishment of a branch office in the Australian Museum. Central to the operations of the Sydney office is a new and exciting national bird census project, the Australian Bird Count (or ABC) coordinated by Dr Stephen Ambrose. The ABC claims to investigate seasonal and year-to-year changes in abundance of bush birds in a broad range of habitats by encouraging people right throughout Australia to count these birds in their local area several times a year. The project has immense conservation and scientific value because it will assist in building up a picture, on a national scale, of the status of Australian bush birds, as well as define those habitats that are most important for the survival of each species.

Already, the first records are indicating the overall value of the ABC project. Previously undocumented movements have been noted for several bird species, the wintering grounds of some migratory honeyeaters in south-eastern Australia have been defined, and the build-up in numbers of some inland species such as Crested Pigeons (probably as a result of the heavy rains that have fallen over much of southern Australia last year) have been recorded. More information of this type will emerge as a more complete national coverage by observers is achieved.

If anyone has past records of regular bird counts in their area, or if they wish to start surveying their local bird populations now, or even know of someone who may be interested in joining the ABC project, then they should contact the RAOU at the Museum. We would like to encourage people in the more remote regions, in particular, to join the ABC because it is often so difficult to obtain regular and reliable information about birds in these regions. All information will be gratefully accepted and acknowledged by the RAOU.

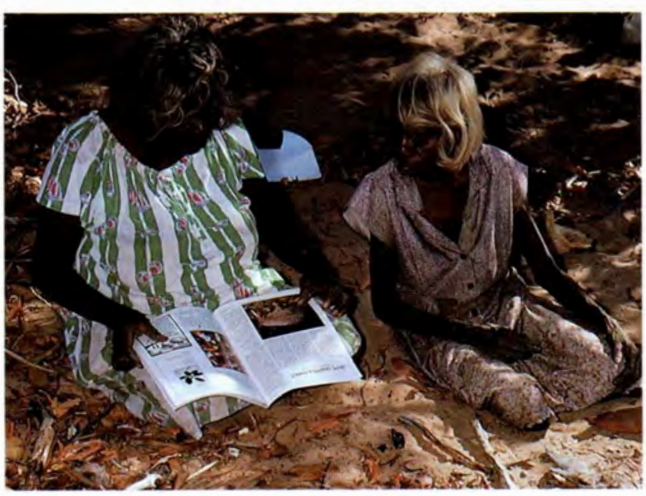
Further information about the ABC and other RAOU activities in Sydney can be obtained by writing to me or phoning (02 339–8183), or by calling into the office personally.

—Stephen Ambrose
Div. Terrestrial Ecology
Australian Museum

RAAF Food Caches

I was interested to read the article "Indonesian Fishermen of Australia's North-west" (ANH vol. 23, no. 3, 1989). During World War II, supplies of food and water were 'cached' on either or both Ashmore and Cartier Reefs in case crippled aircraft returning from the 'Indies' had to crash-land there. I can't recall any details nor do I know if use was ever made of the facilities—I hope not. You may care to pursue the matter through the RAAF Historical Branch. I remember having flown over these reefs at times and being grateful to our reliable Pratt & Whitney aircraft engines!

—Jack Bice
Lennox Head, NSW



Tim Low thought we would appreciate this photograph. It depicts Agnes Lippo and Maggie Timber reading ANH in Belyuen Aboriginal Community near Darwin.

TIM LOW

PETER HENDRIE/THE IMAGE BANK

The Daintree: locals say they know best.

Daintree Blues

I have been a subscriber to ANH for many years and have enjoyed most of the articles that you have printed. However the article on the Daintree (ANH vol. 23, no. 3, 1989) annoyed me quite a lot. I hope that other articles in this magazine are not as incorrect as this one. I think that the people who wrote the article should stick to science and leave the journalism to the journalists.

The beginning of the article, which states that tourists are not able to see inside the rainforest or have their questions about it answered, is utter rot. It is not by chance that young North Americans and Europeans turn up here; it is because they have heard from their friends that it is one of the few places where they can be taken inside the rainforest and have it explained to them. Tourists do not leave the area with questions unanswered.

The writers of the article complain about tour operators hurtling up and down the road in one part and then go on to say that accommodation should not be built in the area. You can't have it both ways. If there was no accommodation here the road would not be able to cope with the number of day visitors. Day visitors to the area must also use toilets and one of the worst aspects of the area is its lack of public toilets.

Other problems with the article: there was no nine-hectare block of land sold for two million dollars, although there was a rumour that went around. There has never been any rezoning of land to High Density Residential at or near Cape Tribulation. And the picture used at the beginning of the article was a mirror image of a negative; even very few locals could work out where it was taken.

Most locals were offended by this article. It assumes that we know nothing about our rainforests. Locals who run tours and work in the tourist industry have very high standards where tourist information is concerned. We have forgotten more about the rainforest than you scientists will ever know. When you come here next time, stick to science and leave the rest to the local people.

—Paul Mason
Cape Tribulation, Qld

How Green is our Government?

It strikes me as rather too convenient for the Prime Minister to move controversially 'green' Minister for the Environment, Senator Graham Richardson, away from that portfolio less than a fortnight after he almost singlehandedly won a narrow election for the Hawke Labour Government.

There is no doubt that Senator Richardson's credibility (not Labour's) with the conservation movement was a crucial factor in Labour gaining a sufficient number of Green and Democrat preferences to win by a slender majority. However, two intricate questions emerge with Senator Richardson's exit from the Environment portfolio and entry into Social Security. Firstly, will the Labour Government honour its pre-election commitment to the environment now that conservation's main party protagonist no longer has a say in the matter? (Or will those promises be broken, as so many others are bound to be?) Secondly, given Senator Richardson's recent record for making and sticking by "hardline" decisions, what surprises lay in waiting for Social Security beneficiaries in the coming months and years of Hawke administration? It is no secret that the nation is in an economic quagmire, groping for ways out.

I wonder what ANH readers think?

—Barry J. Parsons
Bunbury, WA

Land Degradation

It was good to see a thoughtful article on land degradation (ANH vol. 23, no. 3, 1989). Although the most significant *economic* effects of land degradation are in Australia's agricultural lands, the largest areas affected are, of course, in our vast arid lands. It was unfortunate but perhaps fitting, therefore, that an error highlighted a major problem.

The photo of 'spiral pitting' reclamation works near Alice Springs was erroneously captioned 'Replanting of natural vegetation'. In fact, most of this planting was with the introduced species Buffel Grass (*Cenchrus ciliaris*), which is now aggressively invading many parts of inland Australia. Much honest hard effort went into these reclamation works, and there is no denying that Buffel Grass is better than bare blowing soil. In the long run, however, it may not be as good a species as some of the native perennial grasses, either for pastoral production or for conservation purposes.

The reason that Buffel Grass is widely used can probably be put down to the all-too-common Australian preoccupation with the overseas wonder grass (not to mention overseas expertise and technology). Enormous efforts were spent on trials with Buffel Grass in the 1960s, and seed is now readily available. Sadly, equivalent efforts have never been put into our own native species of grass, which now must face the onslaught of Buffel in addition to that of grazing.

Even today, native grass seed is not widely available, and relatively little work has been done on harvesting techniques and establishment. Let's hope the current focus on land degradation includes work on the native grass species for the 70 per cent of our continent that is arid!

—Mark Stafford Smith
Alice Springs, NT

Whigged Again

"Whiggery is accused of stepping over. . .inconvenient details, of leaving out the failures and blind alleys." So says Robyn Williams (ANH vol. 23, no. 3, 1989) who reveals his own whiggery in his quotation attributed to Alexander Pope. Or was Pope's prescience so extraordinary that he could praise scientific theory 200 years into the future?

To set the record straight, Pope wrote Newton's epitaph in the 18th century:

> Nature and Nature's laws lay hid in night
> God said "Let Newton be!" and all was light.

It was the socialist journalist and later Georgian poet and publisher who placed the brilliance of Einstein in appropriate relativity in the 20th century:

> It did not last: the Devil howling "Ho!
> Let Einstein be!" restored the status quo.

But I guess "if we recognise the imperfections and the dead ends, the peccadilloes and the hiccups, then [literature] becomes something for all of us, whether we want to join in or not", just as Williams wants science to be.

—Peter Frith
Daw Park, SA

Lillicot's Bush Fruits

Thomas Lillicot inquired (ANH vol. 23, no. 2, 1989) about whether the passionfruit and raspberries he found in the bush during his childhood were native. I can shed some light both about his childhood rainforest and the surrounding area called Green Point Estate.

This rainforest is quite special—but for more critical things than Lillicot's fruit plants. It is a littoral rainforest area of about three hectares, comprising two adjacent distinct sub-types—'low open' and 'closed'—of extreme conservation significance.

In 1989, botanist Robert Payne inspected habitats around the Estate for a bushland park appraisal study. He did find two passionfruit species: *Passiflora herbertiana* and *P. edulis*. Payne's view is that *P. edulis* is a non-native plant, probably transported by birds. Lillicot recorded its presence 60 years ago—but Belmont was first settled by Europeans more than 100 years before that, ample time for plant invasion into this rainforest.

As for raspberries, Payne recorded none in either rainforest remnant (assuming Mr Lillicot's plant is a *Rubus* family member). One, *R. hilli*, was found adjacent to it, however, in open forest dominated by *Eucalyptus tereticornis*. Elsewhere he found *R. parvifolius* and *R. fruticosus* but these were in Spotted Gum forest, so I doubt these are Lillicot's species.

Neither Payne nor I are bush food tasters so we can't personally comment. However, as Tim Low notes in his book, *Bush tucker*, four types of raspberries occur in Australian rainforest; possibly some will be discovered in this rainforest in the future.

Payne did make one fascinating discovery: the Sydney Herbarium confirmed that the Small Fruited Mock Olive (*Notolaea microcarpa* var. *microcarpa*) has been found in this area. This is a first for the New South Wales coast. I am told it has previously been thought to be a dry rainforest inland species. What else is as yet undiscovered in this rainforest?

I hold some fears for Green Point's fate, especially alongside Belmont. This area is highly valued at a regional level and Payne's study recommended the area be reserved entirely for public recreation and conservation. However, as private property, it carries a high price tag and the local Mayor has sought major excisions for housing (to minimise acquisition costs). I hope that soon all this area becomes a major public reserve.

—Ken Johnson
Warners Bay, NSW

Swap Tourism for Timber

I refer to the article "The Daintree Dilemma" (ANH vol. 23, no. 3, 1989). Just as tourism has suffered from the pilot's dispute, it also suffers from poor management of the areas that bring people over here. People do not come all this way to see built-up areas that were once unique Australian rainforests. They want to see untouched land and, as the article mentioned, such programs have succeeded in many other countries that look at their rainforests as long-term income earners: for medicines, foods, discovery of new life forms and also tourism (that is, 'educational tourism' and 'ecotourism'), not short-term money-makers for wood and buildings. I am sure any high school economics, science or geography student could tell you this.

Thank you for a good magazine. We need this sort of article to be seen more often by our uncaring government. I thought our government would take note of the Amazonian rainforest plight, so the same does not happen in Australia.

—E. Fardoulis
Randwick, NSW

QUIPS, QUOTES & CURIOS

COMPILED BY GEORGINA HICKEY
SCIENTIFIC EDITOR

Blowing the Cat's Trumpet

Why do some cats roar and others miaow or scream? As long ago as 1834 Richard Owen discovered that the Lion (*Panthera leo*) was missing one of the bones of the hyoid apparatus (the group of bones that supports the tongue and larynx). In its place was an elastic ligament about 15 centimetres long capable of stretching to over 20 centimetres, thus lengthening the acoustic pipe (the section of the tube that runs from the larynx to the mouth). This was later found to be the case also for the Tiger (*P. tigris*), Leopard (*P. pardus*), Jaguar (*P. onca*) and Snow Leopard (*P. uncia*). Up until recently it was believed that this elastic ligament in the hyoid apparatus was the structure that allowed roaring in these big cats. However, despite being grouped in the genus *Panthera*—the so-called 'roaring' cats—the Snow Leopard had never been heard to roar.

An elastic ligament that lengthens the acoustic pipe would certainly lower the pitch of the voice and probably increase its resonance, but it would not produce intense amplification of the sound, which is what roaring is. To determine just what allows some cats to roar, Malcolm H. Hast from the Department of Otalaryngology at the Northwestern University Medical School, Chicago, studied the larynges of all big cat species and representatives of all genera of small cats (*J. Anat.* 163: 117–121; 1989).

Hast found that, with the exception of the Snow Leopard, all species of *Panthera* are distinguished from 'non-roaring' cats by a large, rounded pad of fibroelastic tissue on the uppermost part of the vocal cords. The pad of fibroelastic tissue has the effect of lengthening and increasing the mass of the vocal cords. According to basic acoustic principles, a larger mass has a lower natural frequency and thus, when vibrating, will produce a higher acoustical energy (that is, a more intense sound). The rounded pad of fibroelastic tissue also means that the space between the vocal cords, where air passes, is long and narrow and only gradually increases at the end. This design allows for a gradual transition of energy from a high to a low air resistance, resulting in a better transfer of sound energy in an efficient sound radiator (the vocal tract), in other words 'roaring'.

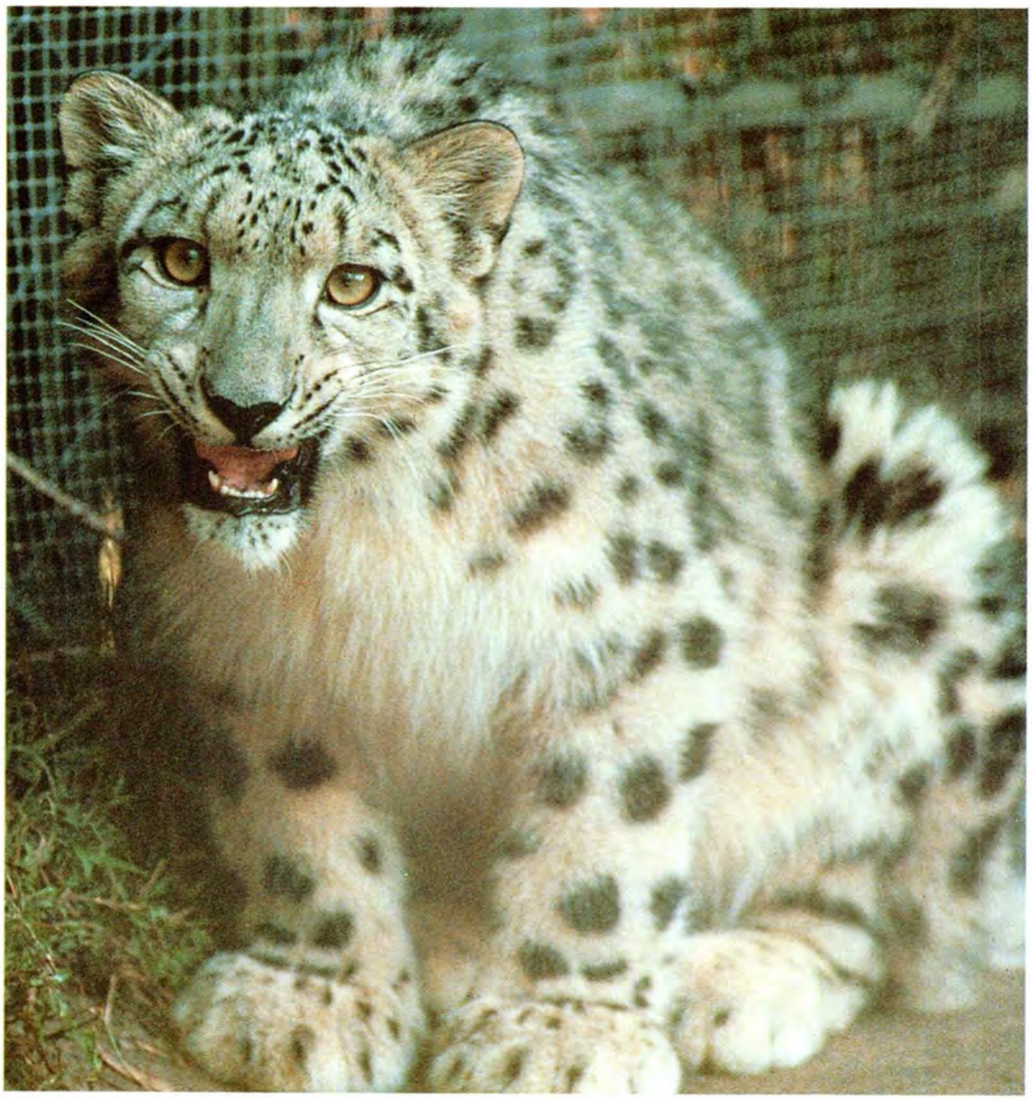
In the Snow Leopard and the small cats studied, there is no pad of fibroelastic tissue to increase the length and mass of the vocal folds. With longitudinally shorter and sharper-edged vocal folds there is a lower resistance to airflow in the vocal tract, resulting in an abrupt change to air flow, a poorer transfer of sound energy and an inability to roar.

Hast draws an analogy between the vocal mechanism that allows roaring and a brass trumpet. He suggests that the vocal cords simulate the trumpet mouthpiece, the wide open mouth of the cat is analogous to the bell of the trumpet, and the elastic ligament that replaces one of the bones in the hyoid apparatus, which was originally believed to be responsible for the roaring sound of big cats, may be analogous to the slide trombone where further lengthening of the instrument proportionately decreases the pitch.

On the basis of his study of laryngeal morphology, Hast believes that the Snow Leopard should not be classified as belonging to the genus *Panthera*; rather it should be reclassified as a separate genus, *Uncia*.

—G.H.

The Snow Leopard (*Panthera uncia*) is the only big cat that doesn't roar.



RICK STEVENS/TARONGA ZOO

Why the Stinkbird Stinks

When 19th-century naturalists first encountered the curious Hoatzin (*Opisthocomos hoazin*) of South America, they were impressed not only by the 750-gram bird's strange appearance and leaf-eating habits, but also by the fact that it stank—like fresh cow manure. Scientists have finally explained why: the Hoatzin or Stinkbird ferments food in its foregut, like a cow (*Science* 245: 1236–1238; 1989).

The Hoatzin is the only creature outside of mammals known to digest food in this way. It uses its crop and oesophagus as the main fermentation structures, some additional fermentation occurring in the paired caeca (between the small and large intestines). Deep ridges in the interior lining of the crop increase the absorptive area of the organ, while an oesophagus with many sac-like dilations effectively delays the passage of particles to the lower gut (for up to 43 hours) to give micro-organisms a chance to break down fibrous and often toxic leaves.

The Hoatzin or Stinkbird from central America

M. WOODBRIDGE WILLIAMS ©1962 NATIONAL GEOGRAPHIC SOCIETY

As a flying leaf-eater, the Hoatzin derives a number of potential advantages over non-flying leaf-eaters such as monkeys, including increased food selectivity and exploitation of extremely patchy resources. However, there appear to be some evolutionary trade-offs. To accommodate the Stinkbird's voluminous fermentation structures (whose contents can weigh up to 17.7 per cent of the bird's total adult mass) the anterior sternum has been greatly reduced, thereby reducing the area for flight muscle attachment. As a consequence, Hoatzins are poor flyers (young require 60–70 days to learn to fly). They have also evolved a couple of particularly peculiar traits: functional claws on the wings for climbing trees (à la *Archaeopteryx*?) and, in young Hoatzins, the curious predator-escape mechanism of diving into water and swimming away.

—S.H.

Liquid Breath of Life

After 15 years of testing on animals, United States scientists have conducted the first human test of liquid breathing (*Science* 245: 1043–45; 1989). For 19 hours, a baby girl born prematurely at 28 weeks was transferred to Saint Christopher's Hospital for Children in Philadelphia and was kept alive, after all else failed, by filling her lungs with a perfluorocarbon liquid—the kind of liquid used to cool electronics gear. Capable of carrying even more dissolved oxygen than air, perfluorocarbons are extremely stable, non-toxic organic molecules in which every possible hydrogen atom has been replaced by a fluorine.

Normally, despite its potential for devastating lung tissue, high-pressure oxygen is used to keep premature babies, born before about 35 weeks, alive. In normal lungs, a natural coating on the moist inner membranes acts like a detergent to lower the water's surface tension, preventing the alveoli, or air sacs, from collapsing. In some very premature babies, the natural coatingis incompletely developed and high pressure is required to keep oxygen moving into the lung tissues.

Physiologist Thomas Shaffer, who performed the human test, believes that in premature babies perfluorocarbon liquid breathing has a big advantage over high-pressure oxygen breathing. Perfluorocarbons have a very low surface tension enabling them to penetrate into the tiniest cavity of the lungs and keep them inflated at normal atmospheric pressure, thus delivering the vital oxygen without causing damage. In the Philadelphia test, the perfluorocarbon liquid was drained from the baby's lungs after only 15 minutes, but enough of the fluid remained in the alveoli to keep them expanded and oxygen moving into the infant's blood for many hours. Schaffer and his colleagues believe that liquid breathing may have other important applications: in treating adults with pulmonary oedema, lung burns and smoke inhalation; and to help preserve rare mammals in captivity, such as Giant Pandas, in which premature birth is a problem.

—S.H.

A premature baby on a high-pressure machine.

WADE HUGHES/LOCHMAN TRANSPARENCIES

Dr Suzanne Hand, School of Biological Science, University of New South Wales, is a regular contributor to QQC.

An Australian Takes the Pitfalls out of Pitfalls

Ant-lions (family Myrmeleontidae) are familiar to many people by the funnel-shaped pitfall traps constructed in sand by larvae of some species for capturing prey. The pit-building habit, which evolved before the fragmentation of Gondwana, is a specialised adaptation that has enabled a few genera, such as *Myrmeleon*, to proliferate and disperse widely. *Myrmeleon* species occur throughout the world, wherever ant-lions are represented, and reflect the success of the pitfall predation technique.

Ant-lion larvae derive considerable benefit from constructing a pit to capture prey. Food is directed to the jaws of the larva, obviating the need to hunt or pursue prey and thereby conserving energy; the pit is a selective device for prey of a suitable size; it affords protection, as large animals disrupting the pit cause the larva to retreat into the substrate to avoid retaliatory attacks; it enables the larva to feed on fast-moving prey that it would otherwise be unable to capture; and the fact that prey is often temporarily disoriented upon tumbling into the pit facilitates the capture of a wide range of organisms, many larger than the predator itself.

Although the ability to modify the immediate sandy environment into a pitfall trap has its advantages, it also places severe restrictions upon the larva. The most important of these is the limited area from which prey can be recruited—in effect this is the circumference of the pit that forms the actual trapping area. The larva is also limited in habitat choice as the pit is usually constructed in sheltered situations and energy invested in pit construction effectively confines the larva to the pit. Development of the pit-building habit has led to a loss of capacity for forward locomotion in some genera (such as *Myrmeleon* and *Hagenomyia*). This prevents them from pursuing prey on the surface or moving quickly to a more favourable position, and thus reduces their versatility as predators. The pit also limits the physical size of the larva as a large pit is conspicuous, rendering its occupant more vulnerable to predation.

The perfection of pit-building therefore appears to have been a specialised evolutionary cul-de-sac, having evolved by a successful branch of the family but apparently with little potential for further development. Recently, however, I discovered a remarkable advance in pit-building specialisation in Australia (*Aust. J. Zool.* 36: 351–356; 1988). The larva of the Australian ant-lion *Callistoleon illustris* has adapted its pit in an ingenious manner to overcome the problem of limited recruitment area, while still retaining the benefits of a pit-dwelling existence.

MERVYN MANSELL

The pit of the Australian ant-lion *Callistoleon illustris*.

Callistoleon illustris builds its pit in well-sheltered situations near the walls of sandstone caves and overhangs in the Carnarvon Mountain Range in Queensland. The pit is constructed in the deep, fine-grained sand characteristic of such habitats, and located in an area where the sand slopes away from the cave wall. It is characterised by several deep, steep-sided, radiating trenches resembling the spokes of a wheel with the pit as the hub. Most of the trenches lie to one side of the pit—the more elevated part of the slope on which the pit is situated—and run downhill into the pit. In some cases, a long furrow is also constructed along the base of the cave wall at the rock–sand interface.

The addition of radiating trenches increases the distance over which food can be secured and, as most furrows run downhill into the pit, potential victims would be expected to follow this (easiest) course and be channelled into the pit. Thus the effective trapping area of the pit can be increased more than six fold. While the radiating trenches enhance prey capture on the sand surface, food can also be collected from the cave wall by the furrow constructed at the sand–rock interface. This trench intercepts organisms moving up or down the wall at that transect and directs them into the pit.

The energy expended in constructing such a complex trapping device is obviously considerable but is offset by two main factors: the possibility of obtaining prey is enhanced by over 400 per cent and, as the pits are constructed in extremely sheltered situations, they are unlikely to deteriorate rapidly from the effects of the weather, thus requiring minimum maintenance.

Apart from a few taxa (such as *Cueta*) that have adapted their pits to counter heat effects, little variation in the conventional pit was apparent, despite its long history, and no species were hitherto known to alter the basic architecture of the pit to improve predation. Now, *C. illustris* has achieved this in Australia. This species has taken a specialised and established adaptation a logical step further by adding radiating trenches to the pitfall. In so doing, *C. illustris* has provided a unique dimension to the evolution of the pit-building habit and to ant-lion predation strategies, as well as to insect predation in general.

—Mervyn Mansell
National Collection of Insects
Plant Protection Research Institute, Pretoria

Odyssey of the Green Turtle

In an amazing display of endurance, each summer Green Turtles (*Chelonia mydas*) leave their shallow-water feeding grounds off Brazil to travel more than 2,000 kilometres to lay their eggs on the sandy beaches of Ascension Island in the middle of the Atlantic Ocean. Tagging studies of this and other breeding colonies in the Atlantic and Pacific Oceans indicate that female Green Turtles return annually to nest on the particular beach—and even section of beach—of their birth (natal homing). For most Green Turtles the return trip to the place of their birth is just a few kilometres, but for the Ascension Island group it is an epic 4,500-kilometre, four-month-long journey.

Two competing theories have been postulated to explain this extraordinary migration. Archie Carr (University of Florida) and Patrick Coleman (University of Western Australia) proposed that the Ascension Island turtles and their ancestors have been making the voyage for millions of years (*Nature* 249: 128–30; 1974). Central to this hypothesis is continental drift theory and the concept of seafloor spreading. In the early Tertiary, Ascension Island was only a few kilometres off the Brazilian coast. However, as seafloor spreading in the mid-Atlantic forced South America and Africa apart, the island gradually became more distant, inducing the turtles to swim further and further to nest, a pattern that would have developed over at least the last 40 million years.

Carr and Coleman's theory has been challenged by, among others, Stephen Jay Gould (*Nat. Hist.* 87: 22–28; 1978). He suggests that over such a long period there would surely have been years in which no suitable nesting beaches existed on Ascension Island. If just one generation of turtles failed to nest on the island, subsequent natal homing would have broken the link between Brazil and Ascension Island. Gould instead prefers one of Carr's earlier theories to explain the odyssey—that the colonisation of Ascension Island by Green Turtles was a relatively recent accident, ce-

KATHIE ATKINSON

Why do Green Turtles sometimes travel thousands of kilometres to lay their eggs?

mented by the mechanism of natal homing.

The debate appears to have been settled in favour of Gould's suggestion as a result of a study of mitochondrial DNA in Green Turtle populations by Brian Bowen, Anne Meylan and John Avise (*Proc. Natl Acad. Sci.* USA 86: 573–76; 1989). These North American researchers found that breeding colonies from Florida, Venezuela and Ascension Island were quite distinct, supporting the natal homing hypothesis, but found no evidence that the mitochondrial DNA of Ascension Island turtles had greatly diverged from that of other Atlantic Ocean turtles, as it would have if Carr and Coleman's interpretation of the antiquity of the Ascension Island population was correct.

Indeed, Bowen and colleagues found an overall similarity among Atlantic Ocean Green Turtle populations, evidently resulting from occasional exchange of genetic material between breeding colonies. To explain this phenomenon they suggest that either a migrating female may stray widely off course, such that her progeny thereafter mixes with turtles of a different population; or there is an occasional loss of nesting grounds so that a colony must seek other beaches on which to lay their eggs, probably thereby bringing together previously separated populations. Bowen and his colleagues believe the data are consistent with an origin of the Ascension Island colony less than 100,000 years ago.

—S.H.

WHAT'S IN A NAME?

Tarantula

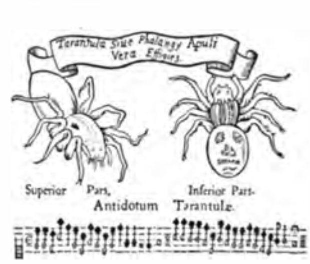
The name 'tarantula' conjures up images of big hairy spiders and it is the classic spiderphobic's nightmare. But just what a 'tarantula' actually is depends on how you use the name and where you live.

The name arose as a common term for a southern European wolf spider (family Lycosidae) that was especially notorious in the farming regions around Taranto in southern Italy. This city and its Roman antecedent Tarentum provided the spider's name and its various spellings: tarantole, tarantola, tarentula, tarantula.

People bitten by a 'tarantole' were seized by painful muscular spasms and their resultant frenzied movements became known as the dance of the tarantella. Victims would perform this strenuous 'dance' day and night to exhaustion, with eventual collapse heralding their cure. Other remedies included placing the victim in an oven and baking him over faggots (a bunch of sticks, not male homosexuals!). Such cures seem rather adventurous in these days of antivenoms.

The wolf spider said to be the cause of all this mischief was named *Aranea tarantula* in 1758 by Carolus Linneaus, the founder of modern zoological taxonomy. At that time all spiders were grouped in the genus *Aranea.* With the recognition of various distinctive spider groups and the application of the Rules of Nomenclature, the name *Aranea* became reserved for the orb web weaving spiders. Latreille, in 1804, was the first to group the wolf spiders under their own generic name. He chose *Lycosa*—a name that appeared as early as 1583 (Lycos*).* Subsequently, as a generic name, *Tara(e)ntula* has fallen foul of the rules of priority (applied to all names designated since 1758) and is now suppressed in favour of *Lycosa.* However, it still survives as the specific name for the 'tarantella' wolf spider *(Lycosa tarantula)* and as the common name for this and several other southern European wolf spiders.

ANTHONY FARR/AUSTRALIAN MUSEUM



Poster for the 1955 movie "Tarantula".

The Red-kneed Tarantula (*Brachypelma smithi*) from Mexico.

The first bars of the tarentella, from an old Italian music sheet in the Bettman Archives.

After all this, it is interesting to note that the locals around Taranto probably got it wrong anyway. The spider that was causing their symptoms was much more likely to have been the European equivalent of our Redback Spider. This is *Latrodectus tredecimguttatus*, the 'Malmignatte', which is common in the fields of southern Europe and whose bite causes painful muscle spasms. The large size and fierceness of the local wolf spider compared with the small, timid Malmignatte probably helped foster this misconception.

To continue this story we must now go to the 'New World' in the year 1756. While living in Jamaica, a naturalist named Patrik Browne wrote a paper describing representatives of two quite different groups of arachnids. These were a tailless whipscorpion (order Amblypygi, a small group of tropical arachnids) and three very large ground-dwelling spiders of the family Theraphosidae (order Araneae). In those days modern taxonomy was in its infancy and Browne described all of his animals under a single generic name, *Tarantula* (he was probably familiar with the term from its common European usage for spiders). Some years later in 1793, Fabricius, another luminary of early taxonomy, decided that the name *Tarantula* would henceforth apply exclusively to Browne's genus of tailless whipscorpions. Under the Rules of Nomenclature this made the name unavailable for any use in spider taxonomy above species level.

So from the viewpoint of scientific nomenclature it seems that a *Tarantula* is not a spider at all but a tailless whipscorpion! However, in the Americas especially, the common name 'tarantula' is now used to refer to any of the large, hairy mygalomorph spiders of the family Theraphosidae, familiar to many from their dubious use in the Indiana Jones adventure films and the 1955 sci-fi film "Tarantula".

In Australia we have chosen to be different. Our tarantulas (often intriguingly corrupted to 'triantelope') are the large, long-legged, often flattened spiders of the family Heteropodidae, more correctly called huntsman spiders. Although we have several indigenous theraphosid spiders, instead of tarantulas we call them whistling spiders (a story in itself!).

—Mike Gray
Australian Museum

New Dinosaur from Queensland

In October 1989, Mr Ian Ievers, who lives on a property just outside Richmond, northern Queensland, rang the Queensland Museum to report his discovery of a fossil skeleton in deposits known to be 100 million years old. He kindly invited the Museum to come and collect it. The skull, he said, had a long toothy snout like that of a Freshwater Crocodile, which suggested it may have been an ichthyosaur ('porpoise-like' marine reptile). Dr Mary Wade, who was keen to study a complete hind paddle of one of these animals, promptly went to excavate the find. She did indeed find the hind paddles but they were of a pliosaur (another marine reptile but with a large head and stout body), not an ichthyosaur.

A fortnight after Mary returned to the Museum with the skeleton, Mr Ievers rang again to say that he had found a second fossil skeleton. We assumed it to be the ichthyosaur that Mary had so hoped to collect just two weeks prior. But, when we received a piece of the skeleton through the mail, we were surprised and excited to realise our assumption was again incorrect. This skeleton was of a dinosaur. In view of the completeness of the pliosaur, we decided to go north as soon as possible to collect the new skeleton. Unfortunately local rains, among other things, delayed the trip until January 1990. When we finally arrived we were to find that the skeleton was an ankylosaur, *Minmi* sp.

The skeleton was lying in the black soil of a ridge nine kilometres east of the homestead. Isolated bones and an odd block of fossil were embedded in the soil. The 'odd block', after two days of examination and a good scrub, was recognised as the skull, with the armour of the neck preserved immediately behind it. Excavating the soil was easy and revealed several large blocks of featureless limestone concretion, one with a limb bone embedded in it. Two blocks of soil with bones in place were jacketed in plaster and polyurethane foam, and brought back to the Museum for further preparation. When the concretionary blocks were removed, they provided a further surprise: on the undersurface of each, the armour of the back of the trunk was preserved, still in place as it had been in life! In all we had almost 75 per cent of the back of this animal. So far it is the most complete dinosaur skeleton found in Australia, with news just to hand that more of the same specimen has been found by Mr Ievers since we returned to the Museum.

Only three other ankylosaurs are known in which the dorsal armour is preserved *in situ*: these are *Edmontonia rugosidens*, *Euoplocephalus cutleri* and *Sauropelta edwardsorum* all from North America. This new specimen of *Minmi* is the first from the Southern Hemisphere to reveal in detail just what the animal looked like. Furthermore, there is an indication on the blocks that traces of the actual skin may be preserved.

The new specimen of *Minmi* also reveals much detail of the mysterious paravertebrae—ossified tendinous structures found along the vertebral column of the trunk. These structures are believed to have reinforced the vertebral column, and to have been linked with the mode of locomotion of the beast. This specimen shows that they are more complex than previously thought.

All in all, the specimen should provide new information on the structure and arrangement of the armour in ankylosaurs, on the unusual paravertebral system, and on the skull and jaw structure (it is the first time that the skull of a Gondwanan ankylosaur has been discovered). Research on these animals should advance our understanding of the prehistory of Australia and the relationship of Australian Cretaceous (140–65-million-year-old) vertebrates to those overseas. But, most importantly, it will increase our knowledge about this particular group of dinosaurs. In all, the discovery is of great importance. We are all grateful to the perception of Mr Ian Ievers in recognising and promptly reporting this important fossil to us, making it available to interested people of Australia and all over the world.

—Ralph Molnar
Queensland Museum

RALPH MOLNAR

Part of the fossil remains of the new ankylosaur species, *Minmi* sp.

Amber Bubble Theory Burst

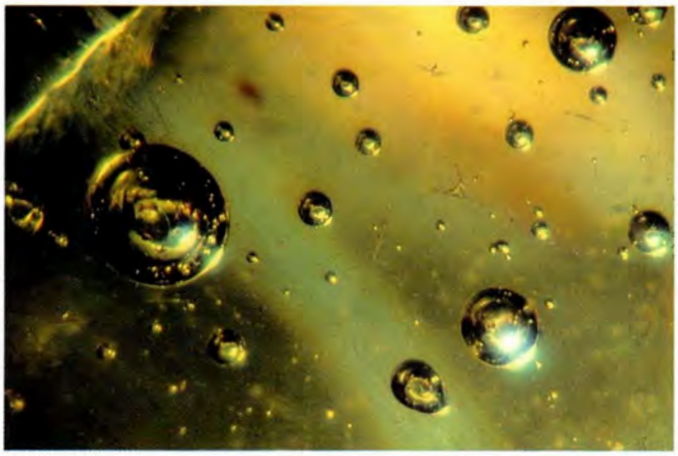
Tiny bubbles of gas trapped in fossilised tree resin reveal that prehistoric atmospheres were very different from today's. That's the claim made by Robert Berner of Yale University and Gary Landis from the United States Geological Survey who believe that bubbles in Cretaceous amber show that the air the dinosaurs breathed was 30 per cent richer in oxygen than now (*Science* 239: 1406–1409; 1988). However, Thure Cerling of the Scripps Institute of Oceanography in California has challenged the time-capsule bubble theory, suggesting that the oxygen measured by Berner and Landis may not have come only from the bubbles (*Nature* 339: 695–696; 1989).

Amber, a translucent, brittle and often honey-coloured resin exuded from trees before being buried and fossilised, commonly contains gas bubbles ranging in diameter from less than ten microns to more than a millimetre. In Berner and Landis' study, amber samples of various ages were crushed under vacuum and the gases released were analysed in a mass spectrometer.

Cerling's research indicates that the process of crushing amber releases not only the oxygen trapped originally in bubbles, but also that which had been chemically incorporated into the matrix. And because, according to Cerling, atmospheric gases freely exchange and react with amber matrix on exposure to the atmosphere (explaining why specimens of amber kept in museums almost always become darker with time), the oxygen measured by Berner and Landis is not a true reflection of the prehistoric atmosphere. Instead, it also reflects the history of the amber since it was exuded from its host tree. In the case of the Cretaceous amber, Cerling reasons that it may have been buried in oxygen-poor sediments but, after erosion (or excavation), exposure to air would have allowed oxygen and other gases to leak into the amber. Thus what was being measured was 'modern', not prehistoric, gases.

—S.H.

Gas trapped in amber may not reflect the true prehistoric nature of the atmosphere.



BILL SECHOS/GEM STUDIES LABORATORY

Cicada Cures

Cicadas have fascinated people for thousands of years, featuring in ancient mythology and medicine, and today retaining their mystique for scientists and school children alike. The folklore of the Chinese, Greeks and Romans contain many references to cicadas. Perhaps this is because of the distinctive and most memorable sounds produced by the males of these insects, or their remarkable metamorphosis from the mud-coated shells of the immature nymphal stage to the winged adults. The Oraibi Indians of Arizona in the United States thought that the life cycles of cicadas symbolised resurrection of the soul.

As long ago as 1600 BC in ancient China, cicadas were reputed to have medicinal properties and the fungi that sometimes attacked the nymphal stage were also attributed with healing properties, some fungi being eaten as a single product rather than combined with other medicines. Today in the People's Republic of China, potions are made from cicadas, cockroaches, beetles and crickets, all believed to be valuable treatments for a range of internal disorders. And during the 1950s in Australia, it was rumoured among Sydney school children that cicada wings were in demand by pharmacists, bringing threepence per dozen for wings of 'desirable' species. At that time cicada wings were claimed to contain medicinal substances but there is no known basis for this claim.

Before the arrival of Europeans, the people of Nokopo, a village in an isolated and rugged part of the Finisterre Ranges of Papua New Guinea, used, as a topical antibiotic for infections, a fungus that is parasitic on the soil-dwelling nymphs of a particular cicada, *Cosmopsaltra aurata*. This cicada thrives in montane rainforests, the nymphs feeding on the sap from roots in the permanently moist soil. When fully grown, which may take several years, the cicada nymph prepares a tunnel to the surface and awaits favourable weather conditions before emerging from the soil. It is in the soil that the nymphs are vulnerable to attack by natural enemies, including the *Cordyceps* fungi.

White, powdery sporing bodies borne on fungal stalks (called 'stipes'), some two to seven centimetres in length, protrude from the bodies of the dead cicada nymphs. It is this white, asexual state of the fungus that was used by the people of Nokopo to treat infected wounds such as tropical ulcers.

Although Nokopo adults are still aware of the healing power of the cicada fungus, its use has been discarded in favour of conventional antibiotics. Even though conventional antibiotics are expensive and not so accessible, the people of Nokopo have been persuaded that 'white man's medicine' is better than their own inherited knowledge.

The use of plants, fungi and insects as medicines in traditional societies of the world has continued to attract the attention of Western scientists in their search for more effective treatments for diseases. This search has been spurred on by the developing resistance of disease-producing organisms to established antibiotics. Although the Chinese as well as Nokopo people have for centuries gathered species of *Cordyceps* fungi from the soil-dwelling cicada nymphs and used them for the treatment of disease, it remains to be seen whether antibiotic properties of this fungus can be demonstrated with Western scientific methods.

The fungus that grows on the cicada nymph *Cosmopsaltra aurata* (inset) is used as a topical antibiotic by the people of Nokopo village, Papua New Guinea.

DON SANDS

—Christin Kocher Schmid
Univ. of Basel, Switzerland
and Don Sands
CSIRO, Div. Entomology, Qld

The Ultimate Single Parent?

Rubbish dumps aren't usually thought of as a source of discovery in the world of natural history, but a Queensland university zoologist, Dr Craig Moritz, has found them to be fruitful hunting grounds for an unusual quarry. He has recently scoured more than 200 dumps in outback Australia for old roofing iron, on the underside of which is often found one of the continent's most remarkable lizards, Bynoe's Gecko (*Heteronotia binoei*).

Bynoe's Gecko is the only known native vertebrate with all-female populations, a trick it manages by being able to reproduce by parthenogenesis, or 'virgin birth'. It is perhaps the ultimate single parent, laying viable eggs without needing fertilisation by male sperm. The eggs have complete sets of chromosomes and balanced sets of genes. The offspring are all (barring random genetic mutations) identical female clones of their mothers.

Dr Moritz has found that Bynoe's Gecko has both all-female and sexually reproducing populations, and that the parthenogenetic ones are unusually widespread (*Qld Univ. News* 16 August 1989: 9). He believes the sexually reproducing varieties evolved first in Australia over one million years ago, while the parthenogenetic varieties seem to have evolved more recently, perhaps only within the past 10,000 years. Their origin was probably in Western Australia and they then spread rapidly to central Australia. The all-female forms may still be spreading eastward, replacing the sexually reproducing lizards as they go.

PAVEL GERMAN

Bynoe's Gecko is the only known native vertebrate with all-female populations.

Parthenogenesis was first recognised as occurring in vertebrates as recently as 1958, and Dr Moritz's research is part of an international study into the phenomenon. As a reproductive strategy it has several advantages over sexual reproduction but evolutionary biologists are uncertain why it is so uncommon. Although a single female can establish a new population and do so rapidly (each one of her offspring is capable of reproducing) while still preserving highly adaptive gene combinations, sexually reproducing species are more likely to adapt quickly to changing environmental conditions through many new and random combinations of genes in each new generation.

—Bob Beale

A more detailed article by Dr Craig Moritz on parthenogenesis will appear in a future issue of ANH.

MYSTERY PHOTOGRAPH SOLUTION

A Parting of the Worm

A plucked quail? Decapitated baby? Something out of Star Wars? No. This animal was found one summer's night swimming in the surface-water layers of the Great Barrier Reef lagoon, around Lizard Island. It is part of a segmented sea worm or polychaete (superfamily Eunicea, probably of the family Lumbrineridae), which spends most of its time within the coral substrate or in the sediment.

During the summer, the worm develops large numbers of eggs or sperm within its segmented body cavity. These sea worms are either males or females. Breeding is synchronous, taking place on only one night of the year, probably triggered by the phase of the moon. At the time of spawning, the rear end of the worm breaks off from the front. The front end remains in the coral or sediment to breed again next year, while the back end fragments into single segments or, in this case, two (the 'waist'-like area separates the two segments). The segments, which are only 0.2–0.4 millimetres wide, then swim off into the surface waters by muscular contraction of the parapodia (the 'arms' or 'legs', one pair of which is attached to each segment) and with the help of the swimming setae (the projections at the end of the parapodia). Later these swimming egg or sperm sacs break up and release their gametes into the water where fertilisation occurs. And then this strange animal is no more.

A swimming sac of polychaete gametes.

This process of reproduction ensures that the gametes are widely dispersed over the reef and that maximum rates of fertilisation occur. The fertilised eggs spend little time in the plankton layer. Instead, the larvae sink to the sea floor where they colonise the sediment or reef substrate, thus completing the cycle.

We are currently unable to relate these swimming sacs of gametes to particular polychaete species. No doubt with the collection and study of further specimens we will be able to. Polychaetes are an important component of coral reef food chains and also contribute significantly to bioerosion of the reef. It is therefore essential, for the study of reef systems in general, to understand polychaete reproduction.

PETER PARKES

—Pat Hutchings
Australian Museum

"The anthropologists were duly surprised to learn that a supposedly 'damaged' cranium that lacked data was, in fact, well documented in a 100-year-old medical journal in the Museum's own library."

THE CURIOUS CASE OF WILLIAM HANCOCK

BY KINGSLEY GREGG
EXHIBITION DIVISION, AUSTRALIAN MUSEUM

WHILE THE AUSTRALIAN MUSEUM constantly updates its image to keep pace with current perceptions of what constitutes a 'modern' museum, some of its activities have hardly changed since its establishment in the late 1820s. The core of these is the upkeep of its burgeoning collections, without which there would be no museum. In their now mostly air-conditioned environments, the collections still evoke a feeling of time frozen—an atmosphere once endemic to the entire Museum, particularly in the cathedral-hush and poor lighting of the early exhibition halls.

The categories of stored items encompass a plethora of invertebrate and vertebrate remains, bottled, dried and stuffed, together with skeletons, fossils and minerals. The vast anthropological collection includes a wonderful assortment of artefacts and specimens, human bones and skulls, mummified and shrunken heads.

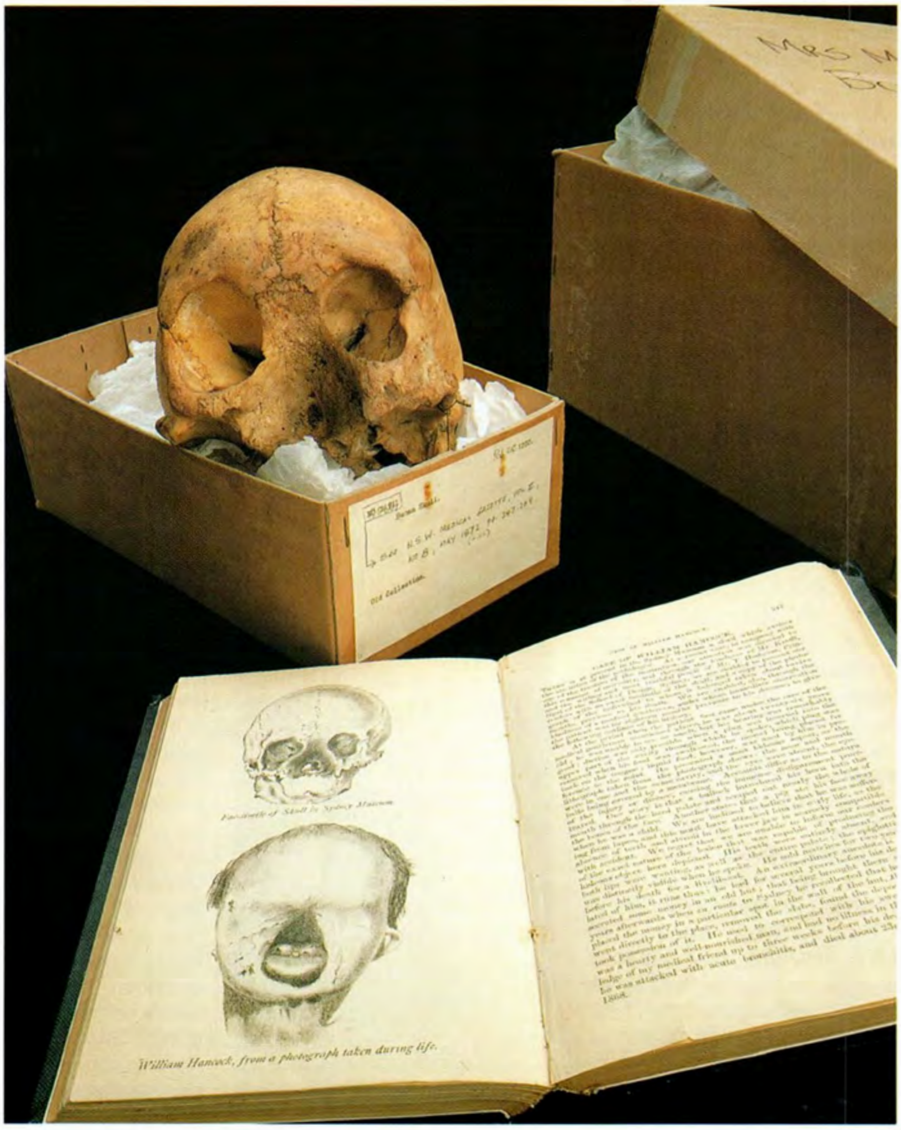
Among the skulls is one that "excites the attention of the pathologist", according to one old medical journal. Its attractions could hardly have been confined to pathologists, however. At a time when such items were commonplace in museums, it must have excited the attention of many visitors. After it was withdrawn from display and passed into the collections, it remained virtually untouched until about 12 years ago, when material was sought for an exhibition and book celebrating the Museum's sesquicentenary.

An article relating to the skull was discovered in a copy of the *New South Wales Medical Gazette* (May 1872). The Museum's library assistant who found it thought the journalistic gem should be included in the sesquicentennial book. Being involved in both the book and the exhibition, I was intrigued by the article and promptly went to look for the skull in the anthropology store. The anthropologists were duly surprised to learn that a supposedly 'damaged' cranium, *sans* lower jaw, that they had seriously considered throwing away because it lacked data was, in fact, well documented in a 100-year-old medical journal in the Museum's own library. The *Gazette* article was not used but the skull was placed in a special 'Rare and Curious' display cabinet for the duration of the exhibition.

The article, entitled "Case of William Hancock", begins: "There is at present in the Sydney Museum a skull which excites the attention of the pathologist. At a recent visit, in company with one of the trustees of the institution, our attention was directed to this remnant of mortality, and through the kindness of Mr. Krefft, and the willing and most truthful pencil of Mr. T. Hodgson, Principal of the School of Design, Sydney, we are enabled to present our readers with an exact facsimile of the skull, and a copy of the photograph of the individual to whom it belonged taken about twelve months previous to his death. We are enabled, also, through the kindness of a medical gentleman, under whose immediate observation the patient was for eighteen months previous to his decease, to give [some] outlines of his history."

It is unusual to find biographical information about those whose bones fill neatly labelled cardboard boxes in an anthropological collection. Although the details of William Hancock's life reported in

Skull and drawing of William Hancock.



ANTHONY FARR/AUSTRALIAN MUSEUM

the *Medical Gazette* are minimal, they give his skull an emotive significance that separates it from others for which data is confined to mere technical details. They also give substance to a person whose appearance must have brought a measure of fame to his neighbourhood.

That he survived as long as he did suggests there was a greater acceptance of his defects than we normally ascribe to the colonial citizens of last century. He supported himself by selling matches for two years before he died. It is also possible that part of his life was spent with a travelling sideshow, a not uncommon fate of people whose deformities made them objects of vulgar curiosity.

William Hancock was about 26 years old when he first "came under the care of the medical gentleman" mentioned in the *Gazette*. He "presented a most hideous aspect": a single hole served as both mouth and nose and the eyeballs were "covered by a membrane". Diction was made possible by inserting a plug into the "upper part of the cavity through which he spoke." The plug was removed when he ate, the "morsel being placed far back on the tongue". Understandably, he preferred a liquid diet. He had no teeth and "both lips were wanting, as well as the entire palate; the epiglottis was clearly visible when he spoke". He lacked any sense of smell but his hearing was apparently excellent.

The cause of William Hancock's "immense disfigurement" was the subject of much medical conjecture. The article's writer was "inclined to believe that he was suffering from lupus, and this must have attacked him in early life, as the absence of teeth and alveoli in the lower jaw is scarcely compatible with accident". I imagine that today's medical practitioners would be more inclined to conclude that Mr Hancock's deformity was congenital.

Before concluding with a long anatomical description of the skull, the writer had this delightful piece to offer: "He used to correspond with his sweetheart, was a hearty and well-nourished man, and had no illness in the knowledge of my medical friend up to three weeks before his death, when he was attacked with acute bronchitis, and died about 23rd August, 1868."

What is not known about William Hancock is where he died, and how soon after death his head was anatomised and displayed for public delectation. There is no doubt that a great deal more to the story of William Hancock is waiting to be uncovered. ■

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Mr Kingsley Gregg is Project Designer at the Australian Museum. He has been there since 1955.

"Snakes (especially venomous snakes) do not raise the same warm sympathy as do 'cuddly' animals like Koalas and kangaroos."

THE BROAD-HEADED SNAKE

BY RICK SHINE
ZOOLOGY DEPARTMENT, UNIVERSITY OF SYDNEY

WE TEND TO THINK OF 'RARE AND endangered' animals as living in far-away, exotic locations such as tropical rainforests or deserts. However, the reality is often quite different: urban development is one of the major factors responsible for destroying the habitats available for many species, so that the remnant populations are to be found close to major cities. For example, the most densely populated area in Australia is the south-eastern coast, and this is the only known habitat of the small spectacularly coloured Broad-headed Snake (*Hoplocephalus bungaroides*, family Elapidae). Although this species was common in the Sydney area at the time of European colonisation, it rapidly became rare. By 1869, when the first book on Australian snakes was written by Gerard Krefft, this species was already vanishing rapidly. The processes responsible for this initial decline have continued ever since. Little is known scientifically about this rare species, even though it is found so close to our largest city. It is not that the species is particularly difficult to study, only that no funds are available for such work. Most of what we know comes from dissections of preserved specimens in museum collections, and recently from successful breeding of this species in captivity. These secretive, nocturnal snakes emerge from their sandstone crevices at night to feed upon small vertebrates. They are venomous, and two serious cases of snakebite have been recorded from this species. Females do not lay eggs, but instead produce about eight live young in late summer. They may not reproduce every year in the wild because food supply may sometimes be too low.

Why is the Broad-headed Snake so rare? This is not as simple a question as it may first appear because there are many reasons why species are classed as 'rare' or 'endangered'. Some taxa are placed in this category simply because they are restricted to habitats so remote and inaccessible that few specimens are ever collected, even though the animals may well be common where they occur. Other common and widespread species, like the Platypus, are regarded as 'rare' because they are secretive and hence not often observed. Many of the genuinely rare species are those that have suffered directly as a result of human settlement in Australia, either through hunting, habitat destruction, or the depredation by feral animals such as cats and Cane Toads. For

RICK SHINE

most reptiles and amphibians, it is ***habitat destruction*** that is the most important threat. Most of these animals are small and not particularly valued by hunters, so direct predation by humans is less significant than the continuing destruction of large areas of critical habitat. If the habitat is destroyed, the species will not be able to persist.

The Broad-headed Snake is in a particularly difficult situation for three reasons. First, the south-eastern coastal area in which it occurs also supports the highest densities of human population in the continent, so that habitat degradation has occurred on a massive scale. Second, weathered sandstone outcrops along ridge tops are essential for this snake, especially the crevices formed by exfoliating layers of sandstone. Unfortunately, these same rocks are highly prized as decorations for home gardens, with the result that many outcrops have been torn apart by commercial collectors of 'bush rock'. And third, snakes (especially venomous snakes) do not raise the same warm sympathy as do 'cuddly' animals like Koalas and kangaroos. Hence, many people see the conservation of reptiles as a less significant environmental issue than conservation of mammals or birds.

Informed members of the general public can play an important role in helping to ensure that the Broad-headed Snake does not move closer to extinction. Here are a few suggestions: 1. Talk to your friends about the importance of conserving ecosystems, not individual species. Many people think that the major problem is to save individual animals (usually large furry ones). This is rarely the case. If we want our grandchildren to enjoy a diversity of Australian wildlife, we must conserve habitats where natural ecosystems can continue to function. This means taking care of all components of these systems, including 'unpopular' animals like snakes. 2. Support the protection of wilderness areas and the creation of national parks. 3. Support funding for research on the basic biology of the Australian native fauna and flora: we will not be able to plan intelligently to save species unless we know something about them! 4. Don't buy 'bush rock' for your backyard, especially the weathered rock that comes from natural outcrops. Old fallen logs are an aesthetically pleasing alternative. If you really must use rocks in landscaping, buy your sandstone boulders from quarries: they will take a little while to 'age' and grow lichens but you will have the satisfaction of knowing that you haven't supported the destruction of an important habitat. 5. If you see a flatbed truck loaded with bush rock in a national park or State forest, report the truck's registration number to the ranger. There have been several successful prosecutions and the National Parks and Wildlife Service is anxious to stamp out these illegal destructive activities.

The continued survival of the Broad-headed Snake (and many other small sandstone-dwelling species of native fauna) depends on public attitudes towards conservation of large areas of sandstone habitats. A unique and diverse assemblage of species has evolved on the Hawkesbury sandstone plateau. Will we destroy it simply to make our gardens a little more attractive? ■

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Dr Rick Shine is a zoologist at the University of Sydney. His research deals with the evolution, ecology and reproductive biology of reptiles, with a strong focus on Australian snakes.

W I L D   F O O D S

"Aborigines long ago learned to crush the seeds and soak them in water for a week or so to leach out the toxins."

SINISTER CYCADS

BY TIM LOW
NATURE WRITER

I AM FOREVER BEING ASKED ABOUT BUSH foraging: "is it dangerous?". I always reply that the risks of poisoning are very slight, that if you trust your senses of taste and smell you will rarely go wrong. The human taste buds are very adept at detecting toxins.

But there are a few plant poisons that our nose and tongue cannot identify, and these can cause problems. The poisons in certain mushrooms, legume seeds, cycads and the northern Queensland Finger Cherry (*Rhodomyrtus macrocarpa*) have no bitter or acrid warning taste. The European Death Cap Mushroom (*Amanita phalloides*), for example, tastes like the edible field mushroom, and has sent many a forager to an early grave. It, more than any other plant, has given wild foods a bad name.

In the era of Australian exploration the palm-like cycads caused many poisonings. These primitive plants (families Cycadaceae and Zamiaceae in the order Cycadales) produce large starchy seeds laced with toxic glycosides, which cooking does not destroy. I once boiled up some Burrawang seeds (*Macrozamia communis*) from southern New South Wales, and was delighted by their sweet chestnut taste, although I would have been severely purged had I swallowed any. It does not surprise me that the exploring parties of De Vlamingh, Cook, La Perouse, Flinders, Grey, Leichhardt and Stuart were all poisoned by these seeds (although never fatally).

Descriptions of such poisonings were sometimes very colourful. Joseph Banks declared that men who ate a seed or two of *Cycas media* "were violently affected by them both upwards and downwards". De Vlamingh's men, poisoned in 1696 in Western Australia by *M. riedlei*, "began to vomit so violently that there was hardly any difference between us and death", and supposedly "crawled all over the earth and made ungovernable movements".

Cycads even have poisonous leaves, with a deceptively pleasant taste. One of John Stuart's men was poisoned in central Australia by a *Macrozamia macdonnellii* leaf, as recounted in Stuart's journal in March 1861: "Lawrence got one of the leaves, ate the lower end of it, and found it sweet—resembling sugar cane; he ate a few inches of it, and in about two hours became very sick, and vomited a good deal during the evening". Cycad leaves are poisonous to cattle and sheep, causing rickets, stomach and liver injury, and graziers have exterminated the plants over wide areas.

Yet cycad seeds were very important Aboriginal foods. Aborigines long ago learned to crush the seeds and soak them in water for a week or so to leach out the toxins. The seed fragments were then ground to paste and baked. In the Northern Territory, Aboriginal women also gathered very old seeds from beneath the trees and, by crushing and sniffing, were able to identify some as being edible without preparation. This discrimination required great skill.

Cycads grow in colonies, usually on infertile soils in open woodland. In northern Australia, Aborigines found they could trigger seeding by firing the groves, and this practice is often cited as an example of 'fire-stick farming', showing that Aborigines were skilled at manipulating their environment. By this technique seeds were produced so abundantly they could sustain huge social gatherings of hundreds of Aborigines for weeks or even months at a time.

Cycads are very important in archaeology. They are one of the very few kinds of plant foods that resist decay, and their seed remains have been found at 11 archaeological sites across the continent—in south-western Australia, in the Top End, in the Carnarvon Range of central Queensland, and across New South

Captain Cook's crew suffered when they sampled the seeds of the cycad *Cycas media* at Endeavour River. They endured violent vomiting and diarrhoea, but were left in better shape than the ship's hogs, which fell down and died.

Sheltered canyons of the Macdonnell Range west of Alice Springs are the habitat of the cycad *Macrozamia macdonnellii*, a survivor from wetter times and the only cycad found in outback Australia. Explorer John Stuart complained that the nut of this species "is not fit to eat".

PHOTOS: TIM LOW

Wales. At Carnarvon, seeds of *M. moorei* were found in rock shelter sediments at estimated densities of up to 600 seeds per cubic metre of soil. Carbon dating shows that Aborigines here have been preparing and eating cycads for at least 4,300 years.

This age is but a wink of time compared to the antiquity of the plants themselves. Cycads date back to the onset of the Mesozoic era 180 million years ago, when dinosaurs first stalked the Earth. Indeed, they are the plants invariably featured in dinosaur dioramas. The fleshy, often reddish outer layer of the seed coat of many species (in genera *Macrozamia* and *Lepidozamia*) may well have evolved to tempt dinosaurs to swallow the fruits and disperse the seeds in their faeces. Nowadays Emus (which are descendants of dinosaurs), possums and wallabies do the job.

Cycads have survived for so long partly because they are so poisonous. This toxicity has not stopped wild food entrepreneurs from proposing them as gourmet foods. Harry Sing, Chairman of the Belyuen Aboriginal Community near Darwin, told me last year that he had been approached by a Sydney wild food supplier wanting cycad seeds for processing into specialist foods. Harry was incredulous. "The seeds are too dangerous!" he said, shaking his head. ■

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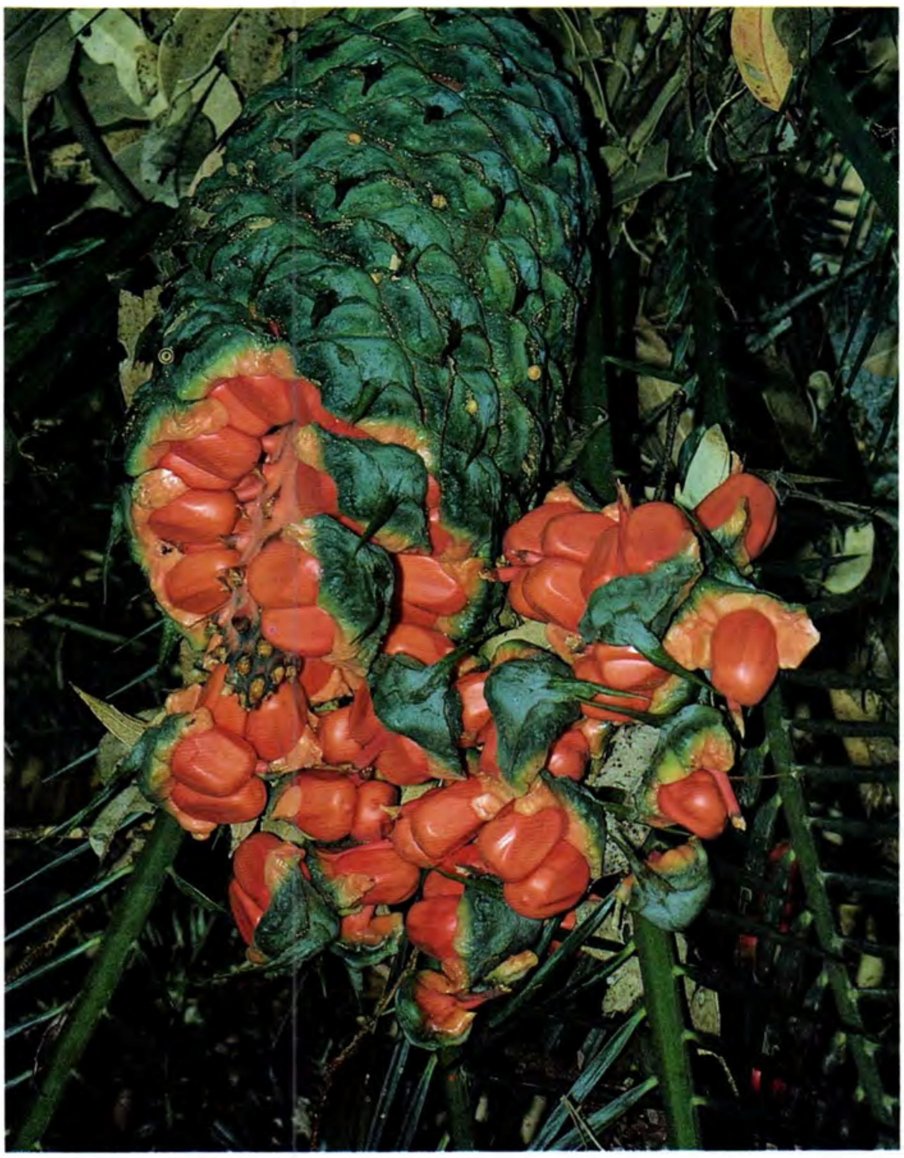
Tim Low is a full-time nature writer living in Brisbane. He is the author of three wild food books, the latest being Bush Tucker *(Angus & Robertson), which includes articles reprinted from his ANH column.*



A crumbling cone of the Burrawang Cycad reveals the brightly coloured pulp surrounding the starch-filled seeds. Emus can eat this pulp; people cannot.

"Scientists have had a tough time in the '80s and, in Australia, their numbers have been dwindling."

A LETTER TO MY DAUGHTER

BY ROBYN WILLIAMS
ABC RADIO SCIENCE SHOW

USUALLY, IN THIS COLUMN, I DO A sketch of an established scientist. This time—if you'll permit—I'd like to address a few remarks to someone who may, one day, become scientifically minded: it could be my daughter, it could be yours. It could be a son. As long as young minds in large numbers turn to science.

Dear Jessica,

I know that your science classes, up to now, have been discouraging and miserable. I know that you've done your best but, like many Australian school children, have found the subject remote and confusing. As soon as you gain a glimmering of understanding of one bit, 20 more are shoved in front of you.

I too had trouble at first. So did Einstein. Dealing with a set curriculum and thick books is never easy, and you hardly ever seem to know enough to be sure of yourself. It's all another world, defined by frightfully clever people, usually men in white coats who use long words and have nothing to do with you.

But my own discovery of science (and I suspect everyone else's too) came from finding out how ***my own*** world works. Why do we sleep? Why does my cat sleep more? What makes my dog want to pee on every other fencepost and why does he turn three times before lying down? Why is the sky blue, the leaves green and poo brown? How do trees know which way is up when they grow, and why don't flies fall off the ceiling? Why do the pouches of Koalas open downwards and why don't the babies fall out? Do Chimpanzees tell jokes?

When I began finding out the answers to some of those questions my everyday life became enormously enriched. I also started to see parts of my school science fall into place. Then I became confused again. People said that biology, my main delight, was rather Mickey Mouse, not a ***real*** subject like maths or physics or chemistry, but an 'easy option' full of fiddling with dead parts and making pretty drawings. But I knew that some of the most stimulating philosophical writing in science was by biologists—J.B.S. Haldane, Sir Julian Huxley, Sir Peter Medawar; and I knew that the old artificial boundaries between the subjects were crashing down. Nowadays scientists working in natural history may use every branch of knowledge under the sun, from the languages of indigenous people to the mathematical ideas in chaos theory, from computation to deep-sea diving.

In fact, 1990 should be recognised as the year biology returned to its pre-eminence. (In the 19th century, when still strongly and correctly linked to natural history, biology was the obsession of every reasonably educated British and Australian household.) I'm not suggesting that biology is *better* than any other discipline. Far from it. Only that it is now wonderfully placed, with all those fabulous new techniques that let us study what's happening right down among the molecules or in the remotest part of the planet, to put it all together.

And why should we want to do that? Well, for the reason I mentioned before: because it's so interesting. Whatever you eventually choose to do for a living, your knowledge of modern science will be enriching, often useful. Another reason is because nature is being badly beaten. Everywhere we look, in the soil, in the air, the oceans or what remain of our forests and wildlife, there are destructive changes underway more worrying than ever before in human history. But there are still plenty of powerful folk who say the scientists have got it all wrong and we don't really have to worry or alter what we do. So many gaps in our understanding of the natural world remain that there's an enormous amount of research to be done, especially in our region.

Scientists have had a tough time in the '80s and, in Australia, their numbers have been dwindling. Now is the time to give them a hand, either as a keen amateur (maybe attached to the Australian Museum Society or a conservation group) or maybe as a pro. The era of the smartypants making a million at the age of 23 is over. What we need now is a brain-led, not a greed-led, recovery.

For these and many more reasons, I hope you'll continue to give science a chance. I'm sure you'll find it fun!

Love RW

PS: When you find out whether Chimpanzees tell jokes, do let me know. ■

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

REBECCA SCOTT

Science is not just men in white lab coats; Australian Museum's Tim Flannery attempts, using pictures, to discover the origin of the rare New Guinean cuscus-skin hat.

"The notion of 'original conservationists' is framed in Eurocentric terms and does not do justice to the complex interactions between Aborigines and their environment."

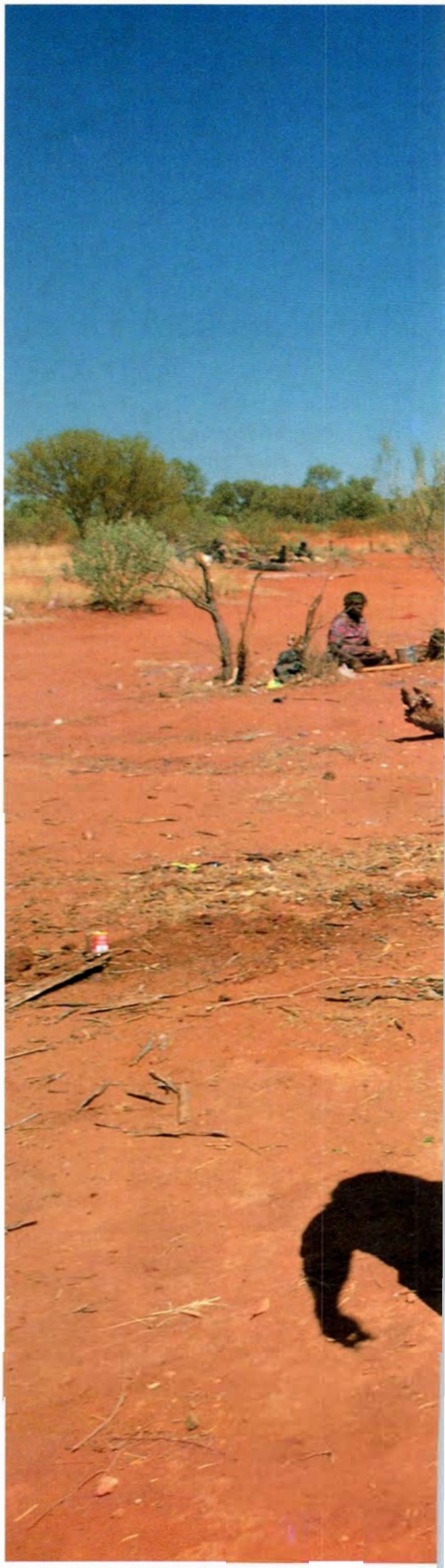
CONSERVATION AND ABORIGINAL LAND RIGHTS:

WHEN GREEN IS NOT BLACK

BY LESLEY HEAD
DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF WOLLONGONG

IT IS NOT SURPRISING THAT AUSTRALIANS interested in the conservation of their natural environment are usually also supportive of Aboriginal land rights. The two groups have much in common but their interests are not identical. Where do conservationists stand, for instance, if Aborigines want to mine uranium on traditional lands, or shoot traditional food sources in national parks?

We must accept the concept of inhabited national parks. In other words, we cannot remove people from their land simply to fulfil a romantic illusion of a pristine, uninhabited past.



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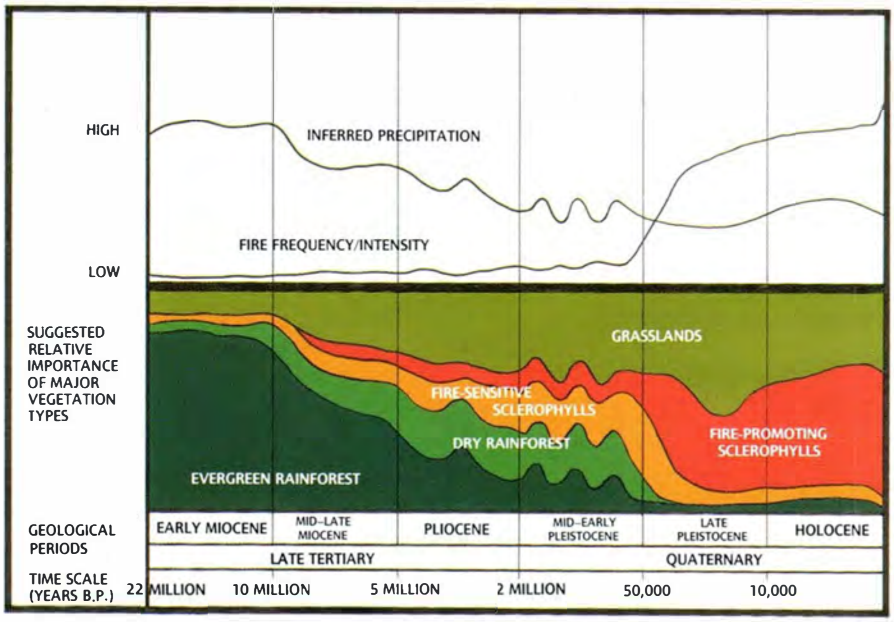


IAN FAULKNER

Environmental and vegetation changes from 22 million years ago to the present. (Adapted from A.P. Kershaw, *L'espace Geo.* 12: 185–194; 1983.)

I want to suggest that the community of interest can be maintained and encouraged, but not if conservationists are locked into a romanticised view of Aborigines and the way they live in the environment. The same applies to our views of the Australian environment itself. Here I hope to show that views of Aborigines as 'the original conservationists' and wilderness as 'unchanging and virgin landscape' are ethnocentric and simplistic. In the long term they may also be counterproductive.

Although many of the environmental and cultural changes that have occurred in Australia happened thousands of years ago, there are several reasons why they are relevant to us today. For a start, ideas about long-term changes in the Australian landscape, and the role of Aborigines in those changes, are being used more often to justify particular land-use decisions. Such ideas take on the role of myths—narratives that justify and give meaning to our actions. Because the ultimate tests of any hypotheses about Australia's past are buried deep in time, the subject will always be controversial and there will be numerous opportunities for competing interest groups to use evidence in conflicting ways.

Also, we can't understand how natural systems are likely to respond to present and future impacts unless we know how they have done so in the past. For example, to predict the impacts of various greenhouse scenarios, researchers are looking at the effects of past climatic and sea-level changes. To use fire as a forest management tool we need to know how different forest types have responded to fire over a time scale longer than a researcher's lifetime.

Perhaps the most significant recent shift in views of the Australian landscape is from a primeval, unchanging, virgin continent to a more dynamic one. We now know that the Australian environment has been shaped by very dramatic climatic changes over thousands and millions of years, probably exacerbated by Aboriginal impacts in more recent times.

Many of our forests have existed in their present distribution and composition for only 10,000 years or so, having retreated to refuges during the last ice age, when open grassland vegetation expanded in the cold, dry conditions. Conservationists who cite great age and stability as reasons for preserving rainforests may thus find such evidence used against them. A few years ago the Queensland Forestry Department, for example, argued that it is acceptable to log rainforests because they have recovered from dramatic climatic change before. This argument completely ignores the relative time scales over which climatic and logging impacts have taken place, but the point is that the myth of the eternal forest is demonstrably false.

A far stronger argument is that a knowledge of forest history gives us much more information about what we are trying to preserve. A knowledge that Australia's rainforests have been shrinking for several million years alerts us even more to the importance of conservation. Monash University geographer Peter Kershaw, the person mainly responsible for our knowledge of northern Queensland forest history through pollen analysis, argues that such knowledge also indicates implications for management. He points out that reserves should be sufficiently large to accommodate potential climatic changes, and should include areas that can act as refuges during adverse conditions. Relict rainforest communities will require special management, such as fire protection, if they are not to disappear completely.

It is dangerous for conservationists to cling to ideas, however attractive, that are shown to be scientifically untenable. There are obvious historical reasons why Western cultures, having destroyed so much of their environment, respond positively to an idealised past when things were better. But we owe it to that very environment to maintain intellectual integrity, for practical reasons as well as ethical ones.

Conservationists have often assumed community of interest with Aborigines because they have a view of Aborigines as 'the original conservationists', living in perfect 'harmony with their environment'. There is then a backlash against the view and the people when they act out of character with the stereotype. Since the stereotype derives largely from perceptions of the way Aborigines 'used to be', we need to examine the evidence in this regard.

The stereotype contrasts the traditional past with the tainted present. This has many parallels with the view of the environment itself as unchanging. Archaeologists have suggested substantial changes in technology, settlement patterns and social organisation during Australia's 40,000-year prehistory. That continues to the present, with Aborigines adopting aspects of Euro-Australian technology and culture. Certainly the pace of change has increased dramatically in the last 200 years, but it is false to contrast a timeless past with an ever-changing present.

Assessments of Aboriginal impacts on the prehistoric landscape relate mainly to the use of fire. It is widely accepted that Aborigines have used fire to enhance plant productivity, facilitate hunting and maintain access for thousands of years.

Much more controversial is the impact of this fire on the wider ecosystem. Scientists are certainly not unanimous in their views on the impact of Aboriginal burning on the Australian vegetation, but there is considerable evidence that it favoured the expansion of fire-tolerant vegetation types such as the sclerophylls at the expense of fire-sensitive vegetation such as drier Araucarian (Hoop Pine etc.) rainforest. Fire may also have had significant if localised impacts in areas of slow regeneration or vulnerability to erosion, and may have exacerbated the effects of drying climate. Debate also continues over the extent to which Aborigines, whether through 'overkill' or destruction of habitat, contributed to the extinction of the megafauna, a range of giant animals.

Despite the controversy, we can make

Lengths of metal (called 'crowbars' or 'wires' depending on thickness) have replaced the wooden digging stick as the fundamental women's tool. Together with an axe, and sometimes a gun, they form a versatile all-purpose toolkit. Here Polly Wandanga has caught a goanna by probing along the burrow with her wire.

L. HEAD & R. FULLAGAR

L. HEAD & R. FULLAGAR

Bought foods such as flour and sugar have replaced many bush food carbohydrates, but most meat, such as this goanna, comes from the bush.

L. HEAD & R. FULLAGAR

Barramundi trapped in a roadside pool in the early dry season are collected with whatever is to hand. Patrick Bitting uses a garden rake.

L. HEAD & R. FULLAGAR

The outstation movement should not be seen as an attempt to return to the past, as the interactions between biosphere and ecosystem peoples have irrevocably altered both the resource base and the technology used to exploit it. Foods of the local ecosystem remain important when they are abundant and easily harvested, for example kilen (Bush Mango, *Buchanania obovata*). Such fruits are confined to particular seasons, in this case the early wet. Kilen is thought to have provided a staple food for intergroup meetings in the past. Today it is an important source of fresh fruit, and a favourite of children like Mary Simon and Helena Thadim (pictured). The method of pounding between stones remains the same as that recorded in the past, with sugar now used as a sweetener instead of bush honey.

some summary statements. 1. Aborigines have been on the continent for at least 40,000 years and have occupied all parts of it. Even the desert centre has been inhabited for more than 20,000 years. The areas that we like to see as wilderness, whether or not they have been moulded by burning, have been someone's home for that length of time. 2. Kershaw suggests that Aboriginal impacts may have been greatest in the early years of colonisation, when they too were coming to terms with a new environment. The fact that Aborigines use fire in Arnhem Land today to protect fire-sensitive monsoon jungle thickets supports this suggestion. As we go into the 1990s we have a lot less time to learn how Australian ecosystems work and modify our actions accordingly. 3. Aboriginal lifestyles were sustainable in the environment for a period of 40,000 years, which is considerably better than what we are doing. This sustainability has more to do with technological and population limitations, in association with detailed local knowledge, than with people being inherent conservationists. The notion of 'original conservationists' is framed in Eurocentric terms and does not do justice to the complex interactions between Aborigines and their environment.

Many Aborigines are today returning from towns, reserves and missions to traditional lands to re-establish aspects of a hunter–gatherer lifestyle. The incorporation of European technology and more sedentary settlement patterns into this lifestyle, as well as high population growth rates among Aborigines, raises some new dilemmas. The use of vehicles, guns and axes provides the potential for more intensive exploitation than occurred in the past. It is this sort of land use that raises the hackles of conservationists concerned about impacts such as hunting of rare species and erosion around settlements. Although there is no shortage of anecdotal evidence on the favourability or otherwise of such impacts, there is a distinct lack of systematic monitoring.

A number of authors have commented on the incongruity of preventing Aboriginal activity in national parks when it is their stewardship over thousands of years that has maintained the country in a state that makes non-Aborigines value it. Aborigines with whom I work in the East Kimberley express bewilderment that their relatives in a nearby national park were expected not to hunt or burn simply to cater for tourists from thousands of kilometres away. We need to re-educate ourselves as tourists. Are our expectations of pristine, uninhabited areas reasonable?

Raymond Dasmann's concepts of 'ecosystem people' and 'biosphere people' are useful here. The former live within a single ecosystem, depending for their survival on the continued functioning of that ecosystem. Biosphere people, on the other hand, are tied in with the global technological and economic system. If they destroy one ecosystem, they can draw on others. The areas that Euro-Australians, as biosphere people, increasingly draw on for recreation and refreshment are often those where Aborigines, as ecosystem peoples, are trying to preserve their culture against mounting pressure. In a collision between the two, ecosystem cultures are extremely fragile and the destruction of both nature and culture is often a result. The economic and ecological dilemmas of Australian Aborigines are similar to those faced by indigenous peoples in many parts of the world, for example, the rainforest inhabitants of South-East Asia and South America.

Aborigines have been forced to justify their land claims within a Western world view, often an inadequate expression of the way they see their own relationship to the land. The result is an undue emphasis on things that might give such claims more credence in white eyes. White Australians, for example, have tended to value antiquity of occupation in absolute terms, so dates of Aboriginal arrival of 40,000 BP (200 bicentenaries), 70,000 BP (350 bicentenaries) or 120,000 BP (600 bicentenaries) are of increasing value. Many Aborigines, on the other hand, see themselves as having *always* been here, since the Dreaming.

Similarly, white attention focuses with some surprise on evidence for complex resource management strategies, stone house sites, village clusters, the systematic use of fire and so on. These lifestyles may be valued by whites as much because they approach their own way of relating to the world as for what they say about prehistoric Aboriginal socioeconomic structures. Such evidence, of course, can be used against Aborigines—if they are seen to be rainforest destroyers it invalidates their claims to land in some quarters. (This argument conveniently avoids the fact that, if rainforest clearance was a barrier to land tenure, we'd all have to leave the country!) Overemphasis on these arguments means that Aborigines literally can't win.

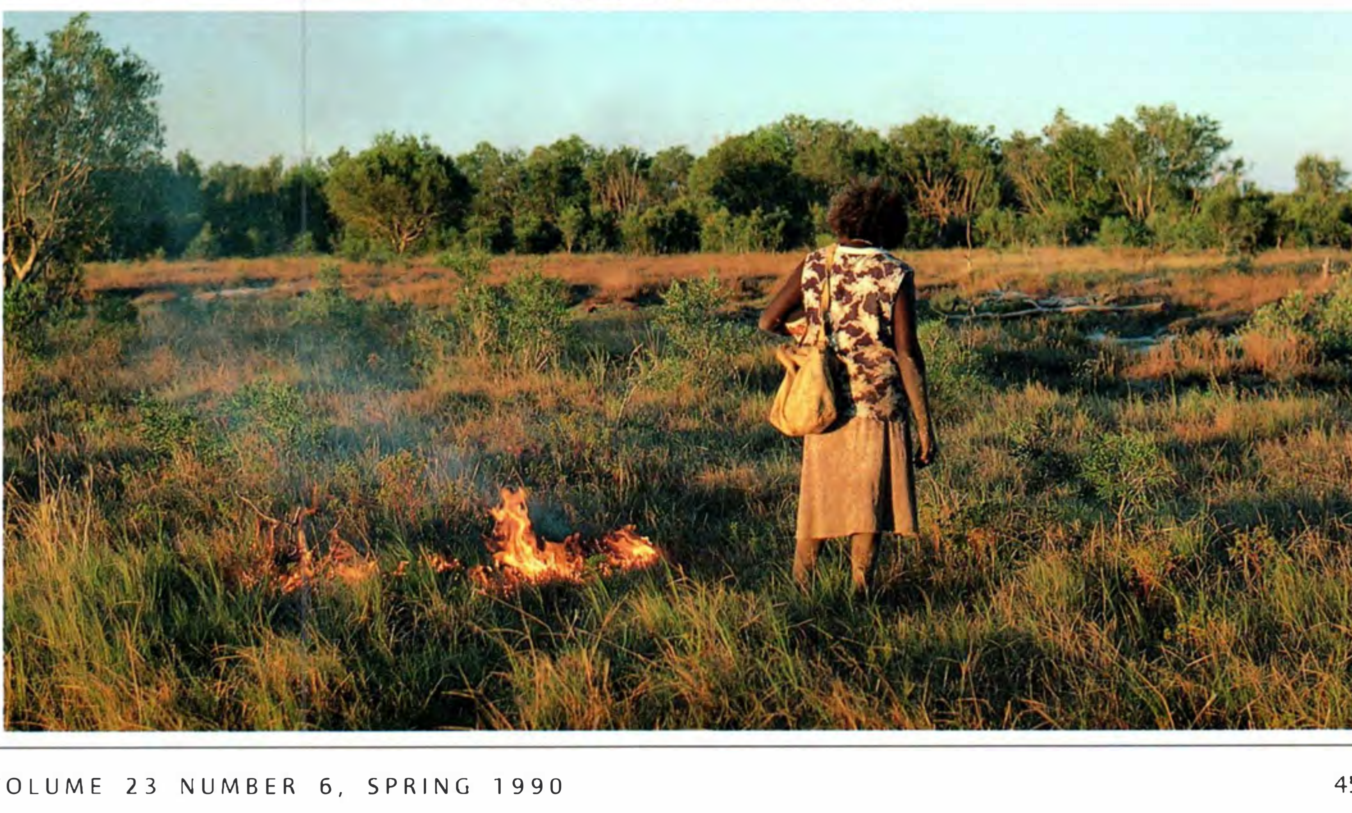
White Australia has much to learn about how Aborigines used and use the land. But this should not constitute the criteria by which we judge land rights. These rights surely lie in the fact that Aborigines were here first and that a well-defined system of land tenure was in operation but ignored by the invaders.

Perhaps the most important step towards the future is to increase our awareness of cultural as well as natural heritage. The logical outcome of such a stance is a recognition of the concept of inhabited national parks, as is well established in the joint management arrangements operating at Kakadu, Uluru and

'Biosphere people', unlike 'ecosystem people', are tied in with the global technological and economic system. They do not rely on just one ecosystem. In winter, for example, fruit and vegetables can be imported from warmer climates.

KATE LOWE/AUSTRALIAN MUSEUM

In the East Kimberley both Aborigines and white pastoralists regularly use fire. Biddy Simon, of Marralam Outstation, burns grassland to help in hunting.



L. HEAD & R. FULLAGAR

L. HEAD & R. FULLAGAR

The Franklin Blockade in 1983: an effective alliance between conservationists and Aborigines. But there are tensions implicit in the simultaneous proclamation of 'World Heritage' and 'Aboriginal Land'.

Gurig. Inhabited national parks do not mean unlimited numbers of people with unfettered technology having unrestricted access. They do mean that we shouldn't be able to remove people from their lands to create replicas of a romantic past that never existed.

In response to the World Commission on Environment Report (also known as the Bruntland Commission Report), the International Union for the Conservation of Nature has resolved to take special measures to protect the rights of traditional peoples in conservation matters, and to give adequate value to what has become known as 'traditional ecological knowledge'.

The importance of cultural heritage is well known among conservationists. Most would be aware that World Heritage areas such as Kakadu, the Willandra Lakes and south-western Tasmania have been proclaimed for conforming to cultural as well as natural criteria. But if we are asking Australia's poorest communities to forego substantial mining royalties in order to conserve places like Kakadu, particularly where such conservation is considered to be in the national interest, then we as a nation must be prepared to pay them for it. Such payments would in part be a recognition that the Aborigines and their ancestors are responsible for the maintenance of the things we value about these environments.

As a biosphere people tied to the global economy, non-Aboriginal Australia increasingly values ecosystems that we have not yet devastated. But in fighting for the absolute preservation of such ecosystems we may unwittingly place a burden on people who are dependent on the renewable resources of those systems. As conservationists we must learn to work with Aborigines in a way that recognises the complexity of these issues as well as the present needs of Australia's original inhabitants. ■

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Dr Lesley Head teaches geography and environmental prehistory at the University of Wollongong. She and Dr R. Fullagar (Australian Museum) are currently researching Aboriginal land use and resource management in the East Kimberley from prehistoric times to the present. *The research is funded by the Australian Institute of Aboriginal Studies and the University of Wollongong. None of it would have been possible without the generous participation of the residents of Marralan Outstation, particularly Biddy Simon and Polly Wandanga.*

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.

Further down the street you'll find the site where the Female School of Industry once stood.

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.

In an effort to pay tribute to this, Caltex, in association with the NSW Public Works Department, has laid twenty commemorative footpath plaques along Macquarie Street, each marking a historical site.

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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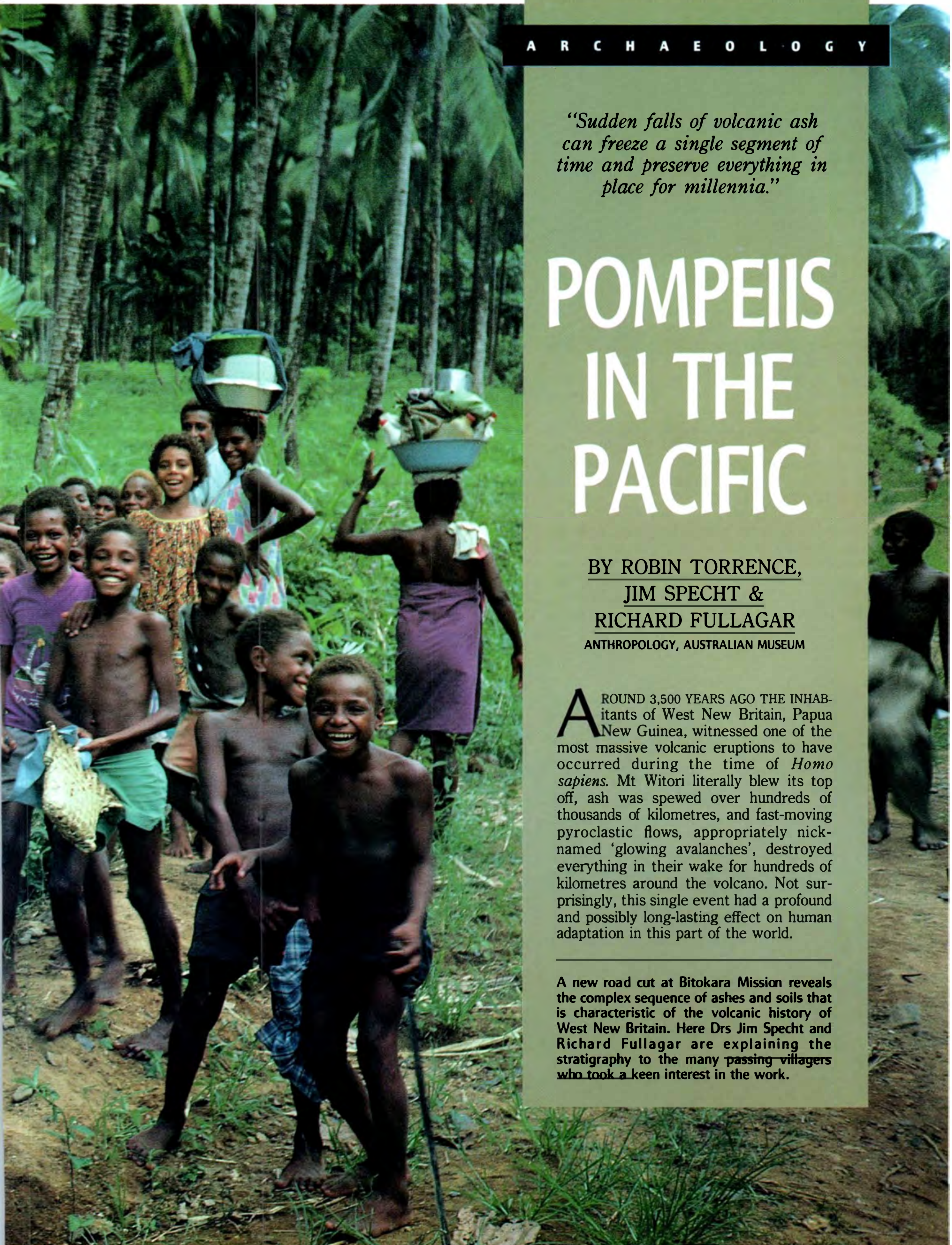
ROBIN TORRENCE



"Sudden falls of volcanic ash can freeze a single segment of time and preserve everything in place for millennia."

POMPEIIS IN THE PACIFIC

BY ROBIN TORRENCE, JIM SPECHT & RICHARD FULLAGAR
ANTHROPOLOGY, AUSTRALIAN MUSEUM

AROUND 3,500 YEARS AGO THE INHABitants of West New Britain, Papua New Guinea, witnessed one of the most massive volcanic eruptions to have occurred during the time of *Homo sapiens*. Mt Witori literally blew its top off, ash was spewed over hundreds of thousands of kilometres, and fast-moving pyroclastic flows, appropriately nicknamed 'glowing avalanches', destroyed everything in their wake for hundreds of kilometres around the volcano. Not surprisingly, this single event had a profound and possibly long-lasting effect on human adaptation in this part of the world.

A new road cut at Bitokara Mission reveals the complex sequence of ashes and soils that is characteristic of the volcanic history of West New Britain. Here Drs Jim Specht and Richard Fullagar are explaining the stratigraphy to the many passing villagers who took a keen interest in the work.

Centuries later archaeologists are grateful for volcanic events because of their unique role in preserving the past. One only has to think of the famous site of Pompeii, which was sealed intact under the ash of the eruption of Mt Vesuvius in AD79. Sudden falls of volcanic ash can freeze a single segment of time and preserve everything in place for millennia. What a difference from the sites that archaeologists normally study. People usually abandon settlements deliberately, leaving only their garbage behind. In contrast, archaeological sites like Pompeii provide us with very rich glimpses into the past, but such golden opportunities are extremely rare.

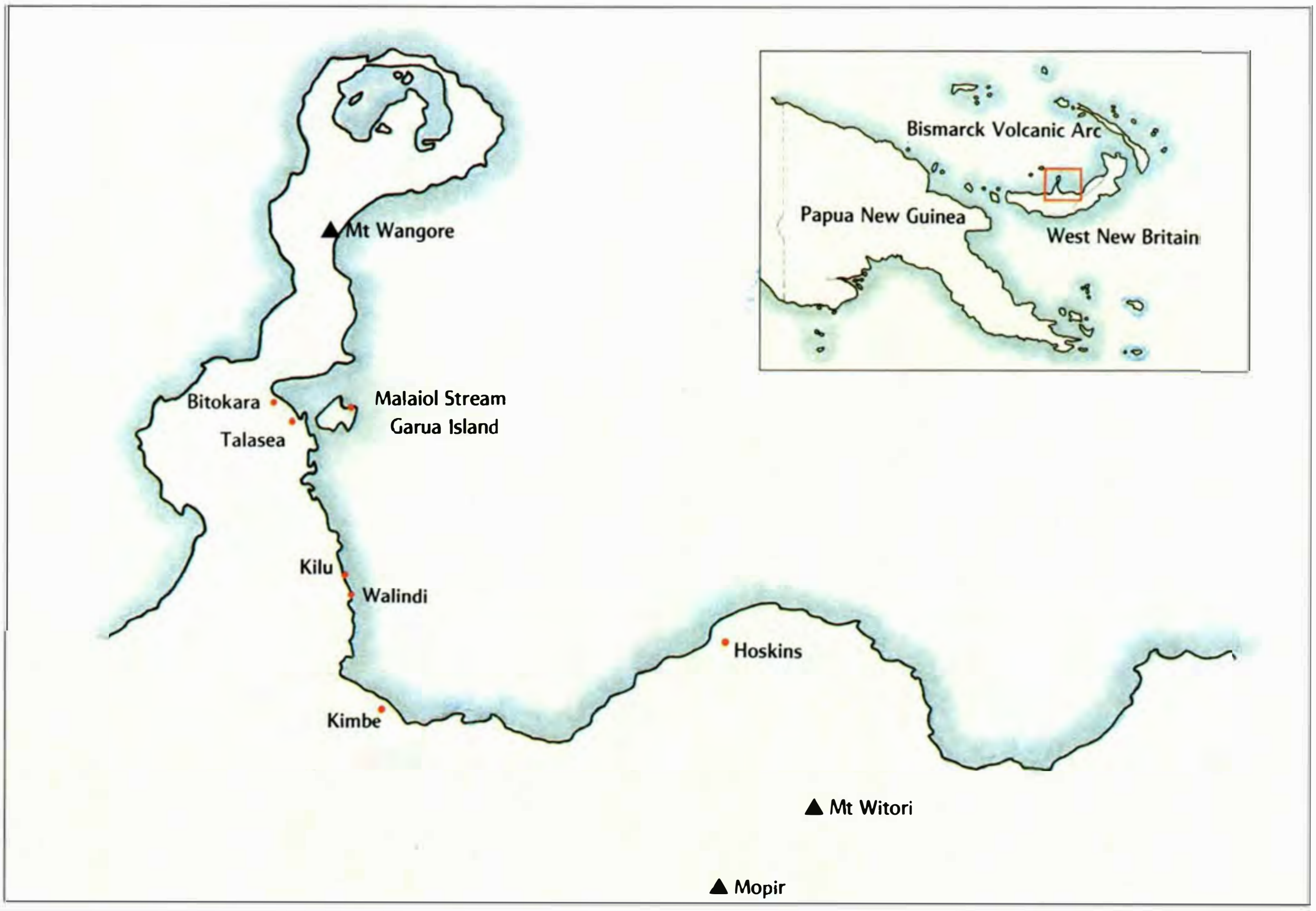
Thanks to the violent eruptions of Mt Witori and other volcanoes in West New Britain, Pompeii-like sites are not uncommon there. Archaeological fieldwork in 1988–89 has revealed that landscapes spread over thousands of square kilometres have been preserved under a series of ashes from a number of different volcanic events over the past 10,000 years. Although nothing so spectacular as Pompeii has emerged, we have discovered buried settlements, quarries and workshops. From the finds unearthed so far, we can begin to speculate about the impact of these dramatic events on shaping human history.

The volcanoes that dominate the landscape of West New Britain belong to the eastern group of the Bismarck Volcanic Arc, which is located where the South Bismarck and Solomon plates come together. The volcanic history of the area has been the recent subject of analysis by Russell Blong from Macquarie University and his Japanese colleagues. Around Cape Hoskins and the Willaumez Peninsula, they have identified nine phases of volcanic eruptions dated within the past 10,000 years. Archaeological remains are sealed under ashes from a number of these events, but the best evidence is centred around the eruption of Mt Witori 3,500 years ago.

RICHARD FULLAGAR

An aerial view across Garua Harbour looking north toward Mt Wangore (see map) shows the active volcanic landscape around Talasea. The cluster of white buildings in the lower left corner is Bitokara Mission.

The area around Talasea provided the focus of our investigations because it holds a special significance for Pacific prehistory. Obsidian derived from outcrops nearby was widely distributed throughout the Pacific from 20,000 years ago up to the present. At its greatest extent, the prehistoric distribution network of Talasea obsidian covered an area stretching from eastern Indonesia to Fiji, about 7,000 kilometres. One aim of our project is to trace changes in the way obsidian was extracted and manufactured at the



CATHY McGAHEY

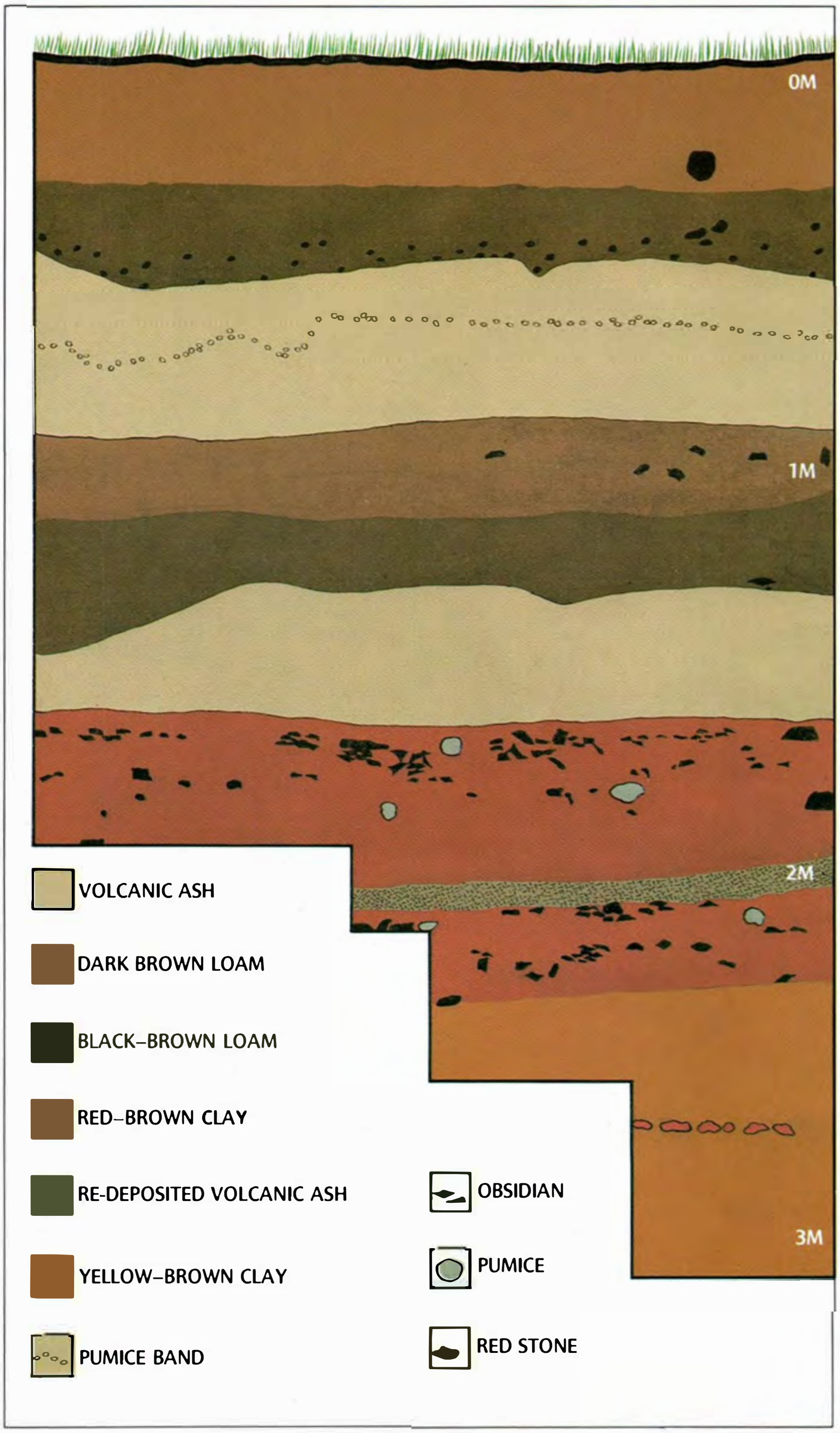
JIM SPECHT

At Bitokara Mission a three-metre-deep trench revealed a textbook example of archaeological stratigraphy. The dark layers are soils that contain the waste by-products from the manufacture of obsidian tools. In two cases these obsidian workshops have been covered by thick falls of volcanic ash, represented by the yellow layers. The lower ash fell when Mt Witori, located 60km east of Talasea, erupted about 3,500 years ago. A dense band of obsidian waste from the manufacture of stemmed tools can be seen in the lowest soil horizon.

sources as a way of reconstructing the cultural mechanisms responsible for distributing it over such a large area.

At Bitokara Mission we found a remarkable layer cake of history. Our three-metre-deep trench revealed three distinct ashes clearly separated by well-developed soils. The distinctive colour and texture of the middle layer of ash identified it as coming from the Witori eruption. A radiocarbon date on charcoal from just below the ash correlates with Blong's date for the eruption at about 3,500 years ago. The excavation revealed waste by-products of obsidian tool manufacture sealed in the dark soil horizons both above and beneath the Witori ash. Slightly further uphill a new road conveniently cut further slices into the well-preserved layers of prehistoric landscapes.

One of the most important findings from Bitokara comes from the obsidian artefacts buried under the Witori ash. Among the abundant flaking debris were retouched tools with various shapes, but all with clearly defined stems or tangs, probably for fitting into a handle. Material preserved along the road shows that people quarried obsidian from outcrops on the hillside, trimmed the nodules, and then knocked off larger pieces that could be made into stemmed tools. Partially prepared flakes were then carried down to the area of our excavation for the final stages of tool manufacture. At this same spot, small flakes also used as tools, were struck from fist-sized nodules. After the Witori ash fell, stemmed tools disappear from Bitokara and the obsidian-working areas contain significantly less waste material.



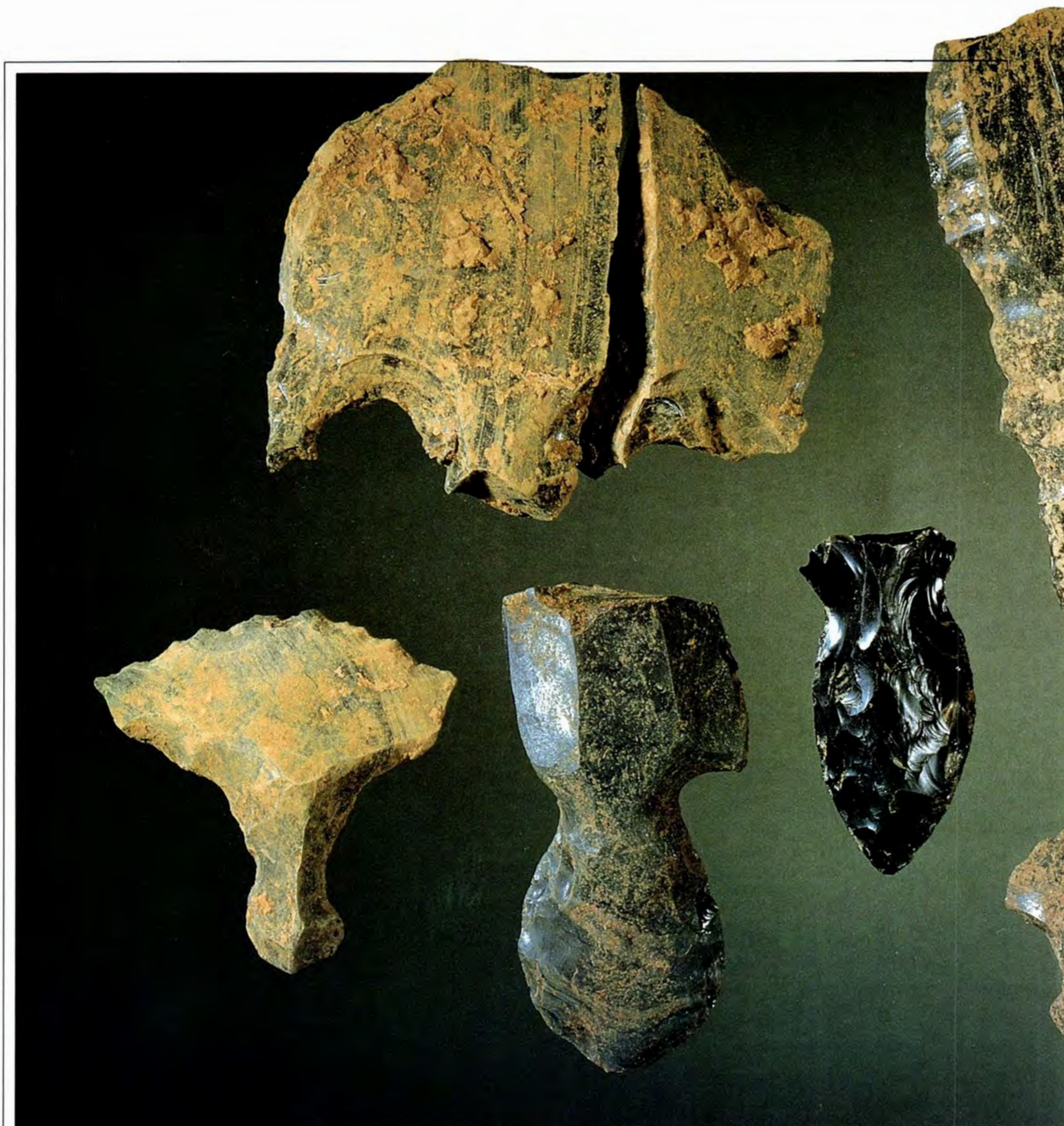
IAN FAULKNER

At Bitokara Mission ashes of two volcanic eruptions have sealed prehistoric obsidian workshops.

RICHARD FULLAGAR

An outcrop of obsidian once buried by volcanic ashes but now uncovered in the bed of Malaiol Stream on Garua Island.

A number of tantalising questions are raised by these preliminary findings. Did the catastrophe associated with the Witori eruption cause the changes in tool production and the decline in the obsidian industry at Bitokara? Does the loss of stemmed tools mean that a different



ANTHONY FARR/AUSTRALIAN MUSEUM

Stemmed obsidian tools come in all shapes and sizes. The largest in this photograph is 21cm long. The stem probably made it easier to hold the tool, but we are uncertain whether it was set into a handle or simply wrapped with leaves or vines to form a grip.

group of people had settled the area? Since at least some of the obsidian outcrops would have been covered over by ash, the Bitokara sources may have gone out of use and been replaced by outcrops in other areas. In any case, buried outcrops would have had to be quarried by a different method than was used previously. What effect would a change in sources have had on the wider exchange network?

TO ANSWER THESE QUESTIONS, WE NEED more information—more 'Pompeiis'. Finding buried archaeological sites requires special strategies. We have found that, apart from scanning fresh road cuttings, the best technique is to look along watercourses. Tracing the course of a stream provides a long, narrow window on past activities: a slice through the layers as well as a transect across the prehistoric landscapes.

Malaiol Stream on Garua Island provides an ideal setting for studying how techniques of obsidian quarrying and tool manufacture changed through time. At one locality we found a series of stratified working floors directly adjacent to an outcrop of obsidian and buried under the Witori ash. As at Bitokara, the greatest density of working material accumulated before the ash fell and the obsidian source was buried. With well over a metre of densely packed obsidian flakes, however, the thickness of the working floors under Witori ash is much greater than at Bitokara. Stemmed tools were recovered throughout the working floors under the ash. Not far downstream from our trench, two tools were discovered lying on a ground surface immediately below the ash. After the Witori ash was deposited, obsidian-working at the Malaiol Stream site declined, possibly because people were forced to dig down to the obsidian.

Outlines of pits present on the sides of the stream show that some were willing to search for outcrops but that others simply quarried the buried waste by-products left by previous obsidian workers.

To date most of our efforts have been devoted to uncovering the obsidian quarry–workshop localities. We have, however, also discovered several settlements sealed under the Witori ash. At site FAO, located on the hillside above Malaiol Stream, two pieces of decorated pottery were discovered directly above the Witori ash. The style of the decoration is Lapita (see ANH vol. 22, no. 9, 1988), which is dated to the period from

ANTHONY FARR/AUSTRALIAN MUSEUM

Obsidian block, or core, partially reconstructed from chipped pieces, or flakes, found in the Bitokara Mission excavation. Although incomplete, this shows the typical way of flaking obsidian to make tools in the period after the Witori eruption. Richard Fullagar has refitted 20 flakes and pieces to reconstruct the original core. Most flakes were struck from the flat surface shown here. The stone tool maker also turned the core to strike off flakes from other flat surfaces, but selected only some flakes to be used as tools. Richard has microscopically examined these tools and has identified traces of plant residues on their edges suggesting that they were used to process plant materials.

RICHARD FULLAGAR

When surveying Malaiol Stream on Garua Island, Richard Fullagar and Robin Torrence found a thick layer of obsidian artefacts in the stream bank several metres below the ground surface and lying underneath a volcanic ash (here visible at about head height).

JIM SPECHT

People living in the vicinity of Bitokara Mission are eager to help archaeologists learn about their past. Leo Metta, shown here with his family, was our main guide and assistant in 1988.

RICHARD FULLAGAR

Archaeologists can find sites by searching along watercourses, such as Malaiol Stream on Garua Island. Here the stream has cut a slice through the layers, revealing a sequence of past landscapes sealed under volcanic ashes. Dr Robin Torrence is standing by a prehistoric workshop that has been covered by a layer of yellow ash.

ANTHONY FARR/AUSTRALIAN MUSEUM

Lapita pottery fragments from Walindi Plantation (bottom left) and the FAO site on Garua Island.

JIM SPECHT

Without the constant high spirits and good cheer of our TAMS volunteers, the excavations at the Walindi site would not have been possible.

about 3,500 to 2,000 years ago. Given the dates we have for the Witori eruption, Lapita production must have begun at Talasea soon after the event.

Lapita sherds have also been found lying on the surface at Walindi Plantation, about 20 kilometres south of Talasea. In July 1989, excavations carried out by volunteers from The Australian Museum Society revealed yet another layer cake of Pompeiis. The earliest use of the site is represented by obsidian artefacts occurring in a sticky brown soil identical to that containing stemmed tools at Malaiol Stream and Bitokara. Next, the landscape was destroyed by the Witori ash. Around 2,000 years ago another village was built on top of the ash. The volunteers unearthed a hearth, post holes and large quantities of shells from coconuts and canarium nuts, but to everyone's disappointment there was very little pottery. By the time of the next volcanic eruption, this village had already been abandoned. On top of a second layer of ash we found obsidian and pottery belonging to a settlement occupied sometime during the last 200 years or so. Local oral history states that this was the ancestral village to modern Kilu, which is now on the beach about two kilometres away.

THE WITORI ERUPTION CLEARLY HAD A profound impact on the way people extracted obsidian and manufactured tools in the Talasea area. Not only did they stop producing stemmed tools after the eruption, but also large-scale quarrying of obsidian at two localities seems to have been abandoned. What other effects could this eruption have had on human life in this region? Although we do not know the original thickness of the Witori ash that fell around Talasea, the depths preserved in our archaeological sites are sufficient to have destroyed all plant life in the area. Tropical plants have been known to recover quickly from such disasters, but it would take several months, if not longer, to re-establish gardens. People at Talasea, as well as their neighbours over hundreds of thousands of square kilometres, would have faced certain starvation. It seems likely that everyone would have been forced to leave the area.

We still know very little about the people who returned to the Talasea area but it is extremely interesting that they possessed Lapita pottery. It is important to note that, at the same time that people were re-colonising the northern coast of West New Britain, groups bearing Lapita pottery were beginning to settle some of the remote islands of the Pacific for the first time—places like Fiji, Samoa and Tonga. What is similar about these two different areas is that they were both risky places for colonists. In the case of Talasea, the eruption had destroyed all the potential sources of food. People would therefore have had to rely on imports until new gardens were established. For the remote Pacific, people faced enormous hazards in travelling long distances to small islands. Having landed safely, they still had to keep themselves alive in an unfamiliar environment.

It seems likely that the pioneers in both areas would have actively sought to keep in touch with people who could provide backup assistance in times of hardship. The widespread distribution of Lapita pottery and of obsidian may be an archaeological signature of the communication networks that linked small communities of pioneers to each other and back to their home bases. Because the designs on Lapita pottery are similar throughout the large area in which it is found, the people who decorated the pots must have shared ideas and been in relatively frequent contact. Similarly, the ob-

The enormous depth of the buff-coloured volcanic ash in a road cutting near Mopir leaves no doubt about the catastrophic effects of volcanic activity on human life in West New Britian.

sidian found on sites spread over a large area of the Pacific at this time comes from only a small number of sources. It could only have been obtained by travelling to the source area, considerable distances in many cases, or by exchange with other groups. Perhaps the people re-colonising Talasea actively promoted the use of obsidian in order to create a reason for people who were potential sources of aid to keep in contact with them.

Whether the people bearing Lapita pottery were new to West New Britain or were previous residents returning with an adaptation to the new risks they would face, cannot yet be determined. Only further research will resolve these issues. But we can be certain that the Pompeiian landscapes around Talasea will be essential for understanding what life was like during the time of Lapita pottery. Excavation in the levels preserved under the Witori ash will also yield highly important data, since sites dating before the time of Lapita pottery are extremely rare anywhere in the Pacific.

The prehistory of West New Britain, like many areas of the Pacific, is a story coloured by cataclysmic volcanic events. It is fascinating to see how over many millennia people have reacted to these disasters. By learning about how prehistoric people interacted with their environment, archaeology can help the crisis managers of the future assess potential hazards and perhaps even suggest strategies for coping with them. ■

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Dr Robin Torrence is a Research Affiliate in the Division of Anthropology, Australian Museum. Previously she taught at the University of Sheffield in England and has carried out archaeological fieldwork in Europe and the United States. Dr Jim Specht is a senior scientist in the Division of Anthropology, Australian Museum. He has carried out archaeological research in Papua New Guinea for over 20 years. His main research interests lie in understanding the development of social and economic structures in the Bismarck Archipelago. Dr Richard Fullagar holds an Australian Research Council National Research Fellowship in the Division of Anthropology, Australian Museum. His research focuses on the study of how stone tools were made and used. Robin, Jim and Richard are currently working together with Dr Chris Gosden, La Trobe University, Melbourne, on an Australian Research Council-funded research project, studying the prehistoric settlement, social and economic systems of West New Britain.

RICHARD FULLAGAR

"During the first part of our residence [at Downe], we went a little into society, and received a few friends here; but my health almost always suffered from the excitement, violent shivering and vomiting attacks being thus brought on."

CHARLES DARWIN:

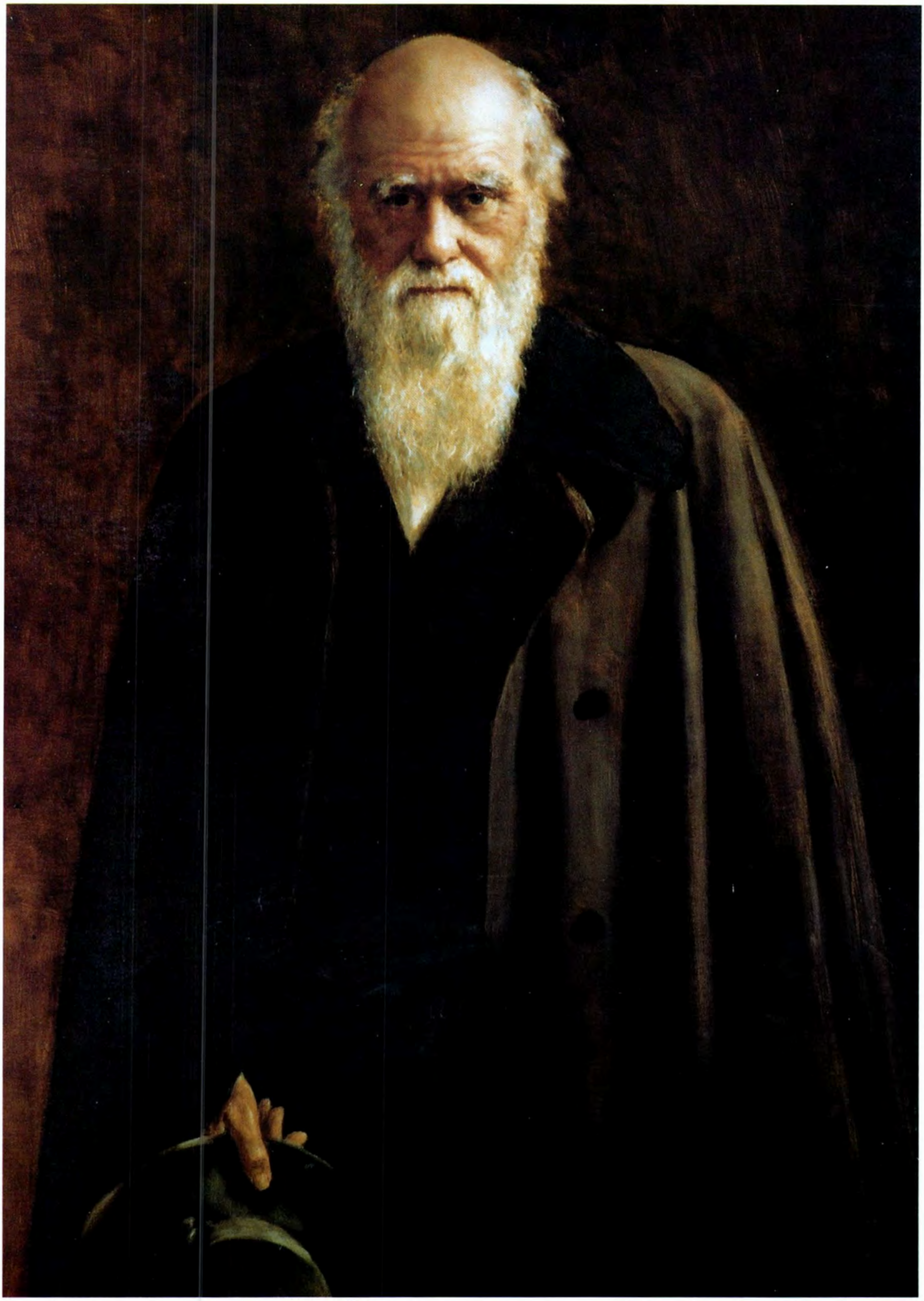
A VICTIM OF AGORAPHOBIA?

BY DAVID RUTHERFORD
ARCHIVIST

MOST PEOPLE KNOW OF CHARLES Darwin as one of the world's great scientists, as the father of modern biology and as the advocate of that most influential of scientific theories, evolution. But how many people know very much about Darwin the man? How many are aware that, for the last half of his life, he was a virtual recluse, unable to leave his house in Kent except for the smallest of journeys. For over 30 years, Darwin saw very few people, apart from his immediate family. As he himself ad-

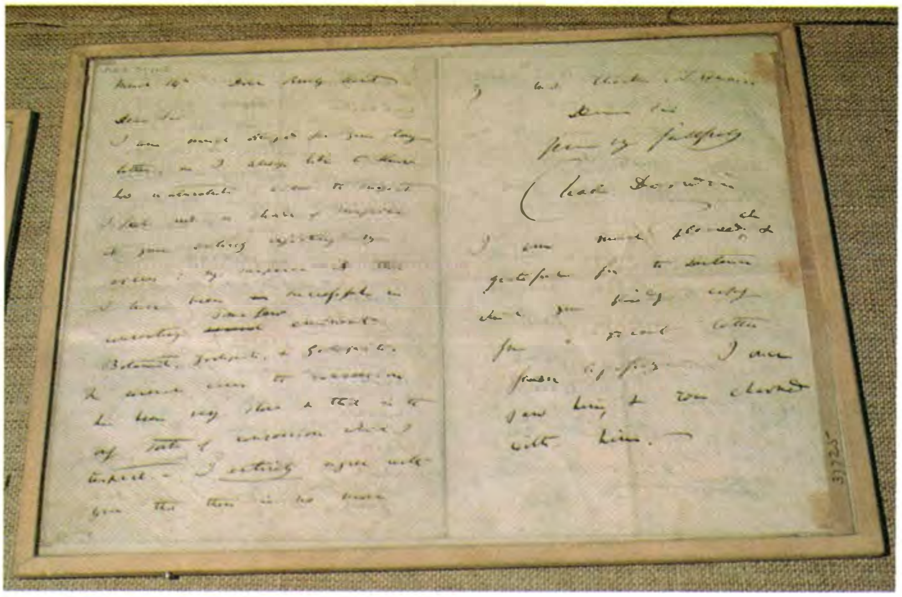
Right: portrait of Charles Darwin by John Collier. Did he suffer from agoraphobia, the fear of public and open places? The image above may capture the feelings an agoraphobic experiences when going out in a crowd.

ANTHONY FARR/AUSTRALIAN MUSEUM



DARWIN MUSEUM/DOWN HOUSE

A.H. TOLHURST



The many letters that Darwin exchanged with friends and family hold clues to the naturalist's 'illness'.

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Charles Darwin and his sister Catherine. As a child, Darwin favoured solitary pursuits.

mitted in his autobiography (quoted in Ralling 1978): "Few persons can have lived a more retired life than we have done. Besides short visits to the houses of relations, and occasionally to the seaside or elsewhere, we have gone nowhere."

Why did Darwin lead such a retired existence? Was it through fear of abuse from opponents of his scientific theories? Not really. He had deliberately chosen to live in a remote part of Kent in 1842, 17 years before *The origin of species* was published. At that stage of his life (he was only 33), Darwin was not known for any radical ideas. Quite the contrary, his writings up to that time placed him in the mainstream of science.

One reason for this very secluded existence was illness. Charles Darwin was the victim of frequent ill health for the last 45 years of his life. In his autobiography, he complained bitterly about all the time that he had lost through illness. But what was this mysterious complaint? Its symptoms were very vague: dizziness, bouts of nausea and persistent tiredness. Moreover, it did not conform to any disease pattern. The attacks came and went. Nor did it prove fatal. Darwin had the complaint for more than 40 years and yet still managed to reach the proverbial three score years and ten. When he finally died in 1882, it was from a heart attack.

There has been much speculation about Darwin's mystery illness. Some writers have argued that it may have been some exotic disease that he picked up during his voyage around the world on HMS *Beagle* (between 1831 and 1835). Before this voyage, Darwin was remarkably healthy; after it, he never knew good health again. Particular attention has focused on South America, where the young naturalist spent a good deal of time. It has been pointed out that in 1836, while travelling through the Argentine, he was bitten by the Benchuca Bug. As Darwin states in his diary, for the purposes of experiment he allowed this blood-sucking beetle to bite him repeatedly. Now the Benchuca Bug is a known carrier of *Trypanosoma cruzi,* a micro-organism that can give rise to Chagas' Disease. This disease has some of the symptoms about which Darwin was later to complain. But if this theory is correct, then there is still the awkward fact of Darwin's longevity. His allegedly fatal complaint took 46 years to kill him.

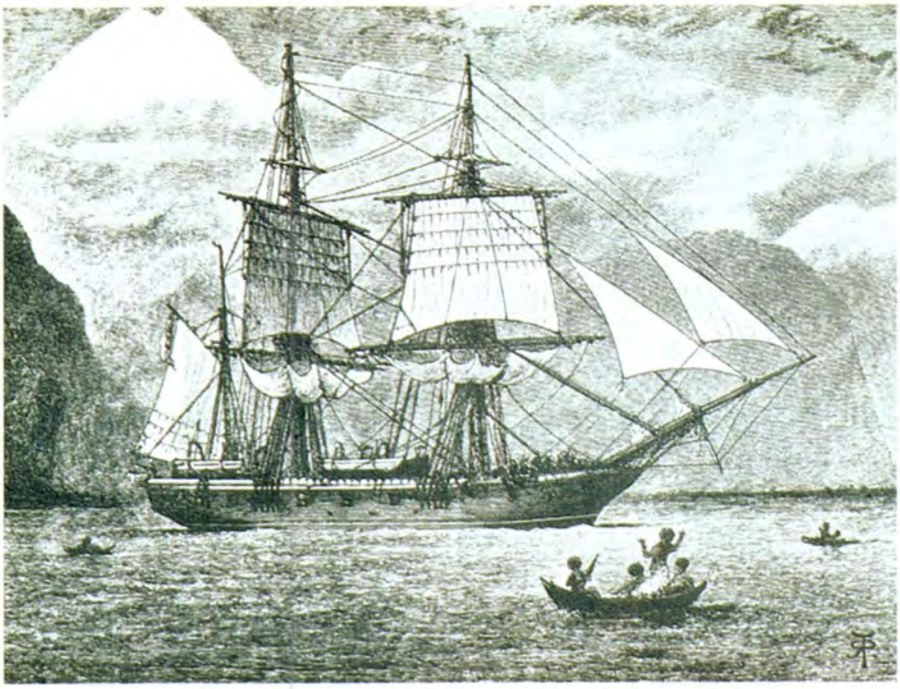
Another group of writers has argued that Darwin did not have a real, long-term illness at all; that his problem was not physical, but psychological. For example, James Bunting in his recent biography has produced a wealth of evidence to the effect that the Darwin family was obsessed with ill health. Many of the naturalist's children fell victim to a range of psychosomatic disorders. Francis Darwin was, in his father's own words a "moody young fellow". He was subsequently to suffer from acute depression. Henrietta and George were notorious hypochondriacs. Leonard was apparently happy as an army officer, until he suddenly resigned his commission. He insisted that his resignation was due to ill health, yet the army doctors could find nothing wrong with him.

This idea that Darwin's illness may have been not physical but psychosomatic is given some weight by the testimony of the naturalist's friends and colleagues. To most of them he looked quite well. As Darwin complained in a letter to his friend, Joseph Hooker, "Every one tells me that I look quite blooming and beautiful; and most think I am shamming..." (quoted by Chancellor 1973).

But if current opinion seems to suggest that a psychological problem may have been the cause of Darwin's 'illness', there is not as yet much agreement on what exactly that problem was. The view I want to put forward here is that Darwin was a victim of agoraphobia. This would explain his obsession with privacy. It would also explain why he was so frequently struck down with 'ill health' when social demands were placed upon him.

The word 'agoraphobia' means fear of public and open places. The condition can take a variety of forms and people can suffer from it to varying degrees. In the worst cases, they are unable to leave their homes for fear of having a panic attack, the symptoms of which can be dizziness, sweating, palpitations, headaches, weakness about the limbs and so on. Home is equated with safety, while the outside world is to be feared and shunned. In the milder cases, the victims of agoraphobia can control their anxiety. For example, they may be afraid of large crowds yet they conquer that fear every day in going to work. It is known that a traumatic experience can sometimes trigger off the condition. Often the person will be struck down with a panic attack when starting a new job or when travelling overseas and this can unleash the full onset of the illness. Subsequent investigation usually shows, however, that it was not the new job or the travel that was the real cause. A long period of stress and a psychological predisposition were the real underlying factors.

TO WHAT EXTENT DOES CHARLES DARWIN fit this model of agoraphobia? The main evidence comes from his autobiographical writings. Shortly before his death, Darwin was persuaded by his wife Emma to write a short account of his life for the benefit of their children. This autobiography was never intended for publication. However, fortunately for posterity, it has been published in full and it provides many insights into the scientist's mind and character. In addition to Darwin's autobiography, there is the diary that he kept during his five years on HMS *Beagle.* This consists of 18 tiny pocket books. A third source is the official journal of the voyage, originally published in three parts in 1839. Part III was written by Darwin and was based on his diary but with many additions and deletions. Finally, there are the many letters that



For most of his five-year voyage around the world on HMS *Beagle*, Darwin suffered from terrible seasickness and homesickness.

Darwin exchanged with friends and family.

On the basis of these sources, it is possible to reconstruct the chief events of Darwin's life. Let us briefly consider what those events were. From his autobiography it is clear that, as a child and as a young man, Darwin was already something of a loner. He favoured solitary pursuits, such as collecting beetles, shooting birds and going for long walks in the countryside. After the death of his mother (when he was only eight), the chief influence on his life was his rather domineering father. Robert Darwin was a medical practitioner in Shrewsbury. Because he was a doctor, he decided that Charles would be one also. In 1825, at the tender age of 16, Darwin was packed off to Edinburgh to study medicine. For a sensitive young man, this was to prove a traumatic experience. During his studies, he witnessed two operations, one of them performed upon a child. This was in the days before anaesthetic and Darwin found them so shocking that he rushed out of the operating theatre, never to return: "The two cases fairly haunted me for many a long year."

It was soon obvious to his family that he was not suited to a medical career. His father then proposed that Charles become a clergyman. This time he went to Cambridge University. It was as a consequence of his studies there that Darwin quite by chance heard about a job going on the British survey ship HMS *Beagle*. Essentially the position involved serving as the ship's naturalist, but without pay. Darwin was accepted and was initially full of enthusiasm for the voyage. He had long hoped to emulate the feats of the great naturalist Alexander von Humboldt who had explored much of South America. But as the date of departure loomed, Darwin started to suffer from acute anxiety about having to leave England for such a long time: "I was troubled with palpitations and pain about the heart, and like many an [ignorant] young man, especially one with a smattering of medical knowledge, was convinced that I had heart disease."

The five-year voyage around the world was to prove a watershed in Darwin's life. It awakened in him an intense interest in geology and palaeontology, subjects that until then he had dismissed as being of little value. It gave him nearly all the original material and research data he was to use in his subsequent scientific work and, towards the end of the voyage, he had already conceived some of his ideas on natural selection. But Darwin also paid a price for these gains. He had to spend five years in cramped quarters (the *Beagle* was just 28 metres long with a crew of 70). This was very hard for a person who craved solitude. Furthermore, he had to share a cabin with the ship's captain, Robert Fitzroy. Fitzroy was a difficult man, prone to bouts of rage and depression (he later committed suicide). But worst of all for Darwin was the suffering caused by seasickness. As he later commented in his journal, this was "no trifling evil cured in a week, as most people suppose." For much of the voyage, he was in a wretched state indeed.

With his usual fortitude, however,

ROYAL COLLEGE OF SURGEONS

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Left: Darwins wife Emma (1808–1896). Below: the Darwin family outside Down House.

CAMBRIDGE UNI LIBRARY

HAL COGGER

In his quest for solitude, Darwin returned to Down House in the secluded village of Downe at the age of 33.

Darwin tried to combat these problems in a positive way. Whenever the ship called into port, Darwin was off on some expedition into the interior. During such journeys he displayed quite remarkable energy. In 1832, he trekked 160 kilometres through the Brazilian jungle; in the following year he travelled 640 kilometres across Patagonia. In March 1835, when the *Beagle* called into Valparaiso (in Chile), Darwin took the opportunity to join an expedition across the Andes. He climbed a height of some 4,270 metres. Almost at every port of call, Darwin was off like a rocket. When the ship stopped at Tahiti, he organised a foray into the interior with a party of natives. They climbed a precipitous peak by means of rope ladders. The route would have challenged most modern mountaineers.

Unfortunately for the young naturalist, these stops on dry land were few and far between. The *Beagle* was a survey ship and, for most of its five-year journey, it was at sea. Apart from seasickness, he also suffered terribly from homesickness. His tribulations were only "partly relieved by anticipating the long-wished-for day of return". He was later to describe the sea as "a tedious waste, a desert of water".

In October 1836, the traveller finally returned home. He was a very different person to the one who had left. Before the voyage, Darwin had a passion for exploration and travel. His journey round the world seemed to have killed that. He never left Britain again (apart from a brief holiday in Paris) and his horizons became more and more restricted. The voyage of the *Beagle* also seems to have affected his relations with other people. His propensity for solitude, already apparent before the voyage, was greatly intensified. For a short time after his return he stayed in London with his new wife (he married his cousin Emma Wedgwood in 1839). However, the city soon became too taxing for him. In 1842, still a young man of 33, he retired to Downe, a secluded village in Kent. According to his autobiography, he was attracted to Downe because of "the extreme quietness and rusticity of the place".

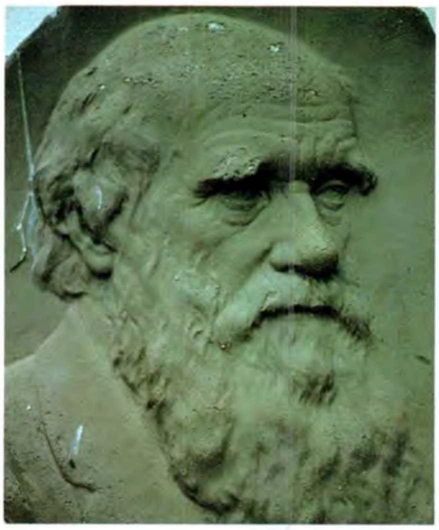
There is evidence that, already at this stage of his life, Darwin was suffering from a form of agoraphobia. The following passage is taken from his autobiography: "During the first part of our residence [at Downe], we went a little into society, and received a few friends here; but my health almost always suffered from the excitement, violent shivering and vomiting attacks being thus brought on. I have therefore been compelled for many years to give up all dinner-parties. . .From the same cause I have been able to invite very few scientific acquaintances."

Darwin's academic friends were bewildered by this craving for solitude. They frequently urged him to take a more active part in the scientific community. Darwin would very much have liked to have done so but his 'illness' made this impossible. He constantly had to decline invitations to attend conferences, chair meetings or meet fellow scientists. In 1854, for example, he was invited to chair a meeting of the British Association's Natural History Section. Darwin regretfully turned down the invitation. Such an occasion, he wrote, "almost invariably brings on so much swimming of the head, nausea and other symptoms, that *the effect of sitting. . .in a public chair would be quite intolerable to me* [my emphasis]."

Darwin's condition seemed to have become worse with age. Towards the end of his life, he found himself shying away

Charles Darwin with his eldest son William. Despite his constant ill health, he was a devoted father. Many of his children fell victim to psychosomatic disorders.

ROYAL COLLEGE OF SURGEONS



FRITHFOTO

Stone carving of Charles Darwin on the front wall of Down House

from all social contact, except for his immediate family. He could not even bear to see his friend and champion Thomas Huxley. Like many agoraphobics, Darwin seems to have used physical illness as a means of avoiding unwanted social contact. To some extent this was unconscious but perhaps not entirely so. As he admitted in his autobiography "Even ill-health, though it has annihilated several years of my life, has saved me from the distractions of society. . ." This is not, of course, to say that all of his ill health was psychosomatic. Darwin was prone to overwork and this probably made him vulnerable to many viral infections.

IN THE FOREGOING SURVEY OF DARWIN'S life, I have concentrated on certain negative aspects of his personality. However, it would be unfair to this great man to leave it simply at that. Darwin had many positive qualities that are worthy of note. Although he was attacked by orthodox Victorians as the Devil incarnate, Darwin was in his private life a model of the family virtues. As his surviving correspondence makes clear, he was a loving husband and a devoted father. He was also extremely tolerant and good-natured, even towards his staunchest critics. Darwin disliked controversy and disputation. When his friend, Thomas Huxley, sprang to his defence, Darwin urged him not to attack the critics too vigorously. Darwin felt that the best defence against criticism was to simply get on with his work. He remained remarkably productive right through his declining years. He was still writing at his death in 1882.

It could be argued, in fact, that Darwin's agoraphobia, far from hindering him in the progress of his scientific work, may actually have helped him. Because he led the life of a recluse for some 40 years, he was entirely free to pursue his own interests, without the pressures of having to account to other people. His isolation also helped to mitigate against the deluge of criticism that followed publication of *The origin of species*. In spite of the storm that raged over his book, Darwin continued to live in peaceful solitude until the end.

Anyone who has read Charles Darwin's autobiographical writings cannot help but respect and admire him. His character was complex. He combined great sensitivity with great courage. He was ambitious, in the sense of seeking public recognition for his ideas but, at the same time, he was a humble and reticent man. To say that he was prone to certain human weaknesses is in no way to detract from his status as one of the great men of science. ■

FRITHFOTO

DARWIN MUSEUM/DOWN HOUSE

Top: the living room in Down House and, below, the study in Down House where Darwin wrote *The origin of species.*

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Mr David Rutherford studied history at the University of Sydney and has a Diploma in Archives Administration. He has held a long-time interest in Charles Darwin.

RHYS JONES

TECHNIQUES

"One of the most exciting applications of residue analysis lies in the extraction and analysis of DNA from both blood and bone."

GETTING BLOOD FROM A STONE

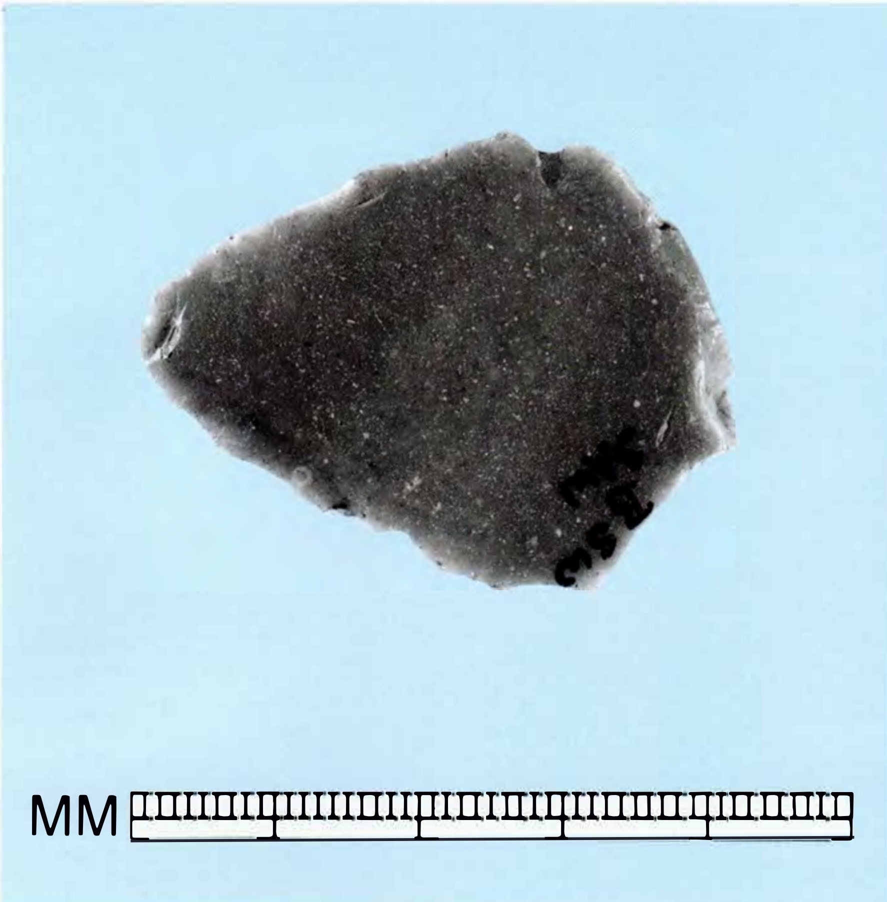
BY TOM H. LOY

RESEARCH SCHOOL OF SOCIAL SCIENCES & PACIFIC STUDIES
AUSTRALIAN NATIONAL UNIVERSITY

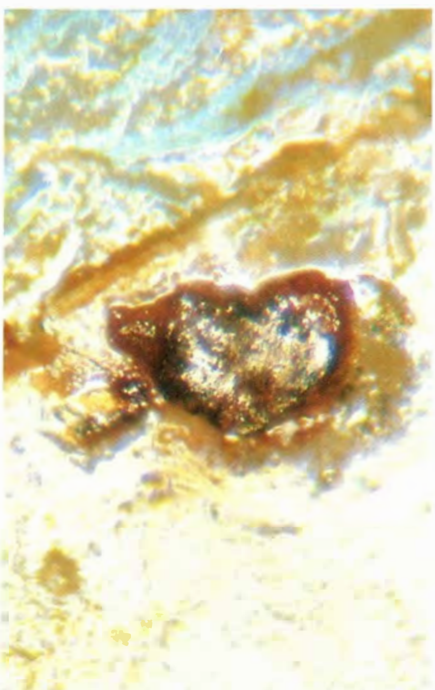
BETWEEN 20 AND 35 THOUSAND YEARS ago a hunter stopped near what is now the southern end of the Lake Mungo sand dune to make and use some stone tools. He left behind a few stone flakes as the only evidence of his passing. Associated with those tools are the bones of extinct animals. Similarly, a few thousand kilometres further north, near what is now called Laurie Creek, a small and faded rock painting is all that remains of a moment of artistic creation in a person's life, a life now only hinted at by that painting.

What was the hunter doing? How were the tools used, and on what materials? Were the extinct animals part of the diet of the hunter, or does their presence merely reflect the natural death of the animals? When was the rock painting made? What part did that creative act play in the life of the painter and his

The sand dune on the shore of Lake Mungo in western New South Wales. People have lived along this lakeshore for at least 30,000 years. Campsites with hearths, scatters of tools and the debris from making these tools, and the bones of extinct animals can be found all along the now-eroding sand dune.



TOM H. LOY



TOM H. LOY

Above: a small scraping tool used to work wood. In the course of tool use, the person using the tool sustained a cut and left behind a thick blood residue, visible as a dark line near the lower edge. Bottom: photomicrograph of some of the thick blood residue on the tool. The tool is from a site in northwestern Iraq that has been dated to about 100,000 years old. This is the oldest human blood yet known. The tool is about four centimetres long and the thick crust of blood is about 50 microns in width.

culture? How closely related in a genetic sense are the two people who made and used the tools and painted on the cliff wall?

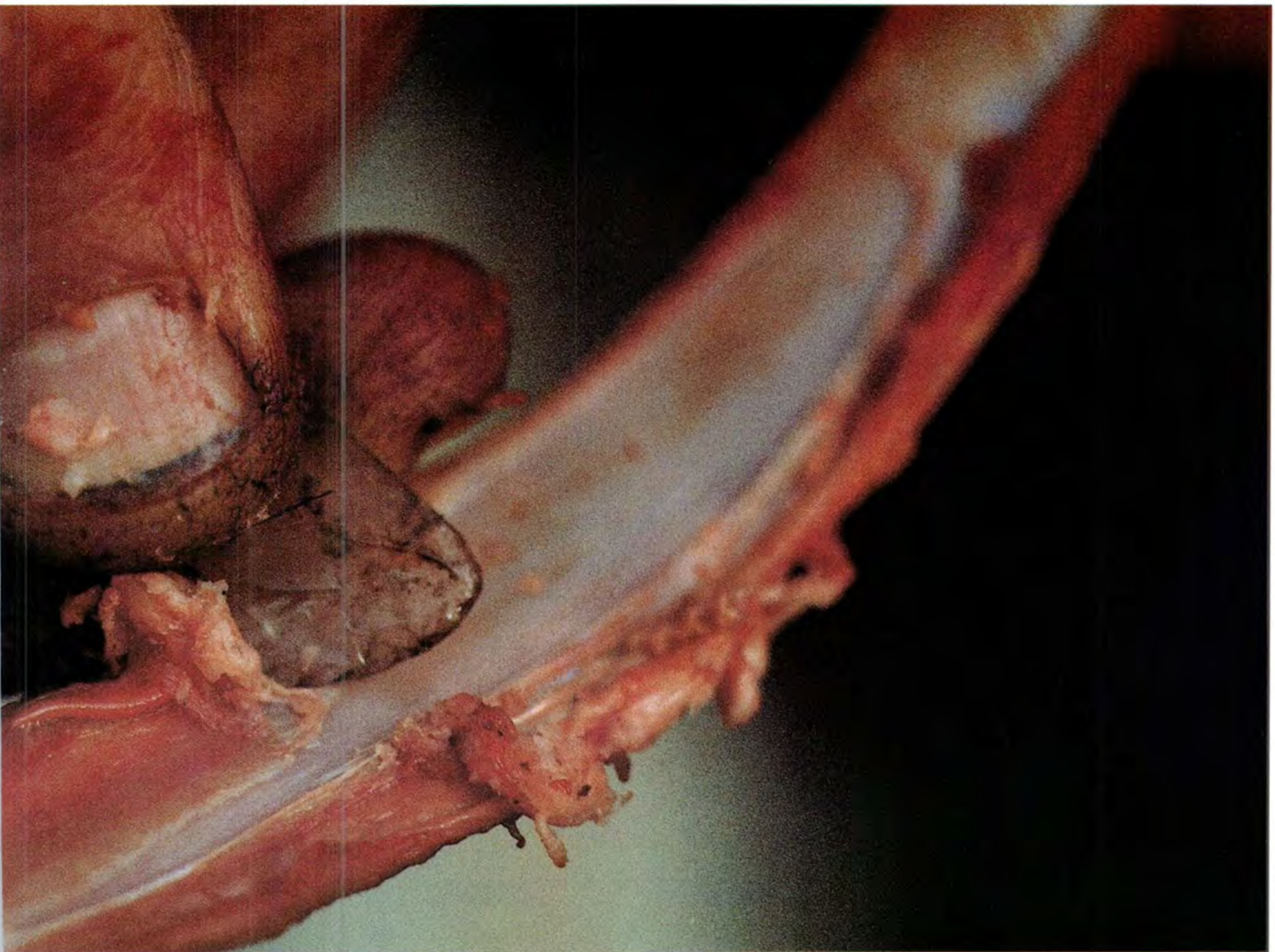
Archaeologists have used many methods to tease answers to such questions out of the fragmentary and often obscure remnants of the lives of peoples past. However, the methods of discovery, excavation and analysis that have been brought to bear on understanding life in prehistoric times have often been limited to answering the most obvious questions.

The limitations come from two major sources. One lies in the fragmentary nature of the evidence itself and reflects the profound difference in technology and lifestyle between ourselves and those whose lifestyles we want to understand. From our own direct experience, for example, we can appreciate and partially understand some of the details of the architectural design, building techniques and economy and organisation of labour of ancient Egypt or Mesoamerica, but we are largely at a loss to comprehend the everyday details of living in Australia 300 years ago, let alone 20,000 years ago.

The other source is largely technological. Faced with the vast amount of enigmatic evidence left by people who lived by hunting animals and collecting plants, the approach has been to describe tools or art and seek the regularities that constitute distinctive cultural patterning and permit subdivisions into similar time periods, task or art styles. Traditionally the methods of archaeological analysis

have emphasised similarity and dissimilarity in tool shape; and the presence or absence of specific types of tools has been used as part of the pattern recognition process. The patterns of prehistory have been analysed using our modern perspective of what makes a tool a tool. And our inferences that lead to the recognition of 'cultural signatures' have been based on a kind of 'what if. . .' mode of thinking. Analogies are drawn from ethnographic accounts of people's lives at the time of historical contact, or from direct interviews with elders who remember the old ways of living; we also rely on our systems of scientific observation and discrimination to weave together broad reconstructions of the past.

To this type of reasoning, modern archaeologists add studies of diet and reconstructions of climate and environments from the evidence of discarded bones and macroscopic plant remains. The study of soils and sediments allows individual site occupations to be distinguished and changes through time to be documented. The analysis of human skeletons can point towards the genetic changes that occurred over long periods of human history. And dating techniques, such as radiocarbon dating, thermoluminescence or



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Modern replica of a tool used experimentally to remove meat and tissue from a rib bone. Note large build-up of organic residue on the tool surface resulting from only a brief period of use.

uranium series dating, have been invaluable in sorting out the relative (and sometimes absolute) chronology of occupations and periods in the past when specific types of tools were made, and correlating changes in environment to better understand the way people coped with a demanding and changing world.

As the physical and biological sciences develop and refine their own analytical techniques, many have been adapted to the study of prehistoric evidence. Archaeologists, too, have refined and broadened their own unique methods of analysis. The recent development of experimental archaeology, for example, has enabled a better understanding of how tools were made and how they sustained damage and wear when they were used to do different tasks. But with most analytical techniques there is an intrinsic uncertainty contained in the reconstruction of past human events and processes.

Eight years ago I discovered a fact that has profound implications in the analysis of past human activities: blood and other organic materials are deposited on tool surfaces during use, and are commonly preserved over time periods that range now in excess of 100,000 years. The use of modern biochemical and genetic techniques of analysis, and small-sample radiocarbon dating of these residues, provides a way to eliminate much of the intrinsic uncertainty of archaeological reconstruction.

THE DISCOVERY HAD ITS BEGINNING SOME ten years ago when I undertook an analysis of over 700 chipped and ground stone tools that came from a large number of sites from the Pacific Northwest Coast of British Columbia in Canada. The purpose of that analysis was to discover the extent, if any, of changes in preferred style of projectile points (arrowheads and spearpoints) during the past 4,000 years. Although there is a commonsense understanding of what constitutes the basic shape of projectile points, it was imperative to be able to specify the exact function of each object under study and thus it was necessary to develop a method of distinguishing similarly shaped objects that had different functions, such as a knife and an arrowhead.

Researchers had been using edge damage to suggest the type of raw material on which the tool was used but accidental damage during manufacture, or even after abandonment of the tool, can lead to uncertainty in the determination of tool function and worked material. Lawrence Keeley, from the University of Chicago's Anthropology Department, then published a series of papers suggesting that, by examination of the surface of the tool at high magnification, it was possible to observe types and degrees of the polish that were produced by different tasks and were specifically related to different raw materials.

During the course of my own experiments to replicate Keeley's use–polish analysis it became clear that, in the majority of cases, the polish was not caused by a *reduction* of the tool surface, but by the *addition* of remnants of the worked material to the surface of the tool. When cutting meat with stone tools I had made myself, for example, the polish I observed was made up of a layer of blood and fat. Another anthropologist, Frederick Bruier from California State University, had published an article describing plant tissues still adhering to tools collected from cave sites in the south-west of the United

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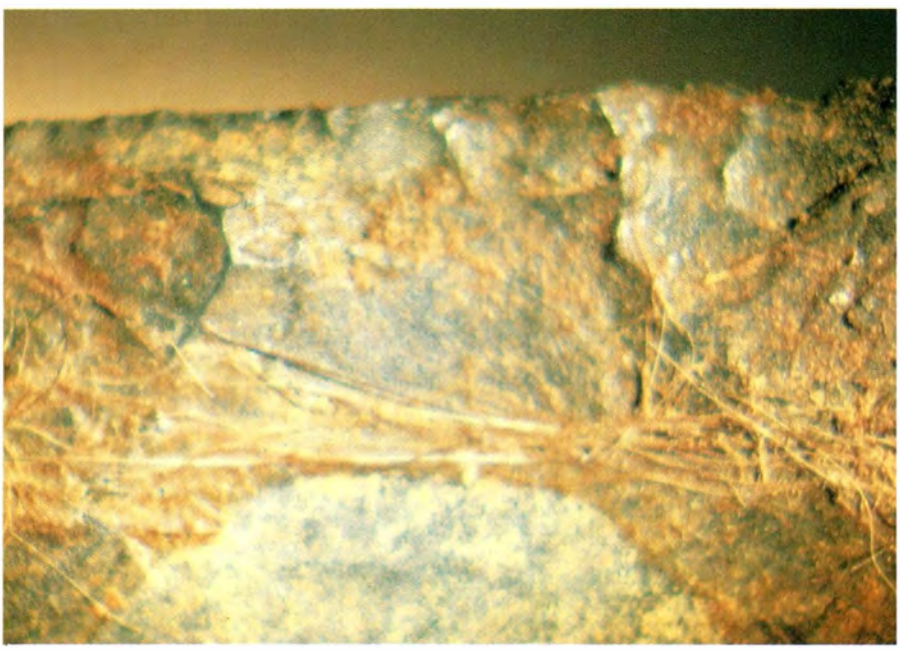

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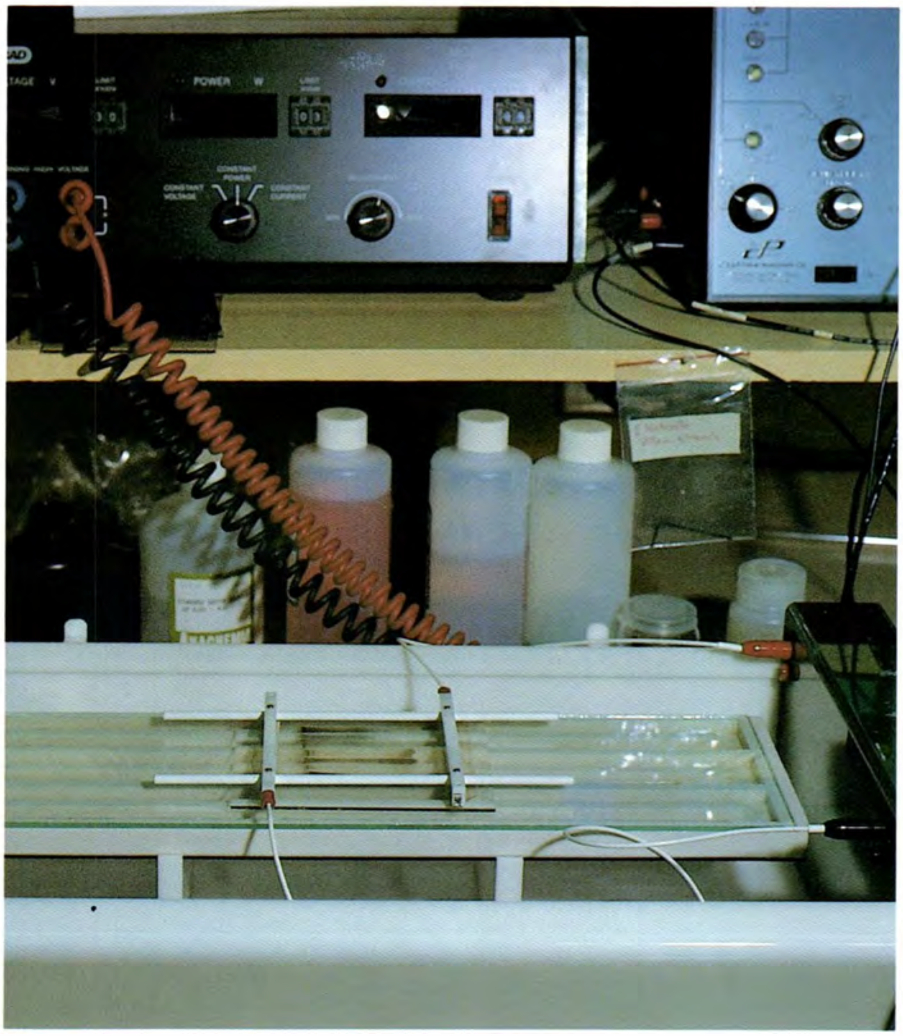
Above: chert knife from north-western Canada covered with blood residue and, near the tip, hairs identified as probably from Bison. Species identification of the blood indicated that the blood was indeed from Bison. Below: a close-up of the hair and blood near the tip of the tool. Fifty micrograms of the blood residue on this tool was radiocarbon dated using Accelerator Mass Spectrometry and yielded a date of tool use about 2,680±280 years ago. This represents the first time a tool has been directly dated. Usually ages are assigned with reference to stratigraphy and dates are based on charcoal in the site.

States; he used biological stains and microscopic techniques to identify some of the residues. Using Keeley's and Bruier's techniques, I decided to examine a collection of microblades (small flakes made by a highly specialised technique) that had not been washed following excavation. On many of the microblades I found features and cells similar to those observed on tools I had used to butcher small game. Using a variety of tests I was eventually able to confirm that the residues contained proteins typical of blood, the most easily identified being the molecules of haemoglobin and albumin. Widening my search and extending the types of tests used, I was able to document the presence not only of blood, but hairs, feathers, starch grains, resins and plant tissue.

While trying to identify the origin of a butchered animal by analysis of scale patterns of hairs imbedded in blood films, I was alerted to a study by Robert Washino (Entomology Department, University of California at Davis) that used the regularity of crystals of haemoglobin extracted from blood to identify the species of animal that mosquitoes had been feeding on. After three years of experimentation and blind testing I was able to adapt the haemoglobin crystallisation technique to the identification of animal species whose blood residues lay on stone tools. Each animal species has a slightly different sequence of amino acids in the haemoglobin molecule; these sequence differences ultimately reflect non-lethal mutations of the DNA genetic code that occur in the course of evolution. The small differences in amino acid sequence change the electrochemical properties of the molecule with the result that, given the right conditions of growth, different species' molecules will form differently shaped crystals. The problem with this method of species identification is that there is no correlation of crystal shapes within higher taxonomic groupings. Although it was possible to identify the species exactly, if no known blood is available for comparison then it is impossible to suggest an identification at the genus or family level.

Other tests for species identification, or simply the identification of specific blood molecules as part of the screening process, have been adapted using immunological techniques. Specific antibodies will bind with target molecules and can be labelled to permit the detection of minute amounts of protein. It is not uncommon to identify less than a thousand-millionth (billionth) of a gram (nanogram) of protein on tool surfaces. Although immunological techniques are very sensitive, highly specific and reliable, they are expensive to make and commercially available antibodies are limited to commonly used laboratory animals and human blood proteins.

Another method of species identification that is still in the final development stages relies, like haemoglobin crystallisation, on the small changes in electrochemical properties caused by genetically driven changes in the amino acid sequence of blood molecules. Called 'isoelectric focusing', the technique uses a strong electric current passed through a thin gel of polyacrylamide that contains a water-based mix of various organic and inorganic compounds. When the current is passed through the gel, the mixture of compounds creates a gradient of pH from one end of the gel to the other (acid at one end, basic or alkaline at the other). A mix of blood proteins is then applied to the gel and the proteins are driven through the gel by the electric current. Each protein has a specific pH value at which it becomes electrically neutral and, at that point in the pH gradient, it ceases to move further. The end result is a pattern of bands along the separation lane on the gel; minor changes to the amino acid sequence will alter the pH value and thus the exact location on the gel. By comparison of the unknown protein mix with blood samples from known species it is possible to calculate a similarity index and, from that, identify the species of animal. Unlike the haemoglobin crystallisation method, isoelectric focusing allows identification of animal bloods



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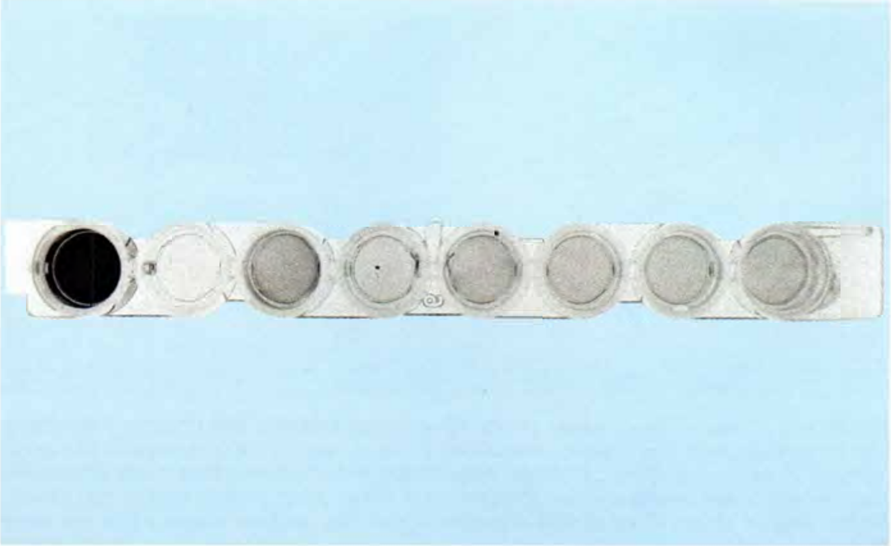
Isoelectric focusing equipment shown here includes a power supply with high-voltage leads attached to a separation chamber with a separation gel plate and electrodes in place. A complex mixture of proteins is separated under high voltage into purified components. This separation is used for further analysis of specific proteins or species of origin of blood residues.



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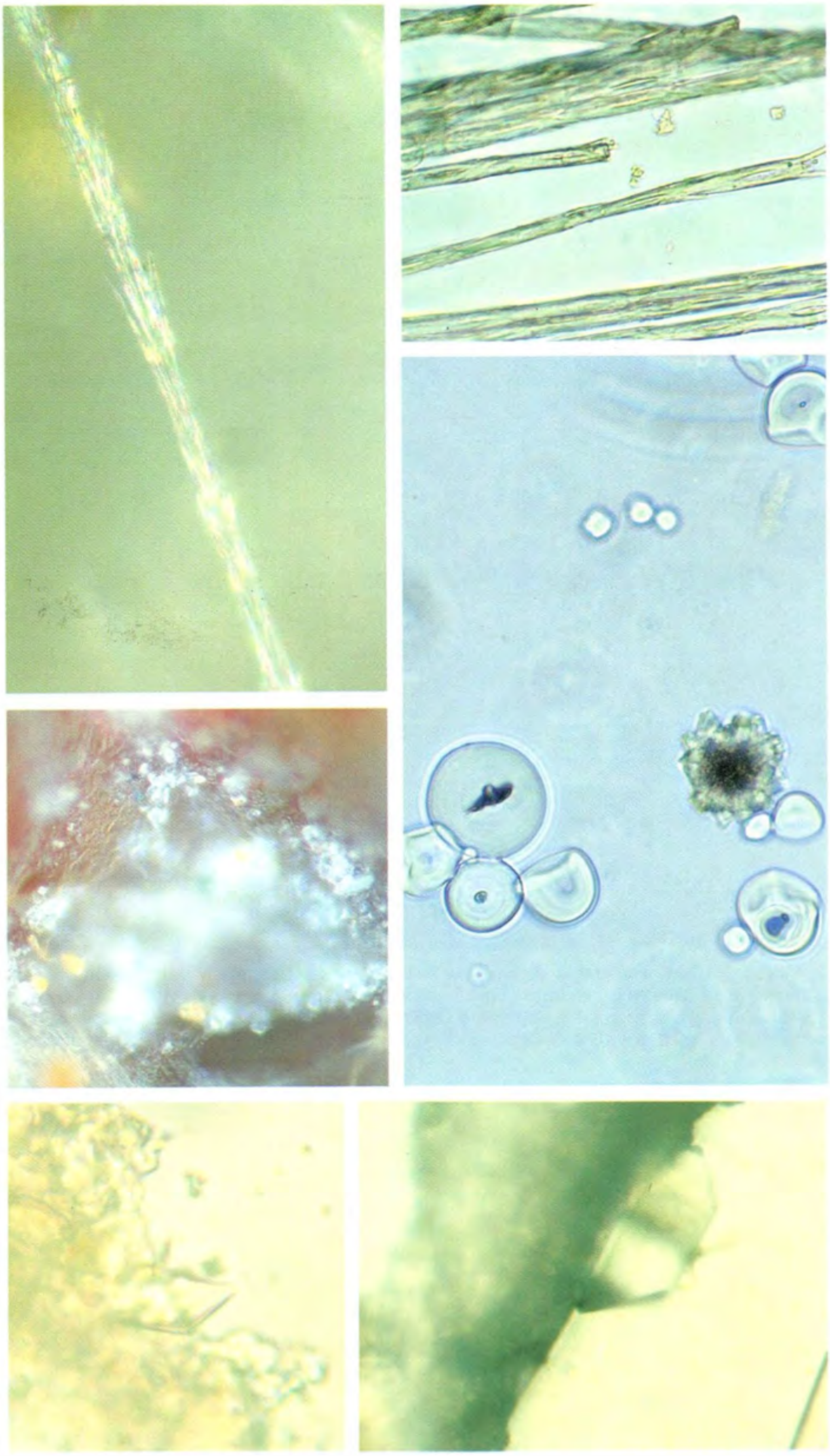
Antibodies that are linked to colour reagents can be used to identify certain molecules from specific animal species with great accuracy. The test illustrated uses a monoclonal antibody to identify serum albumin molecules from human blood. The sample on the far left is known human blood, the next is known non-human blood, and these constitute the control samples. The remainder of the samples come from pigment at two rock art sites, one at Laurie Creek in the Northern Territory and the other from Judds Cavern, Tasmania. The intensity of the colour is a measure of the concentration of the blood in the original extract from the rock art pigment.



Top left: moa feather fragment from a site in New Zealand about 500 years old. The morphology of feather barbules can be used to identify the bird to the taxonomic level of order. Top right: feather barbules from a fragment of a feather cape known to be made from moa feathers. These were used for identification purposes. Feather barbules are about 0.1 millimetres in diameter.

Middle left: a mass of starch grains preserved on the surface of a tool from the Lake Mungo site in western New South Wales, estimated to be at least 30,000 years old. The grains average 15 microns in diameter. Middle right: starch grains removed from a tool of unknown (but probably more recent) age and identified as a native sweet potato (*Ipomea polpha*). The largest grain is about 15 microns in diameter. Preliminary analysis suggests that the starch from the Lake Mungo tool is from a native sweet potato. Bottom left: haemoglobin crystal, bone powder and red cells. The crystal was grown from the bone of an Aurochs—an extinct ox, *Bos primigenius*—to provide an identification of some of the blood found on a sandstone slab in the floor of a building at the Çayönü Tepesi site in central Turkey. Both human and Aurochs blood was identified on the slab floor; the building dates to between 7,000 and 9,000 years old. The crystal is about ten microns in length. Bottom right: the haemoglobin crystal of a California Sea Lion grown from a 1,000-year-old blood residue on a tool from the western coast of Canada; each species' haemoglobin crystal shape is different, permitting identification of species of origin of blood residues. The crystal is about 25 microns in length.

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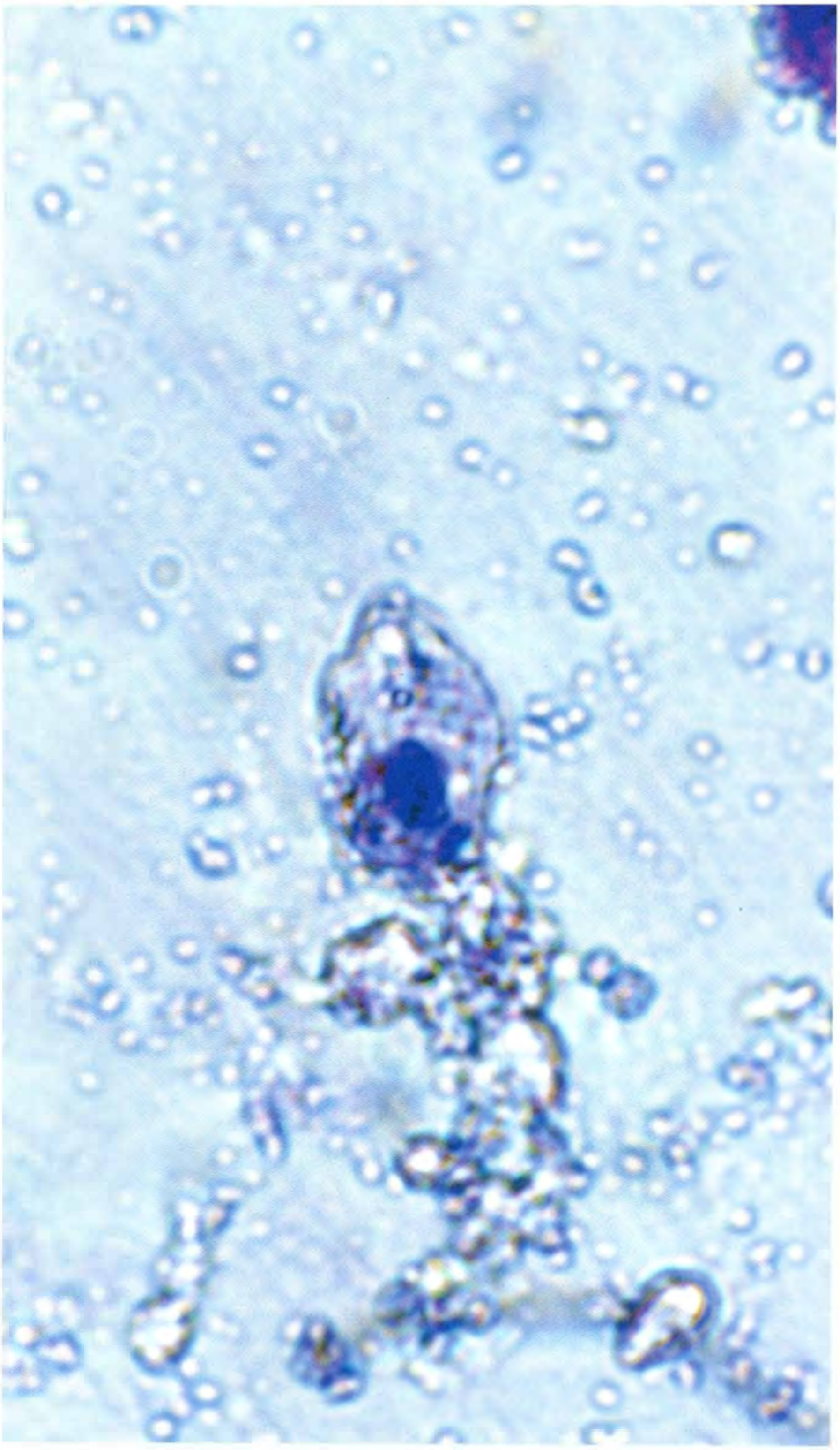
at higher taxonomic levels so, even if the exact species blood is not available, it is possible to suggest identification of the genus or family of the unknown animal blood.

Microscopy is also used to identify the animal of origin using hair and feathers, and the type of root or tuber by analysis of starch grains; some plants can be identified by unique groupings of various tissue attributes, or by chemical markers. For example, yams (*Dioscorea* sp.) contain a unique alkaloid poison called dioscorean that can be relatively easily identified.

So we now know that the hunter who stopped by Lake Mungo to make and use a few stone tools left behind not only the tools but a wealth of information about his activities. Some of the tools in this small group have abundant starch grains on their surfaces as well as small fragments of plant tissue; others still have remnants of blood residues, sinew and the tissue layer that surrounds bone (the periosteum layer). Immediately we can begin to reconstruct some of the details, and two food preparation tasks are evidenced: cleaning tubers and stripping meat from bone. The type of plant tissue is typical of the outer covering or cortex of tubers, and the abundance of starch grains is consistent with cutting or shredding a starchy material. The simultaneous occurrence of blood, sinew and periosteum is consistent with modern experiments involving the removal and cleaning of fresh meat from bone.

Exactly what species of plant and animal are represented by the residues is still unknown. Comparison with a limited and still-growing collection of reference starches and blood allows me at least to say what plants and animals are *not* part of the residue in this collection. One important part of the current research on residues is the continued search for reference materials. This search includes sampling from living populations of plants and animals and, for animals at least, the extraction of still-extant blood molecules from subfossil bone and faunal remains. For example, the blood of the now-extinct progenitor of domesticated cattle, the Aurochs (*Bos primigenius*), was identified by myself and André Wood (Oriental Institute, University of Chicago) on the floor of a 7–9,000-year-old ceremonial building at the Çayönü Tepesi site in Turkey by first crystallising haemoglobin extracted from identified bones of Aurochs found elsewhere in the village site. The bones of the extinct animals at the Lake Mungo site (such as *Diprotodon*



RHYS JONES

TOM H. LOY

Human hand outlined in red ochre and human blood paint from Judds Cavern in south-western Tasmania. Radiocarbon dates using Accelerator Mass Spectrometry on 40 millionths of a gram (40 micrograms) of carbon removed from the paint yielded ages of between 9,500 and 10,500 years. This is the first time rock art has been directly dated in Australia and the first evidence of a ritual significance for the use of human blood in prehistoric painting.

and *Procoptodon* species) will provide the reference samples of blood and may well be represented on the recovered tools.

A bone marrow cell with the nucleus stained a deep blue by Wrights stain (a standard staining technique for blood and bone cells). This cell lies next to fragments of bone. The cell was extracted from a human bone about 30,000 years old from the Lake Mungo site in western New South Wales. The finding of intact nucleated cells in old bone has stimulated research to extract and study DNA from both bone and blood residues. The cell is about 20 microns in diameter.

OTHER APPLICATIONS OF THE TECHniques of residue analysis have revealed startling new evidence about the antiquity of rock art. While recording the Laurie Creek rock art site, Rhys Jones (Department of Prehistory, Australian National University) collected a fingernail-size piece of a small and now-faded painting of a stylised face. This sample, along with others from both Laurie Creek and from Judds Cavern in south-western Tasmania, was collected because Jones suspected that blood might have been used as part of the pigment, or as a binder. I eventually determined that all the samples he had collected contained human blood. Ethnographic evidence, as well as still-current ritual, suggest that human blood is an important element in the creation of rock art. The question of the antiquity of the human blood used in rock art then became very important.

In collaboration with Erle Nelson and his group at the Simon Fraser/MacMaster Universities Accelerator Mass Spectrometry (AMS) dating facility in Canada, I had previously obtained dates from the blood residues on stone tools from sites in north-western Canada. Nelson's group has pioneered the dating of very small carbon samples using the sensitive AMS technique, which directly counts the atoms of radiocarbon to normal carbon contained in the sample (as opposed to the conventional radiocarbon method that estimates the amount of radiocarbon by detecting the radiation as the radiocarbon atoms decay). Having already worked out a method to eliminate contaminants, Nelson and I removed very small amounts of protein (40 micrograms,

or 40 millionths of a gram) from both the Laurie Creek and Judds Cavern pigments and prepared them for dating. The Judds Cavern samples gave ages of 9,200 and 10,700 years, which are in close agreement with other estimates of the occupation of the cave. The Laurie Creek pigment gave an age of 20,000 years—the oldest directly dated rock art now known.

And what about the genetic connection between the tool maker and the artist; how can we ever know those details? One of the most exciting applications of residue analysis lies in the extraction and analysis of DNA from both blood and bone. By examining the genetic material contained in skeletal remains from the Lake Mungo sites and from the human blood in the Laurie Creek pigments, I expect that within the year it will be possible to use the latest techniques in genetic analysis to identify the differences and similarities in the DNA sequence of specific genes extracted from as few as three or four cells. Intact cells containing a nucleus have already been identified from both blood and bone extracts; it now remains to finalise the details of techniques needed to analyse this partially degraded genetic material. These lines of analysis will permit the resolution of longstanding problems in the current debate on the origins of Australian Aborigines and, indeed, the course of human evolution. ■

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Dr Tom H. Loy is a visiting fellow in the Department of Prehistory, Research School of Social Sciences and Pacific Studies, Australian National University. The last ten years of his research have been directed towards blood residue analysis. He is originally from the British Columbia Provincial Museum in Victoria, Canada.

PEST CONTROL

"The Cane Toad is often inappropriately used by opponents of biological control to raise doubts about the safety and effectiveness of the procedure."

BIOLOGICAL CONTROL
AND THE CANE TOAD SYNDROME

RALPH & DAPHNE KELLER/ANT PHOTO LIBRARY

OTTO ROGGE/ANT PHOTO LIBRARY

BY ERNEST S. DELFOSSE
CSIRO DIVISION OF ENTOMOLOGY

MOST AUSTRALIANS WOULD HAVE heard of the beneficial introductions of the *Cactoblastis* moth that controlled prickly pear cacti and the myxomatosis virus for rabbits. Most also would have heard of the disastrous introduction of the Cane Toad to protect Australia's cane crops from marauding beetles. This last example is often inappropriately used by opponents of biological control to raise doubts about the safety and effectiveness of the procedure.

Biological control workers would protest that this is not correct, and that introduction of the Cane Toad is more akin to the introduction of the rabbit than to the *Cactoblastis* moth. They would also point out that Australia has been a world leader in biological control for nearly 90 years, and has an impressive record of safety and effectively managing major invasive pest species with this type of ecological control.

What, then, is biological control? How does it work and what current checks

The Cane Toad (pictured here with a native tree frog on its head) was not subjected to any prior testing for suitability as a biological control agent against cane beetles. Today's strict procedures for biological control would not allow for such a disastrous introduction. Inset: the Greyback Cane Beetle, *Dermolepida albohirtum*.

THE MAIN OPTIONS FOR PEST MANAGEMENT	
Control Method	**Example**
Biological	Natural enemies.
Chemical	Insecticides, miticides, herbicides etc.
Cultural	Crop rotation, mulches, covers, resistant cultivars.
Legal/preventive	Legislation, cleanliness.
Mechanical/physical	Cutting, hoeing, fly swatters.
Genetic	Manipulation of heritable characters.
Integrated	Combinations of other methods.

prevent 'Cane Toad-type' introductions? Does it eradicate pests? When did it begin? Is it ecologically safe to use and economically affordable? In short, what are the risks and advantages of using biological control to help manage major pests?

Biological control is one of several available options for managing pest populations (see table). It involves the study and use of living natural enemies for the regulation of target pest populations. There are a wide variety of natural enemies that can be used, including parasites, predators and diseases. The pests targeted for biological control are usually weeds or insects that interfere with the production of food or fibre, but can include weeds of national parks, other invertebrates (mites, snails, millipedes etc.), plant diseases, vertebrates such as rabbits, or even dung!

There are actually four types of biological control: 'classical' or 'inoculative', which involves introduction of relatively small numbers ('inoculation') of host-specific natural enemies (the biological control agents) from the home range of the pest to the country where the pest is a problem; 'inundative' or 'augmentative', which usually involves the mass production and release of large numbers ('inundation') of host-specific native natural enemies against native pests; 'conservative', where, for example, the number of native parasites, predators and diseases of (usually) native natural enemies of weeds are reduced; and 'broad spectrum', which involves artificial manipulation of numbers of non-specific or habitat-specific natural enemies to restrict the level of attack. Classical biological control was recognised and practised first, and remains the most-used type of biological control.

The modern era of classical biological control began in about 1890. However, the concept and earliest-recorded practice of biological control began with the Chinese hundreds of years ago, and involved the use of predatory ants to control citrus pests. The first use of parasites in biological control occurred in Europe in the early 1800s. Biological control of weeds started in the early 1900s and has experienced the most dramatic growth of any of the techniques in the last 90 years. The following discussion pertains mainly to classical biological weed control.

THERE ARE SEVERAL ADVANTAGES OF biological weed control over other methods of pest management (see table). These fall generally into ecological, economic and risk-analysis areas. Interestingly, the disadvantages of biological control are often just the other side of the coin from the advantages and, depending on your viewpoint, may not be disadvantages at all.

Successful classical biological control results in essentially permanent ecological management, using host-specific natural enemies of the pest, whereas other types of control are relatively short-lived. However, unlike chemical control, for example, biological control is relatively slow-acting, normally taking several years for agents to have widespread effects.

No harmful environmental side effects occur with biological control because the agents selected are restricted either to one pest species or, if acceptable, to a small group of closely related species. Other types of control are often non-specific and can be used to control several pests in one area, but they can cause significant non-target damage.

Biological control agents are self-perpetuating, generally spread without help by humans, and usually fluctuate in number as the population of the target species changes (the 'density-dependent' factor) and thus do not eradicate their host. Other types of control are labour-intensive and usually act regardless of the density of the target pest.

Biological weed control has been used most often in pastures but is also suited to national parks and wildlife reserves where exotic, invasive weeds often push out native vegetation, and chemical herbicides or intensive grazing often cannot be used.

Costs of biological control are non-

ADVANTAGES AND DISADVANTAGES OF CLASSICAL BIOLOGICAL CONTROL	
Advantages	**Disadvantages**
Essentially permanent management of the target pest.	Once released, agents cannot be recalled.
No harmful environmental side effects, because each agent is restricted to one or a small number of target species.	Multiple-pest species groups cannot be controlled.
Agents are self-perpetuating, self-distributing and dependent.	Set-up costs are relatively high.
Risks are known before release into the environment.	Risks are present, albeit much less than other types of pest management, and society must decide if they are worth taking.
	Native natural enemies may impede introduced agents.
High benefit : cost ratios for successful program.	Political commitment must be made to allocate funds.
Once agents are established, no further inputs are needed.	

Paterson's Curse has become a major pest in the rural country (main photo). Among the agents approved for release are the leaf-mining Moth (*Dialectica scalariella*; top right) whose larvae burrow inside the leaves. It was the first agent to be released for this weed and has spread over 20 kilometres in eighteen months. One small release has been made of the Paterson's Curse Weevil (*Ceutorhynchus larvatus*; top left) but it is too early to tell if it has been successful. The adults eat the leaves and the larvae feed on the tap root just below the soil surface. The adults of Paterson's Curse Stem-boring Beetle (*Phytoecia coerulescens*; middle) eat the leaves and flowers, while the larvae bore inside the main stem. This species has not been released and, because it attacks the plant later in the season than some other agents, has a lower priority for introduction.

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recurrent and relatively small compared to the damage caused by the target pest. For example, yearly costs of the CSIRO research program against the introduced Mediterranean weed Paterson's Curse or Salvation Jane (*Echium plantagineum*) are only about two per cent of the *annual* damage caused by this weed. Also, there are high (up to 100:1 or higher) benefit to cost ratios for successful programs.

Importantly, risks of introduction of agents are evaluated and known before release into the Australian environment is allowed. Most of the early effort in a biological weed control program concentrates on testing a large number of plant species to determine the range of plants on which each agent species will feed or reproduce (the 'host range'). If the host range of each agent is restricted, it is then predictable to a high degree. This scientific procedure can be contrasted to introduction of the Cane Toad (*Bufo marinus*), which had no prior testing; in fact, the Cane Toad would not be allowed to be introduced under the strict procedures in place today.

Even though the likely host range of an agent can be predicted, its final effect on the weed cannot. Two or three out of five introduced agent species fail to stress the target significantly. Chemical control of weeds, for example, can give a much more reliable effect on a target weed but, even though chemicals can be used in specific habitats, inherently they are not as specific as biological control.

Biological weed control has an exemplary record of safety, cost-effectiveness and environmental protection. It is ironic that, despite this, it is often the last option investigated for management of pest species. Very rarely is a biological control program funded when the level of the target pest is low and chances for rapid success much higher. However, biological control is not a panacea for pest problems and is clearly not the method of choice in some circumstances. For example, where a new and potentially damaging weed species is discovered in low numbers, an attempt at eradication with herbicides would be the best option.

Finally, although safety of agents is evaluated and is predictable, results are not guaranteed because, once released, agents must cope with the unpredictable elements of the Australian environment. For example, a very promising potential agent (a leaf-galling midge called *Cystiphora schmidti*) for Skeleton Weed has been virtually eliminated as an effective agent because a native wasp (*Tetrastichus* sp.) kills most of the larvae of the midge in the galls each year. It is not often possible to predict these types of biotic interactions, and they can negate years of exploration and safety-testing work.

NEARLY ALL CLASSICAL BIOLOGICAL control programs begin in the same way. An introduced pest species becomes a dominant feature of the environment,

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Common Heliotrope (*Heliotropium europaeum*) can blanket pasture in summer (main photo). There are several possible agents for control of this weed, including the Heliotrope Rust Fungus (*Uromyces heliotropii*), which has the capacity to damage plants severely and halt seed production and which may be released soon in Australia (top); a leaf spot fungus, *Cercospora heliotropii-bocconi*, which is currently under study (middle); and the flea beetle *Longitarsus albineus*, whose larvae feed on the root hairs and rootlets, causing severe stress and possible death of the plant (bottom).

and chemical, mechanical or cultural control methods are tried, often for decades, without much success. An awareness emerges that there are no economically or environmentally acceptable methods of management of the pest species, often a public outcry for a better method arises, and then biological control is suggested.

Each biological weed control program involves basic ecological research, takes 20 scientist-years to conduct and costs

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FRITHPHOTO

Several agents were released to control prickly pear cacti. Shown here is *Opuntia stricta*. The most effective was the *Cactoblastis cactorum* moth whose larvae feed inside the cacti (inset).

perhaps five million dollars. Because of inadequate funding and the current push for conduct of research projects that demand quick and easily identifiable returns, support for basic ecological research has been reduced significantly. Thus, there is at least a 50-year backlog of biological weed control projects to conduct. Damage in Australia from weeds alone exceeds $2 billion per annum, and many of these weeds are suitable targets for biological control.

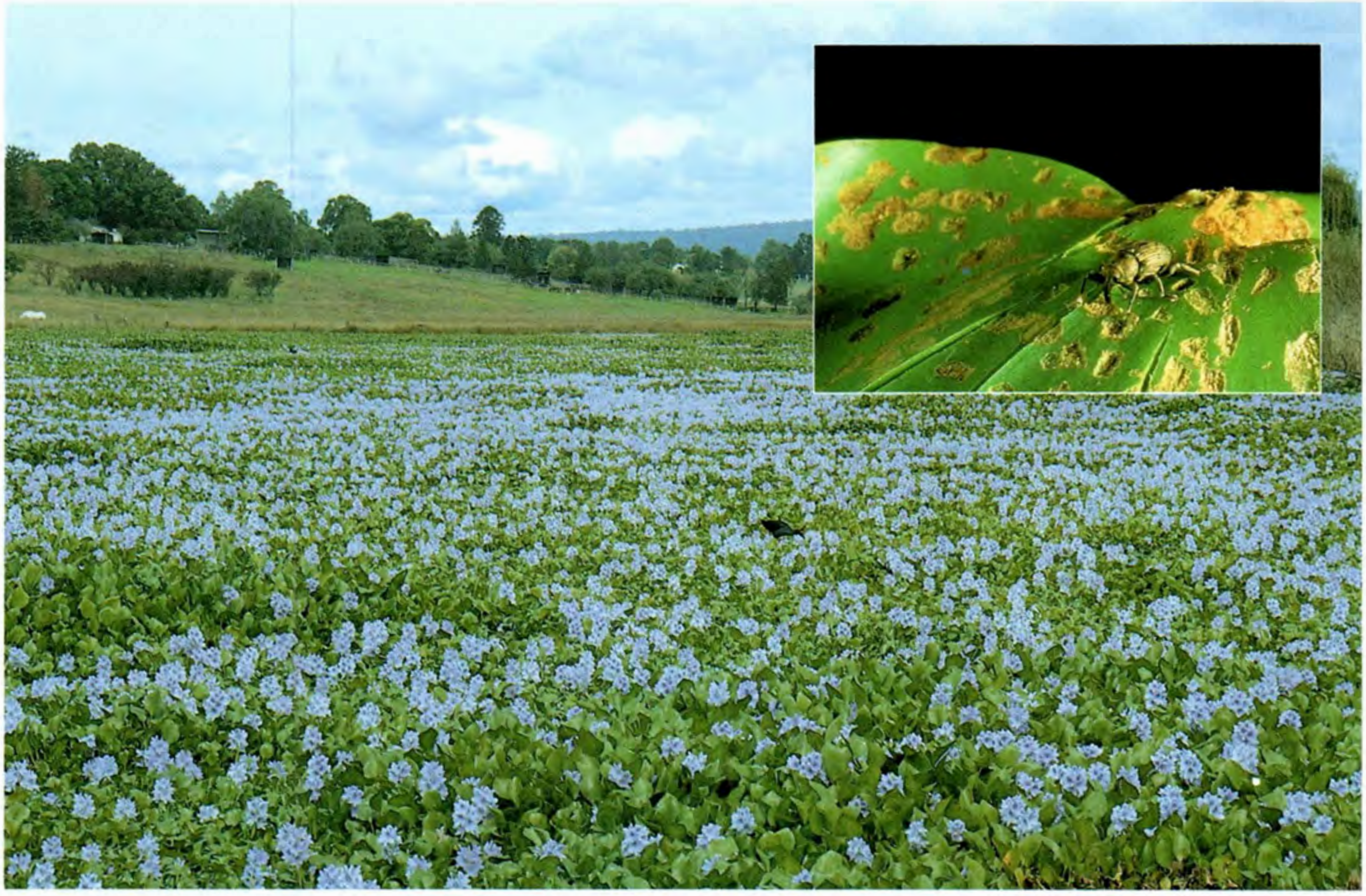
If funding can be found, a project is initiated by determining the native range of the pest, and examining the published literature to find out what is known about the target pest and its natural enemies. For a weed, formal approval is sought as a target species. Once approved, foreign surveys in the home range of the pest are conducted and the natural enemies of the pest are discovered. From this often large group, a short list of the most promising species are subjected to rigorous host-specificity testing. Only those agents that pass these tests are approved by Federal Government bodies (after wide circulation for comment to the Australian agricultural and environmental community) for release as biological control agents.

There have been many outstanding examples of classical biological control in Australia. One of the oldest programs was against prickly pear cacti (*Opuntia* spp.). Several agent species were introduced against the common pest pear *O. inermis* and other cacti. The moth *Cactoblastis cactorum* (released in 1926), whose larvae feed inside the cacti, was the most effective agent in Australia.

Several South American water weeds have been controlled with natural enemies in the subtropical parts of Australia, dramatically reducing the use of herbicides in and around water bodies. Water Hyacinth (*Eichhornia crassipes*), for example, has been controlled by a weevil (*Neochetina eichhorniae*) that feeds on leaves as adults and tunnels inside the bulbous stems as larvae. Another weevil (*Neohydronomous pulchellus*) controlled Water Lettuce (*Pistia stratiotes*) within a few years after release, and has even been more spectacular in Florida in the United States, where it controlled plants within a year after release. Widespread damage to the aquatic form of Alligator Weed (*Alternanthera philoxeroides*) was caused by a flea beetle (*Agasicles hygrophila*) within 14 months of release. Interestingly, this weed also has a terrestrial form that is not controlled by the agents, so additional surveys are needed in South America for a suitable agent.

Possibly the most outstanding example of biological control of aquatic plants is the extremely rapid control in Australia and Papua New Guinea of a water fern called Salvinia (*Salvinia molesta*) by a small weevil (*Cyrtobagous salviniae*) from Brazil. This invasive weed completely covered waterways in both countries. Innovative ecological work was combined in Brazil (the home of the weed) and Australia to match the agent with the weed. The weevil cleared blocked waterways a year after release. This project won the United Nations Science Prize in 1985 for helping save the riverine economy of Sepik villagers. More recently, the Salvinia weevil has been established in Africa, where the rapid successes are continuing.

Terrestrial weeds have also been controlled safely with natural enemies. For example, nine agent species were released in Australia against St John's Wort (*Hypericum perforatum*)—a Mediterranean weed—but only one of these, the beetle *Chrysolina quadrigemina*, contributes significantly to its control. It has controlled millions of hectares of the weed in Australia, the United States, New Zealand, Chile, South Africa and Canada, but only where there is a true Mediterranean climate (that is, predictable long,



CSIRO ENTOMOLOGY

DENSEY CLYNE/MANTIS WILDLIFE

Water Hyacinth choking a lagoon on the Nepean River, Richmond. Inset: a weevil (*Neochetina eichhorniae*) has been released to bring this South American weed under control.

dry summers followed by autumn rains). Where the climate is different from this, as is the case in the Great Dividing Range of eastern Australia, the weed is still a pest because the *Chrysolina* beetle becomes out-of-phase with the weed. How this happens is an interesting example of plant–insect interaction. If rains occur in early summer, the beetles, which normally aestivate in summer, become active and feed on what little St John's Wort is present. They soon consume all the St John's Wort and die. When the autumn break occurs, there are thus no beetles in the area to come out of aestivation, and nothing to cut back on the weed's growth. Management of this weed has thus demanded an integrated approach. In addition to the *Chrysolina* beetle, selective grazing, herbicide application, cultivation, and application of superphosphate fertilisers (resulting in significantly increased plant competition) have been used.

Two new agents have also been studied for biological control of St John's Wort. The first is an aphid (*Aphis chloris*)

L. SKILLING

One of the biological control agents that have been released to control the prickly invader Mimosa (*Mimosa pigra*) is a leaf-feeding beetle (*Chlamisus* sp.). However, it has only established with difficulty and seems unlikely to have a major effect on its own.

DON SANDS

DON SANDS

JIM FRAZIER/MANTIS WILDLIFE

Howard River, Northern Territory, shown covered in Salvinia (top) and six months later (bottom) after control by the Brazilian weevil *Cyrtobagous salviniae* (middle).

that has recently been released. It is spreading widely and is starting to have an effect on the plant. The second is a mite (*Aculus hyperici*) that attacks the growing tips of the plant and, based on studies in its home range, appears to be very effective. Host-specificity testing of this mite has been completed and hopefully it will be released next year.

An outstanding example of biological control of a crop weed also marks the world's first use of a pathogen in biologi-

E.S. DELFOSSE

TIM LOW

JOHN GREEN

St John's Wort on the foreshores of Burrendong Dam near Wellington, New South Wales. This Mediterranean weed often becomes dominant in the Great Dividing Range because the main biological control agent—the *Chrysolina quadrigemina* beetle (left)—is not successful in that climate. Inset: St John's Wort in flower.

cal weed control. A specific strain of a rust fungus (*Puccinia chondrillina*) was released in 1971 to control the most common of the three genetic forms of Skeleton Weed (*Chondrilla juncea*). By 1972 the fungus was widespread on the weed. A high level of control has persisted for nearly 20 years, with no decline in virulence and with massive economic returns to the wheat industry (estimated to be $260 million by the year 2000 for a $3.5 million initial investment). Ironically, however, the extreme specificity of this particular rust strain works against complete biological control of the weed species: the other two forms of Skeleton Weed are not attacked by it and have started to move into some of the areas formerly dominated by the most common form. Work is on-going at the CSIRO Biological Control Unit in Montpellier, France, to find virulent strains of the rust for the other two forms of the weed.

Many other examples of successful programs could be cited (see ANH vol. 23, no. 3, 1989 for a discussion of Paterson's Curse), and new programs are currently underway by CSIRO and State biological control groups for weeds such as Nodding and Slender Thistles (*Carduus* spp.), Scotch Thistle (*Onopordum acanthium*), Parthenium Weed (*Parthenium hysterophorous*), for woody weeds such as Mimosa (*Mimosa pigra*), which threatens Kakadu National Park and vast areas of the Northern Territory and Queensland, and others. Most of these projects could not be conducted without the support of the Rural Industry Research Funds, primarily from the Australian Wool Corporation, the Australian Meat and Live-stock Research and Development Corporation, and the Wheat Research Council.

No biological control agent released after detailed host-specificity testing has ever become a major pest of a crop or native plant species. This includes about 200 organisms released against about 90 weed species over the last 90 years. Thus, classical biological weed control has an extremely good safety record, and fears of lack of specificity by introduced agents (the Cane Toad Syndrome) are unfounded.

There certainly are risks that must be evaluated whenever exotic species are introduced, and such introductions should never be undertaken without exhaustive research into host-specificity and efficacy. For the conservation-minded, classical biological control of introduced weed species that threaten crops, pastures and natural areas should be supported as the best (and sometimes the only) option for safe, inexpensive, permanent and environmentally acceptable control. ■

Suggested Reading

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Dr Ernest Delfosse is a Principle Research Scientist with the CSIRO in Canberra. He is Research Leader for biological control of boraginaceous weeds, and has conducted research on biological and integrated control of terrestrial and aquatic weeds in the United States and Australia.

DESIGN BY PLANKTON

In the 17th century, pioneer microscopist Anton van Leeuwenhoek was probably the first person to see minute creatures, which he called 'animalcules', in pond water. His crude glass lenses were refined and in the 1950s the scanning electron microscope was developed. This instrument gave scientists their first close-up look at this architecturally fascinating and beautiful world of single-celled plankton. These minute plants and animals are so small that 100 could easily fit on the head of a pin and their size is measured not in millimetres but in thousandths of millimetres (microns).

Gustaaf's investigations of the plankton of Australian waters assist oceanographers in delineating the extent of cold- and warm-water currents, and fisheries biologists in finding out which plankton species are critical food for the larvae of commercially important fish. The micrographs shown here have been selected from Gustaaf's book *Plankton: a microscopic world* (CSIRO Publications, $29.95).

BY GUSTAAF HALLEGRAEFF
RESEARCH SCIENTIST, CSIRO

'Birthday cake diatom' *Actinoptychus senarius* (diameter 30 microns). The pill-box shaped silica cell wall is ornamented with pores, ribs and spines radiating in spectacular geometry across the cell surface.

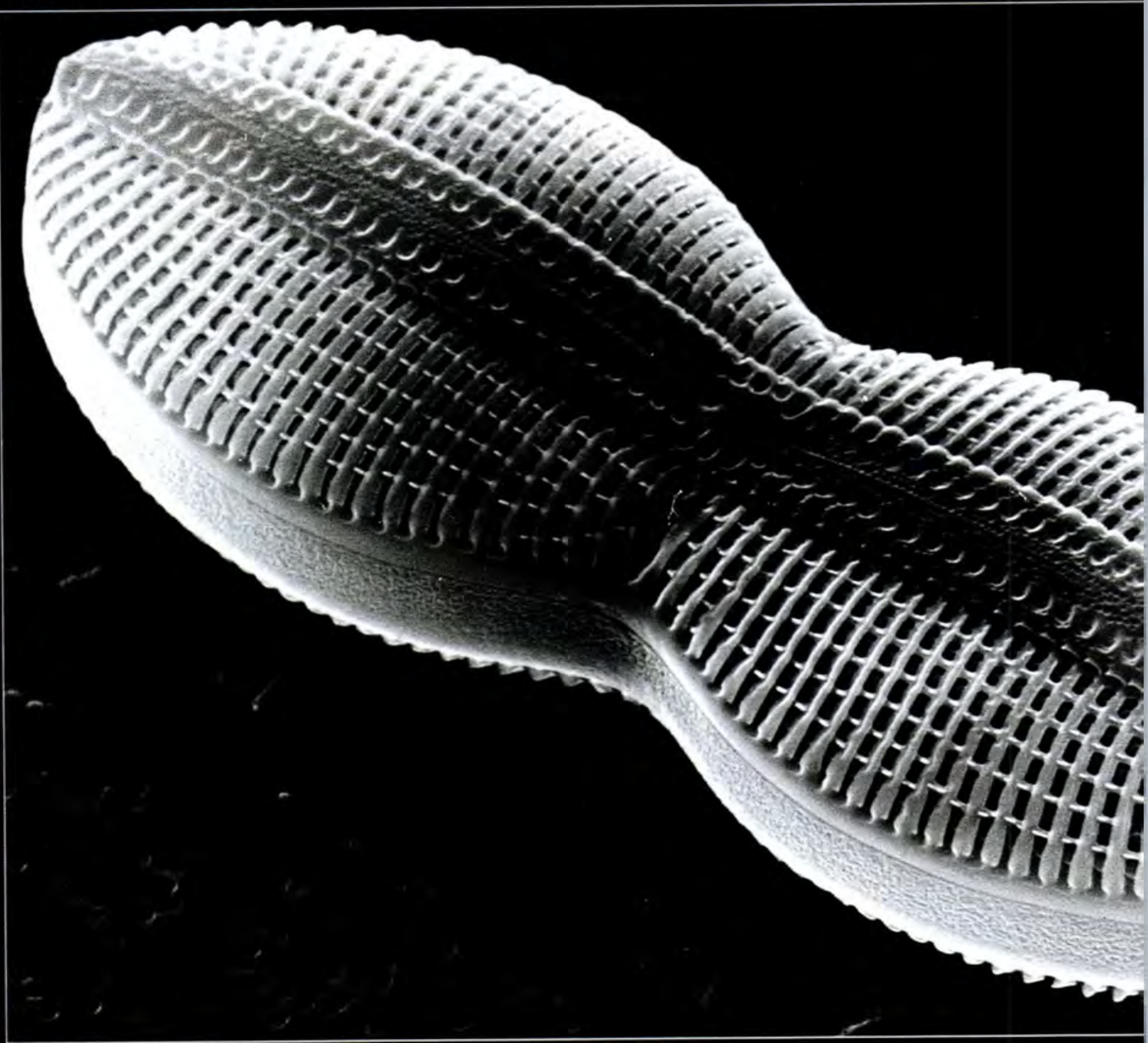
'Leaning Tower of Pisa', the diatom *Paralia sulcata* showing interlocking cells forming a chain (diameter 30 microns).

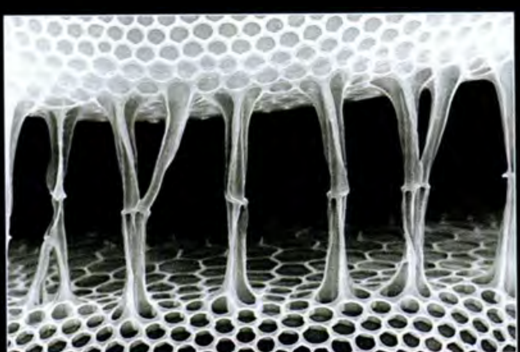
Pair of *Thalassiosira allenii* diatoms, the top cell in frontal view and the bottom cell in side view. Mucous threads exuded from the tube-like processes are used for colony formation (diameter 15 microns).

A group of *Umbilicosphaera sibogae* (individual cell diameter measures 20 microns). This coccolithophorid plankton is covered with delicate calcareous scales called coccoliths, which are also known from sedimentary deposits over 150 million years old.

DESIGN BY PLANKTON

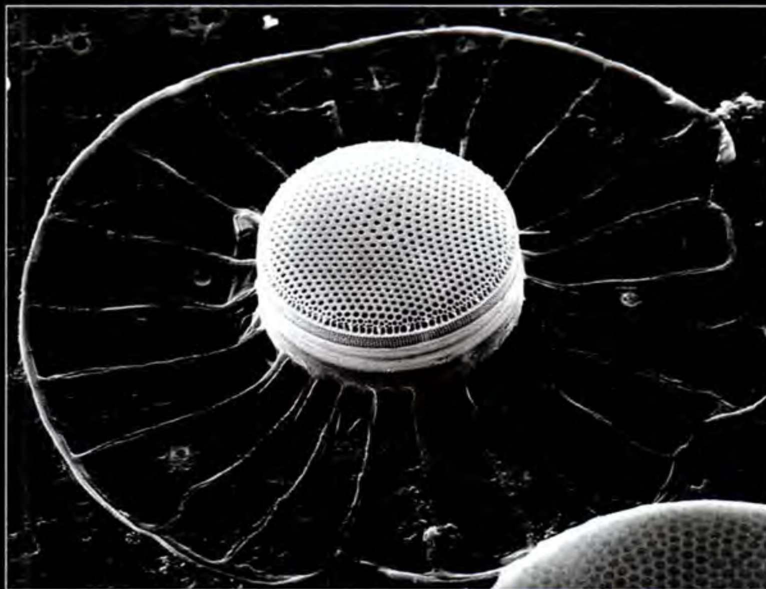
'Footprint-shaped' diatom *Diploneis* sp., caught gliding on the surface of mudflats on Rottnest Island, Western Australia (length 50 microns).



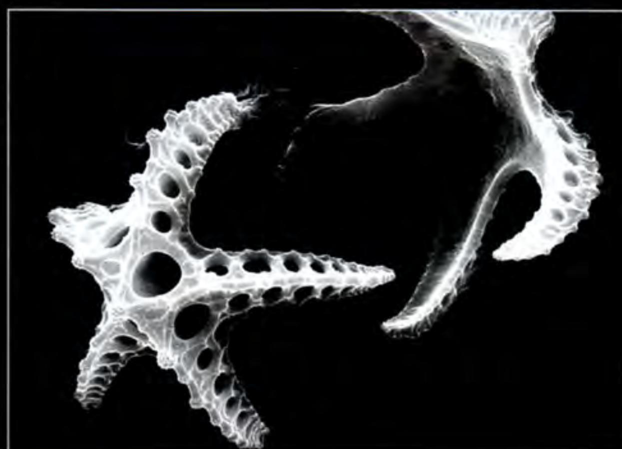


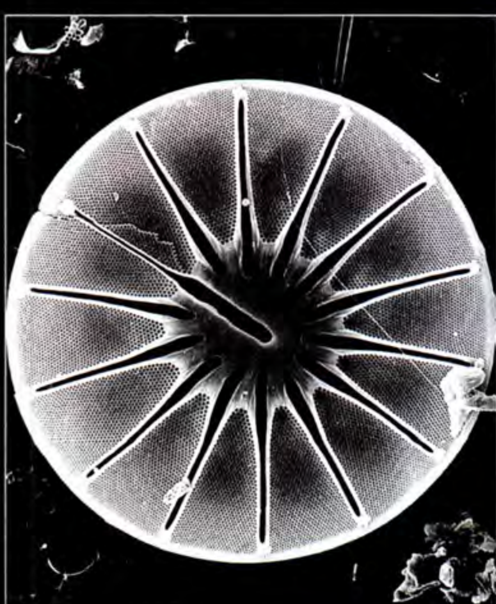
Pillar-like connections between two cells of the chain-forming diatom *Stephanopyxis palmeriana* (total diatom diameter 80 microns).

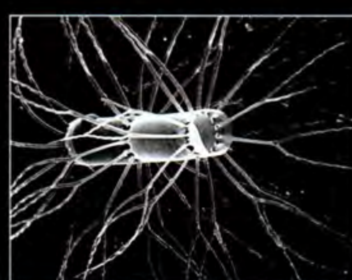
Tropical diatom *Planktoniella sol* with parachute-like wing, which is thought to act as a flotation device (diameter 60 microns).



Star-shaped, siliceous internal skeleton of the dinoflagellate *Actiniscus* sp. These structures have been recovered from fossil sediments over 50 million years old (diameter 30 microns).







'Spider diatom' *Asteromphalus elegans* (diameter 40 microns).

Tropical chain-forming diatom *Bacteriastrum furcatum* with hair-like extensions that are thought to act as a flotation device in less dense, warmer waters of north-western Australia (diameter 30 microns).

"Male nipples may be non-functional vestigial organs—structures betraying an earlier evolutionary condition where both sexes nursed the young."

COMING TO GRIPS WITH MALE NIPPLES

BY MICHAEL ARCHER
SCHOOL OF BIOLOGICAL SCIENCE
UNIVERSITY OF NEW SOUTH WALES

I'LL BET I'M NOT THE ONLY MALE IN THE world who used to feel puzzled and even somewhat squirmy about his nipples. As a young adolescent, it seemed to me that these embarrassing buttons were pasted onto our chests by mother nature to mock our emerging maleness. After all, what possible good were they? Female nipples, on the other hand, were things of mystery and intrigue, part of all that was delightfully woman.

As evolutionary biologists, we are constantly exposed to plausible, if highly imaginative, *post hoc* explanations for the evolutionary development of some structure or behaviour that lacks an adequate fossil record—evolutionary 'just-so' stories as it were. What kind of 'just-so' story could possibly account for male nipples?

Perhaps in the first mammals, *both* males and females shared the task of nourishing the young with milk, the protein-rich skin secretion unique to mammals. Then, at some time this side of 200 million years ago, in a major setback for sexual equality in mammals, males may have begun to specialise at other tasks and shrivelled, while females kept well abreast of the situation and doubled their output. Since then, male nipples may simply have persisted because there was no good reason for natural selection to rub them out. Like the rudimentary hind limbs complete with leg bones and muscles occasionally found protruding from the pelvic regions of whales, male nipples may be non-functional vestigial organs—structures betraying an earlier evolutionary condition where both sexes nursed the young.

Certainly it is clear that genetic instructions for a belly-full of nipples lurk somewhere in the shadowy corners of the human genome. While humans rarely sport more than the standard two-on-the-chest, some individuals (males more frequently than females) are found with extras in other positions. The condition is called polymazia and the largest number recorded is ten. These extra breasts may be an atavism (reappearance of an ancestral condition) because they mostly occur along the position of the primitive mammal nipple lines, which extend, one on each side, from the front of the chest to the lower abdomen. Some mammals produce nipples only at the front of these lines (humans and bats), others at the rear (cows and marsupials), while some go the whole hog (dogs and pigs). Humans of both sexes appear to retain the genetic potential for sporting nipples along the entire length of these prehistoric refuelling lines.

Breasts, nipples and milk do occasionally sprout from other areas of the body (in 1835 a 21-year-old man was recorded whose scrotum exuded milk; Howard 1977) but these are abnormalities presumably resulting from bits of embryonic tissues developing in the wrong place such as dermoid cysts in female ovaries that sometimes contain teeth.

But humour a minor divergence here: if male nipples are useless lumps of ancient history reflecting a more egalitarian past, what of males themselves? What are males as a *whole* in the grand scheme of biological things? Females of many species get along quite well without them, thank you very much. Parthenogenetic births, where eggs develop into viable embryos in the absence of sperm, are surprisingly common in the animal kingdom. Parthenogenetic species are also well known, such as lizard species from central Australia that are only known from females. So why *does* the world have males?

Even though many biological reasons have been offered for males, it amuses me to consider the similarities between the sneaky way sperm invades the egg and tricks it into reproducing the male's DNA, and the way that a virus tricks a host cell into reproducing viral DNA. Understandably, it might not do much for the male ego to be thought of as an incurable, sexually transmitted disease that first infected females 1.5 billion years ago. But perhaps that's how sexuality started?

Whatever, the point follows on. The mass of all humans, from Arnold Schwarzenegger to Madonna, is almost totally made of grade-A female stuff. This is because sperm, being stripped down as it is for the death-defying race along the vaginal–uterine speedway, brings little else to gamete-gathering parties apart from its infective strands of DNA. The naive egg squatting on the finishing line congratulates the infectious winner by swallowing him—something eggs have done to sperm for millions of years, which is perhaps an intimation of how gametic fusion began in the first place—an indigestible meal that came to stay, much in the same way that free-living mitochondria and chloroplasts are thought to have been 'swallowed' by prokaryotic predators but then retained as organelles (Margulis 1981). Anyway, *all* the rest of the resulting embryo is derived from female tissues present in the egg because she alone has the factories and raw materials necessary to build the new beast. He does little else apart from corrupt her genetic blueprint for a female clone.

Seen in this light, it is not the female of the species whose body form departs from the essence of humanity—it is the male. Basic human is female; basic male is perversion of basic female. It is only if and when male hormones (in particular testosterone) start rampaging through our system, following instructions from a rogue 'maleness gene' hidden somewhere on the Y chromosome, that distortion of the basic female pattern occurs. The ovaries do not develop, the developing brain converts from a cyclic to a non-

A woman sports four breasts. This rare condition is known as polymazia.

TESSA GUILFOYLE

One of a number of male goats from a Bathurst herd that showed conspicuous udders as well as scrota and penises. These males sired many of the herd's young.

cyclic organ (the female hypothalamus undergoes monthly cycles in harmony with the cycles of the solar system—imagine how the male ego would have capitalised on this cosmic synchrony if males rather than females menstruated!), the presumptive clitoris develops into a penis, the Müllerian ducts (which normally transport eggs) degenerate, the pelvic bones narrow and humanity's exquisite curves vanish—a metamorphosis so profound it would make Dr Jekyll livid with envy.

Returning to the central points of this essay, maleness may be a perversion of femaleness but, at least when it comes to male nipples, the essential female ground plan is still there. It has long been known that, if male animals are given injections of female hormones, their normally small breasts will enlarge (a condition known as gynaecomastia). For example, if male Echidnas are given ovarian hormone injections, their breasts not only become larger than those of the females, they also begin to secrete milk. Clearly male and female breasts are 'equipotential' insofar as both are capable of producing and secreting milk.

In some human males, as Director of the Sydney STD Centre (Sydney Hospital) Dr Basil Donovan recently told me, constant manipulation of the nipples can cause them to exude colostrum, a protein-rich milk. While the glandular tissue in the male breast rarely merits even a training bra, the duct that normally conducts milk to the nipple does persist in males. If there are higher than normal levels of female hormones (oestrogen, prolactin etc.) in the male's system (such as may occur if there is a tumour of the pituitary gland), the glandular tissue of his breasts may enlarge and he may secrete milk. And just as females without children can be induced to produce milk by allowing someone else's infant to suckle their breasts, some males can do the same. Sixteenth-century missionaries in Brazil even reported a tribe whose women had "small and withered breasts and whose children were brought up from birth by suckling the males" (Howard 1977).

Perhaps a similar uncommon balance of male and female hormones accounts for a herd of goats in the Bathurst area reported to me by Ms Tessa Guilfoyle of Sydney University. The males in this herd not only had huge udders but were deliberately milked by the goatherds who obtained copious quantities of milk.

Here then might be another rationalisation for hanging on to male nipples: as a fall-back system should future natural selection pressures once again nudge males towards a more active role in nourishing their infants. This possibility, combined with the theoretical capacity of males to give birth (via implanted ectopic pregnancies and caesarian deliveries), invites organisations working towards sexual equality to broaden their horizons.

The point of this catalogue of curiosities is not to jam a pin into the chest of macho males or provide a biological rationalisation for the women's liberation movement. Even if males *are* a prehistoric sexually transmitted disease, females have long since come to terms with the plague much as humans as a whole have learned to live with the common cold. On the other hand, because I suspect that most of the blame for human damage to the environment can be laid squarely at the feet of the perverse little bit of DNA that codes for male aggression, can the *Earth* continue to tolerate males?

Anyway, I feel a bit better about my miserable male nipples. Rather than seeing them as pointless bits of biological history, they now appear as reminders of the vast, ancient maternal core lurking just below the thin veneer of all that's male—things that should make the chest-thumping of males sound decidedly hollow. ■

Suggested Reading

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

"With the shift of emphasis from the static to the dynamic—and with the social effects of the French Revolution—the usefulness of hierarchies in biology seemed at an end."

THE SACRED ORDER

BY RALPH MOLNAR & GLEN INGRAM
VERTEBRATE FOSSILS, QUEENSLAND MUSEUM
VERTEBRATE ZOOLOGY, QUEENSLAND MUSEUM

If you have served in the military, you will be familiar with the concept of a hierarchy. Military personnel are given ranks corresponding to the scope of their authority. Those with greater scope are toward the 'top' and those with lesser toward the 'bottom'. In addition to rank, hierarchies have other features: consider that of the Royal Australian Navy (RAN). In order of increasing rank the levels are ordinary seaman, able seaman, leading seaman, petty officer, chief petty officer, warrant officer, sub-lieutenant, lieutenant, lieutenant-commander, commander, captain, commodore, rear admiral and vice admiral. (The admiral participates in the command of the entire Australian Defence Force and so is not included here as part of the RAN.) These ranks have different duties. The rear admiral may decide that the fleet will proceed to the South China Sea, while the commodore might decide that squadron three will make the move. The commander might then decide that HMAS *Runabout* will accompany the third squadron, while the lieutenant in command of that vessel will decide when they will leave Darwin to rendezvous with the squadron in the South China Sea. Each lower rank carries out the decisions of the next higher rank and makes the decisions appropriate to his rank to carry out his superior's orders. So influence 'travels' down the hierarchy from higher to lower rank. Such influences (the orders) are transitive downwards—they affect not only the rank at which they are made, but all ranks below it.

Other influences, in this case reports, are transitive upwards. The chief petty officer reports the condition of the vessel to the lieutenant, the lieutenant reports to the commander, and so on. In this hierarchy information is transitive upwards. Note that the same influences are not transitive both upwards and downwards. A leading seaman may report to a warrant officer, but the warrant officer issues orders to the leading seaman. It is in the nature of hierarchies that the upward and downward influences are not the same.

Not all actions at a given rank are transitive. The lieutenant in command of HMAS *Runabout* decides *when* the vessel will get underway, but it makes no difference to him *how* the vessel gets underway. The leading seaman may start the engines by pressing a button, throwing a switch, or even punching "get underway" into a computer console; it is all the same to the lieutenant (so long as the vessel does get underway). The method of starting the engines is unique to one level of the hierarchy.

Each level in this hierarchy is distinct: captains do not take on the duties of lieutenants, and leading seamen only assume the duties of chief petty officers when they are promoted to that rank.

The military hierarchy is a relic of earlier social hierarchies, of which perhaps the best known is that of traditional Indian society. Not only are the social groups distinct, but some are perceived as superior to others. Most, if not all, societies are stratified into a hierarchy—a word derived from a phrase literally meaning 'the sacred reign' (even the gods had hierarchies). The social hierarchy seems to be of great antiquity.

It is not surprising that hierarchies were also perceived in the natural world. Living organisms, for example, were arranged in a scale of lower to higher, known as the *scala naturae*. Plants were at the lower end of the *scala* and animals, arranged according to the increasing sophistication of their behaviour, toward the top. This arrangement reflected the degree of their similarity either to God (at the higher end), or to inert matter (at the lower). Each level was seen as distinct from every other. The discovery of the hydra by Abraham Trembley in 1740 was thus considered a shock to the system, until it was realised that hydras simply belonged to a hitherto unknown level.

Darwin's theory of evolution explained the *scala* as the result of a continuing process, natural selection, and later modifications of evolutionary theory have added further processes. Thus the *scala naturae* came to be seen not as an established order designed by the Almighty but as the result of dynamic processes. This reflected the integration into biology of processes pioneered for physics by Galileo two-and-a-half centuries earlier. With the shift of emphasis from the static to the dynamic—and with the social effects of the French Revolution—the usefulness of hierarchies in biology seemed at an end.

However, just as social hierarchies had been rehabilitated by the recently deceased Marxist governments of eastern Europe, biological hierarchies have again come into favour. These hierarchies, however, are fundamentally different from the old *scala naturae*. The *scala* ordered the various and diverse known organisms by kind, that is, roughly by the species of modern biology. The modern hierarchies of biology order entities such as genes and populations, which are sometimes less perceptible but no less real. The levels of the hierarchy are not taken to be higher or lower in the same sense as those of the old *scala*. The old terminology is still retained but the direction of the major influence is often reversed (from 'lower' to 'higher').

Perhaps the most concise of the hierarchical evolutionists is Dr Niles Eldredge from the Department of Invertebrate Palaeontology at the American Museum of Natural History, New York. He has suggested that there are two hierarchies. One, which he terms the genealogical hierarchy (GH), includes reproducing enti-

ELDREDGE'S HIERARCHIES

GENEALOGICAL HIERARCHIES	ECOLOGICAL HIERARCHIES
Monophyletic taxon	Regional biota
Species	Community
Deme	Population (or avatar)
Organism	Organism
Reproductive cell (gamete)	
	Somatic cell
Gene	Molecule

D. PARER & E. PARER-COOK/AUSCAPE INTERNATIONAL

Interactions do occur at higher levels of biological hierarchies. Pack hunting by African Hunting Dogs (*Lycaon pictus*) is an example of energy acquisition by a population.

ties and the other, the ecological hierarchy (EH), includes ecological entities. The entities of the EH are involved in the give and take of obtaining energy, primarily by eating or photosynthesis. The interactions of these two hierarchies produce evolution.

Each level of the GH, such as cells (gametes), organisms or species, is considered to be made up of individuals. It is easy enough to recognise separate gametes and organisms as individuals, but we are not used to thinking of species in that light. Nonetheless Eldredge points out that, like reproductive cells and organisms, species have distinct, if sometimes diffuse, boundaries. They also have a discrete origin in time (at the event of speciation) and a discrete 'death' (extinction). Furthermore, they have an internal cohesion or 'glue' that is provided by the reproduction of their component groups. In biology such a component group of reproducing individuals is called a deme. Each entity in the GH has its own characteristic process for making more of itself: genes replicate, chromosomes duplicate, gametes divide, organisms reproduce, demes colonise and species speciate.

And every so often a more profound change may occur in an evolving lineage, with the appearance of differences greater than those that distinguish species. This kind of change marks the appearance of a new monophyletic taxon. It may occur at any level 'above' that of species, even at the family, class or order levels. Eldredge points out that these 'higher' taxa are more resistant to extinction than species. When the level of phylum is reached, that is of groups such as molluscs and arthropods, few of these groups have ever become extinct.

While the lower-level entities of the EH are clear, the higher-level entities (such as biotas or communities) are notoriously difficult to perceive and define. Yet this difficulty may well stem only from our own position, as organisms, in the EH rather than any unreality of the higher levels themselves. We can see directly some interactions at the population level: Eldredge points to pack hunting as an example of energy acquisition by a population.

The hierarchies show both upward and downward influences. 'More-making', as Eldredge calls it, of entities at one level in the GH provides the cohesion for those of the next higher level. But while the processes of 'birth' are unique to each level, those of death are transitive upwards. The deaths of all organisms in a deme will bring about the death of that deme and the 'deaths' of all demes in a species will cause the extinction of the species. Genes, at a lower hierarchical level than organisms, upwardly influence the structure and metabolism of the organism. But natural selection downwardly influences the makeup of the pool of genes by acting on organisms.

How do these hierarchies interact? The impact of the EH on the GH is what we call natural selection according to Eldredge, while it is the GH that provides the participating entities for the EH.

Hierarchies seem to be an inherent feature of biology and in 1973 Richard Levins gave reasons why hierarchical organisations, such as the GH, would be expected as the result of natural processes, especially natural selection. He ended his paper with the observation that we had got it wrong: "Confusion evolves into order spontaneously. What God really said was, 'Let there be chaos'." ■

Suggested Reading

Allen, T.F.H. & Starr, T.B., 1982. *Hierarchy.* University of Chicago Press: Chicago.

Eldredge, N., 1985. *Unfinished synthesis.* Oxford University Press: Oxford.

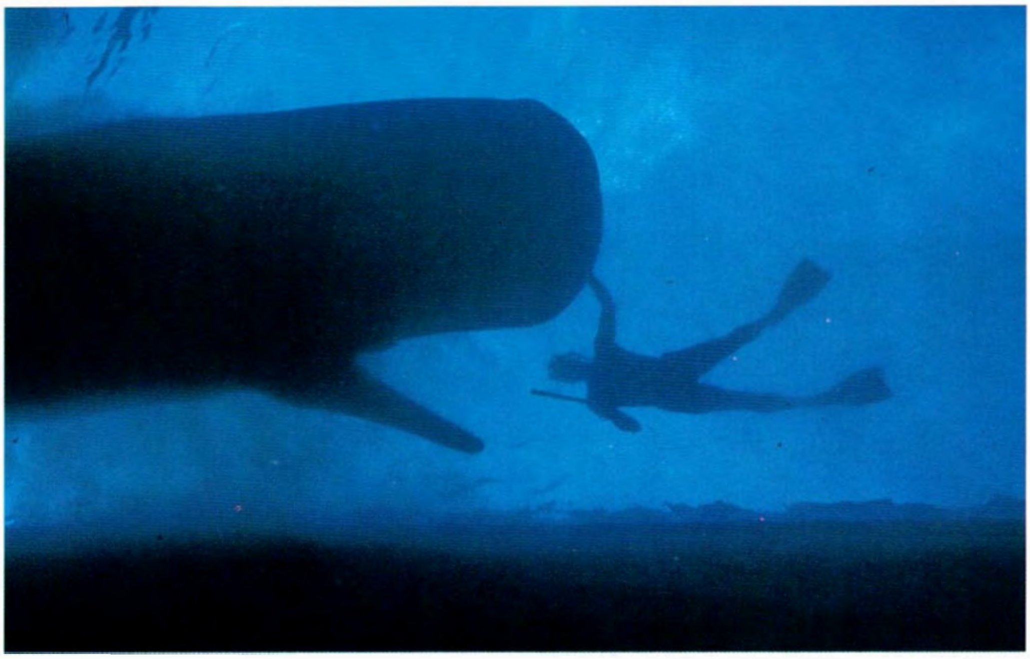
Levins, R., 1973. The limits of complexity. In *Hierarchy theory,* ed. by H.H. Pattee. George Braziller: New York.

Salthe, S.N., 1985. *Evolving hierarchical systems.* Columbia University Press: New York.

Dr Ralph Molnar is curator of Palaeontology at the Queensland Museum. His research has been directed towards filling the vast gap in knowledge of Australian vertebrate history between the Devonian and the Miocene. Dr Glen Ingram is interested in evolution and the philosophy of science. In 1987 he received a special commendation from the BBC Wildlife Nature Writing Awards.

QUESTIONS & ANSWERS

COMPILED BY JENNIFER SAUNDERS
EDITORIAL ASSISTANT



RON & VALERIE TAYLOR/ANT PHOTO LIBRARY

The Giant Sperm Whale, *Physeter macrocephalus.*

A Whale by any Other Name

Q. Depending on which book one reads, the Giant Sperm Whale seems to have two apparently valid scientific names: *Physeter macrocephalus* and *P. catadon.* I read somewhere that the great Linnaeus himself may be to blame. Which is correct?

—Thomas Cobcroft
Ipswich, Qld

A. This is one of those problems that have kept taxonomists busy for years and years, and still it seems that the argument continues. Yes, it is the fault of Linnaeus; he did indeed use both *Physeter catadon* and *P. macrocephalus* in 1758. For many years *P. catadon* was used as it was the first species name. There was some argument that *P. macrocephalus* applied to a different whale, and not the sperm whale. Lately, however, the *P. macrocephalus* supporters have argued that both names are synonyms for the same animal and so the rule called 'first revisor' applies. This means that the first zoologist to revise the taxonomy of the species decides which name applies. In this case, that means *P. macrocephalus* is correct. So current usage supports *P. macrocephalus* as the correct scientific name for the Giant Sperm Whale.

—Linda Gibson
Australian Museum

Paul's IPAT

Q. Could you please answer a query of mine regarding the IPAT equation mentioned in the radio talks given by Paul Ehrlich when he visited Australia recently. The equation is

$$I = P \times A \times T$$

where 'I' refers to environmental impact,'P' population size, 'A' level of affluence and 'T' destructiveness of technology needed. I would like to know what the units are for each of the four variables, that is, how are they quantified and against what etalons?

—J.C. Larcey
Glen Waverely, Vic.

A. 'A' is per capita affluence or consumption, and 'T' is some measure of the environmental destructiveness of the technologies employed to supply each unit of consumption. Obviously, the equation is just a heuristic device and is an oversimplification since the factors are not independent. About the closest we come to actual quantitative treatment of the situation is to use per capita commerical energy consumption as a surrogate for 'A' x 'T'. That can be justified as an approximation, but only as that.

—Paul Ehrlich
Stanford University, Ca., USA

Cockroach Saga Part III

Q. The cockroach problem in my household has, I'm afraid, worsened. No longer content with merely joy-riding in the microwave, they have decided to damage the workings of my flatmate's answering machine to the tune of $67.00. Is there any way of getting rid of the little beasts without having to spray the entire house full of noxious chemicals (which never last long anyway)? I've also tried a number of old remedies including bay leaves, bicarbonate of soda and simply stamping on them. Are there any new, simple and

ANTHONY FARR/AUSTRALIAN MUSEUM

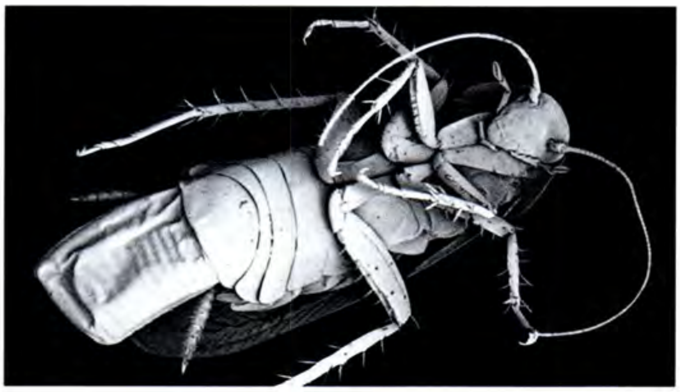
Professor Paul Ehrlich explains his theories on population dynamics to staff at the Australian Museum.

environmentally safe ways to rid our house of the mongrels?

—Matthew Feierabend
Kirribilli, NSW

A: At severe levels of infestation, there is no magical cure for hordes of ravaging cockroaches. Indeed, if there were, somebody certainly would have marketed it and made a fortune by now. If you don't want to use pesticides, you may have to live with the problem. Once cockroaches have taken hold they are extremely difficult to remove. The old remedies can and do work—but usually only at low levels of infestation. It sounds like the level of infestation in your household is high, so an all-out effort is called for. I suggest that you and your flatmate spend an entire day or weekend on 'Operation Cockroach'. Thoroughly scrub all areas of the house where the cockroaches occur, especially the kitchen. Remove and wash everything in the cupboards, making sure that any unsealed food is stored in airtight containers. Seal all cracks—around drainage pipes, under benches, around the sink, and anywhere else they come in—with silicone sealant. Dust any breeding areas and thoroughfares (that are not human 'contact' areas) with small quantities of diatomaceous earth (available from pool supply shops) or spray with synthetic pyrethroids. And finally, get a bulk supply of sticky traps from the hardware store and place these around the house (or make your own baits from borax and honey—but make sure they are inaccessible to children and pets). Follow up by removing all dead cockroaches and, most importantly, maintaining a high level of hygiene. Outside the kitchen you can use 'Roachban' cockroach bombs, which contain a mixture of hydroprene (a growth steriliser) and pyrethrin.

Most people's idea of a good cockroach is a dead cockroach.



GEOFF AVERN

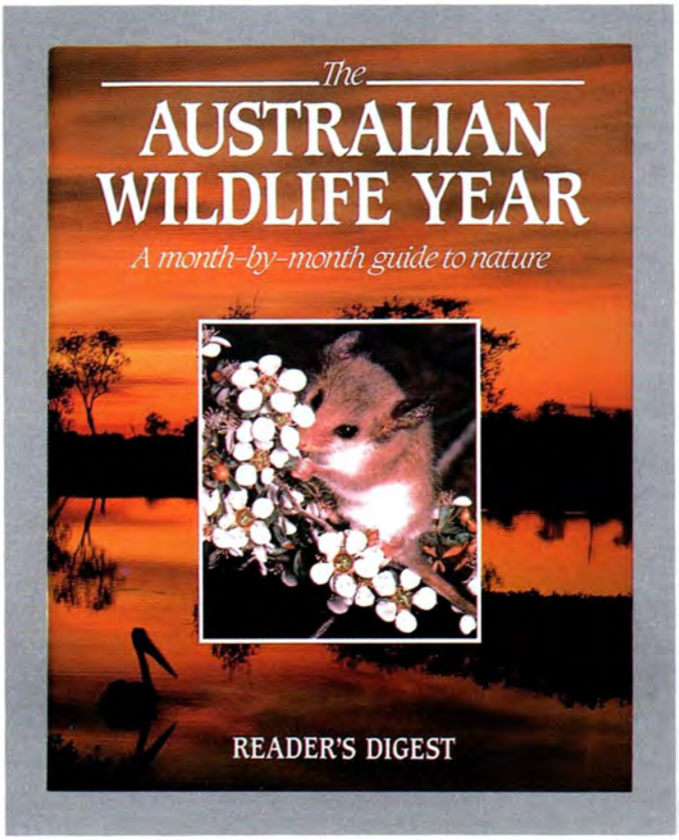
Cockroaches are attracted to electrical equipment because of the warmth. (We even had a couple move into our fax machine in the ANH office!) They cause havoc with the equipment because they can short-circuit it, either by simply walking over or defecating on the circuitry. The only way to rid your electrical appliances of the vermin is to place the appliance inside a big black plastic garbage bag, seal off the opening and leave it out in the sun for a few hours. The high temperature should kill any insects hidden inside but, should it fail, you will have to resort to a squirt of pyrethroids inside the bag. How dead cockroaches affect electrical equipment I don't know. Rotting corpses might even be worse than live cockroaches!

You could always try another old remedy, which I found in the very first issue of this magazine (vol. 1, no. 1, 1921): "Cockroaches are best destroyed by placing baits of borax and breadcrumbs, or equal parts of ground-up chocolate and borax, in the places where they lurk. Plaster of Paris sprinkled about will also be greedily consumed by the insects, and on being taken into their digestion system it hardens, and so causes death. Paris green blown into their hiding places has the effect of driving them out." No guarantees for success, but I'd be interested to hear if anyone has tried this, or knows of a way to get cockroaches out of electrical equipment without damaging it.

—F.D

REVIEWS

COMPILED BY JENNIFER SAUNDERS
EDITORIAL ASSISTANT



The Australian Wildlife Year

By David Underhill. Readers Digest, Sydney, 1989, 336 pp. $45.00.

The Australian Wildlife Year is packed with full-colour photos, together with an interesting text that assumes no prior knowledge of wildlife. It takes an eclectic approach to Australia's animals and plants, covering a wide range of topics and events.

Most of the book is devoted to a month-by-month account of what various creatures are doing at different times of the year and what interesting events are taking place. Also included are sections on how our erratic climate affects wildlife and a useful table of wildlife events throughout the year.

Unfortunately the seasonal approach does have its drawbacks, as species accounts may end up being spread over half a dozen chapters. To get around this difficulty, the author has wisely kept only loosely to the monthly format. So, for example, April deals with interesting general accounts of spiders and flying foxes, as well as seasonal information on ducks, logrunners, boobies, frigatebirds, fish and prawns.

The guide to observing wildlife contains some good ideas—such as going out at dawn and dusk, keeping a notebook of sightings, using your car as a hide and being aware of how the weather will affect the things you want to see. Unfortunately binoculars (one of the naturalist's most useful tools) are not very well dealt with here; you couldn't, for example, go out and choose the right ones after reading this section. In a book of this size, a few extra paragraphs on this point would have been easy to include, making this section much more useful.

One interesting piece of trivia included in this work concerns the courtship of Blue Sharks. The male's idea of 'whispering sweet nothings' is to bite the female's back and sides—hard. To cope with the dental equipment of these over-zealous Romeos, females have especially thick skin in the appropriate areas.

In a nature book of this length, there are bound to be a few problems of fact and disagreements about interpretation. For example, the section on bushfires suggests that all eucalypts need fire to reproduce and that the trees retain their seeds until a fire releases them from the gumnuts. This isn't true for most eucalypts, which drop their seeds each year. The scribbly gums that come up each year in my lawn—without fire—certainly don't fit this rule.

More seriously, the book inadvertently gives only one side of a current debate over fire management. The adaptations of plants to fire feature so prominently that you could be forgiven for thinking fires pose no problem at all for our plants. But no mention is made of the problems caused by fires occurring too close together.

The recent trend towards burning the bush each year during the cooler months, to reduce fire fuels, has great potential for wiping out some species. Plants like banksias that rely on seeds to reproduce are vulnerable. Although their seeds can survive fire, it takes about five years for the seeds to grow into plants old enough to set their own seeds. If another fire comes through the area before this time, the species can be virtually eliminated. By omitting this point, the book plays into the hands of those who would burn the daylights out of the bush each year. Hazard-reduction burning is needed, but it must be used with care.

There are several other inaccuracies throughout the book, but they are generally quite minor and detract only minimally from the book. Its interesting text, original approach to the topic and lavish illustrations make it a very nice addition to the bookshelves of anyone who enjoys nature.

—John Dengate
NSW National Parks and Wildlife

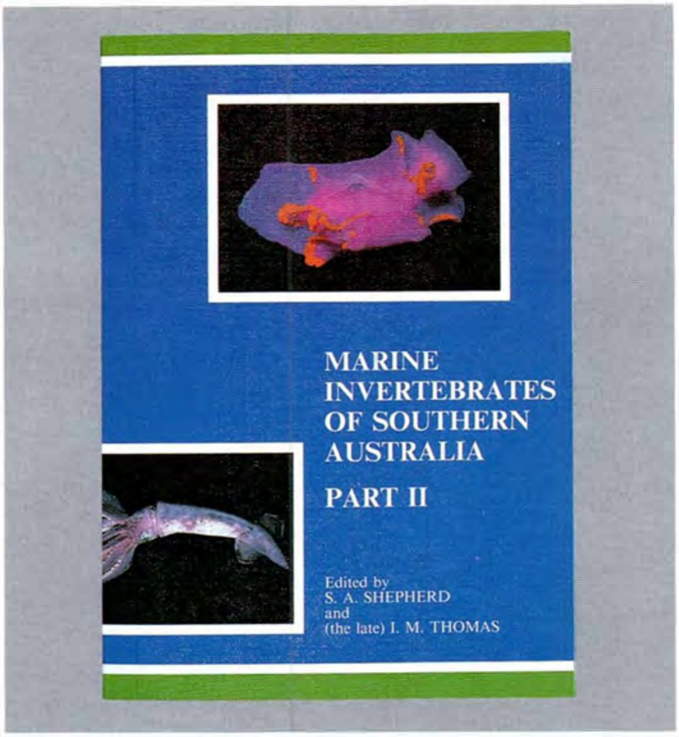
Marine Invertebrates of Southern Australia Part 2

Edited by S.A. Shepherd and I.M. Thomas. South Australian Government Printing Division, Adelaide, 1989, 400 pp. $39.95 (softcover); $49.95 (waterproof).

In 1982 the first of what promised to be an excellent series of handbooks on the marine invertebrate fauna of southern Australia was published by the Flora and Fauna of South Australia Handbooks Committee (South Australian Government). After many years of gestation the second volume, which deals entirely with molluscs, has now been published.

Molluscs, or at least their shells, have been prized collectors' items for centuries, and the South Australian region is historically important for the early collections made by the French during Baudin's voyages on the *Astrolabe* and *Naturaliste* at the beginning of the 19th century. As mentioned in the introduction to this volume, the shallow seas of South Australia support a unique regional molluscan fauna, having its origin, according to N.H. Ludbrook, largely in the faunas of the southern basins formed in the Tertiary after the separation of Australia from Antarctica.

Shell collectors and other students of molluscs have been well served in South Australia from the first published studies by Lamarck in 1818 to the exhaustive *Handbooks of the South Australian Mollusca*, first published in 1938 by B.C. Cotton and F.K. Godfrey, and continued in updated sections by Bernard Cotton until 1961.



Shepherd and Thomas' handbook, then, has to be compared with these earlier studies. Specialist authors have prepared chapters on different groups with comprehensive accounts on the chitons, bivalves, opisthobranchs, cephalopods and planktonic forms. A most innovative and well-illustrated section deals with molluscan egg masses and should be useful for shell collectors and ecologists who often find these puzzling and usually unidentifiable objects.

For a book of this nature it is curious to find that the many groups of sea-snails are dealt with in a cursory manner. In the introduction we are told that "only common and representative species of the region are described briefly and figured". With such a speciose phylum it is necessary to balance the cost of exhaustively describing every known species against the need to present a representative coverage. Unfortunately there are groups that are not given even a representative coverage. For example, among micromolluscs, not one species of the Eatoniellidae, "which reach their greatest numbers in New Zealand and southern Australia", is illustrated, and for the Rissoacea, another prolific group of micromolluscs, only two species living in hypersaline environments are figured.

Among the larger gastropods, perhaps of more interest to shell collectors, there are also puzzling gaps. There are coloured illustrations of five species of the volutes but, in the text, only two species are described and well-known species are not mentioned. Of even greater surprise is the lack of coverage of the Toxoglossa. This huge superfamily of advanced carnivorous snails has many southern representatives. In this handbook they are represented by one species of *Conus*.

In the introduction mention is made of the characteristic, often endemic fauna that is covered in this book, yet no attempt has been made to draw the reader's attention to examples of this endemism. Perhaps the editors of this multi-authored book should have written an introductory account tying the various chapters together and discussing some of the features of this undoubtedly interesting fauna. One last criticism: many of the black-and-white plates have been prepared by cutting out individual photos and rephotographing them. This only works satisfactorily when the cutting-out is done meticulously and accurately. In many cases this has not occurred and the shape of many of the shells has had to be guessed.

To finish on a more positive note: the coloured illustrations are on the whole excellent and cover a representative section of South Australian molluscs. Throughout the text there are many snippets of biological information that raise this publication above the level of most typical descriptive shell books. Hopefully any future edition will concentrate on replacing some of the plates and filling in a few of the obvious gaps in coverage.

The authors, and especially the editors, are to be congratulated for persevering with this handbook. Despite my criticisms this book at $39.95 (softcover) and $49.95 (waterproof) is a valuable addition to Australia's malacological resource material and should be acquired by anyone wishing to collect or study the shells of the region.

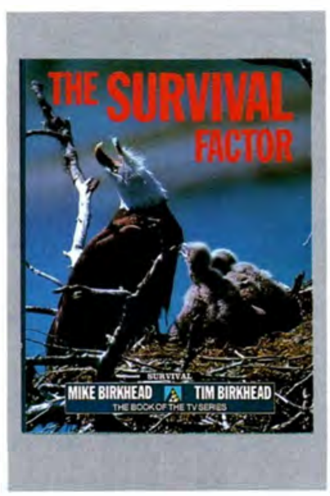
—W.B. Rudman
Australian Museum

The Survival Factor

By Mike Burkhead and Tim Burkhead. Survival Anglia Ltd, England, 1989, 208pp. $37.95.

The Survival Factor is a selection of episodes from the English TV series "Survival". This series deals with wildlife, conservation and the environment. The book deals with why certain animals have adapted to live in certain environments.

In ten chapters, 208 pages, 141 beautiful colour photographs and 39 detailed black-and-white illustrations, the authors set out to give examples of 'survival factors' by showing



case studies of certain animals and how they have adapted to their environments thus ensuring their species' survival. Where possible it also compares and contrasts other strategies used by related species, or unrelated species living under similar conditions. Strategies discussed include mimicry, drought adaptation, tool use, breeding strategies and social organisation.

For a book that has been published as a written version of a TV series, it must be realised that any bias, mistakes, omissions and the like are probably the fault of the TV series. The book can hardly report different information to the series, although it can elaborate. It must also be remembered that, although published in 1989, the footage and script for the series was probably prepared and aired some years previously, so information may be outdated in this way.

Having made these concessions I was still disappointed by some areas of the book. In the authors' blurb on the inside back dustjacket their studies and books on birds are mentioned. This seems to have resulted in a strong leaning towards birds. The subject matter breakdown for the chapters runs as follows: birds—five chapters (The Cuckoo, Bigamy Birds, White Water Blue Duck, Woodpeckers, Eagles); mammals—two chapters (Life on the Edge, Underwater Mammals); general topics—two chapters (Tool Users, Venomous Animals); amphibians—one chapter (The Spadefoot Toad).

While I have nothing against birds, I think that a bias of half a book (or more if you include avian "Tool Users") was overdoing it. A second source of disappointment is the noted shortage of Australian examples given in the book. In fact, it seems that the authors went out of their way to ignore Australia. In the chapter on the Spadefoot Toad, where a lot of other examples of arid adaptation by amphibians were mentioned, the arid zone amphibian fauna of Australia was omitted entirely. Even the famous Water-holding Frog (*Cyclorana platycephala*) about which much has been written didn't get a mention. But perhaps the most surprising omission, especially after the statement "Australia is host to some of the world's most dangerous animals" (p.92) is the passage "only a handful of [spider] species are dangerous. These include the black widow spiders, found in North and South America, Africa and many parts of Australia [no mention of New Zealand here], and to a lesser extent, tarantulas'' (p.96). Now what resident of the United Kingdom has not heard and been warned about the 'dreaded' Sydney Funnel-web Spider? There must be few outside of the book authors! Later on in the same page they mention the female Black Widow being deadlier than the male and promptly miss another opportunity to mention funnel-webs (the male, in this case, is the most potent).

The chapter on venomous animals seems to have given them a bit of trouble all round, for in the beginning (p.89) they define venomous animals as being able to "secret toxic matter and inject it by biting or stinging or by some other means" and "poisonous animals secrete lethal toxins but do not actively attack other creatures with them" (that is, you get sick if you bite or eat them). They then talk about poison glands and poison with regard to sea urchins, which inject it via "prolonged pinchers" when stepped on (p.92) and "symptoms of poisoning" with regard to stonefish and sculpin fin spines. They also seem to have trouble with the terms 'venomous' and 'dangerous to man' as in "approximately 80 per cent of the Australian species [of sea snake] are venomous". As far as I understood it all sea snakes were venomous but not all were dangerous. I also dispute the claim on p.106 that sea snakes' main prey is eels; and the statement "Almost all the major fins [of Scorpion Fish] possess spines and venom glands", as the two largest fins (the showy pectorals) are harmless.

There are other troubling statements in the book but I won't mention them here. All in all the book is easy reading and provides the average person with a mixture of general and detailed information on the various attributes required for a particular lifestyle. The text is poorly researched in some parts and badly explained in others, but overall the book is interesting and stimulates thought on similarities and contrasts between those examples depicted and those in the reader's experience. For that reason, at least, the book is good. Just a final word to the publisher or distributor: if you are going to send a book to Australia on a general natural history subject, use a few more Australian examples and make sure you get them right!

—Martyn Robinson
Australian Museum

Follow that Elephant!

By George Hangay. Mandala Publishers, Sydney, 1990, 331pp. $19.95.

How many museum personnel have not only documented their field travels but actually published them? I haven't, and I know of no others in Australia other than George Hangay. What's more, George hasn't only published them in this delightful book, he's avoided the major publishers and picked an unknown who allowed 331 pages, 21 colour plates, 59 black-and-white photos and innumerable line drawings (all taken or drawn by the author) for the purchase price of just $19.95.

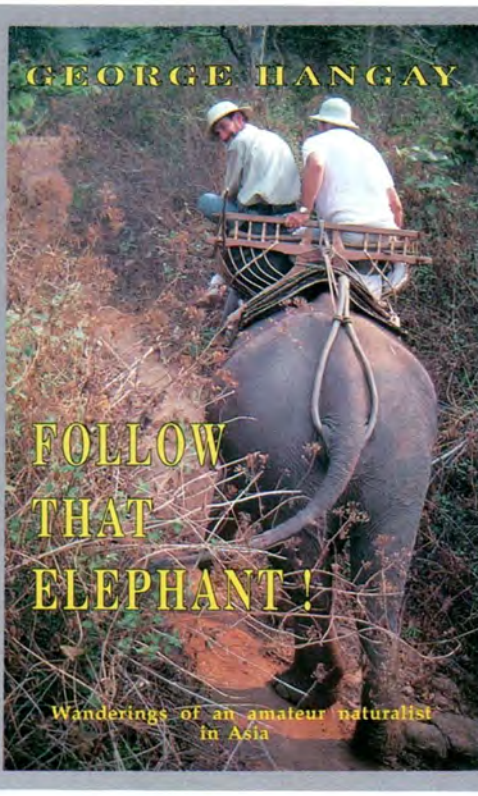
Although George's *Follow that Elephant* will probably not quite join the ranks of Alfred Russell Wallace's documentation of collecting in South-East Asia from the 1850s, this book will join the ranks of a select few that *have* appeared in print for those of you who don't regularly read journals covering Asian biology.

In this book George covers several trips, personal in nature but in all cases of nature value. He flits from Nepal to Sumatra, Sarawak to Thailand, the Philippines to Sabah. Most of the time he has Australian Museum hangers-on in tow, but never has he claimed his trips to be official. He has done the organising, he has picked the personnel to accompany him, and he has decided the ultimate purpose behind the expedition. This has always been, first, a love of travel and adventure, but second, a strive to collect insects, his personal love, from wherever possible on this planet. These trips have boosted the contents of the entomological coffers of the Australian Museum enormously, and George will rest contented with the fact that, although the lands he has visited may by now be covered in rubber plantations and be totally dead insect-wise, his efforts have added at least a chapter, if not more, to the sum total of Indo-Pacific entomological knowledge.

Sure this book is not without errors but, for a good, cheap, accurate and historical read, it is worth every cent of its price.

Follow that Elephant can be purchased through any good bookseller or by post from the Australian Museum Shop, or directly from Mandala Publishers, 80 Gondola Road, Narrabeen, NSW 2101. Postal costs by surface mail within Australia of $3.00 should cover any town.

—Phil Colman
Australian Museum



Man on the Rim: the Peopling of the Pacific

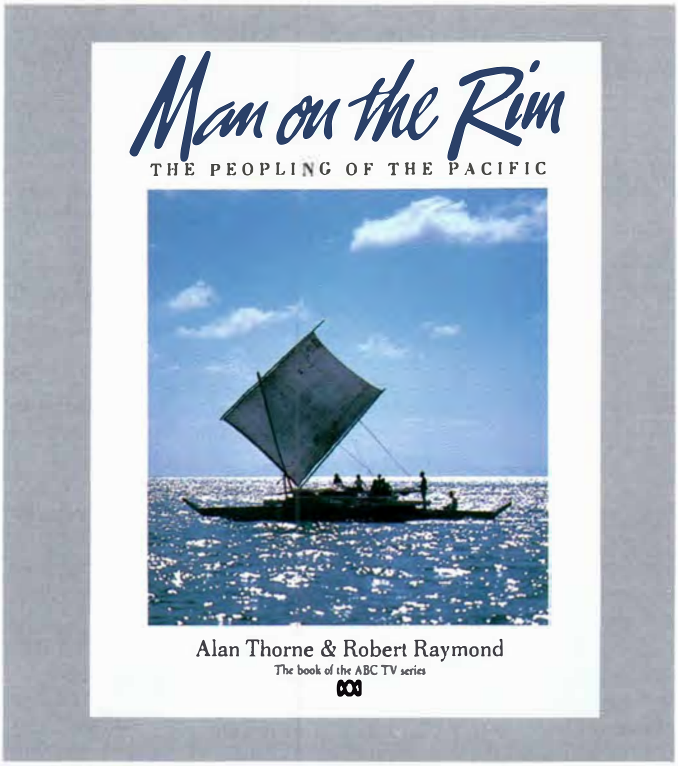
By Alan Thorne and Robert Raymond. Angus & Robertson Publishers and ABC Enterprises, 1989, 288pp. $39.95.

Both the 11-part documentary series (shown on ABC TV late 1989) and this publication have the specific aim of increasing our awareness of the Pacific Rim as a cultural region of world significance. The authors, an Australian prehistorian–physical anthropologist and writer–film-maker, set out to demonstrate that there are strong evolutionary and migratory links among all the peoples of the region, which date back 50,000 years and which underpin the variety of present-day peoples, languages and lifestyles.

Like the TV series, the book first provides evidence of human evolution in Asia, and describes likely migration routes and methods from there around the Pacific. Chapters then cover the populating of Australia and the Arctic; cultural adaptation in Indonesia and New Guinea; technological development in mainland South-East Asia and China; the Japanese story; the habitation of North, Central and South America; and, finally, the settlement of the Pacific Islands themselves.

The scope of such a task is immense and presents the authors with a considerable challenge: how to communicate a synthesis of such a range of subjects in a not-too-superficial way. Do they succeed? The answer is both yes and no.

Where the TV series suffered from an attempt at David Attenborough-style presentation that bordered on caricature (Alan Thorne in front of



anything and everything), the book is a delight to the eye. Also, the content is cleverly structured so that the regional case-study chapters provide opportunities to discuss various themes that are central to the Pacific story: boats and sailing, metal working, domestication of plants and animals, hunting and agricultural developments such as controlled burning and irrigation, physical and cultural adaptation to extremes of habitat and temperature, and the ecological impact of humans in the region.

Unfortunately, however, Thorne's didactic and over-earnest delivery has survived in the prose style. We are told how it (probably) was and, moreover, how we should feel about it, with frequent use of emotive words such as "compelling", "masterly", "astonishing", "unmatched" etc. Thorne's pontifical enthusiasm does not give the reader credit for being able to decide his or her own reactions to the material presented.

A more serious criticism is the authors' decision to present certain contentious theories as if they were generally agreed interpretations of the past. For example, the possibility that Australia was populated by two distinct physical "types" from Indonesia and the Asian mainland (which have subsequently merged to produce modern Aboriginal people) is a theory not highly regarded by Thorne's academic colleagues in the light of present physical anthropological evidence. Not even in the "End Notes/Further Reading" is reference made to alternative interpretations of the evidence, currently favoured by other experts. A similar lack of even-handedness is apparent in the chapters on the Americas, with the coverage of Central America being more adequate and based on more reliable references than the chapter on South America. This lends the book a certain uneasy bias, not to mention a feeling that the authors' personal missionary zeal has overridden their scientific common sense. For the sake of intellectual honesty (at the risk of complexity), I would prefer a more balanced discussion of current interpretations (even if only in the footnotes) or a more open statement from the authors concerning the particular lines they have followed.

With these qualifications in mind, it must be said that the issues raised in this book are timely ones for the Australian reader. Despite its limitations, *Man on the Rim* makes a big contribution to expanding our awareness of the cultural context in which Australia is belatedly learning to function as a nation.

—Zoë Wakelin-King
Australian Museum

"Why not reintroduce the professional rabbit-ohs, the financial return to them being commensurate with the importance of their work with farmers?"

AN OLD SOLUTION TO AN OLD PROBLEM

BY DAN O'DONNELL
HISTORY & EDUCATION WRITER

Australia has always suffered from a delicate ecological balance, its irregular rainfall and climate of extremes making it especially vulnerable to the slightest environmental pressure or disturbance. We learned the lesson well with prickly pear, and we are still paying for the luxury of introducing 24 European rabbits in 1859. Within 20 years the rabbits had spread north and north-west from Thomas Austin's property near Geelong, soon engulfing south-eastern Australia at a rate of over 110 kilometres per year. And in less than half a century the pest had crossed the whole continent. Not even the rare cooperation of all States in the construction of massive rabbit-proof fences could halt its advance.

In 1887, the New South Wales Government offered a huge reward of £25,000 to any person who could devise a method for the extermination of rabbits. Worldwide interest was aroused, the prestigious Pasteur Institute of Paris dispatching representatives forthwith. Their solution of chicken cholera was soon discarded, as were suggestions from home and elsewhere overseas. The United States also manifested much interest, with the United States Commercial Attaché for Newcastle, Thomas Dawson, sending off an urgent dispatch to California on 25 October 1887: "The rabbit pest seems to have become as great a terror to these colonies as the locusts were to Egypt . . . I do not understand why a syndicate could not be formed to preserve and export meat so highly prized to foreign markets." Is the point not still valid? Why can't rabbit meat for the protein-starved markets of the world, especially Indonesia, the Philippines, Thailand and Hong Kong, be harvested and marketed? Why can't a domestic market also be established, with sensible marketing to eradicate historic aversion to the product, an important spin-off being the pet-food market for meat surplus to human needs?

In 1975, just outside Olympia in the State of Washington, a large white Californian hybrid rabbit, dressing to five pounds, was being bred as a source of nutritious protein for both American and Asian consumers. The enterprise, known as Thumpa Industries and which is still a going concern, demonstrates the viability of the venture. By 1976, it was looking at annual production of over ten million rabbits from a breeding stock of two million, all from a self-contained complex of large cages, feed mill, tannery, abattoir and fertilising works, and all constructed on about 140 hectares. Compare this strictly controlled industry with the Australian experience of the 1880s and 1890s, where the continent itself was the rabbit run and the awesome infestation apparently out of control.

> *"Why not make the rabbit pay its way for a change?"*

My own recollection of my consternation in 1950 when I first witnessed the hundreds upon hundreds of hectares of sheep country in western New South Wales rendered useless by the burrowing and foraging of thousands upon thousands of rabbits is still vivid. Vivid also is the memory of my first rabbit drive, the long line of beaters advancing with as much noise as possible to drive thousands of rabbits into the prepared funnel at the end of the 1.5-kilometre-long run. Never had I seen so many rabbits, all swiftly and expertly killed and skinned by the professional rabbit-ohs who later sold pelt and carcass before moving on to the next property. The next year, things were different: myxomatosis had put the rabbit-oh out of business. Within the first few months, the myxoma virus destroyed some 99 per cent of all rabbits but today, with less virulent forms of the virus and with genetic resistance in the rabbit population, another population explosion threatens the nation.

Natural predators such as feral cats, foxes, dingoes and eagles apply some curbs. And farmers employ several self-help measures (poisoning, ripping-up warrens, fumigating and trapping) but these are only small-scale and localised, doomed to ultimate failure as a consequence of the mobility and breeding propensity of the pest. Recent research from Europe offers hope of a solution. One virus, viral tracheopneumonia, has killed some 32 million rabbits in Italy. However, it also affects European hares and its effect on other species is still unknown. From Spain, Australia may import two types of flea considered useful in spreading myxomatosis in arid regions. And in Australia itself, pioneering work with the revolutionary 'gene shears' technology, by which scientists can effectively sterilise rabbits by chemically controlling their genes, holds more promise for the farmer.

But surely Thomas Dawson's suggestion still has much practical merit, not only in controlling the ever-swelling rabbit population but also in providing jobs? Why not reintroduce the professional rabbit-ohs, the financial return to them being commensurate with the importance of their work to farmers? Why could all costs not be recouped by the establishment of a reputable Rabbit Marketing Board, along the lines of a Fish or Meat Marketing Board? The export arms of both these bodies surely could furnish the expertise to gauge the viability of marketing rabbit flesh in Asian, Middle Eastern or European countries. Farmers whose land is saved from degradation would hardly baulk at a modest charge for the service provided by freelance rabbit-ohs, their work monitored by the local Rabbit Board empowered to employ and recompense rabbit-ohs, and maintain standards in the rabbit meat industry.

In pre-myxomatosis days the work of the rabbit-ohs was laudable but poorly paid. Properly harvested and marketed, however, the rabbit could be an enormously valuable natural resource and a potentially lucrative sideline for farmers. After all, the stock is virtually unlimited. Given their preference for the most nutritious of grasses and their capacity for stripping whole fields bare, they exact an exorbitant charge on their host. Why not make the rabbit pay its way for a change? The meat must have enormous potential value, not to mention the fur. ■

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