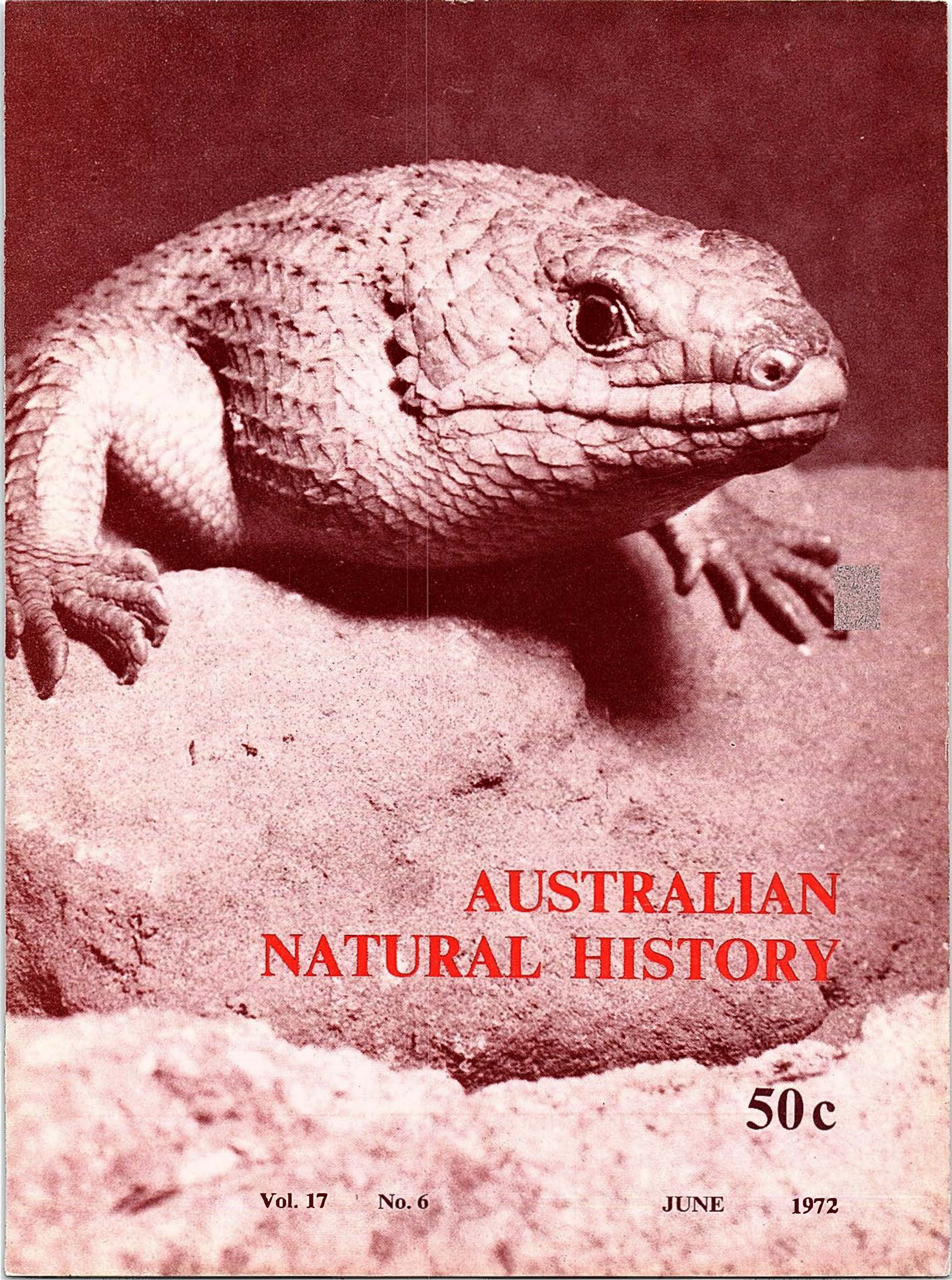

AUSTRALIAN NATURAL HISTORY

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● FRONT COVER: A Western Spiny-tailed or Gidgee Skink (*Egernia stokesii*) from Tibooburra, New South Wales. This insectivorous lizard occurs in much of inland Australia from southern Western Australia to the arid western parts of New South Wales and Queensland. It is usually found in colonies associated with rocky ranges and outcrops, and the specimen illustrated was collected by a recent Australian Museum expedition to the northwestern corner of New South Wales. This species is brown in colour and grows to about a foot long. BACK COVER: This New Britain mask is made of bark cloth over a cane frame, and is painted red and black on a natural buff ground. It comes from the Baining tribe, Sunam village, Gazelle Peninsula, east New Britain, Territory of Papua and New Guinea. It represents a mythical creature, and is worn by men over their heads at various dance ceremonies. The mask, which is about 38 inches high, was presented to the Australian Museum by Miss S. Holmes in 1962. Its registration number is E.60805. It is on display in a temporary New Guinea exhibition at the Museum. [Photos: C. V. Turner.]

NEW DIVING TECHNOLOGY FOR MARINE SCIENTISTS

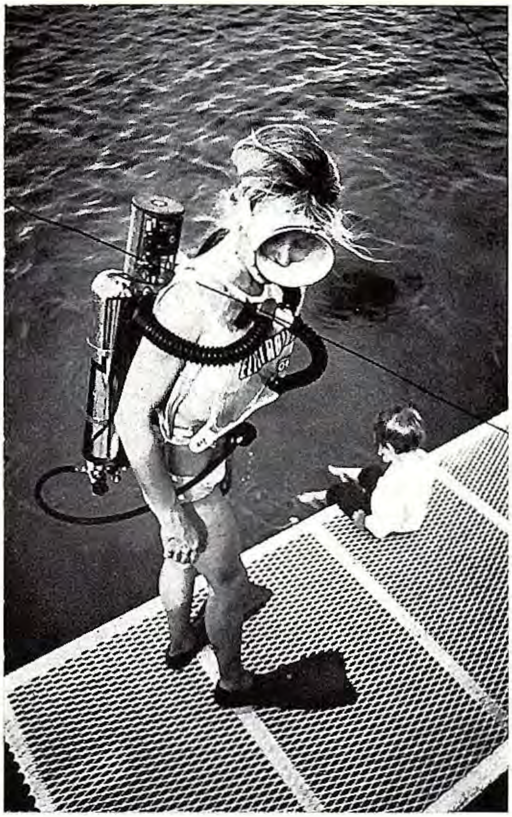
By WALTER A. STARCK II
Research Associate, Bernice P. Bishop Museum, Honolulu, Hawaii

THE development of diving technology has greatly accelerated over recent years, offering the diving scientist a new range of capabilities in undersea investigations. Among the most important of these has been the development of closed-circuit mixed gas breathing apparatus and diver support submersibles.

Closed-circuit breathing apparatus affords the biologist the important advantage of operation without the disturbing din of regulator and bubble noises and the conspicuous pulsating clouds of bubbles that accompany conventional SCUBA diving. The result is that marine life can be observed virtually undisturbed and many aspects of behaviour may be seen at close range that otherwise rarely or never occur in the presence of divers. Since unused gas is not thrown away with every breath a small supply lasts a long time and the duration does not decrease with depth. This makes feasible the use of expensive helium, necessary for deep dives, and provides adequate time for the extended decompression required. Such a system also provides pure oxygen to greatly shorten decompression.

Pure oxygen rebreathers have existed since World War II, but their use is restricted to shallow depths, 25 feet or less, because of the toxicity of oxygen under pressure: they are very dangerous in other respects as well. Dilution of oxygen with an inert gas such as helium eliminates the problem of oxygen toxicity but requires an accurate and reliable means of monitoring and controlling the level of oxygen.

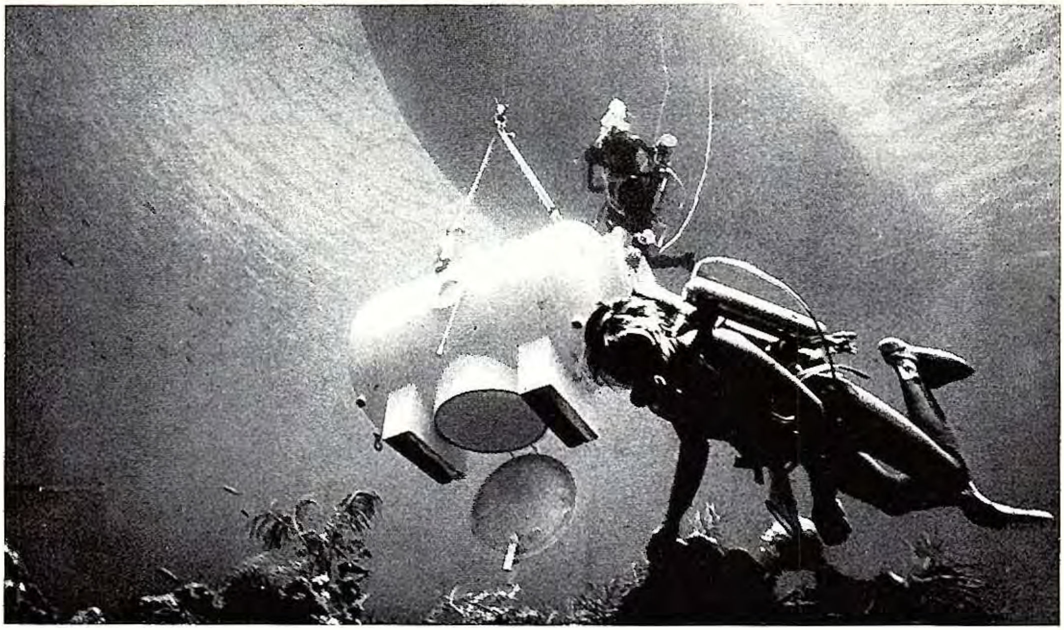
Four years ago Dr John Kanwisher and I met aboard *Sea Diver*, the research vessel of aviation and deep-diving pioneer, Edwin Link. John, an exceptionally talented physiologist from the Woods Hole Oceanographic Institution, was there to make physiological measurements on divers, and I planned to make deep lock-out dives for biological collecting from Mr Link's submarine *Deep Diver*.



The Electrolung electronically-regulated, closed-circuit, mixed-gas breathing apparatus gives the diver greatly increased time and depth capability as well as quiet, bubble-free operation. [Photo: Author.]

Closed-circuit breathing apparatus

Bad weather held up operations for several days, and in the resulting "bull sessions" John and I found that we had been thinking along similar lines in regard to closed-circuit breathing apparatus and that between us we had the information and skills to build such a device. We reached agreement on various features, and John went back to Massachusetts to build the electronic oxygen



Jo Starck descending from a submersible decompression chamber during a 300-foot dive in the Bahama Islands. Such chambers greatly facilitate the lengthy decompression required for deep dives. [Photo: Author.]

sensing and control circuitry and I returned to Florida to build the system in which to fit it. Six weeks later I installed the electronics that John had mailed and test-dived what proved to be the first successful closed-circuit mixed gas breathing apparatus.

The device, now known commercially as the Electrolung, weighs 35 pounds fully charged and holds 9 cubic feet of oxygen and the same of inert gas ($1.60 worth of helium) as compared to about 90 pounds and 144 cubic feet ($23 of helium) for standard double tank SCUBA. Duration of the gas supply with the Electrolung is six hours at a moderate work rate, regardless of depth, as compared to two hours at 30 feet or 35 minutes at 200 feet with the twin-tank SCUBA.

Three oxygen-sensing electrodes continuously monitor the level of oxygen in the breathing mixture and electronic circuitry automatically controls the addition of oxygen as needed to maintain a constant level. If an electrode malfunctions its effect is electronically eliminated and the remaining two continue to control the correct mixture. An alarm beeps in the case of such a malfunction and to warn of high or low oxygen levels. Meter readouts in a wrist display for all three electrodes enable the diver to monitor the system at any time, and manual controls permit over-riding the automatic control in the event of malfunction. A breathing bag on the chest to receive exhaled gas between breaths and a canister of chemical absorbent to remove carbon dioxide complete the major components of the system.

Extensive use of Electrolung

My wife, Jo, and I have subsequently utilized the Electrolung extensively in our biological studies on coral reefs. We have made numerous dives to 300 feet investigating the deepest and previously untouched levels of reefs. We have learned a great deal about the biology of deep reefs. Our collections have included several new species of fishes, but our most exciting find was five perfect living specimens of pleurotomarians, or Slit Shells, the most primitive living gastropods and among the rarest shells in the world. Collectors pay up to $500 and more for good specimens.

In shallower water we have been able to observe behaviour undisturbed. Colonies of

Garden Eels have permitted us to lie quietly an arm's length away while they extended from their burrows in the sand, and sea basses have carried out courtship and spawning only inches in front of our faces. We even observed the courtship of groupers or rock cods which are female early in life but at a larger size reverse sex and become males—a unique answer to women's liberation!

Subsequent to development of the Electrolung, General Electric and Westinghouse Corporations in the United States have developed similar devices which are not yet available commercially but should be in the not-too-distant future.

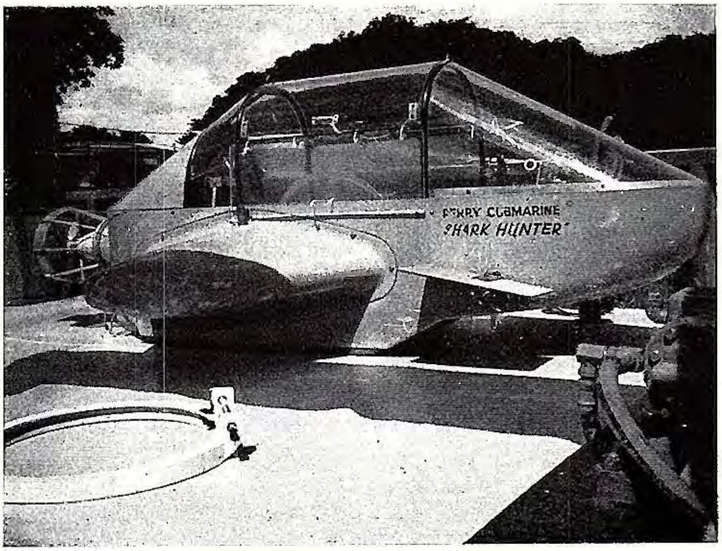
Dry diver lock-out submarines

Both dry diver lock-out and wet type submarines have been recently developed that give the diving scientist greatly extended capabilities. Dry diver lock-out subs act as mobile submersible decompression chambers transporting the divers to the work site at depths down to 1,000 feet or more. At the work site the diving chamber is pressurized and a hatch is opened, permitting the divers to exit and work for any desired period of time, after which the divers get back inside and close the hatch and the sub can return to the mother ship while the divers remain under pressure during their lengthy decompression. The first such sub was the *Deep Diver*.

In the Bahama Islands I made a lock-out dive from *Deep Diver* at 215 feet on a small ledge along a vertical cliff face. Locking out, I entered a luminous, blue, vertical world with the small yellow sub nestled on the sand-covered ledge against the immense dark cliff face that dissolved into the infinity of blue above and below. In the lume of the sub's floodlights I made a fish collection that included a whole series of specimens of a new fairy bass. Since that time Mr Link has designed and built a radically new diver lock-out sub for the Smithsonian Institution, to be used exclusively for scientific research. The new sub consists of a 6½-foot acrylic (Perspex) sphere 4 inches thick which houses the pilot and an observer in a panoramic front-row seat to the undersea world at depths to 2,000 feet. Two divers are carried in a horizontal cylindrical aluminium lock-out chamber behind the plastic sphere and both chamber and sphere are enclosed in a tubular aluminium framework. This sub, known as the *Johnson-Sea-Link*, is now operational and beginning to be used for research dives.

Wet submarines

Dry lock-out subs, by providing adequate means of decompression and life support, most importantly give vertical mobility to a diver, permitting extended time at great depths. Wet subs, on the other hand, afford the diver greatly extended horizontal mobility



The Perry Cubmarine Shark Hunter wet sub, with a speed of 3 knots, greatly increases search and survey ability and gives good protection against sharks. Note a section in the lower rear of the canopy that was broken off by an attacking shark. [Photo: Author.]

at conventional diving depths. Wet subs have existed since World War II, but until recently commercially available ones have been cumbersome, poorly designed monsters that were more trouble than they were worth.

Within the past year, however, the Perry Submarine Company of Riveria Beach, Florida, has begun production of a rugged, practical, wet sub, with good performance, that is a most useful tool. It looks like a two-seat World War II fighter plane with short fat wings. The cockpit is fully enclosed by half-inch Perspex, with a hinged canopy that swings aside for easy exit. The wings serve as ballast tanks that float the sub high in the water so that it can be towed to the diving area by an outboard skiff. Power is provided by a five-horsepower motor and three automobile batteries that give over an hour of constant running at full speed, which is three knots or about twice as fast as a diver can swim for a short distance.

We have recently been using one of these subs in Micronesia for assessment of Crown-of-Thorns Starfish populations and other reef surveys. An hour's run along a reef gives one an entirely different picture of the area than does regular SCUBA diving. Turtles, sharks, and many larger fishes and other animals have populations of a low enough density to be only occasionally encountered in normal diving. The submarine, however, gives a quick look at up to 3 miles of reef, and animals with such low population densities may be consistently found. The best sites for other types of work can also be quickly located.

Two other interesting uses to which we have put the sub have been the collecting of Maori Wrasses and work on the attack behaviour of Grey Sharks.

The Maori Wrasse (*Chelinus undulatus*) is a giant member of the wrasse family that we have found to be a predator on the Crown-of-Thorns Starfish. This fish occurs in scattered populations and is shy and difficult to spear. With the sub we can consistently find them and, by chasing them, cause them to hole up. It is then an easy matter to stop and collect the specimen for stomach content examination.

The Grey Shark (*Charchinus menisorrah*) is a relatively small—up to 6 or 7 feet long—but very aggressive reef shark that has been involved in numerous attacks on divers. The submarine acts as a mobile shark cage for work on these animals. We have had a number of attacks on the sub during this work, some seemingly directed at us inside and glancing off the plexiglas only inches from our faces. One attack on the propeller sheared the drive pin and disabled us.

Ancillary equipment useful to the diving scientist is also being rapidly developed.

Fish-eye lens

In 1964 I adapted an extreme wide angle (180°) Nikon fish-eye lens for underwater use. This lens requires a dome-shaped lens port for use underwater, and, after searching about for suitable optical domes at outrageous prices, I hit on the idea of using the dome from a marine compass. Additional units were made for friends and the idea quickly spread, for compass domes proved to be a cheap, simple, and completely effective means of optically correcting underwater distortion in optical systems.

Two camera housings using dome lens ports for the Nikon F camera system are now available and are ideally suited for scientific work. They are the Niko-Mar housing by Giddings-Felgen Inc., of San Francisco, and the Ocean Eye by Photogrammetry Inc., of Rockville, Maryland. They permit use of lenses from extreme wide angle ones for photographs of large subjects, to macro lenses for very small marine life, to tele-photo lenses for behavioural studies and motor drive for rapid sequences.

Lighting problems

Most invertebrates and many fishes are active only at night. For night diving and for work under ledges, in caves, and in deeper water lights are essential. The various hand lights sold as diving lights are generally in the 3-watt to 5-watt power range and inadequate for useful work. In 1960 we began an extensive programme of night studies on coral reefs in Florida. Adequate lights were our first problem. After many different approaches we settled on a 30-watt sealed beam system powered by a motor-cycle battery in a separate pack worn on the weight belt. The light itself is fastened to a plastic football (U.S. style) helmet and worn as a headlight, leaving the hands free for work. A version of this light is now produced by Beckman Instruments of Fullerton, California.

Many nocturnal animals are insensitive to red light, so we tried a red filter over our lights and found we could observe them undisturbed. For the future, electronic image intensifiers hold great promise for undisturbed night observation by available star and moon light.

Housings for cassette tape recorders for note-taking underwater are easily constructed, and one good commercial unit is available from Hydro-Products of San Diego, California.

A variety of communication devices are now available, ranging in price from several hundred to several thousand dollars per pair. Even the best of them are poor in intelligibility, though a new Japanese unit that I tried briefly before leaving the United States last June seemed quite good in preliminary tests.

Recent electronics developments make feasible a variety of sophisticated acoustical devices, and it is only a matter of time before acceptable communication equipment is available.

Undersea habitats have been used by American, French, English, German, Russian, and probably other scientific groups. They have considerable public appeal but, to date, nothing really significant has been accomplished with them and nothing at all that could not have been achieved by surface diving at a fraction of the cost. Once inside there is no advantage and many disadvantages over being on the surface. They do offer extended diving time, but this becomes significant only at depths greater than that at which most have been used. This does not mean that nothing can be accomplished with habitats but just that their advantages are very limited; cheaper and more efficient means are generally available. A properly equipped surface vessel with submersible decompression chamber or diver lock-out submarine offers the same real advantages, plus many others.

Diving hazards

Man is very poorly equipped physiologically as a diving animal. Besides the still inadequately solved problems of protection against cold and dangerous marine

The author, with a 30-watt sealed-beam headlight powered by a motor-cycle battery in housing on the belt. [Photo: Bates Littlehales—National Geographic Society.]

life there are a host of problems associated with breathing gas under pressure. Oxygen in too great a concentration becomes toxic, leading to convulsions and loss of consciousness; too little, on the other hand, results in unconsciousness from anoxia. The increased density of gases under pressure results in inadequate lung ventilation and carbon dioxide build-up, limiting the amount of work that can be done; this can also result in unconsciousness. Contrariwise, breathing too fast in shallow water can flush out too much CO_2 from the lungs, leading to unconsciousness again. This phenomena is known as hypocapnia tetanus. In every case an unconscious diver becomes very rapidly a dead diver unless quickly rescued, and even then bringing an unconscious diver up can result in a fatal air embolism. Besides air embolism there are the bends from gas dissolved in the body and aseptic bone necrosis and other problems associated with osmotic effects of dissolved gases. I could go on, but I think it is clear that man is poorly equipped to dive. Artificial gills, fluid breathing, and Cousteau's *Homo aquaticus* make good science fiction but involve technical and physiological problems that at present appear to be insurmountable.

Submersibles the answer

Except for temperate and tropical water of moderate depths the future of diving, I believe, lies in submersibles.

The technology exists to develop a small, highly mobile, one-man submersible with a hemispheric Perspex nose and manipulator arms, and having an operating depth of several thousand feet. Such a sub would permit the operator to observe, collect, photograph, and otherwise do what is now done by divers. Some tasks would be slower, but as operations would be in a comfortable environment and isolated from the physiological dangers and limitations of divers, time would be much less critical. One could spend a morning at 1,000 feet, come back for lunch, and return in the afternoon. Communications, powerful lights, sonar, and a wide range of other instrumentation offer little problem with a submersible as compared to a diver.

The future of science beneath the sea is more likely to be accompanied by the hum of electric motors than by the laboured breathing of divers.

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BOOK REVIEW

"PALAEOZOIC FISHES", by J. A. Moy-Thomas, second edition, revised by R. S. Miles; Chapman and Hall Ltd, London, 1971; 270 pages; $13.60.

Moy-Thomas' *Palaeozoic Fishes*, originally published in 1939 and long out-of-print, was a classic little account of the early evolution of fishes. In the period since 1939 intensive research throughout the world and important new discoveries have considerably altered palaeontologists' views on this subject. Although many points are still in dispute and controversy still rages, there is now a broad consensus of opinion concerning most of the story. The time is ripe for a concise up-to-date account, and Miles has produced one by completely revising and rewriting *Palaeozoic Fishes* to incorporate the latest views on the subject, presenting not only a wealth of morphological detail but also invaluable discussions on the mode of life and inter-relationships of the various groups of fishes.

The abundant illustrations are either redrawn from the original sources (and often considerably improved in the process) or specially prepared for this new edition. The labelling is clear and concise, with complete avoidance of abbreviations.

The book should prove invaluable for anyone interested in the early evolution of vertebrates either in high schools or in university zoology and geology departments, and should be acquired by all departmental libraries. It presents and interprets evidence which would otherwise only be available in the specialist scientific literature, and much of it is not readily accessible in Australia. For those students wanting additional information every chapter is followed by an extensive bibliography covering papers published up to June 1970.—*A. Ritchie, Curator of Fossils, Australian Museum.*

Flocks of Silver Gulls (*Larus novaehollandiae*) are the main hazard to aircraft at coastal airports in southern Australia. [Photo: Ederic Slater.]

BIRD HAZARDS TO AIRCRAFT

By G. F. van TETS
Division of Wildlife Research, CSIRO, Canberra, A.C.T.

WHEN aircraft strike flying animals, such as birds, bats, and insects, the incidents are normally fatal only to the animals involved. Occasionally bird strikes cause minor damage to aircraft, and on very rare occasions there have been total losses of aircraft and/or loss of human life.

Birds tend to be more abundant on and near the ground than at the cruising altitudes of passenger aircraft. Consequently, almost all civil and a large portion of military aircraft bird strikes occur in the vicinity of airfields. Birds weighing less than 2 pounds caused 94 per cent of over 800 strikes in Australia and New Guinea, those weighing 2 to 8 pounds 4 per cent, and those weighing 8 to 32 pounds 2 per cent. The damage done to the aircraft is proportional to the weight of the bird. Damage is also proportional in theory to the square and in practice to the cube of the speed of the aircraft. Consequently, in the vicinity of airfields where aircraft speed is a function of altitude, the probability of an aircraft striking a bird decreases with altitude, but the probability of severe damage, if a bird is struck, increases with altitude. Hence, a high-flying hawk is a greater potential hazard to aircraft than a low-flying flock of gulls.

At Sydney Airport the bird-strike rate was found to be proportional to the cube root of the number of birds present, and this suggests that aircraft fly linear tracks through three-dimensional clouds of birds. It also suggests that there must be at least a change in the order of magnitude of the number of birds present before there is a detectable change in the strike frequency.

Although bird-strike damage is relatively rare compared with other kinds of damage to aircraft, high-speed aircraft are expected to remain vulnerable to severe damage involving possible loss of life and/or aircraft for at least another two decades. Loss of passenger planes has been mainly due to striking heavy birds such as swans, geese and cranes at cruising altitudes. Military planes have been lost due to engine power loss during take-off and during low-level flying. Pilots have been severely injured, and a few killed, by birds penetrating windscreens and nose cones.

Bird-resistant aircraft

Resistance to bird-strike damage was not considered when most of the aircraft now flying were designed. Much has been done to strengthen the planes of the future, but to fully protect aircraft against damage by striking the heaviest flying birds (25–35 pounds) at cruising speeds of more than 300 knots is considered impossible. Specifications now call for aircraft components to withstand penetration by a 4-pound chicken at 400 knots, and there are recommendations that this should be increased to an 8-pound turkey at 800 knots.

Turbofan engines are now considered to be reasonably bird-proof. Windscreens can be made strong enough to withstand penetration by the heaviest birds, but at the cost of a reduction in visibility through the windscreen. It is considered advisable for pilots to wear protective headgear to prevent them from being blinded by birds coming through the windscreens.

The possibility of paralyzing birds ahead of an aircraft with microwaves is being investigated in Canada, but it will be many years before this method is likely to become operational.

Keeping birds away from airports

Pilots and airline representatives are very vocal in insisting that, because of the high landing fees, it is the airport authorities' responsibility to keep birds away from the runways and approaches. Airport authorities are finding difficulties in doing this because of lack of funds, personnel, expert advice, and local co-operation.

The Australian Bustard (*Eupodotis australis*) is the heaviest flying bird which is a hazard to aircraft in Australia. [Photo: Ederic Slater.]

Airports differ greatly in the kinds and numbers of birds on and around them. Each airport has its own peculiar bird problems, and measures which substantially reduce bird numbers at one airport may be ineffective at another.

A wide variety of ingenious scaring, trapping, and killing techniques have produced temporary reductions in bird numbers at some airports, but at a high cost in manpower and equipment. Some of these measures have been popular with the press and airport authorities, because something was being done—even if little was being achieved.

Occasionally relatively simple scaring methods are effective, and they should be used when unusual weather circumstances suddenly cause large numbers of birds to invade an airport. To cope with such emergencies, safety officers, firemen, and groundsmen should be trained and have standing orders to act immediately when large flocks of birds start to land on an airfield. If the flocks are allowed to settle even for a few hours it is common experience that subsequent scaring will merely tend to shift them from one part of the airfield to another. The disturbed birds will then be more of a hazard to aircraft than if they had been left in peace.

The numbers of resident birds on and around airports can be reduced by the removal of food and shelter. Most numerous around airports are usually scavenging birds—gulls in temperate regions, kites and vultures in tropical regions. Spectacular reductions in their numbers have been achieved where refuse, offal, and carrion were no longer exposed to them.

Birds usually come onto airfields to feed on small animals, seed, and herbage. Poisons which kill worms, insects, snails, and small mammals have, by removing the food, reduced bird numbers at several airfields. Because of the long-term harmful side-effects of non-specific poisons to man and other animals, their use is being discouraged and, in an increasing number of nations, is prohibited. Other means of animal pest control are now being sought.

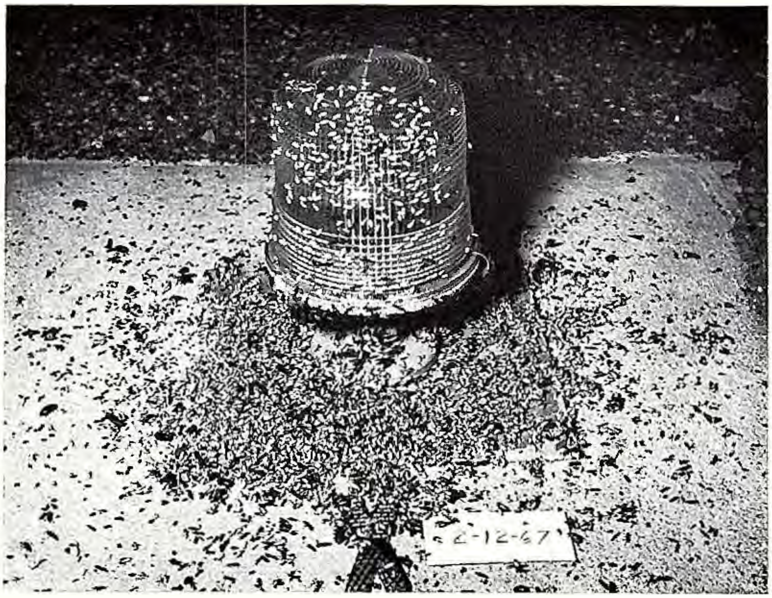
Most airfields can be made less attractive to birds by improving drainage and by removing seed and berry-bearing plants and grasses. Studies are in progress in Canada and the Netherlands to find a plant cover for airfields which would be less attractive to birds than grass is. Some success has been achieved on sandy soils with Three-toothed Cinquefoil (*Potentilla tridentata*) and on clay soils with Silverweed Cinquefoil (*Potentilla anserina*). Studies in Australia indicate that Couch Grass (*Cynodon dactylon*) may provide a solution.

In Pakistan and in Australia it has been noticed that on warm humid nights insects gathering around runway lights form a major source of food for birds on airfields. Experiments in Australia have shown that the use of orange instead of white runway lights can substantially reduce this food source for birds.

Forecasting of bird concentrations

Rapid progress has been made in Europe and North America in using radar to locate and forecast bird concentrations and migratory flight patterns. This service has already resulted in substantial savings in military aircraft damage.

Although the large-scale autumn and spring bird migrations of North America, Europe, and Northern Asia do not occur in Australia,



Insects congregating around runway lights at night are a major source of food for birds at tropical airports. [Photo: Ederic Slater.]

Flocks of Black Kites (*Milvus migrans*) are the main hazard to aircraft at airports in northern Australia. [Photo: Ederic Slater.]

there are in Australia irregular bird migrations in response to rainfall patterns. They include movements by large birds, such as swans (12 pounds) in southern Australia and brolgas (12 pounds) and bustards (14 pounds) in northern Australia, as well as movements by large flocks of smaller birds, such as waders, waterfowl, and parrots.

It would help reduce the en route hazard of bird damage to aircraft if the technology developed in the Northern Hemisphere to locate and forecast bird concentrations and migrations were applied in Australia.

There still is no simple solution to the problem of bird-strike hazards to aircraft, and it is unlikely that there ever will be. It is, however, the responsibility of all those concerned with aviation to co-operate in keeping the hazard at as low a level as is economically and technologically feasible.

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BOOK REVIEWS

"LIVING PLACE AND LIVING SPACE", by W. Stephenson; Angus and Robertson, 1969; 123 pages; $1.95. "PLACES FOR LIVING", by W. Stephenson; Angus and Robertson, 1970; 126 pages; $1.95.

These books will be welcomed by beginning students of ecology. They will also prove valuable to people with a general interest in this science, which is becoming increasingly relevant to our continued survival. Both books answer a long-standing need for a basic text in ecology drawing upon Australian examples to illustrate underlying principles.

The first-mentioned book explains the functioning of ecosystems. Chapters are devoted to energy flow and nutrient cycling and the concepts of standing crop productivity. Animal populations and their interactions with one another are also discussed as well as the long-term and short-term changes which take place in ecosystems.

The second book, subtitled "An Environmental Approach to Ecology", describes the various types of environments: marine, freshwater, and terrestrial, and the problems and opportunities they present to living organisms.

Both books are illustrated with numerous helpful figures and photographs. My only suggestion would be that additional reading briefly indicated at the end of each chapter or section would have been most helpful.—*Stephen S. Clark, Assistant Curator, Department of Environmental Studies, Australian Museum.*

RECENT DISCOVERIES OF FOSSIL MAN IN AUSTRALIA

By A. G. THORNE
Research Fellow in Prehistory, Research School of Pacific Studies, Australian National University, Canberra, A.C.T.

THE last survey of human fossil finds from Australia in *Australian Natural History* was in 1963. At that time Professor N. W. G. Macintosh, of Sydney University, described the skeletal material of possible significance in understanding Aboriginal origins. The list included finds from Talgai, Cohuna, Tartanga and Devon Downs, Keilor and Mossgiel. The finds came from a wide area of eastern Australia, and only the Mossgiel individual was anything approaching a complete skeleton. The Tartanga and Devon Downs remains were dated, but unfortunately they were juvenile or infant.

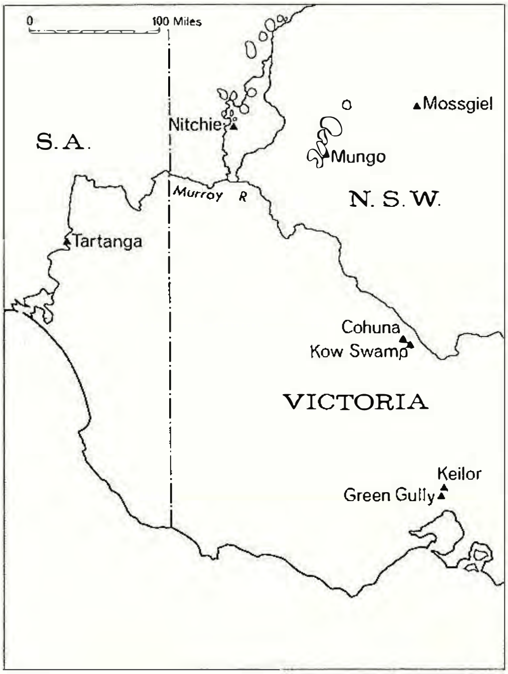
New sites and skeletons have changed the picture dramatically. Accurate dating of some of this material sets new limits for the earliest human occupation of the continent. Further, the new finds are the product of detailed excavations. Although the new sites were accidental discoveries, depositional analysis and examination of individual graves have provided valuable additional information.

In early 1965 human cremations were discovered by Rhys Jones during midden excavations at West Point, in northwestern Tasmania. No complete skeletons were found but portions of at least nine individuals were represented. Typical of a common Tasmanian method of disposing of the dead, the cadavers had been burnt and the charred bones smashed into small pieces. Some of the bone fragments had been gathered together in small pits and in one of these bone fragments were associated with the remains of a pierced-shell necklace. Dating of the site indicates that the cremations are more than 1,000 years old. Although not particularly ancient, the material displays none of the cranial features believed to be characteristic of the Tasmanian Aborigines. These features have been used to distinguish the islanders from mainland Australians. Curiously, the West Point individuals look just like recent Aborigines from eastern Australia. They support the view that the Tasmanians were isolated from the mainland, both spatially and genetically, with the formation of Bass Strait some 12,000 years ago.

Excavation of one of the archaic skeletons from the Kow Swamp area, northern Victoria. The result of a primary burial, the skeleton was embedded in a thick layer of carbonate. [Photo: G. L. Williams.]

The Green Gully burial

What is known as the Green Gully burial was discovered in August 1965 in a terrace of the Maribyrnong River, about 9 miles north of Melbourne. The site was within 2 miles of the 1940 Keilor cranium site and the new burial lay in the same terrace as the Keilor specimen. The skeleton has been dated to about 6,500 years before present. The burial was uncovered while sand was being extracted with a front-end loader. The bones were badly damaged, the face was smashed, and parts of the legs and one arm were dislodged. Examination of the *in situ* bones revealed considerable disturbance within the grave, over and above the damage caused by the front-end loader. This indicated that the burial was a case of delayed disposal. The body had been left to decompose and the bones were buried later. Ethnographically,



The distribution of the major fossil-man sites in southeastern Australia. [Map: W. Mumford.]

this form of disposal has a wide distribution and Green Gully points to a long history for the practice in Australia.

Remarkably, reconstruction of the bones by Professor Macintosh has shown that although no bone is duplicated the skeleton consists of parts of two individuals. One is male and the other female. The left humerus and the bones of the lower extremities are large and rugged while the rest of the skeleton, including the skull, is small and delicate. The Green Gully cranium, although large for a female, is similar in many respects to the Keilor cranium.

Kow Swamp discoveries

Discoveries at Kow Swamp, near the Murray River in northern Victoria, began in 1968 with the excavation of an archaic-looking skeleton, part of which had been sent earlier to the National Museum of Victoria. As in the case of Keilor-Green Gully, the Kow Swamp burial was close to the site of the Cohuna cranium, discovered in 1925. Within a few months several additional burial areas were located in the area, including a dense concentration of burials at the mouth of a creek which empties into Kow Swamp. These new sites were found by a local resident, Mr Gordon Spark. To date, the remains of at least 40 individuals have been recovered and on present indications dozens of burials remain to be excavated.

Although extensive earth-moving had disturbed many burials, eleven were complete enough for detailed examination. The cadavers were placed in the graves in a variety of positions, including extended, crouched, and flexed. Stone artefacts, shells, and ochre appear to have been placed with the bodies in the graves. Preliminary evidence indicates that some of the burials can be dated to around 10,000 B.P.

The Kow Swamp population demonstrates the retention of a primitive morphology in southeastern Australia. Large and rugged, the crania have retreating foreheads and projecting faces. The bones are very thick. The brow ridges are well developed, usually as a torus or ridge extending from one side to the other. Immediately above is a deep groove which accentuates the torus. Behind the brows the forehead is constricted, pinched-in like an hour-glass, with the cheek bones flaring out on either side. The retreat or flatness of the foreheads is continued backward on the crania, giving them a very low outline. The degree of flatness of the forehead is usually expressed as the frontal curvature index. The range for this index in the Kow Swamp population (12·5–19·0) embraces the range seen in *Homo erectus* (12–18·6). There is some overlap with the range for modern Aborigines (17·3–31·7). The facial region is also like that of *Homo erectus*, especially the Javan *Pithecanthropus* group. The chin on the lower jaw is another focus for archaic or "old" features.

It is interesting that most of the archaic features in the Kow Swamp series are concentrated on the front of the jaw and on the face and forehead. This suggests that this part of the skulls preserves an older form, other parts of the skulls having been modified or modernized.

Oldest human remains

The oldest human remains yet found in Australia are from Lake Mungo, in south-western New South Wales. One of a series of dry lake basins in the area, Lake Mungo has a high dune ridge developed on its eastern margin. Because of its size, the Mungo ridge is known appropriately as "The Walls of China". In July 1968 geologist J. M. Bowler found the human remains while surveying an eroded part of the ridge. Initially, the bones were thought to be the food remains of Aborigines who once lived around the Lake at a time when it was filled with water. The bones were cemented together in a calcrete block which was disintegrating. Subsequent excavation and examination of the bones have shown that the Mungo individual had been cremated. Like some of the West Point material, the charred bones were thoroughly smashed, gathered together, and then deposited in a shallow pit. The remains have been dated to between 25,000 and 32,000 B.P.

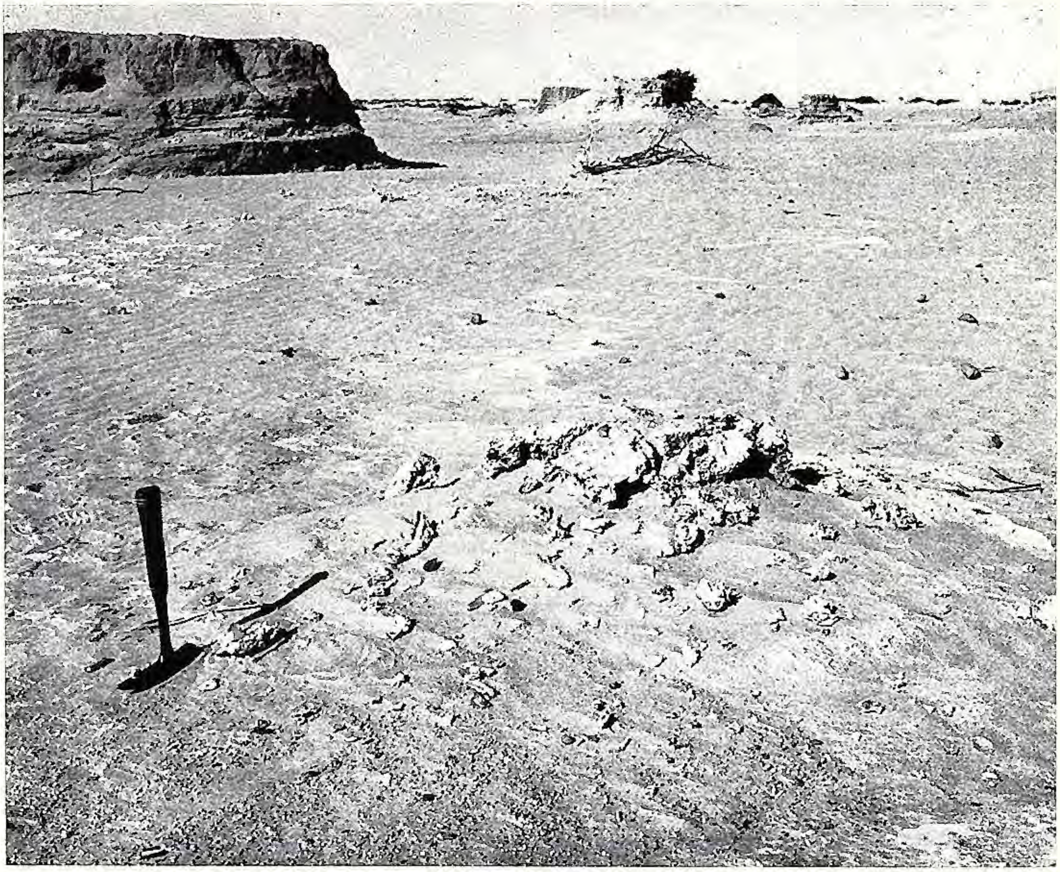
As the Mungo skeleton is smashed so thoroughly, reconstruction is proving a painstaking operation. The cranium, when complete, will represent the assembly of more than 200 bone fragments.

The skeleton is that of a young adult female. The cranium is small by recent Aboriginal standards. Despite its antiquity it is anatomically quite modern and can be contrasted with the more recent but archaic-looking Kow Swamp series. The cranium is fully-rounded and smooth, with little or no indication of muscle insertion sites. The major skull bones are thin. From a lateral aspect the dorsal outline reveals a protruding forehead. Brow ridge development is slight. The temporal regions are expanded, with minimal postorbital constriction. As much of the face is either missing or in very small pieces, all that can be said at present is that it is small and delicate.

Latest discovery

Another western N.S.W. lake site has produced the latest discovery. This is the

One of the reconstructed Kow Swamp crania, seen in right-lateral view. [Photo: D. Markovic.]



The Lake Mungo cremation before excavation, showing the disintegrating calcrete block that contained the bones. The cremated remains of this female have been dated to between 25,000 and 32,000 years ago. [Photo: R. Jones.]

Lake Nitchie skeleton. Excavated in 1970, the remains are the result of a curious burial. The Nitchie grave was cut out of a hard calcareous deposit, but was too small to receive the body of this large male individual. Despite flexure of the lower extremities, it seems that the head and shoulders had to be forced downwards to make them fit into the grave. As some bones were broken or distorted, Professor Macintosh, who excavated the skeleton, has deduced that the man must have been dead for at least a week before he was buried.

A fascinating aspect of this find was the discovery that the Nitchie individual was buried with a unique necklace of pierced teeth. The teeth are all canine teeth from the Tasmanian Devil, *Sarcophilus*, now extinct on the Australian mainland. The 159 teeth in the necklace were derived from a minimum of 46 animals and possibly as many as 100. The presence of so many *Sarcophilus* teeth suggests this animal was relatively common at the time of the burial. Archaeological evidence that the Devil became increasingly uncommon on the mainland after about 3,000 B.P. implies considerable antiquity for the burial.

Anatomical distinctions reinforced

Recent fossil finds from Australia reinforce and extend the anatomical distinctions recognized earlier. The concept of two morphological groups is strengthened. Keilor, Green Gully, and Mungo lie within the skeletal range exhibited by recent Aborigines. They share expanded frontal

A vertical view of the Lake Mungo cranium, showing the expanded temporal fossae and weak brow ridges. The colour variation of the reconstructed fragments is the result of differential firing during cremation. [Photo: D. Markovic.]

and temporal regions, relatively flat faces, and a general smoothness. The other group, however, is quite the reverse. Talgai, Cohuna, Mossgiel, and the Kow Swamp population are large and rugged, with thick vault bone. They display a complex of features not seen in recent Aboriginal skeletal material, including marked frontal flattening, constriction at the temples, and projecting faces.

The Mungo specimen indicates that modern form has existed in Australia for at least 25,000 years. This is supported by evidence that modern morphology reached Tasmania before the formation of Bass Strait. For this reason it is likely that the population represented by Talgai, Cohuna, and Kow Swamp is a relic one, maintained in relative genetic isolation, particularly in the Murray Valley.

On present evidence it is tempting to see recent Aboriginal morphology as the product of at least two colonizing populations. If this were the case then the parent stock of the earliest migrants had had a long and relatively undisturbed history in the Indonesian region while the parent stock of the second group, probably centred in the same general region, had been subjected to considerable genetic modification from the mainland of south-eastern Asia.

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BOOK REVIEW

"DEEP OCEANS", edited by Peter J. Herring and Malcolm R. Clarke; Arthur Barker Ltd, London, 1971; 320 pages; price, $15.85.

This is by far the best book on the deep sea that I have read. For both the scientist and the layman, it is a mine of information—the origin of the oceans, what sea-water really is, the living patterns of strange deep-sea animals, sea-floor topography and its recent exploration, fisheries and whaling, sea-going computers, or the most recent manned submersibles. This book has them all. Quite obviously, no book attempting to describe the huge underwater world can deal with everything, but *Deep Oceans* has a wide and varied coverage, is authoritative, and often deals with subjects in surprising depth.

On first reading the book I liked it so much that I wondered if my prejudice for the very able authors and my own scientific bias might not make me a bad reviewer. I therefore asked a friend of mine, not a scientist but interested in natural history, if she enjoyed it. Her comment: "Absolutely fascinating. It made me aware of a hundred new and interesting things about the deep-sea world. I want to own it and dip into it again and again".

Deep Oceans is profusely illustrated, and the quality of the line drawings and black and white and colour photographs is high. Some of the colour photographs of deep-sea animals are the best I have ever seen. To own this book one needs $15.85, but as a source of real enjoyment and a top-quality reference book it is cheap at the price.—*F. H. Talbot, Director, Australian Museum.*

An Introduction to Polychaetes

By PAT HUTCHINGS
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POLYCHAETES are segmented worms which live predominantly in marine or brackish waters. They differ from other segmented worms, such as earthworms and leeches, in that each segment has a pair of parapodia or lateral paddles with projecting chaetae or bristles.

The polychaetes are divided into a number of families, and these are conveniently split into errant and sedentary families.

The errant polychaetes (see fig. 1) move freely, either crawling or swimming, and they have well formed parapodia and a distinct head or prostomium which has well developed sensory appendages, such as eyes, palps, antennae and tentacular cirri. Eyes are especially well developed in swimming forms. The anterior part of the gut or buccal cavity is eversible, forming a proboscis which may be covered with papilla (small wart-like projections) or have hard chitinous jaws or teeth. The structure of the anterior end of an errant worm, a nereid, is shown in fig. 2.

By comparison, sedentary polychaetes live in tubes of their own construction. These may be calcareous, parchment-like mucus, or consolidated grains of sand or particles of mud. The mucus tubes are very delicate and are often destroyed when collecting the animal, but in other cases the tubes remain long after the worm has died (this is especially true of calcareous ones). These tubiculous worms have less well developed parapodia and chaetae than errant ones and in some cases the parapodia are lost completely. The head of sedentary polychaetes normally lacks sensory appendages; instead, it may have highly extensible feeding tentacles, as in terebellids and ampharetids (see fig. 3), or a branchial crown, as in serpulids and sabellids (see fig. 4). The proboscis of sedentary worms is never armed with jaws or teeth. In many of these sedentary worms and in some errant ones, gills are developed; these may occur over the entire body length or be restricted to the anterior segments.

In the rest of this article the different types of habitats, the feeding and breeding methods of polychaetes are described.

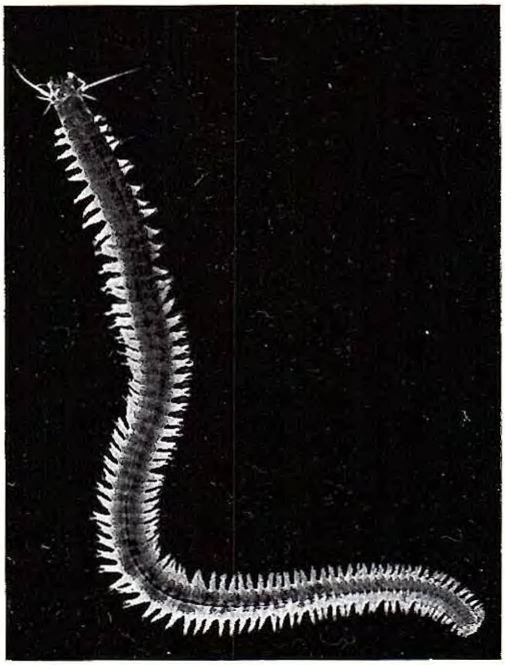

Fig. 1.—*Perinereis amblyodonta,* a nereid which swims or crawls actively. The body is clearly segmented, and each segment bears a pair of parapodia and chaetae. [Photo: C. V. Turner.]

Common names have been used wherever possible, but for many species common names do not exist and the reader is referred to the reading list at the end of this article, where publications are mentioned in which descriptions and figures of these species may be found.

The majority of polychaetes are benthic or bottom-living animals; they are probably the commonest macroscopic animal found on the sea bottom. Polychaetes are found at all depths from the littoral zone of the shore to the deepest parts of the ocean which have yet been sampled. The remaining polychaetes have adopted a pelagic existence—they swim or float on the surface of the sea. These species tend to be small and semi-transparent, with very well developed parapodia and eyes. Some errant species,

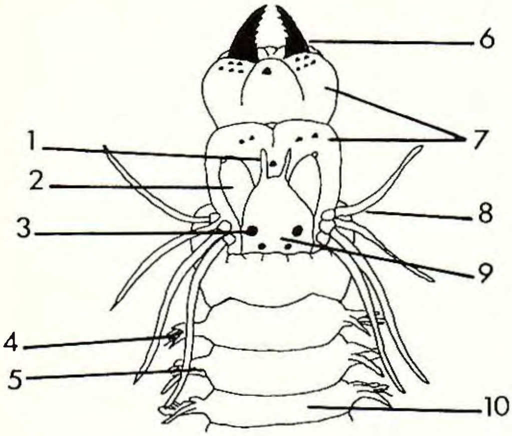

Fig. 2.—Diagram of the anterior end of an errant worm, a nereid. 1, tentacle. 2, palp. 3, eye. 4, chaetae. 5, parapodia. 6, chitinous jaw. 7, extended proboscis. 8, tentacular cirri. 9, prostomium. 10, body segment. [Diagram by the author.]

such as nereids (ragworms), become pelagic at the time of breeding by developing very long swimming chaetae and increasing the size of their parapodia.

Benthic polychaetes are found in a wide range of substrates. For instance, capitellids which live in mucus tubes are found in muddy substrates. They have a protrusible unarmed proboscis, which is used for burrowing and for collecting the mud on which they feed. The worms digest single-celled animals and plants, and dead organic matter which is present in the mud. This type of feeding is very similar to that used by earthworms, and capitellids even resemble them, as they lack parapodia.

Other polychaetes, such as terebellids and ampharetids, live in sandy mud substrates. These worms build tubes of mud, sand and shell particles which are cemented together by mucus, forming a tough but flexible tube. Both these types of worms have a number of grooved feeding tentacles, which can be extended and laid over the surface of the mud with the grooved side downwards (see fig. 3). The walls of the groove are ciliated, and small particles on the surface of the mud are drawn into the groove by ciliary currents and are then transported along the grooves by cilia to the base of the tentacles. Here the particles are cemented together with mucus and these small balls of food are transferred to the mouth by muscular lips. In circumstances like this, these worms are feeding on very small animals and plants found on the surface of the mud. Some of the larger particles of mud and sand which are also collected by the tentacles are not eaten but are used for tube building.

By comparison, the beach worm *Onuphis teres*, which is often used for bait by fishermen, lives in clean sand on surf beaches. These worms have very well developed jaws

Fig. 3.—*Terebella* sp., a terebellid, showing the feeding tentacles extended over the surface of a glass plate. The branched gills are slightly darker in colour and are at the base of the tentacles. [Photo: C. V. Turner.]

and sense of smell; they will come up out of their burrows and catch any small animal (dead or alive) or seaweed which is on the surface of the sand near their burrows and drag it back into their tubes, where it is eaten.

But many polychaetes live on the rocky shore, such as nereids (see fig. 1) and polynoids, or scale worms (see fig. 5). These live under stones and in amongst seaweed. Both these types of worms are scavengers, eating other polychaetes, crabs, shrimps, or seaweed, dead or alive. Others, such as cirratulids, live in crevices or underneath rocks where silt can accumulate; they are surface-deposit feeders, like terebellids and ampharetids.

Another very important family, especially in warmer waters, are the serpulids. These secrete calcareous tubes which are attached to rocks or other animals, such as corals, crabs, barnacles, or molluscs, and a few species settle on seaweed. Serpulids have a well developed branchial crown, which can

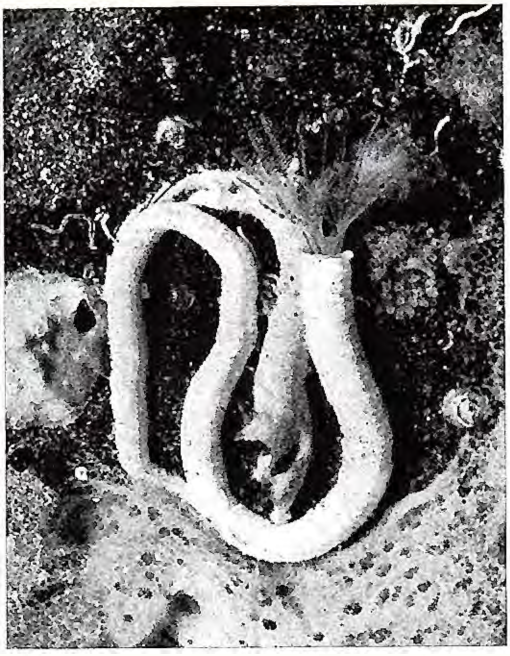

Fig. 4.—*Protula* sp., a serpulid, with its calcareous tube attached to a rock. The branchial crown is extended; it is composed of many filaments which have lateral projections or pinnules forming an effective sieve through which water is filtered. Smaller serpulid tubes can be seen in the background. [Photo: C. V. Turner.]

be held erect in the water to form a cone (see fig. 4). At low tide or when the animal is disturbed it contracts rapidly into the tube and seals it with a calcareous plug or operculum, which is a modified branchial filament. Serpulids are filter feeders; they collect small animals and plants which are suspended in the water by drawing water into the centre of the branchial crown by cilia on the branchial filaments. As water flows between the filaments any suspended material falls out of suspension and becomes trapped in a stream of mucus which is secreted by the epidermal cells of the filaments. These trapped particles are then carried along ciliated grooves on the axis of the filaments to the base, where they are transferred by palps to the mouth. Cilia at the base of the crown direct the filtered water out of the crown and maintain a unidirectional flow of water.

Serpulids may be solitary or form dense colonies, such as *Galeolaria caespitosa*, which on many New South Wales shores forms a distinct Galeolaria zone (the "Sydney Coral)".

Many different patterns of reproduction are shown by polychaetes. In many of the errant species, such as nereids and eunicids (which includes the beach worm), the males and females shed their gametes into the sea, where fertilization takes place. In some of these species which have been studied the population spawns at restricted times of the year, and one very famous worm, the Palolo Worm (*Eunice viridis*), which is found in Samoa, spawns in October or November at the beginning of the lunar quarter. At this time all mature worms in the population develop swimming chaetae and increase the size of their parapodia and eyes. When stimulated by the new moon they leave their burrows and swim to the surface. Here the worms swim rapidly and the males shed their gametes into the water; this stimulates the females to spawn. The natives of Samoa can predict the nights on which the worms are going to swarm, and on these nights they launch their fishing boats and collect large quantities of the spawning worms, which are considered a great delicacy.

This synchronization of spawning is controlled by environmental factors, such as temperature, day-length, or phases of the moon, as in the above example, and is essential to ensure successful fertilization.

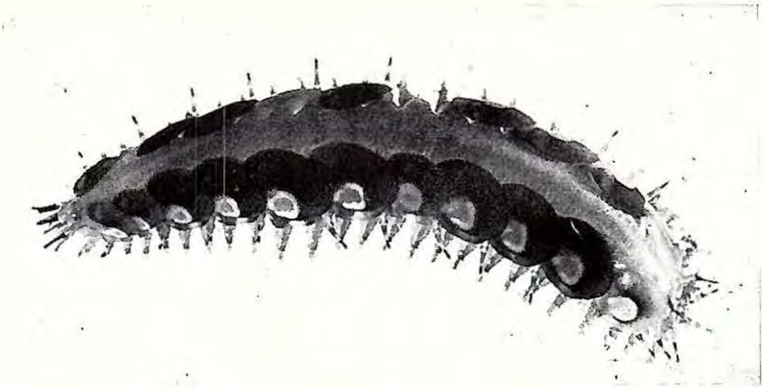

Fig. 5. — *Lepidonotus melanogrammus*, a scale worm. There are twelve pairs of scales, slightly overlapping each other, attached to the animal by stalks or elytrophores. On the right-hand side several of the larger scales have been shed and the elytrophore is visible. The eggs are incubated under the scales. The head (left end) has numerous appendages, and the parapodia and chaetae are clearly visible. [Photo: C. V. Turner.]

After fertilization cell division begins, and some hours later a trochophore, or larva, is produced. These are pelagic and may remain in the plankton for several months, feeding either on reserves which were incorporated into the egg before it was shed or on other members of the plankton. After larval development has been completed a change in behaviour causes the larvae to sink to the sea floor or settle on the shore, and if conditions are suitable the larvae will change or metamorphose into the adult form.

Other polychaetes, such as some polynoids (scale worms), which are normally aggressive to each other, pair at the time of breeding; the male sits on top of the female, and as the eggs are laid the male fertilizes them and they are then transferred by the parapodia of the female to underneath the scales on her back. The worms then separate and become aggressive to one another again. The eggs develop underneath the scales and at some stage, depending upon the species, the larvae are released into the plankton where development is completed. In some of the serpulids the underside of the operculum is modified to form a brood chamber, where the larvae are protected during their entire development.

Polychaetes may breed once and then die, or they may breed several times in a year and then die. Some of the sedentary species which have been studied in detail breed annually for 5–6 years. Unfortunately, the breeding biology of relatively few polychaetes has been studied, even though they are an important group of marine animals in benthic productivity.

All the polychaetes in the photos were found at Long Reef, near Sydney.

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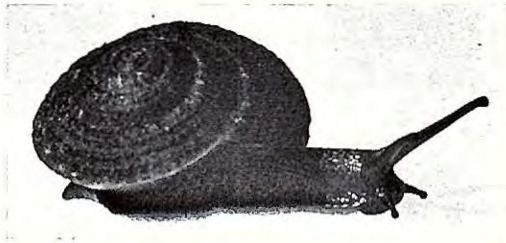
Endemic Tasmanian Land Snails

By ALAN J. DARTNALL
Curator of Invertebrate Zoology, Tasmanian Museum, Hobart

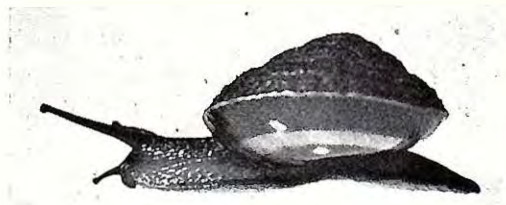
To many naturalists Tasmania is a land of "living fossils". The island certainly includes many primitive and ancient forms among its fauna. Many groups of Tasmanian animals remain to be investigated, and numerous species are not named nor are their habits recorded. Among the land molluscs two striking animals are to be found which are truly Tasmanian:

● *Anoglypta launcestonensis* is known only from the rainforests of northeastern Tasmania. The animal in the photographs measures about 8 cm (about $3\frac{1}{7}$ inches) from outstretched tentacle to the tip of the tail. The shell is approximately 3·5 cm in diameter. In spite of its distinctively patterned shell, brown and rough above, smooth and yellow-banded below, it is a difficult creature to find in its forest habitat.

● *Caryodes dufresnii* is found throughout Tasmania. It lives in leaf litter and under logs and stones in forests throughout the State. The markings on the shell (note the double band on the smaller specimen) are variable. The young have rounded shells when they hatch, but as the animal grows the body whorl enlarges in proportion until an elongated "bulimoid" shell is attained. The large animal in the photo is about 4 cm long.

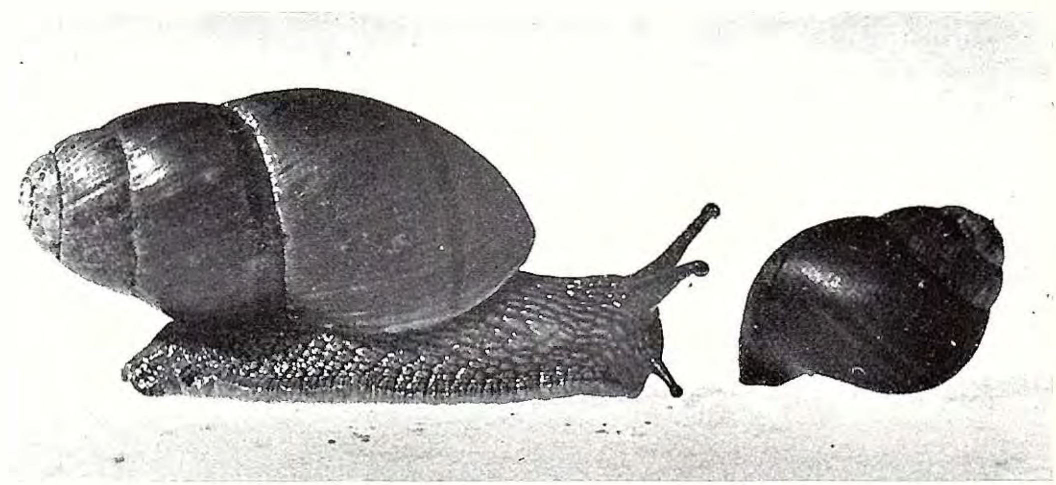


Above and below: *Anoglypta launcestonensis.* At bottom of page: *Caryodes dufresnii.* [Photos: Author.]



The two species are related in spite of the evidence of their dissimilar shells. This has been demonstrated by studies of their reproductive systems and also by examination of their chromosomes. Their nearest relatives are the Pandas and Flat-coiled Snails of eastern Australia. All of these "acavid" snails lay large eggs which look like small birds' eggs.

As the Tasmanian countryside changes in response to exploitation and pollution, it becomes more difficult to study the native fauna. Preservation and conservation of birds and mammals will proceed because those animals are more noticeable, their habits are better known, and to many people they are more appealing. In the case of smaller, lesser-known invertebrates, such as these two snails, our knowledge of their place in the environment is meagre. Studies at present in progress aim to define the ecological and geographic parameters of these animals with greater precision.



Evolution, Structure and Behaviour in the Ascidians

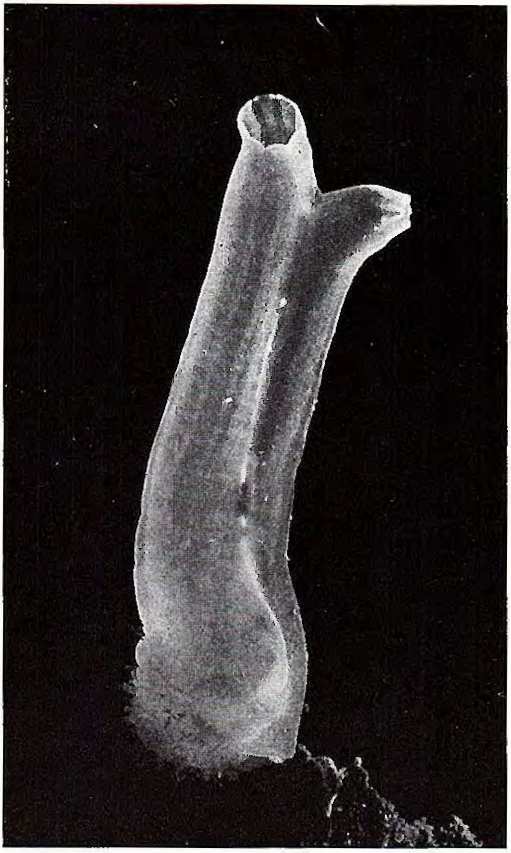
By PATRICIA KOTT
Research Fellow, Zoology Department, University of Queensland, Brisbane

THE range of responses available to any organism depends to some extent on the nature of its sensory receptors, on the variety of stimuli it encounters, and on the versatility of the reactions that its structure will accommodate.

Individuals of the class Ascidiacea are enclosed in a protective non-cellular, cellulose-like covering known as a "test", and are fixed to the substrate, each in an essentially unchanging marine environment. Their sensory apparatus is simplified and their behavioural responses are equally limited.

The structural adaptations that accompany evolution in this group of animals, however, enable different species to exploit a wide variety of conditions and appear to compensate for the limitations in the behavioural responses available.

Larvae are tailed, have a short free-swimming life before metamorphosis, and are slightly more versatile in their range of behavioural responses than are the fixed adults. Larval structure and behaviour are related to the type of environment favoured by the adults. Therefore they are able to select suitable sites for settlement and accordingly avoid too wide dispersal, before metamorphosis. Sufficiently dense populations of these fixed animals are thus effected to ensure subsequent random fertilization in succeeding generations. Nevertheless, despite the relatively greater versatility of larvae in responding to the environment, the success of any species is determined primarily by the ability of the adult to utilize its environment—to survive and to reproduce.



Ciona intestinalis, a common fouling organism on ships' hulls. The longitudinal and transverse body muscles can be seen through the thin, semi-transparent test. [Photo: Douglas P. Wilson.]

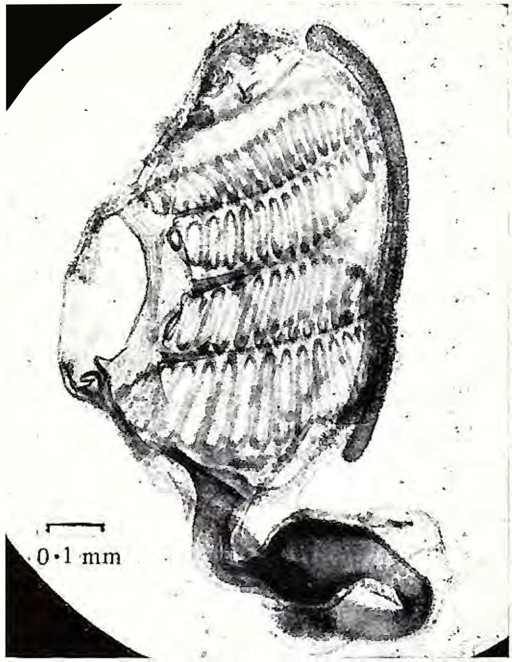
Structure and function

Adult ascidians are generally fixed posteriorly. They have a terminal branchial (incurrent) opening or mouth that leads into an expanded pharynx occupying the centre of the body. The pharynx is perforated by small openings (stigmata) which are lined with small hairs known as cilia. Water is moved from the pharynx into the surrounding peribranchial (atrial) cavity by the action of these cilia. Both the anus and the ducts from the gonads open into this atrial cavity, which opens to the exterior through the atrial opening on the dorsal surface of the body. There are longitudinal and circular muscle bands in the body wall surrounding the atrial cavity. These branch and ramify but, in more primitive species, are generally not interrupted along their length. The unique protective outer coat (the test) is secreted around the outside of the animal and is only loosely connected to the body wall by large blood vessels. The body openings can be closed by contraction of the circular muscles surrounding them, and water can be forced out of the pharynx by contraction of the general body musculature. The extent to which the whole body can be contracted depends on the firmness of the outer test.

As the animal is protected by the inert "test" all its reactions with the environment, including feeding and reproduction, are effected through the apertures. Fertilization, respiration, and feeding are effected by way of the mouth, while gonadial and waste products are liberated through the atrial aperture. Both openings are sensitive to touch, and the "cross-reflex" response, whereby the closure of either opening can be effected by stimulating the inner surface of the other, can be demonstrated. This has obvious advantages associated with driving foreign particles out of the aperture by forcing water out of that same aperture.

At the base of the branchial opening is a ring of tentacles which filters the water entering the aperture and repels large bodies. A neural ganglion and an associated gland which opens to the pharynx are present in the mid-dorsal line between the branchial and atrial apertures. The opening of the neural gland on a small tubercle protected by the branchial tentacles is probably the only actual sense *organ* of the adult ascidian, and appears to be sensitive to chemical stimuli, such as food, in the water entering the pharynx.

An adult ascidian, undisturbed, has both branchial and atrial apertures wide open and the cilia lining the perforations of the pharynx maintain a continuous feeding current through the pharynx from the region around the mouth opening. The atrial aperture, moreover, is of smaller diameter than the mouth, and the spent water, after passing through the pharynx, is projected out through the atrial aperture, a considerable distance away from the animal. The excurrent (or spent) water, containing waste and gonad products, is not therefore dispersed in the region from which the incurrent water is drawn.



An asexually produced zooid taken from a colony of *Sycozoa tenuicaulis*. [Photo: Author.]

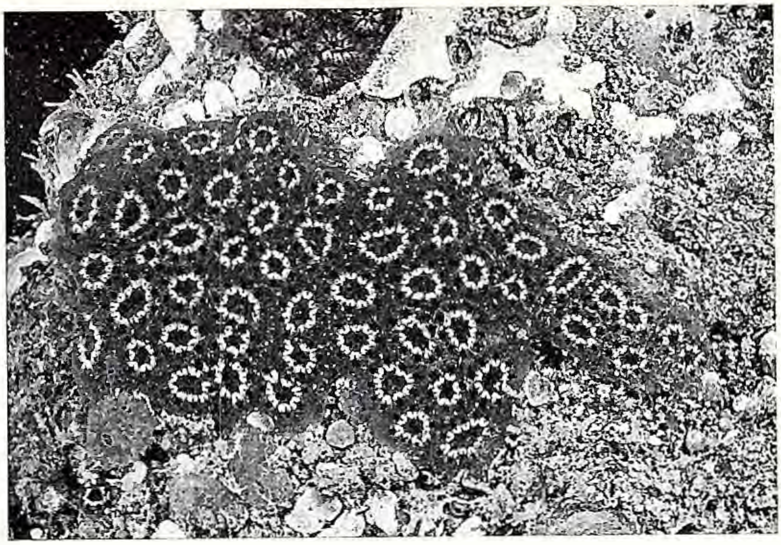
The feeding process can be arrested if the animal is mechanically disturbed or if undesirable substances are present in the water.

When genital products of an animal of the same species are present in the incurrent food stream they are detected by the opening of the neural gland. The secretion of mucus, in which food particles were enmeshed, then ceases and the neural gland secretes the hormone which initiates the nervous activity resulting in the release of sexual cells. This physiological mechanism ensures that eggs or sperms are not ingested as food and that the reciprocal cells of the opposite sex are available for fertilization.

The ancestral ascidian

As the Ascidiacea have neither internal nor external skeleton there is no fossil record of their evolutionary history. The extant genus *Ciona*, however, has many primitive characteristics, and the contemporary fauna appears to have evolved from a *Ciona*-like

A colony of the brilliantly coloured Sea Daisy (*Botryllus schlosseri*). Individuals are arranged in circles around central common cloacal openings to which their atrial openings are directed, as indicated by the white-rimmed upper atrial lips seen in the photo. The white mottled colonies surrounding the botryllid are *Didemnum* species, a true aplousobranch species with minute zooids and extensive cloacal systems. [Photo: Douglas P. Wilson.]



ancestor. *Ciona intestinalis* is a common fouling organism on harbour installations and ships' hulls. Individuals are large and solitary and the whole animal is very soft and contractile. In this species large numbers of eggs are released and fertilized externally; the species favours protected waters, where it is often present in great numbers. The minimal population density necessary to effect external fertilization therefore appears to be high. The larvae have light-sensitive cells and are attracted into shadow; they often develop a gas bubble just before metamorphosis so that they float up to settle on under-surfaces. The adults therefore often hang downwards; their apertures are thus protected from falling detritus that could interrupt the feeding process of these soft organisms, which generally contract completely when disturbed.

Colonial species

From an ancestral *Ciona*-like ascidian two main lines of evolution proceed. In one, represented by the suborder Aplousobranchia, vegetative reproduction (or "budding") interrupts the growth of the parent individual, and smaller mature individuals, enclosed in common test material, form colonies of increasing complexity. As the individuals (known as zooids) decrease in size the thickness of the colony is reduced and sheet-like colonies (Polyclinidae, Didemnidae) are formed which enable these species to occupy turbulent areas, where their flat encrusting form is an advantage. With the reduction in zooid size the eggs are not so freely liberated and are retained for longer in the parent. Subsequently the number of eggs decreases, they are fertilized within the body, commence their development there, and later are released as tadpole larvae. In these viviparous species, when the body of the developing embryo is retained for a long while in the body of the parent, there is an increase in egg-size due to an accumulation of yolk, which tends to reduce the rate of development of the embryo by an increase in volume/surface area ratio. The development of larval organs is then often suppressed in favour of a more direct development to the adult. The colony thus protects the developing embryos and the free-swimming life of the larvae is reduced, so that on release they are not widely dispersed in the turbulent waters favoured by the parents.

The small zooids of these colonial species are also protected by the test in which they are embedded and the test provides a micro-environment for each individual. Here the survival of the vegetatively reproducing colony is more important than the survival of any one individual within the colony, and the ability of the colony to regenerate while even a limited number of individuals remain in it is great.

Simple ascidians

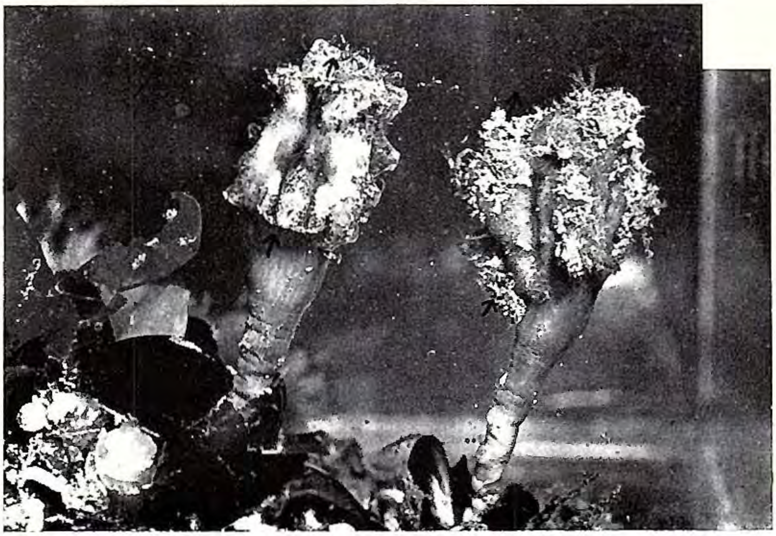
In the other evolutionary line (suborders Phlebobranchia, Stolidobranchia) the ability to "bud" is not generally developed. Individuals thus remain large and solitary and the branchial sac and excretory system develop to serve these single solitary individuals, which are protected by a firm and (as evolution proceeds) an increasingly tough, sometimes hard, test. The adhesive properties of the surface layer of test increase to provide firm anchorage, and often cement a coating of sand, shell, or other foreign particles around it, thus providing added strength and protection. In certain species it is the strength of the test that confers the ability to exploit less sheltered waters.

Further, the value of a generally contractile body wall, inside a rigid test, is lost and the muscle bands decrease in length and are interrupted to serve very special and localized functions. In the genus *Ascidia* short bands of muscle around the dorso-ventral border cause lateral flattening of individuals which lie fixed on their side to the substrate. In the family *Agnesiidae* shortened longitudinal muscles operate flaps of test which close over and further protect the apertures. A special closing device of this type, in the genus *Rhodosoma*, is spectacular, for the whole anterior part of the test forms a thickened lid closing over the apertures which are simultaneously withdrawn.

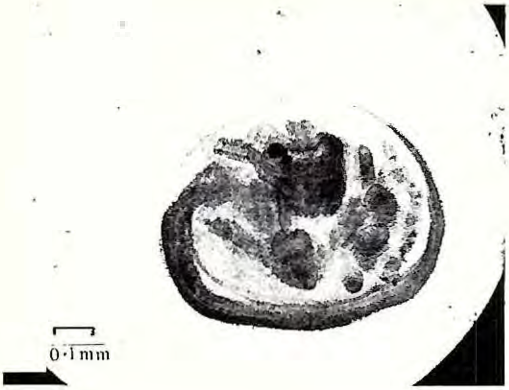
Variation in the orientation of the aperture of each individual ensures that the best use is made of the conditions available, and is often effected by differential growth of the surrounding test. Thus, in certain individuals, especially those that lie on sand, the mouth is turned over toward the substrate, while the atrial aperture remains directed into the water above and away from the animal. The large fleshy, sometimes black-spotted, *Phallusia* demonstrates well this differential growth, or "recurving" of the mouth opening.

Adagnesia, a rare genus which has been taken only from a sandy substrate in Moreton Bay, Queensland, has a sand-hardened brittle test and is laterally flattened. The apertures lie in a slit of very thin test around the anterior end of the body and the test forms a thickened flap which closes down over the mouth opening. Opposite the atrial aperture, the test from the underside of the body forms a flap which closes up over the sessile atrial aperture. The orientation of the mouth and atrial openings down toward the substrate and "up and away", respectively, is thus maintained and accentuated by the closing mechanism.

Orientation of the apertures of stalked species is interesting. These include forms known commonly as "Sea Tulips"—a name generally applied to stalked species such as *Pyura pachydermatina*, on the New South Wales coast, and *Boltenia* species, from the



Two short - stalked specimens of the Sea Tulip (*Pyura pachydermatina*), a sub-littoral species of the Australian coast. The stalks are often very much longer. The arrows indicate the location of incurrent and excurrent openings. Weed and other organisms are growing on the test [Photo: Frank Allen.] .



Larva of *Leptoclinides rufus* taken from the brood pouch of the parent zooid. A light-sensitive organ and a gravity-sensitive organ are seen as pigmented spots in the region of the neural ganglion. The short strong tail is wound around the body of the larva. [Photo: Author.]

Atlantic and Pacific. Invariably the stalk originates from the *anterior* end of the body and the rounded free surface is actually posterior. The animal is standing on its head and the mouth, on the antero-dorsal aspect of the body, is directed toward the substrate and the atrial aperture is postero-dorsal, near the free end of the body.

It has long been assumed that stalked species favour sandy or muddy substrates in which they are rooted and above which they are supported by their sometimes long stalk. However, it seems more likely that the stalk provides a structural adaptation to enable the animal to make the best use of conditions where there is surge, wave action, or current or tidal flow. The base of the stalk fixes itself firmly to rocky substrates, reefs, or overhanging ledges and the animal moves, on its stalk, with the current so that the mouth opening is presented to the oncoming current and augments the ciliary feeding stream, while the atrial aperture faces in the opposite direction.

In the suborders comprising solitary species, fertilization has in general remained external and large numbers of sex cells are produced. However, where species inhabit the open sea-bed or areas where there is turbulence and current flow, an excessive dispersal of eggs and sperm or of larvae is threatened. This dispersal would prejudice the establishment of the minimal population densities necessary for reproduction in succeeding generations. Various structural adaptations therefore ensure that the eggs are fertilized in the atrial cavity and develop, sometimes almost to metamorphosis, there. In this respect the oviduct may be shortened or turned ventrally, away from the opening, so that the eggs lie and develop in the ventral part of the atrial cavity.

Thus, although ascidians lack the sensory and motor equipment generally available to free-swimming organisms and have only a limited spectrum of behavioural responses, different species have evolved to exploit a wide variety of habitats. In colonial species structural modifications increasingly isolate individual zooids from the environment as the colonial system develops. Simple species, on the other hand, demonstrate structural modifications that effect a more efficient direct use of the environment by each individual.

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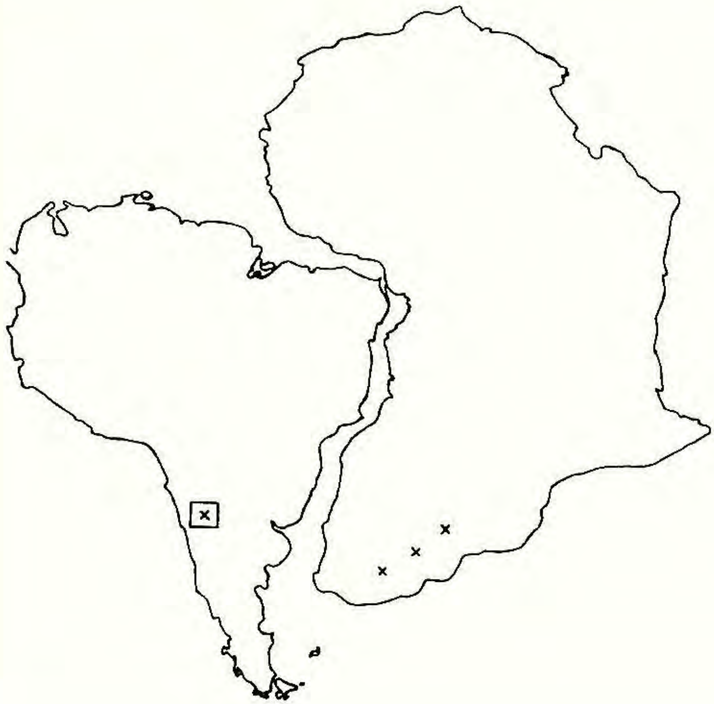
The skeleton of a cynodont, typical of the numerous skeletons and skulls widespread in the Ischigualasto Valley, Argentina

South American Fossil Reptiles as Evidence of Gondwanaland

By ALFRED S. ROMER
Museum of Comparative Zoology, Harvard University, U.S.A.

THIS is an account of two expeditions by Harvard fossil-hunters, in association with museums in Buenos Aires and La Plata, in search of fossil Triassic reptiles in western Argentina. Your immediate question is, why is this published in an Australian magazine? What has this to do with Australia?

The answer is: Gondwanaland. Nearly a century ago workers in peninsular India discovered the presence there of beds of ancient geologic times which were found to be closely comparable to those in the southern continents. Out of this find grew the hypothesis that far back in the earth's history, in Palaeozoic times, there existed one great southern land-mass which is termed Gondwanaland and which included in its make-up South America, Africa, Australia, Antarctica, and even peninsular India. According to this hypothesis, this once-solid unit later broke up, and the various portions of it drifted to their present locations. For decades most geologists tended to regard this as a fanciful idea. But in recent years there has been an accumulation of evidence, from oceanography, geophysics, and geology, which has tended to make this theory a very respectable one, in which a large percentage of those interested in the early history of the earth have now come to believe. Among



The relative positions of South America and Africa as they probably were in Triassic times, about 200 million years ago. The inset in South America indicates the area of the successful 1958 and 1964 Harvard expeditions in search of Triassic reptile remains. The crosses in southern Africa indicate areas where closely related Triassic mammal-like reptiles have been discovered. [Maps by A. Ritchie].

the subjects which must be studied to prove whether or not this hypothesis has any reality is that of the faunas present in ancient days in these various areas. And, although having other results as well, our work in South America has afforded considerable evidence that the animals of the Triassic period of South America, living some 200 million years ago, were quite similar indeed to those living in Africa at the same time and in all probability similar to those then living in other parts of this supposed ancient continent, such as India, Antarctica, and even Australia.

First expedition

In Argentina a great variety of fossil mammals have long been known from the southern part of that country, the bleak area known as Patagonia. The western part of Argentina, however, had been little explored for fossils. In 1958 a group of us at Harvard, including my colleague Professor Bryan Patterson, two excellent preparators, my wife (a good field-hand at fossil collecting), and myself, thought that a fossil exploration trip to the western region of Argentina, up toward the Andes, might be interesting and potentially profitable. Soon, having arranged to work under Argentinian law and with the co-operation of the museum in Buenos Aires, we set forth.

We first made headquarters at Mendoza, a beautiful city in the foothills of the Andes. I happened to have read a report of an Argentinian worker on fossil plants who had explored a valley named Ischigualasto, some 250 miles to the north, and who had found, as well as plants, three scraps of Triassic fossil reptiles. So we decided to explore this region. It was difficult to get there. The only map of this wild country was on the scale of one to a quarter of a million, and we found after we got there that everything shown on the map was quite incorrect. For the last 100 miles roads were non-existent; we hired a local hunter as a guide. Finally, we came to the edge of the valley we sought. Ahead of us to the north, as far as we could see, stretched a valley bounded by grim looking sandstone hills on one side and, on the other, by a high palisade of red sandstone rocks, the "Colorados". Between, the valley, 2 or 3 miles wide, was filled with a series of varicoloured clays, shales and thin sandstones, which looked as if they ought to be excellent fossil collecting beds.

They were. As we descended into the valley to establish camp, skulls and skeletal parts of fossil reptiles were so abundant that we even had upon occasion to turn our car aside to keep from running over good specimens. So rich was the region that for several days we thought we must be dreaming. And how the previous geologic explorer had been able to miss all these finds, heaven knows. For two and a half months we stayed there, collecting skeletons right and left. By the end of our stay we had gathered up several tons of fossil reptile bones, which we had transported to the coast for shipment back to the United States.

Part of the material we collected there was described by scientists working at Harvard. However, we made no bones about the marvellous locality we had discovered in Ischigualasto; the word soon spread in Argentina, and, even within a week or two of the time we left, collectors from Argentinian museums began to invade the valley, and work by local scientists and description by them of new fossils from Ischigualasto have continued to this day.

Second expedition

We at Harvard felt a smug feeling of pride over the fact that we had opened up this new and marvellous collecting area. But then we thought, why not do it again? If, in one short expedition, we could uncover as fabulous a fossil deposit as that of Ischigualasto, perhaps on a second trip we might do something just as good. Since the fossil mammalian production from our trip had not been too great, my colleague, Professor Patterson, had lost interest in Argentinian work and turned to other areas. But the other four of us—my wife and myself and the two excellent collectors, Arnold Lewis and James Jensen—felt a strong urge to return to Argentina and see if our luck would continue. In consequence, we made arrangements, this time collaborating with the La Plata Museum, under the authority of Argentinian national law, to make a second trip to Argentina. The agreement was that we would spend four months in the western deserts, examining areas which were believed to be Triassic or Permian in age but in which fossils were unknown, and see if we could make a second lucky strike.

So we started out in November 1964. The Argentinian geologists were very co-operative in furnishing us with maps of various areas in the west which they believed to be of Permian or Triassic age, and our project was to explore one after the other of such areas until we found something worthwhile. Western Argentina is a dry country, with an average rainfall of only an inch or two a year. Roads are very few, so one must travel mainly up and down the sandy beds of dry creeks and rivers. Frequently we would be 100 miles or more from the nearest available water or gasoline supply. So we equipped ourselves not only with a good four-wheel jeep, but with a four-wheel-drive truck on which we installed a spare gasoline tank of 70-gallon capacity and an equally large tank for water reserves. An especially useful addition to our equipment was a mountain motor-cycle, one geared down to very low speed but with very considerable power, which would ride over very rough country and carry a 50-pound load as well as the rider.

Poor results—then luck changed

We explored one after another of the areas that the geologists had told us about, each for a week or ten days or more. There was the Santa Clara Formation, running over many hundreds of square miles of country, with thousands of feet of massive sandstones and occasional shales and clays. Fossils? A few fossil "minnows" of little importance, and some footprints. The redbeds called "Paganzo II", likewise stretching over a great area of dreary country, we searched under a hot summer's sun. Results? Nothing—not a bone, not a minnow, not a fossil plant leaf, not a footprint. And the Talampaya Formation, 500 feet of beautiful looking, red-brown, soft sandstone, just the sort of thing in which one should find fossils. Results? Completely barren. In this way we spent our first two months.

Then we set off to explore still another region, 100 miles or so out in the desert from Chilecito. And now our luck changed phenomenally. We set up camp and then, on our first day of prospecting (it happened to be my 70th birthday), I found some scrap.

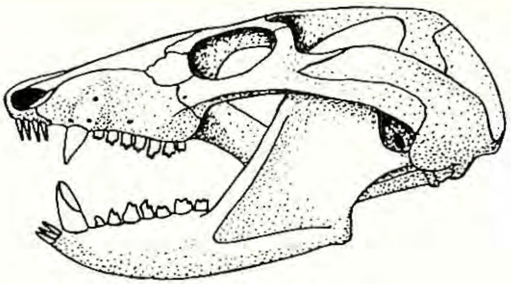
The next day I found several good specimens. And from then on, through January and February, we found fossils as rapidly as we could dig them up. This was in the region of a little dry river called the Chañares, in a most desolate country where it was 40 miles to the nearest settlement one way and 30 the other. Many of the beds there were absolutely barren, but in amongst them was a 200-foot band of white to bluish clays which could be readily followed across country, and in the lower 30 feet or so of these beds fossil reptiles were enormously abundant. We had thought that Ischigualasto was rich collecting, but the Chañares beds were far superior even to those; we all agreed that we would never again in our life expect to find anything as rich in fossils as the beds there!

The number of specimens was staggering. Many times in a collecting trip one feels fortunate if one finds half a dozen skulls and a skeleton or two. Here, during somewhat less than two months, we found well over 200 skulls and great quantities of skeletal material to go with them. We maintained a headquarters at a hacienda at Chilecito, and about every ten days we would load the truck with skulls and skeletons and take them to town. We hired a local carpenter to make eight large, strong boxes, which we gradually filled up with fossils. Since we were working under proper national law, we made no secret of our success. A few local people complained about the fact that we were removing things from the province (La Rioja) in which they were found. However, a La Plata professor and I made eloquent speeches at a local businessmen's club and thought we had things calmed down. Finally it came time to break camp and start for home. We had filled seven of the eight big boxes with fossils. My wife and I stayed in Chilecito to await the arrival of the transport truck to take our finds to the coast; the two preparators returned to break up camp, and they took along with them box number eight, to be filled with fossils left there.

A setback

That evening the trucker arrived, and with the help of six husky peons managed to get the seven heavy boxes into the truck. They drove out the gate of the hacienda—and there

The author and Mrs Romer gaze with satisfaction at the richly fossiliferous Chañares beds which form the lower part of the hill they are facing. (The little hillock on which they are sitting produced half a dozen good specimens).



Skull and lower jaw of a small carnivorous mammal-like reptile called *Probainognathus* from the Middle Triassic Chañares beds of western Argentina. The skull and dentition show many advanced mammal-like features and, although *Probainognathus* is still considered to be a reptile, it is not improbable that it lay close to, and perhaps on, the main evolutionary line leading to mammals. The skull is about $3\frac{1}{2}$ inches in length. [Drawing by A. Ritchie, after Romer.]

were met, by prearrangement, by the local police car! We had, we thought, calmed the feelings of local people—but not those of the governor of La Rioja Province. The police seized our seven precious boxes and transported them to the local police station, saying that these fossils were the property of the province and were not to leave.

We stormed and raved, but without result. Next day a professor from La Plata came up and pointed out to the governor that he was breaking the national law, under which we were virtuously working. He remained firm. Presently there were editorials in the main newspapers in Buenos Aires, protesting against this high-handed conduct of the governor. All to no avail. It was nearly two years before the governor, realizing that he couldn't do anything with these fossils (no one in his province knew a thing about palaeontology or how to prepare a fossil skull), finally released them.

But meantime . . . Do you remember box number eight, that had gone out to camp with the two preparators? They came back into town in the middle of the night, after the seizure. We met them as they came in and told them to turn right around and get out of town as fast as they could, before their presence was discovered. Two hundred miles away were the borders of Cordoba Province, where people didn't give a hang about fossils one way or another. They made their way successfully out of La Rioja and into Cordoba with box number eight, the existence of which was unknown to the governor.

Box number eight reached Harvard and in the course of time the other seven followed. We began work on the fossils, and that work still continues. The specimens are splendid, but it takes considerable time to clear the matrix off each one and get down to the proper surface of the bone; so, although some twelve papers have so far been published, describing much of the material, much further preparation and study still need to be done. The collection consists of specimens of about a score of reptiles, all new to science and many of them represented by complete, or nearly complete, skulls and skeletal material.

Major contribution to knowledge

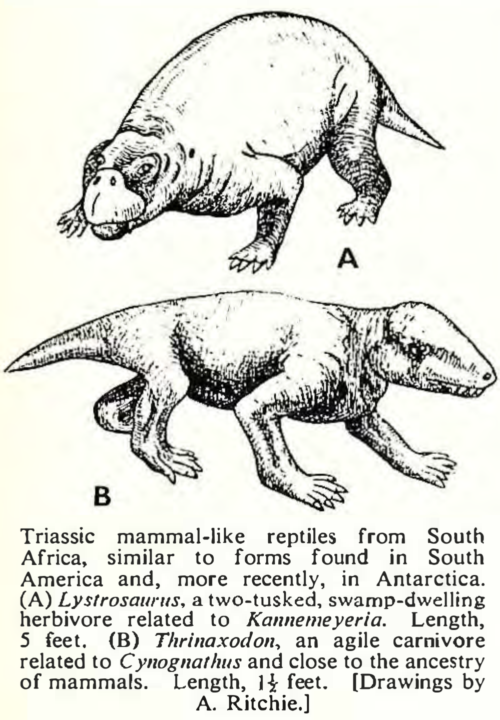
By our discovery of the fossil deposits of Ischigualasto and Chañares, we had made a major contribution to the knowledge of the ancient life of South America. But in addition, we acted, so to speak, as a catalytic agent, in arousing the interest of Argentine scientists to the possibilities of work in the ancient vertebrate-bearing beds of that country. All in all, the result has been that we now know from Argentina and the adjacent southern edge of Brazil about sixty different kinds of Triassic fossil reptiles, all new to science and shedding a great light on the early history of vertebrate life in South America.

In addition to the very considerable knowledge which they give us regarding the reptile life of the Triassic, the fossils that we discovered have made some important contributions to our knowledge of the general evolution of the backboned animals, the vertebrates. For example, there existed in Triassic times a group of reptiles called the Thecodontia, from which, it has long been believed, arose not only the dinosaurs but the crocodilians, flying reptiles, and birds. Before our explorations, relatively few types of thecodonts were known the world around. Our finds of a score or so of thecodonts in South America have not completely solved all the problems of the evolution of these important groups (far from it), but they are contributing greatly toward that end. Again, there have long been known, particularly from South Africa, specimens of a type of

Triassic reptile termed the cynodonts, from which, it is generally believed, arose the warm-blooded mammals, the great group to which we ourselves belong. However, there was until recently a very considerable gap between the most advanced cynodonts and the most primitive of mammals. One of our Chañares discoveries, a little reptile named *Probainognathus*, is a cynodont far advanced over any previously found in the world, and goes far towards bridging the gap in skeletal structure between reptiles and mammals.

Gondwanaland

And now let us come back finally to the question of Gondwanaland, mentioned at the beginning. Much of present belief that Gondwanaland existed back in Triassic and earlier days has been founded on evidence from oceanography and geophysics. Other evidence has come from the existence of ancient glaciers, some 250 million years old, in peninsular India and all the southern continental areas. Still further evidence lies in the fact that all these areas had in early days a peculiar type of flora, the *Glossopteris* flora. Finally, what about animal resemblances? Today, the components of old Gondwanaland are widely scattered over the world and the animals in these different areas differ greatly. Nearly all of the mammals of Australia are absolutely different from those found in any other region of the globe, and the mammal faunas of South America and Africa are so different to each other that many families and even orders are present in one continent and absent from the other. If all these areas were once a single unit, we would expect that the animal life they possessed in olden times would be much more similar, region to region, than it is today. Our South American evidence is one factor toward proof that this was the case. To some extent the fossils we have found in South America do differ from those found in Africa, just as (for example) the animals of western North America differ somewhat from those in the east. But in general, the types of animals found in these two continents are very similar indeed, and, in some cases, there is virtual identity. For example, the two best-known fossil reptiles from the early Triassic of South Africa are a mammal-like carnivore termed *Cynognathus* and a harmless two-tusked herbivore named *Kannemeyeria*. In Argentina are two forms which are the spitting image of those found in South Africa; they may be specifically distinct, but are certainly generically identical. If, in the Triassic, the continents were arranged much as they are today (a belief to which most geologists long adhered and to which some conservatives today still adhere) one can see, from looking at a Mercator's projection, that it is a 20,000-mile trip from one continent to the other by way of Asia and North America. It is highly improbable, *a priori*, that an animal could make this 20,000-mile migration and still retain its identity, and the fact is that today, except for the cats (in a broad use of that term), no two animals in these two southern continents are at all closely similar. The evidence from *Cynognathus* and *Kannemeyeria*, as well as that obtained from the general resemblance of the known Triassic faunas in South America and Africa, are very strong arguments for the Gondwanaland hypothesis.



Triassic mammal-like reptiles from South Africa, similar to forms found in South America and, more recently, in Antarctica. (A) *Lystrosaurus*, a two-tusked, swamp-dwelling herbivore related to *Kannemeyeria*. Length, 5 feet. (B) *Thrinaxodon*, an agile carnivore related to *Cynognathus* and close to the ancestry of mammals. Length, 1½ feet. [Drawings by A. Ritchie.]

Here, of course, we have been dealing only with relationships between Africa and South America. As regards the other Gondwanaland components—India, Australia, and Antarctica—our knowledge of the vertebrates which lived there in Triassic days has been very small indeed up to now. But proof is beginning to mount up. Investigations in India are beginning to reveal there Triassic faunas rather similar to those of South Africa. Within the last two years discoveries in Antarctica have shown there the presence of Triassic reptiles exceedingly similar to those of Africa. In Australia some splendid examples of Triassic amphibians have long been known, but, until lately, practically nothing in the way of Triassic reptiles. Very recently, however, Drs Alan Bartholomai and Anne Howie Warren have found in Queensland fossil pockets in the Rewan Formation of the early Triassic, in which are present not only amphibians but some reptile remains. As yet, these remains are fragmentary and few. But one may have every hope that in years to come further exploration of Triassic areas in Australia will reveal a reptile fauna comparable to that now being uncovered in the other regions which were parts of the ancient continent of Gondwanaland.

MEET OUR CONTRIBUTORS . . .

ALAN J. DARTNALL is Curator of Invertebrate Zoology at the Tasmanian Museum, Hobart. His main interests are the taxonomy and distribution of echinoderms, but, as he himself says, "he cannot keep his hands off interesting and little-known animals". He and Mr R. C. Kershaw, Honorary Malacologist, Queen Victoria Museum, Launceston, are engaged in a project to map and describe the distributions of Tasmanian native snails.

PAT HUTCHINGS is Assistant Curator of Worms and Echinoderms at the Australian Museum. She received a B.Sc. from London University in 1967 and a Ph.D. from the University of Newcastle, England, in 1970. Her thesis for the Ph.D. was on the reproductive biology of a sedentary polychaete. Since arriving in Sydney she has been working on the systematics of the sedentary families of polychaetes, the Terebellidae and Ampharetidae.

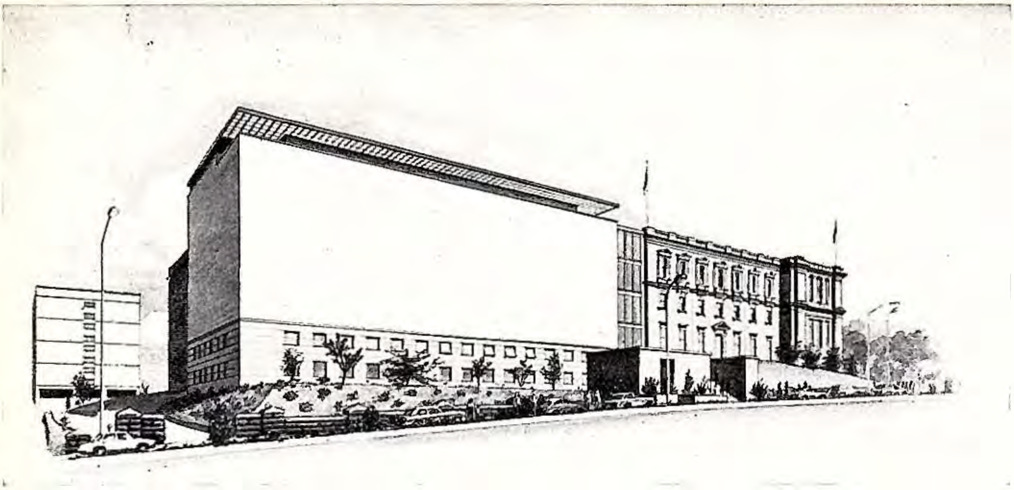
PATRICIA KOTT, D.Sc., is in private life Mrs Wharton B. Mather. Her first experience with the Ascidiacea was in 1948, when, as a first-class honours graduate from the University of Western Australia, she joined the CSIRO, Division of Fisheries and Oceanography, and began working under the guidance of the late Dr Harold Thompson, then the Chief of the Division. Since then Dr Kott has published works on the ascidian fauna of the North Sea, the English Channel, the Red Sea, the Antarctic, and all around the Australian seaboard. Most recently she has completed, while under contract with the Smithsonian Institution, Washington, D.C., U.S.A., an extensive monograph on classification, behaviour, and relationships of the Ascidiacea and on the characteristics and distribution of the ascidian fauna south of 40° S latitude. She has also worked on errant polychaeta and on the zooplankton of the New South Wales coast.

ALFRED S. ROMER, palaeontologist and anatomist, was Professor of Zoology at Harvard University, U.S.A., from 1934 to 1965. Though now aged 77 and retired, he is still active in research and fieldwork. His life interest has been in the history of the vertebrate animals, particularly reptiles and amphibians, and he is the author of standard texts, notably *The Vertebrate Body*, which is in world-wide use, and *Vertebrate Palaeontology*, now in its third edition.

WALTER A. STARCK II was born in 1939, grew up on an island off the southern tip of Florida, and received a Ph.D. in marine biology in 1964. His major field of interest is in the biology and ecology of coral reefs. On an expedition to New Zealand in 1960 he met his chief assistant and diving partner, his Australian wife, Jo. Other expeditions have taken him to the Mediterranean, the Caribbean and West Indies, the eastern Pacific from Columbia to California, Tahiti, Hawaii, Fiji, Micronesia, Australia, and the Indian Ocean.

G. F. van TETS was born in London and educated in Holland, England, Canada, and U.S.A. He received an honours B.A. in 1956, M.A. in 1959, and Ph.D. in 1963 at the University of British Columbia, Canada. He came to Australia in 1963 to become a member of the CSIRO Division of Wildlife Research. He was engaged full-time from 1963 to 1968 and part time from 1968 to 1971 in the study of bird hazards at airports. Since 1968 he has mainly been concerned with the behaviour ecology and zoogeography of cormorants and related birds.

A. G. THORNE is a Research Fellow in the Department of Prehistory, Research School of Pacific Studies, Australian National University, Canberra. He was formerly on the staff of the Department of Anatomy, University of Sydney. His research has centred on the physical anthropology of the Australian Aborigines. He has been involved in archaeological projects in Tasmania and the Northern Territory and on the Nullarbor Plain. Currently he is continuing the excavations at Kow Swamp and a number of other fossil sites in the Murray Valley.



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