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Antipodean Aeronautica

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Abstract: December 17, 2003 will mark precisely one hundred years since the first powered, controlled, sustained, heavier-than-air, human flight. A few months ago, on September 11, 2001, air travel was suddenly stopped throughout the USA. Although only a temporary grounding, the effects have been far reaching. Aviation has figured very prominently in so many aspects of life during the past century and is an appropriate subject for review. The scope of this address covers some of the aeronautical ventures in Australia during the nineteenth century. The events discussed include both the elation due to success and the all too often desolation of failure, with an emphasis on Australia and its position in relation to Europe. As the subject matter for this address has been extracted from research notes for an article proposed for 2003, the period covered will extend only to the end of 1903. For almost this entire period, aviation was really for the birds; for much of the populace, it was a joke. Several of the events I will describe exemplify the public's perception of human flight in the 1800s and beyond.

Keywords: aeronautics, Australian, Hargrave

INTRODUCTION: THE ANTIPODES

Australia – the Great South Land – the last continent to be discovered by Europeans. That place on the Globe most directly opposite Europe. Antipodes is defined as "those who dwell directly opposite to each other on the globe, so that the soles of their feet are, as it were, planted against each other" (Simpson and Weiner, 1989). Is Australia so different to Europe? Australia has often been perceived as the antipodes, in more ways than just the obvious, opposite side of the world. At least a couple of European novelists certainly wrote so.

Robert Paltock wrote about The Life and Adventures of Peter Wilkins – a Cornish man: relating particularly his shipwreck near the South Pole (Paltock 1751). During his ordeal of thirty years, Wilkins met and married a Gawrey – one of the flying people who inhabited the Antipodes. This tale was published in 1751 in England, and has been subsequently republished in Australia in 1979.

Not to be outdone by an Englishman, Nicolas Edmé Restif de la Bretonne wrote La Découverte Australe, par un homme-volant, literally, the discovery of the southern part of the globe, by a flying man (Restif 1781). This too was an adventure novel, set in the Antipodes, the southern land, Australia. Restif sent the hero flying to the other side of the world, where he came upon even more flying people. Their wings were not dissimilar to the Glumms and Gawren of Peter Wilkins, except they also had a parasol arrangement above their heads. Apparently this was another wing, and not a parachute or sunshade! Restif's novel was published in 1781, and he could very well have been influenced by the French translation of "Peter Wilkins". Weird creatures did await the Europeans, although most were found to jump, rather than fly.

Aeronautics is defined as "matters or facts pertaining to aerial navigation", or more simply, sailing the atmosphere (Simpson and Weiner 1989). In 1783 the Montgolfier brothers constructed a hot air balloon in which Francois Pilâtre de Rozier made several tethered flights. On November 21 of that year he was accompanied by Francois Laurent, Marquis d'Arlandes on what was the first human voyage through the air. They floated across Paris in a flight, which lasted 25 minutes (Mackworth-Praed 1990). It had at first been suggested that convicts should be used as the first human cargo, but de Rozier protested, believing free citizens would be more appropriate as the first aeronauts. Just five years later Captain Arthur Phillip landed at Sydney Cove with the First Fleet. European events then began to dominate Australia. Overcrowded gaols, famines and political unrest in Britain led to the creation of the colony of New South Wales.

The most visible aspect of the colony was the transposition of British convicts. Often cast into hulks on English waterways, and set to work each day, the colonial scene must have appeared antipodean – or virtually so. Although still required to work for His Majesty when arriving in the Colony, the opportunity of a Ticket of Leave, a Pardon and sometimes a grant of land provided many British "poor" with a completely new, if not voluntary start.

The sixth governor of New South Wales, His Excellency Major-General (later General) Sir Thomas Makdougall Brisbane Bt., K.C.B, K.C.H., had a keen interest in science and brought out two astronomers in 1821 to begin the local quest for scientific knowledge (Pike 1968). Twenty-two years later news arrived from England of experiments in artificial flight. Natural flight was described as the emulation of animal flight, whereas artificial flight was what we would now consider the norm, aircraft with wings fixed in position. The news from England led to local correspondents describing their various ideas on aerial navigation. Another decade and a half passed before the Australian colonials saw their first examples of aerial navigation, in 1858.

So, what could possibly be antipodean about aeronautics?

THE REALITY OF ANTIPODEAN FLIGHT

French and English rivalry did not stop with the founding of the colony of New South Wales. A French aeronaut advertised his intentions to make a balloon flight in Victoria in 1853, but nothing more appears to have been done (Argus 1853). The first successful navigation of Australian skies occurred on February 1, 1858, over the eastern suburbs of Melbourne. An airship, or balloon, named the Australasian, piloted by an Englishman, William Dean, ascended from Cremorne Gardens (Argus 1858a). Later that same year, on December 13, Dean was accompanied by C.H. Brown as they made the first balloon flight over Sydney (Argus 1858b; Sydney Morning Herald 1858). It must therefore appear strange indeed that an 1856 headstone in St Stephen's Cemetery, Newtown, should be adorned with the carving of a balloon. The headstone marks the grave of an eleven-year-old boy, Thomas Downes. He was the first Australian to die as a result of an aviation mishap, almost fourteen months before any free flight was accomplished in Australia. The inscription declares the last resting place of Thomas Downes, "who was accidentally killed in the Domain at the ascent of a balloon". A Frenchman, Pierre Maigre advertised his reputation as a balloonist, apparently gained before coming to Sydney. Upon his arrival, he had a balloon constructed locally and was keen to demonstrate his skills as an aeronaut.

The method employed for filling balloons in the nineteenth century was to raise the empty balloon by a cord attached to its apex, as shown in figure 1. That cord was attached to another cord, which was strung between two poles. The two wooden poles stood somewhere between twelve metres and twenty-one metres high, depending upon the particular newspaper reports. The poles were secured in place by several guy ropes. In Maigre's case, a fire of straw and wine spirits was lit in an iron furnace beneath the open lower part of the balloon such that the resulting hot air filled the limp envelope.

On December 15, 1856, Maigre intended to make his hot air balloon ascent from the Sydney Domain. This would have been the first ascent in the Colony. The event had been well publicised and a crowd of five thousand rose to twelve thousand by late afternoon. Once the balloon was inflated, Maigre positioned himself on the framework beneath, but the balloon failed to rise more than a few feet. The rope attached to the top of the envelope was still secured, tangled in fact. Unfortunately the time taken to release the rope also permitted the air inside the balloon to cool. No flight ensued and the crowd became unruly. Members of the public had paid to watch, and depending on their proximity to the balloon, the prices ranged from five shillings to one shilling. Maigre escaped, although his hat was destroyed (Sydney Morning Herald 1856a). The crowd burned the balloon, the large poles, seats and anything else they could find. Two young boys were injured when one of the poles came crashing down. One of those, eleven years old Thomas Downes, suffered a fatal fracture of his skull. Accusations were brought against several sailors, who had been in the crowd, but the inquest found that the would-be aeronaut, Maigre should be chastised. He had offered a balloon flight for the entertainment of the public, but failed to deliver (Sydney Morning Herald 1856b).

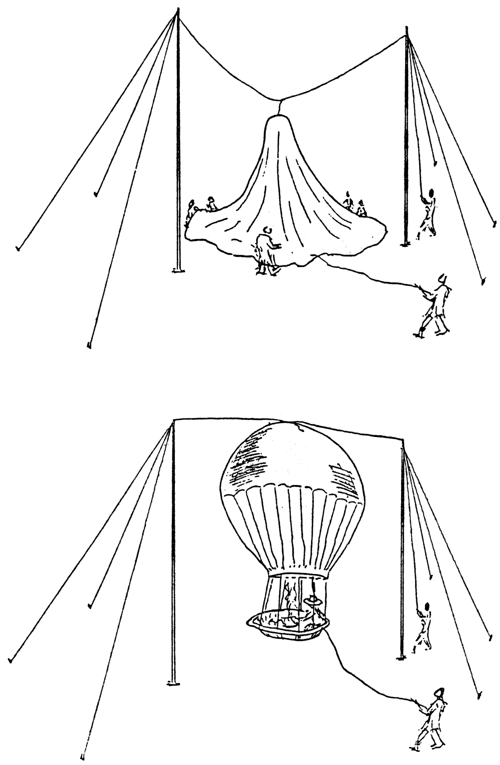

Figure 1: Author's sketch of balloon being inflated.

INSURER'S NIGHTMARE

The Australasian balloon was purchased by Messrs Green and Brown towards the end of 1858, from George Coppin. Coppin was the Manager of Melbourne's Theatre Royal and had imported the balloon from England. The balloon's envelope was twelve metres in diameter, constructed with varnished fabric and had a capacity of 878 000 litres of gas. In Sydney, on Monday April 18, 1859 it ascended from an open space down from the General Post Office (GPO), behind the premises of Abraham Polack, between George and Pitt Streets. This balloon was inflated with coal gas, not hot air. The gas was provided by the Australian Gas Light Company (Sydney Morning Herald 1859a; Argus 1859).

The aeronauts were William Green and Alfred William Wardell, both visitors from England. Green was a nephew of Charles Green, one of the famous aeronauts of the nineteenth century. A number of pilot balloons were released during the afternoon. They remained visible for quite a while and kept the crowd interested, as well as showing the aeronauts their likely aerial path. The balloon and its passengers began to ascend at 5 minutes past 5 o'clock in the afternoon and at first travelled westward. The balloon then drifted towards the east, but began to descend rapidly and landed in the yard of the Woolpack Inn. John Boyd's Woolpack Inn was situated on the eastern side of George Street, next to Campbell Street, in the Haymarket (Sands 1859).

Green had been cautious about their movement eastward, and tried to land in a paddock near Haymarket. That attempt was unsuccessful, but they had lowered the safety line, which was caught by four helpers in the Woolpack yard. The aeronauts considered that yard unsuitable for emptying the balloon of its gas and called to their earthbound assistants to let the line go. All their pleading was to no avail. Green still wanted to go up again and land in the paddock he had earlier selected, and persuaded Wardell to disembark. However, the balloon was now quite definitely on the ground and not going anywhere else. Wardell then began the process of deflating the balloon.

As Wardell began to open the valve to release the gas, he was overcome by the fumes, which had escaped through a 1.2 metre long rent in the balloon's envelope. He was carried, half fainting to an adjoining shed. The crowds gathered around the balloon and into the yard through a narrow gateway. They also sat on the roofs of the sheds surrounding the yard. Large amounts of gas from the tear and the open valve soon filled the air.

Things then suddenly took a turn for the worse. A spectator sitting on the roof of one of the sheds along George Street side of the yard, struck a match, or lucifer, and threw it into the yard below. Whether he intended mischief, or was just mindlessly amusing himself had not been determined. The resulting series of explosions caused numerous burns and other injuries as the frenzied crowd tried to escape. One witness described the flames as "flying fiery serpent"s (Sydney Morning Herald, 1859a). Some escaped into Durand's Alley (which no longer exists), while others scrambled over the stables into George Street. The police and firemen were in attendance and had done an amazing job of maintaining a semblance of order. After the explosion that task of keeping order was virtually impossible.

Those sitting on the roofs of the sheds were first to be burnt, although none of the reports identified the culprit as being one of those so injured. Several small children were trampled under foot and five or six were taken to the nearby medical doctor. Although about a dozen people were injured to varying degrees, amazingly none of their wounds were mortal. William Green had invested heavily in this balloon, which had been secured in the middle of the yard by a few courageous men. The flames were all around and eventually the carriage of the balloon caught alight. Then they realized they could not save the balloon, even though the envelope had been purposely cut open to expedite the release of the gas. The balloon quickly disappeared in an enormous final explosion.

With all of the damage and injuries from the explosions, it would have been appropriate to set up a collection of some description. Such a benefit was offered by the management of the Prince of Wales Theatre, where Green had been expected to make an address about the balloon ascent. Other important people in Sydney discussed the possibilities of raising a subscription. The Australian Gas Light Company agreed to remit the costs associated with filling the balloon. The twist in this story was that the benefits were all directed towards Green and Brown, who had lost their balloon! A pity about the poor burnt wretches and those injured in the rush to escape the explosions.

Green wrote a letter to the newspaper, offering thanks to the citizens of Sydney for their great kindness before and after the ascension. He was, however, rather critical of the great number of people who viewed the proceedings from free vantage points around the GPO. For "a small fee others watched the ascension, while residents of wealth and position mingled with those unpaying poor"! (Sydney Morning Herald 1859b).

A GOOD IDEA

One of the earlier, local residents who became interested in aeronautics was William Bland. He had been asked by Francis Forbes to investigate the possible theft of an airship design. Forbes had written several letters to Sydney newspapers in 1843 about his proposed airship (Sydney Morning Herald 1843). He made a model, but failed to take it any further, before discovering someone in England had proposed a similar airship. Forbes had disclosed his ideas to friends, but still thought he had the exclusive rights to the use of those ideas. Bland was a friend and Forbes asked him to look into the matter during a visit to England. The author is not aware of the results of Bland's enquiries. He did, however, bring his own aeronautical design to public notice, following the germination of the idea in March, 1851. Drawings were created and dispatched to a professional engineer friend in England one month later. In 1852 he exhibited a model of his Atmotic Ship at the Crystal Palace in London. It was displayed at the Paris Universal Exhibition, in 1855. This craft was to be a large semi-rigid airship, inflated with hydrogen. It was to be powered by a steam engine, driving four bladed propellers at each end of the airship. Bland referred to these propellers as "windsails" and described them by their direction of action as "propellents" and "repellents" (The Empire 1860). We now use the terms "pusher" and "tractor". "Tractor" is the configuration of most modern light aircraft, with the propeller in front.

HARGRAVE

"Theft of ideas" was a concept that later concerned Lawrence Hargrave, and this subject will be discussed a little later. His is a name that looms large in Australia's aeronautical history. Hargrave's interests were much wider than just aeronautics, but this Address shall only touch upon some of his aeronautical work. Hargrave's very first recorded interest in aeronautics was a sketch of an airship, which was drawn about 1872. The second idea for a flying machine was produced soon thereafter, but it was not until 1884 that he presented his first paper before the Royal Society of New South Wales (Hargrave 1884a).

Hargrave proposed a theory of natural flight. Observations of worms, fish and birds provided the basis for what he called the trochoided plane theory. His first attempt at constructing a flying machine along the lines of his trochoided plane theory, was successful in 1884. The machine featured a large, flat flight surface, with slight dihedral and a smaller, diamond shaped wing in front, as depicted in figure 2. Between those two wings, Hargrave positioned a couple of flappers, which provided the forward thrust (Hargrave 1884a).

In a 1909 issue of the London Illustrated News, two photographs appeared of the latest French experiments on aerial torpedoes. The close up photograph of the aerial torpedo showed it to be almost an exact replica of Hargrave's 1884 model! This was intended to be launched at enemy balloons, and included a blade in place of the Hargrave foreplane (diamond shaped wing), which would tear the balloon and send it crashing down (London Illustrated News 1909).

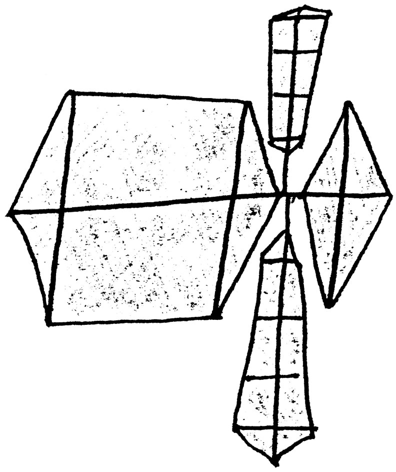

Figure 2: Plan view of Hargrave's 1884 flapping machine (Hargrave, 1884b, reproduced courtesy of the Powerhouse Museum, Sydney).

Hargrave never really let go of this trochoided theory and it stopped his progression in aerodynamics to some extent. Figure 3 depicts Hargrave's 1884 model of a spring powered, mechanical worm. However, it should now be of interest to know that animal locomotion is again being researched. One of those new areas of research involves the creation of a synthetic Lamprey, or eel-like animal. During the 1990s this "creature" was being developed by Joseph Ayers, at the Marine Science Center, Northeastern University, Boston, USA (Adams 1998). Proteus the Penguin Boat has been developed in America at the Massachusetts Institute of Technology (MIT) to demonstrate fish type propulsion. Rather than the now familiar propeller, this vessel was propelled through the water by the action of two foils. The foils were positioned at the stern (rear) of the boat, not unlike twin rudders. They were capable of side-to-side flapping as well as twisting motions, which were synchronized through computer control to obtain the best propulsion. Professor Michael Triantafyllou and James Czarnowski originally developed Robo Tuna in the early 1990s during their study of fish propulsion. (Triantafyllou 1995; Baker 1997).

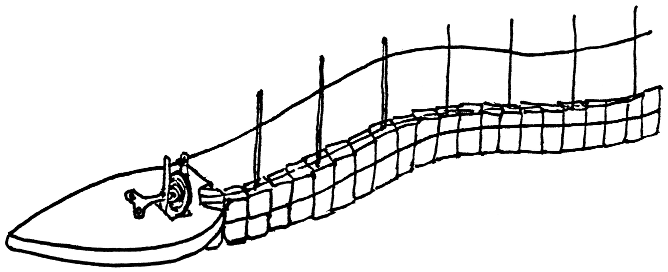

Figure 3: Spring powered, mechanical worm (Hargrave 1884b, reproduced courtesy of the Powerhouse Museum, Sydney).

More recent work at MIT has included experiments with robotic fish, powered by real muscles. Microprocessor controlled electric signals to frog muscles positioned along each side of the artificial fish were alternately contracted and then relaxed. The resultant side-to-side flapping motion of the fish tail provided forward thrust. One of the benefits is virtually silent, efficient propulsion. (Samuel 2001).

Another area of investigation involves shape memory alloys in place of muscles. Work is progressing at Texas A & M University, but accurate comparison against propeller-driven vehicles will apparently have to wait for 2003. Such comparison between the two methods of propulsion are too complex, until an untethered version of the fish-mimicking propulsor can be constructed (Graham-Rowe 2001).

Hargrave's first successes were achieved with model aircraft, driven variously by propellers and flapping wings. By 1887 he had designed a man-powered ornithopter. He conducted a series of tests to determine the lift and drag on a flat surface, moving through the air at different speeds and angles of incidence. The equipment he used for these tests was called a whirling arm. It would have looked something like a modern rotary clothesline, but with only one or two outstretched arms. At the end of one of those arms he placed a flat plate, measuring 0.3 m by 0.3 m. An arrangement of rope, pulleys and lead weights turned the arms at various, adjustable speeds. He designed and built a clever instrument for measuring and recording the forces on that plate as it was moved through the air (Hargrave 1887). The results could have been of more use to Hargrave, but he failed to complete sufficient tests on the flat plate. He also did not test any curved surfaces on the whirling arm, which may have been of greater value than the experiments he did perform with candles and silk tufts (Craddock 1994). The candles and silk tuft experiments merely showed the existence of a vortex beneath the curved surface.

Probably his greatest fame was achieved through kite flying. During 1893 he began to develop the box kite.

Two events in 1894 confirmed Hargrave's importance. In May and June he constructed a full sized glider after hearing about the work of Otto Lilienthal in Germany. Hargrave made several attempts to fly his glider at Stanwell Park. At forty-three years of age he decided that it was more important to maintain life and limb intact, than for him to achieve flight. The hang glider was too light and unwieldy, although he thought it too heavy, at about twenty-two kilograms (Hargrave 1894).

AN ANTIPODEAN BASIS FOR EUROPEAN AIRCRAFT

The other event of 1894 set Hargrave firmly on the world stage of aeronautical history, although today it appears trifling. On November 12, 1894 he succeeded in leaving the ground, beneath a train of four box kites. A flight to 4.9 m above the sand on Stanwell Beach demonstrated the suitability of his box kite structure for stable flight. The box kite became the norm for aircraft structures in France and England during the first decade of powered flight. Members of the Lawrence Hargrave Centenary Committee attempted a repeat of this event in 1994 at Stanwell Beach, but the winds did not achieve the necessary velocity to lift more than the kites alone.

Hargrave detailed the aims of the kite lift experiment at Stanwell Beach, in a letter to Henry C. Russell, Government Astronomer at the Sydney Observatory. Hargrave had previously borrowed a hand anemometer from Russell and was again in need of one for these experiments. "If I can get the velocity of the wind and the head resistance I shall know what thrust my engine would have to give in order that I might let go C and transform my kite into a flying machine" (Hargrave 1894). The reference "C", was the attachment of his tether on the beach, as shown in figure 4.

ANTIPODEAN POWER

Hargrave also developed the rotary engine. In such engines, the crank shaft remains stationary, while the cylinders rotate. Even now, the idea of stationary crankshaft and rotating cylinders seems antipodean. This was a good idea, and according to Shaw (Shaw and Ruhen 1988 p. 179), quite original. Hargrave provided the details of his rotary radial engine by way of an address to the Royal Society of New South Wales, on August 7, 1889 (Shaw and Ruhen 1988, p. 188). The Seguin Brothers in France later devised a similar engine, the Gnome, which became the standard for many aircraft in World War One.

The area of increasing interest to Hargrave during the 1890s, was "soaring" kites.

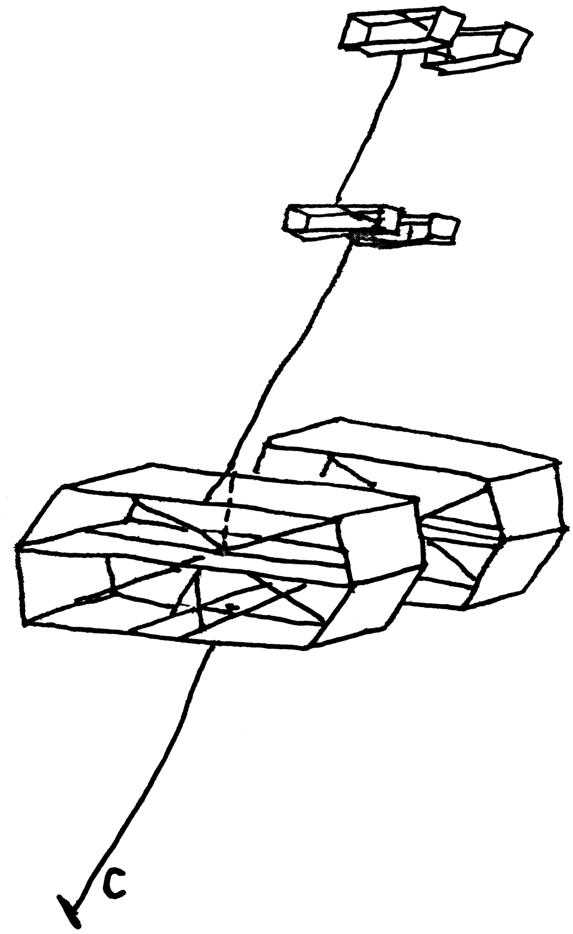

Figure 4: Sketch of proposed kite lift (Hargrave 1894, reproduced courtesy of the Powerhouse Museum, Sydney).

SOMETHING FOR NOTHING

Humans have always pondered the wonder of bird flight. So much so, that inventors have tried to replicate "natural flight" in a number of ways. Firstly, by trying to copy the flapping motion of their wings – this is an ongoing journey, even to this day. However, "as far as practical applications go, flapping flight has few at present – a fact that appears to bother none of the team members" (Chandler 2002). The quest for human powered, natural flight continues. The second way was to try and understand the concept of "soaring", as ably demonstrated by eagles, vultures and the albatross. This concept was not understood for quite a while, but since those early times we have learned more about the passage of wings through the atmosphere. Figure 5 shows the relative gliding performance for several examples of flying machines, from the simple hang glider to the modern, high performance sailplane. The latter, like its animal world equivalent (the eagle) seems able to defy gravity. Indeed, that was how some of these creatures were seen to perform by early aeronautical experimenters.

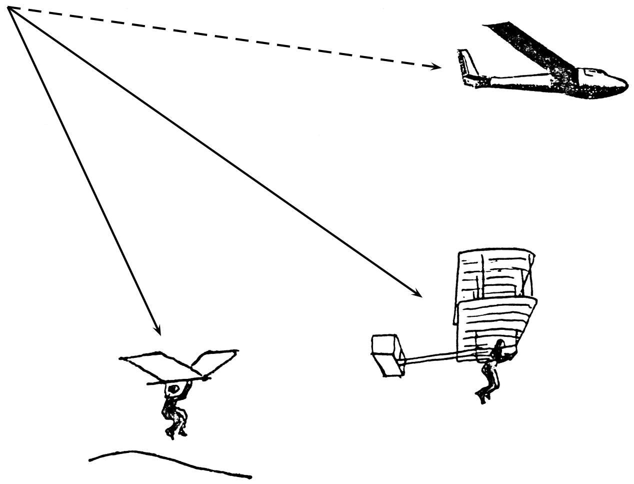

Figure 5: Author's diagram showing gliding performance of various aircraft.

They termed the concept "soaring" or "aspiration" to describe the apparently amazing ability of these birds to maintain or even gain altitude from a wind that blew horizontally. The reality is, as shown in figure 5, that unpowered aircraft all act under the force of gravity, but at rates dependent on their aerodynamic efficiency. So, the ability to "soar" depends somewhat on the shape of the wing, but predominantly on the existence of an upward component of the wind.

Hargrave thought he had found the secret of soaring flight during the 1890s and developed a number of experiments to demonstrate that. He observed a rotating region of air beneath a cambered (or curved) wing. Hargrave believed (wrongly) that forward thrust was provided through the action of that vortex upon the undersurface of the wing. Imagine driving along in an open top sports car, with the resultant wind rushing past the windscreen, and then curling around and apparently blowing back towards the rear (or your side) of the screen. That is what Hargrave saw, and believed that that wind was actually pushing the wing (or sports car) forward. We now understand something more about drag and fluid mechanics, but Hargrave's thesis and "experiments" were unfortunately confirmed for him. His idea was genuinely antipodean, and caused him to suffer derision from America in particular. What he had proposed, and claimed to have proved experimentally, was in direct conflict with the laws of physics. Others correctly stated that there had to be some vertical component of wind to sustain such soaring flight. Of some more recent interest was an American experiment on an

F106B, Delta Dart aircraft, to utilize the vortex identified by Hargrave. The experiments were part of a study into the use of a movable leading edge flap instead of camber, to reduce transonic drag. The flap would be deflected to its greatest downward extent upon touch-down, at which time the "Hargrave" vortex would appear and increase drag, reduce lift and help slow the aircraft (Flight 1985).

Hargrave's soaring kites were created to demonstrate that such wings could make headway into the wind. The arguments that followed Hargrave's claim about these kites, were about whether the wind was really blowing in a perfectly horizontal direction. Hargrave was wrong in his assumption, and he effectively wasted time and effort with these kites. They are however very interesting.

These kites were flown, dangling from a cord stretched between two poles stuck in the sand. The poles were made from oregon, 41 mm in diameter and 7.3 m high. They were spaced 14.6 m apart and held in position by guy ropes. This arrangement is shown in figure 6 and provided a perfectly safe environment for testing delicate kites.

After so many balloon flights in Europe, it appears somewhat strange to see that only Australia (and perhaps Ireland) maintains an ongoing use for those tall poles – Australian Rules Football. The Irish have included a cross-bar for Gaelic Football.

Development of the so-called "soaring" kites occupied a good deal of Hargrave's time during the 1890s. He produced an alphabetic series of such kites, from A to Q. Some of the wing profiles or aerofoils ("aerocurves", as described by Hargrave) are shown in figure 7. The work he did with these kites was published and distributed around the world by way of the Journal of the Royal Society of New South Wales (Shaw 1988, p. 188). Undoubtedly the Wright Brothers had access to this material by way of Octave Chanute and the Smithsonian Library. It is interesting to compare some of the aerofoils employed in the Wright's aircraft with those of Hargrave, although some of the more interesting aerofoils were not considered so by Hargrave, and consequently not included in his published material. The Wrights did their own experimentation and development, because they found they could not trust some of the material provided by other experimenters.

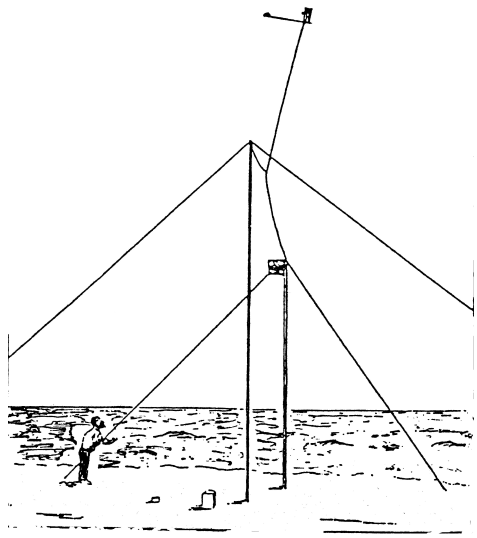

Figure 6: Testing apparatus for soaring kites (Hargrave 1897).

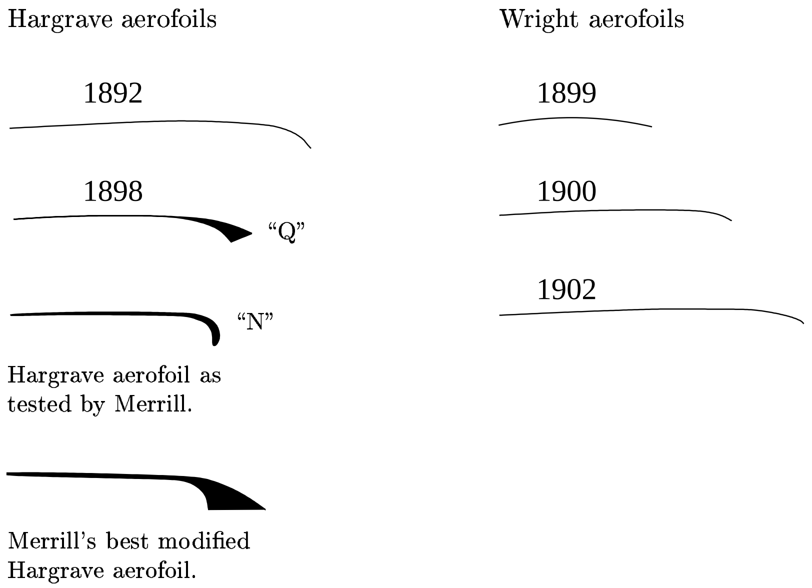

Figure 7: Author's interpretation of several Hargrave and Wright aerofoils.

PARAGLIDERS AND PARAMOTORS

Charles Gibbs-Smith described Hargrave as not really an aeronaut, but rather "chauffeur driven" (Gibbs-Smith 1985) in his works towards the conquest of the air. That statement was at first intriguing, as Gibbs-Smith described chauffeurs as those in pursuit of lift and thrust, regarding "the flying machine as a winged automobile, to be driven into the air by brute force of engine and propeller." The author now suspects that Gibbs-Smith was correct in describing Hargrave as "chauffeur driven". Hargrave's work with kites and their necessary subservience to the vagaries of the atmosphere went a long way to forming his "chauffeur driven" attitude.

After the publication of his successes with soaring kites M and N, an American newspaper published a sketch of an enlarged version of one of the kites, with a human cargo (Hargrave 1898). Hargrave sketched in 1899 another contraption that clearly showed where he was leading (Hargrave 1899). After the success of the 1894 tests with the train of four box-kites at Stanwell Beach, he proposed that similar arrangements of kites could be used for powered flight. The sketch is reproduced in figure 8, with only the bare details shown. He kept this concept in mind for another dozen years. Two photographs of a model he constructed to demonstrate this idea were published in 1911 (Daily Telegraph 1911). This later model featured a single box-kite, flexibly joined to a very simple structure containing pilot, engine and tricycle undercarriage. Although the 1911 model incorporated a rigid lifting surface, there is certainly a strong influence on the modern paramotor. Hargrave's idea went to sleep for eighty years!

The modern paramotor utilizes a parachute instead of the box-kite, or even a soaring kite, but the concept is Hargravian.

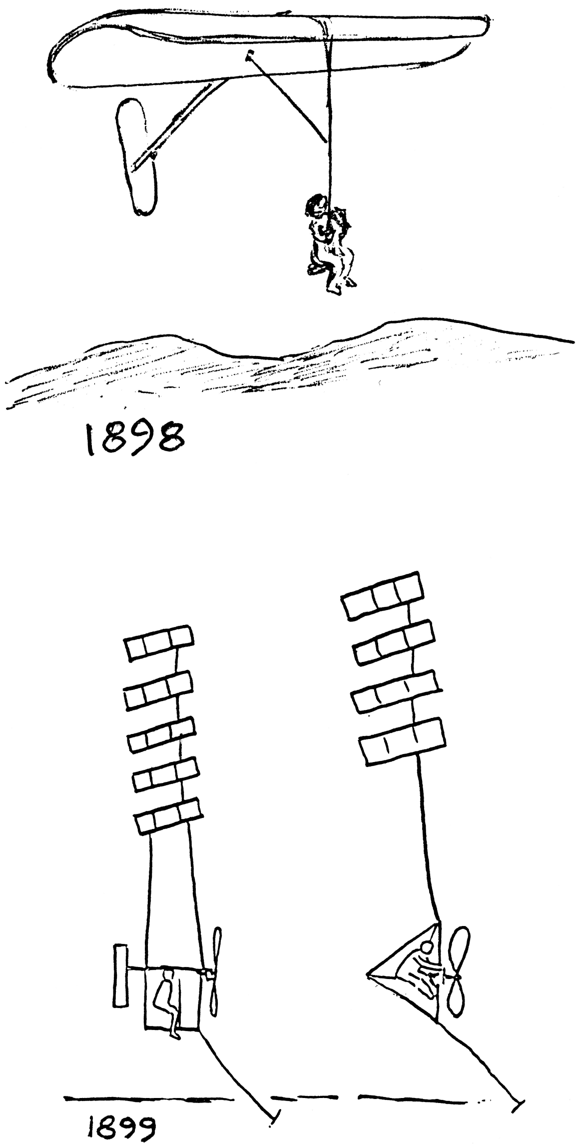

Figure 8: Hargrave's paramotors (Author's sketches, based on Hargrave soaring kite, 1898 and Hargrave's notebook entry, 1899, reproduced courtesy of the Powerhouse Museum, Sydney).

PATENTS

Returning to the earlier subject of theft of ideas, Hargrave's name is often remembered in the context of patents. On several occasions he sought the opinion of Norman Selfe, who was a well-respected engineer in Sydney. The opinions sought by Hargrave concerned the patentability of some of his ideas. Selfe was generally supportive, but Hargrave never took up any patent. He considered that inventors invent and they should be permitted to continue to do so. Patents put a hold on invention and stop the exchange of ideas. Two other prominent Australian aeronautical pioneers, Henry Sutton and later, George Augustine Taylor expressed similar thoughts. It was through Hargrave's annoyance with the patent system, that he reported the findings of his research in the Journal of the Royal Society of New South Wales. Once a patentable idea had been published or demonstrated in public, there was no opportunity for another person to patent that idea. Hargrave wanted other researchers to take his ideas and use them to discover the secret of flight. Yes, he wanted to fly, himself, but he was even more interested in someone succeeding. What an antipodean idea!

The first two Australians to be published in the Journal of the Aeronautical Society of Great Britain, were Henry Sutton and Charles Whittell. Sutton was born at Ballarat, Victoria on September 3, 1856. One of six children, he was keen to learn and by the age of fourteen had read all of the scientific books in the well-stocked Ballarat Mechanics' Institute. He made observations of the flutter of insect wings against smoked glass, which culminated in his theory of bird flight. He was a gifted inventor, who designed and built telephones less than one year after Alexander Graham Bell. He shunned patents, because he wanted to "benefit fellow workers in science" (Nairn 1976). He was acclaimed as one of the best lecturers at Ballarat School of Mines, where he taught electricity and applied magnetism, in the 1880s. Sutton took up the quest to discover the secret of flight and presented his results in "On the Flight of Birds and Aerial Navigation" and "Second paper on the Flight of Birds" both published in the Annual Report of the Aeronautical Society of Great Britain in 1878 (Sutton 1878). The Aeronautical Society of Great Britain is now the Royal Aeronautical Society.

Henry Sutton's first paper described his concept for a flying machine, based partly on animal locomotion and a simple kite. The machine was to be driven by a propeller and "lifted" by two sets of paddles. These paddles were supposed to oscillate around the vertical shaft protruding above the upper wing. The individual panels of those paddles were set at forty-five degrees to the horizontal, and were supposed to provide lift, just like a kite. I do not believe he got any further with this concept. Sutton's second paper was about bird flight.

Hargrave's anti-patent comments appear to have been revived in the latter years of the twentieth century. Amazingly, the basis for the first "open source" consumer product, came from someone in the computer business. Richard Stallman left MIT in 1984 to set up the Free Software Foundation. His concern was with commercial software companies and their use of patents and copyright to maintain their source codes as secrets. Stallman believed such actions "choked off the free flow of ideas." In almost Hargravian terms, "if computer scientists could no longer learn from one another's code, the art of programming would stagnate" (Lawton 2002)

The first example of "open source" is OpenCola, which was created as "a promotional tool to explain open source software." The instructions for making this cola drink are freely available, unlike those better known examples. "Anybody can make the drink, and anyone can modify and improve on the recipe as long as they, too, release their recipe into the public domain." Hargrave believed that inventors cannot help themselves, they just want to invent. In the more recent example of software creation, "the kudos of a successful contribution is its own reward" (Lawton 2002).

THE FUTURE ANNOUNCED

As I have shown with Hargrave's inventions, a number of ideas appear well before their time. However, identifying future trends or inventions is not simple. The Illustrated Sydney News published an article in 1891, describing the writer's concept of flight one hundred years' hence. "This is truly a wonderful age, this year 1991. When one contemplates the vast strides made during the last hundred years, and sees the dreams of our forefathers actually realized – the masterpieces of art and invention, the discoveries in science, and, above all, the genius that has subdued and brought into practical use that limitless power, electricity – it appears to the ordinary mind that perfection has been attained, and that human ingenuity can go no further. And then, when we read of the customs and inventions of the people of the 19^{th} century, of their cumbersome methods of locomotion on land and sea, and their crude attempts to navigate the air, it is difficult to imagine how they could have found life, with all its troubles and inconveniences, more than bearable" (Illustrated Sydney News 1891). The picture accompanying this article, featured a craft with highly tapered, fabric covered wings which appeared capable of flapping. The fuselage was streamlined and a small cabin was located on the top. There was the hint of a propeller at the very tail of this craft, and the picture was set above Sydney. The artist had drawn a bridge across the Harbour, and a large statue on Fort Denison, but there were no high buildings, only chimneys.

The "dreamer" described speeding through the air at 150 miles per hour at an altitude of 1 000 feet. He only woke from the dream when confronted with the thought of a mid-air collision between two such flying machines. From this it appears that prophecy is very difficult. These speeds and altitudes were reached before and during World War One, less than thirty years after the article was published. The most accurate part of the dream appears to have been the horror of mid-air collisions!

One Sydney resident, who decided to do more than merely dream was N. R. Gordon. He designed and built a steam powered, flapping wing flying machine during 1894 (Daily Telegraph 1894). This craft was taken to the cliffs above Chowder Bay, in Sydney Harbour. A set of tram tracks was laid to assist with the take-off. Gordon appeared to have been coerced into the position of attempting flight well before he was really ready, but everything went ahead. After a number of hours spent in preparation and building up steam pressure, Gordon decided to test the craft without a pilot. Just as well he made that decision, as the craft rolled along the tracks, over the edge and flapped to pieces on the beach below (Sydney Morning Herald 1894).

AUSTRALIA'S ANTIPODEAN ATTITUDE

The centenary of Lawrence Hargrave's famous kite lift experiment at Stanwell Beach was celebrated in 1994. A re-enactment of the tethered flight was attempted, but the hoped-for southerly failed to materialize. The wind was not the least of disappointments that year, as the Australian Treasury removed Lawrence Hargrave's image from the $20 banknote!

ANTARCTIC CONCLUSION

As some of my earlier remarks mentioned some imaginary adventures in the Antarctic, it is appropriate to conclude with a quote from that same place, almost exactly one century ago. This is a quotation from one of Captain Robert F. Scott's expeditions to the Antarctic, when in February, 1902 they inflated and flew a captive balloon. The hydrogen-filled balloon was named Eva, and had been manufactured at the R.E. Balloon Factory, Aldershot, by women under the supervision of Colonel Templer. R.W. Skelton, engineer on the expedition, wrote "It would perhaps be rash to say anything about the future of ballooning in polar regions, for when we once more reach civilization, we may find flying machines en route for the poles" (Skelton 1907).

Perhaps no flying machines were on their way to the poles, but it was not long before December 17, 1903 and the success of Orville Wright.

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Aerial and Below Ground Biomass Production of Acacia as Influenced by Organic Waste Substrates During Nursery-Stage Seedling Growth

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Abstract: The influence of growing substrates, primarily organic waste, was determined in a greenhouse experiment on four *Acacia* species. The effect of digested sewage sludge, pine litter, oak litter and perlite on aerial and below ground biomass production was evaluated in 3 substrate volumes. Sewage sludge induced significantly greater biomass production and enhanced growth of *A. aneura*, *A. farnesiana*, *A. saligna* and *A. victoriae* over all other media in all measured parameters. The sewage sludge substrate of 25% quartz sand, 25% silty clay soil and 50% digested, dried sewage sludge (v/v) had higher mineral content and water retention rates than all other media. It was superior in dry biomass production of roots and shoots. Results also indicated inhibited growth in oak (*Quercus coccifera*) litter as plant development progressed. It was concluded that (a) digested sewage sludge can be used as part of the growth substrate to enhance *Acacia* seedling growth, and (b) that organic waste substrates could partly replace more expensive nitrogen sources in nursery-stage *Acacia* production. The physical, chemical and biochemical characteristics of sewage sludge in relation to plant growth are discussed.

Keywords: biomass, *Acacia*, sewage sludge, oak litter

INTRODUCTION

Differences or similarities among plant species in their requirements for successful germination and establishment have important implications for the maintenance of species diversity. The genus *Acacia* contains diverse growth forms including freestanding trees, shrubs and highly tolerant bushes (Gutteridge 1992, Miller and Bayer 2001). These are used as a source of firewood, animal nutrition, building materials and for medicinal purposes (Hall 1972, Pressland 1975, Sheikh 1988, Tiedman and Johnson 1992).

Patterns of germination and establishment can be impacted by the overall characteristics of the different habitats in which *Acacia* grows (Doran et al. 1983, Vellend et al. 2000). However, a common factor that impacts successful establishment is the early growth phase from emergence to the end of the first year of seedling growth (Stout 1935, Oliver 1971, Starr 1983, Al-Mudaris et al. 1998). This stage can be characterised by slow, stagnated growth. Although there is considerable variation in *Acacia* response to nursery-stage practices, in many cases growth is enhanced by the addition of organic material to the growth substrate (Fox and Leeuwen 1985). Given the significance of *Acacia* in afforestation and reforestation efforts in arid and semi-arid savanas in North Africa and the Middle East (Blunt 1926, Whibley 1980, Simmons 1987), it is important to determine the degree to which locally occurring organic substrates could be used to enhance the growth of *Acacia*. The basis for use of organic wastes in plant growth substrates has been an interesting topic for recent studies (Schumann and Sumner 2000, Garling and Boehm 2001).

Comparative studies of varying growth media may be particularly informative because potentially significant growth gains may be made; thus shortening the nursery stage and improving stand establishment, both important factors in *Acacia* production (Simmons 1988).

To examine the interactive effects of local organic waste media, *Acacia* species and substrate volume, we grew *Acacia* seedlings in a split-split block design experiment. Our objectives were to determine whether growth in organic wastes, including sewage sludge and leaf litter, improved above and below ground biomass production relative to conventional nursery media, and whether these effects were modified by species and/or substrate volume. Factors controlling biomass allocation, nutrient impacts on growth and physical substrate characteristics were also evaluated.

MATERIALS AND METHODS

Plant Material

Seeds of *Acacia aneura*, *A. farnesiana*, *A. saligna* and *A. victoriae* were obtained from the Australian Tree Seed Centre in Canberra, Australia. These were treated via acid scarification (sulphuric acid) following Al-Mudaris et al. (1998) (soaked for 45 minutes in H_2SO_4 at room temperature and rinsed in distilled water) and sown into Rootainer® cells (Hummert International, USA) (Maherali and De Lucia 2000). Three-week-old seedlings were randomly plucked and used for this experiment. All seedlings had healthy roots and initial leaf formation.

Measurements were taken from the tip of the root to the tip of the apical meristem, from the crown to the apical meristem and from the crown to the tip of the root. These were taken to be the initial length of above and below ground biomass and the complete plant on initiation of the experiment.

Organic Waste Substrates

The three sources of organic waste chosen to substitute traditional, more expensive peat moss-based growth media were digested sewage sludge, pine forest litter and oak forest litter. In addition, perlite was used as a non-organic, inert substrate to improve air-filled porosity and stability of the media.

Digested, dried sewage sludge was obtained from Al-Salt sewage treatment plant, 7 kilometres to the north of Salt City, Amman, Jordan. The plant is situated at a longitude of 35.73, latitude of 32.03 and altitude of 796 m. It processes 3800 cubic meters of sewage a day. The local area has a population of 57 000, an annual precipitation rate of 557 mm and an average air temperature of 18°C, reaching over 40°C in the hot summer months.

The sewage sludge had been bacteria-digested, spread and dried for 2 months prior to being used in this investigation. Biochemical and nutrient analyses were conducted on sewage samples following Olsen and Dean (1965).

Pine and Oak Litter

A local forest, the Scandinavia, with an 80 to 200 year-old stand of pine (*Pinus halepensis*) and oak (*Quercus coccifera*) was used as the collection site for litter. The forest receives annual precipitation of 500 to 534 mm with slopes of 10–60%. Covering litter and the top 8–10 cm of soil, mostly organic matter, was taken from under the canopy of 40 random trees of pine and oak. A composite sample was obtained by mixing the 40 litter/soil collections, sieving through a 3 mm screen and spreading in a 5-cm thick layer. All samples were air-dried in the sun for 10 days.

Standard Growth Media

Perlite, an inert, commercial substrate, was purchased from a local manufacturer (Dawood, Jordan). Sand and nursery-grade silty clay soil were obtained from a nursery supplier (Al-Ain, Jordan).

Analyses

All media components and mixtures were analysed for chemical and physical characteristics. Nitrogen was analysed using the Kjeldahl method (Bremner 1965), phosphorous, potassium, iron, zinc, copper, cadmium and organic matter were analysed following Olsen and Dean (1965). Bulk density, texture (pipette method) and water retention (ceramic plate method) were also determined (Olsen and Dean 1965).

Polybags

In order to evaluate the impact of substrate volume on *Acacia* biomass production three polybag sizes were used to grow seedlings over the 12-month experimental trial period. These were 12 L, 8.2 L and 6 L. These were made of Grade 1 polythene and purchased from a local stockist (Ahram Plastic, Jordan).

Substrate Components

Four treatments and a control were used to evaluate media impact on growth and biomass production. These were Control, oak litter, pine litter, perlite and digested sewage sludge. The Control was composed of 50% sand and 50% silty clay soil. Oak litter was mixed with sand and silty clay at a ratio of 50:25:25% (volume basis), respectively (hereafter termed Oak). Pine forest litter (Pine), perlite (Perlite) and sewage sludge (Sludge) were mixed with sand and silty clay at the same ratios.

All growth substrates were weighed into polybags and *Acacia* seedlings transferred into them after irrigation with 350 mL water. Thereafter, seedlings were irrigated with 300 mL/week. Samples of the irrigation water were taken monthly and analysed for pH and electrical conductivity (EC). No fertiliser applications were made, and weed management was performed manually as required. Whilst fertilizer application is standard practice in most nursery production facilities today, it is not always the case in local Jordanian seedling production. It should be noted that the lack of fertilizer application was taken to be the worst case scenario of local Jordanian *Acacia* seedling production.

Temperature and relative humidity measurements were taken daily using a Jules, Richard and Pekly® thermohygrograph (JR&P, UK). Growth substrate temperatures were measured twice daily at 7am and 3pm using an electrode thermometer (Hereaus, Germany).

Statistical Analysis

The experiment was performed as a Randomised Complete Block Design (RCBD) with a split-split block arrangement. Each treatment was replicated 5 times for every species and polybag size totalling 300 experimental units. The General Linear Model ANOVA was performed (Barrilleaux and Grace 2000) with mean separation at 5% using Duncan's Multiple Range Test.

Plant Growth Measurement and Biomass Production

Measurements were taken twice a month for 12 months and included plant height (from the crown area to the tip of the apical meristem) and stem diameter. The latter was measured using a Gibbons® gauge (Gibbons, UK) micrometer at 2 cm above the crown region.

At 12 months of age, seedlings were harvested, cleaned and weighed. From these measurements, the fresh mass of shoot (FMS) (representing total aerial biomass) and fresh mass of root (FMR) were obtained. Shoots and roots were separated and dried in an airflow cabinet (Conviron Industries, Canada) at 70°C for 3 days or until sample weight stabilised. Dry samples were weighed and placed in dry storage. These measurements produced the dry mass of root (DMR) and dry mass of shoot (DMS). For brevity, only growth data at 2, 6, 9 and 12 months will be shown in addition to final above and below ground biomass production.

RESULTS AND DISCUSSION

Treatments

Aerial and below ground biomass production revealed significant differences between treatments, indicating substantial growth enhancement or suppression. We found Pine, Perlite and Sludge to induce higher growth just 2 months after initial transfer to growth media over Control- and Oak-grown plants (Table 1). By the end of the 6^{th} month, a further significant difference appeared among these treatments with Sludge-grown plants clearly outperforming Pine and Perlite counterparts by 1.3 times (calculated from Table 1). No significant differences were detected between Control and Oak plants. This pattern of growth continued until month 9 with Sludge significantly outperforming all other treatments. After 12 months of growth, *Acacia* seedlings grown in Sludge reached a height of 116.1 cm followed by 69.5 cm for Pine and 64.6 cm for Perlite. This difference was statistically significant as was the difference between Control (56.5 cm) and Oak (42.7 cm). Sludge plants were 1.6 times higher than Pine and double the height of Control plants.

Stem diameter demonstrated a slightly delayed differentiation in Sludge with significantly higher stem diameter values appearing after 9 months of growth, but not earlier (Table 1). Oak produced shorter and thinner seedlings than even the Control. In fact, at 12 months of age Oak-grown seedlings only had 0.6 the stem diameter of Control and 0.4 that of Sludge. Oak exhibited a clear degree of suppression in seedling growth.

Analysis of biomass production revealed a positive correlation with plant height and diameter, where Sludge produced the highest biomass in terms of FSM, DSM, FRM and DRM (Table 2). There was no variation in the allocation of biomass between shoot and root as shoot: root ratios for all treatments ranged from 1.8 to 1.5 (data not shown). This indicates that treatments did not alter the ratio of allocation of biomass.

Substrate	**2 months**	**6 months**	**9 months**	**12 months**
		Height (cm)		
Control	2.3 b	13.1 c	30.1 c	56.5 d
Oak	3.1 b	13.8 c	26.9 c	42.7 d
Pine	4.1 a	19.3 b	40.8 b	69.5 b
Perlite	4.5 a	19.4 b	38.1 b	64.6 c
Sludge	4.4 a	27.1 a	59.1 a	116.1 a
		Diameter (mm)		
Control	2.2 c	5.9 b	9.1 c	10.6 c
Oak	3.1 bc	4.9 c	6.1 d	7.2 d
Pine	3.8 a	7.3 a	12.1 b	14.0 b
Perlite	3.4 b	6.8 a	10.7 b	13.0 b
Sludge	3.3 bc	7.4 a	13.9 a	17.1 a

Table 1. Effect of growth substrate on stem height and diameter in *Acacia* over a 12-month period under greenhouse conditions.
Mean values within columns are not significantly different at $p \leq 0.05$ if sharing the same letter/s within the same parameter (height or width). Mean separation conducted using Duncan's Multiple Range Test.

Substrate	FSM (gm)	DSM (gm)	FRM (gm)	DSM (gm)
Control	30.6 bc	16.1 bc	16.4 cd	8.9 c
Oak	21.5 b	12.3 c	12.4 d	7.5 c
Pine	39.7 b	21.7 b	22.3 b	13.1 b
Perlite	35.1 b	19.3 bc	19.3 bc	10.7 bc
Sludge	81.8 a	42.5 a	48.1 a	27.8 a

Table 2. Effect of growth substrate on aerial and below ground biomass production in *Acacia* after 12 months of growth.
FSM: Fresh Shoot Mass, DSM: Dry Shoot Mass, FRM: Fresh Root Mass, and DRM: Dry Root Mass. Mean values within columns are not significantly different at $p \leq 0.05$ if sharing the same letter/s. Mean separation conducted using Duncan's Multiple Range Test.

Polybag

Polybag size, and hence substrate volume, only induced significant differences in plant growth, averaged over all treatments, after 6 months of growth. The 12 L polybag showed higher biomass values in terms of plant height, stem diameter, FMS, DMS, FMR and DMR over the other 2 sizes.

Species

Acacia farnesiana exhibited significantly higher growth and biomass production in all media and polybags, followed by *A. saligna*, in comparison to the other 2 species (data not shown). This difference was apparent across the four growth phases at 2 months, 6 months, 9 months and 12 months. *A. aneura* and *A. victoriae* were similar in their growth patterns, each growing to 0.8 the height and stem width of *A. farnesiana*. The same applied to FMS, DMS, FMR and DMR over all four growth phases.

Interactions

Interactive analyses revealed similar results (data not shown) where Sludge out-performed all other treatments and no preference for a particular species or polybag existed. Similarly, all species responded favourably to Sludge and large polybags, and all polybag sizes responded favourably to Sludge. Oak clearly inhibited growth in all species and polybag sizes. The highest overall biomass allocation in all measured parameters was attained in *A. farnesiana* grown in Sludge in 12 L polybags.

The most notable result of these experiments was the positive aerial and below ground biomass allocation in Sludge-grown plants. These results were evidenced by substantial increases in seedling mass, stem growth and root growth in plants exposed to Sludge treatment.

Digested, dried sewage sludge/organic waste has been shown to release nitrogen and phosphorous at rates significantly impacting plant growth (Williams and Whitcombe 1988, Eghball 2000). Indeed, in this study, chemical analysis revealed substantially higher N content in Sludge compared to other treatments. Specifically, Sludge had 1.5 and 3.5 times higher N content than Pine and Oak, respectively, and 4 times more N content than Control and Perlite. The same applied to P, Fe and Zn. As an example, whilst Control had a P content of 3.3 ppm, Sludge had 49.7 ppm. Sludge also had 39.0 ppm Fe compared to 0.9 ppm in Control. Overall, Oak, Pine and Sludge had higher organic matter (5.9, 6.0 and 7.2%, respectively) content than Control or Perlite.

Bulk density was similar for all treatments ranging from $1.4\,g\,cm^{-3}$ for Control to $1.06\,g\,cm^{-3}$ for Perlite. However, an interesting difference was observed in pH and EC levels of Sludge compared to other treatments. Whilst the pH for all other treatments averaged 8, that of Sludge was 6.9. It was more acidic than the other treatments. Sludge also had higher salt content as it reached 1.90 dS m^{-1} compared to an average of 0.40 dS m^{-1} for all other treatments. This points to an altered mineral balance in Sludge with higher N content being balanced by high Na, Cl and Mg content (Kader, unpublished data), which has been shown to affect growth (Glenn and Brown 1998, Houle et al. 2001). Irrigation water pH and EC over 1 year averaged 6.7 and 0.8 dS m^{-1}, respectively.

The higher salt content may reach levels high enough to induce stress (Williams et al. 1998) or alter physiological responses (Howard and Mendelssohn 1999) and growth (Meiners et al. 2002). In this case it appears that Sludge mineral content was sufficient to cause improved growth without any toxicity damage as reported in previous studies for other species (Glenn and Brown 1998).

An additional interesting characteristic of Sludge was its high moisture retention capacity at high-tension levels (lower moisture). At 0.1 bar, Control, Pine, Perlite and Oak averaged a moisture content of 41% (gravimetric) compared to 46% for Sludge. As tension increased to 0.5 bar, this dropped to 29 and 39%, respectively; and to 9.5 and 20%, respectively at 5.0 bar. The largest difference was observed at 10 bar (the permanent wilting point of plants is 15 bar). Here, sludge retained 15% of the moisture content compared to an average of 4% for all other media. This would have a large impact on the solubility of nutrients and movement up the plant roots, thus impacting growth, regeneration (Swagel et al. 1997) and root distribution (Clark et al. 1999).

We observed higher average temperatures in Sludge over all other media across all months of the year and all growth phases. Despite the fact that the sludge used was digested, it revealed significantly higher microbial activity and respiration rates over all other media (Kader et al. unpublished data). The average temperature 8 cm inside the growth medium was 21.2°C across all substrates (excluding Sludge), months, species and polybags. The comparable temperature of Sludge was 26.5°C. Higher substrate temperatures have been found to induce greater nutrient mobilisation rates (Wang and Roberts 1983), higher sink effectiveness and higher associated growth rates (Bailey and Jones 1941) and substrate nutrient release (Giardina et al. 2000). Other changes in substrate temperature and composition may have an impact on phosphorus (Garcia-Montiel et al. 2000), but seedlings may adapt to these situations (Williams et al. 1998, Boorse et al. 1998).

Oak, as a medium, did not induce *Acacia* growth despite its high organic matter content, nitrogen level and good water retention characteristics. This is in line with previous work in this laboratory, which may suggest an inhibitory effect of *Quercus* on other plant species (Kader et al. unpublished data, von Renesse, personal communication) despite the physical enhancement of substrate characteristics (Niklas 1999).

Polyphenols, terpenes and allelopathy have been suggested as causal factors behind reduced growth (Karabourniotis et al. 1998, Llusia and Penuelas 2000, Gordon and Rice 2000). Recent research has shown effects ranging from reduced growth (Kamara, 1998) to inhibition of seedling survival (Nilsen et al. 1999) through chemical (Rice 1979) and other (Gopal and Goel 1993) factors in oak (Abrams 1992).

One of the potential limitations of sewage sludge is the possible toxic effect from high levels of heavy metals it is associated with. Analyses in this laboratory have shown Fe, Zn, Cu and Cd levels of 300, 42, 79 and 37 ppm, respectively. These are sufficiently high enough to cause toxicity to plants and accumulation in plant parts (Hinesly et al. 1978) and has been identified as a health risk, especially in plants of an annual nature (Jensen and Lesperance, 1971). However, there appears to be limited risk associated with plants grown in sewage sludge at the nursery stage, where there is limited likelihood of grazing. *Acacia* seedlings also accumulate less Fe, Zn, Cu and Cd with progressive growth, as analyses in this experiment (Omari et al. unpublished data, Hattar et al. unpublished data) and other time-dependent studies (Wallis et al. 1984, O'Conor 1991) have shown.

A more pressing constraint on sludge utilisation would appear to be the direct health risk associated with the microbiological content of sludge. The sludge used in this experiment contained 10^8 colony forming units (CFU) g^{-1}. It contained both aerobic and anaerobic bacteria in addition to a positive mycological reading. This is in line with previous work (Hamparian et al. 1985) and points to a need for well-defined nursery operations management to accompany such utilisation. The present high microbiological activity would have increased respiration rates inside the substrate and consequently raised it's temperature leading to the observed temperature measurements in Sludge compared to the other substrates. It is of relevance to point out that in New South Wales (Australia), there is a set of guidelines that control the use and application of biosolids issued by the NSW Environmental Protection Authority. These impact the application of sewage sludge in agricultural, horticultural and other areas and may be referred to for guidelines (EPA, 1997).

The fact that *Acacia* growth was significantly higher in 12 L polybags compared to the smaller sizes may be attributed to the need for larger root growth space from 6 months onwards. Samples of bags cut open at this stage revealed a tighter spiralling of roots in the smaller sized bags compared to a better-distributed root system in large bags. This appeared to be the case for all species in all growth media, but was most pronounced in Sludge, where root growth proceeded at a higher rate. A slight departure from this trend was observed in Perlite where roots penetrated the Perlite particle and appeared to circumvent it, creating knot-like root systems.

Perlite is derived from siliceous volcanic rock. It contains some 2–5% moisture and, when crushed and heated to about 1000°C, expands to form a lightweight perlite particle with a closed cellular structure (Verdonck 1983). It is chemically inert and serves as a substrate aeration medium, which enhances root growth in heavier substrates (Paul and Lee 1976). Earlier reports have shown enhanced nitrate, soluble phosphorous, potassium and magnesium uptake due to this aeration (Shanks and Laurie 1949). The aerating effect was also achieved in Pine, as it's bulk density was 0.7 that of the Control. It also had 3.2 times more organic matter. This effect has been found to enhance root elongation and nitrogen intake (Batier et al. 1943, Huck 1970) as well as higher availability of nutrients, due to leaching from tree litter in the substrate.

Based on the results of the present study, digested sewage sludge mixed with sand and soil at a ratio of 25:25:50% (v/v) appears to enhance aerial and below ground biomass production associated with faster growth in *Acacia* seedlings. It is notable that under Australian nursery practices, soil is no longer used in potting mixes, but continues to be used in Jordanian nurseries. Although the results revealed high levels of heavy metal and microbial content in sewage sludge, they suggest higher substrate temperatures and mineral content enhanced early seedling growth in *A. aneura*, *A. farnesiana*, *A. saligna* and *A. victoriae.* Based on the inhibited growth in Pine (*Quercus coccifera*) litter, it is proposed that this medium not be used in potting substrates in *Acacia*. Aeration by way of using Perlite in the growth medium enhances *Acacia* growth.

CONCLUSIONS

It is concluded that sewage sludge in dried, powder format may be used as an alternative potting substrate for *Acacia* seedlings. It produced enhanced aerial and below ground biomass for all *Acacia* species studied and may act as an organic compound of significant practical value in shortening nursery growth periods.

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Deposition of Trace Elements from the Atmosphere in the Sydney Region

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Abstract: An investigation of trace elements in samples of deposition from the atmosphere was carried out at three locations in the Sydney region, namely Lane Cove, Turramurra and Canterbury. Monthly samples were collected over a 3-month period in 1981–82, using the *Sphagnum* moss method. Results are given (as mg/m^2/month) for 29 trace elements, many being environmentally-interesting. The very small amounts of trace elements being deposited are not regarded as harmful. This study can be considered as a reconnaissance exercise relevant to the planning of a more complete investigation.

Keywords: Trace elements, Atmosphere, Sydney Basin

INTRODUCTION

There is a continuing interest in trace elements in the environment because of their essentiality and of their possible toxicity. Although the urban environment is complex and trace element concentrations in the atmosphere are variable, depending on different sources and changing meteorological conditions, it was considered to be worthwhile to measure the amounts of some trace elements in samples of deposition in the Sydney region. Three 1-monthly samples were taken at three locations, namely, Lane Cove, Turramurra, and Canterbury, during the period December 1981 to March 1982. The sites were sheltered and away from local industrial activity and busy roads. Moss was used as the collector of fine particles and its cation exchange properties enhance the retention of cations from rain. Examination of *Sphagnum cristatum* by scanning electron microscopy "showed that the structure is made up of small holes, about 10μm across, and folds" which retain fine particles (Swaine 1990).

EXPERIMENTAL DETAILS

The moss used was *Sphagnum cristatum*, which was collected from an isolated mountainous place. Foreign material, for example, other plants and insects, was removed and the moss was cleaned chemically to reduce its inherent trace-element contents to appropriately low concentrations. Contamination had to be kept in check at all stages. Envelopes, made from woven polypropylene shade cloth, were divided into 4 sections, each about 8 cm square which enclosed 2 g dried moss. The envelopes were held in anodised aluminium frames which were attached to anodised aluminium stakes with the envelopes 2 m above ground. After 1-month exposure, envelopes were taken for analysis. Trace-element contents were determined by optical emission spectrography, atomic absorption spectroscopy and instrumental neutron activation analysis. Full details of the sampling and analysis procedures are given by Swaine (1994) and Godbeer and Swaine (1995).

RESULTS

Results for environmentally-interesting trace elements (Swaine 1990) are given in Table 1 and those for trace elements of no known environmental significance are given in Table 2. Values are stated as mg/m^2/month. Amounts of an element deposited at each location were similar for most trace elements. However, B is higher at Lane Cover probably because this is nearer to the sea than the other two locations and wind-blown seawater is a known source of atmospheric B. At Turramurra lower values were found for Pb, Cd, Zn and Cu, probably because there was much less traffic and hence less input from petrol and tyre wear. In general, the amounts deposited were very low, mostly less that 1 mg/m^2/month, the exceptions being Pb and Zn with up to 5 and up to 2 mg/m^2/month respectively. Most of the Pb comes from anti-knock compounds used in petrol and most of the Zn from the wear of car tyres. It is interesting to note that Br was also deposited, probably derived from ethylene bromide, which is added to the anti-knock fluid in petrol. The Cd is associated with tyre wear as an impurity in the ZnO filler. Results of an analysis of a car tyre have been reported as 12 470 mg/kg Zn, 17.9 mg/kg Cd and 16.2 mg/kg Cu (Charlesworth and Lees 1999). The wear of car tyres is a source of Zn, Cd and Cu in the atmosphere. Several other elements, for example, Cr, Cu and Ni, are emitted as wear products from engines and car bodies. The very small amounts of some other trace elements including those in Table 2, may well be general background values, good examples being Be, Mo and V, each having almost the same value at each location. It should be recalled that atmospheric deposition contains mainly the products of rock and soil weathering which are the background particulates in the atmosphere; these include the elements in Table 2, except Br.

Summations of the three 1-month results for the three Sydney locations can be compared with results for the same three months at a rural location 27 km north of Lithgow, NSW (Table 3). As expected, higher results were found for the Sydney locations for all trace elements except Mo and V. It should be noted that Pb values with accompanying Br values are not always representative of the current situation because much less leaded petrol is used nowadays.

There are no results for trace elements in deposition in the Sydney area, but there are some for trace elements in the air (Ayers et al. 1999). Results for the Sydney samples can be put into perspective by comparing them with published results for overseas places especially cities (Table 4). For several elements there is no relevant information. It is not surprising that the Sydney results are higher than those for the NSW rural site. However, there is one exception, namely V, where the results are virtually the same. Comparisons will be made for each trace element:

As: The Sydney results are lower than those for UK urban sites, perhaps because there is no large-scale burning of coal in Sydney.

B: The Sydney results are lower than those for rain and dust input as estimated by Bowen (1979).

Cd: Cardiff, German towns, West Germany and Talsa are higher in Cd than Sydney. The German legislation limit of 1.8 mg/m^2/y is well above the Sydney values of 0.12–0.20 mg/m^2/y. This maybe because Cd is emitted to the atmosphere during coal burning albeit in small amounts. However Australian coals have lower contents of Cd than overseas coals, so coal burning in Australia contributes very little Cd to the environment (Swaine 1990).

Co: The deposition of Co at the Sydney locations is less than that at Cardiff.

Cr: The Sydney results are about a quarter of those for Tulsa.

Cu: The Sydney results are less than those for Europe (urban/industrial), about the same as those for Cardiff and higher than the German average.

Mo: Although the Sydney results are much lower than that reported from the French rural area, all results are very low.

Ni: The Sydney results are much lower than those reported for Europe and USA. It is surprising that the Sydney results are lower than those for Europe rural.

Pb: Although the Pb values for Sydney may seem high they are only 19–50 mg/m^2/y and these are less than the German legislation limit of 180 mg/m^2/y. They are slightly lower than reported values for UK cities, Cardiff and German towns and much less than the New York City value.

Sb: The Sydney results are in the range of results for seven non-urban sites in the UK.

Se: The Sydney results are the lower end of the range of results for seven non-urban sites in the UK.

Zn: The Sydney results are markedly lower than reported results for European and North American cities. This may be because of much less influence of tyre-wear in Sydney.

Comparisons cannot be made for the trace elements given in Table 2 because of the lack of relevant published data.

CONCLUDING REMARKS

In general, the amounts of trace elements measured at the Sydney locations are lower for some important elements (As, Cd, Pb, Zn) than reported values for overseas locations. Depositions of trace elements were in very low amounts, around a few $mg/m^2/y$, several being less than $1\,mg/m^2/y$. Lead and Zn had slightly higher amounts, but Pb was less than the German legislation limit. In any case, depositions of Pb nowadays will be less than those measured for the Sydney region, because of the marked decrease in the use of leaded petrol. This also means that the amounts of Br in depositions will be decreased, because leaded petrol is a prime source of atmospheric Br. The low amounts of trace elements deposited at the three Sydney locations cannot be regarded as environmentally harmful. It should be stressed that these estimates refer to short-time sampling (3 months) and cannot give estimates for the entire Sydney region. However, they do give order-of-magnitude estimates which are relevant to the planning of any further detailed investigation which should involve many locations for at least a year. Areas in the city, especially near busy traffic, would be expected to give higher results for some trace elements than those found in this study. A recent investigation of trace elements in snow samples collected at different locations in Moscow, Russia, showed a tendency for increased concentrations of trace elements in the centre of the city compared with those in peripheral areas (Latushkina and Stanis 2002).

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	Lane Cove			Turramurra			Canterbury		
	Dec81-Jan82	Jan-Feb82	Feb-Mar82	Dec81-Jan82	Jan-Feb82	Feb-Mar82	Dec81-Jan82	Jan-Feb82	Feb-Mar82
As	<0.005	0.038	<0.005	0.023	0.0013044	0.010	0.029	0.029	
B	0.045	0.057	0.081	0.021	0.005027	0.042	0.040	0.049	
Be	0.003	0.005	0.006	0.004	0.004	0.003004	0.005	0.004	
Cd	0.006	0.021	0.017	0.016	0.006007	0.007	0.026	0.016	
3	0.019	0.031	0.042	0.034	0.044	0.045	0.021	0.036	
	0.34	0.35	0.46	0.30039 0	0.16	0.44			
0.74	0.31	0.0160.51	0.30	0.55					
	<0.001001004	<0.001	0.003						
5	0.05	0.08							
4	3.34	5.09							
	0.027								

Table 1: Results for environmentally-interesting trace elements deposited at three locations in the Sydney area (as $mg/m^2/month$)

	Lane Cove			Turramurra			Canterbury		
	Dec81-Jan82	Jan-Feb82	Feb-Mar82	Dec81-Jan82	Jan-Feb82	Feb-Mar82	Dec81-Jan82	Jan-Feb82	Feb-Mar82
Br	2.1	1.7	1.1	2.1	1.8	1.4	2.2	1.4	2.2
Ce	0.14	0.08 0.16	0.28	0.21	0.17	0.3 0.08 0.22			

0.009 0.01 0.019 0.028 0.017 0.026 0.03 0.008 0.020

03 0.001 0.002 <0.001 0.002

01 <0.001 <0.001

0.007

Table 2: Results for trace elements with no known environmental significance at three locations in the Sydney area (as mg/m^2/month).

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	Lane Cove	Turramurra	Canterbury	Rural site
As	0.042	0.080	0.068	0.008
B	1.8	0.63	0.13	0.25
Be	0.014	0.015	0.013	0.005
Cd	0.044	0.029	0.049	0.002
Co	0.073	0.12	0.10	0.012
Cr	0.96	1.2	1.0	0.12
Cu	1.4	0.62	1.4	0.13
Mo	0.008	0.003	0.007	0.005
Ni	0.22	0.16	0.18	0.08
Pb	12	4.7	13	0.81
Sb	0.054	0.053	0.064	0.002
Se	0.039	0.08	0.044	0.012
Th	0.09	0.18	0.16	0.03
V	0.08	0.023	0.020	0.10
Zn	5.7	1.6	5.0	0.32

Table 3: Comparisons of results for Sydney locations with a NSW rural site (as mg/m^2/3-month). The data for each element are summations of the three 1-monthly results given in Table 1.

As	UK 7 urban sites	2.5-6	Galloway et al. (1982)
	UK, West Midlands, urban	0.12-1.1	Simmons and Pocock (1987)
	NSW rural	0.032	Swaine et al. (1984)
	Sydney 3 locations	0.17-0.32	This study
B	Rain and dust input	4-8	Bowen (1979)
	NSW, rural	1	Swaine et al. (1984)
	Sydney, 3 locations	0.25-1.8	This study
Cd	Cardiff, Wales	0.4-1.9	Goodman and Smith (1975)
	Germany, towns	Up to 2, av. 0.7	Nurnberg(1983)
	Germany legislation	Should not exceed 1.8	Nurnberg (1983)
	West Germany	0.37-1.4	Rohbock et al. (1981)
	Tulsa, Oklahoma	0.85-1.6, av. 0.95	Tate and Bates (1984)
	Sydney, 3 locations	0.12-0.20	This study
Co	Cardiff, Wales	0.7-2.2	Goodman and Smith (1975)
	NSW, rural	0.048	Swaine et al. (1984)
	Sydney, 3 locations	0.29-0.48	This study
Cr	Tulsa, Oklahoma	18-33, av. 26	Tate and Bates (1984)
	NSW, rural	0.48	Swaine et al. (1984)
	Sydney, 3 locations	3.8-4.6	This study
Cu	Cardiff, Wales	3-3.7	Goodman and Smith (1975)
	Germany, average	~1.8	Nurnberg (1983)
	Europe, urban/industrial	8.50, av. 32	Jeffries and Snyder (1981)
	NSW, rural	0.52	Swaine et al. (1984)
	Sydney, 3 locations	2.5-5.6	This study
Mo	France rural	1	Alary et al. (1981)
	NSW, rural	0.020	Swaine et al. (1984)
	Sydney, 3 locations	0.012-0.032	This study
Ni	Cardiff, Wales	7	Goodman and Smith (1975)
	Europe, rural	0.7-10, av. 3.2	Jeffries and Snyder (1981)
	Tulsa, Oklahoma	9-48, av. 25	Tate and Bates (1984)
	NSW, rural	0.32	Swaine et al. (1984)
	Sydney, 3 locations	0.64-0.88	This study
Pb	UK, cities	70	Chamberlain et al. (1979)
	Cardiff, Wales	75	Goodman and Smith (1975)
	Germany, towns	~70	Nurnberg (1983)
	Germany legislation	Should not exceed 180	Nurnberg (1983)
	West Germany	14-58	Rohbock et al. (1981)
	New York City	350	Volchok and Bogen (1971)
	NSW rural	3.2	Swaine et al. (1984)
	Sydney, 3 locations	19-50	This study
Sb	UK, 7 non-urban sites	0.27-0.82	Cawse (1977)
	NSW, rural	0.008	Swaine et al. (1984)
	Sydney, 3 locations	0.21-0.26	This study

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Se	UK, 7 non-urban sites	0.19-0.71	Cawse (1977)
	NSW rural	0.048	Swaine et al. (1984)
	Sydney, 3 locations	0.08-0.32	This study
Zn	UK, 7 non-urban sites	44-140	Cawse (1977)
	Cardiff, Wales	75	Goodman and Smith (1975)
	Copenhagen area, Denmark	40-170	Andersen et al. (1978)
	Germany	190	Lindberg and Harriss (1981)
	Gottingen, Germany	47	Ruppert (1975)
	Europe, urban/industrial	52-190, av. 103	Jeffries and Snyder (1981)
	North America, urban/industrial	4-381, av. 319	Jeffries and Snyder (1981)
	New York City	320	Volchok and Bogen (1971)
	Albany, NY, USA	120	Lazrus et al. (1970)
Zn	NSW, rural	1.2	Swaine et al. (1984)
	Sydney, 3 locations	6.4-23	This study

Table 4: Comparisons of results for Sydney locations with those for published results worldwide (as $mg/m^2/y$).

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The Society's Medal 2001

THE SOCIETY'S MEDAL 2001

The Society's Medal is awarded for scientific research and services to the Royal Society of New South Wales.

Peter Allan Williams graduated from Macquarie University with a BA in 1970, earning his BA honours in 1971. His academic qualifications were gained for both chemistry and geology. Peter then completed his PhD at Macquarie University, in 1975, concentrating on studies in X-Ray crystallography.

Upon completion of his studies, Peter travelled to the University of Wales, where he lectured in chemistry, at University College Cardiff. During his sixteen years at the University of Wales, as lecturer, senior lecturer and Reader in Chemistry, Peter also gained several Visiting Fellowships and Professorships. His research interests span a number of areas of applied inorganic chemistry, and he has numerous publications in the field. His first book "Oxide Zone Geochemistry" was published in 1990 and he was translation editor for "Natural Zeolites" which was published in 1992. Peter has authored more than three hundred refereed articles on geochemistry and chemical mineralogy, studies of chiral metal complexes, and general inorganic and coordination chemistry. He is a member of the Editorial Board, Journal of the Russell Society, Member of the Editorial Board, Australian Journal of Mineralogy, and Editor-in-Chief of the Journal of Coordination Chemistry. In addition to his academic work, Peter has a wide ranging experience in consultancy, covering sponsored research on geochemistry and hydrometallurgy, process mineralogy, exploration geochemistry, supergene processes and exploration and groundwater geochemistry.

Peter is actively involved in research on supergene mineralogy and geochemistry, as well as hydrometallurgical methods to recover metals from their ores. His current interests include the formation of supergene base metal deposits, cobalt mineralogy and geochemistry, the chemistry of salts containing oxyanions, solid solution and transport phenomena in acid mine drainage and the hydrometallurgy of base and noble metals.

He is an Honorary Research Fellow of Macquarie University and of the National Museum of Wales, a Chartered Chemist and a Member of several learned societies. These include the Royal Society of Chemistry, Royal Australian Chemical Institute, Geological Society of Australia, Mineralogical Society of Great Britain, Mineralogical Society of New South Wales, the Russell Society and, since 1973, the Royal Society of New South Wales. Peter's employment at the University of Western Sydney since 1991, as Foundation Professor of Chemistry, had included four years as Dean of the Faculty of Science and Technology, and Chair of the School of Science on the then Nepean Campus.

He has served as a Council Member of the Royal Society of New South Wales since 1999, as President in 2000 and currently as Vice-President. During that time Peter has endeavoured to include tours and lectures on modern art and history into the Society's monthly programme, which fits the aim of the Royal Society of New South Wales to encourage "studies and investigations in Science, Arts, Literature and Philosophy". Professor Williams is therefore a most worthy recipient of the Medal of the Royal Society of New South Wales.

D.A. Craddock, President

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Edgeworth David Medal 2001

SAMANTHA JANE RICHARDSON

The Edgeworth David Medal is awarded for distinguished contributions by a young scientist, under the age of thirty-five years, for work done mainly in Australia or its Territories; or, for contributions to the advancement of Australian science.

Dr Richardson first joined the Department of Biochemistry at the University of Melbourne is Department as an Honours student to work with Dr A. Jaworowski on the transport of transferrin in isolated rat yolk sac membranes. She took up a research assistantship with Professor G. Schreiber at the same institution in 1990 and then a PhD candidature with Professors Schreiber and R. Wettenhall. During her PhD candidature she further developed her skills in protein biochemistry. The topic of her PhD work was the relationship between structure and function of thyroid hormone-binding plasma proteins, using evolutionary change as a guide to understanding function. She discovered that the first appearance of transthyretin synthesis in the liver of adult higher vertebrates during evolution occurred during the radiation of Australian marsupial species about 30 to 40 million years ago. This was considerably later than the first appearance of transthyretin gene expression in the adult brain of the stem reptiles about 350 million years ago. Thus, a change in the pattern of distribution of gene expression lead to transthyretin becoming a plasma protein, after having first evolved as an extracellular brain protein. Together with other members of my research group, Ms Richardson found that the different parts of the transthyretin molecule evolved with different speeds and that acceleration in rate of molecular evolution of transthyretin occurred after the initiation of transthyretin gene expression in the liver.

A total of 13 publications resulted from her PhD work and presentations at numerous national and international scientific meetings attracted various prizes for her presentations, including those for the best student presentation at the Lorne Protein Conference and meetings of the Australian and New Zealand Societies of Comparative Physiology and Biochemistry. She was the recipient of the Progen/ASBMB Fellowship in 1996.

After completion of her PhD in 1995 Dr Richardson stayed on in several research posts in the Department and was involved in the preparation of a successful three year National Health and Medical Research Council project grant application. She was the second chief investigator of an ARC grant for the years 1998 to 2000. She was also awarded an Australian Research Council Postdoctoral Research Fellowship for this period. In 2000, she was sole chief investigator of an Australian Research Council Small Grant. Currently, Dr Richardson holds an Australian Research Council Research Fellowship for 2001 until 2005.

In 1998, she was invited to give the main lecture at a Symposium of the Annual Meeting of the Australian Society for Biochemistry and Molecular Biology in Adelaide. This was followed by an invitation from the same society to organise and chair the symposium on Comparative Biochemistry during the 1999 Annual Conference in Queensland. She organised a session at the Australian and New Zealand Society for Comparative Physiology and Biochemistry Meeting in 1999, and was consequently asked to organise the Comparative Biochemistry sessions for the 6th International Congress of Comparative Physiology and Biochemistry in 2003. In 2000 the was the recipient of an Technology Diffusion Program Award for Young Researchers to attend the Symposium on Australia's Scientific Future at the Australian Academy of Science, and in 2001 she received a further Young Researcher's Award from the Australian Academy of Science to attend the Forum for European – Australian Science and Technology conference. She also represented the Australian Society for

Biochemistry and Molecular Biology at Science meets Parliament Day in 1999, 2000 and 2001.

During her time in Melbourne, Dr Richardson has established probably the largest collection in the world of serum samples from different vertebrate species and, together with other group members, organised and improved a collection of plasma protein cDNA probes, genomic libraries, and liver and brain cDNA libraries. She considerably enlarged the serum collection during a four month visit to the Department of Integrative Biology of the University of California in Berkeley, leading to the inclusion of specimens from American marsupials and reptiles in the collection. In December 1997, Dr Richardson was appointed leader of the transthyretin research group at the University of Melbourne. She has established numerous local, national and international collaborations.

Dr Richardson has carried out all her research in Australia, with the exception of a four month visit to the University of California at Berkeley in 1994 when she investigated thyroid hormone binding proteins in the blood of American marsupials. The uniqueness of the Australian fauna and the insight it has afforded into the evolution of thyroid hormone distribution systems meant that not only has she done her research in Australia, but her research has added to knowledge of Australian fauna, in particular marsupials, monotremes and reptiles. Her data on thyroid hormone binding proteins in the blood of Australian and American marsupials has also assisted in clarifying the phylogenic relationships of marsupials, in particular of the Australian marsupials.

Professor G. Schreiber

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Walter Burfitt Prize for 2001

MICHAEL WILLIAM PARKER

The Walter Burfitt Prize is awarded at intervals of three years to the worker in pure or applied science, resident in Australia or New Zealand, whose papers and other contributions published during the past six years are deemed of the highest scientific merit, account being taken only of investigations described for the first time, and carried out by the author mainly in these countries.

Professor Parker holds a BSc(Hons) degree (first class) from The Australian National University and a PhD from the University of Oxford, UK. He is currently the Head of the Protein Crystallography Unit at the St Vincent's Institute of Medical Research in Melbourne. The major aim of Professor Parker's research has been to determine the structures of biologically important proteins using X-ray crystallography as a basis for understanding their function, with the long term goals of understanding disease processes, as well as exploiting the data for biotech applications such as drugs and biosensors. A substantial body of his work has included studies of membrane proteins, which are critical participants in cellular communication, and glutathione-dependent enzymes, which are essential components of an organism's detoxification mechanism.

In 1997, he solved the structure of perfringolysin O (PFO), a virulence factor of the gas gangrene-causing bacterium, *Clostridium perfringens*, which belongs to a large toxin family responsible for many life-threatening diseases including meningitis and pneumonia. The PFO structure led to a model for membrane insertion and pore formation, revealing as an extraordinary feature the transition of part of the structure from helix to membrane-spanning sheet.

Having determined the structure in 1994 of the *Aeromonas* pore-forming toxin, aerolysin, Parker discovered in 1997 that aerolysin and pertussis toxin (the causative agent of whooping cough) share a common receptor-binding domain. The APT domain was found to share common features with C-type lectins, suggesting it acts as a receptor binding site by binding carbohydrate of glycoproteins. This suggestion has since been confirmed experimentally. These findings provide the basis for the design of new therapeutics against both toxins. In branching out from the study of toxin interactions with membranes, Parker has made a special contribution to understanding of key processes in Alzheimer's Disease. He embarked on a major project to determine the complete structure of amyloid precursor protein (APP), a membrane-bound receptor that plays a central role in Alzheimer's disease, beginning with determination of the structure of two APP fragments. The first structure, consisting of the whole N-terminal domain, revealed a highly charged basic surface that may interact with heparin in the brain. Structural similarities with cysteine-rich growth factors suggested it could function as a growth factor *in vivo*. The second structure is that of a copper binding domain located adjacent to the growth factor domain. The structure revealed how this domain binds and reduces copper. Tthis led to work indicating that copper binding to this domain causes greatly reduced production of the APP proteolytic peptide thought responsible for Alzheimer's disease.

After having solved the first structure of a human glutathione-S-transferase (GST) in 1992, Parker continued to work on determining the crystal structures of GSTs from various organisms in complex with a range of substrates and inhibitors as a basis for understanding the molecular basis of substrate recognition and catalysis by GSTs. Some major findings since 1995 include the crystal structures of four important species, including those of human theta-class hGST T2-2, a bacterial GST, PmGST B1-1, the human pi-class GST and two folding mutants of GST P1-1. Structure comparisons provided compelling evidence that theta class GSTs evolved from an ancestral member of the thioredoxin superfamily.

In addition to these, a number of protein structures solved by the Parker laboratory over the last few years that have brought Australian science right to the forefront internationally. The structure of the protein kinase, twitchin kinase provided direct proof of the theory proposed by Kemp and colleagues of intrasteric regulation of enzyme activity. Another striking example is the determination of the structure of the common chain of the human GM-CSF, IL-3 and IL-5 receptors, complexed to the Fab fragment of a monoclonal antibody. The elucidation of the structure of this ligand-binding domain suggests how three different cytokines recognise a single receptor subunit that may have implications for other analogous receptor systems. Analysis of the interface between the antagonist antibody and the common chain provides a rational basis for designing single molecule antagonists of three cytokines directly implicated in allergic inflammation and myeloid leukemia.

Professor Parker has maximised opportunities for the protein crystallography group by initiating and nurturing collaborations both in Australia and overseas, as well as making the most of all opportunities that present themselves for the solution of structures in the Institute itself. Structural biology is essentially collaborative and Parker's leadership has been instrumental in the successes of the Institute laboratories. He is an outstanding independent scientist and leader whose original research has had a major impact in structural biology. His achievements over the past 6 years have been especially notable.

Dr T.J. Martin

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The Clarke Medal for 2001

GORDON HOWARD PACKHAM

The Clarke Medal is considered for award annually for distinguished work in natural science done in, or on, the Australian Commonwealth and its Territories.

Dr Packham took a BSc(Hons) degree (first class) at the University of Sydney and proceeded to complete a PhD at the same university in 1959. He became Associate Professor in the Geology Department of the University in 1973 and since then has held a number of posts there, most recently as Acting Director of the Ocean Sciences Institute. He remains an Honorary Associate of the School of Geosciences.

Dr Packham's geological work has centred on large scale problems of the Australasian region and his publications have earned him an enviable international reputation. His early work on the Lachlan Fold Belt defined the framework for the work on this region of New South Wales which has continued to the present day. His ideas were taken up by myriads of workers and extended both north and south into Queensland and Victoria. The recognition of the fundamental divisions of the Lachlan Fold Belt by Dr Packham remain essentially unchallenged some forty years after they were defined in his paper *Sedimentary history of part of the Tasman Geosyncline* (1960). Refinements of this work continued in maps and papers published in 1962, 1967, 1968, 1969, 1974, 1975, 1979, 1982, 1985, 1987, 1998, 1999, 2001. Although some of this work was published jointly, his colleagues will attest to the intellectual as well as physical contributions made by Dr Packham through his leadership with ideas and observations.

However there have been numerous other important advances by Dr Packham. A single paper *Sedimentary history as an important factor in the classification of sandstones*, published in 1954, set out some of the basic characteristics of sandstones enabling the recognition of the tectonic environments of the various types of sandstone. This work, while most significant for Australian geology, of course goes well beyond, and has been taken up by sedimentologists world-wide. Associated papers on the physical analysis of sediments (1955) and the implications of the diagenetic facies concept (1960) built on this original idea.

Dr Packham has also been a continuing researcher in palaeontology, particularly in the study of graptolites, refining the work of previous researchers, such as a previous Clarke Medallist, Dr D. Thomas. While this work (1953, 1954, 1955, 1962, 1965, 1967, 1968, 1975, 1982, 1995, 2001) has been largely Australian based it has implications for international graptolite research and biostratigraphy.

In the years from 1970, while not abandoning his researches in the Lachlan Fold Belt and in palaeontology and biostratigraphy, Dr Packham turned his formidable intellect to problems of the Australian continental margin and the relation between Australian and other portions of the Australian Plate. In this work (1970, 1971, 1972, 1973, 1974, 1975, 1976, 1978, 1979, 1980, 1981, 1982, 1985, 1990, 1992, 1994, 1996) he has carried out an extraordinary range of research in projects, some in association with international (and Australian) colleagues, searching the ocean deeps, others personally directed to the Indonesian boundary of the Australian Plate. The implications of this work for understanding the stratigraphic and tectonic development of the Australian Plate continue to be appreciated by younger researchers. I believe this work will be an essential reference for years to come.

Not content with this corpus of work Dr Packham has engaged in smaller but important projects, including the study of Late Palaeozoic glaciation. He has also been involved in the broader educational aspects of geology through the publication of reference volumes and popular publications.

Dr D.F. Branagan

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Biographical Memoir

Vale Emeritus Professor
SAMUEL WARREN CAREY AO
D.Sc.(Syd.), F.N.A.I., F.A.A.
1944 – 2001

Born at Campbelltown, NSW on 1st November 1911, he matriculated from Canterbury High School in 1928, was Foundation President of the Students Geological Society of the University of Sydney, graduated Master of Science in 1934, and Doctor of Science in 1938. He also received Honorary Doctorates from the Universities of Papua New Guinea and Urbino (Italy).

A petroleum exploration geologist in New Guinea and Papua from 1934 to 1942, in 1940 he married Austral Robson. He is survived by Austral, their four children, seven grandchildren and two great granddaughters.

In WW2 he served in the Australian Imperial Force as a paratroop captain in Z Special Unit, 1940–1944, and was Mentioned in Despatches. His brother in the same unit was captured by the Japanese and beheaded by sword. Since the War, Carey had been an active participant in Legacy.

In 1944 he was appointed Chief Government Geologist of Tasmania, and served as Chairman of Trustees of the Tasmanian Museum and Art Gallery. In 1946 he was appointed Professor of Geology of the University of Tasmania, and served as Dean of the Faculty of Science, Chairman of the Professional Board, and Chairman of the Staff Association. He was also Chairman of the Schools Board of Tasmania, President of the Geological Society of Australia, and President of the Australian and New Zealand Association for the Advancement of Science. He was Convenor and editor of six International Symposia:- *Glacial Sedimentation, Dolerite, Lyell Schists, Syntaphral Tectonics, Continental Drift, and Expanding Earth.* He was author of Elsevier Amsterdam: "The Expanding Earth", 488 pp., and Stanford University Press: "Theories of the Earth and Universe", 413 pp.

Carey was an Honorary Life Member of the Geological Society of Australia, the Geological Society of London, the Geological Society of America, The Australian Geophysical Society, the Australian and New Zealand Association for the Advancement of Science, and the Indian National Science Academy.

He was awarded the Clarke Medal of the Royal Society of New South Wales, the Johnstone Medal of the Royal Society of Tasmania, the Browne Medal of the Geological Society of Australia, the Gondwanaland Gold Medal of the Mining, Metallurgical and Geological Society of India, the Weakes Gold Medal of the Australian Petroleum Production and Exploration Association, the Gold Medal of the Australian Geophysical Society and the ANZAAS Medal of the Australian and New Zealand Association for the Advancement of Science. He was a Fellow of the Australian Academy of Science, and an Officer of the Order of Australia. The "Carey Medal" is awarded annually by the Geological Society of Australia.

Samuel Warren Carey joined the Royal Society Of New South Wales on 5th October 1938 as a paid Life Member and a practicing petroleum geologist, his address being c/o Oil Search Ltd, 350 George Street, Sydney. He had been nominated by W.R. Browne, Leo G. Cotton, and G.D. Osborne, three of the "greats" of the University of Sydney.

Papers published in the Journal and Proceedings of the Royal Society of NSW:
(i) Vol LXXII, 1938, pp. 199–208:- S.W. Carey & G.D. Osborne:- "Preliminary Note on the nature of the stresses involved in the late Palaeozoic Diastrophism in New South Wales".
(ii) Vol. LXXI, 1937-1938, pp. 591–614:- S.W. Carey & W.R. Browne:- "Review of the Carboniferous Stratigraphy, Tectonics and Palaeog-

raphy of New South Wales and Queensland".

Official Responsibilities Involving Protocol:
1951 Representative of Australian Government at the Centenary of the Geological Survey of India.
1960 Representative of University of Tasmania at the Tercentenary of the Royal Society, London.
1963 United Nations Technical Expert assigned to Government of Israel (3 months).
1964 Australian delegate to the International Geological Union in Delhi; exercising Australia's only vote.

In 1976 Professor Sam Warren Carey became Hon. Life Member of the Royal Society of New South Wales. This was the year when he retired from active departmental work, but his work continued. In 1996 the University of Tasmania published, on the occasion of the 50th Anniversary of the foundation of the Geological Department of the University of Tasmania, a major work (ISBN 0 85901 715X qto 231 pp. 127 figures) "Earth Universe Cosmos: An Inquest into our Creeds", by S. Warren Carey, AO.

Because of the general interest and the wide field, this was reviewed in the Journal and Proceedings of the Royal Society of New South Wales, Vol. 132, pp. 118–122, 1999. It would be fair to suggest that perhaps only Professor Sam Warren Carey would have possessed the breadth of knowledge and the authority during such an exciting half-century of geological teaching creeds to be able to validly criticise them.

J.C. Grover OBE

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Biographical Memoir

ANDREW JOHN CORBYN

1944 – 2001

Our friend and colleague, Dr Andrew John Corbyn passed away in September 2001 in Papua New Guinea. Born 1944 in Chippenham, England, educated at the Royal School of Mines, London, Andrew graduated in Mining Engineering and also studied for MSc in Geophysics at the same School. He earned PhD from Murdoch University in 1999 while he was with us. His Doctoral work was on Air Movements and Sudden Infant Death. Dr John Andrew Corbyn joined the Royal Society of New South Wales in 1999 (elected 27th October, 1999). Dr Corbyn contributed an article on "Air Movement in the Sleeping Environment and Sudden Infant Death" (Vol. 132, 1999) to the Society's Journal and Proceedings.

In 1968, he came to Australia and was holding dual citizenship of England and Australia. He worked in different mining and geophysical operations in England, Chile, Denmark, South Africa and Australia. He was also Lecturer in Mining Engineering at the Kalgoorlie School of Mines, Western Australia. Andrew came to our Department in January, 1997 as Lecturer in Mining Engineering.

Andrew was a great teacher, lecturer, researcher, adventurer and lived his life with intensity and enthusiasm. To his students, he always taught them to work with their hands, do manual and practical things; to build, design and create mine plans, laboratory experiments and mechanically moving things rather than relying on calculators and computers. He wanted his students to go out to villages to help villagers to improve their living conditions by transferring the knowledge they acquired here.

Andrew will be remembered for odd-looking ingenious experimental set-ups, which he created in our laboratory, to explain basic principles of mechanics and dynamics to our students. We also remember him for his wonderful stories, rattling car and his love for bush walks and alluvial miners.

Andrew was always concerned for the weaker sections of the society and was always ready to help them in whichever way he could. We all sadly miss him. Whenever we were stretched in the teaching resources, I used to ask him to take additional teaching load and he would gladly take it on without any hesitation.

He is survived by his wife Pamela and three daughters, Zoe, Sarah and Naomi. As far as I know, Andrew is also survived by two brothers, Pearce and Jeremy. Jeremy is a British Member of Parliament.

Professor S. Bordia

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Annual Report of Council

For the year ended 31st March 2002

PATRONS

The Council wishes to express its gratitude to His Excellency the Right Reverend Dr Peter Hollingworth AC, OBE, Governor General of the Commonwealth of Australia, and Her Excellency Professor Marie Bashir, AC, Governor of the State of New South Wales for their continuing support as Patrons of the Society during their term of office.

MEETINGS

Nine ordinary monthly meetings and the 134th Annual General Meeting were held during the year at various locations.

SPECIAL MEETINGS AND EVENTS

29th April 2001
The President, Mr David A. Craddock and Hon. Secretary, Mrs M. Krysko v. Tryst, attended the 232nd Anniversary of the landing by Captain James Cook RN at Kurnell by invitation from the Mayor of the Sutherland Shire Council.

17th May 2001
The Pollock Memorial Lecture was delivered by Professor Marcela Bilek, Professor for Applied Physics, in the School of Physics, the University of Sydney in the Carslaw Building of the University of Sydney. The title of the lecture was:- "Enhancing the Functionality of Materials: Recent Advances in Surface Modification Technology".

1st December 2001
The President Mr D.A. Craddock and Mrs J. Craddock attended by invitation the "Centenary of Federation" celebrations at Falconbridge on the 1st of December, 2001. The invitation was extended by the Committee to the President of the Royal Society of New South Wales on account of the involvement of Sir Thomas Brisbane, the 6th Governor General, with the Philosophical Society of Australasia in 1821. That Society was the forerunner of the present Royal Society of New South Wales.

12th February 2002
The Society was a co-sponsor with the Australian Nuclear Association, the Australian Institute of Energy and the Nuclear Engineering Panel of the Institution of Engineers Australia, of a meeting held at the Institute of Engineers, Milsons Point. Dr Clarence J. Hardy, secretary of the Australian Nuclear Association, addressed the Meeting on "The Renaissance in Nuclear Science and Technology". Mr George Fox offered the thank-you vote.

28th February 2002
The Annual Dinner of the Royal Society of New South Wales was held at the Holme and Sutherland Rooms, the Holme Centre, at the University of Sydney. The after- dinner speech on "The Greenhouse All Hot Air? – A Short History of Planet Earth", was delivered by Professor Ian Rutherford Plimer. The President, Mr D.A. Craddock presented the Society's awards for 2001.

6th March 2002
The 51st Clarke Memorial Lecture in Geology, which was scheduled to be delivered by Professor William J. Collins of the Department of Geology, School of Geosciences, University of Newcastle, NSW, had to be cancelled due to unforeseen circumstances.

Attendances at Vice-Regal Events
The President, Mr D.A. Craddock and the Hon. Secretary Mrs M. Krysko v. Tryst called on Her Excellency, the Governor of New South Wales on Wednesday, 13th June, 2001. The President, Mr D.A. Craddock and Mrs Craddock attended the 75th birthday celebration for Her Majesty the Queen on the 12th June, 2001 and the

Christmas Reception on 10th December, 2001 at Government House.

MEETINGS OF COUNCIL

Eleven Meetings of Council were held, ten Meetings were held at the Society's office at 6/142 Herring Road, North Ryde, one special Meeting in April, 2001 at the Sydney Tattersall Club in Pitt Street, Sydney. One meeting in September comprised the Executive only.

PUBLICATIONS

Journal

Vol. 134 (Parts 1–4 incl.), 2001 was published during the year in two issues: July 2001 and December 2001. Parts 1 and 2 contained the Presidential Address 2001 (Colour and Cash: the Exquisite Minerals of the Oxidised Zone), one peer-refereed paper on Aboriginal language, the Pollock Memorial Lecture in Mathematics and Physics 2001 and three Higher Degree Abstracts (geology, medicine and reef-studies), two reports on recipients of Studentships Awards and the Annual Report of Council for 2001–2002 including the Financial Statement and Biographical Memoirs. Parts 3 and 4 carried three peer-refereed papers on Geomechanics, Seed Germination Under Stress, and Factors in the Use of Breast Screening, a symposium on Geodiversity and a Critical Review paper. Also included was one Higher Degree Abstract (Anterior Mandible of *Homo sapien sapien*, Biographical Memoirs and Citations for Awards in 2000. An Index to Vol. 134 concluded the issue. Council wishes to thank all the voluntary referees for their time and efforts. The Society received various requests for permission to reproduce material from the Society's earlier volumes of its "Journal and Proceedings".

Bulletin

Bulletin Nos 239 to 249 incl. were published during 2001–2002. Council's thanks are extended to the various authors of short articles for their contributions and to the other voluntary helpers who facilitated the production and distribution of the Bulletin.

AWARDS

The following awards were made for 2001:-

The Royal Society of New South Wales Medal: Professor Peter A. Williams, of the University of Western Sydney, for achievements in science and service to the Society.

The Clarke Medal (Geology): Dr Gordon H. Packham (formerly University of Sydney)

The Edgeworth David Medal: Dr Samantha J. Richardson, of Melbourne University.

The Walter Burfitt Prize: Professor Michael W. Parker, of the St. Vincent Institute of Medical Research, Melbourne, Victoria.

The following were not awarded for 2001: The James Cook Medal, The Archibald Ollé Prize

MEMBERSHIP

At 31st March, 2002, Membership of the Society was:

Patrons	2
Honorary Members	11
Full Members	247
Associate Members	22
Total (incl. Spouse members)	282
Resignation	10

Council announces with regret the names of the following deceased members:

Dr J.E. Banfield
Mr G.W. Collett
Dr J.A. Corbyn
Emeritus Prof. L.W. Davies
Mr M.E. Scott
Mr K.P. Sims

New members admitted: 11

LIBRARY

Acquisition of journals by gift and exchange has been continued during 2001/02. Exchange material from overseas sources has been forwarded to the Dixson Library, University of New England in Armidale where it is available locally or on inter-library loan. Australian journals and other printed material are kept in the Royal Society's collection at the North Ryde Head Office in the grounds of Macquarie University where they are available to members and approved visitors. Council thanks the staff of Dixson Library for their continuing maintenance of the Society's Collection. The Dixson Library advises the Hon. Librarian of any missing issues of overseas journals who then takes appropriate action. An accession list of literature received during the year has been compiled and an appropriate notice will appear in the Society's Bulletin for the information of members. The Hon. Librarian wishes to inform Council that the present manner of book storage in cardboard boxes is not satisfactory. It encourages the breeding of large cockroaches which cause significant damage to some of the older books. This unsatisfactory situation will, hopefully, be redressed once the Society has acquired more spacious and permanent accommodation.

ABSTRACT OF PROCEEDINGS

4th April 2001
The 134th Annual General Meeting and the 1096th General Monthly Meeting were held at the City Tattersalls Club, Sydney, NSW. The President, Professor Peter A. Williams was in the Chair. The Annual Report of Council and the Financial Report for 2000-2001 were adopted? Mr B.E. Holden, Chartered Accountant was re-appointed Auditor for 2001-2002. Professor P.A. Williams yielded the chair to the incoming president, Mr D.A. Craddock who thanked the outgoing Committee for its work during the preceding year and invited the outgoing President, Professor P.A. Williams to deliver his Presidential Address "Colour and Cash: The Exquisite Minerals of the Oxidized Zone".

The following awards were announced for 2000:- The Royal Society of NSW Medal: Dr Philip Richard Evans, The Clarke Medal (Botany): Prof. Sarah Elizabeth Smith, The Edgeworth David Medal: Dr Michael Soon Yoong Lee

The following members were elected to Council for 2001-2002:-

President:	Mr D.A. Craddock
Vice-President:	Prof. P.A. Williams
	Dr W.E. Smith
	Mr C.F. Wilmot
Honorary Secretaries:	A/Prof. A.T. Baker
	M. Krysko v. Tryst
Acting Secretary:	Prof. P.A. Williams
Honorary Treasurer:	Prof. R.A. Creelman
Honorary Librarian:	Dr E.V. Lassak
Councillors:	Mr J.R. Hardie
	Ms K.F. Kelly
	Mr M.F. Wilmot
	Prof. M.A. Wilson
Southern Highland Branch Rep.:	Mr H.R. Perry

2nd May 2001
The 1097th General Monthly Meeting was held at the Sydney Tattersalls Club, Pitt Street, Sydney. The meeting was addressed by the Construction Director for the Parramatta Rail Link, Mr Michael Flynn on "The Government Rail Link". Professor Peter A. Williams offered a vote of thanks.

6th June 2001
The 1098th General Monthly Meeting was held at Macquarie University. Emeritus Professor Ray Cattell spoke on "How children learn to speak". Dr Edmund Potter offered the vote of thanks.

4th July 2001
The 1099th General Monthly Meeting was convened at the "Search and Discover Room", Australian Museum, Sydney. James Woodford, Environmental Writer at the Sydney Morning Herald, gave a talk on "Wombats and Wollemis: Amazing Organisms and What They Have in Common".

1st August 2001
The 1100th General Monthly Meeting took place at the ASN Theatrette, The Rocks, Sydney. Mr Wayne Johnson of the Sydney Harbour Foreshore Authority lectured to the Meeting on "Archaeology and New Perspective on the Settlement of Sydney:- the Excavation and Reconstruction of the Dawes Point Battery, Sydney's earliest fort". Vote of thanks offered by Professor P.A. Williams.

5th September 2001
The 1101st General Monthly Meeting was held at the "Search and Discover Room", Australian Museum, Sydney. Professor Bernard A. Pailthorpe of the Vislab, School of Physics, University of Sydney, addressed the Meeting on "Visualisation of Galaxies, Oceans, Brains". Mr Matthew Wilmot gave the vote of thanks.

3rd October 2001
The 1102nd General Monthly Meeting took place at the "Search and Discover Room", Australian Museum, Sydney. Dr Stephen Bourke of the School of Archaeology, University of Sydney, addressed the Meeting on "Excavating Pella's Bronze Age Migdol Temple:- The 2001 Field Season". Professor P.A. Williams offered the vote of thanks.

7th November 2001
The 1103rd General Monthly Meeting was held at the "Search and Discover Room", Australian Museum, Sydney. An address entitled "Soft Matter, Rheology and Leonards" was given by Professor Roger Tanner of the Department of Mechanical and Mechatronic Engineering, University of Sydney. Dr Edmund Potter offered a vote of thanks.

3rd April 2002
The 1104th General Monthly Meeting took place at the City Tattersalls Club, Pitt Street, Sydney. It was combined with the 135th Annual General Meeting.

SOUTHERN HIGHLANDS BRANCH

The Southern Highlands Branch held eleven well attended meetings (average attendance about 60 members and visitors). Some new members, attracted by the lecture programme, joined this Branch of the Royal Society of New South Wales during the year.

22nd March 2001
Professor Peter A. Williams, Professor of Chemistry, University of Western Sydney and President of the Royal Society of New South Wales presented a lecture on "Chemistry in the Desert – A Mineral Bonanza". Some 49 people attended including 8 students from local schools.

11th April 2001
The Branch's Annual General Meeting was held at the Fitzroy Inn and the incoming Committee for the Branch was elected:-

Chairman:	Mr Clive Wilmot
Vice-Chairman:	Mr Roy Perry
Hon. Secretary:	Cmdr. David Robertson, CBE
Hon. Treasurer:	Ms Christine Staubner
Members:	Ms Marjorie Roberts
	Mr Imre Holmik
	Mr Brian Maher*

* retired during the year due to other commitments

19th April 2001
Dr Charles Barton, OIC Geomagnetism Group of the Australian Geological Survey Organization, spoke on "The Quest for the Magnetic South Pole". His talk included a brief historical account and personal experiences.

17th May 2001
An audience of 79 people was addressed by Dr Robert Rheinberger, Vice-President of the World Association of Cattle Veterinarians, on the subject of "Foot and Mouth and BSE or Mad-Cow Disease". His talk included references to control measures and effects on rural populations as well as aspects of cross-infection of humans.

21st June 2001
Dr Vijoleta Braach-Maksuytis, co-inventor of the ion-channel switch and Project Leader of Biomimetic Engineering, CSIRO Telecommunications and Industrial Physics Division, gave a general talk on the development of nanotechnology and the impact of materials development on human civilisations.

19th July 2001
48 members and visitors were addressed by Mr Don White Eng., Principal of the private Australian meteorological firm "Weatherwatch" on the "Art and Science of Meteorology Today".

16th August 2001
"The Politics, Economics and Nature of Future War" were the subject of a talk given by Dr Michael McKinley, Senior Lecturer in Global Politics, ANU Dept. of International Relations and Strategic and Defense Studies Centre.

20th September 2001
One of the few remaining life members of the Royal Society of New South Wales, Mr Fred Blanks AM spoke on the subject: "Music Criticism: Conspiracy or Lifeline". The speaker commented on the legal, social and political aspects affecting freedom of expression and the uses to which published criticisms are put.

18th October 2001
Dr Ray Binns, Chief Research Scientist, CSIRO Exploration and Mining, gave an overview of the recent history of deep sea-bed mining activities. The speaker included examples from various localities around Australia and nearby areas and pointed out the importance of results obtained for, among others, biodiversity, ocean chemistry and perhaps climate change.

13th November 2001
Prof. A.T. Baker, of the Department of Chemistry, Materials, and Forensic Science, University of Technology, Sydney, spoke on a number of recent projects using plasma mass spectrometry (ICP-MS) to identify origins of manufactured products as well as its usefulness in the field of archaeology.

21st February 2002
Professor Bernard Pailthorpe and Dr Nicole Bordes gave an outline of the work of VISLAB and a progress report on work undertaken in the United States.

ACKNOWLEDGEMENTS

The Chairman, Mr Clive Wilmot, acknowledges the enthusiastic support given to the Branch by the Head of Winifred West Schools Ltd., Ms Julie Gillick, and the hard work of members of the Branch Committee.

NEW ENGLAND BRANCH

The New England Branch at Armidale NSW has terminated its activities. The funds of the Branch have been remitted to the Royal Society of New South Wales.

NOTICE TO AUTHORS

Manuscripts should be addressed to The Honorary Secretary, Royal Society of New South Wales, PO Box 1525, Macquarie Centre, NSW 2113. Manuscripts submitted by a non-member (through a member) will be reviewed by the Hon. Editor, in consultation with the Editorial Board, to decide whether the paper will be further considered for publication in the Journal.

Manuscripts are subjected to peer review by an independant referee. In the event of initial rejection, manuscripts may be sent to two other referees.

Papers, other than those specially invited by the Editorial Board on behalf of Council, will only be considered if the content is substantially new material which has not been published previously, has not been submitted concurrently elsewhere nor is likely to be published substantially in the same form elsewhere. Well-known work and experimental procedure should be referred to only briefly, and extensive reviews and historical surveys should, as a rule, be avoided. Letters to the Editor and short notes may also be submitted for publication.

Three, single sided, typed copies of the manuscript (double spacing) should be submitted on A4 paper.

Spelling should conform with "The Concise Oxford Dictionary" or "The Macquarie Dictionary". The Systéme International d'Unites (SI) is to be used, with the abbreviations and symbols set out in Australian Standard AS1000.

All stratigaphic names must conform with the International Stratigraphic Guide and new names must first be cleared with the Central Register of Australian Stratigraphic Names, Australian Geological Survey Organisation, Canberra, ACT 2601, Australia. The codes of Botanical and Zoological Nomenclature must also be adhered to as neccessary.

The Abstract should be brief and informative.

Tables and Illustrations should be in the form and size intended for insertion in the master manuscript - 150 mm x 200 mm. If this is not readily possible then an indication of the required reduction (such as 'reduce to 1/2 size') must be clearly stated. Half-tone illustrations (photographs) should be included only when essential and should be presented on glossy paper.

Maps, diagrams and graphs should generally not be larger than a single page. However, larger figures may be split and printed across two opposite pages. The scale of maps or diagrams must be given in bar form.

Half-tone ilustrations should be included only when essential and should be presented on glossy paper.

All tables and illustrations should be numbered consecutively with Arabic numerals in a single sequence and each must have a caption.

References are to be cited in the text by giving the author's name and year of publication. References in the Reference List should be listed alphabetically by author and then chronologically by date. Titles of journals should be cited in full – not abbreviated.

MASTER MANUSCRIPT FOR PRINTING

The journal is printed from master pages prepared by the LaTeX typesetting program. When a paper has been accepted for publication, the author(s) will be supplied with a guide to acceptable electronic format for the submission of the revised manuscript. Galley proofs will be provided to authors for final checking prior to publication.

REPRINTS

An author who is a member of the Society will receive a number of reprints of their paper free. Authors who are not a members of the Society may purchase reprints.

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