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Presidential Address delivered before the Royal Society of New South Wales on 9th April, 2003.

Publish and Perish

DAVID A. CRADDOCK

Abstract: Two major celebrations will occur during this year, 2003. The first is the bicentenary of the publication of the first Australian newspaper, the 'Sydney Gazette and NSW Advertiser.' The other major event will be celebrated at the end of 2003, with the centenary of powered, controlled and sustained human flight. Although the Wright Brothers' flight was an American success, their achievement was initially based on the work of other pioneers. The work of those earlier pioneers became available to the Wrights through the medium of print. This paper explores some of the Australian linkages between the written word and those early aerial endeavours.

Keywords: Australian aviation, Lawrence Hargrave, Wright Brothers, human flight

INTRODUCTION

As well as celebrating the bicentenary of the first publication of Australia's first newspaper, and the centenary of powered, controlled, sustained human flight, another anniversary has been acknowledged in Sydney. The 170th anniversary of the formation of the Sydney Mechanics' School of Arts was celebrated on March 22nd. Three dates commemorating three forms of human communication: newspapers and the written word, schools of arts and the spoken word and the final form of efficient, personal communication, by aerial navigation.

Academics are urged to publish their ideas, otherwise they may perish. Early Australian pioneers in aeronautics often published their ideas in the press and later through the journals of learned societies. Although some ideas may have lasted, most of those pioneers have been long forgotten, as they published and perished.

The first local newspaper was the 'Sydney Gazette and New South Wales Advertiser', which first appeared on 5th March, 1803 and had disappeared by 1842. Another paper, 'The Australian', lasted from 1824 until 1848. The 'Sydney Herald' began in 1831 and continues to this day as the 'Sydney Morning Herald'. Those and several other newspapers provided the medium for the circulation of ideas through the Colony. Some articles on aeronautics fired the imagination of local people, while other correspondence was apparently ignored. Practical understanding and skills as well as ideas, were soon needed in the Colony and a means to help ideas along the next step was provided through adult education.

Schools of Arts were a key element in the movement to educate the adult population, which began in Britain during the latter part of the 18th century. The first such schools or Mechanics' Institutes in Britain, were formed in 1821 in Edinburgh and Glasgow and London by 1823. The Sydney Mechanics' School of Arts was the second in Australia, formed in 1833. The first in Australia was the Van Dieman's Land Mechanics' Institute, which was founded in 1827, but unfortunately no longer exists. The Institutes provided adult education by way of lectures and the maintenance of a library. Many of the lectures were described in some detail in the local newspapers, thus increasing the spread of information to the wider community.

Mechanics' Institutes were created to provide the means for intellectual stimulation for the community through a multitude of subjects, from astronomy to chemistry, phrenology and beauty to language. Mr Arthur A'Beckett's fourth lecture in a series on chemistry in July, 1840 provided the first example of 'aerial navigation' in the Colony. One of his demonstrations included the filling of a small balloon with hydrogen. It 'ascended to the roof of the building, and floated about for a considerable time', but apparently failed to ignite any local interest in lighter-than-air flight (Sydney Herald 1840).

Another of the lecturers at the School of Arts was Mr A. James Slatterie. He wrote a letter to the press (Slatterie) in January, 1841 and proposed the establishment of a philosophical and scientific society in the colony. He claimed 'the teeming resources of this and the neighbouring Colonies are yet scarcely known, and even the information that has been gained, for want of such an institution, is confined within a limited circle.' His proposed institution was to be along the lines of the Royal Society, to collect and communicate scientific information. The Philosophical Society of Australasia had been formed in July, 1821, but fell silent soon thereafter. It was not until the 1850s that such societies were instituted in several of the Australian colonies, and continued to this day as Royal Societies of each State.

Teaching aids were useful to many of the technical lectures and staff at the Sydney Mechanics' School of Arts had anticipated the arrival of scientific and philosophical instruments and apparatus from Scotland. The list of items en route, was published in the press and provides an understanding of the state of knowledge and ability within the colonial community. The list included: steam cylinder, for showing force of steam; combination of levers; an inclined plane with carriage; Archimedes screw and wheel; Torricellian apparatus; Medgeburgh hemispheres, pulleys, clocks, balances and magnets. Unfortunately the equipment was shipped aboard the brig *Australia*, which was lost at sea about one thousand kilometres off the Cape of Good Hope. The equipment had been purchased from a lecturer at the Edinburgh School of Arts and included many items of interest to 'the intelligent mechanic in the pursuit of scientific endeavours.' (Sydney Herald 1841b) The nineteenth century term 'mechanic' would now equate to a tradesman.

OVERSEAS NEWS

News from England in 1841 carried details of an aerial voyage proposed by Charles Green, who was one of Europe's foremost aeronauts. This was to be a balloon flight from England to America. Apparently Green displayed a model of the balloon, which was to incorporate several ingenious adaptations, for directing and propelling power. This would have been the first time that a rudder and large paddles were fitted for a balloon flight. The rudder was to provide direction, while the paddles would propel the balloon. An earlier invention of Green's was the guide rope, which was essential to determine true altitude. It was understood that a barometer, or more specifically, an altimeter, would not be capable of identifying rising ground such as a mountain. Green's proposed voyage required a large sum of money (£3,000) to get off the ground. The balloon would be 27 metres high and 15 metres in diameter. The flight time was estimated at six days, from St Pauls, London to the Cupola, Washington (Sydney Herald 1841a). This flight never eventuated. There was no correspondence in the local press about this proposed voyage and it failed to create any interest, even though the flight would have been a remarkable feat.

A rare item of aeronautical interest appeared from America. One Mr Davidson of Virginia, who was a member of the Bar, proposed a lecture where his ideas could be presented to the public. All that was mentioned in the news article was that Davidson proposed the use of legs and feet to provide the necessary power for propulsion. He claimed that it would be no more tiring than walking. His claimed objective was to fly at 160 kilometres per hour (Sydney Herald 1841c). Nothing more appeared about Davidson, and this article also failed to engender any response from Sydney residents. Accounts of Charles Green's balloon flights from Vauxhall Gardens in England were published locally, but those also failed to raise any public interest in aeronautics in the Colony (Sydney Herald 1841d and 1842).

The seeds of change for transport itself had taken root in Britain, which was in the midst of the Industrial Revolution and spawned new ideas about conquering the air. William Samuel Henson made his application for a patent on 29$^{\text{th}}$ September, 1842, (Henson 1866) which pre-empted the publication in 1843 of the first full set of plans for his aeroplane, the *Ariel*. Henson's aeroplane was to be steam powered, because steam was virtually alone as the meaningful provider of mechanical power. Newspapers in Sydney first reported on Henson's aerial steam carriage on 9$^{\text{th}}$ May, 1843 under the heading 'carriage through the air' (Sydney Morning Herald 1843a). The brief article, repeated some information from the 'London Gazette', noted that Henson's invention was for 'certain improvements for locomotive apparatus and machinery in conveying letters, goods and passengers through the air.' Some aspects of his invention were also applicable to locomotion on land and sea, or so it was claimed.

LOCAL INTEREST

The first brief mention of Henson's carriage apparently caused no influx of correspondence from the newspapers' readership. No letters or other articles on aerial navigation were published until just after the appearance of a second article about Henson, which was published locally on 26$^{\text{th}}$ May, 1843. This second article was gleaned from several English newspapers. The composite article was introduced by a letter, which added some feeling of authenticity, as its writer described his initial scepticism of the machine (Miles).

One feature of newspaper correspondence was the use of pseudonyms. It was more likely for correspondence to be endorsed with initials, or a name appropriate to the subject matter, rather than that of the author. 'Aeronaut' was one such correspondent, who claimed that 'twenty years ago' he 'invented and made known to a few scientific friends a new species of balloon.' It has not been discovered whether Aeronaut was in Britain, or New South Wales, twenty years earlier, but the former was his most likely location. The plan was to 'revert to the old principle of rarefied air and to accomplish the rarefaction by means of portable gas and Argand burners' (Aeronaut 1843a). In other words, a hot air balloon, inflated by gas fires, much like modern balloons.

Aeronaut continued 'a mere balloon would not accomplish the great end of periodical or exact transit' and 'we might ascend by mechanical contrivance by which means instead of being at the mercy of atmospheric currents, we might make them subservient to our wishes.' He was concerned that balloons would always be subservient to the air currents. Aeronaut commented that Sydney would one day be as near to England as Edinburgh was to London, one hundred years earlier, once the navigation of the air was mastered. He suggested that daily mails would be possible between Sydney, Port Phillip (Melbourne, Victoria), Adelaide (South Australia), the Swan (now Perth, Western Australia) and Port Essington (a failed settlement about 150 kilometres north east of Darwin, in the Northern Territory).

Several correspondents described the possibility of using steam power by way of some modification to Hero's (or Heron's) ancient *Aeolipile*. Hero of Alexandria was a Greek mathematician and scientist, who lived in the first century AD. He invented numerous ingenious devices, including the steam engine (Girling p. 218). The 'Avery' engine was described as one of those similar to Hero's steam engine. William Avery, of Syracuse, New York, invented a small reaction steam wheel in the 1830s. For several years it was believed to have been the simplest and cheapest steam engine available. It was used to drive circular saws and cotton gins (Parsons). Two arms were fed by steam, which could exit the outer ends of each arm, but in opposing directions. This resulted in the apparatus spinning quickly about its axis. Aeronaut described the air as the fulcrum for his flying machine. His machine would ascend due to the lift provided by an airscrew arrangement, acting much like a modern helicopter rotor. Forward motion was to be provided by another, horizontally acting airscrew. Of particular interest in Aeronaut's letters, was his description of rudders for directional control, and his identification of flight into various wind conditions '... it is quite possible that a head-wind may prove to be the safest current to ride upon.'

Aeronaut (1843b) also considered air as an alternative to steam for operating the Avery engine. If expanding air could be used to replace heated water, the weight saving would be worthwhile. Aeronaut described his proposed engine, simply as a tube 3.64 m long by 0.91 m in diameter. A wheel with fans would be positioned inside the tube, in a similar manner to the compressor and turbine discs in a modern jet engine. The Avery engine would then be used to provide power to rotate the fans and thus produce forward thrust from those fans. The idea proposed something close to the same principle that operates in a jet engine. It is unclear from this simple correspondence whether Aeronaut had any practical ideas for the detailed construction of such an engine.

Another correspondent was Francis Forbes, the elder son of Sir Francis Forbes, the first Chief Justice of New South Wales. He wrote to the newspaper in early June, 1843, describing his idea, which incorporated a kite and 'Archimedean screw fan'. Forbes compiled some notes of interest in his correspondence to the press, a few days later. '... the screw-fans or vanes must turn on an axis lying in the plane of the kite and they must be placed behind the kite, or at the side, and propel it forward; and when the machine is going through the air, both the plane of the kite and the axes of the screw-fans must be nearly horizontal. A very slight inclination of the plane of the kite upwards being sufficient to support the greatest weight it is capable of sustaining, the screw-fans must be used entirely as a propelling force, and the kite, its plane slanted slightly upwards, as the only supporting power. The axes of the Archimedes screw-fans must be all parallel, if they were inclined at any angle there would be a loss of power. Your correspondent 'Aeronaut' has placed the axis of his principal screw propeller exactly at right angles to what it ought to be, having made the axis perpendicular instead of horizontal. Also, by making two separate forces, one a propelling and one a supporting force, acting at an angle to each other, he would experience a loss of power ... In my model, I have made two rotatory screw-fans to revolve in opposite directions that the machine might balance better, their axes being in the same plane and propelling in the same direction' (Forbes 1843a).

The Archimedes' screw was a device invented for the raising of water, by means of an inclined cylinder, which snugly contained a large diameter 'screw'. The maritime industry found that some modification to the Archimedes' screw resulted in the marine propeller. Steamships were originally propelled by means of paddlewheels. Several people invented screw propellers during the early years of the 19th century, but two excelled as the real developers of this invention. Francis Pettit Smith in England and John Ericsson in the United States brought the screw propeller into practical use. The British Admiralty staged a demonstration during March, 1845 to show the effectiveness of the screw propeller. The steam sloop *Rattler*, fitted with a propeller designed by Smith, was set to pull against another steam sloop, *Alecto*, driven by paddle wheels. Except for their paddles and screw, the ships were identical, powered by 149 kilowatt steam engines. The *Rattler* won the tug-of-war, convincingly towing the *Alecto* backwards at almost 5 kilometres per hour (Kemp). The *Rattler* was built of Oak and launched from the Royal Dockyard Sheerness in 1843 (SMH 1843e). It should be understood that the various terms for Archimedes' screw fan, or propeller would translate into something resembling a modern marine propeller.

Local interest in aerial navigation was still not, it appears, easy to gain. Forbes mentioned a Mr Petrie of Moreton Bay (now Brisbane, Queensland) as the only person he had met who approved of his design. Forbes had tried to interest a Mr Cohen in Sydney with the construction of a working model of his aerial machine, without success. He then spent some months attempting the construction himself, with the aid of a workman 'who has been perpetually ill' (Forbes 1843b). Forbes claimed to have more than half completed the model when the news from England about Henson was published locally. He felt that some of the ideas in Henson's machine were similar to his. From Forbes' description and the published drawings of Henson's machine, there were obvious similarities.

Forbes claimed to have made mention of his ideas to several people in England and Australia, and only met with ridicule for his trouble. He felt that the idea had been pirated, and sought assistance from a friend, William Bland. Forbes claimed to have provided Bland with a list of those people with whom he had discussed the aerial concept (Forbes 1843a). Unfortunately no record of Bland's investigation into this matter has been uncovered.

Forbes built upon some of the published comments and from Aeronaut's letter, he distilled several changes and suggested improvements to the proposal of Aeronaut. He proposed contra-rotating propellers, '... two vanes at least, of great diameter, turning on perpendicular axes in opposite directions'. He suggested the best solution would be for the two propellers to be on the same shaft, one above the other. With this arrangement there would be no need for 'a plane of canvas' at each end of the craft. He proposed that the rotors, as we would now describe them, could be tilted forward to provide forward motion. With rotors replacing the fixed wing, Forbes had proposed a design configuration we now call the helicopter. He was also of the opinion that human power may be a real alternative to steam power. The heavy weight and low power available from steam engines caused Forbes' hopes to be dented, until the invention of Avery's engine. This was hoped to fulfil Forbes' power requirements, but it too, was a doubtful provider of sufficient power (Forbes 1843c).

'RMCE' responded to criticism of Forbes, with support, claiming aerial navigation was possible with and without steam power. This correspondent was Robert Mudie, a Civil Engineer. He had his own design for an aerial machine, which he believed would probably require several million dollars in current values (£5,000) for its development. That was not an amount to be afforded by an individual, so Mudie considered the only possibilities for gaining such support would be through the creation of a company to transfer passengers from Sydney to India and beyond, by air.

Mudie mentioned bird flight in his correspondence, but the main thrust was his conviction that mechanical flight was possible. 'So may an aerial carriage be constructed with mechanical power, to move through the air to any place wished; as a steam-boat in a calm makes her destined port without the aid of wind, so may aerial carriages; and contrary winds only retard their flight' (Mudie 1843a). He later wrote more specifically about his ideas for aerial navigation, which clearly described the basis for the rigid airship of the future (Mudie 1843b).

The editorial of June 28, 1843 succinctly identified some of the changes society had undergone during the previous four decades (SMH 1843b). Mountains and oceans had ceased to be barriers, as steam power surpassed sailing ships. Gas had now been used to light up the cities. The very latest discoveries were 'conveyances upborne upon the winds' and 'the electric fluids'. The editor's words are indeed worthy of repetition '... the improvement of Aeronaut's engine recommended by Mr Forbes, will show how one mind can act upon another, and how rapidly the agitation of a particular theory may carry on its application to perfection.' The Wright Brothers learned this very well and did exactly what the Sydney Morning Herald editor proposed. They built upon the knowledge of all before them, and attained powered, controlled and sustained mechanical flight sixty years and six months later.

As two proposals for flying machines had been published through the newspaper in Sydney, it was argued that so much more could be proposed from those more populous regions, such as Europe, Britain and the East. The Government Astronomer, James Dunlop, was urged to submit his calculations on aerial navigation. He had apparently been a strong supporter of this new field of endeavour, although no mention of this interest appears as record in biographical notes on Dunlop (Pike 1968). The newspaper's editor was incredulous that Henson's machine had been proposed with steam as its motive power. The steam engine was a lumbering, cumbersome creature, which required fuel as well as water for its operation. It had so far baffled '... all schemes to render it buoyant. Neverless as there are pelicans as well as swallows among birds, we may yet behold a stately Leviathan rising in the air' (SMH 1843b).

Even greater promise for the future lay with the electro-magnetic discoveries, expanded air and gases. Electricity had been used to turn machinery since 1833 and during November, 1842 an experiment had demonstrated the use of electricity for propelling a locomotive engine. The editor concluded with his thoughts on the future 'an era when with lightning speed, news will travel round the world, and radiate to its remotest wilds – when the birth of a Prince in England will be telegraphed to Sydney before the dawn of another day' (SMH 1843b).

Correspondents continued to support or criticise earlier writers. One wrote under the initials XYZ, criticising the negative comments of an earlier correspondent, AB. The latter, XYZ made an interesting, and perhaps forgotten suggestion that kites should be flown 'one above the other.' This was most likely stated, just as an off-hand part of his criticism of AB, but it was this very same layout that was so successfully employed by Lawrence Hargrave in a later decade. XYZ also confirmed his strong belief that success would surely come, once a source of power was discovered that was lighter than steam (XYZ).

John Curr of Castlereagh Street, Sydney was not convinced of the likelihood that mechanical flight was possible. Curr supported his argument against the likelihood of successful navigation of the air with some basic calculations. He described the power necessary for flight as a function of ' the complex ratio of the wings, their resistance, and velocity' and used a table generated by Sir Joseph Banks to work out the drag to be overcome. He then calculated the necessary wing area and requisite horsepower for a steam powered aerial machine. The results were either an extra-ordinarily large flight surface of some 338 929 square metres and correspondingly low power, or 637 kilowatts of power and a more reasonable wing area. Both were impractical, and he concluded 'the aerial carriage will turn out a most notorious failure' (Curr).

One John Holtzapffell wrote a letter from London to a friend in Ceylon, identified only as G.S., dated 1st November, 1842. G.S. then sent the letter on to be published on 28th March, 1843 in the 'Straits Messenger'. Re-published in the Australian in late June, 1843, it provided more details of Henson's machine. Holtzapffell described the Ariel's construction from sheets of copper, formed over flattened steel wire. The 'wire' was claimed to be 9.5 millimetres thick. The blades of the propellers were formed of 'light iron ribs covered with a strong silk web, which has been rendered more tough and elastic by a solution of caoutchouc.' He mentioned that the silk had a feature not available in calico. Should a spark from the furnace rest on the propeller surface, it would burn just a spot in the treated silk, and not cause the entire covering to burst into flames (Holtzapffell).

Until this time all correspondence about aerial navigation had been generated through the publication of a few relatively short articles, without any real details or diagrams. The first articles of substance, describing the 'Aerial Steam Carriage' were published in the 'Sydney Morning Herald' and 'The Australian' on 14th August, 1843. Several drawings of the craft appeared in the 'Sydney Morning Herald' and a different view in 'The Australian'. In modern terms it would be described as a monoplane, with twin pusher airscrews. The undercarriage was a tricycle arrangement, which only became commonplace after the Second World War. Henson's intention was to start the machine on a downward slope, and once airborne, continue its motion through the action of its steam engine powered propellers (SMH 1843c). The full-page account in 'The Australian' was accompanied by a drawing of the *Ariel* (Australian 1843b). The effect of publication of details and drawings of Henson's machine was such that 'The Australian' newspaper did reprints of the supplement to satisfy demand. A note about the need for extra copies of their supplement 'deemed this such an extraordinary occasion as may justify us in stepping out of our usual course' (Australian 1843c).

The following day the 'Sydney Morning Herald' published another large article on Henson's Carriage. This second article was based on another London newspaper and included dimensions of the craft. The article had some difficulty describing the craft's wings, calling them a floor or platform, apparently 'merely because of their large area.' The wingspan was to be 45.72 metres, chord of 9.154 metres and tail span of 15.24 metres (SMH 1843d).

Safety issues associated with aerial navigation soon found their way into the correspondents' discussion. What if something broke? What if the engine stopped 'and the machine at a stand-still in the air, loaded with 48 pascals (a pound to the square foot).' According to the London correspondent this last event would have resulted in a rate of descent of 6.7 m per second, which was then equated to jumping off a wall 2.29 m high (Atlas). On the same page of the 'Sydney Morning Herald' was another article, dismissive of the whole business. Under the heading 'The project of aerial locomotion refuted', and 'pigs may fly, but they are very unlikely birds', the article proceeded to dismiss the likelihood of success for Henson. Again, the requisite power from overly heavy steam engines provided the stumbling block. That case was supported with technical details of well-known facts of air pressure on flat plates and the lifting power of kites (Illustrated News).

Correspondence from AB regarding the 'Aerial Steam Carriage' and Francis Forbes' concept was strongly critical of both Forbes and XYZ. In his criticism of those two, AB supported his claims with an English example of about twenty years earlier. Apparently an attempt was made to use a large kite to pull a specially constructed, lightweight carriage along London's Baker Street. That did not work, and AB asserted that Forbes' proposed machine would not work either. AB was also sceptical of Henson's machine and considered it no more than a means of raising money. He claimed 'no names of acknowledged repute in mechanical science, nor of known respectability as regards moral character, have transpired as being in connexion (sic) with this company' (AB). The kite venture to which AB may have referred was actually conducted in 1827 by George Pocock. He hooked up a lightweight carriage to two Malay kites, one attached to the other. That trial showed that such kites could assist ground transport. Pocock's carriage travelled at 32 kilometres per hour over a distance of 64 km from Bristol to Marlborough. He called the arrangement 'Charvolant', after a combination of chariot and the French term for a kite. Pocock identified his kites as 'buoyant sails' (Moolman p. 42).

The 'Melbourne Times' eventually published something about Henson's Ariel, which included their own quaint description, intended to make the readers understand how the Ariel would appear. 'A light wheelbarrow with an additional wheel at each leg – then let a long very long sash frame be tied across the barrow, and then let the handles be very long and stretched over the canvass' (Melbourne Times). The article continued with a description of the propulsion as a 'small windmill turned by a spring in the barrow.' The barrow would contain the engineer, fuel and men. For the sceptical readers, it was suggested that they run against a high wind holding an umbrella, then suddenly unfurl it. That would surely convince them of the buoyant power of the air!

'Arden's Sydney Magazine' confirmed the wheel barrow and umbrella stories in reference to the editor of the 'Sydney Morning Herald' (Arden). It was deemed an incautious suggestion, as both items were readily available and may have led to the clever and courageous youths 'taking a run off the Rocks some fine morning, searching, on a small scale, for the secret of the aërial passage.' Thoughts of the many hang gliding sites along the coast now spring to mind.

Robert Mudie described his proposed aerial carriage, intended as 'amusement to the curious, tend to dispel the doubts of the sceptic in aeronautics, and be the means of forming a company to have it submitted to the test of experiment' (Mudie 1843b). His letter to the newspaper clearly described the features of the rigid airship, that would much later become identified with those of Count Zeppelin. Mudie's airship was described as 45.7 m long, 12.2 m diameter in the centre and tapering to points at front and rear. Around the middle of this structure was to be a strong belt, to which would be fastened two propellers and the carriage. A cruciform tail would be attached to the rear of the airship, and each of those four surfaces was to be connected to the carriage by way of a cord. These tail members were each 6.1 metres wide and 6.1 m span. The overall length of this airship was 52.7 m. To aid the airship's directional control, a fin was to be attached to the upper surface, some 18.3 m long, 3 m high in the middle and tapered to each end. The structural materials were not specified, but the covering was to be silk or fine linen and netting. The entire covered surface would then be coated with caoutchouc for air and waterproofing.

The carriage was to house a 15 kilowatt engine, a receiver for holding gas and a force pump to inflate and deflate the gasbag. It was also to incorporate a retort for making gas. The engine was to burn gas for its fuel. The passengers were to be housed in a small cabin within the main body of the machine. They would be able to move from the cabin to the carriage by way of a rope ladder. The estimated empty weight was 1361 kilograms, with a capability of lifting 817 kg of passengers or other load. Mudie claimed that the obvious problem with Henson's Ariel was the need to take off on a down hill slope, which would cause considerable difficulty in places without suitable grounds.

Another Muswellbrook correspondent to the Herald, identified as F.R.P-H. sought to save people their money by not investing in the various projects identified in the pages of the newspaper. He was correct when he wrote 'That man will one day be enabled to imitate the feathery tribes of the air, in the power of aerial locomotion, is not at all unlikely – so soon as a source of power shall have been discovered capable of being indefinitely increased, like steam, without nevertheless increasing the weight of the apparatus necessary for the generation of such power.' He continued with a dissection of Henson's machine, identifying gravitation and the 'hindering force' (or drag) as obstacles not yet overcome. Henson's steam engine was unable to lift itself. The power needed to overcome drag or the resisting, hindering force, increases dramatically with any increase in speed, or velocity. In fact, as F.R.P-H pointed out, a doubling of the speed of the craft would require eight times the power. 'In short, this Aerial Steam Carriage is a monstrous absurdity, and entitles Mr Henson to a place in Bedlam Asylum' (F.R.P-H).

A model of Henson's machine was eventually displayed in London, at the Royal Adelaide Gallery. This model measured 3.81 m by 0.91 m and weighed 7.71 kg empty. The full-sized craft was to be 43.89 m long. The reality of aerial navigation was still some way distant, as even the model had not flown (SMH 1843f).

In the London of 1843, balloon flight was still the only practical means of navigating the air, where another of the leading aeronauts, Monck Mason showed his latest idea. He demonstrated a small balloon, which could travel at 6 km per hour inside a large room. The demonstration was described in the press in Australia, rekindling local interest in aeronautics in 1844 (The Australian 1844a).

The Reverend John Saunders had arrived in Sydney on 1 December, 1834 aboard the *George Hebbert*. Saunders was Chaplain on that ship, which served as a female emigrant and convict vessel. (Pike 1967) Saunders arranged to conduct a series of lectures on aeronautics at the City Theatre, soon after the publication of the news about Monck Mason's demonstration. Saunders was a correspondent to the Sydney Morning Herald and had made his opinion on various social issues known to the readers. Causes appropriate to his calling, such as aboriginal deaths and abstinence comprised most of his writing.

A small notice appeared in the 'Australian Daily Journal', inviting the public along to hear Saunders present his lecture on Wednesday 12th June. It was mentioned that there would be some models of balloons and the Aerial Machine of Henson (The Australian 1844b). Despite bad weather, a crowd of 400 turned out to hear Saunders. There were models of kites, balloons and the Aerial Machine, upon which Saunders promised another lecture (Saunders 1844a). The 'Sydney Morning Herald' editorial apologised for being unable to publish a thorough report on all of the lecture's content, but mentioned some of the most novel points (SMH 1844). These main points were the adaptation of kites, or as Saunders also named them, buoyant sails, for inland discovery or maritime navigation, a new arrangement of the fire balloon, Dunlop's plan for guiding the air balloon, and a dissection of the flying machine. A fire balloon was another term for an expanded gas, or hot air balloon.

Saunders suggested the use of kites as possible improvement for the operation of sailing vessels. He suggested that kites would be used to increase ships' abilities to sail 'within 5 points of the wind'. That is, to be able to sail more efficiently. This suggestion was very much along the lines of Pocock's light carriage demonstration.

The 'fire balloon' resuscitation was through the use of Argand burners, fuelled by oil and an inner series of burners fuelled by portable gas. Perhaps Saunders had remembered the letter of Aeronaut, one year earlier, when he made this suggestion. Such a burner was invented by Aimé Argand in about 1782 and featured a cylindrical wick. Air was able to pass both inner and outer surfaces, providing improved combustion and brighter light (Simpson p. 622). The gas-fed burners were for emergency use only, and the gas cylinders also provided a solid structure for passengers and equipment. Saunders went on to propose the use of such fire balloons for exploration of Australia. His idea was to employ two balloons for this inland exploration, with one acting as a tender for the other. At some pre-determined location (or perhaps, duration into the flight) the surplus stores of the tender balloon would be re-assigned to the other balloon for its onward journey. This was novel, 'the idea of planting a balloon in the bush is something new, and we give it as a bright thought to bushrangers and dwellers in the "far west" ' (SMH 1844).

Dunlop's plan was described 'Taking the primitive method, which advanced maritime navigation, of joining canoe to canoe, I propose to join balloon to balloon in horizontal parallel rows, each to be covered in the usual way, by netting, for the individual security of each balloon, and to be fastened to one another by cords on the top of the nets, to obtain a compact well arranged body. There may be three rows, consisting of five each on the outside and six in the inside, giving in the whole sixteen balloons. From the lower extremities of the nettings I would suspend a stage or platform, on which the management of the machine would be conducted. This stage is to be furnished below with a keel extending along the whole length; at each end of the keelson a rudder is to be fixed, turning on a pivot in the usual way, through the top of which an axle is to pass, furnished with vanes set at greater angles than those of an ordinary windmill. The vanes are to act against the air, and to be turned by appropriate machinery. By these I propose to gain headway or sternway, and in conjunction with the keel and rudders steerage way: I think that by sternway, steerage way may be more effectually obtained. The stage need not be above three-fifths of the whole breadth, and may be surrounded by netting to prevent accidents.'

'My theory stands thus, sixteen balloons of the usual pear-shape form, of 6.1 m diameter will (if I recollect right) possess a levity of 2 722 kg. This power will be sufficient to sustain the apparatus, voyagers and ballast, and leave a surplus for ascension. By having this sized balloon, the needful pressure will be more nearly equalised with the strength of materials; by their number an accident happening to one, will not endanger the safety of the whole machine, and by their arrangement a better sailing surface is presented. The resistance, when sailing on a current, is as the whole resistance multiplied by the cosine of the angle from the vertical or line of keel' (Dunlop).

Saunders' second and concluding lecture was presented on Friday 14^{th} June. The Australian newspaper published an article the following day, describing Mason's balloon and also allowed Saunders to sight their copy of a drawing of the same machine in their office. The lecture was again well attended, or crowded as reported in the press. Saunders exhibited the model of Henson's machine as well as a diagram of Dunlop's proposed balloon (The Australian 1844c). Saunders' dissection of the flying machines was incomplete, as he had no picture of Mason's machine at the time. However he perceived great similarity in the designs of both Dunlop and Monck Mason. He thought that Dunlop's design contained elements of 'safety and success' that were not possessed by earlier balloons. Dunlop's work appeared slightly advanced compared with that of Monck Mason, in Saunders' view, although both still had the usual problems with aerial navigation. Summarised as 'the great problem of perfect guidance', they are always at the mercy of the atmosphere. In that respect, Saunders considered Monck Mason's employment of Archimedean screws superior to Dunlop's vanes. Those vanes could be more accurately described as flat, windmill-like propellers. Saunders did note that aeronauts had some advantage over their seagoing brothers, in that they may find air currents flowing in slightly different directions and speeds at different altitudes. So, by adjusting the balloon's height above ground, the aerial navigator 'can generally choose one of two or three currents, and having the power to rise or fall, he may enter into one which may suit him best.' Saunders did regret that Dunlop had kept his idea under wraps for some time, and promised to forward the plan to London. He did not state to whom the plan would be sent. He was keen to let London know of the work and that 'Australians must look sharp to vindicate the priority of the colonial inventor, and secure some of the honour to themselves' (Saunders 1844b).

Henson's steam carriage was not well received by Saunders. He apparently identified deficiencies with the area (presumably the wing area), arrangement (or layout of the craft) and the means of control and propulsion. Another of Saunders' comments is noteworthy regarding the design of propellers : '... experiments lately made, the velocity obtained by descending an inclined plain (sic) was diminished rather than sustained by the propellers. As this maintenance of velocity is a main feature to the plan, and it has failed, the whole may be considered an abortion.' It appears that those propellers were providing drag, rather than thrust. Sufficient power must be applied to turn a propeller before it can produce thrust. Otherwise, it merely 'windmills' and produces drag, as evidenced by Saunders. It is also unclear at this distance, to whom Saunders was referring, when noting the recent experiments. Saunders ended positively, even though he had dismissed Henson's craft, the publication of Henson's work had re-kindled the idea of aerial navigation and 'he has given exercise to many ingenious minds, and led to an examination and discussion of principles which may terminate in a good result.' (Saunders 1844b) The main thrust was for success, not for an individual, but rather for humanity.

Saunders concluded his lecture 'until some power was invented, which would give greater speed to the rotary fans, than any plan at present devised, he did not think we should be able to travel the regions of the air.' An aside by the reporting journalist suggested the use of springs and 'the endless screw (Archimedean) such as that applied in the large musical boxes' (Saunders 1844b).

Many people appeared to believe that mechanical, heavier-than-air flight was achievable. By the same token, steam power was generally considered as an unsuitable source of power for aerial navigation. The publication of details about Henson's Ariel certainly formed the basis for serious thought on aerial navigation. Here at last was something that promised more than just a simple balloon flight.

A statement appeared earlier on the subject of the proposed scientific use of balloons. (Australian 1843a) 'Once let it be demonstrated that balloons are not more dangerous than railways and steam-boats, and we shall have a few words to say on the use of which they may prove to science, in relation to an examination of the different strata of the atmosphere.' To arrive at such a situation, serious scientific input to aerial navigation would be required. The most appropriate means for the dissemination of such knowledge were those various learned societies, which eventually began in the colonies.

LEARNED SOCIETIES

Several people made presentations to learned Societies, on their thoughts for aerial navigation, some of which will be mentioned briefly. Dr William Bland addressed the Royal Society of New South Wales on 8$^{\text{th}}$ June, 1859 with a lecture 'On Atmotic Navigation', although it appears that no transcript has survived (Bland). This appears to have been the first lecture on aerial navigation, presented to such a Society in Australia. Bland's *Atmotic Ship* was at first designed with a spherical balloon, but after his initial application for patent, the craft was depicted with the more familiar, cigar shaped envelope.

Michael Costello addressed the Royal Society of Victoria on 29$^{\text{th}}$ September, 1862 with his proposal for a steering apparatus for balloons. He apparently displayed a model of the apparatus at the meeting, but no more details appear to have survived (Costello).

Alexander Adams invented an ornithopter, the details of which were sent to Lawrence Hargrave by George H. Knibbs of the Royal Society of NSW on 24$^{\text{th}}$ September, 1896 (Adams). His ornithopter was to be powered by a hydraulic motor, but it failed to impress Hargrave. Adams sought a partner in this venture and asked if Hargrave was interested, but received a polite refusal. George Hardacre of Coffs Harbour also patented a similar machine in 1897. His craft featured flapping wings, which incorporated hinged valves to reduce drag on the upstroke and increased drag on the down going stroke (Hargrave). He built and flew a man-powered version, while tethered between two trees.

Lawrence Hargrave provided 23 lectures to the Royal Society of New South Wales from 1884 to 1909, 19 of which were on his experimental work in aeronautics (Shaw).

The philosophical Institute of Victoria reported some of the earliest serious investigations into the Australian atmosphere. A. C. Gregory read his report on barometrical observations on 30$^{\text{th}}$ March, 1859 (Gregory).

Across the Tasman Sea, several researchers were publishing their thoughts and one of those was Captain Frederick Wollaston Hutton, 'Sailing Flight of the Albatross' (Hutton). His work was purely ornithological, and not intended to further the idea of human flight. Hutton was a Fellow of the Royal Society, Fellow of the Geographic Society and an Honorary Member of the Royal Society of New South Wales, from which he was awarded the Clarke Memorial Medal in 1891 (RSNSW 1890).

Professor William Charles Kernot, who was Dean of Engineering, Melbourne University, undertook investigations of the atmospheric effects on engineering structures. One of his papers to the Australasian Association for the Advancement of Science, in 1889 was titled 'Notes on the Barometric Measurement of Heights' (Kernot 1889). Maybe not quite aerial navigation, but he followed up in 1892 with an article on 'Wind Pressure' (Kernot 1892), which described some of the difficulties encountered by engineers in those days. Notice was being taken for civil engineering structures, such as railway vehicles, bridges and buildings exposed to the forces of winds. Also, it was quite apparent that the science of designing structures to accommodate such forces required much investigation. Quoting from Kernot's 1892 paper, 'Not many years ago a bridge over the Yarra, in Melbourne, occupying a very sheltered position, was condemned as liable to be overturned by the wind, and altered at great cost, although it would have taken 4.3 kilopascals to move it according to the correct calculation, and 2.7 kPa according to the engineer that reported upon it, while chimneys and railway vehicles that would overturn with not more than 1.4 kPa were continually to be found in positions infinitely more exposed.' Kernot continued with descriptions of the various methods of calculating aerodynamic forces and the experiments he conducted.

Kernot constructed what was probably the first wind tunnel in an Australian university, possibly the first anywhere in Australia. A description of the tunnel was provided in his article on wind pressure (Kernot 1892). It incorporated a wooden, four bladed, screw propeller, of 0.7 m diameter and contoured with a pitch of 1 m. The tunnel itself was a tube 0.76 m diameter by 0.91 m long. The wind tunnel initially did not provide a 'uniform blast' of air, but rather produced 'a cylindrical shell about 0.15 m thick of helically moving air surrounding a central core of dead or motionless air'. He added some form of straightening vanes and funnel, which provided a jet 'of air of fairly uniform direction and velocity' about 0.3 m by 0.25 m cross section. A small flag was used to verify air direction and Revy’s current meter measured the velocity.

NOTICE OF SUCCESS

In the United States, the Wright Brothers also employed a true scientific attitude to the study of aerial navigation. Success came finally to Wilbur and Orville Wright on December 17, 1903 at Kill Devil Hills. How did Australians learn of this triumph? That knowledge was provided through the medium of the newspaper, of course. The great French-born American, Octave Chanute sent news of the success to Lawrence Hargrave, together with American news reports, and the necessary corrections. Hargrave then wrote to the Daily Telegraph and provided an interview to the journalist so assigned. An article was soon published, which described the American success as well as Hargrave’s latest aircraft work. It appeared exactly two months after the Wrights’ success, printed on page nine of the Sydney newspaper (Daily Telegraph 1904)! Aviation was still not page one material.

Newspapers provided the means for communicating ideas for aerial machines from England, initially, and subsequently from local inventors. Many good ideas were thus published, but none came to fruition. Mechanics’ Institutes provided technical education for many in the community, who were then better equipped to put their ideas forward. Learned societies provided the next level of communication, publishing ideas and experimental reports across the globe.

Wilbur and Orville Wright built their experiments on the published works of earlier researchers. They corresponded with a number of those researchers, but kept secret, their understanding of aerodynamic control under the protection of a patent.

CONCLUSION

In summary, several of the early Australian pioneers provided word pictures of aerial machines. Some others provided drawings and models of their ideas. They all failed, but their ideas lived on through the works of others – possibly because they did not hide their ideas away. Lawrence Hargrave published his ideas widely, through the Journals of the Royal Society of New South Wales and the Aeronautical Society of Great Britain. He was a prolific letter writer, who urged others to experiment with his ideas and wished them every success. As he stated in correspondence with Octave Chanute, ‘excellence of design and workmanship will always defy competition’ (Chanute p. 218). Some of his ideas took root, such as the box kite, which appeared in the lineage of Chanute’s hang glider. That hang glider subsequently became the structural model for the Wright kite of 1899. That kite proved the success of wing warping, which was the key to Orville’s powered, sustained and controlled flight at Kill Devil Hills on 17$^{\text{th}}$ December, 1903.

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Thermal Induction, Salt Treatment and the associated Plumule/Radicle Growth Response of Sorghum at 42/19°C

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Abstract: This investigation tested the influence of thermal induction of seeds at various stages of imbibition prior to exposure to heat shock on the germinative and growth response of those seeds and seedlings. Seeds of sorghum (*Sorghum bicolor* L. Moench) were treated in 2, 4 or 6 g NaCl/L solutions and exposed for 2 hours to 45°C during the first, second or third days of imbibition (thermal induction). Thereafter, seeds were dried and germinated at 42/19°C (day/night temperature). Salt treatments did not improve the final germination percentage but increased germination speed over untreated seeds. The higher the salt concentration used, the greater the dry weights of plumules (shoots) and radicles (roots). Thermal induction on the third day of imbibition yielded higher germination percentages than un-induced seeds, while induction on the second day gave faster germination. Both the second and third day induction treatments gave superior germination indices and higher plumule to radicle ratios. It is concluded that thermal induction may assist in acclimating seeds to heat stress.

Keywords: Thermal induction, stress, germination, growth

INTRODUCTION

Seed germination is usually the most critical factor determining the success or failure of stand establishment. Recent interest in presowing seed treatments for improving field emergence under stress has generated considerable advances. Priming with sodium chloride has been used in sorghum and shown to advance germination under drought but not under heat stress (Kader and Jutzi 2001, Kader 2002a). The principle of inducing seeds or whole plants to stress is also well documented (Amzallag et al. 1990) and has likewise been applied to NaCl treatments in sorghum (Kader 2001). Therefore, the possibility of inducing seeds to heat stress by pre-exposure to high temperatures seems to be feasible. In this connection, it would be interesting to investigate the effects of high temperatures during seed soaking on responses to post-treatment heat stress. The objective of this investigation was to test the influence of thermal induction by way of pre-stress acclimative heat exposure and its timing on germination of sorghum variety SPV 462 under heat stress.

MATERIALS AND METHODS

Salt-based seed priming treatments were applied to SPV 462 seeds stored prior to treatment at 5°C and 50% relative humidity for 2 months. Seed lots were obtained from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and had moisture content of

11%, viability (tetrazolium) of 97.3% and germinability of 98.1%. Seed treatments included soaking in 2, 4 or 6 g NaCl/L solutions for 3 days (d) in the dark. These solutions had osmotic potentials of -65, -135 and -180 mOsmol kg^{-1}, respectively, corresponding to -1.5, -3.2 and -4.3 bar, respectively. Electrical conductivity (EC) values for these solutions were 3.8, 7.3 and 9.3 mS cm^{-1}, respectively. A water-soaked control was also tested based on previous work (Kader and Jutzi 2001, Kader 2002a, Kader 2002b).

Thermal induction treatments were conducted on the 1st, 2nd or 3rd day of imbibition by exposing seeds in solutions to a temperature of 45°C for 3 hours (h) and to 13°C for the remainder of the soaking period. After treatment, seeds were surface dried at 25°C for 3 h and plated for germination in polystyrene trays at a rate of 100 seeds/tray. A concomitant day/night temperature of 42/19°C (12 h/12 h) was used in germination cabinets under dark conditions and filter paper moistened with distilled water. Trays were replicated five times and observations of seed germination made on 24-h intervals for 10 d. After 10 d, seedling plumules (shoots) and radicles (roots) were excised for 10 seeds/tray from the 5 middle creases of the filter paper, dried in an air-forced cabinet at 80°C for 3 d and averaged. This yielded the dry weight of plumule (DWP) and dry weight of radicle (DWR). By dividing the DWP by the DWR the plumule: radicle ratio (PRR) was obtained. From daily germination scores, the final germination percentage (FGP), mean germination time (MGT) [MGT = $\sum fx/f$ where f is the number of seeds germinated on day x] (Orchard 1977) and germination index (GI) [GI = $(10 \times n1) + (9 \times n2) + \cdots + (1 \times n10)$ where n1, n2 ... n10 = no. of germinated seeds on the 1st, 2nd and subsequent days until the 10th day; 10, 9 ... and 1 are weights given to the number of germinated seeds on the 1st, 2nd and subsequent days, respectively] (Benech Arnold et al. 1991) were calculated. Analysis of variance (ANOVA) was used to test for salt treatment and thermal induction effects as well as their interaction on arcsine transformed germination percentages. Duncan's Multiple Range Test was used for mean separation. Significance was evaluated at $p \leq 0.05$ using the Statistical Analysis System (SAS ®).

RESULTS AND DISCUSSION

The main effects, i.e. NaCl concentration and treatment timing, and their interactions were significant in their impact on germination and seedling characteristics of sorghum. The results of germination counts following treatment of seeds showed that a 2 g NaCl/L treatment gave the same FGP as the control, but higher percentages than the 4 or 6 g treatments (Table 1).

Enhanced germination rates, as reflected by lower MGT values, revealed a faster germination pattern in all three NaCl treatments when compared to the control. This was accompanied by high GI means in the case of a 2 g NaCl/L treatment as seen from Table 1. The highest DWP and DWR values were observed in 6 g NaCl/L-treated seeds, but untreated seeds appear to have allocated more growth activity to the plumule than to the radicle since they attained the highest PRR ratios (Table 1).

Germination and seedling characteristics as affected by thermal induction are presented in Table 2. Whereas the FGP was not influenced by thermal induction, MGT exhibited progressive decreases when seeds were induced on the 2nd or 3rd days of imbibition. When data in Table 2 are examined, it becomes apparent that the 2nd and 3rd day treatments advanced not only germination speed (lower MGT and higher GI values), but also gave the highest PRR ratios.

Agreement between pooled effects (Tables 1 and 2) and interactive effects of seed treatments and thermal induction, which are shown in Figures 1 and 2, was evident. The FGP was not affected by seed treatment or thermal induction, but germination speed was enhanced by NaCl soaks (Figs 1a–1c). Days 2 and 3 were the best periods to induce seeds during imbibition.

Seed Treatment (g NaCl/L)	FGP (%)	MGT (day)	GI	DWP (mg)	DWR (mg)	PRR
0 (Control)	88.6 ab	3.0 a	699.9 b	4.8 b	1.3 c	3.6 a
2	89.7 a	2.5 b	760.5 a	4.3 c	1.5 b	2.7 c
4	86.1 c	2.5 b	730.2 ab	4.5 bc	1.5 b	3.0 bc
6	86.9 bc	2.5 b	729.3 ab	5.9 a	1.9 a	3.1 b

Table 1. Effect of NaCl-based seed priming treatments on germination and seedling characteristics of sorghum SPV 462 seeds.
Means in columns followed by similar letters are not significantly different according to Duncan's Multiple Range Test ($p \leq 0.05$). FGP: Final Germination Percentage, MGT: Mean Germination Time, GI: Germination Index, DWP: Dry Weight of Plumule, DWR: Dry Weight of Radicle and PRR: Plumule: Radicle Ratio.

Acclimation Time (Days after Imbibition)	FGP (%)	MGT (day)	GI	DWP (mg)	DWR (mg)	PRR
No Acclimation	86.7 a	2.9 a	689.2 b	4.5 b	1.6 b	3.0 b
Day 1	87.9 a	2.7 ab	720.7 b	5.0 a	1.8 a	2.8 b
Day 2	87.4 a	2.3 c	755.0 a	4.8 ab	1.4 b	3.3 a
Day 3	89.4 a	2.5 bc	755.0 a	5.2 a	1.5 b	3.4 a

Table 2. Effect of pre-stress heat acclimation treatments on germination and seedling characteristics of sorghum SPV 462 seeds on exposure to post-treatment heat stress.
Means in columns followed by similar letters are not significantly different according to Duncan's Multiple Range Test ($p \leq 0.05$). FGP: Final Germination Percentage, MGT: Mean Germination Time, GI: Germination Index, DWP: Dry Weight of Plumule, DWR: Dry Weight of Radicle and PRR: Plumule: Radicle Ratio.

As seen from Figure 2a, the highest DWP values were obtained in the 6 g NaCl/L treatment with acclimation on the 1st day of imbibition being superior to other timings at this NaCl level. The highest DWR was observed in the 6 g NaCl/L treatment, when seeds were acclimated on the 1st day (Fig. 2b). Control seeds which were not acclimated yielded the highest PRR (Fig. 2c).

Observation of seed and seedling characteristics confirmed that germination speed was improved and that a 6 g NaCl/L treatment increased both the DWP and DWR whereas control seeds had a higher PRR. Such a PRR value would indicate a tendency, on the seed's part, to shift growth activity to the shoot rather than the root. Speculations on the larger axis (heavier plumules and radicles) in 6 g NaCl-treated seeds can be deduced from reports of earlier differentiation in secondary xylem in seedlings exposed to NaCl conditions for both root and shoot (Valenti et al. 1992). Additionally, osmotic adjustment of plumules and radicles in NaCl-treated seeds may have contributed to this increase in weight due to the accumulation of Na^+ and Cl^- ions (Nabil and Coudret 1995). This, however, is in disagreement with the data of Roundy et al. (1985) who reported that sodium, chloride, sulphate and calcium ions interfered with germination and growth processes resulting in lower radicle growth. We tend to favour the assumption that the accumulation of ions in the seed during the 3 d soaking treatment led to the subsequent translocation of Na^+ and Cl^- to the newly growing parts in the plumule and radicle leading to osmotic adjustment (Kader and Jutzi 2002, Kader et al. unpublished data). This adjustment would render the axis capable of taking up more water from the surrounding medium, thus providing both plumules and radicles of treated seeds with an advantage over untreated counterparts.

While advancement in the speed of germination was obtained by thermally inducing seeds on the 2nd and 3rd days of imbibition, the FGP is postulated to be less "improvable" by acclimation than the MGT. However, the positive effects of thermal induction may not be ruled out since 2nd and 3rd day-treated seeds germinated faster and gave a higher PRR. We take this as evidence that the ratio between shoot and root is governed by the environmental conditions surrounding the seed. We speculate that stress tends to lead to larger radicles resulting in a lower PRR. This stress may take the form of limited moisture, high temperature or osmotic pressure, but in all three cases the reaction on part of the plant would be to enhance root growth in the search for moisture at lower soil profiles. This is reinforced by the fact that untreated seeds had a higher PRR than 6 g NaCl-treated seeds. This may suggest that untreated seeds, because not exposed to "stress" caused by NaCl treatment, "sensed" that no stress existed and thus focused on plumule elongation to emerge and make use of this "non-stress opportunity" (Kader and Jutzi 1998a). Seeds treated with salt, on the other hand, responded by increasing radicle elongation leading, in turn, to a lower PRR.

If the same were true for heat, it would mean that seeds acclimated to heat stress by pre-exposure to 45°C on the 2nd or 3rd day of imbibition did not "sense" stress when they were transferred to a 12-hours-a-day regime of 42°C. They would have been acclimated to such a temperature range through hormonal signals (Kader 2001) and thus the need for producing larger radicles would diminish, leading to a higher PRR. Such gradual acclimation of seeds to high temperatures has been reported in cowpea by El-kholy et al. (1997). Gong et al. (1997), working on maize, also presented evidence that plants have the capacity to acquire thermotolerance when they are prehardened at an elevated but nonlethal temperature. It can be argued that the function of such a treatment would be to activate so-called "Heat-Shock Proteins (HSPs)" (Kader and Jutzi 1997, Kader and Jutzi 1998b, Kader 2001). In studies with soybean, Jinn et al. (1997) found that in seedlings treated with 40°C for 2 h, low molecular weight HSPs were found in aggregated granular structures distributed in the cytoplasm and nucleus. These may assist in the resolubilization of proteins denaturated or aggregated by heat and may also participate in the restoration of organular functions after heat shock.

Abernethy et al. (1989) found that during the initial 9–12 h of imbibition, imbibing wheat cv. Lancer and Guard seed exhibited substantial tolerance to high temperature. This initial tolerance gradually declined with increasing time of seed imbibition. This timing of tolerance is shifted well into the later phases of germination in pearl millet (Carberry and Campbell 1989). The most responsive time to acclimate seeds was observed on the 2nd and 3rd days after soaking. We assume that the seed's inner mechanisms are responsive to external heat impulses during this period or else acclimation at this time would not have advanced subsequent germination (Kader 2001).

During the 1st day of soaking a seed is being forced out of its former dry, quiescent state into a metabolically and physiologically active one (Gong et al. 1997). During this imbibition phase it would not be reasonable to expect response from the seed because it is still in the process of fulfilling the threshold level of moisture needed to initiate this active form (Kader and Jutzi 2002). By the 2nd and 3rd days of soaking the seed is active enough to respond to external factors. From a practical standpoint, despite reports of air temperatures reaching 44.9°C in sorghum growing areas (Maiti 1996), soil temperatures within the vicinity of the seedbed would not stay at these levels for long, and such extreme cases are the exception rather than the rule (Kader 2002c). Finally, reflections from controlled-environment studies such as this are a potentially useful tool in screening for variation in response to temperature (Carauford et al. 1996), but field validation of results obtained is required to advance the application of recommendations.

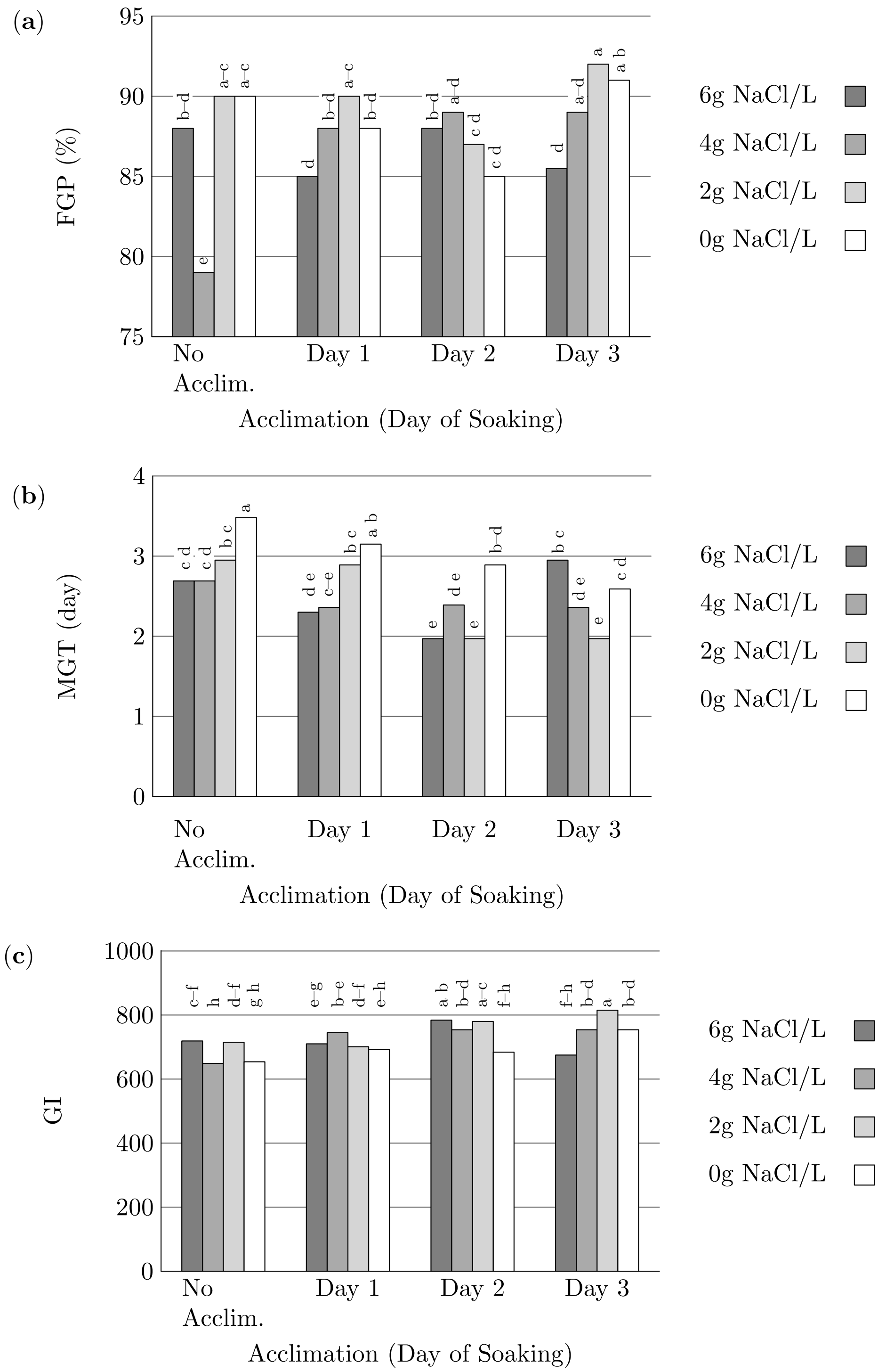

Figure 1. Interactive effects of NaCl-based seed priming treatment and heat induction on (a) the final germination percentage (FGP), (b) mean germination time (MGT) and (c) germination index (GI) of sorghum SPV 462 seeds. Bars having similar letters represent means that are not significantly different according to Duncan's Multiple Range Test (p $\leq$ 0.05).

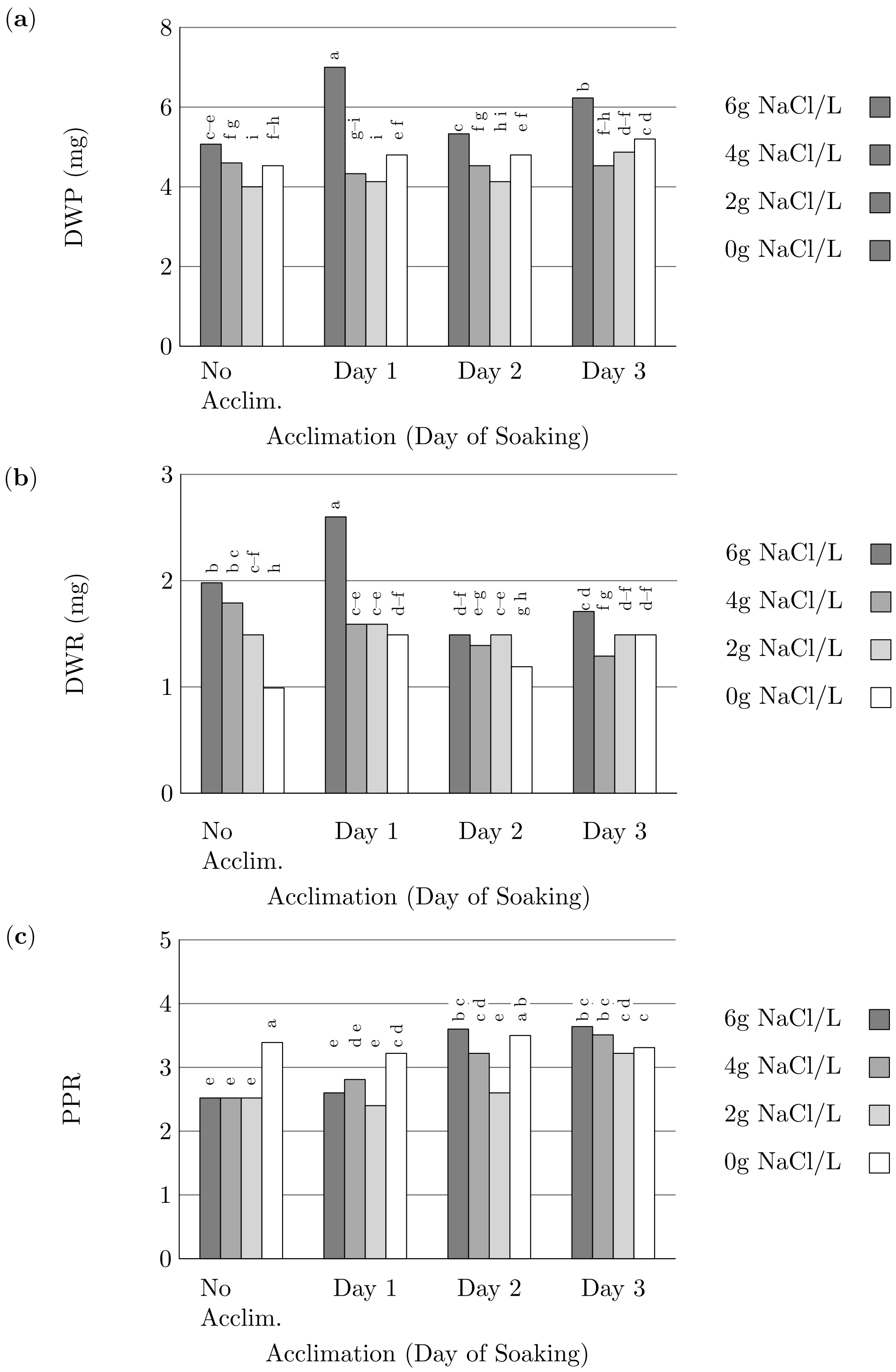

Figure 2. Interactive effects of NaCl-based seed priming treatment and heat induction on (a) the dry weight of plumule (DWP), (b) dry weight of radicle (DWR) and (c) plumule:radicle ratio (PRR). Bars having similar letters represent means that are not significantly different according to Duncan's Multiple Range Test (p $\leq$ 0.05).

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'The Celluloid Strip' — Mass Screening for Tuberculosis in New South Wales, 1950–1975

DR PETER J. TYLER

Abstract: Tuberculosis was a significant cause of mortality at the beginning of the Second World War when the technique of taking miniature X-ray photographs on movie film was introduced to Australia as part of the medical examination of men enlisting in the armed forces. Immediately after the war, the Anti-Tuberculosis Association of NSW expanded its existing diagnostic clinic in Sydney to provide a mobile X-ray service to country areas and industry. That experience provided a model for the subsequent national campaign which the Commonwealth Government funded to detect and treat the disease.

Coincidentally, at the same time as the compulsory national screening program commenced, the first effective therapy for the disease became available. Antibiotic drugs soon achieved results that long periods of rest in a sanatorium had never accomplished. Government funding was withdrawn after the incidence of tuberculosis diminished, so that by 1975 the ubiquitous X-ray caravans began to disappear from street corners around Australia. This paper describes the logistics of the mass screening campaign during the third quarter of the twentieth century, and the technological developments that made it possible.

Keywords: tuberculosis, camera, radiography, screening, X-ray, Anti-Tuberculosis Association

The White Death, consumption, phthisis, TB – by whatever euphemism it was known, tuberculosis was one of the most feared human diseases for at least three millennia. Despite the romantic deaths of operatic heroines like Mimi and Violetta, the reality for most people was more stark. Lassitude and nighttime sweating were early symptoms of pulmonary tuberculosis, followed by a chronic cough, loss of weight and a pallid complexion as the disease progressed, until the terminal stage when the victim was spitting blood. If the patient was the male breadwinner, most families then faced destitution.

When the German bacteriologist Robert Koch devised a technique to visualise the *Mycobacterium tuberculosis* bacillus in 1882, medical practitioners realised that the disease had a microbiological origin, and was not a hereditary affliction or punishment for a dissolute lifestyle as previously believed. Understanding the aetiology was one thing; developing effective therapy that could overcome these germs was another matter.

In the late nineteenth century, the favoured treatment was bed rest, fresh air and a diet rich in saturated fats, preferably taken at a sanatorium in a fashionable resort on a 'Magic Mountain' in the Swiss Alps. For most people this was out of the question. In Australia, from the 1870s there were small private or charitable sanatoria that catered for a handful of patients, but most sufferers stayed at home infecting the other family members who shared their bed or eating utensils. If a patient was too ill to be cared for at home, or had no family, he or she went to one of the State Asylums to die, surrounded by the demented and insane.

It was 1911 before the NSW Government opened the large Waterfall Sanatorium for Consumptives, and by this time there were smaller establishments run by the Red Cross Society and the Queen Victoria Homes on the Blue Mountains and in the Picton area. Sanatoria were some help in preventing the spread of infection, but few of the patients recovered their health.

Various other treatments were tried. Koch himself developed *Tuberculin*, which was popular for a period, and seemed to improve the condition of certain patients. Less reputable practitioners advocated their own miracle cures, such as Spahlinger’s Serum and the expensive, but ineffective gold extract *Sanocrysin*. ‘Artificial sunlight’ enjoyed a vogue in the United Kingdom, but Australia seemed to have enough of the natural variety. Throughout this period, the incidence of tuberculosis in the community was actually declining, which gave physicians an unwarranted sense of optimism about the treatments they were advocating. Nevertheless, in 1910 tuberculosis remained, after heart disease, the most common cause of death in New South Wales.

In 1895, Wilhelm Röntgen discovered the remarkable powers of certain electromagnetic emissions to penetrate the human body, and to visualise the internal organs on a fluorescent screen. By the end of the first decade in the twentieth, primitive X-ray machines were installed in the main Sydney teaching hospitals for orthopaedic procedures such as reducing dislocations or fractured bones. Some physicians also recognised the potential of the technique for revealing abnormal pathology in the lungs, particularly tuberculosis, but their more conservative colleagues were sceptical, claiming that their own experience enabled them to identify tuberculosis sufferers by physical examination and auscultation of the chest through a stethoscope. Pathology tests did become routine, however, with sputum specimens subjected to microscopic examination to determine whether the tuberculosis bacillus was present.

In New South Wales, the first X-ray equipment dedicated to the diagnosis and assessment of tuberculosis was installed at Waterfall Sanatorium in 1929, to be followed shortly afterwards in 1930 by the Anti-Tuberculosis Association of NSW at its chest clinic at Albion Street in Surry Hills. Their Kelly-Koet apparatus was a Heath Robinson contraption by modern standards, and of relatively low efficiency, although at the time it was described as ‘one of the most delicate instruments of its kind in existence’. The radiologist could examine the patient directly through a fluorescent screen placed in front of the chest, or a large piece of specially-coated photographic film would be exposed in a light-tight magazine, to give a life-size image that could be processed and examined later.

The Anti-Tuberculosis Association of New South Wales, later known as Community Health and Tuberculosis Australia, had been founded by a group of influential concerned citizens in 1911 to grapple with the misery caused by tuberculosis amongst the impoverished residents of Sydney who could not afford private treatment. Many of the Association’s practices became a model for other voluntary organisations and government agencies throughout Australia. This paper refers mainly to the New South Wales experience because that can be regarded as a microcosm of the later national campaign.

Early X-rays were a great help in confirming a diagnosis of tuberculosis, but it was a slow, inflexible and relatively expensive procedure. With only a handful of machines available, the technique could be used only with high-risk groups. To illustrate this point, the Anti-Tuberculosis Association recorded only 351 X-rays in its first year of providing this service in one of the poorest parts of Sydney, where there was a high incidence of tuberculosis. It was 1937 before more than one thousand X-rays were taken in a single year. By 1941 this had risen to almost three and a half thousand, with 172 confirmed cases of tuberculosis detected, a rate of one in twenty, which was a rather disturbing result that was never equalled in the later mass surveys.

The obvious limitations of the early technique stimulated researchers to look for a simpler, cheaper solution. In 1936, Dr Manuel de Abreu in Rio de Janeiro began the first mass survey experiments with a camera using 35 mm cinema film. He mounted the camera in an enclosure behind the fluorescent screen so that he could photograph the image, using a wide-angle lens and the faster film emulsions that were becoming available. After reading about these experiments, Dr Harry Wunderly improvised some equipment along the same lines in his Adelaide consulting rooms in 1939. A standard Leica camera was fixed to a cardboard tunnel with adhesive tape. Because the level of this home-made device could not be adjusted, it is said that Wunderly kept a pile of old medical books nearby so patients of different sizes could stand at the correct height for the screen. Some practitioners were sceptical that such a small image (36 mm x 24 mm) would be useful, compared with the image on the conventional 17 inch by 14 inch (430 mm x 360 mm) sheet film. However, by viewing the 35 mm negative through a suitable magnifying viewer, experienced radiologists found that they could detect major abnormalities almost as easily as with the larger film.

New approaches to treatment were also being introduced. The most common intervention was known as artificial pneumothorax, where an incision was made in the chest wall to collapse a diseased lung. To maintain the collapse, nitrogen or compressed air was introduced into the pleural cavity. The theory behind this procedure was that a collapsed lung, being relieved of its breathing function, was given a chance to rest and recuperate. Patients could still live reasonably normally on the remaining active lung, but had to return to a clinic every six or eight weeks to have a 'refill' of the gas, a simple outpatient procedure.

When the Second World War erupted, the Australian military authorities decided that it was necessary to screen all recruits for tuberculosis before enlistment into the armed services. This was intended not only to weed out those who were unfit for active service, but also to prevent transmission of the disease to healthy personnel. Dr Wunderly and others continued their experiments to convince the medical establishment that miniature radiography on 35 mm film was a viable technique. Within two months, over 20,000 men had been examined in this way, and 109 cases of active tuberculosis detected – one in every 183 recruits. Manufacturers soon modified their equipment so that a Leica or Contax miniature camera could be fitted, in addition to the conventional large-film magazine. This paved the way for many images to be made in quick succession on continuous film – 'the celluloid strip' referred to in the title of this paper. This experience prompted the Anti-Tuberculosis Association of NSW to acquire similar miniature equipment for screening the civilian population.

One problem encountered with using standard 35 mm cameras was that the film had to be wound forward manually after each exposure. During a busy period, this could result in inadvertent double exposures, or accidentally winding on more than one frame. Sometimes the film was finished before the operator realised this. If the frame numbers got out of sequence with the patient record cards, the wrong person would be recalled for further examination. Furthermore, it was easy for the camera focus to shift during film winding, so that all subsequent images were indecipherable.

By 1942 the Anti-Tuberculosis Association was in a position to conduct its first mass industrial survey, when all 830 members of the staff of Philips Electrical Industries came to the Albion Street Chest Clinic for X-ray. Following the example of Philips, other factories, shops and government departments began clamouring to be screened for tuberculosis. These surveys were paid for by the firm taking part. Philips had a vested interest in this project because they supplied the equipment, but as the war progressed, it became impossible to source further supplies from Europe. To meet the growing demand, in 1944 the Association ordered additional 35 mm X-ray camera equipment from the Fairchild Corporation in the USA.

This duly arrived, but encountered a couple of unexpected hitches. Firstly, there was a waterfront strike in Sydney Harbour, and the wharf labourers refused to unload the crates. This difficulty was overcome through some deft negotiation, when members of the Waterside Workers' Federation were promised the first screening survey using the new apparatus. Then, to the dismay of the Association, when the crates were unpacked it was found that the equipment consisted of modified aerial photography cameras using 70 mm film, instead of the 35 mm size ordered. None of the existing processing or viewing equipment could use the wider film, but wartime exigencies meant that returning the equipment and replacing it with the correct gear was likely to be a lengthy and uncertain process.

So the Anti-Tuberculosis Association decided to persevere with 70 mm film, and adapted its other equipment to suit. This size then became the de facto standard for all future mass X-ray screening in Australia, as a result of a simple clerical error in an American factory. One advantage was that, being twice the width of the 35 mm film, the image provided better resolution, and made the radiologists' task easier. After the war, when Philips returned to the market they tried to promote a new film size – 40 mm, but in Australia at least they were unsuccessful. Later, 100 mm film was introduced for fixed, stationary installations, as an economical alternative to 17 by 14 inch sheet film.

Following the end of the Second World War, Australia enjoyed an unprecedented period of prosperity and confidence, with a buoyant economy based on worldwide demand for primary products like wheat and wool. Having emerged victorious from the conflict, there was a widespread feeling that no goal was impossible to achieve. Some of the people at the Anti-Tuberculosis Association began to dream of an 'X-ray plant on wheels' that could provide a tuberculosis diagnostic service in major rural or urban centres, as well as the existing facility at the Chest Clinic in Surry Hills. Fundraising appeals organised by community groups in the Southern Tablelands yielded sufficient funds to translate that dream into reality. A standard Sydney single-deck bus was acquired, and fitted-out to the Association's specifications, with space for a physician's consulting room, a photographic darkroom, and storage for the delicate X-ray equipment in transit. On arrival at the selected location, the X-ray apparatus had to be removed from the bus, assembled indoors and connected to the electricity supply.

The first visit by the new mobile unit was to Goulburn in 1947, where over five thousand examinations were made. Participation was voluntary, with a fee of five shillings (fifty cents) charged to individuals, or ten shillings (one dollar) for a family group. Patients were required to partially undress, stripping to the waist – not an inviting prospect in a draughty country shire hall in mid-winter. Because of this, separate sessions for men and women were held each day. Films were processed on the spot and interpreted by the medical officer who accompanied the mobile unit.

In that euphoric spirit of postwar reconstruction, one of the rare amendments to the Australian Constitution was achieved in 1946, when the Commonwealth gained the power to legislate for the provision of medical services. Dr H. (later to become Sir Harry) Wunderly was appointed Commonwealth Director of Tuberculosis to deal with the apparently intractable problem of reducing the damaging effects of tuberculosis on society. Dr Wunderly himself had been a tuberculosis sufferer who had spent some time in sanatoria, both in Switzerland and Australia. His first task as Director was to investigate existing provisions. Overall, they were poor – ranging from fairly good in Tasmania, to being almost nonexistent in Queensland, and not much better in New South Wales. Wunderly estimated that there was a shortage of 3,200 hospital beds for tuberculosis throughout Australia, at a time when the total population was just over seven million.

Coincidentally, the long-awaited therapeutic breakthrough was occurring at the same time, with the release of two new 'wonder drugs' that seemed to promise a cure for tuberculosis. One was the antibiotic *streptomycin*, developed by Selman Waksman and his team of soil microbiologists in the USA. The other was *para-aminosalicylic acid* (PAS), prepared through chemical manipulation of the aspirin molecule by Jorgen Lehmann in Sweden. Although initial results for both therapies were very encouraging, it soon emerged that in some patients there were serious side effects, or more disturbingly, a relapse of the disease. It was apparent that the bacillus developed a resistance to these drugs unless they were used in combination. Even then, about twenty per cent of patients were not cured.

Isoniazid was synthesised in 1952 almost simultaneously in both Europe and America. This was more effective, had few side effects, and was cheap to produce. Once again, however, the tuberculosis bacillus learnt to deal with the new drug, so chemotherapy took the form of a cocktail of all three drugs. During the 1960s a number of new preparations were developed, replacing both streptomycin and PAS, so that modern triple therapy usually consists of these newer drugs.

Thoracic surgeons were also becoming more adventurous in applying their wartime battlefield experience, and were removing diseased portions of lung, or even whole lungs, in selected patients. In other patients, a lung was collapsed by removing several ribs. These techniques stopped the spread of the disease, but could leave the patient disfigured or disabled. As the effectiveness of chemotherapy became evident, such radical surgery became unnecessary, so that the practitioners began to transfer their skills to the emerging discipline of cardio-thoracic surgery.

As Director of Tuberculosis, Dr Wunderly recommended measures for a concerted national campaign to control the disease. The concept of a common strategy had been agreed upon as early as 1911, but the First World War intervened before any action was taken. Then, in 1925, a Royal Commission on Health recommended that the States work together to deal with tuberculosis, but this time the proposals were thwarted by the Great Depression. So the Wunderly Report of 1947 in some ways was a repetition of what the experts had been saying for nearly forty years, except that this time the Government listened, and voted funds to begin a national campaign, whose aim in Prime Minister Ben Chifley's words was 'to reduce tuberculosis to a problem of minor importance within two decades'.

The essence of the Wunderly scheme was that the States should be financed to engage in a program of early detection through compulsory radiography of all adults. This would be supplemented by a massive expansion of treatment facilities, because existing hospitals had extensive waiting lists. Finally, and despite objections from Treasury, an adequate pension would be payable to tuberculous patients while they were infective, to ensure that they followed the prescribed therapy. These principles formed the basis for the Commonwealth *Tuberculosis Act* of 1948, and the subsequent Tuberculosis Agreements under which the Commonwealth Government met all additional capital and operational costs incurred in tuberculosis control by the States, on condition that the services were provided to the public without charge.

New South Wales initially was wary about becoming involved, but eventually signed the Agreement in November 1949. The Anti-Tuberculosis Association of NSW was also invited to participate in the program because of its long involvement with tuberculosis diagnosis, prevention and cure, becoming the only non-government organisation in Australia to be offered this privilege. The Association formally became a partner in April 1952, and twelve months later was ready to begin its intensive case-finding project. Six additional mobile X-ray units were acquired to supplement the two buses already in service, and extra staff were recruited and quickly trained to operate this equipment. At the same time, the Association's new purpose-built Clinic opened on the corner of Crown Street and Foveaux Street in Surry Hills, partially funded by the Commonwealth. This Clinic provided a comprehensive range of diagnostic and treatment services, including a twenty-bed hospital wing.

The new fleet of mobile units benefited from the experience gained in previous years, and the improved equipment then available. Compact 70 mm camera X-ray apparatus fitted comfortably into an eighteen-foot caravan that could be parked in front of a prominent public building such as a railway station or town hall. Patients could remain fully clothed, so there was no need to schedule separate sessions for women and men. Film cassettes were returned to the Association's headquarters in Crown Street for processing. There, each photographic frame would be examined separately by two specialist radiologists, and if there was disagreement about interpretation, a third opinion was sought.

Some of the earlier technical problems had been overcome. Special cameras with fast, short-focus lenses having minimal optical aberrations were available. Large capacity film magazines were fitted, holding up to 400 frames instead of the 36 on a standard 35 mm cassette. More importantly, motorised film advancing mechanisms were linked to the X-ray control panel so that synchronisation was maintained, and the X-ray could not be taken unless there was film in the gate for the next exposure. Later still, the patient record card was photographed on the same frame, to avoid misidentification. It was almost foolproof, but a careless operator could still put the wrong record card in the reader, or forget to take it out between patients. Furthermore, an acceptable result depended ultimately on the quality of the film processing. Careless handling or exhausted chemicals could degrade the image.

To cope with the enormous demand for chest X-rays generated by the mass screening campaign, the mobile units began working a twelve-hour day, 9.00 a.m. to 9.00 p.m. from Monday to Friday, and sometimes on Saturdays. The staff attached to each unit normally worked in two shifts of three people. They were multi-skilled, and rotated the radiography, clerical and reception duties every hour. An experienced team could easily X-ray 800 people a day – better than one a minute. A mobile unit might be touring country regions for up to three months, followed by a three-month stint in suburban areas. This was a lifestyle which did not suit everybody, although some of the young operators relished the opportunity to move away from the parental home in the less permissive era of the 1950s.

Many incidents and tribulations accompanied these efforts. Mobile units had to traverse rough country roads, cross flooded rivers, cope with heat, dust, and torrential downpours, yet still provide X-ray services in a remote town on the advertised dates. An advance party had previously visited the area to arrange a site for the van, electricity connections, and publicity. They also had to enlist teams of volunteers to help the survey proceed smoothly. Members of Red Cross, Country Women's Associations, Rotary Clubs and Boy Scouts were amongst the many recruits who assisted with clerical work.

Every person examined received a response from the Association within three weeks. For most people, this was merely a card to advise that no abnormality existed. If further investigation was needed, the person received a notice to attend the Association's Clinic or a major regional hospital for a larger X-ray and other tests to confirm the diagnosis. In later years, the service was improved by equipping a separate mobile unit for taking large X-rays, and this unit visited many of the smaller centres about three weeks after the initial screening, accompanied by a travelling medical officer who would follow-up doubtful cases.

With the rapid expansion of the service in 1953, it was clear that the Anti-Tuberculosis Association of NSW would never be able to mobilise sufficient resources to cover the whole population with regular surveys. The Division of Tuberculosis within the NSW Department of Health gradually developed its own facilities for community X-ray surveys, based closely on the Association's model. To rationalise the itinerary, the Association agreed to take responsibility for the northern and north-western areas of New South Wales, while the Department took care of the remainder. Similarly, municipalities in the Sydney metropolitan area were shared between the two agencies, with the State's population divided in the ratio of one-third to the Association, two-thirds to the Health Department.

The procedures and equipment that had been developed by the Anti-Tuberculosis Association of NSW also provided a model for the compulsory campaign in other States, where the service was conducted solely by the respective State Health Departments. For three months, NSW stationed some of its mobile units in Melbourne to provide a pilot scheme for the Victorians. Ultimately, there were about thirty chest X-ray caravans working throughout Australia. Surveys in Federal Territories such as the Northern Territory, A.C.T., Nauru and Christmas Island, were conducted by the Anti-Tuberculosis Association of NSW, under contract to the Commonwealth Government.

As the campaign continued, better equipment became available. The most notable improvement was the introduction of the 'Odelca' mirror camera. This was based on the principle of the Schmidt camera used in astronomy, where a spherical mirror is used instead of a lens system to form the optical image. Although this is a rather bulky device, it is much faster and gives better sharpness over the full field.

Although the Wunderly Report recommended that every person over the age of fourteen should be required by law to present for X-ray examination, at first both New South Wales and Victoria were reluctant to implement the sanction of fines for non-compliance. Their stance seemed vindicated in the first survey, where it was common in many areas for 85 per cent of the adult population to present for X-ray. In some western towns of New South Wales, the number of X-rays exceeded the official population statistics. Presumably, people were travelling long distances from outlying settlements.

On the other hand, the fact that the remaining 15–20 per cent of the population were not being examined was a concern, because it was likely that a proportion of these knew or suspected that they may have tuberculosis, and consequently avoided the X-ray examination.

Initially, the results of mass screening were impressive, as the notifications of new tuberculosis cases in Metropolitan Sydney show (Figure 1). The number attending usually declined when the mobile units made return visits two or three years later, probably because people became apathetic after being cleared on their first X-ray.

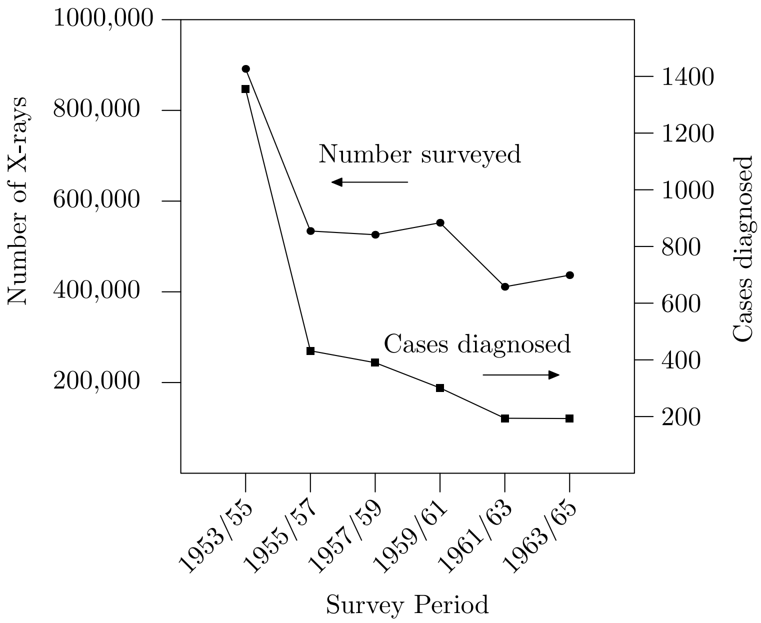


Figure 1: Successive TB surveys in the Sydney metropolitan area.

In 1956, the State Government yielded to Commonwealth pressure, making X-rays compulsory, and imposing a fine of £20 for failing to attend when the mobile X-ray units visited a proclaimed district. A further penalty of two pounds a day could be incurred for every day that elapsed before the defaulter presented for an X-ray. A few 'show trials' took place to convince the populace that the government was serious.

In the twenty-five years between 1950 and 1975, the Anti-Tuberculosis Association took eleven and a half million chest X-rays, using about 900 kilometres of film – a very long 'celluloid strip'. As a result of the surveys, 8 854 new cases of tuberculosis were detected, as well as many inactive cases. To these figures we must add the parallel efforts of the NSW Department of Health. The totals may be a little exaggerated, because there could have been a certain amount of over-diagnosis, as the clinicians would be prone to classify doubtful cases as tubercular, particularly with their own continued employment at stake. Subsequent testing would have confirmed which patients were infected, but the statistics were not adjusted.

Overall, the campaign detected only one case of tuberculosis for every 1,300 X-rays taken. However, this rather small statistical average overlooks the marked discrepancy in cases between different areas. For example, there was one positive diagnosis for every 350 X-rays taken at the Crown Street Clinic. This difference is explained by the fact that many of those presenting at the Clinic already had symptoms and were referred by their private doctor, or they were contacts of known tuberculosis patients.

What these statistics do not reveal is that many other serious abnormalities were detected at the same time, particularly heart conditions or lung cancer. By 1959, such pathologies already exceeded the detection of new cases of tuberculosis. These were referred to private practitioners or public hospitals for further investigation and treatment. In retrospect, this part of the campaign may have been more significant for the long-term health of the population than identifying the relatively few tuberculosis cases.

Because the number of tuberculosis cases was declining, a rationalisation of the mass radiography program in New South Wales took place in 1971. The NSW Department of Health withdrew from the statewide surveys, and transferred its mobile X-ray units to the Anti-Tuberculosis Association, together with some of the operational staff and funding to continue the program. To further reduce costs, the interval between surveys extended to an average of five years. The minimum age for compulsory X-rays was raised from twenty-one to twenty-five years, with an increase to thirty-five years soon afterwards.

At first, nobody asked publicly whether the benefits justified the cost of the national campaign, but the reality is that it was a very expensive exercise. The total Commonwealth expenditure on the program between 1950 and 1977 was $361 million, which of course would be many times that sum at today's prices. In 1977, the Anti-Tuberculosis Association published for the first time the actual costs incurred in producing each 70 mm diagnostic film image. In the metropolitan area this amounted to eighty cents per head, but in regional areas it was twice as expensive, at $1.64 per head. The difference was due to travel and accommodation costs for staff. From nearly a quarter of a million X-rays taken in that year, only 55 cases of tuberculosis were diagnosed, costing somewhere in the vicinity of $5,000 for each case notified. Subsequent treatment costs presumably would have been much greater,

It was becoming obvious that the law of diminishing returns applied. Indeed, it seemed that Ben Chifley's ambition to reduce tuberculosis to a minor problem within two decades had been achieved, so it is not surprising that the Commonwealth Government led by Malcolm Fraser decided to revoke the Tuberculosis Agreement with the States, taking effect from the end of 1976. In retrospect, this may have been a premature decision, occurring just as an increasing number of 'boat people' refugees from the war in Vietnam began settling in Australia. Tuberculosis was endemic in their homeland, and they brought a new locus for the disease to their adopted country. Of course, the way remained open for the State authorities to finance their own control programs, but they were reluctant to divert funds from other responsibilities.

The apparent success of the Australian Tuberculosis Campaign is confused by the fact that streptomycin and similar therapeutic agents were introduced almost concurrently with the commencement of the campaign. Effective treatment that could be administered at home or in a hospital outpatient department quickly rendered many of the new sanatoria and chest hospitals redundant. Certainly, the mass screening surveys still played a useful role in case-finding, identifying patients who could be referred for prompt treatment. In doing so, potential sources of infection were removed from the broader community.

However, it would be presumptuous to claim that the lowered incidence of tuberculosis in Australia was due to the implementation of a compulsory, nation-wide screening program, for the decline in notifications commenced long before the campaign (see Figure 2). With some fluctuations, the trend had been declining steadily for a hundred years. This fact poses some interesting questions. We cannot attribute all of the decline to improved treatment, because effective chemotherapy did not arrive until the late 1940s, so it must be due to other causes. A number of possible factors have been identified, but it is difficult to apportion the relative significance of each. Reticulation of pure water and efficient sewerage disposal in the late nineteenth century were accompanied by heightened awareness of personal hygiene. Increased prosperity led to better housing and nutrition. Smaller families resulted in less overcrowding. These elements combined to reduce exposure to risk, and possibly generated improved resistance to the disease. It is also conceivable that there has been a reduction in the virulence of the bacterium during this period. Chemotherapy did make an impact on the death rate, although this also had been improving steadily since the Great Depression.

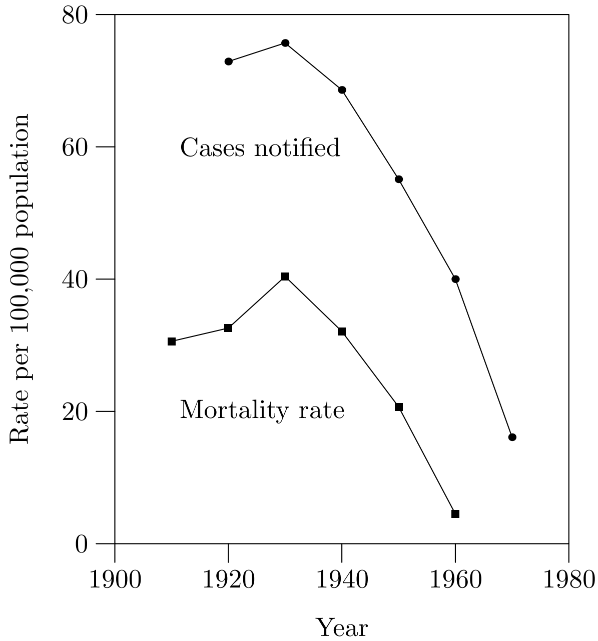
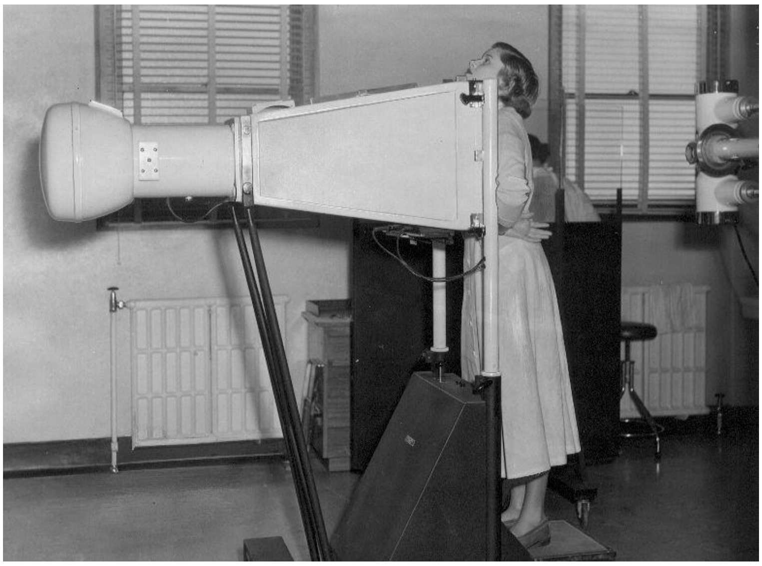


Figure 2: Incidence of TB in NSW.

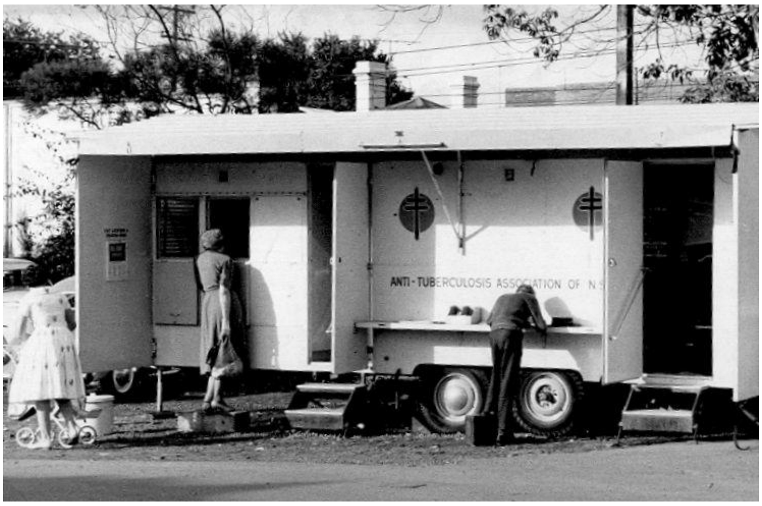
The campaign continued at a reduced scale after Commonwealth funding was withdrawn, but from 1979 it was no longer compulsory, although people over thirty-five were still encouraged to have regular X-rays. Under these circumstances, it was inevitable that mass screening of whole communities would soon cease. Government health authorities decided that tuberculosis detection in future would concentrate on high-risk sections of the community. In 1981, the Health Commission of NSW gave the re-named Community Health and Anti-Tuberculosis Association six months’ notice that it was terminating its arrangement with the Association to provide mass radiographic surveys.

The ubiquitous X-ray caravans then disappeared from street corners around New South Wales.

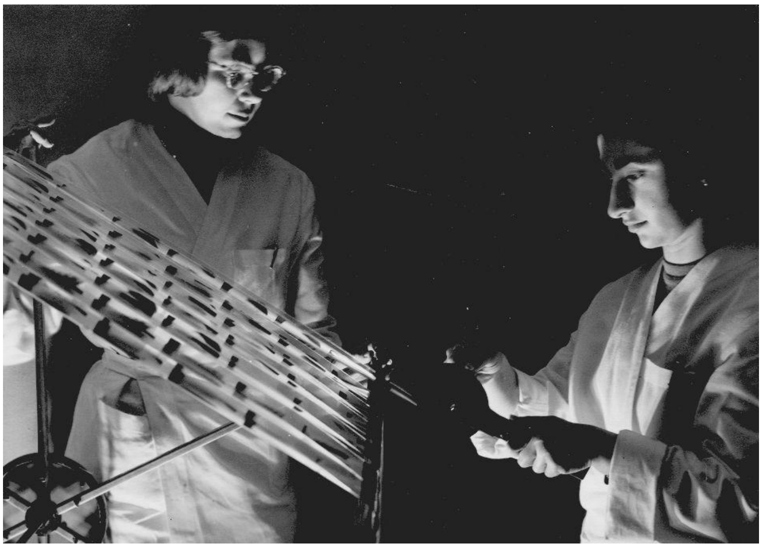
A Mobile Xray Bus at Mudgee. The original mobile X-ray units travelled in a converted Sydney bus, which included space for a photographic darkroom and a radiologist’s consulting room. The large X-ray machines of this era had to be unloaded from the bus and set up in a building, usually the local Town Hall.



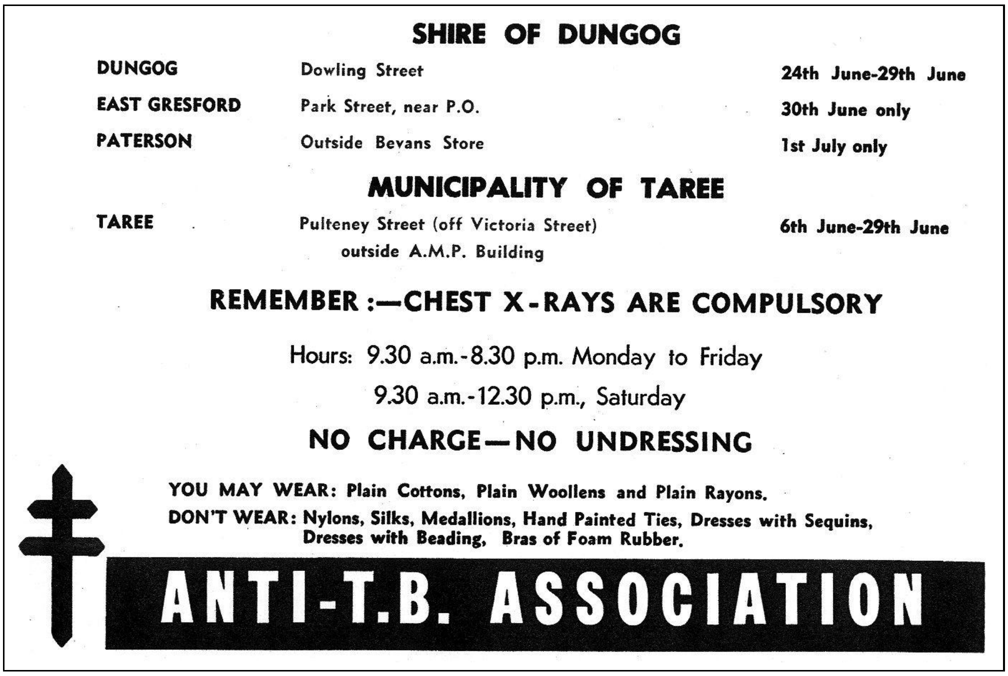
Improvements in equipment resulted in shorter exposure times and better images. This illustration is of an Odelca mirror camera installed in the Sydney clinic of the Anti-Tuberculosis Association. Similar gear was used in mobile units towards the end of the national campaign.



An Anti-Tuberculosis Association mobile X-ray unit. These large caravans were placed in prominent suburban locations for periods from a few days to several months. Each caravan included a small office for registering the client's personal details, as well as the miniature X-ray equipment.



Processing the Celluloid Strip Miniature X-rays consisted of 400 separate images on a single length of 70 mm photographic film - ”the celluloid strip”. Films were returned from the mobile units to a central location for processing. Here technicians are inspecting a film before it is handed to the medical staff for diagnostic examination.



This is a poster announcing a forthcoming visit to country towns by a mobile X-ray unit. The slogan ‘No Charge - No Undressing’ indicated a notable change from the early days of mass population surveys, when a small charge was levied, and clients had to strip to the waist. There were still some restrictions on the type of clothing that could be worn.

ACKNOWLEDGEMENT

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Thesis Abstract: On a Dynamical Origin for Fermion Generations

JIM BASHFORD

Abstract of a Thesis awarded for the Degree of Doctor of Philosophy
University of Adelaide, South Australia 2003

We investigate a proposal [Bass, S.D. and Thomas, A.W. *Mod. Phys. Lett.* A 11, 339, (1996)] addressing several outstanding shortcomings of the perturbative Standard Model of particle physics. Specifically a common, dynamical origin is hypothesised for the number of fermion generations, the spectrum of fermion masses and for Charge-Parity violating processes. The appeal of this proposal is that these features are a manifestation of the high-energy, non-perturbative sector of the Standard Model, requiring no new physics beyond presently attainable experimental limits. The problem is studied by two complementary approaches and a possible analogy with condensed matter physics.

Understanding of how the mass, generations and CP-violation might arise are first investigated in a toy four-fermion model. It is shown that different scale-invariant four-fermion operators are present for three subspaces of the full theory which can be arranged in a hierarchy of phases of a 'fundamental' theory. This enables self-consistent introduction of three fermion generations. Mass 'gap' equations are also derived and found to have non-trivial solutions above critical coupling strengths.

The second part of the thesis is concerned with the dynamical breakdown of chiral symmetry in the quenched hypercharge interaction. In particular we follow the successful procedure developed for quantum electrodynamics, proposing a 1-loop renormalisable vertex *ansatz* for solution of the fermion self-energy Dyson-Schwinger equation. In the absence of dynamical fermion-antifermion bound states it is found there exist two 'mass gaps' indicating several modes of four-fermion pairing in the neighborhood of two critical coupling points. These 'gaps' cannot be interpreted as physical fermion mass , illustrating a key difference between this theory and and studies of conventional chiral symmetry breakdown: Fermion pairing terms associated with the symmetry breaking are a necessary, but not always sufficient, requirement for dynamical mass generation. It is noted that similar behavior may occur in systems of strongly-correlated electrons where a 'pseudo-gap', intermediate to superconducting and normal phases may be observed.

To this end we are motivated to suggest an new, alternative solution to the problem of criticality in the hypercharge theory. In particular a rearrangement of fermionic degrees of analogous to spin-charge separation in low-dimensional condensed matter physics is considered, leading to a new class of high-energy extensions of the Standard Model.

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Thesis Abstract: Remotely Sensing Changes in the Vegetation of Ephemeral Wetlands

SIMON N. BENGER

Abstract of a Thesis awarded for the Degree of Doctor of Philosophy
Australian National University 2002

The ephemeral wetlands of semi-arid Australia provide important habitats for many species and play a significant role in the hydrological and biological regimes of these environments. As most inland wetlands owe their existence to unregulated cycles of flooding and drying, many wetlands are now being forced into decline through flow regulation associated with irrigation for large, highly productive agricultural enterprises. This decline usually manifests itself through reductions in the spatial extent of vegetation stands, transitional effects in the landscape and a deterioration in the physiological condition of individual plants. A time-series of Landsat TM and JERS-1 optical and radar imagery were used to investigate the potential for employing various vegetation species as remotely sensed indicators of wetland decline in the Macquarie Marshes of central western New South Wales. The research examined the utility of remotely sensed imagery for the mapping of semi-arid inland wetland vegetation and assessed its effectiveness in detecting changes in the physiological health of wetland vegetation due to alterations in the hydrological regime.

Four species, river red gum *Eucalyptus camaldulensus*, cumbungi reed *Typha orientalis*, common reed *Phragmites australis*, and water cooch *Paspaulum paspalodes* could be detected at sufficient spatial and spectral resolution to be mappable from satellite imagery. All of these species showed changes in spectral characteristics and radar response as a result of reduced flooding of the wetlands. Two of the species examined, cumbungi reed and common reed, worked well as indicators of short term changes in water availability by manifesting loss of spatial extent and reduction in NDVI. River red gum stands were excellent indicators of longer term decline due to their relative permanence in the landscape and longer response to changes in water availability, while the condition of water cooch pastures was also a good indicator of wetland condition. The development of these techniques offers good potential to facilitate monitoring of the physiological health of inland wetlands and assist in management decisions regarding flow regulation and flood control.

Automated vegetation classification proved to be very accurate in mapping both spatial extent and identity of vegetation types. Transitional landscapes which result from changes in the hydrological regime of the wetlands could also be clearly differentiated from their origins. Degradation of indicator communities also showed up well in the results, causing dramatic changes in NDVI response on a seasonal basis. Characteristic response patterns were revealed for all the indicator species examined, and sug-

gest that NDVI based monitoring would be very effective in an environment where these indicators were present. Analysis of JERS-1 L-band radar imagery over the study area clearly showed that structure is a primary determinant of backscatter. Structural declines due to vegetation alteration were evident in terms of reduced radar returns, which are most significant in defining transitions from river red gum forests to river red gum woodlands and conversion of water cooch pastures through to mixed grassland and then chenopod dominated landscapes. Flood mapping and modelling from optical and radar imagery were also explored in the study and results showed that there is substantial potential for the use of automated flood mapping and modelling in inland wetland environments.

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Thesis Abstract: Temporomandibular Joint: Form and Function

GEORGE J. DIAS

Abstract of a Thesis awarded for the Degree of Doctor of Philosophy
University of Otago, New Zealand 2003

The human temporomandibular joint (TMJ) is susceptible to dysfunction, the etiology of which is poorly understood or unknown. This thesis investigates certain aspects of the form and function of this joint and related structures, with a view to acquiring a better understanding of its disorders.

In considering whether the morphology of the human TMJ, together with the masticatory complex as a whole, adapts to the masticatory environment, two groups of Kuni Kuni pigs were used, one on a hard diet and the other on a soft diet. With a hard diet, there appears to be a shortening of both the mandible and maxilla. It is argued that these findings, in conjunction with the results of other similar studies may challenge the popularly-held view that the relatively soft diets of modern urbanised populations have brought about a reduction in the size of the jaws.

The morphology of the lateral pterygoid muscle was investigated, since it has a major influence on the functional anatomy of the TMJ. Contrary to the accepted view, it was found that the lateral pterygoid muscle consists of three heads of origin – a lower head, an upper head, and a newly described uppermost head. This uppermost head is situated lateral to the upper head and has a vector of force directed lateral to the vector of the upper head.

In an attempt to address the presence of a true antagonist to Bennett movement and to explain the medial dislocation of the disc, an inferior dissection approach to the joint was adopted. A near horizontal band of tissue, consisting of a varied mix of striated muscle bundles interspersed with fibrous tissue and vascular channels, was found in the posteromedial aspect of the mandibular condyle. This is termed the glenomandibular muscle band. It is concluded that this is responsible for producing antagonistic force for the Bennett movement, and is also responsible for the pure medial dislocation of the disc.

Plain film radiographic images have had a major influence on our understanding of TMJ morphology. Despite TMJ imaging?s long history of research and clinical application, the quality of information gathered from imaging is often less than desired. Therefore, it may be clinically useful if a method can be developed that can generate data closer to *actual* joint values, thereby enabling clinicians to make a better informed qualitative assessment of TMJ morphology. This investigation revealed that the more clinically-important larger joint measurements are significantly different between actual joint specimens, and those of the respective oblique lateral transcranial and true lateral radiographs. A novel approach employing a 'neural network' to improve the accuracy of routine plain film radiographs is outlined and tested.

The above findings, that the jaws adapt to the functional environment, that there are hitherto unknown contractile elements acting on the joint, and the ability to improve the qualitative information from routine joint images would in addition to improving knowledge of the form and function of the TMJ and the masticatory complex, lead to a better understanding of TMJ disorders.

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Thesis Abstract: Crescentic Glomerulonephritis: Associations and Transforming Growth Factors

HAROLD J. NEAL

Abstract of a Thesis awarded for the Degree of Doctor of Philosophy
University of Otago, New Zealand 2003

The initial aim of this project was to study the role of mast cells in anti-glomerular basement membrane antibody (anti-GBM) induced crescentic glomerulonephritis (CGN), using experimental autologous, and accelerated autologous rabbit models. A method of biopsy was developed to allow sequential sampling of the kidneys over time, and reduce the number of rabbits required for study,

Early in the project, a significant influx of tissue eosinophilic cells were noted during the progression of the disease, and coincided with the onset of the autologous phase. The study of eosinophil in CGN became the major focus of the project, and early results led to the hypothesis that eosinophils have a relationship GN, and that they may have an association with the fibrotic process by producing certain cytokines such as transforming growth factor (TGF-α) and beta (TGF-β), both of these cytokines being demonstrated by other workers as having direct roles in several scaring and sclerotic conditions.

Using biochemical techniques, light microscopy, transmission electron microscopy, and immunohistochemistry, the eosinophilic cells were confirmed as true eosinophils, and not rabbit heterophil (neutrophil) which has similar morphological features to the eosinophil.

Qualitative and quantitative assessment demonstrated that tissue eosinophils did occur at the onset of the autologous phase, and that they first appeared at, and around, the glomerular vascular pole region. As the glomerular crescents developed, the eosinophils were observed both within the crescents (intracrescentic), and in the interstitium circumscribing the crescent (pericrescentic). Eosinophils were very scant and insignificant in control groups.

The number of eosinophils observed with each individual crescent was associated with the degree of pathological change of the diseased glomerulus, the influx of macrophages, the deposition of collagen within crescents, and glomerular area. An increase in the number of macrophages was also seen in the heterologous phase of the autologous models , preceding the influx of eosinophils at the onset of the autologous phase.

The accelerated autologous model has many similar morphological features to rapidly progressive CGN observed in human renal biopsies, and an audit of human cases was undertaken, The intracrescentic and pericrescentic distribution of eosinophils in human CGN was similar to that observed in the rabbit autologous model. There was also a significant association of eosinophil score with the deposition of collagen within crescents.

Eosinophils in approximately one third of human biopsies were positive for TGF-α and TGF-β_1 proteins. A sequential expression of the two cytokines by red blood cells and fibrin was also seen. The nuclei of some crescentic fibroblasts showed positive TGF-β_1 protein expression.

The results of combined experimental animal research and audited human renal biopsies show significant associations between tissue eosinophils, fibrosis of glomerular crescents, and TGF-α and TGF-β_1 proteins. These findings indicate avenues towards further study, and potential pathways for therapeutic intervention. Important considerations are also raised regarding prior research with experimental ant-GBM antibody CGN in rabbits, in which eosinophils may have been 'neglected', but could influence research outcomes in the pathogenesis of this animal model of such a debilitating human disease.

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Thesis Abstract: Dynamics of outbreak populations of crown-of-thorns starfish (Acanthaster planci L.), and their effects on coral reef ecosystems

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Abstract of a Thesis awarded for the Degree of Doctor of Philosophy in Marine Ecology
James Cook University, Townsville, Queensland 2002

Population outbreaks of crown-of-thorns starfish (*Acanthaster planci* L.) represent one of the most significant biological disturbances affecting coral reef ecosystems. This study examined fine-scale patterns in the size-structure, distribution, and abundance of starfish, during an outbreak at Lizard Island, in the northern Great Barrier Reef. The outbreak resulted from a steady and prolonged increase in starfish densities over several years (1994–1997), with progressive accumulation of starfish from multiple recruitment events. Reef-wide densities of *A. planci* increased to a maximum of 1.0 starfish per 200 m^2 (±0.1 SE), in January 1997, and then remained fairly constant until June 1998, after which time starfish densities declined rapidly. Starfish densities varied greatly among locations (separated by 0.5–8 km), and also between reef zones (<5m apart). Fine-scale patterns in the distribution and abundance of *A. planci* were partly attributable to spatial variation in wave exposure (whereby starfish avoid turbulent environments), but also resulted from spatial variation in recruitment.

Outbreak populations of *A. planci* caused substantial coral mortality, and significantly altered community structure of corals. However, the impacts of *A. planci* were very patchy. At the most severely affected locations (back-reef habitats) coral cover declined by 72% between 1996 and 1999, whereas at several other locations (e.g., lagoonal habitats) there was no observable change in scleractinian coral cover. Crown-of-thorns starfish also had varying impacts among different coral species, caused by significant selectivity in their patterns of feeding. In general, starfish had a disproportionate impact on fast growing branching corals (e.g. *Acropora* spp. and pocilloporids), tending to avoid slow growing massive corals (e.g. *Diploastrea* spp., *Porites* spp.).

Clearly, crown-of-thorns starfish have a major impact on coral communities, but impacts of starfish outbreaks also extend to a wide range of reef associated organisms, such as coral reef fishes. This study examined long-term changes in the distribution and abundance of *Chaetodon* butterflyfish and coral-dwelling damselfish, during the course of the crown-of-thorns outbreak. Depletion of scleractinian corals resulted in significant reductions in the abundance of seven butterflyfish species (*Chaetodon auriga*, *C. citrinellus*, *C. kleinii*, *C. plebius*, *C. rainfordi*, *C. trifascialis*, and *C. unimaculatus*), whereas there was no change in the abundance of *C. aureofasciatus*, *C. baronessa*, *C. ephippium*, *C. lunulatus*, *C. melannotus* or *C. vagabundus*. *Chaetodon*

species affected by coral depletion mostly had a high dependence on live coral for food. However, at least one non-coral feeding butterflyfish, *C. auriga*, was also affected. Among corallivorous butterflyfish, impacts of coral depletion varied in accordance with their degree of feeding specialisation. Similarly, some species coral-dwelling damselfish were affected (*Chromis viridis*, *Dascyllus aruanus*, *D. reticulatus* and *Pomacentrus moluccensis*), but not others (*C. atripectoralis* and *P. amboinensis*). Damselfish species not affected (*C. atripectoralis* and *P. amboinensis*) often inhabited skeletons of dead corals, whereas all other species were strongly dependent on live coral as shelter. This study demonstrates that major disturbances to coral reef habitats can have significant follow-on affects for reef fishes. However, the specific responses of individual species vary in accordance with their diet, habitat preference, distribution, abundance and ecological versatility.

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Thesis Abstract: Microstructural Characterization of Nanocrystalline Fe-Zr-B(-Cu and/or Ge) Soft Magnetic Alloys

DEMING ZHU

Abstract of a Thesis submitted for the Degree of
Master of Engineering Science (Research)
Monash University, Australia 2003

In the research presented in this thesis, the origins of the microstructure and solute partitioning behaviour are characterized in nanocrystalline Fe-Zr-B(-Cu and/or Ge) alloys in order to design new experimental soft magnetic alloys. The structural and microstructural evolution of nanocrystalline $Fe_{93\text{-}x\text{-}y}Zr_7B_xCu_y$ alloys (x = 3 and 9 at.%; y = 0 and 1 at.%) was examined, with the aim of investigating the effect of B and Cu additions. The effect of Ge on the microstructural and magnetic properties of $Fe_{89\text{-}x}Zr_7Bi_3Cu_1Ge_x$ (x = 0 to 5 at.%) alloys was also examined. The experimental techniques used in this research were differential scanning calorimetry (DSC), thermo-gravimetric analysis (TGA), X-ray diffraction (XRD), transmission electron microscopy (TEM), field emission scanning transmission electron microscopy (FESTEM) with nanoprobe energy-dispersive X-ray spectroscopy (NanoEDXS), and dc B-H loop tracer analysis.

In the investigation of the structural and microstructural evolution of nanocrystalline $Fe_{93\text{-}x\text{-}y}Zr_7B_xCu_y$ alloys, the following findings were made. B and Cu play opposite roles in stabilising the amorphous phase. While the addition of B stabilises the amorphous phase, the addition of Cu destabilises it. Cu atoms act as heterogeneous nucleation sites for the primary crystallization and the enhanced nucleation rate leads to nanocrystallites of *bcc* Fe in both low and high B content alloys. In high B content alloys, the crystallization of the amorphous phase occurs through two distinct reaction stages of amorphous → *bcc* Fe + residual amorphous → α-Fe + Fe_2Zr + Fe_3Zr. The ease with which the residual amorphous phase transforms into Fe-Zr based compounds is dependent upon Cu content. In Cu-free high B alloy, both the primary crystallization and secondary crystallization have similar kinetics, and the primary crystallization is immediately followed by the secondary crystallization. However, in the presence of Cu, the enhanced nucleation of *bcc* Fe alters the composition of the residual amorphous phase and thus delays the onset of secondary crystallization. In Cu-free high B alloy, the grain growth of Fe crystallites was observed. This is attributed to the formation of Fe-Zr based compounds, which consumes Zr atoms. In Cu-containing high B alloy, due to the absence of such a reaction, Zr atoms are effective in pinning the *bcc* Fe grain boundaries giving rise to the nanocrystalline microstructure. NanoEDXS studies show the enrichment of Zr at *bcc* Fe grain boundaries confirming the pro-

posed grain refinement process.

In the investigation of the microstructural and magnetic properties of $Fe_{89-x}Zr_7B_3Cu_1Ge_x$ alloys, the following findings were made. The onset temperatures of primary crystallization for amorphous $Fe_{89-x}Zr_7B_3Cu_1Ge_x$ alloys are independent of the Ge content, but the Curie temperatures of these alloys are close to room temperature and increase with increasing Ge content. The crystallization takes place through two stages of amorphous → *bcc* Fe + residual amorphous → α-Fe + Fe_3Zr regardless of Ge content. When the alloys are annealed for 3.6 ks at temperatures between 773 and 923 K, the microstructure consists mainly of *bcc* Fe crystallites with an average grain size of 11 to 13 nm embedded in the amorphous matrix. Ge is enriched in the residual amorphous matrix together with Zr. This increases the Curie temperature and the exchange stiffness in the intergranular region, thereby improving the soft magnetic properties. The coercivity of $Fe_{89-x}Zr_7B_3Cu_1Ge_x$ alloys annealed for 3.6 ks at 773 and 823 K exhibits a tendency to decrease with increasing Ge content, but this effect is not evident at 873 K and 923 K due to the relatively small volume of the residual amorphous phase. The coercivity of $Fe_{89-x}Zr_7B_3Cu_1Ge_x$ alloys annealed for 24 h at 923 K exhibits a tendency to increase rapidly, due to the formation of the more strongly anisotropic Fe_3Zr compound and the enhancement of the grain size (55–60 nm).

Deming Zhu
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(Manuscript received 21-08-2003)

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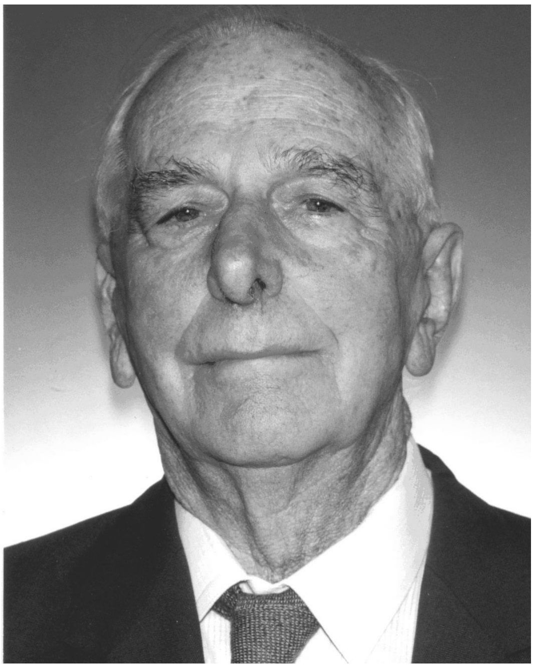
Biographical Memoirs

EDWARD RITCHIE (TED) COLE

1912–2002



Ted Cole, who was passionate about science to the end of his long life, has died shortly after his ninetieth birthday. Although he had some serious illnesses in the last few years of his life, his enthusiasm about getting back to his research seemed to sustain him. During his last weeks, he continued to contemplate chemical problems, and hoped that he could recover sufficiently to complete a research project.

Ted attended Sydney Boy's High School, and then went to Sydney University where he first studied pharmacy. He then obtained Bachelor (1937) and Master (1948) of Science degrees in chemistry, at Sydney University. He joined the NSW Health Department where he was pleased to become the 10th Government Analyst (meaning he was tenth in seniority). During the 1940s he lectured part-time to night students at Sydney Technical College, before taking up a full-time position in Chemistry at the College in 1948. Much of the College became the NSW University of Technology, which was subsequently named the University of NSW, and Ted was a founding member of the Chemistry School. He obtained his PhD from University of NSW, and became an Associate Professor there in 1963. He was appointed Head of the newly created Department of Applied Organic Chemistry in 1962, where he pioneered postgraduate courses with the establishment of the Graduate Diploma in Food and Drug Analysis. Later a Master of Chemistry by coursework was established. He took sabbaticals in England and the USA, and officially retired from the University in 1977.

Although he formally retired at the age of 65, he never retired from an active interest in chemistry. He continued to work as an Honorary Associate at UNSW and was a consultant for a period to Mauri Brothers and Thompson. For the last six years he was an Honorary Associate at Macquarie University. Throughout this time he was active in research and wrote up papers, the last of which was published in 2001.

He joined the Royal Society of NSW in 1940. His membership was proposed by academics in the Departments of Biochemistry, Chemistry and Pharmacy at the University of Sydney. His first two papers were published in the Journal and Proceedings of the RSNSW, both in 1947, on the colorimetric analysis of apomorphine and strychnine. He became an Associate Member of the Royal Society of Chemistry in 1954, a Life Member in 1992, and a Fellow in 1998, entitling him to the letters CChem FRSC. He was a Fellow (and Honorary Life Member) of the Royal Australian Chemical Institute, a Fellow of the Australian Institute of Food Science and Technology, a Member of the Food Technology Association, a Member of the Pharmaceutical Society of Australia and a Life Fellow of the Institute of Food Science and Technology.

He was a versatile chemist and participated in a wide variety of research projects. One of his earliest publications, on the aerial oxidation of lycopene, was adopted for teaching purposes by the University of California, Davis. He was very interested in oxidation generally and in free-radical oxidation in particular. He had a longstanding interest in lead tetraacetate oxidation and his publications on lead tetraacetate spanned the period 1954 to 1986. Other important interests were organosulfur chemistry, organoselenium compounds and the susceptibility of carotenoid pigments to oxidation. He published in journals that covered a wide range of research fields, including biochemistry, biology and medicine. He had a reputation of being generous with his time as a research supervisor.

He was devoted to his family. He met his wife of 61 years, Joyce, while working as a laboratory demonstrator in Pharmacy, and they had two children, Ted jnr and Alison (deceased). He was strongly committed to learning, and to the ideals of academia, and he provided great encouragement to students. He was an engaging and enthusiastic person who held strong opinions. He could be a lively conversationalist. He enjoyed music, especially Beethoven, and was an accomplished amateur pianist. He was a keen cricket and tennis player with a reputation of gaining particular enjoyment from making stylish strokes. In earlier times he enjoyed watching cricket at the Sydney Cricket Ground, but he was not interested in the modern form of the game. In his last competition cricket match for Lane Cove, he carried his bat from the beginning to the end of the innings. This symbolized the enthusiasm and energy that he carried throughout his life.

W.S., T.C. Jnr and P.S-K.

JOHN WILLIAM HUMPHRIES – JACK HUMPHRIES

1916–2003

Jack was born on the 24 Jan 1916 at Wyndham NZ, the son of Herbert, an engineer, and Elizabeth Humphries, a Melbourne girl. Jack was the eldest of three, Tup, and Frank being the other two children. The family became South Island farmers when Herbert moved to the family farm to keep it running after the other Humphries boys had all gone off to fight. Jack was born during the middle of the Great War and before the widespread use of petrol driven vehicles, penicillin and air transport.

Jack's family was not rich and he was greatly affected by the Great Depression of 1929, when he was 13 years old. Despite the time spent in helping to run what was essentially an uneconomic farm, earning pocket money from his rabbit hunting and prize money from athletic events, and just generally surviving, he was able to get a good education. Jack always claimed that he was a dead shot, because he could not afford to waste bullets on the rabbits. He cycled 14 miles a day in the cold winds of the South Island to get to High School. His high school teacher, Chase, the brother of his future wife, saw the merit in this young man and greatly helped him to develop intellectually.

He was apprenticed to the Lands Department of New Zealand in 1934 and moved to New Plymouth. He moved to Wellington about 1938. He commenced university studies in Science and was a part-time evening student all this time while holding down a full-time job in the Lands Department. Many of you will remember his interest in the Geography and Cartography of New Zealand, which developed during this time. He graduated from Victoria University in 1945.

He boarded with the Milne family in Wellington and learned to dance and appreciate music during this time. Chase, his former teacher, wrote to the Werry family in Wellington and they took him under their wing. The story goes that only three people were surprised at Bebe and Jack falling in love — Bebe, Jack and her father,

He married Beatrice, whom we all know as Bebe, in Feb 1944. They had two children.

While studying he obtained a position in the then New Zealand Department of Science and Industrial Research, working in the Standards Laboratory. This was the beginning of his lifelong career in the physics of measurement.

He volunteered during the second world war, but his application was rejected because his occupation was considered essential to the war effort. Many will recall his stories about calibration of instruments on ships and planes. He was however a member of the ‘Territorials’ during the war and again, many will recall his ‘dad's army’ stories.

As a result of a visit to Australia to work with Physicists in the National Standards Laboratory of CSIRO at Sydney University he was offered a position, which he accepted in late 1954.

Just before the family was ready to leave in 1955 tragedy struck and their young son, Antony, died in an accident. This left a deep hole in the family and in Jack's life, and he carried the emotional scars of this for the rest of his lift. The impact of the tragedy was compounded with the need to leave friends and family behind soon after in order to move to Sydney.

The family eventually settled in West Lindfield in May 1956 and their daughter, Elizabeth, continued her schooling at Beaumont Road School, then Hornsby Girls and finally Sydney University. Jack was a source of advice and information not only for Elizabeth's academic studies but also for a number of other young people in the district.

Bebe became deeply involved in the community, the church and the migrant hostel at the old airforce camp, now the site of the CSIRO Division of Telecommunications and Industrial Physics in Bradfield Road. Jack, together with Bebe, were involved with the then branch church of St Albans at West Lindfield (All Saints), which became the parish of West Lindfield, holding positions on the Parish Council at various times. As in NZ, he was also involved in other activities, for example the Community Centre and Neighbourhood Community Watch.

One of Jack's great loves for much of this time was his involvement with the Royal Society of NSW. The pinnacle of this work for him was his appointment as President after many years as Secretary. For his contribution to the Society he was awarded the Society Medal in 1977, a very proud day for him, and a prestigious award.

Many will not realise that Jack played a key role in decimalisation and the introduction of the SI units into Australia. Jack's specialised interest in the National Standards Laboratory was in mass. Many will recall his fond talk of Bertha, much loved by him (the other woman in his life). Bertha is a balance, used for many years to establish and maintain the standard of mass in this country. She featured on the $50 note, although the plastic age saw her removed. This prestigious position for his instrument brought him great pride. His measurements were reputedly the best in the world,

In 1968, soon after their pet cat died, I wandered onto the scene and soon became part of the family. Jack was immensely proud of his grandchildren and while he may not have understood the late 20th century teenager he had a great love for Margaret, Jonathan and Timothy. He helped them in all sorts of ways — taxi driver, baby sitter, and occasional reference book. He was tremendously proud when Margaret graduated and it was sad that he was not able to be present during her graduation.

He retired from CSIRO in 1981. Like everyone, he had a long list of things to do. After 6 months it was abandoned and he just lived a busy life. Bebe and he spent several years travelling around the world. He took meticulous notes of his trips which in the last few years he would take joy in reading to Bebe, and referred to frequently to remind himself of these joyful times.

Jack is the last of the physicists and scientists who started the substantive part of their careers in Australia in the 1940's and 1950's and came to work in the National Standards Laboratory. It is the passing of an era. He had a great breadth of knowledge although he admitted in many conversations that he had not mastered the computer age, which is not surprising as he retired at the time that PCs were being phased in.

Jack's legacy is at several levels. He was a devoted family man who took pride in his family whom he loved dearly. He was a scientist who had a great love for his specialty and worked hard to excel in his work, realising its importance to the development of the nation. He was a man who was intimately acquainted with tragedy and had to manage it. He was a man of immense integrity and honesty. He was meticulous. He was interested in the welfare of others and assisted many in their hour of need.

In the last days we believe that he acknowledged Jesus Christ's love for him. In the final analysis, this is what counts in a person's life and Jack is at peace with God.

This was the full and worthy life of Jack Humphries.

Prepared by the family of Jack Humphries for his funeral service of 10 April 2003

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ISSN 0035-9173/03/020062–8 $4.00/1

Annual Report of Council

For the year ended 31st March 2001

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 general meetings and the 135th Annual General Meeting were held during the year at various locations.

SPECIAL MEETINGS AND EVENTS

The President, Mr David Craddock was involved in two meetings that were convened for the Donovan Trust to discuss grants for work in the field of Astronomy.

The Society took part in two combined afternoon meetings at the Powerhouse Museum with the Powerhouse Museum Society. The respective topics were 'Science and Music' and 'Science of Wine'. These meetings are detailed later in the Report under 'ABSTRACT OF PROCEEDINGS'.

22nd November 2002:
Professor Graham Johnston AM of the Department of Pharmacology, University of Sydney delivered The Royal Society of New South Wales Liversidge Memorial Lecture to a large and enthusiastic audience at the Southern Highlands Branch meeting in Mittagong. The lecture was entitled 'Chemicals in Our Diet May Influence Brain Function'.

17th February 2003:
The Society was a co-sponsor of the annual 2003 Joint Meeting of the Four Societies: Australian Institute of Energy; Australian Nuclear Society; Engineers Australia; and The Royal Society of New South Wales. The meeting, representing the 1113th General Monthly Meeting of the Society was held in Harricks Auditorium, Ground Floor, Engineering House 118 Alfred Street, Milson's Point. Mr Richard Hunwick, Chairman of the Sydney Branch of the Australian Institute of Energy, presented the lecture on 'The Quest for Zero-Waste Nuclear Power'.

21st March 2003:
The Annual Dinner of the Royal Society of New South Wales was held on the evening at the Darlington Centre, City Road, Sydney University. The after-dinner speech was given by Professor Mike Archer, Director of the Australian Museum who delivered a lecture on 'FATE' (The Future of Australia's Threatened Ecosystems). The President, Mr David Craddock, presented the Society's Awards for 2002.

MEETINGS OF COUNCIL

Eleven meetings of Council were held at the Society's Office at 6/142 Herring Road, North Ryde. One meeting comprised Executive members only.

PUBLICATIONS

Journal

Vol. 135 (Parts 1 and 2) July 2002 was published during the year. Parts 1 and 2 contains the Presidential Address for 2002 (Antipodean Aeronautica), two peer-refereed papers: one on agriculture (Biomass Production), one on chemosphere (Trace Elements), citations for four awards for the year 2001 and the Annual Report of Council for the year ended 31st March 2002 including biographical memoirs. The financial report for that year was not available at the time of publication.

Vol. 135 (Parts 3 and 4) for 2002 has not yet been published as only two papers are available so far: the Liversidge Lecture, a paper on seed-hardening plus one biographical memoir. In addition, Part 3 and 4 will carry the index for the total volume.

For some time the Hon. Editor has voiced her strong concern about the scarcity of peer-refereed papers for the Journal.

Council wishes to thank all the voluntary referees for their time and efforts and Dr M. Lake for his voluntary assistance in preparing the master pages for printing.

The Society received various requests for permission to reproduce material from the Society's earlier volumes of its 'Journal and Proceedings'.

Bulletin

Bulletin Nos 250 to 260 incl. were published during the period 2002–2003. Council extends its appreciation to the various authors of short articles for their contributions and to other voluntary helpers who assisted in the production and distribution of the Bulletin.

AWARDS

The following awards were made for 2002:

The Edgeworth David Medal:
Prof. Marcela Bilek of University of Sydney

The Clarke Medal (Botany): Professor Robert Hill of the University of Adelaide

The James Cook Medal was not awarded in 2002.

The Citations for the 2002 Edgeworth David and Clarke recipients were published previously in the Volume 135, Parts 3 and 4, which was published late in the first half of 2003.

A new initiative was undertaken by the Council during 2002 in conjunction with other State Royal Societies to offer a Eureka Prize for Interdisciplinary Scientific Research. The Award of A$10,000 for each year is to be offered over the subsequent three years.

MEMBERSHIP

At 31st March, 2003, Membership of the Society was:

Patrons	2
Honorary Members	9
Full Members	235
Associate Members	21
Total (incl. Spouse Members)	267
Resignations	14
New members admitted	6

Council announces with regret the names of the following four deceased members: Emeritus Professor S.W. Carey (Hon. Member), Dr E.R. Cole, Emeritus Professor, Sir R.W. Firth (Hon. Member) and Mr J.W. Humphries (former President).

LIBRARY

Acquisition of journals by gift and exchange has been continued during 2002/03. 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 cockroaches that cause significant damage to some of the older books. This unsatisfactory situation will, hopefully, he redressed once the Society has acquired more spacious and permanent accommodation.

ABSTRACT OF PROCEEDINGS

3rd April 2002:
The 135th Annual General Meeting and the 1105th General Monthly Meeting were held at the City Tattersall's Club, Pitt Street, Sydney. The President, Mr D.A. Craddock was in the Chair.

The Annual Report of Council for 2001–2002 was adopted, however, the Financial Report that was unavailable at the time was subsequently adopted at a later meeting at which time, Graeme Green, Chartered Accountant was appointed Auditor for 2002. A vote of thanks was extended to Barry Holden of B E Holden & Co, Chartered Accountants for his past services as Auditor. Barry Holden had indicated that he no longer wished to continue as Auditor. The out-going President, Mr D.A. Craddock then delivered his Presidential Address 'Antipodean Aeronautics'.

The awards for 2001 were announced as follows: Edgeworth David Medal: Dr Samantha Jane Richardson; Walter Burfitt Prize: Professor Michael Parker; Clarke Medal (Geology): Dr Gordon Howard Packham; The Royal Society of New South Wales Medal: Prof. Peter Allan Williams.

The following members were elected to Council for 2002–2003:

President	Mr D.A. Craddock (immediate past President – re-elected)
Vice Presidents	Prof. W.E. Smith Prof. P.A. Williams 3 vacancies
Hon. Secretary	vacant
Hon. Secretary	Mrs M. Krysko von Tryst
Hon. Treasurer	Dr R.A. Creelman
Hon. Librarian	Dr E. Lassak
Councillors	Ms K. Kelly Dr J. Kelly Mr C.M. Wilmot Mr M. Wilmot 5 vacancies
Southern Highlands Rep.:	Mr H.R. Perry

1st May 2002:
The 1106th General Monthly Meeting was held in the 'Search and Discover Room', Australian Museum, William Street, Sydney. Dr Tony Collings, a biophysicist with the CSIRO Division of Telecommunications and Industrial Physics gave a talk on 'Broadbeach Revisited', reviewing aspects relating to the archaeological findings of an ancient Aboriginal burial ground at Broadbeach on the Queensland Gold Coast. Dr Michael Lake offered a vote of thanks.

1st June 2002:
The 1107th General Monthly Meeting was held as a Special Joint Meeting with Members of the Powerhouse Museum Society on a Saturday afternoon as 'An Afternoon of Science and Music'. The meeting was held in the Target Theatre of the Powerhouse Museum in Harris St, Ultimo. Speakers were Professor Joe Wolfe who gave a talk on 'Musical Instruments and How They Work' and Professor Ian Johnston who gave a talk entitled 'Music, Physics and the Puzzle of Consonance' — both fascinating presentations carefully interwove music with science.

3rd July 2002:
The 1108th General Monthly Meeting was held in the 'Search and Discover Room', Australian Museum, William Street, Sydney. Professor Peter Leverett of the School of Science, University of Western Sydney gave a talk entitled 'In the Lap of the Gods — the Accreditation of New Minerals'. A vote of thanks was extended by the president, David Craddock.

7th August 2002:
The 1109th General Monthly Meeting was a special event held in the Barnett Court of the Justice and Police Museum, corner of Phillip and Albert Streets, Sydney. The Curator of the Museum, Margot Bray addressed the Meeting with a talk entitled 'Fair Deeds and Foul: The History of the Justice and Police Museum and Policing in New South Wales'. Following a tour of the exhibits held in the Museum, the President thanked Margot Bray for her fascinating presentation.

4th September 2002:
The 1110th General Monthly Meeting was held in the 'Search and Discover Room', Australian Museum, William Street, Sydney. Professor Phillip Moore of the School of Science, Food and Horticulture, University of Western Sydney delivered the lecture entitled 'Skin Deep'; a talk about skin, hair follicles and their growth. A vote of thanks was then extended by Councillor, Karina Kelly.

2nd October 2002:
1111th General Monthly Meeting combined with the conclusion of the 135th Annual General Meeting, that was adjourned from the 3rd April 2002 for acceptance of the Financial Report for 2001-2002 and the appointment of Graeme Green as Auditor for 2002-2003. The meetings were held in the 'Search and Discover Room', Australian Museum, William Street, Sydney. The General Meeting was addressed by Dr Alexander Ritchie who was Palaeontologist at the Australian Museum until his retirement in 1995 and currently Research Fellow of the Museum. Dr Ritchie gave a lecture entitled 'Fishing with a Hammer and a Chisel'; a talk on the Devonian fossil fish finds of the exciting Canowindra deposit and excavation project in central west New South Wales.

2nd November 2002:
The 1112th General Monthly Meeting was the second Special Joint Meeting with Members of the Powerhouse Museum Society held for the year on a Saturday afternoon on the theme 'The Science of Science Wine'. Roger Harris, Winemaker at Brindabella Hills Winery and formerly of CSIRO, and Professor Malcolm Allen of Charles Sturt University gave a talk on 'Red Wine — More Than Just a Vibrant Colour'. A vote of thanks was extended by Vice President, Professor Peter Williams.

9th April 2003:
The 1114th General Monthly Meeting took place at the Lecture Theatrette of the Sydney Harbour Foreshore Authority, 1 Hickson Street, The Rocks, Sydney. It was combined with the 136th Annual General Meeting. The President, David Craddock presented his Presidential Address entitled 'Publish and Perish'. A vote of thanks was extended by Councillor, Jak Kelly.

SOUTHERN HIGHLANDS BRANCH

The Southern Highland Branch held ten meetings (attendance around 60 to 65 members and visitors at each meeting). All meetings were held in the Lecture Room at Frensham School, Waverley Parade, Mittagong, New South Wales.

21st March 2002:
The 72nd Ordinary General Branch Meeting was combined with the Branch's Annual General Meeting at which the Chairman's Report for the year March 2001 to February 2002 was presented. The Committee for 2002/3 was also elected:

Chairman: Mr Clive Wilmot
Vice-Chairman: Mr Roy Perry B.Sc.
Hon. Secretary: Commander D.J. Robertson C.B.E.
Hon. Treasurer: Ms Christine Staubner
Member: Miss Marjory Roberts

Following the General Meeting, Dr Lynne McLaughlin, Lecturer in Environmental Education in the Graduate School of the Environment, Macquarie University delivered the lecture entitled 'Is our Environmental Past "A Foreign Country"'. The meeting was attended by 64 members and friends.

11th April 2002:
The Speaker for the 73rd Meeting was Mr James Woodford, Environmental Reporter for the Sydney Morning Herald newspaper. He spoke on 'Wombats – Australia's Most Underrated Animals – Pests or Biological Superathletes?'. The Meeting was attended by 72 members and visitors including a number of students.

16th May 2002:
An audience of 61 was addressed at the 74th Meeting by Dr Nick Lomb, Curator of Astronomy, Sydney Observatory who spoke on 'The History and Activities of the Sydney Observatory'.

20th June 2002:
The 75th Meeting was attended by 71 members and friends. Following the meeting, Dr Samantha Richardson, ARC Research Fellow at the Russell Grimwade School of Biochemistry and Molecular Biology, University of Melbourne, spoke on the subject 'How Evolutionary Studies on Australian Marsupials will lead to the Treatment of Some Diseases in Humans'

18th July 2002:
The scheduled meeting was cancelled as the speaker was unable to attend at the last

minute and an alternate speaker could not be found at short notice.

15th August 2002:
The 76th Meeting was attended by 43 members and friends. Dr Tony Collings of the CSIRO spoke on ‘The Problems Raised by the Discovery of an Aboriginal Burial Site at Broadbeach, Queensland’.

19th September 2002:
A large audience of 86 members and friends attended the 77th Meeting. The speaker for the evening was Professor Joe Wolfe of the University of New South Wales who addressed the meeting with his talk entitled ‘Musical Instruments and How They Work’. The discussion focussed on wind instruments, in particular, woodwinds.

17th October 2002:
The Speaker for the 78th Ordinary General Meeting was the Archaeologist, Mr Wayne Johnson. He spoke on ‘The Archaeology and a New Perspective on the Settlement of Sydney’ in which he discussed the reasons behind the decision to build the battery (Sydney’s earliest Fort) at Dawes Point and its later excavation and restoration. Regrettably, only 47 people attended due to a clash with another society’s meeting.

22nd November 2002:
The 79th Branch Meeting marked the occasion for the Royal Society of New South Wales’ Liversidge Memorial Lecture which was delivered by Professor Graham Johnston AM of the Department of Pharmacology, University of Sydney. Prof. Johnston’s lecture was entitled ‘Chemicals in Our Diet May Influence Brain Function’. The adult audience of 89 was very enthusiast and a vote of thanks was extended by Councillor, Ross Woollett.

20th February 2003:
The 87th Ordinary General Branch Meeting was attended by 85 people. Professor Ian Plimer of the University of Melbourne addressed the Meeting with his talk entitled ‘Is Greenhouse Gas All Hot Air?’. The talk placed emphasis on the nature, effects and production of the so-called ‘Greenhouse Gases’.

ACKNOWLEDGMENTS

The Council wishes to give a special thanks to Mr Edric Chaffer, for his assistance in the Society’s Office, and especially to Mrs Krysko von Tryst for her 34 years as the Hon. Secretary (Editorial) of the Society’s Journal.

The Chairman of the Southern Highlands Branch, 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.

Independent Audit Report to Members

For the year ended 31^{st} December 2002

SCOPE

I have audited the financial statements, being the Statement of Income and Expenditure, Balance Sheet & Notes to and forming part of the financial statements of The Royal Society of New South Wales for the year ended 31 December, 2002. The Council is responsible for the financial statements. I have conducted an independent audit of these financial statements in order to express an opinion on them to the members.

My audit has been conducted in accordance with Australian Auditing Standards to provide reasonable assurance as to whether the financial statements are free of material misstatement. My procedures included examination, on a test basis, of evidence supporting the amounts and other disclosures in the financial statements and the valuation of accounting policies and significant estimates. These procedures have been undertaken to form an opinion as to whether, in all material respects, the financial statements are presented fairly in accordance with Australian Accounting standards and other professional reporting requirements so as to present a view which is consistent with my understanding of the Society's position and the results of its operations.

The audit opinion expressed in this report has been formed on the above basis.

AUDIT OPINION

In my opinion, the financial statements present fairly in accordance with Australian Accounting Standards and other mandatory reporting requirements the financial position of The Royal Society of New South Wales as at 31 December, 2002 and the results of its operations for the year then ended.

G.M. Green
Registered Auditor No. 15169

(Original signed by G.M. Green in Sydney on 18^{th} April 2003)

Statement by Members of Council

For the year ended 31^{st} December 2002

In the opinion of the committee the financial statements:

present fairly the financial position of The Royal Society of New South Wales at 31 December, 2002 and the results for the year ended on that date in accordance with Australian Accounting Standards and other mandatory professional reporting requirements;

at the date of this statement, there are reasonable grounds to believe that the Society will be able to pay its debts as and when that fall due.

This statement is made in accordance with a resolution of the council and is signed for and on behalf of the Council by:

President ____________________ (Original signed by D.A. Craddock)

Hon. Treasurer ____________________ (Original signed by Dr R.A. Creelman)

Dated this 2^{nd} day of May 2003

Notes

Notes

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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 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 Australian Oxford 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.

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

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.

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.

Details of submission guidelines can be found in the on-line Style Guide for Authors at http://nsw.royalsoc.org.au/

MASTER MANUSCRIPT FOR PRINTING

The journal is printed from master pages prepared by the $\LaTeX\,2_\varepsilon$ typesetting program. 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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Vol. 136 Parts 1–4

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