Journal and Proceedings of the Royal Society of New South Wales

VOLUME 115 1982 PARTS 3 and 4
(Nos. 227 and 228)

Published by the Society
Science Centre, 35 Clarence Street, Sydney
Issued February, 1983
ISSN 0035-9173

THE ROYAL SOCIETY OF NEW SOUTH WALES

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ISSN 0035-9173

JOURNAL AND PROCEEDINGS

OF THE

ROYAL SOCIETY OF NEW SOUTH WALES

VOLUME 115

PARTS 3 and 4 (Nos. 325 and 326)

1982

ISSN 0035-9173

PUBLISHED BY THE SOCIETY
SCIENCE CENTRE, 35 CLARENCE STREET, SYDNEY

Journal and Proceedings, Royal Society of New South Wales, Vol. 115, pp. 79-86, 1982
ISSN 0035-9173/82/0201 — 08 $4.00/1

Late Permian Acritarchs from the Northern Sydney Basin

A. McMinn

ABSTRACT. Five species of spinose acritarchs were encountered in the Late Permian coal measure sequences of the northern Sydney Basin. They occur both in those units previously thought to be marine, such as the Denman Formation, and occasionally in those directly associated with coal seams, e.g. the Middle River Coal. *Mehlisphaeridium* sp. cf. *M. fibratum* Segroves 1967 has a restricted stratigraphic range and is useful in correlating coal bores throughout the basin; the other species are either uncommon or range throughout the Late Permian sequence. *Ulanisphaeridium* is described as a new genus and *U. berryense* is described as a new species.

INTRODUCTION

Because of the need to evaluate the huge coal reserves of the northern Sydney Basin, this area has become the most densely drilled area in New South Wales. In spite of the resulting large volume of drill core, correlations within the sequence remain difficult. Rapid lateral variations in facies and frequent coal seam splitting hamper all but local interseam correlations based on lithology alone. Dulhunty (1945, 1946) aimed to use spore-pollen types to characterise individual coal seams and thus enable interseam correlations on a local and regional basis. Unfortunately, thirty-five years later, his original aspirations remain unrealised.

A palynological zonation for the Permian System in eastern Australia was first developed by Evans in a series of unpublished records (Evans 1964, 1966a, b, c, 1967a, b) and later published (Evans 1969). This framework of five stages was further developed and modified in part by Paten (1969) and Price (1976). The most recent developments in this zonation are presented by Kemp et al. (1977). This latter publication divides Evans' original five stages into eleven subzones. In the northern Sydney Basin almost the entire coal measure sequence, in some areas over 1500m thick, is contained within a single subzone, i.e. Upper Stage 5. Therefore there is a need to find biostratigraphically useful palynomorphs within this interval. In this initial investigation seven sections (see fig. 1) from the Singleton, Ulan and Lithgow areas are studied; these are:

DM Doyles Creek DDH 10
DM Doyles Creek DDH 11
DM Warkworth DDH 1
JDP Ulan DDH 6
JDP Ulan DDH 13
Elecom Lithgow-Newnes DDH 31
Browns Gap Road Section

Illustrated specimens are stored in the Mining Museum Micropalaeontology Collection (MMMC) of the Geological Survey of N.S.W.

PALYNOSTRATIGRAPHY

Traditionally, spinose acritarchs have been considered to indicate marine influence in sedimentation. In the northern and western coalfields of the Sydney Basin they are found in those units usually associated with marine sedimentation such as the Maitland Group, Berry Siltstone, Denman Formation and Bulga Formation and also in some units associated with coal deposition. Recent investigation of the depositional environments of many of these coal units in the western and northern coalfields indicates that they often had a deltaic origin (Herbert 1980) with some degree of marine influence evident.

Most acritarch species encountered during this investigation are long ranging and thus of only limited use in biostratigraphy. It was found however, that at least one species, *Mehlisphaeridium* sp. cf. *M. fibratum*, had its first local occurrence within the sequence. The level of this first local occurrence was found to be at stratigraphically and biostratigraphically equivalent positions within six of the seven sections investigated. The first local occurrence of *M.* sp. cf. *M. fibratum* was between the Bayswater Coal and the Denman Formation of the Singleton Super-Group and between the Irondale Coal and a unit equivalent to the Denman Formation in the Illawarra Coal Measures. This species only occurs above the first occurrence of the spore *Dulhuntyispora parvithola* (Balme & Hennelly) Potonie 1960. The first occurrence of *M.* sp. cf. *M. fibratum* in the Sydney Basin is thus a valuable biostratigraphic datum and can be used in regional correlation between bores. It should be noted that although *M.* sp. cf. *M. fibratum* is useful in regional correlations, *M. fibratum* s.s. occurs in considerably older strata in Western Australia and central Queensland.

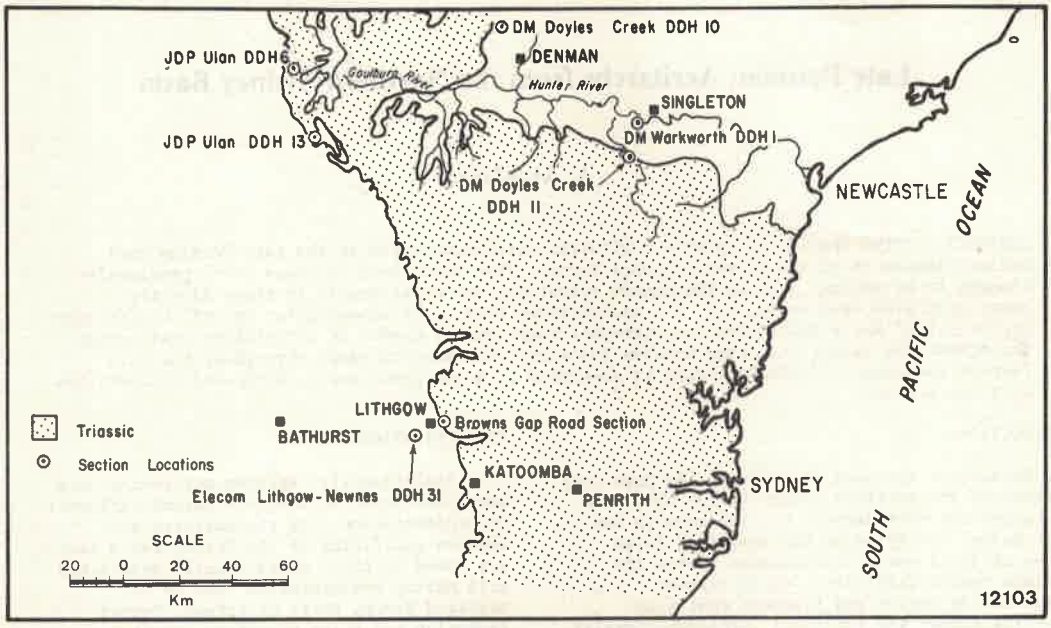

Fig. 1. Location of coal sequences

Figure 2 shows the correlations between the northern and western coalfields based on the first local occurrence of *M.* sp. cf. *M. fibratum*. In each bore the first occurrence of this species is slightly lower than the base of the marine to marginal marine Denman Formation and its western equivalents. The Denman Formation is composed of fine grained, grey to black siltstone and mudstone. It frequently shows burrows and other evidence of bioturbation; a marine microfauna is sporadically present (Scheibnerova pers. comm.). The burrow structures, microfauna and acritarch assemblages of the Denman Formation suggest a shallow marine environment of deposition.

The geographical distribution of acritarchs in the Late Permian of the northern Sydney Basin is apparently uneven. Acritarchs appear to be more common in the Illawarra Coal Measures than in the Singleton Super-Group. This greater abundance of acritarchs in the western areas may relate to environmental differences as there is also a higher ratio of spores to pollen in the Illawarra Coal Measures. An unusual abundance of acritarchs occurs in association with the Middle River Coal of the Illawarra Coal Measures. Acritarchs are found in clay bands actually within the coal seam. The Middle River Coal of the western Illawarra Coal Measures is usually correlated with the Wongawilli Coal of the south-western Illawarra Coal Measures. Byrnes et al. (1981) reported inarticulate brachiopods in clay-bands of the latter seam and suggested a possible marine influence on its deposition. The acritarch assemblages of the Middle River Coal are dominated by *M.* sp. cf. *M. fibratum*.

Two other species of acritarchs occur commonly in the Late Permian coal measures sequence and these are *Micrhystridium karamurzae* Sarjeant 1970 and *Ulanisphaeridium berryense* gen. et sp. nov. Both range throughout the Late Permian coal sequence and have also been recorded from both older and younger strata in other areas. The species *Quadrisporites horridus* Hennelly 1958, although common in sequences of similar age elsewhere, was found in only two samples in this study and these were both from high in the sequence. This species is not further discussed here. A fifth species, *Micrhystridium* sp. cf. *M. inconspicuum* (Deflandre) occurs only in the Berry Siltstone. The rarity of this species however reduces its usefulness as a biostratigraphic datum.

SYSTEMATIC PALAEONTOLOGY

ALGAE INCERTAE SEDIS
Genus MEHLISPHAERIDIUM Segroves 1967

Type species *Mehlisphaeridium fibratum* Segroves 1967

MEHLISPHAERIDIUM sp. cf. M. FIBRATUM Segroves
(Plate 1, figs 3, 4, Plate 2, figs 3, 5)

Description: This form has a spheroidal, two-layered vesicle bearing between 8 and 30 hollow, conical processes (average 15). These processes, which are between 2 µm and 6 µm long, emanate from the outer wall only and often display a coarse, granular structure of anastomosing fibres. Some of these processes open distally. A definite excystment aperture has not been identified on any specimen.

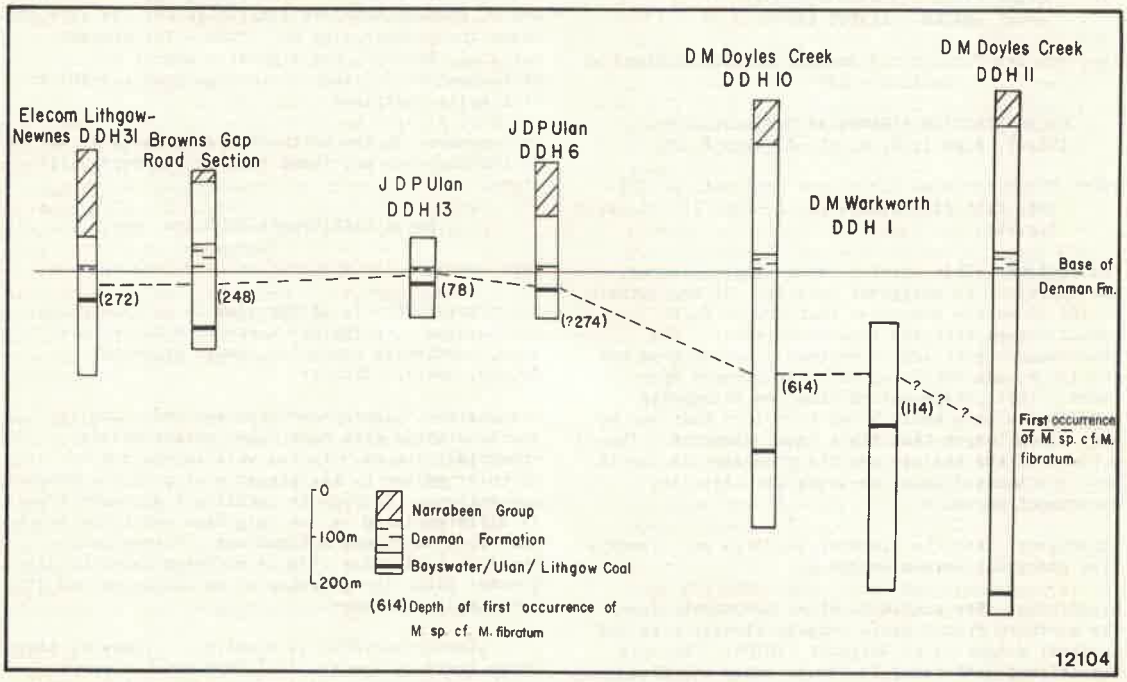

Fig. 2. Correlation of first occurrence of *Mehlisphaeridium* sp. cf. *M. fibratum*

Dimensions: Specimens from the Sydney Basin have a vesicle size range of 13(21)35 µm; 20 specimens were measured.

Discussion: There is a considerable size difference between *M. fibratum* and *M.* sp. cf. *M. fibratum*. Segroves (1967) described *M. fibratum* as having an equatorial diameter of between 37 µm and 94 µm and as having between 5 and 39 processes that were between 5 µm and 30 µm long. The Sydney Basin specimens vary in size between only 13 µm and 35 µm and have fewer, shorter processes.

Specimens in the larger size range have also been illustrated by Foster (1975) from the Early Permian Blair Athol Coal Measures. Specimens from the smaller size range have been illustrated by Rigby & Hekel (1977) from the Late Permian Black Alley Shale and Bandanna Formation of central Queensland. From the few scattered reports of these two forms it appears that the smaller forms, i.e. *M.* sp. cf. *M. fibratum*, may be restricted to the Late Permian. More information on the range of these two forms, particularly in the Early Permian, is needed before any division into separate species would be warranted. Further study of other Permian sequences may also reveal a possible relationship between the environment of deposition and the distribution of these two forms. At the present time the first local occurrence of *M.* sp. cf. *M. fibratum* provides a useful biostratigraphic horizon for correlating between bores in the northern Sydney Basin.

Occurrence: This species was originally described from the Early Permian Poole Sandstone or lowermost Noonkanbah Formation of the Canning Basin, Western Australia by Segroves (1967). It has been illustrated subsequently from the Springsure Anticline, Bowen Basin, central Queensland by Rigby & Hekel (1977) where it occurs probably only in the Late Permian. In their treatment of acritarchs Rigby & Hekel (1977) only distinguished between spinose and non-spinose acritarchs and made no attempts at specific identification. Of their five illustrations of specimens that can be assigned to *M.* sp. cf. *M. fibratum*, all occur in the Late Permian. *M. fibratum* was also recorded from the Early Permian Blair Athol Coal Measures (Foster 1975) and from the Late Permian Baralaba Coal Measures (Foster 1979).

In the Singleton Super-Group *M.* sp. cf. *M. fibratum* first occurs midway in the sequence between the Bayswater Coal and the Denman Formation, probably in the lower Malabar Formation. In the western Illawarra Coal Measures it first occurs between the Irondale Coal and the western equivalent of the Denman Formation. The species is not present in the type section of the Singleton Super-Group at DM Doyles Creek DDH 11 but is present in the nearby bores DM Doyles Creek DDH 10 and DM Warkworth DDH 1.

Genus MICRHYSTRIDIUM Deflandre 1937
emend. Lister 1970

Type species *Micrhystridium inconspicuum* (Deflandre) Deflandre 1937

MICRHYSTRIDIUM KARAMURZAE Sarjeant 1970
(Pl. 1, figs 1, 5, 6, pl. 2, figs 1, 2)

1970 *Micrhystridium karamurzae* Sarjeant, p. 282-283, text fig. 2, 3h, pl. 1, fig. 17, pl. 2, fig. 6.

Description: This species has a single layered, sub-spherical to polygonal vesicle. It has between 15 and 30 hollow processes that are in full communication with the vesicle interior. The processes vary in length between 2 µm and 8 µm and display a wide variation in shape between specimens. Their shape varies from low triangular projections with broad bases to spines that may be many times longer than their basal diameter. The surface of the vesicle and the processes is smooth. Most specimens display an irregular slit-like excystment aperture.

Dimensions: Vesicle diameter 11(20)24 µm. Twenty-five specimens were measured.

Discussion: The specimens of *M. karamurzae* from the northern Sydney Basin compare closely with the original diagnosis of Sarjeant (1970). The only significant difference is the presence of wider process bases in the Sydney Basin specimens. *M. karamurzae* is most similar to the early Palaeozoic species *Micrhystridium nanum* (Deflandre) Deflandre & Deflandre 1965 and *Micrhystridium stellatum* Deflandre 1945. These two species, which represent end members of a size distribution (Lister 1970), always have a relatively greater process length (i.e. always greater than one third vesicle diameter), than *M. karamurzae* (i.e. usually less than one third vesicle diameter).

Micrhystridium breve Jansonius 1962 has a similar size and shape but a greater number of processes (30-50). *Micrhystridium inconspicuum* (Deflandre) Deflandre 1937 has finer processes and is consistently smaller than *M. karamurzae*.

Occurrence: *Micrhystridium karamurzae* is present throughout the Late Permian Maitland Group and Denman Formation of the northern Sydney Basin. Foster (1979) has also recorded it from the Late Permian of Queensland. It was originally described by Sarjeant (1970) from the Late Permian Chhidru Formation of Pakistan.

MICRHYSTRIDIUM sp. cf. M. INCONSPICUUM (Deflandre)
(Pl. 1, fig. 2)

Description: The vesicle is spheroidal to ellipsoidal in shape, single layered and supports between 40 and 80, probably hollow, thin processes that are between 4 µm and 8 µm long. Many processes show slightly expanded bases. Slit-like excystment apertures were observed on many specimens.

Dimensions: Vesicle diameter 6(8)12 µm. Ten specimens were measured.

Discussion: *Micrhystridium* sp. cf. *M. inconspicuum* and *M. inconspicuum* are similar in vesicle size and shape and process size and shape. The present material, however, has a greater number of processes (40-80) than *M. inconspicuum* (15-40) as originally described.

Occurrence: In the northern Sydney Basin *M.* sp. cf. *M. inconspicuum* was found only in the Berry siltstone.

Genus ULANISPHAERIDIUM gen. nov.

Type species *Ulanisphaeridium berryense* sp. nov.

Diagnosis: Vesicle ellipsoidal to sub-spherical, two-layered. Periphragm supports a dense cover of fine, proximally connected, small processes. Pylome, small, circular.

Discussion: *Ulanisphaeridium* gen. nov. can be differentiated from most other approximately spheroidal genera with two wall layers and a circular pylome by the presence of proximal process connections. *Dasylapsis* Loeblich & Wicander 1976 is differentiated by its very fine processes which interlock to form a fibrous mat. *Nanocylopia* Loeblich & Wicander 1976 is differentiated by its greater size, the presence of an operculum and its very small processes.

Ulanisphaeridium is monotypic. However, the Early Tertiary species '*Baltisphaeridium nanum*' Cookson 1965 described from the Browns Creek Clay, Victoria, Australia, fits the generic diagnosis. '*Baltisphaeridium nanum*' Cookson, however, is a junior homonym preoccupied by *Micrhystridium nanum* (Deflandre), which had previously been assigned to *Baltisphaeridium* by Downie (1959). As this paper discusses only Permian forms no new name is introduced for the Tertiary species at this stage.

Derivation of name: The name is derived from the type location at Ulan, N.S.W.

ULANISPHAERIDIUM BERRYENSE sp. nov.
(Pl. 1, figs 7-9, pl. 2, figs 4, 6)

1970 *Micrhystridium* sp. Grebe; pl. 6, fig. 7, 10.
1973 *?Micrhystridium* sp. Helby; pl. 3, fig. 10.
1979 *Micrhystridium* sp. B. Foster; p. 110, pl. 40, figs 2, 3.

Description: The vesicle is small and spheroidal to ellipsoidal. The vesicle wall is composed of two closely appressed layers; a thick (2 µm) smooth endophragm and a very thin (<1 µm) periphragm. The periphragm supports a dense network of proximally connected short, solid and sometimes bulbous, fibrous processes. The low connecting ridges between the processes form a poorly defined reticulation that can be detected only by S.E.M. (Pl. 2, figs 4, 6). The processes vary in thickness and length (1-3 µm) and occasionally bifurcate. A small circular pylome (2-4 µm) is usually present around which the ornament is often reduced. Oxidation and carbonisation readily removes the thin periphragm.

Dimensions: Vesicle diameter 13(19)22 µm (12 specimens from type location).

Discussion: *Ulanisphaeridium berryense* sp. nov. resembles the Tertiary species '*Baltisphaeridium nanum*' Cookson. This species has a similar vesicle size (23 µm - 34 µm), shape and pylome but can be differentiated by its very large number of longer (5 µm - 13 µm) extremely fine, hair-like processes. *Axisphaeridium tomentum* Colbath 1979 can be differentiated from *U. berryense* by its significantly thinner wall (<0.5 µm) and hollow processes. *Gorgonisphaeridium evexispinosum* Wicander 1974 and *Histopalla capillosa* Playford 1981 have similar ornament but lack the circular pylome of *Ulanisphaeridium*.

Occurrence: *Ulanisphaeridium berryense* occurs throughout the upper Maitland Group, Singleton Super-Group, Berry Siltstone, Illawarra Coal Measures and lower Narrabeen Group; Middle to Late Permian.

Type Material: The holotype is located on slide MMMC 01620, Palynology No. 3553. Length 22 µm, width 20 µm, processes 2 µm long, pylome diameter 2 µm. The paratype is located on slide MMMC 01622, Palynology No. 3553. Length 22 µm, width 21 µm, processes 3 µm long, pylome diameter 2 µm. The type location is at 268m, DM Ulan DDH 6, northern Sydney Basin, Illawarra Coal Measures. The name *berryense* is derived from the Berry Siltstone, a unit in which this species is common.

ACKNOWLEDGEMENTS

I would particularly like to thank Dr. R.J. Helby for the time he has spent reviewing the manuscript. This article is published with the permission of the Secretary, New South Wales Department of Mineral Resources.

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(Manuscript first received 2.2.81)

(Manuscript received in final form 14.10.82)

EXPLANATION OF PLATE 1

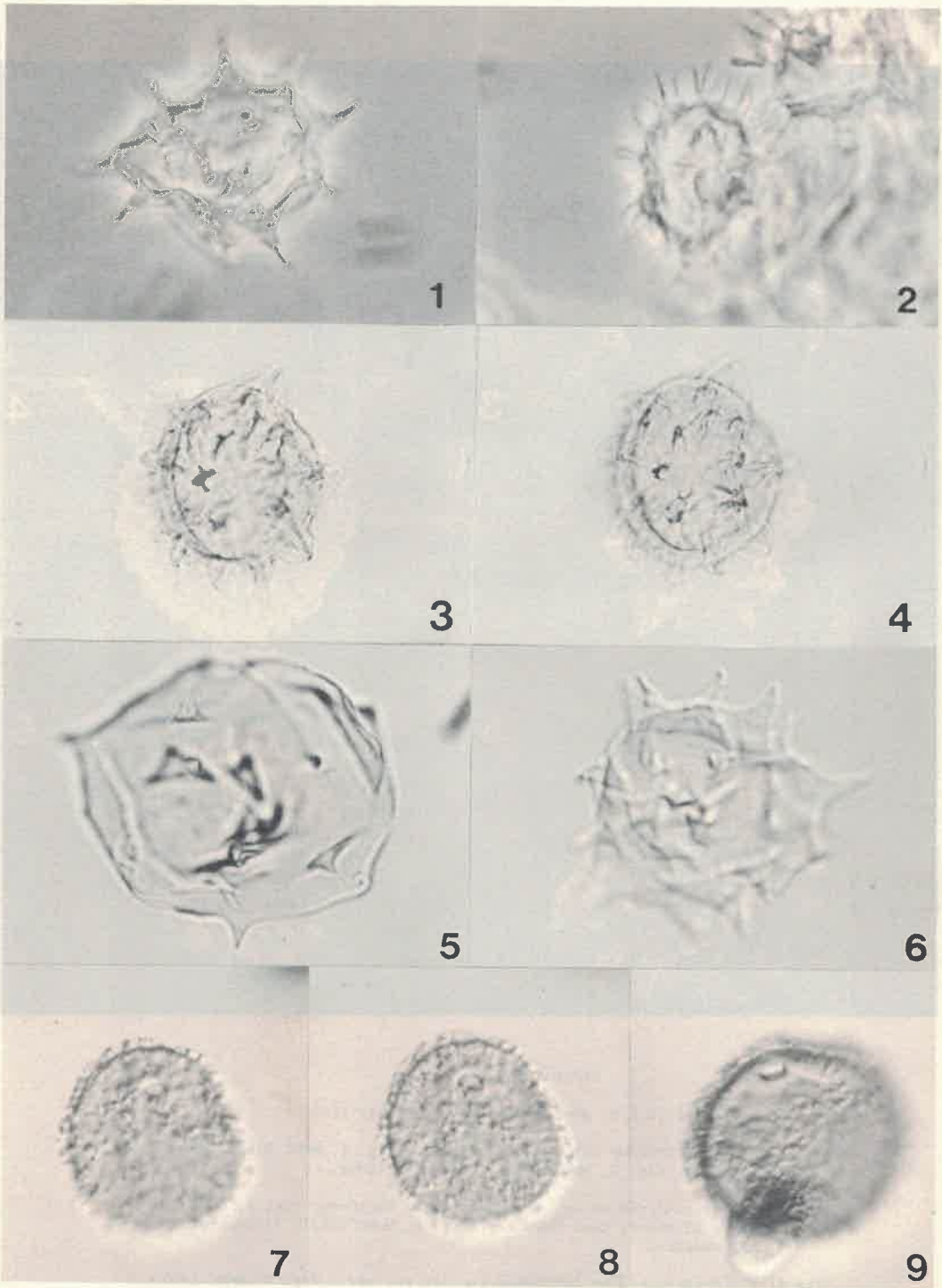
All photographs approximately X1200

Figs 1, 5, 6 *Micrhystridium karamurzae* Sarjeant; fig. 1 MMMC 01614, Berry Siltstone, phase contrast; fig. 5. MMMC 01681, Denman Formation, showing pylome; fig. 6 MMMC 01619, Berry Siltstone, interference contrast.

Fig. 2 *Micrhystridium* sp. cf. *M. inconspicuum* (Deflandre), MMMC 01615, Berry Siltstone, phase contrast.

Figs 3, 4 *Mehlisphaeridium* sp. cf. *M. fibratum* Segroves; fig 3, 4, MMMC 01616, Illawarra Coal Measures.

Figs 7, 8, 9 *Ulanisphaeridium berryense* gen. et sp. nov.; figs 7, 8, Holotype, MMMC 01620, Illawarra Coal Measures, interference contrast; fig. 9, Paratype, MMMC 01622 Illawarra Coal Measures, interference contrast.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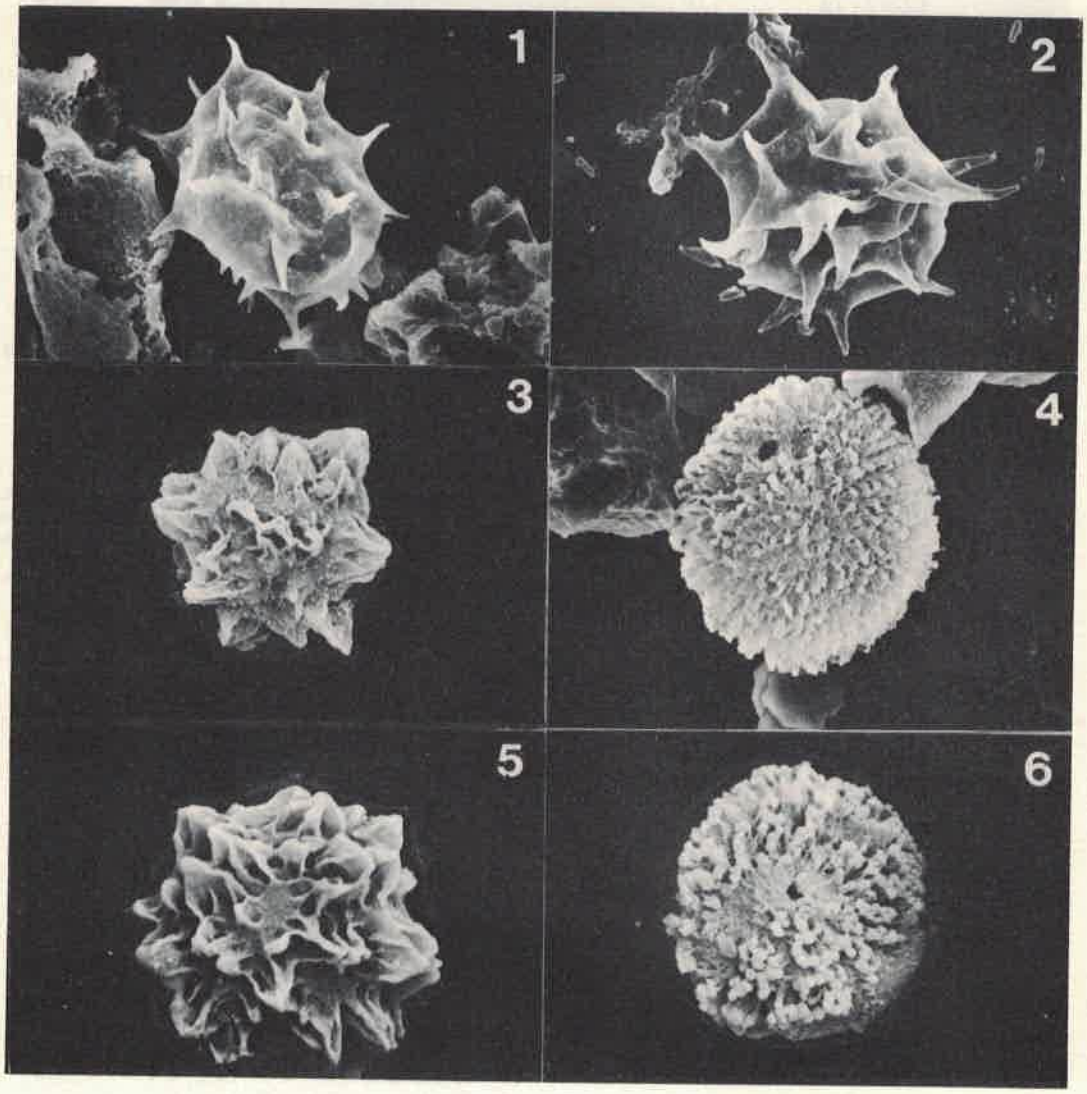

EXPLANATION OF PLATE 2

All S.E.M. photographs approximately X1200

Figs 1, 2 *Micrhystridium karamurzae;* Sarjeant; fig. 1, MMMC 01623 Berry Siltstone, fig. 2, MMMC 01624, Berry Siltstone.

Figs 3, 5 *Mehlisphaeridium* sp. cf. *M. fibratum* Segroves; fig. 3, MMMC 01625, Illawarra Coal Measures, fig. 5, MMMC 01627, Illawarra Coal Measures.

Figs 4, 6 *Ulanisphaeridium berryense* gen. et sp. nov.; fig. 4, MMMC 10626, Illawarra Coal Measures; fig. 6, MMMC 10628, Illawarra Coal Measures.

Journal and Proceedings, Royal Society of New South Wales, Vol. 115, pp. 87-94, 1982
ISSN 0035-9173/82/0202 — 08 $4.00/1

Ethical Problems of Modern Science and Technology

The Royal Society of New South Wales conducted a Symposium on 'Ethical Problems of Modern Science and Technology' on the 4th of November, 1981.

The following are abstracts of two of the addresses delivered before the Royal Society of New South Wales:-

1. Pollak, John K. : 'The Ethical Problems of the Modern Scientist'

2. Orme, W.J. : 'Privacy and Modern Science and Technology'

THE ETHICAL PROBLEMS OF THE MODERN SCIENTIST

JOHN K. POLLAK

The ethical problems of the modern scientist are considerably more difficult to solve than those of scientists of former ages.

Up to and including the 19th century the idea of freedom of research could have passed unchallenged (with some notable exceptions, including Galileo Galilei). The 19th century was a time when science was a gentlemanly pursuit with relatively few pressures on the scientist. In the last century it was often stated that science owed more to the steam-engine, than the steam engine to science. In other words, the world was still sceptical of the relevance of science to technology.

During the 19th century, science belonged largely to those who could afford to practice it in a european society. Moreover the value of human beings living outside that society (making up more than 75% of the world's population) could be conveniently neglected.

In contrast we now live in a world where the major industrial powers are committed to scientific research. It is the results of scientific and technological research which maintains the control system of these powers - political, military and economical.

A number of pressures impinge on the modern scientist with the result that on the one hand his autonomy is threatened, while on the other hand he is made accountable for the use and misuse of science for technological purposes. The autonomy and accountability of the scientist are interrelated and depend on what Ravetz calls the meeting of knowledge and power (1). Because of the power that knowledge can provide, the autonomy of the scientist is threatened by those who want to exploit the knowledge and power provided by the scientist for technological applications. At the same time scientists are regarded by the public as morally accountable for the technological uses and misuses of science. Yet, when a fundamental research problem is conceived and while the research is being carried out, the technological uses and misuses arising from this work are usually not apparent. (Rutherford when questioned on the value of his research on splitting the atomic nucleus, replied that he could think of no useful applications of his work).

Before discussing the relationship between the consequences of the results of scientific research to society and the complex ethical problems confronting the scientist, I shall briefly deal with some other problems affecting the practice of science in the latter half of the 20th century. There are considerable pressures put on the modern scientist to produce results; these pressures are due partly to the increasing cost of scientific research, and partly due to the financial and psychological rewards that scientific research can produce. The drives to justify the cost of research, to produce results and to satisfy personal ambition probably have been at the core of a number of plagiaries, frauds and money-making activities that have increased in recent years. Some of these are so outlandish as to have good anecdotal value. Perhaps one of the most unusual recent cases led to the conviction of a senior scientist at New York University, who having lost the financial support of the National Science Foundation, turned his department to the manufacture of cocaine, LSD and methaqualone in an effort to provide sufficient research funds to keep expensive primate research projects going (2).

But these ethical problems confronting the modern scientist, while extremely serious, are not the ones which are uppermost in my mind. One problem which concerns me greatly is that of the restriction of the traditionally free, open and cooperative communication between scientists. In my view any restriction on the free flow of information goes counter to the long established ethos of science. The science ethos is characterized by intellectual honesty, universalism, organized skepticism, disinterestedness and wide and public accessibility to scientific knowledge (3). The loss of any of these attributes from the practice of science should be avoided at all costs. Furthermore it is also worth considering that deviations from the science ethos are likely to diminish the respect that the community has for the scientist, as this respect is based on the concept that scientists are involved in a disinterested, universally shared search for knowledge and understanding of nature.

Once it is realized that the practice of science is becoming secretive and profit-orientated, goodwill of the public may well disappear and with it the climate which supports research independent of industry and government interests.

The restriction of free communication between scientists may be imposed from the outside, as in instances when scientists work on classified government and military projects, or in industry when research and development of patentable processes are at stake. Self-imposed restriction on communication due to competition in a "hot" area of research is equally objectionable, particularly if it is coupled with the taking out of patents and formation of companies for financial benefit of either the individual scientist or the institute in which the scientist works (these moral decisions have to be made currently in the fields of cell biology and genetic engineering, 4, 5, 6, 7). When secrecy is imposed on scientific research by governments or industry, the scientist has the problem of divided loyalties -- to his government or employer on the one hand and to the science ethos on the other.

Any scientific research for the defence of one's country was in the past considered as an incontrovertible virtue, whether one's country was right or wrong. During the 2nd world war scientists still identified science with the service to the war effort of their nation. Probably the best examples are Leo Szilard and Albert Einstein, both pacifists, who convinced President Roosevelt at the time that it was imperative to have an atomic bomb before Germany obtained it. Since then the moral norm has changed and all patriotic acts are not necessarily accepted as moral. Many scientists believed that particularly the Vietnam war involved perversions of science (chemical and biological warfare and the use of napalm especially against the civilian population) and as such demanded the dissociation of the use, or misuse, of science-based technology and the scientific ethos.

Science generally had popular support until the Vietnam war, but then the confusion between

the responsibilities of the scientific community in safeguarding the integrity of the scientific enterprise as well as the political responsibilities of scientists as citizens, led to conflict. Those scientists who opposed the war on political grounds thought that the perverted use of science-based technology was incompatible with the scientific ethos and thus required the breaking of all links between the military and the scientific community. This led to the formation of Societies of Social Responsibilities in Science in many countries including Australia, and pledges by scientists NOT to engage in war work. Many senior, influential scientists (e.g. Linus Pauling) were very vocal about this. It was suggested that scientists who consistently used their skills in the service of killing should not be asked to attend scientific meetings and should not be recognized as members of the scientific community.

On the other hand those scientists who supported the war against the communists, considered the opponents of war as enemies of freedom, including the freedom of science. Thus the science ethos could provide no guidance for conduct in this situation of moral conflict.

Lastly I want to deal in more detail with the impact that science has on technology and the role that scientists can and should play in a technological society. This is not the venue to make an extensive list of all the problems generated by technology; obviously environmental problems, such as pollution, whether from the petrochemical industry, mining or nuclear reactors are foremost in one's mind. The production of toxic substances by industry (heavy metals effluents, organochlorines such as chlorinated biphenyls, vinyl chloride) are other examples. In addition, while before, the use of technology increased the opportunities for employment, the situation now is reversed, and science-based technology (such as the silicon-chip, robots and monoculture in agriculture) is leading to increased unemployment. Thus there seems to be a conflict between the technological application of science and the general good. The scientist is often caught in the middle of this confrontation.

There is little doubt that if it is left to the special interests that operate through the state or in the market place, some of the consequences of applied science or technology will assuredly be difficult or impossible to monitor, let alone control. The examples of nuclear weapons, nuclear reactors, micro-processors and more recently the development of the molecular biology industry should be a clear warning that more of these problems are to follow.

Additional difficulties arise when the involved scientist tries to investigate such technologies with the aim of minimizing their possible harmful effects. The science "expert" is called in and it is usually found that he is dealing with future contingencies on the basis of inadequate evidence and data. The scientist is then forced to choose between different uncertainties, invoking values and probabilities which really cannot be presented in completely objective, quantitative terms. In other words, scientists are called in as "experts" to make choices which under the circumstances are not amenable to evaluation using the scientific approach. The problems have become sociological and political ones and often the scientist is asked to make value judgements under the guise of scientific expertise. The neutrality and objectivity of science therefore seems to be lost under these circumstances. This also illustrates the dichotomy of the accountability of the scientist, one political to the community, the other moral to the scientific ethos.

It might be, that in the consideration of such problems, when it becomes extremely difficult to disentangle objective data from subjective value judgements and choices, the scientist is out of his depth, as he is no better educated or trained in this sphere than the average citizen. It is my contention that the proper approach in making such value judgements (e.g. rainforests for future generations? -- unemployment now?) is by a team. This team should include - apart from natural scientists - also one or more moral philosophers and social scientists who are better equipped to make the value judgements that are required to solve the problems which arise from the impact of the science-based technology on society. In his role as a private citizen the scientist should be encouraged to make value judgements. In his role as an "expert" called in to solve problems arising out of the impact of technology on society the value judgement of the scientist should take second place to his objective and neutral evaluation of the problem according to the science ethos.

ACKNOWLEDGEMENTS

I would like to thank my wife Audrey for critically reading the manuscript and improving it.

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1. Balancing Privacy and Fundamental Freedoms and Public Interest

1.1 Generally

One of the main reasons which makes privacy so complex is that it is not a separate entity which can be defined and evaluated in isolation, but is a factor in most aspects of modern life and, on some occasions, must give way to more important social objectives.

1.2 Privacy and Research

Privacy only becomes an issue when identifiable personal information is used. Equally, surveys and questions on a totally voluntary and unidentifiable basis do not create privacy problems.

Many researchers come to the Committee to discuss their questions and methodology in advance. The Committee's accumulated experience can be of assistance in the planning stages. Avoiding pitfalls can increase both response rate and the quality of the information.

The Committee does not evaluate the objectives of the research. Our function is to assist the researcher to achieve the desired objective without unjustified invasions of privacy. The Committee would wish to avoid the creation of licensing or government permission as a pre-requisite to conducting research. This would be a major fetter on scientific freedom.

1.3 Absolute Freedom of Research?

While privacy is not an absolute right neither is there an absolute right of a researcher to invade privacy within the armour of academic freedom.

Each must find an effective working relationship with the other. The scientist who cannot see how an individual's privacy is affected by a research project, which to him is one of vital importance, does science a disservice.

Particularly, I note that some researchers who argue so vehemently for their own research to be unfettered by privacy, are the first to complain when their own privacy is invaded by another.

2. Ingenuity Avoids Conflicts

We have found that, with reasonable care and ingenuity, most research objectives can be fairly achieved. One might even ask, who should have greater ingenuity than a competent researcher?

For example, the Committee was approached after researchers had been refused access to medical insurance fund data on women who had had hysterectomies. They wished to contact the women but the fund quite properly refused to supply the names and addresses.

While agreeing with the fund, the Committee recommended that it should send an explanation of the survey to the women on behalf of the research body. The explanation would outline the purpose of the research and ask those women who wished to participate to contact the researchers direct.

This method was adopted and more than sufficient women volunteered to participate in the survey.

Many other examples are set out in the Committee's annual reports.

Researchers are invited to contact the Committee to discuss their proposals or problems that might arise during the course of research, at any time. (Copies of the Committee's two relevant papers on the subject, Guidelines for Surveys - No. 42, November,1979; Research and Confidential Data: Guidelines for Access - No. 35 September, 1978 are available from the Committee on request.

3. What Confidentiality can a Researcher Promise?

The Committee finds that confidentiality can be breached as a result of subpoenas, government powers, search warrants etc., professional clumsiness or lack of physical security. These should all be borne in mind when confidentiality is promised.

3.1 Subpoenas, Government Powers and Search Warrants

There are many provisions for subpoenas, search warrants and other Government powers which make absolute confidentiality impossible. The Committee has developed guidelines with judges, police and other relevant bodies which have worked successfully in New South Wales since they were published in July, 1980. They are too complex to deal with in the time available but they have been widely circulated through professional bodies and magazines and copies are available from the Committee on request (see Appendix).

I might say, however, that the Committee is currently questioning some of the Government powers that do exist and will be reporting on its concern soon.

3.2 Professional Clumsiness

Sheer clumsiness can cause substantial embarrassment to research subjects. A doctor's patient complained to the Committee that he had identified her without her consent, in a case study submitted by him as part of his application for membership of a professional college. The conduct of both the doctor and the College confirmed this view even though they vehemently denied the allegation.

With the consent of the woman I inspected the case study and found that not only did the anonymised details clearly identify the woman but also the woman's actual name and address was clearly typed on the front page. The College was highly embarrassed by the lack of professionalism and the case study was promptly destroyed by way of apology.

3.3 Physical Security

It is dangerous to rely on physical security. Inadvertent breaches of security and accesses by investigators for proper and improper purposes by improper methods will inevitably occur. The main lesson is, "don't become over confident and thereby complacent."

I recently offered a leading hospital who appeared to me to be over-confident about their security a ten-to-one bet that I could obtain, with his consent, the file of my nephew held by a leading hospital within twenty four hours. The hospital did not take the bet but I checked with the investigator I would have used, to ask if he could have won the bet for me. He asked if I were prepared to pay for special delivery, in which case he could have got the file for me within two hours. This is a fact of life.

4. The Examples of Problems Encountered by the Committee Arising from Research Registers

(i) Central Indexes

The Committee is concerned that some hospitals transfer identified patient data to central registries without the patient's consent. Also judgements are called for which can be prejudicial to the patient (for instance assessing his attitude to work). The Committee believes that, wherever possible, if not at all times, information reported to such indexes without the patient's full and informed consent should be in an anonymised form with the capacity to go back through the hospital to the patient where normal ethical controls will apply.

(ii) Genetic Defect Registers

Again, no matter how desirable these might be, informed consent is highly desirable, if not essential. Any exceptions to the consent rule should be established by specific legislation following public debate.

(iii) Attitude of Parents

One hospital planned to ask obstetric sisters to record, on the birth records, their view as to whether or not they thought the mother really wanted the child at the time of the birth. No doubt there was a real research interest in correlating that information with subsequent conduct such as child abuse. However, it was a highly objectionable and dangerous proposal which was quickly dropped.

(iv) Drug and Alcohol Registries

A listing of all drinking habits in a central register was also discontinued after discussion with the Committee.

You must bear in mind that all this information can be subpoenaed in subsequent family law disputes or be subject to search warrant, Consumer Affairs accesses etc.

5. Conclusion

Commonsense and ingenuity can ensure that scientific and technological research objectives can be achieved, and at the same time the researchers can maintain the respect of the public who are the subject of the research and who are presumably served by it.

APPENDIX

SUBPOENA OF SENSITIVE RECORDS:

PROCEDURES FOR PROTECTING PRIVACY
(including search warrants and other official demands)

1. INTRODUCTION

From time to time the Privacy Committee receives complaints that sensitive personal data is produced in court pursuant to a subpoena, or is accessed as a result of a search warrant or other official demand, either without the subject's knowledge or in a way which the data keeper thinks unjustifiably invades his privacy.

While medical and bank records are the more usual type of records which give rise to the problem, it can apply to almost any record, such as:-

(a) Education - pubils' school reports and cards; counselling reports.

(b) Employment - personal files held on employees.

(c) Insurance - policies; reports prepared on claimants.

(d) Finance - credit transactions; wages and income records; home loans; real estate transactions; taxation returns.

(e) Social Work - counselling reports; individual assessments and references.

(f) Adoption - reports maintained by the Department of Youth & Community Services.

(g) Libraries - borrowing patterns and preferences.

What is Sensitive Data?: The prime criterion of sensitivity is whether the data subject considers data sensitive. Wherever a data keeper receives a subpoena dealing with someone else's data, he should immediately advise the data subject of the fact that the subpoena has been received and wherever possible take his views into account and include them in a covering letter as suggested.

2. TYPES OF PROBLEM

2.1 Medical Records:

Three examples are:

(a) Where the Patient's Medical Record contains Information on Other Persons

This is most likely to arise in respect of families. It is not uncommon for doctors to open a file on a patient and to include references to his spouse and children in the same file. This has obvious advantages in relation to familial and communicable illnesses.

(b) Where the Patient's Medical Record contains Sensitive Personal Information

A clear example of this would be in a negligence action for damages where a woman is claiming damages for an injury to her arm. It would generally be irrelevant to the proceedings to know that she had a termination of pregnancy some three years prior to the accident.

(c) Where the Doctor Considers it would be harmful to the Patient to know of his Medical Condition

It is likely that such cases would only arise on rare occasions, e.g. where the patient is suffering from a serious illness and could, if told, attempt to commit suicide.

2.2 Bank Records:

Three examples are:

(a) Where the Subject's Record contains sensitive Information irrelevant to the Proceedings

An example of this could arise in proceedings for settling a property dispute where information not related to that dispute is also included in the record.

(b) Where the Subject's Bank Record contains Information on other Persons

This is likely to arise in respect of families, partnerships, etc. where the financial dealings of a person who is not a party to the proceedings, or involved in them in any way, are mentioned in the subject's record.

(c) Where the Record of a Person who is not a Party to the Proceedings is subpoenaed and it (or any part of it) is not relevant to the Proceedings

X, who was to be married to Y, had her financial records subpoenaed by Y's former wife in connection with a property dispute arising out of the dissolution of a former marriage.

X was required to produce her taxation returns, cheque butts, bank statements, insurance policies, documents relating to the purchase of real estate, wages and income records etc.; her bank was also subpoenaed to produce records of her account. X alleged that these records were irrelevant to the proceedings and that it amounted to an invasion of her privacy, particularly as she was an independent person who did not wish her prospective husband to know the full details of her financial affairs.

3. RECOMMENDATIONS TO DATA KEEPERS WHEN RECEIVING A SUBPOENA

3.1 Subpoenas

Judges will take privacy factors into account if the factors are drawn to their attention. Whenever a data keeper receives a subpoena which raises a privacy issue he should -

(a) forward the record to the court in a sealed envelope marked "Judge Only";

(b) send a covering letter to the Judge setting out his concern for the data subject, and his reasons for such concern if the particular records are produced in open court;

(c) advise the data subject of the subpoena so that the data subject may either be represented by a solicitor or appear in person at the court and ask the Judge to be heard on reasons why his file should not be tendered in open court.

This will enable the Judge to:

(a) discuss the relevance to the case and the privacy issues with the legal representatives (or, where appropriate, the person) before opening the envelope, to ensure that access to the record is necessary;

(b) if access is insisted upon, inspect the record himself to ensure that only relevant information is produced in court.

The above procedures will enable Judges, having regard to the requirements of justice and other competing interests, to ensure that privacy is protected as far as possible.

It should be clear that if the party subpoenaing the records can show that they are relevant, and insists that they be produced in open court, this will in fact occur.

3.2 Search Warrants and Powers of Demand and Search

i. Notification to the Data Subject

Wherever an official demand for access to data occurs, the data subject should be advised as provided for in the recommended procedure (para. 3.1 above). In some instances it is not in the public interest that the data subject be notified while police investigations are taking place. It could be appropriate to advise the Committee of any requests not to notify, for advice and for the Committee's research purposes.

ii. Questioning an Official Demand

In some instances the official demand,

such as a search warrant or use of a power under a particular statute, might create an invasion of privacy which is not justified by the public benefit that flows from it. If the data keeper is in any doubt the Committee should be contacted for advice and assistance. The Committee's experience is that responsible decisions are almost always taken by public sector bodies where the appropriate facts and consequences are brought to their attention.

111. Confidentiality of Mass Health Care Records during Police Investigations

Guidelines have been arrived at between the N.S.W. Police Department, the Privacy Committee, and the Law Society, Bar Association and Australian Medical Association (N.S.W. Branch) to protect privacy when such investigations occur. A copy of the guidelines is attached.

4. ASSISTANCE FROM THE PRIVACY COMMITTEE

Introduced with goodwill and commonsense it is hoped that the unusual types of problems that have come to the Committee's attention will be avoided. Where the above procedures do not provide an adequate protection, either the data keeper or the data subject shoudl approach the Committee for advice and, if necessary, assistance.

In general, the Privacy Committee will not be able to interfere in any way with matters before the court. However, by providing a centre of research and experience in this area it is hoped that if the problems are not solved a more effective remedy will be devised.

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MEDICAL

CONFIDENTIALITY OF PROFESSIONAL RECORDS

DURING POLICE INVESTIGATIONS

GUIDELINES

1. A panel of medical practitioners should be formed to assist Police in the interpretation of medical records.

2. Any mass seizure by warrant of medical records should be carried out only under the supervision of experienced investigators.

3. If practicable, the assistance of a member of the panel should be sought and he should be requested to be in attendance at the seizure.

4. If practicable, records (the subject of the warrant) should be inspected at the premises being searched and only those records considered relevant to the investigation should be seized.

5. A descriptive list should be made and kept of records which are seized.

6. If the medical practitioner concerned indicates that he needs the records seized to enable him to continue the treatment of the patients, he should be supplied with photocopies as soon as practicable.

7. All records which have been seized should be kept in a place of security and only persons involved in the investigation should have access to them.

8. In the event of a patient seeking particulars of the seizure of his medical records, he should be advised to make such request through the office of the Commissioner of Police.

These guidelines would also be applicable where other types of confidential professional records (e.g. solicitors' or accountants' records) were sought for police investigations.

Journal and Proceedings, Royal Society of New South Wales, Vol. 115, pp. 95-100, 1982
ISSN 0035-9173/82/0203 — 06 $4.00/1

Understanding the Cancer Process: Some Aspects of the Spread of Cancer in Man and Experimental Animals

B. A. WARREN

ABSTRACT. The course of the illness in an untreated patient with cancer depends upon the cell of origin of the cancer and the organ in which the cancer arose. Although there are certain general principles concerning spread, malignant tumours comprise a large number of separate diseases rather than a single entity. Removal of the primary tumour (i.e. the tumour in the organ where it first appeared) can usually be achieved and it is the secondary deposits that prove resistant to removal by surgery or treatment by other means. The way these secondary deposits develop is therefore basic to the understanding of the cancer process as a whole and is needed for a rational approach to therapy. Many malignant tumours spread via the blood stream by way of the release of tumour cells into the circulation and the primary malignant tumour must reach a certain stage in development and size before tumour cells are released in significant quantities.

INTRODUCTION

One of the principal threads evident in human evolution from the time of recorded history has been an interest in the nature and of course, the methods of possible cure, of ailments that afflict man. There is a group of illnesses which are termed collectively cancers which consist of unusually rapid proliferation of cells to form abnormal newgrowths. In this group the mass of cells invades the adjacent tissues and often spreads by the dissemination of the abnormal cells.

Cancers were described in antiquity, being mentioned in the earliest literature of Iran and India, and in the Ebers papyrus (1500 B.C.) (Ewing, 1942). Hippocrates (460-375 B.C.) is recorded as having burnt out a cancer of the neck and was aware of cancers of skin, breast, uterus and certain internal organs. Galen of Pergamum (150-200 A.D.) regarded cancer as a concentration of black bile in his humoral system of the explanation of disease.

The elucidation of the circulation of the blood by Harvey in 1628 was the turning point in the rebuttal of the humoral system of disease. The discovery of the lymphatic system by Rudbeck (1652) suggested to LeDran (1685-1770) that breast cancer might spread by "cancer lymph". Morgagni (1682-1772) studied at autopsy many patients who had died of cancers and established major aspects of the pathological anatomy of many internal cancers.

Factual observations of the nature and progress of untreated cancers in the 18th century paved the way for modern concepts of the disorder. The advent of the microscope in the early 19th century allowed Schwann (1838) to enunciate his principle that tissues have a cellular structure. Schwann described the nucleus and nucleolus of the cell.

In 1838 Muller published a study of cancers and first described them as being composed of groups of cells with varying forms and proportions of stroma and cell masses (e.g. Figs. 1 and 2). Virchow founded cellular pathology on the basis that all cells are derived from cells. The doctrine of endogenous reproduction of cells laid the basis for the discovery by Thiersch that changes in normal cells gave rise to tumours. The last decades of the 19th century saw great activity utilising modern methods of processing and sectioning of cancer tissue so that detailed morphology was achieved at a light microscopic level (for historical review see Ewing, 1942).

Ewing (1942) advocated the proposition that cancer is a group of specific disorders, all of which have their own distinctive morphology, and natural history. Progress in therapy is dependent upon a clear understanding of the specific disease under treatment and its usual biologic course. The advent of the electron microscope and practical methods of preparation of tissues for examination in this specialized microscope in the early 1960's led to a great upsurge in the amount of information available at magnifications considerably beyond that realizable by the use of the light microscope.

Definitions

What is a cancer? The classes of cellular response to injury are limited. The cell may die, it may recover completely or it may undergo some permanent modification of structure and behaviour. The formation of cancers appears to be the result of such a permanent modification as a result of contact with a noxious agent. The word "cancer" is the most familiar term relating to newgrowths or tumours and refers to all types of malignant tumours. Normally the cells in the body go through a preordained progress with periods of maturation, full function and then senescence and death. There are both local and general control mechanisms which keep the relative parts of the body in register so that all are co-ordinated.

Ewing (1942) defines a tumour as an

autonomous new growth of tissue and Willis (1967) as an abnormal mass of tissue, the growth of which exceeds and is unco-ordinated with that of the normal tissues and persists in the same excessive manner after cessation of the stumulus which evoked the change.

There are two major divisions of tumours - benign and malignant. The benign tumours grow locally and do not spread to distant sites. Malignant tumours (cancers) invade and destroy local tissues and spread by the lymphatic and blood circulations. A secondary deposit at a distance from the origin of the cancer is called a metastasis. It usually has the same structure as the primary tumour.

Approaches to the cancer problem

Cancer is placed second of the causes of death in New South Wales. The approaches to this disorder can be listed under three main headings which are - prevention, early diagnosis and effective treatment which may include a combination of surgery, radiotherapy and chemotherapy. Ideas regarding the prevention of cancers stem mainly from descriptions of "industrial" cancers and epidemiological surveys. One of the earliest industrial diseases was the scrotal cancers of chimney-sweeps described by Pott in 1775 (Willis, 1967). This skin cancer was due to the application of soot to the skin over a period of many years. Modern methods of travel and communication have led to the discovery of the wide divergence in the incidence of cancers of various organs in different countries (Higginson, 1960). The difference is frequently striking and has led to specific comparative studies of different races under differing cultural influences. For example Japanese who immigrate to the U.S. show a cancer incidence between that of the Japanese in Japan and the rest of the U.S. population. The great number of studies of this type has led Higginson to state that perhaps 70% of all cancers are environmentally induced (Higginson, 1980). It is naturally up to the individual to arrange his own habits to diminish the risk of this disease. Reduction or abolition of cigarette smoking, reduction of excess exposure to sunlight and abolition or marked reduction of exposure to industrial carcinogens and radiation are high on the list of desirable measures to be taken.

Early diagnosis

A slowly enlarging lump or bleeding from any orifice which is not related to trauma are abnormal findings requiring medical attention. Dr. George Papanicolaou, a Greek born physician who spent most of his working life in the U.S., is credited with founding Cytopathology. With Dr. Traut he was able to show that individual cancer cells possess structural features which are characteristic for malignancy (Papanicolaou and Traut, 1943). The study of cells exfoliated from a specific surface has recently given further information regarding the method of progression of certain cancers particularly carcinoma of the cervix and bronchus.

Problems of treatment

The methods used in the treatment of neoplastic disease depend upon the type of cancer involved. Therapy may consist of surgery, radiotherapy or chemotherapy or any combination of these. Probably the major problem of therapy is the development of secondary deposits (metastases) at a distance from the primary tumour.

Investigation of the process of tumour metastasis

My own work on tumour metastases arose out of an interest in the initial lodgment, growth and vascularization of tumour cell clumps released from the main mass of the tumour (also called the primary tumour). The biology of the metastatic cycle consists of release of tumour cells from the primary tumour, the reaction of the tumour cells with the blood components and their circulation in the blood, followed by impaction and growth of the surviving cell clumps in tissues which are susceptible to involvement by metastatic deposits of tumour. This is a complex sequence of events and is difficult to study because of the alteration of the natural mechanisms imposed by the very nature of the means of study.

The release or shedding characteristics of a tumour are difficult to quantify because of the multiplicity of naturally occuring blood vessels supplying the primary tumour in most instances. The blood supply to experimental tumours, may, however be manipulated by encasing an organ, such as the kidney, which has a clearly identifiable vascular pedicle in a capsule of an inert substance such as wax and allowing the parenchyma of the organ to be replaced by tumour tissue. The tumour tissue is then supplied by the renal artery and vein and vascular studies may proceed using these vessels. This was the technique used by Gullino and Grantham (1962) to study the reaction of the blood vessels in the tumour mass to various stimuli.

It appeared to me, that, if progress were to be made the metastatic cycle (diagram 1) would have to be broken down into manageable segments for study and that only then could the conditions of the experiments be sufficiently defined to allow of firm conclusions. My earlier work on endothelium (Warren, 1963) prompted me to start with the phase of attachment of the tumour cell to the vessel wall. Baserga and Saffiotti in 1955 had noted that tumour cells in the lungs actually lodged in the small vessels by adhering to their endothelium. Later studies by Wood (1964) using rabbits showed that when single carcinoma cells (of the ascitic V2 line) were injected into vessels these cells clumped together and fibrin was formed around them. With a German exchange student working with me at the time (F-H Guldner) I decided to study this phenomenon by taking a suspension of a human tumour line (HeLa cells) which were readily available because of their use in the viral laboratory in Oxford and to add this suspension to human vein walls. During the operation of varicose vein stripping many segments of vein are removed from the leg as part of the treatment and and these segments include normal lengths of vein which are present between the varicose regions and the normal segment of vein

at the upper end of the specimen. Half of these normal rectangles of vein were left undamaged and half were damaged by light mechanical trauma. To these segments HeLa cells in suspension were added by pipetting the suspension onto the endothelial surface of the vein segments. These preparations were incubated in tissue culture medium at 37 degrees Centigrade. They were then fixed and studied by electron microscopy.

The HeLa cells were seen to adhere to the regions of damaged vessel wall where the endothelial cells had been abraded off by the previous trauma. The tumour cells stuck to the exposed layer of the vein wall - the basement membrane of the endothelial cell by means of multiple microvilli and the cells eventually flattened themselves against the basement membrane (Warren and Guldner, 1969).

My next studies (1970) were on the reaction of the blood to circulating tumour cells. Because of the intricacies of both the haemostatic/thrombotic processes and the physical design of the circulation, the size and nature of the particles in which the tumour cells travel in the circulation bears directly on the adhesion and impaction events which occur between the tumour containing mass and the damaged vessel wall. Thus single cells flowing over intact smooth endothelium would pass through capillary beds. On the other hand a mass of platelets attached to tumour cells and forming a mass consisting of a number of tumour cells with activated platelets would tend to impact in the capillary bed and also to stick to damaged vessel wall.

In the early work on the ultrastructure of thrombi the Chandler tube apparatus was used. This was a plastic tube into which a ml. of whole blood was placed. The tube was formed into a circle by means of a small connecting piece of tubing placed between the ends, and the circle itself with contained blood rotated on a turntable. A solid mass was formed at the leading edge of the column of blood and this possessed the structure found in a thrombus. This was a platelet, leucocyte and fibrin rich head and a red cell and fibrin tail (Poole, 1959). This system was used to study the interaction of tumour cells and blood. Tumour cell suspensions of Walker 256 carcinoma, which is a tumour cell line derived from a tumour of the mammary region of a rat and a mouse mammary adenocarcinoma were used. Platelet rich plasma suspensions were prepared from rats and mice. 0.5 ml of platelet rich plasma were added to 0.5 ml of a suspension of tumour cells and the mixture rotated in the Chandler tube apparatus. By electron microscopical examination this method was shown to produce particles consisting of a loosely knit body of tumour cells, tumour cell debris, platelets and activated platelets in the case of Walker 256 tumour cells and rat platelet rich plasma. The mouse mammary adenocarcinoma preparations produced a denser body of tumour cells, fibrin and platelets (Warren, 1970).

It is thus evident that at least with some tumours, the tumour cells in the body do not circulate in the blood stream as single cells but as masses of tumour cells, debris, fibrin and platelets.

The next stage was to examine the attachment of "circulating" tumour cells to damaged vessel walls. This was done by injecting tumour cells in suspension into the inferior vena cavae of rats and mice after mechanically damaging by pressure the vessel wall upstream. Suspensions of Walker 256 carcinoma and a thymic lymphoma of mice were injected into rats and mice respectively. Two types of adherent tumour emboli were found. They were distinguished by the presence or absence of endothelial damage of the underlying vessel wall. Where damage had resulted in removal of the endothelial cells, fibrin formed the adhesive between the tumour cells and the vessel wall. In areas where endothelium was intact, tumour cells were attached to platelets and a small amount of fibrin which enclosed the tumour-platelet mass (Warren and Vales, 1972).

Migration of the tumour cells following the more secure adhesional site provided by damaged vessel wall, occurs by insinuation of the tumour cells into the deeper layers of the vessel wall (Warren, 1976). Scanning electron microscopy of human tumours has revealed microvilli on the surface of epidermoid carcinoma cells and to a much lesser extent on human adenocarcinoma cells (Warren, 1978). Veins draining renal adenocarcinomas in man contain activated platelets, tumour cells and debris (Warren, 1978).

Because studies of the vasculature of tumours (Warren, 1979) had led me to consider that the wide bored, thin walled vessels (giant capillaries) found at the edge of tumours possessed "porous" properties with regard to movement of tumour cells, I examined these vessels in experimental tumours by electron microscopy. Identification of these vessels was readily possible if a mm cube fragment of a transplantable tumour is grown on the cheek pouch membrane of a hamster and this membrane and tumour fragment is encased in a transparent chamber which allows observation of the vessels by light microscopy in the living state. The morphology of movement of melanoma cells through the endothelium of these thin walled vessels is by a series of stages. First the tumour cell becomes positioned beneath the basement membrane of the vessel. Erosion of the basement membrane of the vessel next occurs and the tumour cell insinuates itself through the break in the basement membrane to lie beneath the endothelium. The overlying endothelium becomes attenuated or separates and the tumour cell emerges into the vascular lumen often via a dumb-belllike stage (Warren, Shubik and Feldman, 1978). This method of intravasation is not unlike the movement of lymphocytes from the vascular compartment into lymph nodes.

Metastasis via the blood stream is an important route of dissemination of malignancy. The demonstration of tumour cells in the blood stream in the 1960s indicated that tumour embolism is only a stage in a long process before tumour metastasis is established and it was not possible after exhaustive study to correlate prognosis of the patient with the presence or absence of circulating tumour cells (for review see Warren,1981). Why certain tumour emboli proceed to metastasis formation and others do not is unknown. It appears from animal work that the larger the tumour mass involved the more likely it is that

metastasis will result.

If showers of emboli are derived from tumours then recurrent blockage of capillary beds would result in areas of localized damage with fibrin on their surfaces. Such areas following re-routing of the blood stream or re-opening of the capillary bed would provide preferential sites for the lodgment and migration of tumour cells (the micro-injury hypothesis of the formation of micrometastases, Warren, 1981b).

The diagram of the metastatic cycle indicates in outline form the complexities of the process and how difficult it is even in the model situation in animals to study the specific dynamic processes at the moment of adhesion and or impaction of the tumour cell embolus which will progress to tumour metastases. The animal work can give vitally important clues and indications of the processes involved but eventually final studies must be devised for the human situation, with of course due regard for the overwhelming importance of the treatment and welfare of the patient.

Basic studies on the structure and function of the microcirculation of various organs, particularly those in which metastases readily occur (such as the liver, a scanning electron micrograph of which is shown in Fig. 3) are also likely to be of importance in the unravelling of the detail of the metastatic process.

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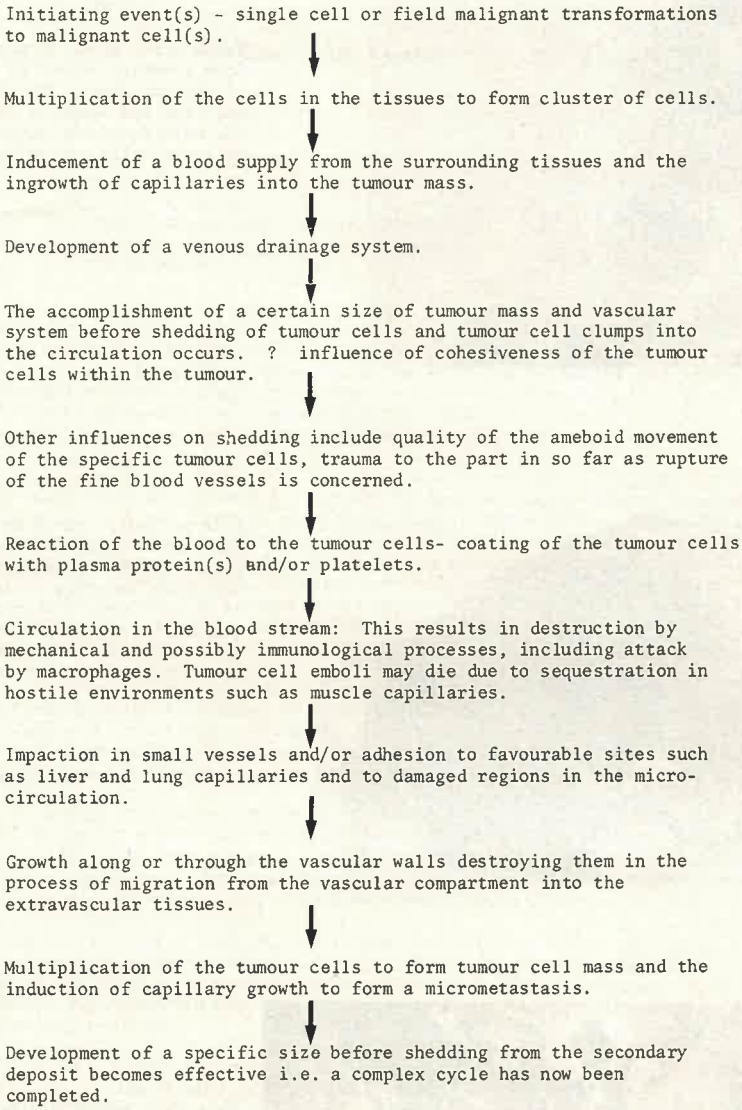

DIAGRAM 1. The metastatic cycle of the blood-borne spread of carcinoma.

Department of Anatomical Pathology,
Prince Henry Hospital and Department of Pathology,
University of New South Wales.

Presidential Address delivered to The Royal Society of New South Wales at Science Centre, Sydney, on April 7, 1982.

(Manuscript received 15.10.82)

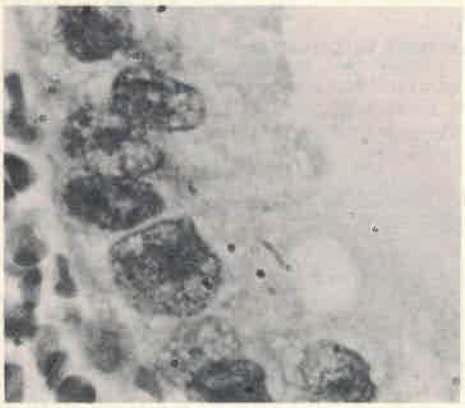

FIG. 1.

These are a group of adenocarcinoma cells from a needle biopsy of an adenocarcinoma of the pancreas. The great variability of the size and shape of the nuclei as well as the molding of the nuclear shapes by the adjacent cells can be seen.

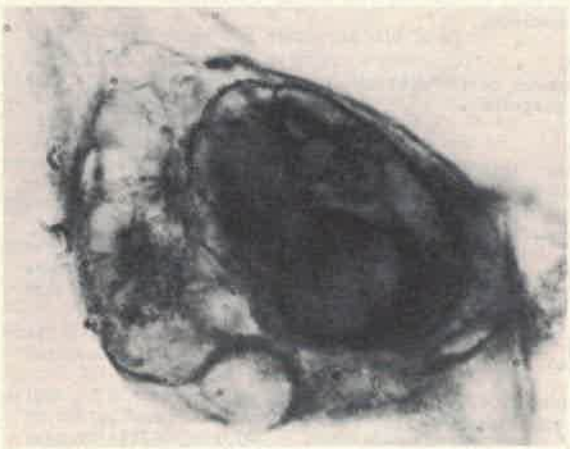

FIG. 2.

A large single adenocarcinoma cell from a pancreatic adenocarcinoma fills this photograph. There is indentation of the nucleus and mucus vacuoles in the cytoplasm. This is from a smear preparation prepared and stained by the Papanicolaou technique. In this technique the whole of the cell is seen not a thin section of the cell.

FIG. 3.

This is a scanning electron micrograph of the cross sectional surface of the liver. The microcirculation of the liver is shown. In two of the sinusoids groups of red cells are present.

The sinusoids of the liver-are a frequent site for the development of tumour metastases. The endothelium is incomplete in the sinusoids and allows direct contact of the tumour cell embolus with some of the collagen components of the sinusoidal wall.

Journal and Proceedings, Royal Society of New South Wales, Vol. 115, pp. 101-102, 1982
ISSN 0035-9173/82/0204 — 02 $4.00/1

Abstracts of Theses

Title: Multi-dimensional Neutron Diffusion

Author: J.M. Barry

Abstract:

The numerical solution of time dependent neutron diffusion approximation to the transport equation is of vital interest to those concerned with reactor design and safety. The growth of modern computing power has increased the scale with which computations may be undertaken. To exploit these electronic advances fully, however, it is necessary to review existing numerical approaches and substitute more efficient techniques wherever appropriate.

This work first summarises an approach typical of the conventional method of solution. It subsequently concentrates on the heart of the method, namely the solution of very large sparse systems of linear equations. A new numerical approach for their solution is formulated. This essentially seeks a splitting for the iteration matrix which makes the iterative process more implicit. The role that 'experimental mathematics' and computer graphics played in its evolution is discussed. The method has three other possible applications. Two of these are pursued here. Of these secondary applications, the acceleration of convergence in energy has tremendous potential for thermal reactor studies.

Various aspects concerning the behaviour of the new iterative approach are observed. The method is tested extensively on a number of reactor configurations which demonstrate several aspects of design and modelling techniques. The implicit approach is contrasted and compared with relaxation and conjugate gradient methods. Considerable attention is devoted to the efficient implementation of the three iterative schemes on computers with virtual memory.

Traditionally, a secondary acceleration of the iterative technique is achieved with a variational approach. Several modern variations of this, with linear approximating functions instead of constant rescaling factors are considered. The scheme requires the solution of a reduced system of linear equations. Matrix properties of the reduced system are considered, and methods of their solution discussed.

Justification for the secondary acceleration is analysed with a Fourier approach. The applicability of each scheme to the three basic iterative methods is considered by analysing the reduction of frequency components of error in the solution estimate. Predictions from theory are then compared with results on several reactor geometries, with and without the secondary acceleration.

Type of Thesis: Thesis for the Degree of Doctor of Philosophy at the University of Wollongong, Wollongong, N.S.W.

Present Address of Author: Australian Atomic Energy Commission,
Research Establishment,
Private Mail Bag,
Sutherland, N.S.W. 2232.

Title: Stabilities of Compounds and Reaction Mechanisms in the Ti-Si-O-N System

Author: Mark Brian Trigg

Abstract:

Silicon nitride had been known as a chemical compound for a number of years. In 1960 the Admiralty Materials Laboratory, in the United Kingdom, developed methods for its fabrication into functional shapes. Since then a great deal of effort has been directed to the use of silicon nitride and related materials in diesel engines for pre-ignition chambers, pistons, combustion chamber liners, nozzle guide vanes, blades, heat exchangers and thermal and acoustic insulation. In spite of these successes, there have been problems in the fabrication of nitrogen ceramics because of the low sintering rates of covalently bonded materials.

An important development in the field of nitrogen ceramics was the finding that in the structure of silicon nitride, part of the silicon content could be replaced by aluminium and part of the nitrogen by oxygen. This gave rise to the sialons. The aim of the present research was to study the effect of titanium in the Si-O-N system, that is to examine the system Ti-Si-O-N. Attention was concentrated firstly on reaction mechanisms and the stability of the compounds formed. Techniques employed included X-ray diffraction, scanning electron microscopy, energy dispersive X-ray analysis and optical microscopy.

Thermodynamic calculations provided an analysis of the energy relations in the system. Particular attention was devoted to the effects of the gas phase. The results of the calculations provided further insight into reaction mechanisms.

Type of Thesis: Thesis for the Degree of Doctor of Philosophy, at the University of New South Wales, Kensington, N.S.W.

Present Address of Author: C/- Professor E.R. McCartney,
Department of Ceramic Engineering,
School of Metallurgy,
University of New South Wales,
Kensington, N.S.W. 2033.

Journal and Proceedings, Royal Society of New South Wales, Vol. 115, pp. 103-108, 1982
ISSN 0035-9173/82/0205 — 06 $4.00/1

The Coming of Age of the New England Branch of the Royal Society of New South Wales

The New England Branch celebrated its'coming of age' on the 23rd March, 1982, at Armidale, N.S.W. Professor R.L. Stanton, who was responsible for the establishment of the Branch in 1960, successfully arranged the 21st anniversary meeting.

Lectures given at the New England Branch
Royal Society of New South Wales, Armidale

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Inaugural Meeting, New England Branch, 24th March, 1961.

Professor K.E. Bullen - Delivering Inaugural Lecture to audience of about 120.

Inaugural Meeting, New England Branch, 24th March, 1961.

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A.A.D.

JOURNAL AND PROCEEDINGS

OF THE

ROYAL SOCIETY OF NEW SOUTH WALES

VOLUME 115

PARTS 1 - 4
(Nos. 323 - 326)

1982

ISSN 0035-9173

PUBLISHED BY THE SOCIETY
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Parts 1 and 2

Parts 3 and 4

Dates of publication:
Parts 1 and 2: August, 1982
Parts 3 and 4: February, 1983

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Manuscripts should be addressed to the Honorary Secretary (address given above).

Manuscripts submitted by a non-member must be communicated by a member of the Society.

Each manuscript will be scrutinised by the Publications Committee before being sent to an independent referee who will advise the Council of the Society on the acceptability of the paper. In the event of rejection, manuscripts may be sent to two other referees.

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PRESENTATION OF INITIAL MANUSCRIPT FOR REVIEW

Typescripts should be submitted on heavy bond A4 paper. A second copy of both text and illustrations is required for office use. This may be a clear carbon or photographic copy. Manuscripts, including the abstract, captions for illustrations and tables, acknowledgments and references should be typed in double spacing on one side of the paper only.

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Spelling follows "The Concise Oxford Dictionary".

The Systeme International d'Unites (SI) is to be used, with the abbreviations and symbols set out in Australian Standard AS1000.

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Abstract. A brief but fully informative abstract must be provided.

Tables should be adjusted for size to fit the format paper of the final publication. Units of measurement should always be indicated in the headings of the columns or rows to which they apply. Tables should be numbered (serially) with Arabic numerals and must have a caption.

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