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John Curtin School of Medical Research

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Electron Microscope Unit

STAFF

Professorial Fellow and Head of Unit:

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Electron Microscopist (Fellow):

M. C. Taylor, M.Sc. (Tas).

Fellow:

A. A. Barton, B.Sc., M.B., B.S. (Lond.).

Research Fellow:

J. D. Pickett-Heaps, B.A., Ph.D. (Cantab.).

Honorary Fellow:

R. C. Williams, Ph.D.

Visiting Fellow:

R. J. Goldacre, B.Sc. (Syd.), Ph.D. (Lond.)

RESEARCH WORK

Introduction

Members of the Unit pursue a diversity of problems united by a common interest in the fine structure of cells and tissues. A major project concerns the structure of several small invertebrates, whose phylogenetic relationship to the more developed phyla is in dispute, and whose fine histology presents novel features. Intracellular organelles and cellular mechanisms, to judge from morphology, prove to be the same in these primitive organisms as in more elaborate forms although the cellular organization may be very different. Some of these organisms (rotifers, nematodes, gastrotrichs) are often thought to be related, but they have proved to be very distinct in fine structural detail.

The discovery of an entirely new intracellular structural element, the microtubule is exciting a great deal of interest among cytologists throughout the world. Microtubules occur in all cells and are associated with phenomena as diverse as cell division, chromosome movement, other forms of intracellular transport and the organization of the cell wall. Several of our current research projects are concerned with intracellular movement and with morphogenesis; microtubules have been found to occur prominently in the cells concerned and to influence these fundamental processes. The distribution of microtubules immediately beneath the cell membrane appears to determine the organization of the material of the wall outside.

A very different project concerns the effect of trauma and infection on peripheral nerves. It is hoped that this work will cast light on the nature of the lesions produced in leprosy.

Amoeboid movement (Mercer, Goldacre[1])

The external membrane of amoeba and several other large cells can be labelled with the dye, alcian blue, which is visible both in the electron microscope and also in the light microscope. This circumstance enables observations to be made on the movement of membranes in living cells and for the membranes to be located subsequently in sections in the electron microscope at higher magnification. The generation of new membrane on the tips of advancing psuedopods of Amoeba proteus and the resorption of membrane at the tail were successfully demonstrated. Similar studies were made using the slime mould, Physarum.

Colour and colour change in the grasshopper Kosiuscola (Day[2], Mercer).

This grasshopper, found only on the highest peaks of the Australian Alps, exhibits a very interesting colour change: it is dark in colour when cold and on warming becomes sky blue.

The change in colour is caused by the movement of granules in the epidermal cells beneath the cuticle. Two kinds of granules are present: a large dense, black granule (about 1μ in diameter) and a very small granule (about 0.2μ). The blue colour is due to light scattering by the small granules seen against a dark ground of black granules deeper within the cells. The same phenomenon is the cause of the blue of the sky and of the cuticle of such insects as dragon flies. In the cold condition the black granules move between the small granules and quench the scattered light.

A system of very fine "microtubules" traverse the epidermal cells in the direction in which the particles move and seems to be associated with their movement. It is of interest to note that similar microtubules are associated with chromosome movement and the migration of pigment in some vertebrates.

Molecules and particles (Taylor)

Techniques for visualizing biological molecules and virus particles based on published methods have been further elaborated. Deoxyribonucleic acid (DNA) from rabbit pox virus, SIV and other viruses has been examined by Kleinschmidt's method to determine the length distribution of the molecules (Taylor, Bellett,[3] Tomkins[4]). It has been established that hyaluronic acid can be spread in similar manner (Taylor, Ogston[5]). High resolution studies of catalase molecules reveal subunits (Williams[6]).

Nerve degeneration and leprosy (Barton)

Transient degenerative changes in the structure of myelinated and non-myelinated fibres are produced by slight damage to nerves. Myelin lamellae become separated, and an irregular swelling of the sinusoids of the endoplasmic reticulum of the axons of the

Schwann cells occurs accompanied by an increase in cytoplasmic volume.

When polystyrene particles are injected into the nerve, at the same time as the nerve is damaged, the polystyrene is phagocytosed by endoneural cells. Nerves treated in this way serve as models for determining the factors controlling the uptake of leprosy bacilli. The lesion produced closely resembles those of polyneuritic leprosy (Barton and M. Barton[7]).

Mitosis and differentiation in plant cells (Pickett-Heaps)

Cell division and differentiation has been studied in wheat seedlings and an alga (Chara). Radioautography has indicated that the endoplasmic reticulum, Golgi bodies and microtubules are involved in wall deposition in xylem cells. Colchicine has been shown to remove wall microtubules from xylem cells with a coincident disruption in the organised pattern of wall deposition. Similar removal of microtubules from spindle structures can be related to mitotic abberations induced by colchicine. For comparison with morphogenesis in higher plants, detailed study has been made of differentiation, spermatogenesis and oogenesis in Chara.

Lower metazoa: Rotifera, Gastrotricha and Nemotoda (Dickson, Mercer)

These minute animals prove to have many ultrastructural features in common with larger animals both vertebrate and invertebrate. Cells secreting mucoid substances contain the same organelles as cells with a similar function in the mammalian gut. Muscle cells have both coarse and fine myofilaments like mammalian striated muscle, although the "Z" bands are not aligned and consequently the muscles seem to be non-striated in the light microscope. Nerves are non-myelinated and resemble platyhelminth nerves in structure; particulate neurosecretion is thought to occur. Hard parts such as the mechanically strong parts of the

teguments and teeth are constructed of fibrous material, probably hardened protein, which is produced by the epidermis and specialised gut epithelia respectively.

Characteristically some of these animals can be revived after severe desiccation in which most of the cellular water is lost and metabolism ceases. In dried rotifers, the cell contents are very condensed, and the plasma membranes and membranous organelles are tightly folded into many-layered stacks of membrane. Intercellular relationships are preserved. When immersed in water the cells expand, the membranes lose their folded appearance, and the animals rapidly resume their normal activities.

The blood supply of small intestine (Pitha)

Studies of ischaemic changes in the small intestine of the rat following the temporary occlusion of the superior mesenteric artery show that necrosis in the wall of the intestine is preceeded by fine structural changes in the parenchymal cells. These provide a basis for the structural reorganisation which follows when vascular occlusion ceases. The reparative process is complex: epithelial cells differentiate rapidly from crypt cells and secondary inflammatory changes occur in the stroma.

TEACHING AND OTHER ACTIVITIES

There are two research scholars proceeding to the degree of Doctor of Philosophy: M. R. Dickson and J. Pitha.
Mr. B. K. Filshie was admitted to the degree of Doctor of Philosophy.

Mr M. C. Taylor spent the period from the end of August until early December on study leave visiting research institutes in Europe, America and Japan. Dr Mercer, Dr Barton and Mr Taylor

attended the Sixth International Congress for Electron Microscopy in Kyoto, Japan and then visited major manufacturers of electron microscopes. Dr Mercer read a paper at the conference. Visits were also made to a number of laboratories to see the facilities for the electron microscopy of biological specimens. Dr Barton visited leprosaria in Japan and Hong Kong.

Professor R. C. Williams of the University of California, Berkeley, spent six months with the Unit. Dr R. J. Goldacre spent four months working with Dr Mercer as a Visiting Fellow. Laboratory facilities have been made available to Mr R. B. Whan of the Bureau of Agricultural Economics to make observations relating to the structure of wool.

Dr Mercer visited the Anatomy Department at Monash University and the Electron Microscopy Unit, Sydney University to deliver lectures.

A number of visitors from this and other Universities have spent short periods of training with the Unit.

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FOOTNOTES

1. Visiting research worker.
2. Member of the C.S.I.R.O.
3. Member of the Department of Microbiology.
4. Member of the Department of Microbiology.
5. Member of the Department of Physical Biochemistry.
6. Visiting research worker.
7. Member of the Department of Experimental Pathology.
8. Member of the Department of Microbiology.
9. Member of the Department of Experimental Pathology.
10. Member of staff of the Chester Beatty Research Institute, London.
11. Member of the Department of Zoology (now at Flinders University, South Australia).
12. Member of the Division of Wildlife, C.S.I.R.O.
13. Member of the Department of Zoology.