

The Emergence of the Field of Developmental Biology in Australia

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Australia appeared to be largely left out of the great revolution in experimental embryology that was occurring in the early part of the 20th century. Taking advantage of the techniques of embryo culture and organ culture, experimental embryologists such as Harrison (1910's), Spemann (1920's) and Hamburger (1930's) were able to address questions that were not possible using classical descriptive embryology and cell stains of Golgi and Cajal, more typical of the late 19th century. In Australia, researchers in Anatomy departments and medical schools, places where experimental embryology was thriving overseas, were instead influenced by prominent researchers in physical anthropology such as Frederic Wood Jones who held chairs in anatomy at the University of Adelaide (1920-30) and the University of Melbourne (1930-38). During this period, experimental studies in embryology appeared to be overshadowed.

Some of the problems at this time lay in the continual struggle for financial support for suitable laboratory space, staff and resources for the medical schools and Universities. In many cases staff were honorary. Staff were often young and inexperienced and out of necessity were forced to teach excessive hours and in many diverse fields, leaving little time for laboratory bench work. The more experienced staff, who were attracted from overseas to Anatomy departments here in Australia, often came because of access to the Australia aboriginal population for their physical anthropological

investigations. Staff were also very difficult to find. In one noted case, an associate professor was advertised in Histology and Embryology in the School of Anatomy at the University of Queensland in 1948 – there was not a single applicant for six years.

In contrast to the lack of progress in experimental embryology or developmental biology, research in virology and immunology, riding on the success of the Walter and Eliza Hall Institute of Medical Research in Melbourne, was thriving in the middle of the 20th century, and perhaps even dominating medical research throughout Australia. The 1970's and 1980's saw a shift in emphasis from cell biology to molecular biology techniques in the field of immunology. It was during this period that a number of new learned societies were founded in Australia, including: the Australia and New Zealand Society for Cell Biology (which arose from the Victorian Cell Biology Society); the Connective Tissue Society of Australia and New Zealand (now Matrix Biology Society of Australia and New Zealand); the Australian Neuroscience Society; and Human Genetics Society of Australasia. While there was no dedicated national society fostering developmental biology at this time, the Cell Biology Society with its interests in cell culture proved to be supportive of developmental biologists, many of whom were using this approach to understand tissue interactions.

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Fig. 1. The Walter and Eliza Hall Institute is one Melbourne's - and Australia's - oldest and most respected research institute. It resides at the hub of one of the world's great biomedical research precincts, the "Parkville strip", just north of the city's centre.

In Western Australia, local meetings of the Cell Biology Society from 1987-1989 formed the basis for the major Combined Biological Sciences meeting now held annually. It was not until 1997 that the Cell Biology Society changed its name to the Australia and New Zealand Society for Cell and Developmental Biology (<http://www.anzscdbi.adelaide.edu.au/>) as the interests of its membership in the field of the developmental biology continued to grow.

Despite the power of the reductionist approach of molecular biology, it was the experimental approach of developmental biology that attracted students and scientists into the field in the 1970's, and from this time the field really began to flourish in Australia. Keith Dixon was developing techniques of nuclear transplantation of gut epithelial cells from adult *Xenopus* into eggs. This highly topical research attracted many students (Marie Dziadek, Paul Whittington and John McAvoy) who now have prominent positions as developmental biologists throughout Australia and New Zealand. Interests in the biochemistry of neurophysiological events saw Richard Mark attract biochemists such as Laurie Austin followed by Bob Rush and Peter Jeffrey into developmental neurobiology. At the same

time Don Newgreen was becoming interested in differentiation of sympathetic neurons *in vitro* using culture techniques that would be of interest to neurophysiologists emerging from Geoff Burnstock's group at the Department of Zoology, University of Melbourne. People such as John Heath, Max Bennett and Gordon Campbell from this group would bring others (Alan Pettigrew, Ian Gibbins, and Caryl Hill) into the field.

With interests in identifying growth factors associated with development flourishing during this period, groups at the Australian National University (Richard Mark, Ian Henry, Caryl Hill and Ian McLennan) and Sydney University (Max Bennett, Victor Nurcombe and Peter Noakes) spurred the momentum in developmental neurobiology through the 1980's. This was encouraged by Lyn Beazley who had arrived from Edinburgh in the 1970's to set up a highly productive developmental biology lab in Perth, initially using *Xenopus* as an experimental model. Beazley's work would complement Alan Lamb's studies in Perth on development of limb motoneurons in *Xenopus* as well as earlier work of Miranda Grounds in 1969 who also used *Xenopus*. The Italian neuroembryologist Piero Giorgi was subsequently appointed at University of Queensland (1980), which would further strengthen the use of *Xenopus* (now in Perth, Adelaide and Brisbane). Giorgi would go on to mentor Brian Key, who in turn used *Xenopus* as an experimental model in developmental biology. At this time more and more researchers from other fields such as zoology (Eldon Ball), cell biology (George Yeoh), biochemistry (Richard Harvey, Peter Rathjen), molecular biology (Rob Saint), stem cell genetics (Peter Koopman) and immunology (Perry Bartlett) began programs in developmental biology that would influence the current generation of young scientists.

There has always been cross fertilization between the fields of reproduction biology, human and animal reproduction and fertility as well as developmental biology. In the middle of the last century, a strong group of reproductive biologists centred on the Department of Veterinary Physiology chaired by C.W. Emmens at the University of Sydney. Here, the preimplantation development of the mammalian embryo was investigated by Ray Wales and his associates. From this environment came many of the biologists who established Australia's reputation in human *in vitro* fertilization and associated technologies. There were several important groups of marsupial embryologists. Both C.H. Tyndale-Biscoe and Roger Short were originally in Canberra before Roger Short and Marilyn Renfree went to Monash University. Tyndale-Biscoe moved on to become head of a large unit within the Commonwealth Scientific and Industrial Research Organization of Wildlife, which eventually metamorphosed into the Centre for Vertebrate Biocontrol. Reproduction biology flourished in Melbourne where Lynne Selwood, Jenny Graves, Marilyn Renfree, Ismail Kola and Alan Trounson were working at the cross-roads of many fields and stimulating much enthusiasm for developmental biology. Of particular note was the pioneering studies performed at the Institute of Reproduction and Development at Monash University (<http://www.monashinstitute.org/>) under the directorship of David de Kretser.

From approximately the 1950s to 80s there was an important group centered on D.T. Anderson, who was Professor of Zoology at the University of Sydney. He was made Fellow of the Royal Society for his work on the development of the fly, *Dacus*, and he wrote several books that are still influential on topics that would now

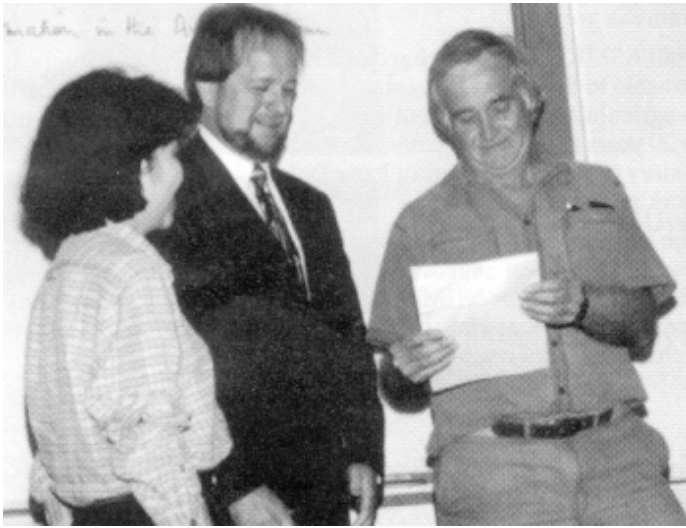


Fig. 2. Kallayane Chawengsaksothak (left) is presented the inaugural Keith Dixon Prize in Developmental Biology in 1997 by Lindsay Woods (center) and Keith Dixon (right). This much sought after prize for young investigators is awarded by the Australia and New Zealand Society for Cell and Developmental Biology at its annual conference.

be classed as evo-devo. He attracted numerous associates and students who worked mainly on the development of marine invertebrates. Valerie Morris was hired by him and was very active in the early days of the Australian and New Zealand Society for Cell Biology. She and Maria Byrne continue to do important work on echinoderm development, with Rudi Raff as a periodic visitor.

Adrian Horridge also had a short-lived but exciting development biology subgroup within the Department of Neurobiology at the Research School of Biological Sciences at the Australian National University, Canberra. He attracted and fostered the work of many people at the School including Eldon Ball, Mike Bate (made Fellow of the Royal Society for the work that he did on grasshopper in Canberra), Ian Meinertzhagen (development of the compound eye), David Young, Mark Tyrer and Jen Altman.

Eldon Ball, Rob Saint and Paul Whittington all played an important role in introducing the use of *Drosophila* to developmental biologists here in Australia and inspiring others to join the ranks (David Merritt, Gary Hime and Helena Richardson). At the end of the 1980's Edna Hardeman, Toshiya Yamada, Seong-Seng Tan and Patrick Tam were attracted from overseas bringing with them both classical and state-of-art technologies to drive developmental biology ahead. In the 1990's the field had grown enormously in Australia, further attracting the attention of histologists, biochemists, molecular biologists and cancer biologists such as John Bertram, Andrew Boyd, Melissa Little, Helen Cooper and Graham Lieschke. Graham Lieschke along with Michael Lardelli were instrumental in establishing zebrafish as an experimental model for developmental biologists in Australia. In the early 1990's both Melbourne (David Bowtell, Seong-Seng Tan and Richard Harvey) and Adelaide (Rob Saint, Peter Rathjen and Keith Dixon) were propelling developmental biology forward with small but very active groups holding regular workshops and meetings. By the mid 1990's molecular geneticists pursuing human malformations (Carole Wicking, Tim Cox) had turned their attention to developmental biology questions.

The basic developmental immunology done by Don Metcalf at the Walter and Eliza Hall Institute of Medical Science in Melbourne fostered the more embryological approaches adopted by the likes of Lorraine Robb, Andrew Elefanty and Andrew Perkins. In Perth, several research groups have emerged around a common theme associated with understanding the factors controlling tissue regeneration, especially in the areas of Neuroscience (Sarah Dunlop, Lyn Beazley, Alan Harvey) and skeletal muscle (Miranda Grounds). Cell therapy and stem cells are also long-standing interests and have resulted in establishment of a Tissue Engineering Research Centre and a new unit in Developmental Biology at the University of Western Australia.

Towards the turn of the 20th century a number of bright and enthusiastic young researchers have either moved or returned (Sally Dunwoodie – former student of Hardeman; Paul Thomas – former student of Rathjen) to Australia to inspire the next generation of developmental biologists. Interestingly, this blossoming of research activities in developmental biology have occurred despite what appears to be little change in the average grant size awarded by the National Health and Medical Research Council over 50 years. In 1951 an amount equivalent to \$6 million today was distributed to 60 workers over 30 institutes (\$100,000/grant). In 2001 459 new grants were awarded a total of \$47 million (\$102,000/grant).

The enthusiasm for developmental biology saw the merging of the annual conferences of the Australia and New Zealand Society for Cell and Developmental Biology and the Society for Biochemistry and Molecular Biology into a combined meeting called "Combio" in 2000. The field of development biology is now firmly established in the Australian research community.

KEY WORDS: *history, development, embryology*



Fig. 3. The Monash Institute of Reproduction and Development (<http://www.monashinstitute.org/>) in Melbourne houses approximately 150 scientists studying a diverse number of problems in the area of life and growth. The Institute under the directorship of David de Kretser is at the forefront of research into assisted reproductive technologies, infertility, prostate disease, functional genomics, fetal development, neonatal medicine, sudden infant death syndrome, women's cancers and reproductive angiogenesis.

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References

CHALMERS, J. and WHITWORTH, J.A. (2001). A half-century of Australian health and medical research. *Med. J. Aust.* 174: 29-32.

CHARLESWORTH, M., FARRALL, L., STOKES, T. and TURNBILL, D. (1989). *Life among the scientists. An anthropological study of an Australian scientific community.* Deakin University Press, Australia.

DOHERTY, R.L. (Ed.). (1986) *A Medical School for Queensland.* Boolarong Publications, Australia.

FINGER, S. (2000) *Minds behind the brains. A history of the pioneers and their discoveries.* Oxford University Press, New York.

SCHOENWOLF, G.C. (2001). Cutting, pasting and painting: experimental embryology and neural development. *Nature Rev. Neurosci.* 2: 763-771.

SPEMANN, H. and MANGOLD, H. (2001) Induction of Embryonic Promordia by Implantation of Organizers from a Different Species. Reproduction of 1924 paper, translated by V. Hamburger. *Int. J. Dev. Biol.* 45: 13-38.