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Microscopy, bioelectronics and other innovations in the flourishing of Glasgow zoology

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As recounted in *Gallery of Memories* (this volume), John Graham Kerr (JGK) arrived in 1902 in a department lacking any kind of scientific equipment. He quickly moved to put in place the essentials of the time: good quality microscopes for teaching and research, and the staff and facilities needed to prepare specimens for examination. A histology preparation room with skilled staff remained part of the Zoology building until the late 1990s. Here, we outline a few of the areas where technical innovations have transformed zoology research and teaching over the last century.

ELECTRON MICROSCOPY

The light microscope had reached the limits of its powers of resolution through the efforts of Abbe and Zeiss in the late 19th century, but biologists were keenly aware that there existed biological structures that they could not distinguish even with the best light microscopy. JGK's lecture notes from 1917 (this volume) give an example: transmissible diseases, but no visualisable organisms. This frustration was alleviated by the invention of the transmission electron microscope, available to biologists after World War 2, and led to the visualisation of viruses and the structures inside cells such as mitochondria and endoplasmic reticulum. In Glasgow Zoology, funding of £14,600 from the Department of Scientific and Industrial Research in 1964 allowed the purchase and installation of an AEI EM6 transmission electron microscope (Anon, 1965) in a basement facility designed by Gareth Owen and Hugh Steedman, both of whom moved elsewhere that year. Jim Cowey was put in charge of the new facility, with Maureen McCallum (later Gardner) as technician. Cowey and Bob Clark (who later moved to Bristol) had published a study on shape-changing in soft-bodied invertebrates (Clark & Cowey, 1958), later regarded as highly influential (Shandwick, 2008). Ultrastructural analysis of parasitic protozoans was a major focus of Keith Vickerman and his group's research from 1968, and this was greatly facilitated by the appointment in 1974 of Laurence Tetley (Fig.1) as research technologist, tasked with managing the Electron Microscope Unit (EMU). In 1978, the University appointed Margaret Mullin straight from school as a trainee technician. Her main duties were to service the biology and medical

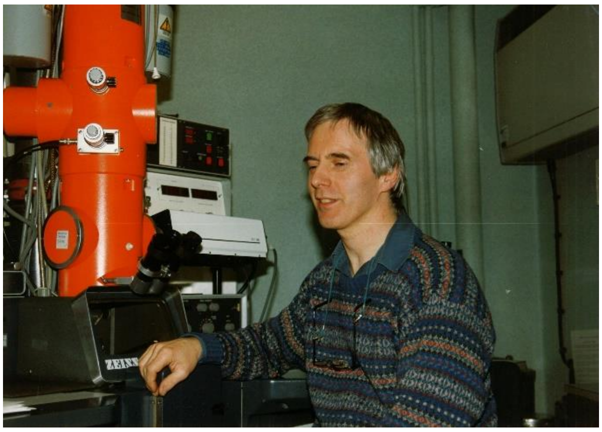

Fig. 1. Laurence Tetley at work at the Zeiss transmission electron microscope, 1980s. (Photo: EMU archives)

teaching laboratories in the Boyd Orr Building, but in the summer vacation, she worked in the EMU, learning how to use all the equipment. Several of the biological science departments had their own electron microscopes, but the re-organisation that led to the formation of the Institute of Biomedical and Life Sciences (IBLS) led to a consolidation of facilities and, in 1989, a combined EMU was located in the Chemistry (Joseph Black) Building: by then, Maureen had become the trade union representative for all University technicians, and Margaret was full-time in the EMU, a post she still occupies happily (Fig. 2), after 46 years in the university! The Unit's facilities have changed and expanded several times over the years: scanning, as well as transmission, electron microscopy; most recently, cryo-transmission allowing the examination of frozen specimens, and a new Jeol 1400 Flash TEM in 2023. This scale of investment shows the continuing importance of ultramicroscopy to many aspects of the biological sciences: for zoology, much of this work has been in parasitology, but there are few aspects where microscopy has not been important.

Fig. 2. Margaret Mullin in the EMU preparation room, 1980s. (Photo: EMU archives)

BIOELECTRONICS UNIT

Comparative and neurophysiological research in zoology both require the development and construction of complex specialist instruments, often not obtainable from commercial sources. This need led in the 1960s to the establishment of a bioelectronics unit, located in the GKB basement, and still there. Don McFarlane was the research technologist in the early days, but Martin Burns, employed as a lecturer, became more and more interested in instrument design using microelectronics, and their deployment for new purposes. For example, he designed a weighing device disguised as a rock which could monitor the weights of wild birds non-invasively. With the formation of IBLS, the Bioelectronics Unit expanded to work for the whole Institute, and for over 30 years Nosrat Mirzai was one of its staff, first under Jim Sinclair, then as its principal: he retired officially in 2020, but remains active. Jakub Czyzewski has taken over as leader of the team.

The Unit works closely with all sorts of biomedical and biological researchers to develop new solutions to problems, delivering cutting-edge innovations that enable research on otherwise intractable and unaffordable topics. For example, the Unit has designed mosquito electrocuting traps (MET) used by Heather Ferguson's team to measure the behaviour of mosquitoes feeding on people (Fig. 3), and vital for the design of vector control strategies against malaria, yellow fever, Zika virus and others. Another major collaboration has been with the researchers studying bird and mammal migrations: the design of Radio Frequency Identification (RFID) devices that can be painlessly attached to wild animals has allowed unprecedentedly accurate information to be gathered on individual animal behaviour. Yet another device has allowed the measurement of the bite force generated by fish, providing insights into the adaptations that allow different species to utilise a range of food sources such as corals. Another example to demonstrate diversity is the device designed to measure spore dispersal by lichens during Sally Eaton's research on epiphytic plants of the Scottish temperate rainforests (Fig. 4).

A recent acquisition is the Unit's 3D printer. For the Baltic Seabird Project's auk laboratory's evaluation of heat dissipation in breeding common guillemots, local microclimate measurements were needed. To obtain accurate air temperature data, the thermocouples used had to be housed in a radiation screen specific to the breeding ledge used by the birds. No commercially available screen could be sourced, but the 3D printer did the job (Fig. 5).

Fig. 3. MET in use in Tanzania, *ca.* 2020. (Photo: Bioelectronics Unit)

Fig. 4. Automated spore collector in use on a Glasgow street, *ca.* 2020. (Photo: Bioelectronics Unit)

OTHER INNOVATIONS

Several other innovations have revolutionised the practice of zoological research over the last century. Mable (2024) describes the most recent: the ability to sequence DNA and its impact on evolutionary and ecological studies. Another obvious example is the pervasive influence of information technology. Modern computers allow the compilation of enormous databases which can then be interrogated by more and more sophisticated statistical methods. Computers also enable the construction of complex mathematical models which can help us understand trends like the impacts of climate change on biodiversity. These developments have meant that the appointment to zoology of staff members whose expertise is primarily mathematical, computational or statistical is now entirely normal. The results of some of their efforts are described in Monaghan (2024).

Fig. 5. The 3D printed radiation screen: white cylinder attached to the wooden box. Two dummy guillemots on the ledge. (Photo: David Stone)

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