

This Week's Citation Classic®

Ellis A E. The leucocytes of fish: a review. *J. Fish Biol.* 11:453-91, 1977.
[Marine Laboratory, Aberdeen, Scotland]

An attempt is made here to assign nomenclature to fish leucocytes on a functional, histochemical, as well as a morphological basis by applying the concepts that have recently arisen in mammalian immunology. It is hoped that this review will provide useful guidelines for future research. (The *SCI*® indicates that this paper has been cited in more than 135 publications, making it the most-cited paper published in this journal.)

Cells of the Fish Immune System

Anthony E. Ellis
SOAFD Marine Laboratory
Aberdeen AB9 8DB
Scotland

During the 1960s, the farming of several freshwater and marine species of fish began to gather momentum around the world. This growing industry, with its anticipated disease problems, gave rise to what has now become a large international body of fish pathologists and immunologists.

From the 1920s to the 1960s, the literature contained reports of several studies on fish leucocytes using a terminology derived from human hematology. However, the application of this nomenclature was based on vague morphological similarities to mammalian cells and a limited number of staining procedures. Different authors subscribed to different theories of blood cell origins and development, all of which predated the revolutionary findings of mammalian immunologists¹ that demonstrated that lymphocytes were highly differentiated immunocompetent cells. Although rapid advances in understanding cells in mammals took place in the 1960s and 1970s, many fish pathologists were unaware of them, and the publications on fish blood cells referred to an outmoded hematological scheme.

It was in such an environment that I began my studies in 1969 on the leucocytes and immune responses of fish as a PhD student unfamiliar with the term "lymphocyte." My good fortune began immediately in having two pioneering, enthusiastic, and highly supportive supervi-

sors—Alan Munro, in the Marine Laboratory, Aberdeen, Scotland, and Ron Roberts, then of the Veterinary School in Glasgow, Scotland, and subsequently director of the Institute of Aquaculture, University of Stirling, Scotland. It was not long before my mentors included several people in the Department of Bacteriology and Immunology, University of Glasgow, who were to set me on a course of study that has given me immense satisfaction and delight. These people were Delphine Parrott, Peter Wilkinson, R.G. White, and, principally, Maria de Sousa, with whom I collaborated on several experiments to establish the immunocompetent nature of fish lymphocytes.² At one time, she painstakingly salvaged one important experiment by sellotaping together the shattered remnants of dozens of autoradiographs that had fallen from the roof of her car, when having forgotten to stow them within, she began to drive away.

The task was clear enough: to take a modern immunological approach to the study of fish leucocytes and lymphoid tissues. Thus, I undertook to critically review the literature of fish leucocytes, in the light of modern immunological knowledge and the results of my own work, in order to put forward guidelines for future studies. This resulted in "The leucocytes of fish: a review," which caused my director some consternation as to the apparent way in which I was laying down the law.

Since the publication of this paper, major advances in understanding the nature of fish lymphocyte subpopulations have been made, principally by the group led by Bill (L.W.) Clem,^{3,4} in Jackson, Mississippi, and on macrophage activation by Chris J. Secombes,⁵ in Aberdeen. There are nevertheless several unresolved problems, especially relating to the function of fish granulocytes and the problem of mast cells in fish that appear to have an interesting analogue, if not homologue, of mammalian mast cells.⁶

Fish immunology is now a respectable science. I feel greatly privileged to have contributed to it. And, I thank all those wonderful people who contributed to what is me.

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Received April 1, 1991