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LEECH BIOLOGY AND BEHAVIOUR

Roy T. Sawyer, Managing Director, Biopharm (UK) Ltd., Swansea

This new three-volume work provides a complete study of this well-known group of animals, dealing with every level of their biological organization, from the molecular to the zoogeographical.

The leech, once so prominent in the history of medicine, is again being used widely in modern hospitals, especially in microsurgery. Revival in the use of leeches coincides with recent revelations about the rich diversity of pharmacologically active peptides secreted by the leech, including the powerful anticoagulant Hirudin which was discovered in 1884. The author who has studied leeches extensively for many years, documents for the first time the scientific and biological rationale underlying the medicinal use of leeches and concludes that there was a nucleus of truth behind their use in previous centuries.

In recent years the leech has been the subject of much neurobiological research, but such research has tended to emphasize the neurophysiological aspects. This book gives an authoritative account of leech neurobiology from the biological viewpoint, with emphasis on the neuronal basis and the evolution of leech behaviour.

The book takes up Manton's controversial thesis that insects, myriapods, and onychophorans constitute a new phylum (Uniramia) unrelated to the Crustacea. He also significantly extends the argument by proposing that leeches are also allied to the Uniramia. This proposal is a major intrusion into the traditional classification of the animal kingdom, and as such is likely to gain considerable attention.

A "key" to the leeches of each zoogeographical region of the world and an extensive bibliography (volume 3) are included.

The diverse and wide-ranging nature of the book should make it of interest to research workers and students in various disciplines, particularly medicine, molecular biology, neurobiology, zoology and marine biology.

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Preface

By its very nature a work like this prompts questions such as 'Why study leeches?.' Over the years this and similar questions have often been put to me. They have always been difficult to answer, mainly because the interest in leeches started at such an early age. I use this preface as an opportunity to relate briefly some of the events which led to my commitment to the leech and to the writing of this book which documents for the first time the scientific rationale behind the use of leeches in medicine, a practice that dates back to prehistory.

My interest in leeches springs from early childhood spent in the coastal lowlands of the Carolinas where I first encountered a leech, firmly attached to the shell of a turtle. Subsequent, and not infrequent, encounters with leeches on turtles, fish, and on myself were always met with curiosity. At the age of fourteen I conducted a school biology project on local leeches. (Some of these leeches were undescribed species which I had the honour of naming years later (Sawyer and Shelley 1976).) By my mid-teens I had also developed an interest in the nineteenth-century naturalists, interlaced with the spirit of adventure epitomized by *The Voyage of the Beagle*. Thus, prior to entering university I was steeped in the natural history of the Carolinas, including its leeches, and was excited by the natural history tradition of the last century.

At university my enthusiasm for biology was quickly whittled away by formal training in the subject. During this period I gradually became aware that the cause of my dissatisfaction was that the modern approach to biology fails to achieve a thorough understanding of any group of animal or plant. The vast scope of biological knowledge leads most modern biologists to retreat into increasingly narrow experimental specializations. This mosaic training artificially polarizes experimental science from the descriptive, more circumspect, science of natural history. The personal conclusion was reached that in order to have a balanced perspective of biology it was essential to focus on the natural history of a single group of animal or plant. In contemporary terms this meant having an understanding of a biological group at every level of organization from molecular to zoogeographical. The group I chose was the leech with its compelling mystique in the history of medicine.

Whatever the reasons for choosing leeches the commitment has been enduring and satisfying. During the ensuing months, and then years, I developed a considerable curiosity about anything to do with leeches. At the beginning there was no pattern or conscious objective to this pursuit, other than a will to comprehend fully this one group of animals. In addition to original research, a great deal of time was spent delving into the voluminous literature on leeches with a special

fascination for the early accounts. Finally, it was the act of writing this book, over a period of about twelve years, which most significantly played a role in digesting and integrating the information into manageable themes. Because of the desire to understand the broad outlines of leech evolution, the book had to be more than a collection of facts. Gradually a mental picture of leech evolution emerged, conceptionally derived from the living relict *Acanthobdella peledina*. However, about 1975 it became apparent that the lack of a strategically vital piece of information prevented a full understanding of the group's history. This gap emerged from awareness that there were actually two parallel trends in leech evolution. Each group culminates with parasitism of mammals but reaches this end-point via a different evolutionary route. One group is the jawed leeches (Arhynchobdellida), represented by the well-known European medicinal leech *Hirudo medicinalis*. The other group is the proboscis-bearing leeches (Rhynchobdellida). The most advanced representative of the latter was known at that time from only two specimens collected in the Amazon in the nineteenth century. In 1977, with assistance from The American Philosophical Society, I organized and led an expedition to the Amazon in search of the elusive giant leech *Haementeria ghilianii*. We were successful in bringing back a few specimens from which are descended all individuals currently being used for research, and now available commercially.

The significance of this particular leech should be put clearly into perspective. *Haementeria ghilianii* is an advanced mammalian parasite representing the end-point of rhynchobdellid evolution. Before a comparison could be made with its much better known arhynchobdellid counterpart *Hirudo medicinalis*, it was necessary for us to study diverse aspects of *Haementeria* biology. Thus followed a period of years in which we reported on its growth and reproduction (Sawyer, LePont, Stuart, and Kramer 1981), neurophysiology (Kramer 1981), development (Weisblat 1981; Stent and Weisblat 1982; Glover and Kramer 1982), behaviour (Sawyer 1981*a*); and salivary gland anatomy (Sawyer, Damas, and Tomic 1982), physiology (Marshall and Lent 1984; Jones, Sawyer, and Berry 1985), pharmacology (Gasic, Viner, Budzynski, and Gasic 1983), and biochemistry (Budzynski, Olexa, and Sawyer 1981; Malinconico, Katz, and Budzynski 1984). The most significant outcome of this study was the discovery in the *Haementeria* salivary gland of the fibrinolytic enzyme *hementin*, so fundamentally different from the antithrombin *hirudin* found in *Hirudo*.

The conclusion of this study of leeches is the awareness that there is a legitimate biological rationale behind the use of leeches in medicine. Like so many traditional remedies there was a nucleus of scientific fact behind leeching. The following pages document in some detail that:

(i) a diversity of biologically active substances occur in the salivary gland of the leech;

(ii) these biochemicals are not used in digestion, but are the result of adaptation to feeding on the blood of mammals; and

(iii) each leech species has to some extent its own unique range of biochemicals.

Stated more clearly, the leech is a living pharmacopoeia which is the mirror image of human physiology. The considerable potential of these substances in modern medicine has been impeded, however, by difficulties of supply (in 1983 *Hirudo medicinalis* was listed in the *Invertebrate Red Data Book*). In order to overcome the problem of supply, I founded a commercial leech farm, Biopharm (UK) Ltd., which markets live leeches of several species, in addition to biochemicals extracted from their salivary glands. With these products Biopharm serves universities and hospitals throughout the world, and thus stimulates further research into this exciting new biomedical field.

Acknowledgements

So many people and institutions have helped me along the way that a full list is impractical. However, at the risk of offending someone by omission, I would like to mention the following who have been perhaps the most directly influential in helping me understand leeches. Foremost, my grandmother, Carrie Virginia Weatherly, who first opened my eyes to natural history. For help in later years my thanks go to E. W. Knight-Jones, G. S. Stent, J. G. Nicholls, E. M. Burreson, D. J. Klemm, M. C. Meyer, L. R. Richardson, D. A. Weisblat, W. B. Kristan Jnr., A. Z. Budzynski, F. O. Hechtel, R. H. Shelley, R. W. Sims, M. Pettibone, G. J. Gasic, R. W. Davies, I. Cantrell, H. van der Schalie, Ray Leonard, and others known to yourselves. The Molecular Biology Department of the University of California-Berkeley and the Zoology Department of the University of Wales-Swansea, both gave considerable tangible assistance over the years.

Ar lefel personol hoffwn fanteisio ar y cyfle yma i ddiolch i'r rheinya rhoddodd gymorth amhrisiadwy dros y blynyddoedd. Yn bennaf hoffwn gyflwyno'r llyfr hwn, na fyddaimewn bod onibaiamdani, i Lorna; hefyd i Tom ac Evelyn, eu cefnogaeth cyson a fu'n gefn inni mwy nac unwaith mewn ambell hinddrwg. Mynegir hefyd diolch arbennig i bobl Penclawdd a Llanelli a rhoddodd mwy o ymddiried a chymorth ymarferolo lawer na'r US National Science Foundation. Â fy niolch tragwyddol i Gymru fy ngwlad mabwysiedig am gynnig aelwyd ddi-hafal i ysgrifennu creadigol.

Swansea
April 1985

R. T. S.

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