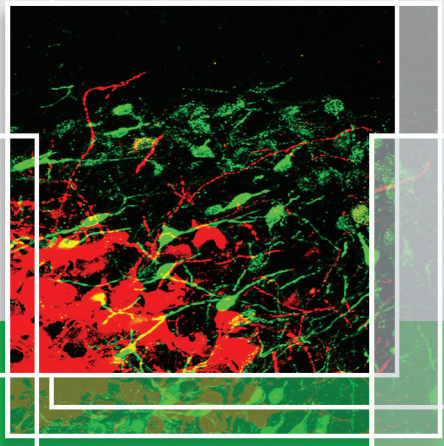
Masterclass in Neuroendocrinology Series

Neurophysiology of Neuroendocrine Neurons

Editors: William E. Armstrong & Jeffrey G. Tasker



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Series Preface

This Series is a joint venture between the International Neuroendocrine Federation and Wiley-Blackwell. The broad aim of the Series is to provide established researchers, trainees, and students with authoritative up-to-date accounts of the present state of knowledge, and prospects for the future across a range of topics in the burgeoning field of neuroendocrinology. The Series is aimed at a wide audience as neuroendocrinology integrates neuroscience and endocrinology. We define neuroendocrinology as study of the control of endocrine function by the brain and the actions of hormones on the brain. It encompasses study of normal and abnormal function, and the developmental origins of disease. It includes study of the neural networks in the brain that regulate and form neuroendocrine systems. It includes study of behaviors and mental states that are influenced or regulated by hormones. It necessarily includes understanding and study of peripheral physiological systems that are regulated by neuroendocrine mechanisms. Clearly, neuroendocrinology embraces many current issues of concern to human health and well-being, but research on these issues necessitates reductionist animal models.

Contemporary research in neuroendocrinology involves use of a wide range of techniques and technologies, from subcellular to systems and whole-organism level. A particular aim of the Series is to provide expert advice and discussion about experimental or study protocols in research in neuroendocrinology, and to further advance the field by giving information and advice about novel techniques, technologies, and inter-disciplinary approaches.

To achieve our aims each book is on a particular theme in neuroendocrinology, and for each book we have recruited an editor, or pair of editors, expert in the field, and they have engaged an international team of experts to contribute chapters in their individual areas of expertise. Their mission was to give an update of knowledge and recent discoveries, to discuss new approaches, "gold-standard" protocols, translational possibilities, and future prospects. Authors were asked to write for a wide audience to minimize references, and to consider use of video clips and explanatory text boxes; each chapter is peer-reviewed and has a glossary, and each book has a detailed index. We have been guided by an Advisory Editorial

Board. The Masterclass Series is open-ended: books in preparation include *Neuroendocrinology of Stress*; *Computational Neuroendocrinology*; *Molecular Neuroendocrinology*; and *Neuroendocrinology of Appetite*.

Feedback and suggestions are welcome.

John A. Russell, University of Edinburgh, and William E. Armstrong, University of Tennessee

International Neuroendocrine Federation – www.isneuro.org

Preface

Our understanding of the mechanisms underlying neurohormone release has evolved remarkably since the initial discovery that hypothalamic magnocellular neurons synthesizing oxytocin and vasopressin share electrical and synaptic excitability with other central nervous system neurons, and release these peptides from axon terminals in the neurohypophysis in an action potential dependent manner. In this volume, chapters range from those describing the rich history and current state of *in vivo* recordings, highlighting the precise relationship between the patterns of action potential discharge in these neurons and hormone release, to *in vitro* approaches where neuroendocrine neurons can be precisely identified and their membrane properties, morphology, and synaptic responses, directly examined. These modern approaches have led to an increased appreciation of the role the neurons play in regulating their own activity, including a new understanding of the electrical excitability and peptide-releasing capability of dendrites, and the characterization of the unique properties that axonal terminals possess to shape release. Thus, we hope that researchers and students of neuroendocrinology and neuroscience in general will glean from this volume not only an understanding of neuroendocrine cell electrophysiology, but also an appreciation of how this model system affords access to virtually all parts of the neuron for detailed study—something unique compared to most types of neurons in the brain.

Another aspect worth noting is that *in vivo* recording continues to provide the necessary physiological context in which we place rapidly expanding knowledge of the increasingly complex molecular characteristics of these neurons. Such work, whether it demonstrates the synchronous discharge of oxytocin neurons during lactation or the pulsatility of the gonadotropin-releasing hormone (GnRH) pulse generator, is inherently difficult, but critical to demonstrate the physiological importance of newly discovered ion channels, transporters, transmitter receptors, and transcription factors that shape the activity of these neurons.

Several chapters demonstrate the diverse power of *in vitro* techniques, whether using isolated neurohypophysial terminals, visually identified neurosecretory cells in cell cultures or *ex vivo* brain slices from transgenic rodents, or organ cultures that mimic *in vivo* activity. Whole-cell patch

recording has further allowed the identification of mRNAs in single neurons, documenting the expression of many channels and neurotransmitter receptors. These techniques have been critical for understanding the cellular physiology of neuroendocrine neurons because *in vivo* intracellular recordings are not routinely possible from these cells, due either to their deep and scattered locations in the brain, as is the case for the GnRH neurons, or to their proximity to pulsating large blood vessels that produce mechanical instability, as is the case for oxytocin and vasopressin neurons. Thus, intracellular recordings of GnRH neurons, for example, have only been accomplished *in vitro*, and there are only two short publications describing very brief *in vivo* recordings from vasopressin or oxytocin neurons.

Studies of neuroendocrine neurons have been pioneering in the discovery of the dendritic release of neurotransmitters and of the regulation of synaptic transmission by astrocytes. Several of the chapters herein consider different aspects of the release of neuropeptides and "retrograde," or backward-acting, messengers from the dendrites of neuroendocrine neurons, and describe the dynamic regulation of the actions of these retrograde messengers by astrocytes. The remarkable plasticity of the interactions between neuroendocrine neurons and their associated astrocytes under different physiological conditions makes for a fluid and ever-changing environment of synaptic modulation. In addition to modulating neurotransmission between pre- and postsynaptic neuronal elements by controlling neurotransmitter levels, glia also directly contribute to synaptic and extrasynaptic transmission via direct gliotransmitter release and actions on neurons. These are exciting times in the area of glial–neuronal interactions, and neuroendocrine neurons are at the forefront of discovery in this rapidly expanding field.

Thus, neuroendocrine neurons, "hybrids" of nerve and glandular cells that signal from the brain to the pituitary and the body, provide remarkably rich and accessible models for the study of intrinsic membrane currents, forward and backward synaptic transmission, and reciprocal neuronal–glial interactions. This volume introduces the reader to the current understanding of the physiological workings of this fascinating cell type, an introduction that hopefully will provide inspiration for further exploration into the exciting field of neuroendocrinology.

William E. Armstrong, Ph.D.
Jeffrey G. Tasker, Ph.D.

About the Companion Website

This book is accompanied by a companion website:

www.wiley.com/go/armstrong/neurophysiology

The website includes:

- End-of-chapter references and glossary
- Powerpoints of all figures and tables from the book
- Demonstration videos