Muscle Contraction

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Skeletal Muscle Cambridge University Press
Muscular contraction provides one of the most fascinating topics for a biophysicist to study. Although muscle comprises a molecular machine whereby chemical energy is converted to mechanical work, its action in producing force is something that is readily observable in everyday life, a feature that does not apply to most other structures of biophysical inter est. In addition, muscle is so beautifully organized at the microscopic level that those important structural probes, electron microscopy (with the associated image analysis methods) and X-ray diffraction, have pro vided a wealth of information about the arrangements of the constituent proteins in a variety of muscle types. But, despite all this, the answer to the question "How does muscle work?" is still uncertain, especially with regard to the molecular events by which force is actually generated, and the question remains one of the major unsolved problems in biology. With this problem in mind, this book has been written to collect together the available evidence on the structures of the muscle fila ments and on their arrangements in different muscle cells, to extract the common structural features of these cells, and thus to attempt to define a possible series of mechanical steps that will describe at molecular resolu tion the process by which force is generated. The book cannot be considered to be an introductory text; in fact, it presents a very detailed account of muscle structure as gleaned mainly from electron microscopy and X-ray diffraction.

Molecular Mechanism of Muscle Contraction NYU Press
This volume presents the proceedings of a muscle symposium, which was supported by the grant from the Fujihara Foundation of Science to be held as the Fourth Fujihara Seminar on October 28 -November 1, 2002, at Hakone, Japan. The Fujihara Seminar covers all fields of natural science, while only one proposal is granted every year. It is therefore a great honor for me to be able to organize this meeting. Before this symposium, I have organized muscle symposia five times, and published the proceedings: " Cross-bridge Mechanism in Muscle Contraction (University of Tokyo Press, 1978), "Contractile Mechanisms in Muscle" (plenum, 1984); "Molecular Mechanisms of Muscle

Contraction" (plenum, 1988); "Mechanism of MyofIlament Sliding in Muscle contraction" (plenum, 1993); "Mechanisms of Work Production and Work Absorption in Muscle" (plenum, 1998). As with these proceedings, this volume contains records of discussions made not only after each presentation but also during the periods of General Discussion, in order that general readers may properly evaluate each presentation and the up-to-date situation of this research field. It was my great pleasure to have Dr. Hugh Huxley, a principal discoverer of the sliding fIlament mechanism in muscle contraction, in this meeting. On my request, Dr. Huxley kindly gave a special lecture on his monumental discovery of myofIlament-lattice structure by X-ray diffraction of living skeletal muscle. I hope general readers to learn how a breakthrough in a specific research field can be achieved.

Anatomy and Physiology New York : Liss

Composed of a set of chapters contributed by past and present collaborators of the Nobel laureate Sir Andrew Huxley, this book covers the areas of muscle research to which Huxley made major contributions. The purpose of the book is to discuss the way that muscles work, asking questions at a fundamental level about the molecular basis of muscle tone production and muscle contraction. The majority of the chapters are concerned with muscle physiology and the relation between structure and function. The process of activation of muscles is discussed, along with the mechanism of contraction itself. Although most of the book deals with vertebrate skeletal muscle, several chapters cover cardiac muscle. Also featured are two chapters discussing Sir Andrew's achievements in both nerve and muscle physiology.

Muscle Contraction Springer

This valuable resource provides a systematic account of the biochemistry of smooth muscle contraction. As a comprehensive guide to this rapidly growing area of research, it covers the structure and characteristic properties of contractile and regulatory proteins, with special emphasis on their predicted function in the live muscle. Also included in this book are intermediate filament proteins, and desmin and vimentin, whose function in smooth muscle is unknown; and several enzymes involved in the phosphorylation-dephosphorylation of contractile and other proteins.

Mechanism of Myofilament Sliding in Muscle Contraction Springer Science & Business Media

This is a collection of papers that presents a novel interpretation of data from the literature to reason logically for an overlooked mechanism of stimulus-contraction coupling in muscle. This mechanism is then used to explain aspects of the puzzles relating to both an important physiological function of the heart, The Frank-Starling Law, and the basis of a common inherited disease state, familial hypertrophic cardiomyopathy (FHCM).

Molecular and Cellular Aspects of Muscle Contraction Springer Science & Business Media

Understanding the molecular mechanism of muscle contraction started with the discovery that striated muscle is composed of interdigitating filaments which slide against each other. Sliding filaments and the working-stroke mechanism provide the framework for individual myosin motors to act in parallel, generating tension and loaded shortening with an efficient use of chemical energy. Our knowledge of this exquisitely structured molecular machine has exploded in the last four decades, thanks to a bewildering array of techniques for studying intact muscle, muscle fibres, myofibrils and single myosin molecules. After reviewing the mechanical and biochemical background, this monograph shows how old and new experimental discoveries can be modelled, interpreted and incorporated into a coherent mathematical theory of contractility at the molecular level. The theory is applied to steady-state and transient phenomena in muscle fibres, wing-beat oscillations in insect flight muscle, motility assays and single-molecule experiments with optical trapping. Such a synthesis addresses major issues, most notably whether a single myosin motor is driven by a working stroke or a ratchet mechanism, how the working stroke is coupled to phosphate release, and whether one cycle of attachment is driven by the hydrolysis of one molecule of ATP. Ways in which the theory can be extended are explored in appendices. A separate theory is required for the cooperative regulation of muscle by calcium via tropomyosin and troponin on actin filaments. The book reviews the evolution of models for actin-based regulation, culminating in a model motivated by cryo-EM studies where tropomyosin protomers are linked to form a continuous flexible chain. It also explores muscle behaviour as a function of calcium level, including emergent phenomena such as spontaneous oscillatory contractions and direct myosin regulation by its regulatory light chains. Contraction models can be extended to all levels of calcium-activation by embedding them in a cooperative theory of thin-filament regulation, and a method for achieving this grand synthesis is proposed. Dr. David Aitchison Smith is a theoretical physicist with thirty years of research experience in modelling muscle contractility, in collaboration with experimental groups in different laboratories.

Energetic Aspects of Muscle Contraction Elsevier

Dieses Teilgebiet der Biomechanik ist für Sportwissenschaftler und Physiologen von großer Bedeutung! Die umfassende, aktuelle Abhandlung der Skelettmuskelmechanik beschäftigt sich mit drei Themenkreisen: den Mechanismen der Skelettmuskelkontraktion, der Muskelfunktion in vivo und theoretischen Modellen der Muskelfunktion. Auch ein knapper historischer Abriß und ein Ausblick auf noch offene Fragen fehlen nicht. (08/00)

Muscle Contraction and Cell Motility Springer Science & Business Media

Recent years have witnessed an explosion of knowledge lea- ding to a molecular understanding of the mechanisms of ac- tion of calcium on excitation and contraction coupling and its role in the regulation of contractility. This book highlights the most recent progress as well as providing a historial perspective of the field. It presents a concise and comprehensive overview of our current knowledge regar- ding calcium channels and regulatory proteins as well as in- tracellular calcium handling and the mechanisms underlying the activation of contractile proteins. It also describes how these basic mechanisms have been adapted in various types of muscle, especially in cardiac and smooth muscle.

The Kinetics of Muscle Contraction Springer Science & Business Media

There has been a lot of debate concerning the nature of the molecular mechanism that produces filament sliding and muscle shortening. This book presents the different kinds of structural and mechanical evidence in favour of the swinging of myosin heads on actin during the contractile cycle.

Mysteries in Muscle Contraction Springer

Provides readers with a detailed understanding of the different facets of muscle physiology. Examines motoneuron and muscle structure and function. It is intended for those need to know about skeletal muscle--from undergraduate and graduate students gaining advanced knowledge in kinesiology to physiotherapists, physiatrists, and other professionals whose work demands understanding of muscle form and function.

Muscle Contraction Springer Science & Business Media

This book describes the evolution of ideas relating to the mechanism of muscular contraction since the discovery of sliding filaments in 1954. An amazing variety of experimental techniques

have been employed to investigate the mechanism of muscular contraction and relaxation. Some background of these various techniques is presented in order to gain a fuller appreciation of their strengths and weaknesses. Controversies in the muscle field are discussed along with some missed opportunities and false trails. The pathway to ATP and the high energy phosphate bond will be discussed, as well as the discovery of myosin, contraction coupling and the emergence of cell and molecular biology in the muscle field. Numerous figures from original papers are also included for readers to see the data that led to important conclusions. This book is published on behalf of the American Physiological Society by Springer. Access to APS books published with Springer is free to APS members.

Reflections on Muscle Springer Science & Business Media

This volume presents the entire proceedings of the symposium organized by one of us (H. S.) on November 11 to 15, 1991 at Hakone, Japan, under the title of "Mechanism of Myofllament Sliding in Muscle Contraction. " Among various kinds of energy transduction mechanisms in biological systems, the mechanism of muscle contraction has been studied most intensively and extensively over many years. Since the monumental discovery by the two Huxleys and coworkers that muscle contraction results from relative sliding between the thick and thin myofilaments, attention of muscle investigators has been focused on the question, what makes the fllaments slide past one another. In response to the above question, A. F. Huxley and Simmons put forward a contraction model in 1971, in which globular heads of myosin (cross-bridges) extending from the thick fllament first attach to actin on the thin fllament, and then change their angle of attachment to actin (power stroke) leading to force generation or myofilament sliding until they detach from the thin fllament. The rocking cross-bridge contraction model seemed to be entirely consistent with the kinetic scheme of actomyosin ATPase published by Lymn and Taylor at the same time, thus giving a strong impression to the people concerned that the muscle contraction mechanism would soon be sorted out. In his review lecture in 1974, however, A. F.

Regulation of Smooth Muscle Contraction Human Kinetics

`In contrast to common practice, we have always tried to include as many discussions held at the meeting in our proceedings as possible, so as to enable readers to properly evaluate each paper presented, as well as to learn of future prospects in this field of research. Although the policy of including discussions occasions a long publication delay, we believe that it is worth repeating in our future publication, as we have met a number of young investigators fascinated by the discussions in our proceedings.... In the concluding remarks in this volume, Dr. Hugh E. Huxley, a principal architect of the sliding filament mechanism of muscle contraction, states that the molecular mechanism of myofilament sliding remains mysterious to all of us. We hope that this volume will stimulate muscle investigators to design and perform novel experiments to clarify the mysteries in muscle contraction.' Haruo Sugi and Gerald H. Pollack, excerpted from the Preface.

Muscular Contraction Springer Science & Business Media

Sliding Filament Mechanism in Muscle Contraction: Fifty Years of Research covers the history of the sliding filament mechanism in muscle contraction from its discovery in 1954 by H.E. Huxley through and including modern day research. Chapters include topics in dynamic X-ray diffraction, electron microscopy, muscle mechanisms, in-vitro motility assay, cardiac versus smooth muscle, motile systems, and much more.

Muscle Contraction Elsevier

It is now widely recognized that fundamental progress in science is made not in a continuous manner but in a stepwise manner. In the field of the molecular mechanism of contraction in striated muscle, the stepwise progress was achieved by three great investigators in 1940's and 1950's. In the early 1940's, Albert Szent-Gyorgyi and his associates showed biochemically that muscle contraction is essentially an interaction between actin and myosin coupled with ATP hydrolysis. Then, in the 1950's, Hugh E. Huxley together with Jean Hanson demonstrated that striated muscle is composed of a hexagonal lattice of two kinds of interdigtating myofilaments consisting of action and myosin respectively, and made a monumental discovery that muscle contraction results from the relative sliding between the actin and myosin filaments. Andrew F. Huxley, who also participated in the discovery of the sliding filament mechanism of muscle contraction was attributed to the attachment-detachment cycle between the cross-bridges extending from the myosin filament and the complementary sites on the actin filament. After the above stepwise progress, however, muscle research appears to have entered into a period of so-called 'normal science' where detailed knowledge has been accumulating around the well established 'central dogmas' but without fundamental progress. More specifically, most experiments on muscle contraction mechanisms have been designed, carried out and interpreted on the basis of the Huxley's 1957 and the Huxley-Simmons' 1971 contraction models, as well as the kinetic scheme of actomyosin ATPase; but the molecular mechanism of contraction still remains to be a matter for debate and speculation. For further fundamental progress in this field of research, we feel it necessary to reconsider the validity of these dogmas and to interpret the results more freely. In 1978, one of us (H.S.) organized a symposium in Tokyo based on the above idea, and we published the proceedings under the title of "Cross-bridge Mechanism in Muscle Contraction" (ed. H. Sugi and G.H. Pollack, University of Tokyo Press/University Park Press, 1979). The unusual interest of muscle physiologists in this symposium encouraged us to organize a second symposium on muscle contraction in Seattle in 1982, and proceedings was again published under the title of "Contractile Mechanisms in Muscle" (ed. G.H. Pollack and H. Sugi, Plenum Publishing Corporation, 1984). We were again very much encouraged by the intense interest of the people at the symposium as well as by readers of the proceedings, and became convinced that the symposia of this kind would greatly accelerate the progress in this field. The present symposium was organized by one of us (H.S.) as the third "Cross-bride" symposium. Though most papers are concerned, as in the previous two symposia, with experiments on intact and demembranated muscle fibers and isolated myofibrils, where the three-Dimensional muofilament-lattice structures have been preserved, the results are frequently discussed in connection with the kinetics of actomyosin ATPase, reflecting the recent development of experimental methods connecting physiology and biochemistry. It has also become possible to obtain direct information about the orientation and configuration of the cross-bridges as various stages during muscle contraction.

Mechanics of Muscle Springer Science & Business Media

The student of biolo,gical science in his final years as an undergraduate and his first years as a graduate is expected to gain some familiarity with current research at the frontiers of his discipline. New research work is published in a perplexing diversity of publications and is inevitably concerned with the minutiae of the subject. The sheer number of research journals and papers also causes confusion and difficulties of assimilation. Review articles usually presuppose a background knowledge of the field and are inevitably rather restricted in scope. There is thus a need for short but authoritative introductions to those areas of modern biological research which are either not dealt with in standard introductory textbooks or are not dealt with in

sufficient detail to enable the student to go on from them to read scholarly reviews with profit. This series of books is designed to satisfy this need. The authors have been asked to produce a brief outline of their subject assuming that their readers will have read and remembered much of a standard introductory textbook of biology. This outline then sets out to provide by building on this basis, the conceptual framework within which modern research work is progressing and aims to give the reader an indication of the problems, both conceptual and practical, which must be overcome if progress is to be maintained.

Sliding Filament Mechanism in Muscle Contraction CRC Press

Muscle contraction has been the focus of scientific investigation for more than two centuries, and major discoveries have changed the field over the years. Early in the twentieth century, Fenn (1924, 1923) showed that the total energy liberated during a contraction (heat + work) was increased when the muscle was allowed to shorten and perform work. The result implied that chemical reactions during contractions were load-dependent. The observation underlying the “Fenn effect” was taken to a greater extent when Hill (1938) published a pivotal study showing in details the relation between heat production and the amount of muscle shortening, providing investigators with the force-velocity relation for skeletal muscles. Subsequently, two papers paved the way for the current paradigm in the field of muscle contraction. Huxley and Niedergerke (1954), and Huxley and Hanson (1954) showed that the width of the A-bands did not change during muscle stretch or activation. Contraction, previously believed to be caused by shortening of muscle filaments, was associated with sliding of the thick and thin filaments. These studies were followed by the classic paper by Huxley (1957), in which he conceptualized for the first time the cross-bridge theory; filament sliding was driven by the cyclical interactions of myosin heads (cross-bridges) with actin. The original cross-bridge theory has been revised over the years but the basic features have remained mostly intact. It now influences studies performed with molecular motors responsible for tasks as diverse as muscle contraction, cell division and vesicle transport.

Regulation of the Contractile Cycle in Smooth Muscle Springer

This volume intends to provide a comprehensive overview on the mecha nisms of muscle contraction and non-muscle cell motility at the molecu lar and cellular level, not only for investigators in these fields but also for general readers interested in these topics. A most attractive feature of various living organisms in the animal and plant kingdoms is their ability to move. In spite of a great diversity in the structure and function of various motile systems, it has frequently been assumed since the nineteenth century that all kinds of "motility" are essentially the same. Based on this assumption, some investigators in the nineteenth century thought that the mechanisms of motility could better be studied on primitive non-muscle motile systems such as amoeboid movement, rath er than on highly specialized muscle cells. Contrary to their expectation, however, the basic mechanisms of motility have been revealed solely by investigations on vertebrate skeletal muscles, since a monumental discovery of Szent-Gyorgyi and his coworkers in the early 1940s that muscle contraction results from the interaction between two different contractile proteins, actin and myosin, coupled with ATP hydrolysis.

Mechanism of Myofilament Sliding in Muscle Contraction Springer Science & Business Media

First published in 1985, the revised edition of this text consists of seven chapters describing the muscle, its anatomy, its mechanics, and its chemical and neuro-control systems. It documents empirical, analytical, and experimental analyses and equations in the field of muscle mechanics.

Mechanism of Muscular Contraction CRC Press

This book explores the author’s wide-ranging work on muscle research, which spans more than 50 years. It delves into the dogmas of muscle contraction: how the models were constructed and what was overlooked during the process, including their resulting shortcomings. The text stimulates general readers’ and researchers’ interest, highlights the author’s pioneering work on the electron microscopic recording of myosin head power and recovery strokes, and presents a frank discussion on how the original work sometimes tends to be overlooked by competing scientists, who hinder the progress of science.

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