

Muscle Contraction

HASPI Medical Anatomy & Physiology 09b
Lab Activity

Background

Muscle Cell Structure

Muscle cells are specialized to contract. An individual muscle is actually a bundle of hundreds to thousands of long cylindrical muscle fibers or cells. The cell membrane of muscle cells is called the sarcolemma, the cytoplasm is the sarcoplasm, and the endoplasmic reticulum is modified into the sarcoplasmic reticulum (SR). Channels from the sarcolemma into the sarcoplasm and SR are called transverse (T) tubules. The T tubules allow for electrical impulses from motor neurons to be channeled directly to the SR, causing it to release calcium ions and initiate a contraction. Muscle cells are made up of bundles of myofibrils that contain the contracting units, called sarcomeres, made up of two main proteins - myosin and actin.



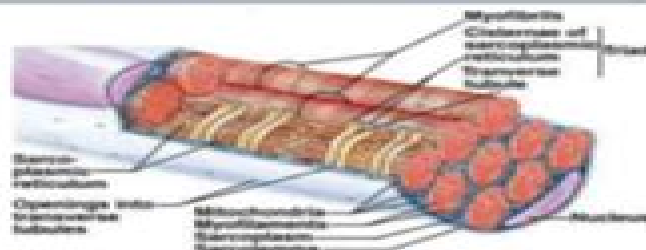
The Motor Unit

Motor neurons connect to skeletal muscles to control movement. Each motor neuron actually controls a group of muscle cells called a motor unit. All of the cells in the motor unit will be stimulated by the motor neuron at the same time. Movements that need fine motor skills, like writing with a pencil, have only a few muscle cells for each motor unit, which allows for precision. Larger movements, like picking up a bag, have many muscle cells for each motor unit.

Muscle Contraction

A muscle contraction is a complicated cycle and can differ according to the type of contraction and the type of muscle tissue. The following chart describes and diagrams the steps of a muscle contraction according to the sliding filament theory.

Steps of a Muscle Contraction	
1	The brain or spinal cord sends an impulse to the muscle.
2	The impulse travels down the motor neuron and reaches a neuromuscular junction where it releases acetylcholine, which triggers the impulse in the muscle.
3	The impulse travels through the plasma membrane (sarcolemma) and down T tubules surrounding the myofibrils.
4	As the impulse passes through the T tubules, it causes the sarcoplasmic reticulum (SR) surrounding the T tubule to release calcium ions (Ca^{2+}) into the sarcoplasm, eventually reaching the sarcomere.



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Robert S. Moreland



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Molecular and Cellular Aspects of Muscle Contraction Haruo Sugi, 2003 This volume presents the proceedings of a muscle symposium which was held as the Fourth Fujihara seminar on October 28 November 1 2002 at Hakone Japan This volume covers all fields of muscle biology from molecules to humans This book provides information about recent progress of muscle research as well as the problems that remain to be investigated This volume will stimulate muscle investigators to design and perform novel experiments to clarify the mysteries in muscle contraction Regulation of Smooth Muscle Contraction Robert S. Moreland, 2012-12-06 Sixth Annual Graduate Hospital Research Symposium REGULATION OF SMOOTH MUSCLE PROGRESS IN SOLVING THE PUZZLE Every so often a scientific conference comes at a time when everyone has new and exciting information when old dogmas do not seem to be as well established and when speakers and participants alike are ready to challenge interpretations of old and new experimental data This was such a conference What turns on a smooth muscle cell The precise answer to this question has eluded scientists for much longer than I have been involved in the field We know that an increase in cytosolic calcium is necessary and we know that phosphorylation of the 20 kDa myosin light chain is an important step in the process We do not know if other processes are necessary for the initiation and maintenance of a smooth muscle contraction nor do we know if other processes modulate the regulation of contraction The goal of the symposium on which this volume is based was to explore the most current hypotheses for the answers to these questions I believe that after reading the chapters included in this volume you will agree that this goal was achieved The importance of calcium and calmodulin dependent myosin light chain phosphorylation in the regulation of smooth muscle contraction was reinforced by many presentations However the status of myosin light chain phosphorylation as a simple calcium dependent switch came under serious suspicion Mechanism of Muscular Contraction Jack A. Rall, 2014-10-21 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 The Sliding-Filament Theory of Muscle Contraction David Aitchison Smith, 2019-02-05 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.

Muscle

Contraction Clive R. Bagshaw, 1982-10-21. The student of biological 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.

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