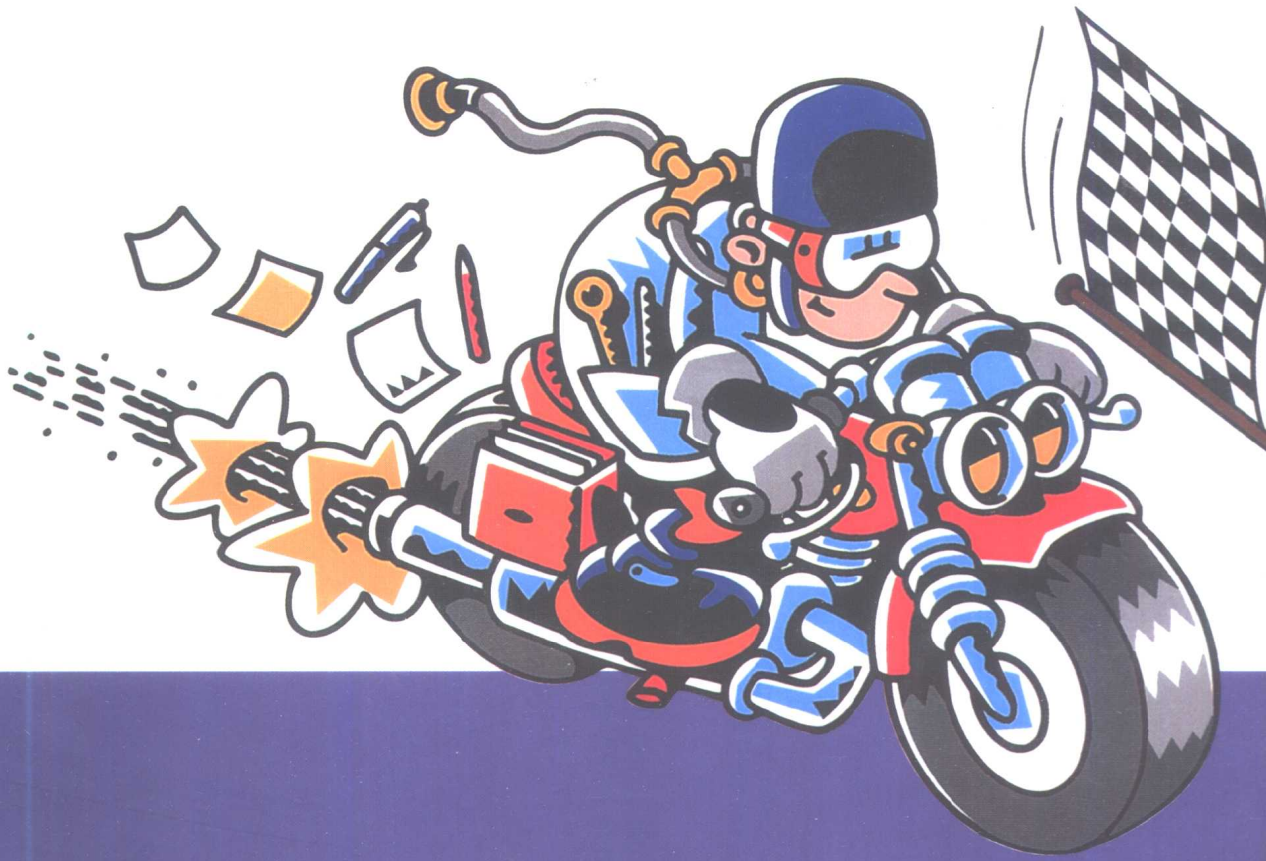
风暴式医学教程 MOSBY'S CRASH COURSE (原版英文医学教程)

肌肉骨骼系统
Musculoskeletal System

Sona V.Biswas ⊙ Rehana K.Iqbal
with Daniel Horton-Szar as Series Editor



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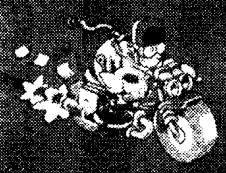


Preface

Crash Course Musculokeletal System aims to present a comprehensive overview of the musculoskeletal system in a clear and concise manner for medical students.

The preclinical aspects of anatomy, physiology, pharmacology, and pathology are integrated into a single system format in line with the new systems-based curricula that many medical schools teach. Clinical applications of the basic sciences relevant to the musculoskeletal system include the skills of history taking and examination, as well as some orthopaedics and rheumatology, covering common presenting complaints encountered by medical students in their clinical years.

The text has been compiled from our perspective as medical students. We hope you find it useful.

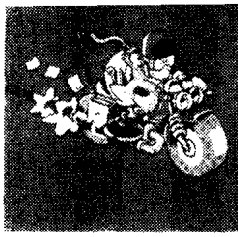
Good luck in your imminent exams.

Sona V Biswas
Rehana K Iqbal

This book on the musculoskeletal system, aimed at students in the preclinical years of their medical course, allows them to learn and revise the subject. *Crash Course Musculoskeletal System* provides a detailed yet concise guide through the structural organization, physiology, and pathology of the system, giving the reader sufficient information for a thorough understanding. The text is clearly presented mostly in bulleted form for easy comprehension and is supplemented with a number of informative illustrations.

Many medical schools now have fully integrated medical courses, but there are few textbooks to complement these recent changes in curricula. One of the difficulties experienced by today's medical students is the problem of finding relevant information from traditional textbooks which tend to include vast detail. Hence, there is a need for student-friendly books which cover pertinent topics whilst avoiding superfluous descriptions. *Crash Course Musculoskeletal System* is written by two medical students for their peers and more than meets these needs. It will enable the reader to master the basic science related to the musculoskeletal system and appreciate its relevance to medical practice.

Sam Jacob
Faculty Advisor



Preface

OK, no-one ever said medicine was going to be easy, but the thing is, there are very few parts of this enormous subject that are actually difficult to understand. The problem for most of us is the sheer volume of information that must be absorbed before each round of exams. It's not fun when time is getting short and you realize that: a) you really should have done a bit more work by now; and b) there are large gaps in your lecture notes that you meant to copy up but never quite got round to.

This series has been designed and written by senior medical students and doctors with recent experience of basic medical science exams. We've brought together all the information you need into compact, manageable volumes that integrate basic science with clinical skills. There is a consistent structure and layout across the series, and every title is checked for accuracy by senior faculty members from medical schools across the UK.

I hope this book makes things a little easier!

Danny Horton-Szar
Series Editor (Basic Medical Sciences)

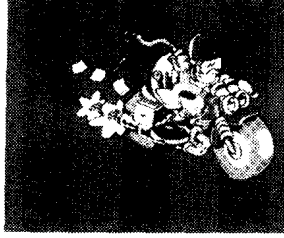


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Figure Credits

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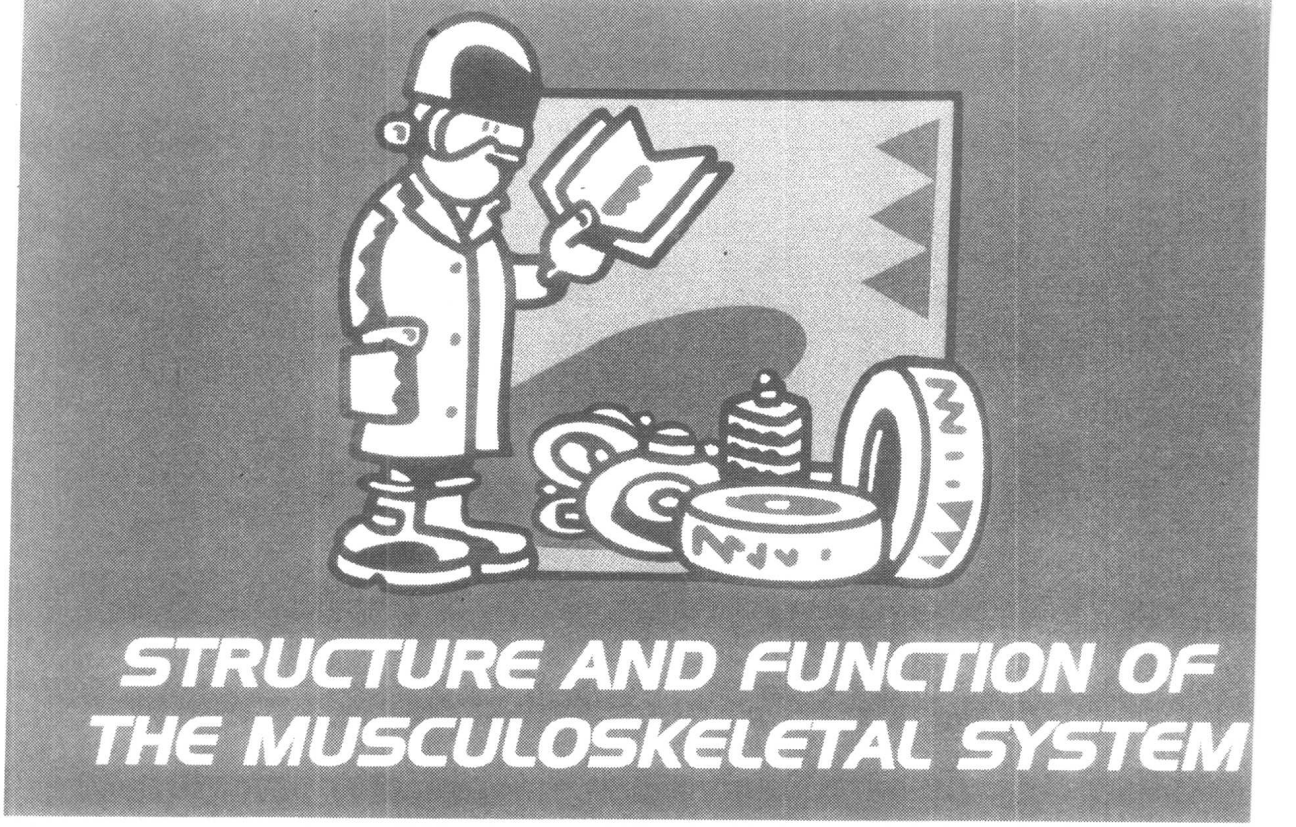
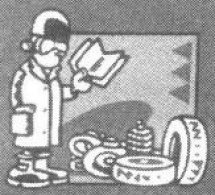


STRUCTURE AND FUNCTION OF THE MUSCULOSKELETAL SYSTEM



1. Musculoskeletal System — an Overview

OVERVIEW OF THE MUSCULOSKELETAL SYSTEM

Introduction

The musculoskeletal system comprises muscles, bones, and joints. It makes up most of the body's mass and performs several essential functions, including:

- The maintenance of body shape.
- The support and protection of soft tissue structures.
- Movement.
- Breathing.
- The storage of calcium and phosphate in bone.

Connective tissue

Most of the musculoskeletal system is made up of connective tissue such as bone and cartilage. Connective tissue comprises specialized cells embedded in an extracellular matrix of collagen, elastin, and structural proteoglycans. In bone, this matrix is mineralized and rigid.

Muscle

There are three types of muscle: skeletal, cardiac and smooth muscle.

Skeletal muscle

Skeletal muscle, which is striated muscle controlled by the nervous system. Most muscle in the body is of this type.

Cardiac muscle

Cardiac muscle, which is striated muscle of the heart.

Smooth muscle

Smooth muscle, which is non-striated muscle controlled by a variety of chemical mediators. Smooth muscle is important in the function of most tissues, for example, blood vessels, the gastrointestinal and reproductive tracts.

Energy stored as ATP is converted by muscle tissue into mechanical energy. This produces movement or tension.

The contraction of muscle requires stimulation. The type of stimulation varies: for example, skeletal muscle is activated by motor neurons, cardiac muscle initiates its own contractions, and smooth muscle is activated by a variety of chemical mediators. Stimulation of muscle causes actin and myosin, protein filaments within its cells, to interact, producing a contractile force.

The skeleton

The skeleton consists of bone, cartilage, and fibrous ligaments (p. 49). A joint is the site at which bones are attached to each other. A joint can be rigid or flexible depending on how the bones meet .

Bone

Bone is rigid and forms most of the skeleton. It provides a supportive framework for the musculoskeletal system, and sites for muscle attachment, the mechanical basis for locomotion. Other functions of bone include mineral storage in its matrix and formation of blood cells (haemopoiesis) within the marrow.

Cartilage

Cartilage is a resilient tissue that provides semi-rigid support in some parts of the skeleton. Cartilage is also a component of some types of joint. Most bone is formed within a cartilaginous template during development.

Ligaments, tendons, and aponeuroses

Ligaments, tendons, and aponeuroses are fibrous tissues that connect the various components of the musculoskeletal system.

Ligaments are flexible bands that connect bones or cartilage together, strengthening and stabilizing joints.

Tendons are connections between muscle and bone.

An aponeurosis may be considered as a broad, sheet-like tendon.

Joints

Joints are composite structures between bones. They may also include cartilage and fibrous connective tissue. There are several types of joint (p. 66). The strength of a joint and the range of movement it allows depend upon its position and function.

Control of the musculoskeletal system

The musculoskeletal system is controlled by the nervous system to produce coordinated movements and locomotion. There are a number of elements to this control. These include:

- Efferent motor neurons, which activate groups of muscle fibres to produce contraction.
- Afferent feedback from stretch receptors in muscles and tendons, and sensory nerve endings in joints and skin allowing coordination of movement.
- Neural pathways within the spinal cord, which coordinate the action of related muscle groups (agonist–antagonist pairs, for example) and also initiate repetitive actions, such as walking ('central pattern generator').

For further information about central control of movement and locomotion, refer to *Crash Course: Nervous System and Special Senses*.

- **List the components of the musculoskeletal system.**
- **What are the general functions of the musculoskeletal system?**

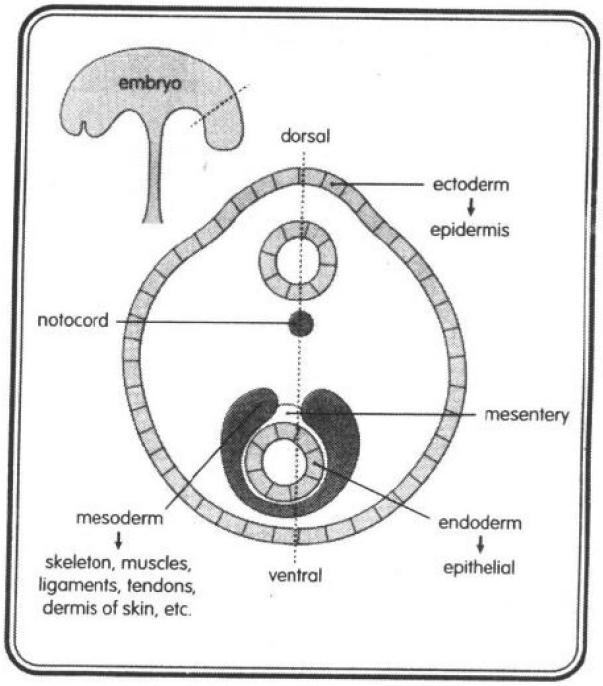


Fig. 1.1 The three primitive embryonic layers and their derivative structures.

CONNECTIVE TISSUE

Definition

Connective tissue is a basic type of tissue. It comprises cells embedded in an extracellular matrix of ground substance and fibres. Connective tissue is characterized by a high matrix:cell ratio.

Origins

Connective tissue is derived from the embryonic mesoderm and neural crest. These differentiate into the embryonic connective tissue or mesenchyme (Fig. 1.1).

Functions

Connective tissue performs several functions. These include:

- Mediating the exchange of nutrients and metabolic products between tissues and the circulatory system.
- Mechanical support, both physical as well as allowing for muscle attachment.
- Packaging, as connective tissue encloses and lies between other specialized tissues.
- A metabolic role, allowing fat storage in adipose tissue.
- Insulation.
- Defence and repair; some cells are involved in the immune response.

Components

The three main components of connective tissue are cells, fibres, and ground substance.

Cells

Connective tissue comprises several cell types. These cells each perform a certain function (Fig. 1.2).

Fibres

Collagen

Collagen is the main fibre found in the extracellular matrix of connective tissue. Collagen is produced from

tropocollagen, a substance synthesized by the endoplasmic reticulum of matrix-secreting cells. Tropocollagen becomes modified to collagen when it is released into the extracellular matrix.

Collagen comprises three helical polypeptide chains (Fig. 1.3). Differences in these chains result in at least 15 types of collagen molecules, each with a particular function (Fig. 1.4).

Elastin

Elastin is a component of elastic fibres. Elastic fibres are found in the skin, lung, and blood vessels. They are thinner than collagen and are arranged in random sheets.

Elastin is produced from proelastin, a substance synthesized by matrix-secreting cells. Proelastin becomes modified to elastin by the cell's Golgi apparatus, when it is released into the extracellular matrix.

Structural proteoglycans

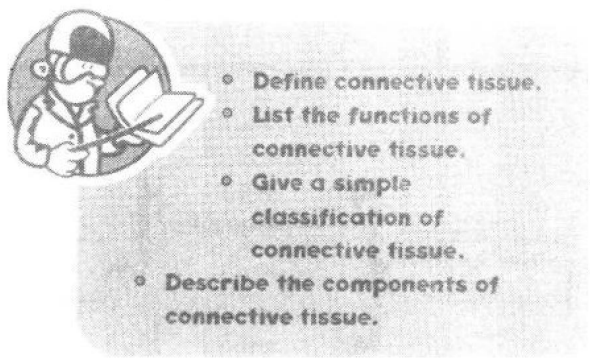
Structural proteoglycans provide a ground substance surrounding the cells and fibres of connective tissue. They comprise protein chains bound to branched polysaccharides and form fibres such as fibronectin and laminin. Some structural proteoglycans are found on the surface of cells, where their functions include cell–cell recognition, adhesion, and migration.

Fig. 1.5 provides a classification of connective tissue.

Connective tissue cell types and functions

	Cell type	Functions
fixed cells	fibroblasts, chondroblasts, osteoblasts, osteoclasts	synthesis and maintenance of matrix
	adipocytes	fat metabolism
	mast cells	release of histamine
	mesenchymal cells	mature cell precursors
transient cells	white blood cells	immune response
	melanocytes	pigmentation

Fig. 1.2 Connective tissue cell types and their functions.



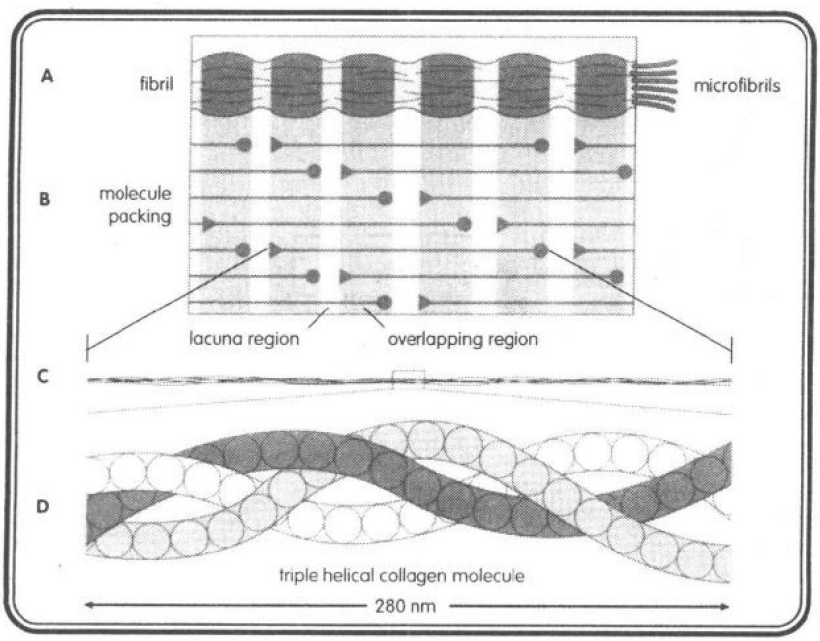


Fig. 1.3 Microstructure of the collagen fibril. (A) Microfibril; (B) packing of molecules; (C) collagen molecule; and (D) triple helix of polypeptide (α) chains.

Functions of collagen types		
Type	**Location**	**Function**
I	skin, tendon, ligaments, bone, fascia and organ capsules (accounts for 90% of body collagen)	provides variable mechanical support (loose or dense)
II	hyaline and elastic cartilage, notochord, and intervertebral discs	provides shape and resistance to pressure
III	connective tissue of organs (liver, lymphoid organs, etc.), blood vessels, and fetal skin	forms reticular networks
IV	basement membrane of epithelial and endothelial cells	provides support and a filtration barrier
V	basement membrane of smooth and skeletal muscle cells	provides support (other functions poorly understood)

Fig. 1.4 Functions of the different types of collagen.

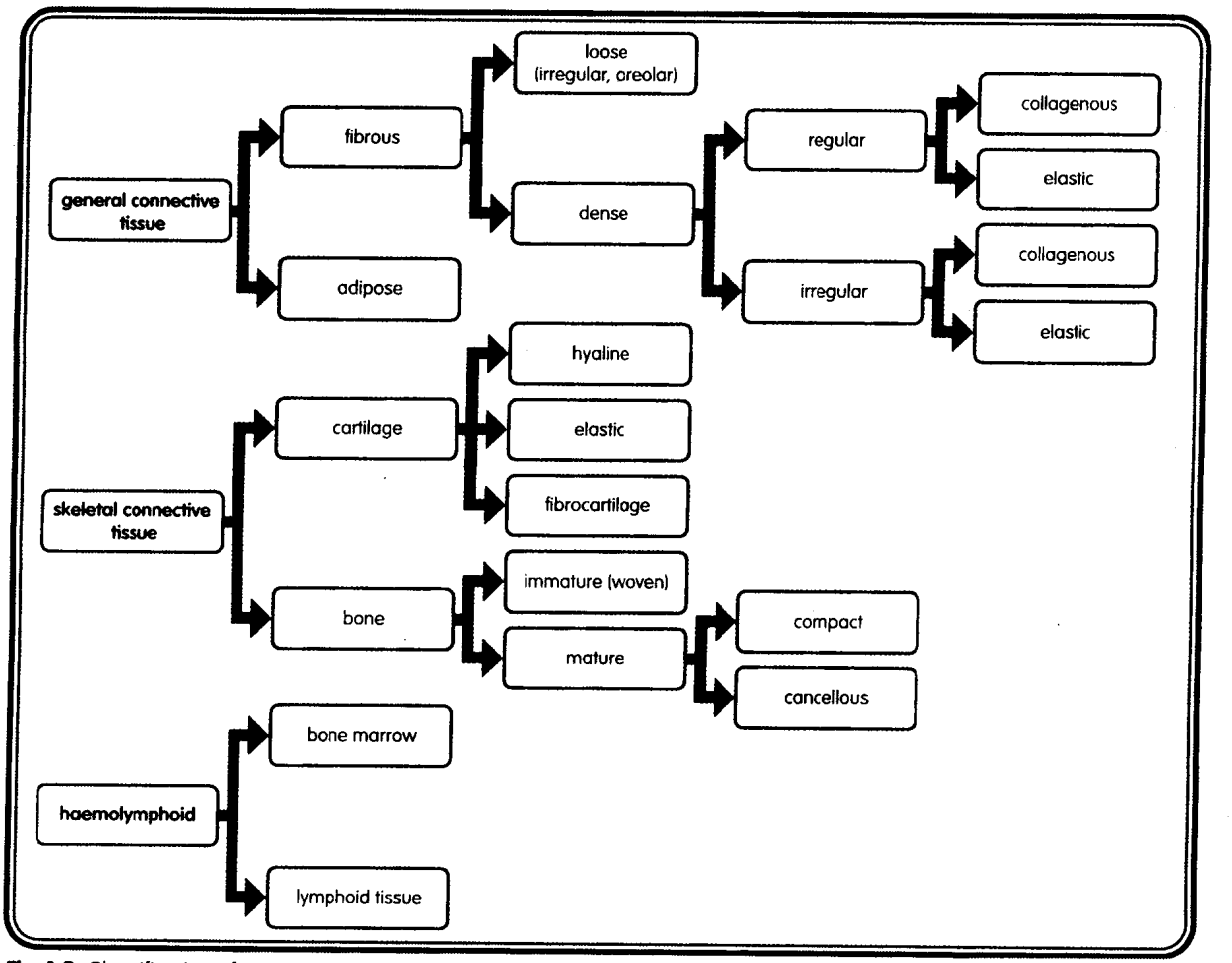
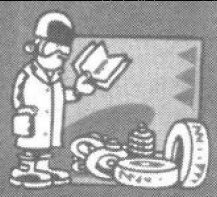


Fig. 1.5 Classification of connective tissue.



2. Muscle

OVERVIEW OF MUSCLE

Muscle is a tissue made up of contractile cells. These cells are capable of producing movement or tension. Other examples of contractile cells include myoepithelial cells (see p. 47) and myofibroblasts, found in connective tissue.

Three types of muscle tissue are found in the human body—skeletal, cardiac, and smooth (Fig. 2.1).

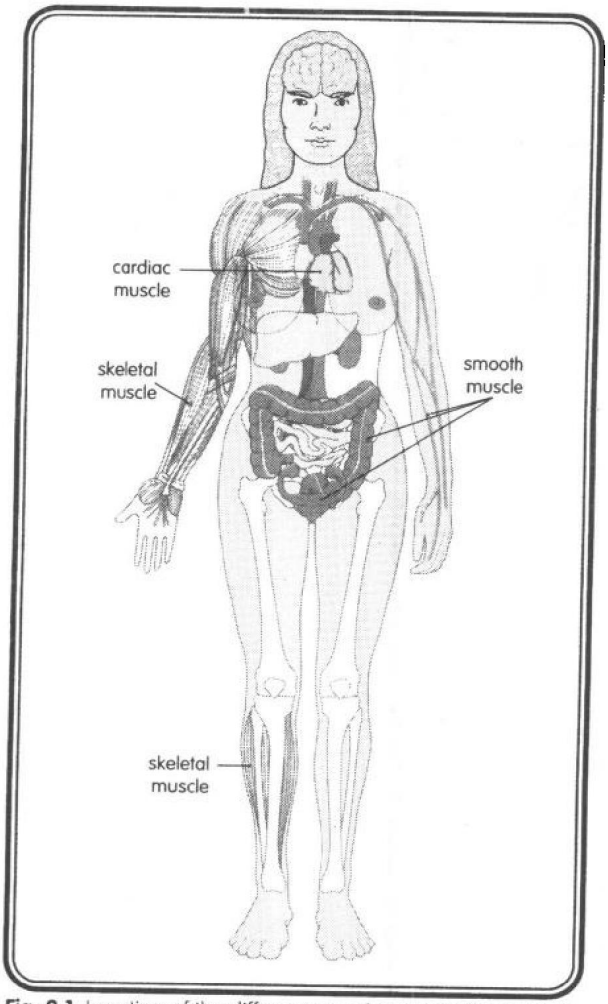


Fig. 2.1 Location of the different muscle types in the human body.

Skeletal muscle

The alternative names for skeletal muscle are striated—from its histological appearance—or voluntary—from the mechanism by which contraction is controlled.

Sites

The majority of muscle found within the body is skeletal (Fig. 2.1). It is found in the limbs, thorax, abdominal wall, pelvis, and face.

Control

Contraction of skeletal muscle tends to be voluntary or reflex and is controlled by the somatic nervous system.

Histological appearance

Skeletal muscle cells are long and thin and therefore often referred to as muscle fibres. The cells are multinucleated and appear cross-striated under light microscopy.

Cell size

Skeletal muscle cells are 50–60 μm in diameter (range 10–100 μm) and up to 10 cm long.

Nature of contraction

Rapid contraction and relaxation of skeletal muscle occurs as a twitch. The nature of the stimulus is important because, if the muscle is stimulated rapidly and repetitively, contractions may summate to produce smooth and sustained contractions.

Function

Skeletal muscle has an important role in voluntary movement of the skeleton and maintenance of posture. It is also involved in the movement of the tongue and globe of eye.

Cardiac muscle

The alternative name for cardiac muscle is myocardium.

Sites

Myocardium forms the muscular component of the heart (Fig. 2.1) lying between the pericardium and endocardium (Fig. 2.33; p. 38).

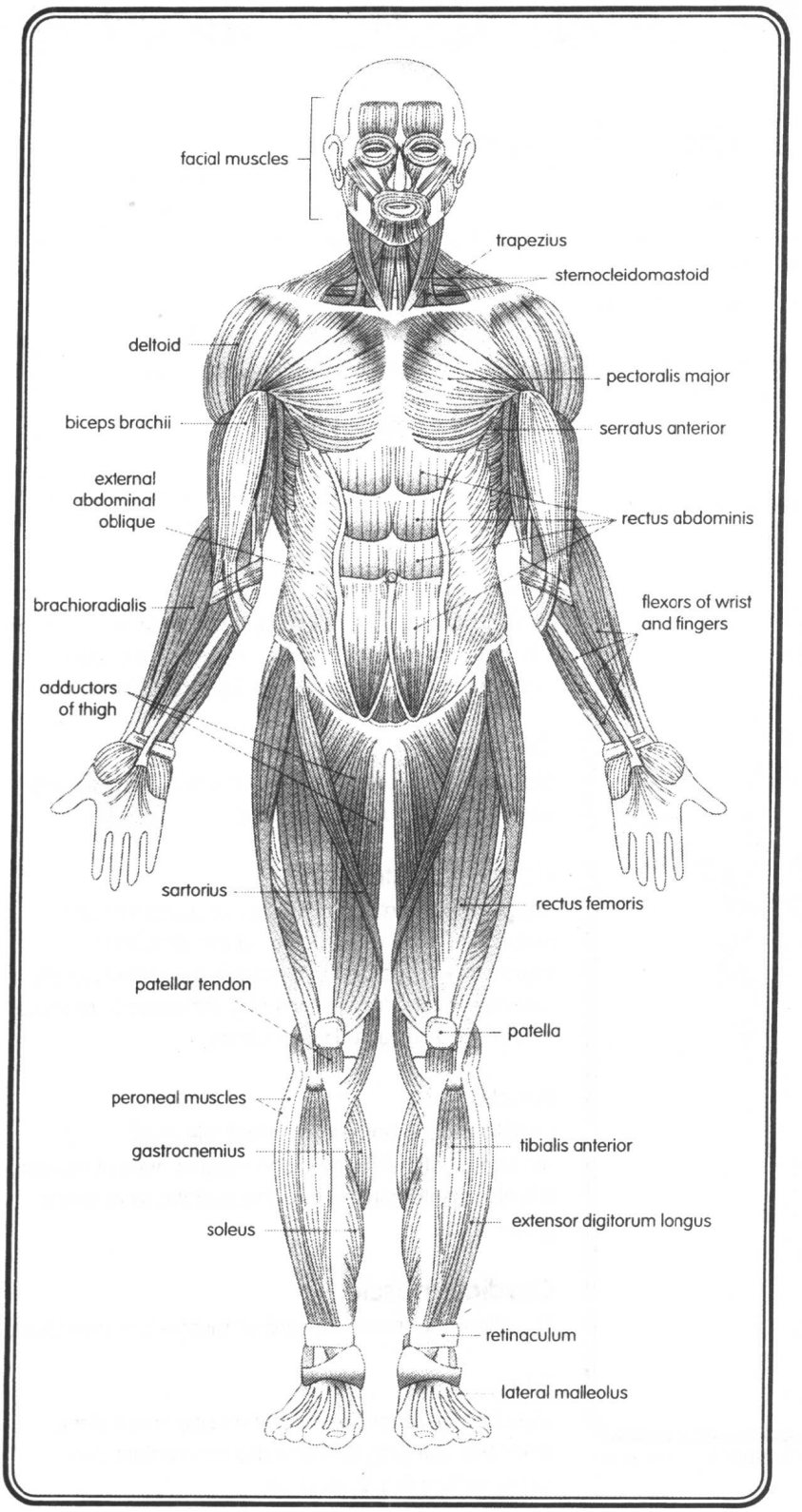


Fig. 2.2A Anterior view of major muscle groups in the body. (Courtesy of Dr K.M. Backhouse.)

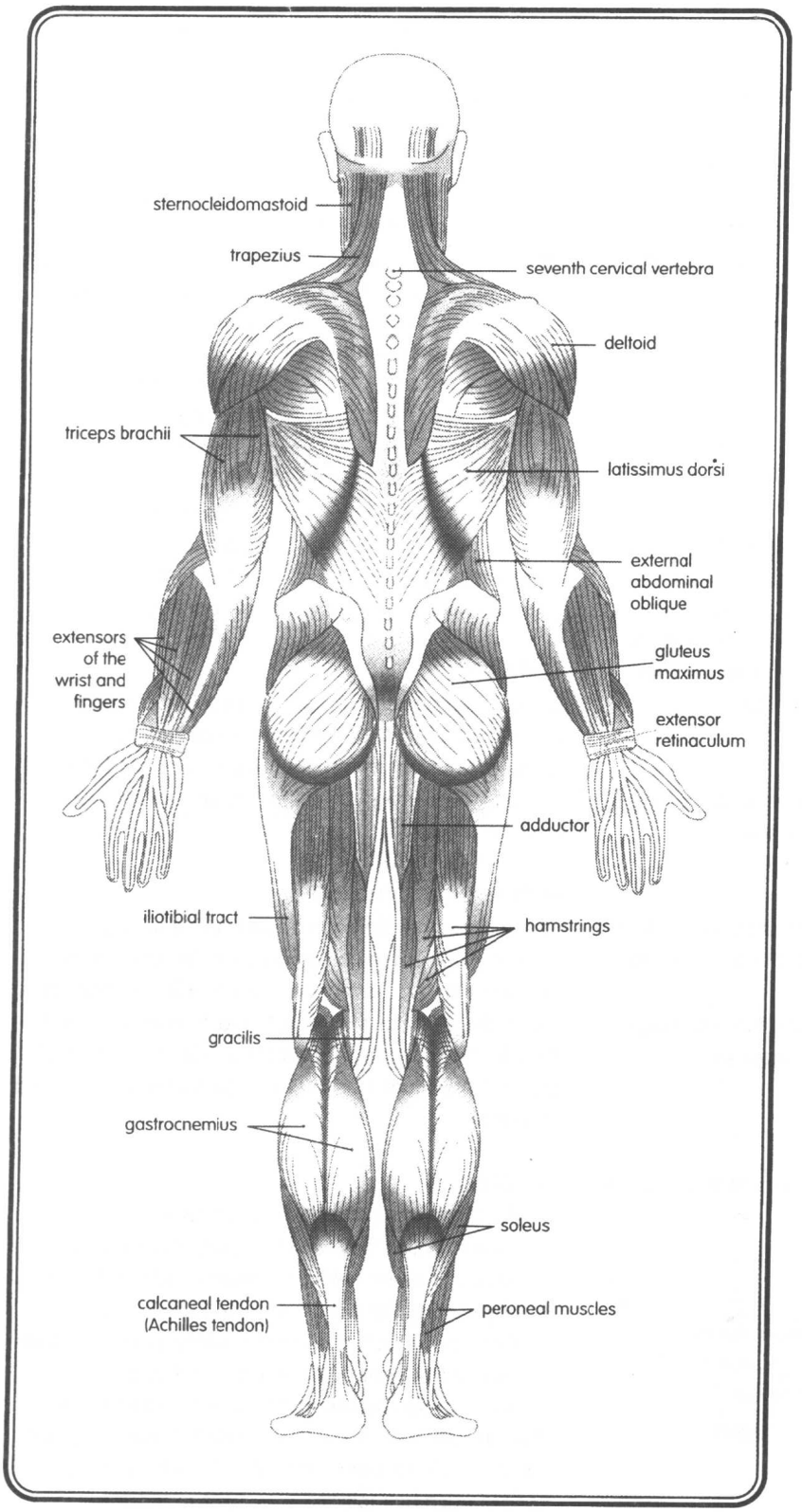


Fig. 2.2B Posterior view of major muscle groups in the body. (Courtesy of Dr K.M. Backhouse.)

Control
Contraction of myocardium is regulated by pacemaker cells within the tissue. The autonomic nervous system can modify contraction of myocardium by altering heart rate and therefore the duration and strength of contraction.

Histological appearance
As with skeletal muscle, longitudinal and transverse striations are seen under light microscopy. However, cardiac cells are smaller and branched and have single central nuclei. Intercellular junctions are often seen. These are called intercalated discs.

Cell size
Myocardium cells are 15 μm in diameter and 100 μm long.

Nature of contraction
Myocardium undergoes spontaneous and rhythmical contractions. These contractions are always brief twitches followed by a long refractory period. This enables cardiac muscle to relax, allowing the heart to fill with blood. The long refractory period means that summation of contractions does not occur.

Function
Myocardium pumps deoxygenated blood to the lungs and oxygenated blood to the body tissues.

Smooth muscle
The alternative name for smooth muscle is involuntary muscle, from the mechanism by which contraction is controlled.

Smooth muscle can be divided into visceral (single unit or syncytial) or multi-unit types. Most smooth muscle is of the visceral type.

Sites
Single-unit smooth muscle is found in small blood vessels, the ducts of secretory glands, and the walls of hollow organs of the gastrointestinal and urogenital systems (Fig. 2.1). Multi-unit smooth muscle is found in large blood vessels, large airways, the eye, and hair follicles.

Cardiac muscle is a type of striated muscle and its properties can be considered to lie between those of smooth and skeletal muscle.

Control
Smooth muscle contraction is under involuntary control. In the case of visceral smooth muscle, initiation of contraction is inherent (pacemaker cells within the smooth muscle tissue which discharge irregularly) and can be modified by hormones, local metabolites, and the autonomic nervous system. Multi-unit smooth muscle, however, is neurogenic and initiation of contraction is under the control of the autonomic nervous system.

Histological appearance
The structure of smooth muscle is less organized than skeletal muscle and myocardium as no striations are seen under light microscopy. The cells are spindle shaped and have large, single, central nuclei.

Cell size
Smooth muscle cells are 2–10 μm in diameter and 20–400 μm long. Cell size varies, depending on location, e.g. very small cells (20 μm) are found in small blood vessels while cells up to 400 μm in length are found in the uterus.

Nature of contraction
Low-force contraction of smooth muscle occurs with relatively little energy expenditure. In the case of multi-unit smooth muscle, individual muscle fibres contract. This is the same as skeletal muscle. In visceral smooth muscle, however, as the whole muscle mass contracts and not individual muscle fibres, contraction is slow and sustained.

Function
The functions of smooth muscle are related to the structure in which they are found, e.g. the smooth muscle component of blood vessels regulates blood flow by altering the diameter of the blood vessels.

Multi-unit smooth muscle is involved in the alteration of pupil size by contraction of iris muscles, and accommodation by contraction of the ciliary muscle. Multi-unit smooth muscle is also responsible for 'goose bumps', which result from contraction of muscle at the base of each hair follicle.