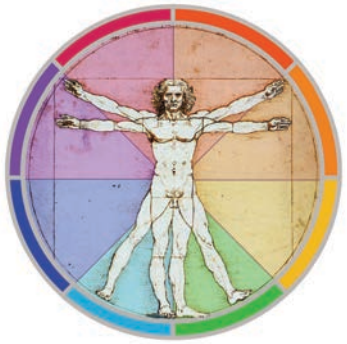
HUBS191 Lecture Material

This pre-lecture material is to help you prepare for the lecture and to assist your note-taking within the lecture,

it is NOT a substitute for the lecture !



Please note that although every effort is made to ensure this pre-lecture material corresponds to the live-lecture there may be differences / additions.

HUBS191

Physiological
Principles of Human Movement and Sensation

Dr Regis Lamberts

University of Otago
Te Whare Wānanga o Otāgo
NEW ZEALAND

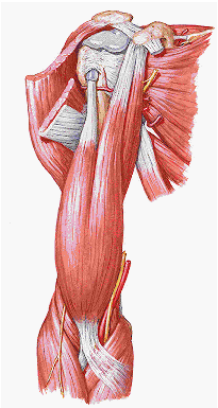
Physiology
Otago

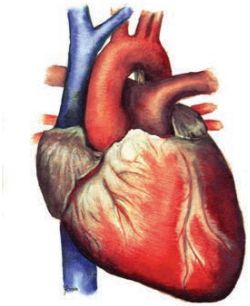
HEARTOTAGO

Lecture 27 – Cardiac and Smooth Muscle: Comparison of Functional Differences

Topics of Today's Lecture

- Structural and functional differences between skeletal, cardiac and smooth muscle



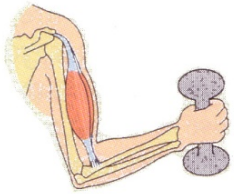


Structure and Function of Muscle

Structure determines Function

Function defines Structure

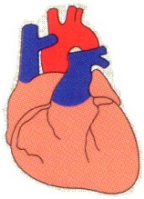
Skeletal



Posture, Movement, Heat

On-demand
Individual - specific

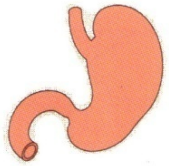
Cardiac



Pumping blood

Continuous
All at once
Build pressure

Smooth



Movement of contents of viscera - specific functions

Sheets - peristaltic movement
Individual - specific

Cardiac muscle: Structure and Function

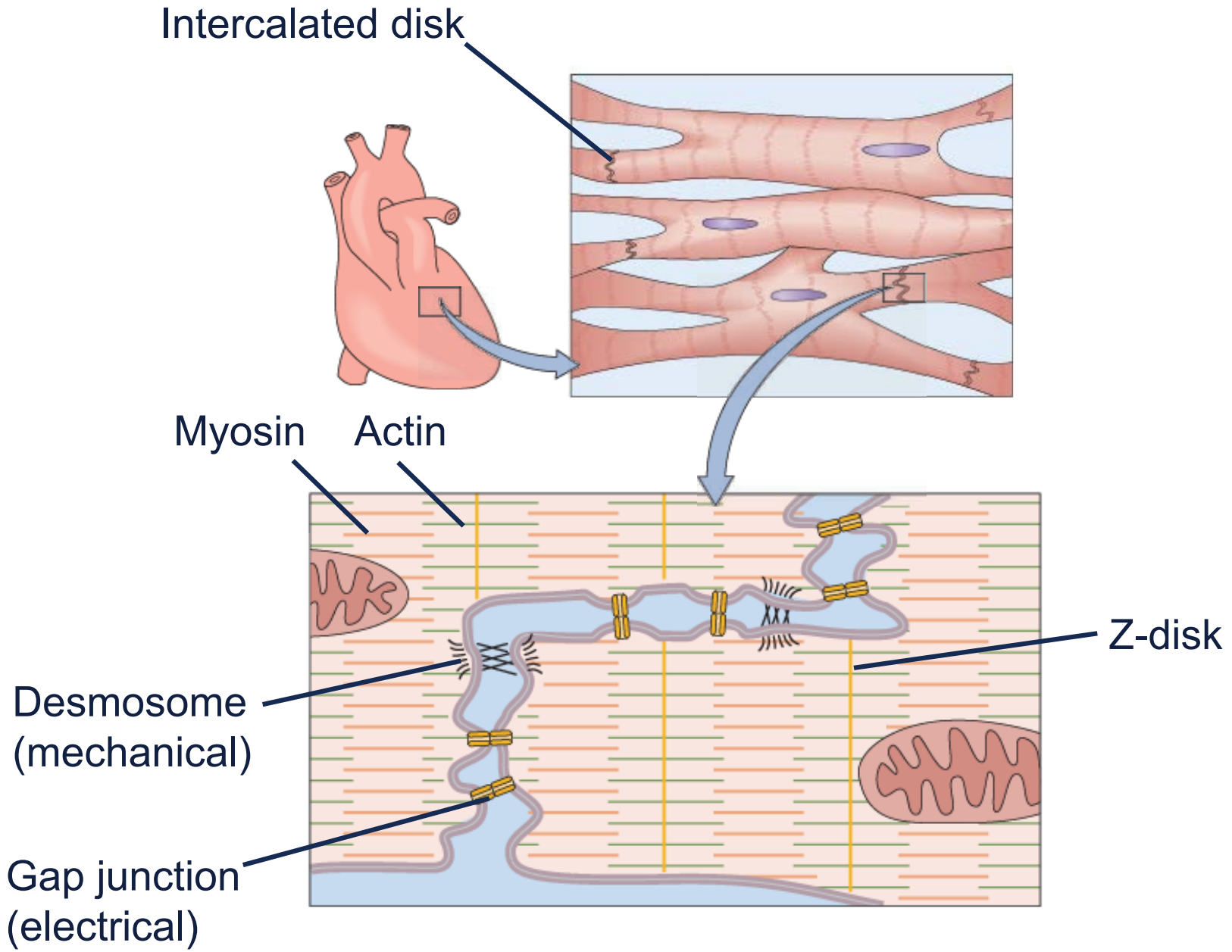


Figure 9-13 Boron & Boulpaep. Medical Physiology 2nd updated edition.

Co-ordinated contraction of the heart

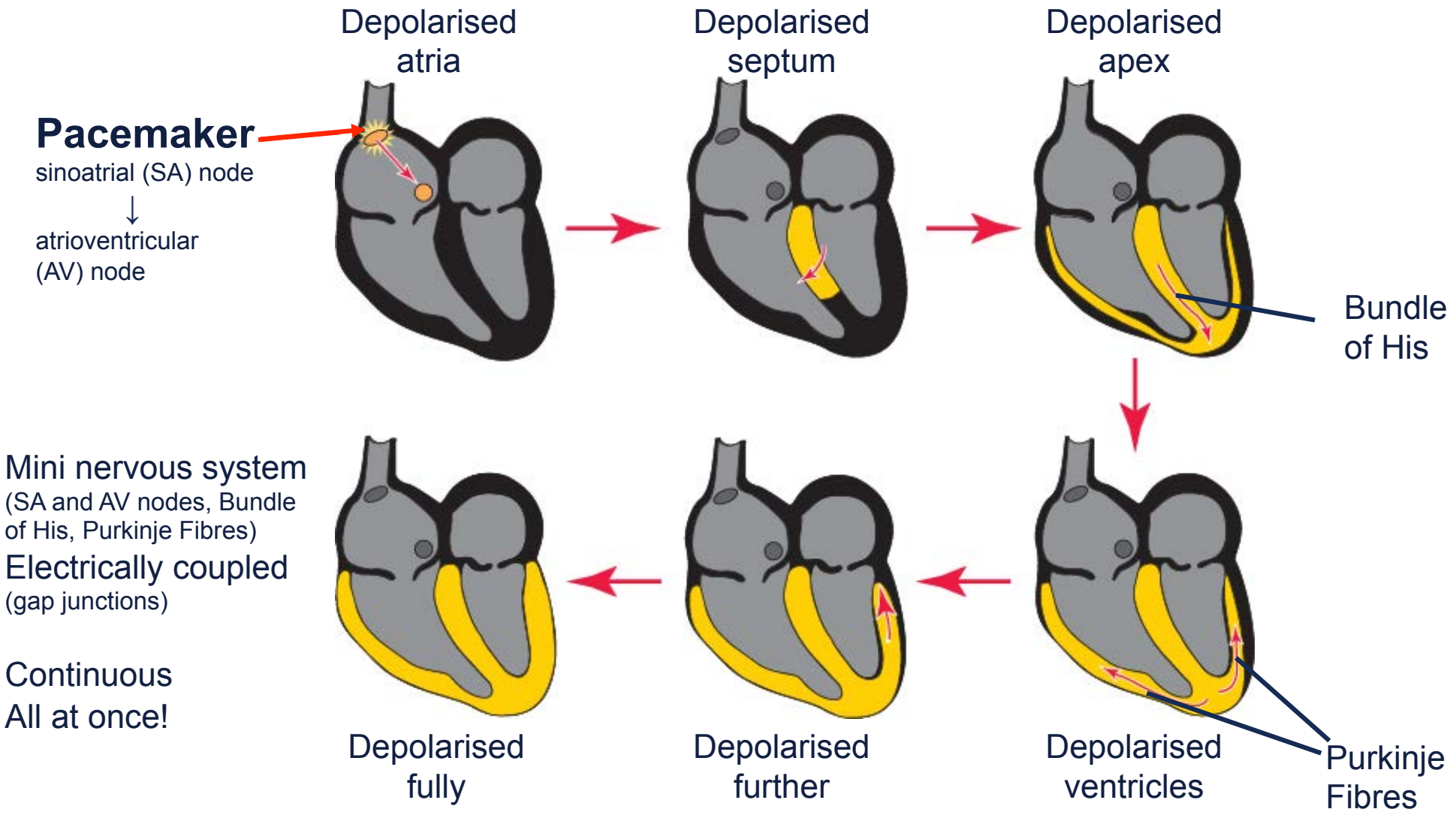
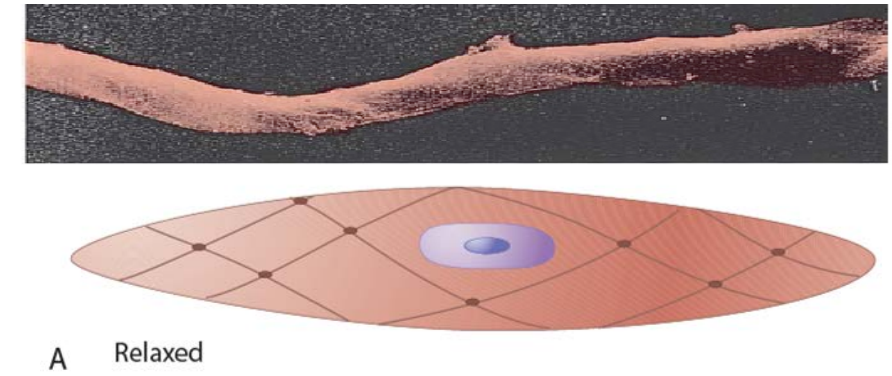
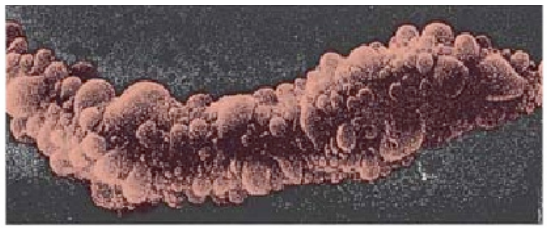


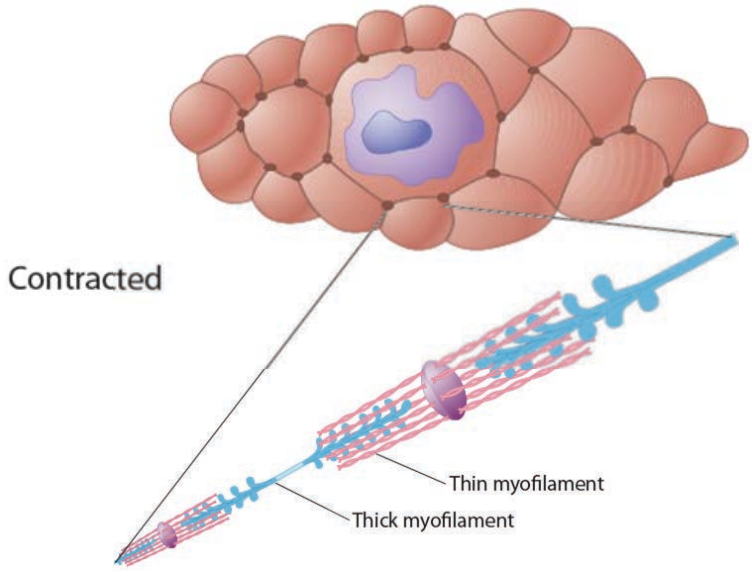
Figure 21-5 Boron & Boulpaep. Medical Physiology. 2nd update edition

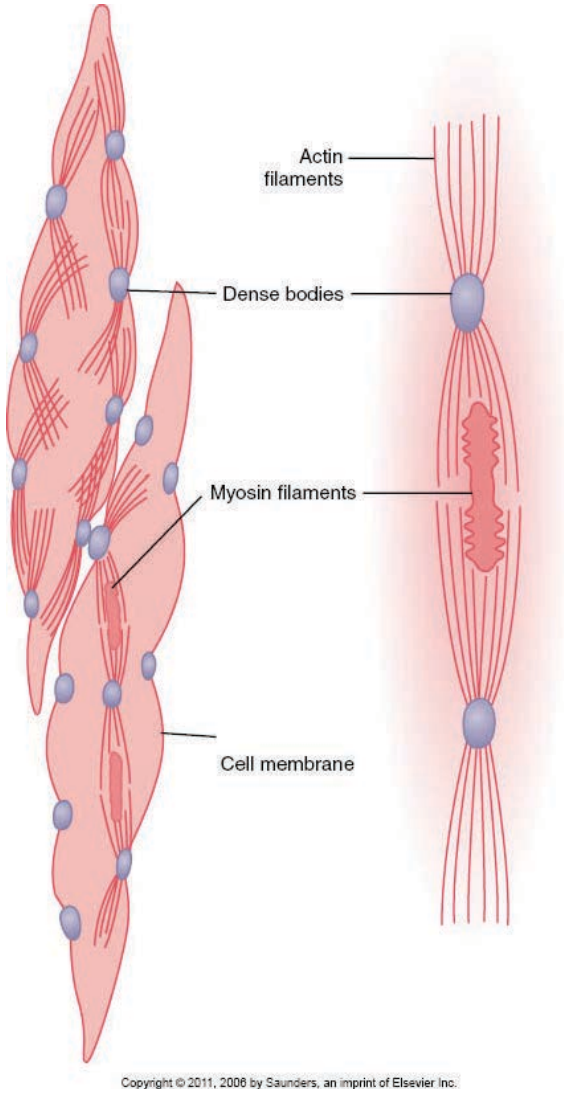
Smooth Muscle: Structure and Function



A Relaxed





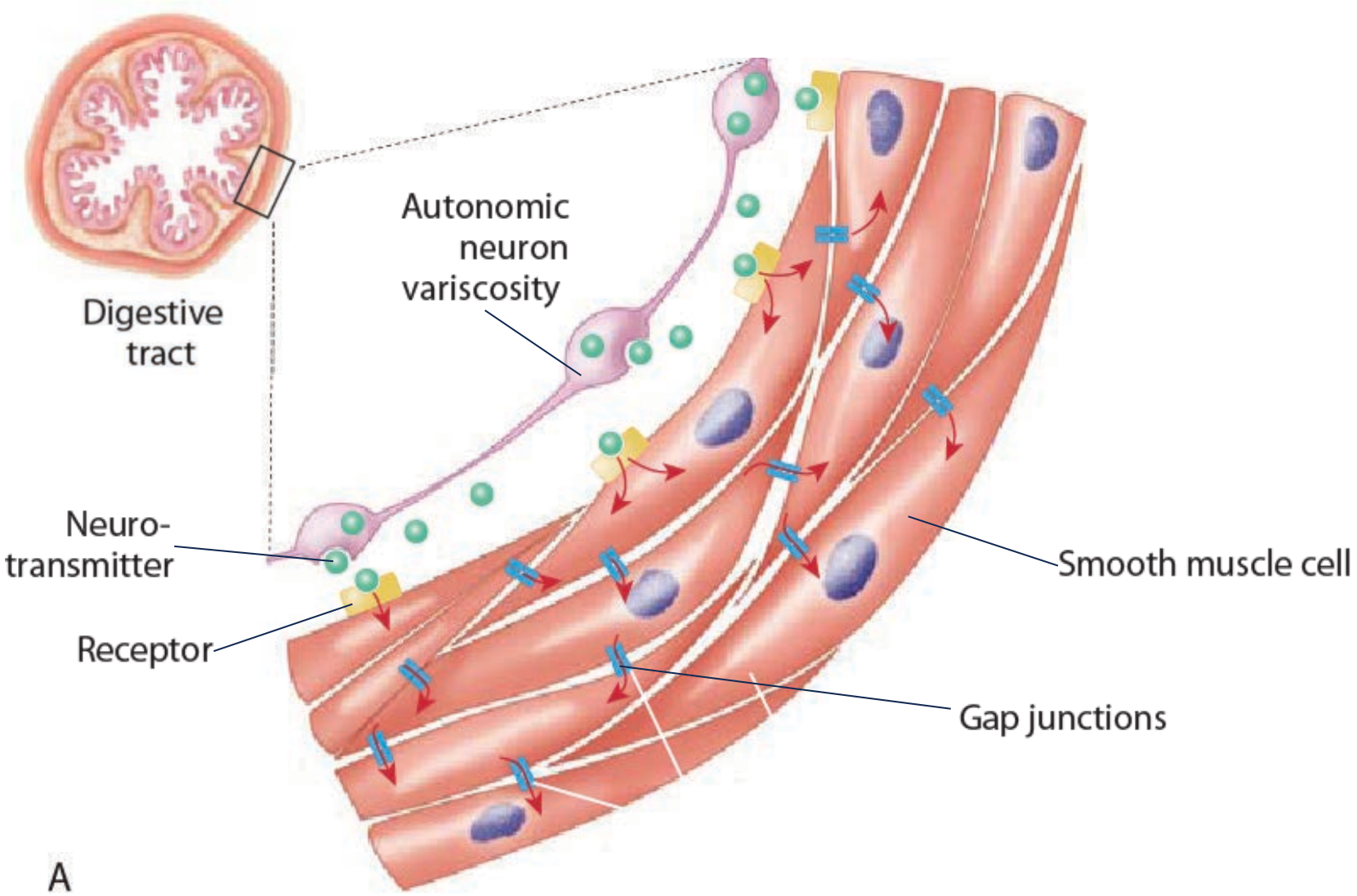


Large length changes (e.g. bladder)
Sustained tension (e.g. sphincters)

Figure 12-30. Patton & Thibodeau. Anatomy & Physiology (8th ed)

Figure 8.2 Guyton and Hall: Medical Physiology, 12th Edition

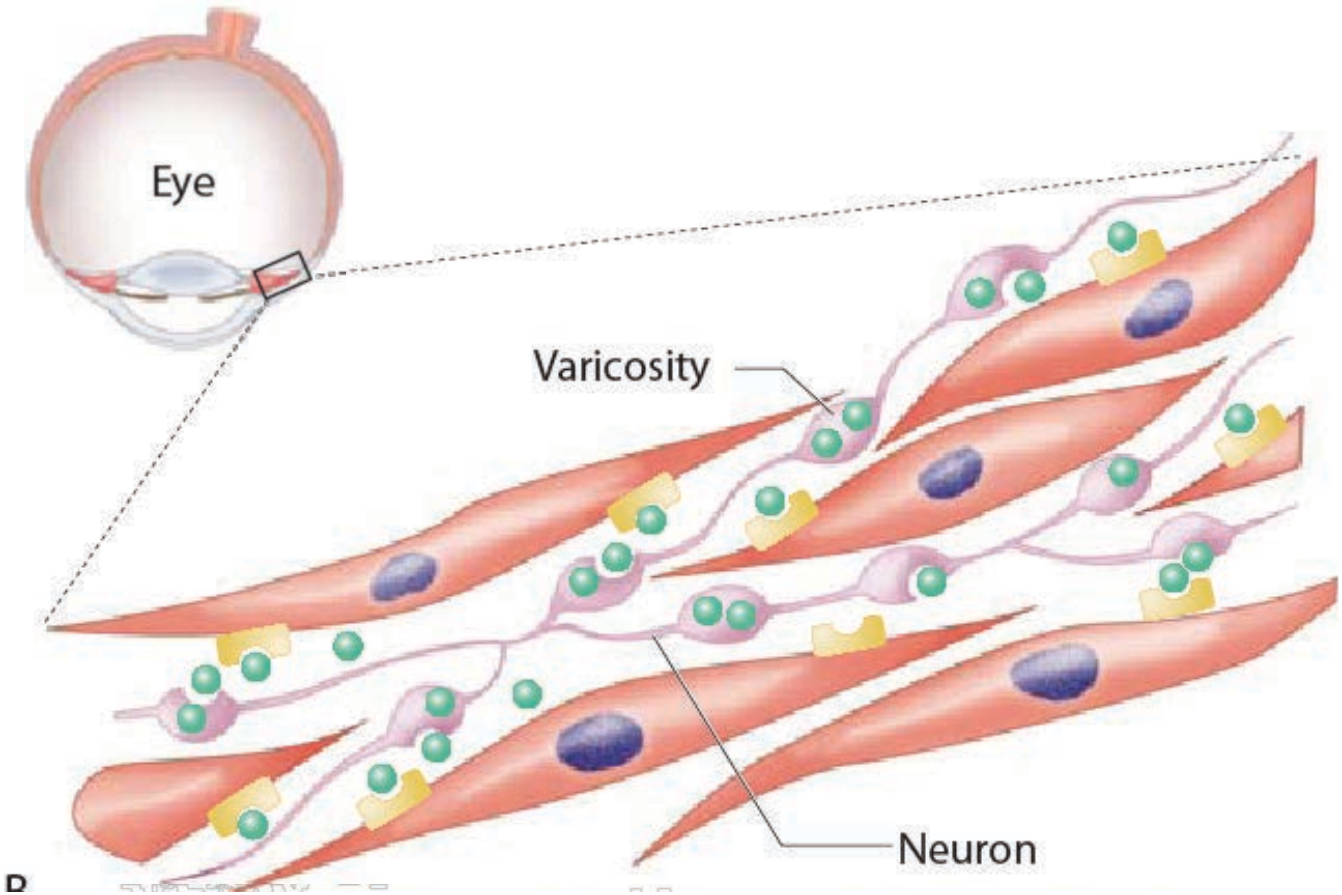
Single-unit Smooth Muscle



- Gap junctions allow spread of excitation between cells

Figure 12-31A. Patton & Thibodeau. Anatomy & Physiology (8th ed)

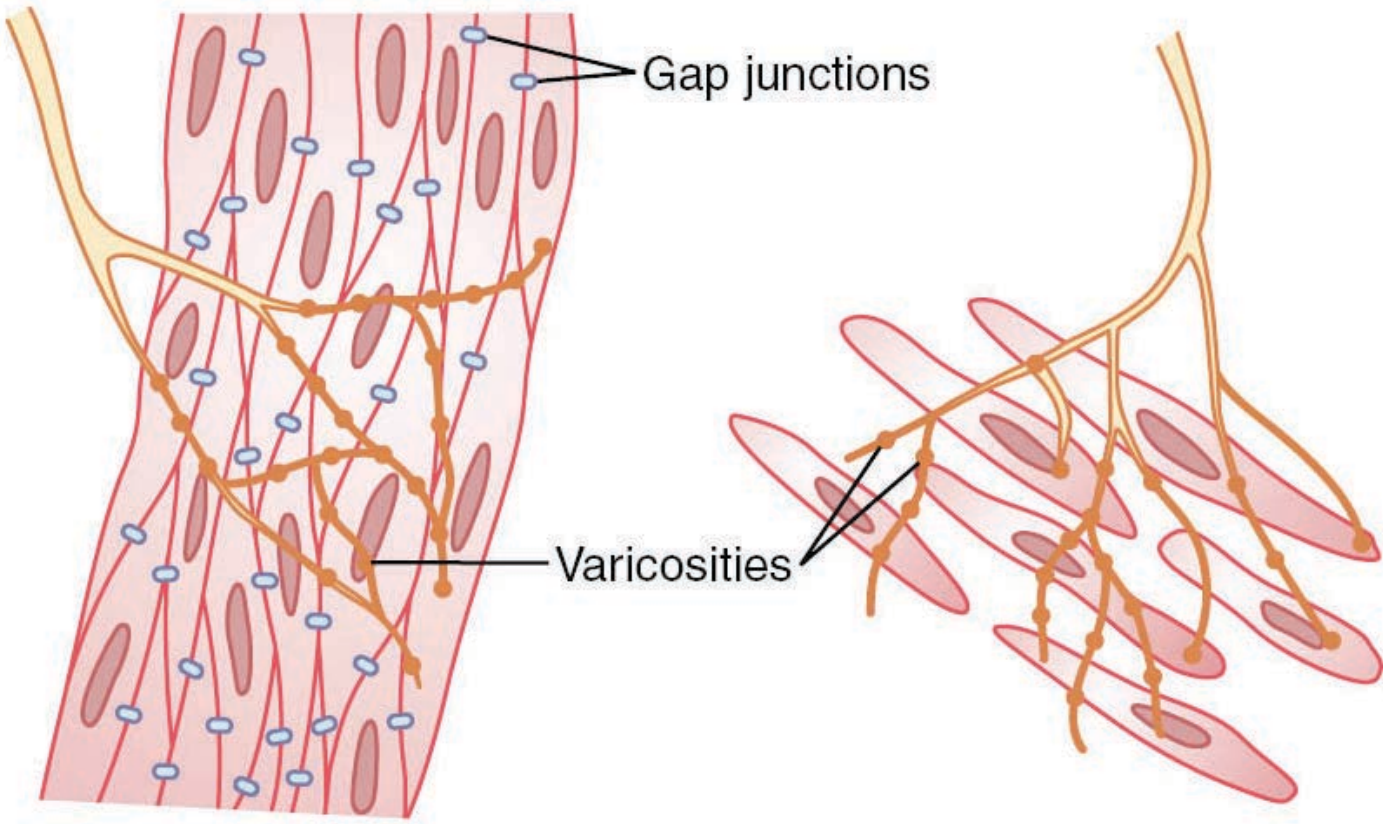
Multi-unit Smooth Muscle



- Absence of gap junctions allows for fine control of individual smooth muscle cells

Figure 11-31B. Patton & Thibodeau. Anatomy & Physiology (8th ed)

Single-unit vs. Multi-unit



Digestive, urinary and reproductive tracts

Pili muscles skin, eye muscles; Blood vessels (sheets)

Figure 8.4 Guyton and Hall: Medical Physiology, 12th Edition

Smooth Muscle: Function

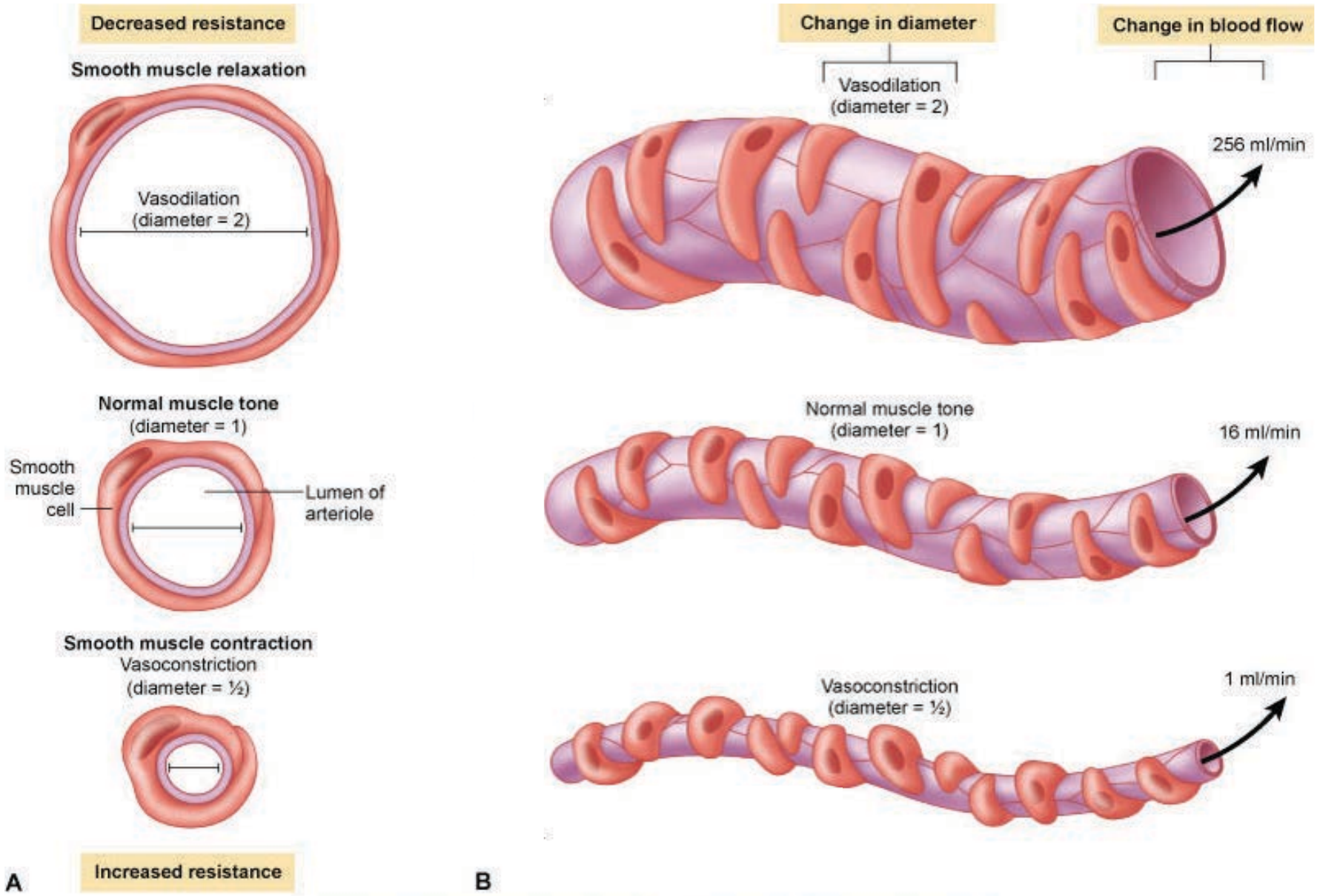
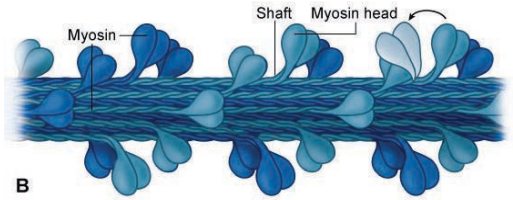


Figure 22-17. Patton & Thibodeau. Anatomy & Physiology (8th ed)

Smooth Muscle: Excitation-Contraction

- Action potential or hormones provide Ca^{2+} rise
- Ca^{2+} binds to calmodulin
- Ca-calmodulin complex activates MLCK (myosin light chain kinase)
- MLCK activates MLC (myosin light chain) which activates the crossbridge



- **Myosin filament regulated**

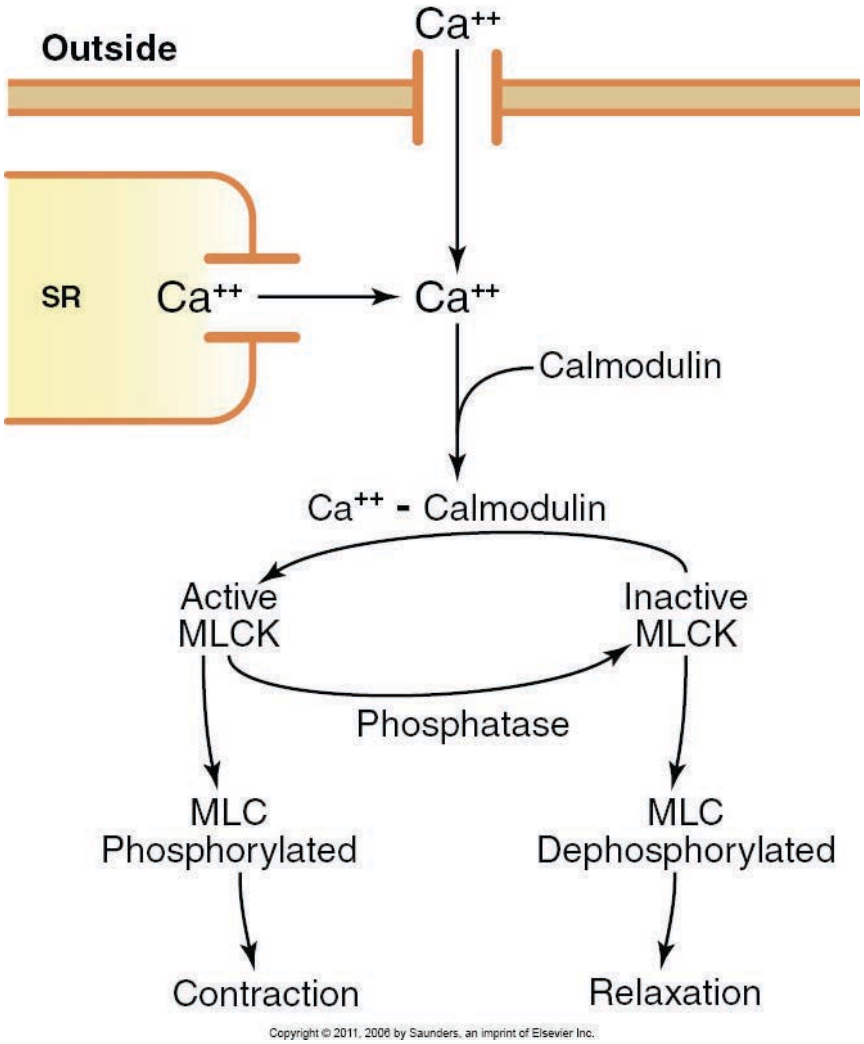


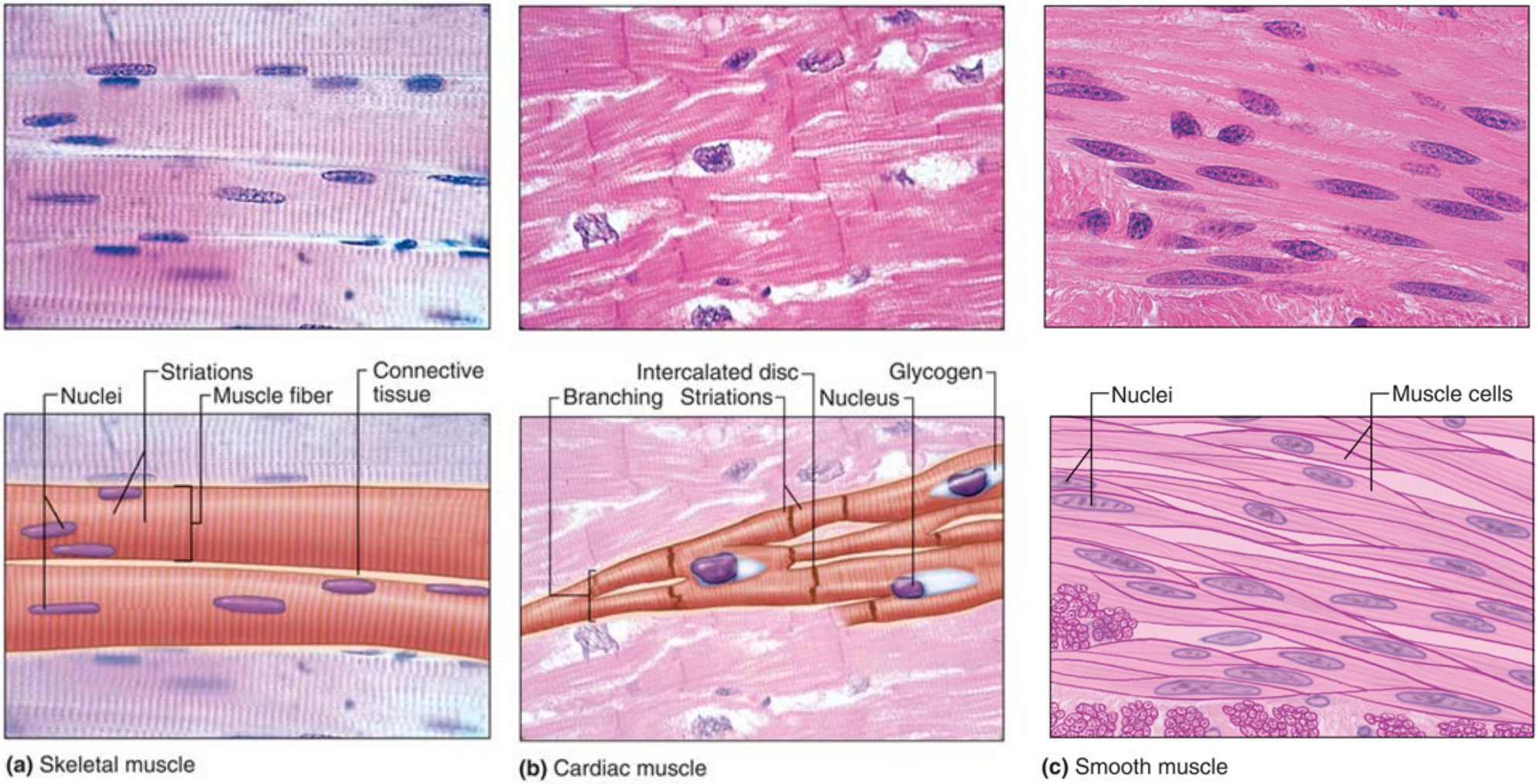
Figure 8.3 Guyton and Hall: Medical Physiology, 12th Edition

Question?

Single-Unit Smooth Muscle cells contain:

A) Gap Junctions
B) Striations
C) Are individually controlled by neurons
D) Answers A and C are correct
E) Answers A, B and C are correct

Structure and function: Muscle Cells



(a) Skeletal muscle **(b)** Cardiac muscle **(c)** Smooth muscle

9.1ab: © Ed Reschke; 9.1c: © McGraw-Hill Higher Education

Vander's Human Physiology (11th ed.) Figure 9.01 p255

Skeletal

Long, cylindrical, multinucleate cells

Cardiac

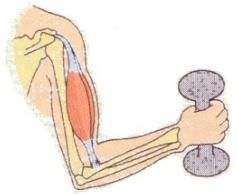
Mononucleate branching cells

Smooth

Mononucleate spindle-shaped cells

Structure and function: Amplitude Direction of Force

Striated = sarcomeres

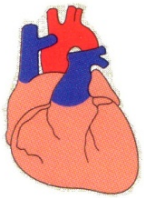


Skeletal

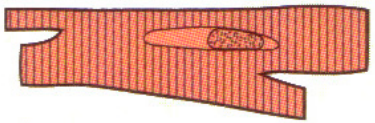
Present

Actin and myosin organised along an axis therefore stronger force along the axis

Thin filament regulated
Calcium - troponin

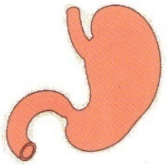


Cardiac

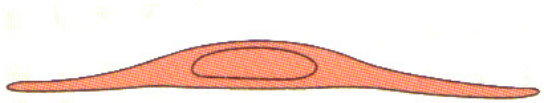


Present

As for skeletal muscle



Smooth



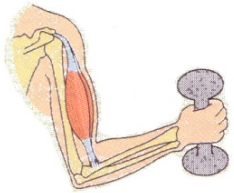
Absent

Actin and myosin arranged in various directions so exert weaker force, but in many directions

Thick filament regulated
Calcium-calmodulin - MLCK - MLC

Structure and function: Excitation

Action potential spread from cell to cell?

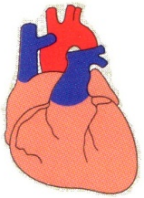


Skeletal

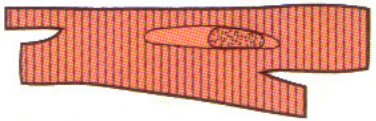
No

Organised into motor units

T-tubuli



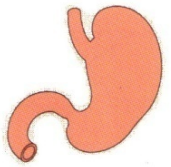
Cardiac



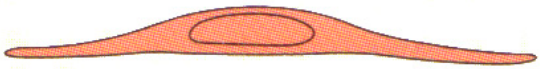
Yes

Via gap junctions
Syncitium

T-tubuli



Smooth

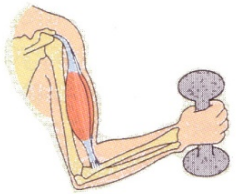


Yes/No

Via gap junctions
Only in single-unit smooth muscle

No T-tubuli

Structure and function: Control

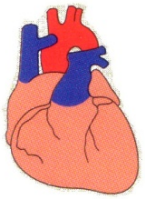


Skeletal

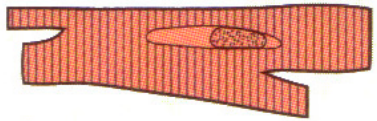
Voluntary

Each cell has one synapse (neuromuscular junction)

Organised into motor units



Cardiac

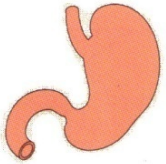


Involuntary

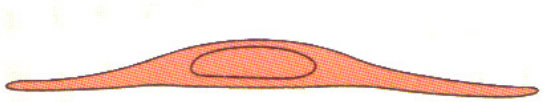
No discrete synapses

"Spontaneous" depolarisations initiated by pacemaker cells
Self-exciting (HUBS 192)

Modified by autonomic nervous system and hormonal input



Smooth



Involuntary

No discrete synapses

Can be spontaneous (pacemaker) or initiated by nerve input

Structure and function: Speed of Contraction

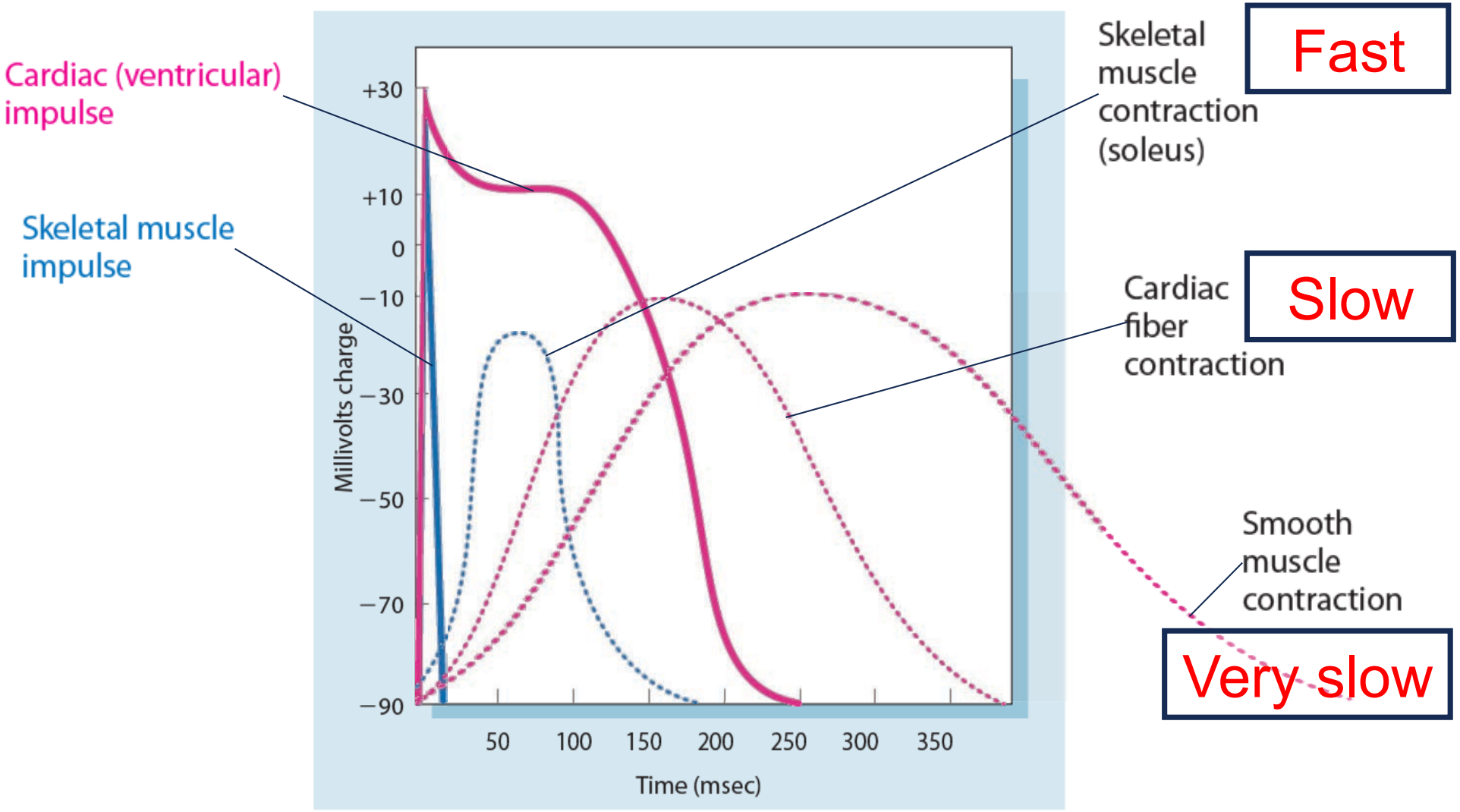


Figure 11-29. Patton & Thibodeau. Anatomy & Physiology (7th ed) Elsevier, 2010

Lab 4 - Sensory and Motor Physiology (S & MP) 24-April until 5th of May

https://canvas.brown.edu/courses/851434/assignments/4953274

- Explore how brain interprets our experience in the external environment using a binary system of action potentials (AP).
  - *How do we detect touch, pressure, temperature, and shapes?*
  - *Let alone sight, smells, hearing etc.*
- External electrical stimulation of the ulnar nerve
  - *Watch your hand twitch uncontrollably*
  - *Feel some odd sensations!*
  - *Measure speed of AP conduction (summation of twitches)*
- Measuring an electromyogram (EMG)
  - *Analyse the electrical activity in the biceps brachii muscle*

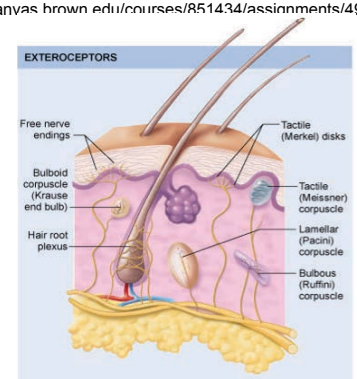
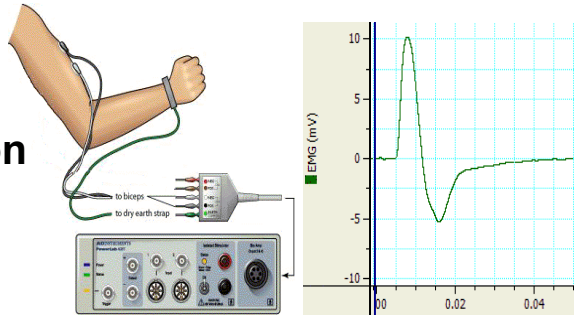
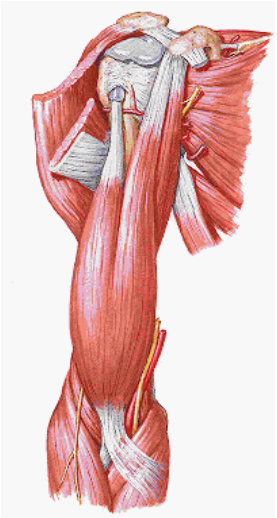


Figure 17-5. Patton & Thibodeau. Anatomy & Physiology (8th ed) Elsevier, 2013

- **Please wear a T-shirt or clothing where you can access the skin at your elbow**
- **No labs on Anzac day (25th April) – if your lab is normally on Tuesday of week A, you have been restreamed automatically.**
  - **Tuesday morning → Friday morning of week B.**
  - **Tuesday afternoon → Friday afternoon of week A.**
  - **Tuesday evening → Monday evening of week A.**
- **Contact HUBS office if you have any issues.**



Lecture 25 – 27 overview - summary

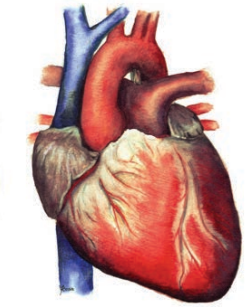


1. Why do we need muscle?
2. The structure of skeletal muscle

   (The Motor Unit, NMJ)
3. Mechanism of Contraction of Skeletal Muscle

   (Excitation – Contraction – Relaxation)
4. Energy Sources for Contraction of Skeletal Muscle

   (ATP, CP, anaerobic, aerobic)



5. Twitch and Tetanus

   (Treppe, summation)
6. Skeletal Muscle Fibre Types

   (Fast / white / myosin II vs. Slow / red / myosin I - Exercise & Fatigue)

7. Structural/Functional differences: Skeletal, Cardiac and Smooth muscle

Always remember to ……

HUBS191