https://www.nature.com/articles/s41586-021-03836-1

112年
高中生物人才
培育計畫

★解剖學實作
★組織學實作

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112.8.12

課程進度

☐ 上午
- 雞翅解剖講解
- 雞翅解剖實作
- 豬腎解剖講解
- 豬腎解剖實作（老師操作，同學觀察）

☐ 下午
- 各器官組織學介紹
- 組織學玻片觀察
- 小考（解剖學＋組織學）

學習目標

☐ 學習解剖學基本概念

☐ 認識肌肉，骨骼和關節三者之間的密切關係

☐ 學習解剖的方法並熟悉如何使用解剖工具

☐ 學習分辨動脈、靜脈、神經

☐ 學習各種組織的不同型態及分層

參考資料

☐ Loukas *et al*. (2013) GRAY'S CLINICAL PHOTOGRAPHIC DISSECTOR OF THE HUMAN BODY

☐ 高醫解剖學科何宛怡老師大體解剖學實驗講義

☐ Chicken wing dissection

https://www2.nau.edu/lrm22/lessons/chicken_wing/wing.html

☐ Performing a chicken wing dissection (Written by: Science ASSIST)

☐ Ross and Pawlina. Histology: A Text and Atlas

學好解剖的訣竅

□ 名詞要記熟並且知道其功能和相關位置，搭配圖譜和影片，多觀察

□ 親手解剖：當你親自把構造從頭到尾做出來的時候，這個構造不再只是課本或圖譜上的圖片，而是會內化成經驗的一部分

□ **不要怕失敗！！！ 不小心割斷構造不算什麼，從失敗中學習，愈害怕失敗，愈學不到東西，就會失去成長和學習的機會**

□ 每一個構造都要清楚他的起源、走向和深淺，以及和其他構造的相對位置，這些都是辨認的線索

□ 當你已經非常熟悉一個構造的特徵時，即使只是看到局部(有時候受限於無法將整個構造完全解剖出來)，也應該可以正確地推斷它是什麼
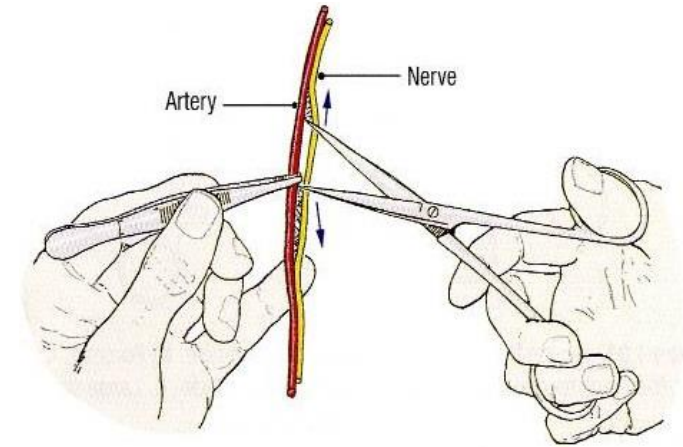
□ 但只靠形狀、走向或是顏色來作為分辨的唯一依據，錯誤率會很高→瞎子摸象

解剖器械
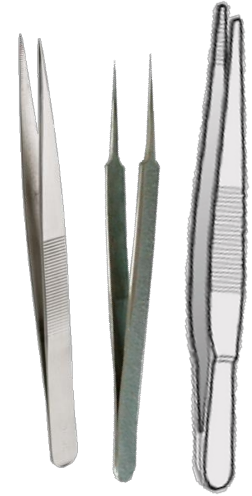
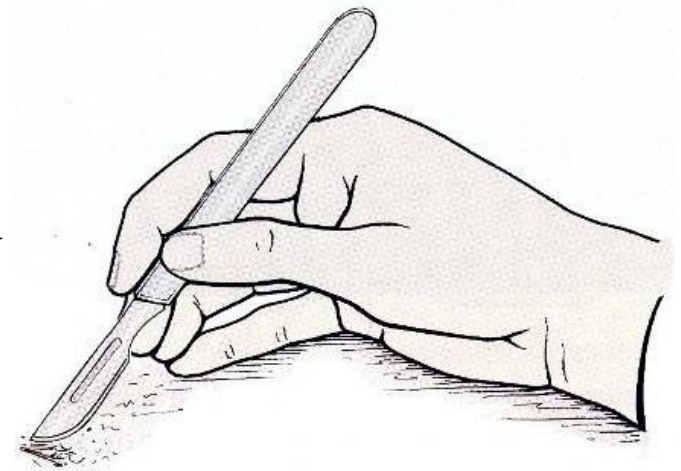- ☐ 戴合適尺寸的手套
- ☐ 微細的構造要用小號器械做
- ☐ 醫藥箱

解剖術語

□ **鈍剝離 (blunt dissection)**
- 使用手指或剪刀
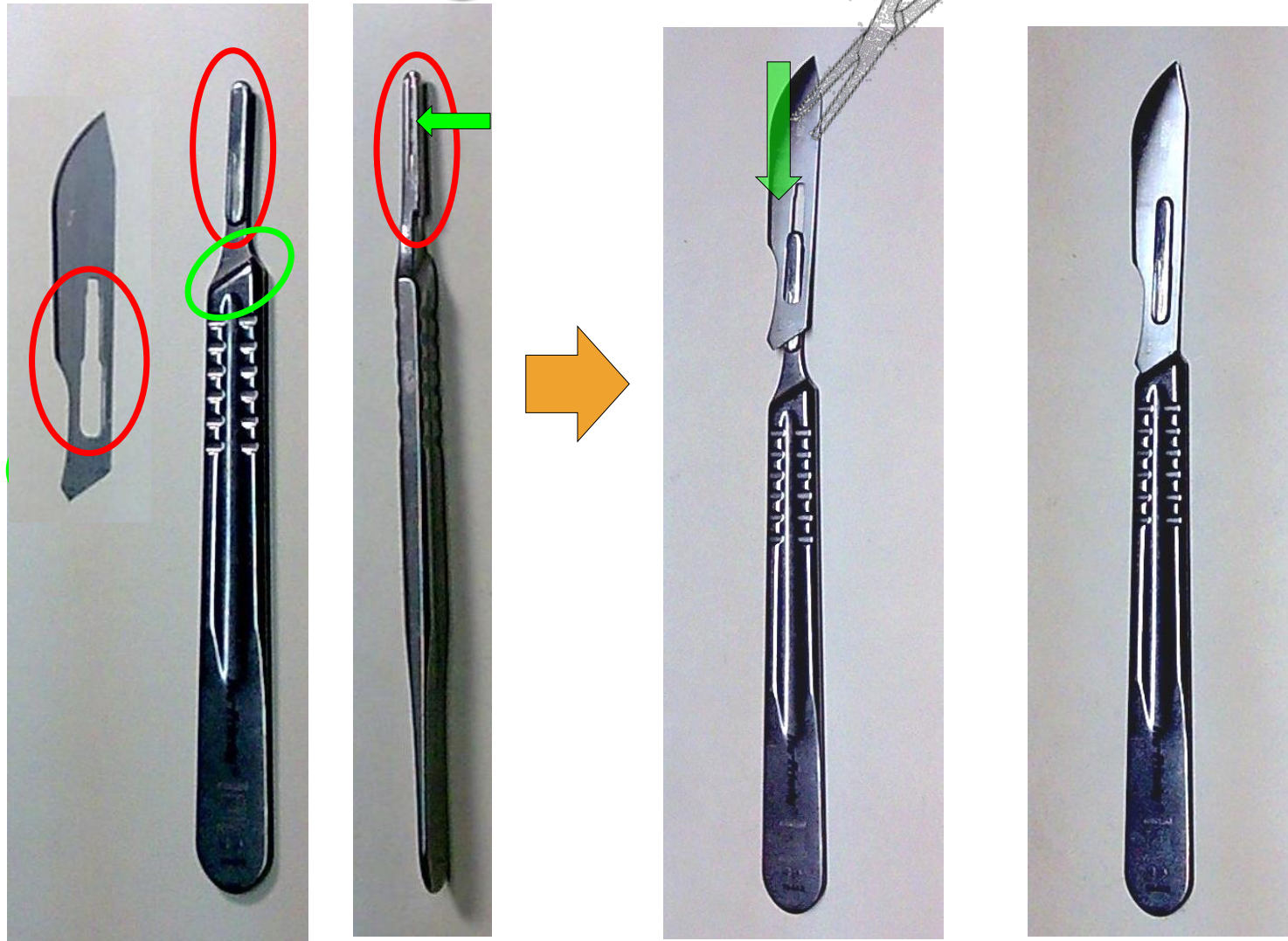- 使用剪刀進行鈍剝離是解剖
  神經跟血管有效率的方式

□ **銳剝離 (sharp dissection)**
- 使用手術刀
- 較少用到，通常用於切除某個構造

How to Change the Blade?

一般進行解剖的步驟

- ☐ 課前預習
- ☐ 使用好的圖譜
- ☐ 觸摸：骨頭的標誌 (bone marking)、韌帶、肌腱
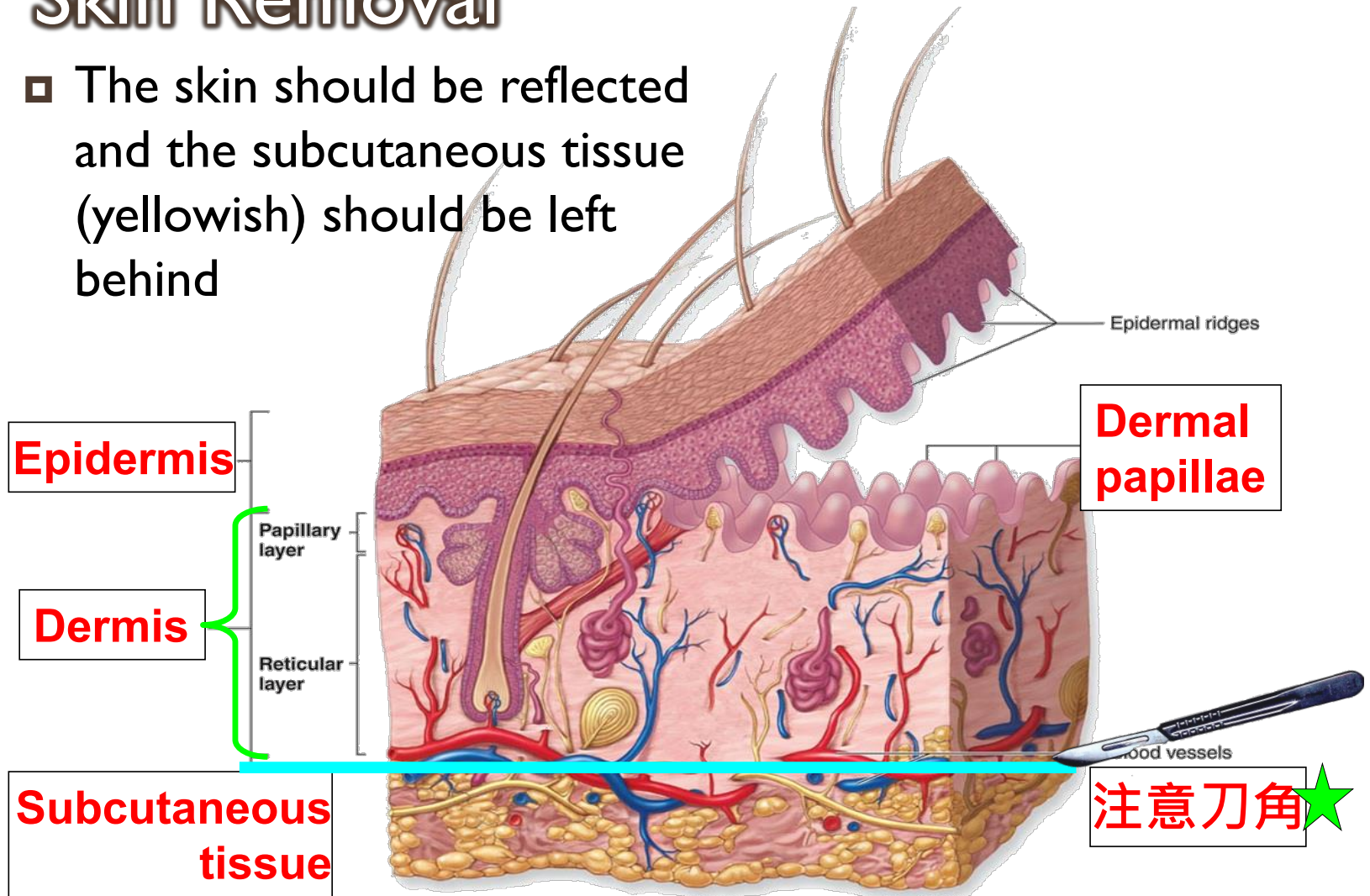- ☐ 移除脂肪，結締組織，小靜脈→會花很多時間，要有耐心
- ☐ 在每堂解剖實驗課結束後，複習今天解剖出來的構造

FIGURE 1-11. Using the scalpel tip to create skin incisions. Note the grip of the scalpel provides side-to-side and back-to-front blade stability.
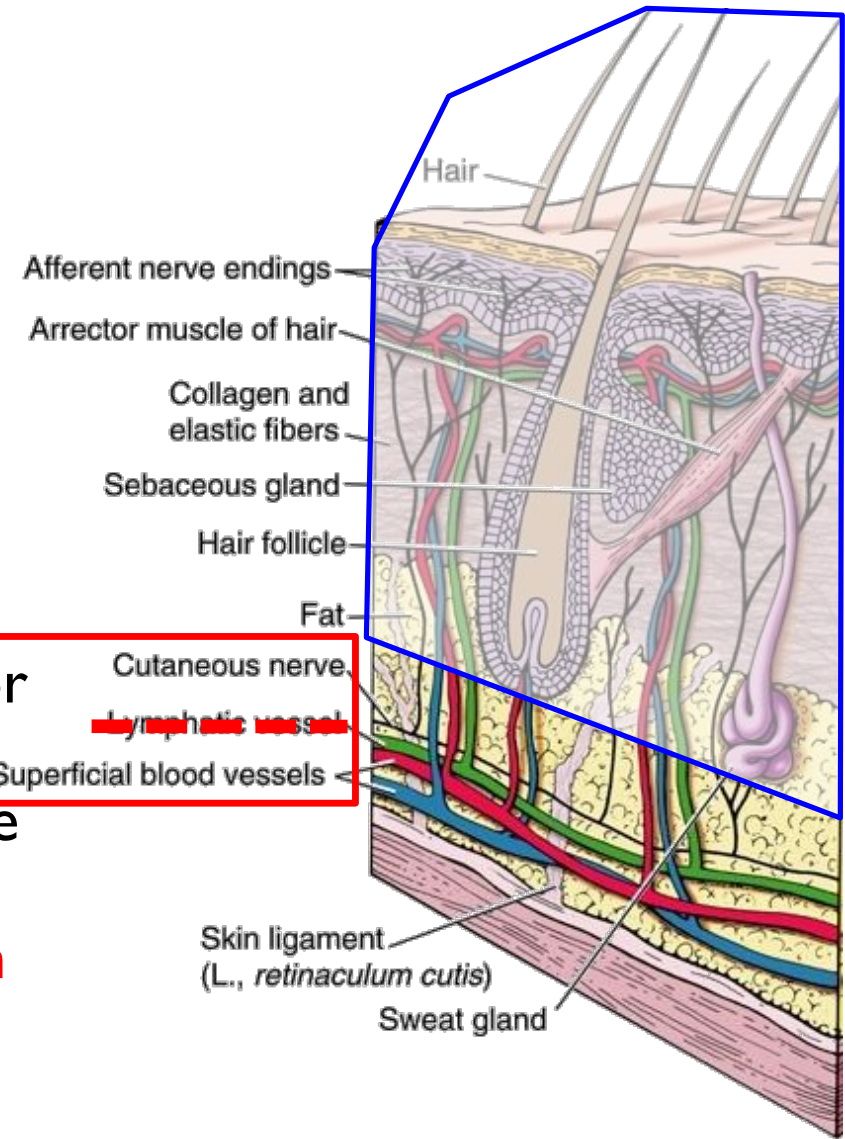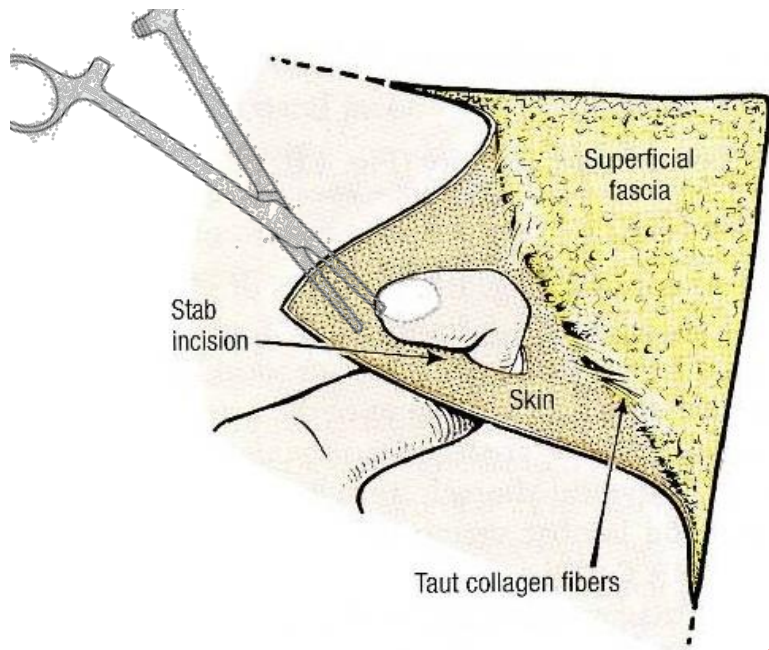

FIGURE 1-12. Holding toothed forceps with a 360-degree view, and using the scalpel tip between tissue layers while maintaining tension of superficial tissue layer.

Skin Removal

- The skin should be reflected and the subcutaneous tissue (yellowish) should be left behind
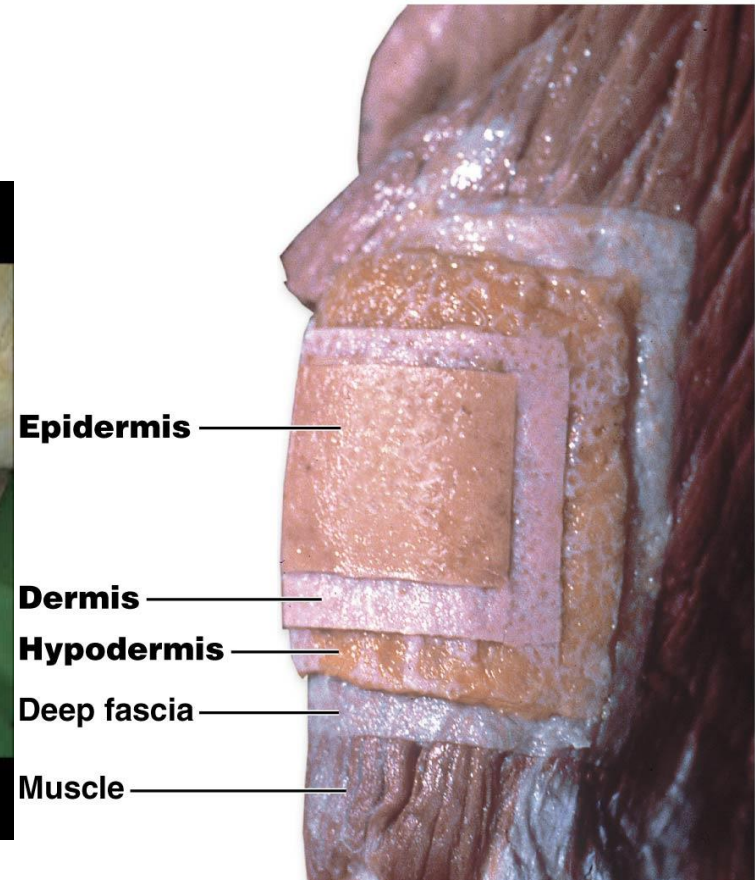
Epidermis

Dermis

Subcutaneous tissue

Dermal papillae

Epidermal ridges

Papillary layer

Reticular layer

Blood vessels

注意刀角 ★

Human Anatomy, McKinley
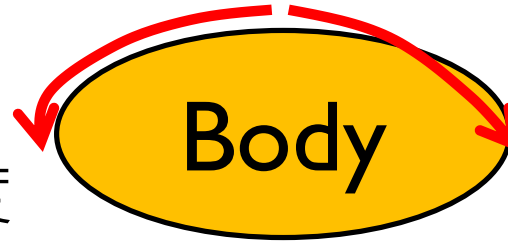
- If you can see the silver or white deep fascia or red/brown <u>striated</u> muscle fibers → cut too deep!!!
- Preserve the main branch of the superficial blood vessels and cutaneous nerves

Skin Removal

Body

- 大體老師的胖瘦程度
- 背部及臀區皮膚最厚
- 剝皮時注意肢體曲度 ⭐

Epidermis ———
Dermis ———
Hypodermis ———
Deep fascia ———
Muscle ———

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Differences Among N.A.V.

- **Nerves**
  - Silver-white, flat but tough
  - No lumen or elasticity
- **Arteries**
  - Whitish, thick wall, have circular lumen and elasticity
  - Be accompanied by vein(s)
- **Veins**
  - Darker than the artery
  - Have thin wall and collapsed lumen, no elasticity
  - If blood or clot accumulates in the lumen → circular
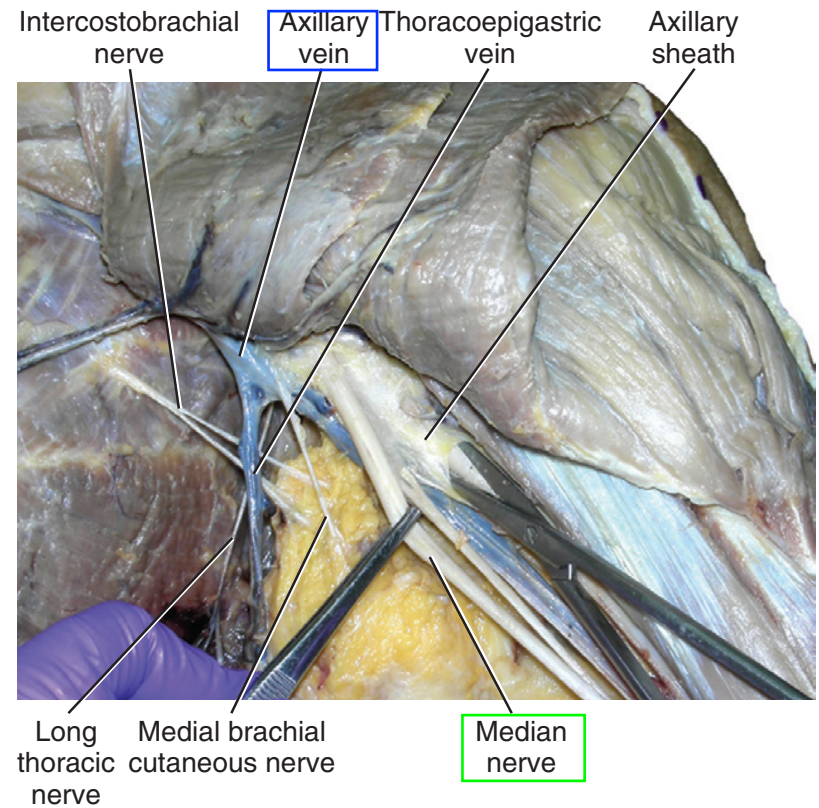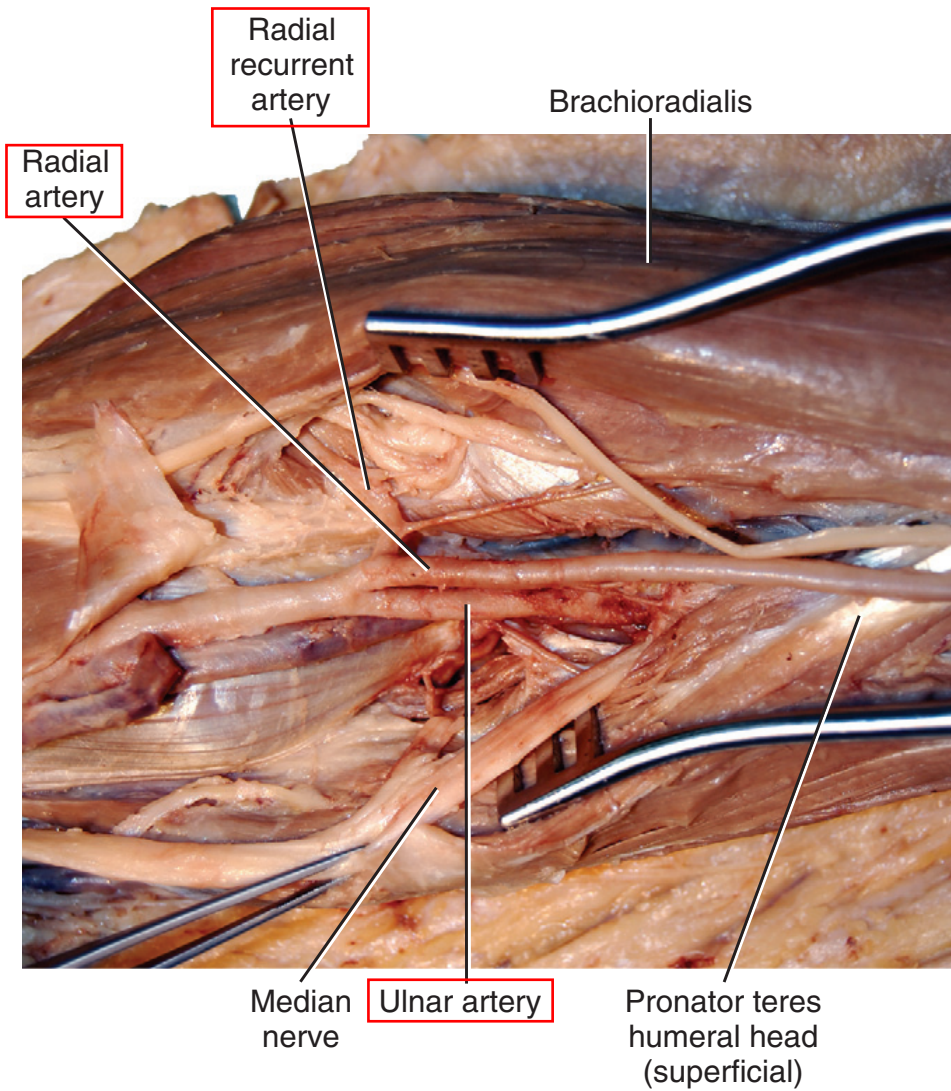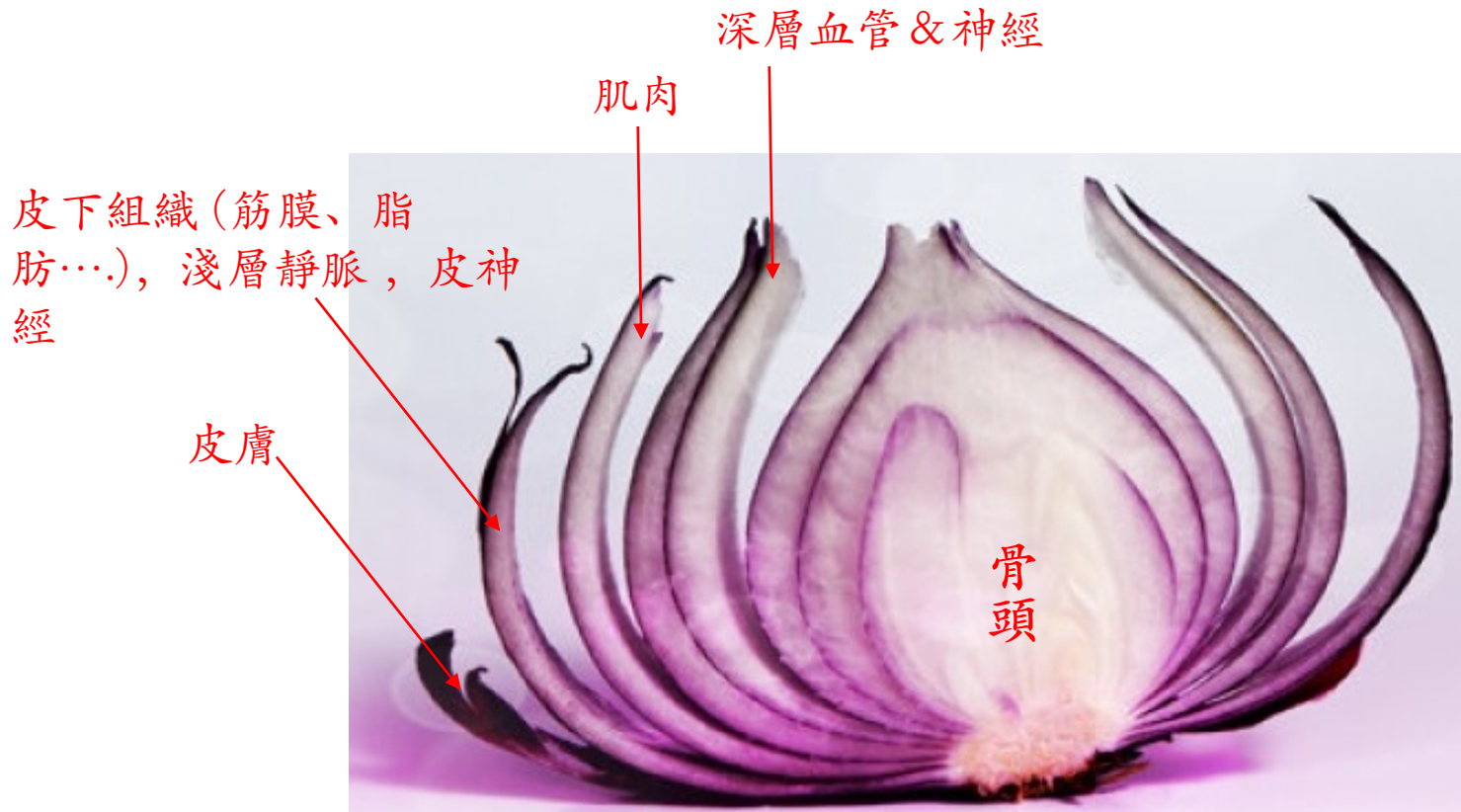 - Broken → nearby structures is stained

Radial recurrent artery

Brachioradialis

Radial artery

Median nerve

Ulnar artery

Pronator teres humeral head (superficial)

Intercostobrachial nerve

Axillary vein

Thoracoepigastric vein

Axillary sheath

Long thoracic nerve

Medial brachial cutaneous nerve

Median nerve

FIGURE 7-2. Anterior axillary region with pectoralis muscles reflected, revealing excision of axillary sheath to expose terminal branches of brachial plexus.
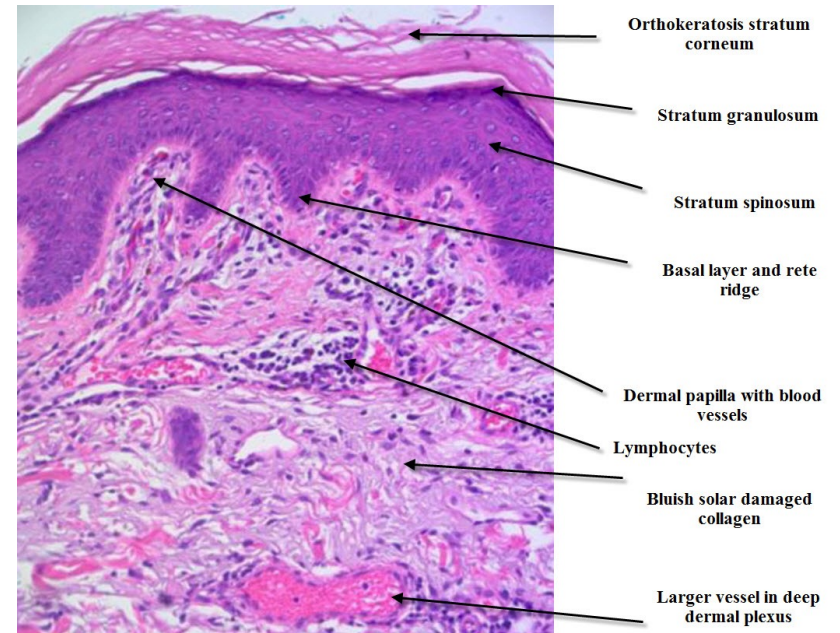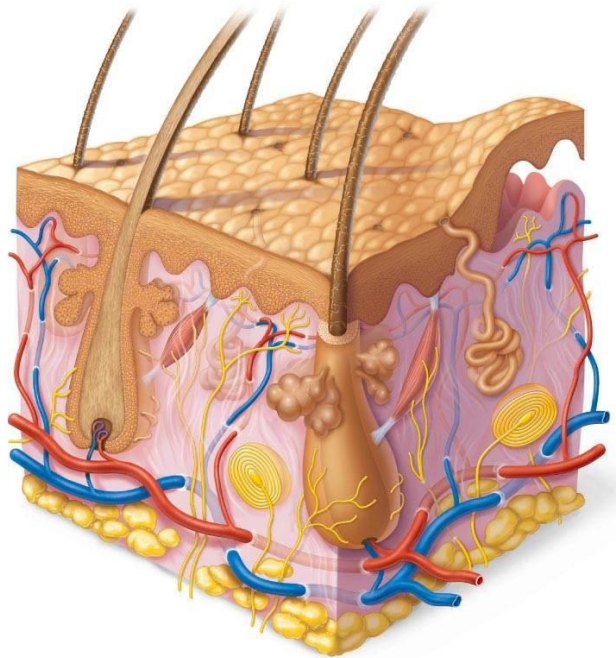
Medial

解剖基本概念

☐ 由淺到深
☐ 由大構造開到小構造

皮膚→皮下組織（筋膜、脂肪….），淺層靜脈，皮神經→肌肉→深層血管＆神經→骨頭

深層血管＆神經

肌肉

皮下組織（筋膜、脂肪….），淺層靜脈，皮神經

皮膚

骨頭

皮膚

Orthokeratosis stratum corneum

Stratum granulosum

Stratum spinosum

Basal layer and rete ridge

Dermal papilla with blood vessels

Lymphocytes

Bluish solar damaged collagen

Larger vessel in deep dermal plexus
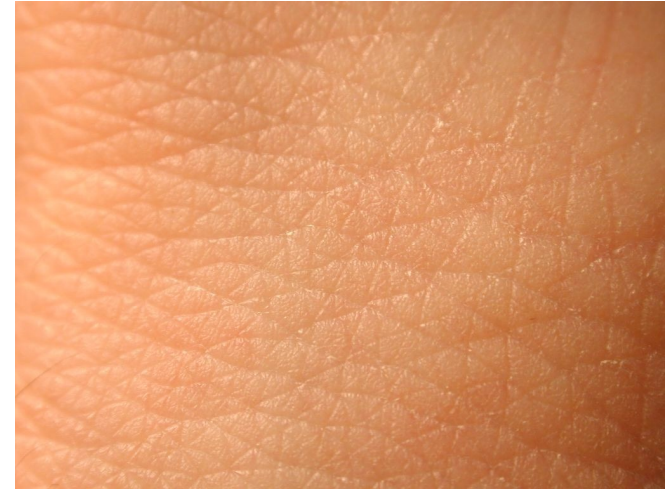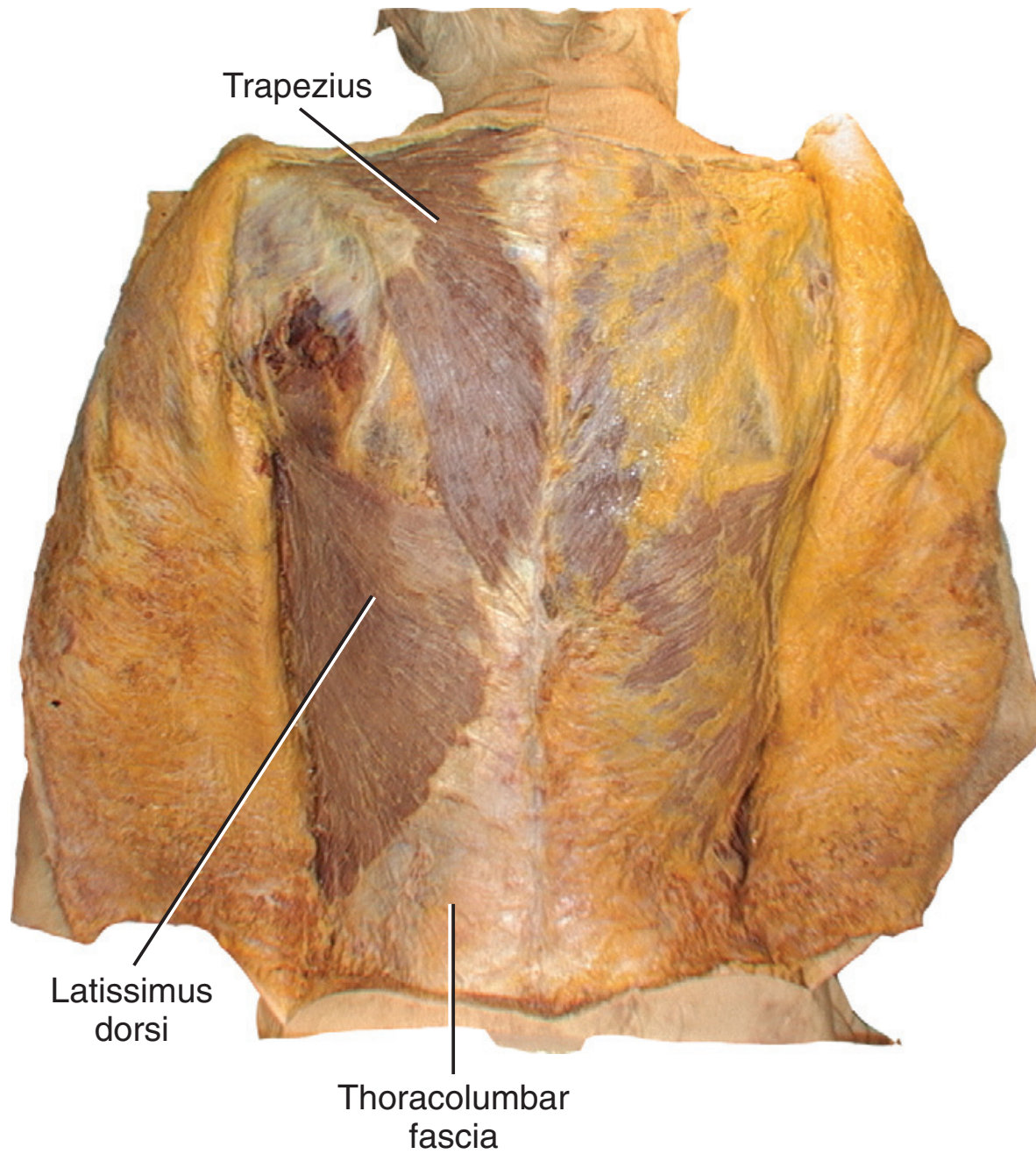
Trapezius

Latissimus
dorsi

Thoracolumbar
fascia

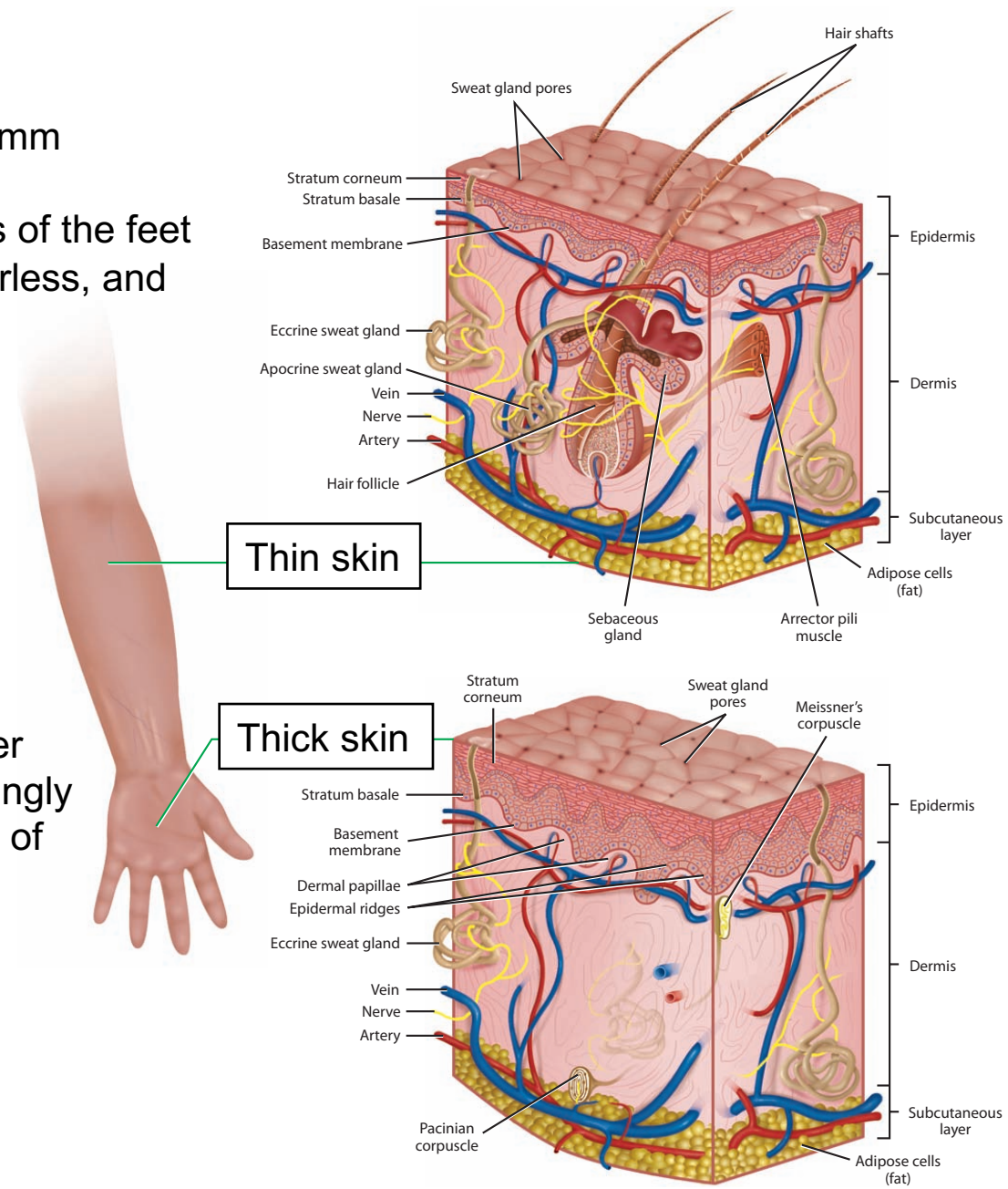# Thick and thin skin

- ☐ Thick skin and thin skin:
  a reflection of thickness and location
- ☐ From less than 1 mm to more than 5 mm
- ☐ **Thick skin**:
  - the palms of the hands and the soles of the feet
  - subject to the most abrasion, are hairless, and have a much thicker epidermal layer
- ☐ **Thin skin**:
  - the skin possesses a much thinner epidermis
  - contains hair follicles

- ☐ Refer only to the thickness of the epidermal layer (表皮層)

- ☐ The thickest skin is found on the upper portion of the back (dermis is exceedingly thick, epidermis is comparable to that of thin skin)

Thin skin

Labels: Hair shafts, Sweat gland pores, Stratum corneum, Stratum basale, Basement membrane, Eccrine sweat gland, Apocrine sweat gland, Vein, Nerve, Artery, Hair follicle, Epidermis, Dermis, Subcutaneous layer, Adipose cells (fat), Sebaceous gland, Arrector pili muscle

Thick skin

Labels: Stratum corneum, Sweat gland pores, Meissner's corpuscle, Stratum basale, Basement membrane, Dermal papillae, Epidermal ridges, Eccrine sweat gland, Vein, Nerve, Artery, Pacinian corpuscle, Epidermis, Dermis, Subcutaneous layer, Adipose cells (fat)

Thick vs. thin skin

- ☐ **Histology**: epidermis
- ☐ **Gross anatomy**: epidermis + dermis

Thick skin
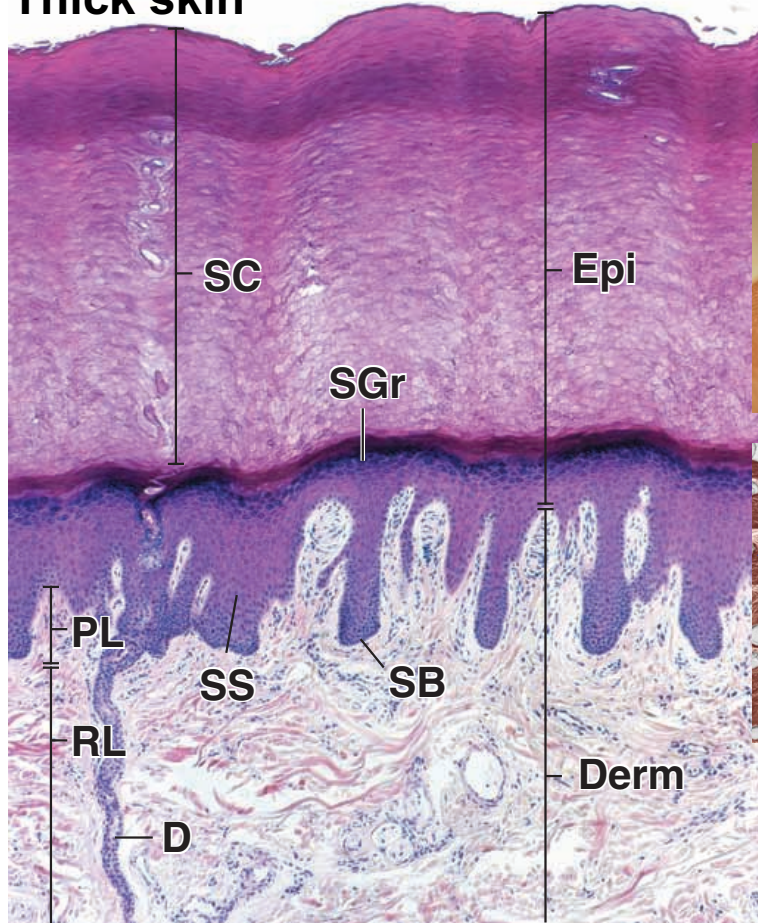
Thin skin

Epi: epithelium

SC: stratum corneum

SGr: stratum granulosum

SS: stratum spinosum

Derm: dermis

D: duct of seat gland

SB: stratum basale
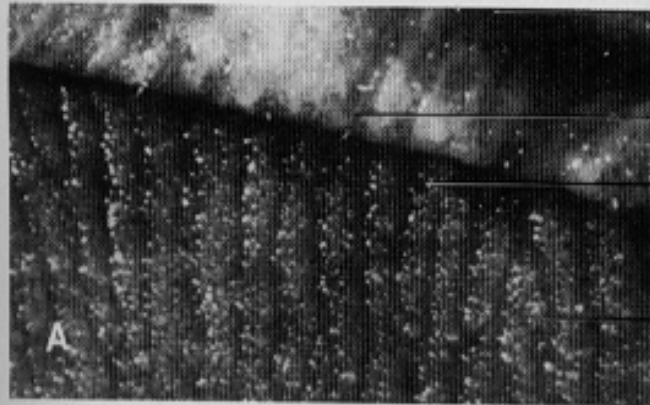
PL: papillary layer
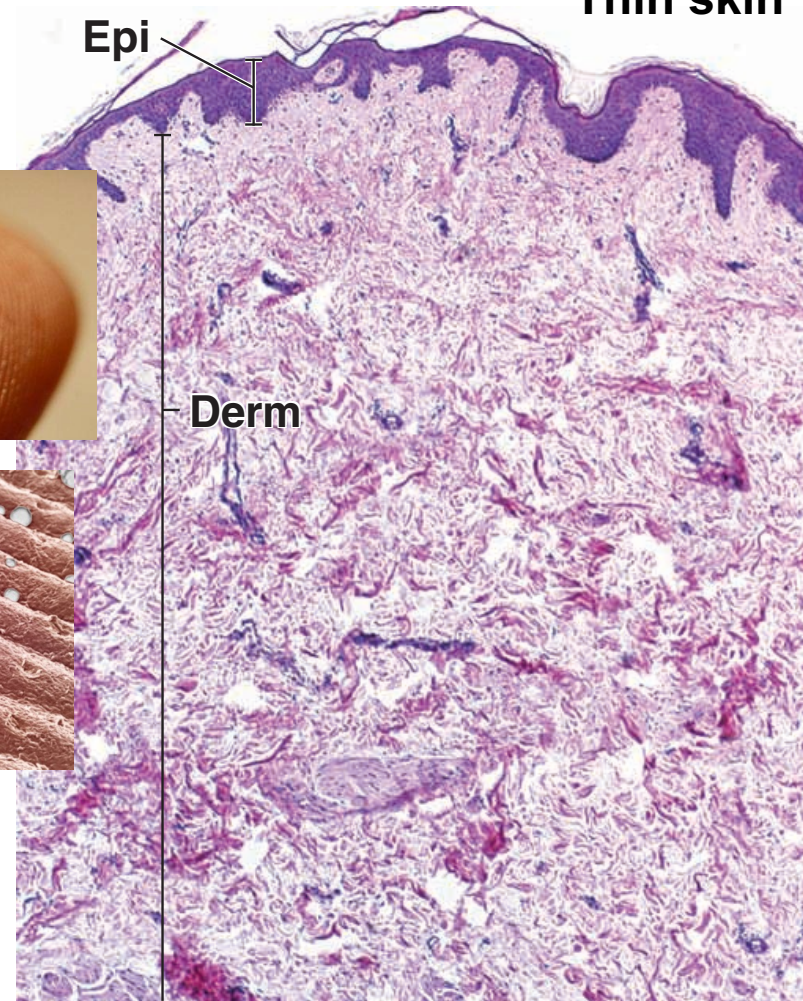
RL: reticular layer
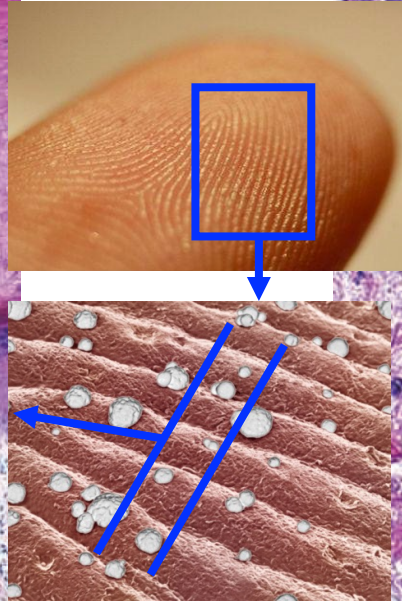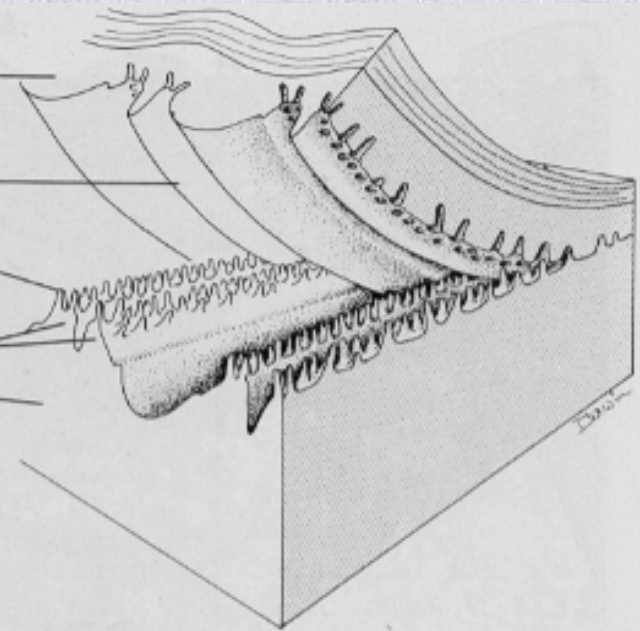
Fingerprints

Thick skin

Epidermis
Interpapillary peg
Dermal papillae
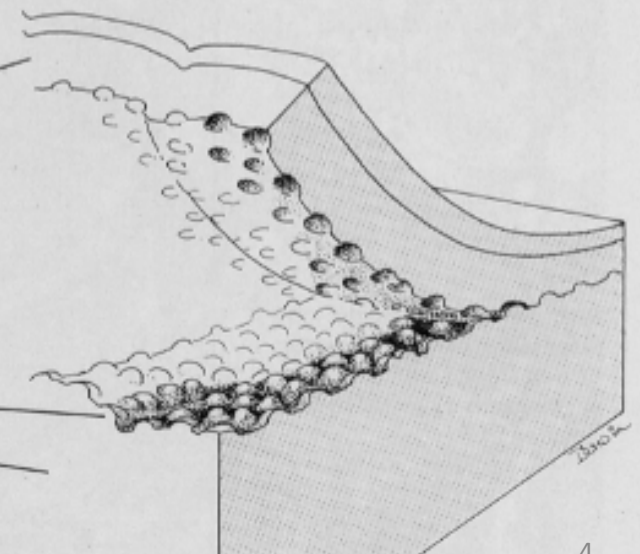Secondary dermal ridges
Dermis

Thin skin

Epidermis
Dermal papillae (flat and round)
Dermis

Layers of the skin

☐ **Epidermis**
- Stratum basale (stratum germinativum): mitotically active cells, stem cells of the
  (基底層)   epidermis
- Stratum spinosum: light microscopic appearance of short processes extending from
  (棘層)   cell to cell
- Stratum granulosum (顆粒層): contains numerous intensely staining granules
- Stratum lucidum (透明層): limited to thick skin and considered a subdivision of
                              stratum corneum
- Stratum corneum (角質層): is composed of keratinized cells
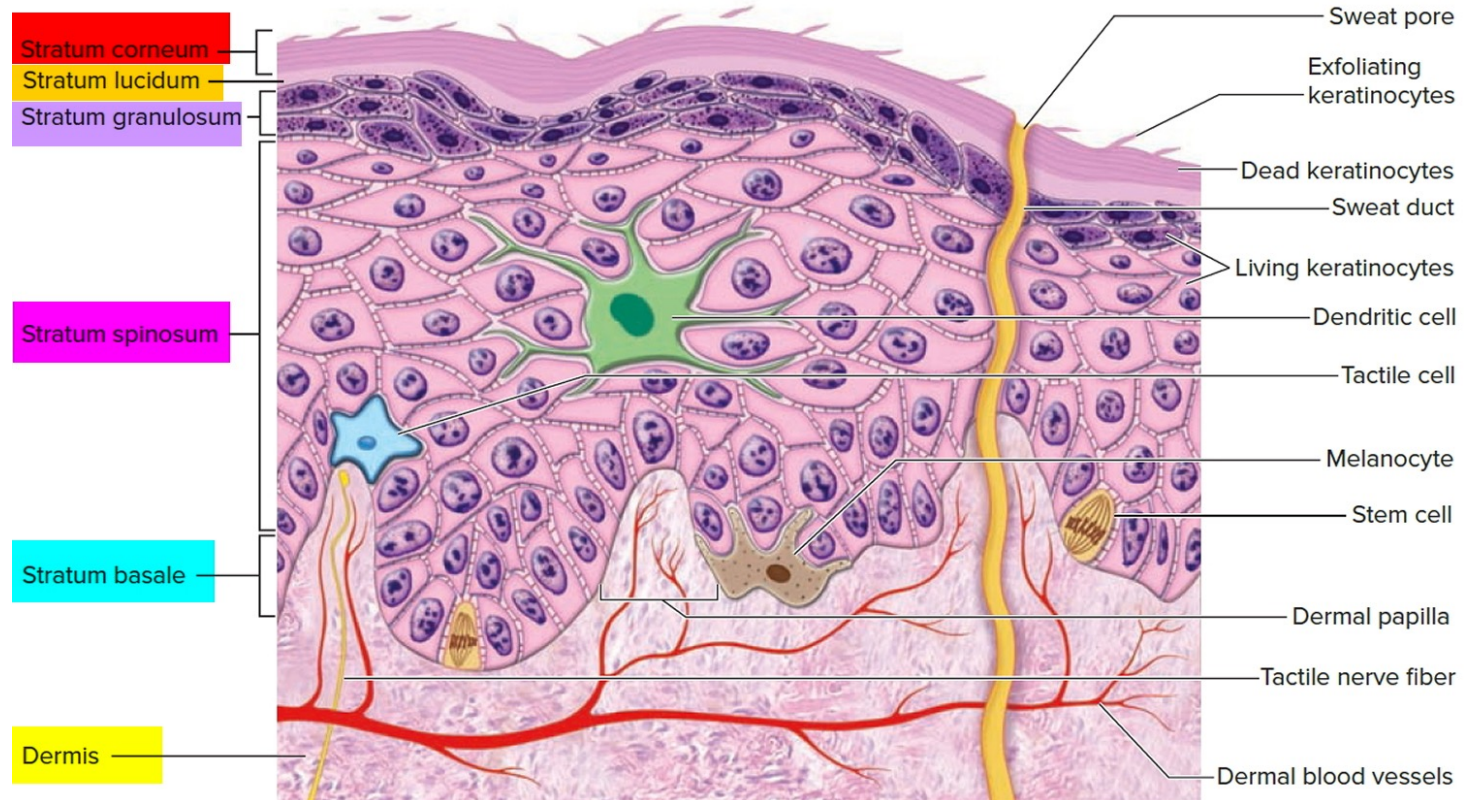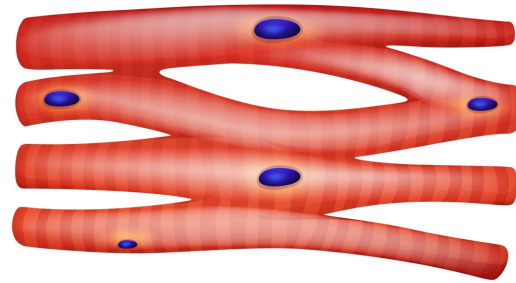
Layers of the skin
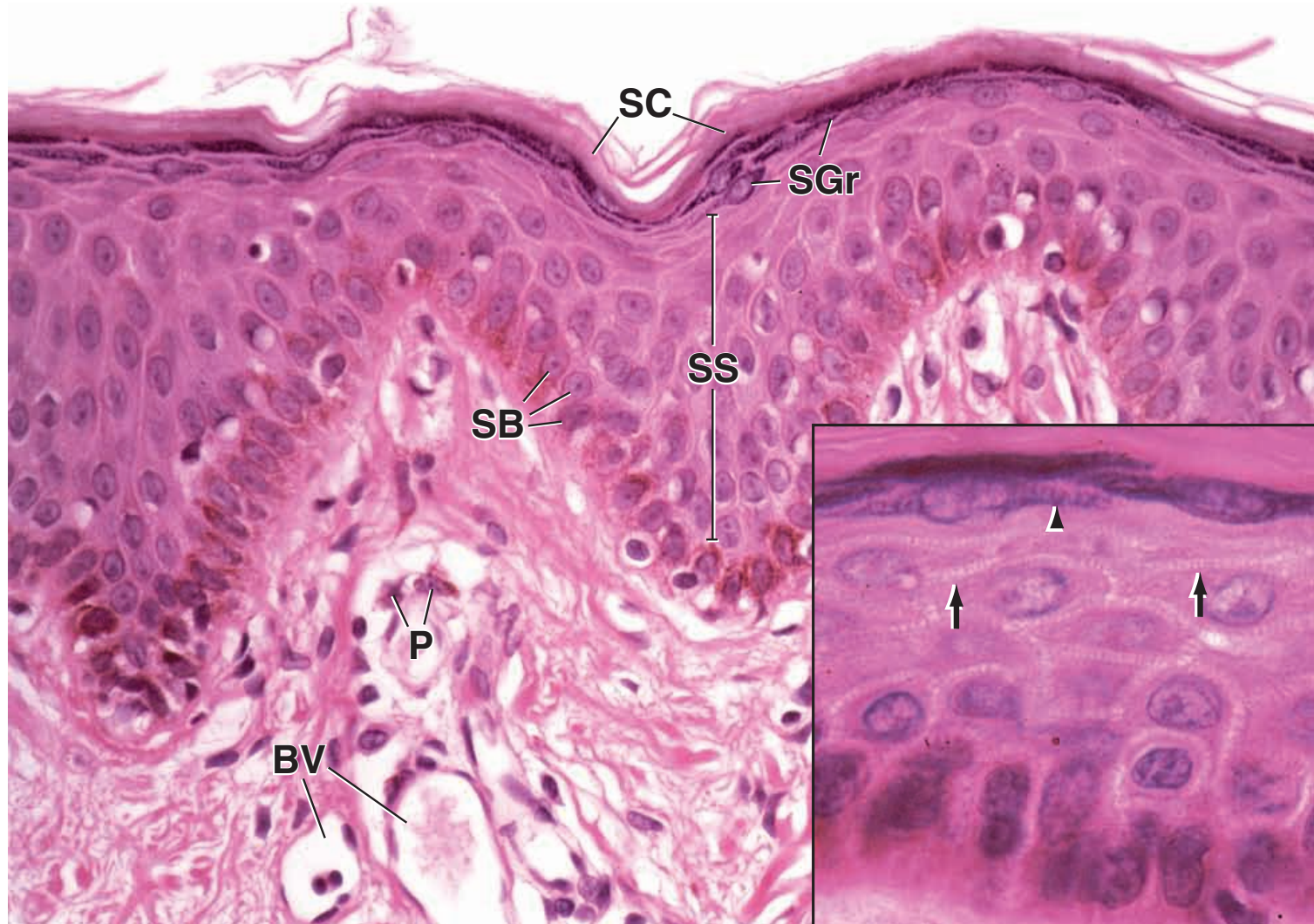
SC: stratum corneum
SGr: stratum granulosum
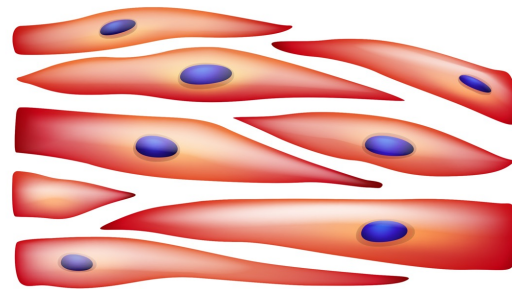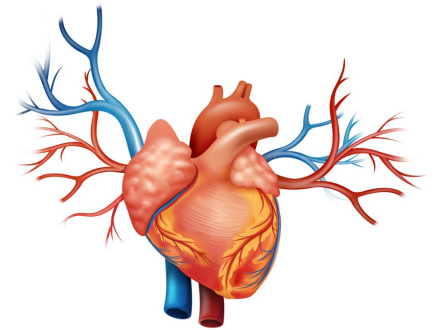**SS**: stratum spinosum
SB: stratum basale

P: pigment
BV: blood vessels
➤: granules in cell of stratum granulosum
→: intercellular bridges

肌肉 (Muscle)

- 肌肉 (Muscle)—源自拉丁文，意思是「小老鼠」
- 肌肉是下列構造的主要組織，可分成三種肌肉：
  - 心肌組織 (cardiac muscles): 心臟
  - 平滑肌組織 (smooth muscles): 中空器官壁
  - 骨骼肌 (skeletal muscles): 佔身體近一半的質量

cardiac muscle

smooth muscle
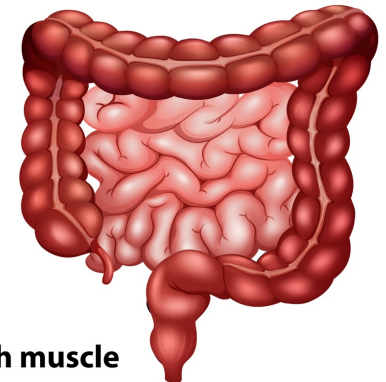
肌肉組織的特性

- 收縮性 **(Contractility)**
  - 肌絲 (myofilaments)負責使肌肉細胞變短
    - 肌絲有兩種，分別為肌動蛋白 (actin) 和肌凝蛋白 (myosin)
- 興奮性 **(Excitability)**
  - 神經訊號可使肌肉細胞興奮，導致電脈衝沿著肌膜傳送
- 延展性 **(Extensibility)**
  - 骨骼肌收縮會拉長相對的肌肉
  - 平滑肌會因為中空器官當中的物質而被撐大
    - 胃內的食物；膀胱內的尿液
- 彈性 **(Elasticity)**
  - 被拉扯後會彈回

肌肉組織的特殊命名

- *Myo* 和 *mys*—意指「肌肉」的字首
- *Sarco*—意指「肉」的字首
  - 肌膜 **(Sarcolemma)**—肌肉細胞的細胞膜
  - 肌質 **(Sarcoplasm)**—肌肉細胞的細胞質
  - 肌漿網 **(sarcoplasmic reticulum)**- 肌肉細胞的內質網

Details of a muscle fiber

Figure 10-2c Principles of Anatomy and Physiology, 11/e
© 2006 John Wiley & Sons
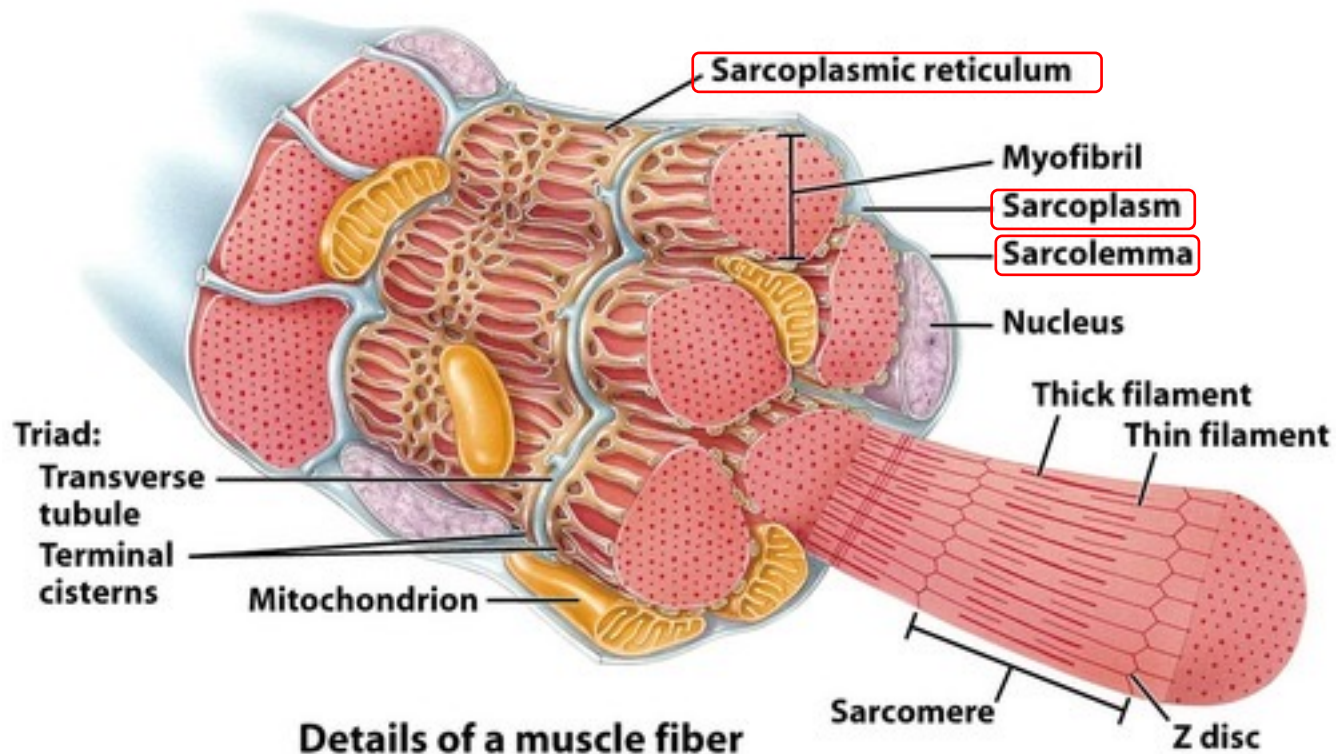
肌肉組織的功能

☐ 開啟及關閉身體通道
- 充當閥門的括約肌
  - 放鬆時可允許物質通過
  - 收縮時關閉通道
☐ 產生運動
- **骨骼肌 (Skeletal muscle)**—附著至骨骼
  - 透過移動骨頭來移動身體
- **平滑肌 (Smooth muscle)**—將液體和其他物質擠過中空器官
☐ 維持姿勢及穩定關節
- 使身體能維持站姿或坐姿
- 肌肉張力有助於穩定許多滑液關節
☐ 生熱
- 肌肉收縮產生熱
- 協助維持正常體溫
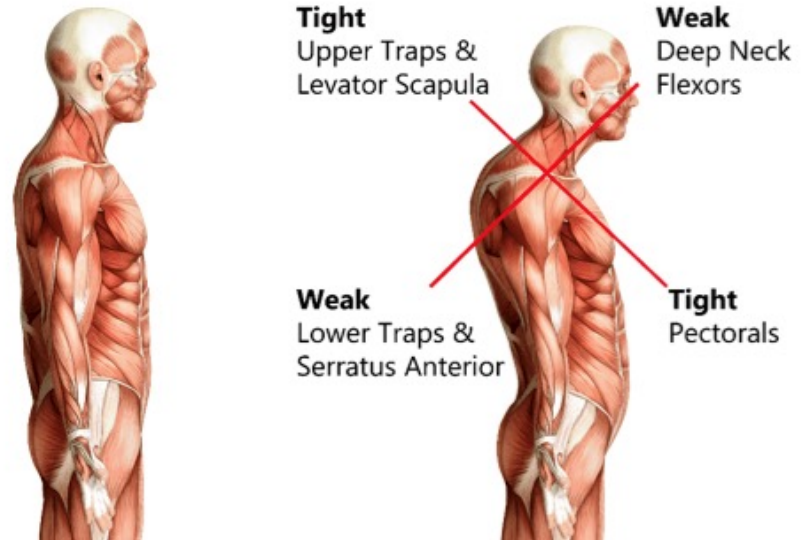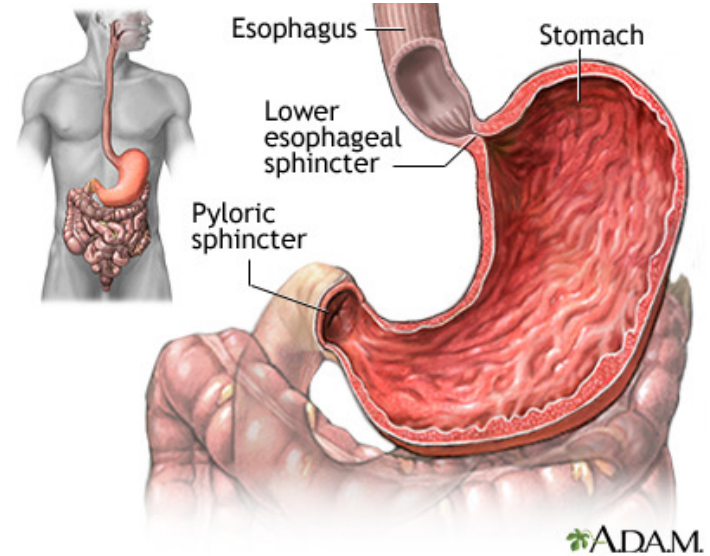
肌肉組織的類型

□ 骨骼肌組織 (Skeletal muscle tissue)
- 組合成骨骼肌 (skeletal muscles)
- 佔體重的40%
- 細胞具有橫紋
- 骨骼肌受到神經系統的隨意區支配

Skeletal muscle

□ 心肌組織 (Cardiac muscle tissue)
- 只存在心臟壁
- 細胞具有橫紋
- 收縮是不隨意的
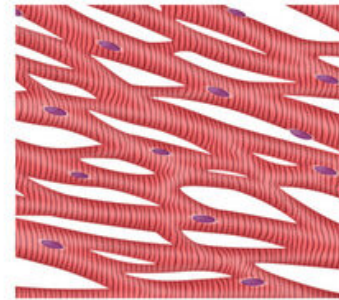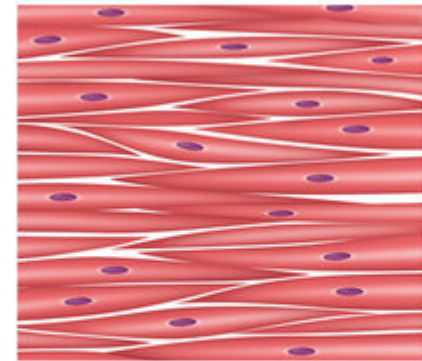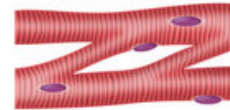
□ 平滑肌組織 (Smooth muscle tissue)
- 位在中空器官壁
- 細胞缺乏橫紋
- 受到神經系統的不隨意區支配

Cardiac muscle

Smooth muscle

骨骼肌

☐ 每塊肌肉都是一個**器官**
- 主要由**肌肉組織 (muscle tissue)** 構成
- 骨骼肌也含有：結締組織、血管、神經

☐ *結締組織* 與**肌束 (fascicles)**
- 結締組織鞘將骨骼肌和其纖維結合在一起
  肌外膜 (Epimysium)—圍繞整塊肌肉的緻密規則結締組織
  肌束膜 (Perimysium)—圍繞每條肌束(成群的肌纖維)
  肌內膜 (Endomysium)—包裹個別肌肉細胞的纖細結締組織鞘

☐ *結締組織鞘 (肌內膜，肌束膜，肌外膜)* 與***肌腱*** 相連
- 當肌纖維收縮，施加拉力至肌腱的所有結締組織層，並將力量傳至肌腱連結的骨頭
- 結締組織鞘提供彈性，並含有血管和神經

圖 10.1 骨骼肌中的結締組織鞘：肌外膜、肌束膜和肌內膜。

骨頭
Bone

肌外膜
Epimysium

肌腱
Tendon

肌外膜
Epimysium

肌束膜
Perimysium

肌內膜
Endomysium

Muscle fiber
in middle of
a fascicle
肌束中間
的肌纖維

(b)

Blood vessel 血管

Fascicle 肌束(為肌束膜所包覆)
(wrapped by perimysium)

Endomysium 肌內膜
**(between individual
muscle fibers)**
(介於個別的肌纖維之間)

Epimysium
肌外膜

Perimysium
肌束膜

Fascicle
肌束

Endomysium
肌內膜

Muscle fiber
肌纖維

(a)
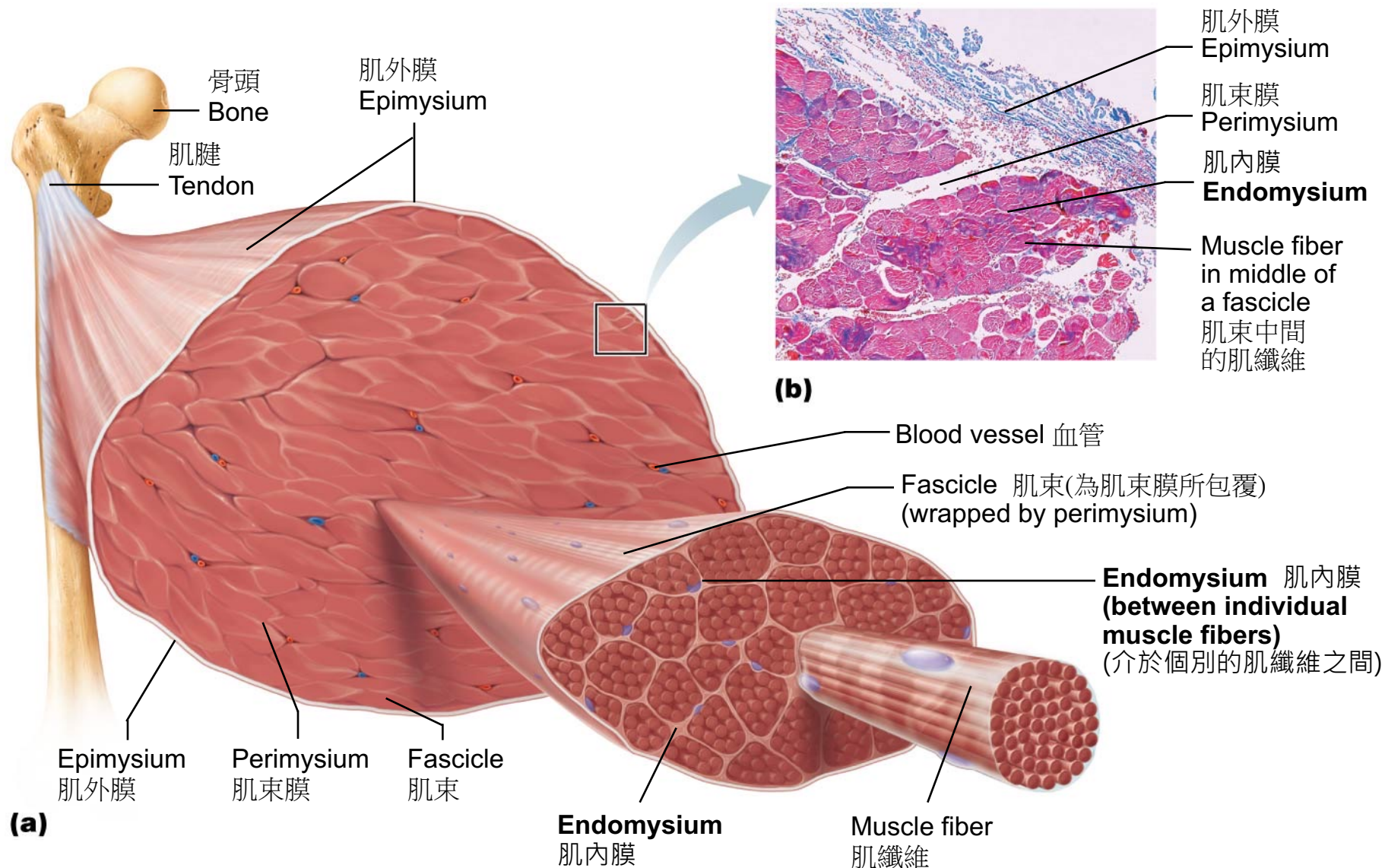
骨骼肌的大體解剖學

- *神經與血管*
  - 每塊骨骼肌會有下列構造的分支供應
    - 一條神經
    - 一條動脈
    - 一條以上的靜脈
  - 神經和血管多次分岔
    - 最小的分支供應個別的肌纖維

Figure 10.2 Photomicrograph of the capillary network surrounding skeletal muscle fibers. The arterial supply was injected with dark red gelatin to demonstrate the capillary bed. The muscle fibers, which run horizontally across the photograph, are stained orange. Note the wavy appearance of the thinnest capillaries (75×).
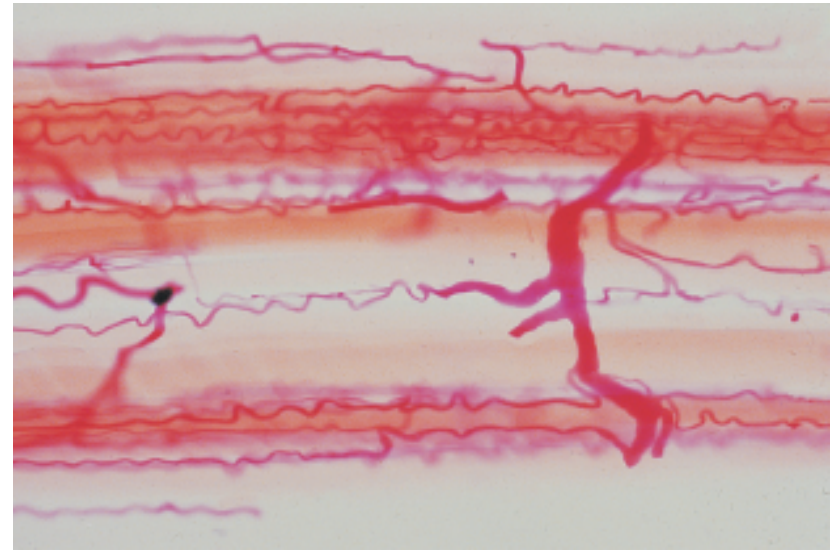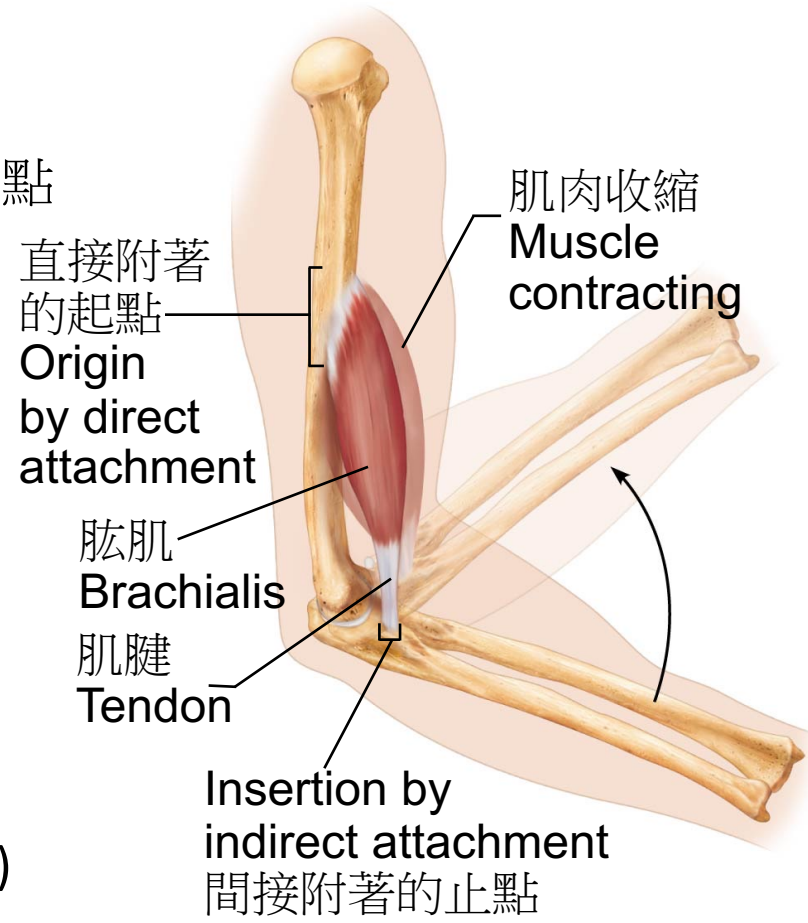
肌肉附著點 (Muscle attachments)

- 大多數骨骼肌是由一塊骨頭延伸到另一塊骨頭
- 一塊骨頭會移動；另一塊骨頭則固定
  - **起點 (Origin)**—可動性較低的附著點
  - **止點 (Insertion)**—可動性較高的附著點

肌肉附著點

- 肌肉透過結締組織 (CT)
  附著至起點與止點
  - **肌肉性附著點 (Fleshy attachments)**
    —結締組織纖維短
  - **間接附著點 (Indirect attachments)**
    —結締組織形成肌腱或是腱膜
- 肌腱與骨頭交會處有骨標記
  - **結節 (Tubercles)**、**轉子 (trochanters)**
    和**嵴 (crests)**

肌肉收縮
Muscle
contracting

直接附著
的起點
Origin
by direct
attachment

肱肌
Brachialis

肌腱
Tendon
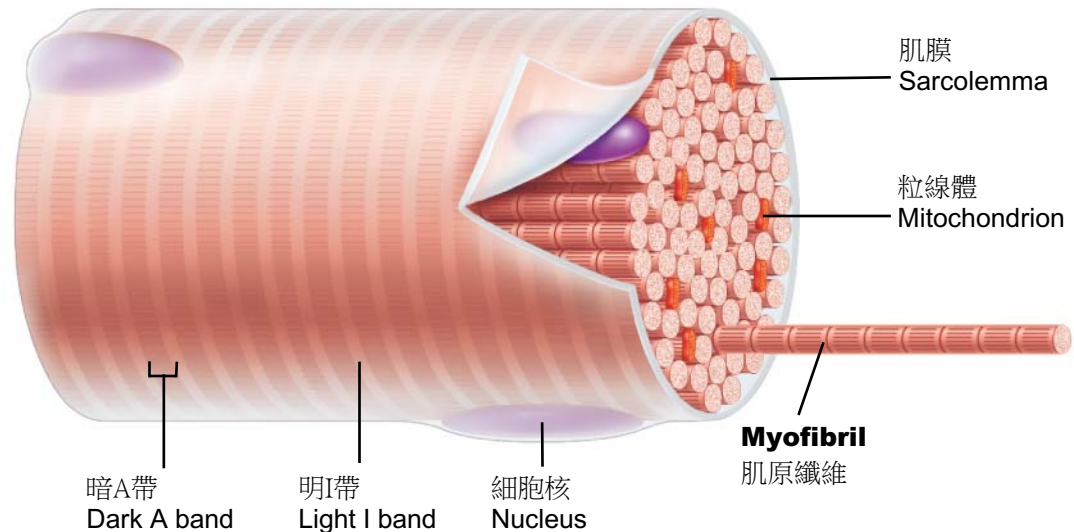
Insertion by
indirect attachment
間接附著的止點

手臂彎曲

引體向上

骨骼肌組織的顯微與功能解剖學

☐ 骨骼肌纖維 (骨骼肌細胞)

- 纖維為長圓柱狀
  - *是巨大的細胞*—直徑 10–100 μm
  - *長度*—數公分到數十公分
- 每個骨骼肌細胞是*胚胎細胞*融合而形
- 細胞是**多核的 (multinucleate)**
- 細胞核位在細胞*週邊*

(b) 顯現出肌原纖維的一條肌纖維局部的圖示。一條肌原纖維被從肌纖維切斷的那端拉出。

肌膜
Sarcolemma

粒線體
Mitochondrion

Myofibril
肌原纖維

暗A帶
Dark A band

明I帶
Light I band

細胞核
Nucleus

肌原纖維和肌節

☐ 橫紋是源自*肌原纖維的內部構造*

☐ **肌原纖維 (Myofibrils)**
- 是在肌質當中的長桿狀物體
- 佔肌質的 80%
- *是存在於肌肉組織內的特化收縮性胞器*
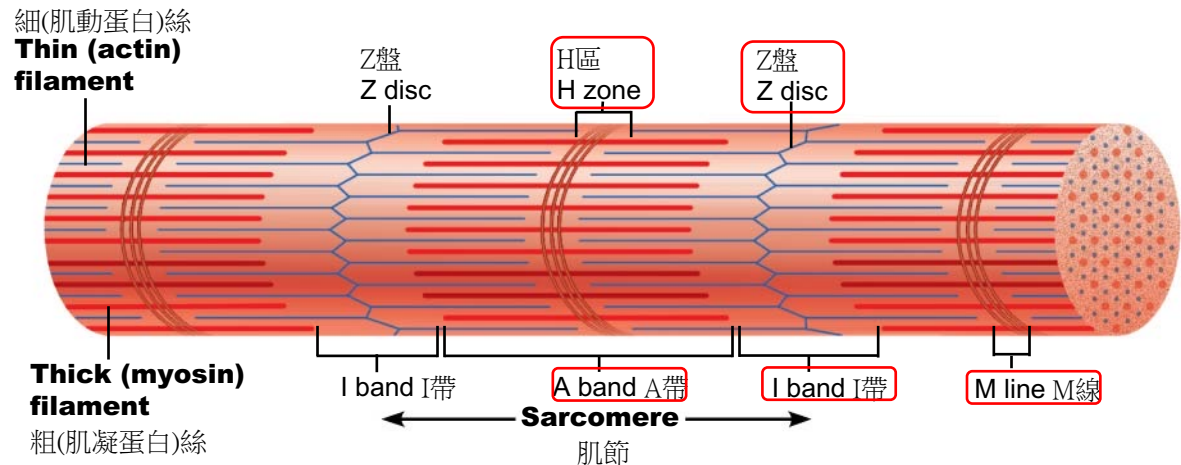- 是一長列重複的節段，這些節段稱為**肌節 (sarcomeres；**骨骼肌組織的功能性單位)

☐ *骨骼肌收縮的基本單位*
- **Z盤 (Z線) [Z disc (Z line)]**—每個肌節的邊界
- **細 (肌動蛋白) 絲 [Thin (actin) filaments]**—由Z盤往肌節的中央延伸
- **粗 (肌凝蛋白) 絲 [Thick (myosin) filaments]**—位在肌節中央
  - *與細肌絲的內側端重疊*
  - *含有ATP酶*

肌原纖維和肌節

☐ **A帶 (A bands)**—粗肌絲的全長
- 包括細肌絲的內側端

☐ **H區 (H zone)**—沒有細肌絲的A帶中央部位

☐ A帶和 I 帶折射偏振光的方式不同
- A 帶—*非等向性 (anisotropic)*
- I 帶—*等向性 (isotropic)*

☐ **M線 (M line)**—在H區的中央
- 含有將粗肌絲連在一起的微小桿狀物

☐ **I 帶 (I band)**—只具有細肌絲的區域
- 位在兩個相鄰的肌節當中

細(肌動蛋白)絲
Thin (actin) filament

Z盤
Z disc

H區
H zone

Z盤
Z disc

(c) 局部放大的一條肌纖維以顯現出肌絲造成條紋狀的圖樣。每個肌節均由一個Z盤延伸到下一個Z盤。

Thick (myosin) filament
粗(肌凝蛋白)絲

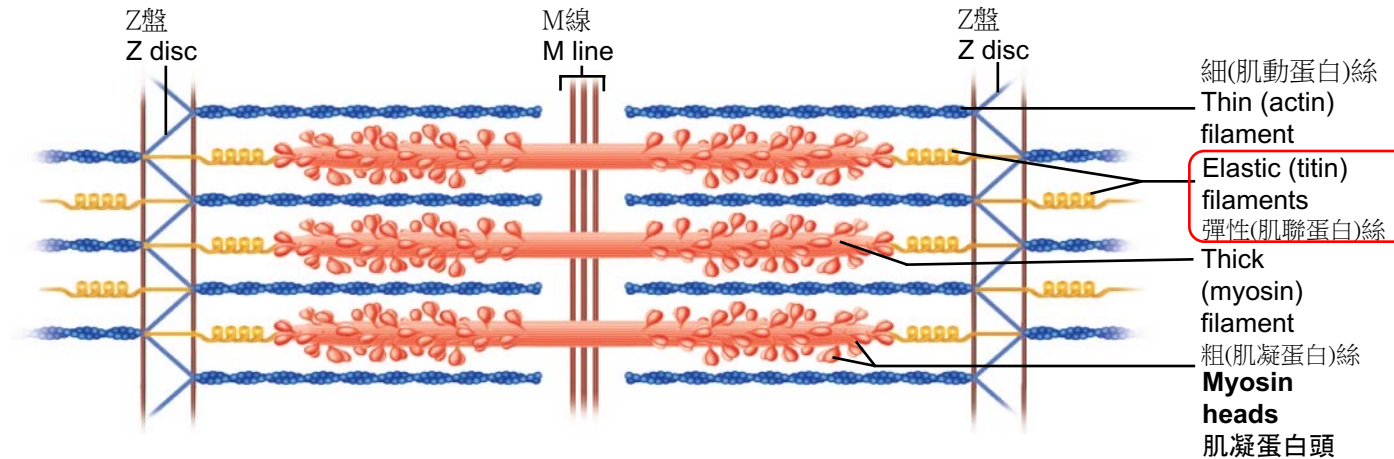I band I帶   A band A帶   I band I帶   M line M線

Sarcomere
肌節

肌聯蛋白與其他肌原纖維蛋白

☐ 肌聯蛋白 (Titin) 是抵抗過度拉扯的彈簧狀分子

- 肌聯蛋白分子從Z盤延伸到粗肌絲，接到M線
  - 兩種功能
    1. 將粗肌絲固定在適當位置
    2. 肌肉被拉長時展開

(d) 肌節放大(縱向切開)。
注意粗肌絲上的肌凝蛋
白頭。.

Z盤
Z disc

M線
M line

Z盤
Z disc

細(肌動蛋白)絲
Thin (actin) filament

Elastic (titin) filaments
彈性(肌聯蛋白)絲

Thick (myosin) filament
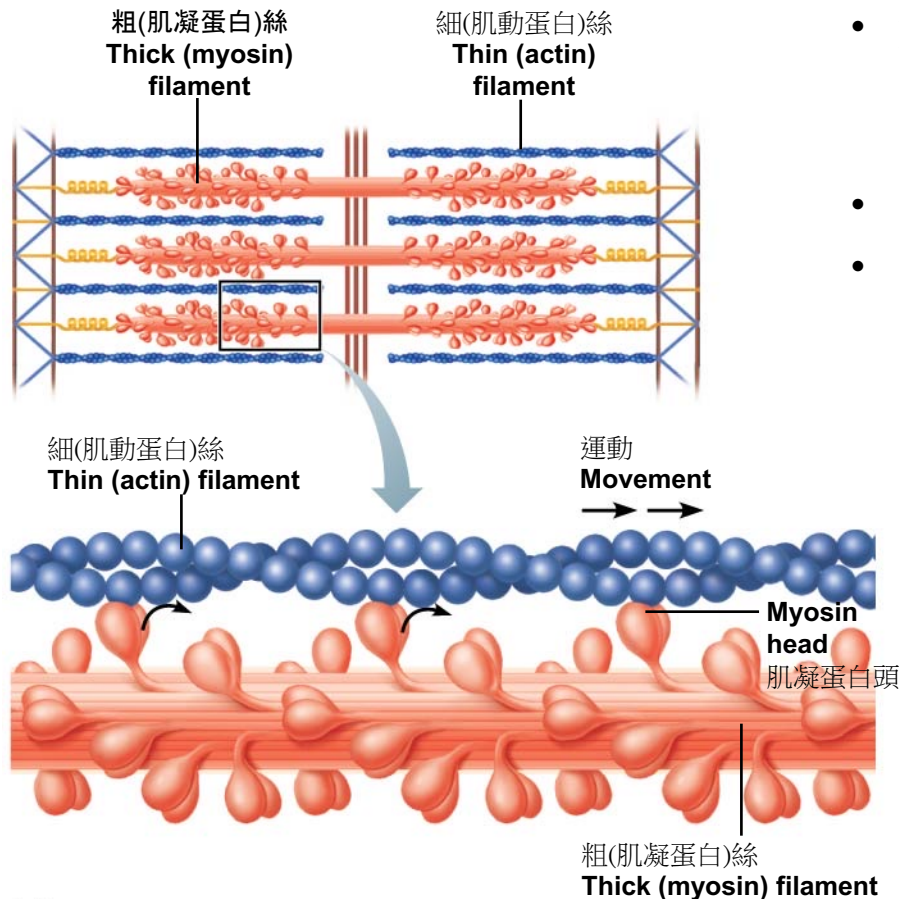
粗(肌凝蛋白)絲
Myosin heads
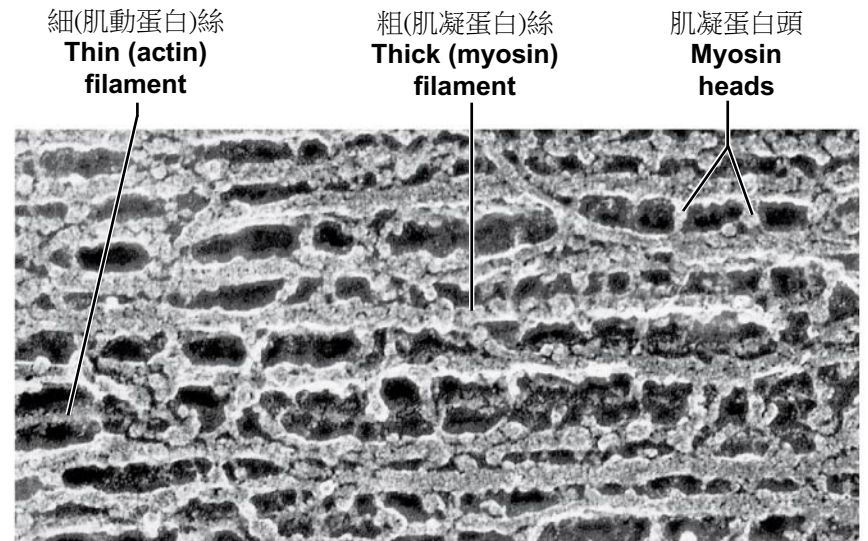**肌凝蛋白頭**

收縮機制

□ 兩大收縮類型
- **同心收縮 (Concentric contraction)**—肌肉縮短而做功
- **離心收縮 (Eccentric contraction)**—肌肉變長時產生力量
  - 肌肉擔任抵抗重力的「煞車」
  - 伏地挺身中的伏地向下便是一個離心收縮的例子

□ 肌絲滑動機制 **(Sliding filament mechanism)**
- 解釋了同心收縮
  - 肌凝蛋白頭附著至在肌節兩端的細肌絲, 然後將細肌絲拉向肌節的中央
- 肌質網釋出鈣離子啟動肌絲滑動機制
- 由ATP供應能量

粗(肌凝蛋白)絲
Thick (myosin) filament

細(肌動蛋白)絲
Thin (actin) filament

細(肌動蛋白)絲
Thin (actin) filament

運動
Movement

Myosin head
肌凝蛋白頭

粗(肌凝蛋白)絲
Thick (myosin) filament

(a) 肌凝蛋白頭附著至細肌絲中的肌動蛋白，然後轉動將細肌絲往內拉。

細(肌動蛋白)絲
Thin (actin) filament

粗(肌凝蛋白)絲
Thick (myosin) filament

肌凝蛋白頭
Myosin heads

(b) 通過肌節A帶的冷凍碎裂穿透式電子顯微照片，顯示出**肌凝蛋白頭**附著至細肌絲。

1. 等長收縮 (**Isometric Muscle Action**)

等長收縮與它字面上的意思相同，就是肌肉「長度不變」的用力狀態，也就是肌肉收縮的力量等於外在的負荷重量。舉例來說：以前被老師處罰半蹲的時候，就是全身的肌肉進行等長收縮，用力維持著半蹲狀態，無法移動的時候。

Isometric contraction
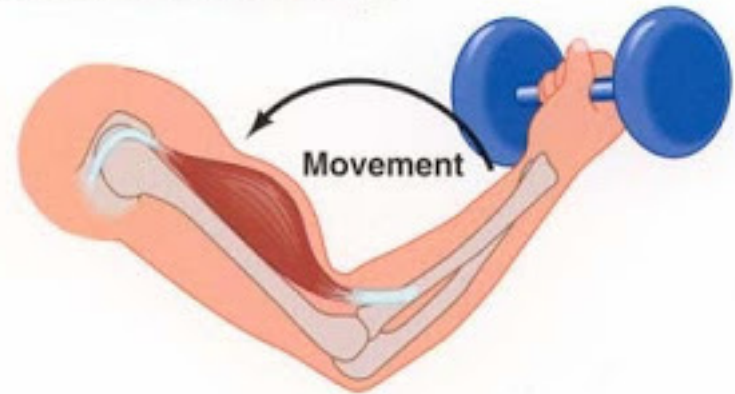Muscle contracts
but does not shorten

No movement

(a)

2. 向心收縮 (**Concentric Muscle Action**)

向心收縮指的是，肌肉收縮力量大於外在的負荷重量時，肌肉縮短的過程；簡單來說，就是肌肉「長度」縮短的動作狀態，譬如：我們從口袋拿手機出來看時，就是我們手臂前側的肱二頭肌向心收縮，把手機舉到我們面前。
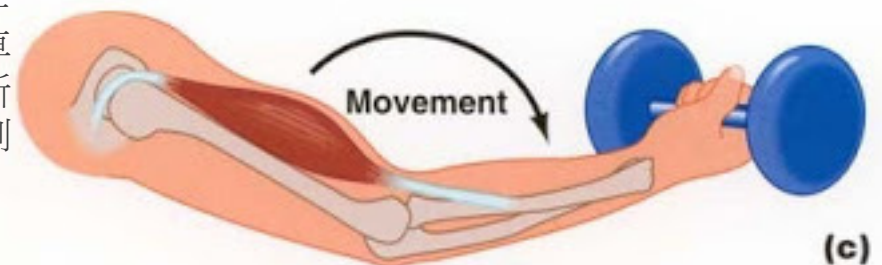
Concentric contraction

Movement

(b)

3. 離心收縮 (**Eccentric Muscle Action**)

離心收縮則與向心收縮相反，當肌肉的收縮力量小於負荷重量時，肌肉慢慢「被拉長」的過程；由於它的動作狀態是肌肉被慢慢拉長的狀態，所以筆者常常以「汽車避震器」去比喻離心收縮的功能，主要便是緩衝我們所受到的衝擊，譬如：我們從高台落地時，我們大腿前側的股四頭肌便會出力慢慢拉長而抵抗衝擊力。
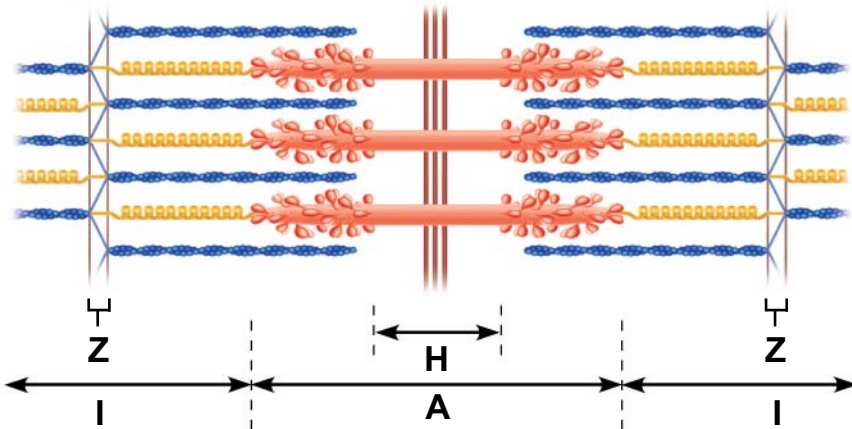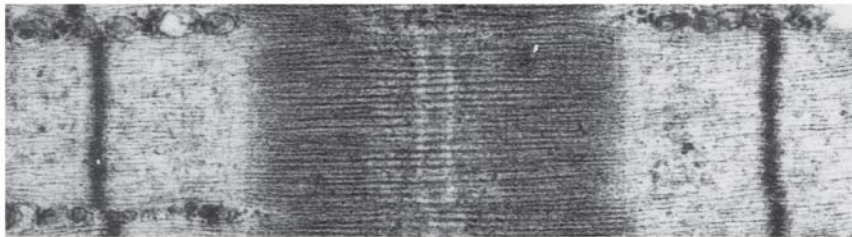
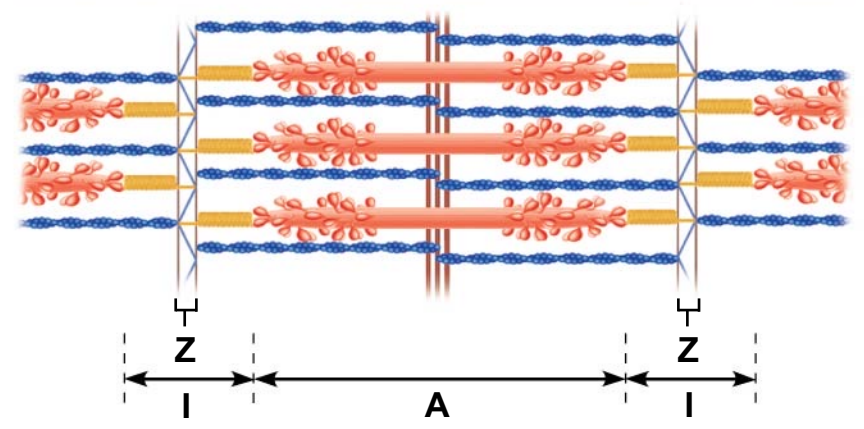**Eccentric contraction**

Movement

(c)

肌絲滑動機制

☐ 收縮改變橫紋的圖樣
- 完全放鬆—細肌絲與粗肌絲有部分重疊
- 收縮—Z盤彼此拉近
  - 肌節變短
  - I 帶變短；H區消失
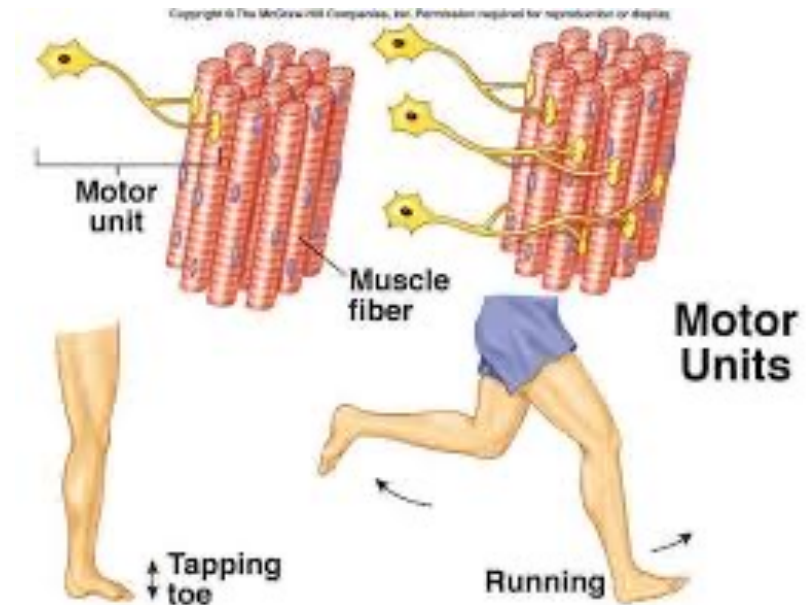 - A帶維持相同的長度

① 肌纖維完全放鬆的肌節

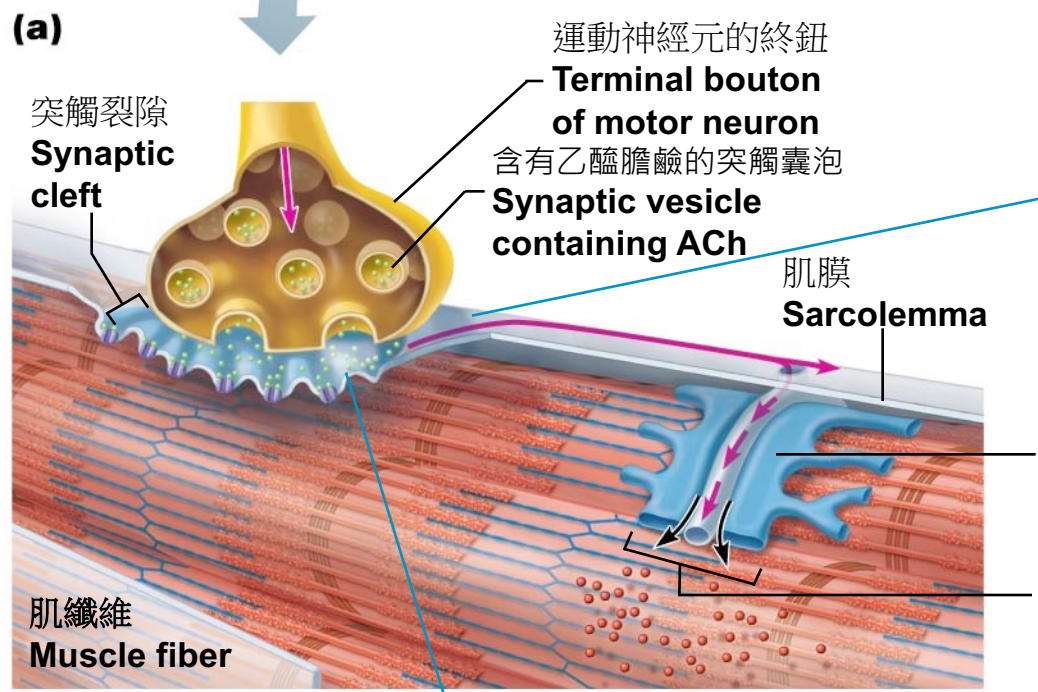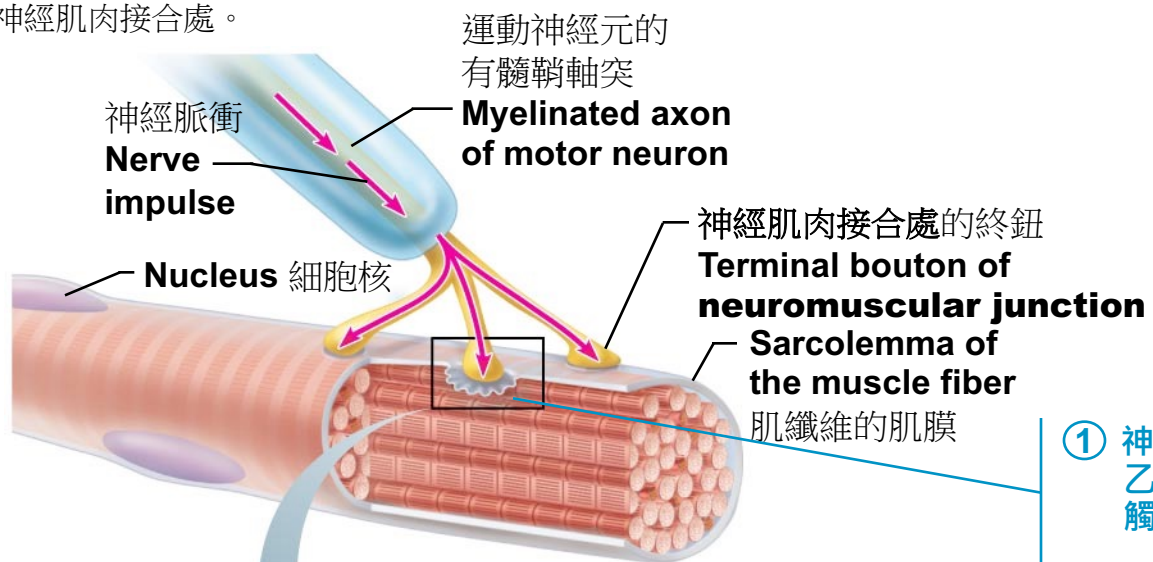② 肌纖維完全收縮的肌節

骨骼肌的神經支配

☐ 運動神經元支配骨骼肌組織
- **神經肌肉接合處 (Neuromuscular junction)** 是神經末梢與肌纖維交會的位點
- **終鈕** (軸突終末) [**Terminal boutons** (axon terminals)]
    - 位在軸突末端
    - 儲存神經傳遞物
- **突觸裂隙 (Synaptic cleft)**
    - 軸突終末與肌膜之間的空間

☐ 運動單元 (Motor unit):
- 一個運動神經元和其支配的所有肌肉纖維
- 一個運動神經元支配的肌肉纖維數量可以從最少4個到好幾百個
- 需要做愈精細動作的肌肉 (例如手指和眼睛的肌肉)，運動單元中的肌肉纖維就愈少

圖 10.8 神經肌肉接合處。

運動神經元的
有髓鞘軸突
**Myelinated axon
of motor neuron**

神經脈衝
**Nerve
impulse**

神經肌肉接合處的終鈕
**Terminal bouton of
neuromuscular junction**

Nucleus 細胞核

**Sarcolemma of
the muscle fiber**
肌纖維的肌膜

① 神經脈衝刺激神經傳遞物
乙醯膽鹼(Ach)釋放到突
觸裂隙。

(a)

運動神經元的終鈕
**Terminal bouton
of motor neuron**
含有乙醯膽鹼的突觸囊泡
**Synaptic vesicle
containing ACh**

突觸裂隙
**Synaptic
cleft**

肌膜
Sarcolemma

② 乙醯膽鹼(Ach)刺激使肌
纖維興奮的肌膜變化。這
個刺激會被往下傳,至而
引起纖維收縮。

肌質網的終池
**Terminal
cistern of SR**

肌纖維
Muscle fiber

Triad 三合體

(b)

Ca²⁺

③ 突觸裂隙內的酵素會分解乙醯
膽鹼(Ach),乙醯膽鹼的作用僅
限於單次肌肉抽動。

圖 10.9 運動單位。

脊髓
Spinal cord

運動
單位1
**Motor
unit 1**

運動
單位2
**Motor
unit 2**

神經肌肉接合處
的終鈕

到運動單位的
分岔軸突

Nerve
神經

**Motor neuron
cell body**
運動神經元
細胞本體

**Motor
neuron
axon**
運動神經元
軸突

肌肉
Muscle

**Muscle
fibers**
肌纖維

(b) 來自神經肌肉接合處的分支
終鈕，一條肌纖維配有一個
終鈕(光學顯微照片320x)。
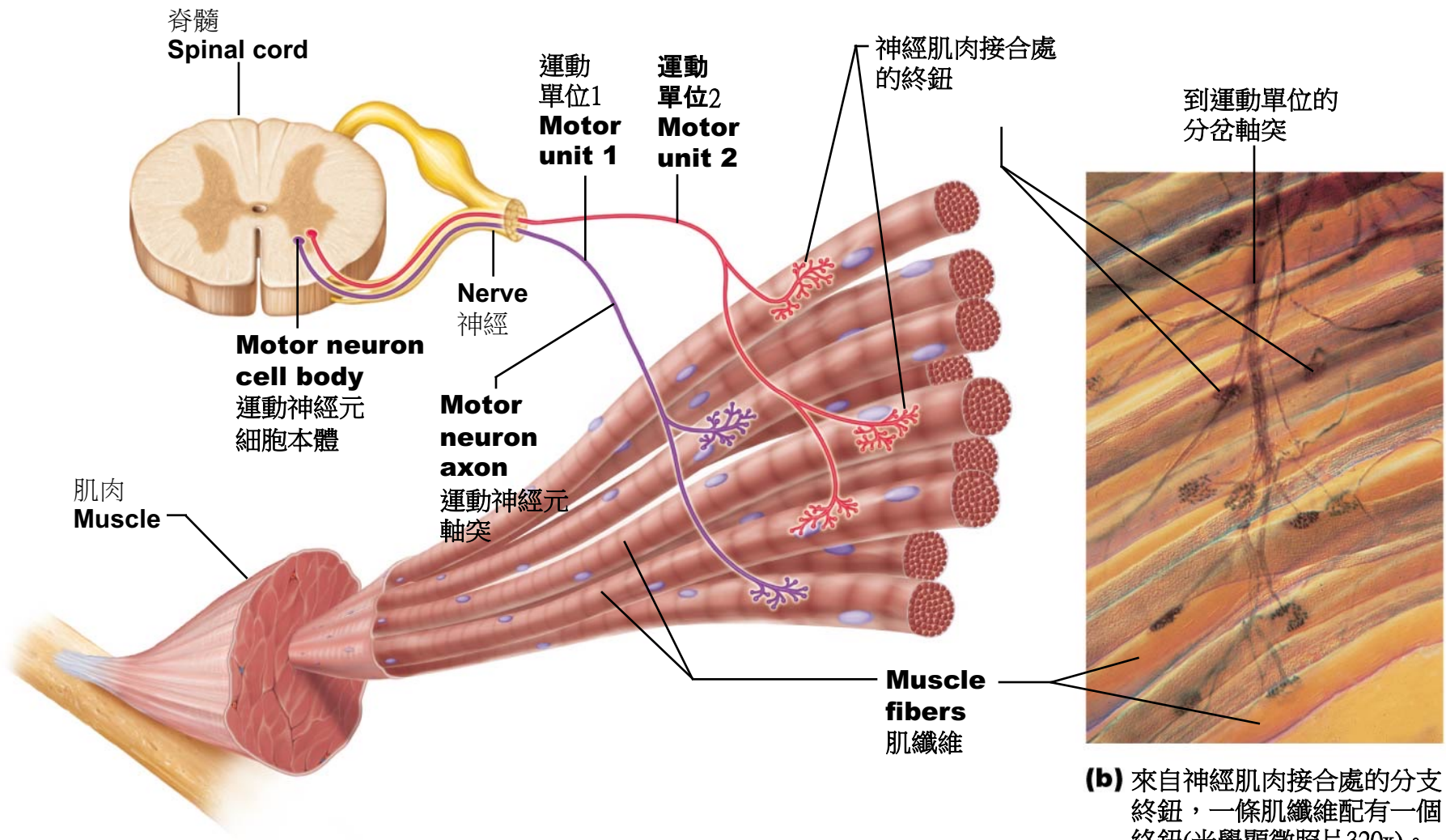
(a) 從脊髓延伸到肌肉的運動神經元軸突。每個軸突會分裂成很多個終鈕，遍佈在肌肉的終鈕
與肌纖維形成神經肌肉接合處。

骨骼肌纖維的類型

☐ 骨骼肌纖維依據兩種特徵加以分類
　　1. 它們如何製造能量 (ATP)
　　　　- 氧化型纖維 (Oxidative fibers)—以有氧方式製造ATP
　　　　- 糖解型纖維 (Glycolytic fibers)—經由糖解作用，以無氧方式製造ATP
　　2. 它們收縮的速度有多快

☐ 骨骼肌纖維
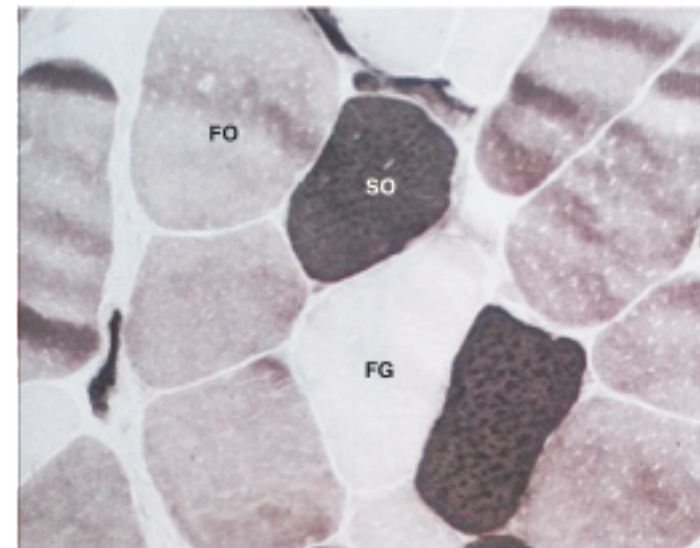　　• 分成三類
　　　　1. 慢速氧化型纖維 (Slow oxidative fibers)
　　　　　　- 紅色的慢速氧化型纖維
　　　　2. 快速糖解型纖維 (Fast glycolytic fibers)
　　　　　　- 白色的快速糖解型纖維
　　　　3. 快速氧化型纖維 (Fast oxidative fibers)
　　　　　　- 中間型纖維

骨骼肌纖維的類型

☐ **慢速氧化型纖維 (Slow oxidative fibers)**
- 因為豐富的肌紅素而呈現紅色
- 從有氧代謝反應獲得能量
- 含有大量粒線體
- 有豐富的微血管
- 收縮慢且抗疲勞
- 纖維直徑小

☐ **快速氧化型纖維**
- 直徑介於另兩種纖維之間
- 和快速糖解型纖維一樣收縮速度快
- 需要氧氣
- 肌紅素含量高，且有豐富的微血管
- 稍微抗疲勞
- 比慢速氧化型纖維有力

Types Of Muscle Fibres

Type 1	Type 2A	Type 2B
Slow twitch	Fast oxidative	Fast glycolytic

☐ **快速糖解型纖維**
- *幾乎不含肌紅素和粒線體*
- 直徑為慢速氧化型纖維的兩倍
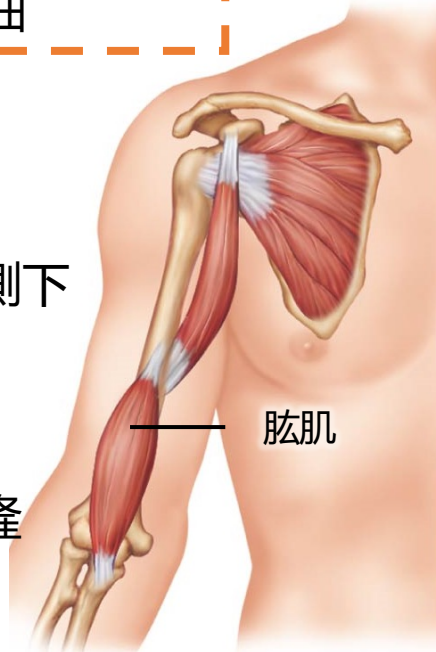- 含有較多的肌絲並產生較大的力量
- 仰賴無氧路徑
- 收縮快速也疲勞得快
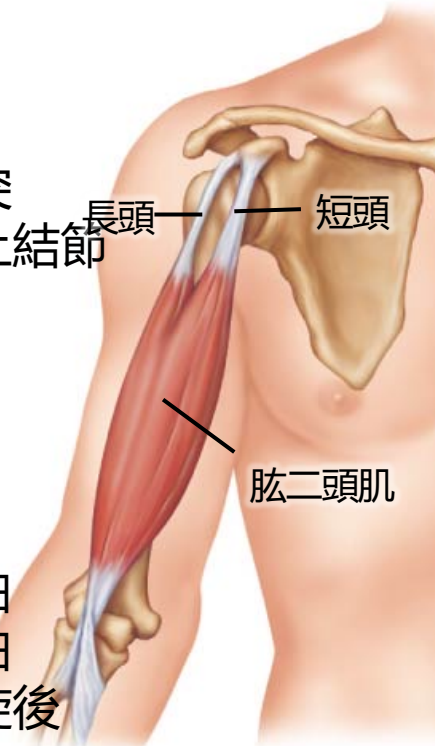
上臂前側

- 肱肌

  - 近端接點：
    - 肱骨前側下 1/3

  - 遠端接點：
    - 尺骨粗隆

  - 動作：
    - 肘關節屈曲

肱肌

- 肱二頭肌

  - 近端接點：
    - 短頭：喙突
    - 長頭：盂上結節

  - 遠端接點：
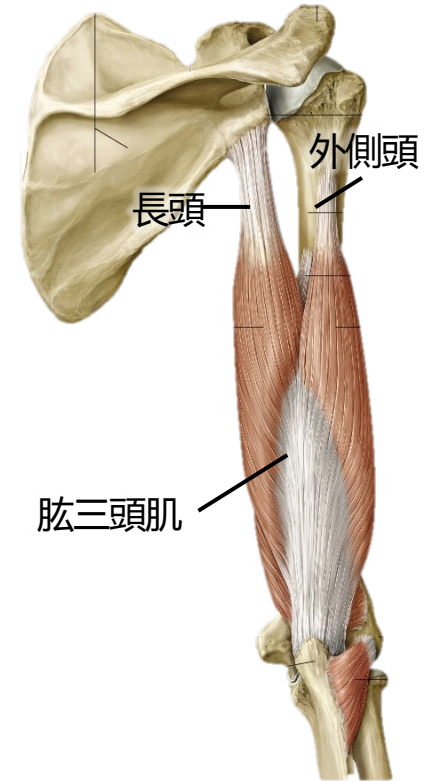   - 橈骨粗隆

  - 動作：
    - 肩關節屈曲
    - 肘關節屈曲
    - 橈尺關節旋後

長頭 —— —— 短頭

肱二頭肌

上臂後側

上臂後側

- 神經
  - 橈神經

- 動作：
  - 手肘伸直

肱三頭肌

- 近端接點：
  - 外、內側頭：肱骨
  - 長頭：肩胛骨的盂下結節

- 遠端接點：
  - 尺骨的鷹嘴突

- 動作：
  - 肩關節伸直
  - 肘關節伸直

外側頭

長頭

肱三頭肌

Synovial joint (滑液關節)

(a) Plane joint　　平面關節　　Nonaxial movement

Metacarpals

Carpals

Flat articular surfaces

Gliding

Examples: Intercarpal joints, intertarsal joints, joints between vertebral articular surfaces

(b) Hinge joint　　屈戌關節/樞紐關節　　Uniaxial movement

Humerus

Ulna

Cylinder

Trough

Medial/lateral axis

Flexion and extension

Examples: Elbow joints, interphalangeal joints

(c) Pivot joint　　車軸關節　　Uniaxial movement

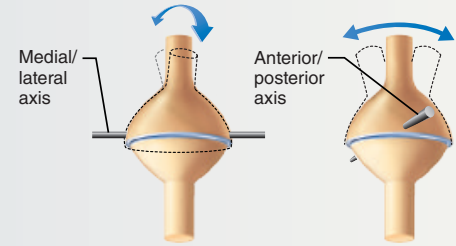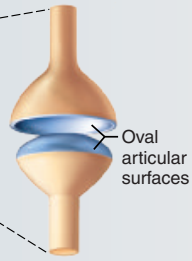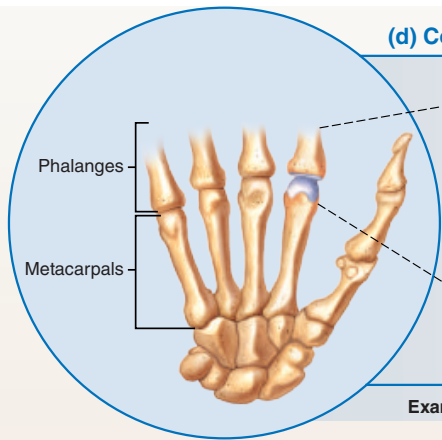Ulna

Radius

Sleeve (bone and ligament)

Axle (rounded bone)

Vertical axis

Rotation

Examples: Proximal radioulnar joints, atlantoaxial joint

(d) Condylar joint 髁狀關節 — **Biaxial movement**

Phalanges

Metacarpals

Oval articular surfaces

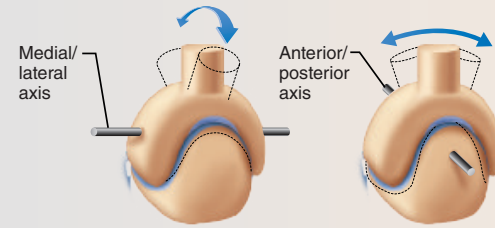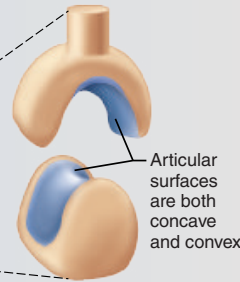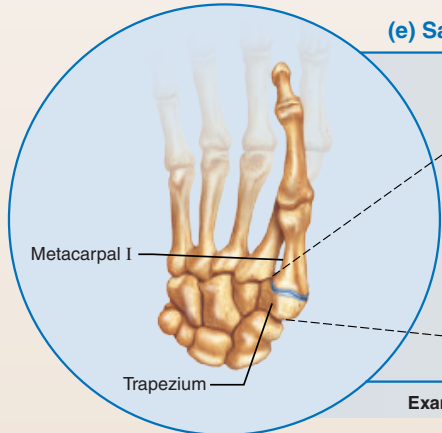Medial/lateral axis — Anterior/posterior axis

Flexion and extension   **Adduction and abduction**

Examples: Metacarpophalangeal (knuckle) joints, wrist joints　掌指關節，腕關節

(e) Saddle joint 鞍狀關節 — **Biaxial movement**

Metacarpal I

Trapezium

Articular surfaces are both concave and convex

Medial/lateral axis — Anterior/posterior axis

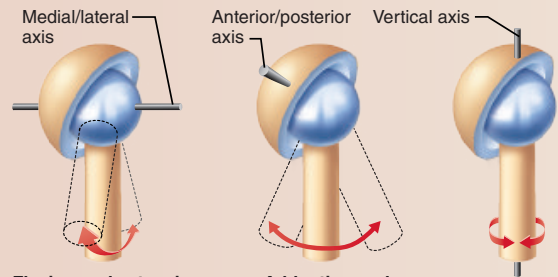**Adduction and abduction**   **Flexion and extension**

Example: Carpometacarpal joints of the thumbs

(f) Ball-and-socket joint 球窩關節 — **Multiaxial movement**

Cup (socket)

Scapula

Spherical head (ball)

Humerus

Medial/lateral axis — Anterior/posterior axis — Vertical axis
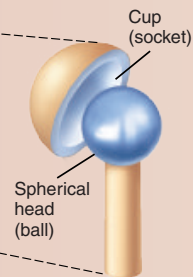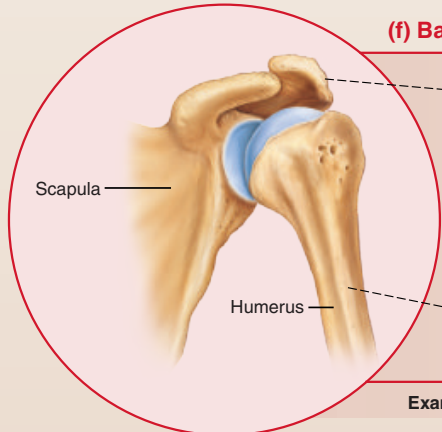
Flexion and extension   **Adduction and abduction**   **Rotation**

Examples: Shoulder joints and hip joints

Humerus   Carpals
Radius   Metacarpals
Ulna   Phalanges

Ask A Biologist coloring page

Web address: askabiologist.asu.edu/activities/coloring
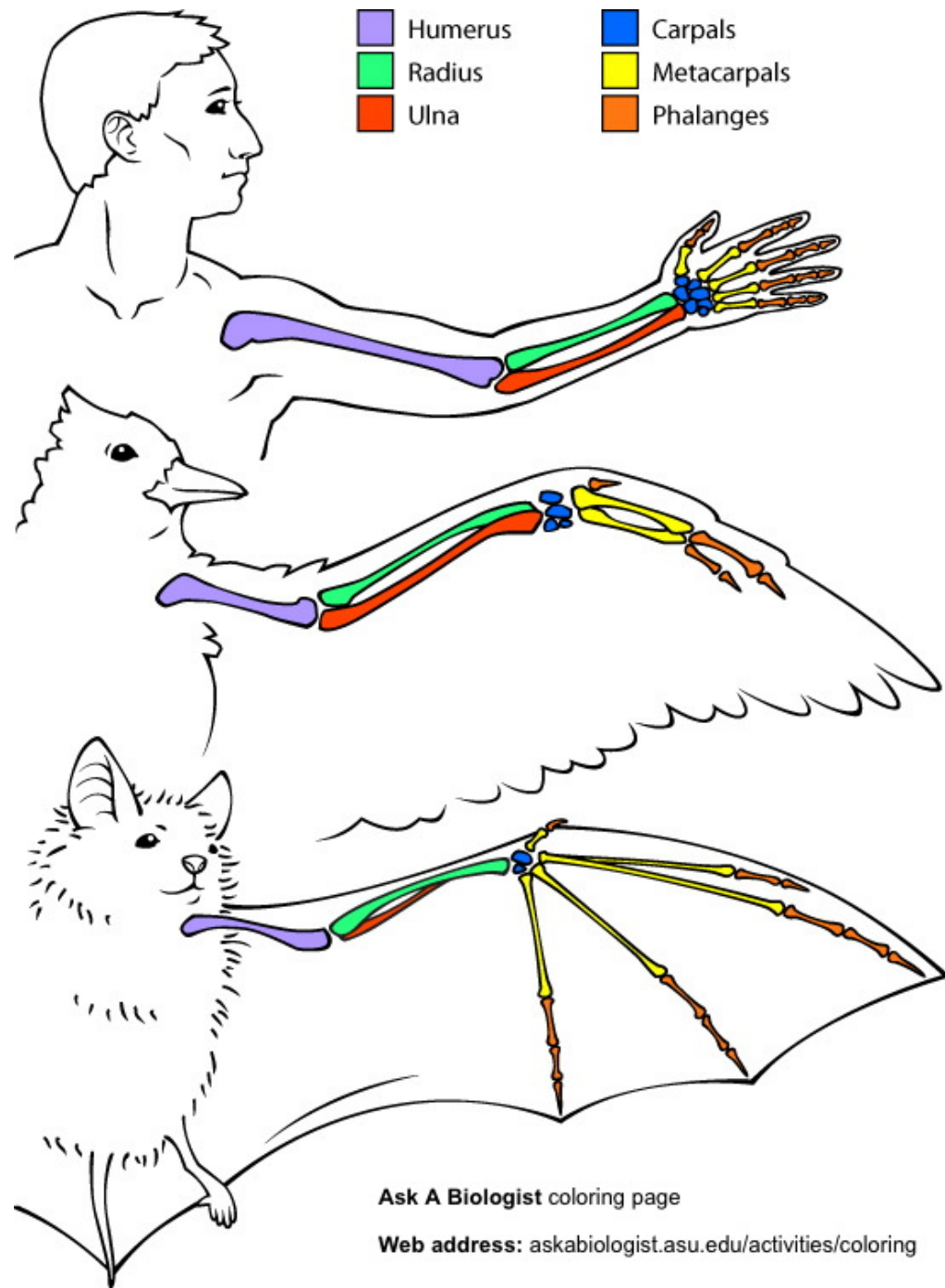
解剖雞翅要觀察及學習的構造

- Bones
    - [Humerus](#)
    - [Radius](#)
    - [Ulna](#)
    - [Carpal](#)
    - [Metacarpal](#)
    - [Phalanges](#)
- Soft Tissues
    - [Flexion and Extension](#)
    - [Adduction and Abduction](#)
    - [Cartilage](#)
    - [Ligament](#)
    - [Tendon](#)

在開始解剖雞翅之前…

☐ 觀察雞皮上的疙瘩 (bumps)，這些疙瘩是羽毛長出來的地方
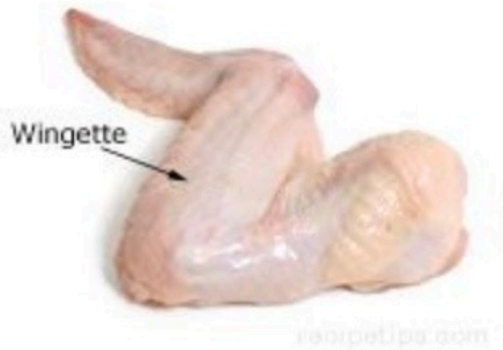☐ 想像雞翅原本連接在雞胸上是長怎麼樣
☐ 用手觸摸在雞皮底下的肌肉和骨頭
☐ 觀察關節的位置

BREAST

DRUMMETTE
小雞腿；棒棒腿

WING TIP 翅尖

WING FLAT
小雞翅 (wingette)

THIGH

TAIL

WHOLE LEG
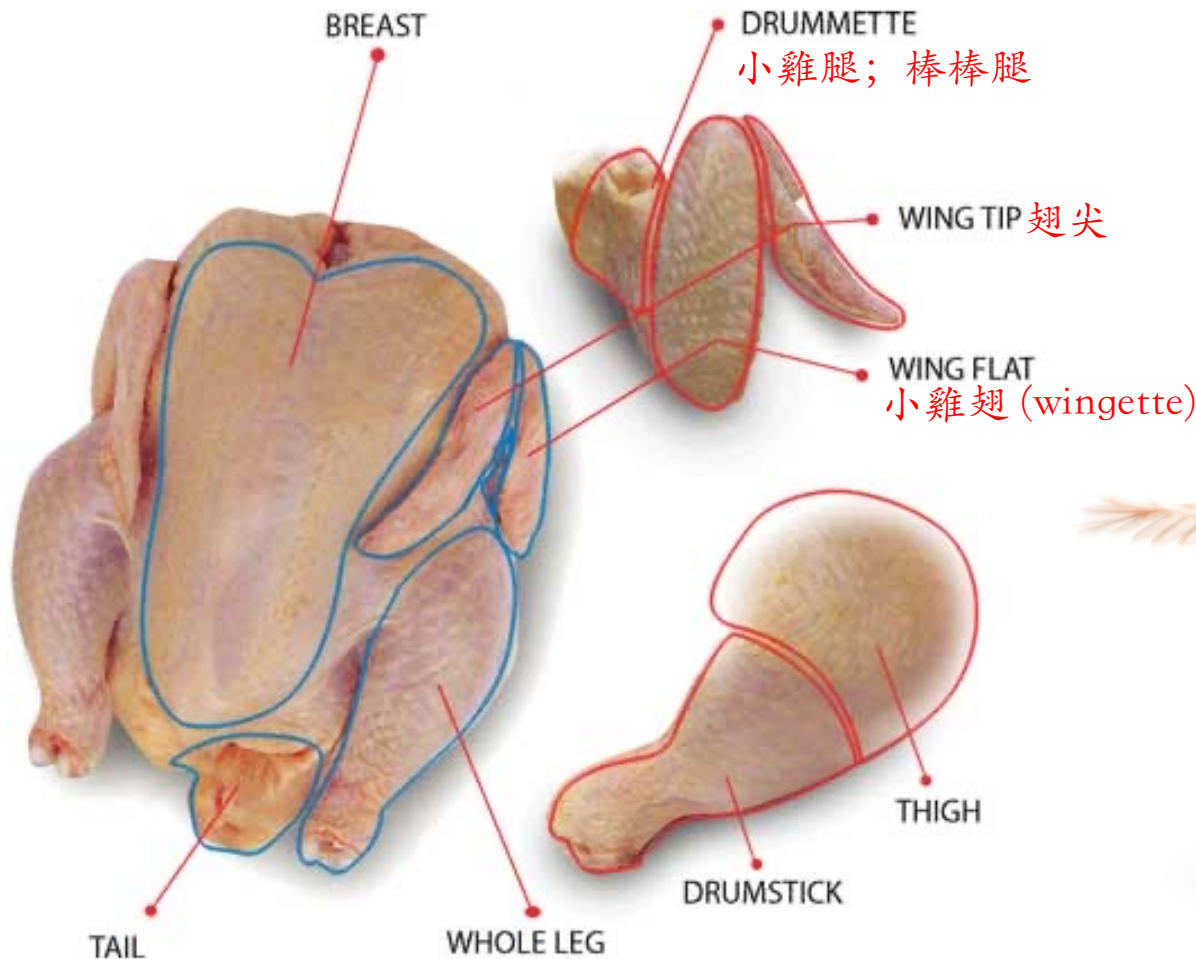
DRUMSTICK

Drummette:

The section of the wing that is connected to the body of the bird and contains most of the wings meat. It resembles a very small drumstick.

Drummette

Wingette:

Also referred to as the flat wing tip. The middle section of the wing, which does not contain much meat, but is generally moister than the drummette.

Wingette
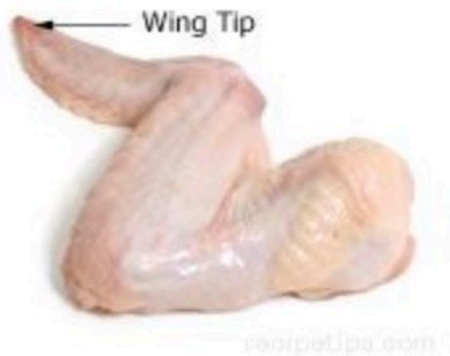
Wing Tip:

The third and outer most section of the wing Does not contain much meat and is many times discarded. It can be used when making stock to help add flavor to the broth.

Wing Tip
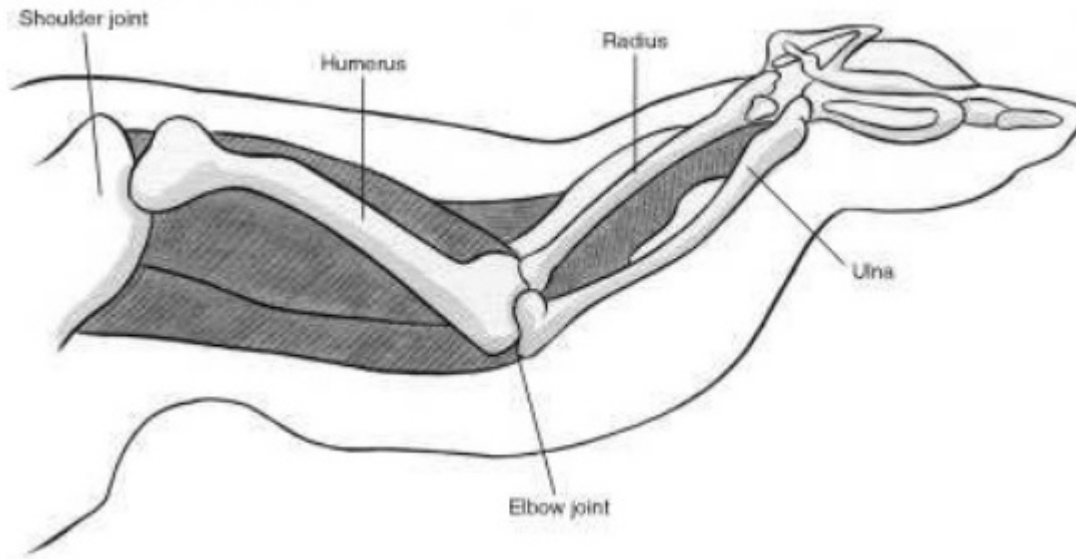
Chicken wing with skin and muscle attached
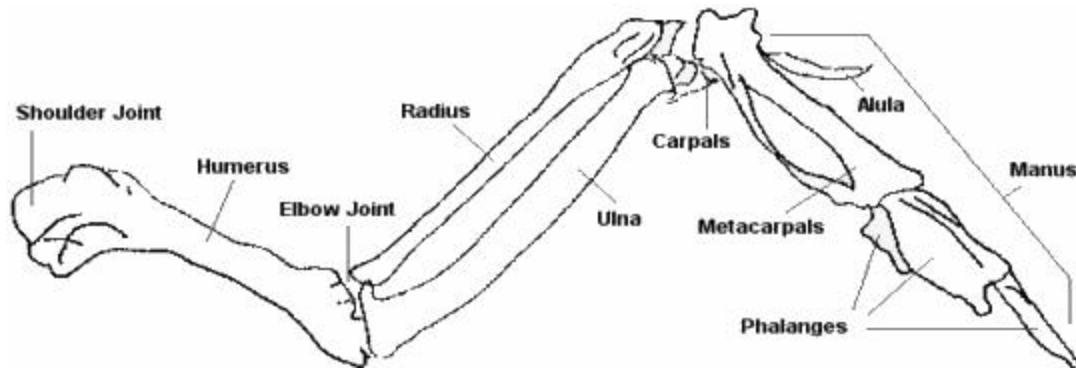
Bones of the chicken wing

VENTRAL VIEW OF RIGHT WING

Deep radial a.

Extensor digitorum longus

Extensor metacarpi radialis

Pronator profundus

Flexor digitorum profundus

Superficial ulnar a.

Pronator superficialis
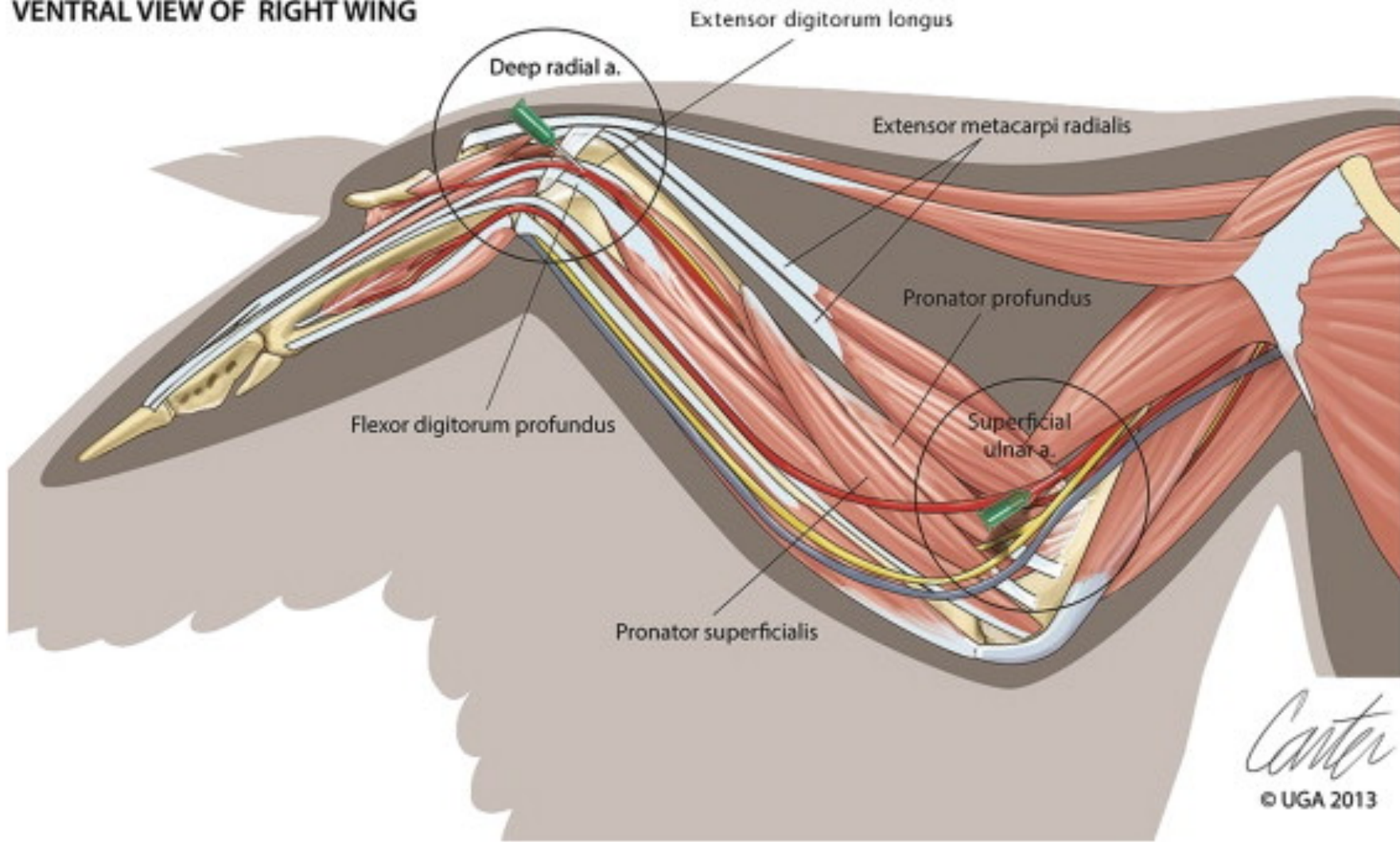
© UGA 2013
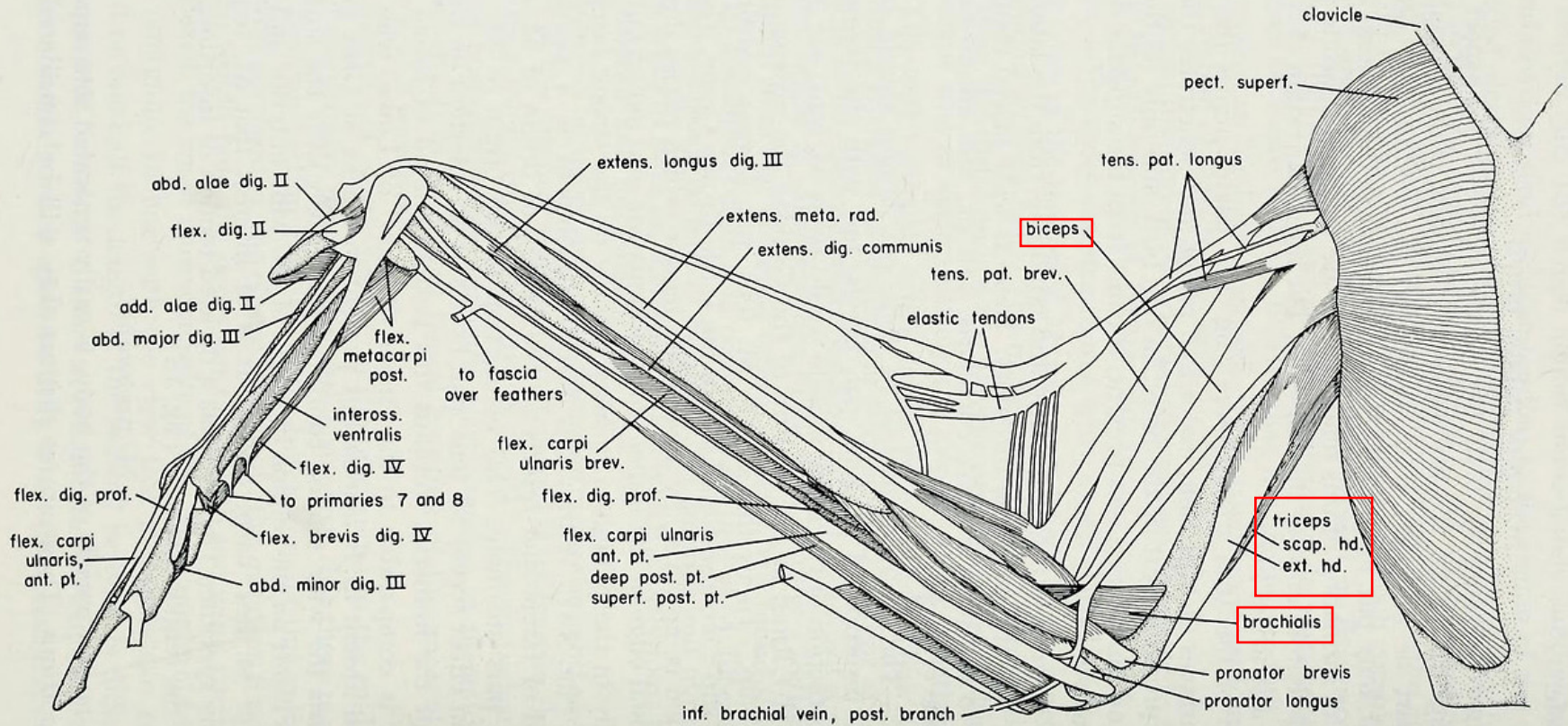
Fig. 16. Ventral view of the superficial muscles of the breast and wing of the right side.
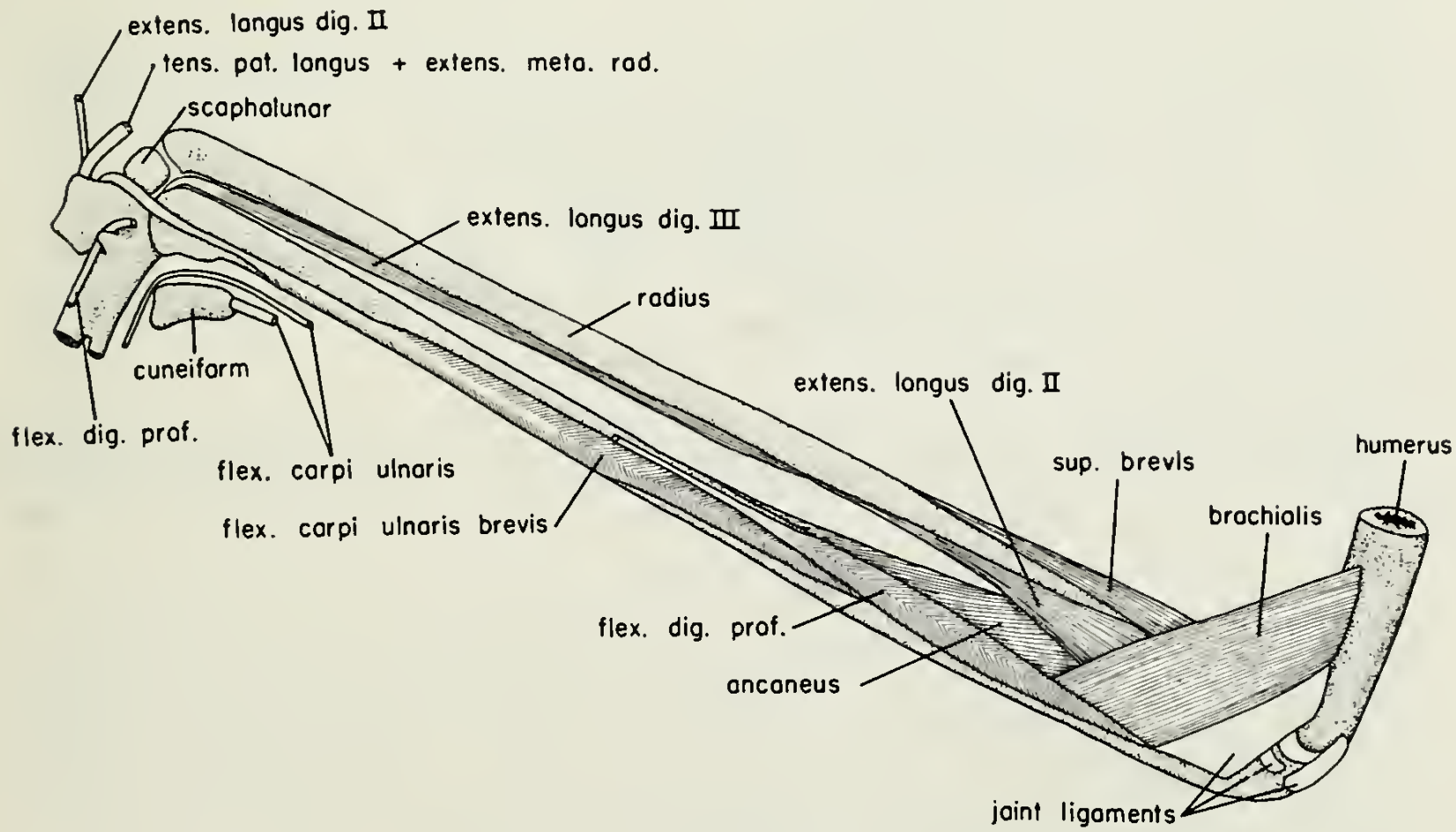
FIG. 21. The deep musculature of the right forewing as seen in ventral view.

開剖！！！

Manus

Wing tip

Upper wing

Anula

Lower wing
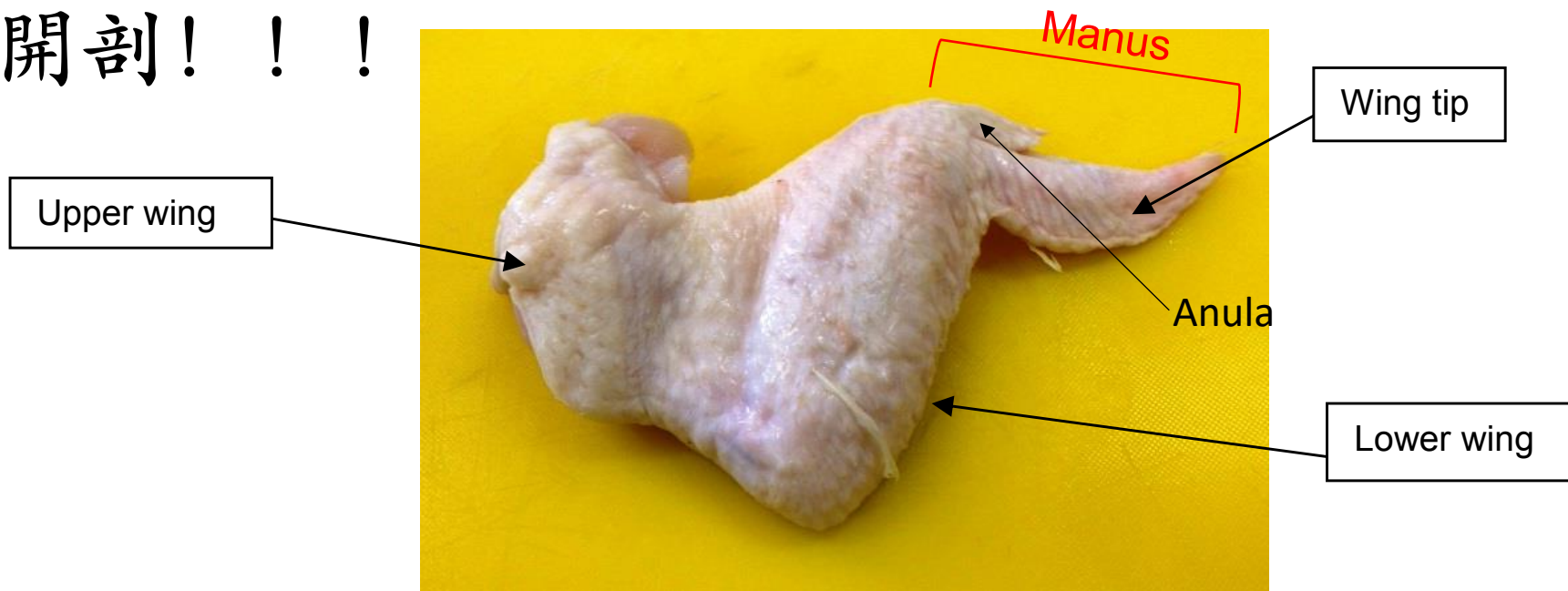
Figure 1: The external structures visible of the chicken wing. (Image by K. Szalai, 2017)

1. 使用剪刀移除皮膚
   注意不要切到肌肉、韌帶和肌腱
   Tips: 可先用鑷子夾起皮膚，在用剪刀戳進去剪
2. Manus相當於人體的哪個地方?
3. Wrist joint (腕關節)在哪裡?
4. Anula 相當於手的哪個部分?

Figure 2: Shows the skin being carefully cut and peeled back from the wing to expose the muscles and underlying tissues. (Image by K. Szalai, 2017)

1. 觀察肌肉及其附著的地方
2. 觀察不同方向的肌肉，是否一塊肌肉收縮，另一塊相對方向的肌肉會拉長
3. 觀察位於關節間的軟骨
4. 移動下部雞翅的肌肉位於上部雞翅，那移動上部雞翅的肌肉位於?
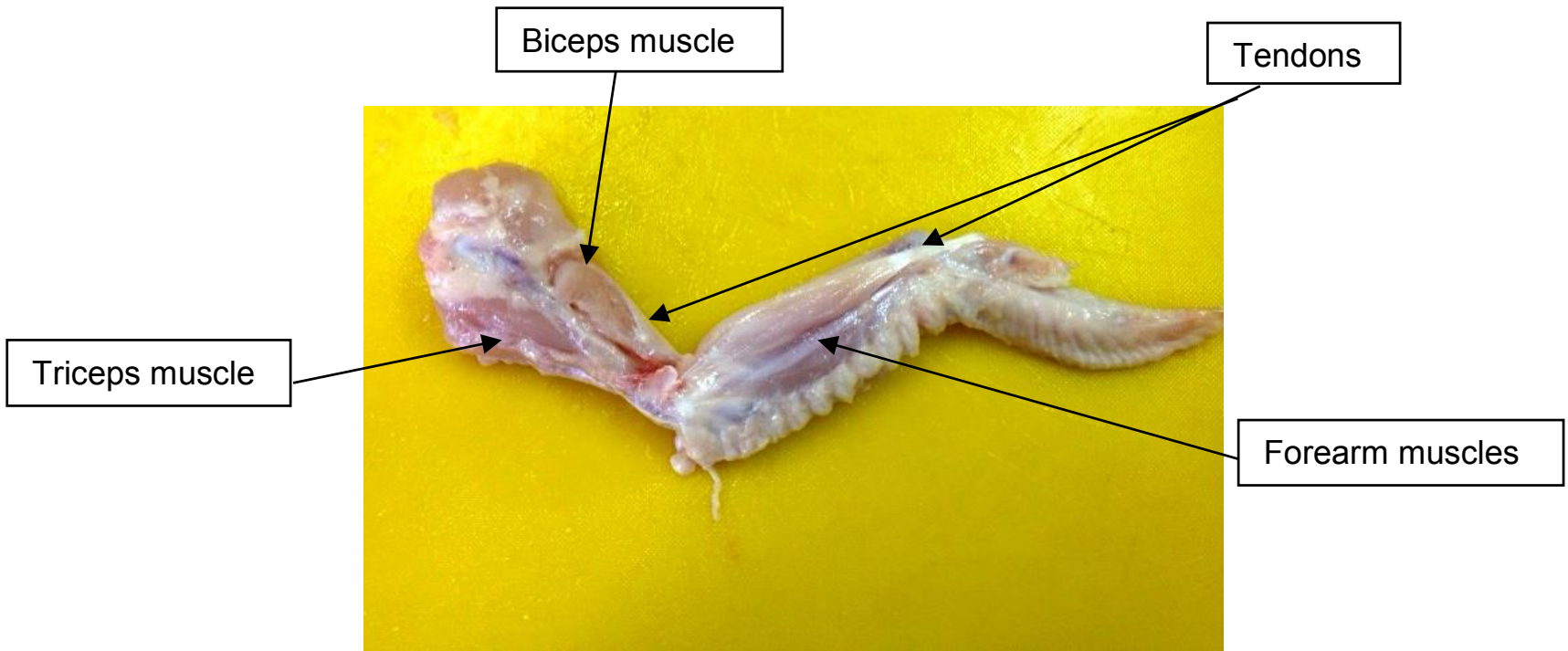
Figure 3a: Shows the muscle groups of the chicken wing.
(Image by K. Szalai, 2017)

1. 找出骨頭之間的韌帶
2. 移動指頭的肌肉位於何處?
3. 大拇指對於抓取物品的重要性。試試看不用大拇指拿起東西
4. 彎曲手臂舉起重物，感受肌肉的變化

Blood vessels

Alula (thumb)

Phalanges

Blood vessels

Alula (thumb)

Phalanges

Triceps and biceps tendons

Metacarpals
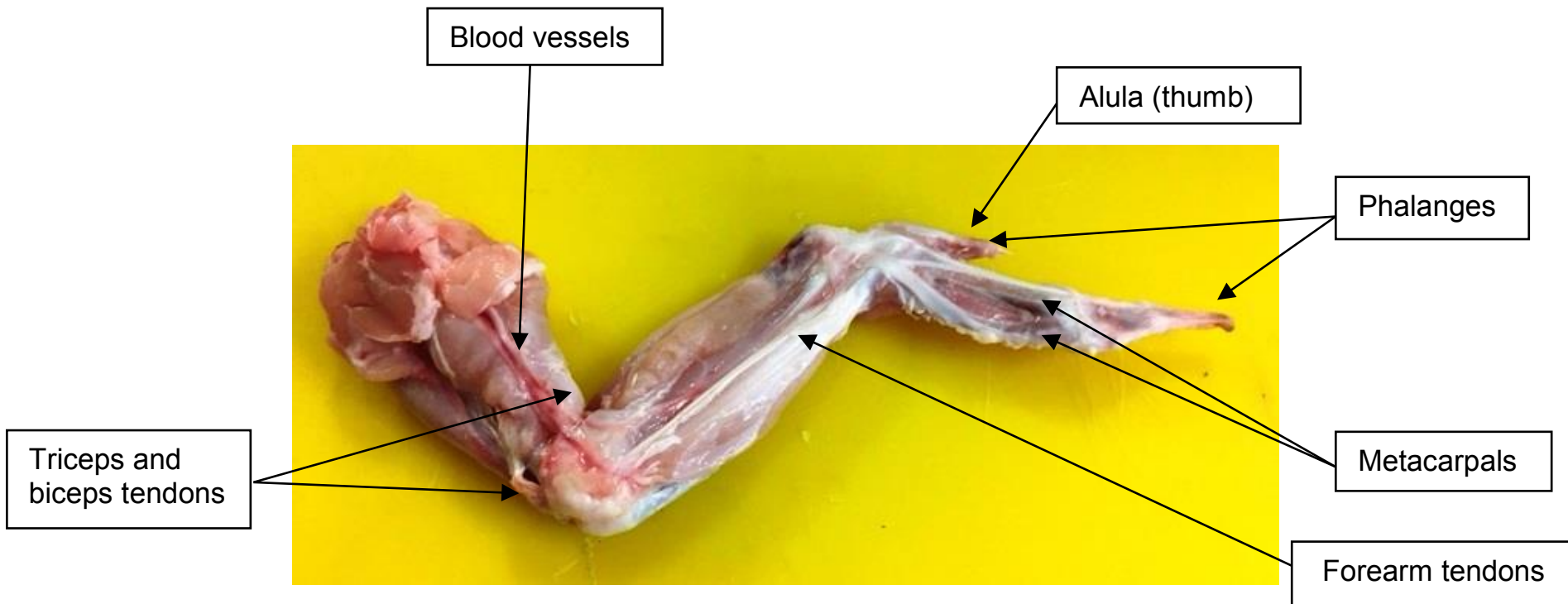
Forearm tendons

Figure 3b: Shows the tendons connecting the muscle to the bone in several muscle groups, and the rest of the wing tip which composed of modified hand bones. (Image by K. Szalai, 2017)

Forearm tendons

Triceps tendon

Figure 4a: The muscles dissected away from the bones showing tendons attached (Image by K. Szalai, 2017)

☐ 了解韌帶 (ligament)和肌腱 (tendon)的差別

Radius

Tendon
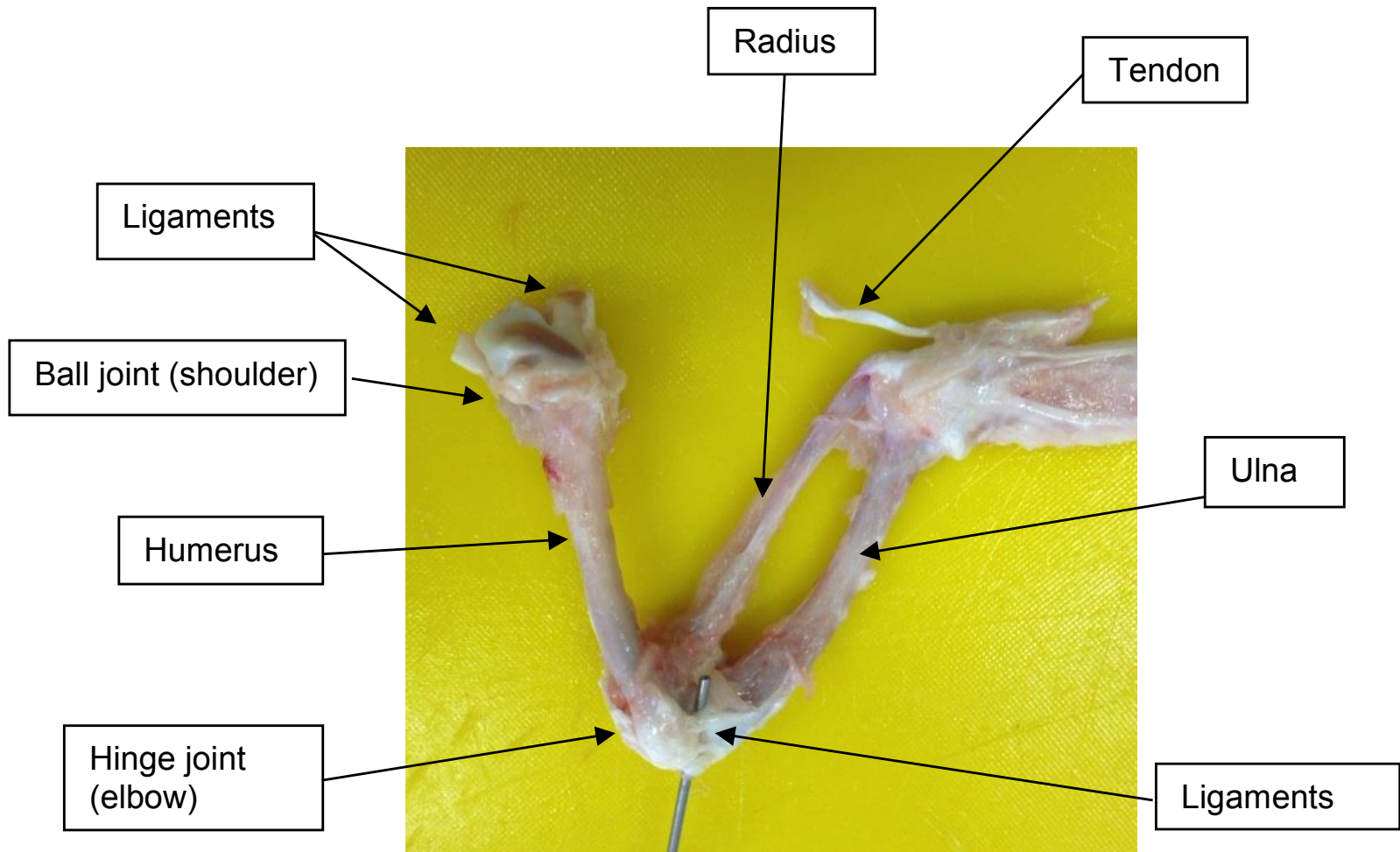
Ligaments

Figure 4b: The muscles removed to expose the bones, joints and ligaments of the wing. (Image by K. Szalai, 2017)

Figure 5: Shows protective cartilage at the surface of the bones forming the elbow joint. (Image by K. Szalai, 2017)

Ligaments

Articular cartilage

Figure 5: Shows protective cartilage at the surface of the bones forming the elbow joint. (Image by K. Szalai, 2017)

Bone marrow

Figure 6: Cartilage removed from the surface of the bone showing pink bone marrow. (Image by K. Szalai, 2017)

Bone marrow

Gastrointestinal Tract (胃腸道)

Pharynx

esophagus

Liver
Stomach
Duodenum
Transverse colon
Ascending colon
Descending colon
Small intestine
Caecum
Appendix
Sigmoid colon
Rectum
Anus
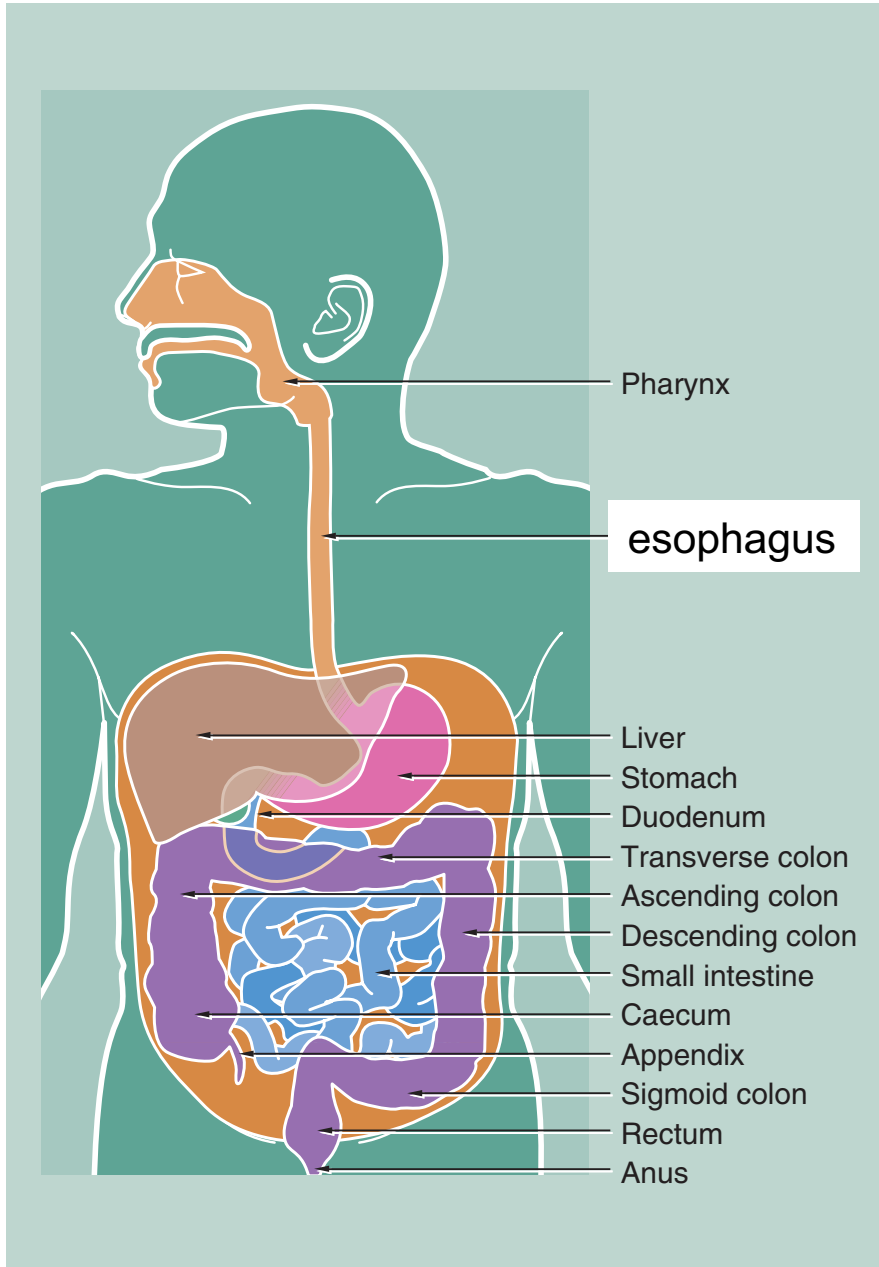
- ☐ Ingestion, fragmentation, digestion, absorption, elimination
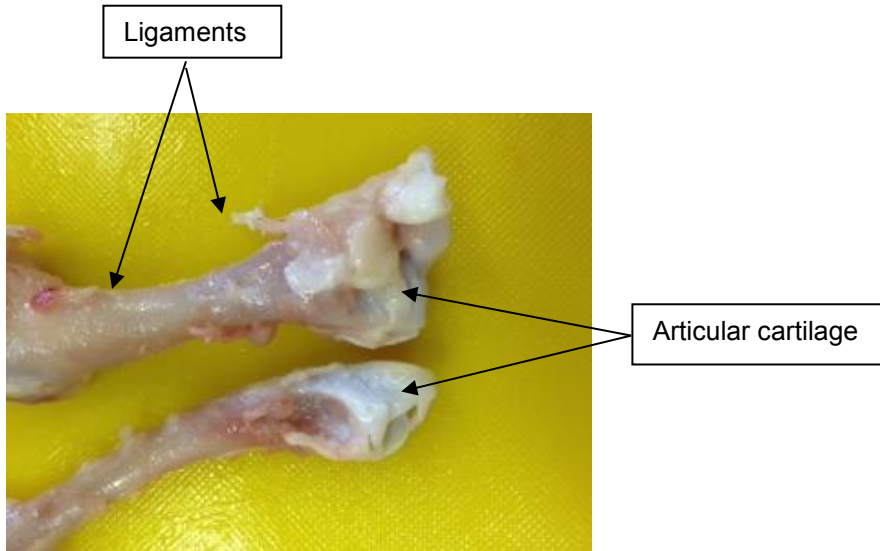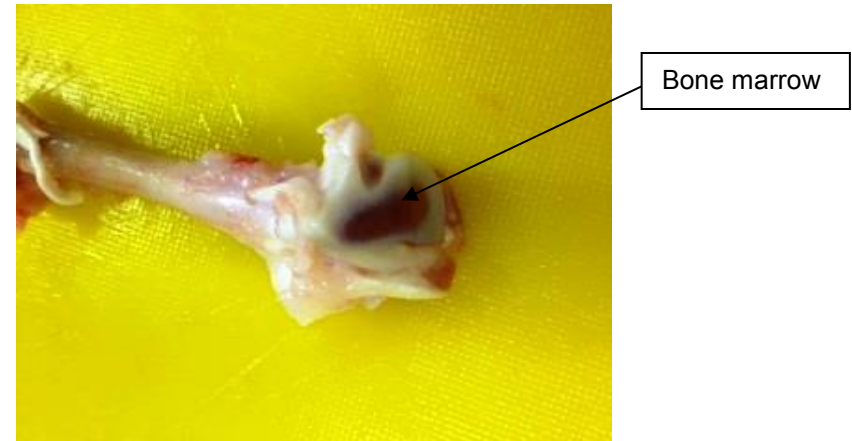- ☐ **Muscular tube** lined by a <u>mucous membrane</u> that exhibits regional variations, reflecting the changing functions of the system from mouth to anus
- ☐ <u>Oral cavity</u>: ingestion and fragmentation by saliva
- ☐ <u>Esophagus</u>: conduct food
- ☐ <u>Stomach</u>: semi-digested liquid called *chyme*
- ☐ <u>Small intestine</u>: absorption phase
- ☐ <u>Large intestine</u>: water is absorbed from the liquid residue,
- ☐ <u>Anal canal</u>: elimination

Tongue

☐ **Sulcus terminalis (界溝)**
☐ **Foramen cecum (舌盲孔)**
☐ **Lingual papillae**
  1. **Filiform papillae (絲狀乳頭)**
     - smallest and most numerous
     - covered with highly keratinized stratified squamous epithelium
     - no taste buds (味蕾)
     - are distributed over the entire anterior dorsal surface of the tongue

1/3

2/3

palatine tonsil
epiglottis
lingual tonsil
foramen cecum
circumvallate papillae
foliate papillae
fungiform

filiform papillae

a

舌頭肌肉束的
走向互相垂直

Tongue

taste buds

circumvallate
papilla

serous
glands

d
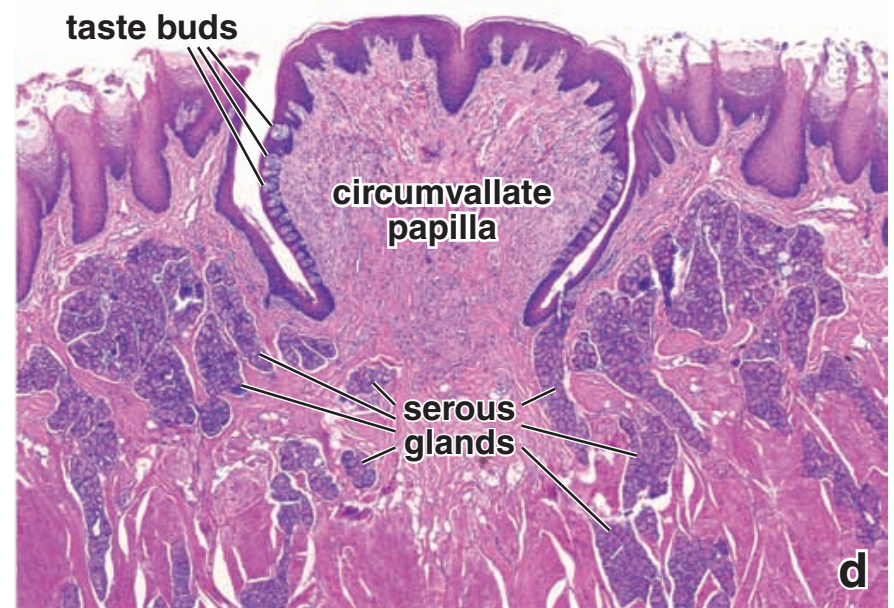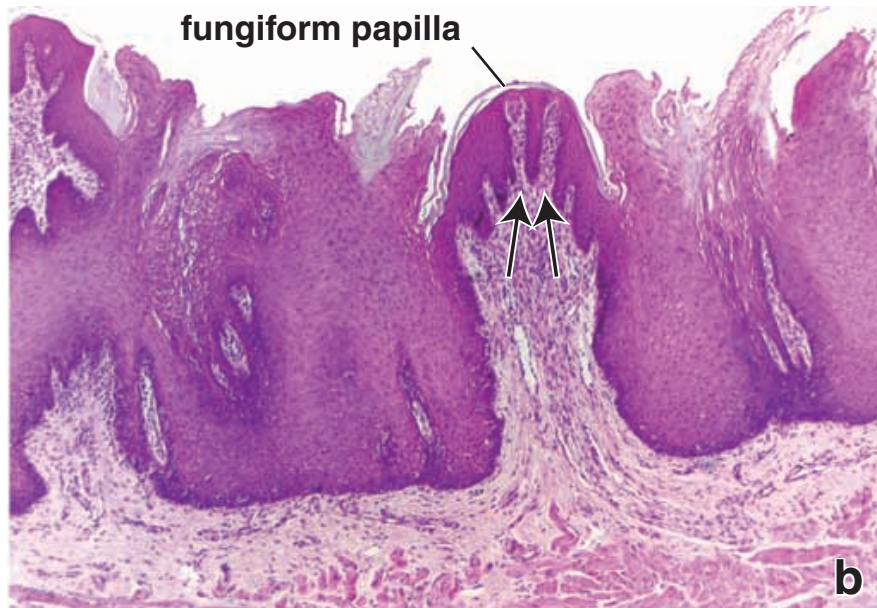
Tongue

4. **Foliate papillae (**葉狀乳頭**)**
- on the lateral edge of the tongue
- in younger individuals, they are easily found on the posterior lateral surface of the tongue and contain many taste buds
- serous glands (von Ebner's glands)

foliate papilla
taste buds
ducts
serous glands
striated muscle
C

CTP
SE
LCT
C
Ep
C
D
D
LSG
LSG
SE
CTP
LCT
Ep
D

Bundle of muscle fibers
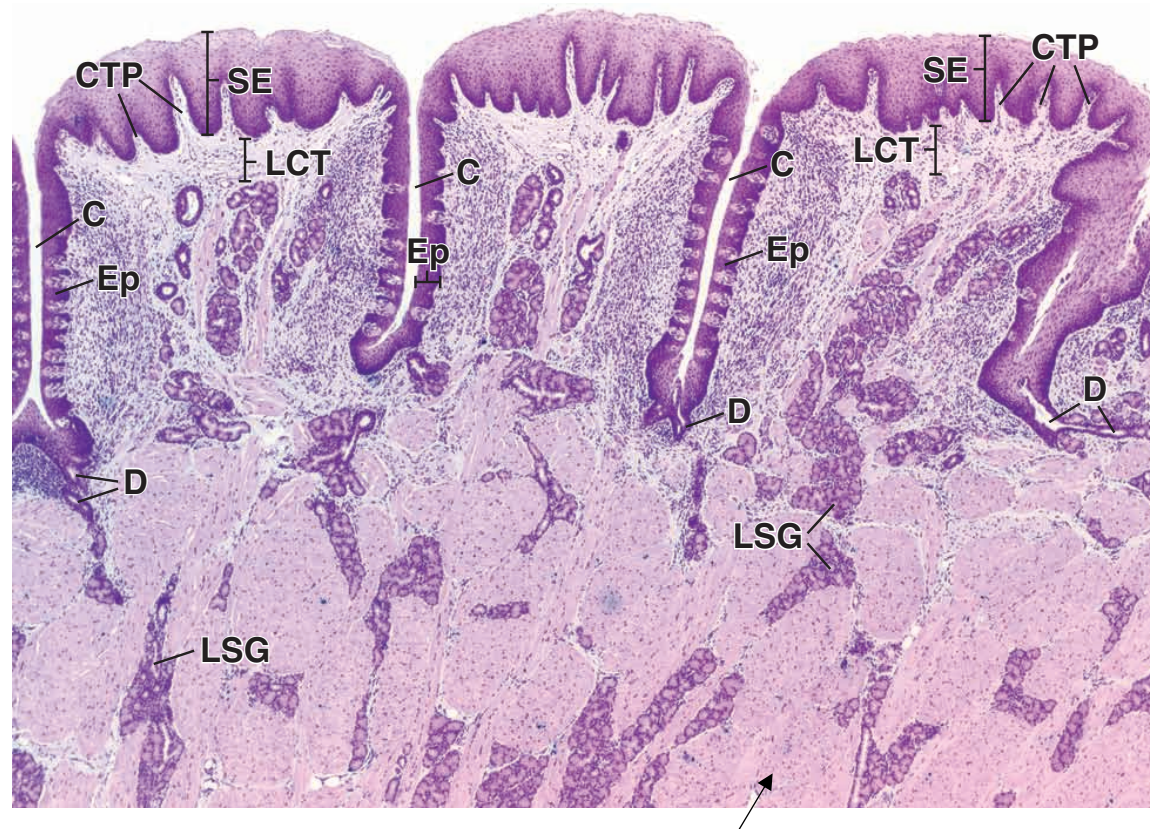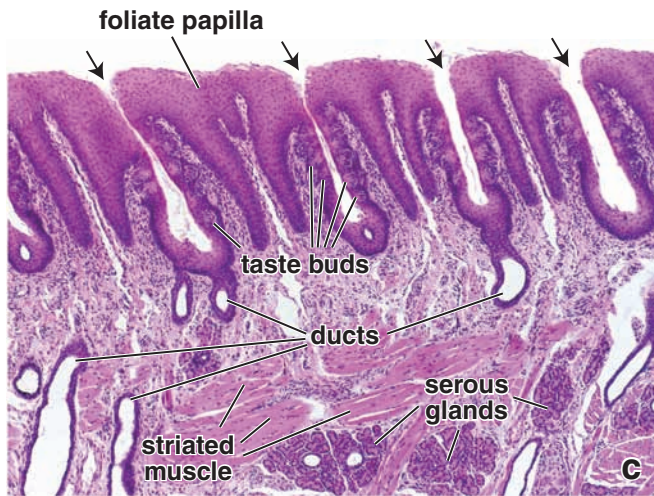
SE: stratified nonkeratinized epithelium
CTP: connective tissue papillae
C: cleft
LCT: loose connective tissue
D: ducts
LSG: lingual serous glands

Taste buds

- **Taste pore**: a small opening onto the epithelial surface at the apex of the taste bud
- Cells of taste buds:
  1. Neuroepithelial (sensory) cells)
     - most numerous cells in the taste buds
     - microvilli
     - large, round nuclei
     - are connected to neighboring neuroepithelial or supporting cells by tight junctions
     - form a synapse with the processes of afferent sensory neurons of the **facial** (cranial nerve VII), **glossopharyngeal** (cranial nerve IX), or **vagus** (cranial nerve X) nerves
     - turnover time: 10 days
  2. Supporting cells
     - less numerous
     - microvilli
     - turnover time: 10 days
  3. Basal cells
     - stem cells for other cell types
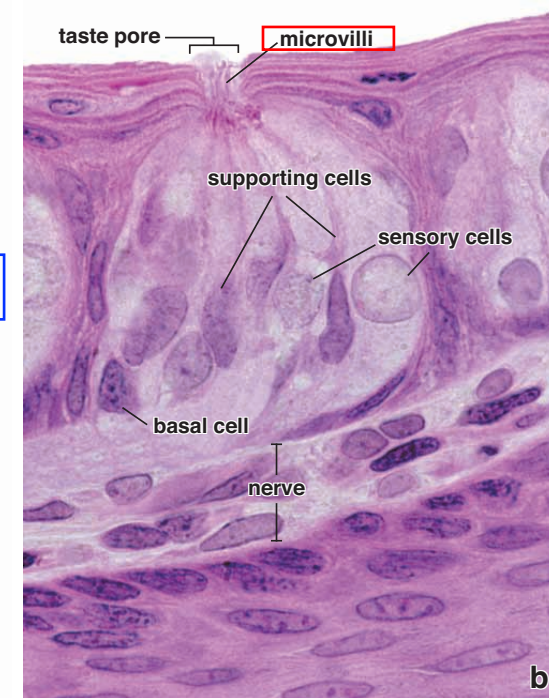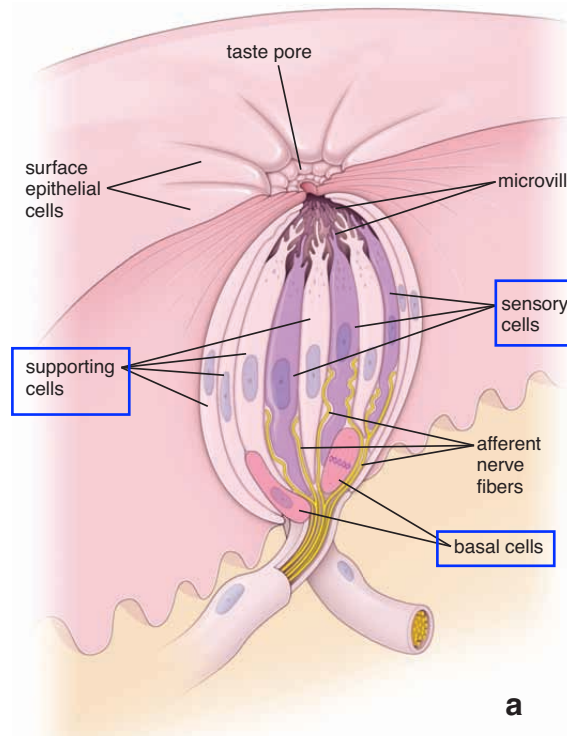
Taste buds
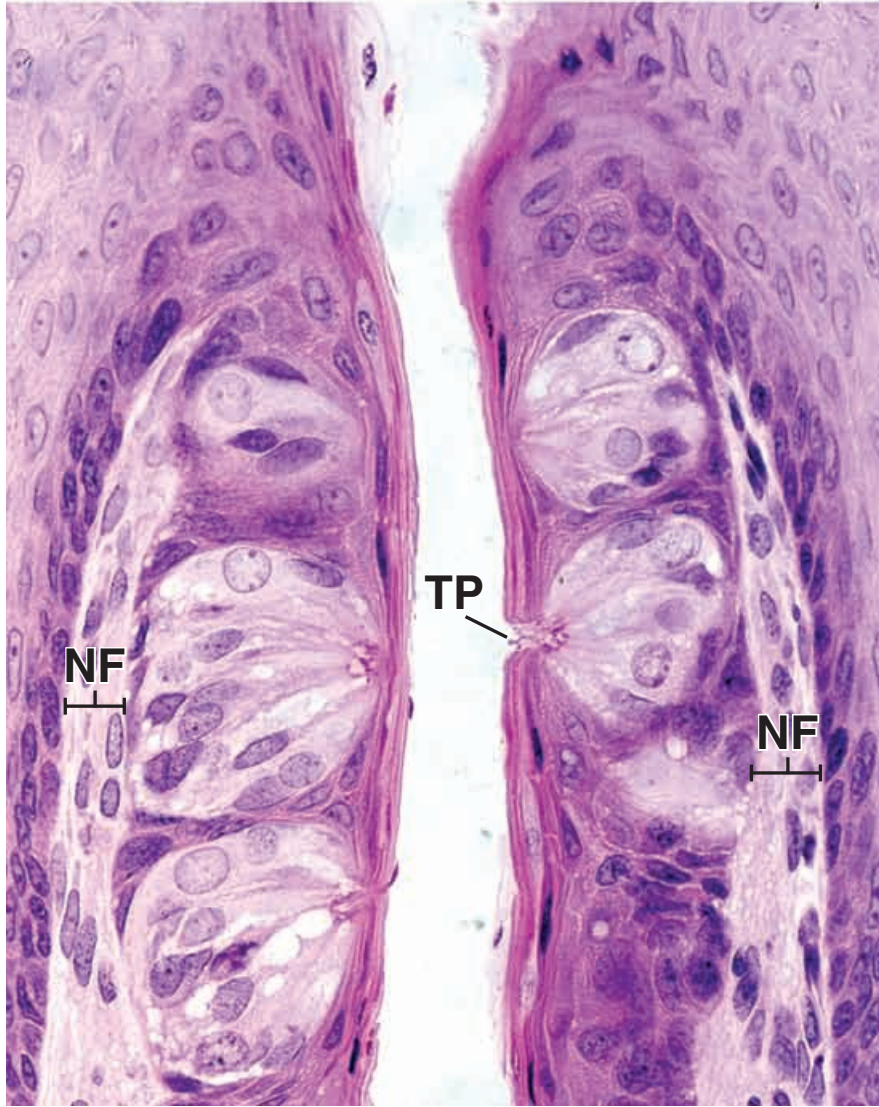
NF: nerve fibers   **TP**: taste pore
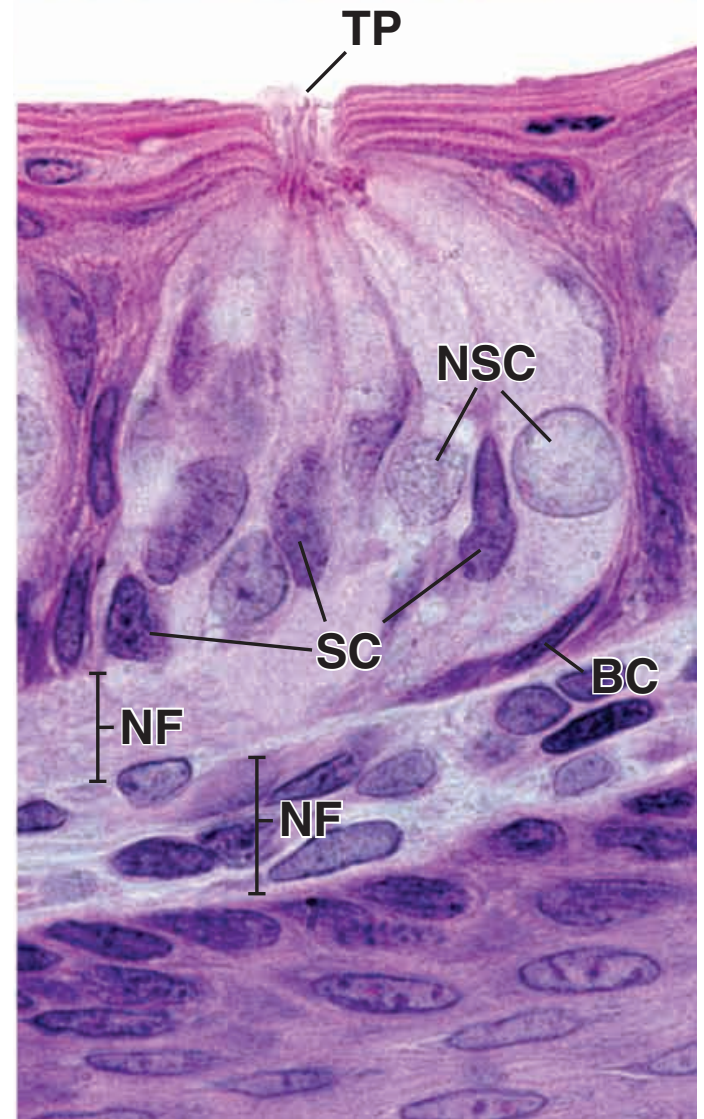
NSC: neuroepithelial sensory cells
SC: supporting cells
BC: basal cells

37 下列那一種舌乳突（lingual papillae）不含味蕾？ (103-1)
⒜輪廓（circumvallate）乳突 　　　　　　⒝蕈狀（fungiform）乳突
⒞葉狀（foliate）乳突 　　　　　　　　　⒟絲狀（filiform）乳突

Taste buds
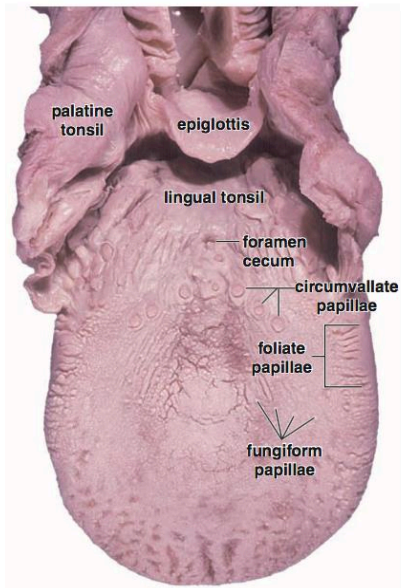
注意味蕾的位置！

	Epithelium	Taste bud		Epithelium
Filiform	Highly-Keratinized	X	Fi Ant. 2/3	Highly-keratinized
Foliate	Non-keratinized	Lat. Surface	Foliate Surface	Non-keratinized
Fungiform	Thin-keratinized	apical side	Tip and two sides	n-keratinized
Circumvallate	Thin-keratinized	Lat. Surface	Ci Ant. Terminal sulcus	-keratinized

Structure of Gastrointestinal Tract

Muscularis mucosae
Lamina propria
Lumen
Epithelium
Adventitia
Submucosal plexus
Lymphoid aggregate
Submucosa
Myenteric plexus
Muscularis propria: inner circular layer
Muscularis propria: outer longitudinal layer
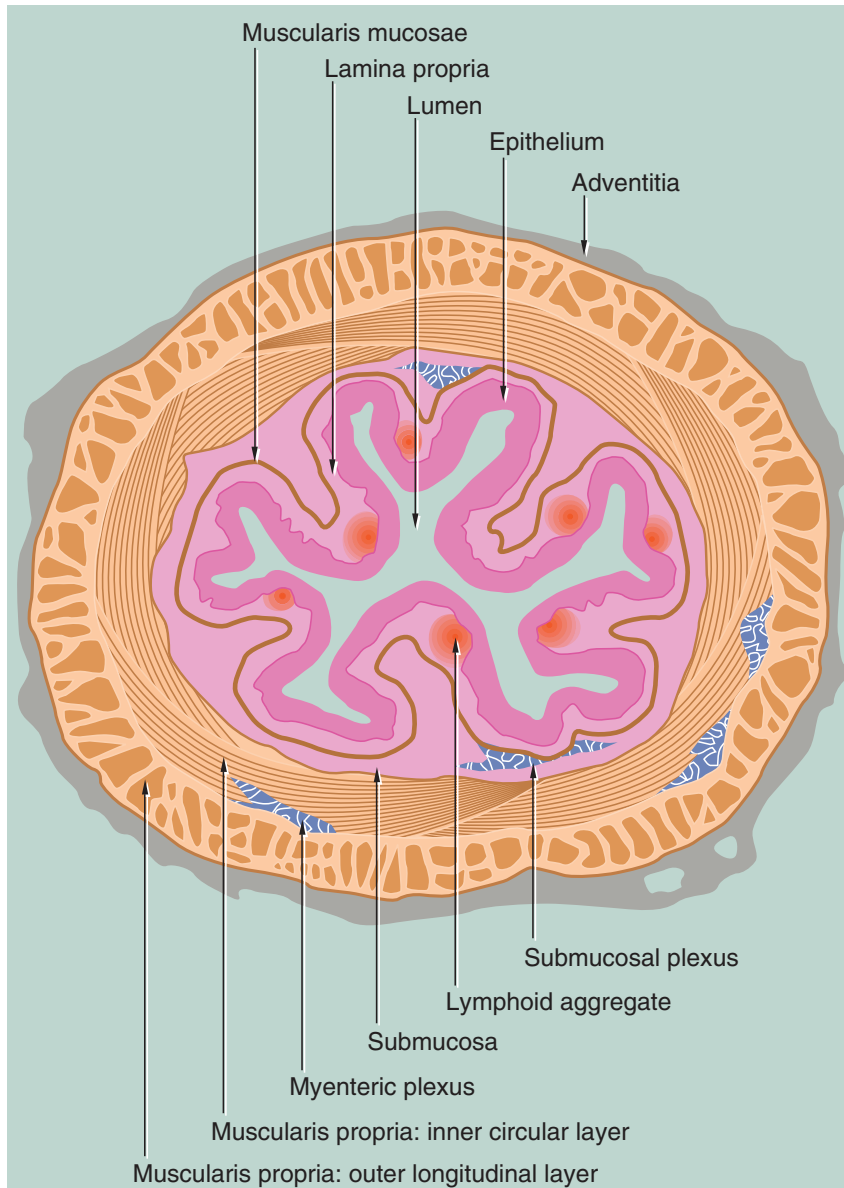
- ☐ **Mucosa (**粘膜**)**
  - Epithelium, lamina propria, muscularis mucosa
  - Transition at the gastroesophageal junction, the gastroduodenal junction, the ileocaecal junction and the rectoanal junction
- ☐ **Submucosa (**粘膜下層**)**
  - loose collagenous connective tissue, large vessels, lymphatic and nerves
- ☐ **Muscularis propria (**固有肌肉層**)**
  - Inner circular and outer longitudinal smooth muscle layer (stomach: inner oblique layer)
  - Peristaltic (蠕動) contraction
- ☐ **Adventitia (**外膜**)**
  - Loose supporting tissue conducts the major vessels, nerves and contains variable adipose tissue
  - the ***serosa*** (***visceral peritoneum***) and is lined by a simple squamous epithelium (***mesothelium***)

Structure of Gastrointestinal Tract

- Peristalsis and the secretory activity are modulated by the *autonomic nervous system* and a variety of hormones
- *Diffuse neuroendocrine system*
- *Enteric nervous system (腸神經系統)*
- *Interstitial cells of Cajal* initiate contraction of smooth muscle
- *Submucosal plexus*, *Meissner plexus*, also contains postganglionic sympathetic fibers arising from the superior mesenteric plexus
- *Myenteric plexus* or *Auerbach plexus*: found between the two layers of the muscularis propria
- Glands: mucosa is arranged into glands, submucosa, pancreas, liver
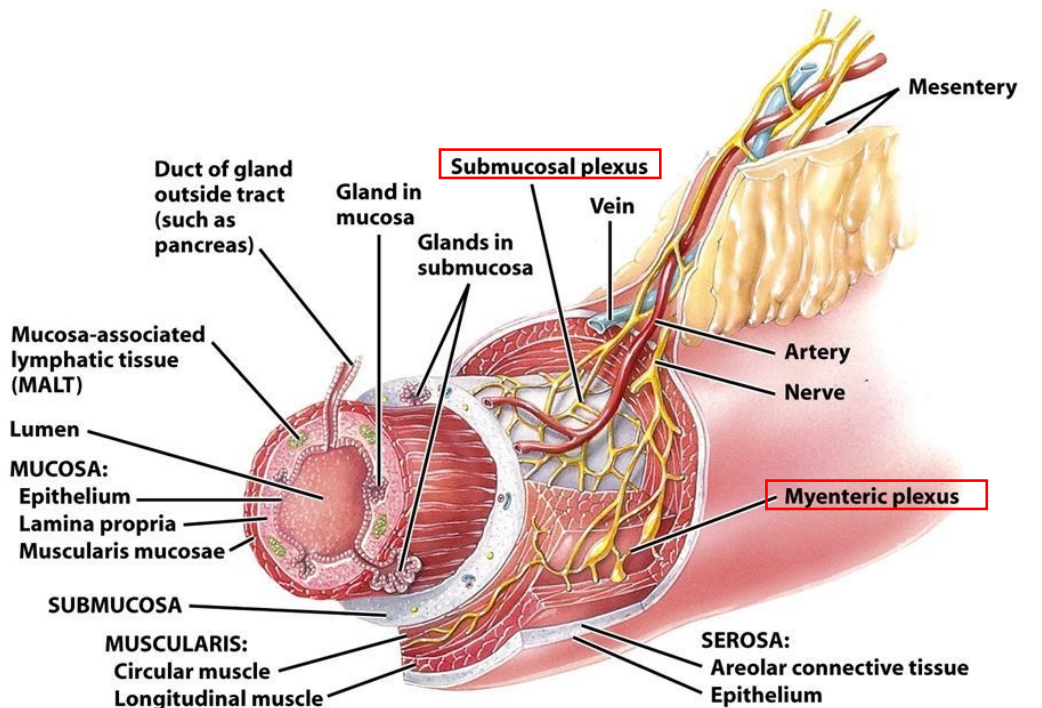
Figure 23-2 Anatomy and Physiology: From Science to Life
© 2006 John Wiley & Sons
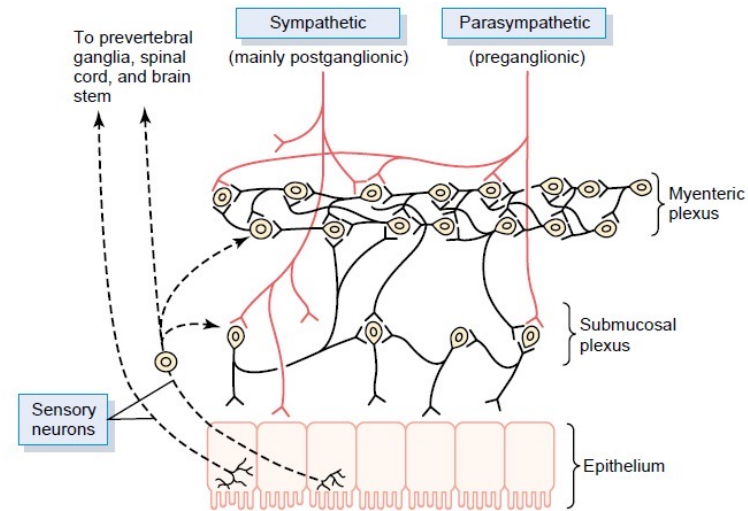
Figure 62–4

Neural control of the gut wall, showing (1) the myenteric and submucosal plexuses (*black fibers*); (2) extrinsic control of these plexuses by the sympathetic and parasympathetic nervous systems (*red fibers*); and (3) sensory fibers passing from the luminal epithelium and gut wall to the enteric plexuses, then to the prevertebral ganglia of the spinal cord and directly to the spinal cord and brain stem (*dashed fibers*).

Basic mucosal types in the gastrointestinal tract
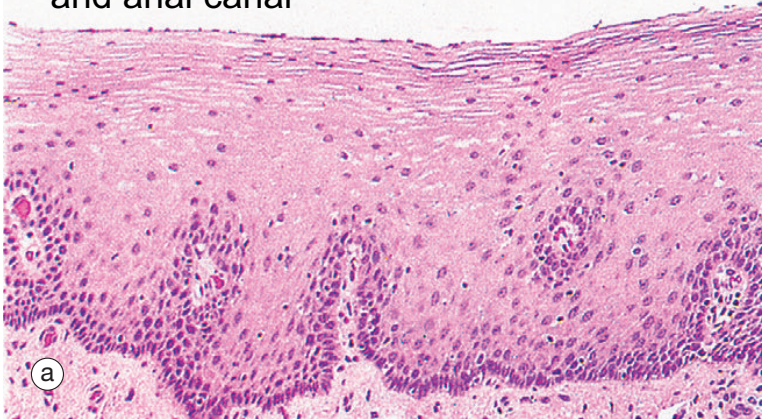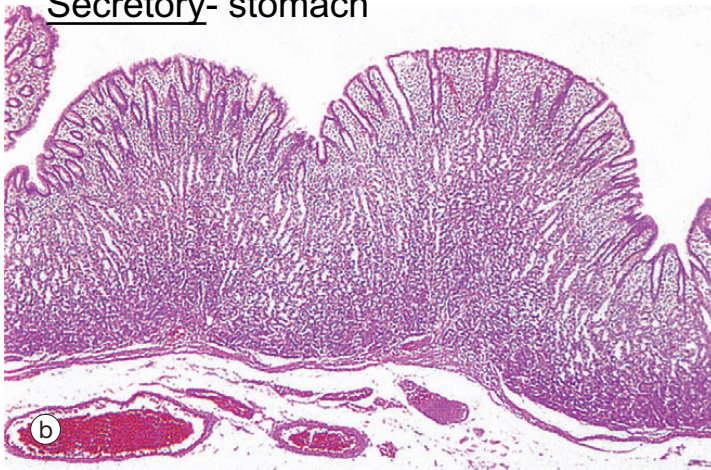
Absorptive/protective-Entire large intestine
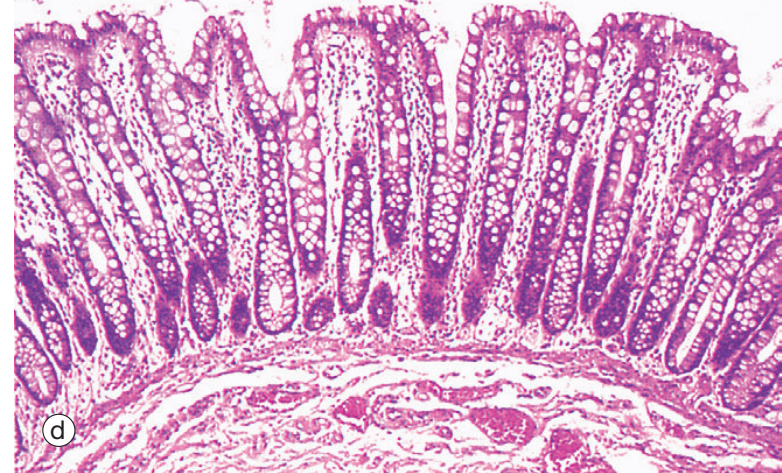
☐ **Protective**
- Stratified squamous type (not keratinized in humans)

☐ **Secretory**
- Long, closely packed tubular glands that are simple or branched

☐ **Absorptive**
- Finger-like projection- villi
- Crypts (Submucosal glands called Brunner's glands in duodenum)

☐ **Absorptive/protective**
- Straight tubular glands, goblet cells

Appendix

- Suspensory mesentery/mesoappendix (M): 跟serosa (S) 為連續構造，主要是來自胃腸道的神經和血管
- Appendix最大的特徵就是在lamina propria (LP)以及upper submucosa (SM)會有淋巴球聚集形成的follicles (F)
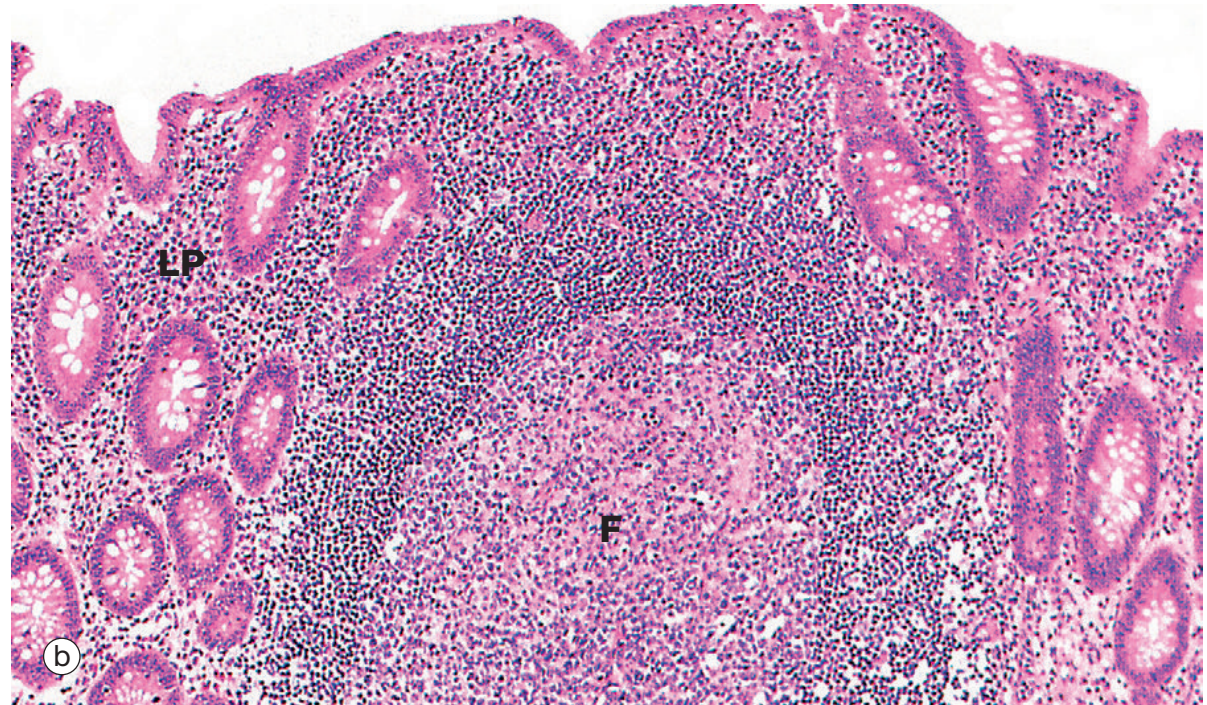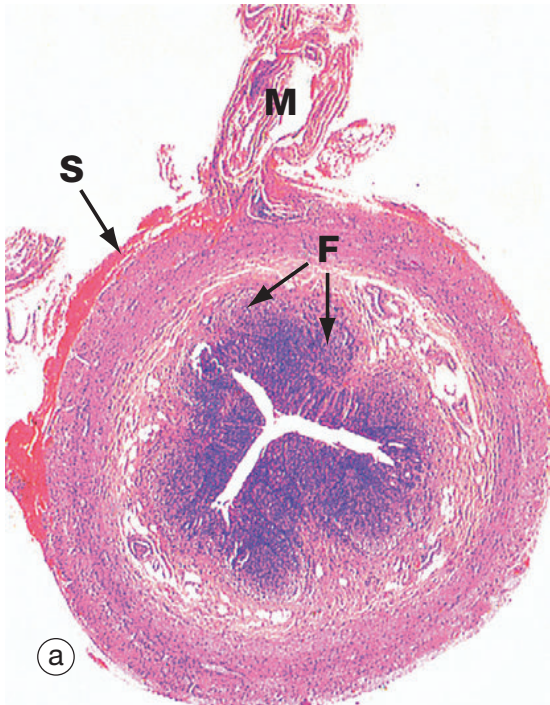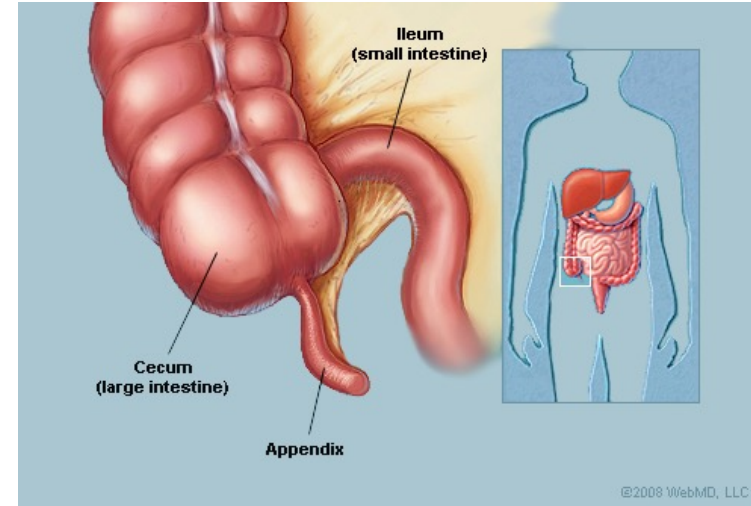
內分泌系統 (endocrine system)

☐ Synthesis and secretion of chemical messengers known as *hormones*

The endocrine system

- Hypothalamus, Pituitary gland
- Pineal gland
- Thyroid gland
- Thymus
- Pancreas
- Adrenal gland
- Testicle
- Ovaries

1143710566
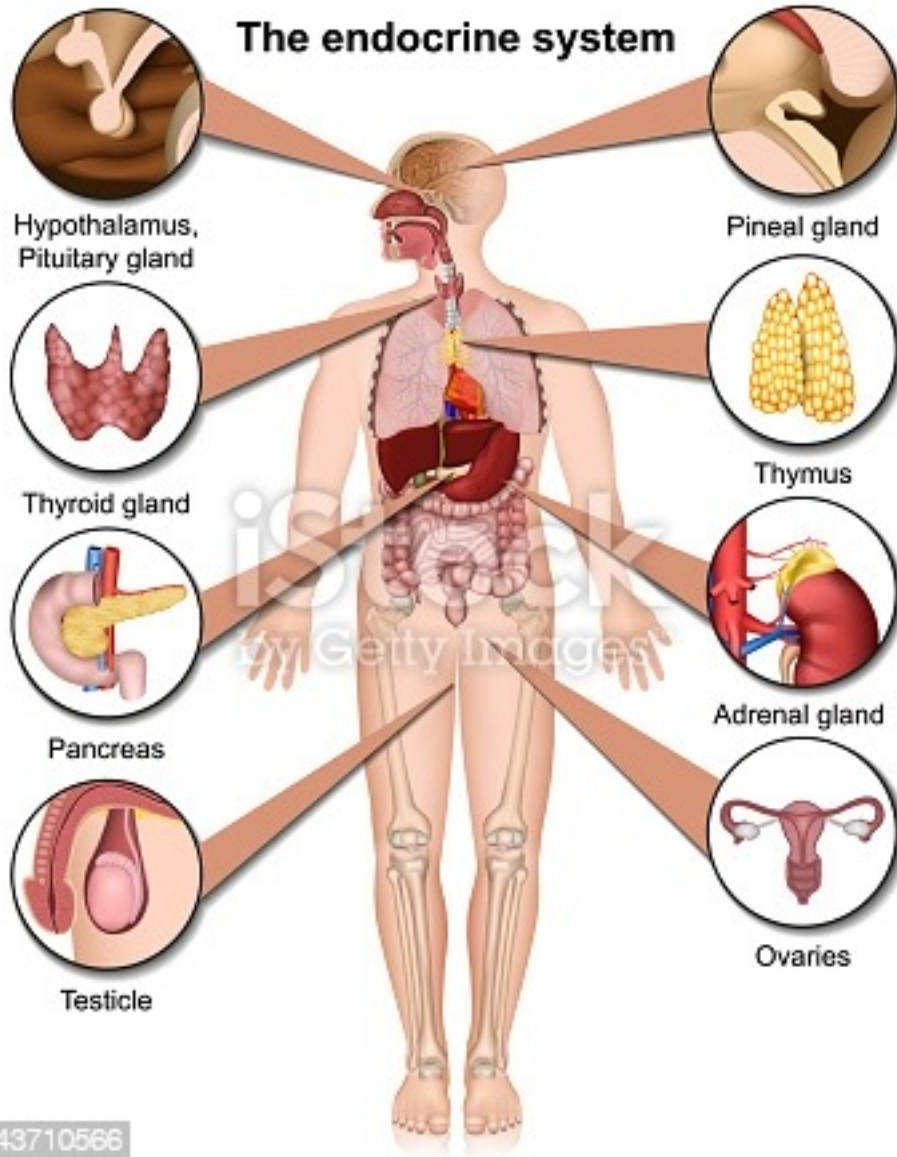
☐ Endocrine glands are composed of islands of secretory epithelial cells with intervening supporting tissue, rich in blood and lymphatic capillaries

☐ Cells of the endocrine system have prominent nuclei and abundant mitochondria, endoplasmic reticulum, Golgi bodies and secretory vesicles

☐ Four main group of chemicals
1. Protein and glycoprotein molecules
2. Small peptide molecules
3. Amino acid derivatives
4. Steroids derived from cholesterol

☐ Divided into 3 parts:

1. **Major endocrine organs**: the sole or major function of the organ is the synthesis, storage and secretion of hormones

2. **Endocrine components within other solid organs**

3. **The diffuse endocrine system:** scattered individual hormone cells (or small clumps), usually within an extensive epithelium

Thyroid gland

☐ Produces hormones of two types:

1. **Iodine-containing hormones tri-iodothyronine (T3) and thyroxine (tetra-iodothyronine, T4)**
   - T4 converted to T3 in the general circulation
   - Thyroid hormone regulates the basal metabolic rate and has an important influence on growth and maturation, particularly of nerve tissue
   - The secretion of these hormones is regulated by TSH secreted by the anterior pituitary

2. Polypeptide hormone *calcitonin*
   - Regulates blood calcium levels, lowers blood calcium levels by inhibiting the rate of decalcification of bone by osteoclastic resorption and by stimulating osteoblastic activity

Anatomy of the Thyroid and Parathyroid Glands

Larynx

Thyroid gland

Trachea

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Thyroid gland (front view)

Right lobe   Left lobe
Isthmus

Thyroid gland (back view)

Parathyroid glands

F

F

a
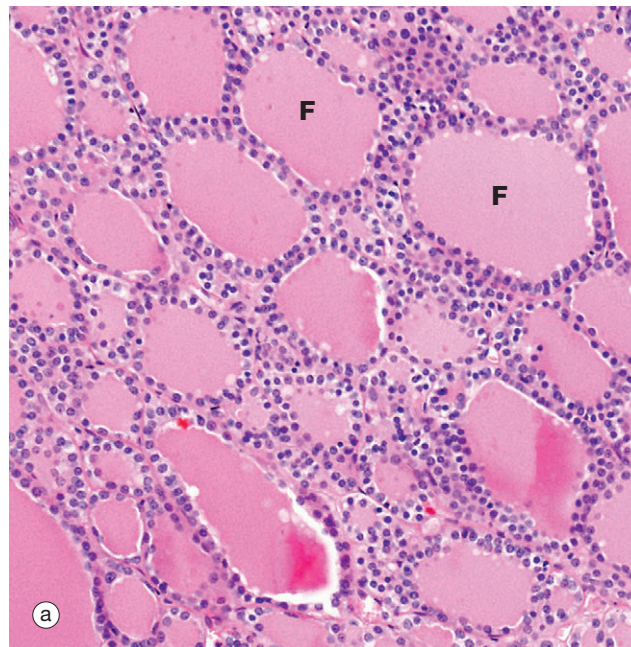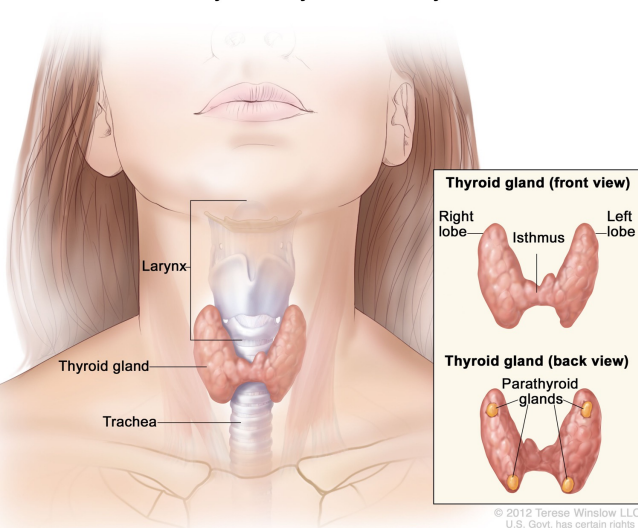
☐ The functional units of the thyroid gland are the *thyroid follicles (F)*, spheroidal structures composed of a single layer of cuboidal epithelial cells, bounded by a basement membrane

☐ **Colloid**: stain pink

Thyroid gland

- Tiny capillaries percolate through the thyroid tissue and surround the follicles
- The follicles are lined by epithelial cells which are initially responsible for the synthesis of the glycoprotein component of thyroglobulin and for the conversion of iodide to iodine
- When inactive, thyroid epithelial cells are simple flat or cuboidal cells

inactive
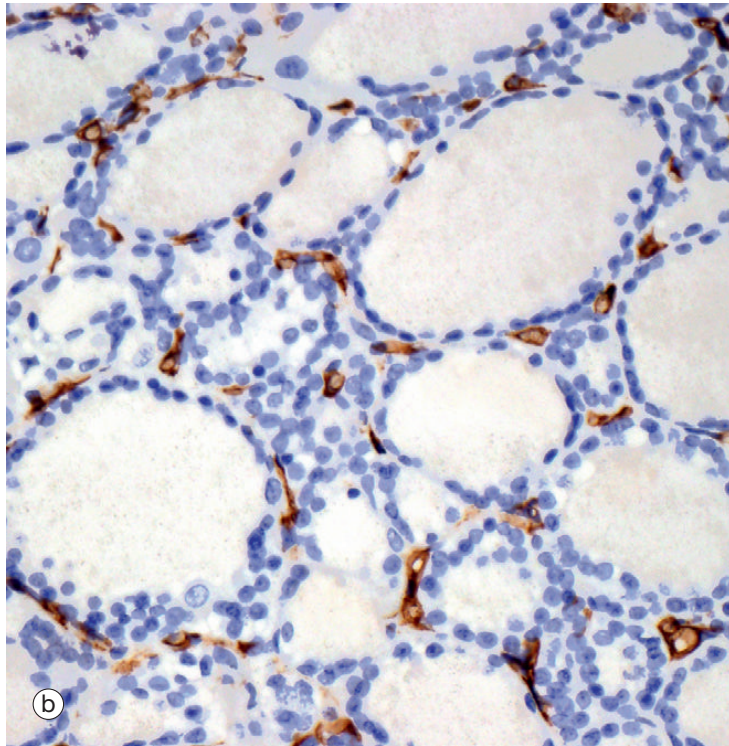
CD34
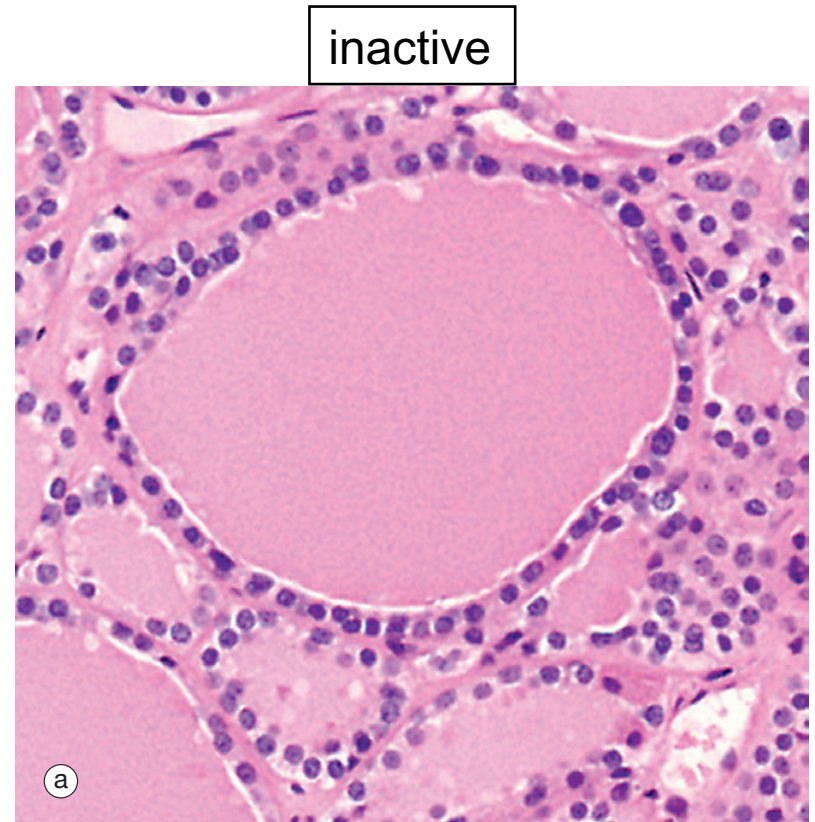
Adrenal gland- zona glomerulosa (G)
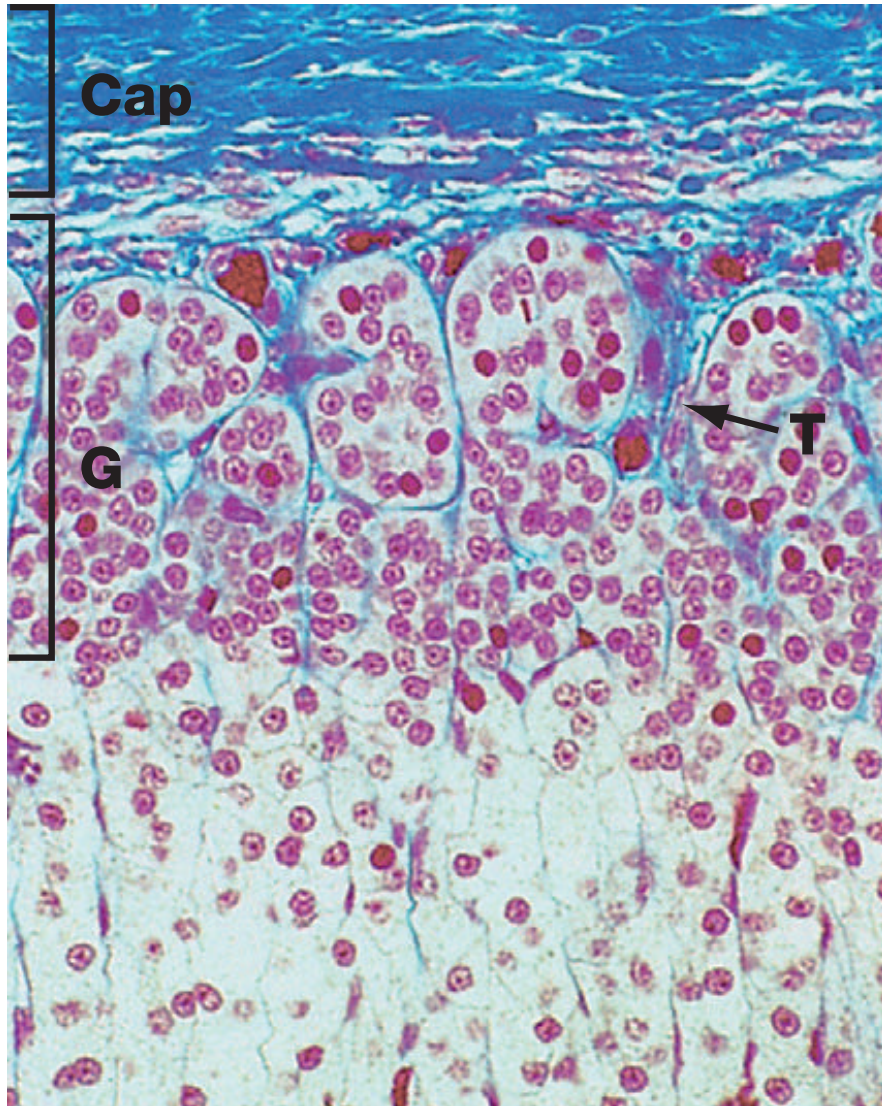
Azan stain

- Composed of cells arranged in irregular ovoid clusters separated by delicate fibrous trabeculae (**T)**, which are continuous with the fibrocollagenous capsule (**Cap)**
- The cells have round nuclei and less cytoplasm
- Secrete mineralocorticoid hormones, principally ***aldosterone***, the secretion of which is controlled by the renin-angiotensin system
- Aldosterone acts directly on the renal tubules to increase sodium and therefore water retention
- Increase extracellular fluid volume, blood pressure ↑
- Aldosterone secretion is independent of ACTH control

Adrenal gland- zona fasciculata (F)
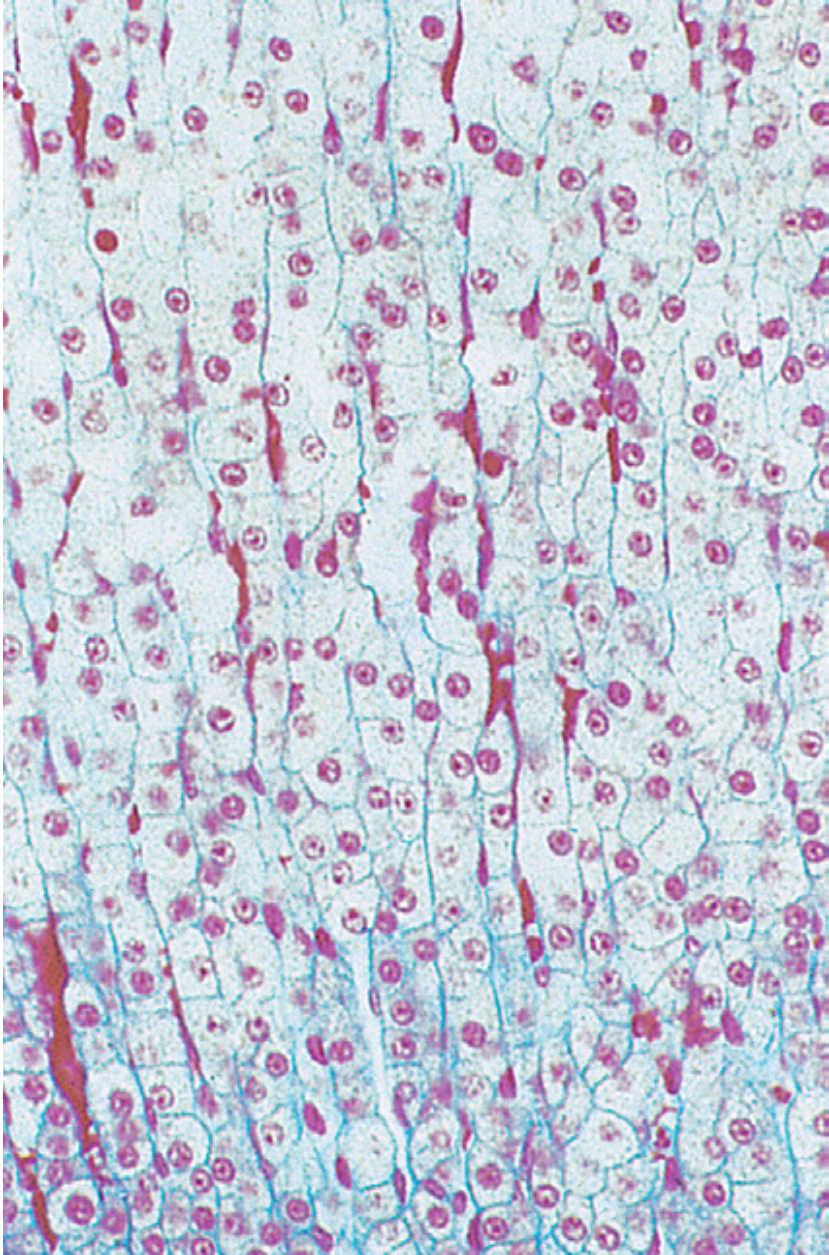
- Middle and broadest of the three cortical zones
- Consists of narrow columns and cords of cells, often only one cell thick, separated by fine strands of collagen and wide-bore capillaries
- Cytoplasm is abundant and pale staining due to the large number of lipid droplets present
- Secrete glucocorticoid hormones, mainly ***cortisol***, which have many metabolic effects
- Cortisol secretion is controlled by the hypothalamus via the anterior pituitary trophic hormone ACTH
- Secretion of small amounts of androgenic sex hormones

Azan stain

Adrenal gland- zona reticularis (R)

- Thin, innermost layer of the adrenal cortex and lies next to the adrenal medulla (**M**)
- Cells are much smaller than those of the adjacent zona fasciculata, with less cytoplasm
- Cytoplasm is darker staining because it contains considerably fewer lipid droplets
- Lipofuscin
- Secretes small quantities of <u>androgens</u> and <u>glucocorticoids</u>
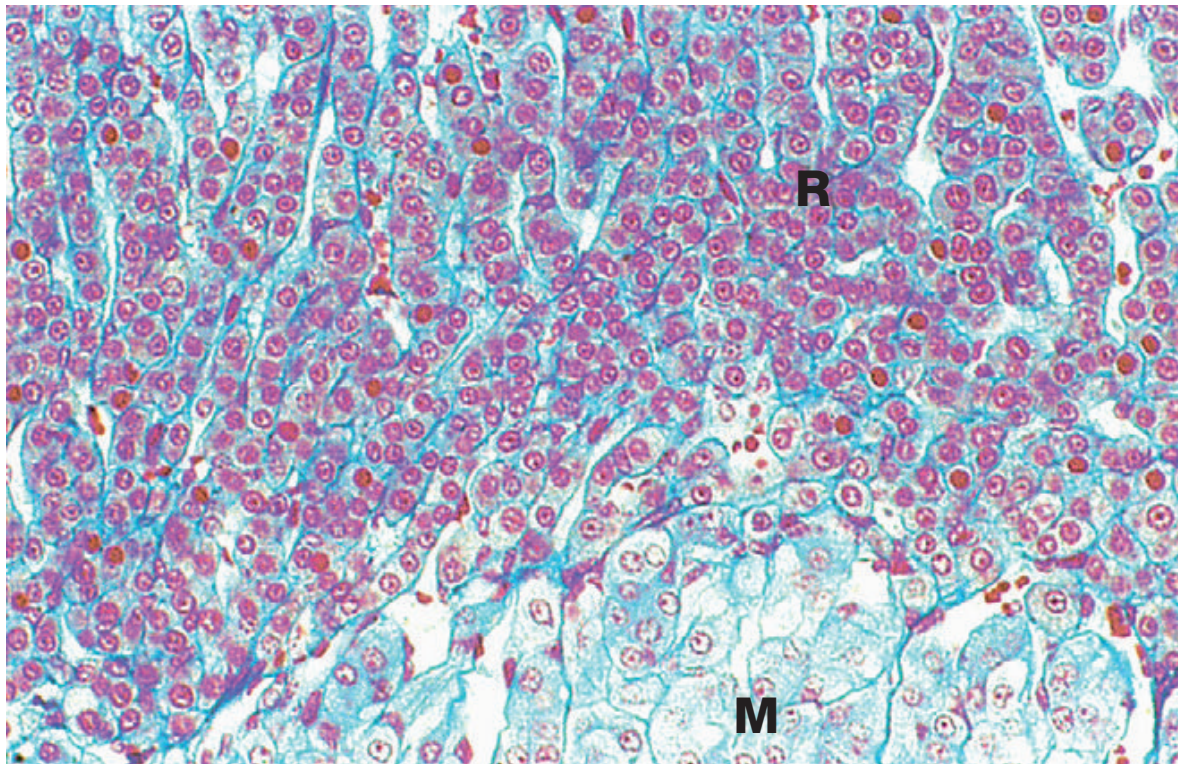
Pineal gland

☐ Lies in the midline of the brain, just below the posterior end of the corpus callosum

☐ Synthesises the hormone **_melatonin_** which acts as an endocrine transducer

☐ Melatonin production by the pineal is induced by darkness and inhibited by light

☐ Melatonin has been used as a treatment for sleep disturbance (e.g. jet lag) and melatonin analogues are also used to treat depression.
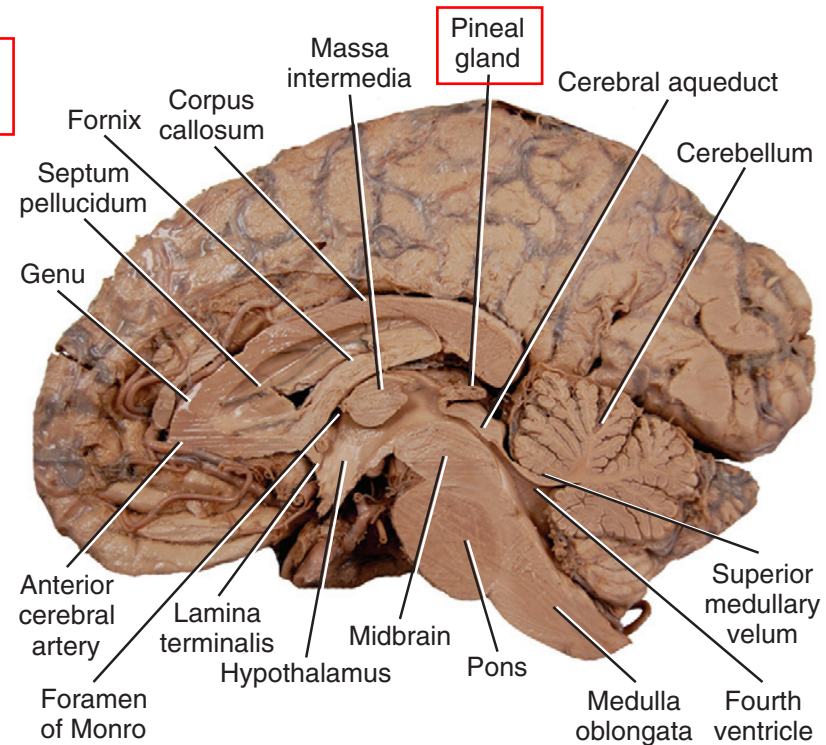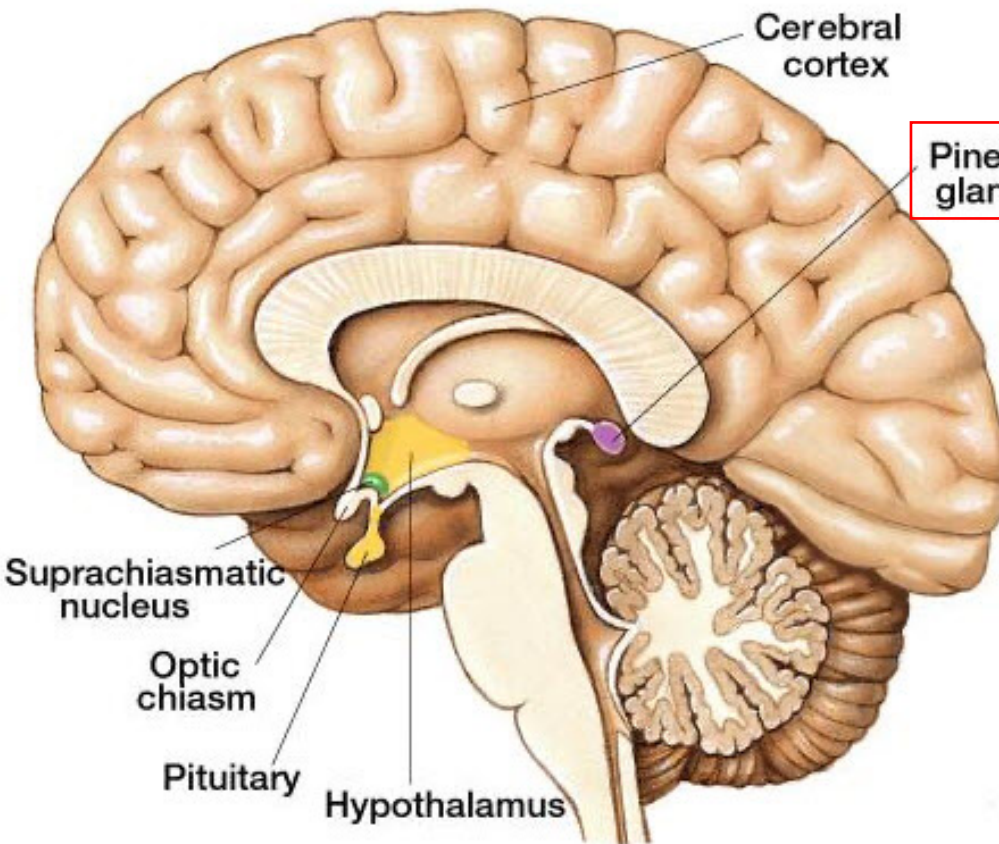
Pineal gland

☐ *Pinealocytes* (*pineal chief cells*) and *neuroglial cells*
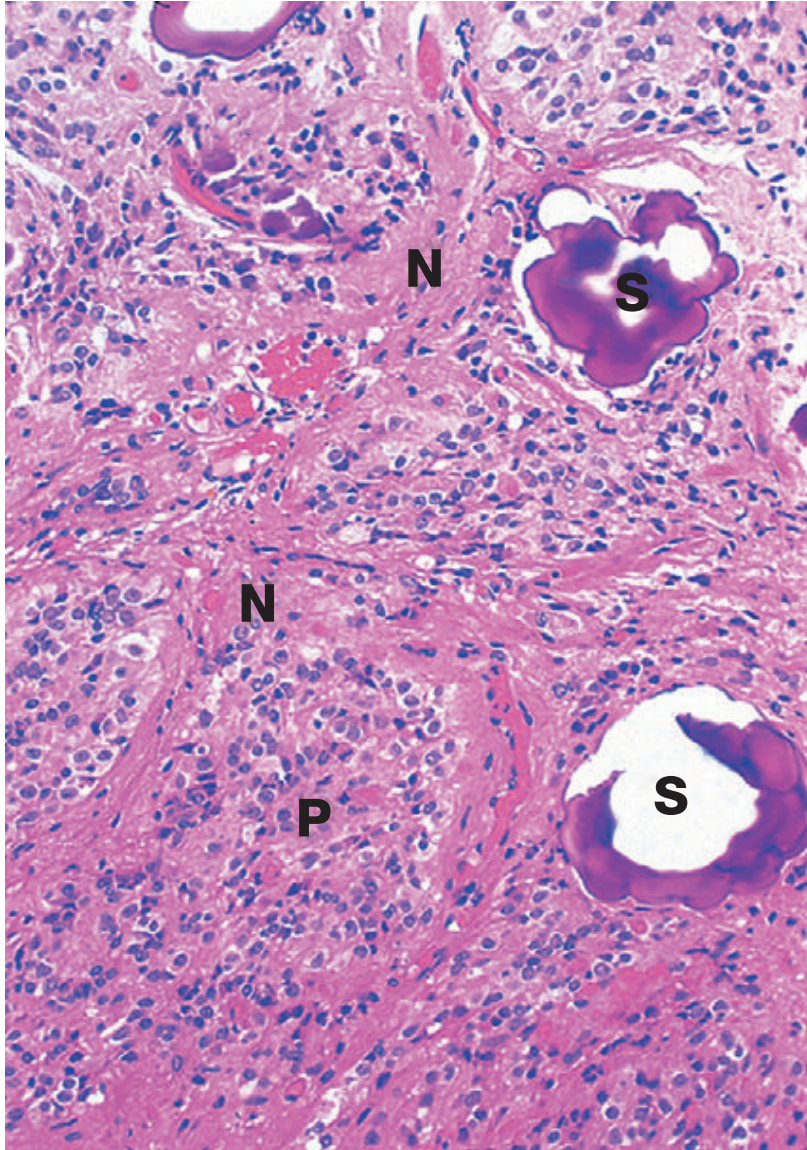
☐ **Pinealocytes (P)**
  - highly modified neurones, arranged in clusters and cords surrounded by a rich network of fenestrated capillaries
  - round nuclei with prominent nucleoli and granular cytoplasm and many highly branched processes

☐ **Neuroglial cells (N)**
  - similar to the astrocytes of the rest of the CNS

☐ Ageing pineal is the presence of basophilic extracellular bodies called ***pineal sand (*S)***, consisting of concentric layers of calcium and magnesium phosphate in an organic matrix

Kidney

- Capsule
- Cortex
- Medullary pyramid
- Calyx
- Hilum
- Renal artery
- Renal vein
- Renal pelvis
- Renal papilla
- Renal sinus
- Ureter
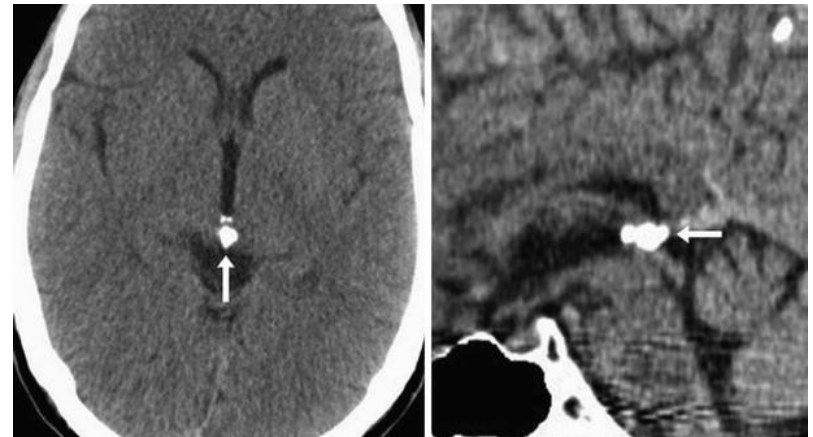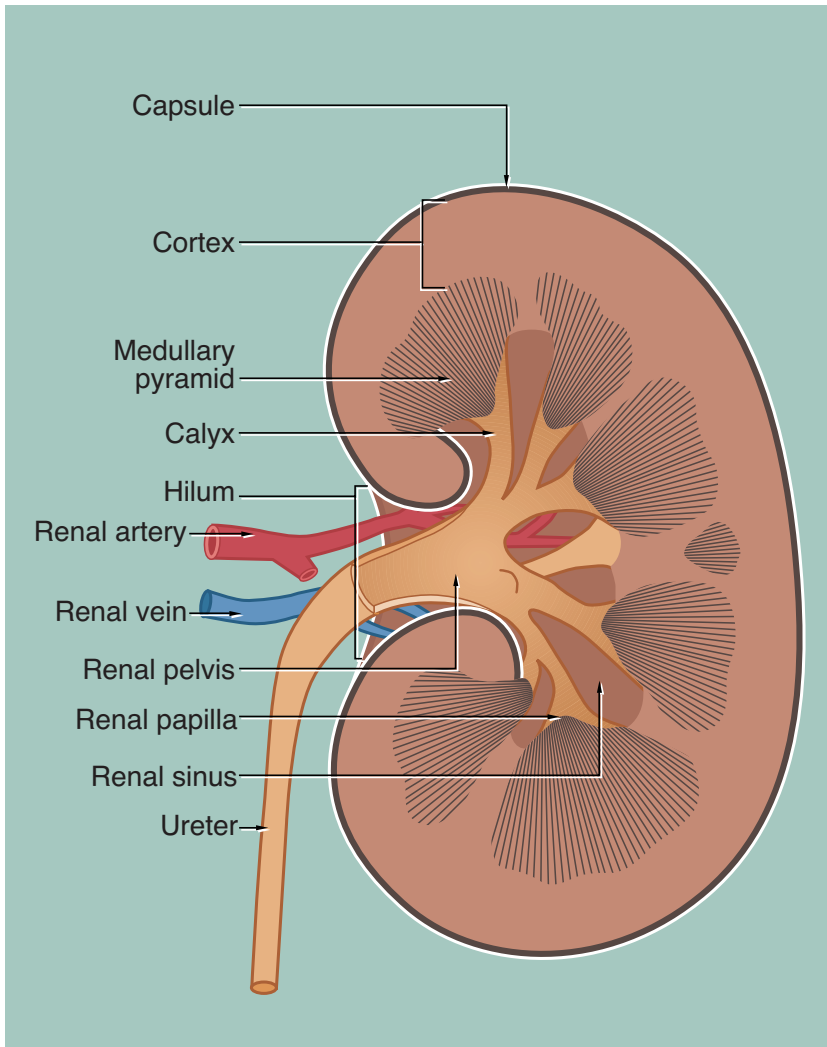
☐ **Hilum**
☐ **Medullary pyramid**: the renal corpuscles and the proximal and distal parts of the tubules
☐ **Renal papilla**: apical part of pyramid
☐ **Renal pelvis**
☐ **Calyx**
☐ **Pelvicalyceal system** (腎盂腎盞系統)
☐ **Renal sinus**: space between the branches of the pelvicalyceal system is filled with fatty supporting tissue
☐ **Gerota's fascia**

- Adrenal gland
- Fibrous tissue (Gerota's fascia)
- Fat layer
- Kidney
- Renal pelvis
- Ureter
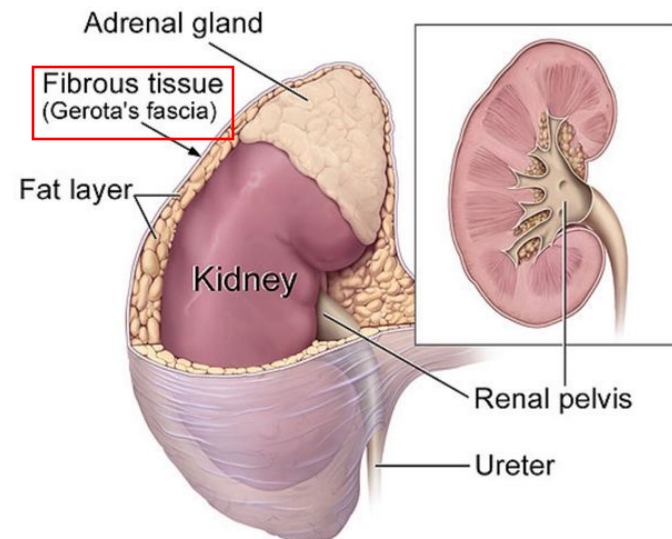
Kidney
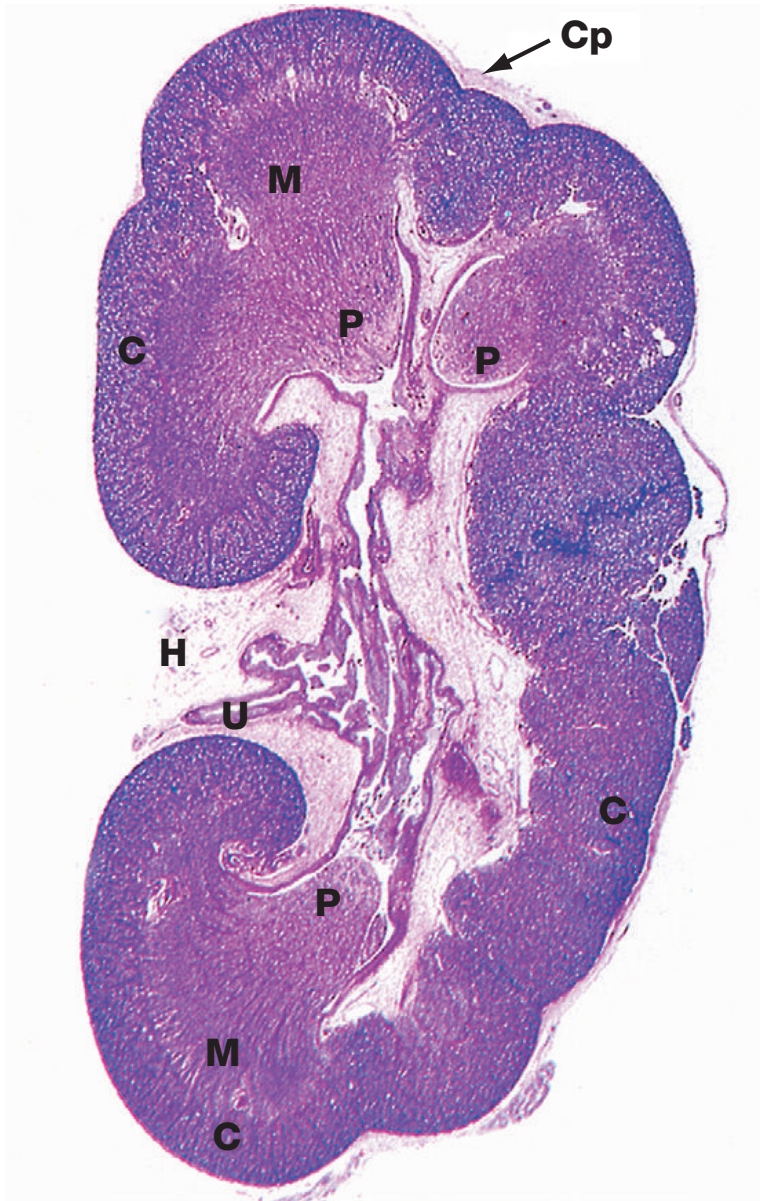
- ☐ **Papilla (P)**
- ☐ **Ureter (U)**
- ☐ **Hilum (H)**
- ☐ **Cortex (C)** (darker-stained)
  - renal corpuscles
- ☐ **Medulla (M)**
- Numerous tubules
- ☐ **Capsule (Cp)**: fibrous connective tissue

☐ *Nephron*
- Renal corpuscle
- Renal tubule

☐ *Renal corpuscle (腎小體)*
- Bowman's capsule: single layer of flattened cells resting on a basement membrane
- Glomerulus- a globular network of anastomosing capillaries
    - invested by the visceral layer of Bowman's capsule
        (a highly specialised layer of epithelial cells called *podocytes*
- Bowman's space
- Glomerular ultrafiltrate (腎絲球濾出液)
- Glomerular filtration barrier:
    capillary endothelium, the podocyte layer and
    their common basement membrane known as
    the *glomerular basement membrane*
- Afferent arteriole (入球小動脈):
    supply glomerulus
- Efferent arteriole (出球小動脈)
- Vascular pole
- Urinary pole
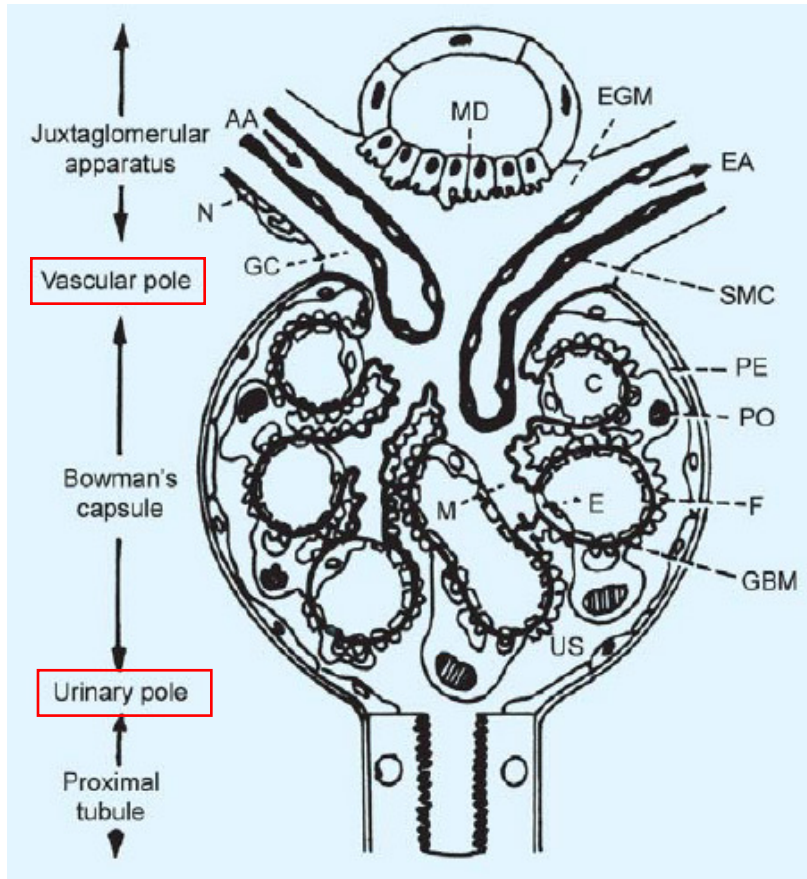
Renal corpuscle

- ❑ The glomerulus is suspended in Bowman's space from the vascular pole
- ❑ The spaces between the capillary loops in each glomerular lobule are filled by *mesangium* which contains *mesangial cells*
- ❑ The efferent arteriole is of smaller diameter than the afferent arteriole, and a pressure gradient is thus maintained that drives the filtration of plasma into Bowman's space
- ❑ *Parietal epithelial cells* of Bowman's capsule becomes continuous with the first part of the renal tubule, the proximal convoluted tubule.

Afferent arteriole

Bowman's capsule

Bowman's space

VASCULAR POLE

Efferent arteriole

Basement membrane of Bowman's capsule

Glomerulus

Proximal convoluted tubule

URINARY POLE

a
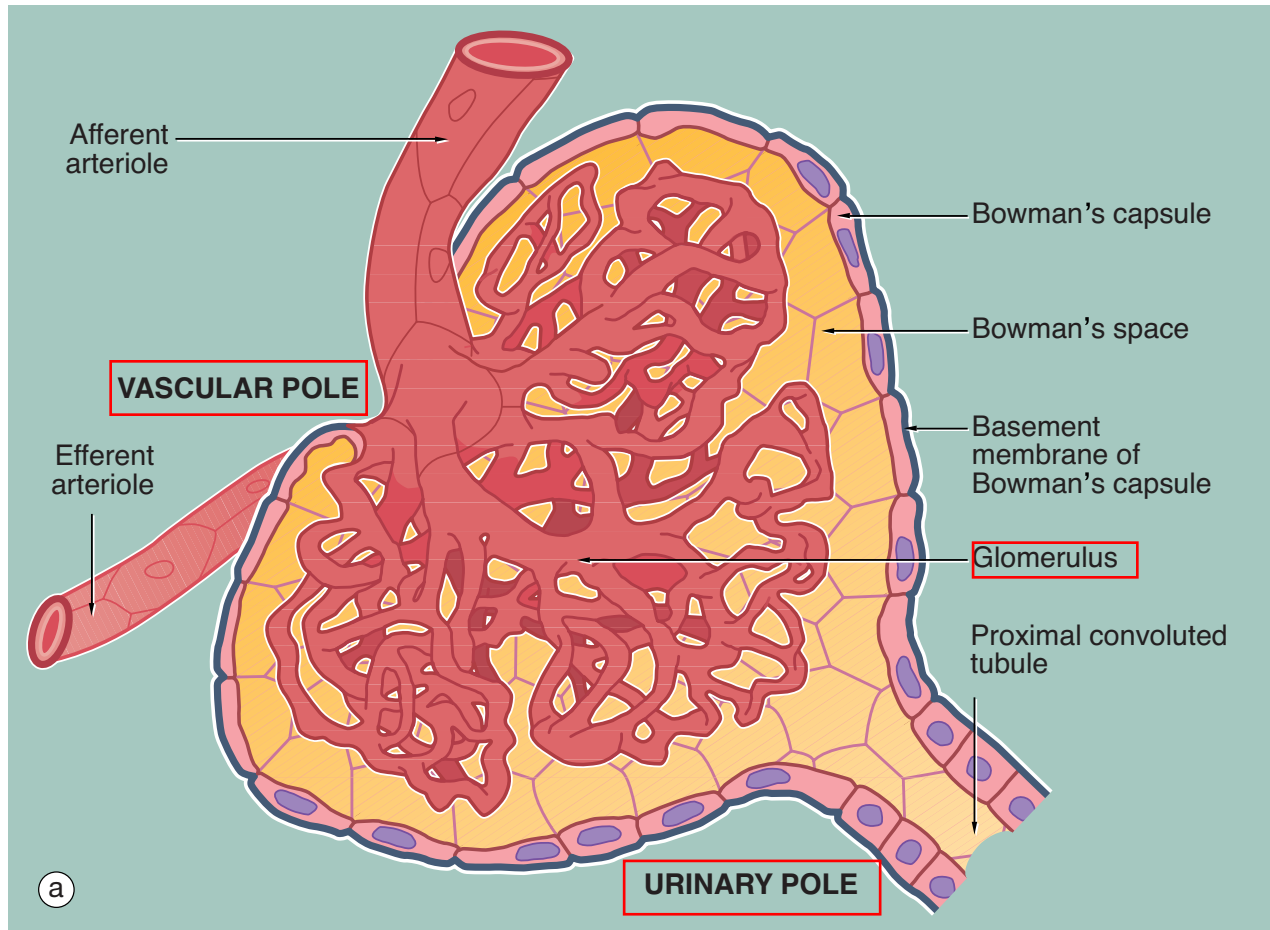
Renal corpuscle

- Afferent arteriole (**A**) entering the glomerulus
- Proximal convoluted tubule (PCT)
- Renal interstitium (I)
- Glomerular capillaries (C)
- Glomerular basement membrane (GBM)
- Mesangium (M)含有類似basement membrane 的構造，所以會被PAS染上
- Endothelial cell (E)
- Parietal epithelial cells (**S**)
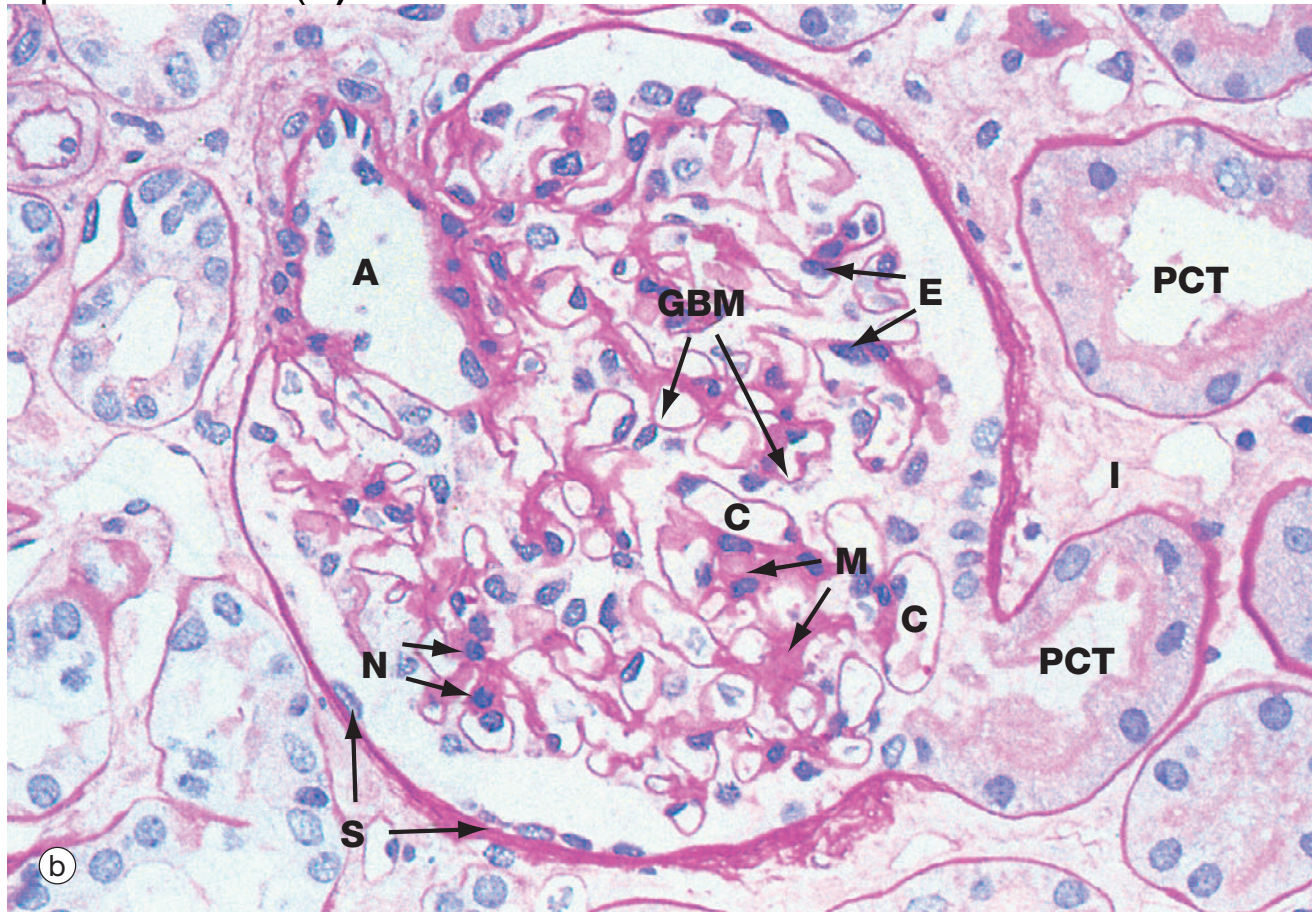
PAS stain

Proximal convoluted tubules

- The <u>proximal convoluted tubule (PCT)</u> is a coiled tube measuring approximately 14 mm in length and random sections of PCT thus occupy most of the renal cortex
- Approximately 65% of the glomerular filtrate is reabsorbed from the PCT
- Proximal convoluted tubule arising from a renal corpuscle
- The simple cuboidal epithelium has a prominent blue-stained brush border of tall microvilli
- The cytoplasm of PCT epithelial cells stains intensely due to a high content of organelles, principally mitochondria, basement membrane (BM)在此染色之下會被染成<u>藍色</u>
- Brush border (BB)
- PCT的細胞核是圓形，有明顯的核仁 (nucleolus)

C: capillary

Azan stain

PAS
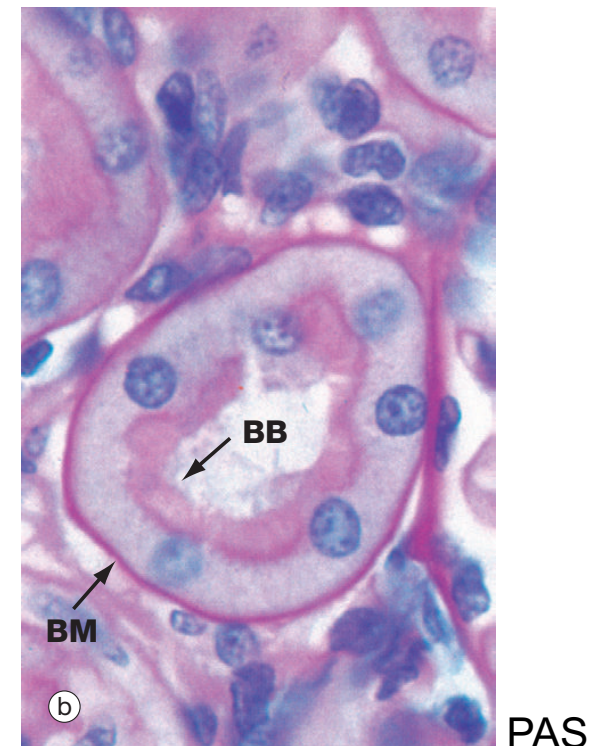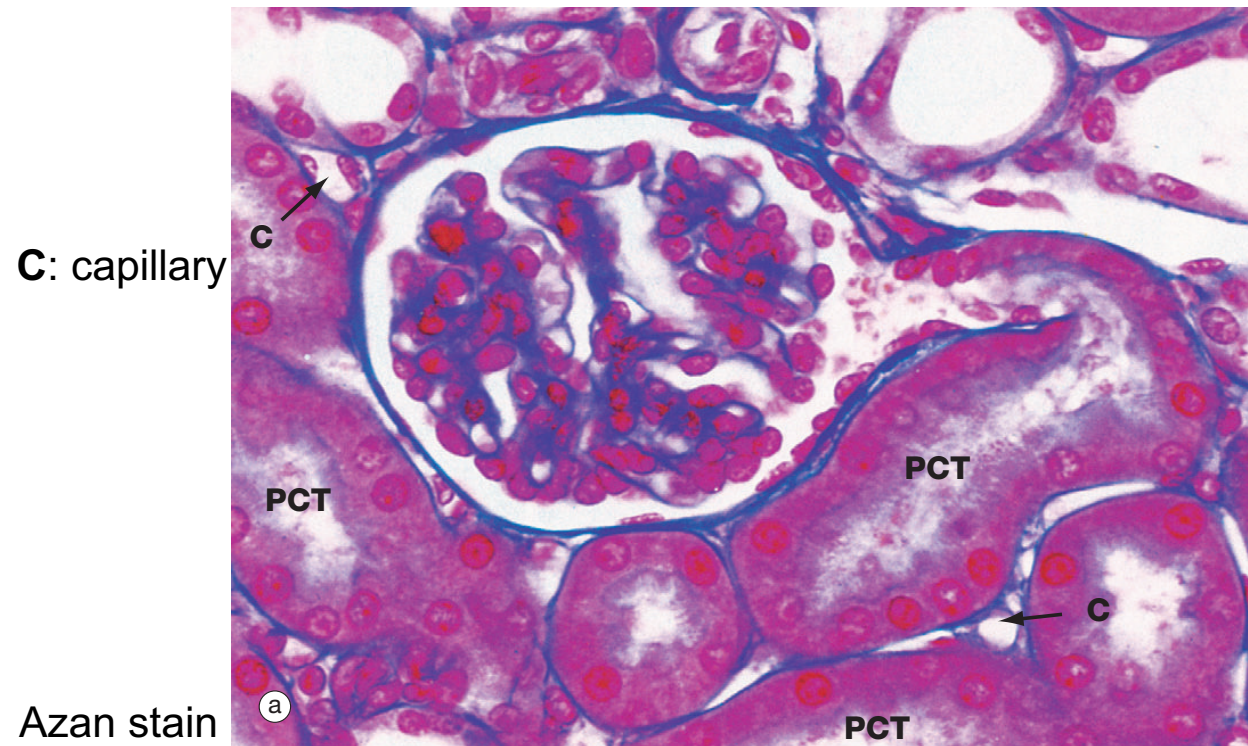
Distal convoluted tubules

- Distal tubules are thus found within the cortex among the proximal convoluted tubules
- The first part of the distal tubule forms the *macula densa* while the remainder makes up the distal convoluted tubule (DCT)
- In the DCT, sodium ions are reabsorbed from the tubular fluid, with one hydrogen or potassium ion being secreted in exchange
- DCT沒有brush border, 管腔較大較乾淨, 被切到的核比較多 (因為DCT細胞比PCT還小)，細胞質較淡染 (因為 胞器較少)
- DCT的切面數量比PCT少，因為DCT比較短
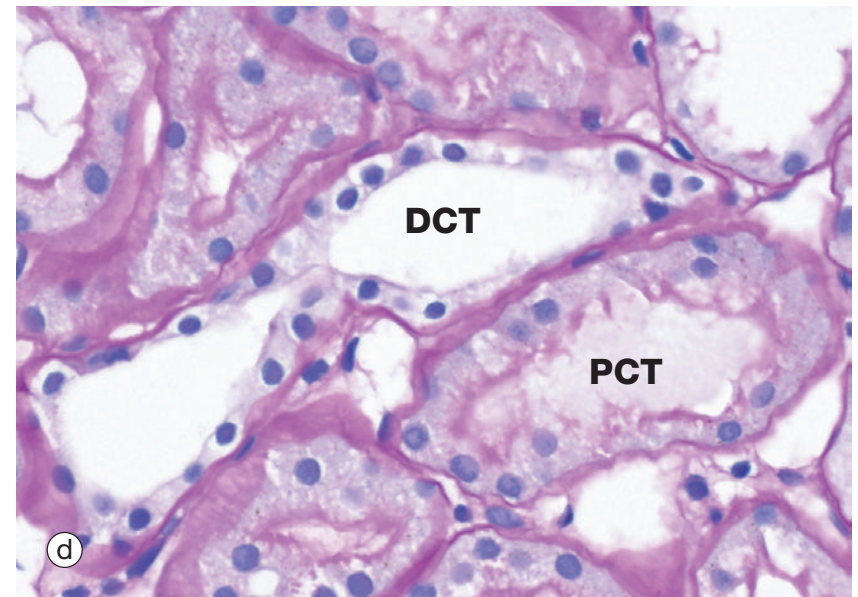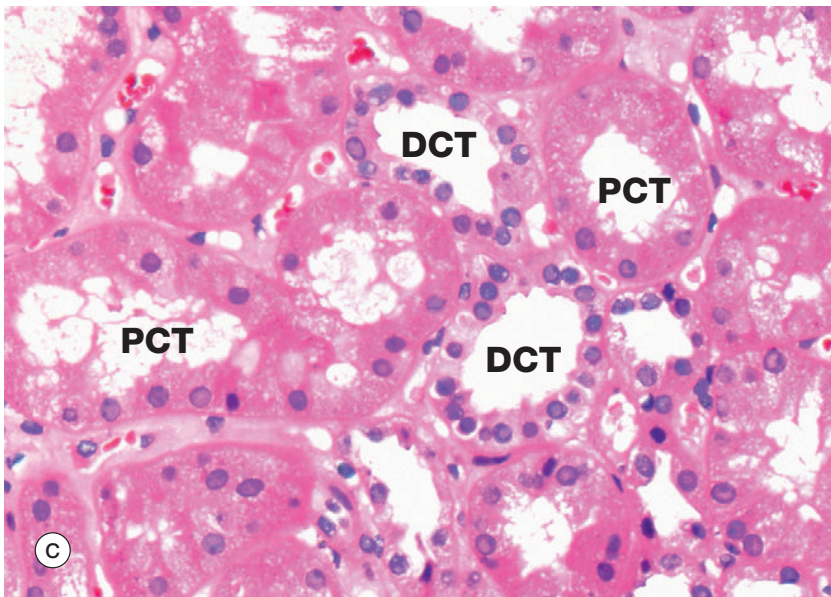
PCT有明顯的刷狀緣 (PAS 染色)

Juxtaglomerular apparatus (JGA)

☐ A specialization of the glomerular afferent arteriole (**AA)** and the distal convoluted tubule (**DCT)** of the same nephron and is involved in the regulation of systemic blood pressure via the *renin-angiotensin- aldosterone system* (*RAAS*)

☐ 由下列三種構造組成：
1. Macula densa (MD)
- an area of closely packed, specialised DCT epithelial cells where the DCT abuts the vascular pole of the glomerulus
- 此處的細胞比較高，核明顯且靠近管腔處
- The cells of the macula densa are sensitive to the concentration of sodium ions in the fluid within the DCT
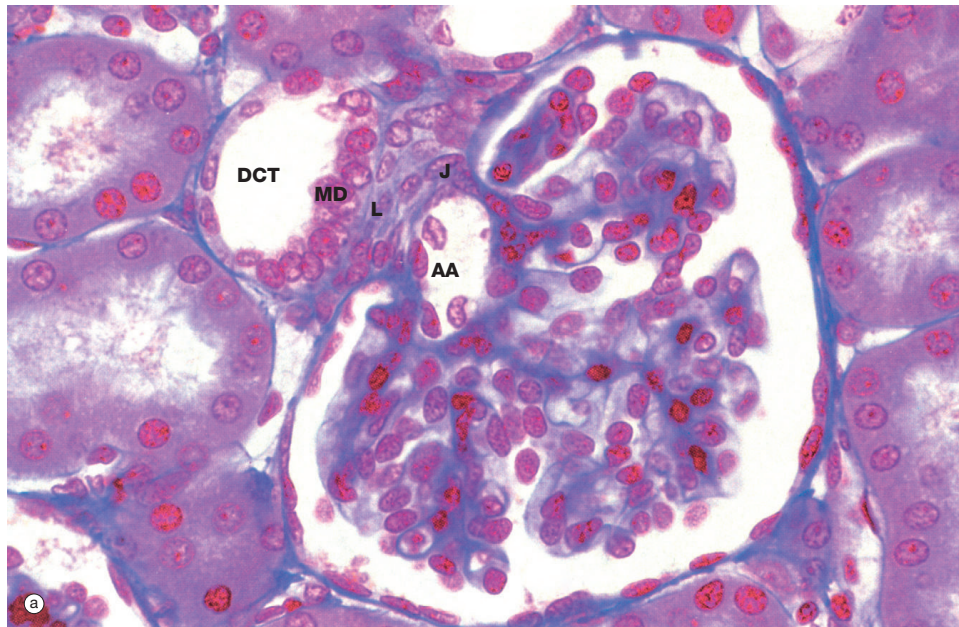
Lower urinary tract

- ☐ Includes the renal pelvis and calyces, the ureters, the urinary bladder and the urethra
- ☐ Specialised for the storage and excretion of urine
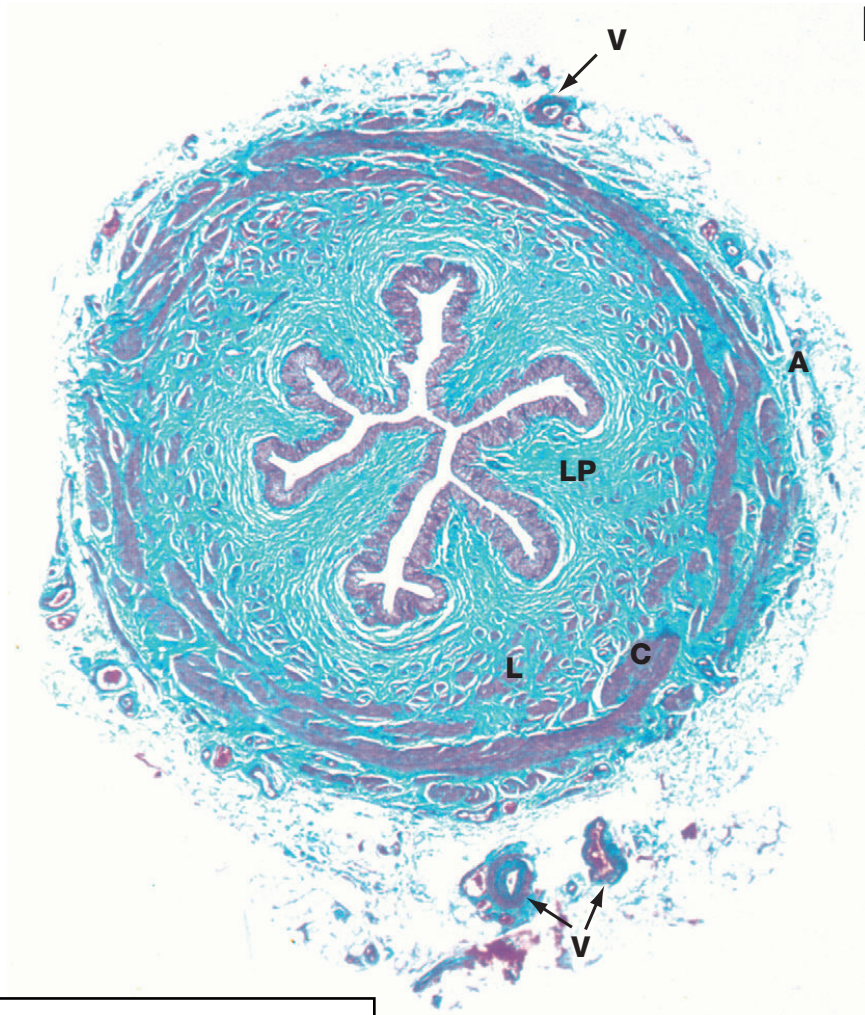
Mallory-Azan stain

- ☐ **Ureters**
  - contains two layers of smooth muscle, arranged as an inner elongated spiral but traditionally known as the *longitudinal layer (*L*)* and an outer tight spiral traditionally described as the *circular layer (C)*
  - another *outer longitudinal layer* is present in the lower third of the ureter
  - The lumen of the ureter is lined by *transitional epithelium* (*urothelium*)
  - beneath the epithelium is a broad collagenous lamina propria (**LP**), the collagen fibres of which are stained greenish-blue in this preparation
  - loose collagenous adventitia (**A**) containing blood vessels (**V**), lymphatics and nerves

Urinary bladder

- The wall of the bladder consists of three loosely arranged layers of smooth muscle and elastic fibres
- *Inner longitudinal (*IL), *outer circular (C)* and *outermost longitudinal (*OL)
- **Detrusor muscle**
- The transitional epithelium lining the bladder is thrown into many folds in the relaxed state
- A delicate, often incomplete <u>muscularis mucosa</u> separates the lamina propria from the submucosa in some but not all individuals
- Adventitia (A)
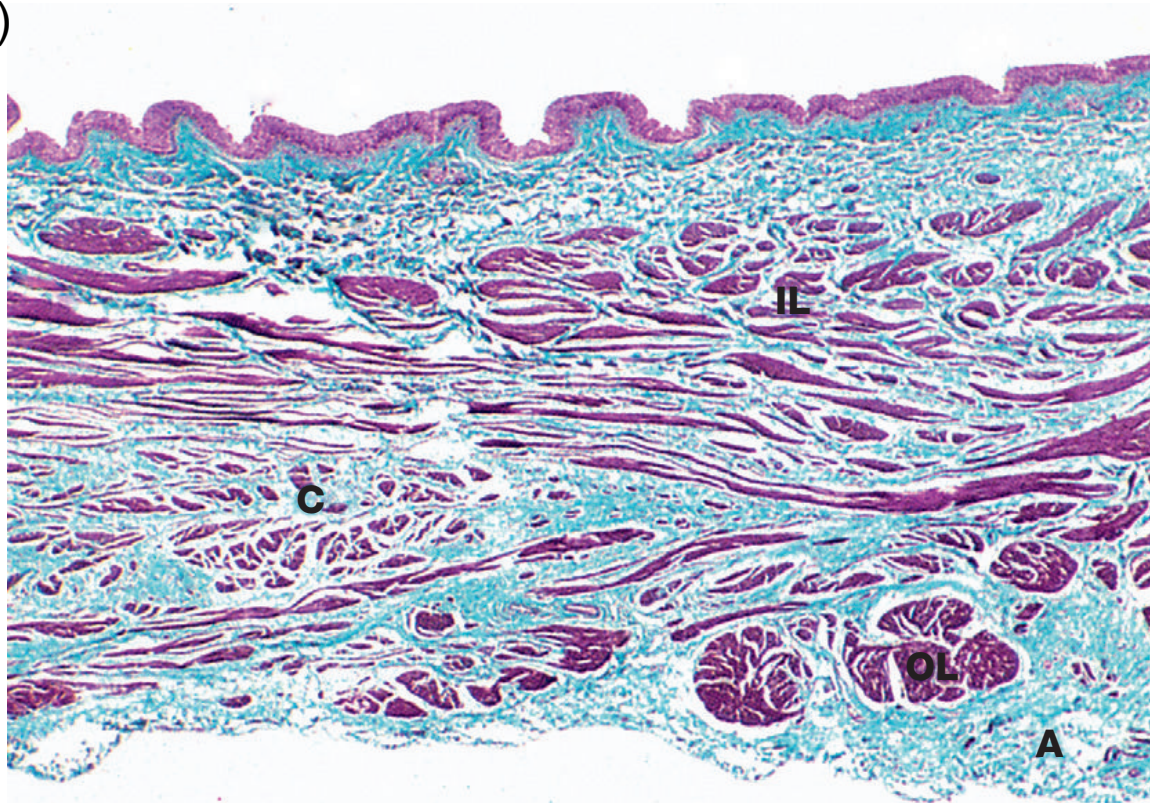
The organs of the immune system

Tonsil

Adenoid

Lymph nodes

Thymus

Hilar lymph nodes

Lymphoid aggregates (large intestine)

Spleen

Peyer's patches (small intestine)

Appendix

Bone marrow
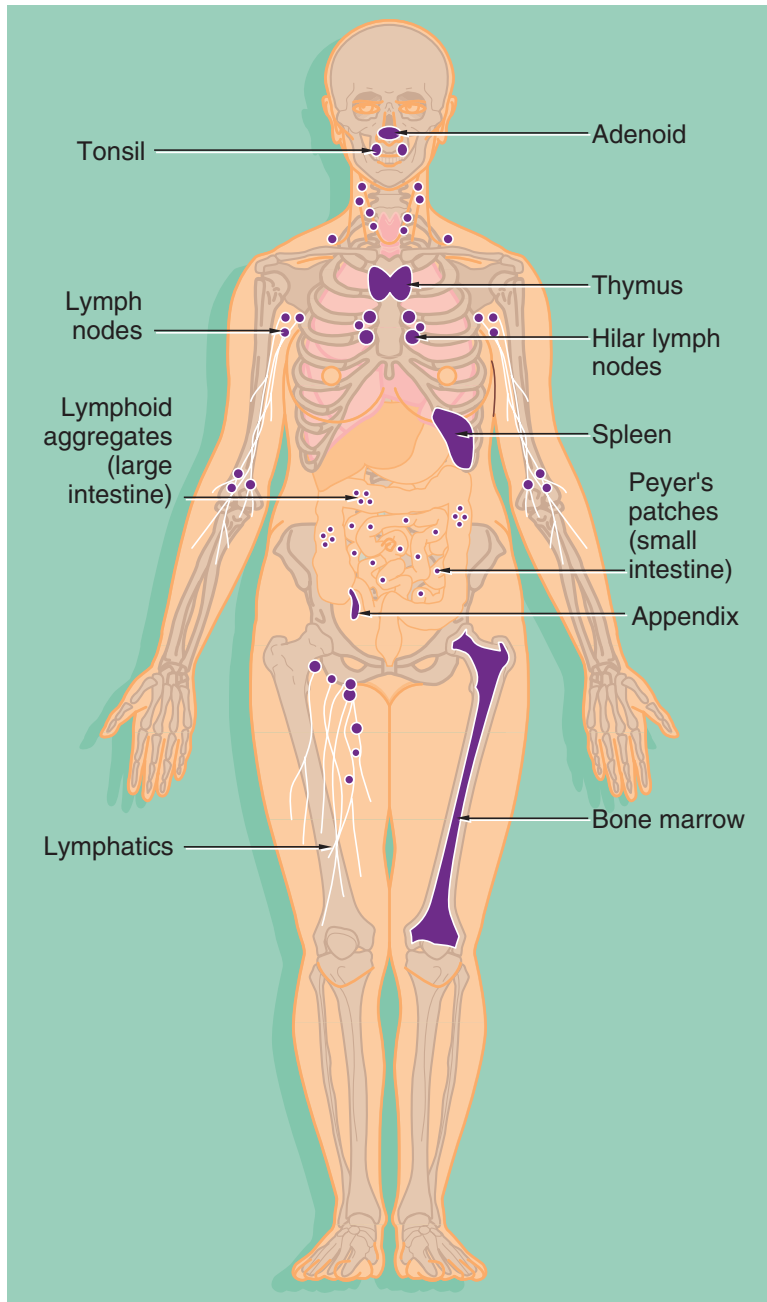
Lymphatics

☐ **Thymus (primary)**
  - the site of maturation of immature T lymphocytes
☐ **Bone marrow (primary)**
  - home of lymphocyte stem cells
  - the site of B lymphocyte maturation
☐ **Lymph nodes (secondary)**
  - the junctions of major lymphatic vessels
  - lymphocytes interact with antigen and antigen-presenting cells (APCs), leading to lymphocyte activation and cell division
☐ **Spleen (secondary)**
  - T and B lymphocytes may interact with blood-borne antigen and undergo stimulation and cell division
☐ **Mucosa-associated lymphoid tissue** (**MALT**)
 - tonsils and adenoids in oropharynx
  - Peyer' patch and lymphoid aggregates in small and large intestine
  - diffuse population of lymphocytes in mucosa of GI, respiratory, and genitourinary tract
☐ **Primary lymphoid organs:** where immature lymphocytes acquire the receptors to recognize antigen
☐ **Secondary lymphoid organs**: lymphocytes are activated in response to antigen

Thymus

☐ Located in the upper anterior mediastinum and lower part of the neck
☐ Most active during childhood, reaching a weight of about 30 to 40 g at puberty
☐ Highly cellular outer *cortex* and a less cellular central *medulla*
☐ **Blood-thymus barrier**: formed by thymus epithelial cells
☐ Functions:
  • Development of immunocompetent T lymphocytes from bone marrow–derived T cell precursors to produce mature T_H and T_C cells
  • Proliferation of clones of mature naïve T cells to supply the circulating lymphocyte pool and peripheral tissues
  • Development of immunological self-tolerance
  • Secrete polypeptides to regulate T cell maturation, proliferation and function
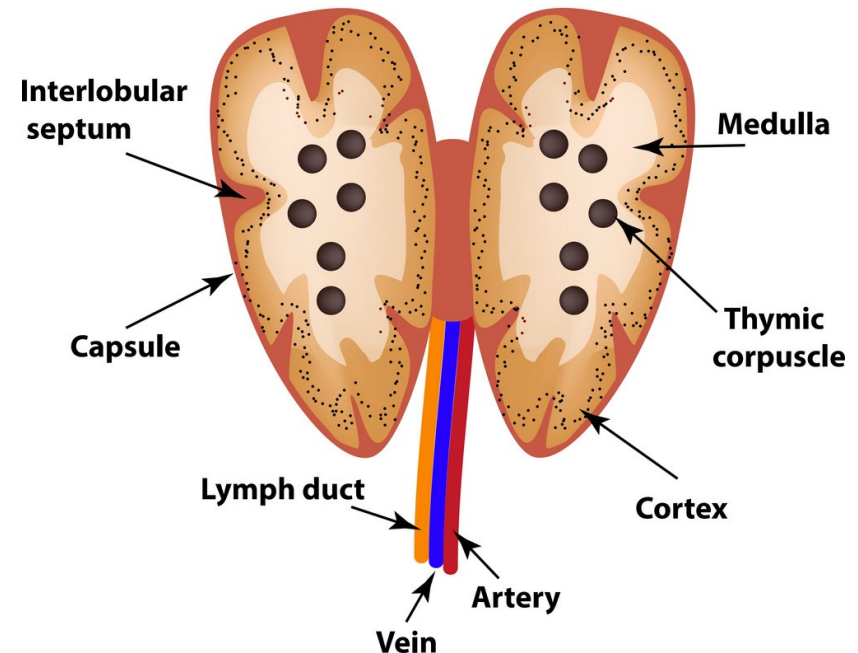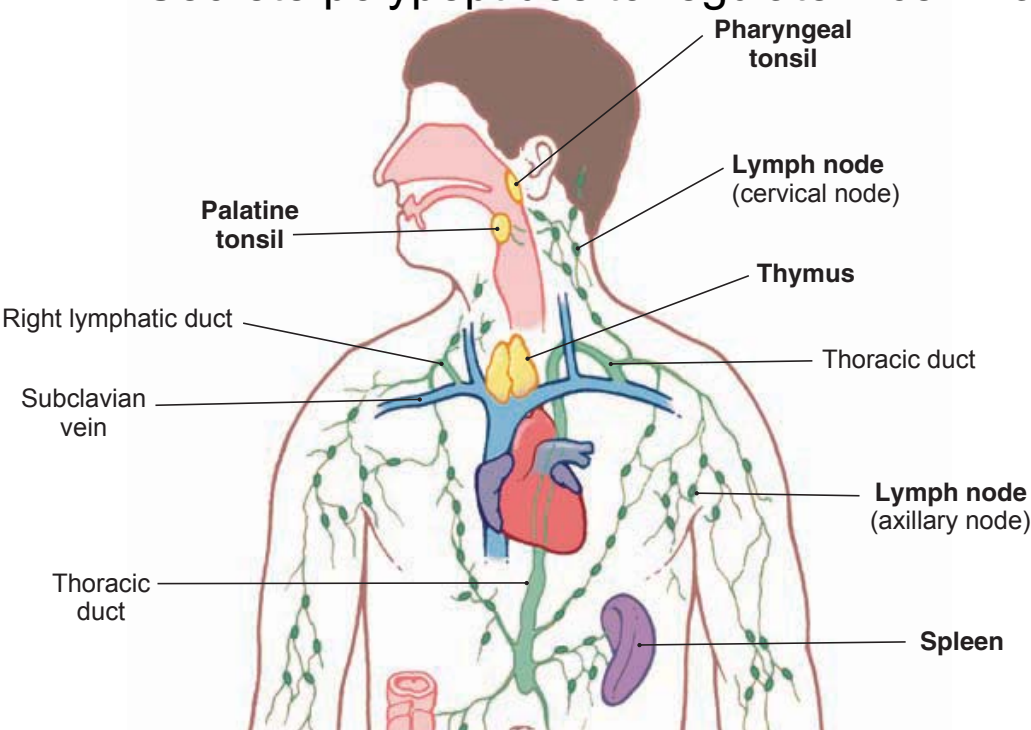
Thymus

- ☐ Lobulated organ invested by a loose collagenous capsule *(C)*
- ☐ Interlobular septa *(S)* containing blood vessels radiate into the substance of the organ
- ☐ Cortex (**Cx**): basophilic; Medulla (**M**): eosinophilic
- ☐ In adult: fatty infiltration and lymphocyte depletion
- ☐ Continues to provide mature T lymphocytes to the circulating pool and peripheral tissues
- ☐ Cords of epithelial cells persist and continue to secrete thymic hormones throughout life
- ☐ Postcapillary venules in the corticomedullary region have a specialized cuboidal endothelium which allows passage of lymphocytes into and out of the thymus
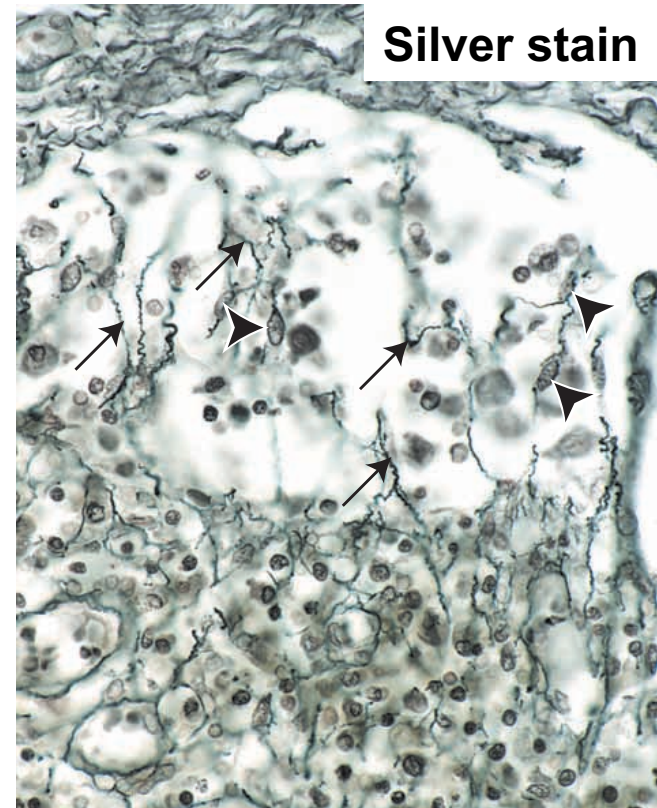
infant

adult
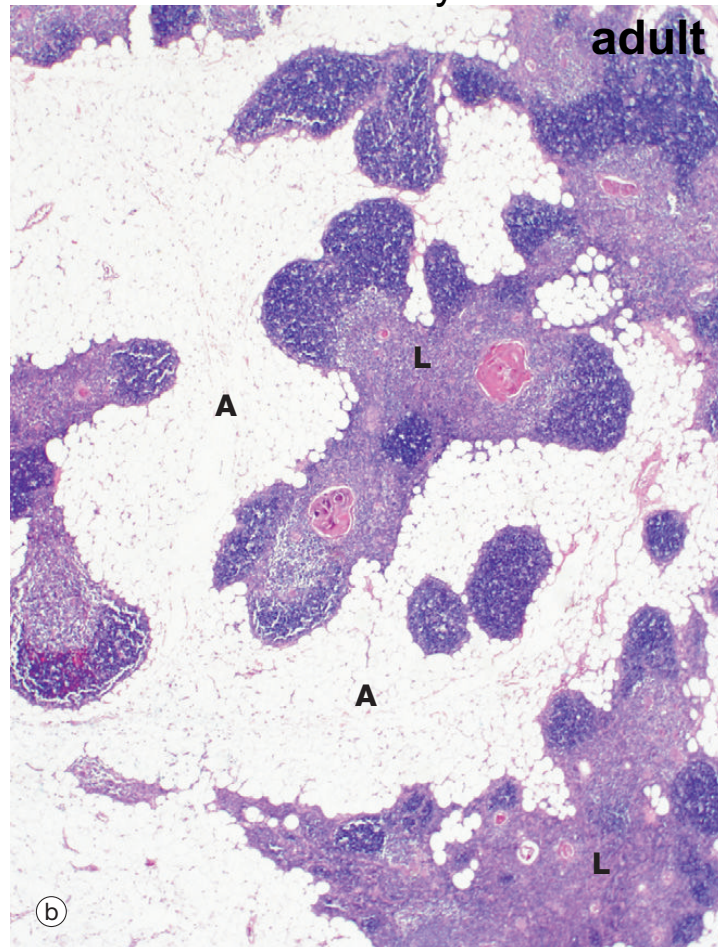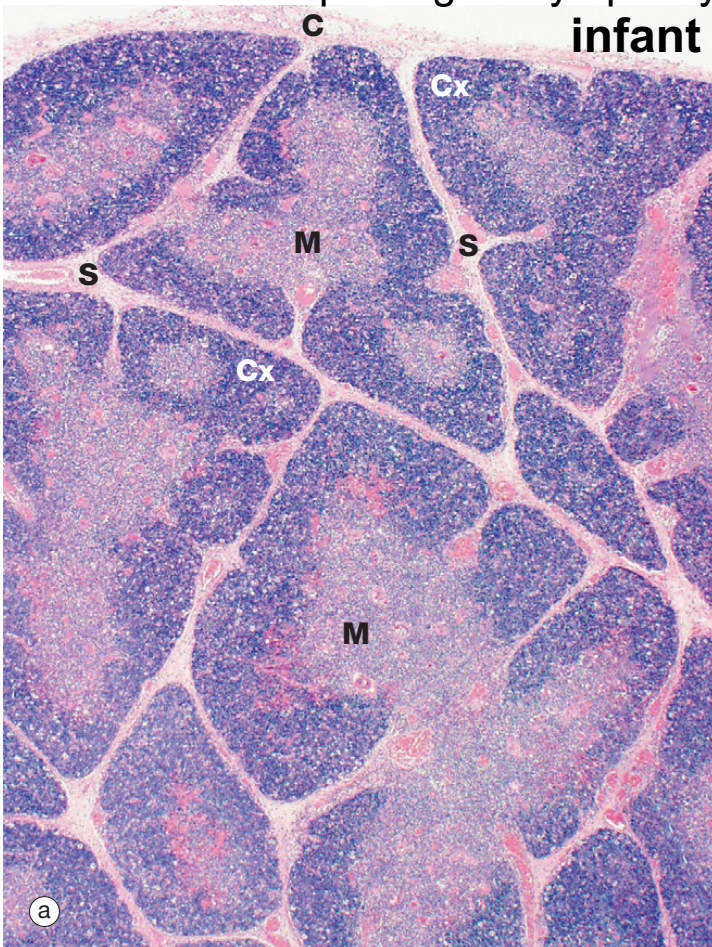
- ☐ **No afferent lymphatic vessels**

- ☐ Sympathetic and parasympathetic nerve fibers derived from the sympathetic chain and phrenic nerves, respectively, accompany the blood vessels into the thymus

L: lymphoid tissue
A: adipose tissue

Lymph Nodes (淋巴

- Bean-shaped, encapsulated organs that filter lymph located a
  vessels (neck, axilla, groins (腹股溝), lung hila, mesentery of the bowel and para-aortic area)
- 1 mm~2 cm
- Afferent lymphatic vessels and efferent lymphatic vessels
- Supporting elements:
  - Capsule (被囊)- dense connective tissue
  - Trabeculae (小樑)- dense connective tissue
  - Reticular tissue- composed of reticular cells and reticular fibers

Afferent lymph vessel
Lymphoid nodule
Cortex
Capsule
Subcapsular sinus
Paracortex
Medulla
Medullary sinus
→ Lymph
← Arterial blood
→ Lymph
→ Venous blood
Artery
Efferent lymphatic vessels
Vein
Subcapsular sinus
Postcapillary venules
Capillary bed
Trabecular sinus
Trabecula

Silver stain
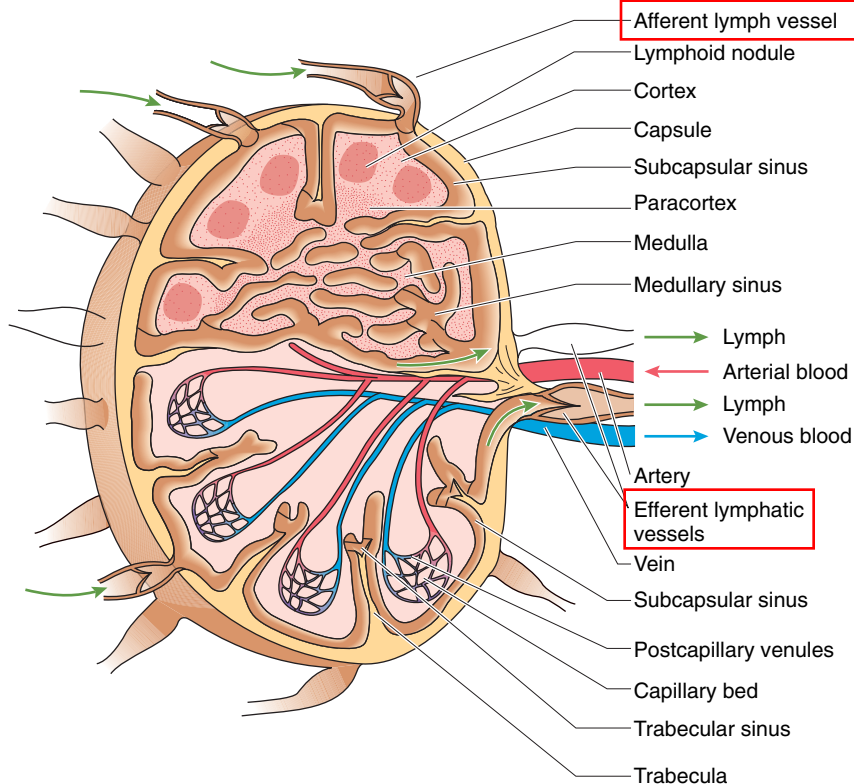
→: reticular fibers   ➤: reticular cells

Lymph Nodes (淋巴結)

- **Cortex (Cx)**: highly cellular
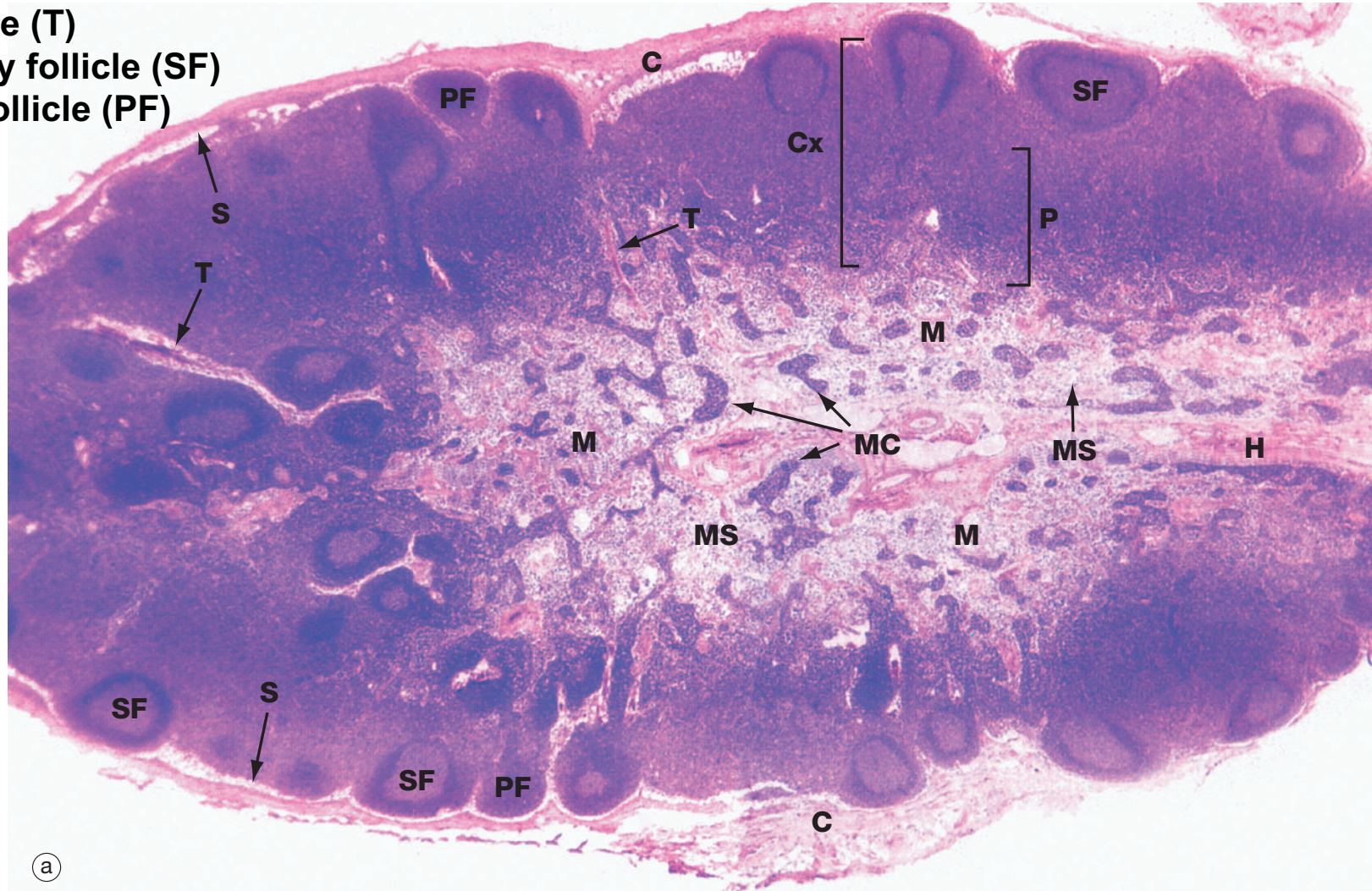- **Paracortex (P)**
- **Medulla (M):** less cellular
- **Hilum (H)**: efferent lymphatic vessels, artery and vein
- **Capsule (C)**
- **Trabeculae (T)**
- **Secondary follicle (SF)**
- **Primary follicle (PF)**

- **Subscapular sinus (S)**
- **Medullary cord (MC)**
- **Medullary sinus (MS)**

Spleen

- ☐ White pulp (**WP**): lymphatic aggregations
- ☐ Red pulp (**RP**): making up the bulk of the organ, is a highly vascular tissue
- ☐ Capsule (**C**)
- ☐ Trabeculae (**T**)
- ☐ No afferent lymphatics but efferent lymphatics at the hilum
- ☐ In the white pulp, the T cell areas surround the central arteries, forming the *periarteriolar lymphoid sheath* (*PALS*)
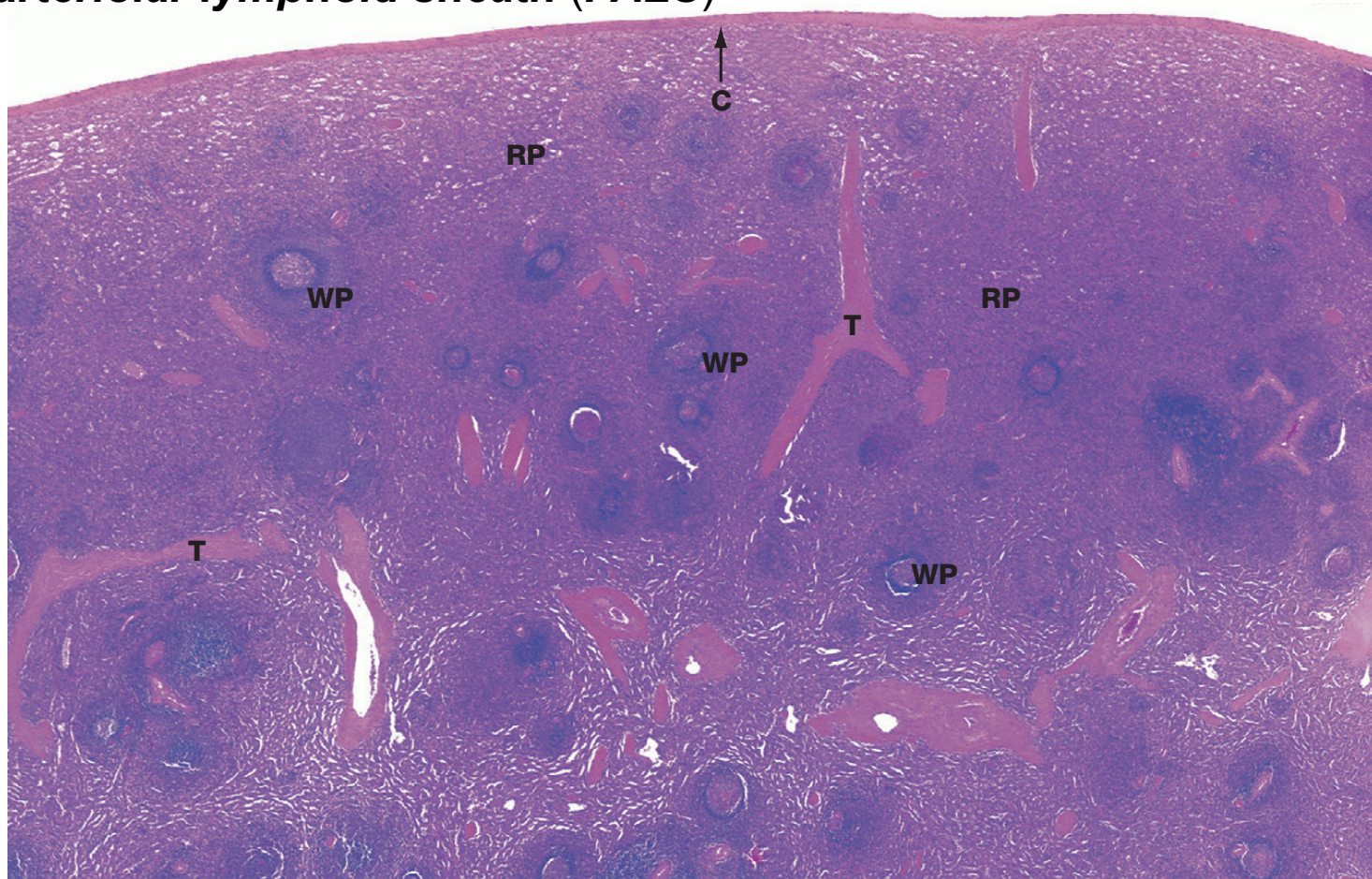
Overview of respiratory system

nasal cavity
nasopharynx
oropharynx
larynx
trachea
bronchus
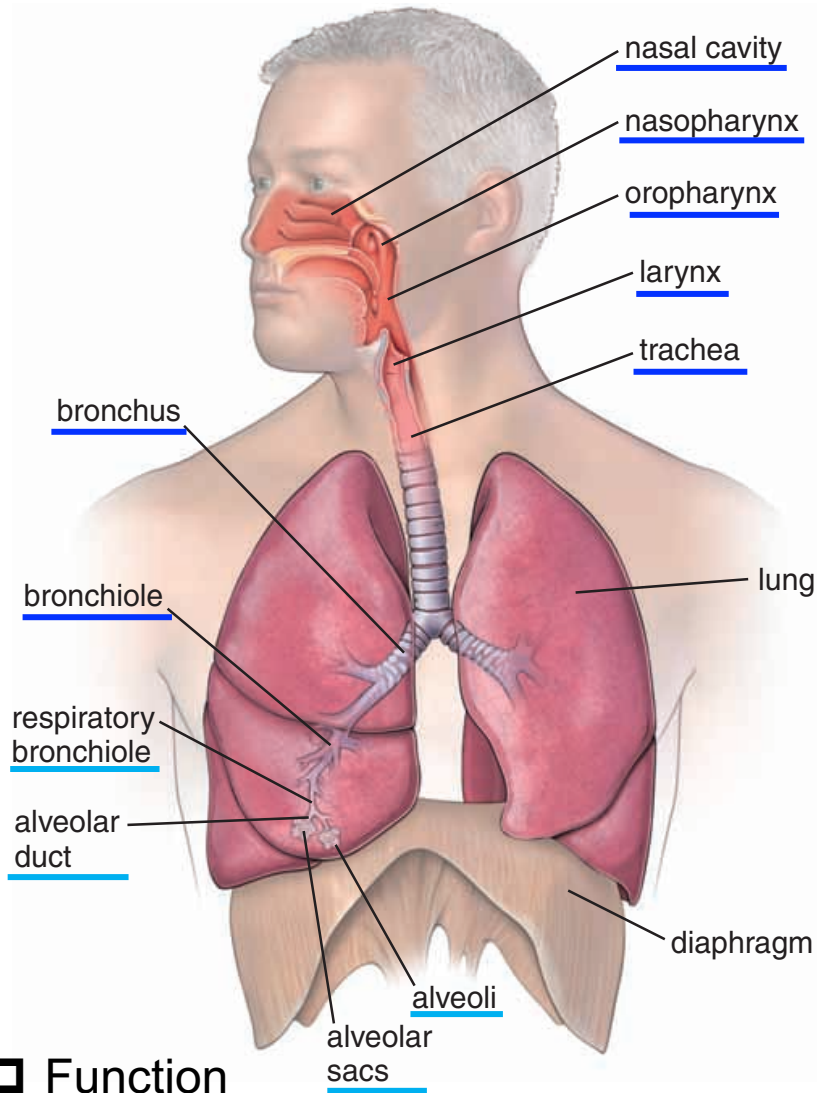lung
bronchiole
respiratory bronchiole
alveolar duct
diaphragm
alveoli
alveolar sacs

☐ Function
  • Modified inspired air
  • Facilitates olfaction
  • Respiratory gas exchange
  • Sound production

☐ **Conducting portion**
  • Nasal cavities
  • Nasopharynx
  • Oropharynx
  • Larynx
  • Trachea
  • Paired main (primary) bronchi
  • Bronchi
  • Bronchioles
  • Terminal bronchioles

external to the lungs

within the lungs

☐ **Respiratory portion**
  • Respiratory bronchioles-
    air conduction and gas exchange
  • Alveolar ducts
  • Alveolar sacs
  • Alveoli-primary sites of gas exchange

☐ Conditioning
  • Occurs in conducting portion
  • Warming, moistening, removal of particulate materials
  • Mucous and serous secretions
  • Goblet cells and mucus-secreting glands

Trachea

- 2.5 cm in diameter and 10 cm long
- Divides into the two main (primary) bronchi at about the middle of the thorax
- The wall of the trachea:
  - <u>Mucosa</u>→ ciliated, pseudostratified epithelium and an elastic, fiber-rich lamina propria
  - <u>Submucosa</u> →connective tissue
  - <u>Cartilaginous layer</u> → C-shaped hyaline cartilages
  - <u>Adventitia</u> → connective tissue that binds the trachea to adjacent structures

Tracheal epithelium

A

Cilia

Neuroendocrine cells

Goblet cell

Ciliated columnar cell

Basal cell
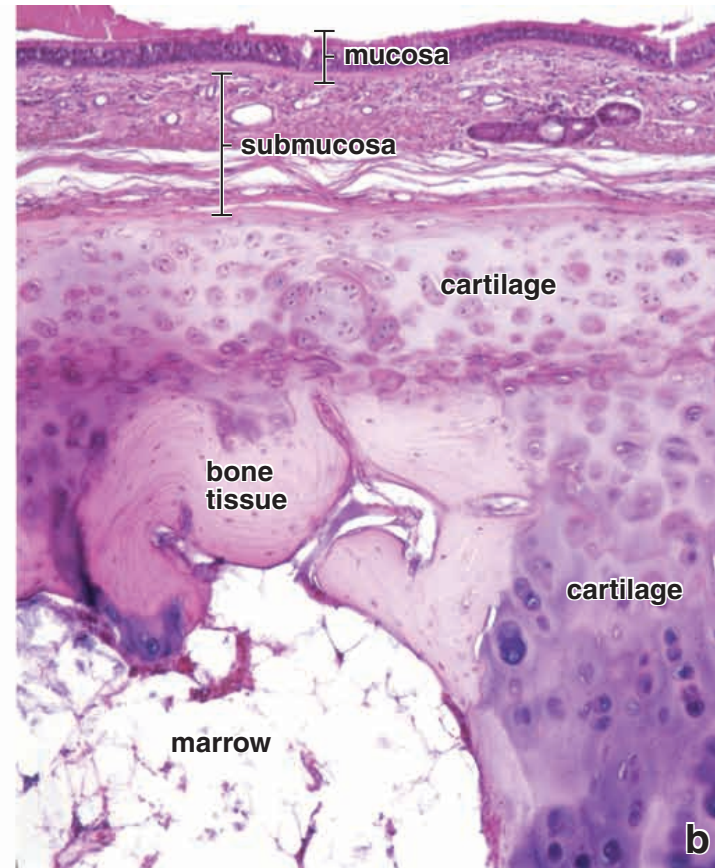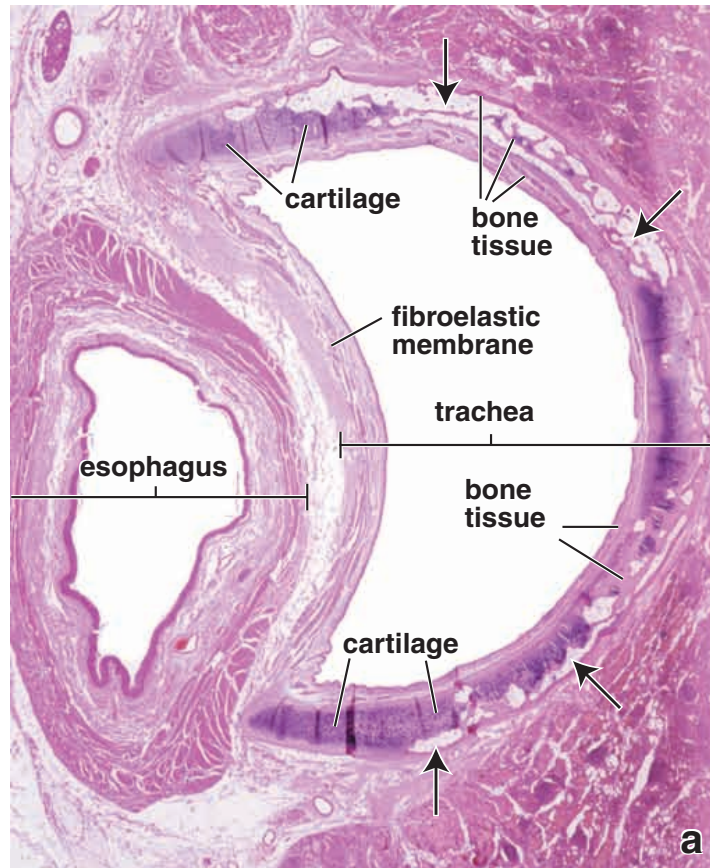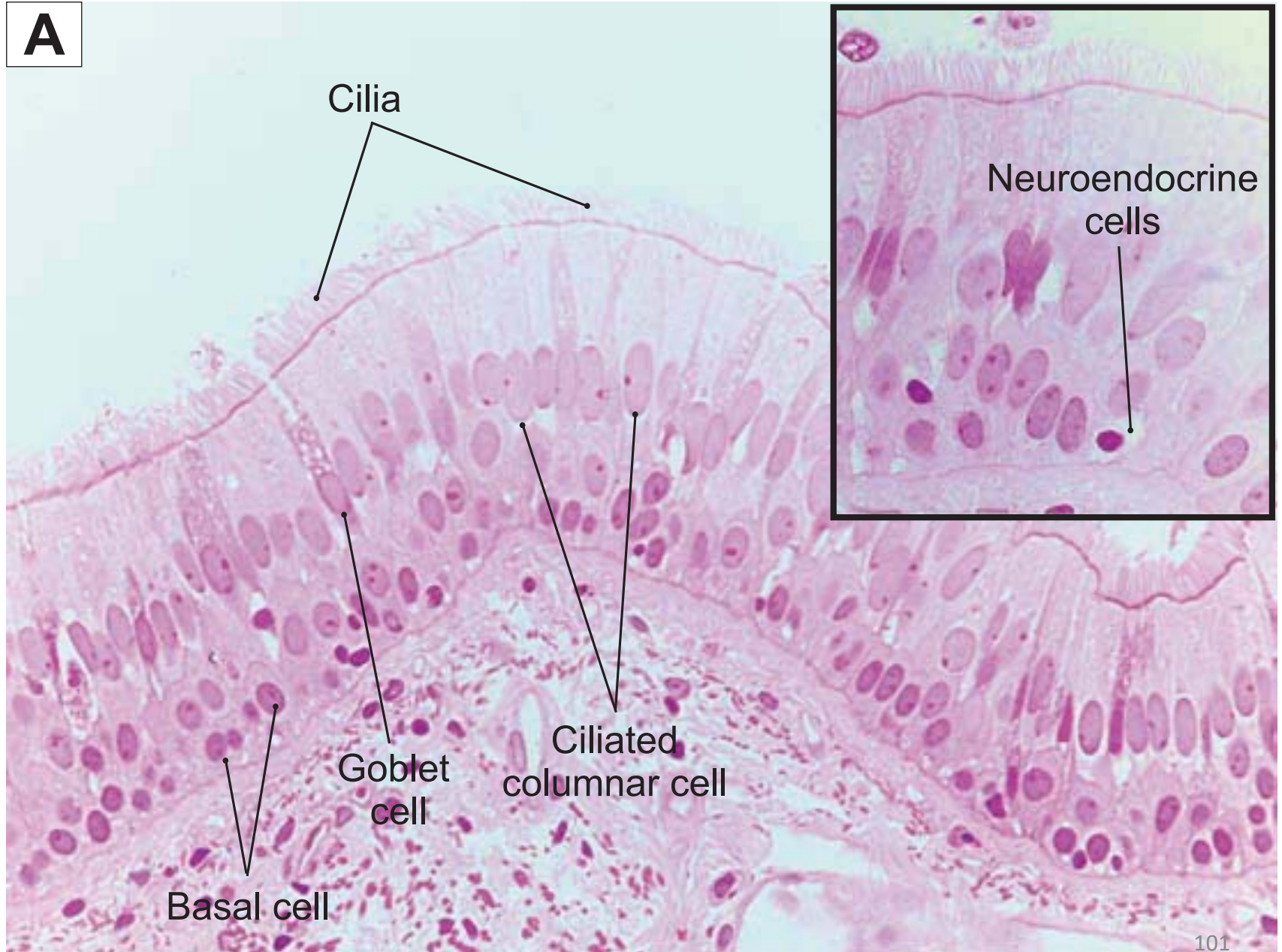
Trachea

- **Tracheal cartilages**
  - C-shaped
  - Hyaline cartilage-flexibility
- **Adventitia**
  - Binds the trachea to adjacent structures
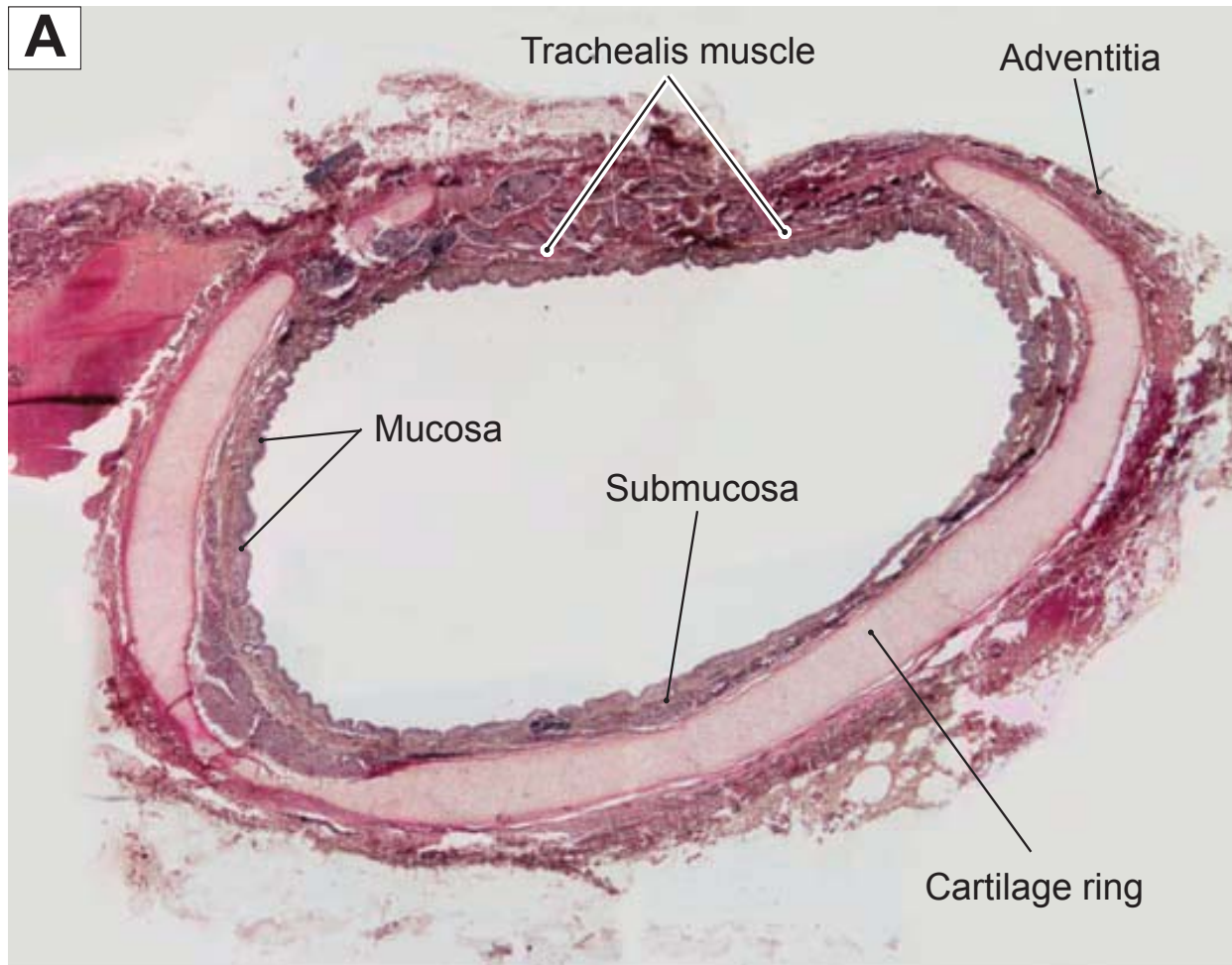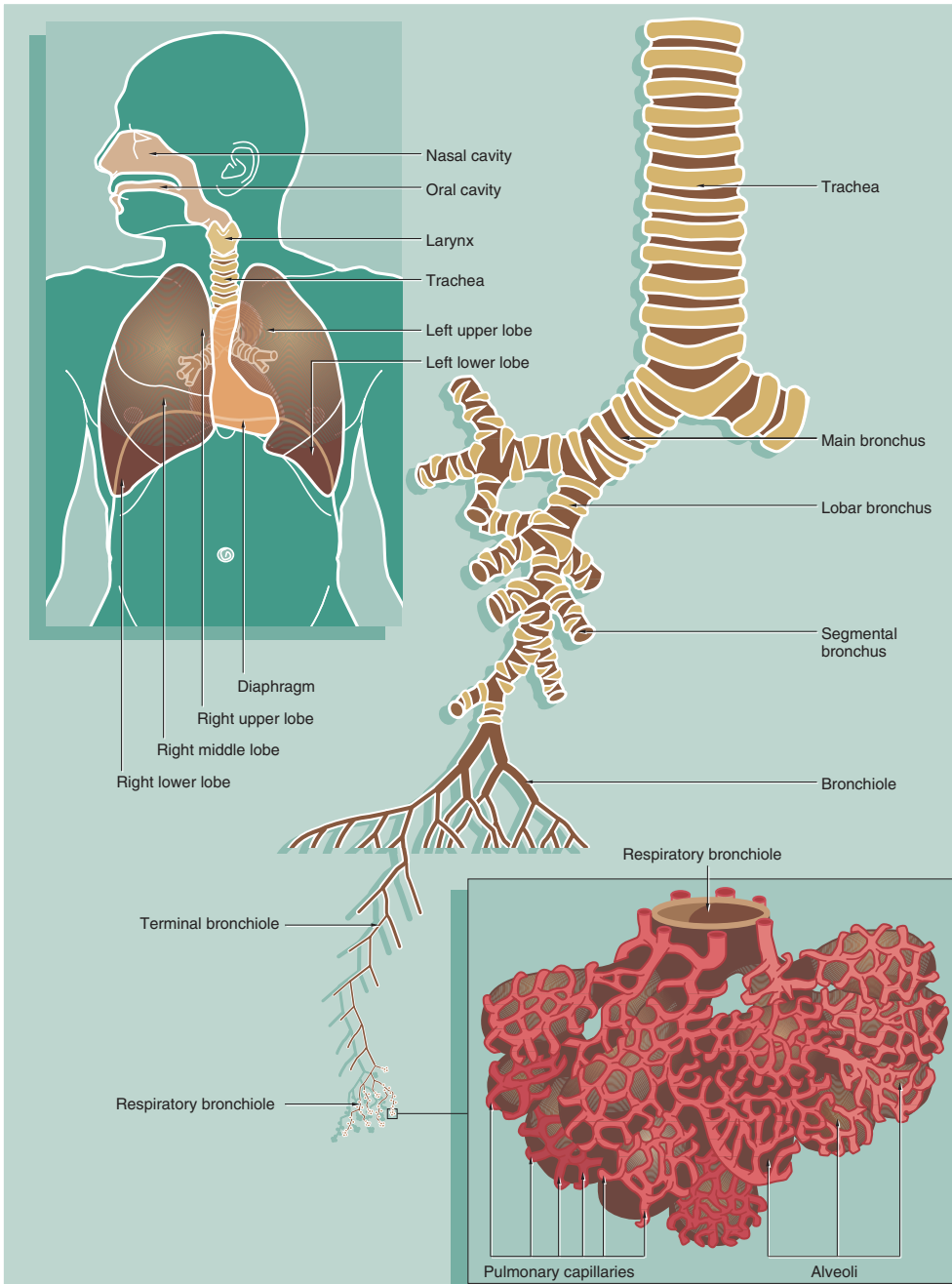 - Contains largest blood vessels and nerves

A

Trachealis muscle

Adventitia

Mucosa

Submucosa

Cartilage ring

Bronchi

Nasal cavity
Oral cavity
Larynx
Trachea
Left upper lobe
Left lower lobe
Diaphragm
Right upper lobe
Right middle lobe
Right lower lobe

Trachea
Main bronchus
Lobar bronchus
Segmental bronchus
Bronchiole
Respiratory bronchiole
Terminal bronchiole
Respiratory bronchiole
Pulmonary capillaries
Alveoli

☐ Trachea→
  {Right main (primary) bronchus:
        wider and significantly shorter
  {Left main (primary) bronchus

  ↓

  {Right lobar bronchi: 3
  {(secondary bronchi)
  {Left lobar bronchi : 2

  ↓

  {Right segmental bronchi: 10
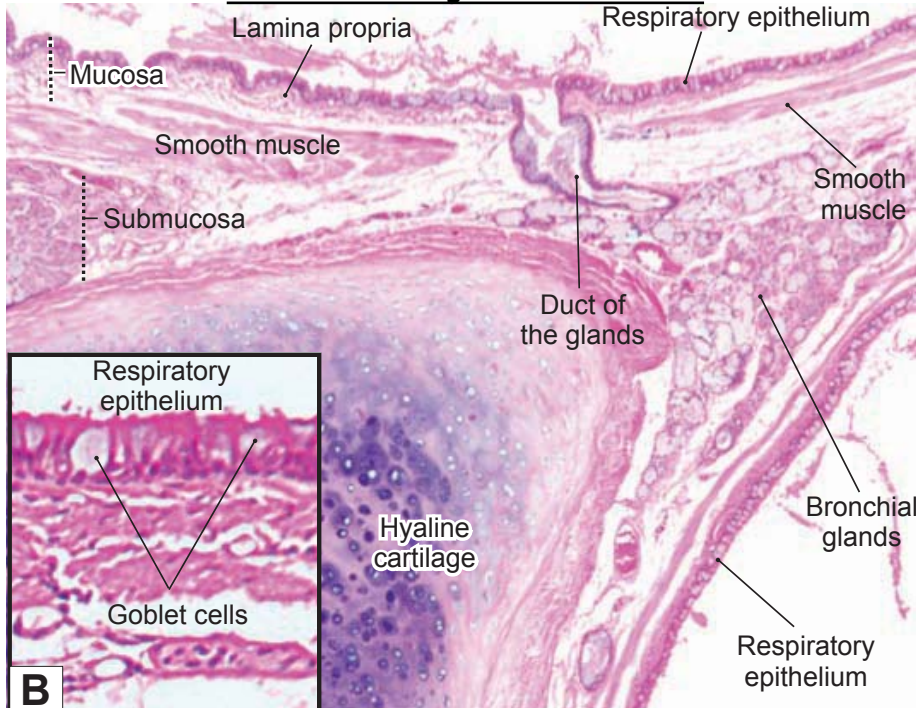 {Left segmental bronchi: 8

☐ Intrapulmonary bronchi
  • Cartilage ring →cartilage plates
  • The plates ultimately disappear at the
    point where the airway reaches a
    diameter of about 1 mm, whereupon the
    branch is designated a **bronchiole**
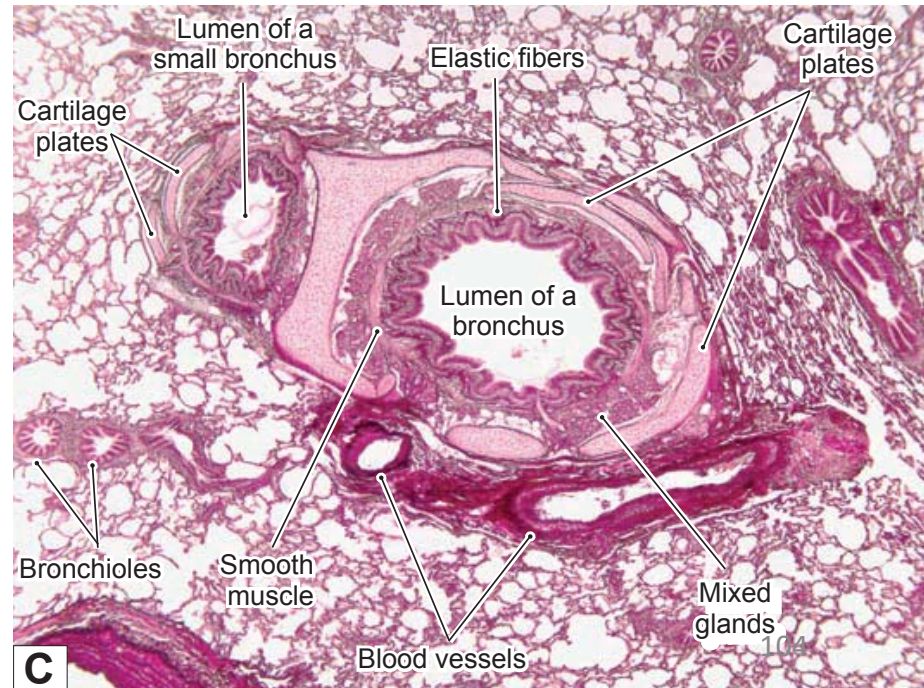 • Smooth muscle forms a complete
    circumferential layer

103

Cartilage layer- discontinuous cartilage [...]
• **Adventitia**- dense connective tissue, con[...]
lung parenchyma

Secondary bronchus

Lamina propria
Respiratory epithelium
Mucosa
Smooth muscle
Submucosa
Duct of
the glands
Smooth
muscle
Respiratory
epithelium
Goblet cells
Hyaline
cartilage
Bronchial
glands
Respiratory
epithelium
B

Tertiary bronchus

Lumen of a
small bronchus
Elastic fibers
Cartilage
plates
Cartilage
plates
Lumen of a
bronchus
Bronchioles
Smooth
muscle
Blood vessels
Mixed
glands
C
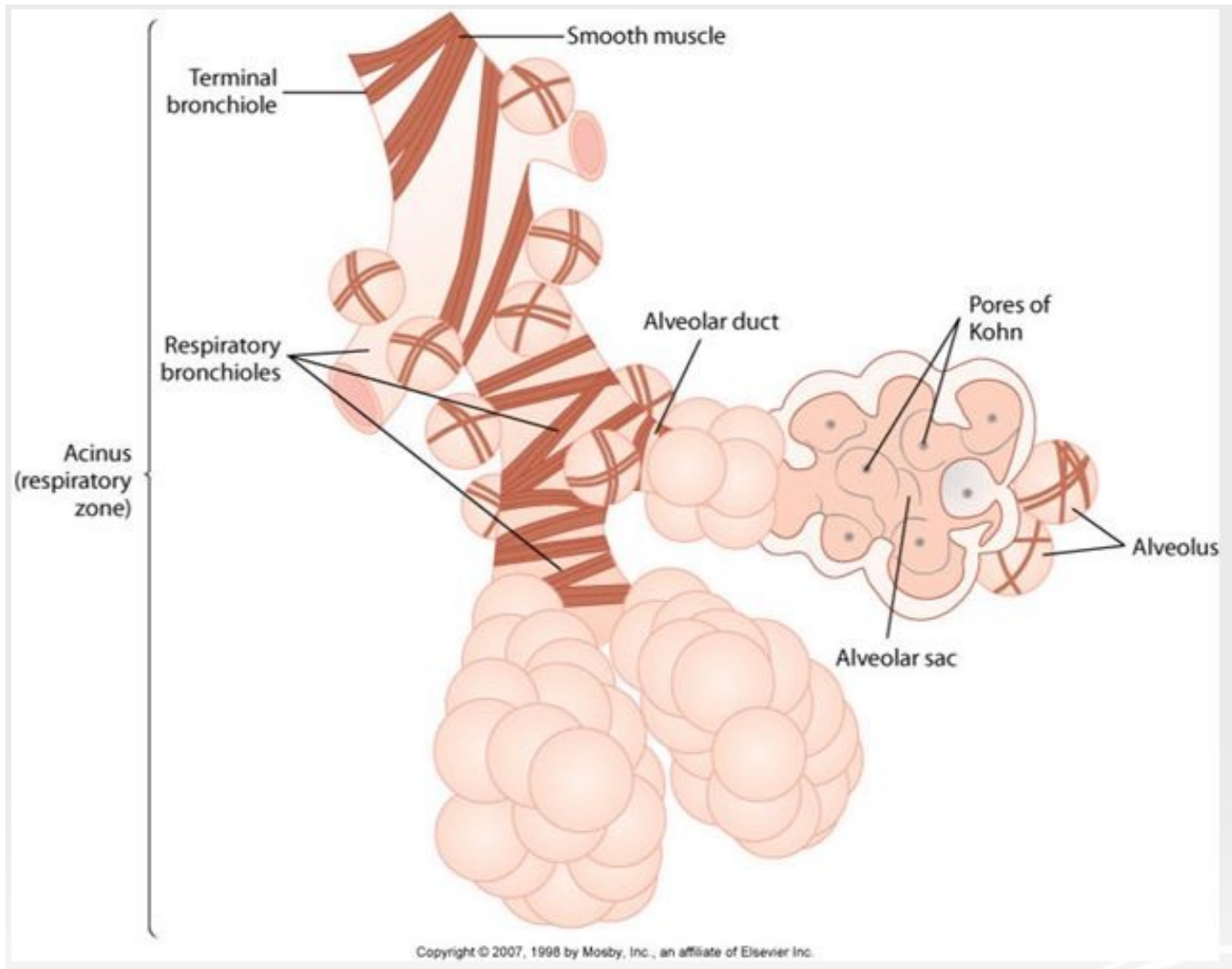
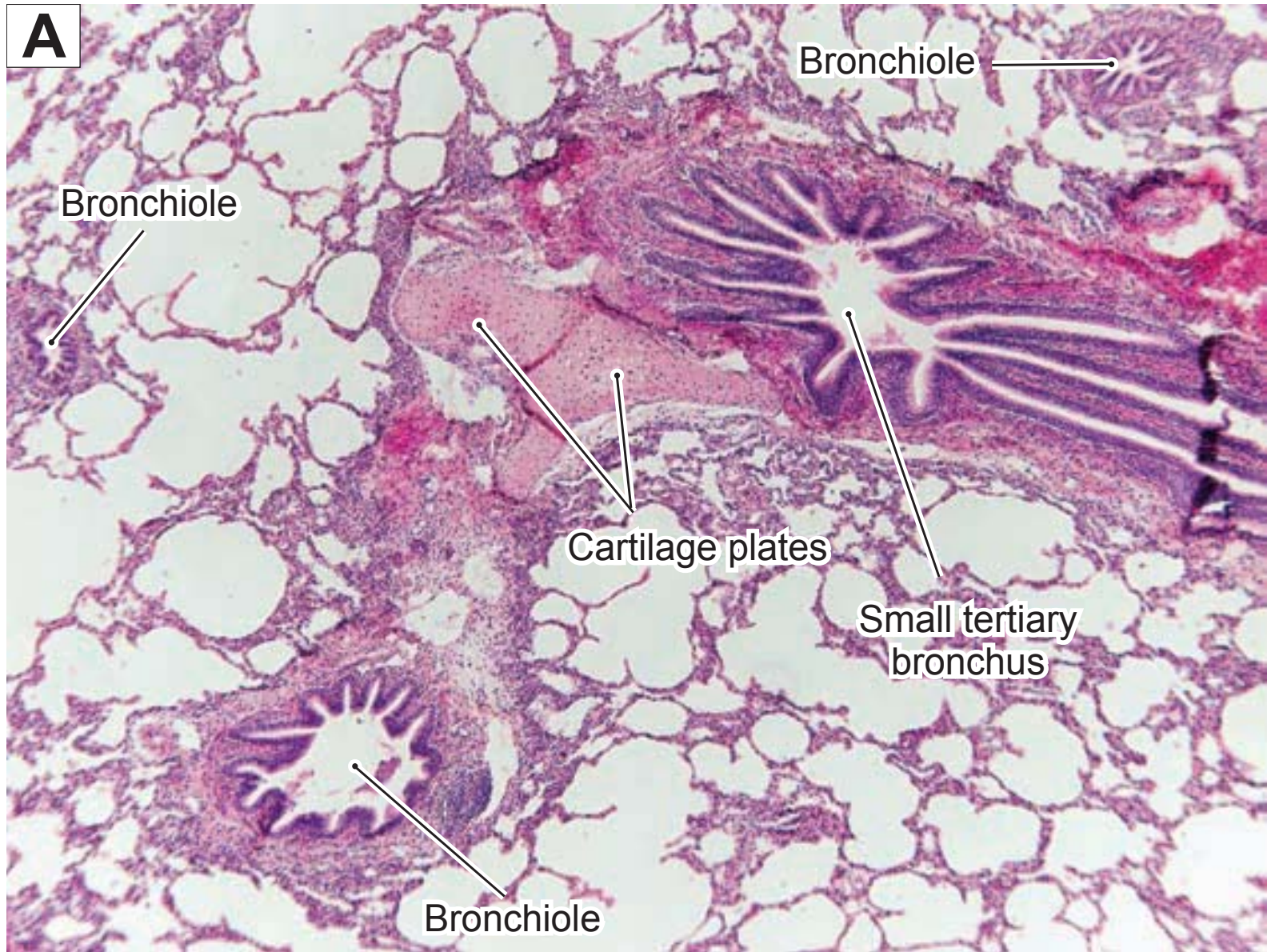# Bronchioles

☐ Bronchopulmonary segments →pulmonary lobules
     (Segmental bronchi)   (Bronchioles)

☐ <u>Pulmonary acini</u> →terminal bronchiole+respiratory bronchiole+alveoli
☐ <u>Respiratory bronchiolar unit</u> →single respiratory bronchiole +alveoli

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Bronchioles

A

Bronchiole

Bronchiole

Cartilage plates

Small tertiary bronchus

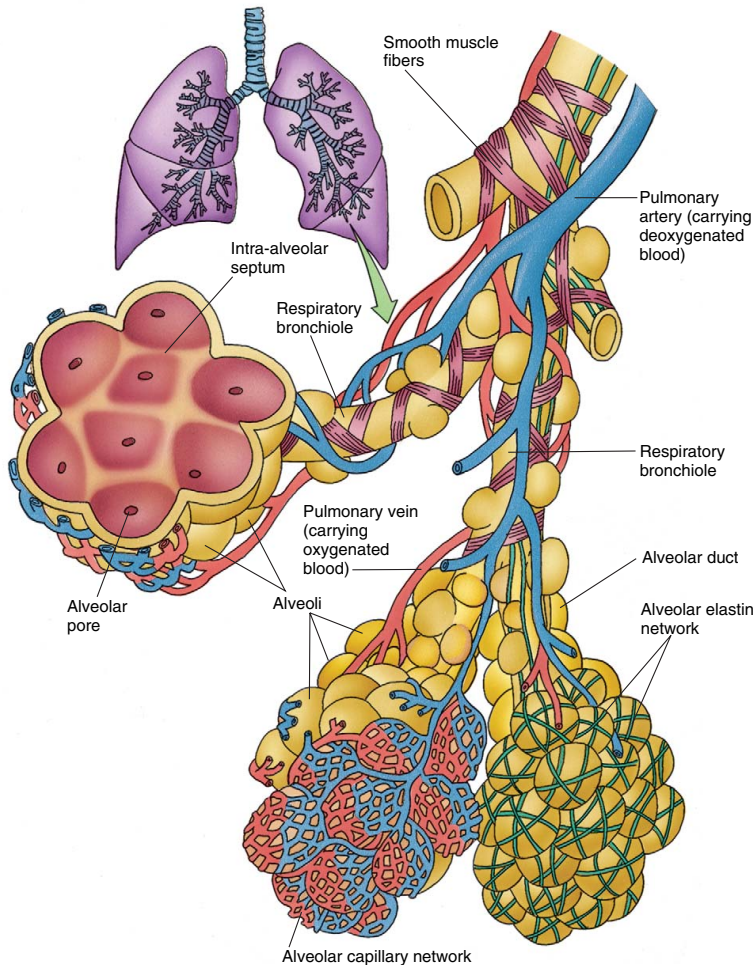Bronchiole

Alveoli

- ☐ Site of gas exchange
- ☐ 150-250 million alveoli in each adult lung
- ☐ **Alveolar ducts**→no walls, only alveoli, as their peripheral boundary
  → rings of smooth muscle are present in the knob-like interalveolar septa
- ☐ **Alveolar sacs**→ spaces surrounded by clusters of alveoli
- ☐ **Alveolar septum/septal wall** → tissue between adjacent alveolar air spaces

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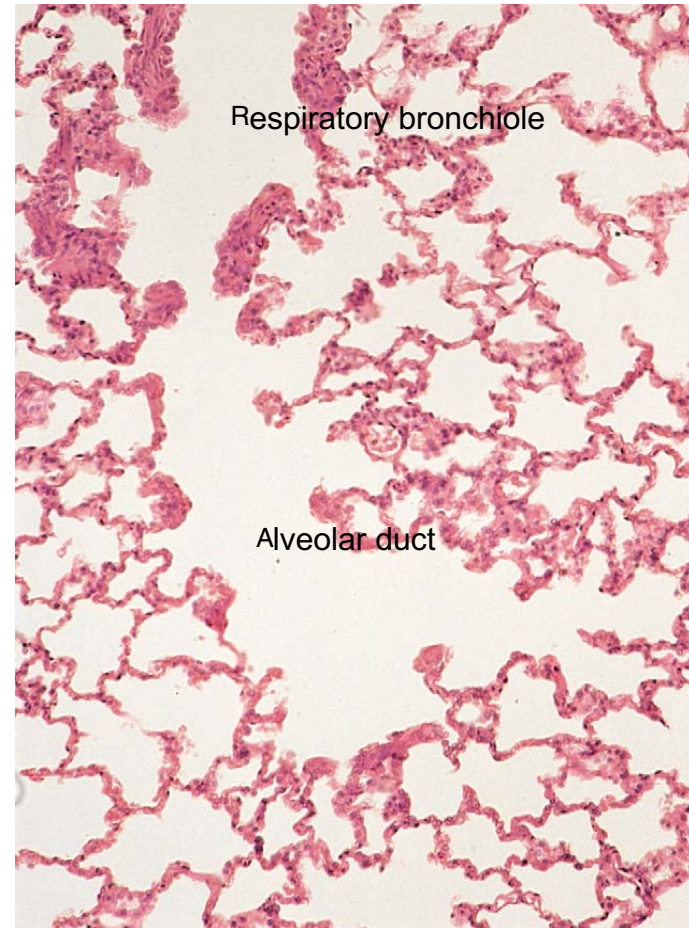
Alveolar epithelium

- **Type I alveolar cells (type I pneumocytes) (佔40 %，覆蓋表面積 95 %)**
  - Thin squamous cells
  - Not capable of cell division
- **Type II alveolar cells (type II pneumocytes, septal cells)**
  - Secretory cells: surfactant
  - Cuboidal cells
  - Lamellar bodies
  - Progenitor cells for type I alveolar cells
- **Brush cells**: monitor air quality in the lung

Endothelial cell
Fused basement laminae
Type II pneumocyte
O_2
CO_2
Type I pneumocyte
Alveolar macrophage (dust cell)

Type II pneumocyte
Alveolar septum
Capillary
Endothelial cell

A
Air space (alveolus)
Type I pneumocytes
Type I pneumocytes
Interalveolar septa
Type I pneumocyte