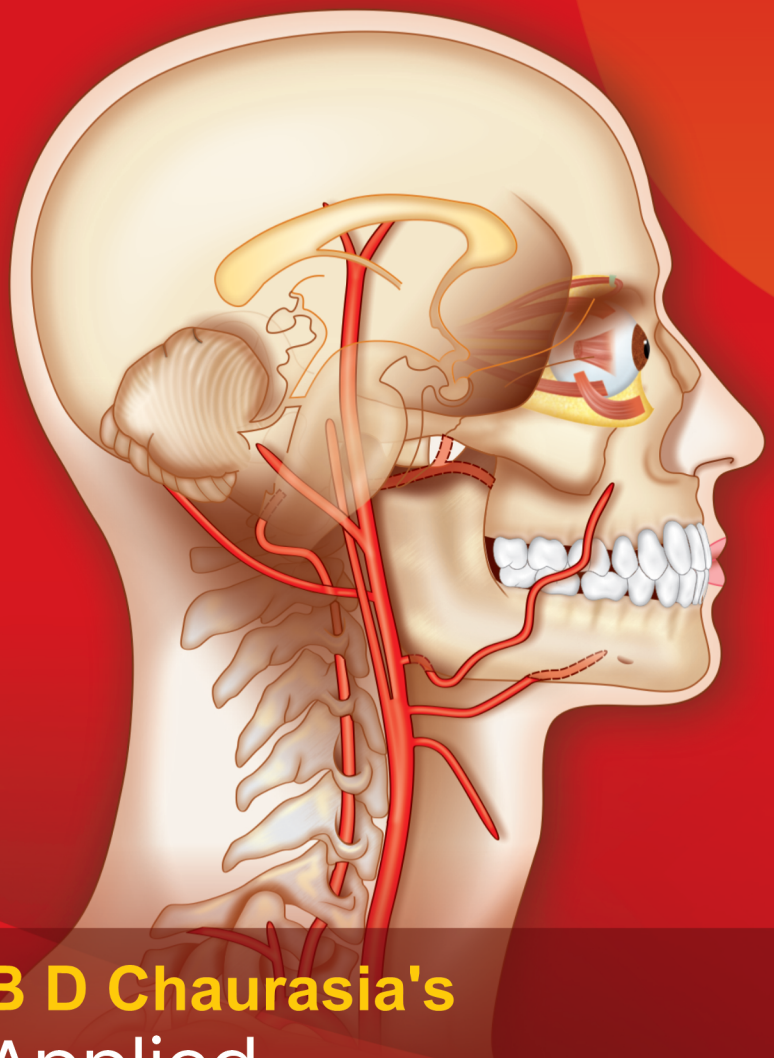
The Best Selling
Medical Book is now available for
Nursing Students

Compiled and reviewed by the leading Medical and Nursing Faculties PAN India
Now study Anatomy & Physiology in the most simplified and interactive way

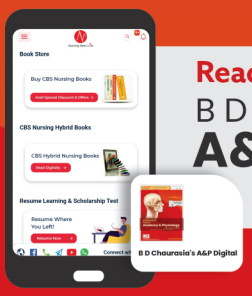
Based on
INC Syllabus
2021-22

I
Semester

International Standard Colored Edition



The **Hybrid** *Edition*
(Book + Digital)



Read Digitally
B D Chaurasia's
A&P Digital

B D Chaurasia's
Applied
Anatomy & Physiology
for BSc Nursing Students

As per the Revised INC Syllabus (2021-22) for BSc Nursing

CBS
Dedicated to Education
Nursing Knowledge Tree
An Initiative by CBS Nursing Division

CBS Publishers & Distributors Pvt. Ltd.

Edited by **Krishna Garg**

6 Amazing Features

See & Perceive
Get **100+** Images in 3D Animation videos with labelings & voice-overs.

Read digitally
200+ Key terminologies with their meanings

Listen and Recall
Chapter wise Golden Points for Last Minute Revision in Podcast form **(Only in App)**

Revise on the Go
500+ Chapter wise High Yielding Tables, Flowcharts & Images for Quick Reference

Assess Yourself
Chapter wise MCQs/Match the Following/Fill in the Blanks

Dil Mange More Content
- Chapter wise Long and Short Answer Questions (Solved)
- 5-10 Conceptual videos of Physiology in animation form (Optional)
- 50+ Dissection images in High Resolution
- Regular Hybrid Updates covering Recent Advances, Mnemonics, Tips & Tricks and much more

B D Chaurasia's A&P Digital
Read Digitally

How to Access B D Chaurasia's A&P Digital

Content will be unlocked on 1st Jan 2022

Validity: 1 Year from the Date of Activation of Code

Scan the QR Code to know "How to access **B D Chaurasia's A&P Digital** in Nursing Next Live App"

- Gently scratch above to reveal your unique code.
- Download Nursing Next Live App from Google Play Store
- Complete the sign up process
- On Home Screen, click on "CBS Hybrid Nursing Books (Read Digitally)" tab and then click on **B D Chaurasia's A&P Digital**
- Enter the unique code mentioned above
- Start exploring the content

- **B D Chaurasia's A&P Digital** is free for the buyers of **B D Chaurasia's Applied Anatomy & Physiology for BSc Nursing Students** which will be valid for 1 year and the reader can't claim any refund in case he/she is not able to access **B D Chaurasia's A&P Digital**.
- Content given in this section is completely different from other packages of Nursing Next Live.
- **B D Chaurasia's A&P Digital** cannot be clubbed with any other package of Nursing Next Live App. The reader needs to buy other packages of Nursing Next Live in order to access them.
- The Unique Code is for one-time use only. In case the unique code given in this book is already in use, company will not issue any new code in any circumstances.
- **The validity of this package is 1 year from the date of Activation of Code.**
- In case there is no unique code in the book, kindly share the image of this page along with a copy of the bill on the helpline number.

Scan the QR code to download NNL App & to view the sample video in 3D Animation Form

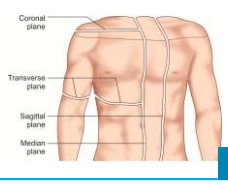
Nursing Next Live App > CBS Hybrid Nursing Books > B D Chaurasia A&P Digital

For any assistance
Email at **cbs_hybridbooks@nursingnextlive.in**
or Call/Whatsapp @ **+91-98-111-32-333**
Mon to Sat 10:00 AM to 6:00 PM

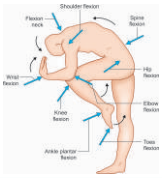
See & Perceive

Believe on what you see & perceive from what you watch

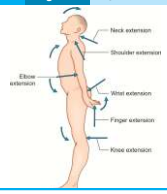
Get 100+ Images in 3D Animation videos
with labelings & voice-over

Median, sagittal, coronal and transverse planes
Chapter 1 Page 6 Fig 1.9


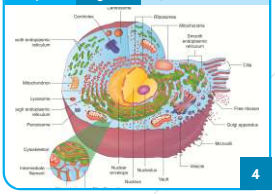
1

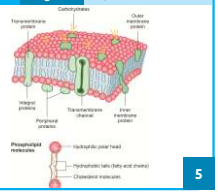
Flexion movements
Chapter 1 Page 11 Fig 1.24


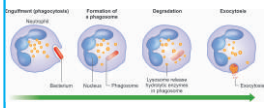
2

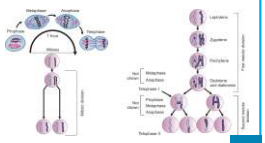
Extension movements
Chapter 1 Page 11 Fig 1.25


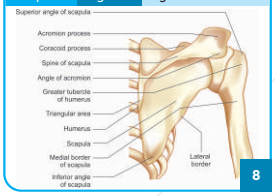
3

B. Electron microscopic structure of a cell
Chapter 2 Page 19 Fig 2.2B

4

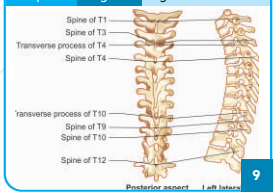
B. Fluid mosaic model in detail
Chapter 2 Page 20 Fig 2.3B

5

Phagocytosis
Chapter 2 Page 23 Fig 2.8

6

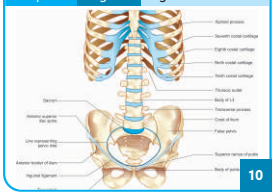
A. Mitosis; B. Meiosis
Chapter 2 Page 33 Fig 2.22A and B

7

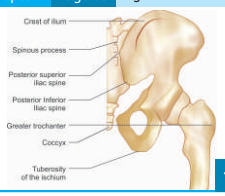
Figs 4.9 B: Bony landmarks in the scapular region with underlying bones: B. Skeletal view
Chapter 4 Page 77 Fig 4.9B


8

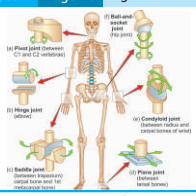
Surface landmarks on the thoracic part of body-spine with posterior and left lateral views of the thoracic vertebrae
Chapter 4 Page 80 Fig 4.14B


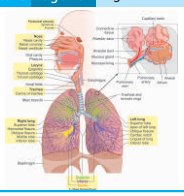
9

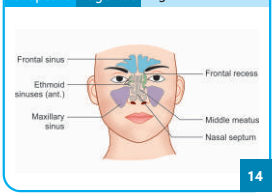
Bony landmarks in lower part of thorax, lumbar vertebrae, false and true pelvis
Chapter 4 Page 82 Fig 4.17

10

Bony landmarks on gluteal region with underlying bones: B. Skeletal view
Chapter 4 Page 83 Fig 4.20B


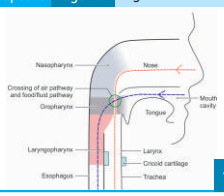
11

Various joints of a human body
Chapter 4 Page 90 Fig 4.31B

12

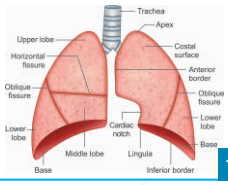
Human Respiratory System
Chapter 5 Page 104 Fig 5.1

13

Paranasal sinuses. B. Front view
Chapter 5 Page 108 Fig 5.10B


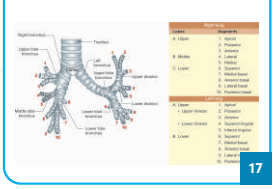
14

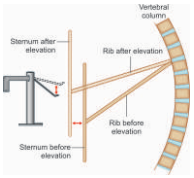
Passage of air and fluid through the pharynx - B. Diagrammatic representation
Chapter 5 Page 109 Fig 5.11B


15

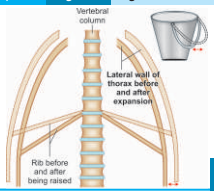
Anatomical differences between right and left lungs
Chapter 5 Page 118 Fig 5.23


16

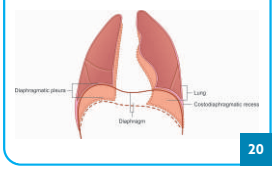
Bronchopulmonary segments of the lungs
Chapter 5 Page 119 Fig 5.25

17

Pump-handle movement
Chapter 5 Page 121 Fig 5.27


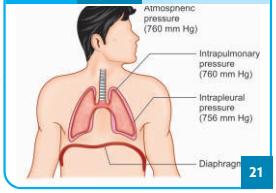
18

Bucket-handle movement
Chapter 5 Page 121 Fig 5.28


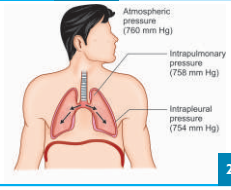
19

Lung and diaphragm during expiration and descent of diaphragm during inspiration
Chapter 5 Page 122 Fig 5.29


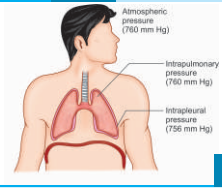
20

Before inspiration
Chapter 5 Page 122 Fig 5.30


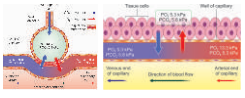
21

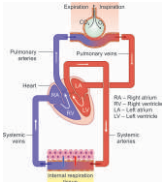
Beginning of inspiration
Chapter 5 Page 122 Fig 5.31


22

End of inspiration
Chapter 5 Page 123 Fig 5.32


23

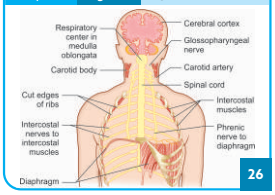
Lung and diaphragm during expiration and descent of diaphragm during inspiration
Chapter 5 Page 125 Fig 5.34A and B

24

External and internal respiration
Chapter 5 Page 125 Fig 5.35


25

Nerves involved in the control of respiration

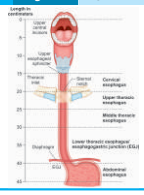
Chapter 5 Page 126 Fig 5.36



26

B. Length of esophagus from incisors

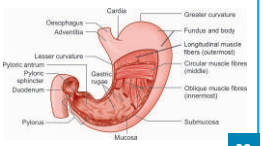
Chapter 6 Page 157 Fig 6.11B



27

Structure of stomach with musculature

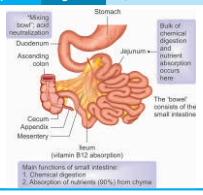
Chapter 6 Page 165 Fig 6.22



28

Structure and functions of small intestine

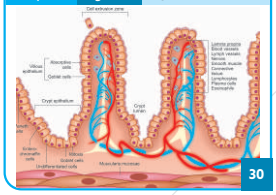
Chapter 6 Page 169 Fig 6.27



29

Histology of mucosal layer of small intestine

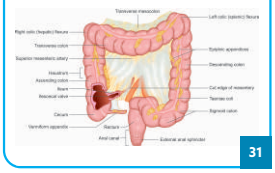
Chapter 6 Page 171 Fig 6.30



30

Large intestine and the position of vermiform appendix

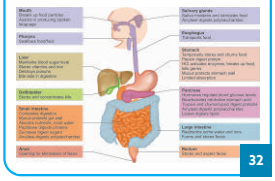
Chapter 6 Page 173 Fig 6.33



31

Functions of various parts of digestive system

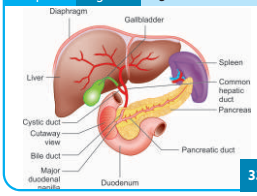
Chapter 6 Page 178 Fig 6.40



32

Accessory organs of digestive system

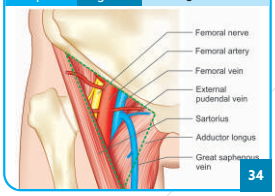
Chapter 6 Page 182 Fig 6.42



33

Femoral triangle

Chapter 7 Page 84 Box Figure



34

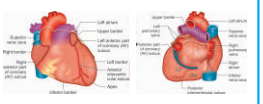
Common pulse sites

Chapter 7 Page 219 Fig 7.16

35

A. Sternocostal surface; B. Base of the heart

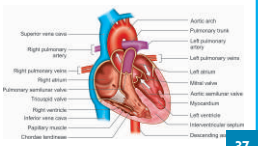
Chapter 7 Page 207 Fig 7.2A and B



36

Chambers of the Heart

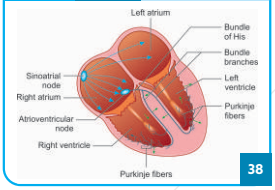
Chapter 7 Page 208 Fig 7.3



37

Conduction system of the heart and spread of impulse

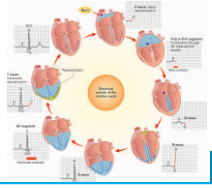
Chapter 7 Page 212 Fig 7.7



38

Electrical events in heart

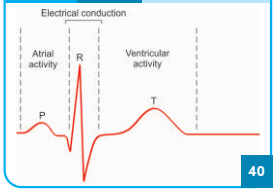
Chapter 7 Page 213 Fig 7.9



39

Normal electrocardiogram

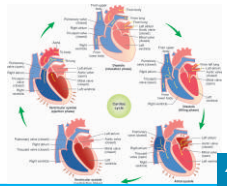
Chapter 7 Page 213 Fig 7.10



40

Cardiac cycle

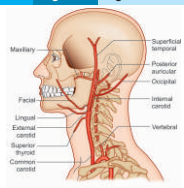
Chapter 7 Page 215 Fig 7.11



41

B. Branches of external carotid artery

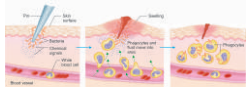
Chapter 7 Page 232 Fig 7.31B



42

Inflammation

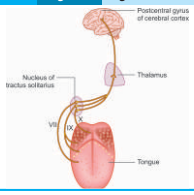
Chapter 8 Page 268 Fig 8.12A to C



43

Taste pathway

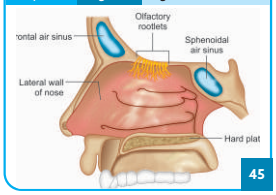
Chapter 11 Page 336 Fig 11.4A



44

Olfactory rootlets for sense of smell

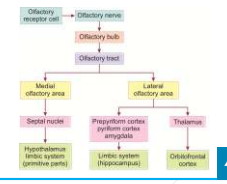
Chapter 11 Page 338 Fig 11.5A



45

Pathway of Smell

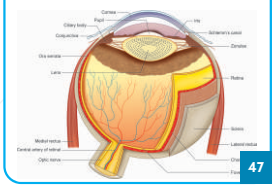
Chapter 11 Page 339 Fig 11.7B



46

Cross section of human eye

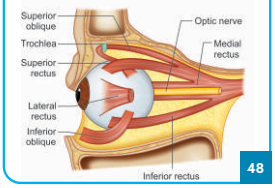
Chapter 11 Page 341 Fig 11.9



47

Extraocular muscles-lateral view

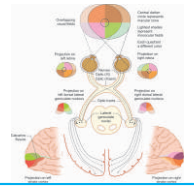
Chapter 11 Page 344 Fig 11.13



48

Visual Pathway

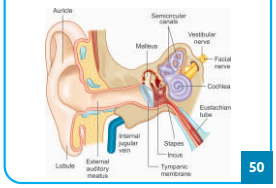
Chapter 11 Page 346 Fig 11.16



49

Ear - A. Anatomy

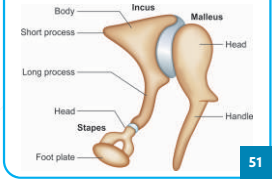
Chapter 11 Page 348 Fig 11.20



50

Auditory Ossicles of Middle Ear

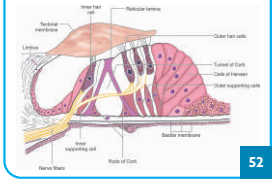
Chapter 11 Page 349 Fig 11.23



51

Structure of Cochlea

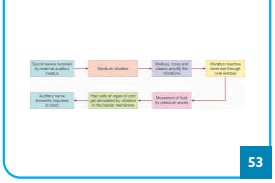
Chapter 11 Page 350 Fig 11.27



52

Mechanism of hearing

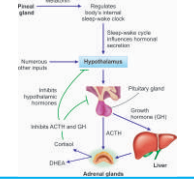
Chapter 11 Page 352 Fig 11.30



53

Pineal gland and Role in sleep and wake cycle

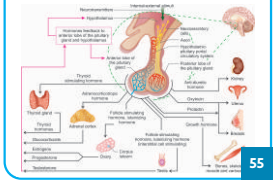
Chapter 12 Page 375 Fig 12.5B



54

Hormones of the posterior and anterior pituitary

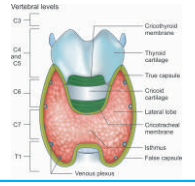
Chapter 12 Page 378 Fig 12.8



55

Thyroid Gland — Location and Parts

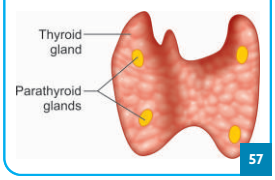
Chapter 12 Page 381 Fig 12.12



56

Position of parathyroid gland

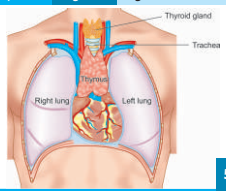
Chapter 12 Page 384 Fig 12.16



57

A. Thymus - location of thymus

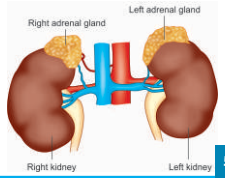
Chapter 12 Page 385 Fig 12.18A



58

Adrenal gland

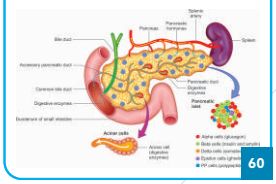
Chapter 12 Page 387 Fig 12.21A



59

A. Anatomy of pancreas with pancreatic islet

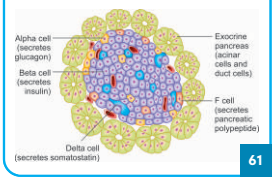
Chapter 12 Page 391 Fig 12.27A



60

B. Cells of the islets of Langerhans

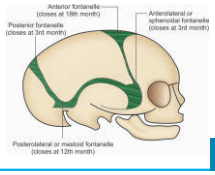
Chapter 12 Page 391 Fig 12.27B



61

Fontanels of the skull

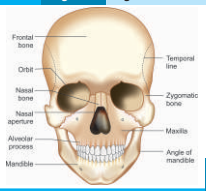
Chapter 13 Page 416 Fig 13.15



62

Skull: A. Front view

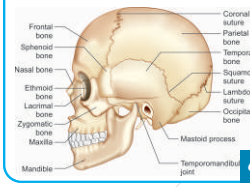
Chapter 13 Page 417 Fig 13.16A



63

Skull: B. Lateral view

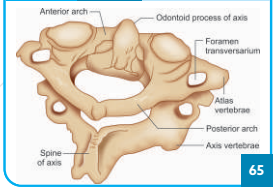
Chapter 13 Page 417 Fig 13.16B



64

Articulation between atlas and axis vertebrae

Chapter 13 Page 421 Fig 13.22



65

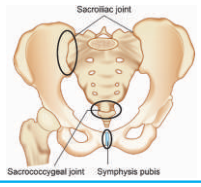
Bones of upper limb

Chapter 13 Page 422 Fig 13.24

66

A. Pelvic girdle

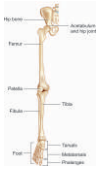
Chapter 13 Page 425 Fig 13.29A



67

B. Bones of lower limb

Chapter 13 Page 425 Fig 13.29B



68

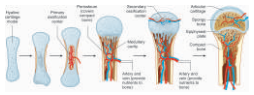
Arches of foot

Chapter 13 Page 427 Fig 13.33

69

Ossification

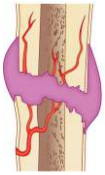
Chapter 13 Page 412 Fig 13.9A to F



70

Bone Healing

Chapter 13 Page 413 Fig 13.11A



71

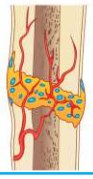
Bone Healing

Chapter 13 Page 413 Fig 13.11B

72

Bone Healing

Chapter 13 Page 413 Fig 13.11C



73

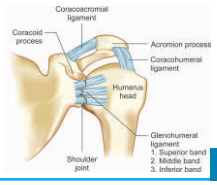
Bone Healing

Chapter 13 Page 413 Fig 13.11D

74

Shoulder joint: B. Anterior view

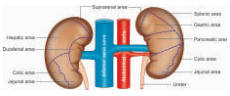
Chapter 14 Page 439 Fig 14.7B



75

Anterior relations of kidneys

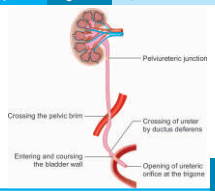
Chapter 16 Page 504 Fig 16.3



76

Constrictions in the course of ureter

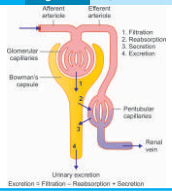
Chapter 16 Page 507 Fig 16.12



77

Tubular secretion—steps involved in urine formation

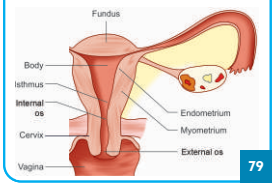
Chapter 16 Page 516 Fig 16.25



78

Ovaries and their relationships to uterine tube and uterus

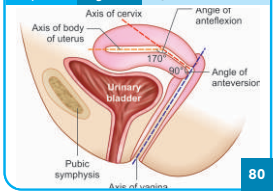
Chapter 16 Page 534 Fig 17.7



79

Uterus - Angulation of uterus, vagina and cervix with body of uterus

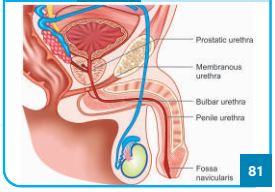
Chapter 17 Page 538 Fig 17.11B



80

Male reproductive organs

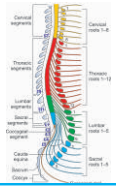
Chapter 18 Page 562 Fig 18.1



81

Spinal cord with 31 pairs of spinal nerves

Chapter 19 Page 600 Fig 19.19



82

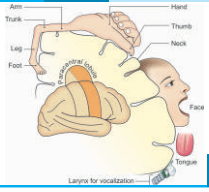
Superolateral surface of cerebral hemisphere: A. Original

Chapter 19 Page 616 Fig 19.43A

83

Motor homunculus on the precentral gyrus

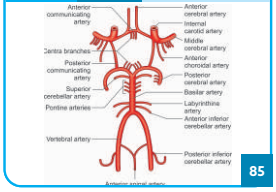
Chapter 19 Page 618 Fig 19.47



84

Circle of Willis and the branches of arteries supplying the brain

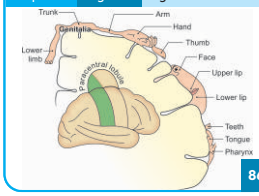
Chapter 19 Page 629 Fig 19.59



85

Sensory homunculus of the postcentral gyrus

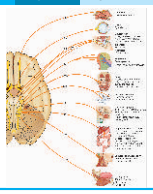
Chapter 19 Page 620 Fig 19.49



86

Summary of the cranial nerves

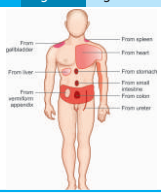
Chapter 20 Page 652 Fig 20.14



87

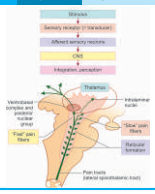
Common areas of referred pain;

Chapter 20 Page 655 Fig 20.16



Pain pathway: A. Up to thalamus

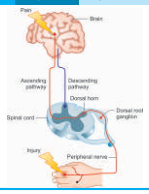
Chapter 20 Page 656 Fig 20.17A



88

Pain pathway: B. Up to cerebrum

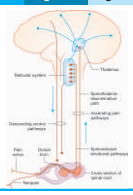
Chapter 20 Page 656 Fig 20.17B



90

Descending pain control mechanism

Chapter 20 Page 657 Fig 20.19



91

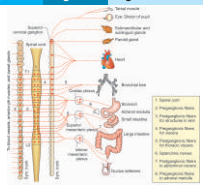
Parasympathetic divisions of autonomic nervous system

Chapter 20 Page 673 Fig 20.37

92

Sympathetic division of autonomic nervous system

Chapter 20 Page 675 Fig 20.39

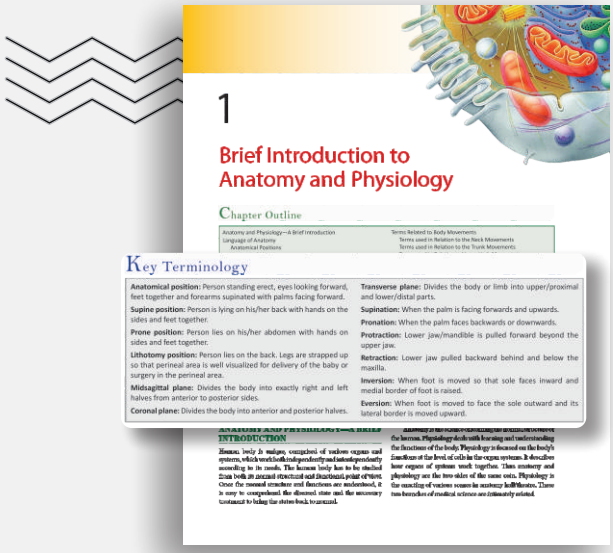


93

Read Digitally

Make every digital touch count

200+ Key terminologies with their meanings



Listen and Recall

Learn what you listen & Recall what you learn

Chapter wise Golden Points for Last Minute Revision in Podcast form (Only in App)

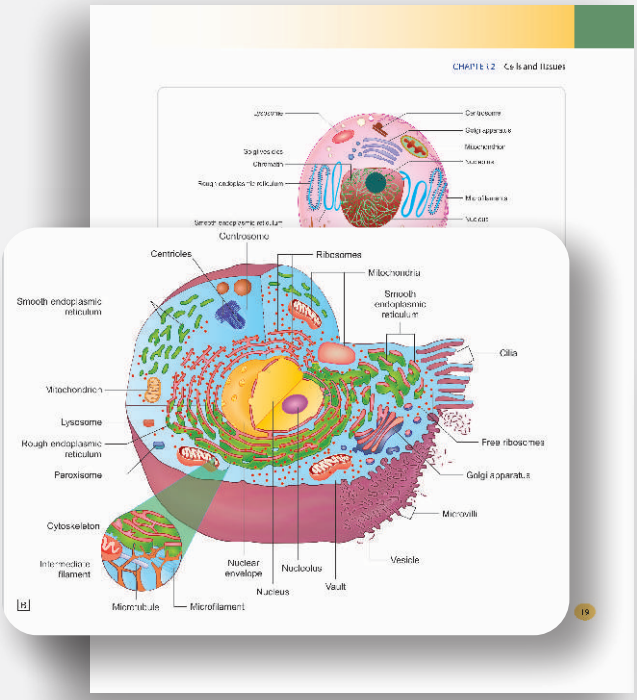
Download the App
Nursing Next Live
The Next Level of Nursing Education

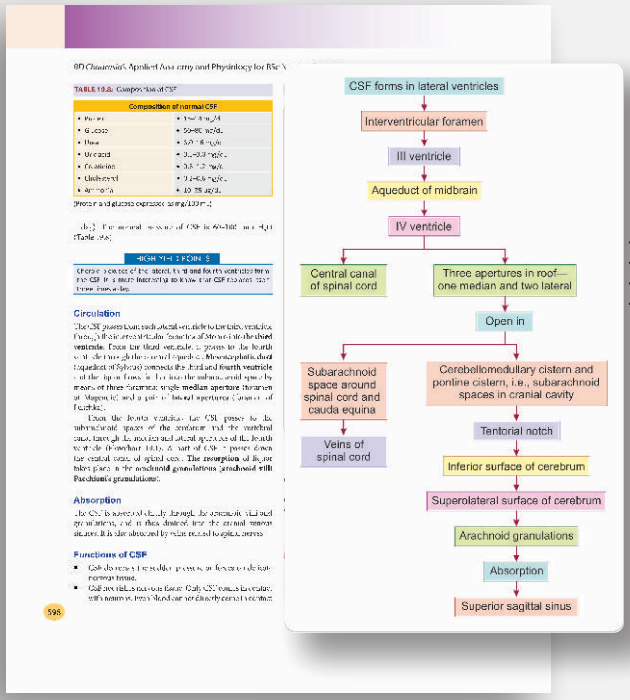
CBS Hybrid Nursing Books >
B D Chaurasia's A&P Digital

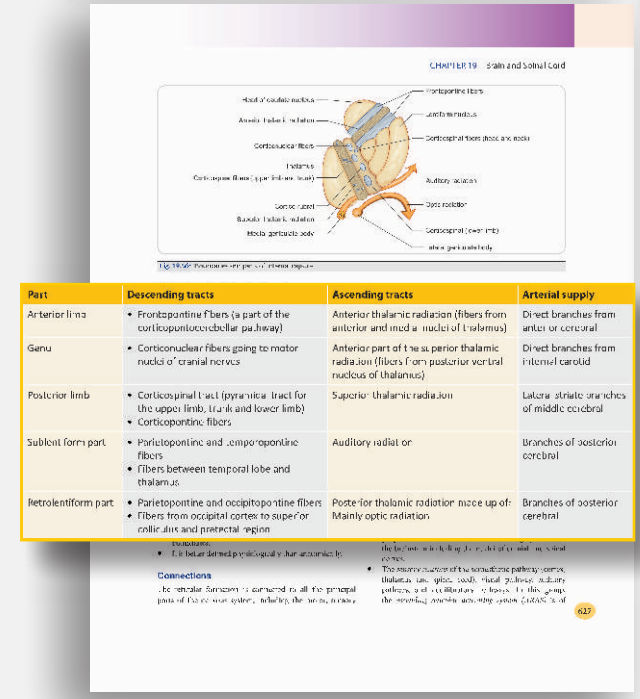
Revise on the Go

Learning cannot be limited to the book

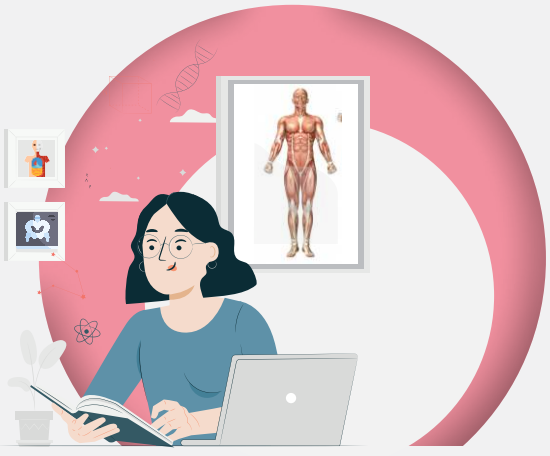
500+ Chapter wise High Yielding Tables, Flowcharts & Images for Quick Reference







Part	Descending tracts	Ascending tracts	Arterial supply
Anterior limb	• Frontopontine fibers (a part of the corticopontocerebellar pathway)	Anterior thalamic radiation (fibers from anterior and medial nuclei of thalamus)	Direct branches from anterior cerebral
Genu	• Corticonuclear fibers going to motor nuclei of cranial nerves	Anterior part of the superior thalamic radiation (fibers from posterior ventral nucleus of thalamus)	Direct branches from internal carotid
Posterior limb	• Corticospinal tract (pyramidal tract for the upper limb, trunk and lower limb) • Corticopontine fibers	Superior thalamic radiation	Lateral striate branches of middle cerebral
Sublent form part	• Parietopontine and temporopontine fibers • Fibers between temporal lobe and thalamus	Auditory radiation	Branches of posterior cerebral
Retrolentiform part	• Parietopontine and occipitopontine fibers • Fibers from occipital cortex to superior colliculus and pretectal region	Posterior thalamic radiation made up of: Mainly optic radiation	Branches of posterior cerebral



Download the App
Nursing Next Live
The Next Level of Nursing Education

CBS Hybrid Nursing Books >
B D Chaurasia's A&P Digital

Assess Yourself

Test your brain circuit with Self-Assessments

Chapter wise MCQs/Match the Following/Fill in the Blanks

True or False

1. Group of cells performing same function is called a tissue
2. Epithelium lines the inside of the organs or covers the organs externally
3. Smooth muscle fibers are striated
4. Oligodendrocytes lays down myelin sheath on the peripheral nerves
5. Specialised connective tissue is cartilage/bone

Fill in the Blanks

1. The _____ of a neuron receives a stimulus and conduct it to the cell body.
2. _____ system includes hair, nail skin, sweat and sebaceous glands.
3. Proteins of cell membrane are _____ and _____.
4. Nissl bodies are found in _____.
5. Cells in the bone are _____, _____ and _____.

Match the Following

Column A	Column B
1. Serous gland	a. Astrocyte
2. Mucous gland	b. Parotid gland
3. Unicellular gland	c. Sublingual gland
4. Branching muscle fibers	d. Goblet cells
5. Neuroglia	e. Cardiac muscle fibers

Give One Word Answer

1. Small organs with in the cytosol _____
2. Bags containing enzymes which breakdown the used up organelles _____
3. Programmed cell death _____
4. Cells secreting heparin, histamine _____
5. Epithelium with several layers of cells _____

Multiple Choice Questions

1. Which of the following cell organelle provides energy for functions of the cell?
   a. Lysosomes b. Centriole
   c. Cilia d. Mitochondria
2. Intracellular digestion is done by one of the following organelles:
   a. Centriole b. Lysosome
   c. Endoplasmic reticulum d. Golgi apparatus
3. Steroid synthesis is done by:
   a. Golgi apparatus b. Lysosome
   c. Smooth endoplasmic reticulum d. Mitochondria
4. Microtubules are not present in:
   a. Centriole b. Flagella
   c. Cilia d. Microvilli

Dil Mange More Content

Don't settle for less... go beyond

a. Chapter wise Long and Short Answer Questions (Solved)
b. 5-10 Conceptual videos of Physiology in animation form (Optional)
c. 50+ Dissection images in High Resolution
d. Regular Hybrid Updates covering Recent Advances, Mnemonics, Tips & Tricks and much more.

a.

Assess Yourself

Long Answer Questions

1. Discuss the details of cell communication.
2. Discuss formation and regeneration of tissues. What are cell organelles? Discuss in detail.
3. Enumerate the functions of plasma membrane.

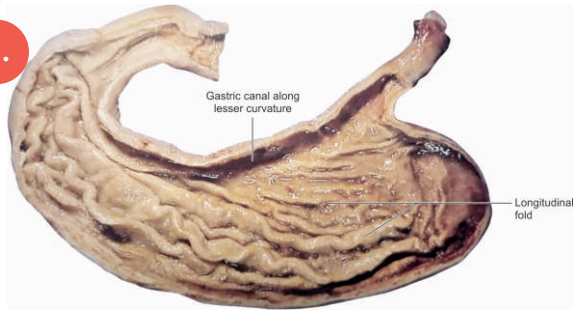
Short Answer Questions

1. Cell membrane
2. Mitochondria
3. Meiosis

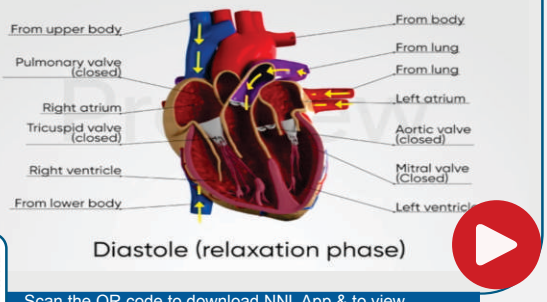
Write short notes on:

a. Mitochondria
b. Chromatin
c. Mitosis

c.



b.



Scan the QR code to download NNL App & to view the sample video in 3D Animation Form

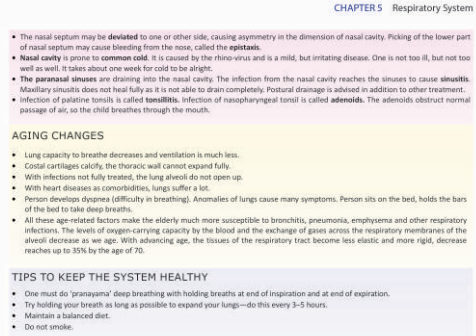
d1

APPENDIX 3

Tips to Memorize

1. Attachments of bicipital groove—"**Lady between 2 majors**"
   Lady – Latissimus dorsi
   2 majors – **Pectoralis major (Laterally) and Teres major**
2. Contents of cubital fossa—"MBBR (from medial to lateral side)"
   M – Median nerve
   B – Brachial artery and its 2 terminal branches
   B – Biceps brachii
   R – Radial nerve and its 2 branches
3. Carpal bone—"She looks too pretty Try to catch her"
   She – Scaphoid
   Looks – Lunate
   Too – Triquetral
   Pretty – Pisiform
   Try – Trapezium
   To – Trapezoid
   Catch – Capitate
   Her – Hamate
4. Thorax – **Structures in the costal groove – "VAN"**
   V – Posterior intercostal vein
   A – Posterior intercostal artery
   N – Intercostal nerve
5. Main openings in the diaphragm—"John **ate 10 dozens**"
   Ate – Th8—Inferior vena cava, right phrenic nerve
   Ten – Th10—Esophagus with left gastric vessels
   Dozens – Th12—Thoracic aorta, vena azygos
6. Lower limb
   - Order of structures under inguinal ligament from medial to lateral side (**Fe CVAN**): Femoral canal, femoral vein, femoral artery and femoral nerve
   - Structures in femoral sheath from medial to lateral side (**Fe CVA**): Femoral canal, femoral vein, femoral artery
   - **Structures in different parts of popliteal fossa:**
     - Upper part from medial to lateral (**Pop AVN**): Popliteal artery, popliteal vein and tibial nerve
     - Lower part from medial to lateral (**Tibetan nurse picks victory card and pops ahead**): Tibial nerve, popliteal vein, popliteal artery
   - Structures under extensor retinaculum of ankle joint: "The Himalayas Are Not Dry Places"
     The – Tibialis anterior
     Himalayas – Extensor hallucis longus
     Are – Anterior tibial artery
     Not – Deep peroneal nerve
     Dry – Extensor digitorum longus
     Places – Peroneus tertius
   - Structures under Flexor retinaculum of ankle joint - "Tulsi dass Ameer Nahi Hai"
     Tulsi – Tibialis posterior
     Dass – Flexor digitorum longus
     Ameer – Posterior tibial artery
     Nahi – Tibial nerve
     Hai – Flexor hallucis longus
7. Abdomen
   - Structures in the porta hepatis of liver – "DAV"
     D – Hepatic ducts (right and left)
     A – Hepatic arteries (right and left)
     V – Portal vein – (right and left)
   - Branches of abdominal aorta
     Ventral – Celic trunk, Superior mesenteric and inferior mesenteric
     Lateral – Inferior phrenic, middle suprarenal, renal and gonadal
     Posterior – 4 pairs of lumbar arteries and median sacral artery
     Terminal – Right and left common iliac arteries

d2



CHAPTER 5 Respiratory System

- The nasal septum may be **deviated** to one or other side, causing asymmetry in the dimension of nasal cavity. Picking of the lower part of nasal septum may cause bleeding from the nose, called the **epistaxis**.
- **Nasal cavity** is prone to **common cold**. It is caused by the rhino-virus and is a mild, but irritating disease. One is not too ill, but not too well as well. It takes about one week for cold to be alright.
- **The paranasal sinuses** are draining into the nasal cavity. The infection from the nasal cavity reaches the sinuses to cause **sinusitis**. Maxillary sinusitis does not heal fully as it is not able to drain completely. Postural drainage is advised in addition to other treatment.
- Infection of palatine tonsils is called **tonsillitis**. Infection of nasopharyngeal tonsil is called **adenoids**. The adenoids obstruct normal passage of air, so the child breathes through the mouth.

AGING CHANGES

- Lung capacity to breathe decreases and ventilation is much less.
- Costal cartilages calcify, the thoracic wall cannot expand fully.
- With infections not fully treated, the lung alveoli do not open up.
- With heart diseases as comorbidities, lungs suffer a lot.
- Person develops dyspnea (difficulty in breathing). Anomalies of lungs cause many symptoms. Person sits on the bed, holds the bars of the bed to take deep breaths.
- All these age-related factors make the elderly much more susceptible to bronchitis, pneumonia, emphysema and other respiratory infections. The levels of oxygen-carrying capacity by the blood and the exchange of gases across the respiratory membranes of the alveoli decrease as we age. With advancing age, the tissues of the respiratory tract become less elastic and more rigid, decrease reaches up to 35% by the age of 70.

TIPS TO KEEP THE SYSTEM HEALTHY

- One must do 'pranayama' deep breathing with holding breaths at end of inspiration and at end of expiration.
- Try holding your breath as long as possible to expand your lungs—do this every 3–5 hours.
- Maintain a balanced diet.
- Do not smoke.

B D Chaurasia's
Applied
Anatomy & Physiology
for BSc Nursing Students

As per the Revised INC Syllabus (2021-22) for BSc Nursing

Edited by

Krishna Garg

MBBS, MS, PhD, FAMS, FIAMS, FIMSA, FASI
Legend of Anatomy, Nation's Who's Who, NAMS Awardee
Member and Fellow, Academy of Medical Sciences
Fellow, Indian Academy of Medical Specialists
Fellow, International Medical Science Academy
Fellow, Anatomical Society of India
Lifetime Achievement Awardee
DMA Distinguished Service Awardee
Ex-Professor and Head, Department of Anatomy
Lady Hardinge Medical College
New Delhi

Special Contribution

Anju Dhir

BSc (Med), MSc (Micro), PhD (Biotech)
Ex-Lecturer (Microbiol)
Shivalik Institute of Nursing, Shimla, Himachal Pradesh
Product Manager cum
Commissioning Editor – Medical
CBS Publishers & Distributors Pvt Ltd.

CBS Publishers & Distributors Pvt Ltd

• New Delhi • Bengaluru • Chennai • Kochi • Kolkata • Lucknow
• Mumbai • Hyderabad • Nagpur • Patna • Pune • Vijayawada

B D Chaurasia's
Applied
Anatomy & Physiology
for BSc Nursing Students

As per the Revised INC Syllabus (2021-22) for BSc Nursing

ISBN: 978-93-90619-65-8

First Edition: 2022

Published by **Satish Kumar Jain** and produced by **Varun Jain** for

CBS Publishers & Distributors Pvt Ltd

4819/XI Prahlad Street, 24 Ansari Road, Daryaganj, New Delhi 110 002, India.
Ph: +91-11-23289259, 23266861, 23266867 Website: www.cbspd.com
Fax: 011-23243014
e-mail: delhi@cbspd.com; cbspubs@airtelmail.in.

Corporate Office: 204 FIE, Industrial Area, Patparganj, Delhi 110 092
Ph: +91-11-4934 4934 Fax: 4934 4935
e-mail: feedback@cbspd.com; bhupesharora@cbspd.com

Branches

- **Bengaluru:** Seema House 2975, 17th Cross, K.R. Road, Banasankari 2nd Stage, Bengaluru 560 070, Karnataka
  Ph: +91-80-26771678/79 Fax: +91-80-26771680 e-mail: bangalore@cbspd.com
- **Chennai:** 7, Subbaraya Street, Shenoy Nagar, Chennai 600 030, Tamil Nadu
  Ph: +91-44-26680620, 26681266 Fax: +91-44-42032115 e-mail: chennai@cbspd.com
- **Kochi:** 68/1534, 35, 36-Power House Road, Opp. KSEB, Cochin-682018, Kochi, Kerala
  Ph: +91-484-4059061-65 Fax: +91-484-4059065 e-mail: kochi@cbspd.com
- **Kolkata:** 6/B, Ground Floor, Rameswar Shaw Road, Kolkata-700 014, West Bengal
  Ph: +91-33-22891126, 22891127, 22891128 e-mail: kolkata@cbspd.com
- **Lucknow:** Basement, Khushnuma Complex, 7-Meerabai Ma Rg, (Behind Jawahar Bhawan), Lucknow-226001, Uttar Pradesh
  Ph: +0522-4000032 e-mail: tiwari.lucknow@cbspd.com
- **Mumbai:** PWD Shed, Gala No. 25/26, Ramchandra Bhatt Marg, Next to J.J. Hospital Gate No. 2, Opp. Union Bank of India, Noor Baug, Mumbai-400009
  Ph: +91-22-66661880/89 Fax: +91-22-24902342 e-mail: mumbai@cbspd.com

Representatives

- **Hyderabad** +91-9885175004
- **Pune** +91-9623451994
- **Patna** +91-9334159340
- **Vijayawada** +91-9000660880

Printed at:

Nursing Knowledge Tree

An Initiative by CBS Nursing Division

Extends its Tribute to

Dr B D Chaurasia

(1937–1985)

Dr B D Chaurasia was Reader in Anatomy at GR Medical College, Gwalior.
He completed his MBBS in 1960, MS in 1965 and received his PhD degree in 1975.
He was an elected fellow of National Academy of Medical Sciences (India) in 1982.
He was a member of the Advisory Board of the *Acta Anatomica* since 1981,
member of the editorial board of *Bionature*, and in addition
member of a number of scientific societies.
He was posthumously honoured by Dr Kailash Nath Kathju Award for
Science from MP State government.
He had a large number of research papers to his credit.

About the Editor

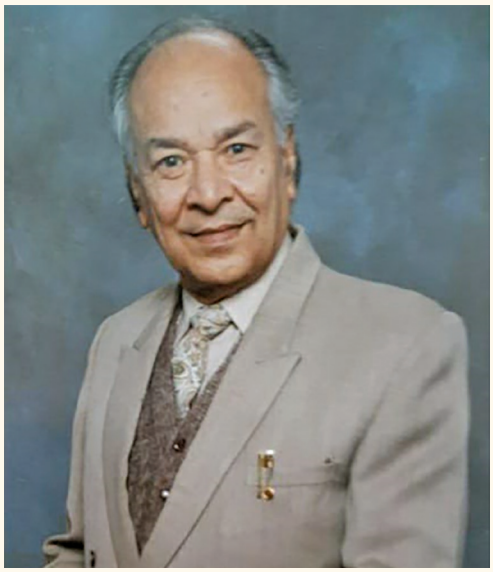
Krishna Garg MBBS, MS, PhD, FAMS, FIAMS, FIMSA, FASI, is ex-Professor and Head of Department of Anatomy, Lady Hardinge Medical College (LHMC), New Delhi. She joined LHMC in 1964 where she completed her MS and PhD and taught anatomy till 1996. At present she is associated with Bakson's Homeopathic Medical College, Greater Noida and Kalka Dental College, Meerut as faculty of Anatomy.

She has been the editor of B D Chaurasia's Human Anatomy of 4th – 6th editions and is Chief Editor of 7th and 8th editions. She has received Fellowship of the Academy of Medical Sciences (FAMS) in 2005. She was honoured with Excellence award in Anatomy in 2004 from Delhi Medical Association and award from NAMS in 2021. She received Life-Time Achievement Award in 2015, Fellowship of Anatomical Society of India and DMA Distinguished Services Award in 2012.

She is an avid writer. She is an author of companion pocketbooks—BDC Human Anatomy (Vols 1–3) and BDC Human Anatomy for Dental Students 4/e. She is the co-author of Textbook of Histology 5/e, Textbook of Neuroanatomy 6/e, Anatomy and Physiology for GNM, Anatomy and Physiology for Allied Health Sciences, Practical Anatomy Workbook, Practical Histology Workbook, Practical Anatomy Workbook for Dental students and Theory and Practical of Anatomy & Physiology for Diploma Students of Pharmacy. She is editor of Human Embryology 2/e and Handbook of General Anatomy 6/e. There are two books in Hindi – one for nursing and another for Allied Health Sciences. Her last book so far is Manual of Human Anatomy Practical Dissection.

Dedicated to

The memories of my husband Late Dr D P Garg



21-7-1936 — 28-10-2020
MBBS, DMRT, DMRD, MD (Radiodiagnosis)
Ex Prof & HOD of Radiology
Lady Hardinge Medical College and Associated Hospitals, New Delhi

—Krishna Garg

Contributor and Advisory Board

Special Contribution

Anju Dhir

BSc (Med), MSc (Micro), PhD (Biotech)

Ex-Lecturer (Microbiol)
Shivalik Institute of Nursing
Shimla, Himachal Pradesh
Product Manager cum
Commissioning Editor – Medical
CBS Publishers & Distributors Pvt Ltd.

Advisory Board

Anupinder Thind

Assistant Professor

MD Physiology
Government Medical College and
Rajindra Hospital
Patiala, Punjab

H H Sudhakar

MBBS, MD (Physiology)

Professor and Head

Kempegowda Institute of Medical Sciences
Bangalore

K Raviraj

MBBS MD (Anatomy)

S Krishna Kumar

MBBS, MD (Physiology)

Sabina Ali

RN, RM, MSc (N)

(Critical Care Nursing)

Senior Content Strategist
Nursing Next Live
CBS Publishers & Distributors Pvt Ltd.
New Delhi

Saumya Srivastava

MSN (Oncology Nursing), RN, RM

Nursing Tutor

Vivekananda College of Nursing
Lucknow

Swati Mehra

BDS, MDS

Sr. Content Strategist & Quality Check

CBS Nursing Division
New Delhi

Swati Tiwari Bakshi

MD Anatomy

MAMC

New Delhi

Reviewers

Alka Saxena
MSc (MSN)
Principal
KS Nursing College
Gwalior, Madhya Pradesh

Amrita Charlotte Kapoor
MSc (N) Medical Surgical Nursing
Professor cum Principal
Himalyan Institute of Nursing
Himachal Pradesh

Amrita Lenka
Professor
Kalinga Institute of Nursing Sciences
Bhubaneswar, Odisha

Anil Sharma
PhD (Clinical Research)
MSc, Medical Surgical Nursing
Principal
Manikaka Topawala Institute of Nursing
Anand, Gujarat

Babita Sood
PhD(N), MSc(MSN), BSc(N), Diploma in Hospital Administration
Principal
Amar Professional College of Nursing
Mohali, Punjab

BV Kathyayni
MSc (Pediatric Nursing)
Principal
University CON, BFUHS
Faridkot, Punjab

Elsa Sanatombi
PhD, Medical Surgical Nursing
Professor and Head
Manipal CON
Manipal University
Karnataka

G Dhanalakshmi
RN, RM, MSc(N), MSc(Psy), MBA, PhD
Professor cum Vice Principal
Head of Department
Medical Surgical Nursing
Billroth College of Nursing
Chennai, Tamil Nadu

Harinder Jeet Goyal
PhD, MSc (MSN)
Former Principal
RAKCON
New Delhi

Indarjit Walia
PhD (Community Medicine), MSc (CHN)
Former Principal
PGI NINE
Chandigarh, Punjab

Jacintha D'Souza
MPhil (N)
Principal and Professor
Father Muller CON
Mangalore, Karnataka

Jyoti Sarin
Director Principal
M.M. College of Nursing Ambala, Haryana

Kanika Rai
Professor & HOD
MMCON, Mullana
Ambala, Haryana

L Gopichandran
Associate Professor
College of Nursing, AIIMS New Delhi
President, TNAI
Delhi Branch

Muthuvenkatachalam Srinivasan
PhD (INC Consortium), MSc (AIIMS), D Pharm
RN (NMBA Australia)
Associate Professor
College of Nursing
All India Institute of Medical Sciences
New Delhi

Niyati Das
Vice Pricinpal & HOD, Child Health Nursing
Kalinga Inst. Nsg Sciences
KIIT University
Bhubaneswar, Odisha

Panchali Pal
PhD Scholar (WBUHS), MSc(N) (SNDT University)
BSc(N) (AIIMS), MA Public Administration
Professor cum Principal
Kothari Institute of Nursing
Kothari Medical Centre
The West Bengal University of Health Sciences
Kolkata

Raman Kalia
MSc (Nursing), PhD
Director-Principal
Saraswati Nursing Institute
Vill Dhianpura Kurali
Roopnagar, Punjab

Rashmi E John
MSc (N)
Officiating Principal
KGMU, Lucknow, Uttar Pradesh

Ratna Prakash
PhD, MSc (MSN)
Prof. & Academic Director (Former Principal) Pal College of Nursing
Haldwani, Uttarakhand

S Kanchana
RN RM, PhD (N), PDF(R)
Principal
Omayal Achi College of Nursing
Chennai, Tamil Nadu

Sandhya Ghai
PhD, MSc (N)
Former Principal
NINE, PGIMER
Chandigarh, Punjab

Shyamala D Manivannan
RN, RM, MSc, PhD (CHN)
Professor and Director
Dr MGR Educational & Research Inst.
University
Chennai, Tamil Nadu

Sripriya Gopalkrishna
Medical Surgical Nursing
Principal
Sadhu Vaswani College of Nursing
Pune, Maharashtra

Sunita Lawrence
MSc OBG (N), PhD (Nursing Education)
Principal
Pragyan Nursing College
Bhopal, MP

T Samuel Ravi
Retired Head Emergency
Nursing Trauma Center
Coordinator Christian Medical College Vellore
Tamil Nadu

T Sivabalan
Principal
Pravara Institute of Medical Sciences, College of Nursing
Ahmednagar, Rahata, Maharashtra

Usha Ukande
PhD, MSc, OBG (N)
Former Principal
Choithram CON
Indore, Madhya Pradesh

Reviewers' names are arranged in alphabetical order

Preface

B D Chaurasia has been a core title for students of anatomy for nearly 42 years. This book has been prepared for the students of medical stream. It is immensely popular and liked by the readers. This book is widely recommended for other medical streams too.

As an author my journey started in the year 2017 when myself and Dr Medha Joshi wrote a book for GNM students under CBS Banner. This book had been well accepted by the students. Besides, I have also been Chief Editor of B D Chaurasia for UG medical students. This year, I was invited to write a book for UG (BSc) Nursing students because with the passage of time, a need was felt to have a book of anatomy integrated with physiology for the students. It was decided by CBS to come up with latest version of *BD Chaurasia* book according to latest INC Syllabus. This book is written to meet the needs of students of nursing and allied health sciences.

The human body is studied by having system wise presentation. The approach is straight, simple and informative. Each chapter is supplemented by Nursing implications/Applications, Applied Aspect and Aging Changes.

"Each image speaks thousand words"—I kept this in mind and have used self-explanatory images in the book. The figures in the text are easy-to-digest and mainly line diagrams so that a student can easily draw and reproduce these. Each chapter starts with Chapter Outline, followed by Key Terminology, Anatomical Description with integrated physiology supported by figures and tables.

Unit I is especially dedicated to the basics of anatomy and physiology for proper understanding of the concepts that are under discussion in the book. Rest of the units from Unit I to Unit X are dedicated to separate description of the systems in a human body.

Assess Yourself section in the end of each chapter is an added advantage to the readers as the knowledge gained by reading can be easily assessed by self-evaluation. Here, the student is given the long and short answer questions with a worksheet that has MCQs including—Match the Columns, One Word Answers, Label the Images, Enumeration and defining of the various terms.

This book is hybrid edition with multiple digital feature like, See and Perceive, Dil Mange More, Listen and Recall, Read Digitally, Assess yourself.

Nonetheless, the book has supporting features including High Yield Points, Extra Edge, Recent Advances, Note, Nursing implications, Clinical Aspects and Aging Changes. These features will definitely update the knowledge of the readers.

I am always pleased to receive feedback from readers. It helps me to improve the further editions of the book.

Special Features of the book

- First Book as per the Revised INC Syllabus 2021-22
- A perfect amalgamation of Applied Anatomy and Physiology
- Content supported with Nursing Implications and Applications
- Chapter wise Applied Aspects and Aging Changes highlighted
- Appendices covering Important Dissectors/Cadaveric Images of Human Body Organs, Charts and High Yield Topics
- 1000+ Illustrations, Real-Time Photographs Flowcharts, Tables and Graphs
- 20+ Self-assessment Exercises
- 500+ Key Terminologies
- 10+ Animated Videos
- 20+ Chapter wise Self-Assessment Exercises

6 Amazing features of BD Chaurasia's A&P Digital

- **See & Perceive** - Get 100+ Images in 3D Animation videos with labelings and voice-overs.
- **Read digitally** - 200+ Key terminologies with their meanings
- **Listen and Recall** - Chapter wise Golden Points for Last-Minute Revision in Podcast form (Only in App)
- **Revise on the Go** - 500+ Chapter-wise High Yielding Tables, Flowcharts & Images for Quick Reference

- **Assess Yourself** - Chapter wise MCQs/Match the Following/Fill in the Blanks
- **Dil Mange More Content**
  - Chapter wise Long and Short Answer Questions (Solved)
  - 5-10 Conceptual videos of Physiology in animation form (Optional)
  - 50+ Dissection images in High Resolution
  - Regular Hybrid Updates covering Recent Advances, Mnemonics, Tips & Tricks and much more

Krishna Garg

Acknowledgments

I am highly grateful to The Almighty for His guidance and grace to enable me to do this important book with multiple facets.

I want to mention the names of my colleagues who have always encouraged and also imparted valuable suggestions—Dr Gayatri Rath, Dr Shashi Raheja, Dr Mangala Kohli and Dr Medha Joshi. Moreover, I can't forget to appreciate the moral support rendered by my family members—Dr Suvira Gupta, Dr J P Gupta, Ms Meenakshi Saran, Mr Manoj Garg, Ms Rekha Garg, Dr Manish Garg, Dr Shilpa Garg, Dr Surbhi Gupta, Ms Kanika Saran, Mr Shikhar Garg, Ms Sarita Garg and all other dear family members.

I owe thanks to Dr Sudipta Kundu—Head and Associate Professor of Physiology, Kalka Dental College, Meerut, UP.

I extend my special thanks to **Mr Satish Kumar Jain** (Chairman) and **Mr Varun Jain** (Managing Director), M/s CBS Publishers and Distributors Pvt Ltd for their wholehearted support in publication of this book.

I am thankful for the discussions and suggestions by **Mr Bhupesh Aarora**, Sr. Vice President – Publishing & Marketing (Health Sciences Division) from the time of inception of this book till its launch.

My thanks to Ms Nitasha Arora (Publishing Head & Content Strategist – PGMEE & Nursing) for her continuous generous support for help and Dr Anju Dhir (Product Manager cum Commissioning Editor – Medical) for taking whole hearted interest to shape this book like making a statue from clay.

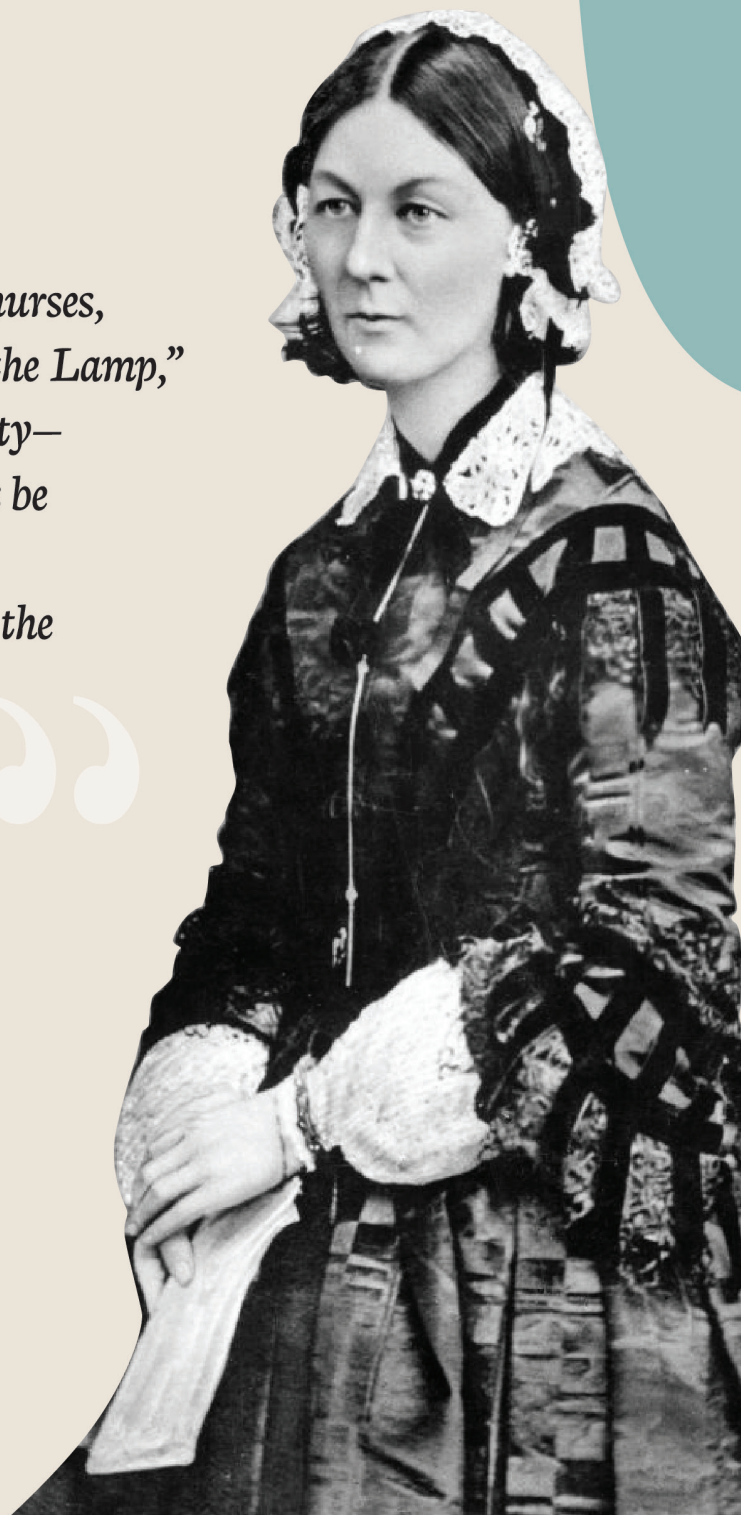
I sincerely extend my thanks to Mr Shivendu Bhushan Pandey (Sr. Manager & Team Lead), Mr Manoj K Yadav (Production Manager), Mr Ashutosh Pathak (Sr. Proofreader cum Team Coordinator) and all the CBS production team members for devoting their laborious hours in designing and typesetting the book.

CBS Nursing Knowledge Tree

Extends its Tribute to

Florence Nightingale

For glorifying the role of women as nurses,
For holding the title of " The Lady with the Lamp,"
For working tirelessly for humanity–
Florence Nightingale will always be
remembered for her
selfless and memorable services to the
human race.

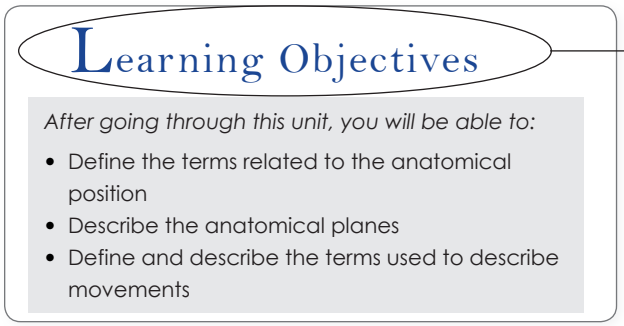


Florence Nightingale
(May 1820 – August 1910)

Special Features of the Book

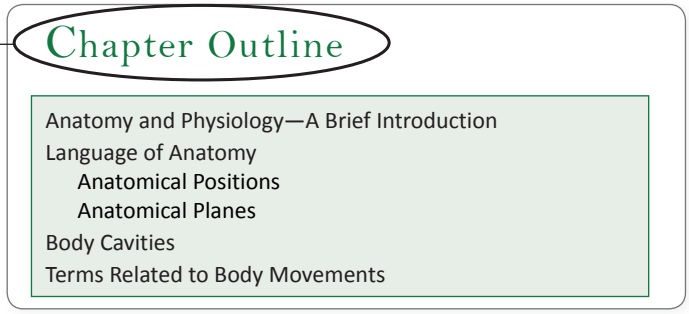
Dear Students

All of us who have been part of the Publishing Process in CBS, congratulate you all for choosing an exciting and rewarding profession. This book is conceived and designed to equip you with basic as well as applied knowledge of Anatomy and Physiology which will certainly help you all during practice.

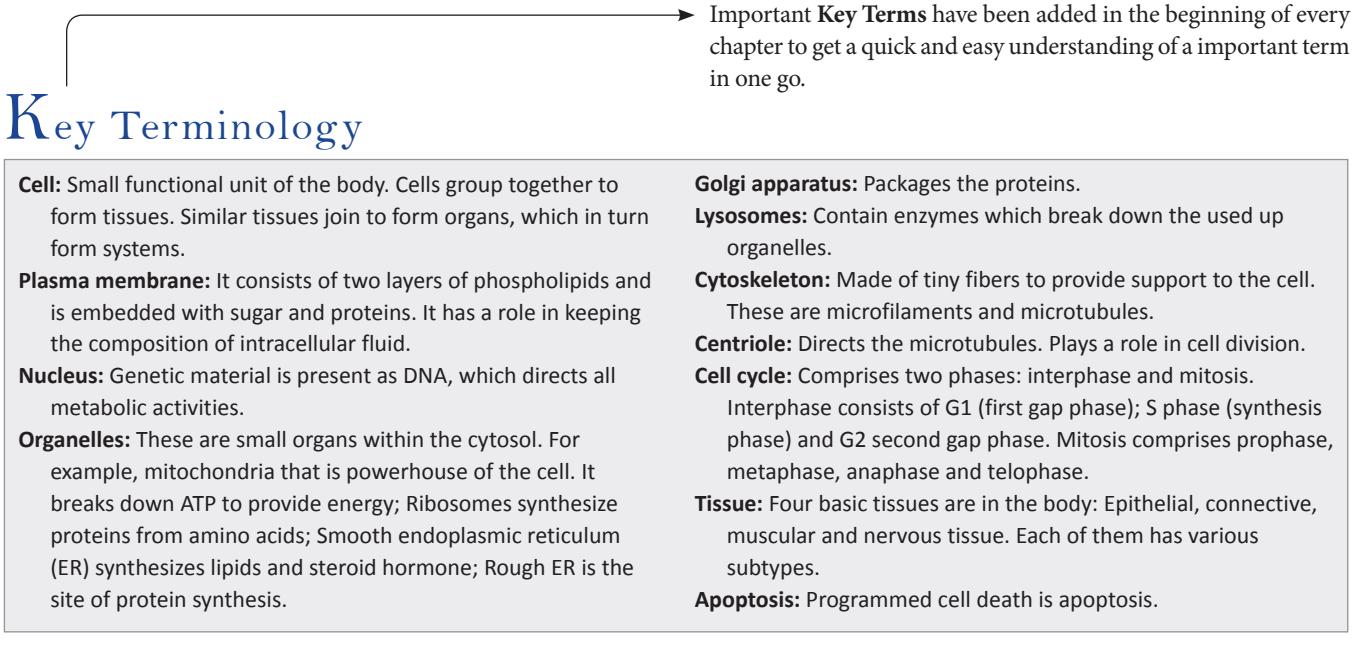


Learning Objectives enlist what the students will learn after studying the entire chapter.

Chapter Outline enlist the quick outline of the entire chapter in one go.



Important **Key Terms** have been added in the beginning of every chapter to get a quick and easy understanding of a important term in one go.



HIGH YIELD POINT

The fluid mosaic model also states that cell membranes are composed of a phospholipid bilayer with admixed protein molecules that are freely floating around it. It is called fluid because individual phospholipids and proteins move side-to-side within the layer like a liquid; and is termed mosaic because of the topographic pattern produced by the scattered protein molecules.

Important facts, concept and points have been covered in between the text under **High Yield Points Boxes**.

Must know Topics or concepts important from exam point of view have been given as a separate entity **Know It boxes**.

Know it

Telomeres-importance in Cell Division

A telomere is a region where repetitive nucleotide sequences lie that is associated with specialized proteins at the ends of linear chromosomes. The telomeres are a widespread genetic material that is most commonly found in eukaryotes. Cell replication involves not only DNA polymerase but a special reverse transcriptase that synthesizes the short repeats of DNA which are the ends (telomeres) of chromosomes. Without these transcriptase and related enzymes called telomerase, somatic cells lose DNA as they divide for 40–60 times and then become old and undergo apoptosis. On the contrary with high activity of these, the cells keep multiplying indefinitely. This fact is of interest in cancer and aging.

Numerous tables have been used in the Units to facilitate learning in a quick way.

TABLE 1.1: Body cavities

Cranial cavity	Formed by the cranial bones and holds the brain
Vertebral canal	Formed by the vertebrae and contains the spinal cord
Thoracic cavity	Formed by the thoracic cage, muscles of the chest, sternum, and the thoracic vertebrae; contains the pleural, pericardial, and cavities
Pleural cavity	Fluid-filled space that surround both lungs
Pericardial cavity	Fluid-filled space that surrounds the heart; the serous membrane of the pericardial cavity is the pericardium
Mediastinum	Central portion of the thoracic cavity; contains the heart, thymus, trachea, several major blood vessels, and esophagus
Abdominal cavity	Contains liver, stomach, spleen, small intestine, and most of the large intestine; the serous membrane of the abdominal cavity is the peritoneum

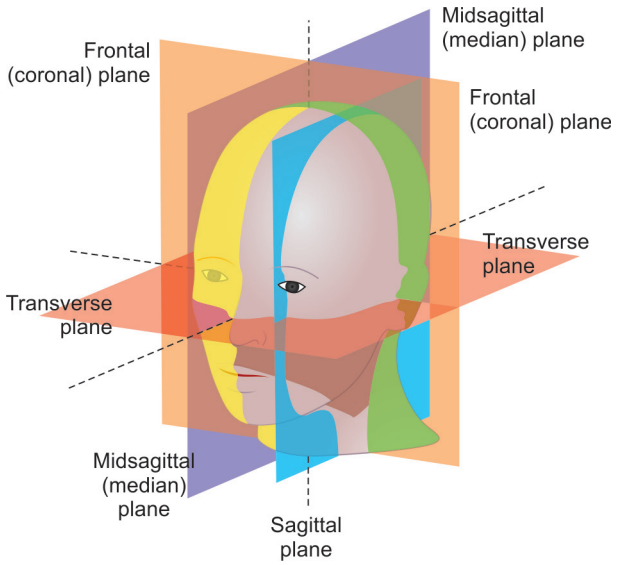
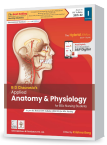


Fig. 1.7: Anatomical planes

Numerous figures, Illustration and real-time anatomical structures images are used to make learning easy for students.



Recent Advances

Latest updates or advancement in respective fields have been covered under **Recent Advances Boxes**.

Stem Cell Research

Shinya Yamanaka, Japanese physician and researcher shared the 2012 Nobel Prize for Physiology or Medicine with British development biologist John B Gurdon for the discovery on how the mature cells could be reprogrammed. They inserted specific genes into the nuclei of adult cells, (e.g., connective tissue cells), and this process resulted in the reversion of cells from an adult state to a pluripotent state. As pluripotent cells, these cells regained the capacity to differentiate into any cell type of the body.

Extra Edge boxes covering the related detailed information have been covered.

EXTRA EDGE

Suckling Reflex

When baby begins sucking the breast, the sensory nerves along the nipple area detect the tactile stimulus and carry these signals to the paraventricular nuclei and supraoptic nucleus in the hypothalamus, and these nuclei send to the posterior pituitary gland to release oxytocin. Oxytocin enters the circulation and is carried to the myoepithelial cells of the mammary gland producing its contraction and milk ejection.

FACTS TO REMEMBER

50+ Histological slides with **Facts to Remember** have been provided for their identification from practical point of view.

- Capsule shows stratified squamous non-keratinized epithelium on its oral aspect

Fig. 5.16: Histology of palatine onsil

Many important must know facts from Nursing point of view have been covered under **Nursing Implication and Applications** at the last of every chapter for better understanding of Nursing Clinical Correlation of the relevant system disease condition.

NURSING IMPLICATIONS AND APPLICATIONS

Hypernatremia

It is a condition when concentration of sodium is increased. The symptoms are restlessness, excess thirst and dry mucous membranes patient must be given adequate water at frequent intervals. Check if his/her diet contains more salt or he/she is suffering from diabetes insipidus. Try to alleviate these conditions with guidance from the clinician, so that sodium level becomes less and patient feels better.

Sodium Electrolyte Imbalance

The example of sodium electrolyte imbalance and its management has been summarized here:

APPENDIX 4

Dissection Images

Anatomy is learnt with the help of various human bones and by dissecting (cutting open) the dead human body (cadaver). The cadaver is embalmed by formalin and few other chemicals to prevent breakdown of proteins. This preserves the body

Important appendices including High Yield Topics and **Dissector/Cadaveric Images** added covering important actual dissection photographs of human body organs and parts to keep yourself abreast before your practical examination.

Effect of Aging in various systems have been emphasized for better understanding of anatomical and physiological changes in elderly population.

AGING CHANGES

Body water content, ages 40–60
- Males 55%
- Females 47%

After age 60
- Males 50%
- Females 45%

APPLIED ASPECTS

Fetal pH Control
- Buffers in fetal bloodstream provide short- term pH control
- Maternal kidneys eliminate generated H^+

Clinical aspects related to the different topics in a chapter are given under heading **Applied Aspects**.

At many places **Tips to Keep the system healthy** and importance of diet, Yoga and mediation have been incorporated to keep yourself aware about the health crisis and maintain ideal health.

TIPS TO KEEP THE SYSTEM HEALTHY

- One must do 'pranayama' deep breathing with holding breaths at end of inspiration and at end of expiration.
- Try holding your breath as long as possible to expand your lungs—do this every 3–5 hours.
- Maintain a balanced diet.

Assess Yourself

Long Answer Questions

1. Discuss fluid and electrolyte imbalance? How is its knowledge helpful in nursing?
2. Write an essay on distribution of body fluids?
3. How is water balance maintained?

Short Answer Questions

1. Name the particles in an atom.
2. Differentiate between diffusion and osmosis.

Detailed **Assess Yourself** exercises in each and every chapter which will facilitates structured learning and revision of the material provided in the respective chapters.

Syllabus

APPLIED ANATOMY

Placement: I Semester **Time:** Theory 3 credits (60 hours)

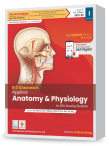
Description: The course is designed to assists student to recall and further acquire the knowledge of the normal structure of human body, identify alteration in anatomical structure with emphasis on clinical application to practice nursing.

Unit	Time (Hrs)	Learning outcomes	Content	Teaching/learning activities	Assessment methods
I	8 (T)	Define the terms related to the anatomical position	**Introduction to Anatomical Terms and Organization of the Human Body** Introduction to anatomical terms relative to position—anterior, ventral, posterior dorsal, superior, inferior, median, lateral, proximal,distal, superficial, deep, prone, supine, palmar and plantar	• Lecture cum discussion	• Quiz • MCQ • Short answer
		Describe the anatomical planes	Anatomical planes (axial/transverse/ horizontal, sagittal/vertical plane and coronal/frontal/oblique plane)	• Use of models	
		Define and describe the terms used to describe movements	Movements (flexion, extension, abduction, adduction, medial rotation, lateral rotation, inversion, eversion, supination, pronation, plantar flexion, dorsal flexion and circumduction	• Video demonstration	
			Cell structure, Cell division	• Use of microscopicslides	
		Organization of human body and structure of cell, tissues membranes and glands	• Tissue—definition, types, characteristics, classification, location • Membrane, glands—classification and structure • Identify major surface and bony landmarks in each body region, Organization of human body	• Lecture cum discussion	
			• Hyaline, fibro cartilage, elastic cartilage	• Video/Slides • Anatomical Torso	
		Describe the types of cartilage	• Features of skeletal, smooth and cardiacmuscle		
		Compare and contrast the features of skeletal, smooth and cardiac muscle	• Application and implication in nursing		
II	6 (T)	Describe the structure of respiratory system	**Respiratory System** • Structure of the organs of respiration	• Lecture cum discussion • Models • Video/Slides	• Short answer • Objective type
		Identify the muscles of respiration and examine their contribution to the mechanism of breathing	• Muscles of respiration • Application and implication in nursing		

Contd...

Unit	Time (Hrs)	Learning outcomes	Content	Teaching/learning activities	Assessment methods
III	6 (T)	Describe the structure of digestive system	**Digestive System** • Structure of alimentary canal and accessory organs of digestion • Application and implications in nursing	• Lecture cum discussion • Video/Slides • Anatomical Torso	• Short answer • Objective type
IV	6 (T)	Describe the structure of circulatory and lymphatic system	**Circulatory and Lymphatic System** • Structure of blood components, blood vessels ▪ Arterial and Venous system • Position of heart relative to the associated structures • Chambers of heart, layers of heart • Heart valves, coronary arteries • Nerve and blood supply to heart • Lymphatic tissue • Veins used for IV injections • Application and implication in nursing	• Lecture • Models • Video/Slides	• Short answer • MCQ
V	4 (T)	Identify the major endocrine glands and describe the structure of endocrine glands	**Endocrine System** • Structure of hypothalamus, pineal gland, pituitary gland, thyroid, parathyroid, thymus, pancreas and adrenal glands	• Lecture • Models/charts	• Short answer • Objective type
VI	4 (T)	Describe the structure of various sensory organs	**Sensory Organs** • Structure of skin, eye, ear, nose and tongue • Application and implications in nursing	• Lecture • Explain with Video/models/ charts	• Short answer • MCQ
VII	10 (T)	• Describe anatomical position and structureof bones and joints • Identify major bones that make up the axialand appendicular skeleton • Classify the joints • Identify the application and implications in nursing • Describe the structureof muscle	**Musculoskeletal System** **Skeletal System** • Anatomical positions • Bones—types, structure, growth and ossification • Axial and appendicular skeleton • Joints—classification, major joints and structure • Application and implications in nursing	• Review – discussion • Lecture • Discussions • Explain using charts, skeleton and loose bones and torso • Identifying muscles involved in nursing procedures in lab	• Short answer • Objective type
		Apply the knowledge in performing nursing procedures/skills	**Muscular System** • Types and structure of muscles • Muscle groups—muscles of the head, neck, thorax, abdomen, pelvis, upper limb and lower limbs • Principal muscles—deltoid, biceps, triceps, respiratory, abdominal, pelvic floor, pelvic floor muscles, gluteal muscles and vastus lateralis • Major muscles involved in nursing procedures		
VIII	5 (T)	Describe the structure of renal system	**Renal System** • Structure of kidney, ureters, bladder, urethra • Application and implication in nursing	• Lecture • Models/charts	• MCQ • Short answer

Contd...



Unit	Time (Hrs)	Learning outcomes	Content	Teaching/learning activities	Assessment methods
IX	5 (T)	Describe the structure of reproductive system	**Reproductive System** • Structure of male reproductive organs • Structure of female reproductive organs • Structure of breast	• Lecture • Models/charts	• MCQ • Short answer
X	6 (T)	• Describe the structure of nervous system including the distribution of the nerves, nerve plexuses • Describe the ventricular system	**Nervous System** • Review structure of neurons • CNS, ANS and PNS (Central, autonomic and peripheral) • Structure of brain, spinal cord, cranial nerves, spinal nerves, peripheral nerves, functional areas of cerebral cortex • Ventricular system—formation, circulation, and drainage • Application and implication in nursing	• Lecture • Explain with models • Video slides	• MCQ • Short answer

Note: Few lab hours can be planned for visits, observation and handling (less than 1 credit lab hours are not specified separately)

APPLIED PHYSIOLOGY

Placement: I Semester **Time:** Theory 3 credits (60 hours)

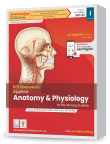
Description: The course is designed to assists student to acquire comprehensive knowledge of the normal functions of the organ systems of the human body to facilitate understanding of physiological basis of health, identify alteration in functions and provide the student with the necessary physiological knowledge to practice nursing.

Unit	Time (Hrs)	Learning outcomes	Content	Teaching/learning activities	Assessment methods
I	4 (T)	Describe the physiology of cell, tissues, membranes and glands	**General Physiology—Basic Concepts** • Cell physiology including transportationacross cell membrane • Body fluid compartments, Distribution of total body fluid, intracellular and extracellular compartments, major electrolytes and maintenance of homeostasis • Cell cycle • Tissue—formation, repair • Membranes and glands—functions • Application and implication in nursing	• Review – discussion • Lecture cum discussion • Video demonstrations	• Quiz • MCQ • Short answer
II	6 (T)	• Describe the physiology and mechanism of respiration • Identify the muscles of respiration and examine their contribution to the mechanism of breathing	**Respiratory System** • Functions of respiratory organs • Physiology of respiration • Pulmonary circulation—functional features • Pulmonary ventilation, exchange of gases • Carriage of oxygen and carbon dioxide, exchange of gases in tissue • Regulation of respiration • Hypoxia, cyanosis, dyspnea, periodic breathing • Respiratory changes during exercise • Application and implication in nursing	• Lecture • Video slides	• Essay • Short answer • MCQ

Contd...

Unit	Time (Hrs)	Learning outcomes	Content	Teaching/learning activities	Assessment methods
III	8 (T)	Describe the functions of digestive system	**Digestive System** • Functions of the organs of digestive tract • Saliva—composition, regulation of secretion and functions of saliva • Composition and function of gastric juice, mechanism and regulation of gastric secretion • Composition of pancreatic juice, function, regulation of pancreatic secretion • Functions of liver, gallbladder and pancreas • Composition of bile and function • Secretion and function of small and large intestine • Movements of alimentary tract • Digestion in mouth, stomach, small intestine, large intestine, absorption of food • Application and implications in nursing	• Lecture cum discussion • Video/slides	• Essay • Short answer • MCQ
IV	6 (T)	Explain the functions of the heart, and physiology of circulation	**Circulatory and Lymphatic System** • Functions of heart, conduction system, cardiac cycle, stroke volume and cardiac output • Blood pressure and pulse • Circulation—principles, factors influencing blood pressure, pulse • Coronary circulation, pulmonary and systemic circulation • Heart rate—regulation of heart rate • Normal value and variations • Cardiovascular homeostasis in exercise and posture • Application and implication in nursing	• Lecture • Discussion • Video/slides	• Short answer • MCQ
V	5 (T)	Describe the composition and functions of blood	**Blood** • Blood—functions, physical characteristics • Formation of blood cells • Erythropoiesis—functions of RBC, RBC lifecycle • WBC—types, functions • Platelets—function and production of platelets • Clotting mechanism of blood, clotting time, bleeding time, PTT • Hemostasis—role of vasoconstriction, platelet plug formation in hemostasis, coagulation factors, intrinsic and extrinsic pathways of coagulation • Blood groups and types • Functions of reticuloendothelial system, immunity • Application in nursing	• Lecture • Discussion • Videos	• Essay • Short answer • MCQ
VI	5 (T)	Identify the major endocrine glands and describe their functions	**Endocrine System** • Functions and hormones of pineal gland, pituitary gland, thyroid, parathyroid, thymus, pancreas and adrenal glands • Other hormones • Alterations in disease • Application and implication in nursing	• Lecture • Explain using charts	• Short answer • MCQ

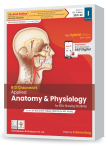
Contd...



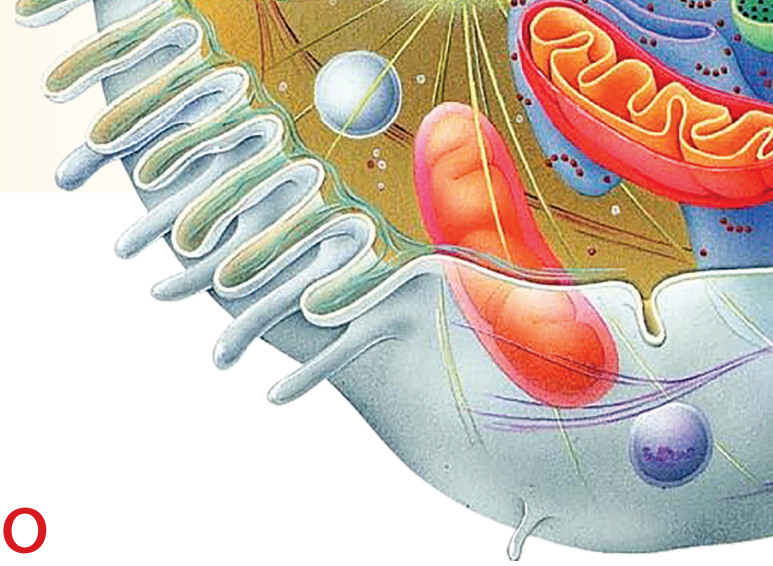
Unit	Time (Hrs)	Learning outcomes	Content	Teaching/learning activities	Assessment methods
VII	4 (T)	Describe the structure of various sensory organs	**Sensory Organs** • Functions of skin • Vision, hearing, taste and smell • Errors of refraction, aging changes • Application and implications in nursing	• Lecture • Video	• Short answer • MCQ
VIII	6 (T)	Describe the functions of bones, joints, various types of muscles, its special properties and nerves supplying them	**Musculoskeletal System** • Bones—functions, movements of bones of axial and appendicular skeleton, bone healing • Joints and joint movements • Alteration of joint disease • Properties and functions of skeletal muscles—mechanism of muscle contraction • Structure and properties of cardiac muscles and smooth muscles • Application and implication in nursing	• Lecture • Discussion • Video presentation	• Structured essay • Short answer • MCQ
IX	4 (T)	Describe the physiology of renal system	**Renal System** • Functions of kidney in maintaining homeostasis • GFR • Functions of ureters, bladder and urethra • Micturition • Regulation of renal function • Application and implication in nursing	• Lecture • Charts and models	• Short answer • MCQ
X	4 (T)	Describe the structure of reproductive system	**Reproductive System** • Female reproductive system—menstrual cycle, function and hormones of ovary, oogenesis, fertilization, implantation, functions of breast • Male reproductive system—spermatogenesis, hormones and its functions, semen • Application and implication in providing nursing care	• Lecture • Explain using charts, models, specimens	• Short answer • MCQ
XI	8 (T)	Describe the functions of brain, physiology of nerve stimulus, reflexes, cranial and spinal nerves	**Nervous System** • Overview of nervous system • Review of types, structure and functions of neurons • Nerve impulse • Review functions of brain-medulla, pons, cerebrum, cerebellum • Sensory and motor nervous system • Peripheral nervous system • Autonomic nervous system • Limbic system and higher mental functions—hippocampus, thalamus, hypothalamus • Vestibular apparatus • Functions of cranial nerves • Autonomic functions • Physiology of pain—somatic, visceral and referred • Reflexes • CSF formation, composition, circulation of CSF, blood brain barrier and blood CSF barrier • Application and implication in nursing	• Lecture cum • Discussion • Video slides	• Brief structured essays • Short answer • MCQ • Critical reflection

Note: Few lab hours can be planned for visits, observation and handling (less than 1 credit lab hours are not specified separately)

Contents



For more Dissection Images refer **BD Chaurasia's A&P Digital**



1

Brief Introduction to Anatomy and Physiology

Chapter Outline

Key Terminology

Anatomical position: Person standing erect, eyes looking forward, feet together and forearms supinated with palms facing forward.

Supine position: Person is lying on his/her back with hands on the sides and feet together.

Prone position: Person lies on his/her abdomen with hands on sides and feet together.

Lithotomy position: Person lies on the back. Legs are strapped up so that perineal area is well visualized for delivery of the baby or surgery in the perineal area.

Midsagittal plane: Divides the body into exactly right and left halves from anterior to posterior sides.

Coronal plane: Divides the body into anterior and posterior halves.

Transverse plane: Divides the body or limb into upper/proximal and lower/distal parts.

Supination: When the palm is facing forwards and upwards.

Pronation: When the palm faces backwards or downwards.

Protraction: Lower jaw/mandible is pulled forward beyond the upper jaw.

Retraction: Lower jaw pulled backward behind and below the maxilla.

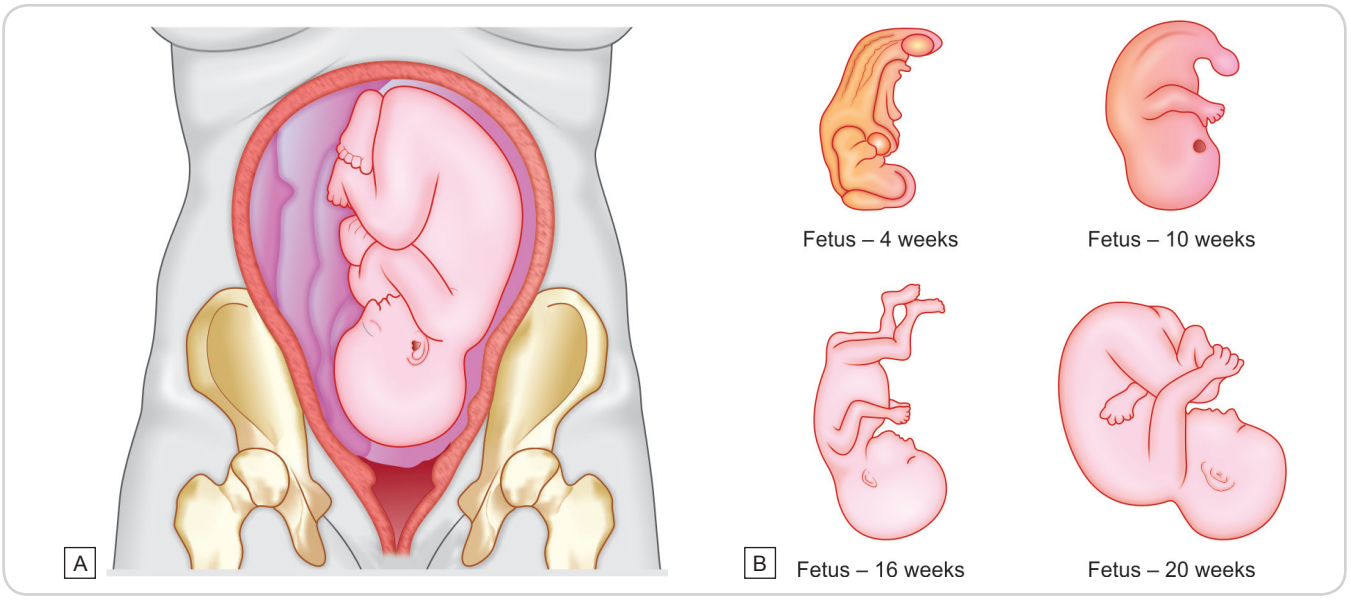
Inversion: When foot is moved so that sole faces inward and medial border of foot is raised.

Eversion: When foot is moved to face the sole outward and its lateral border is moved upward.

ANATOMY AND PHYSIOLOGY—A BRIEF INTRODUCTION

Human body is unique, comprised of various organs and systems, which work both independently and interdependently according to its needs. The human body has to be studied from both its normal structural and functional point of view. Once the normal structure and functions are understood, it is easy to comprehend the diseased state and the necessary treatment to bring the status back to normal.

Anatomy is the science of learning the normal structure of the human. **Physiology** deals with learning and understanding the functions of the body. Physiology is focused on the body's functions at the level of cells in the organ systems. It describes how organs of systems work together. Thus anatomy and physiology are the two sides of the same coin. Physiology is the enacting of various scenes in anatomy hall/theatre. These two branches of medical science are intimately related.



Figs 1.1A and B: Human embryology

The main subdivisions of anatomy are:

- **Cadaveric anatomy** where study is done on dead, or embalmed (preserved) bodies. It is usually done with the naked eyes (macroscopic or gross anatomy). It is done by two methods.
  - *Regional anatomy* in which the body is studied in parts, like the upper limb, lower limb, thorax, abdomen, head and neck, and brain.
  - *Systemic anatomy* in which the body is studied in systems, like the osteology (skeletal system), myology (muscular system). Arthrology or syndesmology, angiology (vascular system), neurology, respiratory, digestive, urogenital systems (splanchnology). The locomotor system includes osteology, arthrology and myology.
- **Living anatomy** is studied by inspection, palpation, auscultation, percussion, endoscopy (bronchoscopy, gastroscopy), radiography, electromyography, etc.
- **Embryology (developmental anatomy)** (Figs 1.1A and B) is the study of the developmental stages/changes that occur in an individual while in mother's womb. The developmental history is called 'ontogeny'. On the other hand, the evolutionary history is called 'phylogeny'.
- **Microscopic anatomy (histology and cytology)** is the study of various structures of body, like tissues and organs with the help of a microscope.
- **Surface anatomy (topographic anatomy)** describes deeper parts of the body but in relation to the skin surface. It helps the healthcare teams in clinical practice and surgical operations.
- **Radiographic and imaging anatomy** is the study of the bones and deeper organs by plain and contrast radiography, by ultrasound and computerized tomographic (CT) scans (Fig. 1.2).

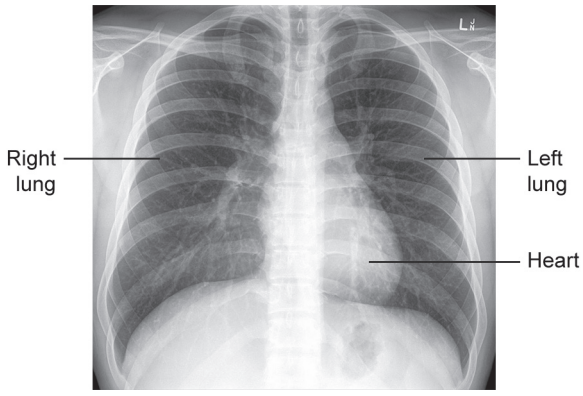


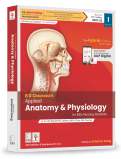
Fig. 1.2: Posteroanterior view of X-ray chest

- **Clinical anatomy** correlates anatomy with signs and symptoms to reach a diagnosis.

Physiology refers to the study of normal functioning of the body. It helps the body in maintaining, adaptation and homeostatsis.

Various subdivisions of physiology are as follows:

- **Cell physiology:** It is the study of individual activities of the cell to maintain homeostasis.
- **General physiology:** It is the study of principles, which are basic to the functions of all systems of the body.
- **Systemic physiology:** Here, we study the functioning of all the diverse systems of the body.
- **Immunology:** It is the study of immune system in the body.



LANGUAGE OF ANATOMY

Various positions, planes, and terms used in relation to different regions and movements of a body are as follows:

Anatomical Positions

When a person is standing straight with eyes looking forward, both arms by the sides of body, palms facing forward and both feet together—the position is known as anatomical position (Fig. 1.3). This position is used to ensure consistency and accuracy in anatomical descriptions.

- **Supine position:** When a person is lying on her/his back, arms by the side, palms facing upward and feet put together, the position is supine position. The arms are extended and secured on padded arm boards. **Supine position** is generally **used** for procedures such as cardiac, intracranial, abdominal, laparoscopic, endovascular, lower extremity procedures, and ear, nose, throat, neck and face (Fig. 1.4).

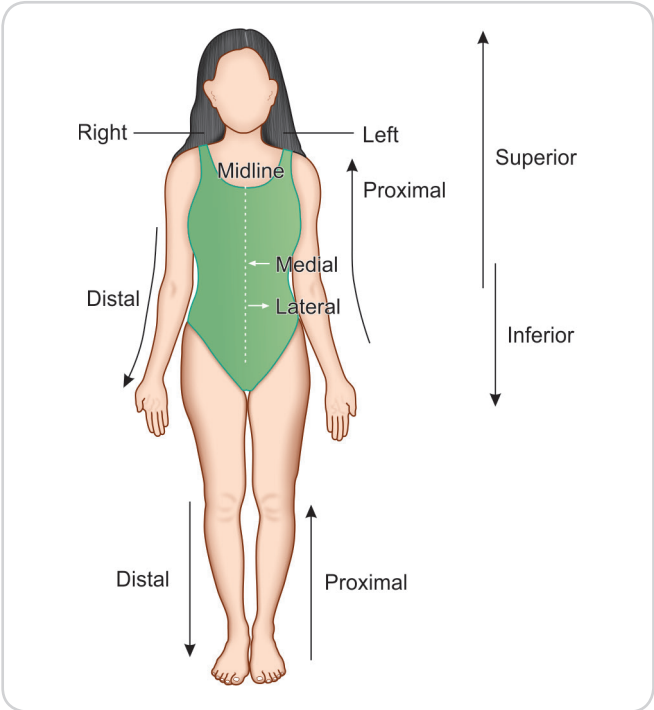


Fig. 1.3: Anatomical position

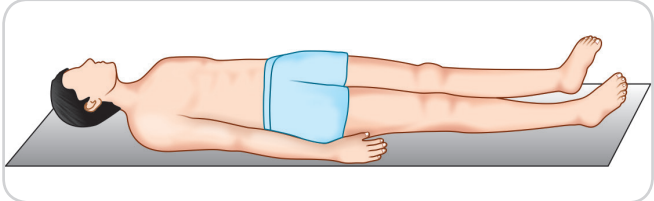


Fig. 1.4: Supine positio

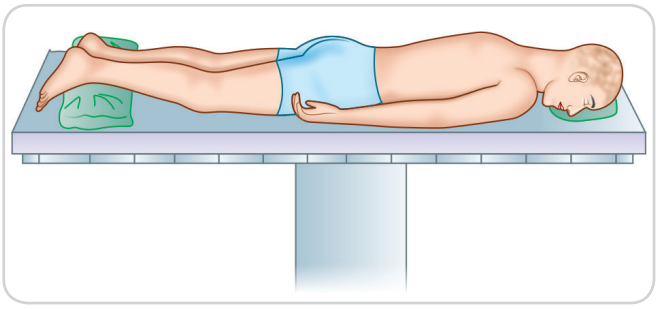


Fig. 1.5: Prone positio

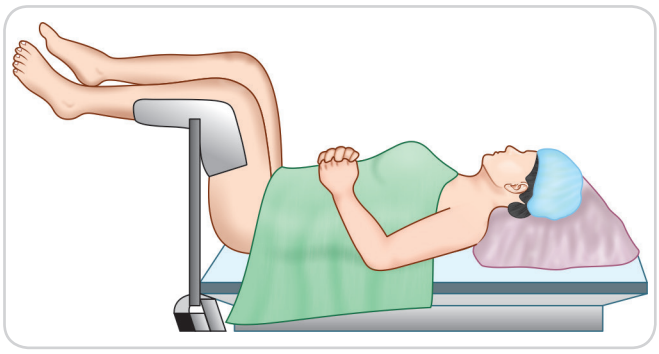


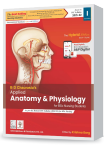
Fig. 1.6: Lithotomy positio

- **Prone position:** Person lying on his/her face, chest and abdomen, is said to be in prone position. This position is generally **used** for sedated patients who require a ventilator (Fig. 1.5).
- **Lithotomy position:** It involves lying on one's back with legs flexed at 90 degrees at hips. Person's knees are bent at 70 to 90 degrees, and padded feet rest attached to the table supports both the legs. This position is mostly **used** during childbirth and surgery in the pelvic area (Fig. 1.6).

Anatomical Planes

The planes divide the body into different sections and make it easy to describe or visualize the internal arrangement from different viewpoints. There are four body planes that lie at right angles to each other (Fig. 1.7). These are:

- **Midsagittal (median) and sagittal:** A plane passing through the center of the body dividing it into two equal right and left halves, is the median or midsagittal plane. Plane parallel to median or midsagittal plane is the sagittal plane (Fig. 1.8). Sagittal plane shows the viscera anteroposteriorly.
- **Coronal or frontal plane:** A plane at right angles to sagittal or median plane which divides the body into anterior and posterior halves is called a coronal or frontal plane (Figs 1.9 and 1.10). It shows the extent of a viscera anteroposteriorly.



NURSING IMPLICATIONS AND APPLICATIONS

- The anatomical terms are very useful in understanding various movements of the joints.
- Sagittal, coronal and horizontal planes show the internal structure of the body from different angles. These planes thus are extensively used in imaging techniques like CT scan, MRI and ultrasound scans.

Applications of Body Planes

- One of the primary applications of body planes is in the medical imaging techniques such as CT scans, sonography, MRI scans, or PET scans, etc. The patient is placed in standard anatomical position, and a radiologist can build an X-Y-Z axis around the patient and can apply body planes to the images. The body planes are then used to identify and locate the positions of the patient's internal organs. Each individual organ can further be divided with the help of planes to extract knowledge about smaller structures within that organ.
- These planes delineate the structure/tumor growth. It makes it easy for the surgeon to remove it or burn it, so that only the tumor tissue is removed without harming the neighboring normal tissues.
- Body planes are also used to describe the coordinate system with the help of which the body moves (anatomical motion in the X-Y-Z). An anatomist is able to model a limb's range of motion by measuring planes of the limb and can analyze movement.
- The various changes in anatomy during embryological development can be well described and measured with the help of body planes. During human embryonic development the coronal plane is horizontal, but it changes plane to become vertical when the embryo further develops into a fetus.

APPLIED ASPECTS

Orthopedic surgeons and physiotherapists use the extent of various movements before and after appropriate treatment.

AGING CHANGES

With increasing age, joints tend to lose the synovial fluid, decreasing the movements. There may be osteophytes making movements painful and restricted.

Assess Yourself

Long Answer Questions

1. Describe the body cavities in detail.
2. Discuss the importance of body planes.
3. Enumerate the subdivisions of anatomy and describe these briefly.

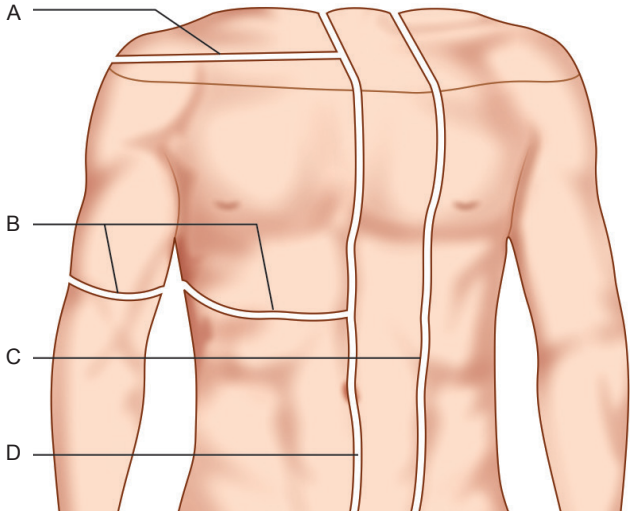
Short Answer Questions

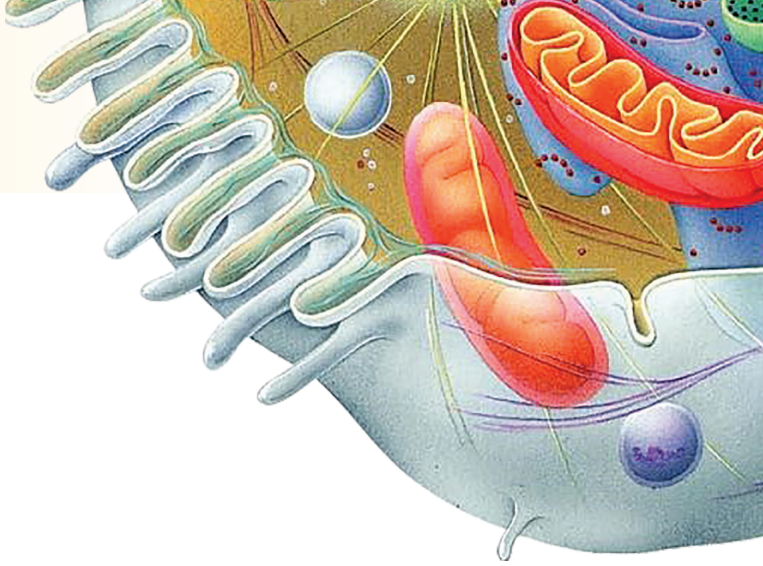
1. Write a short note on anatomical position.
2. Write a note on body movements.
3. Define:
   a. Supine position
   b. Prone position
   c. Eversion of foot
   d. Inversion of foot
   e. Protraction of jaw

Image-related Questions

1. Draw a diagram of a person in anatomical position

2. Label A, B, C, and D planes:





2

Cells and Tissues

Chapter Outline

Key Terminology

Cell: Small functional unit of the body. Cells group together to form tissues. Similar tissues join to form organs, which in turn form systems.

Plasma membrane: It consists of two layers of phospholipids and is embedded with sugar and proteins. It has a role in keeping the composition of intracellular fluid.

Nucleus: Genetic material is present as DNA, which directs all metabolic activities.

Organelles: These are small organs within the cytosol. For example, mitochondria. It is powerhouse of the cell. It breaks down ATP to provide energy.

Ribosomes: It synthesize proteins from amino acids; Smooth endoplasmic reticulum (ER) synthesizes lipids and steroid hormone; Rough ER is the site of protein synthesis.

Golgi apparatus: Packages the proteins.

Lysosomes: Contain enzymes which break down the used up organelles.

Cytoskeleton: Made of tiny fibers to provide support to the cell. These are intermediate filaments, microfilaments and microtubules.

Centriole: Directs the microtubules. Plays a role in cell division.

Cell cycle: Comprises two phases: interphase and mitosis. Interphase consists of G1 (first gap phase); S phase (synthesis phase) and G2 second gap phase. Mitosis comprises prophase, metaphase, anaphase and telophase.

Tissue: Four basic tissues are in the body: Epithelial, connective, muscular and nervous tissue. Each of them has various subtypes.

Apoptosis: Programmed cell death is apoptosis.

The living substance of plants and animals is described by the general term, *protoplasm*, which is bounded by a delicate membrane and contains various microscopic and submicroscopic structures. The smallest unit of protoplasm, capable of existing independently, is known as the cell. The word *cell* is derived from *Latin* and this means—a storeroom, a chamber and was first introduced to the biology by Robert Hooke (1635–1703) (Fig. 2.1).

The cell is the structural and functional unit of the living matter and is capable of carrying on the processes of life independently.

Fig. 2.1: Robert Hooke (1635–1703)

In the unicellular organism, a single cell is capable of multiple functions. However, in the multicellular organisms, all these functionalities of protoplasm are divided and delegated to the specific cells' organelles including protoplasm (Table 2.1). It is quite amazing to note that complex human body develops from a single cell—zygote, which is an outcome of fusion of ovum and sperm. A cell divides and redivides to form a fetus. These cells have same genetic make-up and they resemble the genetic make-up of zygote. As the fetus grows, cells differentiate with different functional specializations and perform separate functions. These functions may be inter related or intra related in a body to carry out all the activities smoothly.

CELL STRUCTURE

A cell has protoplasm suspended with plenty of organelles and surrounded by plasma membrane. Each cell can be broadly divided into principal units discussed ahead (Figs 2.2A and B):

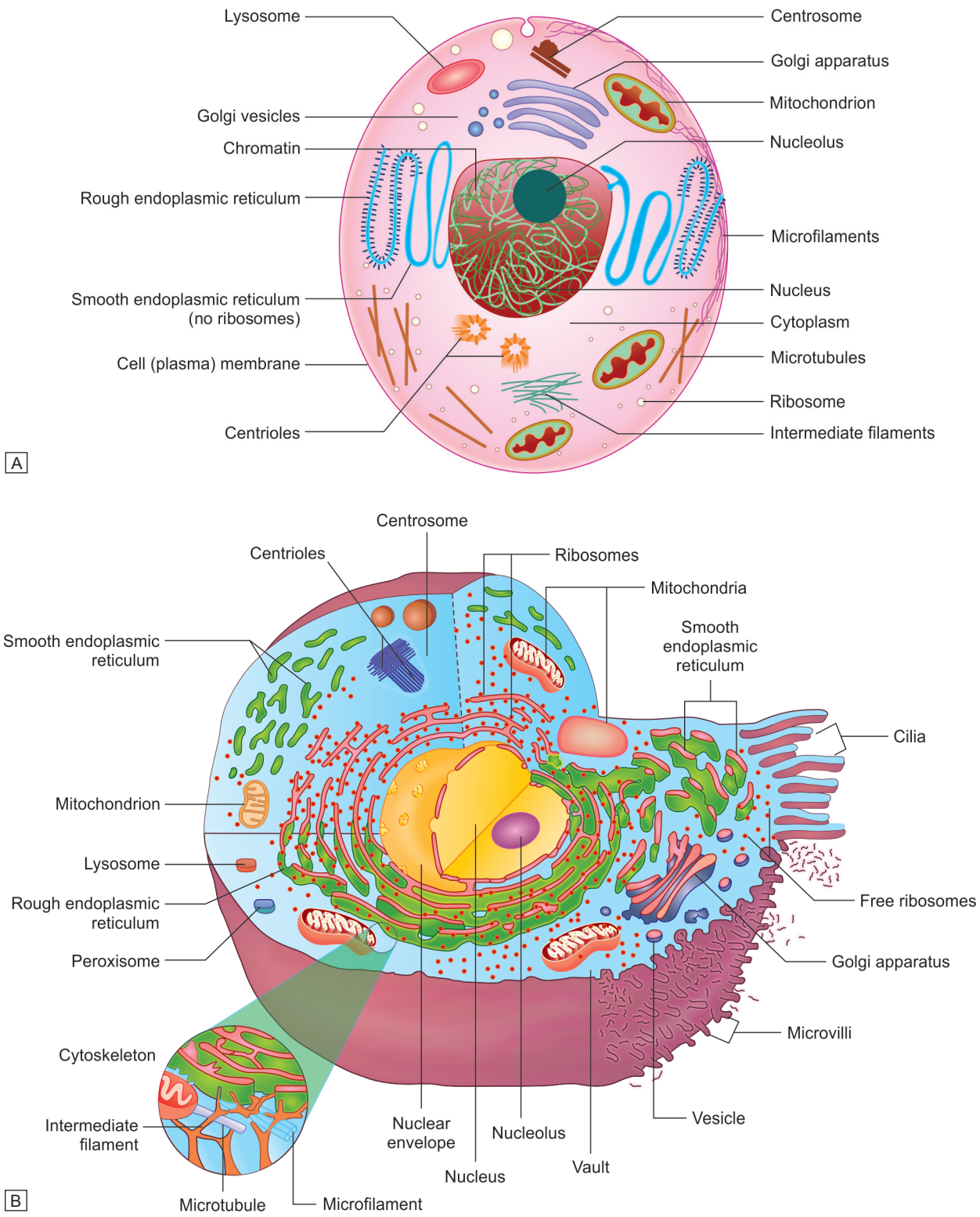
- Plasma membrane/cell membrane
- Cytoplasm and its cytoskeleton, organelles and cell inclusions.
- Nucleus

Plasma Membrane/Cell Membrane

The plasma membrane or plasmalemma or cell membrane is a selectively permeable outer covering of the cell and is flexible, responsive and dynamic in structure. This membrane isolates the individual cell from its neighbors and takes part in the

TABLE 2.1: Principal differences between prokaryotic cells and eukaryotic cells

Characteristics	Prokaryotic cell	Eukaryotic cell
Size of cell	Typically 0.2–2.0 μm in diameter	Typically 10–100 μm in diameter
Example	Bacteria and Archaea	Animals and plants
Nucleus	Absent	Present
Membrane-enclosed organelles	Absent	Present; examples include lysosomes, Golgi complex, endoplasmic reticulum, mitochondria & chloroplasts
Flagella	Consist of two protein building blocks	Complex; consist of multiple microtubules
Cell wall	Usually present; chemically complex	Only in plant cells and fungi (chemically simpler)
Plasma membrane with steroid	Usually no	Yes
Cytoplasm	No cytoskeleton or cytoplasmic streaming	Cytoskeleton; cytoplasmic streaming
Ribosomes	Smaller	Larger
Cell division	Binary fission	Mitosis
Number of chromosome	One, but not true chromosome	More than one
Sexual reproduction	No meiosis; transfer of DNA fragments only (conjugation)	Involves meiosis

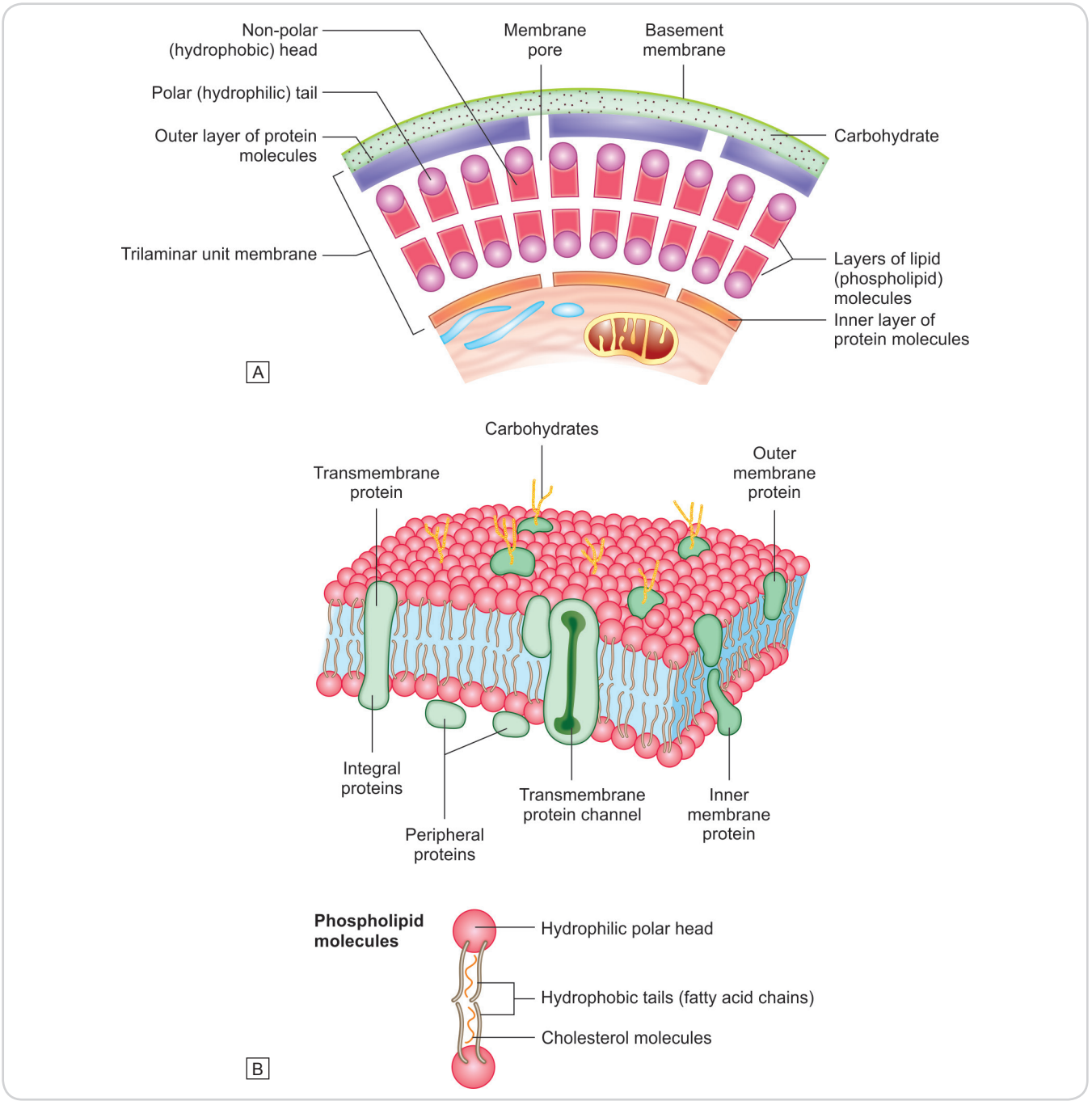


Figs 2.2A and B: **A.** Simplified tructure of a cell; **B.** Electron microscopic structure of a cell

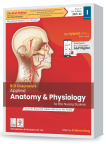
maintenance of the intracellular environment by controlling active transport of ions and nutrients. It has receptor for small molecules for recognition. It helps cell in cell interaction.

Under light microscope, the membrane is thin and invisible although the limits of cell can be approximated by the presence of cuticular folds or cellular secretions on the membrane.

Under electron microscope, the cell membrane is 7.2–8 nm thick and is a trilaminar (triple-layered) structure with proteins and sugars embedded in it. This basic trilaminar structure of cell membrane is generally described as *unit membrane* and it consists of double (bimolecular) layer of lipid molecules (light-stained), which are sandwiched within the two densely-stained protein layers (Figs 2.3A and B).



Figs 2.3A and B: **A.** Diagrammatic p esentation of cell memb ane; **B.** Fluid mosaic model in detail



Fluid Mosaic Model

At present the accepted models of cell membrane is the fluid mosaic model. This structure was further modified by Singer and Nicolson in 1972, and the model of cell membrane is now known as modified fluid mosaic model. The fluid mosaic model states that:

Cell membrane is comprised of approximately 55% of proteins, 25% phospholipids, 13% cholesterol, 4% of other lipids and around 3% carbohydrates (Fig. 2.3B).

HIGH YIELD POINT

The fluid mosaic model also states that cell membranes are composed of a phospholipid bilayer with admixed protein molecules that are freely floating around it. It is called fluid because individual phospholipids and proteins move side-to-side within the layer like a liquid; and is termed mosaic because of the topographic pattern produced by the scattered protein molecules.

The lipid bilayer consists of phospholipid molecules. The fatty acid portion of phospholipid is hydrophobic tail (hates water) and faces the interior of the membrane while phosphate end is hydrophilic head (loves water) in nature and this faces the exterior of the cell toward the extracellular fluid (ECF) on one side and the intracellular fluid (ICF) on the other side.

The proteins of cell membrane are glycoprotein and lipoprotein. The glycoprotein acts as receptors for hormones and neurotransmitters while lipoprotein functions as ion channels and enzymes.

The proteins extend through the membrane and act as channels for the passage of electrolytes and other nutrients. *The membrane proteins perform functions as follows*:

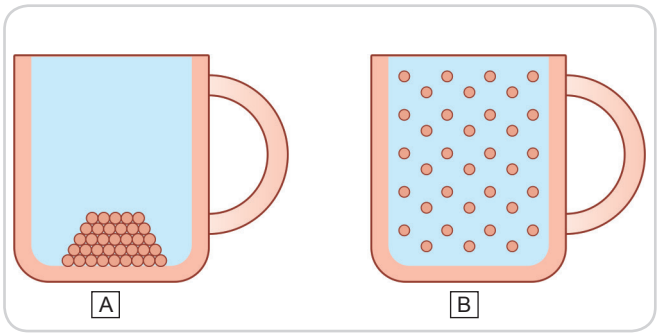
- They act as enzymes.
- Acts as receptor proteins which binds to specific hormones or substrate.
- These proteins act as channels for the transportation of minute water soluble ions.
- They give immunological identity to the cell because of their carbohydrates molecules.
- They are involved in active transport pumps for transportation of substances through the membrane.

The membrane carbohydrates are in the form of glycoprotein or glycolipid. The glycol part of carbohydrate molecules protrude outside of the cell. Both glycolipids and glycoproteins can act as cell receptor sites.

Functions of Cell Membrane

Membrane Transport

Cell membrane facilitates the transport of materials across it. It is selectively permeable to certain substances and helps transport of substances needed for survival. Therefore, the cell membrane acts as a selective barrier. Mainly two processes are involved in transportation of substances across the cell membrane.



Figs 2.4A and B: Diffusio

Passive transport

In this case the molecules move down the concentration gradient without involving energy.

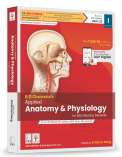
The various passive transport mechanisms are:

- *Diffusion:* Lipid soluble materials like oxygen, carbon dioxide, etc., small molecules, etc. are transported across the cell membrane by diffusion and water soluble materials like sodium, calcium, etc. are transported by passing through water filled channels in the membrane (passive osmosis Figs 2.4 and 2.5).
- *Transmembrane protein channels and transporters aid in this transport,* for example, Aquaporins for water transport, ion channels for sodium and potassium transport, etc. (Fig. 2.5B)
- *Osmosis:* It is the movement of a solvent across a semipermeable membrane toward a higher concentration of solute (lower concentration of solvent). In cells generally, water is the solvent. Osmosis helps the body to get nutrients from food. It also removes waste products out of the blood (Fig. 2.6)

Active transport

The transportation of molecules against their concentration ingredient is active transport. The substances move from lower to higher concentration and for this energy is used in the form of ATP. The ATP is derived from the proteins molecules (Fig. 2.5C).

- *Pinocytosis:* The transfer of large particles occurs by pinocytosis. It helps the cell to transport fluid substances.
- *Endocytosis and exocytosis:* Small vesicles are formed by a process of pinocytosis (drinking by cells). They encircle and carry fluid within them and across the membrane. By the pinocytosis process fluid of smaller molecules (0.01–2.0 mm) can be engulfed and transported (Fig. 2.7).
  - *Exocytosis* is a process in which cells remove undigested or waste metabolites/products that were brought in the cell by endocytosis. This process is also used by the cell to secrete enzymes and hormones or to excrete substances outside the cell.



APPLIED ASPECTS

Mutations and genetic disorders

Mutation when genetic make up of cell is altered, it is said to mutate. Mutation may occur by X-rays, cosmic rays, etc. Mutations may result in cell death, inborn errors of metabolism.

Separation of chromosomes in 1st meiotic division or separation of chromatids in 2nd meiotic division is called disjunction. If it does not occur properly, it is named as nondisjunction. In such a case the daughter cells may not receive the desired number of chromosomes. There may be less or more number of chromosomes. Such cases are: Turner's syndrome—person has only 45 chromosomes Y chromosome is lacking. Klinefelter's syndrome: An extra chromosome in male; Down's syndrome—chromosome number 21 has trisomy.

Damaged DNA must be repaired, otherwise. It is vulnerable to form cancer.

Legal help

DNA fingerprinting is of value in investigating paternity and crimes.

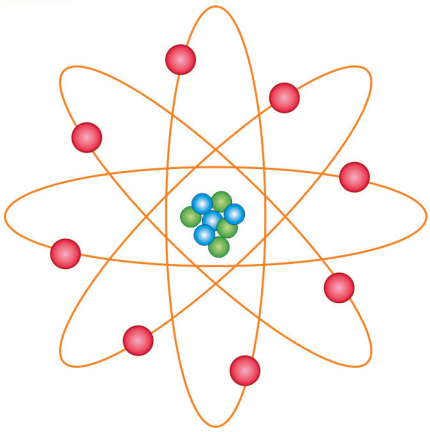
AGING CHANGES

The cell cycle is slowed by aging. As enough nutrition does not enter the body, cells cannot multiply. Muscle mass becomes less slow. The bones become osteoporotic. Persons are more likely to fall causing fracture of the bones. Healing of bones is very opportunistic infection add to the already existing problem.

Neurons start dying. Ability to see, walk, etc. goes down, making life miserable especially with other diseases like diabetes, hypertension, etc.

3

Chemistry of Life



Chapter Outline

Matter
- Atoms
- Element
- Molecules
- Compound

Body Fluids

Distribution of Body Fluid
- Body Fluid Compartments

Fluid and Electrolyte Balance

Regulation of Electrolyte Intake and Output
- Ionic Concentration in Intracellular and Extracellular Fluids

Water Balance in the Body
- Regulation of Water Intake
- Regulation of Water Output

Acid-base Balance
- Hydrogen Ion Concentration of the Body Fluids

Homeostasis
- Role of Various Systems of Body in Homeostasis
- Role of Neuroendocrine Reflex in Homeostasis
- Feedback Mechanism
- Factors Influencing Homeostasis
- Importance of Electrolyte Balance in Homeostasis

Factors Affecting Blood Volume

Key Terminology

Atom: The simplest building block of matter. It is the smallest unit of element.

Composition of atom: Atoms are made of proton (+ charged), electron (– charged) and neutron (neutral).

Ions: Atoms with either extra or missing electrons.

Atomic mass: Total mass of a single atom of an element that can be measured.

Atomic number: Total number of protons and neutrons in the nucleus of an atom.

Molecules: A molecule is an electrically neutral group of 2 or more atom held together by chemical bonds.

Compound: It consists of atom of more than one element held together by chemical bonds.

Water: It is the most abundant fluid in the body and makes up 70% of total body weight.

Body fluid compartments: Intracellular compartment and extracellular compartment. Concentration of substances in the two compartment are constantly different, 55% of water is present in intracellular spaces.

Transcellular fluid: Fluid separated from the other extracellular fluid by an epithelial membrane. Example are CSF, synovial fluid, intraocular fluid, fluid in serous cavities, etc.

Electrolytes: Important electrolytes are Na^+, Ca^{++}, HPO_4^2 and Cl^-.

Water balance: Intake should be equal to output to maintain the water balance. Acid base balance is maintained by lungs and kidneys.

pH: pH of body fluid is 7.35–7.45. If it rises above 7.45, it is called alkalosis. pH lower than 7.35 is called acidosis.

Homeostasis: It is dynamic equilibrium between extracellular fluid with Na^+, Cl^-, HCO_3^- and intracellular fluid with K^+, Mg, PO_4^{3-}. Most of the systems work to maintain homeostasis. In addition there are negative and positive feedback mechanisms to maintain homeostasis.

Factors affecting blood volume: These are age, sex, body weight, muscular exercise, blood pressure, anoxia, adrenaline injection.

MATTER

The simplest building block of matter is subatomic particles, atoms and molecules. All matter in the universe are composed of atoms.

Atoms

The smallest unit of pure substances also called element is an atom. Atoms are made up of subatomic particles and these subatomic particles (*sub-* means "smaller size") are (Fig. 3.1):

- **Proton** (p^+),—positively (+) charged
- **Electron** (e^-),—negatively (–) charged
- **Neutron** (n^0),—no charge (neutral).

Protons and neutrons occupy the center of the **nucleus**, in an atom. Electrons are present in regions called **shells** outside the nucleus. Electrostatic forces are responsible to hold atoms in an element, e.g. two hydrogen atoms are held together in element of H_2 gas. The oppositely charged protons (+) and electrons (–) maintain the structure of an atom.

The chemical properties of an atom are characterized by number of electrons and protons in an atom. The atoms are of the following types:

- **Stable:** The protons, neutrons and electrons are balanced in stable atoms. The stable atom stays indefinitely the same.
- **Ions:** Atoms with extra or missing electrons are called ions. They have either a positive or negative electric charge. They are responsible for numerous chemical reactions.
- **Isotopes:** Elements may have isotopes. Such isotopes have a different number of neutrons, otherwise they are same. The presence of different number of neutrons affects atomic weight. This further makes them radioactive.

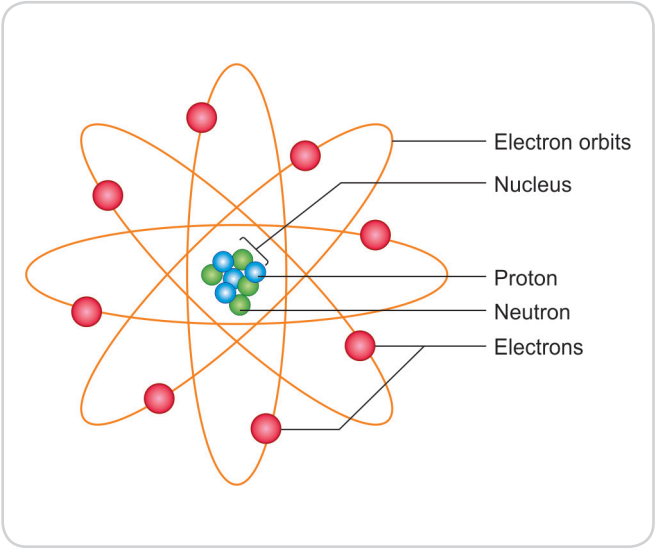


Fig. 3.1: Atomic structure

- **Radioactive:** There are some atoms where too many neutrons are present in the nucleus and this makes them unstable. They remain radioactive and keep on giving off particles until they become stable.
- **Antimatter:** Every atomic particle has a twin anti-particle, with an opposite electric charge. Antimatter hydrogen atoms are created in the laboratory, containing an anti-proton and anti-electron. Antimatter particles are very rare and fragile.

Atomic Number and Atomic Mass

- **Atomic mass:** The atomic mass that is also called atomic weight is the total mass of an element's atom that can be measured.
- **Atomic number:** Whereas, atomic number is the total number of protons in the nucleus of an atom (Table 3.1).

Element

An element that is made up of only one type of atom is called monoatomic. They are made of a single (*mon-*) atom (*-atomic*) in their molecular form, e.g. Helium (He). Others contain two or more atoms in their molecular form. Hydrogen (H_2) and oxygen (O_2) have two atoms, ozone (O_3), has three atoms, whereas sulfur (S_8) has eight atoms.

All elemental molecules are made of atoms of a single element (Fig. 3.2).

TABLE 3.1: Differences between atomic mass and atomic number

Atomic mass	Atomic number
Atomic mass is denoted by A	The letter Z is used to represent an atomic number.
It is the average weight of an element.	It is the total number of neutrons and protons in the nucleus.
Atomic mass is associated with the number of neutrons and protons that are present in a particular nucleus of an element.	Atomic number is usually the number of protons present in an atom's nucleus.
Atomic mass is mostly measured using atomic mass unit (amu).	Atomic number is just a digit used to place elements in a periodic table.
Atomic mass is also used to classify different isotopes of the same element	Isotopes only share the same atomic number.
Atomic mass is not helpful to define the type of element.	Atomic number helps in the classification and identification of an element.

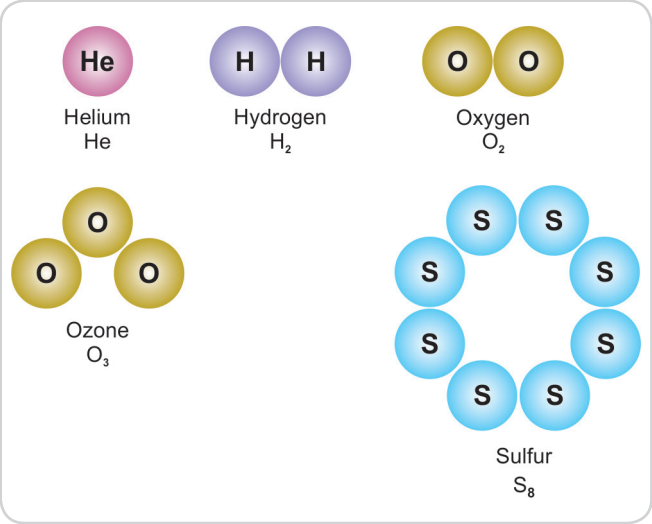


Fig. 3.2: Elements

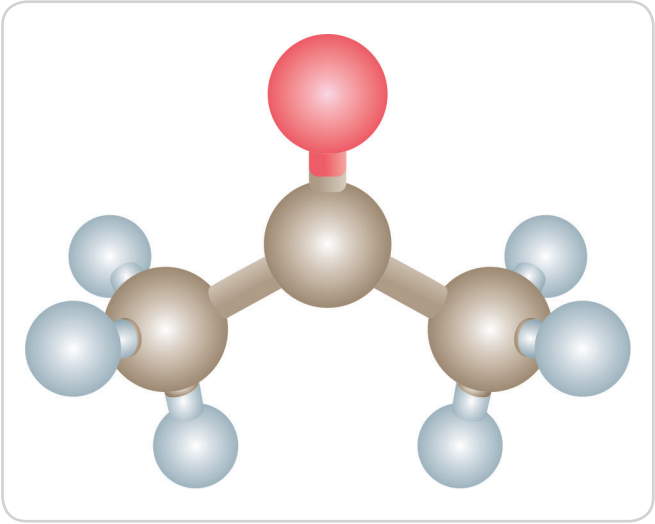


Fig. 3.4: Compound

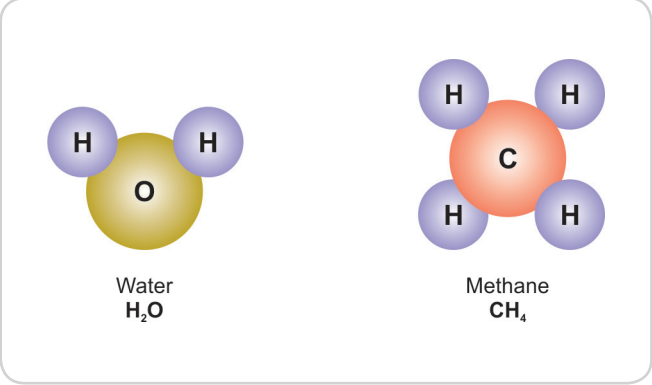


Fig. 3.3: Molecules

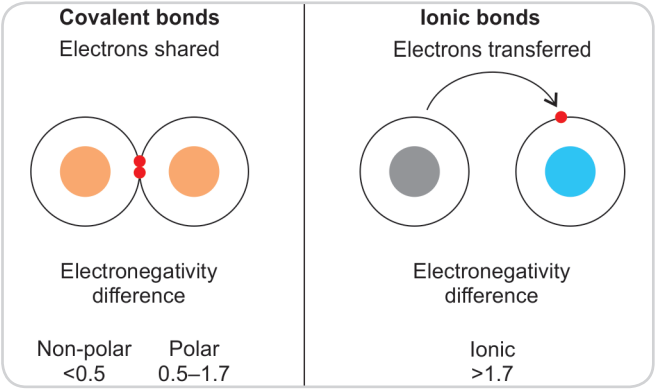


Fig. 3.5: Di erences between-covalent-and-ionic-bonds

Molecules

When two or more atoms combine they form a molecule, e.g., water, methane, proteins, and sugars found in living things (Fig. 3.3). Molecules are the chemical building blocks of whole body. **Molecules** are held together by covalent bonds.

Compound

They contain two or more atoms of different element, which are held together with the help of ionic and covalent bonds. The atoms within a compound are different from each other. Living tissues are made up of organic compounds although inorganic compounds are also needed (Fig. 3.4). Compounds containing carbon and hydrogen are organic and all others are inorganic.

Covalent and Ionic Bonds

The organic and inorganic compounds taken in by a body are broken down to release energy for metabolic activities. The atoms are joined together by covalent or ionic bonds (Fig. 3.5).

Covalent bonds are formed when the electrons are shared by the atoms. It is a strong and stable bond. Water molecule is an example of having covalent bond. When one oxygen atom combines with two hydrogen atoms, the outer shells of both get stabilized by sharing the electrons (Hydrogen has 1 electron but requires 2; and oxygen has 6 electrons in outer shell and requires 2 more to get stabilized). When they share the electrons, both hydrogen and oxygen form a stable molecule of water.

Ionic bonds are weaker than covalent bonds. They are formed when electrons are transferred from one atom to another. For example, sodium chloride where only electron in the outer shell of sodium shifts to the outer shell of chlorine. This way both sodium and chlorine attain a stable electronic configuration. As the bond is not strong enough, sodium chloride dissolves easily in the water.

BODY FLUIDS

Water is the most vital and at the same time; the most abundant component of the human body. It constitutes about 70% of the total body weight and within which the major cations like sodium, potassium, calcium, hydrogen, magnesium and anions like chloride, bicarbonate and protein of the body are dissolved. Without water there would be no form of life. It forms the intracellular medium within which metabolic reactions—characteristics of living substances—take place. Water-deprivation brings about death earlier than that of food-deprivation. If water is given instead of food, life may continue for several weeks by the loss of most of the body fat and 50% of tissue protein.

Know it

- **Mole:** A mole is the amount of a substance that contains the number of molecules equal to Avogadro's number.
- **Avogadro's number:** This is the number of molecules in one mole of a substance (i.e., 6.023×10^{23}).
- **Osmole:** It is the amount of a substance that dissociates in solution to form one mole of osmolality active particles.
- **Osmolality of a solution:** It is the number of osmoles of solute per kilogram of solvent.
- **Osmolarity of a solution:** It is the number of osmoles of solute per liter of solution.
- **Colloids** is a term used to collectively refer to the large molecular weight (nominally MW >30,000) particles present in a solution. In normal plasma, the plasma proteins are the major colloids present. As the colloids are solutes they contribute to the total osmotic pressure and referred to as colloid osmotic pressure (or sometimes as the oncotic pressure).

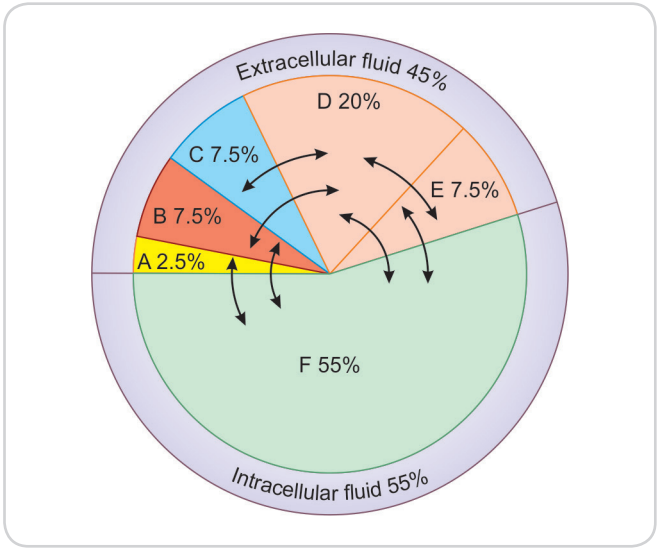
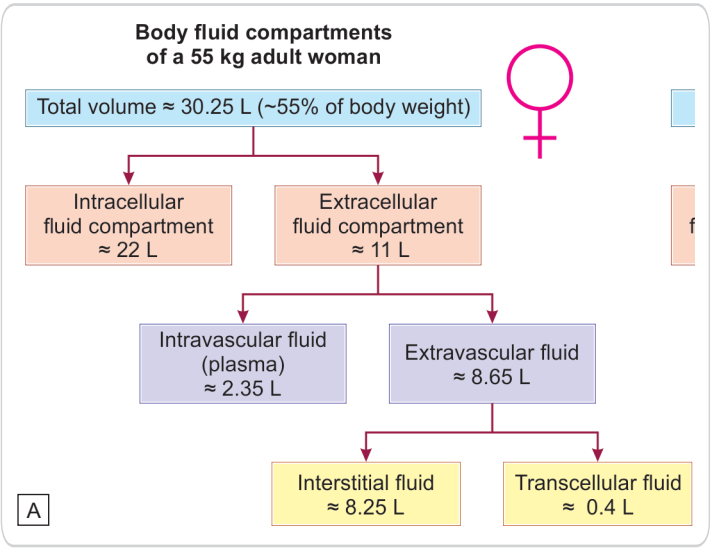


Fig. 3.6: Distribu on of body water in di erent compartments; **(A)** Transcellular water (2.5%); **(B)** Dense connecti e tissue and cartila e water (7.5%); **(C)** Plasma water (7.5%); **(D)** Interstiti and cartila e water (20%); **(E)** Inaccessible bone water (7.5%); **(F)** Intracellular water (55%);

DISTRIBUTION OF BODY FLUID

Total body water content in an average human being weighing about 70 kg is 40–45 L. In an average *human being* it is about 65% of the body weight in males and about 10% less in females. The water content is more in babies and young people. In elderly, this content lowers down. The distribution of body fluid in male and female is shown in Figures 3.6 and 3.7.

Average intake and output/day of body fluid is given in Figure 3.8.



Figs 3.7A and B: Body fluid ompartments in (A) male and (B) female

4

Organization of Human Body

Chapter Outline

- Surface Anatomy
- Head and Neck Region
  - Cranium
  - Face
  - Neck
- Shoulder and Upper Limb Region
  - Arm and Elbow
  - Forearm
  - Hand
- Thorax Region
- Abdomen and Pelvic Region
- Lower Limb Region
- Organ System
  - Skeletal System
  - Joints
  - Muscular System
  - Respiratory System
  - Blood
  - Cardiovascular System
  - Lymphatic System
  - Digestive System
  - Urinary System
  - Reproductive System
  - Nervous System
  - Endocrine System
  - Special Senses/Sensory Organs
  - Integumentary system
- Resistance and Immunity

Key Terminology

Tissues: Cells of different types form tissues. Different tissues form organs. Organs serving similar functions form a system.

Skeletal system: Made up of flexible cartilages and hard bones. There are more bones in child than in an adult.

Joints: Bones united together by fibrous tissue, cartilage or synovial fluid and capsule. The last one permits movements.

Muscular system:
- Skeletal muscles move joints
- Smooth muscles move viscera
- Cardiac muscles move heart only

Respiratory system: Taking in oxygen and exhaling out CO_2 constitutes a respiration. An adult breathes 12–15 times/min. The passage of respiration is kept patent.

Blood: Fluid vehicle of the body. It is 4.5–5 L and is divided into various organs. After eating food, more blood is diverted to digestive system and there is relatively less for brain, so one tends to be sleepy.

Cardiovascular system: Circulation of blood from heart to tissues and back to heart is systemic circulation. Circulation of blood from heart to lungs and back to heart after oxygenation is pulmonary circulation. It includes the lymphatic system as well.

Digestive system: It is a long tube, convoluted in small intestine from oral cavity to the anal canal of anus. Associated with three pairs of salivary glands, liver, gallbladder, pancreas, glands in wall of stomach, intestine.

Nutrition: Food stuffs with their contents and their biological value form nutrition. Balanced food provides ideal nutrition, which metabolizes into various substrates.

Urinary system: Richly supplied by blood. Excretes urea from the body, maintains pH of blood, water balance, etc.

Contd...

Reproductive system: Different in males and females. It is a means of continuation of species.

Nervous system: Highest evolved system. Parts are CNS and peripheral nervous system made of 12 pairs of cranial and 31 pairs of spinal nerves. Autonomic nervous system is involuntary system.

Endocrine system: Spread as small organs throughout the body. Acts to maintain homeostasis.

Special senses: Sense of smell, vision, taste, hearing, balance and touch, form the special senses.

Skin and fasciae: Largest garment is the skin with multiple functions. Fascia are superficial and deep.

Resistance and immunity: It is nonspecific and specific. Cells are prepared to fight/kill the various antigens.

Regions of the body:
Brain
Head and neck
Thorax
Abdomen
Upper limb
Lower limb
(Various important landmarks are given).

SURFACE ANATOMY

A branch of gross anatomy that examines shapes and markings on the surface of the body as they relate to the deeper structures, is surface anatomy. Every region of human anatomy shows major surface areas and the deeper bony landmarks. These are useful in surface anatomy. The knowledge of surface markings is essential in locating and identifying anatomic structures prior to studying internal gross anatomy. Health-care personnel use surface anatomy to help diagnose medical conditions and to treat patients.

Four techniques are in use when examining surface anatomy. These are:

- **Visual inspection:** Here the structure and markings of surface features are directly observed.
- **Palpation:** It is feeling with firm pressure or perceiving by the sense of touch. It helps in precisely locating and identifying anatomical features under the skin.
- **Percussion:** The use of sharply tapping on specific body sites to detect resonating vibrations.
- **Auscultation:** Listening to the sounds emitted from organs by the stethoscope.

The following is the discussion regarding major surface areas in the body.

Major surface areas and bony landmarks are divided in regions in head and neck, upper limb, thorax, abdomen and lower limb.

HEAD AND NECK REGION

Cranium

Cranium (cranial region or braincase) is covered by the scalp, which is composed of skin and subcutaneous tissue. Cranium can be subdivided into three regions, each having prominent surface anatomy features. The frontal region of the cranium is the forehead. Covering the frontal region is the frontalis muscle, which overlies the frontal bone. The frontal region terminates at the superciliary arches. Figure 4.1 shows anatomical position of skull.

Face

- **Auricular region:** Composed of the visible surface structures of the ear as well as the ear's internal organs, which function in hearing and maintaining equilibrium. Auricle or pinna, is the fleshy part of the external ear (Figs 4.2A and B). Within the auricle is a tubular opening into the middle ear called the external auditory meatus canal. The mastoid process is posterior and inferior to the auricle.
- **Orbital (or ocular) region:** It includes the eyeballs and associated structures. Surface features protect the eye. Eyebrows protect against sunlight and potential mechanical damage. Eyelids close reflexly to protect against objects moving near the eye. Eyelashes prevent airborne particles from contacting the eyeball (Fig. 4.2).
- **Nasal region:** It contains the nose. The bridge is formed by the union of the nasal bones. The fleshy part of the nose is called the dorsum nasi. The tip of the nose is called the apex. Nostrils or external nares are the paired openings into the nose. Ala nasi (wing of the nose) forms the flared lateral margin of each nostril (Fig. 4.2).
- **Oral region:** It is inferior to the nasal region which includes the buccal (cheek) region, the fleshy upper and lower lips (labia), and the structures of the oral cavity (mouth) that can be observed when the mouth is open. The vertical depression between one's nose and upper lip is called the philtrum.
- **Mental region:** The mental region contains the mentum, or chin. The mentum tends to be pointed and almost triangular in females. Males tend to have a "squared-off" mentum.

Neck

Triangles of the neck: Neck/cervical region/cervix is a complex region that connects the head to the trunk. Spinal cord, nerves, trachea, esophagus, and major vessels traverse this highly flexible area. Neck contains other organs and several important glands. Neck can be subdivided into anterior, posterior, and lateral regions.

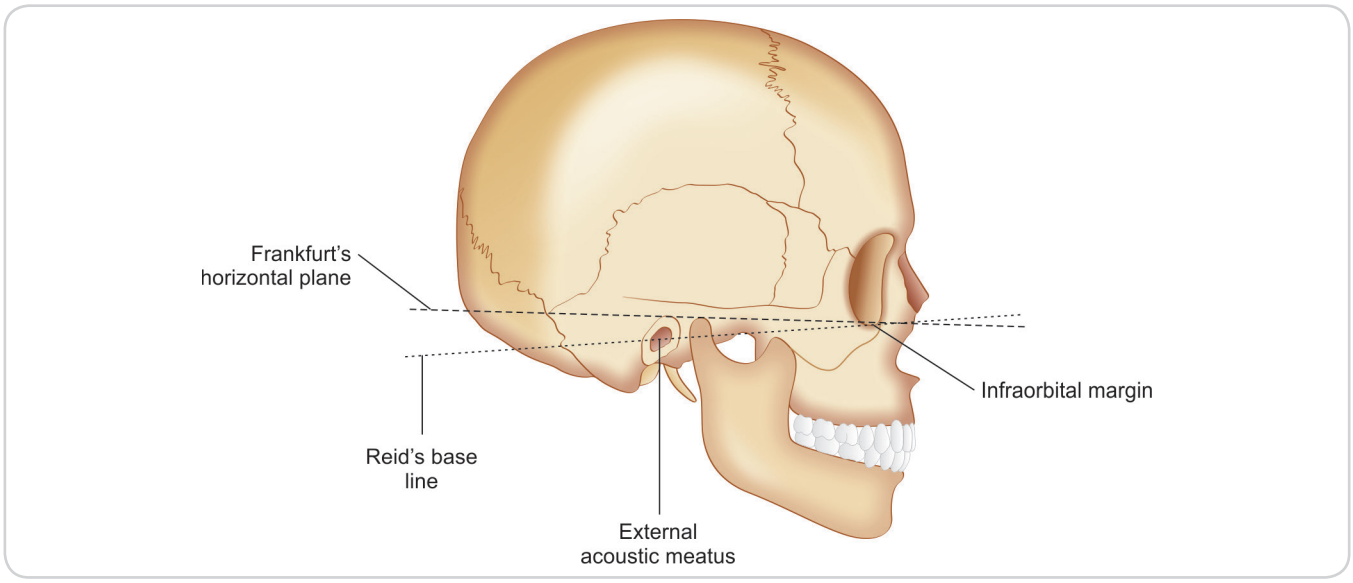
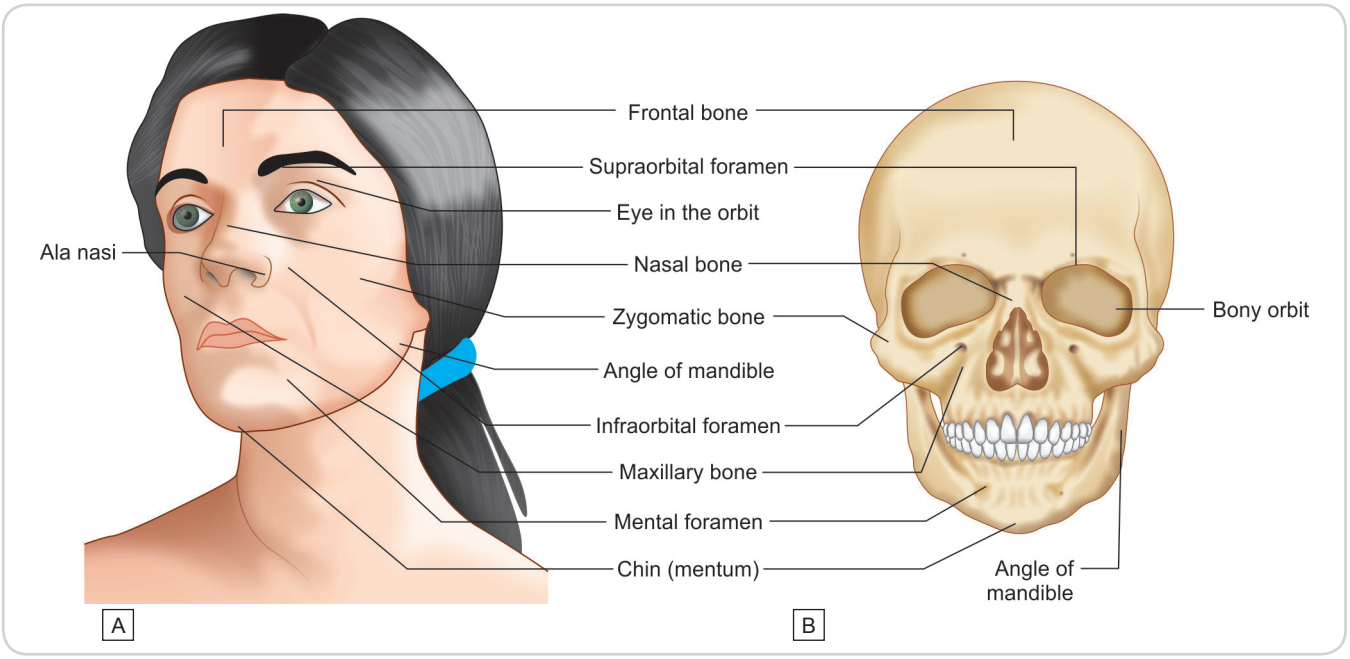
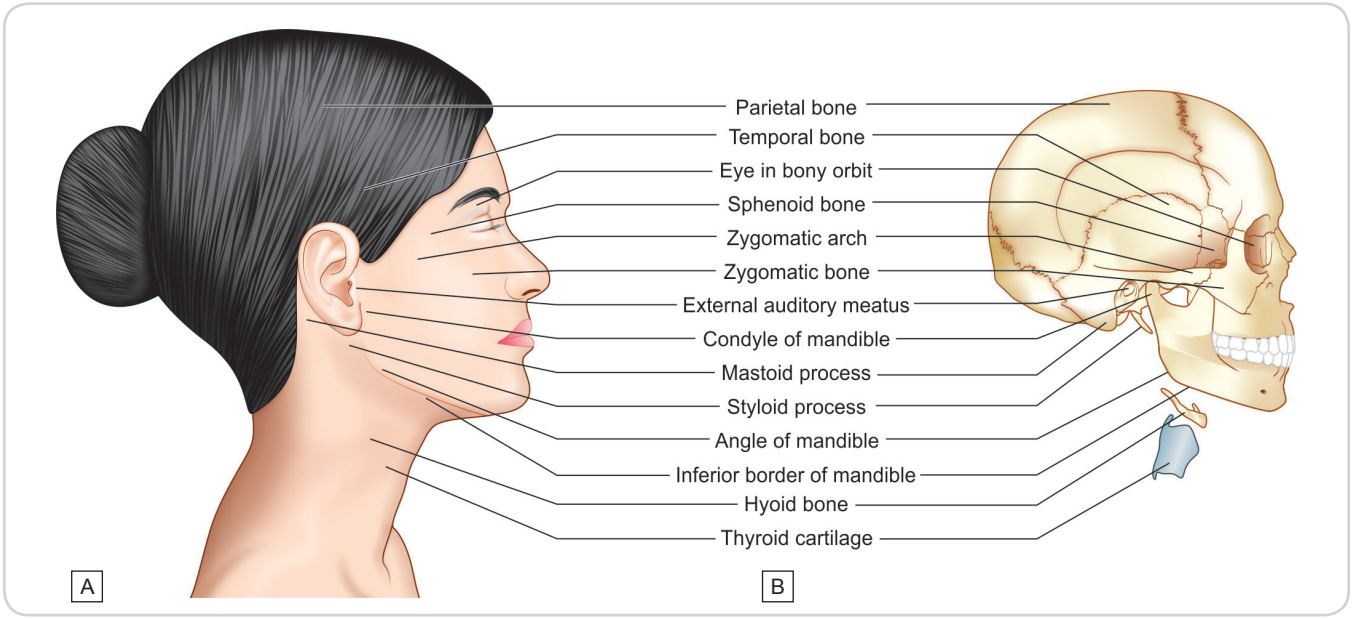


Fig. 4.1: Anatomical positions of s ull

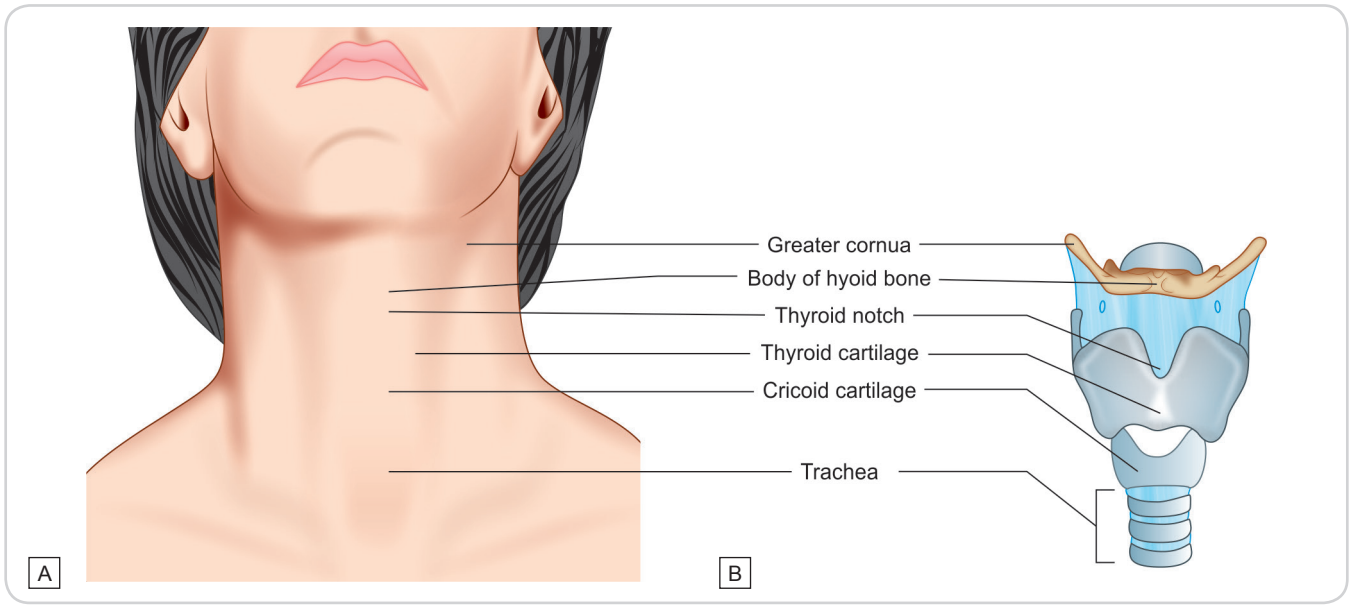


Figs 4.2A and B: Body landmarks on the front of face/Norma frontalis: **A.** Body view; **B.** Skeletal view

- **Anterior region of the neck:** It has several palpable landmarks, including the larynx, trachea, and sternal notch. The larynx found in the middle of the neck is composed of multiple cartilages—Thyroid cartilage or "Adam's apple" (Figs 4.3A and B). Inferior to the thyroid are the cricoid cartilage and trachea (Figs 4.4A and B). It terminates at the sternal (jugular) notch of the manubrium and the left and right clavicles.
- **Nuchal region:** The posterior neck region houses the spinal cord, cervical vertebrae, and associated structures (Figs 4.5A and B). The bump at the lower boundary of this region is the vertebra prominens. Superiorly along the midline of the neck, is the ligamentum nuchae, a thick ligament that runs from C7 to the nuchal lines of the skull transverse process palpable laterally (Figs 4.5 and 4.6).
- **Left and right lateral portions of the neck:** These portions contain the sternocleidomastoid muscles which partition the neck into two clinically important triangles, an anterior triangle and a posterior triangle. Each triangle houses important structures that run through the neck.



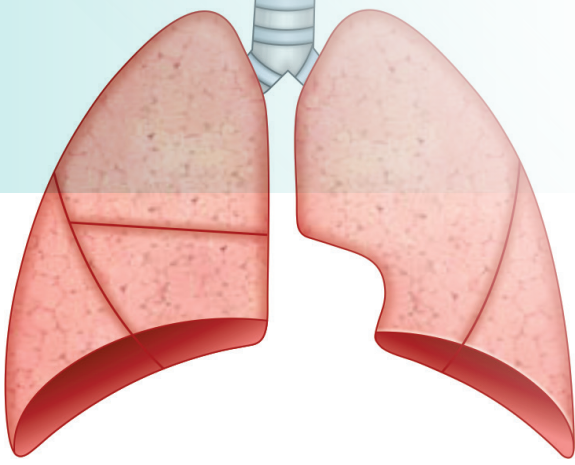
Figs 4.3A and B: Body landmarks on lateral side of face/norma lateralis: **A.** Body view; **B.** Skeletal view



Figs 4.4A and B: Bony landmarks in front of neck and deeper structure: **A.** Body view; **B.** Skeletal view

Triangles are further subdivided into smaller triangles. Anterior triangle lies anterior to the sternocleidomastoid muscle and inferior to the mandible. It is subdivided into four smaller triangles—the submental, submandibular digastric, carotid, and muscular triangles (Fig. 4.7).

- **Submental triangle:** It is most superiorly placed of the four triangles the subdivisions of the anterior triangle. It lies inferior to the chin in the midline of the neck and is partially bounded by the anterior belly of the digastric



5

Respiratory System

Chapter Outline

Key Terminology

Respiration: Taking oxygen in the body and expelling carbon-dioxide from the body.

External respiration: Exchange of gases between the blood and the alveoli of the lungs.

Internal respiration: Interchange of gases in the tissues.

Olfactory epithelium: Lines the uppermost part of nasal cavity. The impulses carry the sense of smell.

Paranasal sinus: Air spaces between the two tables of some of the skull bones. Paranasal sinus lightens the weight of the head, humidifies and heats up or cools down the inhaled inspired air.

Nasopharynx: Part of pharynx posterior to the posterior nasal apertures. Few lymph nodules lie in this area.

Larynx: Also called voice box. Muscles move the vocal cords to produce sounds/vowels. Safety muscle of larynx is posterior cricoarytenoid as it is the only abductor of vocal cord.

Pleura: Serous double-layered membrane around lungs with slight negative pressure.

Pump handle movement: Elevation of 2nd–6th ribs with sternum increases anteroposterior diameter of the thorax.

Bucket handle movement: 7th–10th ribs get elevated to increase transverse diameter of the thorax.

Piston-like movement: Diaphragm descends vertically like a piston to increase vertical diameter of thorax.

Pleural effusion: Collection of fluid in pleural cavity. Mostly it is due to tuberculosis of lung.

Dyspnea: Difficulty in breathing.

Chemoreceptors: Aortic and carotid bodies act as chemoreceptors, i.e., respond to changes in pH, pO_2 and pCO_2.

Surfactant: Lipid substance secreted by type II pneumocytes of alveoli is surfactant. It lowers the surface tension of alveoli and prevents them from collapsing.

Cyanosis: It is bluish discoloration of body tissues due to decreased levels of oxygen bound hemoglobin. If deoxy Hb levels increases more then 5 g/dL it causes cyanosis.

Respiratory system consists of organs which provide the pathway for supply of oxygen to the body and expulsion of carbon dioxide from the body to the surrounding atmosphere. Oxygen is required for the chemical reactions to release energy that is used for the proper functioning of the cells.

Respiration involves exchange of gases and is a twofold process:

1. **External respiration** is the exchange of gases between the blood and the alveoli of the lungs.
2. **Internal respiration** is the interchange of gases in the tissues.

ORGANS OF RESPIRATION

These include organs which help in the mechanism of respiration (Fig. 5.1). These are as follows:

- **Nose:** External nares, nasal cavity and posterior nares
- Paranasal sinuses
- Nasopharynx
- Larynx
- Trachea and bronchi
- Lungs in the pleural cavity
- **Respiratory muscles:** The diaphragm and intercostal muscles.

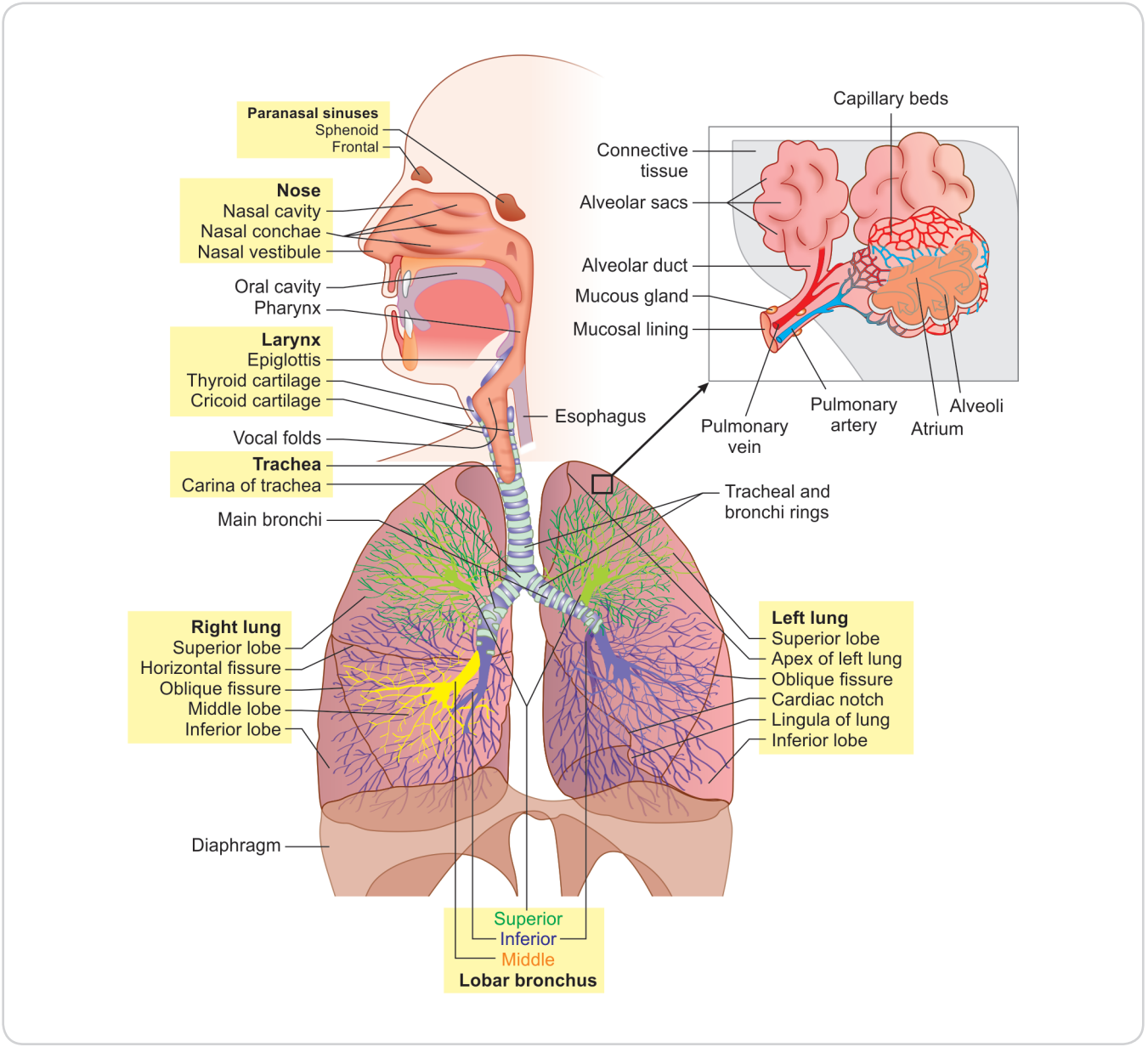


Fig. 5.1: Human respiratory system

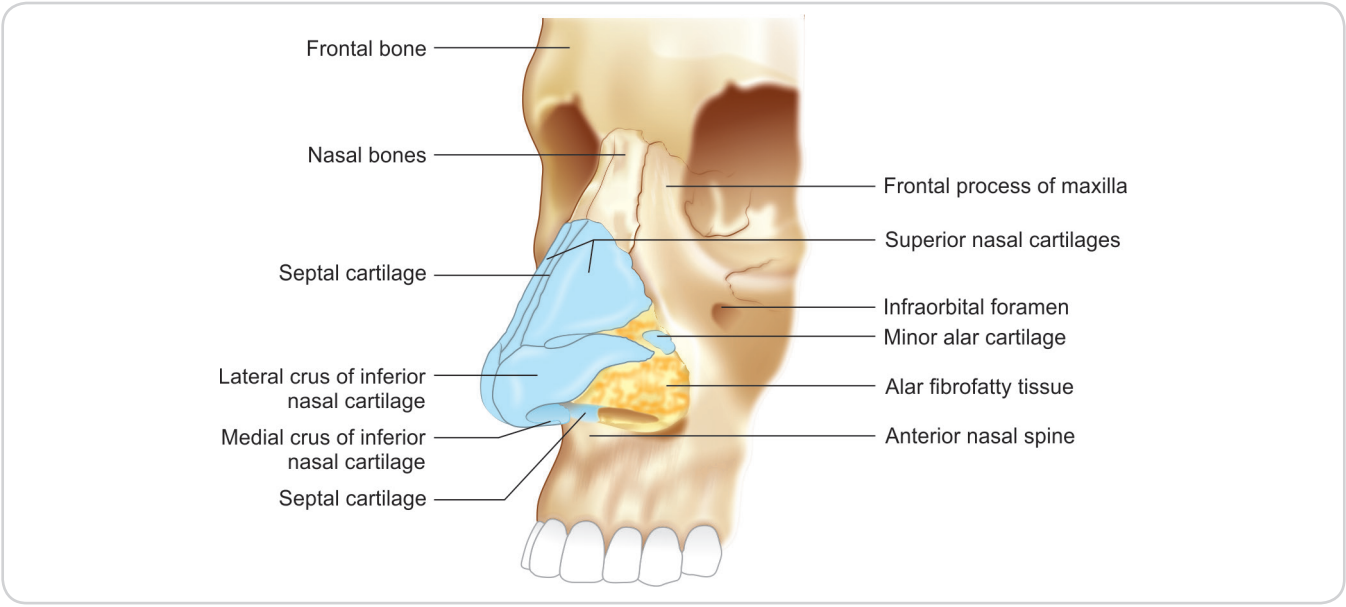


Fig. 5.2: Skeletal framework of external nose

Nose

The upper narrow end of the nose just below the forehead is the root of the nose. It is continuous with a prominent ridge which separates the right and left halves of the nose and is called the dorsum.

The lower end of the dorsum is in the form of a rounded part called the tip of the nose.

At the lower end of nose there are right and left nostrils or anterior nares. The two nostrils are separated by a soft median partition, the columella. This is continuous with nasal septum which separates the two nasal cavities. Each nostril is bounded laterally by ala.

External Nose

The external nose has a skeletal framework that is partly bony and partly cartilaginous. The bones are the nasal bones, and the frontal processes of the maxillae. The cartilages are the superior and inferior nasal cartilage with medial crus and lateral crus, the septal cartilage, and minor alar cartilages (Fig. 5.2).

Nasal Septum

Figure 5.3 shows one nasal cavity.

The *nasal septum* is a median osseocartilaginous partition between the two halves of the nasal cavity. On each side, it is covered by mucous membrane and forms the medial wall of both nasal cavities (Figs 5.4A).

The *bony part* is formed almost entirely by: The vomer and the perpendicular plate of ethmoid.

The *cartilaginous part* is formed by: The septal cartilage and the *cuticular part* or lower end is formed by fibrofatty tissue covered by skin. The lower margin of the septum is called the *columella*.

Arterial Supply

The arterial supply of nasal septum is shown in Figure 5.5.

Nerve Supply

The nerve supply is shown in Figure 5.4B

Nasal Cavity

The nasal cavity extends from the external nares or nostrils to the posterior nasal apertures, and is subdivided into right and left halves by the nasal septum (Fig. 5.6).

The *roof* slopes downwards, both in front and behind. The middle horizontal part is formed by the cribriform plate of the ethmoid. The anterior slope is formed by nasal bone, and the nasal cartilages. The posterior slope is formed by the inferior surface of the body of the sphenoid bone.

The *floor* is formed by the palatine process of the maxilla and the horizontal plate of the palatine bone (*See* Fig. 5.3).

- Olfactory nerve—1st nerve
  - The *olfactory cells* (16–20 million in human) are bipolar neurons. They lie in the olfactory part of the nasal mucosa, and serve both as receptors as well as the first neurons in the olfactory pathway.
  - The *olfactory* nerves, about 20 in number, represent central processes of the olfactory cells. They pass through the cribriform plate of ethmoid and make synaptic glomeruli with cells of olfactory bulb. The mitral and tufted cells in the olfactory bulb give off fibers that form the *olfactory tract* and reach the anterior perforated substance and uncus.

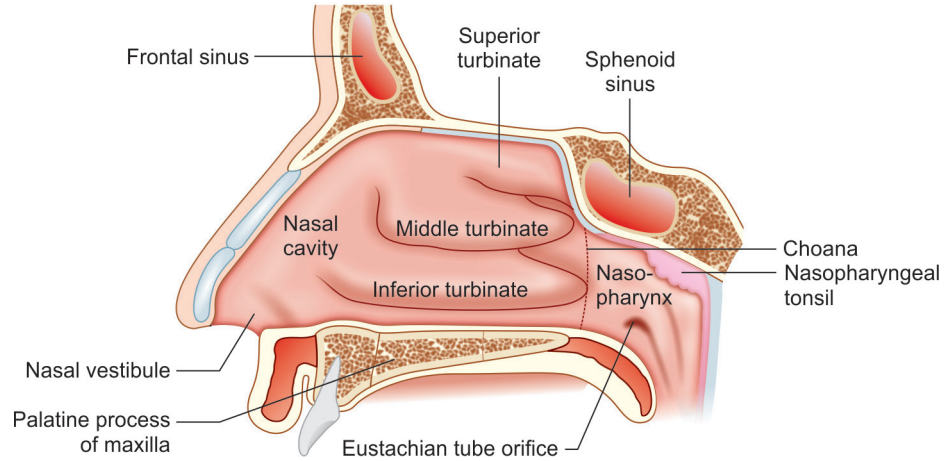
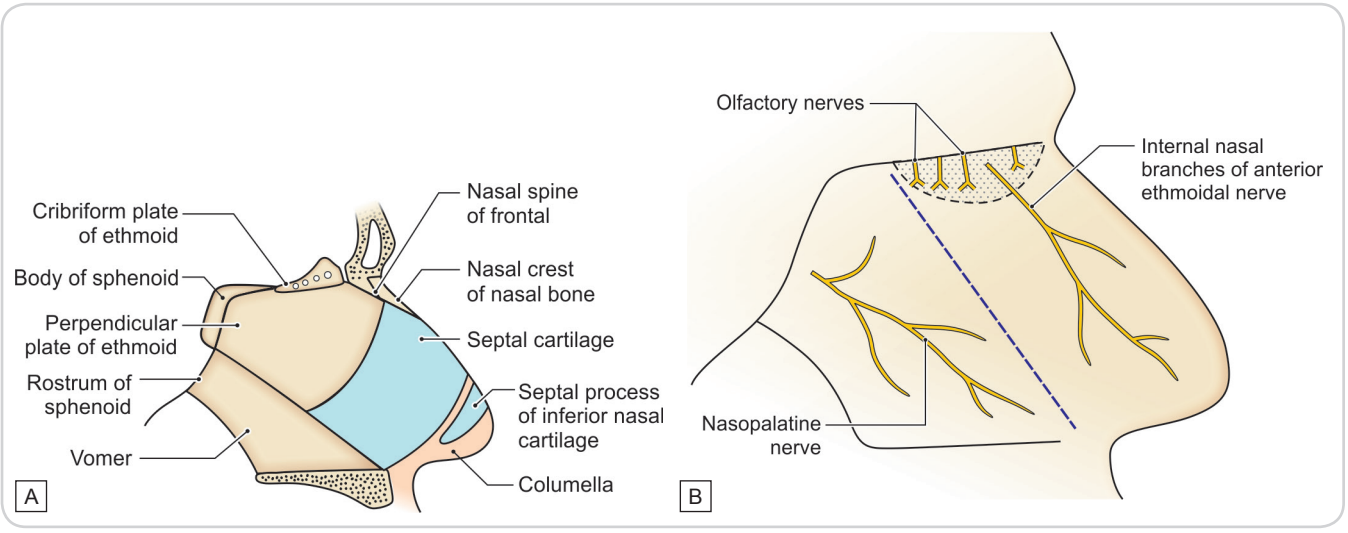


Fig. 5.3: Anatomy of nasal cavity



Figs 5.4A and B: Nasal septum: **A.** Components; **B.** Nerve supply

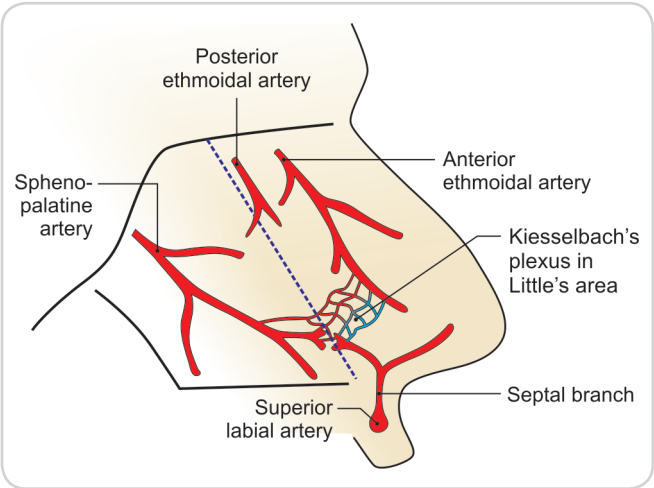
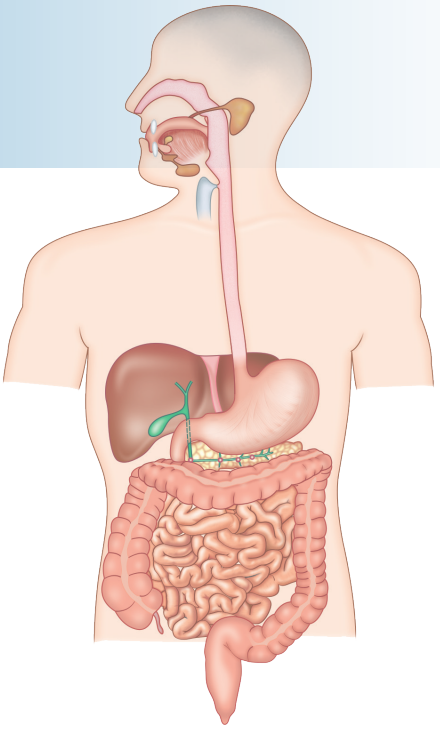


Fig. 5.5: Arterial supply of nasal septum

6

Digestive System



Chapter Outline

Key Terminology

Components of digestive system: (i) The alimentary canal or gastrointestinal tract (GIT) beginning at mouth and ending at anus. It runs through neck, thorax, abdomen and pelvis, (ii) Accessory glands, e.g., three pairs of salivary glands, liver, gallbladder, pancreas and biliary tract.

Layers of GIT: Mucosa, submucosa, muscularis externa and serosa/adventitia.

Activities of digestive system:

Ingestion: Taking in of the fluid/food
Propulsion: Passage of fluid/food
Digestion: Mechanical and chemical breakdown of food
Absorption: Passage of products of digestion in blood and lymph capillaries

Ejection: Expulsion of waste products through anus

Vestibule of mouth: Spaces on each side of the oral cavity properly space bounded by teeth. The duct of parotid gland opens into vestibule of mouth opposite 2nd upper molar tooth.

Salivary glands: Parotid glands are purely serous innervated by glossopharyngeal nerves. Duct opens in vestibule. Submandibular glands are mixed, innervated by chorda tympani nerve. Duct opens

Contd...

at submandibular papilla on the floor of mouth. Sublingual glands are purely mucus glands, innervated by chorda tympani nerve, 8–10 ducts open on sublingual papilla on the floor of mouth.

Pharynx: Comprises upper nasopharynx; middle oropharynx and lower laryngopharynx. Food passage and air passage cross each other in the region of oropharynx.

Esophagus: 25 cm long passage with course in neck, thorax and abdomen. Lower end of esophagus has portacaval anastomoses which may rupture in cirrhosis of liver leading to hematemesis.

Stomach: Has three layers of smooth muscles fibers. Peptic ulcer is seen along its lesser curvature.

Brunner's glands: Present in the duodenum, neutralize the acidity of gastric juice.

Villi: Characteristic feature of small intestine. Blood capillaries absorb glucose and amino acids, while lymph capillaries absorb fatty acids.

Appendicitis: Early pain of appendicitis is referred to umbilicus. Sympathetic fibers to appendix come from thoracic 10 segment of spinal cord (lateral horn); sensations from the skin of umbilicus also reach T10 segment of spinal cord. Since somatic pain is better appreciated than visceral pain, pain of early appendicitis is referred to the umbilicus.

Blood supply to liver: 80% of blood reaches liver via portal vein and 20% reaches via hepatic artery.

Support to liver: Intraabdominal pressure, ligaments attached to liver and hepatic veins emerging from liver draining into inferior vena cava.

Direction of flow in hepatic lobule: Blood flows from periphery to center towards the central vein. Bile flows from central part of the lobule toward periphery into bile ductule.

Kupffer's cells: Line the sinusoids of hepatic lobule. These digest worn out blood cells and foreign particles of the blood coursing through the liver.

Cholecystokinin: Hormone secreted by duodenum, to cause contraction of gallbladder to release bile into cystic and bile ducts.

Digestive system is a collection of organs that helps in the breakdown of food and liquids into simpler substances. These simple substances are used by the body for energy, growth, and tissue repair. Waste products of food that the body cannot use leave the body via anus because of bowel movements. The digestive system is concerned with the ingestion and breakdown of food including its absorption.

PARTS OF DIGESTIVE SYSTEM

The main component of the digestive system is the **digestive tract/alimentary canal**. The tract begins at mouth where food is taken in and ends at the anus from where the unwanted material is eliminated.

Parts of digestive system are shown in Figure 6.1.

Associated with the tract are a number of glands, which help in the digestive process. These are the salivary glands, liver, gallbladder, pancreas and intestinal glands.

The main parts are the mouth, pharynx, esophagus, stomach, small intestine, large intestine. The last part of large intestine is the rectum and anal canal which ends at the anus.

Mouth

Mouth is the beginning of digestive tract and is guarded by two **lips** with the **cheeks** at the sides. It contains the **tongue** and **teeth**. It opens posteriorly into the **pharynx**. Roof of mouth is formed by palate. It is divided into anterior **hard palate** which is bony part, is longer and separates mouth cavity from the nasal cavity. The posterior part of the palate, the **soft palate**, is like a curtain. It is muscular, shorter and hangs down at the back. Uvula, which is a curved fold of muscles and is covered by mucus membrane, hangs down from middle of the soft border of soft palate. Anatomy of oral cavity is shown in Figure 6.2.

Floor of the mouth is formed by two mylohyoid muscles.

- **Vestibule of the mouth:** It is part of mouth cavity inside the lips and cheeks and outside the gums and teeth.
- **Mouth cavity proper:** This is the cavity lying within the teeth and gums all around. It contains the mobile tongue. In the midline, the floor of front of oral cavity is a fold of mucus membrane, the **frenulum** of tongue.

Salivary Glands

Three pairs of salivary glands are parotid glands, submandibular glands and sublingual glands (Fig. 6.3).

1. **Parotid glands** are situated one on each side of face just below the external acoustic meatus. Each gland has a **parotid duct**, opening into the vestibule of mouth opposite the 2nd upper molar tooth.
2. **Submandibular glands** lie one on each side of face under the angle of jaw. The **duct of submandibular gland** opens on the side of the frenulum (Fig. 6.4).
3. **Sublingual glands** lie under mucus membrane of the floor of mouth in front of submandibular glands and they open by 8–10 ducts in the floor of the mouth.

Each gland is made up of several lobules made up of small acini lined with secretory cells. The secretions are poured into ductules which join to form larger ducts leading into mouth. The saliva provides the necessary fluid for chewing and swallowing and some enzymes as well. The Figure 6.5 explains the action of saliva on food.

- **Blood supply:** Branches of external carotid artery supply the glands and tributaries of internal jugular vein drain them.

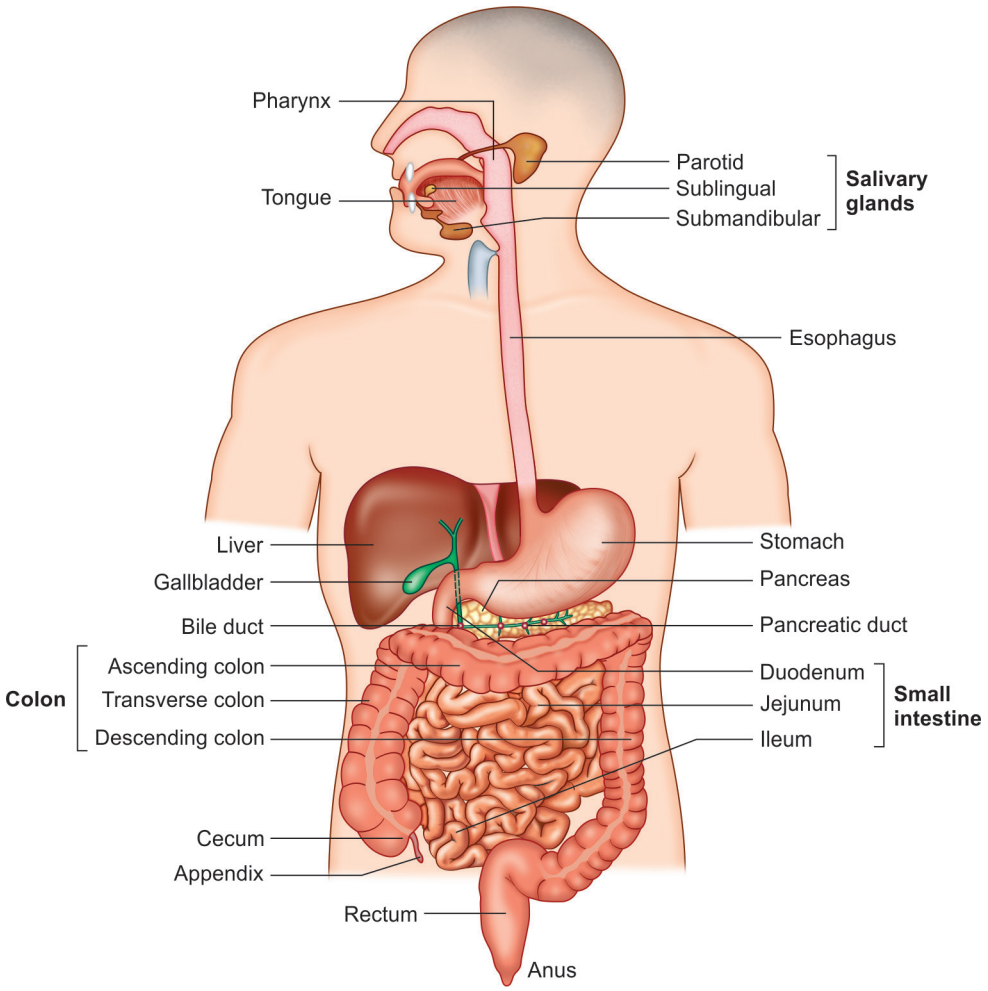


Fig. 6.1: Parts of human digesti e system

Tongue

The tongue is muscular organ within the mouth cavity proper.

Functions

- It helps in swallowing of food. It cleans the mouth.
- It helps in speech.
- It helps in taste.

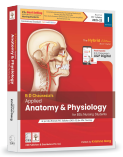
Parts

Tongue consists of a **root** with which it is attached to the mandible and hyoid bone and is prevented from swallowing. And by a fold of mucus membrane covering – frenulum, it is attached to the floor of the mouth. It contains sensory receptors for the sense of taste. Its **dorsal surface** is rough made of squamous epithelium and divided into posterior 1/3rd and anterior 2/3rd by 'V' shaped **sulcus terminalis** (Fig. 6.6). The **ventral surface** is smooth and a **tip** points anteriorly.

Papillae

The dorsum of tongue is rough as it contains three types of papillae:

1. **Filiform:** Thin and pointed with no taste buds. They are present on anterior two thirds of the tongue.
2. **Fungiform:** Mushroom like structures with a few taste buds. They are present on sides and tip of tongue.
3. **Vallate papillae:** 10–12 in number lying in front of 'V' shaped sulcus. These contain maximum number of taste buds.
   - **Muscles:** Eight voluntary muscles are present in each half of the tongue. **Intrinsic** muscles change the shape of tongue. Extrinsic muscles **move the tongue**. **Genioglossus** is the most important muscle as it keeps the tongue anteriorly in position and prevents it from blocking the air pathway (Table 6.1).



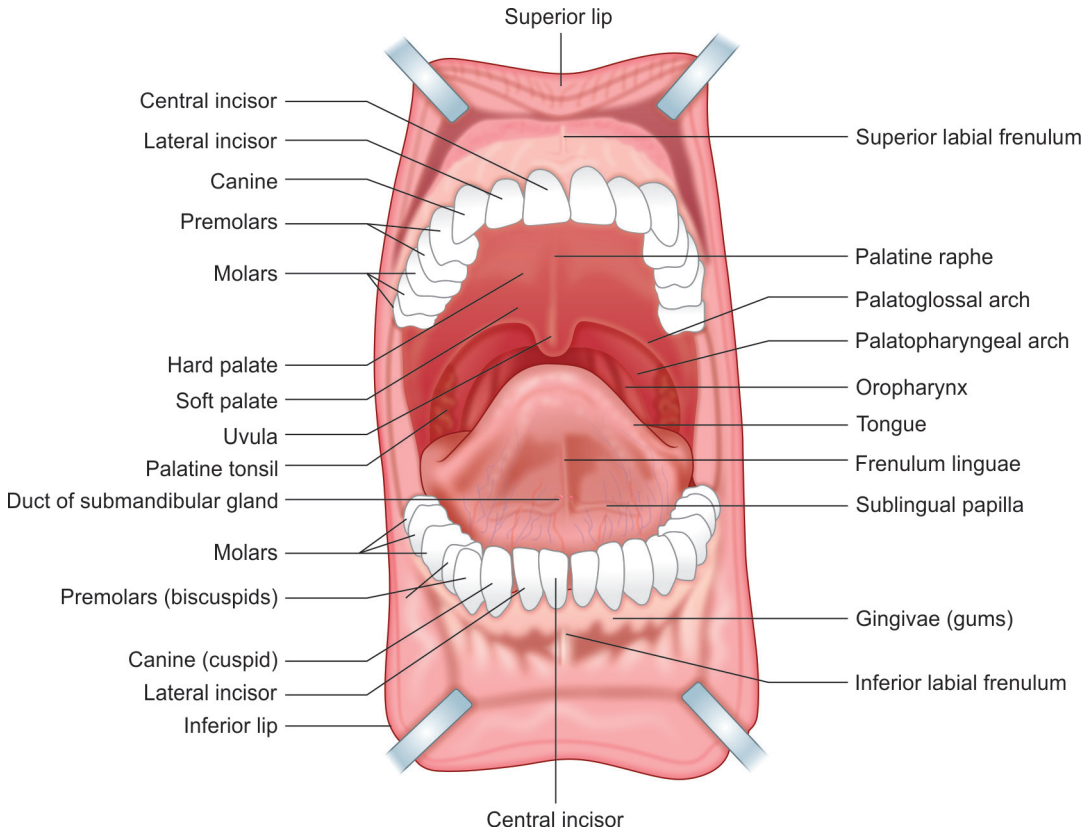


Fig. 6.2: Anatomy of oral cavity

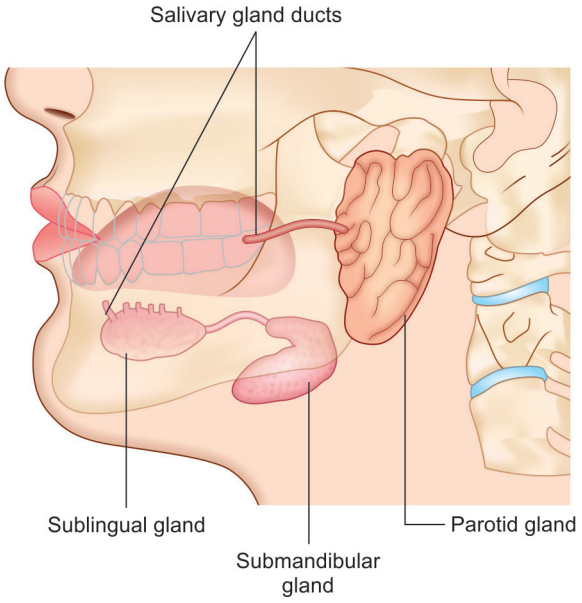
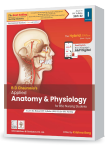
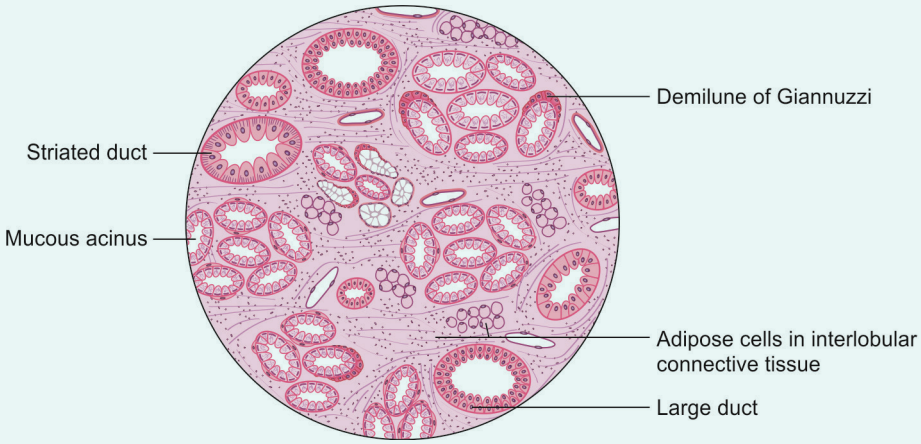


Fig. 6.3: Various salivary glands



FACTS TO REMEMBER



- Mucus acini are larger, light stained and variable in size
- Typical demilunes of Giannuzzi on one side of mucus acini
- Nuclei of mucus acini are flattened and peripheral

Fig. 6.4: Histology of submandibular gland

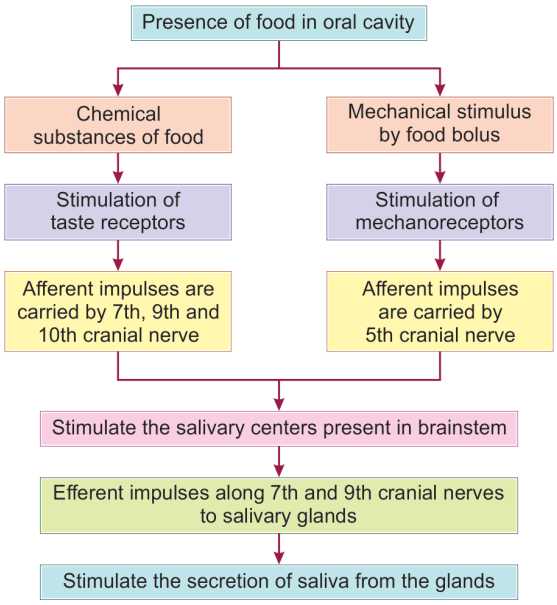


Fig. 6.5: Secretion of sali a

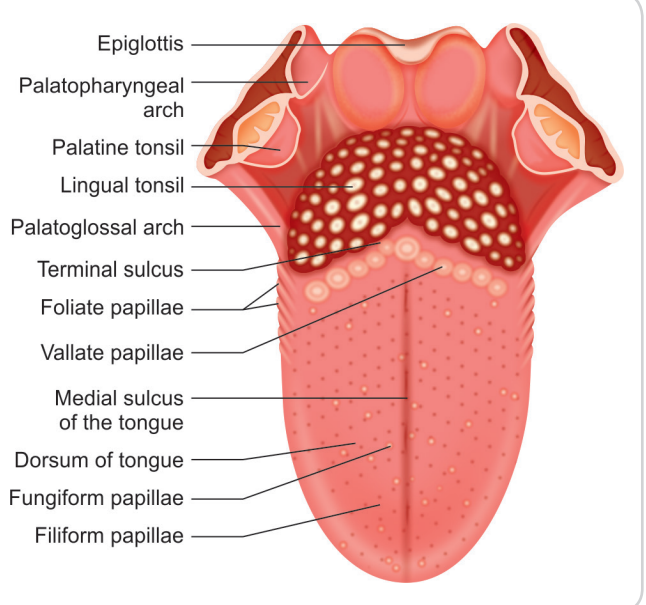
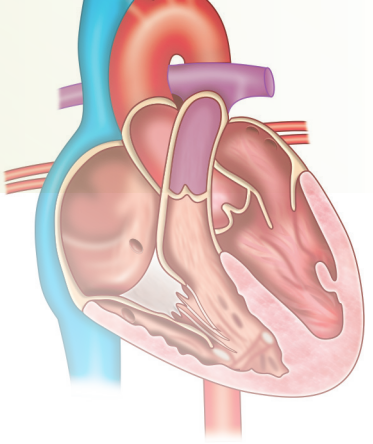


Fig. 6.6: Dorsal aspect of tongue

TABLE 6.1: Tongue muscles and their actions

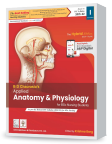
Intrinsic muscles	Action	Extrinsic muscles	Actions
Superior longitudinal	Shortens the tongue, makes its dorsum concave	**Genioglossus:** From upper genial tubercle of mandible to the root of the tongue	Protrudes the tongue and is a **life saving muscle**
Inferior longitudinal	Shortens the tongue, makes its dorsum convex	**Hyoglossus:** From greater cornua of hyoid bone to lateral side of tongue	Depresses the tongue
Transverse	Makes the tongue narrow and elongated	**Styloglossus:** From styloid process of temporal bone to posterior side of tongue	Retracts the tongue
Vertical	Makes the tongue broad and flattened	**Palatoglossus:** From palatine aponeurosis to junction of oral and pharyngeal parts of tongue	Elevates the tongue



7

Heart and Circulatory System

Chapter Outline



Key Terminology

Circulatory system: Comprises heart enveloped in pericardium with arteries, capillaries and veins.

Pericardium: Consists of an outer fibrous pericardium and inner double layered serous pericardium; made of an outer parietal and an inner visceral layer, most important content of pericardium is the heart with vessels entering and leaving it.

Heart: External features show a base, an apex; four borders-upper, inferior, right and left; two surfaces—sternocostal and diaphragmatic; atrioventricular/coronary sulcus, interventricular and interatrial grooves; chambers-right atrium and right ventricle are venous chambers and left atrium and left ventricle are arterial chambers.

AV valves: Right atrioventricular valve has three cusps while left AV valve has two stronger cusps.

Semilunar valves: Aortic valve contains one anterior and one right posterior and one left posterior cusps. Pulmonary valve shows one posterior and two anterior cusps.

Thickest chamber: Left ventricle has thickest myocardium as its thickest artery, the aorta supplies blood from head to the toes (top to toe).

Pulse: Radial artery at the wrist is mostly used. Common carotid/internal carotid arteries of neck are also used.

Blood pressure: Lateral pressure exerted by blood on the arterial walls. It is recorded by auscultating brachial artery universally.

Arteries: These take blood from heart to the organs. The large arteries are elastic, limb arteries are muscular and the smallest ones are the arterioles.

Capillaries: Minute channels through which exchange of gases and nutrients occur.

Veins: Start from the periphery like small rivers, join with each other to form large veins–the vena cava which bring venous blood to heart.

Coronary arteries: These are the first arteries to arise from the ascending aorta. These are functional end arteries and are likely to be partially/completely blocked.

Arch of aorta: Gives three branches. One branch divides into two two. So there are two arteries each for right side and two for the left side of head, neck, brain, upper limbs and thorax.

Descending thoracic aorta: Mainly gives branches as 9 pairs of intercostal and one pair of subcostal arteries.

Descending abdominal aorta: Gives three main ventral branches for foregut, midgut and hindgut derived structures. Also gives renal, gonadal arteries, etc.

It ends at level of the lumbar four vertebral by dividing into two common iliac arteries.

Common iliac arteries: Gives internal iliac which supplies visceral branches to pelvic viscera and external iliac which continues as the femoral artery for lower limb.

Circulatory system comprises heart enveloped in pericardium along with arteries, capillaries and veins.

HEART

Heart is enveloped by pericardium. The heart is placed obliquely behind the body of the sternum and adjoining parts of the costal cartilage, so that one-third of it lies to the right and two-thirds to the left of the median plane. The direction of blood flow, from atria to the ventricles is downwards, forwards and to the left. The heart measures about 12 × 9 cm and weighs about 300 g in males and 250 g in females.

Pericardium

Features

The pericardium (Greek word that means "*around heart*") is a fibroserous sac which encloses the heart and the roots of the great vessels. It is situated in the middle mediastinum. It consists of the *fibrous pericardium* and the *serous pericardium* (Fig. 7.1).

Fibrous pericardium encloses the heart and fuses with the vessels which enter/leave the heart. Heart is situated within the fibrous and serous pericardial sacs.

- **Fibrous pericardium:** Fibrous pericardium is a conical sac made up of fibrous tissue. The parietal layer of serous pericardium is attached to its deep surface. The following features of the fibrous pericardium are noteworthy:
  - The apex is blunt and lies at the level of the sternal angle. It is fused with the roots of the great vessels and with the pretracheal fascia.
  - The base is broad and inseparably blended with the central tendon of the diaphragm.
  - It protects the heart against sudden overfilling and prevents overexpansion of the heart.

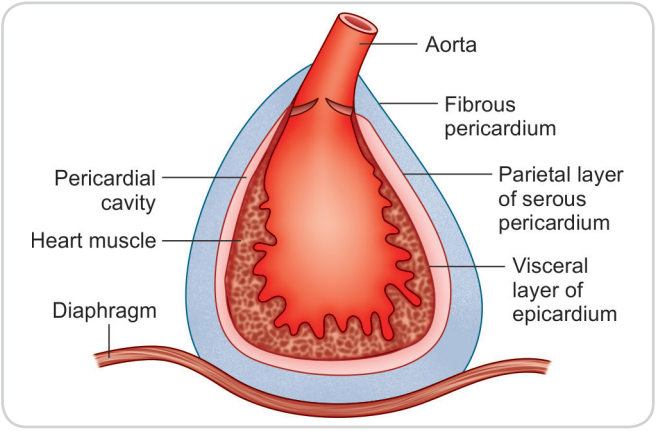


Fig. 7.1: Pericardium

- **Serous pericardium:** Serous pericardium is thin, double-layered serous membrane lined by mesothelium. The outer layer or parietal pericardium is fused with the fibrous pericardium. The inner layer or the visceral pericardium, or epicardium is fused to the heart.
  - The *pericardial cavity* is a potential space between the parietal pericardium and the visceral pericardium. It contains only a thin film of serous fluid which lubricates the apposed surfaces and allows the heart to beat smoothly.

Contents of Pericardium

- Heart with cardiac vessels and nerves
- Ascending aorta
- Pulmonary trunk
- Lower half of the superior vena cava
- Terminal part of the inferior vena cava
- Terminal parts of the pulmonary veins

Blood Supply

The fibrous and parietal pericardia are supplied by branches from:

- Internal thoracic arteries
- Musculophrenic arteries
- The descending thoracic aorta
- Veins drain into corresponding veins

Nerve Supply

- Phrenic nerves
- Intercostal nerves

External Features of Heart

Borders

- *Upper border* formed by the two atria
- *Inferior border* formed by the right ventricle
- *Right border* formed by the right atrium
- *Left border* formed by the left ventricle

Surfaces

- *Sternocostal surface* formed by the right atrium and the right ventricle and partly by the left ventricle.
- *Diaphragmatic surface* formed mainly by the left ventricle (2/3) and partly by the right ventricle (1/3).

Apex and Base

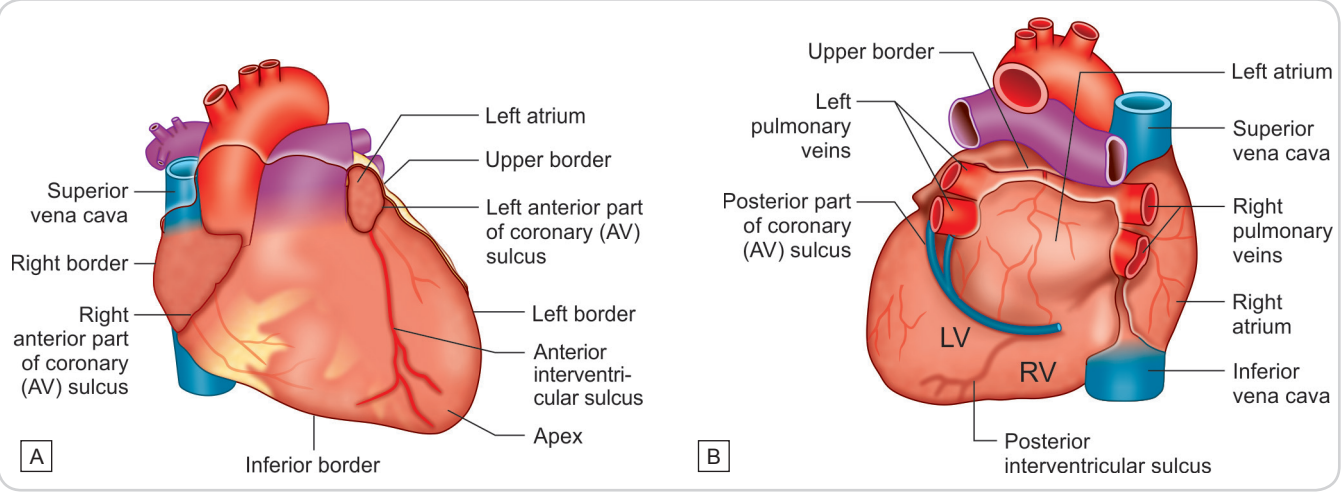
- Apex of the heart is formed exclusively by the *left ventricle*. It is directed downwards to the left and is palpable in the left fifth intercostal space 9 cm from the midline especially after running.
- Base of the heart is formed mainly by the left atrium and partly by the right atrium (Figs 7.2A and B).

Grooves or Sulci

The atria are separated from the ventricles by a circular *atrioventricular or coronary* sulcus. It is overlapped anteriorly by the ascending aorta and the pulmonary trunk. The *interatrial groove* is faintly visible posteriorly, while anteriorly it is hidden by the aorta and pulmonary trunk. The *anterior interventricular groove* is nearer to the left margin of the heart. The lower end of the groove separates the apex from the rest of the inferior border of the heart. The *posterior interventricular groove* is situated on the diaphragmatic or inferior surface of the heart. It is nearer to the right margin of this surface. The two interventricular grooves meet at the inferior border near the apex.

Relations of the Heart

- **Anteriorly:** Sternum, 2nd–5th costal cartilages and intercostal spaces of both sides.
- **Posteriorly:** Esophagus, descending thoracic aorta, and thoracic vertebrae



Figs 7.2A and B: **A.** Sternocostal surface; **B.** Base of the heart

- **Laterally:** Lungs and pleurae on each side
- **Inferiorly:** Central tendon of diaphragm
- **Superiorly:** Aorta, pulmonary trunk, superior vena cava

The *heart* is composed of following layers:

- **Epicardium:** The visceral layer of serous pericardium.
- **Myocardium:** The musculature of the heart which is of varying thickness in different chambers.
- **Endocardium:** The smooth lining of the myocardium. This layer is folded upon itself to form various valves of the heart. These cause unidirectional flow of blood through the heart.

Chambers of the Heart

The heart is composed of *two atria* and *two ventricles*. The right atrium and right ventricle lie anterior to the left atrium and left ventricle. The two atria are divided by an *interatrial septum*. Similarly, the two ventricles are also divided into right and left ventricles by the *interventricular septum*. Each atrium has a smooth posterior surface and a rough anterior part called the auricle. The auricle of the atria has resemblance to a dog's ear.

Ventricles have much thicker walls than the atria. The left ventricle has the thickest wall of myocardium as it has to pump the blood to the whole body.

The interior of each ventricle is marked by the muscular ridges called as trabeculae carnae. Some are small elevations. While others are pointed papillary muscles to which are attached tendinous cords known as chordae tendinae. Their other ends are attached to cusps of the tricuspid/bicuspid valves (Fig. 7.3).

Right Atrium

Right atrium receives the entire systemic blood. It has very thin walls. It forms whole of right border, part of the base, upper border and a part of the sternocostal surface of the heart.

Features

Its upper end is prolonged to the left as the *auricle*, and it has resemblance to a dog's ear.

Along its right border there is a shallow groove, the '*sulcus terminalis*' extending from superior vena cava to inferior vena cava opening below. Opposite to this sulcus, the interior of atrium presents a vertical ridge of heart muscle, the '*crista terminalis*'. Arising from crista terminalis are parallel *musculi pectinati*'. These pass downwards towards atrioventricular orifice. Those extending into the auricle form a network arrangement.

The *right atrioventricular groove* separates the right atrium from right ventricle and lodges the right coronary artery and small cardiac vein.

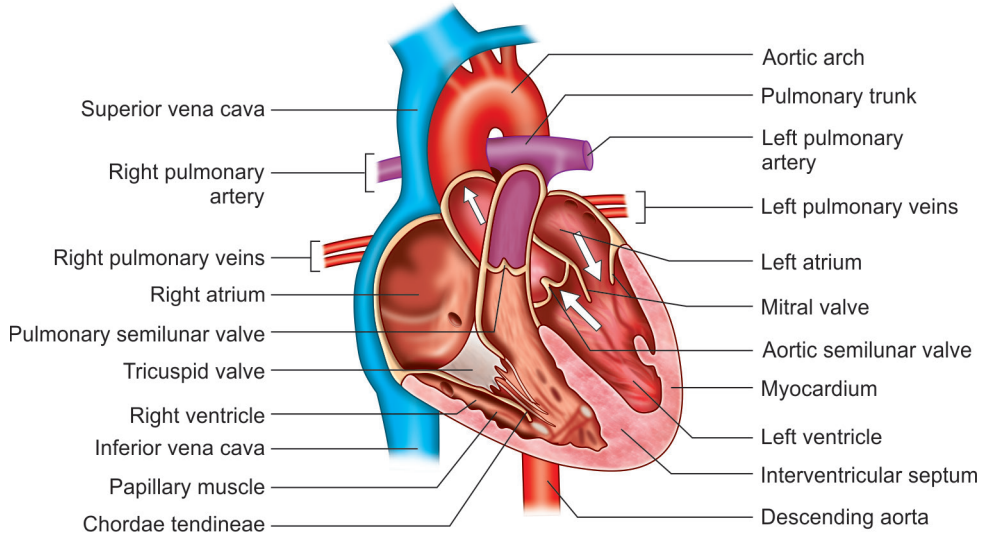
Openings in the Right Atrium

- **Of entry:** Superior vena cava, inferior vena cava, coronary sinus, venae cordis minimae and anterior cardiac veins.
- **Of exit:** Right atrioventricualr orifice. This is guarded by a tricuspid orifice which allows venous blood to flow only from right atrium towards right ventricle.

Interior of Right Atrium

Rough anterior part including the auricle: This part contains musculi pectinati and network arrangement in the auricle.

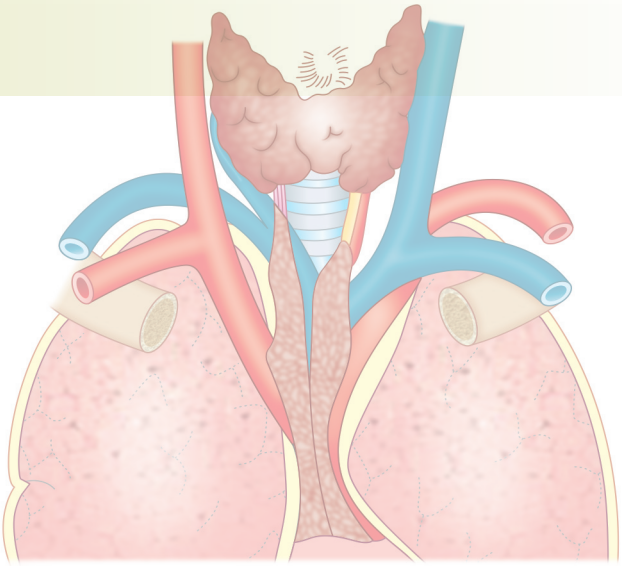
Smooth posterior part where entry channels drain. Superior vena cava opens in the upper part, inferior vena cava



Figs 7.3: Chambers of the Heart

8

Lymphatic System and Immunity



Chapter Outline

Key Terminology

Lymph capillaries: These are minute channels starting blindly in tissue spaces. These capillaries unite to form lymph vessels.

Lymph vessels: These are superficial and deep. Superficial ones accompany superficial veins while deep ones accompany deeper arteries and veins. Lymph vessels join together to form two lymph trunks.

Thoracic duct: It is the largest lymph duct draining both lower limbs, abdomen, left halves of thorax, head and neck and upper limb.

Right thoracic duct: It drains right halves of thorax, head and neck and upper limb. Both these terminate into the respective brachiocephalic veins in the thorax.

Central lymphoid tissues: These are bone marrow and thymus.

Peripheral lymphoid organs: These are numerous lymph nodes and spleen.

Lymph nodes: These are present in neck, axilla, posterior thoracic and abdominal wall, inguinal region.

Lymphocytes: These are of two types: 'T' and 'B' lymphocytes.

Growth pattern of lymphocytes: Lymphoid tissue is prominent at birth. These grow rapidly during childhood, but atrophy after puberty. These may become enlarged in case of infection or tumor formation, or autoimmune disease.

Immunity: Resistance to diseases due to biological defences.

Innate or non-specific immunity: It occurs due to genetic, mechanical barriers, biochemical factors and cellular factors.

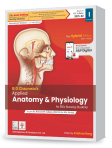
Specific immunity: It is due to types of T cells, i.e., helper, suppressor and cytotoxic and B cells, i.e., memory B cells and plasma cells.

Active immunity: Resistance acquired due to antigenic stimulus.

Passive immunity: Resistance provided passively.

Immune response: Response provided as result of exposure to antigen is immune response. It may be cellular response or humoral response.

Phagocytosis: It is process by which neutrophils and macrophages (phagocytes) engulf and digest bacteria, infected cells, or foreign bodies.



LYMPHATIC SYSTEM

Lymphatic system is essentially a drainage system, which is accessory to the venous system. It is a network of organs, tissues and vessels that work together to move a colorless, watery fluid called lymph, back into your circulatory system. Twenty liters of plasma flow through arteries, smaller arterioles and capillaries every day. The major parts of the lymph tissue are located in the bone marrow, spleen, thymus gland, lymph nodes, and the tonsils. The lungs, intestines, liver, and skin also contain lymphatic tissue.

Components of Lymphatic System

The lymphatic system comprises:

- Lymph capillaries and lymph vessels
- Central lymphoid tissues
- Peripheral lymphoid organs
- Circulating lymphocytes

Lymph Capillaries and Lymph Vessels

The lymph capillaries begin blindly in the tissue spaces and form intricate networks. Their caliber is greater and less regular than that of blood capillaries, and their endothelial wall is permeable to substances of much greater molecular size.

Lymph capillaries are absent from the cellular structures like brain, spinal cord, splenic pulp, bone marrow, articular cartilage, epidermis, hair, nail and cornea.

The lymph capillaries join to form lymphatics, which are superficial and deep lymphatics. The superficial lymphatics accompany veins, while the deep lymphatics accompany arteries.

The lymph passes through filters or barriers of the regional lymph nodes, which trap the particulate matter (Table 8.1).

The filtered lymph passes through larger lymphatics and is eventually collected into two large trunks, the *thoracic duct* and *right lymphatic duct*, which pour their lymph into the brachiocephalic veins. Thoracic duct drains *both* lower limbs, abdomen, left halves of thorax, head and neck and left upper limb. Right lymphatic duct drains right halves of thorax, head and neck and right upper limb.

The transport of lymph is as shown in following Figures 8.1A to C.

Central Lymphoid Tissues

Central lymphoid tissues are comprised of bone marrow and thymus.

- **Bone marrow:** All 'pluripotent' lymphoid stem cells are initially produced by bone marrow. The stem cells undergo differentiation in the central lymphoid tissues.

  Bone marrow helps differentiation of the (committed) B-lymphocytes, which are capable of synthesizing antibodies after getting transformed into plasma cells.

TABLE 8.1: Comparison of lymph vessels and blood capillaries

Lymph vessels	Blood capillaries
• Colorless, difficult to observe	• Reddish, easy to observe
• Blind (closed at the tip)	• Joined to arterioles at one end and to venules at another end
• Wider than blood capillaries	• Narrower than lymph capillaries
• Wall consist of thin endothelium and poorly developed basement membrane	• Wall consist of normal endothelium and basement membrane
• Contain colorless lymph	• Contain red blood cells
• Have relatively low pressure	• Have relatively high pressure
• Absorb tissue fluid from intercellular spaces	• Add tissue fluid to intercellular spaces

- **Thymus:** The thymus is an important lymphoid organ, situated in the anterior and superior mediastina of the thorax (Fig. 8.2).

  It is well developed at birth, continues to grow up to puberty, and thereafter undergoes gradual atrophy and replacement by fat. It is the only lymphoid organ well developed at birth.

Functions

- The thymus controls lymphopoiesis.
- It controls development of the peripheral lymphoid tissues of the body during the neonatal period. By puberty, the main lymphoid tissues are fully developed.
- The cortical lymphocytes of the thymus arise from stem cells of bone marrow origin.
- The medullary epithelial cells of the thymus are thought to secrete:
  - Lymphopoietin
  - The competence-inducing factor

Peripheral Lymphoid Organs

Peripheral lymphoid organs comprise lymph nodes, spleen.

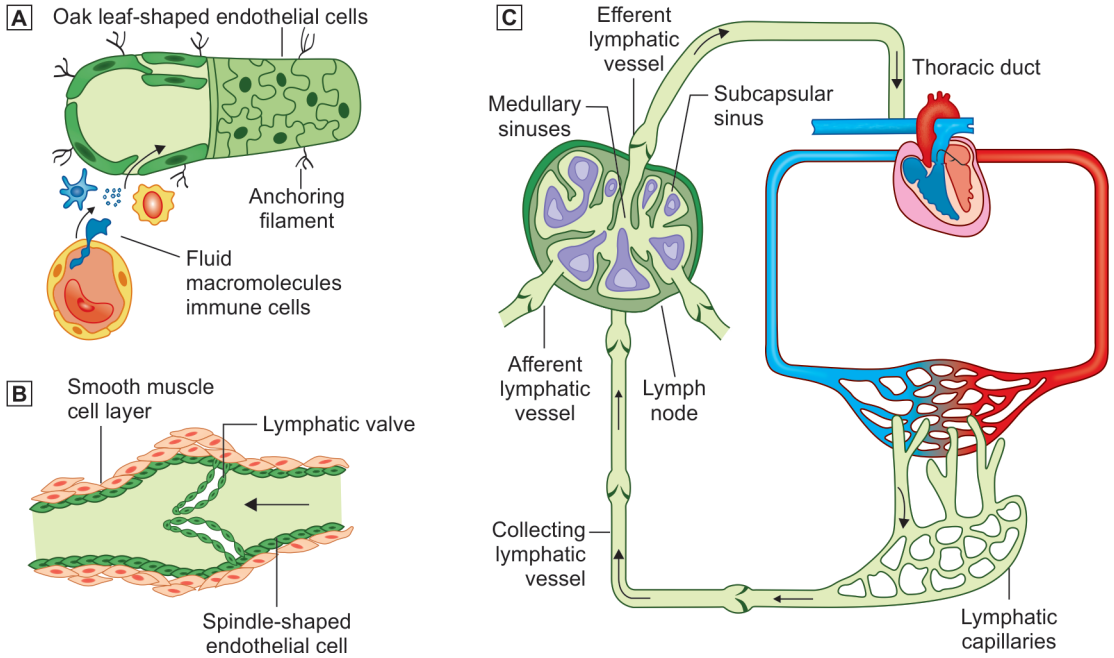
Circulating Lymphocytes

Circulating lymphocytes comprise of T cells, B cells. Natural killer (NK) cells.

Lymphatic Follicles (Nodule)

The follicle is a spherical collection of lymphocytes with a pale center known as germinal center, where the lymphocytes are more loosely packed.

The central cells are larger in size, stain less deeply, and divide more rapidly, than the peripheral cells.



Figs 8.1A to C: A. Endothelial cells; B. Lymphatic alve; C. Lymph transportatio

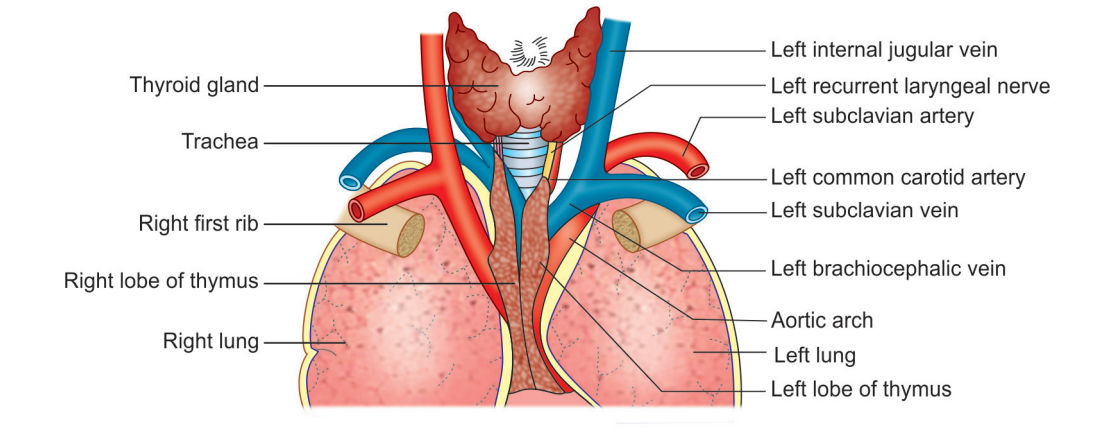


Fig. 8.2: Thymus—structure and positio

Lymph Nodes

Lymph nodes are small nodules of lymphoid tissue found in the course of smaller lymphatics (Fig. 8.3). The nodes are oval or reniform in shape, 1–25 mm long, and light brown, black (pulmonary), or creamy white (intestinal) in color.

Usually they occur in groups (cervical, axillary, inguinal, mesenteric, mediastinal, etc.) Superficial nodes are arranged along the veins, and the deep nodes along the arteries.

Each lymph node has a slight depression on one side, called hilum. The artery enters the node, and the vein with efferent lymphatic comes out of it, at the hilum.

Structurally, a lymph node is made up of the following parts:

- Fibrous and reticular framework
- Lymphatic channels
- **Cortex:** According to the distribution of B- and T-lymphocytes, the cortex is divided into: An outer part, which contains immature B-lymphocytes; and an inner part, between the germinal center and the medulla, which contains T-lymphocytes. This part is known as *paracortex* or *thymus dependent zone.*

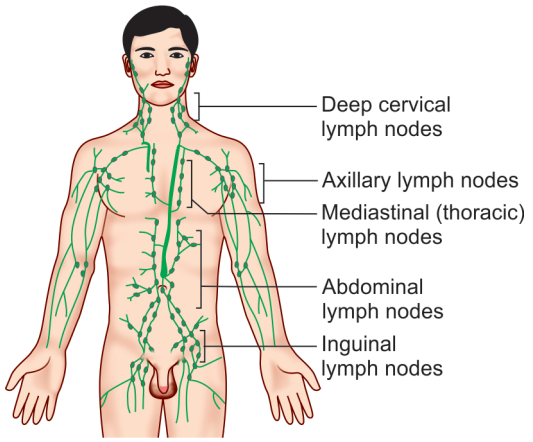


Fig. 8.3: Various groups of lymph nodes

- **Medulla:** It is the central part of the lymph node, containing loosely packed lymphocytes.
- **Blood channels** are used to deliver blood to different body parts.

Spleen

Spleen is the largest lymphoid organ and is covered by a dense connective tissue **capsule** (Fig. 8.4). **Trabeculae** extend inward from capsule. Cellular material of spleen is divided into **white pulp** and **red pulp**.

Red pulp consists of blood filled venous sinuses and white pulp comprises lymphatic tissue, consisting of lymphocytes and macrophages. Spleen is a part of the lymphatic system and its functions are:

Phagocytosis, storage of blood, immunity, erythropoiesis, storage of platelets, circulating pool of lymphocytes.

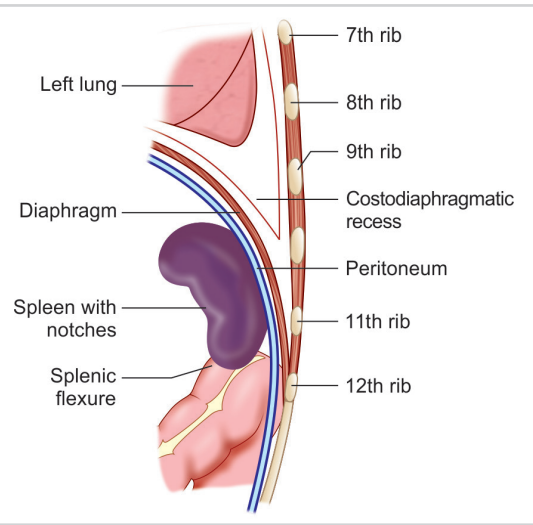


Fig. 8.4: Spleen with its ends and borders

Table 8.2 shows the approximate percentage of lymphocytes in lymphoid organs.

Epitheliolymphoid System

Epitheliolymphoid system comprises Mucosa Associated Lymphoid Tissue (MALT) in digestive system and Bronchus Associated Lymphoid Tissue (BALT) in respiratory system.

The MALT initiates immune responses to specific antigens encountered along all mucosal surfaces. MALT inductive sites are secondary immune tissues where antigen sampling occurs and immune responses are initiated. The mucosa of the digestive, respiratory and urinary tracts contains these as lymphoid follicles. In some cases, these aggregations are large and occur in the tonsils, peyers patches and the appendix.

BALT is a tertiary lymphoid structure. It is a part of mucosa-associated lymphoid tissue (MALT), and has lymphoid follicles in the lungs and bronchus. BALT is an effective priming site of the mucosal and systemic immune responses.

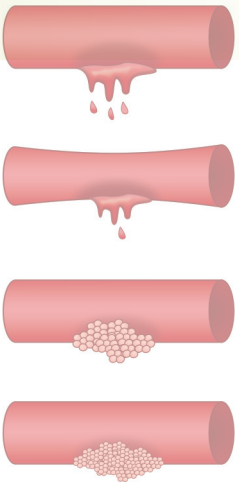
In the region of posterior one-third of tongue, oropharynx, nasopharynx, there is a ring of lymphoid tissue under the mucous membrane. Its components are lingual tonsil, palatine tonsils, tubal tonsils and nasopharyngeal tonsil. This ring is called Waldeyer's ring (Fig. 8.5). It contains lymphocytes (a type of immune cell) that help the body fight infection and disease. Peyer's patches of ileum of small intestine and lymphoid tissue of vermiform appendix belong to MALT.

TABLE 8.2: Approximate percentage of lymphocytes in lymphoid organs

Lymphoid organ	T-lymphocytes	B-lymphocytes
Thymus	100%	0%
Lymph node	60%	40%
Spleen	45%	55%
Bone marrow	10%	90%
Blood	80%	20%

9

Blood



Chapter Outline

Key Terminology

Plasma: Blood minus the cellular components is plasma. (Made of water and solids)

RBC: Red blood cells

WBC: White blood cells

Platelets: Thrombocytes

Red bone marrow: Cavities in the bones, like humerus, and femur where RBC, WBC and platelets are produced.

Yellow bone marrow: After puberty, red bone marrow in many bones is replaced by fat and is called yellow bone marrow. Red bone marrow only remains in the ends of long bones, sternum, iliac crest and skull bones.

Hematopoietic stem cells (HSC): All blood cells develop from the progenitor cells called HSC.

Pluripotent stem cells: Progenitor/HSC changes to pluripotent stem cell. Blood cells arising from pluripotent stem cells are uncommitted stem cells.

Multipotent stem cells: Pluripotent stem cell divides into two types of multipotent stem cells. These are common lymphoid stem cells and common myeloid stem cells.

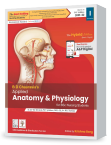
Erythropoiesis: Formation of red blood cells.

Erythropoietin: Hormone produced by kidney that is released during hypoxia.

Pernicious anemia: This type of anemia is a one cause of vitamin B_{12} dificiency anemia.

Eryptosis: Process of removal of RBC after 120 days.

Blood bank: A bank where blood of different groups is stored.



INTRODUCTION

Blood may be described as a specialized connective tissue in which there are liquid intercellular substances known as plasma and formed elements, like the red blood cells, the white blood cells and the platelets that are suspended in the plasma.

Physical Characteristics

- **Color of blood:** Arterial blood is scarlet red in color. The venous blood appears purple red in color.
- **Total blood volume:** 5–6 L (8% of body weight).
- **Specific gravity:** 1.050–1.061 (total blood)
- **pH of blood:** 7.4 ± 0.05.
- **Viscosity:** Viscosity of blood is an important factor, since it determines the peripheral resistance of the blood flow through the blood vessels and thus helps to maintain blood pressure. It is four to five times that of water. Human blood is five times more viscous than distilled water. The viscosity of the whole blood is mainly due to cells and that of plasma is due to plasma proteins.

Functions

Table 9.1 shows the functions of blood. It helps in transport of respiratory gases, nutrition and other essential chemicals.

TABLE 9.1: Functions of blood

Nutrition and hormones	It carries digested food material absorbed from the intestine to the tissue cells for utilization.
It acts as a vehicle	By its help, the hormones, the vitamins and other essential chemicals are brought to their places of activity.
Drainage of waste products	It carries the waste products of cellular activity.
Maintenance of water balance	Maintains 'Water balance' of the body.
Maintenance of acid-base equilibrium	It maintains acid-base equilibrium by its efficient buffering power (e.g. plasma proteins, reduced and oxidized hemoglobin, etc.) and with the help of kidney, skin and lungs.
Maintenance of ion balance	Between the cells and the surrounding fluid.
Regulation of body temperature	The water content of blood possesses various qualities which make it very suitable for this purpose.
Defensive action	Blood acts as a great defensive mechanism.
Coagulation	By the property of coagulation it guards against hemorrhage.

Components of Blood

The general composition of the whole blood (Figs 9.1A and B) is as follows.

- **Whole blood cells:**
  - Red blood corpuscles or erythrocytes (RBC)
  - White blood corpuscles or leucocytes (WBC)
  - Platelets or thrombocytes
- **Plasma:**
  - Obtained from blood after centrifugation/or addition of anticoagulant. Cells settle down.
  - **Water:** 91–92% and solids (8–9%)
- **Inorganic constituents (0.1%):** These constitute 0.9% sodium, potassium, calcium, magnesium, phosphorus, iron, copper, etc.
- **Organic constituents (8%):**
  - **Proteins 7%:** Serum albumin, serum globulin, fibrinogen, prothrombin, etc.
  - **Non-protein nitrogenous (NPN) substances (1%):** Urea, uric acid, xanthine, hypoxanthine, creatine, creatinine, ammonia, amino acids, etc.
  - **Carbohydrate:** Glucose, etc.
  - **Fats:** Neutral fat, phospholipid, cholesterol, cholesterides, etc.
  - **Other substances:** Internal secretions, antibodies and various enzymes (amylases, proteases, lipases, phosphatases, etc.).

Know it

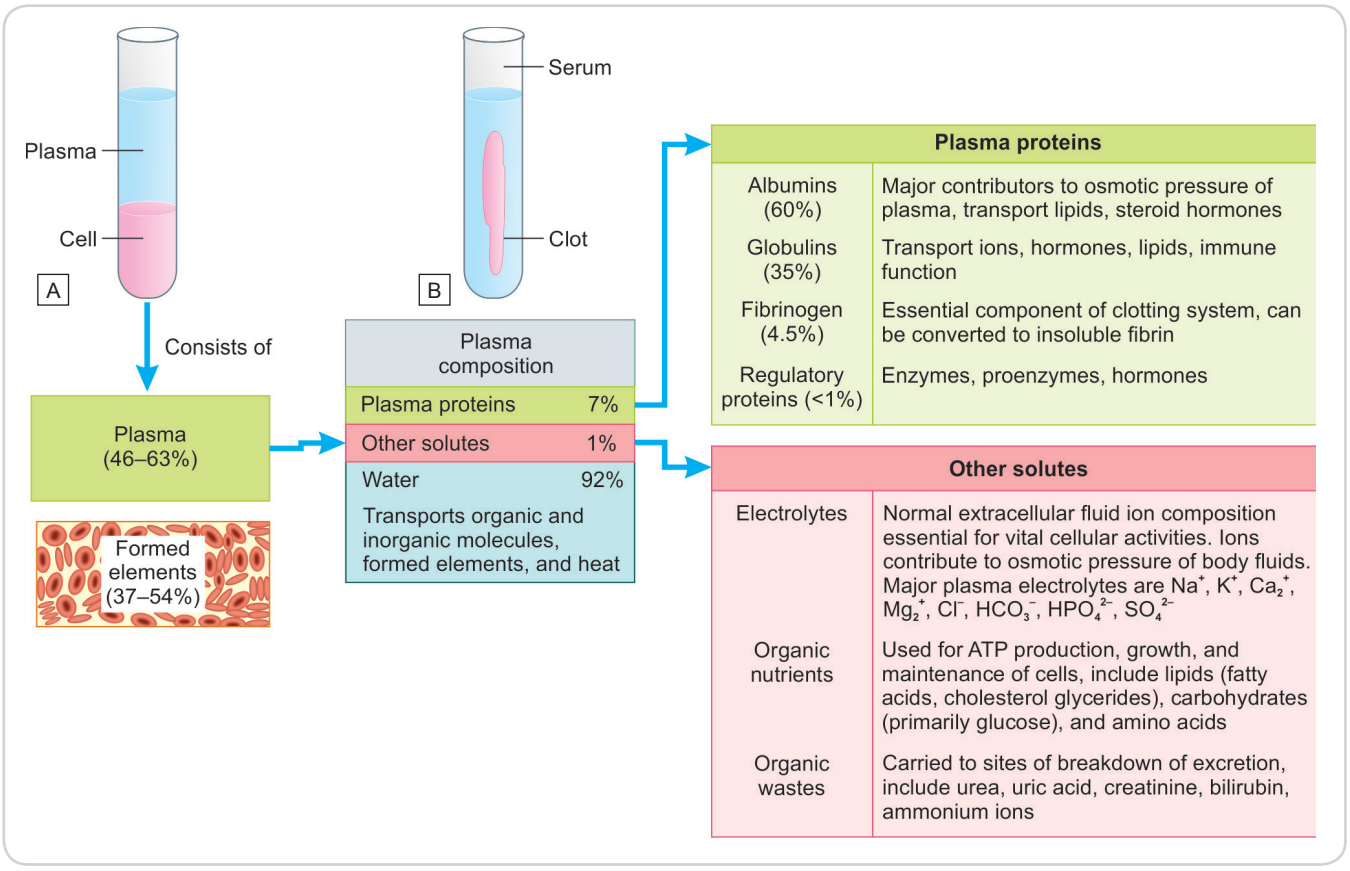
The yellow color of plasma is due to small amounts of bilirubin, carotene and xanthophyllin. (Serum is plasma minus its fibrinogen).

Bone Marrow

Bone marrow is the cellulovascular tissue occupying the medullary cavities and the cancellous spaces of the bone.

Active marrow in the adult is estimated at from 3.5 to 6% of body weight. The volume of the marrow is 70 mL at birth and about 4000 mL in the adult. In the adults, only about half of the marrow is in active state, known as red bone marrow, the remainder being inactive—yellow bone marrow (Fig. 9.2). By the age of 20, the marrow in cavities of all long bones with exception of the upper ends of humerus and femur becomes inactive. **Hence, in adults red marrow is present in the axial skeleton; skull, pelvis, ribs, sternum, vertebrae; and proximal ends of femur and humerus.**

For a newborn baby, all bone marrow are red and as age increases, red bone marrow remains active only in membrane bones. In a newborn, if hematopoiesis is going on outside the bone marrow, i.e., in liver, spleen and lymph nodes, it is called **Extra Medullary Hematopoiesis.** If there is need of excessive



Figs 9.1A and B: Composition of the whole blood. **A.** The proportions of blood cells and plasma in whole blood to which anti oagulant has been added; **B.** Clot in sample where anti oagulant has not been added showing serum

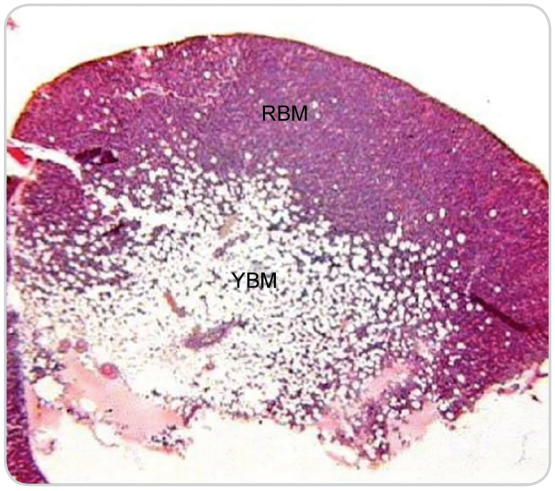


Fig. 9.2: Yellow and red bone marrow histology

Abbreviations: RBM, red bone marrow; YBM, yellow bone marrow

hematopoietic activity, yellow bone marrow has a capacity to be reactivated and converted into red bone marrow (seen in severe hemolysis).

At and after birth, blood cells (red blood cells, most white blood cells, and platelets) are formed only in the bone marrow. All blood cells originate from pluripotent stem cells, which are uncommitted stem cells and go through several stages of development. These, the pluripotent stem cells differentiate into different committed stem cells called the progenitor cells (Table 9.2).

Red bone marrow: Red cells are actively manufactured here, hence the color. **Red bone marrow is vascular and rich in hematopoietic stem cells.** In fetal stage, most of the bones contain red bone marrow. But with the advancement of age and in postnatal life, the red bone marrow is only located in the upper ends of humerus and femur, the bones of skull and thorax, the vertebrae and crest of the innominate/ilium bones of the pelvis.

Yellow bone marrow: It is made of fat and a little reticular tissue with blood vessels. Because **yellow bone marrow has fat cells, so it is yellow in color.** Here, red cells are not manufactured. In the adult life, they occupy the spaces where red marrow is absent.

TABLE 9.2: Differences between red and yellow bone marrow

Red bone marrow	Yellow bone marrow
Occurs inside the spongy bones.	Occurs inside the compact bones.
Rich in blood supply.	Poor blood supply.
It is a mesh of networks that contains the developmental stages of red blood cells, white blood cells, and megakaryocytes.	It primarily contains fat and replaces the red bone marrow in the long bones during adolescence.
Also known as medulla ossium rubra.	It is known as medulla ossium flava.
Produces red blood cells, white blood cells, and platelets.	Produces fat cells, cartilage, and bones.
Red color is due to the hemoglobin present in the red blood cells.	Yellow color is due to the carotenoids in the fat droplets.
The cells actively divide to produce blood cells.	The cells store fats; and also produce blood cells when needed.
It occurs in the skull, ribs, spine, shoulder blades, and at the end of the long bones.	It occurs in the marrow cavity of the long bones.
Red bone marrow occurs throughout the skeleton during the fetal life.	With age, yellow bone marrow replaces the red bone marrow in long bones.
It gets its red color due to the hemoglobin present in the red blood cells.	This gets its yellow color due to the carotenoids in the fat droplets.

Formation of Bone Marrow

From birth up to the fourth year, all the bones contain red bone marrow. *By seven years,* the marrow becomes less active and is pale red in color. *Between ten to fourteen years,* a patch of yellow bone marrow appears in the distal ends of the shafts of the long bones and gradually extends on both sides.

At the age of twenty, entire red bone marrow of the long bones is replaced by yellow bone marrow except the upper ends of femur and humerus. Throughout adult life this distribution persists.

Peculiarities of Bone Marrow

Bone marrow provides unique environment for proliferation and differentiation of these stem cells and precursor cells. Bone marrow is rich in stromal cells, which support hematopoietic process. Stromal cells are capable of concentrating a lot of soluble factors (growth and differentiation factors) like erythropoietin, thrombopoietin, stem cell colony stimulating factors, IL-3, etc. IL-3 is responsible for stem cell proliferation. Stromal cells have cell-to-cell interaction with hematopoietic cells and direct their differentiation.

Soluble factors, like erythropoietin, thrombopoietin, granulocyte monocyte colony stimulating factors and granulocyte colony stimulating factors are synthesized by genetic recombinant techniques and are used commercially.

Bone marrow provides "homing in tendency" for stem cells. The bone marrow stromal cells have special surface adhesion molecules and these stem cells get attracted to those adhesion molecules.

Bone marrow stem cells can also produce non-hematopoietic stem cells, like liver cells, biliary duct cells, myocardial cells, skeletal muscle cells, fully mature neurons and glial cells.

Functions of Bone Marrow

- **Hematopoietic (hemopoietic) function (production and release of blood cells):** Production of myeloid elements is the important function of bone marrow. It has been described that red bone marrow is active and has the capacity of forming red cells as well as other blood cells.
- **Erythroplasia or destruction of RBC:** In the bone marrow not only the blood cells are formed but also the abnormal, imperfect, damaged and aged RBCs are destroyed.
- **Storage functions:** Bone marrow is an important site for storage of iron in the form of ferritin and of hemosiderin. These come from food sources as transferrin and also from destruction of RBC through phagocytosis. These stored irons are easily utilized for the synthesis of hemoglobin.
- **Reticuloendothelial function:** Bone marrow plays an important role in the inactivation of toxins or other toxic substances of the body.
- **Osteogenic function:** The cellular elements which take part in the formation of bone are formed in the marrow. The osteoclast, osteoblast, osteocyte and endosteum of blood vessels are formed within the marrow.

10

Integumentary System (Skin) and Fasciae

Chapter Outline

Key Terminology

Layers of epidermis: These are stratum basale, stratum spinosum, stratum granulosum, stratum lucidum and stratum corneum.

Layers of dermis: These are outer reticular layer and inner papillary layer

Appendages of skin: They are sweat glands, sebaceous gland, hair follicle arrector pilorum muscle and nails

Sweat glands: They are of two types. Apocrine glands are present mainly in the axilla; eccrine glands are present all over the body. Sweat maintains temperature and water balance of the body.

Sebaceous glands: They are holocrine gland present in the angle between hair follicle and the arrector pilorum muscle.

Arrector pilorum muscle: These are smooth muscle fibers, supplied by sympathetic fibers; on contraction, the hair becomes erect.

Hair follicle: It consists of shaft of hair medulla cortex and cuticle with inner root sheath, outer root sheath and connective tissue sheath.

Nails: They consist of root, body (nail plate) free edge, nail fold and lunula.

Color of nails: Pink color shows enough hemoglobin; blue color shows cyanosis; yellow color reveals the jaundice in the person.

Sense organs are the specialized organs composed of sensory neurons, which help us to perceive and respond to our surroundings. There are five sense organs—**skin** with its appendages **eyes**, **ears**, **nose** and **tongue**. Skin and fasciae are dealt in this chapter. Rest are described in the Chapter on Sensory Organs.

SKIN

Skin is the general covering of the entire external surface of the body. It is continuous with the mucous membrane at the orifices of the body (Fig. 10.1). It has sensory nerve endings that help in perceiving pain, touch, hot or cold, etc. Because of the presence of sweat glands, it helps the body in temperature regulation.

Histology of Skin

Surface Area

In an adult, the surface area of the skin is 1.5–2 (average 1.7) sq. meters.

Know it

Du Bois formula: The surface area of an individual can be calculated by Du Bois formula. Therefore,

$$A = W \times H \times 71.84$$

where A = Surface area in sq.cm, W = weight in kg, and H = height in cm.

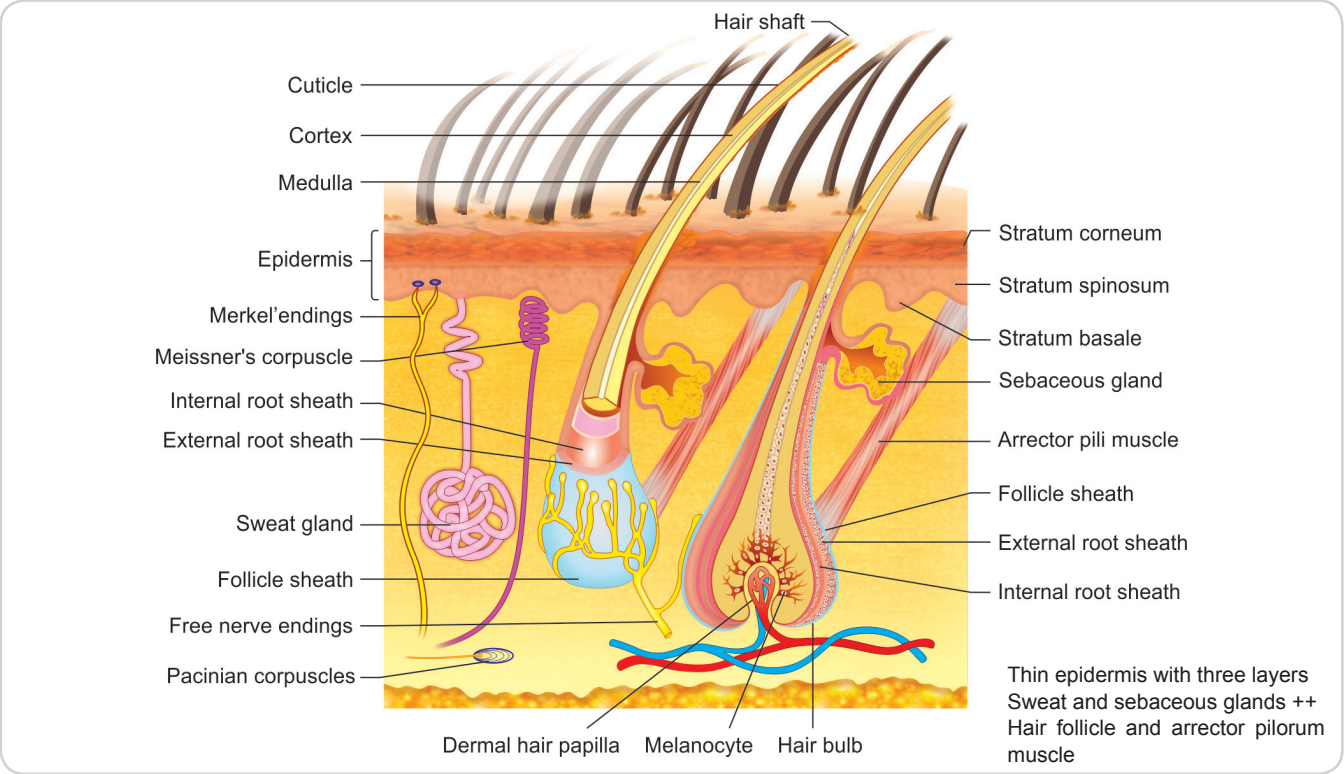


Fig. 10.1: Histology of thin skin with nerve endings

Pigmentation of Skin

The color of the skin is determined by at least five pigments present in it.

- *Melanin* (brown), present in the germinative zone of the epidermis.
- *Melanoid*, (resembles melanin present diffusely throughout the epidermis.
- *Carotene* (yellow to orange), present in stratum corneum and the fat cells of dermis and superficial fascia.
- *Hemoglobin* (purple).
- *Oxyhemoglobin* (red), present in the cutaneous vessels.

Thickness

The thickness of the skin varies from about 0.5–3 mm.

The skin is composed of two distinct layers, epidermis and dermis.

- **Epidermis:** It is the superficial, avascular layer of stratified squamous epithelium. It is ectodermal in origin and gives rise to the appendages of the skin, namely hair, nails, sweat glands and sebaceous glands.

  Structurally, the epidermis is made up of a deep **germinative zone**, comprising stratum basale, Stratum spinosum, and Stratum granulosum. (Fig. 10.2).

  Superficial cornified zone: Stratum lucidum, and Stratum corneum

  The germinative zone contains:
  - 'dopa' positive *melanocytes* of neural crest origin, which synthesize melanin.
  - Langerhans cells, which are phagocytic in nature.
  - Merkel's cells which are sensory receptor cells in stratum basale.
- **Dermis or corium:** Dermis or corium is the deep, vascular layer of the skin, derived from mesoderm.

  It is made up of connective tissue (with variable elastic fibers). The connective tissue is arranged into a superficial *papillary layer* and a deep *reticular layer*.

  The papillary layer forms conical, blunt projections which fit into reciprocal depressions on the undersurface of the epidermis. The reticular layer is composed chiefly of the white fibrous tissue arranged mostly in parallel bundles.

  The direction of the bundles, constituting flexure or *cleavage lines* (Langer's lines), is longitudinal in the limbs and horizontal in the trunk and neck (Fig. 10.2).

  Dermis is the real skin, because when dried it makes hide, and when gets tanned it looks like leather.

Blood Supply

The dermis is vascular while epidermis is avascular.

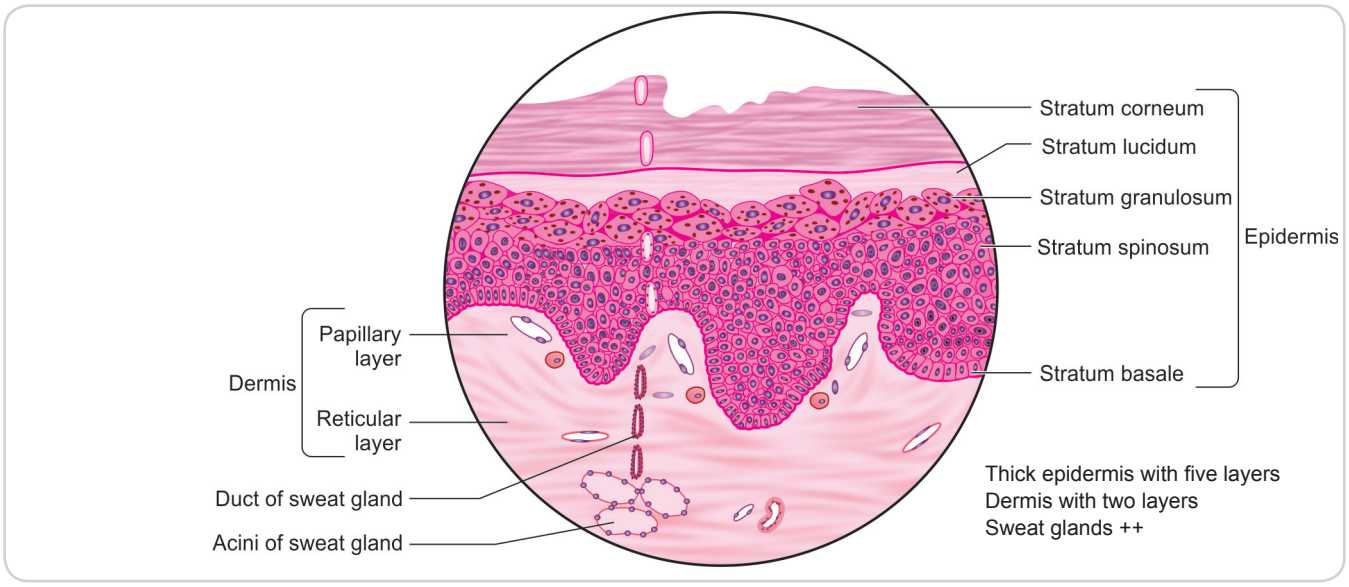


Fig. 10.2: Histology of thick skin

Nerve Supply

There are motor and sensory nerves. The motor nerve fibers are autonomic nerve fibers which are sudomotor, pilomotor and vasomotor. The sensory nerve endings in the skin are of the following types:

- Free nerve endings, Merkel's disc, Meissner's corpuscles
- Pacinian corpuscles, Ruffini's endings, Krause' bulbs

Surface Irregularities of the Skin

Skin is marked by three types of surface irregularities:

1. **Tension lines:** These lines to some extent correspond to variations in the pattern of fibers in the dermis.
2. **Flexure lines (skin creases or skin joints):** These are certain permanent lines along which the skin folds during habitual movements of the joints.
3. **Papillary ridges (friction ridges):** They are confined to palms, soles and their digits. They form narrow ridges separated by fine parallel grooves, arranged in curved arrays. They correspond to patterns of dermal papillae. Their study constitutes a branch of science, called dermatoglyphics (finger prints).

HIGH YIELD POINTS

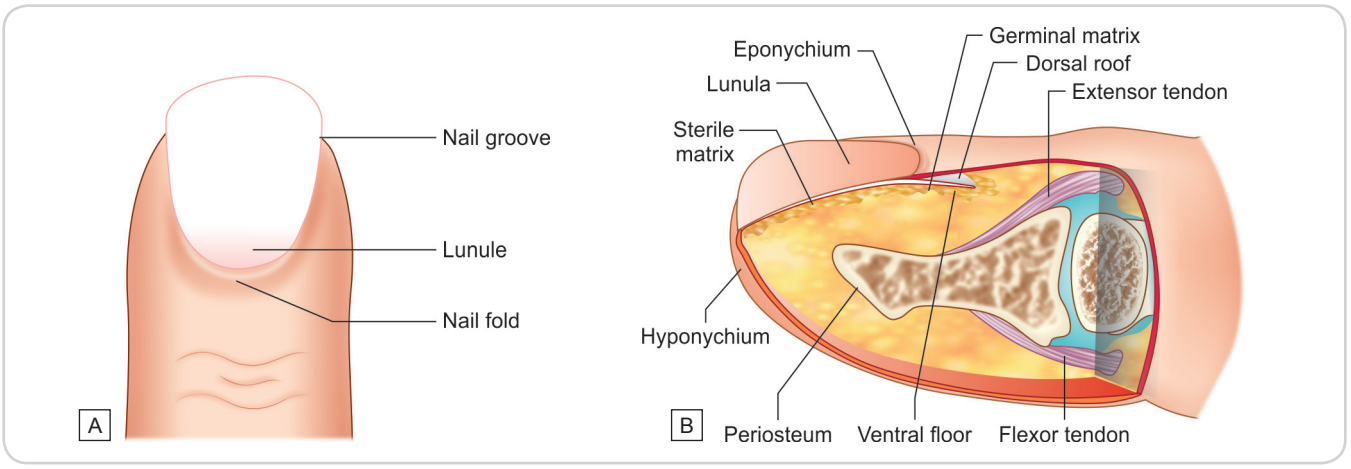
- Three major patterns in the human fingerprints include loops, whorls and arches (Fig. 10.3).
- These patterns and many other minor features are determined genetically by multifactorial inheritance.
- These do not change throughout life, except to enlarge. This serves as a basis for identification through fingerprints or footprints.

Skin of palm and sole is thick, rest of the body has thin skin. Table 10.1 compares the two types of skin.

Fig. 10.3: Types of papillary ridges

TABLE 10.1: Differences between thick and thin skin

Thick skin	Thin skin
The skin from the palms and soles, so named because of its relatively thick epidermis	The skin from areas of the body other than the palms and soles, so named because of its relatively thin epidermis
Occurs on the soles of feet, palms of hands, and the surface lining of the fingers and toes	Covers the rest of the body
Thick epidermis of five layers 1. Stratum basale 2. Stratum spinosum 3. Stratum granulosum 4. Stratum lucidum 5. Stratum corneum	Thin epidermis of three layers 1. Stratum basale 2. Stratum spinosum 3. Thin stratum corneum
Lacks hair follicles	Contains hair follicles
Lacks arrector pili muscles	Contains arrector pili muscles attached to hair follicles
Thin dermis	Thick dermis
Lacks sebaceous glands	Contains sebaceous glands
Has numerous, spirally coiled sweat glands	Has fewer sweat glands
Denser sensory receptors	Sparser sensory receptors
Contains both ridges and furrows on the surface	Lacks ridges and furrows on the surface
Contains regular dermal papillae	Contains irregular dermal papillae
More restricted to mechanical abrasion	Performs the other functions of the skin



Figs 10.4A and B: **A.** Parts of a nail; **B.** Anatomy of nail

Appendages of Skin

Nails

Nails are hardened keratin plates (cornified zone) on the dorsal surface of the tips of fingers and toes. Each nail has the following parts.

- *Root* is the proximal hidden part which is buried into the nail groove and is overlapped by the nail fold of the skin (Figs 10.4A and B).
- *Body* is the exposed part of the nail which is adherent to the underlying skin; root and body together form *nail's plate*.
- *Free border* is the distal part free from the skin. It is attached to the under surface by hyponychium.

The proximal part of the body presents a white opaque crescent called *lunule*. Each lateral border of the nail body is overlapped by a fold of a skin, termed the *nail* fold and the groove between nail body and nail fold is called *nail groove*.

The skin (germinative zone + dermis) beneath the root and body of the nail is called *nail bed*. The germinative zone of the nail bed beneath the root and lunule is thick and proliferative (germinal matrix), and is responsible for the growth of the nail. The rest of the nail bed is thin (sterile matrix) over which the growing nail glides. Under the translucent body (except lunule) of the nail, the corium is very vascular. This accounts for their pink color.

Nail of middle finger grows the fastest.

Hair

Hairs are keratinous filaments derived from invaginations of the germinative layer of epidermis into the dermis.

These are peculiar to mammals and help in conservation of their body heat.

Hair are distributed all over the body, except for the palms, soles, dorsal aspect of distal phalanges, umbilicus, glans penis, inner surface of prepuce, the labia minora, and inner surface of labia majora.

Structure of hair: Each hair has an implanted part called the **root**, a **bulb** and a projecting part, called the **shaft**.

Layers of shaft: Innermost is the medulla, cortex is the middle one and cuticle is a single outer layer:

The root is surrounded by a **hair follicle** (a sheath of epidermis and dermis), and is expanded at its proximal end to form the **hair bulb**. Each hair bulb is invaginated at its end by hair papilla (vascular connective tissue) which forms the neurovascular hilum of the hair and its sheath.

Hair follicle surrounds the hair. Wall of the follicle comprises:

- Inner root sheath
- Outer root sheath
- Connective tissue sheath (Fig. 10.5).

The arrectores pilorum muscles (smooth muscles supplied by sympathetic nerve) connect the undersurface of the follicles to the superficial part of the dermis. Arrector pili muscles are absent in a few regions like hair of face, axilla, eyelashes, eyebrows, hair of anterior nares and of external auditory meatus.

Growth of hair: The hairs grow at the rate of about 1.5–2.2 mm/week.

Color of hair: Color of hair depends upon the amount and type of melanin pigment.

Sweat Glands

Sudoriferous or sweat glands are distributed all over the skin, except for the lips, glans penis, and nail bed. These glands are of two types; *eccrine* and *apocrine* (Table 10.2).

- **Eccrine glands:** The eccrine glands are much more abundant and distributed in almost every part of the skin.

The coiled part, called the *body* of the gland, lies in the deeper part of corium or in the subcutaneous tissue. The straight part, called the *duct*, traverses the dermis and epidermis and opens on the surface of the skin.

- **Location:** The glands are large in the axilla and groin, most numerous in the palms and soles. The eccrine glands are *merocrine* in nature, i.e., produce thin watery secretion without any disintegration of the epithelial cells.
- **Control:** They are supplied and controlled by *cholinergic sympathetic nerves*
- **Functions:** The glands help in regulation of the body temperature by evaporation of sweat, and also help in excreting the body salts.

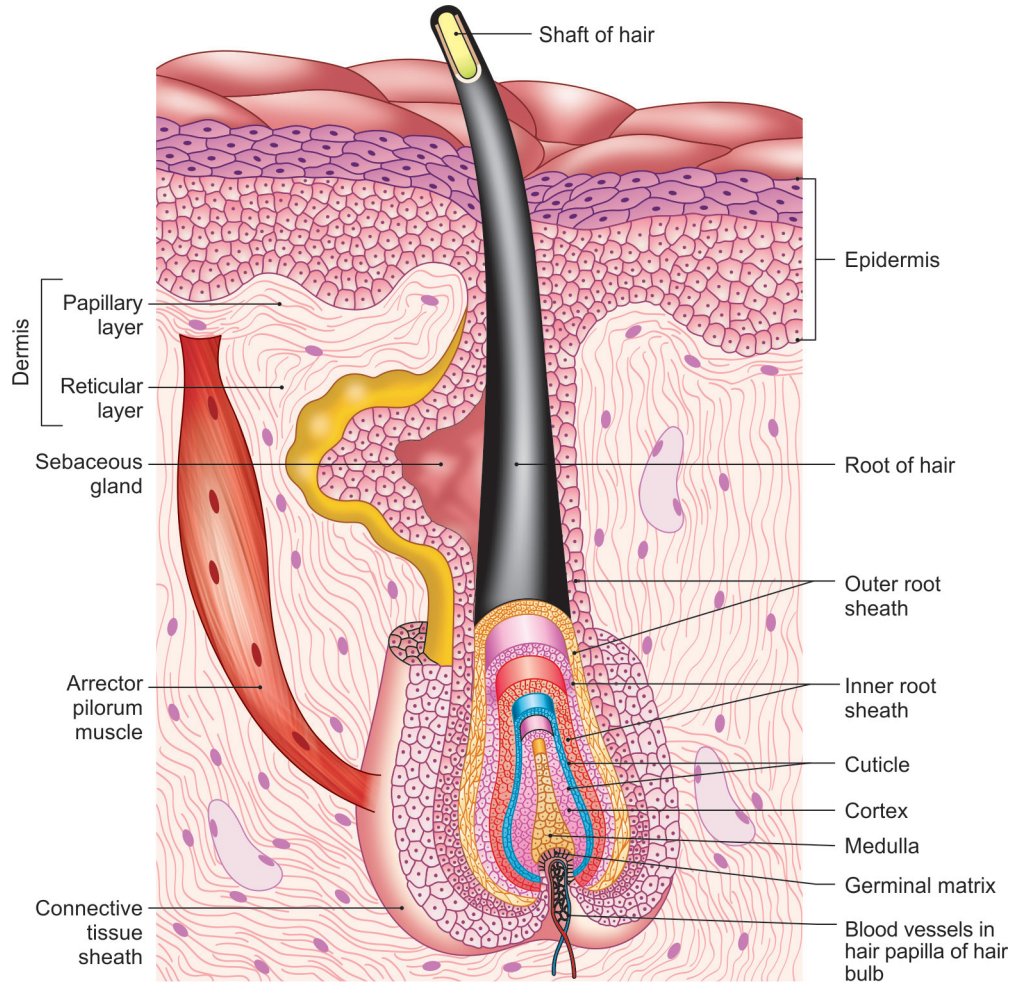


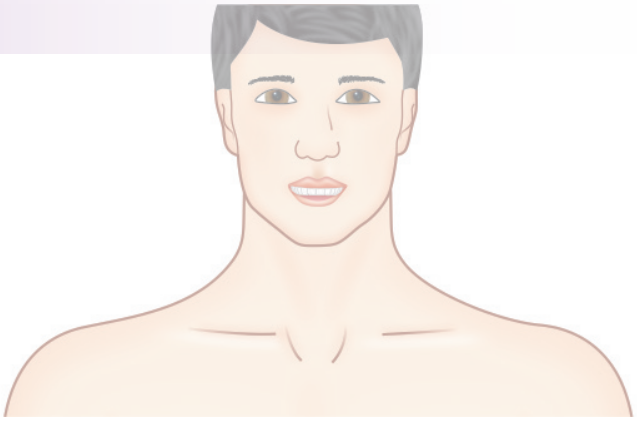
Fig. 10.5: Hair follicle with arrector pilorum muscle

TABLE 10.2: Difference between eccrine and apocrine sweat glands

Characteristics	Eccrine sweat gland	Apocrine sweat gland
Activity	Throughout life	Active at puberty
Opening on surface	Through the sweat pore	Around hair shaft
Function	Maintain temperature	Provides peculiar odor
Nervous control	Postganglionic sympathetic neurons, which are cholinergic	Postganglionic sympathetic neurons which are adrenergic
Secretion	Watery with salts	Viscid with lipids and proteins

11

Sensory Organs



Chapter Outline

Tongue
- Areas of Taste
- Taste Pathway
- Physiology of Taste

Nose
- Physiology of Smell
- Mechanism

Eye
- Refractive Media in the Eye
- Eyeball
- Accessory Components of Eye

Visual Pathway
- Optic Nerve
- Optic Chiasma and Optic Tract
- Mechanism of Vision

Ear
- External Ear
- Middle Ear
- Internal Ear

Hearing

Balance of Human Body/Vestibular Pathway
- Role of Vestibular Apparatus in Balancing the Body

Central Vestibular Pathways

Proprioceptive System

Key Terminology

Names of special senses: Senses of taste, smell, sight, hearing, balance and touch are the special senses.

Basic tastes: Sweet, sour, salt, bitter and umami.

Cells of taste bud: Basal, sustentacular and gustatory (taste) cells.

Nerves carrying taste: Chorda tympani branch of facial from most of anterior 2/3rd of tongue, IX from circumvallate papillae and posterior 1/3rd of tongue.

X from posterior most part of tongue vallecula and epiglottis.

Area of taste: Area of taste is in the lowest part of postcentral gyrus.

Sense of olfaction: Limited to 5–7 mm area on the uppermost part of lateral walls and both sides of septum of nose.

Olfactory epithelium: Comprises supporting cells and olfactory receptor cells.

Center for olfaction: Lies in hippocampas and occipitofrontal cortex.

Peculiarities of human vision: Human vision is binocular, colored and three dimensional in nature.

Layers of eyeball: Sclera and transparent cornea–I layer, choroid, ciliary body and iris–II, retina with photoreceptors III.

Blood supply of retina: The inner six layers are supplied by one end artery only-central artery of retina.

Muscles supplied by III nerve:
Extraocular muscles: Part of levator palpebrae superioris (LPS), superior rectus, medial rectus, inferior rectus, inferior oblique and intraocular muscles, e.g., ciliaris muscles and sphincter pupillae muscle.

Sympathetic nerves: Supply dilator pupillae and part of LPS.

Muscles supplied by IV and VI nerves: Superior oblique–IV nerve; lateral rectus–VI nerve.

Accommodation of eye: While reading, accommodation takes place. Both medial rectus muscles contract. Constrictor pupillae constricts the pupil. Ciliaris increases the thickness of lens so that light rays focus on the retina.

Blind spot: Lies at the optic disc of retina. There are no rods/cones at this spot.

Macula with fovea centralis: Lies at posterior pole of retina. Contains only cones for best vision.

Parts of lacrimal apparatus: Lacrimal gland, conjunctival sac, lacrimal papilla, lacrimal sac and nasolacrimal duct. Nerve supply of lacrimal gland is by greater petrosal nerve after relaying in pterygopalatine ganglion.

Optic chiasma: Fibers from nasal halves of two retinae cross each other. These impulses come from the temporal fields of vision. So, in case of injury to central part of optic chiasma, person has tubular vision. He/she cannot see structures on the lateral sides-tubular vision.

Center for sight: Lies on occipital lobe of the cerebrum, above and below calcarine sulcus.

Parts of ear: External, middle and internal ears.

Type of cartilage in pinna: There is elastic cartilage in pinna. So, even if it is pulled, it comes back to normal position.

Functions of ear: Hairy pinna if present shows feature "Y chromosome". Even if hairy pinna is not there-males remain males.

Function of middle ear: The sound waves are magnified by middle ear. Its communication with nasopharynx equalizes pressure on both sides of the tympanic membrane for its proper vibrations.

Internal ear: Sound waves travel through fluid medium and then as nerve impulses. Internal ear also functions as a vestibular organ for balancing the body, at rest or during movements.

Bones of internal ear bony ossicles: Malleus, incus and smallest is stapes.

Parts of internal ear: Bony labyrinth consists of vestibule, cochlea and semicircular canals.

Membranous labyrinth also consists of cochlear duct and semicircular ducts. Vestibule of bony labyrinth contains saccule and utricle.

Fluids in internal ear: Bony labyrinth contains perilymph; membranous parts contain endolymph.

Cells in the cochlea: Inner hair cells and phalangeal cells.

Shaking/nodding head: It is called angular acceleration. Each semicircular duct has an ampulla corresponding to that of bony canal. In each ampulla, there is an ampullary crista or cupola. Cristae respond to pressure changes in the endolymph caused by movements of the head.

Saccule and utricle: Medial walls of saccule and utricle are thickened to form macula. The maculae give information about the position of head. They are static balance receptors. Saccule gets stimulated by vertical linear motion (going in a lift). The utricle gets stimulated by horizontal linear motion, e.g., going in a car.

Center of hearing: Lies in the posterior part of superior temporal gyrus.

Center for balancing: Impulses from SCC, saccule/utricle reach vestibular ganglion and end in vestibular nuclei in medulla. These are connected to cerebellum, nerves supplying extraocular muscles and sternocleidomastoid and trapezius muscless.

The special senses are the senses having ***specialized organs*** devoted to ***them like sense organs*** of taste, sight, smell and hearing. Neurons send information through central nervous system to the brain. The sense organs have specialized receptors on them. These sense receptors are found in organs, i.e., tongue, eye, nose and ear, in close vicinity of brain and are governed by cranial nerves. Special senses work in harmony with each other and also with various muscles and glands (Fig. 11.1).

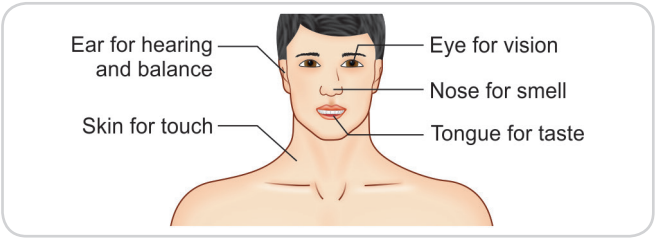


Fig. 11.1: Sensory organs

TONGUE

It is a voluntary muscular organ situated in the oral cavity. It has following functions:

- Helps in speech
- Helps in swallowing
- Contains **taste buds** which make us aware of various tastes. The multitude of eating shops like Pizza Huts, etc. is to please the taste buds. Stomach has none at all.

Musculature of tongue is comprised of intrinsic muscles (lying within tongue) and extrinsic muscles (one attachment is outside the tongue and other within it). Most of these are supplied by XII or hypoglossal nerve.

Arterial supply of tongue is by lingual artery, branch of external carotid artery.

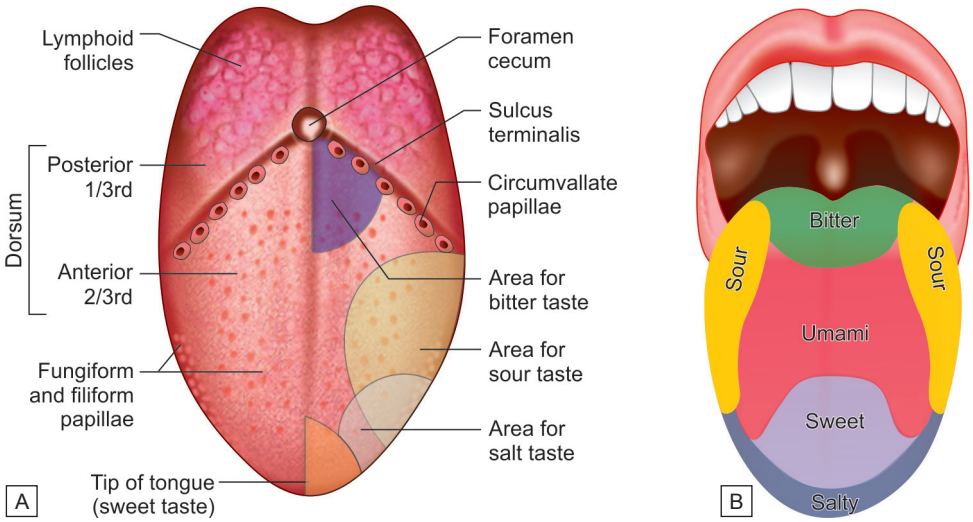
Veins unite to form lingual vein which drains into internal jugular vein.

Lymph drains to submandibular and deep cervical nodes. Lymph vessels cross within tongue from one side to the other.

Areas of Taste

The tongue has papillae for analysis of taste. The areas of taste are located at different sites on the surface of tongue.

The basic tastes are sweet, salt, sour, bitter and umami (Figs 11.2A and B).



Figs 11.2A and B: Tongue: **A.** Gross anatomy; **B.** Zones of di erent tastes on tongue

- **Sweet:** Mainly on tip of tongue. The sweet taste is evoked by configuration of glucose.
- **Sour:** Mainly on edges of tongue. Caused by acids which contain free hydrogen ion, H^+.
- **Salt:** This is mainly situated on dorsum—anteriorly; stimulated by chemical salts, mainly sodium chloride
- **Bitter:** Mainly situated at the back of tongue; bitter taste is brought about by more chemically diverse group of taste substances. For examples, alkaloids, toxic plant derivatives, poisonous substances.
- **Umami:** Meaty or savory taste, a pleasant taste.

Papillae

There are three types of papillae according to their shape is (Fig. 11.3A).

1. Filiform, which make the dorsal surface of tongue rough (Figs 11.3A and B) for licking ice creams.
2. Fungiform is seen on the sides, contain few taste buds.
3. Vallate is present in posterior part of anterior two-thirds of tongue. Contains maximum taste buds.

The sensation of taste is carried by cranial nerve branch of VII (facial) from most of the anterior two-thirds; by branch of IX (glossopharyngeal) from vallate papillae and posterior one-third of tongue; by branch of X (vagus) from posterior most part of tongue. Taste buds contain receptors on papillae of tongue. These are stimulated by chemicals that enter the pores dissolved in saliva (Fig. 11.3B).

General sensation from anterior two-thirds is carried by cranial nerves as lingual branch of V3 (mandibular branch of trigeminal nerve); from posterior one-third by IX; from posterior most part by X.

Taste Pathway

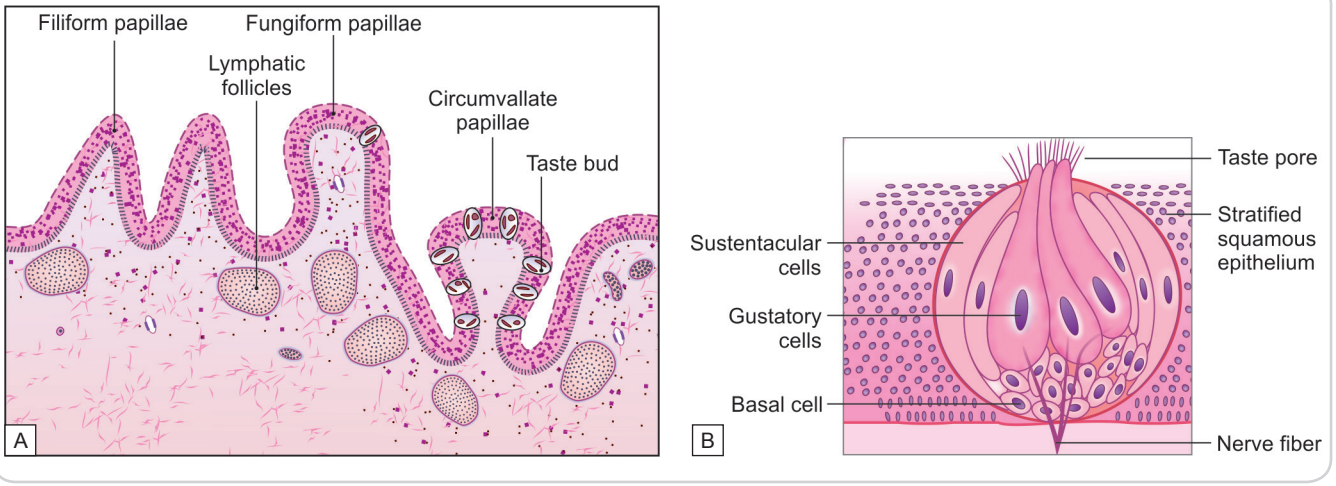
Sense of taste allows us to differentiate undesirable or even lethal foods from those that are pleasant to eat. Taste stimulates secretion of saliva and gastric juices. It allows selection of food and Figure 11.4A the taste pathway.

Primary Sensations of Taste

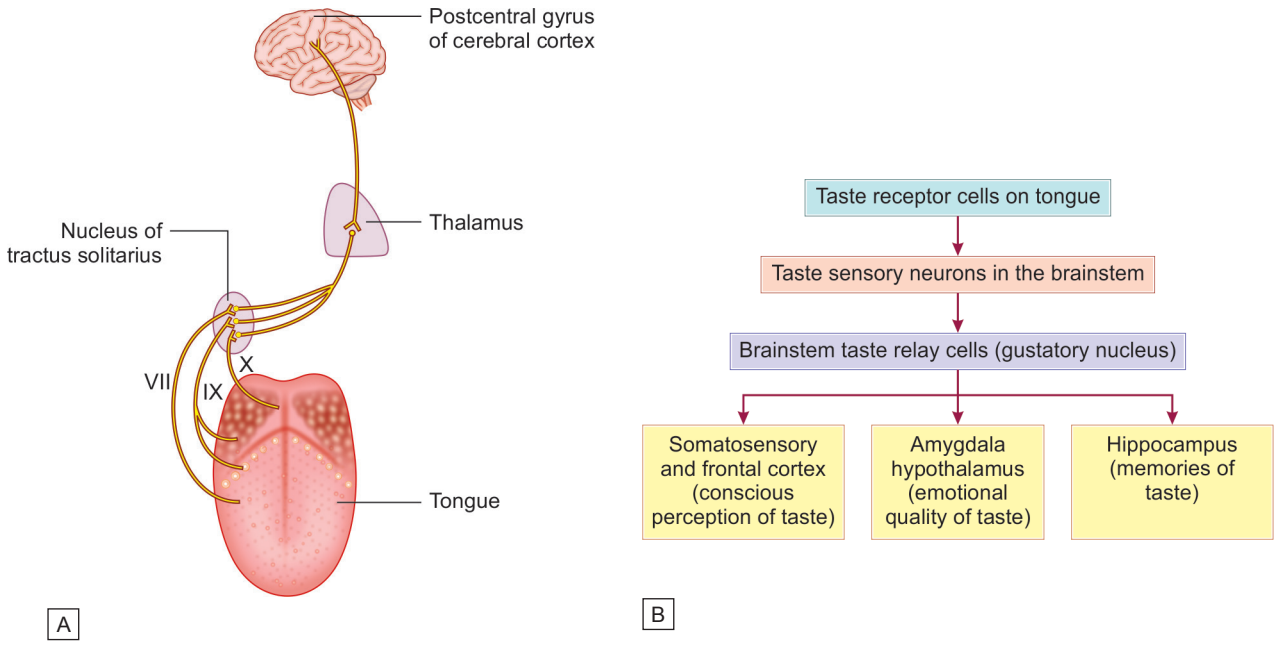
The primary sensations of taste is made by:

2	Sodium receptors
2	Potassium receptors
1	Chloride receptor
1	Adenosine receptor
1	Inosine receptor
2	Sweet receptors
2	Bitter receptors
1	Glutamate receptor
1	Hydrogen ion receptor

The mechanism, of taste pathway is shown in Figure 11.4B:



Figs 11.3A and B: **A.** Types of papillae with taste buds; **B.** Magnified aste bud



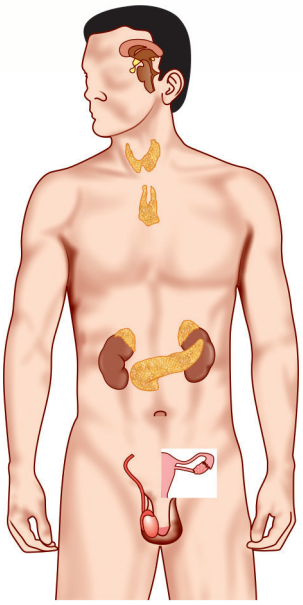
Steps of the gustatory pathway in the appropriate order:

- Tastants dissolve in saliva and enter the taste pores
- There is a depolarization of the taste cell's membrane
- The sense of taste is perceived
- The taste cell releases a neurotransmitter
- The neurotransmitter stimulates action potentials in the sensory neurons

Figs 11.4A and B: **A.** Taste pathway; **B.** Mechanism of taste pathway

12

Endocrine System



Chapter Outline

Key Terminology

Assay of hormones: Assay of hormones is done by radioimmunoassay and enzyme-linked immunosorbent method.

Gigantism: Excessive secretion of growth hormone from acidophils of anterior pituitary before puberty. Person becomes very tall looking like a 'giant'.

Acromegaly: Excessive secretion of growth hormone from acidophils of anterior pituitary after puberty. The looks get coarse, hands and feet become large. Person shows thick lips, macroglossia.

Hyperprolactinemia: When secretion of prolactin hormone is more than normal. There is amenorrhea, infertility and secretion of milk during non-pregnant stage.

Pituitary dwarfism: Occurs due to lack of growth hormone in childhood. The height is less, but mental activity is normal.

Pituitary necrosis: Also called Sheehan's syndrome. There are variable signs and symptoms due to lack of functions of thyroid, adrenal glands and gonads.

Graves disease: Autoimmune disease, causing excess of TSH secretion. Main feature is exophthalmos.

Cretinism: Lack of thyroid hormone during first year of life.

Myxedema: Lack of thyroid hormone during adult age.

Endemic goiter: Enlargement of thyroid gland due to lack of iodine in water and soil. Seen in hilly areas.

Hyperparathyroidism: There is hypercalcemia, hypercalciuria and repeated renal calculi/stones, and repeated fracture of bones.

Tetany: Due to low levels of parathormone, hand goes into carpal spasm.

Cushing's syndromes: There is obesity, hirsutism, diabetes and hypogonadism. This occurs due to excessive secretion of adrenal cortical hormones.

Addison's disease: Lack of cortical hormones.

Pheochromocytoma: Tumor of adrenal medulla with attacks of hypertension, headache.

Diabetes mellitus: There is hyperglycemia due to lack of insulin. Most common is type II/adult type of diabetes.

Hypoglycemia: Lack of glucose. It is very serious and may cause coma and death.

The endocrine or ductless glands are situated in various regions of the body. They are devoid of ducts and the secretions are poured directly into the blood through the capillaries and numerous sinusoids draining and irrigating the gland. These have rich blood supply (Fig. 12.1).

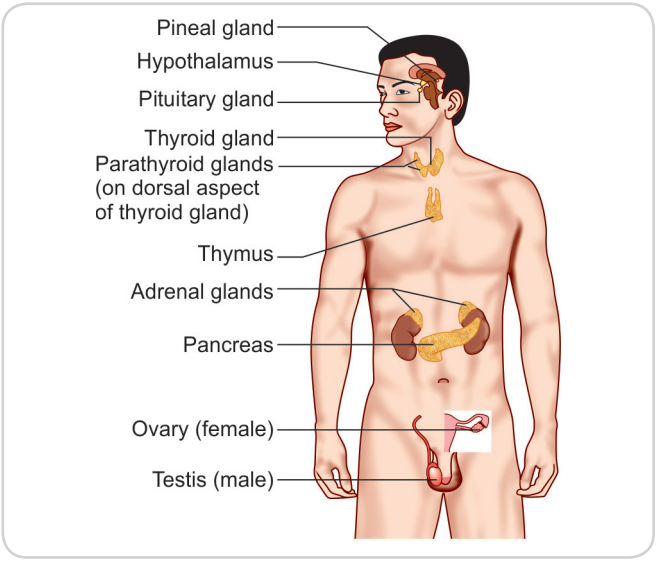


Fig. 12.2: Endocrine glands

HORMONES

Each of the glands secretes specific hormones with distinct functions. The principal endocrine glands are:

Hypophysis cereberi or pituitary gland, thyroid gland, parathyroid gland, suprarenal or adrenal glands, pineal gland (Fig. 12.2).

Other organs that secrete hormones as a second function are:

Hypothalamus, thymus, pancreas, ovaries and testes, kidneys, stomach, liver, small intestine, skin, heart, placenta.

Some of the hormones like prostaglandin do not travel to remote organs and act locally.

Release of Hormones

The endocrine system is a collection of glands that secrete chemical messages known as hormones. These signals are passed through the blood to arrive at a target organ, which has cells possessing the appropriate receptor.

The gland that produces it passes the hormone through the bloodstream to the cells designed to receive its message. These cells are called target cells. Along the way to the target

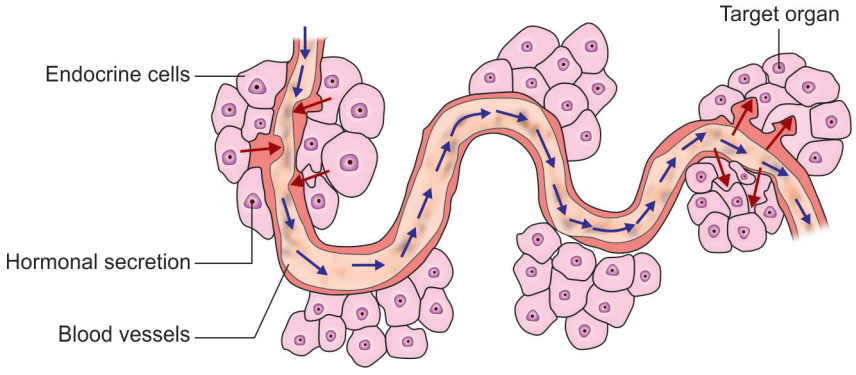
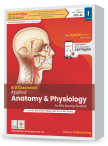


Fig. 12.1: Endocrine gland



cells, special proteins bind to some of the hormones. These proteins act as carriers that control the amount of hormone available for the cells to use.

The target cells have receptors that latch onto only specific hormones, and each hormone has its own receptor, so that each hormone will communicate only with specific target cells that have receptors for that hormone. When the hormone reaches its target cell, it locks onto the cell's specific receptors and these hormone-receptor combinations transmit chemical instructions to the inner workings of the cell. When hormone levels reach a certain normal amount, the endocrine system helps the body to keep that level of hormone in the blood.

An example of this process is - parathyroid hormone. Parathyroid hormone increases the level of calcium in the blood. When the blood calcium level rises, the parathyroid glands sense the change and reduce their secretion of parathyroid hormone. This turnoff process is called a negative feedback system.

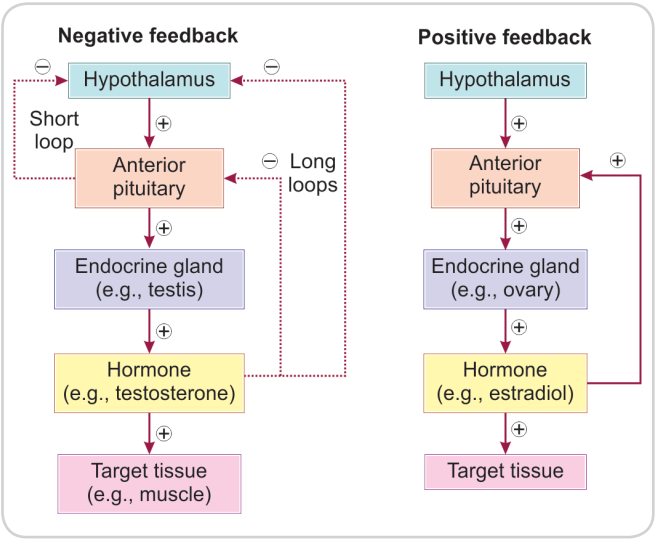


Fig. 12.4: Feedback control of hormone secretio

Mechanism of Hormone Action

The nervous system modifies the stimulation of endocrine glands and their negative feedback mechanisms. The nervous system can override normal endocrine controls.

Two systems, i.e., nervous system and endocrine system coordinate their activities: certain parts of the nervous system stimulate or inhibit the release of hormones (e.g., hypothalamus) and in turn, certain hormones can stimulate or inhibit the flow of nerve impulses.

Whole process is summarized as Figure 12.3.

- Hormones produce one or more of the following cellular changes in target cells.
- Stimulate protein synthesis.
- Induce secretory activity.
- Alter plasma membrane permeability.
- Activate or deactivate enzyme systems.
- Induce secretory activity.
- Stimulate mitosis.

Control of Hormone Secretion

It is regulated by signals from nervous system, chemical changes in the blood or by other hormones. Control of hormones is by negative or positive feedback (Fig. 12.4). Hormones may be lipid based like steroids and tyrosine. These may be peptide hormones like adrenaline, glucagon, etc.

- **Negative feedback control (most common):** Decrease/ increase in blood level is reversed. When the plasma

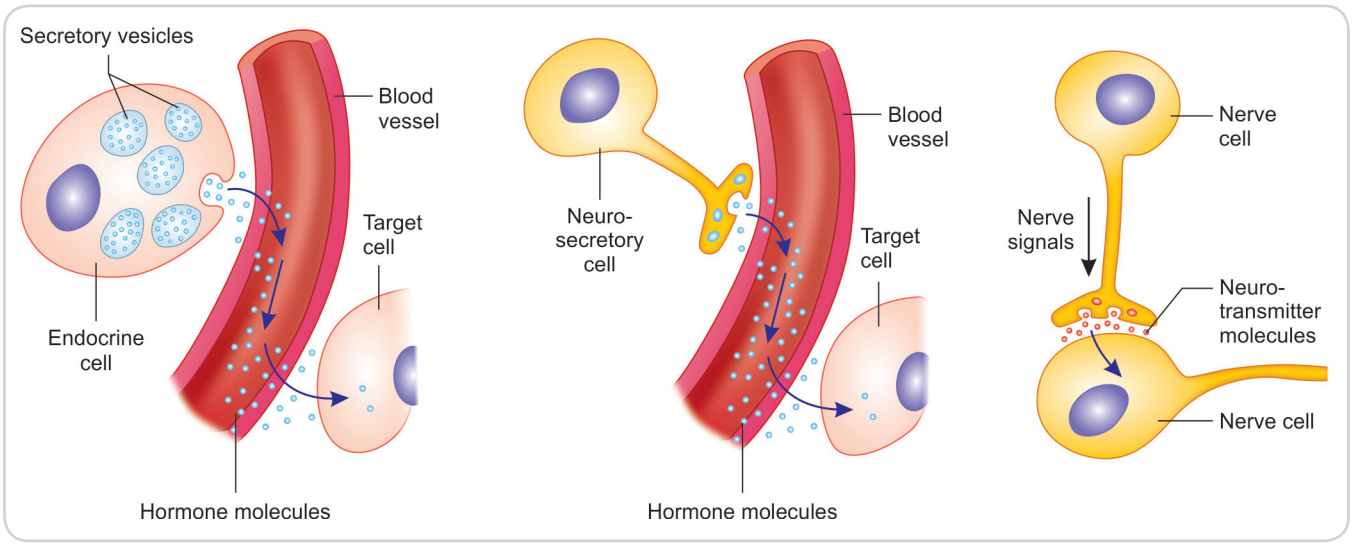
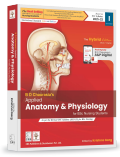


Fig. 12.3: Hormones neurotransmi ers



Medulla consists of loose connective tissue, elastic fibers, numerous blood vessels and a few smooth muscle fibers.

Gonadotropin releasing hormone (GnRH) is secreted by hypothalamus and transported to anterior pituitary gland.

Ovarian hormones

- Estrogen
- Progesterone
- Small amounts of androgens
- Inhibin (inhibits FSH secretion)
- Activin (increases FSH secretion)
- Relaxin (decreases uterine contractility)

Functions

Regulation of gonads

- **Follicle-stimulating hormone (FSH):** Enlargement of follicles, ovulation, secretion of estrogen.
- **Luteinizing hormone (LH):** Ovulation, release of estrogens and progesterone. Estrogens appear to inhibit FSH release and may lead to regression of the smaller, less mature follicles.

The functions of ovary, i.e., production of ova and secretion of hormones are governed by the follicle stimulating hormone (FSH) and the luteinizing hormone (LH) of the anterior pituitary.

Some Other Hormones

Various hormones secreted by other body organs are:

- Kidney secretes erythropoietin, which acts on red bone marrow to stimulate the formation of RBCs. Its secretion is regulated by the amount of oxygen delivered to that organ.
- Placenta secretes human chorionic gonadotropin which acts on ovary to increase production of estrogen and progesterone during pregnancy.
- Heart (atrium) forms anti-natriuretic hormone which acts on kidney tubules to increased reabsorption of sodium and water.
- Adipose tissue secretes hormone and it acts on hypothalamus. This is known as leptin that gives feeling of fullness after eating which subdues the appetite. In obesity there are high levels of leptin and negative feedback mechanism that does not operate well. Leptin secreted by adipose tissue is involved in syntheses of gonadotropin releasing hormone and gonadotropins at puberty.
  - As leptin is lower in thin girls, these thin girls reach puberty later. They have difficulty in conceiving. Their menstruation may also stop due to low levels of gonadotropins.
- Gastric mucosa secretes gastrin which increases secretion of gastric juice.
- Intestinal mucosa secretes secretin and cholecystokinin which help to increase secretion of pancreatic juice and expulsion of bile.
- **Histamine** is synthesized by mast cells in the tissues and basophils in blood. When there is inflammation in the tissues, histamine is released and there will be increased capillary permeability. It also causes contraction of smooth muscles of the bronchi and alimentary tract and stimulates the secretion of gastric juice.
- **Serotonin (5-hydroxytryptamine):** It is present in platelets, in the brain and in the intestinal wall. It causes intestinal secretion and contraction of smooth muscle.
- **Prostaglandins:** They are produced by the cells in most tissues. The members of the group may enhance the process of coagulation or may assist in promoting allergic responses. This may cause vasodilation and inhibition of platelet aggregation.

In addition, the prostglandins influence the response of the pituitary gland to hypothalamic hormones.

- Requires **education of the patient** and **frequent interactions** with diabetes management team; Short acting insulin analogs are used
- Advantages:
  - Programmed dose
  - Basal infusion rates altered during exercise
  - Different doses of insulin can be matched based on meals
- Disadvantages:
  - Infection
  - Hyperglycemia
  - DKA

APPLIED ASPECTS

Effects of secretion of growth hormone (Fig. 12.31)

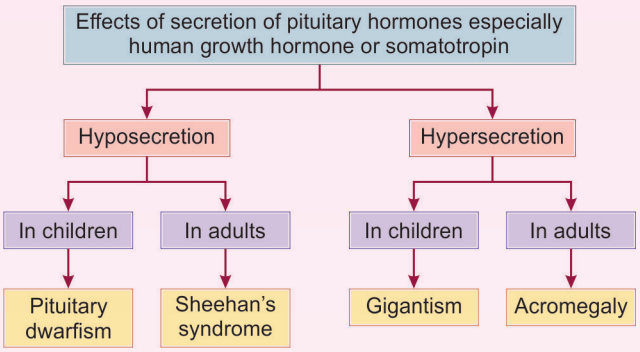
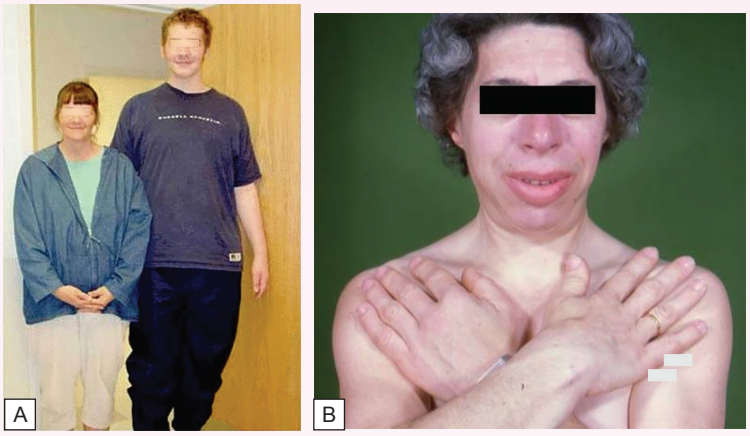


Fig. 12.31: Effects of secretion of somatotropin/growth hormone

Hypersecretion of hormones

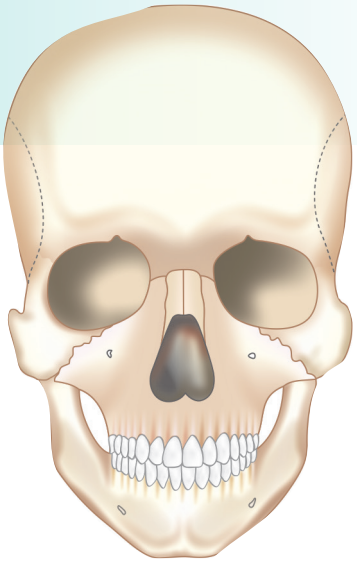
Gigantism: Excessive secretion of growth hormone from acidophils of anterior pituitary before puberty. Person becomes very tall looking like a 'giant'. Fig. 12.32A)

Acromegaly: Excessive secretion of growth hormone from acidophils of anterior pituitary after puberty. The looks get coarse, hands and feet become large. Person shows thick lips, macroglossia. It is due to slow growing adenoma and skeletal overgrowth (Fig. 12.32B).



Figs 12.32: **A.** Gigantism (left); **B.** Acromegaly (right)

Hyperprolactinemia: When secretion of prolactin hormone is more than normal. There is amenorrhea, infertility and secretion of milk during non-pregnant stage (Fig. 12.33).



13

Skeletal System

Chapter Outline

Key Terminology

Composition of bone: Inorganic matter is 2/3rd–calcium hydroxyapatite crystals [$Ca_{10}(PO_4)_6$ OH_2] and organic matter 1/3rd is collagen fibers.

Classification of bones: According to shape, position, and ossification.

Periosteum: Outer covering of bone is made of fibrous and an osteogenic layer. Richly supplied by blood and nerves.

Parts of a young long bone: Diaphysis, metaphysis, growth plate, in centre, epiphyses and articular cartilage at each end.

Blood supply of young long bone: Arteries are nutrient, periosteal, metaphyseal and epiphyseal.

Types of ossification: Intramembranous, i.e., membrane → bone. Intracartilaginous, i.e., membrane → cartilage → replaced by bone.

Types of cartilages: Hyaline, e.g., costal cartilages, white fibro, e.g., intervertebral disc, yellow elastic, e.g., epiglottis.

Names of paranasals sinuses: Pairs of maxillary, frontal, sphenoid, anterior (12) middle and posterior ethmoidal air sinuses.

Emissary veins: These veins connect the extracranial veins with intracranial venous sinuses. These veins pass through numerous foramina in the base and cap of skull.

Diploic veins: These veins drain the formed blood cells in the diploe (spaces) between the two tables of skull.

Osteophytes: Bony spicules in relation to intervertebral foramina, which may press on the emerging spinal nerve roots/nerves.

Disc prolapse: Nucleus pulposus (soft mass) of intervertebral disc may herniate posterolaterally to press on the spinal nerves.

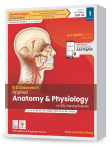
Winging of scapula: Medial border of scapula projects toward the surface in the paralysis of serratus anterior muscle.

Osteomyelitis of tibia: Osteomyelitis of tibia is commonest and affects the knee joint.

Pulled elbow: Pulling the hand of a child may dislocate the head of radius at superior radioulnar joint.

Radius and ulna: Colles' fracture is fracture of both ulna and radius bones in their lower parts, giving rise to dinner fork deformity.

Fibula: An ideal bone for bone grafting.



Humerus: Fracture of its surgical neck causes injury to axillary nerve, leading to paralysis of deltoid muscle. Fracture of medial epicondyle causes injury to ulnar nerve leading to paralysis of intrinsic muscles of hand.

Ribs: Fracture of middle ribs is common. Broken ends may injure lung/spleen or diaphragm. Notching of ribs occurs in coarctation of aorta due to tortuosity of posterior intercostal arteries.

Paracentesis thoracis: Needle is put in lower part of intercostal space to avoid injury to intercostal vessels and intercostal nerve.

Tumors of the bone: May be primary or metastatic from breast, thyroid, etc.

Osteoporosis: Lack of bone density due to imbalance between bone deposition and bone resorption causes osteoporosis.

Viability of fetus: Lower end of femur gets secondary ossification center during 9th month of intrauterine life X-ray taken to show the center ensures the viability of the fetus.

Fracture: A break in continuity of a bone. Fracture may be simple when it is not connected with the skin; or compound when fractured bone comes out of the skin. Fracture line may be spiral, horizontal or oblique.

If Dens of Axis (2nd cervical vertebra) gets fractured, it hits the vital centers in medulla oblongata, leading to immediate death.

The internal framework of human body is its skeleton. The skeleton consists of around 270 bones at birth. These later diffuse and the number decreases to around 206 bones in adults. All bones and cartilages of the body make the skeletal system. The skeleton provides support and protection to the different organs of the body. One studies the bones and cartilages in osteology.

Osteology: Science which deals with bones and cartilages is called osteology.

BONES

Each bone is a complex living organ. It is made up of protein fibers, cells, and minerals. Bone heals after fracture.

Functions of Bones

- Bone is a living tissue with arteries, veins, nerves and lymphatics.
- Reticuloendothelial cells of bone marrow are cyclic in nature, these take part in immune responses of the body.
- Paranasal sinuses alter the timber of voice (quality of voice)
- It undergoes remodeling and can withstand stress and strain.
- It provides framework to the body.
- Bones form cavities for many organs, e.g., cranial cavity for brain, vertebral canal for spinal cord, thoracic cavity for heart, lungs, abdominal and pelvic cavities for their respective organs.
- Serves as a means of muscle and tendon attachment.
- Helps in body movements.
- Hemopoiesis occurs in the red bone marrow.
- Bones are store houses for calcium and phosphorous. These mineral salts are responsible for rigidity of bones and give radiopacity in X-ray films. The calcium phosphate that it stores is so essential for maintenance of calcium level in blood.
- Bones form important landmarks for determining position of internal organs.
- Bones given shape, support and form rigid framework of the body.
- Bones act as levers for muscles and thus help in movements.

Composition

HIGH YIELD POINT

It has 2/3rd inorganic matter, i.e., $Ca_{10}(PO_4)_6OH_2$ and 1/3rd organic matter made up of collagen fibers.

Bone tissue is the structural and supportive connective tissue of the body that forms the rigid part of the bones to make the skeleton. Bones are made up of tissue, bone marrow, blood vessels and nerves.

There are two types of bone tissues: Cortical which is compact and cancellous which is trabecular and spongy.

Cortical bone forms the extremely hard exterior while cancellous bone fills the interior. These tissues are biologically identical and differ only in their arrangement of microstructure.

Bone Cells

Osteoblasts that are involved in the creation and mineralization of bones.

Osteocytes maintain the bone and osteoclasts are involved in the reabsorption of bone tissues. The mineralized matrix of bone tissue is composed of collagen which is an organic component. The other part has an inorganic mineral component made up of various salts.

Classification of Bones

According to shape: *Long bones (Fig. 13.1):* Consists of shaft (diaphysis) with two ends (epiphysis)—e.g., humerus.

- **Short long bone**, e.g., metacarpal.
- **Short bones:** These are cuboidal in shape, e.g., carpals and tarsals (Fig. 13.2).
- **Flat bones:** The flat bones are made of two plates of compact bone with spongy bone in between (Fig. 13.3).

Know it

Important Terms for Bones in Osteology

- Ala—wing
- Canal—bony tunnel
- Condyle—articular portion at end of a bone
- Crest—a ridge
- Epicondyle—non-articular projection above the condyle
- Foramen—opening in box
- Fossa—depression on surface of bone
- Groove—narrow channel
- Hiatus—gap in bone
- Lamina—flat piece of bone
- Meatus—narrow passage
- Ossicle—small bone
- Process—small elevation
- Spine—pointed bony process
- Suture—union between skull bones
- Trochanter—big non-articular projection
- Tubercle—small localized rounded thickening
- Tuberosity—large localized rounded thickening

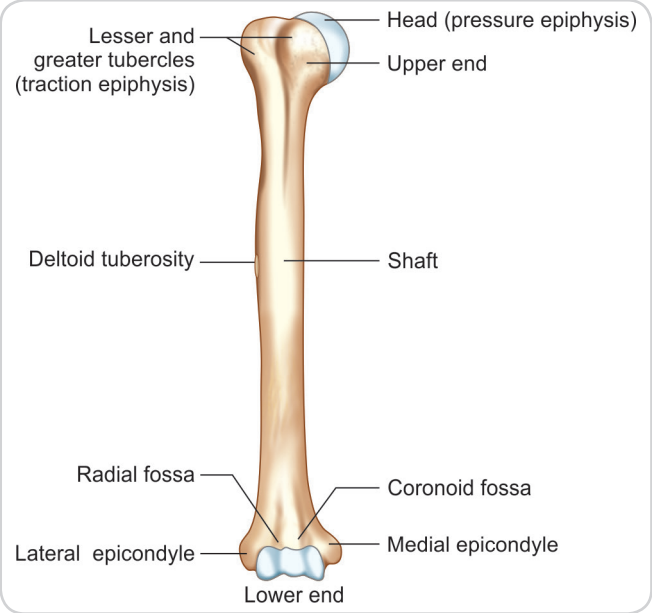


Fig. 13.1: Gross anatomy of long bone—humerus

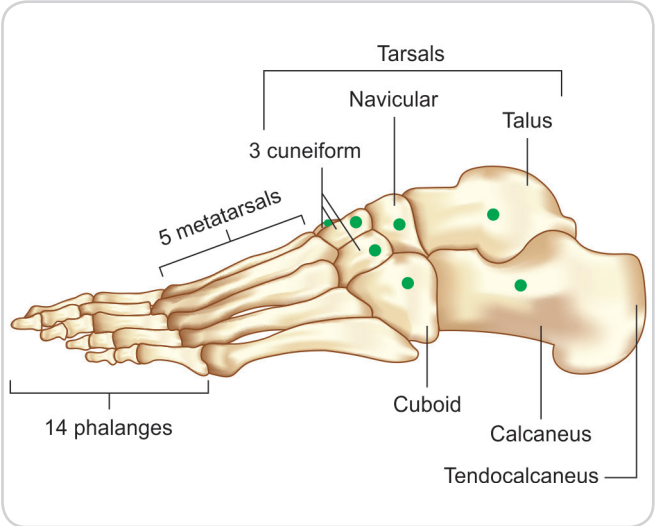


Fig. 13.2: Gross anatomy of short bones—tarsal and—metatarsals

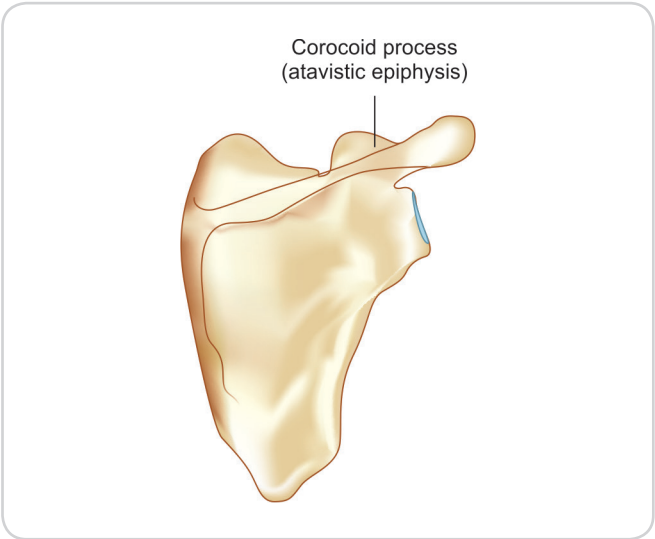


Fig. 13.3: Flat bone

- **Irregular bones:** These have irregular shapes, e.g., vertebrae, hip bone.
- **Pneumatic bones:** These bones have spaces which are lined by mucus membrane, e.g., frontal, maxilla, ethmoid and sphenoid (Fig. 13.4).
- **Sesamoid bones:** These are bones developing in tendons of some muscles, e.g., patella in tendon of quadriceps femoris pisiform in tendon of flexor carpi ulnaris.

According to position:

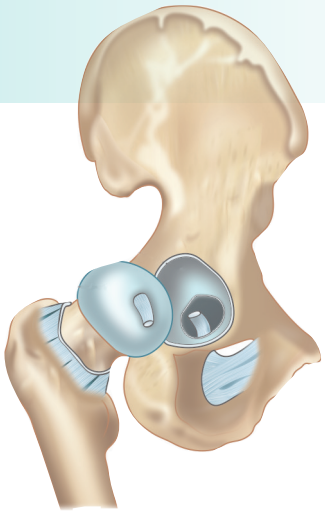
- Axial skeleton, e.g., skull, vertebrae, ribs, sternum
- Appendicular skeleton, e.g., bones of limbs

According to ossification:

- **Cartilaginous bones:** Membrane becomes cartilage which is later replaced by bone.

14

Joints



Chapter Outline

Key Terminology

Abduction: Moving a bone away from the midline of the body.

Adduction: The movement of a bone toward the midline of the body.

Pronation: The action of rotating the forearm so that the palm of the hand is turned down or back.

Supination: The action of rotating the forearm so that the palm of the hand is turned up or forward.

Joint: As a junction of two or more bones or cartilages. It is a device to permit movements.

Fibrous joints: These are immobile and united by fibrous tissue seen in sutures of skull and gomphosis of the teeth.

Cartilaginous joints: These are united by cartilage. Primary cartilaginous joints are seen in a growing bone present between its diaphysis and epiphysis. There is no movement. Secondary cartilaginous joints are present in the midline of the body, e.g., intervertebral disc of the bodies of the vertebrae, pubic symphysis and manubriosternal joint. These allow slight movement.

Synovial joints: These are the mobile joints. Movement may be in one, two or three axes according to the shape of bones, e.g., shoulder joint, elbow joint, knee. In thoracic cage and in between joint cartilages of larynx, which permit movements of breathing and speech.

Joints or articulations are junctions between two or more bones or cartilages. The greater the range of movement, higher is the risk of injury because the strength of the joint is reduced.

The knee joint is the most complicated joint in the entire body. Here the parts are different that cannot normally be found in other joints such as knee ligaments, the meniscus and a kneecap. The joints can be classified according to their structural composition and according to the amount of movement of which they are capable.

CLASSIFICATION OF JOINTS

Structural classification		
• Fibrous joint or synarthrosis ▪ Sutures ▪ Syndesmosis ▪ Gomphosis	• Cartilaginous joint ▪ Primary cartilaginous joint or synchondrosis ▪ Secondary cartilaginous joint or symphysis	• Synovial joint or diarthrosis ▪ Ball and socket or spheroidal joint ▪ Sellar or saddle joint ▪ Condylar or bicondylar joints ▪ Ellipsoid joint ▪ Hinge joint ▪ Pivot or trochoid joint ▪ Plane joint
Regional classification		
• **Skull type:** Immovable (Fig. 14.1)	• **Vertebral type:** Slightly moveable (Fig. 14.2)	• **Limb type:** Freely moveable (Fig. 14.3)

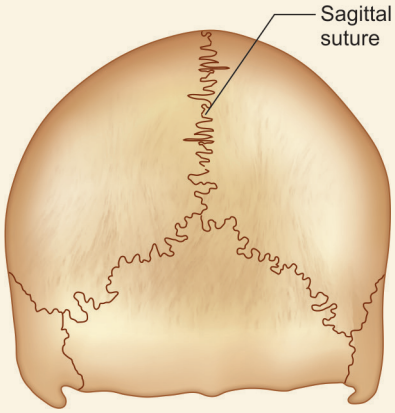


Fig. 14.1: Immovable-skull Showing Sagi al suture

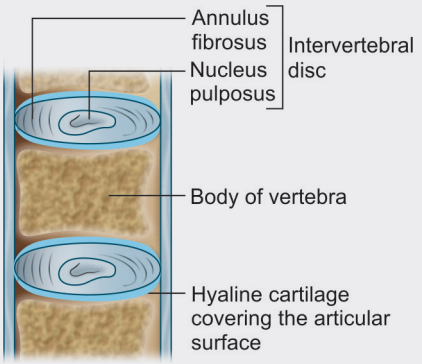


Fig. 14.2: Slightly moveable-intervertebral joint

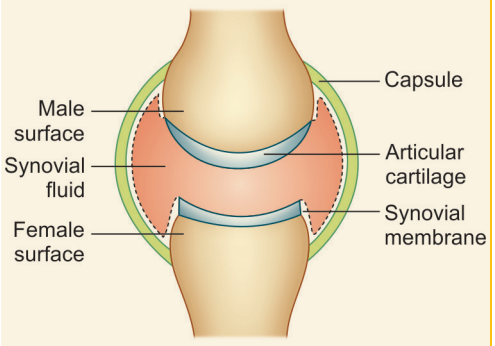


Fig. 14.3: Freely moveable-synovial joint

Fibrous Joints

In fibrous joints, the bones are joined by fibrous tissue. These joints are immovable.

- **Sutures:** These are peculiar to skull, and are immovable. These unite various bones of the skull, at the same time allowing growth of these bones. At birth, the angles of parietal bone of skull show membranous gaps known as fontanels.

Know it

In neonatal skull there are six fontanels—1 anterior, 1 posterior, 2 anterolateral and 2 posterolateral. These allow bones to grow to accommodate the size of the growing brain within the skull.

- **Syndesmosis:** The bones are connected by the interosseous ligament, e.g., inferior tibio-fibular joint.
- **Gomphosis:** It is a specialized fibrous joint that anchors a tooth to its socket in the jaw. It is also known as peg and socket joint. For example, tooth in its socket (Fig. 14.4).

Cartilaginous Joints

Primary cartilaginous (synchondrosis) joint	Secondary cartilaginous (symphysis) joint
Bones are connected by hyaline cartilage	Bones are connected by white fibrocartilage
No movement	Limited movement
Epiphyseal cartilage of growing bone	Joints in the middle line of body

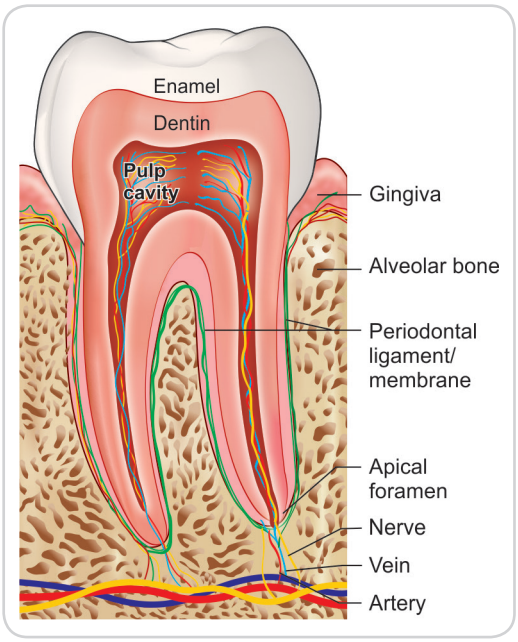


Fig. 14.4: Gomphosis-joint anchoring tooth in the gum

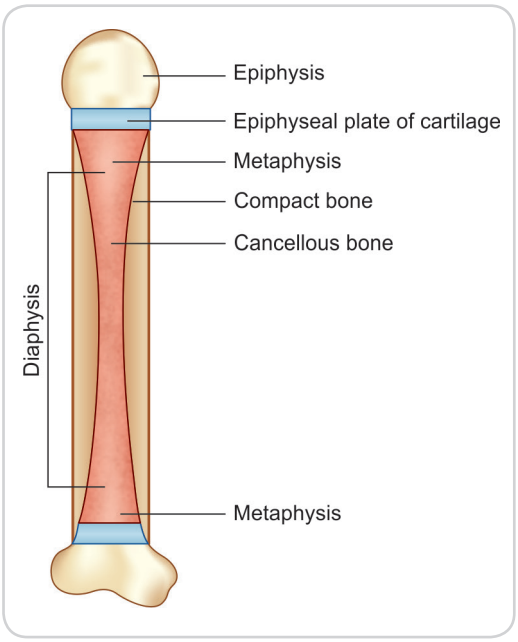


Fig. 14.5: Primary cartilaginous joi t

In this type of joints, the bones are joined by cartilages. They are of the following two types:

1. **Primary cartilaginous joint (synchondrosis):** The bones are united by a plate of hyaline cartilage. These joints are temporary in nature as the cartilaginous plate is replaced by bone (synostosis), viz.
   - Joints between epiphysis and diaphysis of growing long bone.
   - First chondrosternal joint. These joints allow growth in length of long bones. These are temporary joints (Fig. 14.5).
2. **Secondary cartilaginous joint (symphysis):** The articular surface is covered by a thin layer of hyaline cartilage, and united by a disc of fibrocartilage. These are permanent joints, e.g., pubic symphysis, intervertebral joint, manubriosternal joint.

Synovial Joints

Synovial joints are most evolved joints and therefore most mobile type of joints.

The articular surface is covered with hyaline (articular) cartilage. A joint cavity filled with synovial fluid is present between the articular surfaces. The cavity may be partially or completely subdivided by an articular disc or meniscus. The joint is surrounded by an articular capsule, which is made up of a fibrous capsule lined by synovial membrane. Because of its rich nerve supply, the fibrous capsule is sensitive to stretches imposed by movement. This sets up appropriate reflexes to protect the joint from any sprain and is called "*watch dog*" action of the capsule.

The fibrous capsule is often reinforced by various ligaments. The synovial membrane lines whole of the interior of the joint, except for the articular surfaces covered by hyaline cartilage. The membrane secretes a viscous fluid called synovial fluid, which lubricates the joint. Varying degrees of movements are always permitted at the synovial joints.

Classification of synovial joints is given in a table form as follows:

Type	Axes of movements	Example
• **Plane or gliding**	All axes	Intercarpal joints
• **Uniaxial joints** ▪ Hinge joint ▪ Pivot joint	 Transverse Vertical	 Elbow joint, ankle joint Superior and inferior radioulnar joints
• **Biaxial joints** ▪ Condylar joint ▪ Ellipsoid joint	 Transverse and vertical Transverse and antero-posterior axes	 Knee joint Wrist joint
• **Multiaxial joints** ▪ Ball-and-socket joint ▪ Saddle joint	 Transverse, antero-posterior and vertical axes Transverse and antero-posterior axes with rotation	 Shoulder and hip joints 1st carpometacarpal joint

JOINTS OF THE UPPER EXTREMITY

Joints of the Shoulder Girdle

- **Sternoclavicular joint:** This is a saddle variety of joint between the medial end of clavicle and the clavicular notch of sternum (Fig. 14.6). This joint contains an articular disc (Table 14.1).
  - **Blood supply:** Suprascapular and internal thoracic arteries.
  - **Nerve supply:** Medial supraclavicular nerve.
- **Acromioclavicular joint:** This is a plane synovial joint between the lateral or acromial end of clavicle and acromion process of scapula. Coracoclavicular ligament forms syndesmosis between the coracoid process of scapula and inferior aspect of lower 1/4th of clavicle.
  - **Blood supply:** Suprascapular and thoracoacronial arteries.
  - **Nerve supply:** Lateral supraclavicular nerve.

Shoulder Joint or Glenohumeral Joint

It is a synovial joint of ball and socket variety. It allows wide range of mobility to the upper limb. The mobility is at the cost of stability of the joint.

Bones participating in this joint are the head of humerus forming one third of the sphere articulating with shallow

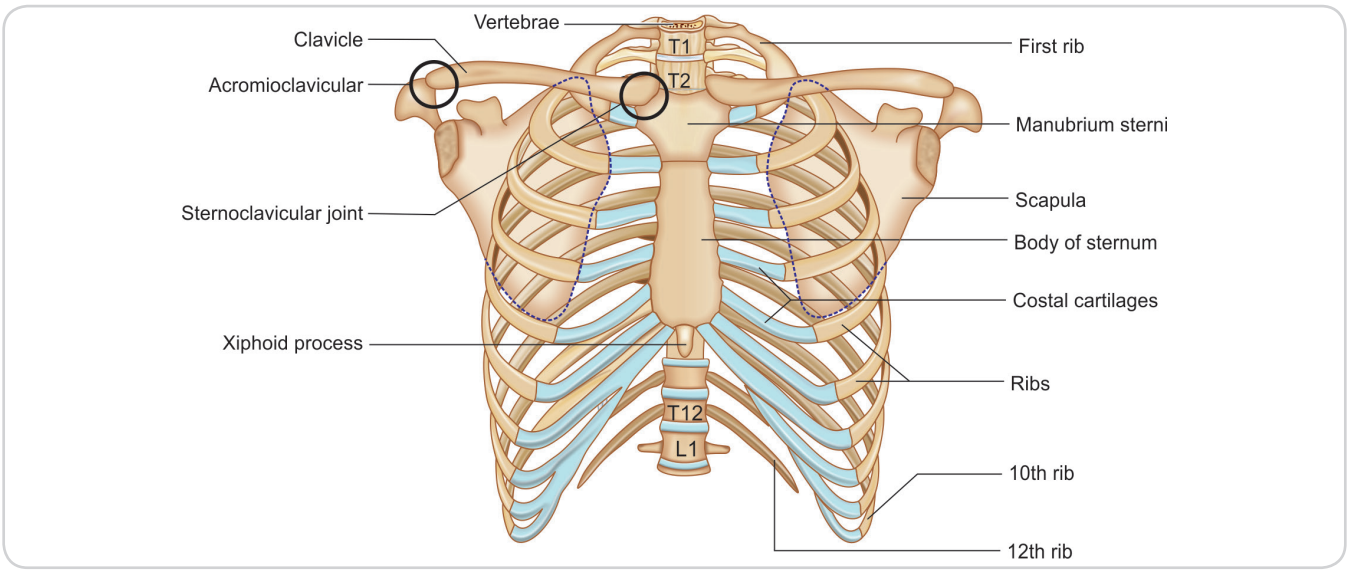


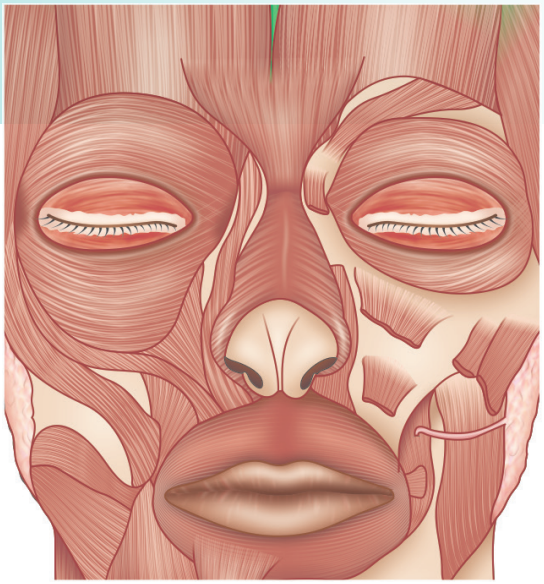
Fig. 14.6: Thoracic cage-showing Sternoclavicular and acromioclavicular joint

TABLE 14.1: Movements of shoulder girdle

Movement		Muscles	Explanation
1.	Elevation	Trapezius, levator scapulae	Trapezius elevates lateral end of scapula, levator scapulae elevates medial border. Contraction of both causes simple elevation.
2.	Depression	Pectoralis minor	Muscle pulling on coracoid process and indirectly scapula causes depression.
3.	Protraction	Serratus anterior	Muscle from the chest wall getting inserted into medial border of scapula rotates scapula around chest wall causing protraction.
4.	Retraction	Rhomboids muscles, middle fibers of trapezius	Muscles extending between the lower cervical, upper thoracic spines and medial border of scapula cause retraction or bracing back of shoulder.
5.	Lateral rotation (with glenoid cavity facing upwards)	Serratus anterior, trapezius	This movement occurs in overhead abduction of shoulder joint. Both these muscles act as a couple (trapezius pulls the root of spine of scapula downwards and serratus anterior pulls inferior angle upwards resulting in glenoid cavity facing upwards.
6.	Medial rotation	Rhomboids muscles, weight of upper limb	This causes glenoid cavity to face downward.

15

Muscular System



Chapter Outline

Key Terminology

Muscle: It is a contractile tissue which causes movements. These are like motors of the body.

Skeletal/striped/somatic/voluntary muscles: These are maximum in amount; present on the external aspect of various regions of the body. These are also present in tongue, pharynx and upper part of esophagus. These are supplied by cranial nerves (head and neck region and rest all by 31 pairs of spinal nerves).

Visceral/unstriped/involuntary: They are present inside the body cavity, e.g., digestive system, genitourinary system and all blood vessels. These are innervated by autonomic nerves.

Cardiac/involuntary: Only situated in heart supplied by autonomic nerves.

Classification of skeletal muscles. According to actions

Prime movers—chief muscles

Synergist—assisting chief muscles

Antagonist—opposing chief muscles

Fixators: Fix the proximal joints so that distal parts, i.e., hand can do the movements.

Change of length/tension in the muscle: Isotonic—Length of muscle may decrease or increase but tension is constant.

Isometric: Tension increases, but length remains same, e.g., holding glass of water in air.

Concentric: Muscle shortens with increased tension.

The muscular system is composed of specialized cells called muscle fibers. Their main function is contractibility. Muscles, attached to bones, internal organs and blood vessels are responsible for movement. Generally, all movements in the body are the results of muscle contraction.

There are five main properties of the muscular system as discussed ahead.

1. **Contractibility:** After receiving stimulation, they are capable of contracting, or shortening. The muscles can contract easily.
2. **Elasticity:** Because of elasticity, a muscle is able to return to its original shape and length after being extended or contracted.
3. **Excitable:** Muscles are excitable and this means that they receive stimulation and respond to this stimulation because of nerves.
4. **Extensible:** It refers to a state where the muscles can be stretched without damage when force is applied.
5. **Adaptability:** The muscular system is adaptable because it can change the response to how it is used. For example, a muscle can go in atrophy, or waste away if deprived of work; whereas it will enlarge, or undergo hypertrophy with increased work.

STRUCTURE OF SKELETAL/STRIATED MUSCLE

Each muscle is made of numerous subunits or bundles called fascicles that are surrounded by connective tissue called the perimysium. Each fascicle is composed of numerous muscle fibers. Muscle cells are enclosed by endomysium, and is made up of myofibrils. These myofibrils are composed of long protein molecules called myofilaments.

Two Ends

- ***Origin*** is one end of the muscle which mostly remains fixed during its contraction.
- ***Insertion*** is the other end which mostly moves during its contraction. In the ***limb*** muscles, the origin is usually proximal to insertion.

However, the terms origin and insertion at times are interchangeable, and at other times difficult to define, as in the intercostal muscles.

HIGH YIELD POINT

Muscles of pharynx, esophagus, and the diaphragm act as involuntary muscles.

The two parts of muscles are:

1. ***Fleshy part*** is contractile, and is called the 'belly'.
2. ***Fibrous part*** is noncontractile and inelastic. When cord-like or rope-like, it is called tendon (Fig. 15.1); when flattened, it is called aponeurosis. The tendon receives Golgi tendon proprioceptive receptor nerve endings.

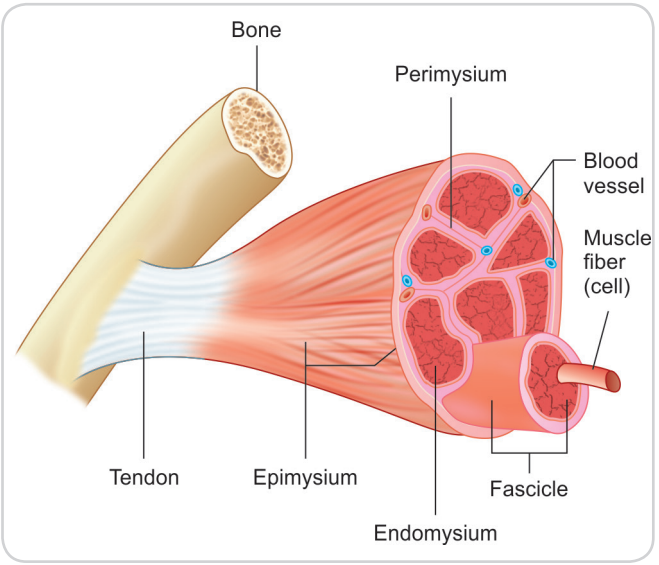
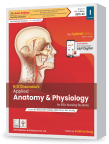


Fig. 15.1: Structure of a muscle fibe



Types of Tissues

Contractile Tissue

Each muscle is composed of numerous muscle fibers. Each ***muscle fiber*** is a multinucleated, cross-striated cylindrical cell (myocyte) 1–300 mm long. It is made up of sarcolemma (cell membrane) enclosing sarcoplasm (cytoplasm).

Embedded in the sarcoplasm there are several hundred nuclei arranged at the periphery beneath the sarcolemma. A number of evenly distributed longitudinal threads are called **myofibrils**. Each myofibril shows alternate dark and light bands. Dark bands are known as A bands (anistropic) and the light bands are known as I bands (isotropic). The bands of adjacent fibrils are aligned transversely so that the muscle fiber appears cross-striated. In the middle of dark band there is a light H band. In the middle of I band, there is a dark Z line or Krause's membrane. The segment of myofibril between two Z lines is called sarcomere (Fig. 15.2).

Muscle → fasciculi → fibers → myofibril → myofilaments

Supporting Tissue

Supporting tissue helps in organization of the muscle.

- *Endomysium* surrounds each muscle fiber separately.
- *Perimysium* surrounds bundles (fasciculi or myonemes) of muscle fibers of various sizes.

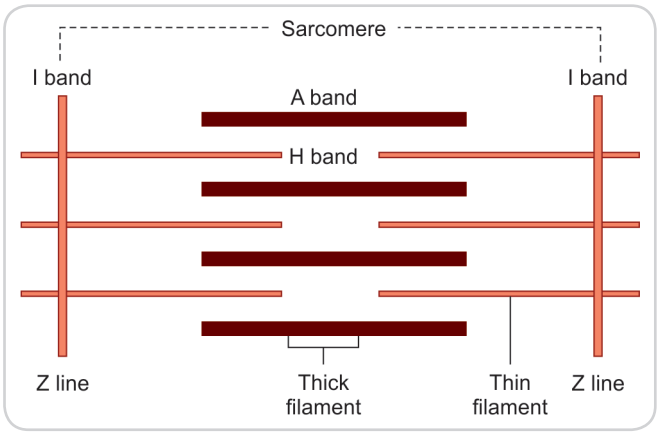


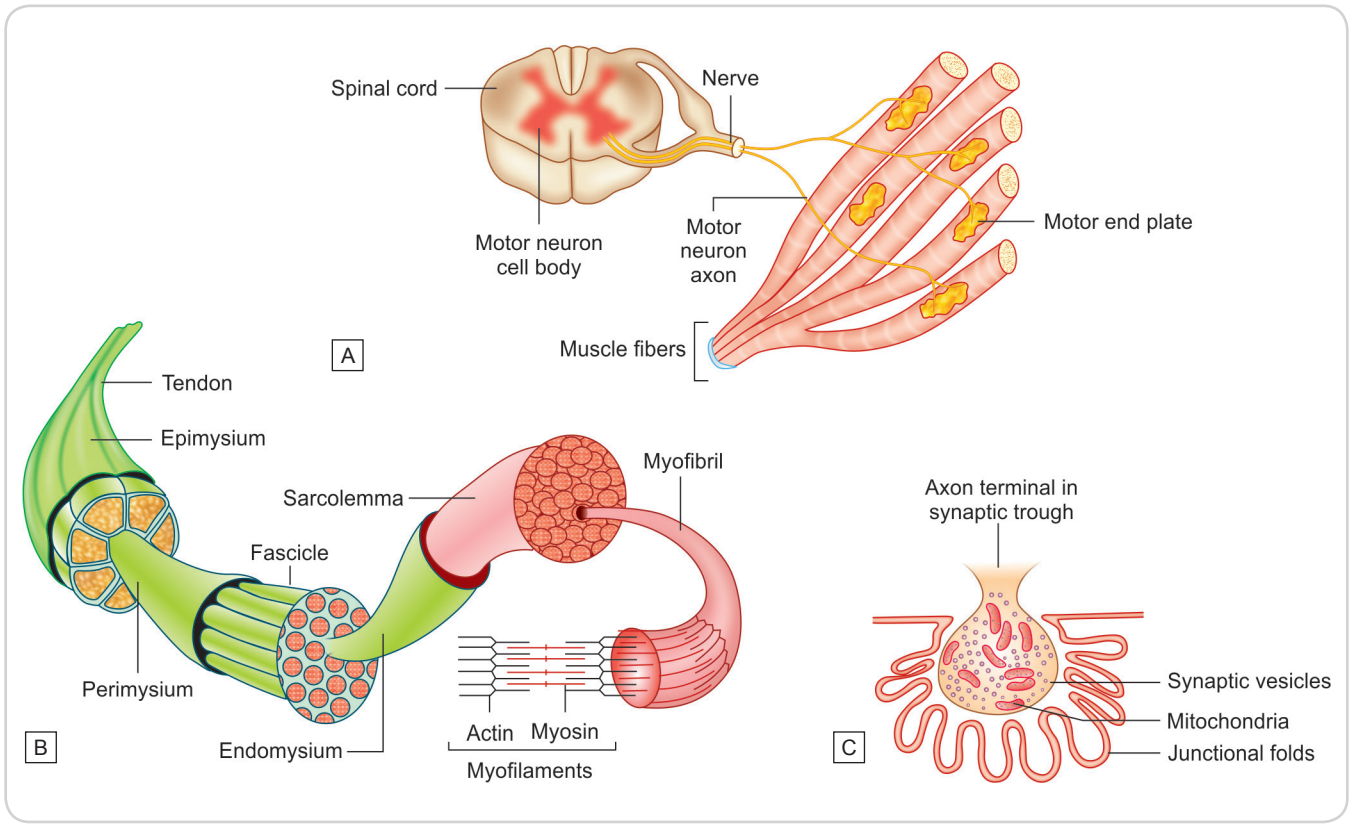
Fig. 15.2: Myofibrils in s eletal muscle

- *Epimysium* surrounds the entire muscle. The connective tissue of the muscle becomes continuous with the tendon (Figs 15.3A to C).

Types of Fibers

Type I (Slow) Fibers

Show a slow 'tonic' contraction characteristic of postural muscles like gluteus maximus.



Figs 15.3A to C: Skeletal muscle: **A.** Nerve supply to muscle fibe s; **B.** Supporting tissue of a muscle **C.** Motor end plate in a muscle

TABLE 15.1: Comparison between type I and type II muscle fibers

Parameters	Red fibers/type I	Pale fibers/type II
Diameter	Small	Large
Blood supply	Rich blood supply	Poor blood supply
Nerve supply	Small nerve fibers	Large nerve fibers
Contraction	Slow twitch	Fast twitch
Force of contraction	Weak, sustained	Strong, less sustained
Fatigue	Fatigue later	Easily fatigued
Myoglobin	Plenty, gives it red color	Scanty
Mitochondria	Rich	Scanty
ATP and glycogen	Poor	Rich
Oxidative enzymes	Rich	Poor

These are red in color because of large amounts of myoglobin. The fibers are rich in mitochondria and oxidative enzymes, but poor in phosphorylases.

Because of a well-developed aerobic metabolism, slow fibers are highly resistant to fatigue.

Know it

Striated muscles have repeating functional units called sarcomeres. The presence of sarcomeres makes a series of bands that are visible along the muscle fibers, which is responsible for the striated appearance observed under the microscope.

Type IIA (Fast) Fibers

Show a fast 'phasic' contraction required for large-scale movements of body segments.

These are paler (white) in color because of small amounts of myoglobin. The fibers are rich in glycogen and phosphorylases, but poor in mitochondria and oxidative enzymes.

Because of a glycolytic respiration, the fast fibers are quite easily fatigued. Table 15.1 shows the comparison between type I and type II muscle fibers.

Type IIB/Intermediate Fibers

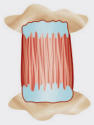
Represent a variant of type II (fast) fibers which are relatively resistant to fatigue, although less than type I (slow) fibers (Burke et al., 1973).

In man, most of the skeletal muscles show a mixture of fiber types, but any one type may predominate.

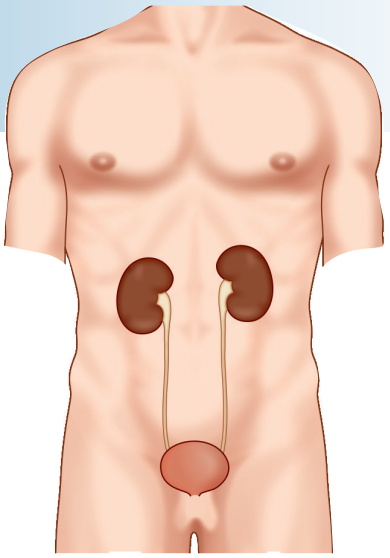
Fascicular Architecture of Skeletal Muscles

The arrangement of muscle fibers varies according to the direction, force and range of habitual movement at a particular joint. The force of movement is directly proportional to the number and size of muscle fibers, and the range of movement is proportional to the length of fibers. The muscles can be classified according to the arrangement of their fasciculi into the following groups (Tables 15.2 and 15.3).

TABLE 15.2: Fascicular architecture of muscle fibers

Parallel fasciculi	
Quadrilateral (thyrohyoid)	Quadrilateral 
Strap-like, e.g., sartorius	Strap 

Contd...



16

Urinary System

Chapter Outline

Key Terminology

Hilum of kidney: Middle of medial border of kidney shows a depression, this depression is hilum of kidney and structure seen at hilum are renal vein, renal artery and renal pelvis from before backwards.

Supports of kidney:

Renal fascia: Encloses kidney.

Perirenal fat: More at the hilum.

Pararenal fat: More toward lower pole of kidney.

Renal pyramid: These are 10–12 conical masses present in the medulla of kidney. Their apices form renal papillae which indent the minor calyces.

Renal column: Part of the cortex of kidney lying in between the pyramids of kidney.

Cortical arches/lobules: Part of the cortex arching over the pyramid of kidney.

Lobe of kidney: One pyramid with its overlying cortex is called lobe of kidney.

Renal pelvis: The upper expanded end of ureter is renal pelvis. The pelvis is divided into 2–3 major calyces and these in turn divide into 7–13 minor calyces. Each minor calyx gets indented by renal papilla which is the apex of pyramid.

Vascular segments: There are 4 vascular segments on anterior aspect of kidney. These are apical, upper, middle and lower on anterior aspect. On posterior aspect, segments are posterior and parts of apical and lower segments. Total segments are 5.

Ureter

Dimensions: Length of ureter is 25 cm, of which upper half lies in abdomen and lower half lies in pelvis, its diameter is 3 mm.

Normal constriction: There are 5 normal constrictions:
- At the pelvis–ureteric junction
- At the brim of lesser pelvis
- At the point of crossing of ureter by ductus deferens or round ligament of uterus
- During its oblique passage through the wall of bladder
- At its opening in the lateral angle of trigone of the bladder.

Course in female

Ureter lies 2 cm lateral to supravaginal part of the cervix

Uterine artery crosses the ureter from lateral to medial side

Ureter is whitish in color and shows peristalsis. It must not be injured while uterine artery is ligated during hysterectomy (removal of uterus). Artery crosses the ureter.

Histology of ureter:

Ureter shows the following layers:

Mucous membrane lined by transitional epithelium.
Middle layer of well-developed smooth muscle layer
Outer tunica adventitia.

Urinary bladder

Parts of empty bladder: Apex, base—directed backwards; neck–lowest and fixed part; three surfaces—superior, right and left inferolateral. Four borders—anterior, posterior and 2 lateral.

Relations in female: Parts of bladder are closely related to cervix of uterus. During removal of uterus one needs to be careful of urinary bladder so that it is not injured.

Male urethra: Parts of male urethra (15–20 cm long) are:

Posterior pat: Pre-prostatic, prostatic part, and membranous part.

Anterior part: Perineal/bulbar part and penile urethra.

Female urethra: It is 4–5 cm long and its parts are: Membranous and perineal part.

Oliguria: Urine output less than 400 mg/day
Proteinuria: Presence of protein in urine
Anuria: No urine excretion
Glycosuria: Presence of glucose in urine.
Polyuria: Passing large amount of urine/day.

THE URINARY SYSTEM

Urinary system is one of the four excretory systems in our body. The other three are associated with bowel, lungs, and skin. The urinary system is also known as the renal system. It consists of the kidneys, ureters, bladder, and the urethra. Main purpose of the urinary system is to eliminate waste from the body, control levels of electrolytes and metabolites, regulate blood volume and blood pressure and blood pH. It consists of a pair of kidneys, renal pelvis, ureters, bladder and urethra (Figs 16.1A and B).

PARTS OF URINARY SYSTEM

Kidneys

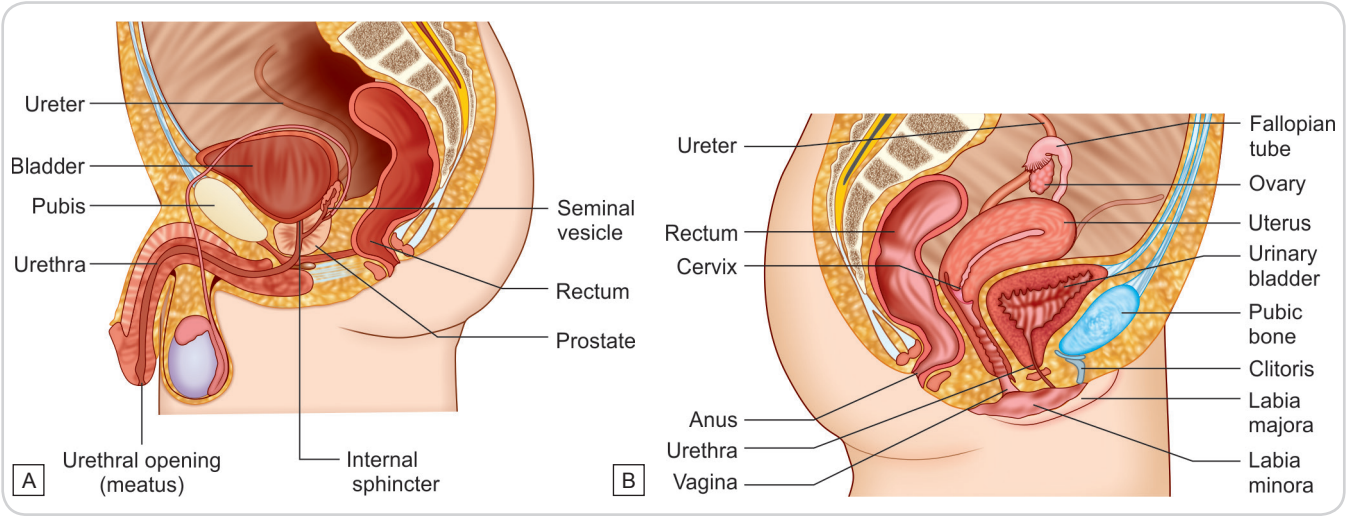
The closely packed structure and numerous functions of the kidney illustrate the beautiful workmanship of our *creator*. It not only applies to the kidney but to each and every part of our body. The human body has two paired kidneys one on the left and another on the right. The functional unit of the kidney is nephron. Urine is formed by nephrons. Their function is to:

- Keep substances stable in the blood
- Remove waste from the blood in the form of urine
- Make vitamin D active
- Make erythropoietin, a hormone which helps to make red blood cells

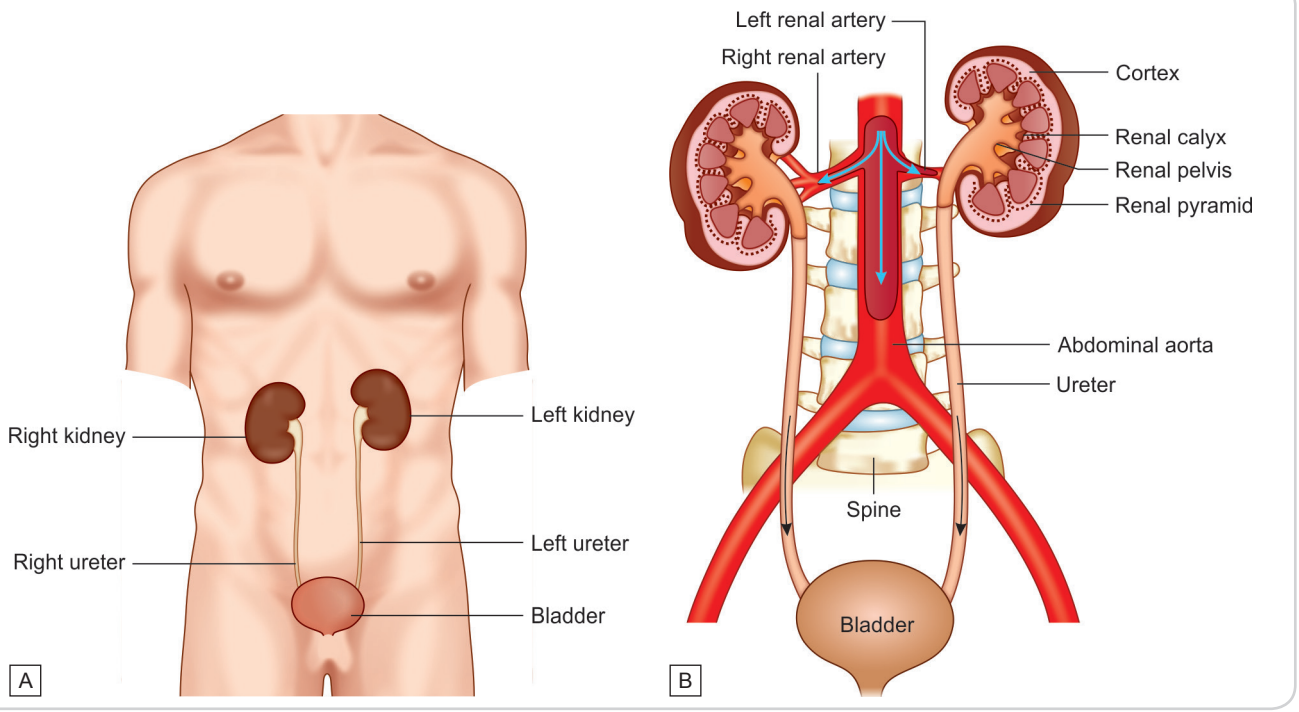
External Features

Location

The kidneys occupy the epigastric, hypochondriac, lumbar and umbilical regions (Figs 16.2A and B). Vertically, they extend from the upper border of twelfth thoracic vertebra to the center of the body of third lumbar vertebra. The right kidney is slightly lower than the left, and the left kidney is a little nearer to the median plane than the right.



Figs 16.1A and B: Urinary system: **A.** Male; **B.** Female



Figs 16.2A and B: **A.** Component of urinary system; **B.** Cut section of kidn y with ureter and urinary bladder

The transpyloric plane passes through the upper part of the hilus of the right kidney, and through the lower part of the hilus of the left kidney.

Shape

Each kidney is bean-shaped. It has upper and lower poles, medial and lateral borders, with anterior and posterior surfaces.

Poles

The *upper pole* is broad and is in close contact with the corresponding suprarenal gland. The *lower pole* is pointed.

Surfaces

The *anterior surface* is said to be irregular and the *posterior surface* is flat, but it is often difficult to recognize the anterior and posterior aspects of the kidney by looking at the surfaces only. The proper way to do this is to examine the structures present in the hilum as described ahead.

Borders

The *lateral border* is convex. The *medial border* is concave. Its middle part shows a depression, the hilus or hilum.

Hilum: The following structures are seen in the hilum from anterior side to posterior side.

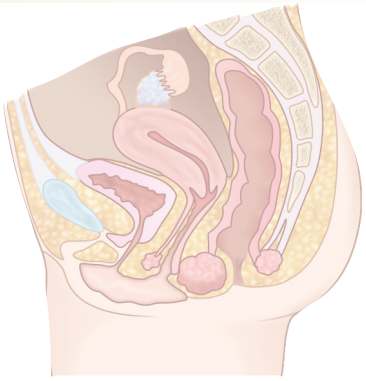
- The renal vein
- The renal artery
- The renal pelvis, which is the expanded upper end of the ureter.

Relations of the Kidneys

The kidneys are retroperitoneal organs and are only partly covered by peritoneum anteriorly (Fig. 16.3).

17

Female Reproductive System



Chapter Outline

Key Terminology

Female gamete: Mature ovum with 22 + XX chromosomes.

Female external genital organs: Mons pubis, labia majora, labia minora, clitoris, vestibule and greater vestibular glands.

Clitoris: Composed of only two corpora cavernosa. There is no corpus spongiosum and no urethra in the clitoris.

Internal genital organs in female: Two ovaries, one uterus, two fallopian tubes and one vagina.

Parts of uterus: Fundus, body and cervix. Cervix has internal os cervical canal and external os.

Arterial supply of uterus: Supplied by tortuous uterine artery, a branch of anterior division of internal iliac artery. It runs medially, crosses ureter anteriorly, bends to run along the lateral side of uterus. It supplies uterus and part of fallopian tube. One needs to be careful during removal of uterus, only to ligate uterine artery and not the ureter.

Supports of Uterus

Muscular supports are the pelvic diaphragm/levator ani muscles and muscles of urogenital triangle.

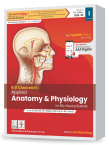
Ligamentous supports are:
- Two transverse cervical (cardinal) ligaments from the sides of cervix and vagina to the side wall of pelvis
- Two uterosacral ligaments from posterior aspect of cervix and vagina, these extend backwards on each side of rectum to be attached to the sacrum
- Pubocervical ligaments
- Broad ligaments
- Round ligaments

Angulation: Angle of anteversion between vagina and uterus 90°.

Phases of menstrual cycle:
- Menstrual phase 1st–4th days
- Proliferative phase 5th–14th days
- Progestational phase 14th–28th days

Pervaginal (PV) examination: By introducing gloved index and middle fingers into vagina, one can palpate vagina, cervix, uterus, ovaries, pulsation of uterine arteries during pregnancy.

Uterine tube: Also called oviduct/fallopian tube. It is 10 cm long on each side of uterus and runs tortuously because of lack of space. Its parts are infundibulum with fimbriae, ampulla, isthmus and intramural parts. Fertilization usually occurs in its ampulla.



Ovaries: Ovaries are the female gonads. These are two almond shaped structures in the lateral wall of true pelvis. The ovary is supplied by the ovarian artery that is a branch of abdominal aorta. Ovary secretes estrogen under the effect of FSH of anterior pituitary and progesterone under the effect of LH of anterior pituitary. Ovary shows many types of follicles in its cortex.

Puberty: Puberty in females is marked by first episode of menstrual flow at about 12–14 years. During puberty, the reproductive organs reach maturity, axillary and pubic hair grow; breasts enlarge and fat gets deposited in subcutaneous tissue.

Menopause: Occurs during 45–50 years of age and main feature is the end of menstruation, and end of child bearing period. Ovaries and other sex organ atrophy, axillary and pubic hair become less. There may be flushing, sweating, palpitation and disturbed sleeping pattern.

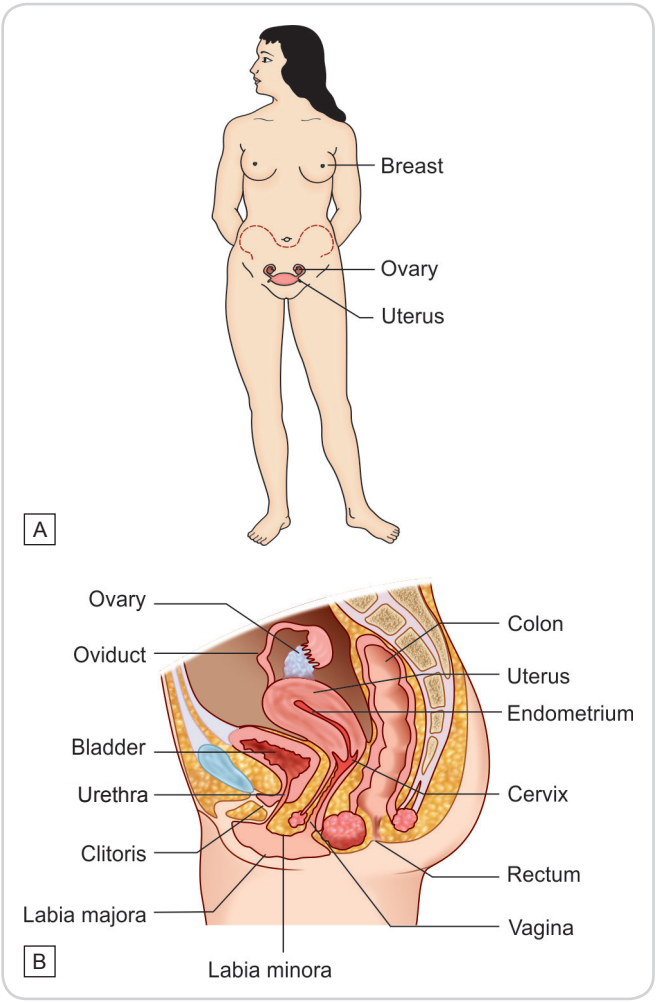
The Breast

Structure: The breast comprises areola, nipple, parenchyma made of 15–20 lobes and connective tissue stroma.

Lymphatic drainage: 75% lymph drains into axillary nodes and 20% into internal thoracic nodes and 5% into posterior intercostal nodes.

Milk secretion and ejection: Prolactin, with estrogen, progesterone cause milk secretion. Oxytocin helps in milk ejection.

The female reproductive system is comprised of the external and internal sex organs. These organs play role in the reproduction. The female reproductive system is immature at birth in humans and develops to maturity at puberty and then it is able to produce gametes and can carry a fetus to full term (Figs 17.1A and B).



Figs 17.1A and B: Female reproducti e system: **A.** Outside projection, **B.** Sagi al sectio

EXTERNAL GENITAL ORGANS—PUDENDUM/VULVA

Pudendum means "The external genital organs" **(Fig. 17.2)** of a woman include:

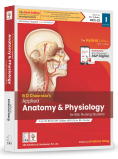
Mons pubis, labia majora, labia minora, clitoris, vestibule of the vagina, bulbs of the vestibule, greater vestibular glands

Mons pubis: Mons pubis is a rounded eminence present in front of the pubic symphysis. It is formed by accumulation of subcutaneous fat. It is covered with pubic hair. The hair-bearing area has a nearly horizontal upper limit.

Labia majora: Labia majora are two thick folds of skin enclosing fat. They form the lateral boundaries of the *pudendal cleft*. Their outer surfaces are covered with hair, and the inner surfaces are studded with large sebaceous glands. The larger anterior ends are connected to each other below the mons pubis to form the *anterior commissure*. The skin connecting the less prominent posterior ends of the labia is known as the *posterior commissure*. The area between the posterior commissure and the anus which is about 2.5 cm long constitutes the *gynecological perineum*.

Labia minora: Labia minora are two thin folds of skin, which lie within the pudendal cleft. Anteriorly, each labium minus splits into two layers; the upper layer joins the corresponding layer of the opposite side to form the *prepuce of the clitoris*. Similarly, the lower layers of the two sides join to form the *frenulum of the clitoris*. Posteriorly, the two labia minora meet to form the *fourchette*. The inner surface of the labia minora contains numerous sebaceous glands.

Clitoris: The clitoris is an erectile organ, homologous with the penis. However, *it is not traversed by urethra*. It lies in the anterior part of pudendal cleft. The body of clitoris is made up of two *corpora cavernosa* enclosed in a fibrous sheath and partly separated by an incomplete *pectiniform septum*. *The corpus spongiosum is absent*. The surface of glans is highly sensitive and plays an important role in sexual responses (Fig. 17.3).



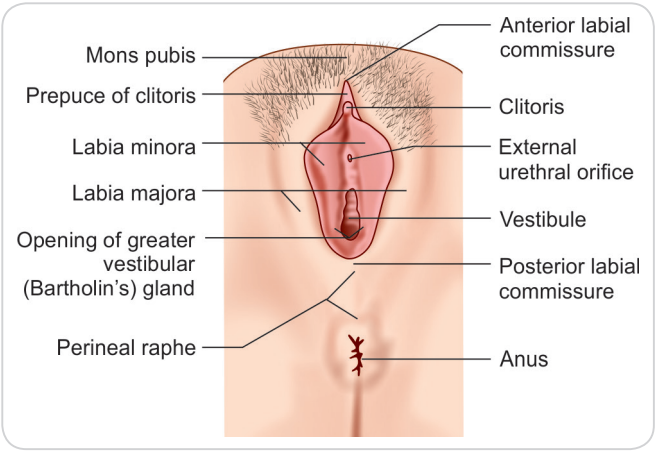


Fig. 17.2: Female external genital organs

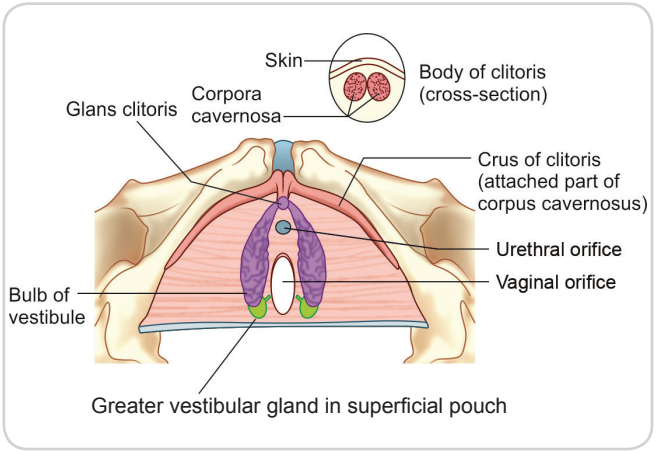


Fig. 17.3: Clitoris and vestibul

Vestibule of the vagina: It is a space between two labia minora. Its features are as follows:

Clitoris is placed most anteriorly.

The *urethral orifice* lies about 2.5 cm behind the clitoris and just in front of the vaginal orifice.

Vaginal orifice or *introitus* lies in the posterior part of the vestibule and is partly closed in the virgin by a thin membrane called the *hymen*.

Orifices of the ducts of greater vestibular glands lie one on each side of vaginal orifice.

Greater vestibular glands of Bartholin: Greater vestibular glands are homologous with the bulbourethral glands of Cowper in the male. These lie in the superficial perineal space. Each gland has a long duct about 2 cm long which opens at the side of the hymen, between the hymen and the labium minora.

These glands secrete mucus, which keeps vulva moist.

INTERNAL GENITAL ORGANS

Ovaries

The ovaries are the female gonads (Fig. 17.4).

Situation: Each ovary lies in the ovarian fossa on the lateral pelvic wall.

Position: The position of the ovary is variable. In nulliparous woman, its long axis is nearly vertical so that the ovary is usually described as having an upper pole and a lower pole. However, in multiparous woman, the long axis becomes horizontal; so that the upper pole points laterally and the lower pole medially (Figs 17.5A and B).

External Features

In young girls, *before the onset of ovulation*, the ovaries have smooth surfaces, which are **greyish pink** in color.

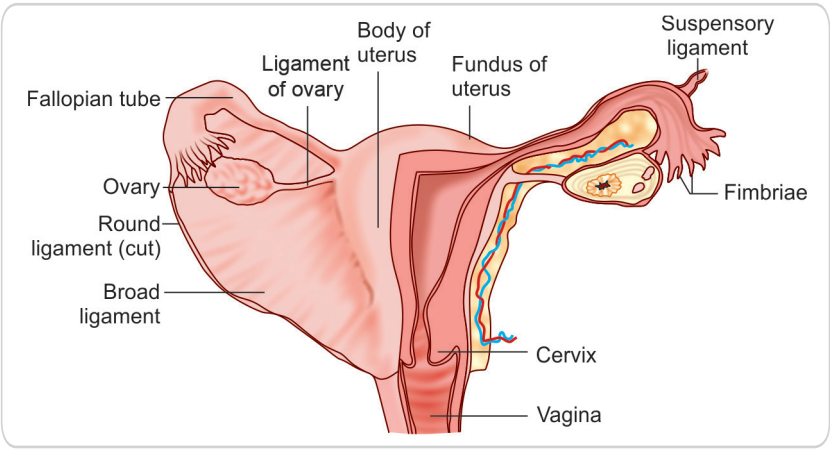
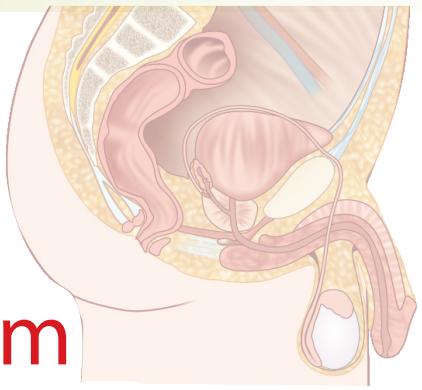


Fig. 17.4: Composite diagram of ovary

18

Male Reproductive System



Chapter Outline

Key Terminology

External genital organs: Scrotum containing testes, epididymis, vas deferens with blood vessels and penis.

Spermatozoa: It is the male gamete (22 + Y/22 + X chromosomes). It consists of a head with acrosome and nucleus, middle piece with mitochondria; tail piece with flagellum and an end piece.

Spermatic cord: This cord starts at the upper end of testis, courses through superficial inguinal ring, inguinal canal and deep inguinal ring, where its contents separate out. Its contents are vas deferens, its artery, testicular artery, venous plexus, autonomic nerves and its coverings.

Cells present in the testis: Spermatogenic series of cells, Leydig's cells which secrete testosterone and cells of Sertoli.

Descent of testis: Testis descends outside the abdominal cavity as spermatogenesis requires 2°–3°C lower temperature than the abdominal cavity.

Semen: Semen is a viscous white fluid containing sperms and seminal fluid. One milliliter of semen contains 100–300 million sperms. Seminal fluid is combined secretion of seminiferous tubules, seminal vesicles, prostate and bulbourethral glands.

The ability to reproduce is one of the properties distinguishing living from non-living matter. The more primitive is the animal, the simpler is the process of reproduction. In mammals, including humans, the process is one of sexual reproduction, in which the male and female organs differ anatomically and physiologically, and the new individual develops from the fusion of two different sex cells (gametes). The male gametes are called spermatozoa and the female gametes are called ova. It has been already explained in Chapter 2.

MALE REPRODUCTIVE SYSTEM

Parts of Reproductive Organs (Fig. 18.1)

The male reproductive system is responsible for sexual function, as well as urination. The male reproductive system is mostly located outside of the body. These external organs include the penis, scrotum and testicles. Internal organs include:

- Two gonads—Testes

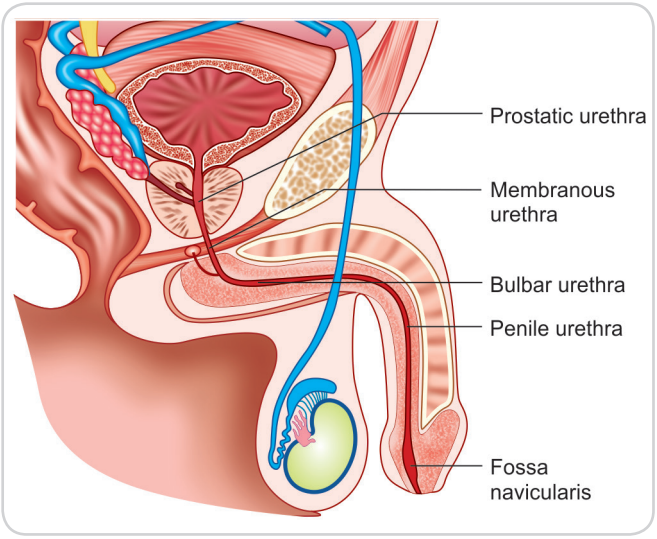


Fig. 18.1: Male reproducti e organs

- Duct system—Epididymis, Head, body, tail (one on each side), Ductus deferens, Ejaculatory duct, and associated glands
- Prostate (single), pair of seminal vesicles, common passage for urine and ejaculate—Urethra

External Genital Organs

Penis

The penis is the male organ of copulation. It is made up of: A root or attached portion, and a body or free portion (Fig. 18.2).

Root of Penis

The root of the penis is composed of three masses of erectile tissue, namely the two crura and one bulb. Each crura is covered by the *ischiocavernosus muscles*. The *bulb* is covered by the *bulbospongiosus muscles*.

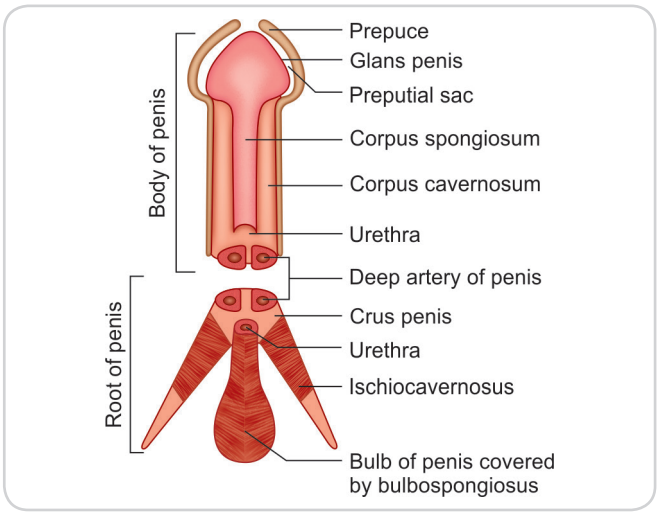


Fig. 18.2: Constitue t parts of the penis: ventral view

Body of Penis

The penis has a ventral surface that faces backwards and downwards, and a dorsal surface that faces forwards and upwards. The free portion of the penis is completely enveloped by skin. It is composed of three elongated masses of erectile tissue. These masses are the right and left corpora cavernosa, and a median corpus spongiosum.

The two *corpora cavernosa* are the forward continuations of the crura. They are in close apposition with each other throughout their length. The corpora cavernosa do not reach the end of the penis. Each of them terminates under cover of the glans penis in a blunt conical extremity. They are surrounded by a strong fibrous envelope called the *tunica albuginea*.

The *corpus spongiosum* is the forward continuation of the bulb of the penis. Its terminal part is expanded to form a conical enlargement, called the glans penis. Throughout its whole length, it is traversed by the urethra.

The base of the *glans penis* has a projecting margin, the *corona glandis*, which overhangs an obliquely grooved constriction, known as the *neck of the penis*. Within the glans, the urethra shows a dilatation (in its roof) called the *navicular fossa*.

The *skin* covering the penis is very thin and dark in color. It is loosely connected with the fascial sheath of the organ. At the neck, it is folded to form the *prepuce* or *foreskin*, which covers the glans to a varying extent and can be retracted backwards to expose the glans. On the undersurface of the glans there is a median fold of skin called the *frenulum*.

Figure 18.3 shows the structures seen in transverse section through the body of the penis.

Arteries of the Penis

The internal pudendal artery gives off three branches which supply the penis.

- The *deep artery of the penis* runs in the corpus cavernosum.
- The *dorsal artery of the penis* runs on the dorsum, deep to the deep fascia, and supplies the glans penis and the distal part of the corpus spongiosum, the prepuce and the frenulum.
- The artery of the bulb of the penis supplies the bulb and the proximal half of the corpus spongiosum.

Scrotum

The scrotum is a cutaneous bag containing the right and left testes, the epididymis and the lower parts of the spermatic cords.

Externally, the scrotum is divided into right and left parts by a ridge or raphe.

Under the influence of cold, and in young and robust persons, the scrotum is short, corrugated and closely applied

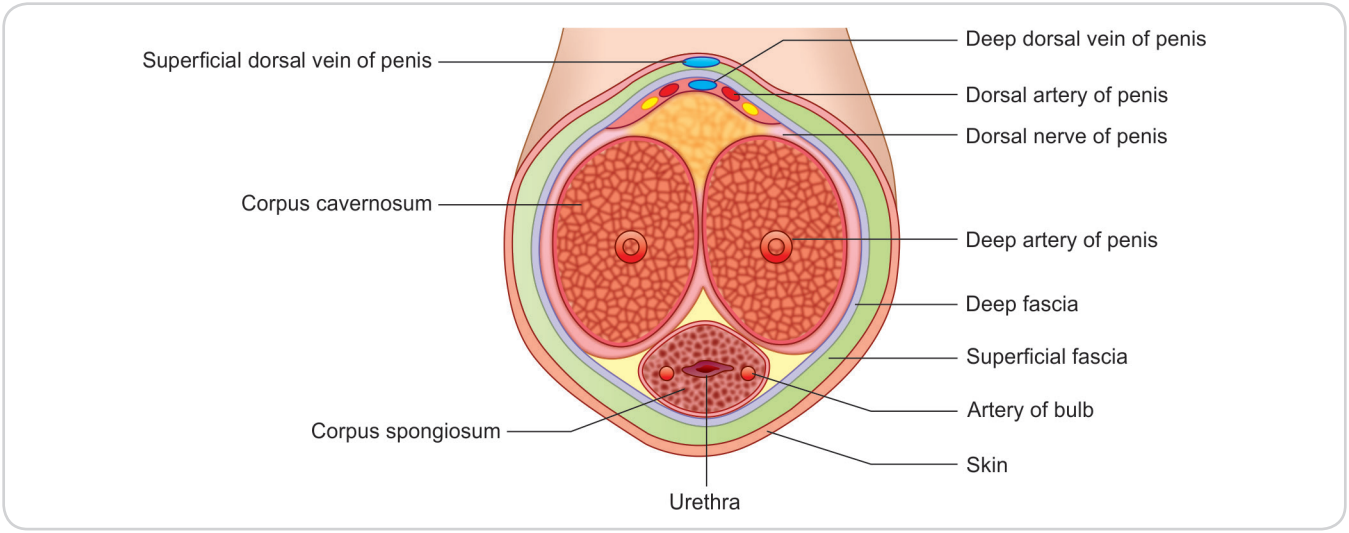


Fig. 18.3: Transverse section th ough the body of the penis

to the testis. This is due to contraction of the subcutaneous muscle of the scrotum, called the *dartos*, which helps in regulation of the temperature within the scrotum.

Layers of Scrotum

The scrotum is made up of the following layers from without inwards (Fig. 18.4).

- Skin
- Dartos muscle
- The external spermatic fascia
- The cremasteric muscle and fascia
- The internal spermatic fascia

Blood Supply

The scrotum is supplied by the arteries—superficial external pudendal, deep external pudendal and scrotal branches of internal pudendal.

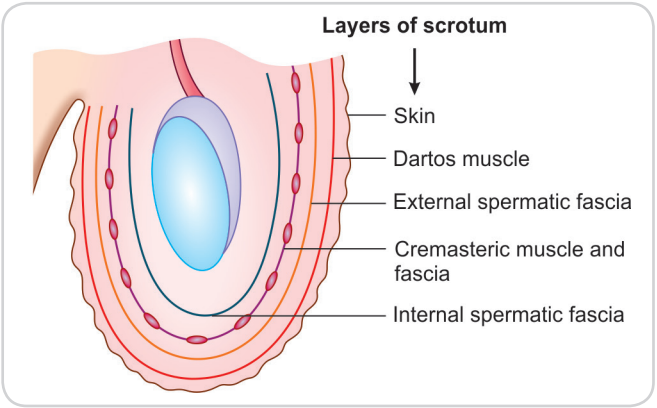


Fig. 18.4: Layers of scrotum

Testis

The testis is the male gonad. It is homologous with the ovary of the female. It is suspended in the scrotum by the spermatic cord.

The testis is oval in shape, and is compressed from side to side. It is 3.75 cm long, 2.5 cm broad from before backwards, and 1.8 cm thick from side to side. An adult testis weighs about 10–15 g.

HIGH YIELD POINTS

The male testes and female ovaries are homologous structures that develop from the undifferentiated gonads of the embryo. Similarly the male penis and female clitoris are homologous structures.

External Features

The testis has:

- Two poles or ends—upper and lower
- Two borders, anterior and posterior
- Two surfaces—medial and lateral

Anatomy of the Testis

The glandular part of the testis consists of 200–300 lobules. Each lobule contains two to three seminiferous tubules. Each tubule is highly coiled on itself. The tubules are lined by cells which represent stages in the formation of spermatozoa (Fig. 18.5).

The *seminiferous tubules* join together at the apices of the lobules to form 20 to 30 *straight tubules which* enter the mediastinum (Fig. 18.6). Here they anastomose with each other to form a network of tubules, called the *rete testis*.

In its turn, the rete testis gives rise to 12–30 *efferent ductules* which emerge near the upper pole of the testis and

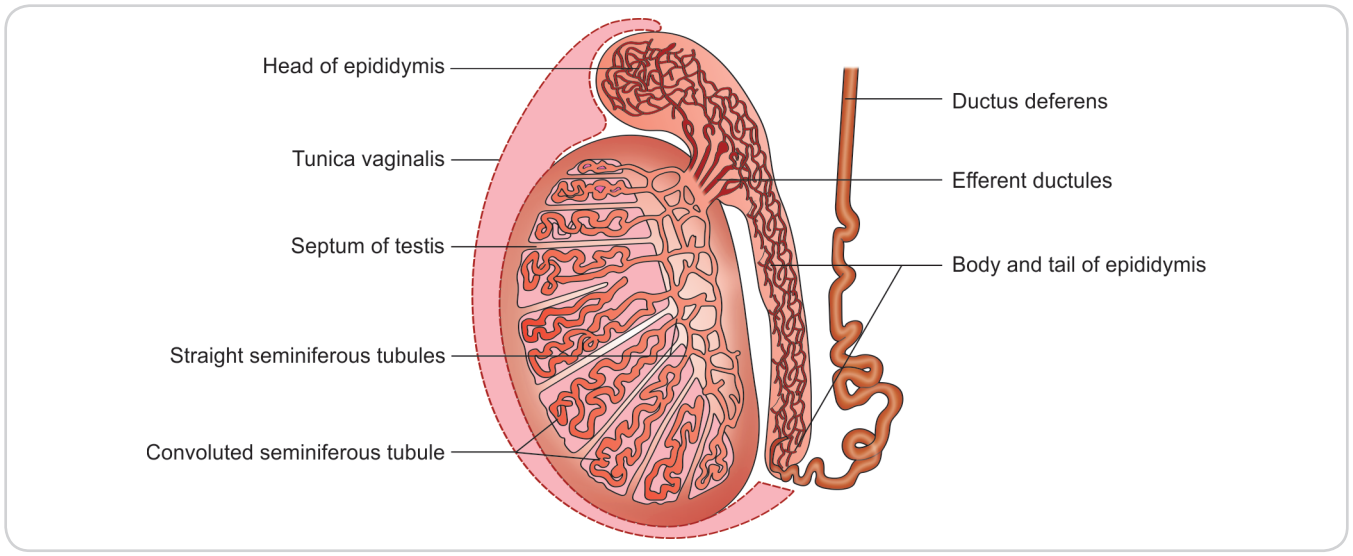


Fig. 18.5: Anatomy of testi

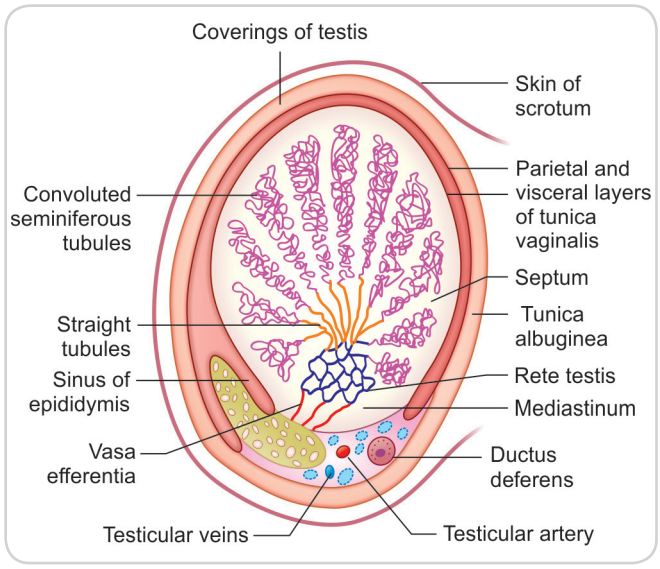


Fig. 18.6: Transverse section through the right testis and surrounding structures

enter the epididymis. The tubules end in a single duct which is coiled on itself to form the head, body, and tail of the epididymis. It is continuous with the ductus deferens.

Arterial Supply

The *testicular artery* is a branch of the abdominal aorta given off at the level of vertebra L2.

Know it

Interstitial cells in the testis synthesize the hormone testosterone.

Venous Drainage

The veins emerging from the testis form the *pampiniform plexus* (pampiniform = like a vine). The plexus condenses into four veins at the superficial inguinal ring, and into two veins at the deep inguinal ring. These veins accompany the testicular artery. Ultimately, one vein is formed which drains into the *inferior vena cava* on the *right side*, and into the *left renal vein* on the *left side*.

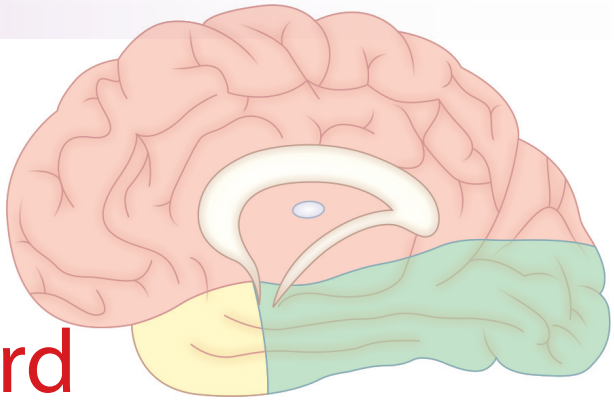
Histology of testis (Fig. 18.7). Leydig's cells and cells of Sertoli are described with male hormones.

Functions of Testis

- **Spermatogenesis:** This takes place at the seminiferous tubules. Degeneration, hypoactivity or malformation of these tubules disturbs the production of spermatozoa.
- **Secretion of testosterone:** The interstitial cells, which represent the endocrine tissue of the testis, synthesize the hormone. Testis secrete testosterone which is required for the growth of secondary sex characters.

19

Brain and Spinal Cord



Chapter Outline

Key Terminology

Central nervous system: Comprises brain and spinal cord.

Peripheral nervous system: Comprises 31 pairs of spinal nerves and 12 pairs of cranial nerves.

Types of neurons: Unipolar, pseudounipolar, bipolar and multipolar

Autonomic nervous system: Regulates involuntary activities of the body. Divided into sympathetic and parasympathetic components.

Names of important neurotransmitters: Acetylcholine, dopamine norepinephrine, serotonin, GABA.

Synapse: Area of connection of process of one neuron with process or body of other neuron. There is contiguity and not continuity.

Neuroglial cells: Astrocytes, oligodendrocytes and microglia.

Parts of brain: Medulla oblongata, pons, midbrain, cerebellum, diencephalon and cerebral hemispheres.

Meninges of brain: Dura mater (endosteal and meningeal layers) arachnoid mater and pia mater (from outside to inside).

Folds of meningeal layer of duramater: Falx cerebri, falx cerebelli, tentorium cerebelli and diaphragma sellae.

Ventricles of brain: Right and left lateral ventricles, one third ventricle, aqueduct of midbrain and one fourth ventricle.

Arachnoid granulations: CSF is resorbed into the superior sagittal venous sinus via arachnoid granulations.

Blood brain barrier: Formed by capillary endothelium, basement membrane of these cells, processes of astrocytes.

Circle of Willis: Formed by branches of internal carotid artery and branches of basilar artery.

Branches of cerebral arteries: Are cortical, central and choroidal.

Motor areas: Precentral gyrus and paracentral lobule.

Sensory areas: Postcentral gyrus and paracentral lobule.

Auditory area: Posterior part of superior temporal gyrus.

Cerebellum: Structure is homotypical, controls same side of body.

Monro-Kellie doctrine: This hypothesis states that the sum of volumes of brain, CSF, and intracranial blood is constant. Further it adds that an increase in one should cause a decrease in one or both of the remaining two.

Connections of cerebellum: To medulla via inferior cerebellar peduncles
To pons via middle cerebellar peduncles
To midbrain via superior cerebellar peduncles

Thalamus: Gateway to cerebral cortex. All sensory inputs pass through it to the higher level of brain. Receives sensory, motor and visceral impulses.

Amygdaloid body: Functions: Anxiety, depression and aggressiveness.

Spinal nerves: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal

Ascending tracts to cerebrum: 1st neuron—dorsal root ganglion
2nd neuron—spinal cord/medulla
3rd neuron—thalamus.

Reflex: Fast involuntary action for muscular contraction/glandular secretion.

Pain: Somatic, visceral, referred pain.

Part of limbic system: Hippocampus—(long-term memory) parahippocampal gyrus—spatial memory. Amygdala–Anxiety, aggression, emotional memory. Mammillary body–memory. Limbic system influences learning, memory and behavior.

Papez circuit: Its parts are hippocampus, fornix, mammillary body, anterior nucleus of thalamus cingulate gyrus, parahippocampal gyrus. All these are important for long term permanent memory.

OVERVIEW OF THE NERVOUS SYSTEM

Nervous system is the chief controlling and coordinating system of the body. It is responsible for judgment, intelligence and memory. Nervous system is highly evolved at the cost of regeneration. It is the most complex system of the body.

It adjusts the body to the surroundings and regulates all bodily activities both voluntary and involuntary. The sensory part of the nervous system collects information from the surroundings and helps in gaining knowledge and experience, whereas the motor part is responsible for responses of the body.

With more than 100 trillion connections, the human brain is the core organ of the nervous system. Messages are conveyed to the brain via the spinal cord, which runs in middle of the back and contains threadlike nerves that branch out to every organ and body part (Fig. 19.1).

Central nervous system (CNS) comprises brain and spinal cord. It is responsible for integrating, coordinating the sensory information and ordering appropriate motor actions. CNS is the seat of learning, memory, intelligence and emotions. It is made of delicate tissue but is well protected by the skull and vertebrae. The blood-brain barrier also prevents many toxins from entering the brain. The CNS acts as the control center. It sends and receives information to and from muscles, glands, organs and other systems in the body through the peripheral nervous system.

Peripheral nervous system (PNS) acts as a relay center and transmits information between the CNS and the rest of the body. PNS is not protected by the vertebral column and skull, or by the blood-brain barrier, therefore it remains exposed to toxins and mechanical injuries. *Peripheral nervous system (PNS)* includes 12 pairs of cranial nerves and 31 pairs of spinal nerves. These pairs provide afferent impulses to CNS and carry efferent impulses to muscles, glands and blood vessels.

The PNS includes a sensory division and a motor division.

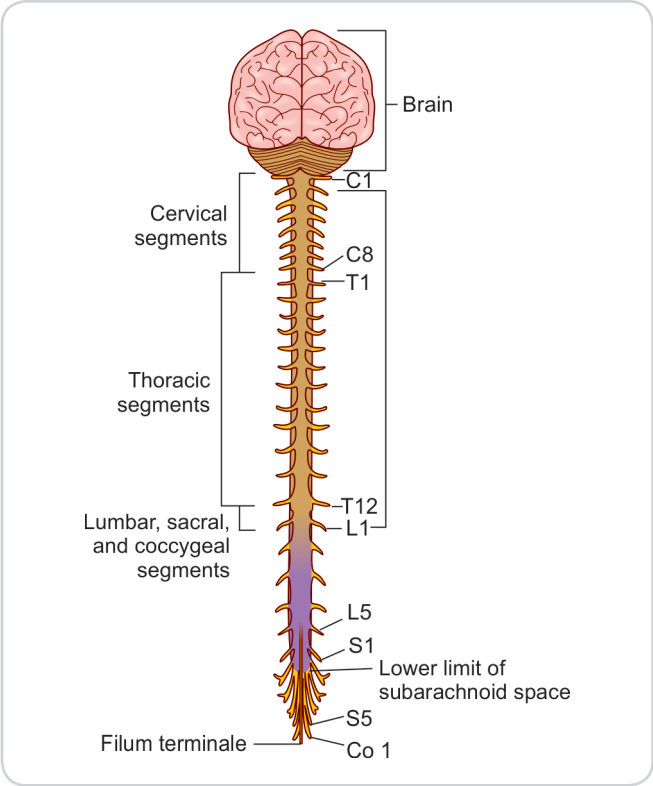


Fig. 19.1: Nervous system-diagrammatic epresentatio

The sensory and motor divisions each include a part of the somatic system and the autonomic system.

Somatic Nervous System

In Greek, "Sōma means body", therefore, somatic means related to the body. The somatic system relays information about most of the body's conscious activity to and from the CNS. The somatic sensory receptors receive information from the senses and send it to the CNS while the somatic motor division sends information from the CNS to control the actions of the skeletal muscles.

Autonomic Nervous System

The autonomic nervous system primarily regulates involuntary or unconscious activities of body such as heart rate, breathing and pupil dilation. It also helps in regulating glands and internal organs, blood pressure, digestion, and many chemical processes that keep our body functioning.

The autonomic sensory receptors collect information from these systems and send it to the CNS, on the other hand the autonomic motor division sends information from the CNS to these systems.

The autonomic motor division is divided into two complimentary subsystems: the sympathetic and the parasympathetic system. These systems constantly work to shift the body to more prepared and more relaxed states. The constant shifting of control between these two systems keeps the body ready for any situation. The comparison between sympathetic, parasympathetic and enteric nervous systems has been presented in Table 19.1.

Know it

Receptors and Effectors

There are two basic types of neurons: receptors and effectors.

Receptors are part of the sensory division and they receive information about changes in the environment.

Effectors are part of the motor division because they produce changes in the body that can affect the outside world.

TABLE 19.1: Comparison of sympathetic, parasympathetic and enteric nervous systems

	Sympathetic nervous system (SNS)	Parasympathetic nervous system	Enteric nervous system
How it works	Prepares the body to react and spend energy during stress.	Helps in conserving energy and maintaining functions under ordinary conditions	Known as the "second brain" or the brain in the gut **because it can operate independently of the brain and spinal cord, the central nervous system**
Reaction	Reacts with the "fight-or-flight" or fright phenomenon	Helps the body by "rest-and-digest"	Includes a number of neural circuits—a mesh-like system of neurons that governs the function of the gastrointestinal tract
Actions	Quickens the heart rate and fastens the breathing to increase oxygen, further dilates pupils for better vision, reduces digestion so as to conserve energy	Acts slowly as compared to SNS and may take longer time to get the body back to a normal relaxed state after some stressful situations	Controls motor functions, local blood flow, mucosal transport and secretions, and modulates immune and endocrine functions

CELLULAR COMPONENTS OF THE NERVOUS SYSTEM

Neurons

Neurons are the cells that form a framework for communication throughout the nervous system (Fig. 19.2).

Neurons are the main functional units of the nervous system. They can generate electrical signals to quickly transmit information over long distances and pass them onto many other neurons. Glial cells support this network by cleaning, regulating, protecting, healing and insulating the neurons and their connections. They can be in several shapes and sizes depending on their specialized functions but all neurons have axons and dendrites that protrude from the cell body. Each neuron is made up of the dendrites and axons.

Dendrites

Dendrites (Greek word that means "branch of a tree") are many, short or long, richly branched and specialized extensions that resemble the branch of a tree, often varicose. Most neurons have many short dendrites. These receive signals, send them inward toward the cell body as electrical impulses. Dendrites help to increase the surface area required for connections with the adjacent neurons and receive incoming signals from them.

Functions

- Acquiring chemical impulses from neurons and other cells
- Converting the chemical signals into electrical impulses
- Further carrying electrical impulses toward the next part of the neuron, the cell body.

Cell Body or Soma

It is the central part of the neuron, which is similar to a cell and contains the nucleus along with other cell organelles. The cell body is the largest part of a neuron and is enclosed by a cell membrane, which protects the cell from the immediate surroundings and allows interaction with the outside environment. They attach to all the dendrites and, therefore integrate all the signals. All metabolic activities of the cell happen in the cell body. It also contains DNA, the genetic material of the neuron.

Functions

- Supports and organizes the functions of the whole neuron
- Joins the signals received by the dendrites and pass them to the axons, the next part of the neuron.

Axons

Most neurons have a single axon that generally sends electrical impulses outward that is away from the cell body. The axon is a single elongated fiber-like extension of the nerve cell membrane. Axons run from the cell body of one neuron until the terminal of the next neuron. The larger the diameter of the axon, the faster is the rate of transmission of nerve signals.

The branches of axons often arise at right angles and are called the collaterals. Axons are the longest part of the neuron that varies widely in length from extremely short to more than 3 feet, for example, to reach from the base of the spine to ankle. Collectively the axons form tracts (white matter) in the CNS, and nerves in the peripheral nervous system. A single axon may be highly branched to allow better communication with multiple target neurons at the same time.

Parts of an Axon

- **Axon hillock:** The part of the axon that remains attached to the cell body or soma.
- **Myelin sheath:** The layer of fatty acid produced from specialized cells called Schwann cells that are wrapped around the axon.

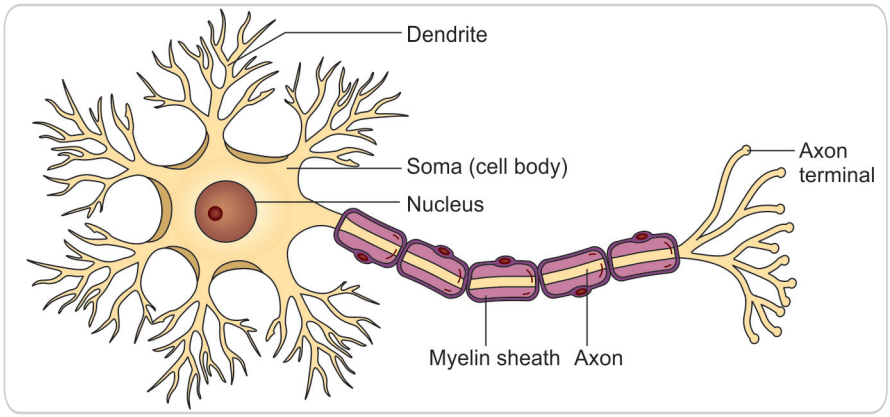
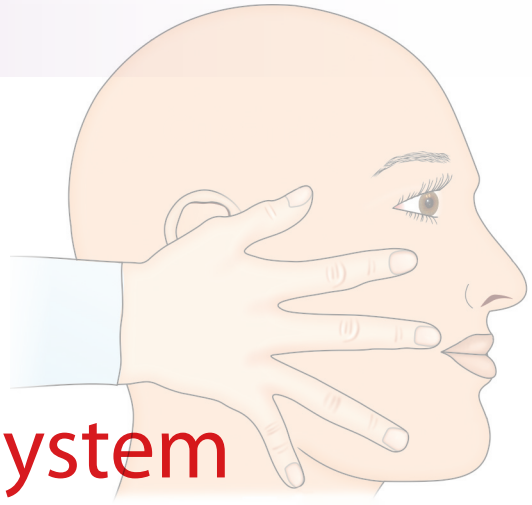


Fig. 19.2: Structure of neuron

20

Nerves and Autonomic Nervous System



Chapter Outline

Key Terminology

Anosmia: Loss of sense of small with aging.

CSF rhinorrhea: Leakage of CSF through nose in injury to the anterior cranial fossa of skull.

Stoma: Certain points of retina may become blind spots due to lesion in retina.

Human vision: If is binocular, colored and three dimensional, i.e., height, width and thickness of a person is seen, left homonymous hemianopia; occurs due to lesion of right optic tract.

Opening of eyes: Done by levator palpebrae superioris muscle innervated by both oculomotor nerve and sympathetic fibers.

Edinger-Westphal nucleus: Part of III nerve complex contains parasympathetic motor fibers for the ciliary muscles and constrictor pupillae muscles. Both are used in reading.

Mandibular branch of trigeminal nerve innervates all 4 muscles of mastication, used in chewing the food.

Facial nerve: Innervated all six groups of muscles of facial expression. In its upper motor neuron paralysis of right side, there is paralysis of lower left quarter of facial muscles. In its lower motor neuron paralysis at right stylomastoid foramen, there is paralysis of right upper and right lower quadrants of facial muscles.

Jugular foramen: Gives exit to IX, X and XI cranial nerves.

XII nerve: Supplies most of the muscles of tongue – In paralysis of right XII nerve, the tip of the tongue gets protruded to right side, i.e., paralyzed side.

Spinal cervical nerves: These are 8 in number. C1–C4 form cervical plexus and C5–C8 on including T1 form the brachial plexus.

Erb's point: Meeting point of ventral rami of C5, C6, to form upper trunk. Which divides into anterior and posterior divisions and few branches. Klumpke's paralysis, paralysis of lower trunk of branchial plexus leads to complete claw hand.

Wrist drop: Due to injury to radial nerve in the radial groove, or on the lateral epicondyle of humerus.

Carpal tunnel syndrome: Occurs due to pressure on median nerve as passes deep to flexor retinaculum to enter the palm.

Ulnar claw hand: Paralysis of ulnar nerve causes claw hand with paralysis of muscles of hypothenar eminence. The metacarpal bones become prominent due to paralysis of interossei muscles. Flattening of shoulder occurs due to paralysis of the important deltoid muscle.

Typical intercostal nerve: These are only T3 – T6 nerves, as they course through only the thoracic wall. Others either give branch to upper limb or the abdominal wall.

Femoral nerve: Arises from dorsal divisions of ventral primary rami of L2, L3, part of L 4 segments of spinal cord. Obturator nerve arises from ventral divisions of ventral primary rami of L2, L3 and part of L4 segments of spinal cord.

Sciatica: Herniated lumbar disc may press any of the root of the sciatic nerve. There is pain along the course of the nerve.

Foot drop: Injury to sciatic nerve, common peroneal nerve, deep peroneal nerve results in "foot drop". The foot remains in plantar flexed position. Injury to common peroneal nerve or the neck of fibula is the commonest reason for 'foot drop'.

NERVES

A nerve is bundle of axons or fibers enclosed in the peripheral nervous system. A nerve transmits electrical impulses in the form of electrical signals. It is an important unit of the peripheral nervous system. Mainly there are three types of nerves:

1. **Motor nerves:** These control movements and actions of a body by passing information from brain and spinal cord to the muscles.
2. **Autonomic nerves:** These control the involuntary or partially voluntary activities of a body, such as blood pressure, heart rate, digestion, and temperature regulation.
3. **Sensory nerves:** These nerves relay information from skin and muscles back to the spinal cord and brain. The information is further processed and pain and other sensations are felt.

The sciatic nerve is the largest and longest spinal nerve in the human body. It extends from the lumbar and sacral plexuses in the lower back. This nerve runs through the buttocks and into the thighs. It relays nerve signals to and from the muscles and skin of the thighs, lower legs and feet.

Trochlear nerve is the smallest nerve in terms of the number of axons it contains.

CRANIAL NERVES

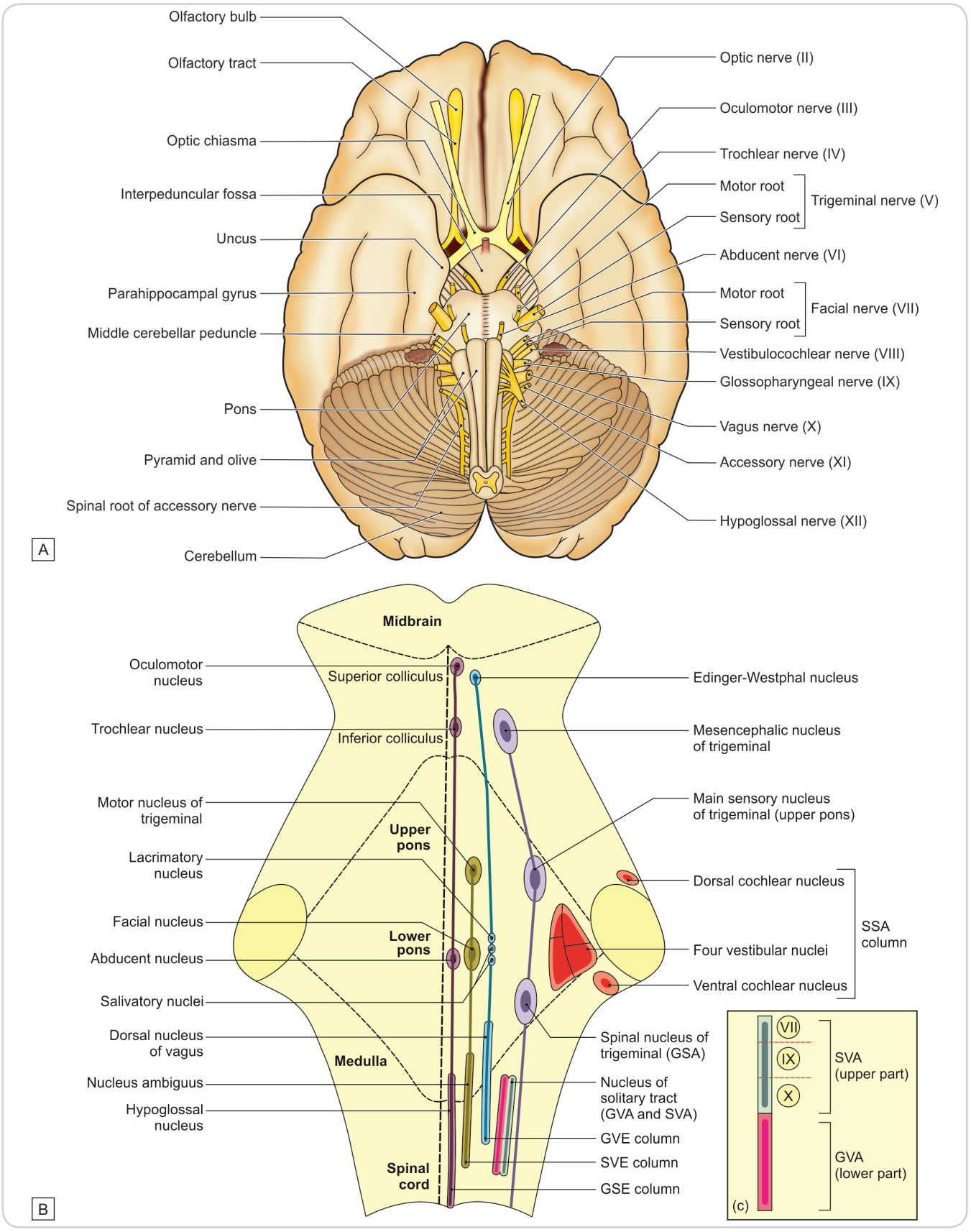
The 12 pairs of cranial nerves arise from the brain inside the cranial cavity and pass through various foramina in the bones of the cranium. According to function these are divided into three types: Sensory nerves, Motor nerves and Mixed nerves.

Attachment on the ventral surface of brain is shown in Figure 20.1A and B.

HIGH YIELD POINT

Dermatome

A dermatome is an area of skin that is mainly supplied by a single spinal nerve of both sides through their dorsal and ventral rami. There are 8 cervical nerves (Note: C1 has no dermatome), 12 thoracic nerves, 5 lumbar nerves and 5 sacral nerves. Each of these spinal nerves relay sensation from a particular region of the skin to the brain.



Figs 20.1A and B: **A.** A achment of cranial nerves to the base of brain; **B.** Scheme to show cranial nerve nuclei as projected on the posterior surface of brainstem. Parts of nucleus of tractions soli arius: VII- facial; IX glossopharyngeal and X-vagus.

12 pairs of cranial nerves are discussed as follows:

Olfactory Nerve (I)

Olfactory nerves end in the brain in paired masses of grey matter called the olfactory bulbs. Two extensions of the brain rest on the cribriform plate. Within the olfactory bulbs, the axon terminals of olfactory receptor form synapses with the dendrite and cell bodies of the next neurons in the olfactory pathway. The axons of these neurons make up the olfactory tract, which extends posteriorly from the olfactory bulbs. Axons in the olfactory tract end in the primary olfactory area in the temporal lobe of the temporal cerebral cortex (Fig. 20.2).

- Sensory nerve.
- Contains axons that conduct impulses for olfaction, the sense of smell.
- The olfactory epithelium occupies the superior part of the nasal cavity, covering the inferior surface of the cribriform plate and extending down along the superior nasal concha.

The olfactory receptors within the olfactory epithelium are bipolar neuron. Each has a single odor-sensitive dendrite projecting from one side of the cell body and an unmyelinated axon extending from the other side. Bundle of axons of olfactory receptors extends through about 20 olfactory foramina in the cribriform plate of the ethmoid bone.

Optic Nerve (II)

It is a sensory nerve and contains axons that conduct nerve impulses for vision. In the retina, rods and cones initiate visual signals and relay them to bipolar cells, which transmit the signals to ganglion cells. Axons of all ganglion cells in the retina of each eye join to form an optic nerve, which passes through the optic foramen.

It lies posterior to the eyeball, and the two optic nerves merge to form the optic chiasm. Within the chiasm, axons from the medial half of each eye cross to the opposite side, axons from the lateral half remains on the same side.

Posterior to the chiasm, the regrouped axons, some from each eye, form the optic tracts. Most axons in the optic tracts end in the lateral geniculate nucleus of the thalamus. There, they synapse with neuron whose axons extend to the primary visual area in the occipital lobe of the cerebral cortex. A few axons pass through the optic chiasm and then extend to the superior colliculi of the midbrain. They synapse with motor neurons that control the extrinsic (move the eyeball) and intrinsic eye muscles (control light intensity).

Visual Pathway

Retina → optic nerve → optic chiasma → optic tract → lateral geniculate body → optic radiation → visual area in occipital lobe. Details are given in Chapter 11 Sensory organs.

Oculomotor Nerve (III)

It is a motor nerve. Oculomotor nerve extends anteriorly and divides into superior and inferior branches, both of which pass through the superior orbital fissure into the orbit. Axons in the superior branch innervate the superior rectus (extrinsic eyeball muscle) and part of the levator palpebrae superioris (muscles of upper eyelid) (Figs 20.3A and B).

Axons in the inferior branch supply the medial rectus, inferior rectus and inferior oblique muscles (all extrinsic eyeball muscles). These somatic motor neurons control movements of the eyeball and upper eyelid. The inferior branch of the oculomotor nerve also provides parasympathetic innervation to intrinsic eyeball muscles, which are smooth muscles.

They include the ciliary muscles of the eyeball and the circular muscles (sphincter pupillae) of the iris. Parasympathetic impulses propagate from oculomotor nucleus in the midbrain to the ciliary ganglion, a relay center of the autonomic nervous system.

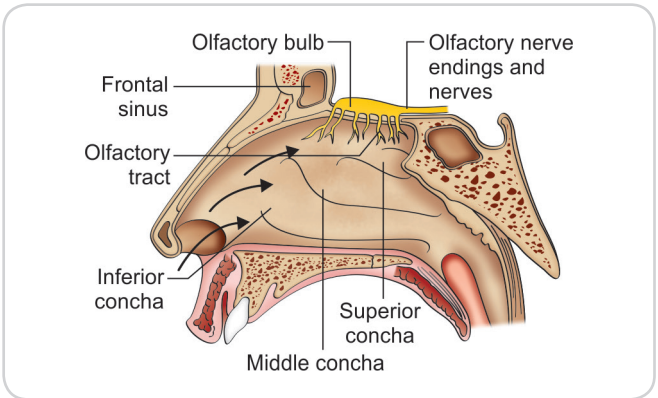
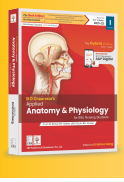


Fig. 20.2: Olfactory nerve

DISSECTION IMAGES *(in App)*

DISSECTOR 1	Ventral Aspect of Forearm and Palm *(Book and App)*
DISSECTOR 2	Section Showing Interior of Left Atrium and Left Ventricle *(Book and App)*
DISSECTOR 3	Muscles of Anterior/Extensor and Medial Compartments of Thigh *(Book and App)*
DISSECTOR 4	Layers Enclosing the Testis *(Book and App)*
DISSECTOR 5	Mucous Membrane of Stomach *(Book and App)*
DISSECTOR 6	Interior of Uterine Cavity and Cervix *(Book and App)*
DISSECTOR 7	Parotid Region *(Book and App)*
DISSECTOR 8	Digastric and Carotid Triangles *(Book and App)*
DISSECTOR 9	Spinal Cord at Various Levels *(Book and App)*
DISSECTOR 10	Arteries at the Base of Brain *(Book and App)*
DISSECTOR 11	Dorsal aspect of mid brain with a pair each of superior and inferior colliculi; middle part is pons; lower part is medulla oblongata with its open and closed parts *(App)*
DISSECTOR 12	Structure of cerebellum with arbor vitae pattern showing important dentate nucleus *(App)*
DISSECTOR 13	Superolateral surface of cerebral hemisphere with various functional areas (area 4, 6–motor and premotor area; 3, 1, 2 sensory area; 44, 45 Broca's speech area; 41, 42 Hearing area; 17 visual area) *(App)*
DISSECTOR 14	Medial surface of cerebral hemisphere with functional areas (area 4 motor area; 3, 1, 2 sensory; 5, 7 sensory association; 17, 18, 19 visual area) *(App)*
DISSECTOR 15	Intercostal muscles—transversus abdominis with lower intercostal nerves. Serratus anterior is also seen *(App)*
DISSECTOR 16	Tibial nerve seen is most superficial in the popliteal fossa. Deep to tibial nerve lies popliteal vessels. Popliteal fossa is bounded by the muscles and tendons seen in the figure *(App)*
DISSECTOR 17	Posterior 1/3rd tongue with lymphoid follicles and epiglottis. Fungiform and circumvallate papillae are also seen *(App)*
DISSECTOR 18	Lateral wall of nose with three conchae *(App)*
DISSECTOR 19	Posterior wall of pharynx incised to show nasal cavity, soft palate with uvula; posterior 1/3rd of tongue; laryngeal cartilages enclosing laryngeal cavity *(App)*
DISSECTOR 20	Laryngeal cartilages, e.g., thyroid, epiglottis anterior, arytenoid with cricoid posterior enclosing the cavity of larynx. *(App)*
DISSECTOR 21	Medial surfaces of right and left lungs *(App)*
DISSECTOR 22	Visceral relations of liver *(App)*
DISSECTOR 23	Sternocostal surface of heart *(App)*
DISSECTOR 24	Pulmonary trunk arising from pulmonary valve with 3 semilunar cusps. Lower part of the dissection shows right AV valve. Papillary muscles are also visible. *(App)*
DISSECTOR 25	Arch of aorta with its 3 branches and right and left vagus nerves. Appreciate the high origin of right recurrent laryngeal nerve and lower origin of left recurrent laryngeal nerve. *(App)*
DISSECTOR 26	Femoral triangle with its contents: Femoral vein with great saphenous vein draining into it, femoral artery with profunda femoris artery and branches of femoral nerve can be seen *(App)*
DISSECTOR 27	Veins in the roof of cubital fossa with some of its contents. *(App)*
DISSECTOR 28	Medial malleolus as a guide to great saphenous vein is used for transfusion of fluids/blood. *(App)*
DISSECTOR 29	Various joints of the forearm and hand, wrist joint, first carpometacarpal and metacarpophalangeal joints *(App)*
DISSECTOR 30	Lateral, central, posterior and apical groups of lymph nodes of axilla and some important branches of brachial plexus, e.g., ulnar from medial cord, musculoutaneous from lateral cord and median nerve by two roots, one each from lateral and medial cords *(App)*



APPENDIX 1

Nutrition—Chemical Source of Energy

We are all made of chemical units that are the end results of metabolism after intake of food. The chemical units include both inorganic and organic compounds. Our human body requires a perfectly balanced intake of all the nutrients to sustain growth, development, maintenance, and repair and to conserve good health. It is certainly valuable to know about the nutrition and nutritional requirements of a body.

NUTRITION

Nutrition is a science that deals with digestion, absorption, and metabolism of food in our body. World Health Organization (WHO) states—"Good health is a state of complete physical, mental and social wellbeing and not just mere absence of disease or infirmity."

Inorganic compounds include elements like copper, potassium, magnesium, manganese, calcium, sodium, iron, iodine, zinc, and phosphorus.

Organic compounds include lipids, carbohydrates, and proteins as basic units.

Gases like hydrogen, oxygen, nitrogen, and carbon dioxide are also part of our body's chemical compounds.

The above mentioned organic and inorganic substances are obtained from nutrition. Therefore, it is necessary to know about the sources of these compounds and their role in diseases as a balance is required to keep fit.

Not only the nutrition but various other factors also affect our body's need for different nutrients including age, gender, activity, body weight, height and physique. Additionally, climatic conditions, physiological and pathological stress also influence the body's need for various nutrients.

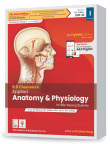
BALANCED DIET

All foods are chemical substances, these chemicals are used in the body to provide energy, and structural material and to prepare regulating agents to support growth, maintenance, and repair of body tissues—these all are parameters of good health. Each food group has a specific nutritional significance (Table 1).

Balanced diet is one which contains different types of food (from all food groups) in appropriate quantity and in correct proportion to fulfil body's requirements. With the help

TABLE 1: Food items in various groups used in balanced diet

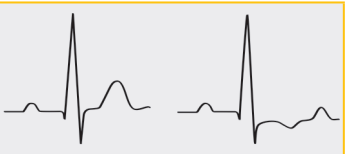
S. No.	Food group	Mix and match food items
1.	Milk products group	1 cup or about 237 mL of milk or yogurt 2 slices of cheese, 1/8" thick(1 1/2 oz.) 2 cups of cottage cheese 1 and 1/2 cups of ice milk, ice cream or frozen yogurt
2.	Meat group	59–89 mL of cooked lean meat, poultry, fish, 2 eggs
3.	Vegetables group	1 cup cooked legumes or dried beans or peas 4 tablespoons peanut butter 1/2 cup nuts or seeds 1/2 cup cooked vegetables 1/2 cup raw chopped vegetables 1 cup raw leafy vegetables 1/2 to 3/4 cup vegetable juice
4.	Fruits	1 whole medium fruit (about 1 cup) 1/4 cup dried fruit 1/2 cup canned fruit 1/2 to 3/4 cup fruit juice
5.	Bread and Cereals	1 slice bread 1 medium muffin 1/2 hot dog bun or hamburger bun 4 small crackers 1 tortilla 1 cup cold cereal 1/2 cup cooked cereal 1/2 cup rice 1/2 cup pasta



APPENDIX 2

Normal Values

ECG Changes

• **(K) Hypokalemia:** ▪ ST depression ▪ Flat/inverted T wave ▪ U wave	 Normal sinus rhythm Hypokalemia
• **(K) Hyperkalemia:** ▪ Flat P wave ▪ Prolonged PR interval ▪ QRS widening ▪ Tall, peaked T wave	 Hyperkalemia
• **(Ca) Hypocalcemia:** ▪ Prolonged ST segment ▪ Prolonged QT interval	 Hypocalcemia
• **(Ca) Hypercalcemia:** ▪ Shortened ST segment ▪ Widened T wave	 Hypercalcemia
• **(Mg) Hypomagnesemia:** ▪ Tall T wave ▪ ST depression	 Hypomagnesemia
• **(Mg) Hypermagnesemia:** ▪ Prolonged PR interval ▪ QRS widening	 Hypermagnesemia

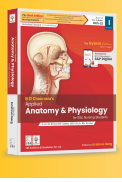
Arterial Blood Gases

	pH	$PaCO_2$	HCO_3
Respiratory alkalosis	↑	↓	Normal
Respiratory acidosis	↓	↑	Normal
Metabolic alkalosis	↑	Normal	↑
Metabolic acidosis	↓	Normal	↓

Normal Range (Panel of Kidney Function Tests)

Albumin 3.4–5.4 g/dL	**BUN** 7–20 mg/dL	**Calcium** 8.6–10.2 mg/dL
CO_2 23–29 mEq/L	**Chloride** 97–107 mg/dL	**Creatinine** 0.5–1.2 mg/dL
eGFR >60	**Glucose** 72–90 mg/dL	**Phosphorus** 2.5–4.5 mg/dL
Potassium 3.5–5.0 mEq/L	**Sodium** 135–145 mEq/L	

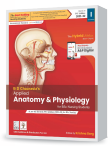
Abbreviations: BUN—Blood urea nitrogen; eGFR—estimated glomerular filtration rate



APPENDIX 3

Tips to Memorize

1. Attachments of bicipital groove—"**Lady between 2 majors**"
   Lady – **L**atissimus **d**orsi
   2 majors – **P**ectoralis major (Laterally) and **T**eres **m**ajor
2. Contents of cubital fossa—"**MBBR** (from medial to lateral side)"
   M – **M**edian nerve
   B – **B**rachial artery and its 2 terminal branches
   B – **B**iceps brachii
   R – **R**adial nerve and its 2 branches
3. Carpal bone—"**S**he **l**ooks **t**oo **p**retty **T**ry **t**o **c**atch **h**er"
   She – **S**caphoid
   Looks – **L**unate
   Too – **T**riquetral
   Pretty – **P**isiform
   Try – **T**rapezium
   To – **T**rapezoid
   Catch – **C**apitate
   Her – **H**amate
4. Thorax – Structures in the costal groove – "**VAN**"
   V – Posterior intercostal **v**ein
   A – Posterior intercostal **a**rtery
   N – Intercostal **n**erve
5. Main openings in the diaphragm—"John **ate 10 dozens**"
   Ate – **Th8**—Inferior vena cava, right phrenic nerve
   Ten – **Th10**—Esophagus with left gastric vessels
   Dozens – **Th12**—Thoracic aorta, vena azygos
6. Lower limb
   - Order of structures under inguinal ligament from medial to lateral side (**Fe CVAN**): Femoral **c**anal, femoral **v**ein, femoral **a**rtery and femoral **n**erve
   - Structures in femoral sheath from medial to lateral side (**Fe CVA**): Femoral **c**anal, femoral **v**ein, femoral **a**rtery
   - Structures in different parts of popliteal fossa:
     - Upper part from medial to lateral (**Pop AVN**): Popliteal **a**rtery, popliteal **v**ein and tibial **n**erve
     - Lower part from medial to lateral (**Tibetan nurse picks victory card and pops ahead**): **T**ibial **n**erve, **p**opliteal **v**ein, **p**opliteal **a**rtery
   - Structures under extensor retinaculum of ankle joint: "**The Himalayas Are Not Dry Places**"
     The – **T**ibialis anterior
     Himalayas – Extensor **h**allucis longus
     Are – **A**nterior tibial artery
     Not – Deep peroneal **n**erve
     Dry – Extensor **d**igitorum longus
     Places – **P**eroneus tertius
   - Structures under Flexor retinaculum of ankle joint - "**Tulsi dass Ameer Nahi Hai**"
     Tulsi – **T**ibialis posterior
     Dass – Flexor **d**igitorum longus
     Ameer – Posterior tibial **a**rtery
     Nahi – Tibial **n**erve
     Hai – Flexor **h**allucis longus
7. Abdomen
   - Structures in the porta hepatis of liver – "**DAV**"
     D – Hepatic **d**ucts (right and left)
     A – Hepatic **a**rteries (right and left)
     V – Portal **v**ein – (right and left)
   - Branches of abdominal aorta
     Ventral – Celic trunk, Superior mesenteric and inferior mesenteric
     Lateral – Inferior phrenic, middle suprarenal, renal and gonadal
     Posterior – 4 pairs of lumbar arteries and median sacral artery
     Terminal – Right and left common iliac arteries

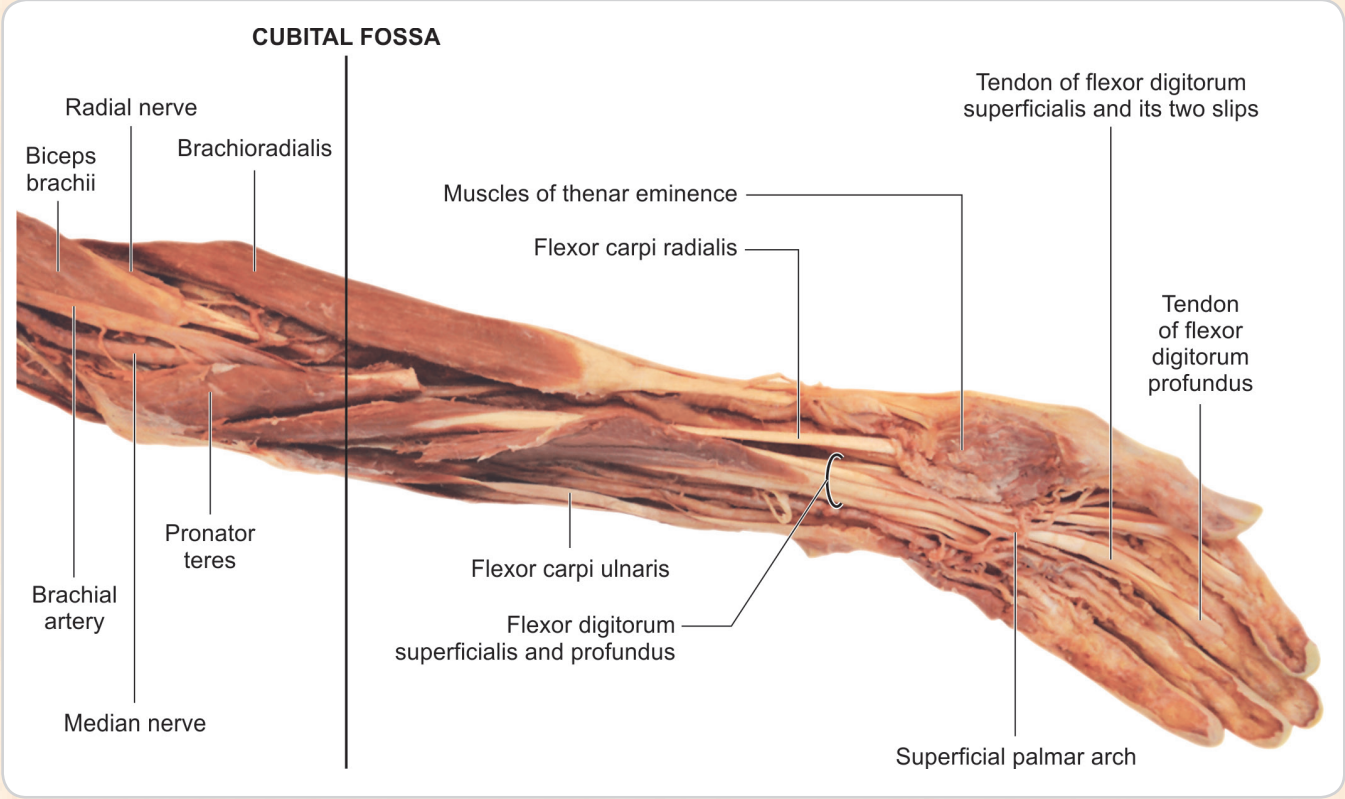


APPENDIX 4

Dissection Images

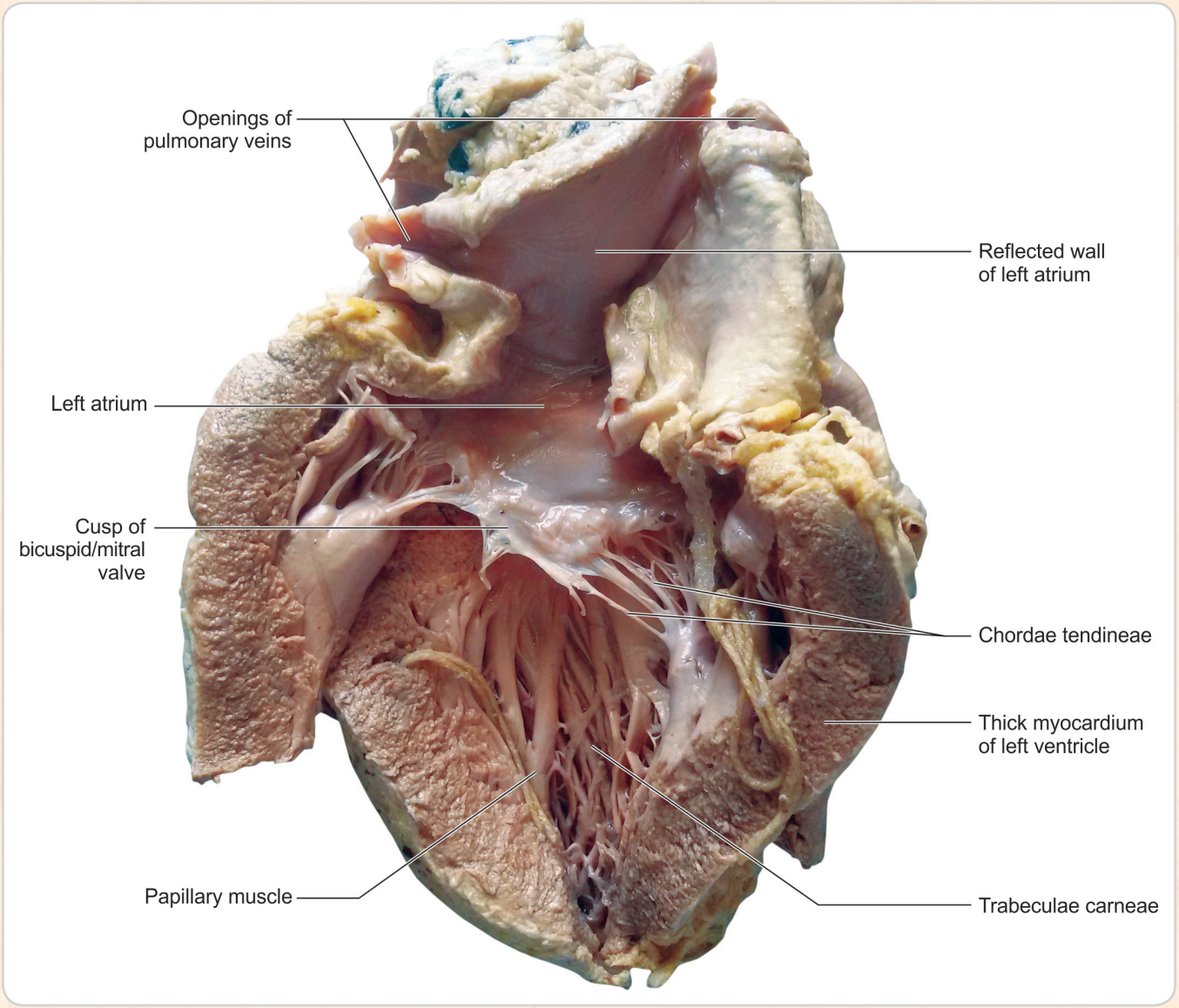
Anatomy is learnt with the help of various human bones and by dissecting (cutting open) the dead human body (cadaver). The cadaver is embalmed by formalin and few other chemicals to prevent breakdown of proteins. This preserves the body or body parts. Dissection is a slow and steady process mostly undertaken by the medical students. Nursing students usually do not do the dissection themselves but are shown important dissected specimens. These dissected specimens give nursing students an idea of the various components of human body. An attempt has been made in this book to show actual/real dissections images and not the diagrammatic one. Real time photographs of respiratory, digestive, circulatory, special sensory organs, joints, muscles, parts of female and male reproductive systems, parts of nerves and central nervous system with their legends are presented. Students can see these actual dissections to get a "feel" of the human body.

DISSECTOR 1 Ventral Aspect of Forearm and Palm

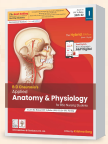


Cubital fossa, muscles and tendons of front of arm and palm including the superficial palmar arch.

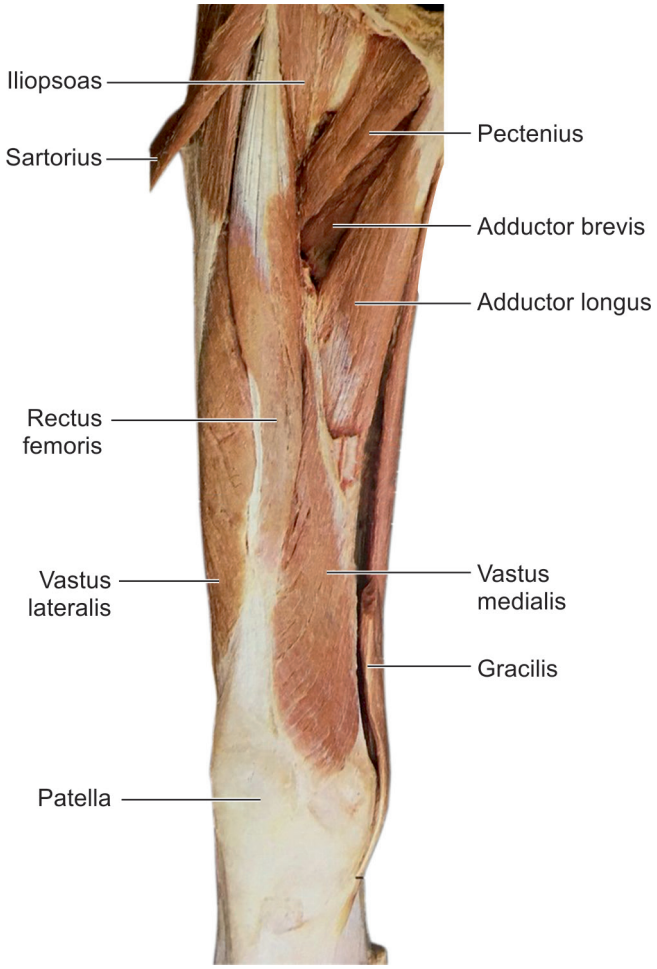
DISSECTOR 2 Section Showing Interior of Left Atrium and Left Ventricle



Thick left ventricular wall with papillary muscles, chordae tendinae and smooth left atrium.



DISSECTOR 3 Muscles of Anterior/Extensor and Medial Compartments of Thigh



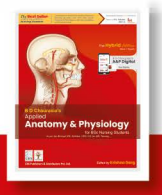
Muscles of anterior compartment seen are—rectus femoris, vastus lateralis and vastus medialis.
Muscles of medial compartment seen are—pectineus, adductor longus, adductor brevis and gracilis.

B D Chaurasia's
Applied

Anatomy & Physiology

for BSc Nursing Students

The **Hybrid** *Edition* (Book + Digital)



Salient Features of the book

- India's Best Selling Book B D Chaurasia's Textbook of Anatomy, is now available for Nursing Students covering Anatomy & Physiology
- First Book as per the Revised INC Syllabus 2021-22 covering the Applied Aspects in all the chapters
- First Hybrid Nursing Textbook with most Interactive Features, like Anatomy and Physiology Animated & 3D Videos, Audio Podcast
- Edited by the Most Senior Faculty & Reviewed by the Top Medical & Nursing Faculties from All over India
- A perfect amalgamation of Applied Anatomy and Physiology with Integrated Approach, and covering Nursing Implications and Applications
- Useful Appendices covering Important Dissectors/Cadaveric Images of Human Body Organs, Charts and High Yield Topics
- 1000+ Illustrations, real-time photographs, flowcharts, tables and graphs
- 500+ Important Key Terminologies
- 50+ Histological Slides
- 10+ Animated Videos clearing the Anatomical and Physiological concepts
- 20+ Chapter wise Self-assessment Exercises

6 Amazing Features of B D Chaurasia's A&P Digital

See & Perceive

Believe on what you see & perceive from what you watch

Get 100+ Images in 3D Animation videos with labelings and voice-overs

Revise on the Go

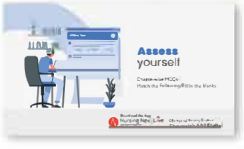
Learning cannot be limited to the book

500+ Chapter wise High Yielding Tables, Flowcharts & Images for Quick Reference

Read Digitally

Make every digital touch count

200+ Key terminologies with their meanings



Assess Yourself

Test your brain circuit with Self-Assessments

Chapter wise Multiple Choice Questions/ Match the Following/Fill in the Blanks

Listen and Recall

Learn what you listen & Recall what you learn

Chapter wise Golden Points for Last-minute Revision in Podcast form (Only in App)

Dil Mange More Content

Don't settle for less... go beyond

Chapter wise Long and Short Answer Questions (Solved), 5-10 Conceptual videos of Physiology in animation form (Optional), 50+ Dissection images in High Resolution, Regular Hybrid Updates covering Recent Advances, Mnemonics, Tips & Tricks and much more

CBS

Nursing Knowledge Tree | NURSING NEXT SOCIAL | Nursing Next Live

CBS Publishers & Distributors Pvt. Ltd.

4819/XI, Prahlad Street, 24 Ansari Road, Daryaganj, New Delhi 110 002, India

E-mail: feedback@cbspd.com, **Website:** www.cbspd.com

New Delhi | Bengaluru | Chennai | Kochi | Kolkata | Lucknow | Mumbai | Pune

Hyderabad | Nagpur | Patna | Vijayawada

CBS Dedicated to Education

ISBN: 978-93-90619-65-8