The National Medical Series for Independent Study

histology and embryology

Kurt E. Johnson, Ph.D.

The National Medical Series for Independent Study

histology and embryology

Kurt E. Johnson, Ph.D.
Associate Professor of Anatomy
George Washington University
Medical Center
Washington, D.C.

A WILEY MEDICAL PUBLICATION
JOHN WILEY & SONS
New York • Chichester • Brisbane • Toronto • Singapore

Harwal Publishing Company, Media, Pa.

Preface

Histology and Embryology evolved from class outlines and handouts that were distributed to first- and second-year medical students at Duke University and George Washington University. Each chapter covers the essential features of the microscopic anatomy of an organ or organ system and includes some discussion of developmental anatomy. Approximately 100 figures appear in *Histology and Embryology*, most of which are light and electron micrographs. The micrographs that are incorporated in the study questions give medical students valuable practice with the picture-type questions that appear in National Board examinations.

The author hopes that students find *Histology and Embryology* a useful and comprehensive study guide.

Kurt E. Johnson

Acknowledgments

I received a good deal of help in this project from my colleagues both past and present. Dr. Michael K. Reedy of Duke University provided me with a truly outstanding micrograph illustrating muscle tissue. I am especially grateful to my fellow anatomists at George Washington University for the micrographs they provided. These contributors include Dr. Ernest N. Albert, Dr. Frank Allan, Dr. Daniel P. DeSimone, Dr. Marilyn J. Koering, Dr. Jeffrey M. Rosenstein, Dr. Frank J. Slaby, and Dr. Raymond J. Walsh.

Dr. Mark R. Adelman of the Uniformed Services University of the Health Sciences read the manuscript. Dr. Helen A. Padykula of the University of Massachusetts donated a classic electron micrograph of muscular tissue. Dr. John A. Long of UCLA gave a fine electron micrograph of the ultrastructure of human adrenal cortex. Dr. Bela Gulyas of NICHD donated micrographs of corpus luteum.

I wish to acknowledge Lois Gottlieb for her help in locating specimens for me to photograph and Judy Gunther for her artwork. I also want to thank the secretarial staff in the Anatomy Department for their skillful typing. The editorial assistance of Debra L. Dreger also is gratefully acknowledged.

I appreciate all of these contributions and acknowledge that any errors contained herein are my own.

Introduction

Histology and Embryology is one of seven basic science review books in a series entitled, *The National Medical Series for Independent Study*. This series has been designed to provide students, house officers, as well as physicians, with a concise but comprehensive instrument for self-evaluation and review within the basic sciences. Although *Histology and Embryology* would be most useful for students preparing for the National Board of Medical Examiners examinations (Part I, FLEX, VQE, and ECFMG), it should also be useful for students studying for course examinations. These books are not intended to replace the standard basic science texts, but, rather, to complement them.

The books in this series present the core content of each basic science area using an outline format and featuring a total of 300 study questions. The questions are distributed throughout the book at the end of each chapter and in a pretest and posttest. In addition, each question is accompanied by the correct answer, a paragraph-length explanation of the correct answer, and specific reference to the outline points under which the information necessary to answer the question can be found.

We have chosen an outline format to allow maximum ease in retrieving information, assuming that the time available to the reader is limited. Considerable editorial time has been spent to ensure that the information required by all medical school curricula has been included and that each question parallels the format of the questions on the National Board examinations. We feel that the combination of the outline format and board-type study questions provides a unique teaching device

We hope you will find this series interesting, relevant, and challenging. The authors, as well as the John Wiley and Harwal staffs, welcome your comments and suggestions.

Contents

Pretest

QUESTIONS

Directions: Each question below contains five suggested answers. Choose the **one best** response to each question.

1. The tongue has filiform, fungiform, and circumvallate papillae. Which statement best describes these papillae?

(A) The predominant papillae are fungiform
(B) Fungiform papillae are located at the tongue root
(C) Circumvallate papillae are located on the dorsal surface
(D) Circumvallate papillae contain taste buds
(E) Filiform papillae contain taste buds

2. The adrenal cortex shows a striking zonation. One of these zones, the zona reticularis, has cells distinguished by which of the following activities?

(A) Cortisol secretion
(B) Mineralocorticoid secretion
(C) Pregnenolone synthetase
(D) 17-α-Hydroxylase activity
(E) Response to adrenocorticotropic hormone

3. Which of the following statements is true concerning the presence of fixation artifacts in histologic specimens?

(A) Most preparative techniques do not introduce artifacts
(B) Live cells can be examined microscopically without fixation and thus without artifacts
(C) Glutaraldehyde fixation does not introduce artifacts
(D) Staining introduces artifacts under most circumstances
(E) The cell nucleus can be interpreted as a fixation artifact

Questions 4 and 5

The epithelium pictured below was taken from a 24-year old patient.

Reprinted with permission from Johnson KE: *Histology: Microscopic Anatomy and Embryology*. New York, John Wiley, 1981, p 219.

4. What type of epithelium is pictured above?

(A) Columnar
(B) Cuboidal
(C) Pseudostratified
(D) Transitional
(E) Stratified columnar

5. In which of the following sites in the body can this type of epithelium be found?

(A) Respiratory system
(B) Vagina
(C) Oviduct
(D) Seminal vesicle
(E) Duodenum

6. All of the following statements concerning granulopoiesis are true EXCEPT

(A) heterochromatinization of the nucleus occurs in association with specific granule accumulation
(B) metamyelocytes contain both specific and azurophilic granules
(C) specific granules invariably outnumber azurophilic granules
(D) promyelocytes lack specific granules
(E) myeloblasts lack specific granules

7. Which of the following statements best describes the prostate gland?

(A) It functions normally without androgenic stimulation
(B) Its secretions are rich in proteolytic enzymes
(C) It is lined by a ciliated epithelium
(D) It stores spermatozoa
(E) It contributes little to the volume of the ejaculate

8. All of the following statements describing parathormone are true EXCEPT

(A) it is a low molecular weight polypeptide hormone
(B) it is antagonistic to the effects of calcitonin
(C) it inhibits osteocytic osteolysis
(D) it promotes renal tubular resorption of calcium
(E) it stimulates renal tubular excretion of phosphate

9. The ciliary body, located between the edge of the retina and the edge of the lens, is characterized by all of the following EXCEPT

(A) an epithelium that contains cones
(B) an epithelium that secretes aqueous humor
(C) an epithelium that is continuous with the retina
(D) ciliary muscles
(E) ciliary processes that suspend the lens

10. Which of the following components of the respiratory system does not have ciliated cells in its epithelium?

(A) Olfactory mucosa
(B) Nasal cavity
(C) Trachea
(D) Bronchiole
(E) Alveolus

11. An acidophilic structure is best identified by

(A) a net negative charge
(B) staining with toluidine blue
(C) staining with eosin or orange G
(D) a positive Feulgen reaction
(E) a positive periodic acid-Schiff (PAS) reaction

12. Connective tissue has all of the following components EXCEPT

(A) cells derived from mesoderm
(B) cells that commonly secrete collagen
(C) extracellular fibers
(D) amorphous ground substance
(E) a basal lamina

13. A macrophage has all of the following features EXCEPT

(A) an irregularly shaped nucleus
(B) many lysosomes
(C) many surface projections
(D) few microfilaments
(E) the ability to engage in active pinocytosis

14. All of the following statements concerning T cells are true EXCEPT

(A) they are similar to B cells when seen with the light microscope
(B) they are derived from bone marrow stem cells and require thymosin for their differentiation
(C) they are abundant in the thymus and in the spleen
(D) they have fewer surface immunoglobulins than B cells
(E) they undergo functional maturation in the spleen

Directions: Each question below contains four suggested answers of which **one or more** is correct. Choose the answer

A if **1, 2, and 3** are correct
B if **1 and 3** are correct
C if **2 and 4** are correct
D if **4** is correct
E if **1, 2, 3, and 4** are correct

15. The central veins of the liver drain into which of the following vessels or structures?

(1) Biliary apparatus
(2) Hepatic connective tissue
(3) Hepatic sinusoids
(4) Sublobular veins

16. Components of adipose tissue include

(1) collagen fibers
(2) fibroblasts
(3) amorphous ground substance
(4) elastic fibers

17. A proximal convoluted tubule is characterized by

(1) an epithelial lining that has many microvilli
(2) cytoplasm that is strikingly eosinophilic and packed with mitochondria
(3) the ability to actively resorb protein from the glomerular filtrate by pinocytosis
(4) increased permeability to water when stimulated by antidiuretic hormone (ADH)

18. The dermis is characterized by

(1) a lack of chondroitin sulfate in the extracellular matrix
(2) avascularity
(3) greater thinness in thin skin than in thick skin
(4) numerous collagen fibers and elastic fibers

19. Features of endochondral bone formation include

(1) cartilage degeneration that is directly proportional to the increase in bone
(2) frequent cell division
(3) bones that grow in length and girth
(4) osteoprogenitor cells that differentiate into osteoblasts

20. Steps taken with freeze-fracture etching include

(1) glutaraldehyde fixation
(2) glycerol treatment to prevent the formation of ice crystals
(3) heavy metal coating to emphasize relief of specimens
(4) slow freezing (over 1 to 3 hours)

21. Hyaline cartilage matrix contains

(1) large amounts of collagen
(2) chondroitin sulfate
(3) glycoproteins
(4) many elastic fibers

22. The auditory tube of the ear is characterized by

(1) direct communication with the cavity containing the ossicles
(2) parts that are lined by pseudostratified epithelium
(3) mucous glands in the mucosa and lymphoid nodules in the lamina propria
(4) ceruminous glands

23. Testosterone is characterized by which of the following statements?

(1) It is made from cholesterol in the Leydig cells
(2) It is controlled by the hypothalamus
(3) It is required for spermatogenesis and prostatic secretion
(4) It stimulates luteinizing hormone releasing hormone (LH-RH) production

24. Chief cells are abundant in the fundic gastric glands and contain

(1) prominent nucleoli
(2) strongly basophilic cytoplasm
(3) well-developed Golgi apparatus
(4) abundant smooth endoplasmic reticulum

SUMMARY OF DIRECTIONS

A	B	C	D	E
1,2,3 only	1,3 only	2,4 only	4 only	All are correct

25 Components of the tracheal microanatomy include

(1) smooth muscle
(2) scattered mucous cells
(3) short cells
(4) adipose tissue

26. Blood thyroxine levels are regulated in a classic feedback-loop system. Components of this system include

(1) thyroid-stimulating hormone (TSH)
(2) thyrotropin releasing hormone (TRH)
(3) thyroxine
(4) thyroglobulin

27. Tears are characterized by which of the following statements?

(1) They are produced mainly by the lacrimal glands
(2) They are important for cleansing the eyes
(3) Secretions from the conjunctiva help prevent their evaporation
(4) Secretions from the meibomian glands help prevent their evaporation

28. Secretions of the enterochromaffin system include

(1) secretin
(2) polypeptide hormones
(3) serotonin
(4) glucagon

29. There are two types of bone marrow—red marrow and yellow marrow. How do these marrow types differ?

(1) Yellow marrow is more hematopoietically active than red marrow
(2) Yellow marrow contains more fat cells than red marrow
(3) Only yellow marrow is found in newborns
(4) Only red marrow is found in adult skull bones

30. Schwann cells are characterized by which of the following statements?

(1) They are neural crest derivatives
(2) They are responsible for myelination of peripheral neurons
(3) They are separated from one another by nodes of Ranvier
(4) They sometimes exhibit defects called Schmidt-Lantermann clefts

31. Components of mature enamel include

(1) glycoproteins
(2) collagen
(3) hydroxyapatite
(4) cellular processes

32. Eccrine sweat glands are found over most of the body. Features of these glands include

(1) abundance in the palm of the hand
(2) connection to the body surface by a coiled duct
(3) the ability to produce a copious secretion to cool the body
(4) the ability to produce a hypertonic solution of sodium, chloride, and urea

Directions: The groups of questions below consist of lettered choices followed by several numbered items. For each numbered item select the **one** lettered choice with which it is **most** closely associated. Each lettered choice may be used once, more than once, or not at all.

Questions 33–36

For each description of cardiovascular layers, select the appropriate layer or layers.

(A) Tunica intima
(B) Tunica adventitia
(C) Both
(D) Neither

33. Homologous to the endocardium
34. Homologous to the epicardium
35. Intrinsic blood vessels in the aorta found here
36. Absent in muscular arteries

Questions 37–40

For each description of cell characteristics, select the appropriate leukocytes.

(A) Granulocytes
(B) Agranulocytes
(C) Both
(D) Neither

37. Can be phagocytic
38. Lack specific granules
39. Lack lysosomes
40. Have lobulated nuclei with two to four lobes

Questions 41–43

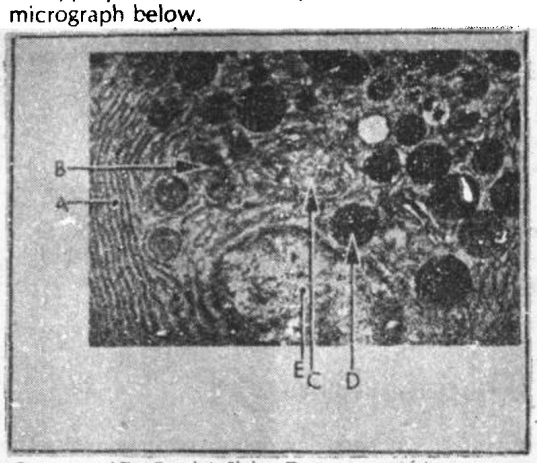
For each description of cells involved in ovarian follicular development, select the appropriate cell type.

(A) Granulosa cells
(B) Granulosa-lutein cells
(C) Theca interna cells
(D) Theca-lutein cells
(E) None of the above

41. Form after ovulation and secrete progesterone
42. Secrete glycoproteins
43. Secrete androgens

Questions 44–48

For each of the following descriptions of sites or structures of the pancreatic acinar cell, select the appropriate lettered component shown in the micrograph below.



Courtesy of Dr. Frank J. Slaby, Department of Anatomy, George Washington University.

44. Granules of secretion product
45. Membranous structure involved in processing secretion products for transport
46. Site of oxidative phosphorylation
47. Site of polypeptide chain synthesis
48. Site of localization of glycosyltransferase enzymes

Questions 49–52

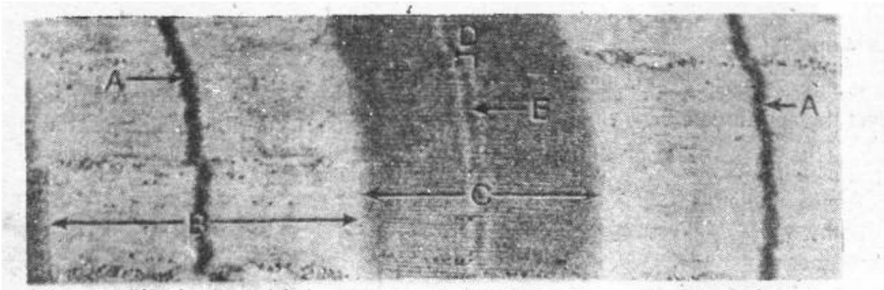
For each of the following characteristics of types of cells found in the hypophysis, select the appropriate cell type.

(A) Lactotrops
(B) Thyrotrops
(C) Both
(D) Neither

49. Present in the pars distalis
50. Present in the median eminence in the neurohypophysis
51. Produces a low molecular weight polypeptide hormone
52. Produces a high molecular weight glycoprotein hormone

Questions 53–57

For each description of different regions within a sarcomere, select the lettered area shown in the micrograph below with which it is most likely to be associated.



Courtesy of Helen A. Padykula, Department of Anatomy, University of Massachusetts.

53. Z line

54. I band

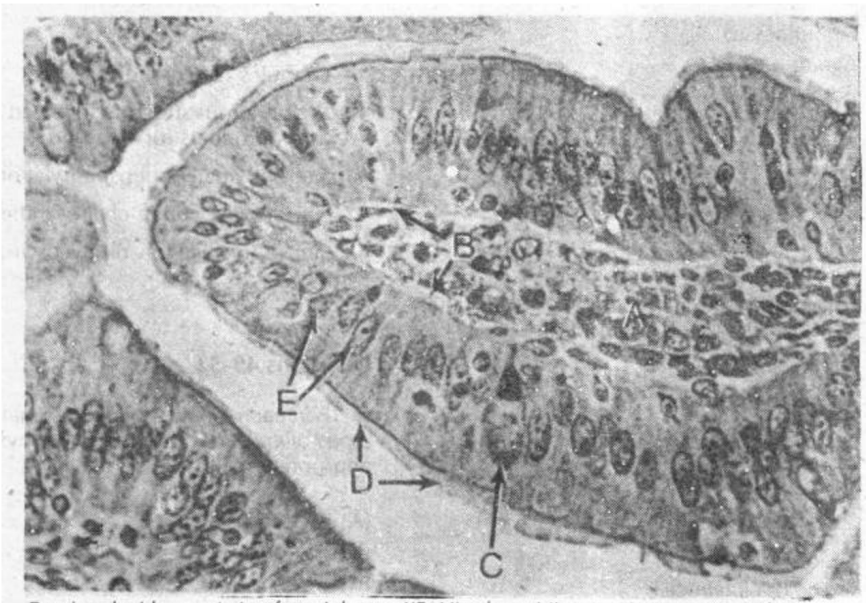
55. H band

56. Middle of sarcomere

57. End of sarcomere

Questions 58–60

For each description of components of an ileal villus, select the lettered structure in the micrograph below with which it is most likely to be associated.



Reprinted with permission from Johnson KE: *Histology: Microscopic Anatomy and Embryology*. New York, John Wiley, 1981, p 219.

58. Protective mucus is secreted here

59. Microvilli here increase the surface area available for absorption

60. Polymorphonuclear leukocytes, plasma cells, and lymphocytes occur here

ANSWERS AND EXPLANATIONS

1. The answer is D. (*Chapter 13 IV B*) The tongue has three types of papillae. Filiform papi lae, the most numerous, have no taste buds associated with them. Fungiform papillae are scattered among the filiform papillae on the dorsal surface of the tongue. Circumvallate papillae are restricted to the root of the tongue. Both fungiform and circumvallate papillae have taste buds.

2. The answer is B. (*Chapter 19 IV A 4*) The zona reticularis and zona fasciculata both secrete cortisol, under the influence of adrenocorticotropic hormone (ACTH). A key enzyme in cortisol synthesis, 17-α-hydroxylase, would be expected to occur in both zones. Pregnenolone synthetase is an enzyme active in an early stage of steroid biosynthesis, and its product, pregnenolone, is a precursor for the synthesis of many steroids. Thus, pregnenolone synthetase is widely distributed in the adrenal cortex. Aldosterone, a mineralocorticoid, is synthesized in the zona glomerulosa.

3. The answer is B. (*Chapter 1 IV D 1,4*) Almost all forms of preparative techniques for histologic examination of specimens produce some sort of artifact. Phase-contrast microscopy, on the other hand, allows scientists to examine live cells without fixation and therefore without the introduction of fixation artifacts. While staining increases the contrast of structures, in most instances it does not introduce artifacts. The cell nucleus is not, of course, an artifact.

4 and 5. The answers are: 4-C, 5-D. (*Chapter 3 III B*) This is an example of pseudostratified epithelium. It might be mistaken for columnar epithelium, but close inspection reveals the curved basal nuclei typical of pseudostratified epithelium. Notice the prominent clear area in the apices of the tall cells. This represents the dilated cisternae of the Golgi apparatus. This secretory epithelium is found in the seminal vesicle; it produces some of the material in the ejaculate.

6. The answer is C. (*Chapter 9 V B*) The azurophilic granules outnumber specific granules in the mature neutrophil. Metamyelocytes have granules typical of a mature granulocyte but have an immature nuclear morphology. Myeloblasts and promyelocytes both lack specific granules.

7. The answer is B. (*Chapter 22 VIII B*) The prostate requires androgenic stimulation but does not actually store spermatozoa. The prostate has glands lined by a pseudostratified epithelium without cilia. Its secretions contribute a considerable amount to the volume of the ejaculate.

8. The answer is C. (*Chapter 18 IV E*) Parathormone is a low molecular weight hormone whose antagonistic effect on calcitonin causes a systemic increase in serum calcium. Parathormone promotes osteolysis and renal resorption of calcium, and it stimulates phosphate excretion.

9. The answer is A. (*Chapter 24 III B*) The ciliary body is covered by a double-layered epithelium. This epithelium is continuous with the retina but lacks photoreceptors characteristic of the more posterior part of the retina. Also, the ciliary epithelium secretes the aqueous humor. Many long ciliary processes project from the ciliary body toward the lens. The major components of the ciliary body, however, are the ciliary muscles. Cones are found in the retina, not in the ciliary body.

10. The answer is E. (*Chapter 12 II A, B; III A; IV B; V B*) The nasal cavity has a pseudostratified ciliated columnar (PCC) epithelium. The olfactory mucosa also has a PCC epithelium; here the epithelium is tall and modified for olfaction. The PCC epithelium of the trachea contains six types of cells, all of which help to perform the diverse functions of this tubular structure. Ciliated cells are commonly found in bronchioles. Alveolar epithelium, however, lacks ciliated cells and contains type I and type II cells.

11. The answer is C. (*Chapter 1 III B 1,3; C 2; E 1,5*) Acidophilic structures have a net positive charge and typically will stain with eosin or orange G, two negatively charged acidic dyes. Acidophilic structures will not stain with toluidine blue because toluidine blue is positively charged and so stains basophilic structures. There is no direct connection between acidophilia and the periodic acid-Schiff (PAS) status of a specimen, nor is there a connection between acidophilia and the Feulgen reaction, which is a test for DNA.

12. The answer is E. (*Chapter 4 VI C; VIII; XI A*) Practically all of the body's connective tissue is derived from mesoderm. Also, connective tissue has extracellular fibers, collagen fibers, and amorphous ground substance. A basal lamina is an epithelial, not connective tissue, characteristic.

13. The answer is D. (*Chapter 10 III A, B*) As part of its motility system, a macrophage has numerous microfilaments. Since it is an active phagocyte, this cell also has many lysosomes and surface projections and is active in pinocytosis. A macrophage has an irregularly shaped nucleus.

14. The answer is E. (*Chapter 10 IV A, C*) T cells undergo functional maturation in the thymus, where they are stimulated to differentiate by the thymic hormone, thymosin. T cells do not undergo functional maturation in the spleen, but they are abundant there and in the thymus.

15. The answer is D (4). (*Chapter 16 III A, B*) Blood coming to the liver flows from the branches of the portal veins, through the hepatic sinusoids, and into the central veins. The central veins empty into sublobular veins. The central veins do not nourish the connective tissue and biliary apparatus of the liver. This function is performed by branches of the hepatic artery.

16. The answer is E (all). (*Chapter 4 VI C; VII C; VIII; IX A*) Almost all types of connective tissues have at least some elastic fibers, and adipose tissue is no exception. Likewise, amorphous ground substance is found in varying amounts in all connective tissue types. In addition to these components, adipose tissue contains scattered collagen fibers and fibroblasts.

17. The answer is A (1, 2, 3). (*Chapter 23 III A 3, 4, 6*) The proximal convoluted tubule (PCT), like the distal convoluted tubule (DCT), has numerous apical microvilli. The PCT is very active in both ion and macromolecule transport (by pinocytosis) and has many mitochondria in its cells. These organelles produce adenosine triphosphate (ATP) for transport. Antidiuretic hormone (ADH) makes the collecting tubules more permeable to water, but it has no effect on either the PCT or the DCT.

18. The answer is D (4). (*Chapter 17 VI A–C*) The dermis of thin skin is thick, and the dermis of thick skin is thin. The dermis is highly vascular; its blood supply is important for thermoregulation. It contains collagen, hyaluronate, and chondroitin sulfate in its extracellular matrix. The dermis also has many elastic fibers.

19. The answer is E (all). (*Chapter 5 IX C*) During endochondral bone formation, cartilage is replaced by bone. Bones increase in length and girth partly as a result of cell division. Osteoprogenitor cells are the main source of osteoblasts.

20. The answer is A (1, 2, 3). (*Chapter 1 VI B*) In freeze-fracture etching, specimens that are unfixed or lightly fixed with glutaraldehyde are infiltrated first with glycerol. Rapid freezing of the water-glycerol solution in cells prevents ice crystal formation and reduces the destructive effects of freezing. After the frozen specimen has been fractured with a razor blade, it is coated with heavy metal to bring out details of its relief.

21. The answer is A (1, 2, 3). (*Chapter 5 III E*) Glycoproteins and proteoglycans are contained in the amorphous ground substance of cartilage. The matrix of hyaline cartilage contains one particularly prominent proteoglycan. It is a copolymer of protein with three glycosaminoglycans—chondroitin sulfate, hyaluronate, and keratan sulfate. This matrix also contains large amounts of type I collagen but only a few elastic fibers.

22. The answer is A (1, 2, 3). (*Chapter 25 II B; III D*) The auditory tube connects the middle ear to the pharynx and is lined, in places, by a pseudostratified epithelium. The auditory tube can have mucous glands and sometimes exhibits lymphoid nodules in close association with it; however, there are no ceruminous glands in the auditory tube. The external auditory meatus, an indentation in the side of the head, leads to the tympanic membrane and is lined by modified skin with ceruminous glands.

23. The answer is A (1, 2, 3). (*Chapter 22 V A 6*) Testosterone is made from cholesterol in the Leydig cells and is under the control of the hypothalamus. Spermatogenesis and prostatic secretion are testosterone-dependent. Testosterone inhibits luteinizing hormone releasing hormone (LH-RH) production.

24. The answer is A (1, 2, 3). (*Chapter 14 IV B 3 b*) Chief cells are abundant in the glands of the fundic portion of the stomach. These cells secrete pepsinogen, a protein, into the stomach. Like all cells specialized for the synthesis of protein for export, chief cells have prominent nucleoli, well-developed Golgi apparatus, and cytoplasmic basophilia due to an abundance of rough endoplasmic reticulum. Abundant smooth endoplasmic reticulum is a characteristic feature of steroid-secreting cells.

25. The answer is E (all). (*Chapter 12 III A, B*) The trachea is lined by a pseudostratified ciliated columnar epithelium that contains six types of cells. Two of these are mucous cells and short cells. Secretions from mucous cells form a continuous layer on the tracheal epithelium. Short cells are abundant and rest on the basement membrane of the epithelium. C-shaped rings of cartilage keep the trachea open; where the cartilage is absent there is a band of smooth muscle. The tracheal adventitia contains blood vessels, nerves, and adipose tissue.

26. The answer is E (all). (*Chapter 18 II D 3*) Blood thyroxine levels are regulated in a classic feedback-loop system. Low thyroxine levels indirectly stimulate the secretion of thyrotropin releasing hormone (TRH); the secretion of TRH then directly stimulates the secretion of thyroid-stimulating hormone (TSH). TSH stimulates thyroid follicular cells to engulf stored thyroglobulin, which is degraded into active thyroxine. The thyroxine then is secreted from the thyroid. When blood thyroxine levels are high again, TSH secretion is inhibited.

27. The answer is E (all). (*Chapter 24 IV A–C*) Tears are secreted by lacrimal glands and help to cleanse the cornea. Oily secretions from the meibomian glands and mucus from the conjunctival glands form a thin film on the tears, helping to prevent evaporation of tears.

28. The answer is E (all). (*Chapter 14 V B*) The enterochromaffin system is a group of cells scattered throughout the epithelium of the gastrointestinal tract. These cells secrete a collection of different polypeptide hormones including secretin, cholecystokinin (a polypeptide hormone), serotonin, and glucagon. The enterochromaffin cells function in the regulation of gastrointestinal tract motility.

29. The answer is C (2, 4). (*Chapter 9 II A, B 4*) Red marrow is characterized by active hematopoiesis. Yellow marrow is hematopoietically inactive; lipid-laden fat cells far outnumber hematopoietic cells in yellow marrow. Practically all marrow in newborns is red; however, yellow marrow replaces most red marrow by the time an individual reaches puberty. In an adult, red marrow is found only in the skull bones, clavicle, vertebrae, sternum, and pelvic bones.

30. The answer is E (all). (*Chapter 7 I E; VI D*) Schwann cells are derived from neural crest and form myelin sheaths around the axons of peripheral neurons. Gaps between Schwann cells are called nodes of Ranvier. Defects in the myelin sheaths are called Schmidt-Lantermann clefts.

31. The answer is B (1, 3). (*Chapter 13 III B, C*) Enamel covers the crown of every tooth and is a secretion product of ameloblasts. Its peculiar hardness is a result of its lack of cellular processes. Enamel is composed of proteins, glycoproteins, and hydroxyapatite, and it is chemically distinct from dentin. Dentin, not enamel, contains collagen.

32. The answer is A (1, 2, 3). (*Chapter 17 III A 2*) Eccrine sweat glands are found over most of the body, including the palms of the hands. These glands have coiled ducts and produce a large volume of sweat when the body becomes overheated. Sweat is a hypotonic, not hypertonic, solution of water, sodium chloride, urea, and other components.

33–36. The answers are: 33-A, 34-B, 35-B, 36-D. (*Chapter 12 II C; IV; V*) The tunica adventitia and the epicardium both are located at the abluminal portion of the cardiovascular system. They are similar histologically. The tunica intima and the endocardium both are located at the luminal portion of the cardiovascular system. They are similar histologically. The tunica adventitia contains the vasa vasorum.

The vasa vasorum comprise the intrinsic blood supply of the large vessels such as the aorta. Muscular arteries have both an intima and an adventitia.

37–40. The answers are: 37-C, 38-B, 39-D, 40-A. (*Chapter 8 III B, C*) Neutrophils are examples of granulocytes and monocytes are examples of agranulocytes; both are phagocytes. All leukocytes have a nuclear envelope and mitochondria. Granulocytes contain specific granules and, like agranulocytes, have many lysosomes. Unlike agranulocytes, granulocytes have several prominent nuclear lobes.

41–43. The answers are: 41-B, 42-A, 43-C. (*Chapter 21 III B 1–4, II; III C–E; III F 2 a, b*) Granulosa cells secrete glycoproteins into the spaces surrounding them in primary ovarian follicles. The glycoproteins coalesce into Call-Exner bodies, which in turn are thought to fuse to form the antrum of the secondary follicle. In the preovulatory follicle, the granulosa cells secrete liquor folliculi, which accumulates in the antrum and causes its volume to increase. A mound of granulosa cells, called the cumulus oophorus, surrounds the oocyte in the preovulatory follicle. Theca interna cells secrete androgens, which are converted to estrogens in the granulosa cells. At ovulation, the mature follicle ejects the oocyte together with an attached layer of granulosa cells called the corona radiata. The follicle then becomes a corpus luteum, formed from both granulosa and theca interna cells. The granulosa cells become granulosa-lutein cells, cease to secrete glycoproteins, and begin to secrete progesterone. The theca interna cells become theca-lutein cells, which are thought to secrete steroids other than progesterone.

44–48. The answers are: 44-D, 45-C, 46-B, 47-A, 48-C. (*Chapter 2 III B; V B; VIII B*) This electron micrograph is of a pancreatic acinar cell, a classic example of a cell specialized for protein synthesis. It has ribosome-studded endoplasmic reticulum for protein synthesis and mitochondria for adenosine triphosphate (ATP) production. It also has granules of secretion product and a Golgi apparatus with glycosyltransferases for adding carbohydrate moieties to products destined for secretion.

49–52. The answers are: 49-C, 50-D, 51-A, 52-B. (*Chapter 20 V B 3 c, d*) Lactotrops are acidophils that secrete a low molecular weight polypeptide hormone called prolactin. Thyrotrops are basophils that secrete a high molecular weight glycoprotein hormone called thyroid-stimulating hormone (TSH). Both lactotrops and thyrotrops are found in the pars distalis of the adenohypophysis.

53–57. The answers are: 53-A, 54-B, 55-D, 56-E, 57-A. (*Chapter 6 IV B 1*) Thin filaments insert at the Z line (A) and are the sole component of the I band (B). There is no overlap between thick and thin filaments in the H band (D). The M line (E) is the middle of the sarcomere, and the Z line is the end of the sarcomere. As the extent of thick and thin filament overlap changes during the contraction and relaxation cycle, the I band changes length.

58–60. The answers are: 58-C, 59-D, 60-A. (*Chapter 15 II C 3*) The ileal villus is a connective tissue core of lamina propria (A), where formed elements of the blood can be found. The epithelium covering the villus is composed of tall columnar cells (E), with many associated microvilli in a brush border (D) and mucus-secreting goblet cells (C) resting on a basement membrane (B).

1
Techniques Used in Microscopic and Developmental Anatomy

I. INTRODUCTION

A. SPECIMEN PREPARATION

B. STAINING METHODS

C. METHODS USED TO EXTEND HUMAN PERCEPTION.

The following methods are used to diagnose disease, to learn more about structure-function relationships, and to elucidate causes of disease of unknown etiology in order to cure disease.

1. **Microscopy.**
   - a. Light Microscopy.
     - (1) Brightfield
     - (2) Phase contrast
     - (3) Differential interference contrast
   - b. Electron Microscopy.
     - (1) Transmission electron microscopy (TEM)
     - (2) Scanning electron microscopy (SEM)
   - c. Freeze-Fracture Etching (FFE).
2. **Differential Centrifugation.**

II. SPECIMEN PREPARATION

A. FIXATION

1. For light microscopy, specimens usually are immersed in a solution of an appropriate buffer and formaldehyde.
2. For electron microscopy, specimens usually are immersed in a solution of buffer and glutaraldehyde followed by several rinsing steps and postfixation in buffered osmium tetroxide.

B. DEHYDRATION

1. Dehydration usually is done with increasing concentrations of **ethanol** known as a graded ethanol series.
2. Dehydration can be done with other organic solvents such as **acetone** or dioxane.
3. Dehydration introduces some artifacts (e.g., lipid extraction).

C. EMBEDDING

1. **Paraffin** is used for light microscopy.
2. **Epoxy** resins are used for TEM.
3. For SEM specimens, embedding is not performed.

D. SEM PREPARATION

1. Following dehydration in a graded series of ethanol, specimens are **critical point dried**, which serves to dehydrate the specimens without subjecting them to the surface tension