. The ability of superactive analogs of gonadotropin-releasing hormone (GnRH) to inhibit the secretion of gonadotropins is caused by

(A) a decreased biologic half-life for the gonadotropins
(B) decreased synthesis of sex hormone-binding globulin
(C) down-regulation of GnRH receptors
(D) increased conversion of testosterone to estradiol in the hypothalamus
(E) negative feedback by luteinizing hormone

1. Removal of the parathyroid glands will result in

	Blood Concentrations	
	Calcium	Phosphorus
(A)	↑	↑
(B)	↑	↓
(C)	↓	↑
(D)	↓	↓
(E)	↓	normal

2. Secretion of catecholamines by cells of the adrenal medulla is dependent upon

(A) exocytosis of calmodulin
(B) hyperpolarization of the cell membrane
(C) inactivation of the release of somatostatin
(D) the increased concentration of Ca^{2+} in the cytoplasm
(E) the release of norepinephrine from preganglionic sympathetic neurons

3. Secretion of parathyroid hormone is increased by

(A) an increase in extracellular concentration of magnesium
(B) an increase in extracellular concentration of phosphate
(C) high intake of dietary calcium
(D) hypocalciuria
(E) treatment with thiazide diuretics

34. The storage form of thyroid hormone is

(A) diiodothyronine
(B) diiodotyrosine
(C) thyroglobulin
(D) thyroxine (T_4)
(E) triiodothyronine (T_3)

35. A drug that prevents the binding of cortisol to its receptors would cause

(A) a negative nitrogen balance
(B) decreased concentrations of ACTH in the blood
(C) decreased concentrations of cortisol in cell nuclei
(D) decreased concentrations of cortisol in the blood
(E) increased concentrations of insulin in the blood

36. Which of the following causes of brain hypoxia would most strongly stimulate the aortic and carotid chemoreceptors?

(A) Carbon monoxide poisoning
(B) Severe anemia
(C) Formation of methemoglobin
(D) A marked decrease in the pulmonary diffusing capacity
(E) Acute respiratory alkalosis

37. Shortly after insulin is discontinued in a patient with diabetes mellitus, the

(A) blood glucose concentration decreases
(B) excretion of nitrogen increases
(C) glycogen content in the liver increases
(D) plasma concentration of bicarbonate increases
(E) rate of conversion of alanine to glucose decreases

38. In a steady state, the difference in CO_2 content between the venous blood leaving a tissue and the arterial blood entering the tissue is determined by the

(A) ratio of alveolar ventilation to tissue blood flow
(B) ratio of tissue CO_2 production to tissue blood flow
(C) ratio of tissue CO_2 production to tissue O_2 consumption
(D) ratio of tissue CO_2 production to venous P_{CO_2}
(E) slope of the CO_2 dissociation curve

39. Airways resistance is gas flow, measured at the mouth, divided into the

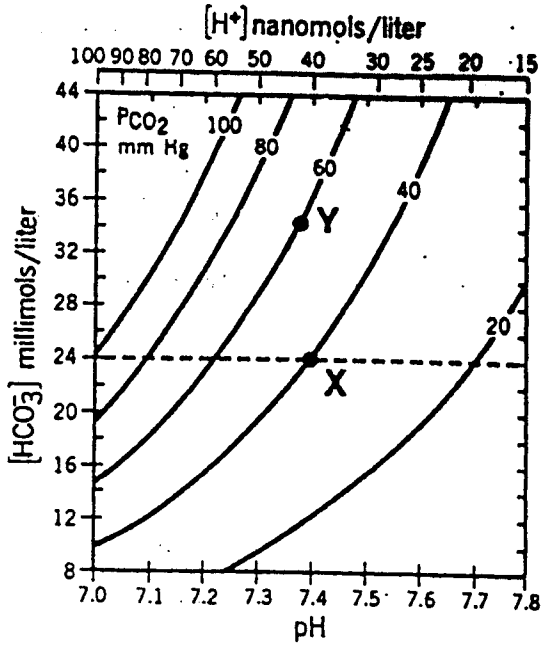
(A) compliance
(B) difference between end-expiratory and end-inspiratory pleural pressures
(C) difference between mouth pressure and alveolar pressure
(D) difference between mouth pressure and pleural pressure
(E) tidal volume

40. Reabsorption of glucose from the renal tubular lumen into cells

(A) occurs against an electrochemical gradient
(B) is a primary active transport process
(C) is inhibited by the simultaneous transport of para-aminohippuric acid (PAH)
(D) depends upon the presence of sodium in tubular fluid
(E) occurs mainly in the distal tubule

41. In target cells, stimulation of cyclic AMP by epinephrine

(A) depends upon the internalization of epinephrine-receptor complexes
(B) is amplified by prior long-term exposure of the cells to norepinephrine
(C) is inversely related to the number of adrenergic receptors present on the cells
(D) is mediated by a protein that binds GTP
(E) requires translocation of epinephrine into the nucleus



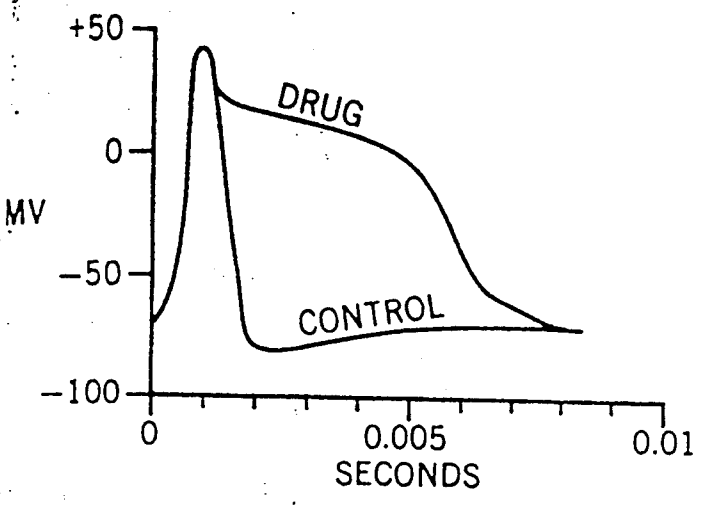
42. In the diagram, point X indicates a normal person's acid-base status. The condition indicated by point Y would be caused by

(A) adaptation to high altitude
(B) chronic pulmonary obstruction
(C) diarrhea
(D) ingestion of a strong acid
(E) severe and prolonged vomiting

---

43. Drug X applied to a nerve axon decreases the action potential duration without affecting the resting potential or peak amplitude of the action potential. Drug X could be acting by

(A) blocking the voltage-dependent Na^+ permeability
(B) decreasing the rate of Na^+ inactivation
(C) decreasing voltage-dependent Na^+ permeability
(D) increasing the rate of voltage-dependent changes in K^+ permeability
(E) inhibiting the Na^+-K^+ pump



44. The graph illustrates the effects of tetraethylammonium (TEA) on the action potential of an axon. The most likely action of TEA is to

(A) open K^+ gates, causing membrane permeability to K^+ to increase during the action potential
(B) block K^+ gates, preventing membrane permeability to K^+ from increasing during the action potential
(C) open Na^+ gates, causing membrane permeability to Na^+ to increase
(D) block the Na^+-K^+ active pump during the action potential
(E) close Na^+ gates, preventing membrane permeability to Na^+ from increasing during the action potential

45. A stroke resulting in damage to the internal capsule characteristically produces

(A) ballismus
(B) chorea
(C) cogwheel rigidity
(D) spastic paralysis
(E) tremor

46. The most striking difference between the composition of cerebrospinal fluid and plasma is in

(A) concentration of glucose
(B) concentration of potassium
(C) concentration of protein
(D) concentration of sodium
(E) osmolality

47. A miniature end-plate potential results from the

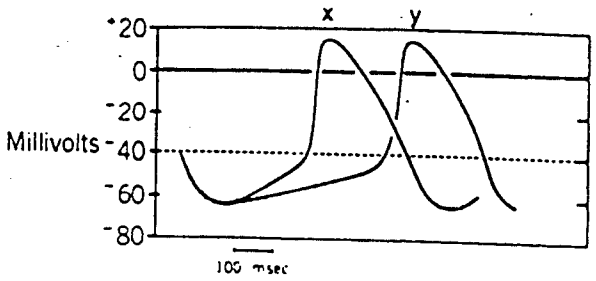
(A) action of acetylcholinesterase
(B) action potential in a presynaptic terminal
(C) opening of a single postsynaptic channel by acetylcholine
(D) spontaneous release of a quantal package of acetylcholine
(E) subthreshold depolarization of a presynaptic terminal

48. Which of the following statements represents the major difference between olfaction and other sensory systems?

(A) Olfactory pathways are directly linked with gustatory pathways
(B) Olfactory pathways have no direct access to the thalamus
(C) Olfactory receptors code their responses without action potentials
(D) Peripheral olfactory pathways are crossed
(E) Substance P is primarily used in olfactory pathways

49. The secretion of ADH (vasopressin) is normally

(A) decreased by somatostatin
(B) decreased following ingestion of NaCl
(C) decreased in response to breast feeding
(D) increased during sustained exercise
(E) increased following ingestion of alcohol



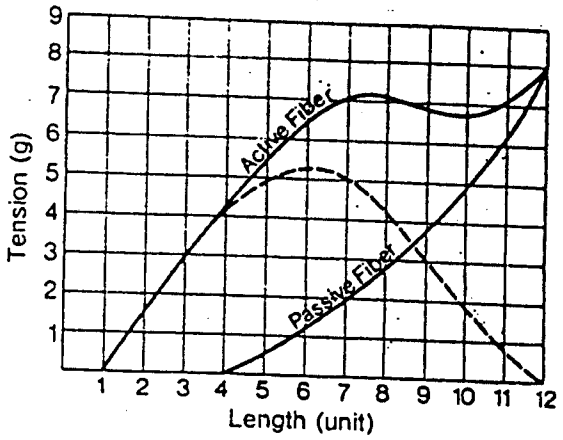
50. The recordings shown were made by inserting a microelectrode into a cardiac muscle cell. Recording X was made before exposing the heart to a particular agent, and recording Y was made after adding the agent. The two recordings are superimposed for ease of comparison. The microelectrode was inserted into

(A) an atrial muscle cell
(B) an atrioventricular node cell
(C) a Purkinje cell
(D) a sinoatrial node cell
(E) a ventricular muscle cell

---

51. In humans, total adrenalectomy is invariably fatal without replacement therapy whereas hypophysectomy is not. This is because, after hypophysectomy,

(A) adrenal catecholamines compensate for the metabolic actions of cortisol
(B) plasma concentrations of angiotensin II do not increase to values that are toxic
(C) the adrenal cortex undergoes compensatory hypertrophy
(D) the secretion of aldosterone is not markedly decreased
(E) tissue requirements for corticosteroids fall to low levels



52. The graph shows the isometric length-tension relations before activation (passive) and after maximal activation (active) of a striated muscle fiber. The dashed curve is the difference between these two relations. If the passive muscle fiber is stretched to 2 g of tension and then activated to contract isometrically, the total tension (in g) developed will be approximately

(A) 3
(B) 5
(C) 7
(D) 9
(E) 11

---

53. A patient who monitors her blood pressure at home daily has a diastolic pressure under 100 mm Hg on 70% of the days and over 100 mm Hg on 30% of the days. What is the probability that the patient will record a diastolic pressure above 100 mm Hg on three consecutive days, assuming there is no real change in pressure?

(A) 2.7%
(B) 9.0%
(C) 30.0%
(D) 34.3%
(E) 70.0%

Items 54-55

For a given patient, the results of laboratory and experimental studies are as follows:

Hematocrit	55%
Oxygen consumption	250 mL/min
Arterial-to-mixed venous blood oxygen difference	25 mL/L blood
Arterial oxygen saturation	70%

54. The output of the left ventricle (in L/min) is

(A) 1.25
(B) 5.0
(C) 7.5
(D) 10.0
(E) 15.0

55. These data are consistent with

(A) acute blood loss
(B) acute cardiac failure
(C) overtransfusion
(D) severe mitral stenosis
(E) shunting of venous blood from the right to the left side of the heart

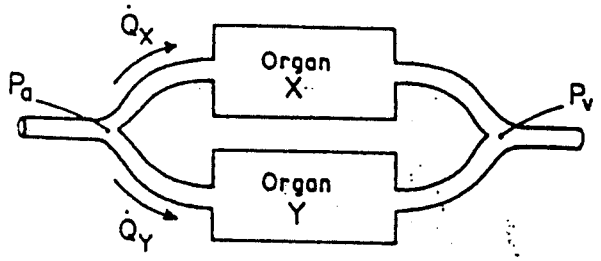
---

56. The danger of breathing compressed gas consisting of pure O_2 is

(A) CO_2 retention consequent to loss of hypoxic ventilatory drive
(B) inactivation of angiotensin-converting enzyme
(C) the anesthetic effects of O_2
(D) the likelihood of decompression sickness
(E) toxic effects of O_2 on the lung and brain

Items 57-58

Two organ-vascular beds, X and Y, are arranged in parallel, as shown in the drawing. Blood pressure in the aorta, P_a, and in the vena cava, P_v, and blood flow, Q_X and Q_Y, are indicated.



57. The total resistance to flow offered by both organs (in mm Hg/mL/min) is

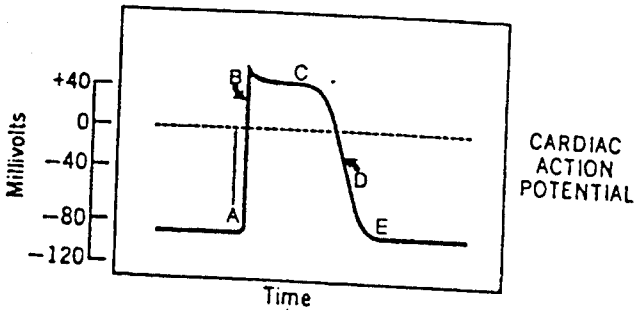
(A) 0.01
(B) 0.10
(C) 1.00
(D) 10.00
(E) 100.00

58. When the resistance of organ Y is doubled without a change in P_a or P_v, the mean blood flow in organ Y

(A) becomes equal to the blood flow in organ X
(B) is decreased to 1/2 of its former value
(C) is decreased to 1/16 of its former value
(D) is increased by a factor of 2
(E) is increased by a factor of 16

DIRECTIONS (ITEMS 59-80): Each group of items in this section consists of lettered options followed by a set of num bered items. For each item, select the ONE lettered option that is most closely associated with it and fill in the circle cor taining the corresponding letter on the answer sheet. Each lettered option may be selected once, more than once, or no at all.

Items 59-60



59. Maximal efflux of potassium

60. Influx of sodium and calcium through slow channels

Items 61-62

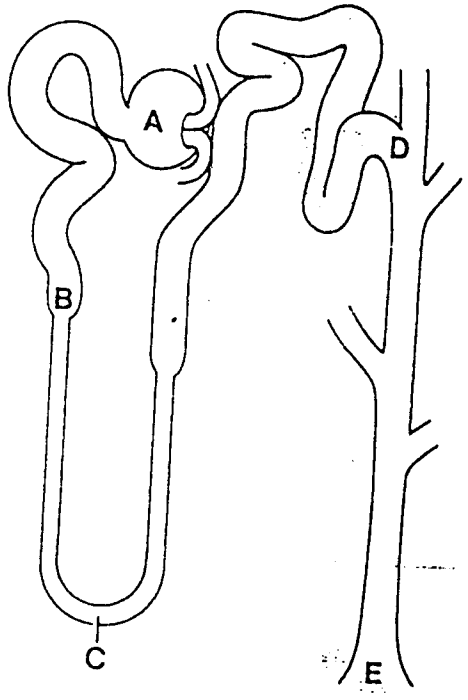
In the kidney:

(A) Tubular transport depends on luminal Na^+ concentration
(B) Active secretion occurs into tubular fluid
(C) Transport affected by parathyroid hormone
(D) Transport lowered by ADH (vasopressin)
(E) Transport blocked by aldosterone

61. Glycine

62. Glucose

Items 63-64

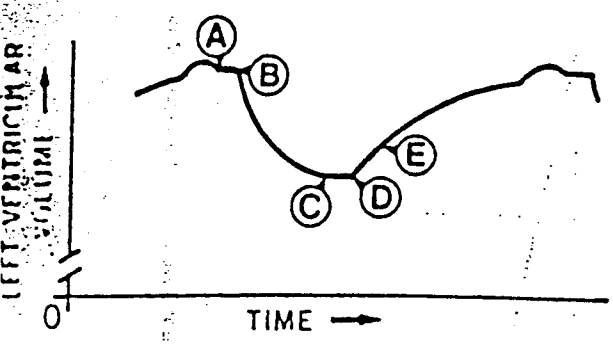


The diagram is of a nephron from a person on a normal diet.

63. Sodium concentration of tubular fluid is higher than in systemic plasma

64. After injection, inulin concentration of tubular fluid is equal to that of plasma water

Items 65-66



(A) Q wave on the electrocardiogram

(B) Second heart sound

Items 67-68

(A) Inhibits contractions of the gallbladder
(B) Synthesized mainly in the gastric antrum
(C) Major action is to stimulate secretion of pancreatic fluid
(D) Major action is to stimulate secretion of pancreatic enzymes
(E) Inhibits secretion of pancreatic fluid

67. Secretin

68. Cholecystokinin

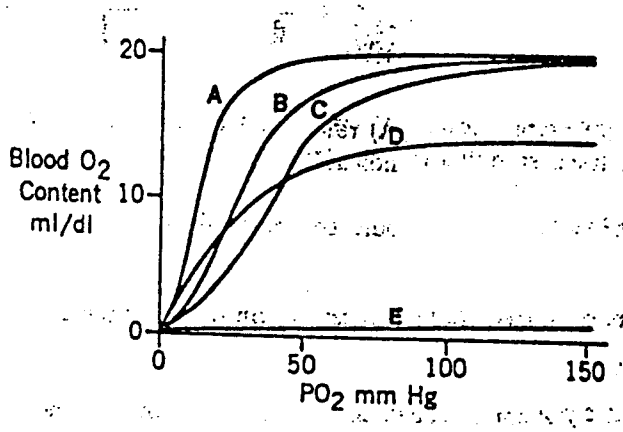
Items 69-70

(A) Cholecystokinin (CCK)
(B) Gastrin
(C) Gastrin-releasing peptide (GRP)
(D) Glucagon
(E) Vasoactive intestinal peptide (VIP)

69. In physiologic concentrations, stimulates pancreatic exocrine cell growth

70. Neurocrine agent that is a member of the secretin family of peptides; relaxes smooth muscle

Items 71-72

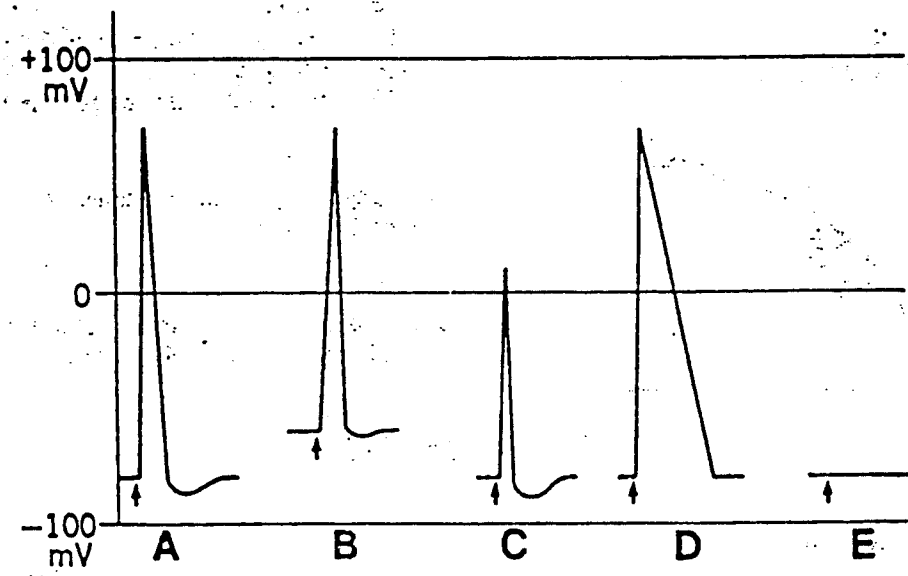


In the graph of blood oxygen content vs oxygen partial pressure (PO_2), curve B represents normal human blood O_2 content at 37 C and pH 7.4.

71. Normal human plasma

72. Human blood at 37 C and pH 7.4 depleted of 2,3-diphosphoglycerate

Items 73-74



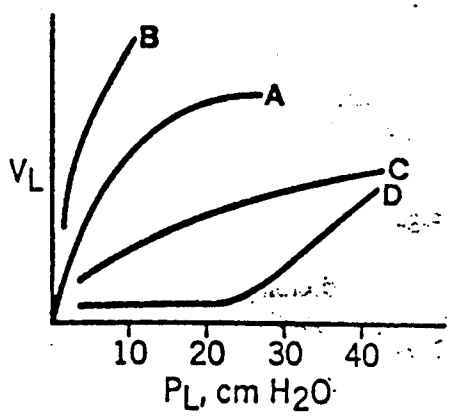
In the graph shown, (A) represents the normal action potential of an axon recorded with intracellular microelectrodes; the electrical stimulus is indicated by the arrow.

The recording that would be expected if:

73. The extracellular concentration of K^+ is increased

74. An agent is added that reduces a change in the permeability of the membrane to K^+

Items 75-76



Static pressure-volume curves of the lung are shown. Curve A is normal.

The curve that indicates:

75. Loss of collagen and elastin

76. Loss of pulmonary surfactant

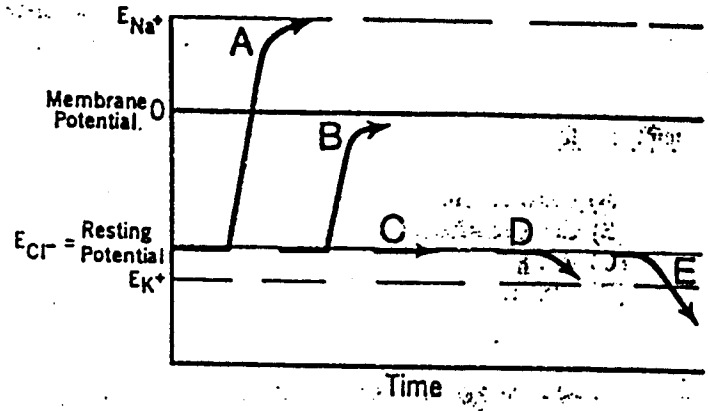
Items 77-78

(A) Actin
(B) Heavy meromyosin
(C) Light meromyosin
(D) Tropomyosin
(E) Troponin

77. ATPase

78. Prevents myosin attachment to actin

Items 79-80



79. Membrane potential trajectory if membrane permeability increases for both sodium and potassium

80. Membrane potential trajectory if membrane permeability increases for potassium only

DIRECTIONS (ITEMS 81-84): Each group of items in this section consists of lettered headings followed by a set of numbered words or phrases. For each numbered word or phrase, fill in the circle on the answer sheet containing

A if the item is associated with (A) *only*
B if the item is associated with (B) *only*
C if the item is associated with *both* (A) *and* (B)
D if the item is associated with *neither* (A) *nor* (B)

Items 81-82

(A) Cardiac preload
(B) Cardiac afterload
(C) Both
(D) Neither

81. Increased when the heart rate is decreased by intense vagal stimulation

82. Decreased in a patient with severe diarrhea

Items 83-84

(A) Thyroidectomy
(B) Hypophysectomy
(C) Both
(D) Neither

83. Reduced metabolic rate

84. Failure of growth

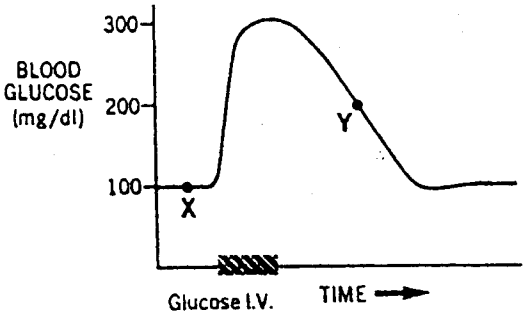
)IRECTIONS (ITEMS 85-144): For each of the items in this section, ONE or MORE of the numbered options is correct.)n the answer sheet fill in the circle containing

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

FOR EACH ITEM FILL IN ONLY ONE CIRCLE ON YOUR ANSWER SHEET.

DIRECTIONS SUMMARIZED

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



85. The graph shows the change in concentration of glucose in the blood of a fasted normal subject during and after an intravenous infusion of glucose. Point X would be displaced upward if the subject

(1) were hypophysectomized
(2) had been treated with excess amounts of cortisol
(3) had an isolated growth hormone deficiency
(4) had diabetes mellitus

86. In comparison with cones, rods

(1) are more common in the central retina
(2) are more involved in color vision
(3) yield a greater acuity of vision
(4) have a lower threshold to light

87. After severe hemorrhage, a patient's blood pressure is 60/40 mm Hg, his heart rate is 130/min, and his peripheral pulse is weak. Immediately following infusion of 2 L of saline, his blood pressure rises to 100/70 mm Hg, and his heart rate slows to 90/min. Thirty minutes after the infusion, his blood pressure has fallen to 80/60 mm Hg. In this patient, before the infusion of saline, measurements likely to be lower than normal include

(1) cardiac output
(2) stroke volume
(3) right atrial pressure
(4) total peripheral resistance

88. If a drug that inhibits converting enzyme in the renin-angiotensin system is given to a salt-depleted person, there will be a decrease in the

(1) secretion of aldosterone
(2) plasma concentration of angiotensin I
(3) plasma concentration of angiotensin II
(4) secretion of renin

89. An increase in filtration fraction can be produced by

(1) increased glomerular capillary hydrostatic pressure
(2) increased efferent arteriolar resistance
(3) decreased plasma colloid osmotic pressure
(4) increased hydrostatic pressure in Bowman's space

FOR EACH ITEM FILL IN ONLY ONE CIRCLE ON YOUR ANSWER SHEET

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

90. In metabolic acidosis, excretion of hydrogen ion is greater than normal because:

(1) Production of ammonia by renal cells is stimulated
(2) Carbonic anhydrase is inhibited
(3) A decreased tubular fluid pH favors trapping of NH_4^+ in the lumen
(4) Urinary pH can be decreased to 3.0

91. The rate of conversion of 25-hydroxycholecalciferol is increased by

(1) vitamin D intoxication
(2) an increased circulating concentration of parathyroid hormone
(3) hyperphosphatemia
(4) hypocalcemia

92. If the aorta becomes rigid and loses its distensibility (but the ejection volume and ejection time of the left ventricle are unchanged), there will be an increase in the

(1) aortic systolic pressure
(2) work of the left ventricle
(3) rate of fall of pressure during diastole
(4) pulse pressure

93. Infusion of 1 L of whole blood into a normal adult human would decrease

(1) venous return
(2) the flow of lymph
(3) central venous pressure
(4) reabsorption of fluid at the capillaries

94. End-diastolic ventricular volume depends on the

(1) central venous pressure
(2) duration of diastole
(3) strength of atrial contraction
(4) distensibility of the ventricle

95. A patient experiences a hemorrhage of 30 minutes' duration. At the end of that time, the mean arterial pressure has dropped from 90 to 75 mm Hg. The heart rate has increased from 70 to 150/min, and the skin becomes cold. At this time, the hematocrit is 30%. It can be concluded that the

(1) capillary hydrostatic pressure is decreased
(2) interstitial fluid volume is decreased
(3) capillary colloid osmotic pressure is decreased
(4) interstitial fluid pressure is increased

96. An increased heart rate resulting from increased sympathetic nervous activity would be accompanied by

(1) a decrease in the duration of the ejection phase of ventricular systole
(2) an increase in the rate of left ventricular pressure development
(3) an increase in the rate of ventricular relaxation
(4) a decrease in systolic arterial pressure

97. Assuming normal reflex control of the cardiovascular system, when a person stands up, receptors that would be occupied by increased neurotransmitter include

(1) β-adrenergic receptors of the ventricles
(2) α-adrenergic receptors of the arterial smooth muscle
(3) β-adrenergic receptors of the juxtaglomerular cell
(4) muscarinic cholinergic receptors of the sinoatrial node

98. Axonal transport is directly involved in the

(1) maintenance of the axonal membrane
(2) regeneration of damaged axons
(3) supply of enzymes in synaptic terminals
(4) propagation of action potentials

ring dynamic whole-body exercise, venous return aided by

(1) contraction of skeletal muscle
(2) respiratory movements
(3) reduced total peripheral resistance
(4) increased venous compliance

00. When a skeletal muscle performs work, O_2 delivery from capillary blood to the muscle is increased by an increase in the

(1) local hydrogen ion concentration
(2) local temperature of the muscle
(3) local CO_2 pressure
(4) number of open capillaries

101. Determinants of cardiac oxygen consumption include

(1) systolic arterial blood pressure
(2) heart rate
(3) stroke volume
(4) ventricular volume

102. In humans, sympathetic input to the heart increases the

(1) strength of ventricular contraction
(2) amplitude of the ventricular action potential
(3) rate of rise of ventricular pressure development
(4) duration of ventricular contraction

103. In an anesthetized animal, occlusion of both common carotid arteries normally increases femoral arterial pressure. This increase would be less if the occlusion occurred after

(1) complete blockade of all adrenergic receptors
(2) complete blockade of sympathetic cholinergic axons to skeletal muscle
(3) complete blockade of all autonomic ganglia
(4) cutting both vagus (X) nerves

104. Changes that will occur in the myocardium within a few minutes following the lodging of a clot in a coronary artery include

(1) release of adenosine
(2) arteriolar dilation
(3) a decrease in capillary hydrostatic pressure
(4) reactive hyperemia if the clot is then dissolved

105. In humans, heat loss may be reduced by

(1) increasing ambient temperature
(2) increasing the partial pressure of CO_2
(3) increasing humidity in the air
(4) consuming a protein-rich diet

106. Body temperature is controlled by hypothalamic centers that

(1) respond to information from peripheral temperature receptors
(2) change heat production but not heat loss
(3) respond to changes in brain temperature
(4) have efferent outflow restricted to autonomic pathways

107. In adults, prolonged bed rest induces

(1) decreased heart rate at a given metabolic load
(2) loss of skeletal calcium in the urine
(3) positive nitrogen balance
(4) orthostatic hypotension

108. Destruction of the interstitial (Leydig) cells of the testes would result, directly or indirectly, in

(1) inhibition of spermatogenesis
(2) decreased secretion of testosterone
(3) decreased size of the prostate gland
(4) increased secretion of luteinizing hormone

FOR EACH ITEM FILL IN ONLY ONE CIRCLE ON YOUR ANSWER SHEET

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

109. A new drug strongly stimulates hormone-sensitive lipase. This will probably result, directly or indirectly, in decreased

(1) hepatic gluconeogenesis
(2) plasma concentration of glycerol
(3) plasma concentration of free fatty acids
(4) glucose utilization

110. Bone is a target tissue for

(1) calcitonin
(2) growth hormone
(3) parathyroid hormone
(4) testosterone

111. In normal persons, treatment with large amounts of cortisol causes

(1) increased hepatic glycogen content
(2) decreased adrenal size
(3) central deposition of fat (truncal obesity)
(4) mobilization of amino acids

112. Interruption of the hypophyseal portal circulation results in

(1) stimulation of secretion of prolactin
(2) decreased secretion of growth hormone
(3) decreased secretion of β-endorphin
(4) stimulation of secretion of ADH (vasopressin)

113. A person lacking functional ADH (vasopressin) receptors will have

(1) below normal concentrations of circulating ADH
(2) urine that is hyperosmolar
(3) below normal hematocrit during fluid loading
(4) above normal hematocrit during fluid restriction

114. Parathyroid hormone influences plasma concentrations of calcium by

(1) directly inhibiting the release of calcitonin
(2) influencing the absorption of calcium in the distal renal tubule
(3) regulating the intestinal absorption of cholecalciferol (vitamin D)
(4) regulating the mobilization of calcium from bone

115. Thyroid-stimulating hormone acts on the thyroid gland to stimulate the

(1) uptake of iodide
(2) hydrolysis of thyroglobulin
(3) synthesis of thyroglobulin
(4) release of calcitonin

116. Over the course of the normal menstrual cycle, the secretion of gonadotropins is

(1) stimulated by estrogen
(2) inhibited by estrogen
(3) stimulated by gonadotropin-releasing hormone
(4) inhibited by somatostatin

117. The effects of insulin include increasing the formation of

(1) carbon dioxide from glucose
(2) fat from carbohydrate
(3) free fatty acids from triglycerides
(4) protein from amino acids

118. After acid enters the duodenum, there is

(1) increased bile flow from the liver
(2) decreased rate of gastric acid secretion
(3) decreased rate of gastric emptying
(4) increased volume of pancreatic secretion

119. Following complete hepatectomy in an experimental animal, substances that would show decreased plasma concentration include

(1) fibrinogen
(2) urea
(3) bilirubin glucuronide
(4) ammonia

120. Impaired maturation of erythrocytes could result from resection of the

(1) colon
(2) ileum
(3) duodenum
(4) stomach

121. Entry of fatty acids into the upper small intestine

(1) is a potent stimulant of pancreatic secretion of HCO_3^-
(2) results in contraction of the gallbladder
(3) slows gastric emptying by releasing vasoactive intestinal peptide
(4) stimulates the release of cholecystokinin

122. Surgical removal of the ileum results in

(1) malabsorption of cyanocobalamin (vitamin B_{12})
(2) malabsorption of phytonadione (vitamin K)
(3) increased synthesis of bile acids by the liver
(4) malabsorption of bile salts

123. Axonal conduction velocity decreases in progressively smaller branches of an axon because:

(1) Ion concentration gradients cannot be maintained in small branches
(2) The thinner the branch, the longer the internodal distances
(3) Part of the energy required for propagation is lost in the branches
(4) Internal, longitudinal current is impeded

124. At the same P_{CO_2}, blood with a high oxygen saturation carries less total CO_2 than blood with a low oxygen saturation because:

(1) Reduced hemoglobin carries more CO_2 as carbamino compounds than oxygenated hemoglobin
(2) Hypoxemia causes the kidney to retain bicarbonate
(3) Reduced hemoglobin combines with more H^+ than oxygenated hemoglobin
(4) The presence of oxygen slows the chloride shift

125. If a child inhales a peanut that reduces ventilation to one lobe of the lung, one may expect, in that lobe, a decrease in the

(1) alveolar P_{O_2}
(2) pH of the blood draining from the lobe
(3) blood flow
(4) alveolar P_{CO_2}

126. The rate of transport of O_2 from blood to mitochondria is determined by the

(1) P_{O_2} difference between the two sites
(2) distance between the two sites
(3) number of capillaries being perfused
(4) size of capillary pores

127. In humans, metabolic acidosis produces

(1) hypoxemia
(2) decreased plasma concentration of bicarbonate
(3) decreased blood concentration of ammonia
(4) hyperventilation

128. In humans, neuromuscular transmission in smooth muscle differs from that in skeletal muscle in that:

(1) There is closer apposition of nerve and muscle membranes in smooth muscle
(2) The transmitter in smooth muscle may not be acetylcholine
(3) Ca^{2+} is not required for neurotransmitter release from prejunctional terminals in smooth muscle
(4) Nerve stimulation may lead to relaxation of smooth muscle

FOR EACH ITEM FILL IN ONLY ONE CIRCLE ON YOUR ANSWER SHEET

DIRECTIONS SUMMARIZED

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

129. The force developed in a muscle during voluntary contraction is normally graded by varying the

(1) amount of acetylcholine liberated per impulse at each end-plate
(2) discharge frequency of individual motor units
(3) rate of hydrolysis of acetylcholine
(4) number of active motor units

130. Loss of sympathetic innervation to one side of the head results in

(1) partial ptosis
(2) absence of a pupillary light reflex
(3) loss of sweating
(4) pupillary dilation

131. The source of a sound reaching the two ears can be localized by differences in

(1) sound intensities
(2) frequency spectra
(3) arrival times
(4) harmonic content

132. Transection of a nerve supplying a skeletal muscle usually causes

(1) muscle atrophy
(2) chromatolysis of motor neurons
(3) fibrillations in muscle fibers
(4) appearance of new extrajunctional acetylcholine receptors

133. Administration of excess anticholinesterase is likely to cause

(1) profuse salivation
(2) bradycardia
(3) increased gastrointestinal motility
(4) sweating

134. Transmitter release can be increased by increasing the

(1) duration of presynaptic action potential
(2) concentration of extracellular magnesium
(3) presynaptic calcium current
(4) concentration of intracellular sodium

135. Release of synaptic transmitter can be controlled by the

(1) state of polarization of the presynaptic membrane
(2) number of activated presynaptic Ca^{2+} channels
(3) cyclic nucleotide cascade
(4) open time of postsynaptic chemically gated channels

136. Impulse conduction in axons can be blocked by

(1) pressure
(2) cold
(3) tetrodotoxin
(4) ischemia

137. Unilateral deafness would be produced by unilateral destruction of the

(1) medial geniculate body
(2) organ of Corti
(3) auditory cortex
(4) cochlear nucleus

138. An increase in the strength of a cutaneous stimulus will cause an increase in the

(1) frequency of impulses in sensory axons
(2) number of sensory axons firing in response to the stimulus
(3) number of types of receptors activated
(4) size of the action potentials in all sensory axons

139. Homonymous visual field defects can be associated with lesions of the

(1) visual cortex
(2) lateral geniculate body
(3) optic radiation
(4) optic (II) nerve

140. Localized electrical stimulation of the motor cortex can elicit

(1) all the movements involved in tying one's shoelaces
(2) the reliving of a past experience
(3) all the movements involved in throwing a ball
(4) contraction of some muscles

141. In a normal resting subject, the heart rate is maintained at 50% above normal by right atrial pacing. In the new steady state, the

(1) cardiac output would be approximately twice normal
(2) stroke volume would be subnormal
(3) right atrial pressure would be approximately twice normal
(4) arterial pulse pressure would be subnormal

142. When skeletal muscle contracts,

(1) shortening increases with load
(2) external work varies with shortening and load
(3) velocity of shortening increases with load
(4) the greatest force occurs with the slowest contractions

143. In normal physiologic amounts, agents that stimulate widespread protein synthesis include

(1) human chorionic gonadotropin
(2) aldosterone
(3) angiotensin II
(4) insulin

144. Characteristics of thyroxine (T_4) include:

(1) Conversion to triiodothyronine (T_3) takes place within target tissue cells
(2) Large amounts are stored extracellularly
(3) Its half-life in blood is greater than one hour
(4) More than 90% of the hormone in the circulation is bound to plasma protein

DIRECTIONS (ITEMS 1-48): Each of the numbered items or incomplete statements in this section is followed by answers or by completions of the statement. Select the ONE lettered answer or completion that is BEST in each case and fill in the circle containing the corresponding letter on the answer sheet.

1. Fatty acid synthesis from acetyl CoA involves

(A) succinyl CoA
(B) malonyl CoA
(C) methylmalonyl CoA
(D) propionyl CoA
(E) hydroxymethylglutaryl CoA

2. Ketone bodies are utilized

(A) by conversion to succinate
(B) by conversion to succinyl CoA
(C) by conversion to 2 acetyl CoA
(D) through a series of reactions leading to pyruvate
(E) by direct condensation to fatty acids with even numbers of carbon atoms

3. Of the following, the first to be affected by an increase in cyclic AMP concentrations in the liver would be

(A) stimulation of adenylate cyclase
(B) conversion of phosphorylase b (inactive) to phosphorylase a (active)
(C) conversion of glycogen synthetase I (inactive) to glycogen synthetase D
(D) phosphorylation of phosphorylase b kinase
(E) activation of protein kinase

4.

Reaction	ΔG^{σ} in kcal (joules)/mole
X ⇌ W	+ 5 (+21)
X ⇌ Y	- 5 (-21)
Y ⇌ Z	+10 (+42)

For the reaction Z ⇌ W, the ΔG^{σ} in kcal (joules)/mole is

(A) -10 (-42)
(B) - 5 (-21)
(C) 0
(D) + 5 (+21)
(E) +10 (+42)

5. The rate of a reaction depends upon the

(A) change in entropy
(B) change in enthalpy
(C) change in free energy
(D) energy of activation
(E) total energy of the system

6. In muscle, pyruvate can be converted by a single enzyme (or enzyme complex) to each of the following compounds EXCEPT

(A) acetaldehyde
(B) acetyl CoA
(C) alanine
(D) lactate
(E) oxaloacetate

he predominant energy store in mammals is

(A) adipocyte triglycerides
(B) blood ketone bodies
(C) hepatic glycogen
(D) muscle creatinine phosphate
(E) muscle glycogen

Hypoglycemia is caused by a deficiency of each of he following EXCEPT

(A) fructose 1,6-diphosphatase
(B) glucose 6-phosphatase
(C) phosphoenolpyruvate carboxykinase
(D) pyruvate carboxylase
(E) pyruvate dehydrogenase

-Fluorouracil inhibits DNA synthesis by decreasing he cell's supply of dTMP. This drug

(A) activates uridine phosphorylase
(B) activates uracil phosphoribosyl transferase
(C) inhibits ribonucleotide reductase
(D) inhibits thymidylate synthetase
(E) inhibits thymidine kinase

The anatomic site of urobilinogen formation is the

(A) reticuloendothelial tissue
(B) blood stream
(C) liver
(D) gallbladder
(E) bowel

The major source of ammonia excreted into the urine by the kidneys of most vertebrate animals is

(A) alanine
(B) asparagine
(C) glutamic acid
(D) glutamine
(E) glycine

12. In mammalian cells, molecular oxygen is required for each of the following EXCEPT the

(A) conversion of epinephrine to norepinephrine
(B) conversion of heme to biliverdin
(C) conversion of phenylalanine to tyrosine
(D) desaturation of fatty acids
(E) hydroxylation of the steroid ring

13. Hereditary hyperammonemia, characterized by a grossly abnormal electroencephalogram and a high blood ammonium ion concentration, could be caused by a deficiency of

(A) asparagine synthetase
(B) carbamoyl phosphate synthetase I
(C) fumarase
(D) glutamate-oxaloacetate aminotransferase
(E) glutaminase

14. Which of the following compounds does NOT contribute carbon or nitrogen to the purine ring?

(A) Arginine
(B) Aspartate
(C) Formate
(D) Glutamine
(E) Glycine

15. The earliest intermediate in heme biosynthesis is

(A) coproporphyrinogen III
(B) δ-aminolevulinic acid
(C) porphobilinogen
(D) protoporphyrin III
(E) uroporphyrinogen III

16. Acridine dyes produce single base pair insertions and deletions. Which of the following would be the result of such a mutation?

(A) A protein would be produced that would differ in more than one amino acid residue change from the normal protein
(B) A single amino acid residue change would occur, giving rise generally to a functional protein
(C) A single amino acid residue change would occur, giving rise to a nonfunctional protein
(D) No detectable change would result in the protein produced
(E) No product would be generated from the mutant gene

17. Hereditary disorders involving the metabolism of mucopolysaccharides usually are related to deficiencies of

(A) biosynthetic enzymes
(B) glycosyl transferases of the Golgi complex
(C) lysosomal hydrolases
(D) lysosomal proteases
(E) lysosomal phosphatases

	Without inhibitor	With 5 mM inhibitor
K_m	1.8×10^{-4}M	3.6×10^{-4}M
V_{max}	20	20
Hill Constant	1	1

18. From the above data, it may be concluded that the

(A) inhibitor binds at the active site
(B) inhibitor binds at the allosteric site
(C) inhibitor does not compete with the substrate at the active site
(D) inhibitor produces irreversible inactivation of the enzyme
(E) K_i is lower than 5 mM

19. Pulmonary surfactant material primarily consists of

(A) cardiolipin
(B) dipalmitoylphosphatidylcholine
(C) lysolecithin
(D) lysophosphatidic acid
(E) sphingomyelin

20. D-glucose and D-ribose are

(A) aldoses
(B) anomers
(C) diastereomers
(D) epimers
(E) pyranoses

21. Deficiency of vitamin C results in defective collage because of

(A) activation of collagenase
(B) decreased activity of lysyl oxidase
(C) incomplete glycosylation of hydroxylysin residues
(D) incomplete hydroxylation of proline
(E) lack of procollagen peptidase activity

22. Which of the following constitutes the 5′ terminus or cap of eukaryotic mRNA?

(A) dUMP
(B) Polyadenylate
(C) Pseudouridine
(D) Ribothymidine
(E) 7-Methyl guanylate

23. A genetic code is degenerate when

(A) a nucleotide triplet can code for more than one amino acid
(B) a tRNA can be charged by more than one synthetase
(C) an amino acid can be coded for by more then one nucleotide triplet
(D) an aminoacyl tRNA synthetase can charge more than one tRNA species
(E) the third base in an anticodon is not important for coding

24. Which of the following amino acids is found in naturally occurring proteins?

(A) β-Alanine
(B) D-serine
(C) Homoserine
(D) Hydroxyproline
(E) Ornithine

Which of the following amino acids has a side chain that can be involved in hydrogen bond formation?

(A) Alanine
(B) Glycine
(C) Histidine
(D) Leucine
(E) Phenylalanine

5. Which of the following compounds will diffuse LEAST rapidly across a protein-free lipid bilayer?

(A) Alanine
(B) ATP
(C) Glucose
(D) Glycerol
(E) Urea

7. At an enzyme active site, the amino acid most likely to be affected by changes in pH between 5 and 7 is

(A) arginine
(B) asparagine
(C) glutamine
(D) histidine
(E) lysine

28. The following buffer solutions all have the same total concentration of conjugate base $[A^-]$ plus weak acid [HA], i.e., $[A^-] + [HA]$ is constant in all samples. Which will be the most resistant to pH change upon the addition of relatively small amounts of NaOH or HCl?

	pK	Ratio $[A^-]/[HA]$
(A)	6.4	10.0
(B)	7.4	2.0
(C)	6.4	3.0
(D)	7.4	10.0
(E)	6.4	1.0

29. Methylmalonic aciduria can be corrected in some patients by administration of

(A) cobalamin
(B) folic acid
(C) isoleucine or valine
(D) malonic acid
(E) propionic acid

30. Each of the following is a precursor of low molecular weight substances that function as neurotransmitters EXCEPT

(A) choline
(B) glutamate
(C) lysine
(D) tryptophan
(E) tyrosine

31. The apolar central core of plasma lipoproteins primarily contains

(A) apolipoproteins and cholesterol esters
(B) apolipoproteins and phospholipids
(C) phospholipids and cholesterol
(D) phospholipids and triacylglycerols
(E) triacylglycerols and cholesterol esters

32. In humans, the major nitrogenous component of urine is

(A) ammonium ion
(B) creatinine
(C) glutamine
(D) urea
(E) uric acid

33. Each of the following enzymes may function in the conversion of starch to glucose EXCEPT

(A) isomaltase
(B) maltase
(C) pancreatic amylase
(D) salivary amylase
(E) sucrase

34. The intermediate of biosynthesis of phosphoinositols is

(A) ADP-diglyceride
(B) AMP-diglyceride
(C) CDP-diglyceride
(D) GDP-diglyceride
(E) GMP-diglyceride

35. An antibiotic added to an in vitro translation reaction directed by AUGUUUUUU... allows synthesis only of fMet-Phe. The intermediate event that is inhibited is

(A) activity of peptidyl transferase
(B) amino acid-tRNA ribosomal binding
(C) initiation
(D) termination of peptide chains
(E) the GTP-requiring translocation event

36. Which of the following findings best supports the idea that DNA is the genetic material?

(A) DNA has transforming activity
(B) DNA in chromosomes contains two complementary chains
(C) DNA is present in the nuclei of all eukaryotic cells
(D) RNA synthesis requires a DNA template
(E) Viruses contain DNA

37. Protein synthesis occurs on ribosomes that are associated with the rough endoplasmic reticulum under which of following conditions?

(A) After cleavage of the signal recognition particle
(B) For proteins destined for secretion outside of the cell
(C) For proteins whose solubility is limited
(D) From mRNA with a signal sequence at its 3′ terminus
(E) On a special class of ribosomes with hydrophobic properties

38. In an attempt to correct a specific genetic defect in the activity of pyruvate dehydrogenase, the most effective treatment would involve the administration of large doses of

(A) acyl carrier protein
(B) biotin
(C) cyanocobalamin (vitamin B_{12})
(D) pyridoxine (vitamin B_6)
(E) thiamine (vitamin B_1)

39. Metabolism of 100 g of carbohydrate, 25 g of fat and 20 g of protein yields approximately how many kilocalories?

(A) 300
(B) 500
(C) 700
(D) 900
(E) 1100

40. Accumulation of citrate in vivo would

(A) increase both glycolysis and fatty acid synthesis
(B) decrease both glycolysis and fatty acid synthesis
(C) decrease glycolysis and increase fatty acid synthesis
(D) decrease the rate of both glycolysis and oxidation of fatty acids
(E) do none of the above

41. Proteins that are secreted from the cell in which they are synthesized

(A) are cleaved prior to transport into the endoplasmic reticulum
(B) are inserted into the membranes of the endoplasmic reticulum via their signal sequences
(C) are post-translationally acetylated at their amino termini
(D) are synthesized on mitochondrial membrane-bound ribosomes
(E) have hydrophobic carboxy termini

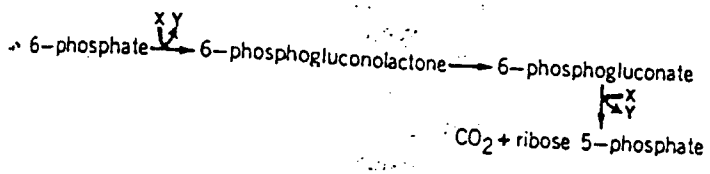
42. Most vegetable proteins are considered to be nutritionally inferior to most animal proteins because:

(A) Although they generally contain all the amino acids that animal proteins do, they contain polypeptide sequences that cannot be digested
(B) They contain small amounts of abnormal amino acids which tend to inhibit synthesis of protein
(C) They contain few carbohydrate residues
(D) They lack glutamine
(E) They tend to have a low content of essential amino acids

43. The leader sequence of a secretory protein

(A) contains a high content of hydrophilic amino acids
(B) interacts with membranes
(C) is added by post-translational modifications
(D) is cleaved within the cytoplasm
(E) is located at its carboxyl end

Items 44-45

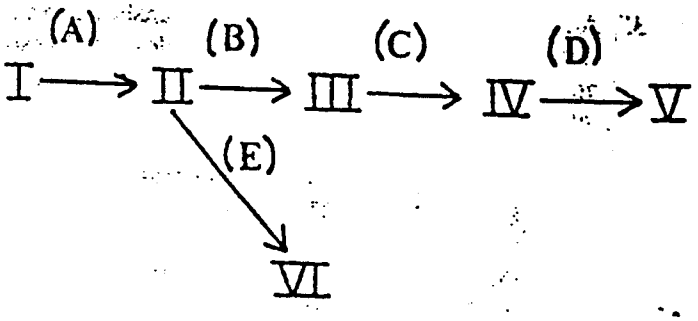


44. In the pathway, compound X is

(A) ATP
(B) NAD^+
(C) NADH
(D) $NADP^+$
(E) NADPH

45. From (1-^{14}C) glucose 6-phosphate, the labeled ^{14}C products will be

(A) $^{14}CO_2$
(B) (1-^{14}C) ribose 5-phosphate
(C) (5-^{14}C) ribose 5-phosphate
(D) (5-^{14}C) ribose 5-phosphate + (^{14}C) CO_2
(E) uniformly labeled ribose 5-phosphate



46. In the branched-chain metabolic pathway in which a different single enzyme catalyzes each of the individual steps, the enzyme that would be expected to be most severely inhibited by compound V is enzyme

(A) A
(B) B
(C) C
(D) D
(E) E

47. Hyaluronic acid is a

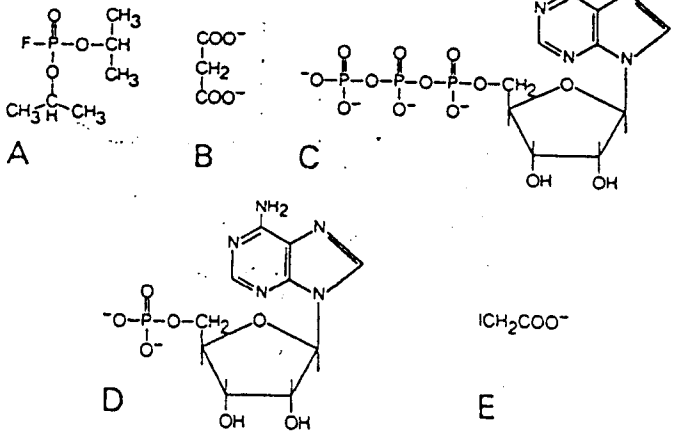
(A) high molecular weight glycoprotein
(B) high molecular weight, negatively charged polysaccharide
(C) high molecular weight, positively charged polysaccharide
(D) glycolipid
(E) homopolysaccharide of galacturonic acid

48. The transfer of electrons from the $FADH_2$ group of succinate dehydrogenase to oxygen through the electron transport chain

(A) bypasses site II of ATP synthesis
(B) involves cytochrome P_{450}
(C) involves the FMN group of the NADH dehydrogenase complex
(D) involves the reduction and oxidation of ubiquinone
(E) yields a P:O ratio of 3

DIRECTIONS (ITEMS 49-67): Each group of items in this section consists of lettered options followed by a set of numbered items. For each item, select the ONE lettered option that is most closely associated with it and fill in the circle containing the corresponding letter on the answer sheet. Each lettered option may be selected once, more than once, or not at all.

Items 49-50



49. Competitive inhibitor of succinate dehydrogenase

50. Allosteric activator of phosphofructokinase

Items 51-52

(A) ADP
(B) Citrate
(C) Malonyl CoA
(D) Oxaloacetate
(E) Pyruvate

51. Most active positive effector of acetyl CoA carboxylase

52. Source of mitochondrial acetyl CoA

Items 53-55

(A) Biotin
(B) Cyanocobalamin (vitamin B_{12})
(C) Pyridoxine (vitamin B_6)
(D) Riboflavin (vitamin B_2)
(E) Thiamine (vitamin B_1)

Enzyme reactions involving:

53. Carboxylation

54. Transamination

55. Methylation

Items 56-57

(A) CTP
(B) NADP+
(C) Pyridoxal phosphate
(D) Thiamine pyrophosphate
(E) UTP

Required for conversion of glucose to:

56. Alanine

57. Ribose 5-phosphate

Items 58-59

(A) Arginine
(B) Glutamate
(C) Histidine
(D) Serine
(E) Tryptophan

58. Least soluble in water at neutral pH

59. Contains R group with highest pK'

Items 60-61

(A) NH_2 ala pro met phe trp asn val - COOH
(B) NH_2 val asp cys glu his arg tyr - COOH
(C) NH_2 ser glu ala gly asp asn val - COOH
(D) NH_2 thr asp gly cys val glu his - COOH

60. Cleaved by trypsin

61. Found in the interior of a protein structure

Items 62-63

(A) Biotin
(B) Pantothenic acid
(C) CoA
(D) Thiamine pyrophosphate
(E) Cystine

62. A constituent of pyruvate carboxylase

63. Cofactor for transketolase

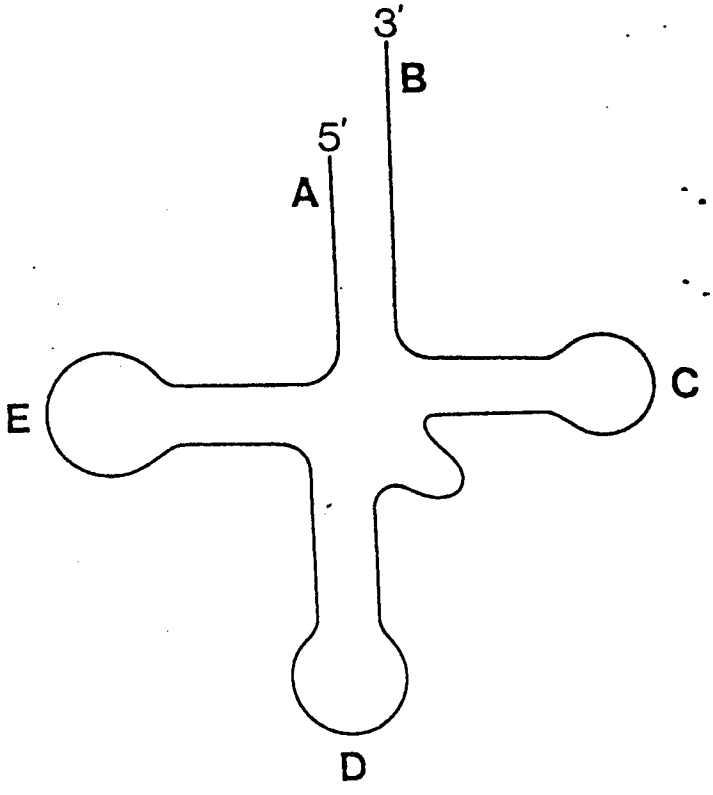
Items 64-65

The representation of a β-globin gene shows sites of mutations producing β-thalassemias.

64. Loss of poly(A) addition

65. Loss of promoter function

Items 66-67



From the diagram shown, the part of the tRNA molecule that:

66. Recognizes mRNA

67. Binds amino acids