FACULTY OF SCIENCE

DEPARTMENT OF BIOCHEMISTRY

MODULE : BIC02B2/BIC 2B01

CAMPUS : APK

SPECIAL EXAM : January 2022

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SESSION : 8:00-11:00

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MODERATOR: **PROF LESETJA R MOTADI**

DURATION: 3 HOURS **MARKS: 100**

NUMBER OF PAGES: 11 PAGES

Please read the following instructions carefully

1. Answer all the questions.
2. Answer all the questions in the exam answer sheet/book provided.
3. Hand in the question paper and answer sheets/book.

Section A [35 marks]

1. Fructose is metabolized by

a) fructose 1-phosphate pathway
b) fructose 6-phosphate pathway
c) glyceraldehyde 3-phosphate pathway
d) dihydroxyacetone phosphate pathway
e) both (a) and (b) are correct

2. How many ATP equivalents per mole of glucose input are required for gluconeogenesis?

a) 2
b) 6
c) 8
d) 4
e) 3

3. Gluconeogenesis requires a higher amount of ATP equivalents as compared to that produced by glycolysis because

a) gluconeogenesis releases energy as heat
b) glycolysis releases energy as heat
c) glycolysis occurs in the mitochondria while gluconeogenesis occurs in the cytosol
d) glycolysis does not require oxygen
e) all of the above are correct

5. Gluconeogenesis is the

a) formation of glycogen
b) breakdown of glucose to pyruvate
c) breakdown of glycogen to glucose
d) synthesis of glucose from non-carbohydrate precursors
e) breakdown of glucose to acetyl-CoA

6. A catabolic intermediate which stimulates phosphofructokinase would stimulate

a) gluconeogenesis
b) glycolysis
c) glycogen synthesis
d) none of the above
e) all of the above

7. In signal transduction what is an effector enzyme?

a) An integral membrane protein that changes conformation upon binding of a ligand to a cell surface receptor

b) A small molecule that diffuses within a cell and carries a signal to its ultimate destination

c) A protein, associated with the interior of a cell membrane via a lipid anchor, that generates a second messenger

d) An enzyme, bound on the exterior surface of a cell that is a receptor site for a ligand

e) an enzyme that generates energy

8. Another name for facilitated diffusion is

a) active transport
b) non-selective diffusion
c) lateral diffusion
d) passive transport
e) non-selective transport

9. Facilitated diffusion through a biological membrane is

a) generally irreversible
b) driven by the ATP to ADP conversion
c) driven by a concentration gradient
d)endergonic
e)amphipathic

10. In neutrotransmission (signaling via nerve endings) the impulse generated is

a) produced by charge depolarisation
b) driven by the ATP to ADP conversion
c) driven by a concentration gradient
d) endergonic
e) Both (a) and (c) are corect

11. If the concentration of a solute is the same both inside and outside the cell, what might you expect with regard to its transport by an active membrane transport protein?

a) Since there is no concentration gradient, no transport either in or out of the cell is possible
b) Movement of the solute across the membrane could occur and cause accumulation on one side of the membrane
c)The transport protein would have been saturated and no movement would occur
d) The solute must be phosphorylated before further transport can occur
e) Movement could not occur

12. The membrane transport protein Na^+-K^+ ATPase carries both Na^+ and K^+ ions across the plasma membrane. Typically this maintains the concentration of K^+ at inside the cell at about 30 times that in extracellular fluids. The concentration of Na^+ is maintained at a level about 20 times lower inside the cell than that outside the cell in extracellular fluids. Based on this information, which statement below is false?

a) The proper functioning of Na^+/K^+ ATPase could serve as an energy source for secondary active transport proteins

b) The pump is a symport
c) Transport of Na^+ and K^+ must be coupled to an exergonic reaction
d) Na^+/K^+ ATPase likely undergoes conformational changes during transport
e) The pump is an antiport pump

13. Which of the following directly drives secondary active transport of an ion across a membrane through a secondary active transporter?

a) Light
b) the generated ion concentration gradient
c) electron transport
d) the conversion of ATP → ADP
e) an antiport ion

14. Which statement is not true about G proteins?

a) They are integral membrane proteins
b) They are multi-subunit proteins consisting of α, β and γ subunits
c)They are activated by exchanging GDP for GTP
d) They act as transducers for hydrophilic signalling hormones
e) They are farnesylated proteins

15. The toxins from cholera and whooping cough both interfere with the proper functioning of

a) G proteins
b) DNA polymerase
c)ATP synthesis
d) protein kinase A
e) protein synthesis

16. Match the description "paracrine signal transduction" to the signalling transduction descriptions below:

a) signal to neighboring cells
b) signal to self
c) signal to distant organ cells
d) signalling to the pituitary from the adrenal gland
e) signal to the thyroid from the adrenal gland

17. Tetanus toxin has an enzyme component that is an/a

a) ATP-dependent phosphorylating enzyme
b) APD-ribosylating enzyme
c) pore-forming toxin
d) fusion-protein cleavaging enzyme
e) guanylate cyclase

18. The transporter required for import of long chain fatty acids into the mitochondrion is called

a) co-enzyme A
b) carnitine
c) aconitase
d) the pyruvate dehydrogenase complex
e) acyl carrier protein (ACP)

19. Ketone bodies are produced due to

a) starvation or prolonged fasting
b) excessive breakdown of fatty acids
c)diversion of acetyl-CoA by the liver
d) All of the above
e) None of the above

20. Ketone bodies

a) replace glucose as a major energy source during starvation
b) replace amino acids as a major energy source during starvation
c)examples are acetoacetate, acetone and 3-hydroxybutyrate
d) All of the above
e) Only a) and b)

Study Figure 1 below and answer questions 21-23

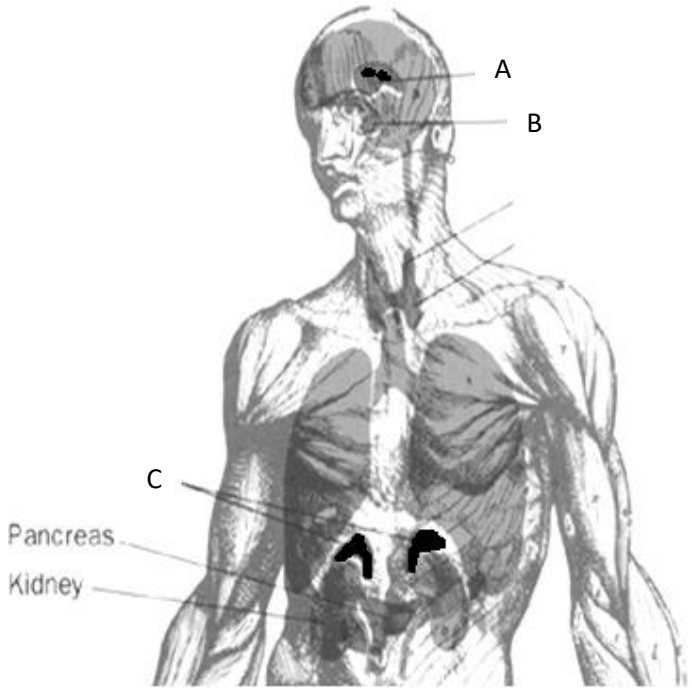


Figure 1

21. The hormone-secreting gland labelled A is

a) pituitary
b) hypothalamus
c) adrenal gland
d) parathyroid
e) thyroid

22. The hormone-secreting gland labelled B is

a) pituary
b) hypothalamus
c) adrenal gland
d) parathyroid
e) thyroid

23. The hormone-secreting gland labelled C is

a) pituary
b) hypothalamus
c) adrenal gland
d) parathyroid
e) thyroid

Use Figure 2 below, showing the mechanism for freeing fatty acids from fat tissue stores to answer questions 24-27

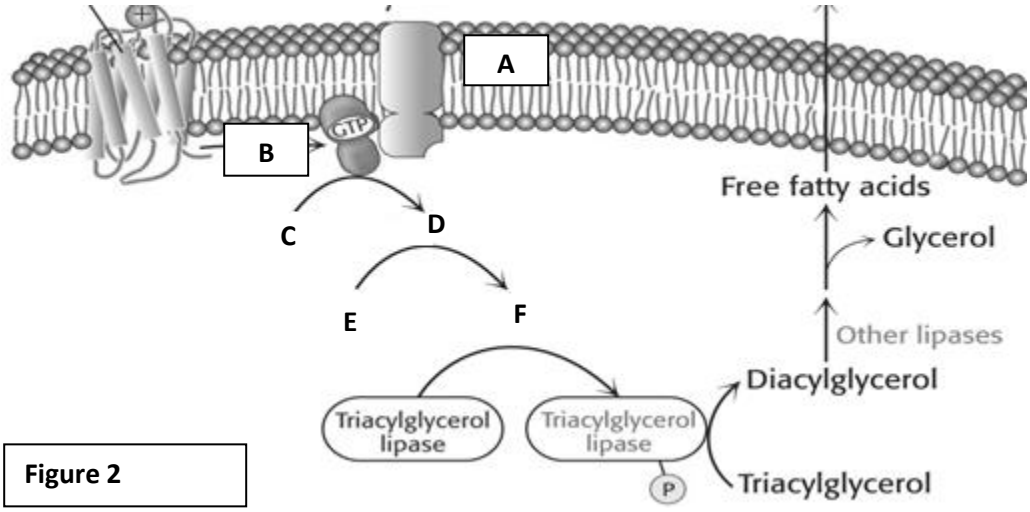


Figure 2

24. The protein labelled "A" is

a) an ATP-dependent phosphorylating enzyme

b) APD-ribosylating enzyme
c) a G protein
d) an adenylate cyclase enzyme
e) an NADH-dependent enzyme

25. The protein labelled "B" is

a) an ATP-dependent phosphorylating enzyme
b) APD-ribosylating enzyme
c) a G protein
d) an adenylate cyclase enzyme
e) an NADH dependant enzyme

26. C and D represent

a) ATP and cAMP, respectively
b) cAMP and ATP, respectively
c) cAMP and PKA
d) cGMP and GTP
e) ADP and ATP

27. E and F represent

a) ATP and cAMP, respectively
b) cAMP and ATP, respectively
c) inactive and active PKA, respectively
d) cGMP and GTP
e) ADP and ATP

28. Breakdown of fatty acids (beta-oxidation) in the cell occurs

a) in the cytoplasm and requires the action of PKA
b) in the mitochondrial inner membrane and requires an aconitase enzyme
c)in the mitochondrial matrix and requires an aconitase enzyme
d) in the mitochondrial matrix and requires an acyl carnitine transport
e) in the smooth ER

29. Conversion of odd numbered propionyl fatty acids to succinyl CoA require the presence of two vitamins

a) biotin and vitamin B12
b) vitamin B1 and B12
c) B3 and B6
d) B6 and B12
e) E and K

30. Acetyl units are shuttled

a) out of the mitochondrion into the cytoplasm via the malate shuttle
b) out of the mitochondrion into the cytoplasm via the citrate shuttle
c) into the cytoplasm from the mitochondrion as citrate
d) into the mitochondrion from the cytoplasm as pyruvate
e) all of the above

31. In the fatty acid synthase complex reaction the acyl carrier protein contains the vitamin

a) biotin
b) vitamin B12
c) pantothenic acid
d) niacin
e) adenosine
f)

32. Histidine is degraded to α-ketoglutarate and is described as a

a) gluco amino acid

b) glucogenic amino acid

c) ketogenic amino acid

d) keto-gluco amino acid

e) Pyruvic acid

33. Which of the following amino acids is considered as both ketogenic and glucogenic?

a) valine

b) tryptophan

c) lysine

d) cysteine

e) None of these

34. A glucogenic amino acid is one which is degraded to

a) keto-sugars

b) either acetyl CoA or acetoacetyl CoA

c) pyruvate or citric acid cycle intermediates

d) phosphoenolpyruvate

e) none of the above

35. Which of the following is the best described glucogenic amino acid?

a) Lysine

b) Tryptophan

c) Valine

d) cysteine

e) None of these

NB: PLEASE HAND THIS PART OF THE QUESTION PAPER IN WITH YOUR MCQ ANSWER SHEET AND ANSWER BOOKS

Section B [65 marks]

1.For the hydrolysis of 1 mole of ATP to ADP at 37 ˚C, the standard free enthalpy change ΔG^0= –35 kJ . mol-1. Calculate the free enthalpy change ΔG at the ratio ATP/ADP =100:1. (Temperature 37^{0}C, R = 8.3143 J K–1 mol –1. Concentrations of water and inorganic phosphate are to be omitted from the equilibrium equation, assuming that they do not change significantly) (5)

ATP + H2O <-> ADP + Pi
100 1

$$\Delta G = -35\,000 + 8.3143 \times 310.15 \times \ln \frac{1}{100} = \textbf{(1)}$$

= − 35 000 − 11 875.26 = **(1)**
= − 46 875.26 = **(1)**
≅ – 46.9 kJ mol –1 **(1)**

2.“Glycolysis and gluconeogenesis are effectively two sides of the same coin”. Explain what is meant by this statement by describing the reactions of each pathway and discussing their regulation. (10)

Glycolysis = Energy Gain **(1)**, Glucose -→ Pyruvate **(1)**, Location = All of body’s cells **(1)**
Gluconeogenesis = Energy Loss **(1)**, Pyruvate--- >Glucose **(1)**, Location = Liver and small regions Kidney **(2)**
Regulatory enzymes: Hexokinase **(1)**, Phosphofructokinase **(1)** and pyruvate kinase **(1)**.

3.Write the net equation of the citric acid cycle (5)

$$\text{Acetyl CoA} + 3\,\text{NAD}^{\oplus} + \text{Q} + \text{GDP (or ADP)} + \text{P}_\text{i} + 2\,\text{H}_2\text{O} \longrightarrow$$
$$\text{HS-CoA} + 3\,\text{NADH} + \text{QH}_2 + \text{GTP (or ATP)} + 2\,\text{CO}_2 + 2\,\text{H}^{\oplus}$$

4.The citric acid cycle is frequently described as the major pathway of aerobic catabolism, which means that it is an oxygen-dependent degradative process. However, none of the reactions of the cycle directly involves oxygen as a reactant. Why is the pathway oxygen-dependent? (4)

The citric acid cycle produces NADH **(1)**. If this NADH is not reoxidized via the electron transport chain, the citric acid cycle will come to a stop **(1)**, by feedback inhibition (or because NAD+ is a required substrate for several reactions) **(1)**. Oxygen is consumed by the re-oxidation of NADH **(1)**.

5.Even though glycogen contains no phosphate, the two products of glycogenolysis are mostly glucose-1-phosphate along with a minority of glucose molecules.

A. Explain how glucose-1-phosphate is produced and why it is not the only product of glycogenolysis. **(3)**

B. G1P is produced from glycogen by phosphorolysis of a terminal glucose linked via a α1-4 glycosyl bond by glycogen phosphorylase **(1)**. Nearly all of the linkages in glycogen are α1-4 **(1)**, so nearly all of glucoses are released as glucose-1-phosphate **(1)**.

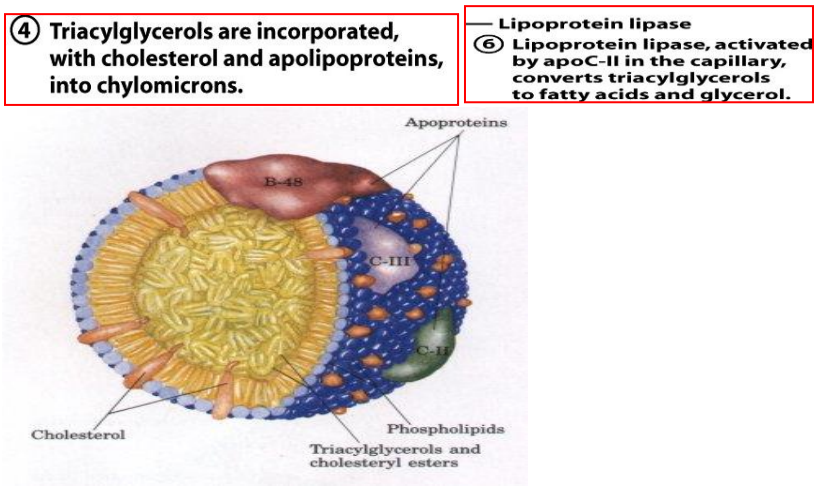
C. Explain why glucose is produced by glycogenolysis and why glucose is the minority product of glycogenolysis. **(3)**

Glucose is produced from glycogen by hydrolysis of a terminal glucose linked via a α1-6 glycosyl bond by glycogen debranching enzyme **(1)**. Only a small fraction of the linkages in glycogen are α1-6 **(1)**, so only a small fraction of glucoses are released as glucose **(1)**.

6.What is the function of the electron transport chain? (2)

forms a proton gradient **(1)**
regenerates FAD and NAD+ (high energy electron carriers**) (1)**

7.Draw a diagram of the composition of a chylomicron and indicating where specific molecules are situated in the droplet and what activates lipoprotein lipase. (5)



8. Acetyl-CoA carboxylase catalyzes the first committed step in the biosynthesis of fatty acids.

A. Name two allosteric regulators of acetyl-CoA carboxylase. Indicate for each whether it is a stimulator or inhibitor of the enzyme. (2)

Stimulator: Citrate **(1)**
Inhibitor: AMP OR Palmitoyl-CoA **(1)**
(Any two of these 3 answers)

B. Name two hormone regulators of acetyl-CoA carboxylase. Indicate for each whether action of the hormone results in stimulation or inhibition of the enzyme. (2)

Stimulator: Insulin **(1)**

Inhibitor: Glucagon OR Epinephrine (adrenaline) **(1)**

(Any two of these 3 answers)

9.Name the three ketone bodies, and why are they important in metabolism? (5)

The three ketone bodies are acetone, acetoacetate and beta-hydroxybutyrate **(3)**. They are water soluble reduced carbon compounds that can be transported in the circulation (blood) and cross the blood/brain barrier **(1)**. Their concentration increases under conditions of (extreme) glucose starvation **(1)**.

10.What is the final sugar of pentose phosphate pathway and why is it such an essential intermediate? (4)

The final sugar is ribulose 5-phosphate which is converted to ribose 5-phosphate **(2),** required in nucleic acid biosynthesis **(2)**.

11.Briefly discuss the fate of pyruvate under different metabolic conditions (5)

Pyruvate has a few main fates. Pyruvate can be converted to alanine **(1)**. Alternatively, pyruvate can be converted to oxaloacetate **(1)**, either as part of gluconeogenesis or for other biosynthetic purposes, or it can be converted to acetyl –CoA **(1)**. In animals, the conversion of pyruvate to acetyl-CoA is irreversible, and produces a compound that has fewer physiological uses. Pyruvate can also be converted to lactate under anaerobic conditions in vigorously exercising muscles **(1)**. Anaerobic conditions convert pyruvate to ethanol **(1)**.

12.During heavy exercise, the hormone adrenaline is released ultimately leading to the activation of Protein Kinase A (PKA). Describe the events that occurs following adrenaline release that leads to the activation of PKA. [Hint: signal transduction] (10)

Adrenaline binds to beta-adrenergic receptor **(1)**

Receptor activates heterotrimetic G protein **(1)**

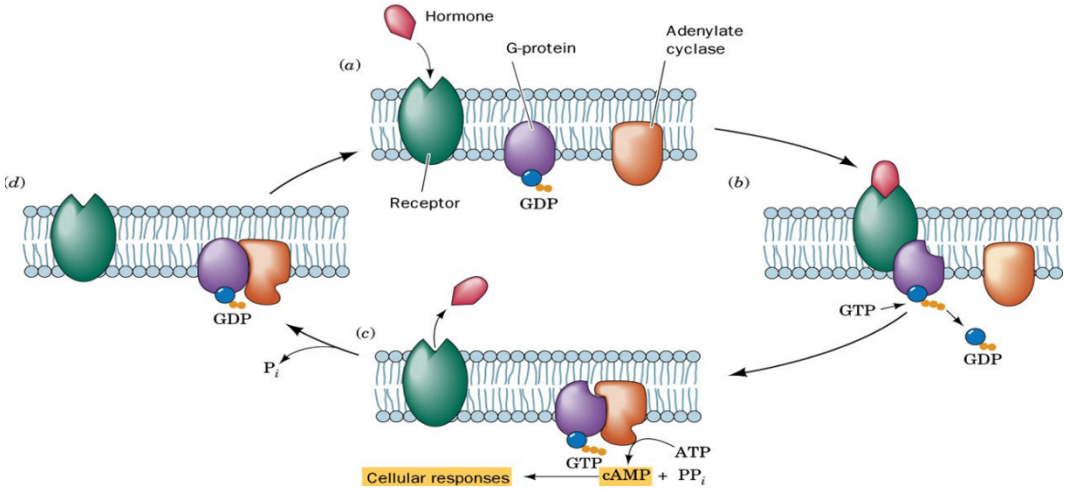
(binding of GTP, replacement of GDP)[points 1-4 of fig below] **(3)**

Binds to and activates adenylate cyclase **(1)**

AC stimulates increased production of cAMP **(1)**

activates cAMP-dependent Prot Kinase (APK, PKA), **(1)**

which phosphorylates proteins: **(1)**


Hormone
G-protein
Adenylate cyclase
(a)
Receptor
GDP
(b)
GTP
GDP
(c)
GTP
ATP
Cellular responses
cAMP + PP$_i$
(d)
GDP
P$_i$