COVENANT UNIVERSITY
NIGERIA

TUTORIAL KIT
OMEGA SEMESTER

PROGRAMME: BIOCHEMISTRY

COURSE: BCH 222

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BCH 222: General Aspects of Metabolism

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1. Define autotrophs and heterothrophs

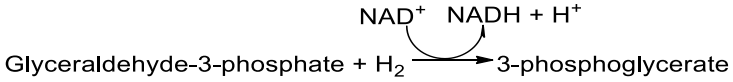
Authotrophs are organisms that have the ability to synthesize their own food. E.g plants and algae. They make their own food from inorganic substances. They are called producers because they produce chemical energy for the entire ecosystem. They convert inorganic substances and light into organic substances containing chemical energy i.e food.

Heterotrophs are known as consumers, they get their energy from eating other things. They consume the organic molecules produce by autotrophs. E.g Deer, mushroom and rabbits.

2. Describe the light reactions of photosynthesis
3. Define respiration

An **anabolic, endergonic, carbon dioxide (CO_2)** requiring process that uses **light energy (photons)** and **water (H_2O)** to produce **organic macromolecules (glucose).**

4. Draw the structure of the chloroplast and mention the processes that take place in each compartment.
5. What are the three main steps in respiration?
6. Differentiate between the electron transport chain in photosynthesis and respiration.
7. Describe the calvin cycle
8. Explain the processes in nitrogen cycle
9. Discuss the implications of the Nitrogen Cycle and nitrogen to living Organisms
10. Describe the enzymatic mechanism of Nitrogen cycle and nitrogen metabolism in living systems
11. Explain the term 'metabolism'
12. Explain amino acid metabolism
13. Describe the phases in glycolytic pathway
14. Suppose a mutant yeast was discovered whose glycolytic pathway was shorter because of the presence of a new enzyme catalysing the reaction below:



Would shortening the glycolytic pathway in this way benefit the cell? Explain. (**10 marks**)

No **2 mark**

In the normal glycolytic pathway

There is conversion of glyceraldehydes-3-phosphate to 3-phosphoglycerate involves the production of 2 molecules of NADH + H^+ and 2 molecules of ATP but in the mutant yeast only 2 molecules of NADH + H^+ was produced. - 4 **marks**

This is not beneficial to the cell because the net production of ATP produced in the mutant yeast was zero (0) while the net production of ATP in the normal glycolytic pathway is 2 ATP. - 4 **marks**

15. A middle aged man, consumed excessive quantity of protein rich in alanine and aspartate. Explain the catabolism of excess amino acids in excess of those needed for biosynthesis.

Catabolism of alanine and aspartate **(15 marks)**

i) The first step in the catabolism of amino acids is deamination - 1 **marks**

ii) Separate equation reflecting deamination of alanine and aspartate. Illustrating amino acid, α-ketoglutarate, α-ketoacid, glutamate and enzyme at **4 marks** per equation

Alanine + α-ketoglutarate ⟶ pyruvate + glutamate **2 marks**

(Alanine aminotransferase) **2 marks**

Aspartate + α-ketoglutarate ⟶ oxaloacetate + glutamate **2 marks**

(Aspartate aminotransferase) **2 marks**

iii) The conversion of the amino group from aspartate and carbamoyl phosphate to citrulline, argininosuccinate , arginine and to urea in the Urea cycle 4 **marks**

iv) The conversion of the carbon group from the α-ketoacid into energy pathways. (Pyruvate through gluconeogenesis / glycolysis and oxaloacetate through the citric acid cycle) - **2 marks**

16. Enumerate reasons why glucose is preferred as metabolic fuel instead of other monosaccharide. (**4 marks**)

Glucose is used as prominent metabolic fuel instead of other monosaccharide because of the following reasons:

Glucose has a low tendency, relative to other monosaccharides, to nonenzymatically glycosylate proteins. - **2 marks**

Glucose has a strong tendency to exist in the ring formation hence, having high relative stability and, consequently, relatively little tendency to modify proteins. - **2 marks**

17. Briefly explain four (**4**) regulatory mechanisms in metabolic integration.
18. Discuss the metabolic importance of specialized organs.
19. Diferentiate between catabolic and anabolic reactions giving examples of such pathways.
20. Is glycolysis a complete reversal of gluconoegenesis? Explain.
21. A student had excessive consumption of a meal of white rice, stew and chicken for breakfast and will take the next meal at dinner. Give a description of the pattern of metabolism before the next meal. (**15 marks**)

A description of the pattern of metabolism in the fed state

Any 15 point @ 1 mark each 15 marks

The food contains lipids, carbohydrate and protein; they will be metabolised into their monomeric units which are fatty acids, glucose and amino acids.

In the fed state, glucose will be absorbed from the intestine, leading to increase in the blood glucose level,

When blood glucose rises, GLUT2 transporters carry glucose into the β cells, where it is immediately converted to glucose 6-phosphate by hexokinase IV (glucokinase) and enters glycolysis.

The increased rate of glucose catabolism raises [ATP], causing the closing of ATP-gated K^+ channels in the plasma membrane.

Reduced efflux of K^+ depolarizes the membrane, thereby opening voltage-sensitive Ca^{2+} channels in the plasma membrane.

The resulting influx of Ca^{2+} triggers the release of insulin by exocytosis.

Insulin lowers blood glucose by stimulating glucose uptake by the tissues

In the liver, insulin also activates glycogen synthase and inactivates glycogen phosphorylase

Insulin also stimulates the storage of excess fuel as fat; fatty acid synthesis is initiated

The fatty acid consumed is also channel into fatty acid synthesis

Insulin activates both the oxidation of glucose 6-phosphate to pyruvate via glycolysis and the oxidation of pyruvate to acetyl-CoA.

More ATP is produced through the initiation of the citric acid cycle.

A description of the pattern of metabolism in the staved state

There will be low level of glucose

Lowered blood glucose triggers secretion of glucagon and decreases insulin release.

Glucagon causes an increase in blood glucose concentration by stimulating the net breakdown of liver glycogen by activating glycogen phosphorylase and inactivating glycogen synthase.

Glucagon causes an increase in blood glucose concentration by inhibiting glucose breakdown by glycolysis in the liver and stimulating glucose synthesis by gluconeogenesis

By stimulating glycogen breakdown, preventing glycolysis, and promoting gluconeogenesis in hepatocytes, glucagon enables the liver to export glucose, restoring blood glucose to its normal level.

Amino acid degradation for energy production is activated

Fatty acid degradation is also activated for energy production.

21. Discuss the intracellular degradation of damaged protein. **(6 marks)**

Damaged or unneeded proteins marked for destruction are covalently attached to small protein called ubiquitin. - **3 marks**
Polyubiquitinated proteins are subsequently degraded by a large, ATP-dependent complex called the proteasome. - **3 marks**

22. Write explicitly on metabolism or What is metabolism?

Metabolism represents the sum of all the chemical transformations or changes that takes place in a cell or organism and it occurs through a series of enzyme-catalyzed reactions that constitute metabolic pathways. **2 mark**

Functions of Metabolism: Any 3 points at 1 mark each 3 marks

1. The generation of energy to drive cellular functions and the synthesis of biological molecules.
2. The conversion of nutrients into macromolecules.
3. Assemble macromolecules into cellular structures.
4. Degrade macromolecules as required for biological function.

Principles of Metabolic Pathways Any **3 points at 1 mark each 3 marks**

1. Metabolic pathways are irreversible
2. Every metabolic pathway has a first committed step
3. All metabolic pathways are regulated
4. Metabolic pathways in eukaryotes occur is specific cellular locations - compartmentalization of Metabolic Pathways

23. Discuss the various approaches to the study of metabolism.

Approaches to the study of metabolism
Any 5 at 2 marks each with explanation 10 marks

- The use of metabolic inhibitors: - The pathway intermediate accumulates in the presence of biochemical genetic.
- The use of genetic defect:- Genetic defect can also cause metabolic intermediates to accumulate, e.g. homogenistic acid in alcaptonuria, phenylpyruvate in the presence of phenylketonuria.
- The use of genetic manipulations: - Metabolic blocks can be generated by genetic manipulations of organisms, in the use of mutagens (chemical agents, X-ray etc.)
- The use of transgenic organisms: - Genetic manipulations of higher organisms can provide deep metabolic insight e.g. the introduction of creatine kinase into the liver causes liver to synthesis phosphocreatine.
- Use of chemical labeling: - example the fatty acid oxidation pathway was studied using phenyl group to label fatty acid before being ingested into a dog.
- Isotopic labeling: - Metabolic pathways involving H, C, P, can be measured using NMR.

- Radioactive isotopic labeling: - Metabolic pathway can be measured by labeling with radioactive isotope ^{3}H, ^{14}C, ^{32}P,
- The use of isolated organ or cell:- Metabolic products produced by a particular organ can be studied by organ perfusion or in tissue slices.

24. Explain hormonal regulation of energy metabolism

The blood glucose level is well regulated near 4.5 mM. This involves the combined actions of insulin, glucagon, epinephrine, and cortisol on metabolic processes in many body tissues, but especially in liver, muscle, and adipose tissue. **1 mark**

Any 3 points at 2 marks each **6 marks**

- Insulin signals to tissues that blood glucose is higher than necessary; as a result, cells take up excess glucose from the blood and convert it to the storage compounds glycogen and triacylglycerol.
- Glucagon signals that blood glucose is too low, and tissues respond by producing glucose through glycogen breakdown and (in liver) gluconeogenesis and by oxidizing fats to reduce the use of glucose.
- Epinephrine is released into the blood to prepare the muscles, lungs, and heart for a burst of activity.
- Cortisol mediates the body's response to longer-term stresses.