A PRESENTATION BY

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ADAPTATION OF METABOLISM AND ENERGETICS TO ENVIRONMENTAL CHANGE

INTRODUCTION

- Metabolism stems from the Greek word 'metabole' meaning change.
- It is the sum total of biochemical reactions that occur in organisms
- Consists of two parts: catabolism and anabolism

- Catabolism: breakdown of food in the body to release energy e.g. Transport of molecules into cells
- Anabolism: Use of energy to built up macromolecules. e.g. Photosynthesis

Cellular and Animal Metabolism

Cellular metabolism

- Process by which cells produce the energy they need to survive.
- Cells use oxygen to break down ATP stored in the mitochondria.
- Cells need energy to grow and divide

Animal metabolism

- Food consumed is broken down, used and some stored in the body tissues.

PHYSICAL PRINCIPLES

- *Laws of thermodynamics*
- Thermodynamics: study of energy
- Deal with conversion of energy from one form to another

- *First law:* Total energy in a closed system is constant
- *Second law:* Entropy can never decrease in a system
- *Third law:* Absolute zero cannot be attained by any procedure in a finite number of steps

BIOLOGICAL ENERGETCS

- Involves all processes by which living cells use, store and release energy
- Exists in several forms e.g. radiant energy and kinetic energy
- All cells transform energy: e.g. Plant cells use sunlight to make carbohydrates from simple inorganic chemicals in Photosynthesis

- Radiant energy from the sun is converted into stored chemical energy
- Animals feeding on plants breakdown carbohydrates and transform chemical energy to kinetic energy in movements for example.

Some definitions:

- A calorie is the amount of heat needed to raise the temperature of

- **Entropy:** Measures how close a system is to equilibrium
- **Enthalpy**: Amount of energy possessed by a thermodynamic system from transfer between itself and its environment.
- **Gibb's free energy:** combined contribution of entropy and enthalpy

Food as energy source

- Food provides ATP for active transport, biosynthesis of macromolecules, muscle contraction and many other functions
- Every animal has its feeding habits

ATP The energy currency

- ATP = Adenosine triphosphate

Built in mitochondria

- Usually characterised as a coenzyme
- Adenosine part= adenine, nitrogen containing compound and ribose: a 4 carbon sugar.
- 3 phosphate units each made of 1 phosphate atom and 4 oxygen atoms are attached to the ribose.

- Phosphate bonds are high energy bonds therefore very weak: easily split by enzyme action to release energy
- Another phosphagen (high energy molecule serving as phosphate bond energy reservoir) is arginine phosphate.

FORMATION OF ATP

- *Direct formation:* <u>step 1 hydrolysis of dietary macromolecules</u>

Purpose: degrade large food molecules into component subunits (amino acids, simple sugars, fatty acid and glycerol).

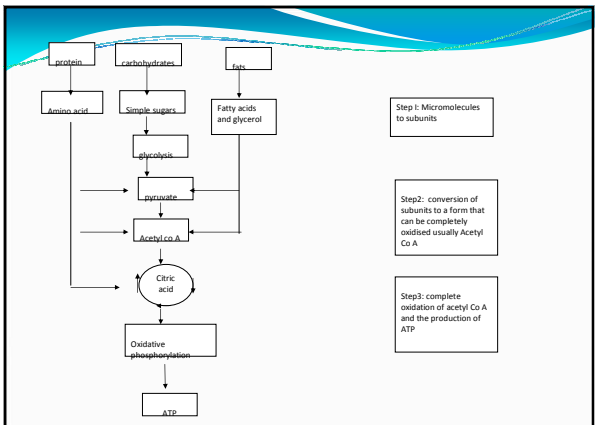
This stage is also known as ***<u>digestion.</u>***

- <u>Step 2 conversion of monomers in a form that can easily be oxidised</u>

Purpose: subunits are assimilated into pathways of energy metabolism

<u>Step 3 complete oxidation of nutrients and the production of ATP</u>

- Acetyl coA carries two carbon remnants of nutrients, acetyl groups to the citric cycle



<u>Formation of ATP by electron transport chain</u>

- The chain involves a series of carrier molecules on the inner mitochondria membrane capable of oxidation and reduction.
- As electrons pass through the chain, there is stepwise release of energy that is used to form ATP

<u>Oxygen consumption and carbon dioxide production</u>

- O_2 quantity consumed influences metabolism
- O_2 consumption is directly related to body side and mass: surface area/volume

<u>Measuring metabolism</u>

- Purpose: ensuring that supply of a specific molecule for a cell to carry out a process is constant

Metabolic rates

- Measure of the total energy metabolised by an animal in unit time.
- Assessed using: direct calorimetry or Indirect calorimetry

Levels of metabolic rate

- Standard metabolic rate (SMR)
- Average daily metabolic rate (DMR)
- Respiratory quotient (RQ)

Active metabolic rate (AMR)

- Basal metabolic rate (BMR)

Open and closed systems

- Open systems: blood vessels absent, blood flows to sinusis e.g. Snails, insects
- Closed system: presence of blood vessels e.g. Mammals

Relationship between O_2 consumption and heat energy

- Spirometer measures rate of O_2 consumed

Ecological Energetics

- Flow of energy in an ecosystem
- Chemical energy is passed from one trophic level to another through feeding.
- A large proportion of energy is lost at each level mostly as heat from

NB: BMR is greater in males than in females, lower in children than adults and lower during sleep.

THANK YOU

- Factors influencing metabolism

1. Body mass: greater size implies greater heat production

- The amount of heat is not proportional to body weight
- Short fat animals have lower metabolic rate

2. Ambient temperature: looked at with respect to their status:

- Ectotherms
- Endotherms
- Poikilotherms
- homeotherms

3. Dietary effects

- Endothermic animals produce more heat than ectothermic animals

ANOXIA

- Condition of inadequate supply of O_2 to body tissues
- Tolerance is very short in verterbrates
- Anaerobic metabolism creates O_2 debts

Facultative anaerobes: no dependence for O_2 for survival e.g. Lung fish

- A good example of an animal who tolerates anoxia: fresh water turtle (USA) because: In such environments there is depression of metabolic processes within cells

  - buffering capacity of the turtles shell to neutralise accummulated lactic acid

The animal can live in this environment for 3 to 4 months in temp= three degrees

<u>Comparing running, swimming, flying</u>

- Running: uses more energy while walking uses less
- Swimming: requires less energy because of the fish's buoyancy and a streamlined body
- Flying in terms of energy is economical to running

THANKS FOR LISTENING

GOD BLESS YOU