Lec: 4 Microbial Metabolism

I. Metabolism

• Metabolism is all of an organism's chemical processes (an emergent property that arises from interactions of molecules in the orderly environment of the cell)

• Metabolism is very important for the management of cellular material and energy resources

Metabolic reactions

• Metabolic reactions are organized into pathways of enzyme controlled chemical reactions.

• Cells need a supply of molecules and energy

• Cells need to get rid of waste products

Catabolic pathways

• Break down complex molecules into simple molecules

• Energy stored in complex molecules is made available to do work or transformed into readily usable chemical forms (i.e., ATP)

• small molecules resulting from the catabolism of complex energy rich molecules may be used by the cell to build new molecules

• e.g., cellular respiration

Energy stored in compounds can be used to perform cellular work

• mechanical - movement of cilia, chromosomes, organelles

• transport - movement of substances across membranes

• chemical - endergonic reactions

Anabolic pathways

• Use energy for the biosynthesis of complex molecules from simple molecules.

• Energy is obtained from usable chemical forms of energy (i.e., ATP) produced during catabolic

processes or from energy released during catabolic processes

• e.g., synthesis of macromolecules

II. Metabolic diversity among microorganisms

• Life is based on organic molecules made of carbon skeletons

• Oxygen and hydrogen are important elements of organic compounds

• Electrons are needed i) for processes that provide energy (e.g., movement of electrons along energy transport chains and during oxidation reduction reactions) for cellular work and ii) to reduce molecules during biosynthesis

• Molecules that serve as a source of carbon may also provide a source of oxygen and hydrogen

• Microbes show an incredible ability to use organic molecules as carbon sources

Organisms can be classified based on their sources of carbon, energy and electrons

Carbon Source

- Autotroph – CO_2 is the sole or principal carbon source

- Heterotroph – reduced, preformed, organic molecules from other organisms

Energy Source

- Phototrophs – Light

- Chemotrophs – oxidation of organic or inorganic compounds

Electron Source

- Lithotrophs – reduced inorganic chemicals

- Organotrophs – Organic molecules

III Heterotrophic (Chemoorganotrophic) Metabolism

• Conversion of organic substrate molecules to end products by a metabolic pathway that releases sufficient energy for it to be coupled to the formation of ATP.

• Chemoorganotrophs have three options for generating ATP from organic molecules; the electron acceptor used differentiates these processes: i) aerobic respiration, ii) anaerobic respiration and iii) fermentation

i. Respiration

• An external terminal electron acceptor is present and is not derived from the organic substrate

• Involves the activity of an electron transport chain, proton motive force (PMF) is generated and ATP produced predominantly by oxidative phosphorylation

a) Aerobic - O_2 is the terminal electron acceptor.

$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$ + (ATP + Heat)

b) Anaerobic - compounds other than O_2 serve as electron acceptor r (e.g., NO_3^-, SO_4^{-2} ,CO_2, fumarate,…)

*Some microbes can carry out both aerobic and anaerobic respiration – dependent upon the conditions

ii. Fermentation

• An external terminal electron acceptor is absent

• Fermentation does not use an electron transport chain or the generation of a PMF

• Fermentations are internally balanced oxidation-reduction reactions – i.e., the terminal electron acceptor is derived from the initial substrate or electron donor (e.g., glucose)

• The terminal electron acceptor is required to balance redox reactions

• Net result is energy production and an internally balanced redox reactions

• ATP produced predominantly by substrate-level phosphorylation