Metabolism

Dr.kareema Amine Al-Khafaji Assistant professor in microbiology, and dermatologist Babylon University , College of Medicine , Department of Microbiology.

Metabolism – sum of all chemical processes

– Anabolism – reactions that require energy to synthesis complex molecules from simpler one.

• Essential for growth, reproduction & repair

– Catabolism – reactions that release energy by breaking complex molecules into simpler ones

• Essential for providing energy for life processes; movement, transport & synthesis of complex molecules

Energy metabolism

• Catabolic reactions involve electron transfer – allows energy to be captured in high energy compounds such as ATP

• Electron transport related directly to oxidation & reduction

- enzymes are specific for a given substrate
- energy for reactions is stored as **ATP (adenosine triphosphate**)
- when a bond is broken energy released is used to run other reactions
- ATP is generated in some reactions and used to drive others

– **Oxidation** = loss or removal of electrons

• Many substances combine with O and transfer electrons to O2; O2 need not be present if there is another electron acceptor available

– **Reduction** = gain of electrons

• Energy is released and another substance must gain the electrons or be reduced at the same time

• Eg 2 H2 + O2 □ 2H2O : hydrogen is electron donor (reducing agent) and oxygen in electron acceptor (oxidising agent)

• As oxidation & reduction must occur simultaneously the reactions in which they occur are called redox reactions

Respiration – 3 phases (Net production of ~38 ATP molecules)

1. Glycolysis – breakdown of glucose – ATP produced
2. Krebs Cycle – further breakdown, more ATP produced
3. Electron Transport Chain – electrons transported through a series of carriers, ATP produced

Fermentation

- no Krebs Cycle - no Electron Transport Chain

- only Glycolysis - net production of ~ 4 ATP

1. Ethanolic Fermentation

- yeast used to make beer, wine, by-product is ethanol
- yeast used to make bread – by-product carbon dioxide used as rising agent, ethanol is released during baking

2. Lactic Acid Fermentation

- make cheese, yogurt - e.g. bacterium *Lactobacillus*

Food Catabolism

1. **Carbohydrates** – sugar building blocks (e.g. glucose) enter via glycolysis
2. **Lipids** – broken down into Fatty Acids and Glycerol by enzymes called **Lipases**,
then glycerol enters via glycolysis and fatty acids via Krebs Cycle
3. **Proteins** – broken down into amino acids by enzymes called **Proteases** and join either glycolysis or Krebs Cycle

Anabolism – many components of glycolysis and Krebs Cycle are the starting point to make amino acids, fatty acids, nucleotides (all building blocks).

Energy metabolism in microbes

• Microorganisms versatile in ways they obtain energy

• Classified into groups on the basis of how they capture energy and carbon

• Carbon

– Autotrophs (self feeding) – use CO2

– Heterotrophs (other feeding) – use organic carbon

• Energy

– Light (photo-) Organic compounds (chemo-)

-Chemoautotrophic

-(chemolithotrophic) metabolism –

• **Sodium** – not required by all organisms; need often reflects the natural habitat of the organism

– marine organisms require sodium, fresh water organisms do not.

Iron

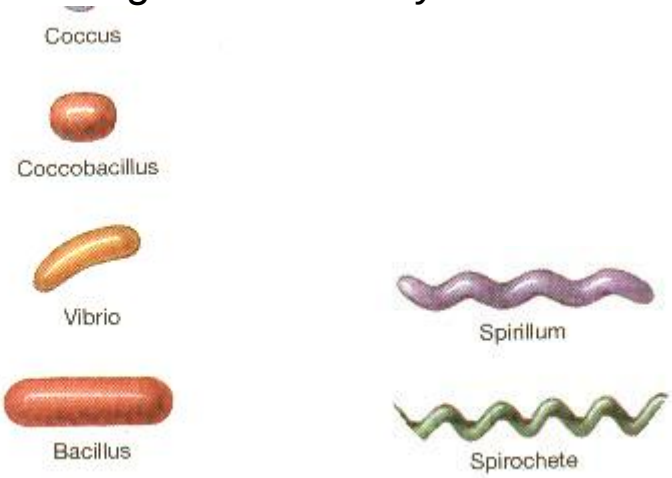
• Iron – key role in cellular respiration – key component in cytochromes and iron-sulphur proteins involved in electron transport
• Under anoxic (anaerobic) conditions iron is in Fe2+ state & soluble; but under oxic (aerobic) conditions it is often Fe3+ & forms various insoluble minerals
• Bacteria have developed iron-binding proteins (siderophores) that solubilise such iron & transport it into the cell eg hydroxamic acid derivatives
– Chelate Fe3+ very strongly – complex carried into cell – iron is split off and hydroxamate exits the cell and repeats the process
– examples of siderophores: Enterobactins – *Escherichia coli* and *Salmonella* Typhi murium

Micronutrients (trace elements)
• Critical to cell function even if only required in small amounts
• Micronutrients are metals – structural role in many enzymes
• Examples include cobalt, manganese, molybdenum nickel selenium zinc molybdenum, nickel, selenium, Growth factors
• Organic compounds – required in very small amounts and only by some cells
• Include vitamins, amino acids, purines, pyrimidines
• Most micro-organisms can synthesis all of these compounds – some require one or more to be pre-formed in culture environment
• **Vitamins** are the most commonly needed growth factors; most function as parts of co-enzymes
• Most commonly required vitamins are thiamine (vitamin B1), biotin, pyridoxine (vitamin B6) and cobalamine (vitamin B12)

Categories of growth media
• **Enriched**
– Nutrient medium containing enrichments such as blood or serum or yeast extract – Enrichment provides additional growth factors for more fastidious organisms (includes many pathogens – eg Blood agar
• Enrichment – Contains special nutrients that allow the growth of a particular organism that may be present in low numbers and so masked by other organisms

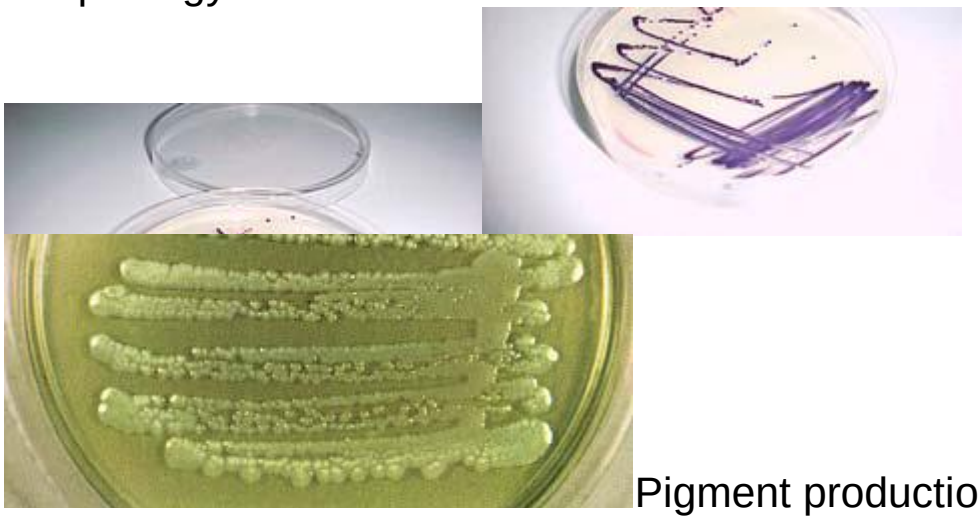
– Usually a broth culture medium
– Eg Rappaport's medium for salmonella, Enterococcosal Broth for enterococci
• **Selective**
– Encourages the growth of some organisms but suppresses the growth of others
– Eg Mannitol salt agar for isolation of *Staphylococcus aureus*
• **Differential**
– Contains a constituent that causes an observable change (change in color or change in pH)
in the medium when a particular biochemical reaction occurs
– eg fermentation of lactose in MacConkey medium causes a pH change – lactose fermenting colonies pink, non-lactose-fermenting colonies colorless
• Combined selective and differential media
– Eg MacConkey Agar – contains crystal violet & bile salts which inhibit Gram-positive bacteria plus lactose and pH indicator (see previously Categories of growth media salt agar for isolation of *Staphylococcus aureus*

• Stain the organisms so they are visible under the microscope



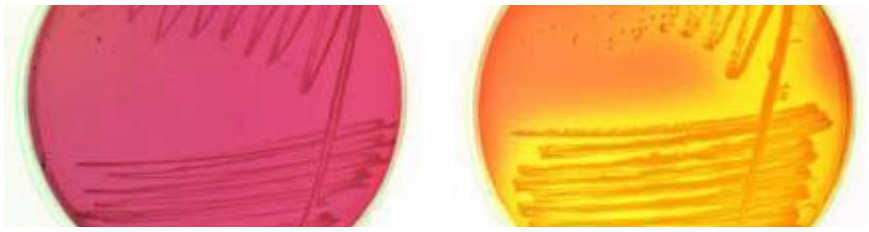
(1000X magnification) • Gram stain is a common staining reaction used
• Morphology of organisms determined (rod,coccus etc)
Culture of organisms on agar plates

Colony morphology



Pigment production

Differential media



Mannitol salt Aga

Differential & selective media • *Salmonella typhimurium* on MacConkey Agar:• *Escherichia coli* on MacConkey Agar: growth, colorless colonies growth, with pink colonies


MacConkey agar

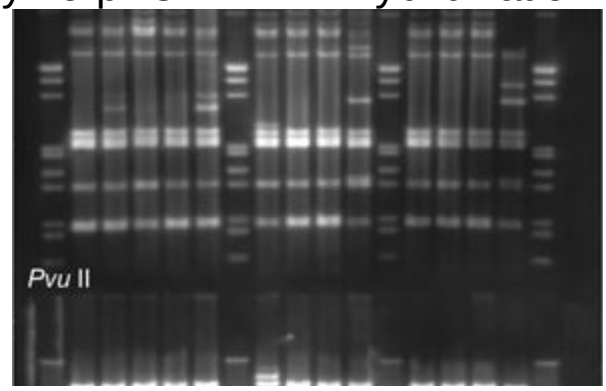

Metabolic characteristics

• Fermentation of sugars/carbohydrates • Break down of polysaccharides (starch)and proteins (casein)

• Break down of amino acids (tryptopan

indole) • Utilization of different carbon and nitrogen Compounds • Requirements for enriched media (eg ،blood agar, chocolate blood agar ..) **Molecular techniques:**

• Rib typing • Retracement Fragment Length Polymorphism • DNA hybridization • rRNA sequencing



Clinical & diagnostic methods for isolation & identification of bacteria