PITHAPUR RAJAH'S GOVERNMENT COLLEGE

Autonomous and NAAC Re-accredited with 'A' Grade (3.17/4.00 CGPA)

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LECTURER IN MICROBIOLOGY

DEPARTMENT OF MICROBIOLOGY

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microbial physiology and metabolism

proteins. these are also involved in catalysis of reactions and maintenance of protein structure

(2) Uptake of nutrients by the cell:

The first step in nutrient use is uptake of the required nutrients by the microbial cell, uptake mechanism must be specific - that is the necessary substances and not others, must be acquired. Nutrients must pass through a selectively permeable plasma membrane that will not permit the free passage of most substances.

the most important transport mechanisms are.

(1) Passive diffusion: the process in which molecules move from a region of higher concentration to one of lower concentration because of random thermal agitation. the rate of passive diffusion is dependent on the size of the concentration gradient between a cell's exterior and it's interior, very small molecules (H_2O, O_2 & CO_2) often move across membranes by passive diffusion.

(2) Facilitated diffusion: the rate of diffusion across selectively permeable membranes is greatly increased by using carrier proteins, called permeases, which are embedded in the plasma membrane. Because carrier aids the diffusion process, it is called facilitated diffusion. the rate of transport increases with the concentration gradient much more rapidly

and at lower concentrations of the diffusing molecule than that of passive diffusion. the curve below resembles an enzyme-substrate and is different from the linear response seen with passive diffusion.

(3) Active transport: M.O often live in habitats with very dilute nutrients sources, must be able to transport and concentrate these nutrients, thus facilitated diffusion mechanisms ~~are such situa~~ not always adequate and other approaches must be used, the two most important transport mechanisms in such situation are; active transport & group translocation, both energy-dependent processes.

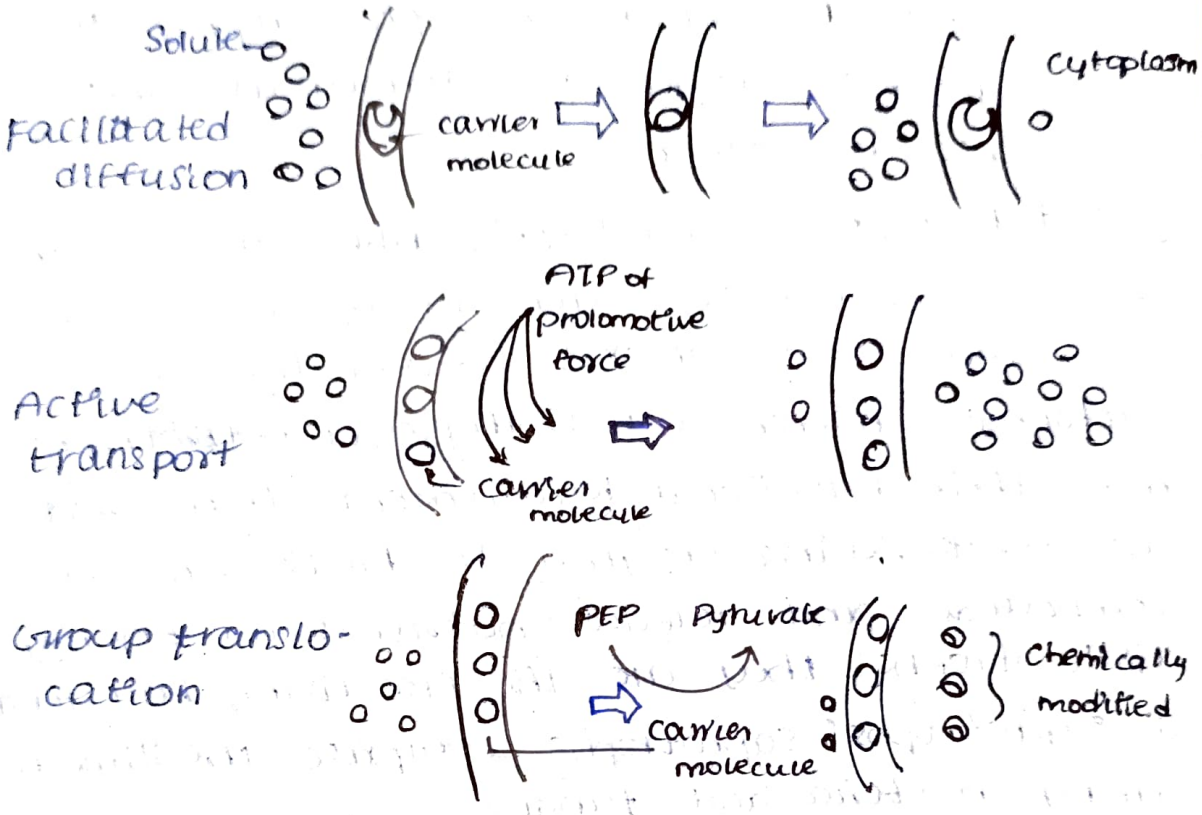
the transport of solute molecules to higher concentrations, or against concentration gradient with the use of metabolic energy. the carrier proteins or permeases bind particular solute with great specificity, is also carrier saturation effect at high solute concentration.

(4) Group translocation: Many bacteria take up molecules by group translocation, a process in which a molecule is transported into the cell while being chemically altered. It is energy-dependent transport because metabolic energy is used. the 1, 2, 3 types the solute molecules move across a membrane without modification.

The best-known group translocation system

is phosphoenolpyruvate.

sugar phosphotransferase system (PTS). it is transports a variety of sugars into cells while phosphorylating them using phosphoenolpyruvate (PEP) as the phosphate donar.



(3) Nutritional groups of microorganisms:

Microorganisms, like all living organisms, require energy and nutrients to build proteins and structural membranes and drive biochemical processes. Microorganisms require source of carbon, nitrogen, phosphorous, iron and a large number of other minerals. carbon, nitrogen and water are used in highest quantities.

these nutritional groups are classified into

(1) Autotrophs: Autotrophic microorganisms are those which obtain their nutrition from inorganic compounds. carbon dioxide is typically

the role source of cellular carbon. Autotrophs use hydrogen sulphide, ammonia or hydrogen gas to reduce carbon into necessary sugars.

Most autotrophs are photoautotrophs and can fix carbon. again divided into two types. those which do not produce oxygen as a byproduct are termed as anaerobic anoxygenic phototrophs. those which produce oxygen are termed as aerobic anoxygenic phototrophs.

(2) Heterotrophs: Heterotrophic M.O can acquire inorganic metabolites such as H_2O and CO_2 from the environment, but can not convert them into foods. saprophytic microbes are examples of heterotrophs. they meet their nutritional requirement from dead organic matter, using enzymes to breakdown complex compounds and release nutrients and energy.

(i) Holotrophs: they are the free-living bulk-feeders

(ii) saprotrophs: saprotrophs comprise the slime molds many bacteria and fungi.

(iii) Parasites: Parasites are those which live entirely on other living organisms for nutrition which they extract from the hosts.

(iv) Symbionts: which depends upon other for supplement of certain ingredients of nutrition which they cannot acquire from nature or can't synthesize

(3) Lithotrophs: lithotrophs are bacteria which use reduced inorganic compounds are the electron (H-donor) in anaerobic (or) aerobic respiration.

(i) chemolithotrophs is a able to use inorganic reduced compounds as a source of energy through oxidation & ATP synthesis

(ii) Photo lithotrophs: obtain energy from light and use inorganic electron donors only to fuel biosynthetic reaction

(4) Mixotrophs: It is an organism that can use a mix of different sources of energy and carbon, instead of having a single trophic mode. Mixotrophy may be obligate/facultative.

(i) obligate mixotrophy (ii) Facultative mixotrophy.

(4) Growth Media (or) Culture Media

* Microorganisms now can be cultivated and maintained in the laboratory environment by providing all the nutrients and environmental conditions need for their optimal growth. the nutrients can be supplied in required proportion while making solid or liquid media. such a nutrient preparation which is used to grow and maintain microorganisms is called a growth medium (or) culture medium.
* growth media are also known as culture media.
* there are thousands of different kinds of media already known. All these can be broadly classified into two categories called non-synthetic and synthetic media
* Non-synthetic media are consist natural ingredients semi-synthetic media.
* Synthetic media are consist of chemicals.

Non-synthetic media (or) Natural media: they contain simple ingredients having nutrients of unknown composition like peptone, beef extract, yeast extract, potato, etc. which provides a wide range of nutrients aminoacids, peptides, nucleotides, vitamins, minerals, carbon source.

~~Non-synthetic media~~: Ex:- Blood agar, chocolate agar, s

Synthetic media: these media are constructed using specific chemicals in their exact proportion. it commonly used for growth of micr

organisms. Ex: Nutrient agar, Macconkey agar.

Basal (or) Minimal media:

A minimal medium is one which supplies only the minimal nutritional requirements of a particular organism. these type of media supports most non-fastidious organisms. Ex: Nutrient broth, Nutrient agar.

Enriched media:

When extra nutrients like blood, serum egg yolk, etc. are added to the minimal medium, it becomes enriched. It supports the growth of nutritionally fastidious bacteria.

Ex: blood agar, serum agar

Selective media:

The media which encourages the growth of a sought after microorganisms by inhibiting the growth of all other microorganisms are called selective media.

Ex: XLD agar, Mannitol salt agar

Xylose Lysine Deoxycholate XLD

Differential media:

The media which are used to distinguish between microorganisms without selecting for the growth of a particular type are called differential media. It favours the appearance of specific identifying traits that are characteristics of particular microorganism. Ex: Blood agar in haemolytic and Non-haemolytic bacteria.

Unit-II Microbial growth

Different phases of growth in batch cultures: Growth curve of Microbial population:

Pattern of microbial growth shows a definite pattern which can be plotted in a graph, such forms a curve called growth curve of the microbes. the curve shows s-shaped pattern called sigmoid curve.

The bacterial growth curve:

When microbes are cultivated in a defined medium where all necessary conditions are provided the growth passes through seven distinct stages. the curve depicts how in initial stage the growth is very slow and then the growth increases rapidly only to come to a stand still after the no gain no loss the population number decline and finally all die.

Phases of growth:

(1) Lag phase
(2) Accelerating phase
(3) Log or exponential phase
(4) Declining growth phase
(5) Stationary phase
(6) Death or decline phase
(7) Log or death phase

(1) Lag phase:

Lag phase is the period of growth phase during which neither cell number nor cell mass increases. In this period the cell which adaptation

will undergo division adapt and acclimatize itself to the situation. the duration of the phase varies depending on factors like the environment.. existing in the culture setup, the quality of the inoculated cells. status of of nutrient, previous growth condition from which the inoculums has been taken. etc. If the inoculums is taken from old culture, the lag phase would be longer as cell take time to repair cellular components. when the vigorously growing culture is used for inoculation, lag phase become shorter.

(2) Accelerating Growth phase:

This is transition period between the lag phase and the log. phase. cells begins to increase in numbers as the time of adaption and acclimatization comes to an end and simultaneously the enzyme systems begins to act.

(3) Log or exponential phase: rapid growth

Lag and accelerating phase when comes to an end the cells start dividing regularly at constant rate, with an increase in their number and mass. During exponential phase, the cellular metabolic activities reach their peak. In this situation the rate of growth remains constant and the cell number becomes double with every cell division. Mathematically, it can be represented as

$$N_t = N_0 2^n$$

where N_t is the number of microbes

t = time

N_0 = number of microbes at time zero

n = number of generations

The time taken by a cell to divide is termed as generation time 'g'. For example - Saccharomyces cerevisiae produces ethanol as a primary metabolite between the lag

(4) Declining growth phase: It is a transition period between the log phase and the stationary phase. In this phase decrease in growth rate takes place due to exhaustion of nutrients and accumulation of toxic waste products. Nutrition or environmental condition can revive the system. However all microbes do not die at a time. Those microbes which produce endospores or cysts escape death.

(5) Stationary phase: growth plateaus

Growth completely ceases due to exhaustion of most nutrients in the medium and also due to accumulation of toxic waste produced by the cells during growth phases. These cause the curve to move straight. In this phase, no net increases in the population size takes place. Here, the number of cells formed equals the number of cells died. the population size is at its peak during stationary phase. the time required to reach stationary phase and the duration of the

phase vary with the type of microorganism the nutrient availability and other environmental conditions.

(6) Death or declining phase

Growth stationary phase is short. It leads to declining phase where growth rate sharply start declining. cells neither get nutrition nor the condition is suitable for growth due to accumulation of metabolic waste and therefore cells cannot repair the damage. Death rate rapidly increases. the total mass may remain constant due to the fact that the dead cells remain present.

(7) Log Death phase! cell death exceeds growth

In this phase the rate of the cell death exceeds the rate of new cell formation this leads to rapid decrease in the population size and which ultimately leads to exponential death or wholesale death. It means the entire system become dead. No addition of nutrition or environmental condition can revive the system. However all microbes do not die at a time. those microbes which produce endospores or cysts escape death.

Obligate anaerobes:

this microorganisms don't need oxygen and it is present they die.

Methods of measuring microbial growth:

The purpose of estimating any clinical sample pus, blood, sputum is to measure the rate of infection of an individual by measuring the bacterial growth per an water sample tells us whether the water is suitable for drinking are not by using this methods contaminated food or drugs can be identified.

there are two approaches for measure the bacterial growth. they are

(1) direct method

(2) Indirect method

(1) Direct method:

The actual number of bacteria are can be estimated. Examples of this method are membrane filter method, most propable number (MPN), direct microscopic count, standard plate count method.

(i) Direct microscopic count method:

Bacteria can be counted ~~essayly~~ easily and accurately with the petroff-hausser chamber this is a special slide accurately ruled into squares that are 1/400 mmsquare. a glass cover slip rest above the slide a suspension of unstained bacteria can be counted in the chamber using a phase contrast microscope. Direct microscopic count can be made rapidly and simply with a minimum of equipment moreover the morphology of the bacteria can be observed. very dense suspensions can be counted if they are diluted appropriately suspension having low number of bacteria at the begining of the

(ii) Standard plate count (or) Viable count:

This method allows determination of the number of cells that will multiply under certain defined conditions a measured amount of bacterial suspension is introduced into petridish after which the agar medium is added and the to thoroughly mixed by rotating the plate when the medium solidfys the organism are trapped in the gel. each organism grow reproducing selfs until a visible mass of organisms (a colony) is developed. that is one organism gives rise to one colony. Hence a colony count performed and the ~~they~~ reveals the viable population of the inoculum. the origin

sample is usually diluted so that number of colony developing on the plate will fall in the range of 30 - 300 no. of colonies. colonies are usually counted by illuminating them from below (dark field illumination) so that they are easily visible and a large magnifying lens is of an used.

(iii) Most probable number
(iv) Dry weight of cells

(2) Indirect method:

Indirect methods for measuring microbial growth primarily involve measuring a characteristic associated with cell mass, like turbidity (cloudiness) using a spectrophotometer and biomass

(i) **turbidity:** these cloudiness of a bacterial suspension is measured using a spectrophotometer to estimate cell density. the amount of light passing through a bacterial suspension with higher turbidity indicating a larger microbial population, which is usually expressed as absorbance or optical density (OD) value

(ii) **Biomass:** the most common methods involve estimating the total mass of living mo. within a sample by analyzing specific cellular components like phospholipid fatty-acids (PLFAs), microbial carbon extracted using chloroform fumigation or by measuring ATP. which are considered good indicators of active microbial biomass.

(iii) absorbance

Factors influencing microbial growth:

The growth of the microorganisms depends on various factors. these factors can be classified into physical, chemical and nutritional factors. they are:

(1) **Temperature:** temperature influences the growth by affecting the enzyme activities of microorganisms. the are minimum, maximum and optimum temperature. No growth occurs below the minimum or above maximum growth temperature. Enzyme activity stops when the minimum and the maximum temperature cross. the rate of chemical reaction increases almost doubles with every 10°c rise in temperature and the microorganisms grow faster. there are divided into 5 types based on temperature requirement. Psychrophiles, psychrotrophs, obligate psychrophiles, Mesophiles, Thermophiles. Hyperthermophiles.

(2) **pH:** one of the most important factor determines the growth of microorganisms is the hydrogen ion concentration (pH) of the medium of growth. Microorganisms can grow over a wide range of pH from zero to around 10.

(a) **Acidophiles:** these thrive well at very low pH values with optima between pH 0 and 5.5. Most fungi fall in this category.

(b) **Neutrophiles:** These organisms prefer pH in near neutral range. these can grow within a pH range of 5.5 to 8. Most bacteria comes category

(c) Alcalophiles: these organisms grow well within pH range of 8.5 to 11.5. Extreme alkalophiles have optima at pH 10 or higher eg: Bacillus alcalophilus.

(3) Oxygen concentration: Microorganisms vary in their requirement for atmospheric oxygen. Algae are always aerobic. Fungi except yeast are normally aerobic

They are five categories based on use of oxygen

(a) Obligate aerobes: oxygen used to their growth. It is used as terminal electron acceptor for electron transpoot chain during aerobic respiration and also in synthesis of sterols and unsaturated fatty acids.

(b) Macroaerophiles: Oxygen for growth at a level of 2 to 10%.

(c) Facultative anaerobes: they can grow both in presence or absence of oxygen

(d) Aerotolerant anaerobes: they do not use oxygen even if it is present.

(e) Obligate anaerobes: they do not need oxygen is present they die. these anaerobes are generate energy by fermentation.

(4) Water activity: water is essential for growth and development of microorganisms as they take in all nutrients in soluble form. Most M.O are sensitive to osmotic pressure and do no tolerate high osmotic pressure. those which prefer high osmotic pressure are called Osmophiles. these are some which ~~toler~~ do not require high osmotic pressure but can tolerate high osmotic pressure, are called osmotolerants. which are

① HMP pathway

* HMP pathway or HMP shunt is also called as pentose phosphate pathway or phosphogluconate pathway.
* This is an alternative pathway to glycolysis and TCA cycle for the oxidation of glucose.
* HMP shunt is more anabolic in nature.
* It is concerned with the biosynthesis of NADPH & pentoses.
* About 10% of glucose entering in the pathway 1day
* The liver & RBC metabolise about 30% of glucose by this pathway

② Location of the pathway

* The enzymes are located in the cytosol
* This tissues such as liver, adipose tissue adrenal gland, erythrocytes, testes & lactating mammary gland are highly active in HMP shunt.

③ Reactions of the pathway

Divided into two phases

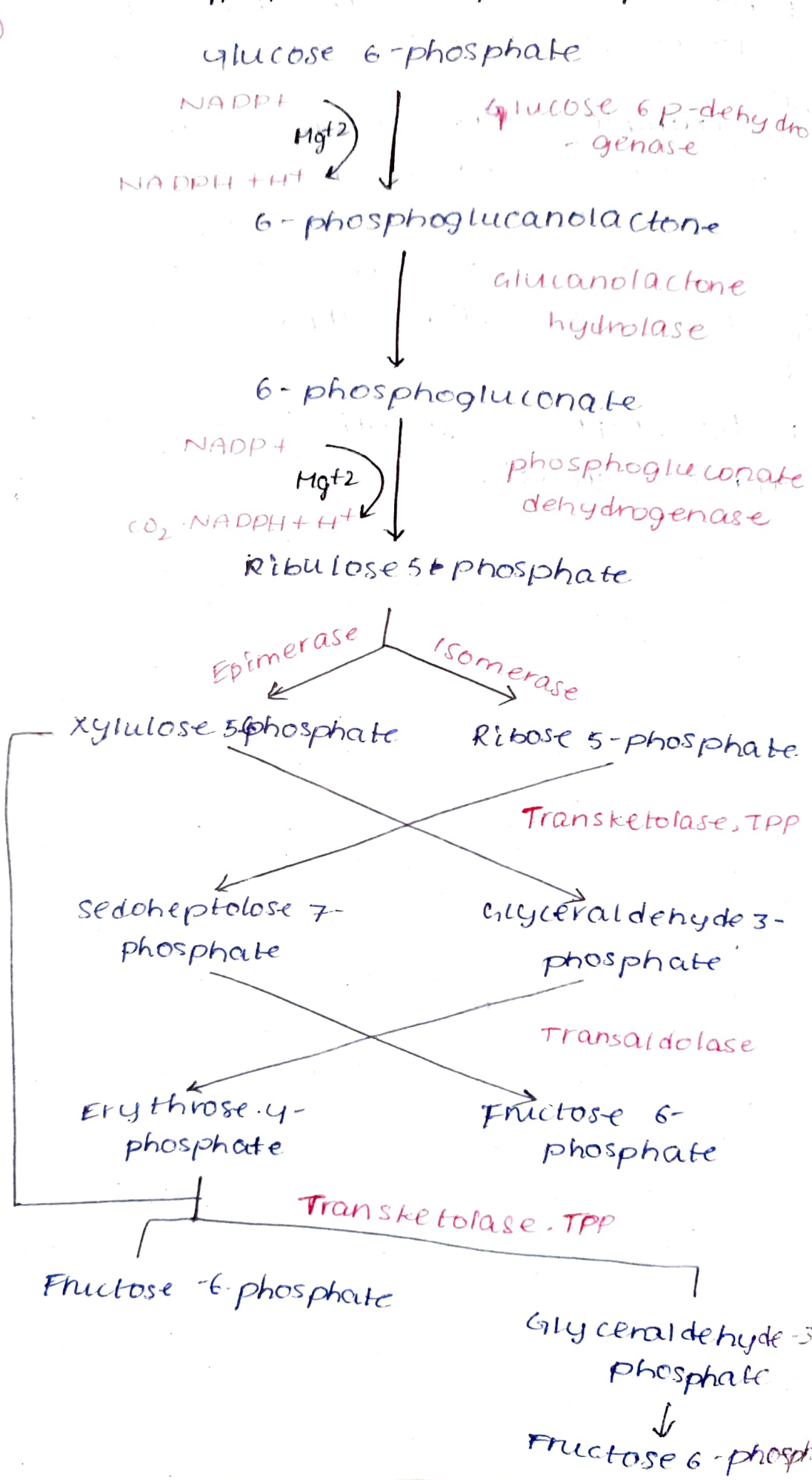
→ Oxidative phase

→ Non oxidative phase

Unit-III

(4)

HMP-shunt pathway



⑤ Significance of HMP shunt

HMP shunt is unique in generating two important products pentoses and NADPH.

→ Importance of pentoses

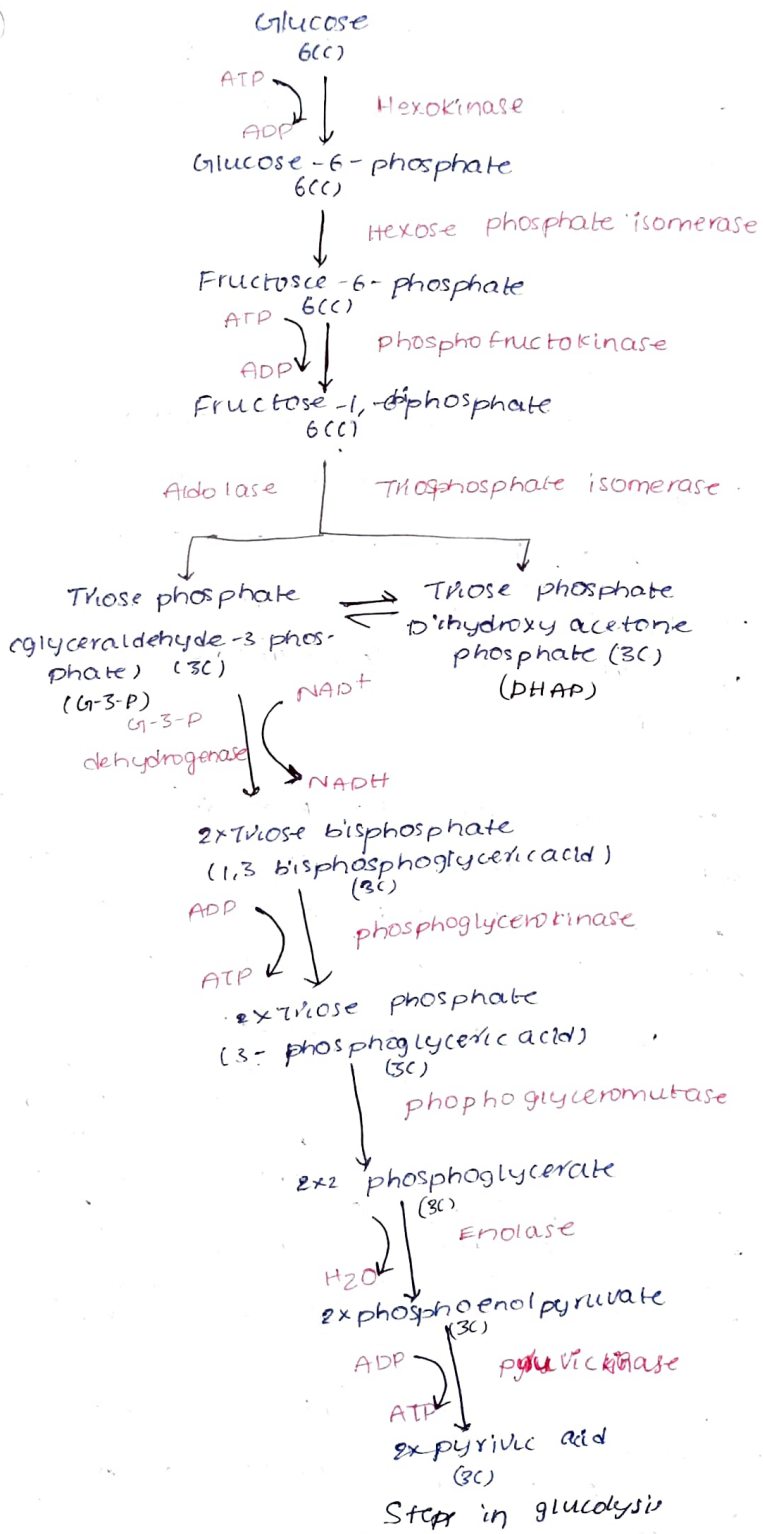
* In HMP shunt, hexoses are converted into pentoses, the most important being ribose 5-phosphate.
* This pentose or it derivatives are useful for the synthesis of nucleic acids (DNA & RNA)

→ Importance of NADPH

* NADPH is required for the biosynthesis of fatty acids and steroids
* NADPH is used in the synthesis of certain amino acids involving the enzym glutamate & dehydrogenase.

⇒ Glycolysis

1. Glucose is broken down into 2 molecules of pyrivic acid is called glycolysis.
2. It was given by Gustav Embden, otto Mayerhof and J. Parnas so called EMP Pathway.
3. It occurs in cytoplasam of the cell and takes place in all living organisms.
4. In this 4 ATP are formed of which to are utilized and 2 NADH + H^+ are formed as end products.
5. The ATP and NADH + H^+ are utilised for fixation



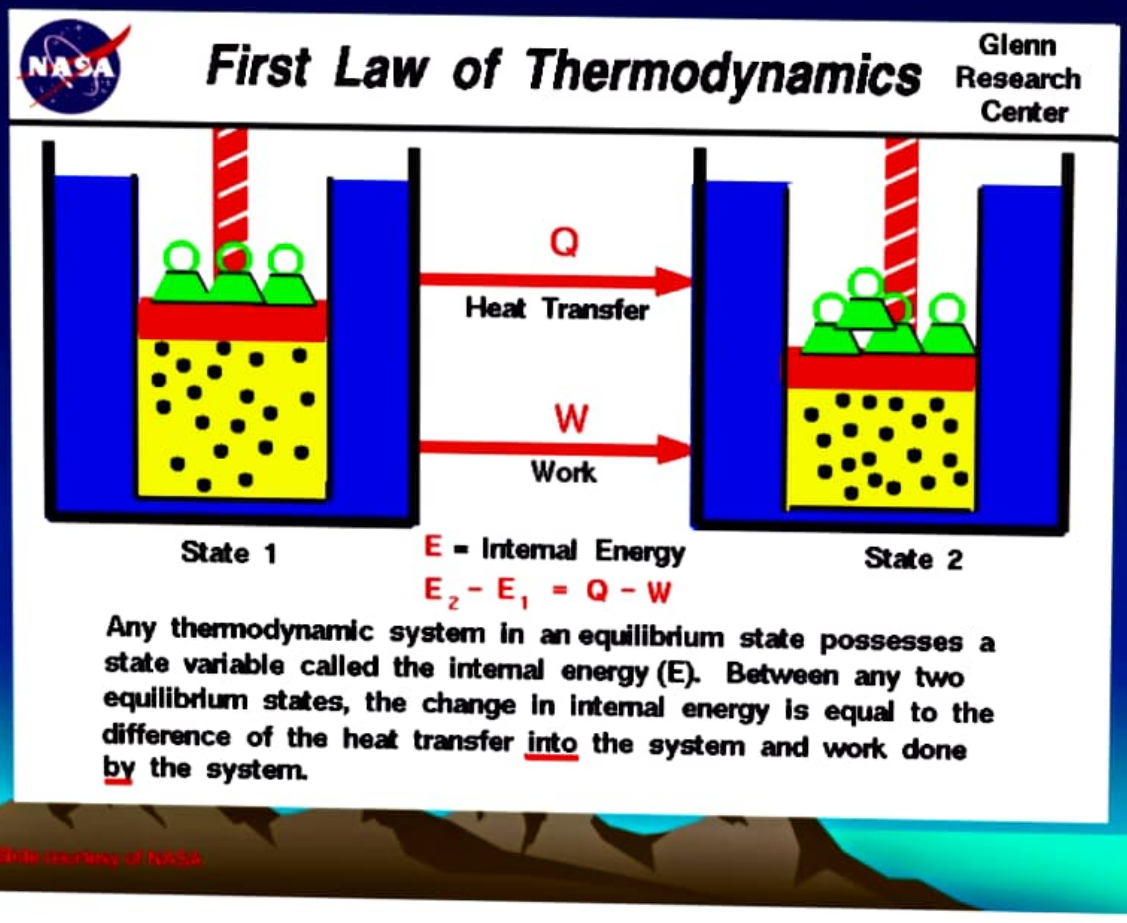
1st law of thermodynamics

- The first law of thermodynamics is an extension of the law of conservation of energy
- The change in internal energy of a system is equal to the heat added to the system minus the work done by the system

$$\Delta U = Q - W$$

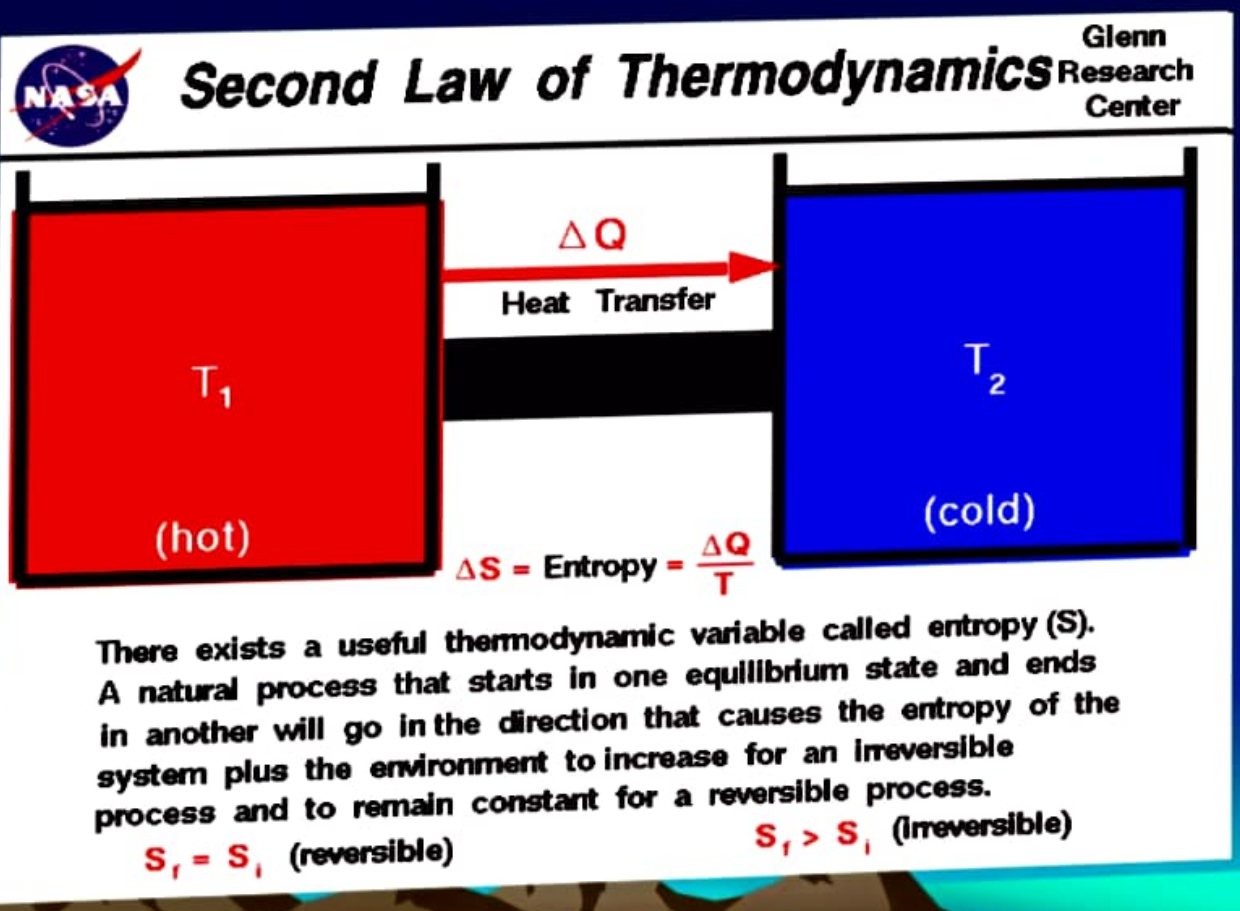
If heat added to a system, there are two things that can be done

- Change the internal energy of the system, or Cause the system to do work
- Combination of the two



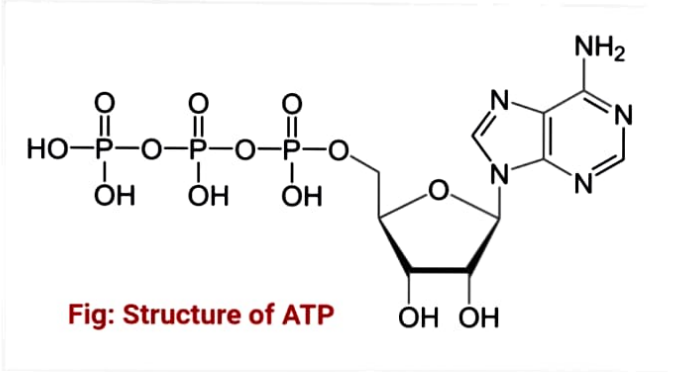
2nd Law of thermodynamics

- Concept of temperature gradient as a natural phenomenon.
- The 2nd Law can also be stated that heat flows spontaneously from a hot object to a cold object (spontaneously means without the assistance of external work)



Slide courtesy of NASA

Structure of ATP



Structure of ATP

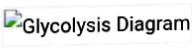
It consists of adenine, ribose, and a triphosphate moiety. Adenosine is attached by the 9-nitrogen atom to the 1-carbon atom of ribose which in turn is attached at the 5-carbon atom of sugar to a triphosphate group. Three phosphate groups form a triphosphate moiety. They are termed alpha (α), beta (β), and gamma (γ) phosphate groups. There are three phosphodiester bonds; one between phosphate groups, the second between the phosphate groups, and the third between the phosphate and ribose sugar. The first two are high-energy phosphodiester linkage and produce energy during hydrolysis. Hence, hydrolysis of ATP to ADP (Adenosine Diphosphate) and again to AMP (Adenosine Monophosphate) yields energy, but the breaking of the phosphodiester bond between ribose and the phosphate requires energy.

Production of ATP

ATP is an energy-rich compound primarily synthesized during cellular respiration in aerobic and anaerobic cells. Oxidation of glucose, lipids (fats), and amino acids produce the ATP molecules inside cells. The energy released during the oxidation of these nutrients is trapped in the form of the high-energy phosphodiester bond in the ATP molecule.

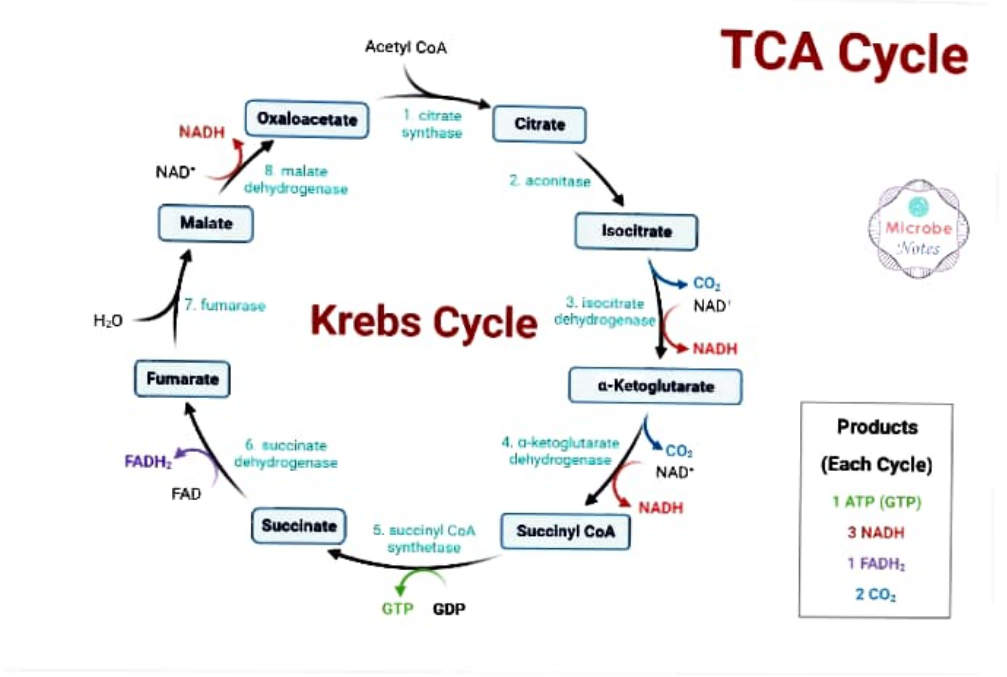
Glucose and ATP

Carbohydrate is the primary source of energy. Carbohydrates consumed in different forms (starch, sucrose, dextrose, lactose, fructose, etc.) are mostly broken down to monosaccharide form 'glucose.' Glucose is then subjected to metabolic reactions, glycolysis, Krebs cycle, and oxidative phosphorylation and is oxidized to release energy. This released energy is trapped and stored in the form of ATP.



Similarly, proteins and lipids metabolism also produce simple end products like acetyl CoA, succinyl CoA, keto-acids, ammonia, etc., which are then subjected to the Krebs cycle and oxidative phosphorylation to yield ATP molecules.

The Krebs cycle, also known as the citric acid cycle or TCA cycle, is a series of reactions that take place in the mitochondria, resulting in the oxidation of acetyl CoA to release carbon dioxide and hydrogen atoms that later lead to the formation of water.



Krebs Cycle

- This cycle is termed the citric acid cycle as the first metabolic intermediate formed in the cycle is citric acid.
- This cycle is also termed tricarboxylic acid (TCA) because it was then not certain whether citric acid or some other tricarboxylic acid (*g.*, isocitric acid) was the first product of the cycle. However, now it has been known that the first product is indeed citric acid and thus the use of this name has since been discouraged.
- This cycle only occurs under aerobic conditions as energy-rich molecules like NAD^+ and FAD can only be retrieved from their reduced form once they transfer electrons to molecular oxygen.
- The citric acid cycle is the final common pathway for the oxidation of all biomolecules; proteins, fatty acids, carbohydrates. Molecules from other cycles and pathways enter this cycle through Acetyl CoA.
- The citric acid cycle is a cyclic sequence of reactions formed of 8 enzyme-mediated reactions.
- This cycle is also particularly important as it provides electrons/ high-energy molecules to the electron transport chain for the production of ATPs and water.
- Pyruvate formed at the end of **glycolysis** is first oxidized into Acetyl CoA which then enters the citric acid cycle.

Electron Transport System (ETS)

The Electron Transport System (ETS) is a series of protein complexes located in the mitochondrial inner membrane. It plays a crucial role in generating energy for the cell through the process of oxidative phosphorylation.Components of ETSThe ETS consists of five complexes

:1. *Complex I (NADH dehydrogenase)*: Transfers electrons from NADH to ubiquinone.

2. *Complex II (Succinate dehydrogenase)*: Transfers electrons from succinate to ubiquinone

.3. *Complex III (Cytochrome b-c1 complex)*: Transfers electrons from ubiquinone to cytochrome c.

4. *Complex IV (Cytochrome oxidase)*: Transfers electrons from cytochrome c to oxygen

.5. *ATP synthase*: Uses the energy from the proton gradient to produce ATP.Process of ETSThe ETS works by passing electrons through a series of protein complexes,

which generates a proton gradient across the mitochondrial inner membrane. This gradient is used to produce ATP through the process of chemiosmosis.Oxidative PhosphorylationOxidative phosphorylation is the process by which energy is generated in the form of ATP during the transfer of electrons from high-energy molecules to oxygen. It occurs in the mitochondrial inner membrane and is driven by the ETS.Mechanism of Oxidative PhosphorylationThe mechanism of oxidative phosphorylation involves:1. *Electron transport*: Electrons are passed through the ETS, generating a proton gradient.2. *Proton gradient*: The proton gradient is used to drive the production of ATP through chemiosmosis.3. *ATP synthesis*: ATP is produced by the enzyme ATP synthase using the energy from the proton gradient.Importance of Oxidative PhosphorylationOxidative phosphorylation is essential for generating energy in aerobic organisms. It produces the majority of ATP in cells and is critical for maintaining cellular function.Regulation of Oxidative PhosphorylationOxidative phosphorylation is regulated by:1. *Energy demand*: The rate of oxidative phosphorylation is adjusted according to the energy needs of the cell.2. *Substrate availability*: The availability of substrates, such as NADH and FADH2, affects the rate of oxidative phosphorylation.3. *Oxygen availability*: Oxygen is the final electron acceptor in the ETS, and its availability affects the rate of oxidative phosphorylation.

MODES OF FERMENTATION

Submitted to: Ramsaran sir
Submitted by: Muskan arora
Monika
Shalini
Megha
kanica

Fermentation:

•Fermentation is a metabolic process that converts sugar to acids, gases or alcohol.

• It occurs in yeast and bacteria, and also in oxygen-starved (Deficient) muscle cells, as in the case of lactic acid fermentation.

• Fermentation, chemical process by which molecules such as glucose are broken down anaerobically.

Modes of fermentation:

- Batch fermentation
- Continuous fermentation
- Fed batch fermentation

•**Batch culture technique** is also called as closed system of cultivation.

•In this technique at first nutrient solution is prepared and it is inoculated with inoculum and then nothing is added in the fermentation tank except aeration.

•In batch culture, neither fresh medium is added nor used up media is removed from the cultivation vessel. Therefore volume of culture remains same.

•Since fresh media is not added during the course of incubation, concentration of nutrition decreases continuously. Furthermore various toxic metabolites also accumulates in the culture vessel. Therefore batch culture technique gives characteristics growth curve with lag phase, log phase, stationary phase and decline

production of L.A., 1880.

- Several carbohydrate substances such as corn, starch , molasses and whey can be used for the production of L.A.
-
- Derivatives of L.A. are used in the treatment of calcium deficiency (calcium lactate) and of anemia (iron lactate), as a solvent in lacquers (n-butyl lactate) and a plasticizer and humectant (sodium lactate)

LAB (Lactic acid bacteria)

Two types:

- Homofermentative:

✓ Only one product: LA

✓ As little substrate as possible is converted into cell material plus byproducts and as much as possible is metabolized into L.A.

- Mainly *Lb. delbrueckii* and *Lb. leichmannii* when glucose is used as substrate.
- *Lb. bulgaricus* when whey is used.

E.g. *Lb bulgaricus, Lactococcus lactis, Streptococcus thermophilus* etc.

- Heterofermentative:

✓ Besides L.A. many other products (byproducts) are there so, not suitable for commercial purpose

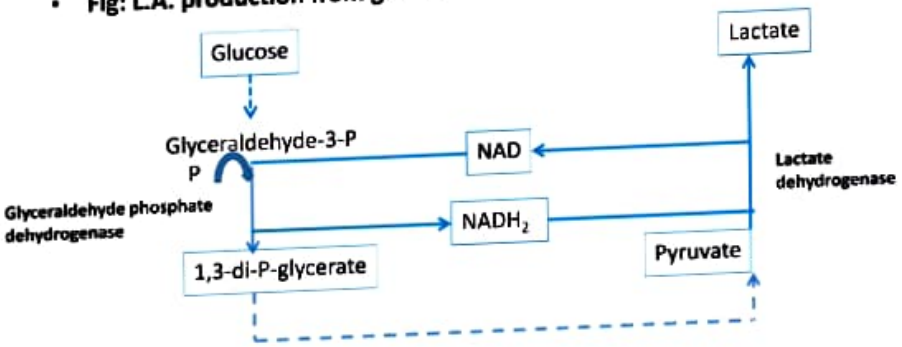
✓ E.g. *Lb plantarum, Lb casei*, Leuconostoc etc.

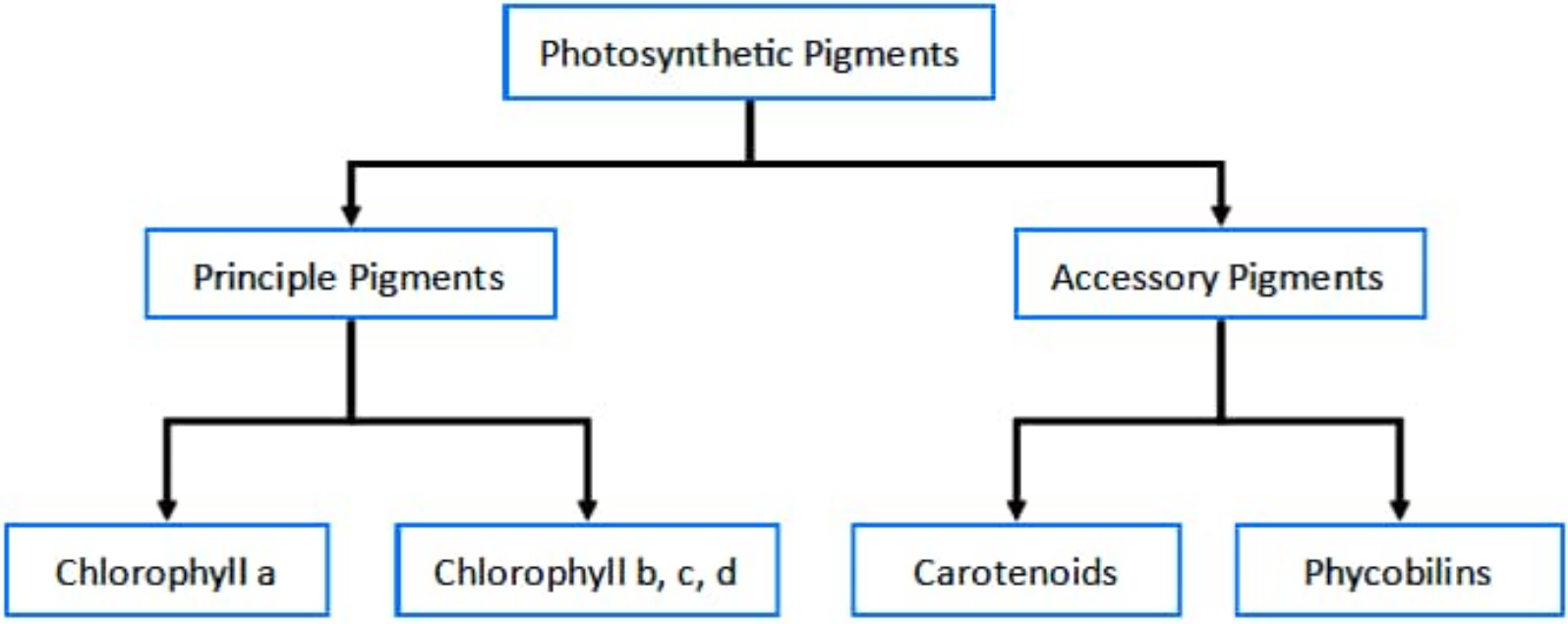
❖ **All LAB (Lactic Acid Bacteria) are Facultative rather than obligate anaerobes. So bioreactors need not to run with compete O_2 exclusion**

Biosynthesis

L.A. from glucose via glyceraldehyde-3-P, 1,3-di-P-glycerate and pyruvate

- Reducing power produced during oxidation of glyceraldehyde phosphate is transferred with an NAD-dependent lactate dehydrogenase to pyruvate, is reduced stereospecifically to L(+) or D(-) L.A.
- Theoretically, two moles of lactate are produced from 1 mole of glucose.
- **Fig: L.A. production from glucose**





Flowchart of photosynthetic Pigments

Activa

TYPES OF PHOTOSYNTHESIS

There are two types of photosynthesis

1. **Anoxygenic Photosynthesis** -phototrophic bacteria H2O is not oxidized and O2 is not produced, and thus the process is called **anoxygenic photosynthesis.**

$CO_2+2H_2A+Light \rightarrow [CH_2O]+2A$

Example-Purple bacteria

$H_2A=H_2O, H_2S, H_2$ etc.

2. **Oxygenic Photosynthesis**-The oxidation of H2O produces molecular oxygen (O2) as a by-product. Because O2 is produced, photosynthesis in these organisms is called **oxygenic photosynthesis.**

$2H_2O \rightarrow 4H^+ + O_2 + 4e^-$

$6CO_2+12\,H_2O+light \rightarrow C_6H_{12}O_6+6O_2+6H_2O$

Example-Eukaryotes and cyanobacteria

ANOXYGENIC PHOTOSYNTHESIS

- It is type of photosynthesis process which frequently occurs in the microorganism which are mostly found in aquatic habitat . This reaction does not involve production of oxygen.
- Sulfur is used as a reducing agent during the process in green sulfur bacteria and purple bacteria.

AD

ANOXYGENIC PHOTOSYNTHETIC BACTERIA

- Some photosynthetic bacteria can use light energy to extract electrons from molecules other than water.
- These organisms are of ancient origin, presumed to have evolved before oxygenic photosynthetic organisms.
- Anoxygenic photosynthetic organisms occur in the domain Bacteria and have representatives in four phyla – Purple-Sulphur Bacteria, Purple non- Sulphur Bacteria, Green-Sulfur Bacteria, Green non- Sulfur Bacteria.
- Anoxygenic photosynthesis depends on electron donors such as reduced sulphur compounds, molecular hydrogen or organic compounds.
- They are found in fresh water, brackish water, marine and hypersaline water.
- Anoxygenic photosynthetic bacteria have been divided into three groups on the basis of pigmentation: purple bacteria, green bacteria and heliobacteria.

OXYGENIC PHOTOSYNTHETIC BACTERIA

- The Oxygenic Photosynthetic Bacteria are unicellular or multicellular and possess bacteriochlorophyll a and carry out oxygenic photosynthesis.
- They are mostly represented by gram-negative cynobacteria.
- Carboxysomes and gas vesicles are present and also show gliding movement.
- Photosynthesis is oxygenic and autotrophic.
- Photosynthates get accumulated in the form ofglycogen.