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BT102 – Microbiology

Current paper solved question mid term December 2019

1. Function of cell membrane factors of bacterial cell death. 5 marks

cell membrane is composed of a phospholipid. molecules arranged tail to tail with heads facing away from each other. This makes lipid molecules to appear as a bilayer. So all membranes enclosing the organelle in the cell or the cell itself look as bilayer structures. This is the basic design of the plasma membrane. Protein and carbohydrates are also inserted into the plasma membrane.

There are some basic function of cell membrane in bacteria.

1) Selective permeable barrier
2) Passive and Active Transport
3) Respiration in microbes (bacteria)
4) Photosynthesis in microbes
5) Lipid synthesis
6) regulates the transport of substances in and out of the cell.
7) receives chemical messengers from other cell.
8) cell mobility, secretions, and absorptions of substances

• Cell wall parts are transported by a molecule called bactoprenol which is present in the plasma membrane.

• PM has many receptors in it with which various ligands can bind and initiate signals for gene expression etc.

Cell membrane lipids can be disrupted by alcohols, quaternary ammonium compounds and polymixins. So, these compounds are used as disinfectants or for controlling microbial growth.

2. Oxidative phosphorylation and mechanism of phosphorylation.3marks

Oxidative Phosphorylation

a. Electrons captured from foods are transferred to co-enzymes such as NAD+ or FAD etc.

b. Then these electrons pass through a series of electron carriers and then ultimately to the last electron acceptor molecules such as O2 or other inorganic compounds (nitrate, sulphate, carbonate etc) through a series of these electron carriers in system called electron transport chains.

c. During these events, ATP is generated by chemiosmosis.

Photophosphorylation

a. This occurs in plants and chlorophyll containing microbes or photosynthetic cells. In these cells, light energy is finally converted into ATP. An electron transport chain is also involved here. This is summarized in the accompanying diagram above.

3. Dry heat method of sterilization.3 marks

Form of dry heat include:

1. Dry heat (hot-air oven),
2. Flaming (Platinum loop sterilization in the flame of Bunsen burner),
3. Incineration (burning to ashes).

Similarly, moist heat can also be grouped into autoclaving (15psi), boiling at 100_oC, and Tyndallization (100_oC for 3 consecutive days to sterilize sugar solution that can be degraded by autoclaving) and pasteurization (usually at low temperature than 100_oC).

4. F+cell.2 marks.

In E. coli, fertility factor (F factor) plasmid was the first plasmid observed to be transferred from one organism to the other, hence those bacteria that have this plasmid are called F_+ cells to differentiate from those that do not have one (F_-). However, once F_- cells acquire F_+ plasmid, they also become F_+.

5. Western boltting.5 marks

Western Blotting: We can use this technique for the detection of antigen in the serum. Microbial proteins can be separated on SDS-PAGE by electrophoresis and the presence of these proteins can be detected by enzyme-tagged antibodies specific to those proteins. A color band will be seen where the specific protein (antigen) is present on the gel. Please remember that proteins in the gel are first transferred to a paper strip before they could be detected by specific antibodies as seen in the accompanying figure.

6. Function of cell wall in bacteria .5 marks

Cell wall is the most important layer in bacteria. It is rigid layer just outside the plasma membrane.

- Most important structure in prokaryotes
- It provides shape to the organism.
- It provides protection from osmotic lysis.
- It is involved in pathogenicity (ability of the organism to cause the disease).
- Several antibiotics act on it.

Each bacterium is enclosed by a rigid cell wall composed of peptidoglycan, a protein-sugar (polysaccharide) molecule. The wall gives the cell its shape and surrounds the cytoplasmic membrane, protecting it from the environment. It also helps to anchor appendages like the pili and flagella, which originate in the cytoplasm membrane and protrude through the wall to the outside. The strength of the wall is responsible for keeping the cell from bursting when there are large differences in osmotic pressure between the cytoplasm and the environment.

7. What is vertical and horizontal gene transfer and also write type of lateral gene transfer.3marks

Vertical Gene Transfer

This is a normal way of transferring genes from parents to offspring. This happens when a cell divides. Each daughter cell receives exactly what its parent cell has.

Horizontal Gene Transfer

When genes are transferred from cells to cells within the same species, the process is called horizontal gene transfer. This can happen between cells of the same species, or across different species of organisms. Horizontal gene transfer involves a donor and a recipient cell. The recipient cell then incorporates received DNA into its own genome and this genome becomes a recombinant molecule or recombinant DNA. The cell that has this recombinant DNA in it is called a recombinant cell. Three processes are known by which genes can be transferred horizontally from one cell to the other, and they include:

1. Transformation
2. Conjugation
3. Transduction

8. Osmotic pressure.osmtic layer and plasmolysis . 3 marks

Osmotic pressure is the force caused by a solution passing through a semi permeable surface by **osmosis**, which is equal to the force required to resist the solution from passing back through the surface. An example of **osmotic pressure** is the process to filter water.

plasmolysis

If cells are placed in hypertonic solutions, water leaves the cells shrinking the cells and damaging them. This process is called plasmolysis.
Plasmolysis is the process in which cells lose water in a hypertonic solution

9. What is sporogenesis.2 marks

Formation of spores takes place within a vegetative cell and the process is called sporulation or sporogenesis. It is initiated when nutrients become unavailable.

10. Why 70% alcohol is more effective the 100% alcohol.2 marks.

Ethanol, isopropanol are examples. Alcohols denature proteins, and dissolve lipids. Alcohols require water for being more effective. This is the reason that seventy percent alcohol is more effective than 100%. Please note that alcohols can effectively kill vegetative form of bacteria, and fungi but not spores. Alcohols are not very effective on wounds. Commonly used in hand sanitizers.

11. L-form bacteria.2marks

Some cells, called **L-form** organisms, are naturally found without the cell wall. In other words, normally, they have cell wall but under certain conditions, they may lack a cell wall. These cells can be created when grown in the presence of penicillin which inhibits cell wall synthesis.

12. What is HRF and function.2 marks

13. If F factor gets integrated into the chromosome of the recipient cells, the bacterium becomes high frequency of recombination cell (Hfr).

➢ Conjugation can be used for gene mapping on the chromosomes.

➢ conjugation_mapping.html

➢ High frequency of recombination is also a kind of conjugation.

Can be used for mapping genes.

high frequency of recombination

In some cells that carry F^+, F^+ (Fertility factor) gets incorporated in the chromosomal DNA which converts F^+ cells to high frequency of recombination cells (Hfr cells). When conjugation occurs between an Hfr cell and an F^- cell, the Hfr cell's chromosome (with its integrated F factor) replicates, and a parental strand of the chromosome is transferred to the
recipient cell. Since this transfer starts from the middle of F factor gene, and most of the time, this transfer is not complete; the whole chromosome of Hfr cell is not transferred. However, some genes can be transferred during this process. When these genes become integrated into the genomic DNA of the recipient cells, the recipient cells acquires new versions of genes that were not part of its genome previously. It may be noted that F^- cells remains F^- negative cell because F factor is not transferred completely. This whole process is illustrated in the accompanying diagram. Also remember that these newly acquired genes can be mapped easily with respect to the time they get transferred to F^- cells.

So, conjugation can be used to map the genes on the bacterial chromosome. Video clip in the lecture illustrates this mapping very well.

14. Pilli and its functions.5 marks

These are hair-like structure composed of pilin, usually one to ten in number.

a. Longer than fimbriae
b. Used for attachment to:
   - Host cells
   - Bacteria
c. Used for DNA transfer from on bacterium to another:
   Conjugation (Sex pili)
d. Also function in twitching Motility

Gliding Motility is also the function of the pili.

15. Process of fermentation.

Fermentation: Initial steps for glucose oxidation by fermentation are the same as they occur in glycolysis for respiration. However, when pyruvate is generated through glycolysis, electrons are also captured by NADH and this NADH needs to be regenerated into NAD^+ for recycling. If the final electron acceptor is one of the end products such as ethanol, lactic acid, acetic acid etc, the process is called fermentation. Both anaerobic respiration and fermentation do not use oxygen during these processes, and during fermentation, there are no electron transport chain involved as you can see in the accompanying diagram. Examples of fermentation are given in the accompanying diagram:

16. Process of germination of spore.

Spore germinates when it finds a conducive environment for its growth. Germination has 3 phases or stages:

Activation: It prepares the spore for germination. Heat can activate the spore when appropriate moisture and nutrients are present in the environment.

Germination: Spore starts swelling and loosing its coats etc. It becomes metabolically active.

Outgrowth: New components are made.

17. Characterstic of magnetosome.

Inclusions of iron oxide

Surrounded by invaginations of plasma membrane

Present in G negative bacteria

Act like a magnet. Bacteria can stick to iron containing rocks for nutrition.

Decompose H_2O_2 which is toxic for cells.

18. Four bacterial growth curve phase.

There are four distinct phases of this curve.

1. **The Lag Phase:** cells prepares for growth in this phase. No growth is observed during this period or phase, however. Cells are metabolically very active during this phase.

2. **The Log Phase:** During this phase, organisms multiply exponentially or logarithmically. Generation time becomes constant during this phase and that is the reason, the log graph will show a straight line. Cells are in the most active stage during this phase of growth curve. For commercial applications such as vaccine production, cells have to remain in this phase in order to reproduce most efficiently resulting in increased cell mass or number. Another application of this phase of growth is to determine the generation time.

3. **The Stationary Phase:** This is also called a period of equilibrium as microbial deaths equal production of new cells. In other words, organisms start dying during this phase, however, the number of dead organisms is replaced by new organisms because there is still replication of cells going on. So, overall number of organisms does not change. This is the reason, it is called a stationary phase.

4. **The Death Phase:** The number of deaths exceeds the number of new cells formed during this phase. In other words, overall number decreases. It is also called logarithmic decline phase. Why there is a decline phase or death phase. The reason is simple: Nutrients are depleted and waste products which are toxic to the cells accumulate suppressing the growth and killing the cells.

19. Name five kingdom classification.5 marks.

20. Taxonomic Hierarchy 5 marks

Microbes are placed in groups based on similarities that they share with each other. All organisms can be grouped into a series of subdivisions that make up the taxonomic hierarchy. A bacterial **species** represents ―a monophyletic and genomically coherent cluster of individual organisms that show a high degree of overall similarity with respect to many independent characteristics, and is diagnosable by a discriminative phenotypic property‖ (definition taken from the internet). A **genus** consists of various specie; however, these species differ from each other in certain ways, although these are related by descent with each other. Related genera make up a **family**. A group of similar families constitutes an **order,** and a group of similar orders makes up a **class.** Related classes, in turn, make up a **phylum.** All phyla that are related to each other make up a **kingdom**, and related kingdoms are grouped into a **domain**.

Domain

➢ Kingdom

▪ Phylum

• Class

 Order

➢ Family

▪ Genus

• Species

21.Inclusion bodies 3 marks

Inclusions are reserved deposits of nutrients. Bacteria accumulate nutrients when nutrients are plentiful.

Concentrating nutrients in the form of inclusions avoids the increase in osmotic pressure due to accumulation of nutrients in one place. Not all organisms accumulate them. So, inclusions vary from bacteria to bacteria. They can also serve as markers for bacterial identification as some are limited to specific organisms. The followings are some of the important inclusions:

• Metachromatic granules

• Polysaccharide granules

• Lipid inclusions

• Sulfur granules etc.

22.Antisepsis, sepsis, sterilization definition.3 marks

Antisepsis: Removing pathogens from living tissue

Sepsis: Microbial contamination
A toxic inflammatory condition arising from the spread of an organism from a focus of infection.
Sanitization: Lowering microbial counts on eating utensils

23.Oxidation and reduction 2 marks

Oxidation = loss of electrons, or gain of oxygen, or loss of hydrogen .
Reduction = gain of electrons, or loss of oxygen, or gain of hydrogen

24. Three character of algae.

These are simple eukaryotic cells. Some are unicellular, others are multicellular (thallus); however, they lack tissues such as roots, stem and leaves typically seen in plants. Algae absorb nutrients from water through their surfaces and are mostly photoautotrophs; however, a few are chemoheterotrophs. They are responsible for 80% atmospheric O_2 on the face of the earth. Microscopic exam is needed to identify unicellular and filamentous algae. However, multicellular algae that are commonly known as seaweeds are macroscopic in nature and can be identified morphologically without the help of a microscope. Four groups of such algae include blue-green algae, green algae, brown algae and red algae. These algae are located in the sea at various locations and absorb light of various wavelengths, hence red algae are located far from the surface and can use blue light from the sun as blue light is of shorter wavelength and can penetrate deep in the sea. Please see the accompanying figure (above) for a better understanding of how wavelength relates with various algae. Also remember, blue-green algae need magnification in order to be correctly identified, although they are not microscopic. o Body of multicellular alga such as seaweed is called a thallus which consists of branched holdfasts (anchor alga to rock) stemlike hollow stipes and leaflike blades. There is no vascular tissue in these algae. Also, the stipe is not lignified or woody, so it does not provide support to the weed. Surrounding water provides the support for the thallus. Some algae have a gas filled body inside them which keeps them floating in the water. This gas filled structure is called pneumatocyst or float.
These are eukaryotes. Their cell wall consists of cellulose. These are photosynthetic and produce oxygen. They are usually unicellular, but multicellular algae are also common. Seaweeds and pond scum are some of the examples.

25.Thermal death point and thermal death rate.

Thermal Death Point: It is the lowest temperature at which all cells in a culture are killed in 10 min. It will be a specific temperature for a specific species of organism.

Thermal Death Time: Time (minimum) during which all cells in a culture are killed at a given temperature. This will vary from temperature to temperature for the same organism. Obviously, higher temperatures will take less time to kill the organisms than low temperatures.

26. How bacteria can be identified.

Microbes especially bacteria (disease causing) can be identified by three methods:

A. Classical or Conventional Method
B. Serological Methods
C. Nucleic Acid based Methods

Classical methods of microbial identification involve differential staining of the sample before it its culturing, culturing the sample onto nutrient agar, blood agar and MacConkey's agar, purifying the culture (colonies expected to be involved in the disease) and detection of various enzymes that belong to various metabolic pathways. Classically, such methods used
to take a long time to perform (3 days at least); however, rapid identification methods have become available now which use preformed media that can be used for testing the presence of metabolic enzymes. Such a kit is shown in the figure above (previous page).
Serological methods involve antibodies and antigen interactions. Antibodies are produced by B lymphocytes against any foreign antigens such as bacteria and their toxins that enter the body of animals or humans. Antibodies are very specific in their interaction. In other words, antibodies made against E. coli do not bind or interact with Staphylococci or vice versa. Although, there are many serological techniques that can be successfully used for identification of microbial infections, we will focus on only a few of them. The main advantage of using serological method is the speed and economy. In other words, serological methods are quick to do (take only about an hour) and can work directly on the sample (sample does not have to be cultured and purified as is needed in conventional methods of identification). Serological methods can be performed on cultured microbes as well which again speed up the diagnosis. Also remember that in all these serological tests, either the serum or the antigen should be known to us.

27.Catalase and its protocol.

When H_2O_2 is produced, it gives rise to peroxide anions which are toxic to the cells. Cells have evolved to deal with this toxic H_2O_2 by an enzyme called catalase as under:

Reduction = gain of electrons, or Loss of oxygen, or gain of hydrogen
Oxidation: Removal of electrons from an atom

1. • **Reduction**: Gain of electron • Oxidation and reduction reactions are coupled.

28. write names of 5 kingdom system (5)

In 1969, five kingdom classification was proposed by Robert Whittaker as under:

1. Monera: Bacteria
2. Plantae: plants
3. Animalia: Animals
4. Fungi: Yeasts, molds and mushrooms
5. Protista: These are unicellular eukaryotes. Organisms that do not fit into any other category are placed in Protista. They are larger than prokaryotes. They include algae, protozoa, slime molds and water molds.

Five Kingdom Classification of Organisms

1.Animalia
2.Plantae
3.Fungi
4.Monera
5.Protista

Living organisms are subdivided into 5 major kingdoms, including the Monera, the Protista (Protoctista), the Fungi, the Plantae, and the Animalia. Each kingdom is further subdivided into separate phyla or divisions. Generally "animals" are subdivided into phyla, while "plants" are subdivide.

29. Refractive index. 2 marks.

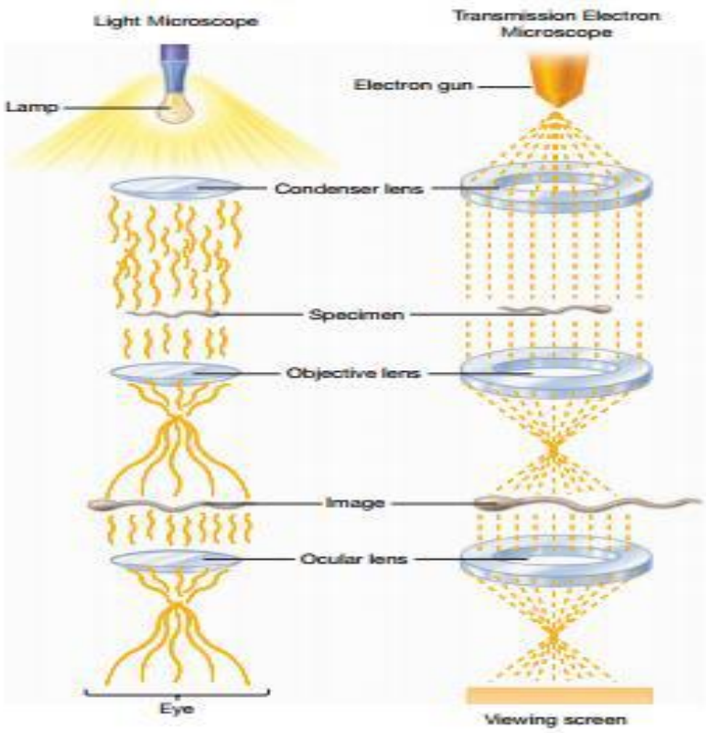
30.Using of ionization radiation 2 marks.

include gamma rays, X rays, or high-energy electron beams. The ionizing radiation possesses a wavelength shorter than that of nonionizing radiation, less than about 1 nm. All these short wavelengths cause ionization of water generating high reactive hydroxyl radicals which are damaging to the cells as they bind to DNA and results in mutations. Medical plastic supplies, medicines and meat products can be sterilized by radiation.

Three characteristics of integral prtein.3marks

Integral proteins are inserted in the membrane or embedded in the membrane.
integral proteins are not static in position in the membrane. They can diffuse laterally and change positions in the membrane from time to time. So, plasma membrane is like water pond and integral proteins are like plastic bags people throw in the pond. These plastic bags swim and move by air currents. Membranes are much like that. Integral proteins act as channels or carriers in facilitated diffusion. Integral proteins are called transporters or permeases.

31.Labelling of electron transmission microscope 5 marks



32. Definition of gene, chromosome genome, phenotype 5 marks
33. Identification methods for microbial growth 5 marks
34. Pili and its types5 marks

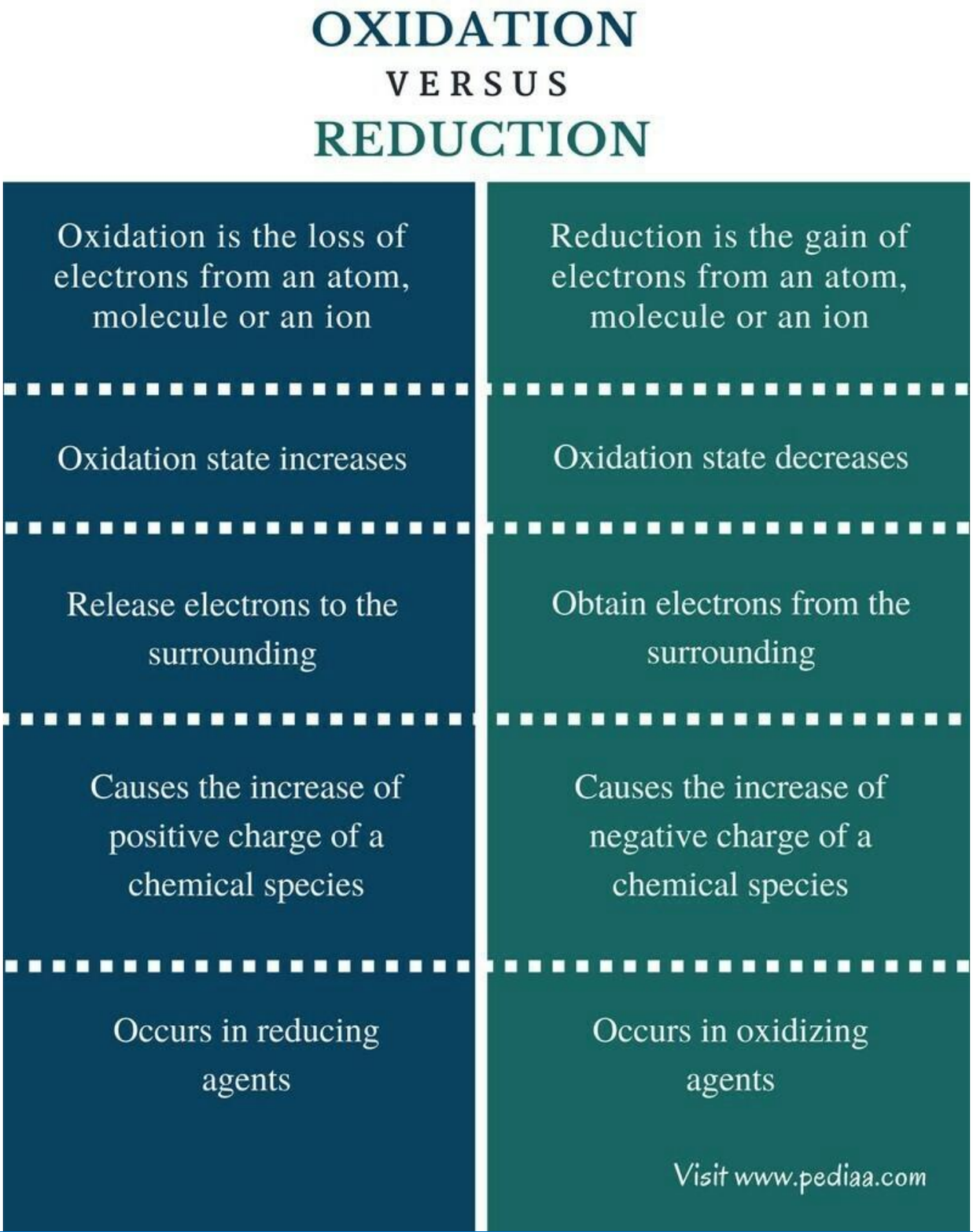
35. Physical and chemical method of making of smear 3marks

Staining starts with making a smear using a glass slide.
• Using a platinum loop, a colony of a drop of broth culture can be smeared into a thin film on a glass slide for making a smear.

• The specimen is spread into a thin film (smear).
• Smear is air-dried.
  • Smear is fixed (attached) to the slide before staining.
  • **Heating** the slide is one way of fixing the smear.
  • **Methyl alcohol** can be used.

36.Difference between oxidation and reduction 2 marks

Oxidation is the process of loss of electrons whereas **Reduction** is the process of gain of electrons. **Oxidation** can also be gaining of oxygen atoms whereas **Reduction** is loss of Oxygen atoms.



37. Buffer

Buffers are used to maintain desired pH o Peptones and amino acids are used as buffers o Phosphates are also used for buffers **.**

A buffer is a solution that can maintain a nearly constant pH if it is diluted, or if relatively small amounts of strong acids or bases are added. A buffer solution can be made by mixing a weak acid with one of its salts OR mixing a weak base with one of its salts.

38.Five name of bacteria which grow on optimal temperature.

Organisms are basically classified into three groups based on the temp requirements:

1. **Psychrophiles:** These are further divided into strict psychrophiles and psychrotrophs:
   - o **Psychrotrophs:** Cold loving: 15 ^{0}C
   - o **Psychrotrophs:** Optimum temp is 20-30 ^{0}C. Food spoilage bacteria that can spoil food during refrigeration.
2. **Mesophiles:** 25 – 40 ^{0}C: These are the ones that cause diseases in animals and humans.
   - o Moderate temp loving organisms
   - o Optimum: 37 ^{0}C as this is the body temperature of humans and animals.
3. **Thermophiles:** 50 – 60 ^{0}C
   - o Heat loving
   - o Important in organic compost piles
   - o These are further divided into hyperthermophiles that grow optimally at 80 ^{0}C. They live in hot springs.

39. Branches of mycology 2 marks

Mycology is the branch of biology concerned with the study of fungi, including their genetic and biochemical properties, their taxonomy and their use to humans as a source for tinder, traditional medicine, food, and entheogens, as well as their dangers, such as toxicity or infection.

- Medical mycology
- Agricultural mycology
- Ecological mycology – Decomposers of woods, leaves, feces and other organic matters

40. Difference between precipitation and agglutination test 2 marks

41. **Agglutination Test:** Let's first talk about a few definitions that will make our life easier. There are two words we must know about them: They are agglutination and precipitation. **Agglutination** is a process in which soluble antibodies interact with a particulate antigen. **Precipitation** is a process in which soluble antibodies interact with a soluble antigen. Now let's talk about a few examples of agglutination tests:
   - o **Blood Grouping:** This is a typical agglutination test which involves antibodies (that are always soluble in nature) and RBCs (that are particulate in nature).
   - o **Rose Bengal Plate Agglutination Test:** This test is used to diagnose Brucellosis in animals in which serum of animals suspected for Brucellosis is mixed with Brucella antigen (bacterim). The resulting positive interaction is seen as flocculation as are shown in the accompanying figure:
   - o **Widal Test:** This test involves Salmonella cells (Antigen) and Salmonella antibodies.
   - o **Coombs Test:** This involves antibodies coated RBCs (antigen) and antiantibodies.

agglutination tests are qualitative **tests** used to detect the presence of antibodies in serology laboratories and blood banks. Treated red blood cells or colored latex beads, coated with antigen, clump in the presence of antibody to the antigen.

Precipitation Tests: These involve soluble antigens and soluble antibodies. Examples include:

o **Agar Gel Diffusion Test:** This test is performed in agarose gel which is poured in a petri dish and wells are created which are used to place antigens and antibodies for interactions with each other. Antigens and antibodies diffuse from their respective wells and, where these molecules meet each other, a precipitation line is formed as shown in the accompanying figure.

o **Precipitation of proteins:** This method can also be used to isolate a specific

protein from cells by using protein specific antibodies which precipitate out that protein from a mixture of cellular proteins.

A **precipitation reaction** is a **test** which is involved in the serology, for the detection of antigens and antibodies. ... **Precipitation test** is used to quantify both antigen and antibody, and therefore its specificity also depends upon the concentration of both the reactants

42.Briefly explain conjugation .transformation,transduction,

a. **Conjugation** is the process by which one **bacterium** transfers genetic material to another through direct contact. During **conjugation**, one **bacterium** serves as the donor of the genetic material, and the other serves as the recipient
   Genes transfer process can be mediated by plasmids. Plasmids are extra chromosomal circular DNA fragments that replicate independently of bacterial chromosome. Conjugation requires direct cell to cell contact and cells have to be opposite mating types.
b. **Transduction** is the process by which foreign DNA is introduced into a bacterial cell by a virus or viral vector. An example is the viral transfer of DNA from one bacterium to another and hence an example of horizontal gene transfer
   Transferring of a gene from a bacterium to another bacterium via a virus is called transduction. o When a bacteriophage infects a bacterium such as E. coli, it replicates inside E. coli and also produces a protein coat (which is called a capsid) in which viral DNA is packed before the virus is released.
c. **Bacterial transformation** is a process of horizontal gene transfer by which some **bacteria** take up foreign genetic material (naked DNA) from the environment. ... The prerequisite for **bacteria** to undergo **transformation** is its ability to take up free, extracellular genetic material. Such **bacteria** are termed as competent cells.
   Naked DNA in solution is transferred from one bacterium to another during this process.

43. Characteristics Antibiotic chemicals.

Although antibiotics are used to kill organisms in disease states, some antibiotics are not very effective for this purpose; however, these antibiotics could be used in food to prevent food spoilage. Nisin and natamycin prevent spoilage of cheese.

44.Define culture , culture medium, inoculum

a. What is culture.

This term is used to define growth of microbes. In other words, microbial growth in the lab is called a culture.

b. What is a culture medium?

o A nutrient material that supports the growth of microbes in the lab is called a culture medium.

A culture media is a special medium used in microbiological laboratories to grow different kinds of microorganisms. A growth or a culture medium is composed of different nutrients that are essential for microbial growth.

c. **Inoculum** Microbes introduced into a culture medium that initiate growth of organisms.

inoculum A small amount of material containing **bacteria**, viruses, or other microorganisms that is used to start a culture

45. Advantage of staining

I. Most organisms appear colorless when seen under a microscope.

II. Staining emphasizes certain structures of the organisms.

III. Staining is just coloring with a dye.

IV. Staining increases visibility of microbes because staining increases contrast.

V. Shape, size and arrangements of the organisms can be readily seen.

VI. Purity or contamination of a culture could be determined.

VII. Differentiation and classification of microbes is possible. For example, microbes can be categorized into Gram positive or Gram negative groups.

VIII. Structures such as flagella, capsule and spores etc. of bacteria can be detected with staining.

1. It gives quick results when examining infections.
2. It is simple and cost-effective.
3. It helps with determining appropriate treatments for infection.
4. It allows for various methods of testing.
5. It is basically a key procedure in identifying bacteria.

46.Five layer of endospores.

1) **Exosporium:** A thin delicate outermost covering of the spore
2) **Spore coat:** 2nd layer underneath the exosporium. It is thick and composed of several protein layers. Resistant to chemicals .It contains enzymes for germination. Germination of spores into vegetative form occurs when environment becomes favorable for their growth.
3) **Cortex:** It is the 3rd layer from outside in. It has peptidoglycan in it.
4) **Spore cell wall or core wall:** Surrounds the protoplast or spore core
5) **Spore core:** Contains nucleoid and ribosomes

47.Name three buffers used for controlling PH of culture medium? 3

I. Peptones
II. amino acids
III. PBS

48. Three shapes of bacteria? 3

• Coccus These are circular or spherical in shape.

• Bacillus These rod shaped bacteria.

• Spiral These are curved shaped bacteria. They are further divided into 3 more subgroups.

- **Vibrio:** curved rods
- **Spirillum:** Helical but **rigid**
- **Spirochete:** Helical but **flexible**
- Spirochetes move by axial filaments which are enclosed by the outer membrane.