

**Instruction Hours / week: L: 4 T: 0 P: 0****Marks: Internal: 40 External: 60 Total: 100****End Semester Exam: 3 Hours****UNIT – I**

Aquatic environment - microbiology of water - water pollution and water borne pathogens. Bacteriological examination of water, indicator organism. Microbiology of sewage. Chemical and biochemical characteristic of sewage. methods of sewage treatment - physical screening, chemical, biological (sludge digestion; activated sludge, aerating filters, oxidation pond).

**UNIT – II**

Microbiology of air - Microbial contaminants of air, sources of contamination, microbial indicators of air pollution. Enumeration of bacteria in air. Air samplers and Sampling techniques. Air sanitation.

**UNIT – III**

Bioremediation – contaminated soil, aquifers, marine pollutants, air pollutants, stimulation of oil spills degradation. Bioremediation of air pollutants. Bioleaching – recovery of metal from ores – oxidation of minerals – testing for biodegradability.

**UNIT – IV**

Biological nitrogen fixation - symbiotic and non-symbiotic microorganisms, root nodule formation, nitrogen fixers, hydrogenase, Nitrogenase, *Nif* gene regulation. Biochemistry of nitrogen fixation, Rhizosphere- R: S ratio, Interaction of microbes with plants. Bioconversion of agricultural wastes. Genetically Modified organisms and crops.

**UNIT – V**

Biofertilizer - Application of biofertilizers and biomanures – A combination of biofertilizer and manure applications with reference to soil, seed and leaf sprays. Laboratory and field application; Cost-benefit analysis of biofertilizer and biomanure production. Biopesticides and its application.

**SUGGESTED READINGS****TEXT BOOKS**

1. Subba Rao, N.S. (1999). *Biofertilizers in Agriculture and Agroforestry*. Oxford and IBH, New Delhi.
2. Rangaswami, G., and Bhagyaraj, D.J., (2001). *Agricultural Microbiology*. (2<sup>nd</sup> ed.). Prentice Hall, New Delhi.
3. Rao, N.S. (1995). *Soil Microorganisms and plant Growth*. Oxford and IBH Publishing Co., New Delhi.
4. Pelzar, M.J., and Reid, M., (2003). *Microbiology*. (5<sup>th</sup> ed.). Tata Mc Graw-Hill, New York.
5. Reinheimer, G. (1991). *Aquatic Microbiology*. (4<sup>th</sup> ed.). John Wiley and Sons, New York.

**REFERENCES**

1. Deniel, J.C. (1996). *Environmental aspects of microbiology*, British Sun Publication, Chennai.
2. Abbasi, S.A. (1998). *Environmental pollution and its control*. Cogent International publishers, Pondicherry.
3. Sen, K., and Ashbolt, N.J., (2010). *Environmental Microbiology: Current Technology and Water Applications*.
4. Josdand, S.N. (1995). *Environmental Biotechnology*. Himalaya Publishing House, Bombay.
5. Maier, R.M., Pepper, I.L., and Gerba, C.P., (2009). *Environmental Microbiology*. (2<sup>nd</sup> ed.). Elsevier Publisher.
6. Metcalf, R.L., and Luckmann, W.H., (1994). *Introduction to insect pest management*. (3<sup>rd</sup> ed). John Willey and Sons, Inc.
7. Atlas, R.M., and Bartha, M., (2000). *Microbial Ecology - Fundamental and Applications*. (3<sup>rd</sup> ed.). Redwood City CA. Benjamin/Cumming Science Publishing Co., New Delhi.
8. Maier, R.M., Pepper, I.L., and Gerba, C.P., (2000). *Environmental Microbiology*. (1<sup>st</sup> ed.). Academic Press, New York.
9. Mitchell, R. (1992). *Introduction to Environmental Microbiology*; Prentice Hall. Inc. Englewood Cliffs- New Jersey.
- Motsara, M.R., Bhattacharyya, P., and Srivastava, B., (1995). *Biofertilizer- Technology, Marketing and Usage. Fertilizer Development and Consultant Organization*, New Delhi.



## KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University Established Under Section 3 of UGC Act 1956)

Coimbatore – 641 021.

### LECTURE PLAN DEPARTMENT OF MICROBIOLOGY

STAFF NAME: Dr. RAMALAKSHMI. S

SUBJECT NAME: ENVIRONMENTAL AND AGRICULTURAL MICROBIOLOGY

SUB.CODE:17MBP204

SEMESTER: II

CLASS: I M.Sc (MB)

S.No	Lecture Duration Period	Topics to be Covered	Support Material/Page Nos
		<b>UNIT-I</b>	
1	1	Microbiology of water	T1- 364-365
2	1	Water pollution and water borne pathogens	T2- 680-681
3	1	Bacteriological examination of water , indicator organism	W1
4	1	Microbiology of sewage	T1- 368-369
5	1	Chemical & biochemical characteristics of sewage	W2
6	1	Methods of sewage treatment- physical screening	T3- 508
7	1	Methods of sewage treatment – chemical screening	T3- 508
8	1	Methods of sewage treatment – biological screening sludge digestion	T3- 508
9	1	Activated sludge	T3- 510-512
10	1	Aerating filters	T3- 508-510
11	1	Oxidation ponds	T3- 520-521
12	1	Recapitulation and Discussion of Important Questions	
	<b>Total No of Hours Planned For Unit 1=12</b>		

		<b>UNIT-II</b>	
1	1	Microbiology of air	T1- 362-363
2	1	Microbial contaminants of air	T3- 105-107
3	1	Source of contaminants	T3- 105-107
4	1	Microbial indicators of air pollution	T3- 113-115
5	1	Microbial indicators of air pollution	T3- 113-115
6	1	Enumeration of bacteria in air	T3- 98-100,114
7	1	Air samplers	T1-. 222-224
8	1	Air samplers	T1- 222-224
9	1	Sampling techniques	T3- 103-106,118-119
10	1	Sampling techniques	T3- 103-106,118-119
11	1	Air sanitization	T3- 112
12	1	Recapitulation and Discussion of Important Questions	
	<b>Total No of Hours Planned For Unit II=12</b>		
		<b>UNIT-III</b>	
1	1	Introduction to bioremediation	T4: 115-126, W3
2	1	Contaminated soil	T2: 727-729, W4
3	1	Aquifers	T3:. 74, W5:
4	1	Marine pollutants	W6
5	1	Air pollutants	T2, 669,W7:
6	1	Stimulation of oil spills degradation	W8
7	1	Bioremediation of air pollutants	T2: 673-678,
8	1	Bioleaching – recovery of metal from ore	W9:
9	1	Oxidation of minerals	W10:
10	1	Oxidation of minerals	W10:
11	1	Testing for biodegradability	T2: 718-724
12	1	Recapitulation and Discussion of	

		Important Questions	
	<b>Total No of Hours Planned For Unit III=12</b>		
		<b>UNIT-IV</b>	
1	1	Biological nitrogen fixation	R1: 102&108
2	1	Symbiotic microorganism	R1: 115-116
3	1	Non-symbiotic microorganism	R1: : 115-116,
4	1	Root nodule formation	R1: 108, T5: 189-196
5	1	Nitrogen fixers and hydrogenase	T5: 196-199
6	1	Nitrogenase	R1: 108
7	1	Nif genes regulation	R1: 113-115
8	1	Biochemistry of nitrogen fixation	R1: 108-112
9	1	Rhizosphere – R:S ratio	R1,p. 99-102
10	1	Interaction of microbes with plants	R1: 116-119
11	1	Bioconversion of agricultural wastes	W11
12	1	Recapitulation And Discussion Of Important Questions	
	<b>Total No of Hours Planned For Unit IV=12</b>		
		<b>UNIT-V</b>	
1	1	Biofertilizers – Introduction	T7: 166-172
2	1	Production of biofertilizer	T7: 166-172
3	1	Application of biofertilizer	T7: 381
4	1	Bio-manures	T7: 252-270
5	1	Combination of biofertilizers	T7: 381
6	1	Manure application with reference to soil, seed, leaf sprays	T7: 266
7	1	Laboratory and field application	T7: 270-310 W12:
8	1	Cost benefit analysis of biofertilizer	T7: 166-172

9	1	Biomanure production	T7: 266
10	1	Recapitulation and Discussion of important Questions	
11	1	Discussion of Previous ESE Question Papers.	
12	1	Discussion of Previous ESE Question Papers.	
13	1	Discussion of Previous ESE Question Papers.	
	<b>Total No of Hours Planned for unit V=13</b>		
Total Planned Hours	<b>61 HRS</b>		

**Textbooks:**

T1- Rangaswami.G.A.D.J.Bhagyaraj,2001. Agricultural Microbiology,2nd edition,Prentice Hall,New Delhi.

T2- Sathyanarayana,Victoria, 2005,Biotechnology, Uppala-Publisher interlinks.

T3- Maoer, R.M.,Pepper,I.L.Gerba, C.P., 2009.Environmental Microbiology-Second edition,Elsevier Publisher.

T4: Josdand,S.N.,1995.Environmental Biotechnology.Himalaya publishing house,Bombay. 115-126,

T5: Subha Rao,N.S (1999) Biofertilisers in Agriculture and Agroforestry, Oxford and IBTT, New Delhi.

T7: Subha Rao. N.S Soil Microbiology.

**References:**

R1: Atlas,R.M and M.Bartha,2000.Microbial Ecology,Fundamental and application : 3rd edition. Redwood city CA. Benjamin/Cunning science.Publishing Co. New Delhi.

**Websites**

W1: <https://en.wikipedia.org/wiki/water-pollution>.

W2: [www.who.int/water-Sanitation-health/Resource/ quality/wqmchap/0.pdf](http://www.who.int/water-Sanitation-health/Resource/quality/wqmchap/0.pdf)

W3: [Scetcivi/weekly.com/uploads/5/3/5/5395830/14 characteristics of sewage and treatment-required pdf](http://Scetcivi/weekly.com/uploads/5/3/5/5395830/14_characteristics_of_sewage_and_treatment-required.pdf).

W4: <http://en.wikipedia.org/wiki/Bioremediation>.

W5: [http://en.wikipedia.org/wiki/soil contamination](http://en.wikipedia.org/wiki/soil_contamination).

W6: <http://en.wikipedia.org/wiki/Aquifer>

W7: [http://en.wikipedia.org/wiki/marine pollution](http://en.wikipedia.org/wiki/marine_pollution)

W8: [http://en.wikipedia.org/wiki/air pollution](http://en.wikipedia.org/wiki/air_pollution).

W9: [http://en.wikipedia.org/wiki/Microbial degradation](http://en.wikipedia.org/wiki/Microbial_degradation).

W10: <http://en.wikipedia.org/wiki/Bioleaching>

W11 : [www.minisocam.org](http://www.minisocam.org)

W12: [www.manidharmabiotech.com](http://www.manidharmabiotech.com)

**UNIT – 1****Aquatic environment**

An aquatic ecosystem is an ecosystem in a body of water. Communities of organisms that are dependent on each other and on their environment live in aquatic ecosystems. The two main types of aquatic ecosystems are marine ecosystems and freshwater ecosystems

**Marine ecosystem**

Marine ecosystems cover approximately 71% of the Earth's surface and contain approximately 97% of the planet's water. Marine ecosystems can be divided into many zones depending upon water depth and shoreline features.

The oceanic zone is the vast open part of the ocean where animals such as whales, sharks, and tuna live.

The benthic zone consists of substrates below water where many invertebrates live.

The intertidal zone is the area between high and low tides; in this figure it is termed the littoral zone.

**Freshwater ecosystem**

Freshwater ecosystems cover 0.80% of the Earth's surface and inhabit 0.009% of its total water. They generate nearly 3% of its net primary production. Freshwater ecosystems contain 41% of the world's known fish species.

There are three basic types of freshwater ecosystems

- Lentic: slow moving water, including pools, ponds, and lakes.
- Lotic: faster moving water, for example streams and rivers.
- Wetlands: areas where the soil is saturated or inundated for at least part of the time

This biota have a size range (maximum linear dimension) up to 200 mm, and vary from viruses through bacteria and archaea, to micro-algae, fungi and protozoa.

**Functions**

Aquatic ecosystems perform many important environmental functions. For example, they [recycle nutrients](#), purify water, attenuate floods, recharge ground water and provide habitats for wildlife. Aquatic ecosystems are also used for human recreation, and are very important to the [tourism](#) industry, especially in coastal regions.

The health of an aquatic ecosystem is degraded when the ecosystem's ability to absorb a stress has been exceeded. A stress on an aquatic ecosystem can be a result of physical, chemical

or biological alterations of the environment. Physical alterations include changes in water temperature, water flow and light availability. Chemical alterations include changes in the loading rates of biostimulatory nutrients, oxygen consuming materials, and toxins. Biological alterations include over-harvesting of commercial species and the introduction of exotic species. Human populations can impose excessive stresses on aquatic ecosystems. There are many examples of excessive stresses with negative consequences. Consider three. The environmental history of the Great Lakes of North America illustrates this problem, particularly how multiple stresses, such as water pollution, over-harvesting and invasive species can combine. The Norfolk Broadlands in England illustrate similar decline with pollution and invasive species. Lake Pontchartrain along the Gulf of Mexico illustrates the negative effects of different stresses including levee construction, logging of swamps, invasive species and salt water intrusion.

### **Microbiology of water**

Water microbiology is concerned with the microorganisms that live in the water, or those that can be transported from one habitat to another by water. The improvement of pathogen detection methodology is an important issue for the efficient prevention of waterborne outbreaks. Bacterial populations are a natural component of lakes, rivers, streams and other aquatic systems. Over 60 genera of bacteria are present in aquatic systems and numbers can range from forty thousand to over twelve million bacterial cells in an amount of water. The immense numbers of these small organisms can have an enormous impact on processes that occur in aquatic ecosystems such as carbon, nitrogen, and sulphur transformations. They can also have an impact on the quality of water by controlling the amount of oxygen in the water and causing diseases in aquatic organisms as well as in humans. Naturally some microorganisms have learned to live on or in the human body. Many of these microorganisms do not harm, and are even beneficial because they compete with other microorganisms that might cause diseases. A few microorganisms can cause disease in humans. These microorganisms are called pathogens. Some pathogens live out their lives in the soil and water and only cause disease under unusual circumstances. The microorganism that causes tetanus (a bacterium named *Clostridium tetani*). This microorganism lives normally in the soil. Other pathogens are more closely associated with humans and other warmblooded animals. These pathogens are transmitted from one organism to another by direct contact, or by contamination of food or water. However, the presence of other disease causing microbes in water is unhealthy and even life threatening. For example, bacteria that live in the intestinal tracts of humans and other warm blooded animals, such as *Escherichia coli*, *Salmonella*, *Shigella*, and *Vibrio*, can contaminate water if feces enter the water. Contamination of drinking water with a type of *Escherichia coli* known as O157:H7 can be fatal. The contamination of the municipal water supply of Walkerton, Ontario, Canada in the summer of 2000 by strain O157:H7 sickened 2,000 people and killed seven people.

The intestinal tract of warm-blooded animals also contains viruses that can contaminate water and cause disease. Examples include rotavirus, enteroviruses, and coxsackievirus.

Another group of microbes of concern in water microbiology are protozoa. The two protozoa of the most concern are *Giardia* and *Cryptosporidium*. They live normally in the intestinal tract of animals such as beaver and deer. *Giardia* and *Cryptosporidium* form dormant



and hardy forms called cysts during their life cycles. The cyst forms are resistant to chlorine, which is the most popular form of drinking water disinfection, and can pass through the filters used in many water treatment plants. If ingested in drinking water they can cause debilitating and prolonged diarrhea in humans, and can be life threatening to those people with impaired immune systems. *Cryptosporidium* contamination of the drinking water of Milwaukee, Wisconsin with in 1993 sickened more than 400,000 people and killed 47 people.

Many microorganisms are found naturally in fresh and saltwater. These include bacteria, cyanobacteria, protozoa, algae, and tiny animals such as rotifers. These can be important in the food chain that forms the basis of life in the water. For example, the microbes called cyanobacteria can convert the energy of the sun into the energy it needs to live. The plentiful numbers of these organisms in turn are used as food for other life. The algae that thrive in water is also an important food source for other forms of life.

A variety of microorganisms live in fresh water. The region of a water body near the shoreline (the littoral zone) is well lighted, shallow, and warmer than other regions of the water. Photosynthetic algae and bacteria that use light as energy thrive in this zone. Further away from the shore is the limnetic zone. Photosynthetic microbes also live here. As the water deepens, temperatures become colder and the oxygen concentration and light in the water decrease. Now, microbes that require oxygen do not thrive. Instead, purple and green sulfur bacteria, which can grow without oxygen, dominate. Finally, at the bottom of fresh waters (the benthic zone), few microbes survive. Bacteria that can survive in the absence of oxygen and sunlight, such as methane producing bacteria, thrive.

Saltwater presents a different environment to microorganisms. The higher salt concentration, higher pH, and lower nutrients, relative to freshwater, are lethal to many microorganisms. But, salt loving (halophilic) bacteria abound near the surface, and some bacteria that also live in freshwater are plentiful (i.e., *Pseudomonas* and *Vibrio*). Also, in 2001, researchers demonstrated that the ancient form of microbial life known as archaeobacteria is one of the dominant forms of life in the ocean. The role of archaeobacteria in the ocean food chain is not yet known, but must be of vital importance.

Another microorganism found in saltwater are a type of algae known as dinoflagellates. The rapid growth and multiplication of dinoflagellates can turn the water red. This "red tide" depletes the water of nutrients and oxygen, which can cause many fish to die. As well, humans can become ill by eating contaminated fish.

Water can also be an ideal means of transporting microorganisms from one place to another. For example, the water that is carried in the hulls of ships to stabilize the vessels during their ocean voyages is now known to be a means of transporting microorganisms around the globe. One of these organisms, a bacterium called *Vibrio cholerae*, causes life threatening diarrhea in humans.

Drinking water is usually treated to minimize the risk of microbial contamination. The importance of drinking water treatment has been known for centuries. For example, in pre-Christian times the storage of drinking water in jugs made of metal was practiced. Now, the anti-

bacterial effect of some metals is known. Similarly, the boiling of drinking water, as a means of protection of water has long been known.

Chemicals such as chlorine or chlorine derivatives has been a popular means of killing bacteria such as *Escherichia coli* in water since the early decades of the twentieth century. Other bacteria-killing treatments that are increasingly becoming popular include the use of a gas called ozone and the disabling of the microbe's genetic material by the use of ultraviolet light. Microbes can also be physically excluded from the water by passing the water through a filter. Modern filters have holes in them that are so tiny that even particles as miniscule as viruses can be trapped.

An important aspect of water microbiology, particularly for drinking water, is the testing of the water to ensure that it is safe to drink. Water quality testing can be done in several ways. One popular test measures the turbidity of the water. Turbidity gives an indication of the amount of suspended material in the water. Typically, if material such as soil is present in the water then microorganisms will also be present. The presence of particles even as small as bacteria and viruses can decrease the clarity of the water. Turbidity is a quick way of indicating if water quality is deteriorating, and so if action should be taken to correct the water problem.

In many countries, water microbiology is also the subject of legislation. Regulations specify how often water sources are sampled, how the sampling is done, how the analysis will be performed, what microbes are detected, and the acceptable limits for the target microorganisms in the water sample. Testing for microbes that cause disease (i.e., *Salmonella typhimurium* and *Vibrio cholerae*) can be expensive and, if the bacteria are present in low numbers, they may escape detection. Instead, other more numerous bacteria provide an indication of fecal pollution of the water. *Escherichia coli* have been used as an indicator of fecal pollution for decades. The bacterium is present in the intestinal tract in huge numbers, and is more numerous than the disease-causing bacteria and viruses. The chances of detecting *Escherichia coli* are better than detecting the actual disease causing microorganisms. *Escherichia coli* also had the advantage of not being capable of growing and reproducing in the water (except in the warm and food-laden waters of tropical countries). Thus, the presence of the bacterium in water is indicative of recent fecal pollution. Finally, *Escherichia coli* can be detected easily and inexpensively.

### **Water pollution**

**Definition:** Water pollution is characterized by certain observable disturbance in normal properties and functions of fresh water. Eg : includes offensive odour, bad taste etc.,

Water pollution occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds.

Surface water and groundwater have often been studied and managed as separate resources, although they are interrelated. Surface water seeps through the soil and becomes groundwater.

**Ground water pollution**

Ground water is considered to be safe and useful for drinking, agricultural and industrial purpose. The specific contaminants leading to pollution in water include chemicals and substances such as fluoride, arsenic, nitrate etc., the concentration is the key in determining contaminant. High concentrations of naturally occurring substances can have negative impacts on aquatic flora and fauna and the substances are toxic to humans.

**Surface water pollution**

Surface water includes rivers, lakes and reservoirs, surface water is susceptible for pollution eg : industrial, domestic, agricultural etc.,

**Nature of pollutants**

Pollutants may be Dissolved, Suspended, Colloidal in state, they are further categorised as

- Organic pollutants
- Synthetic organic pollutants
- Inorganic pollutants

Organic water pollutants include

*Detergents*

Disinfection by-products found in chemically disinfected drinking water, such as chloroform. Food processing waste, which can include oxygen-demanding substances, fats and grease, Insecticides and herbicides, a huge range of organohalides and other chemical compounds, Petroleum hydrocarbons, including fuels (gasoline, diesel fuel, jet fuels, and fuel oil) and lubricants (motor oil), and fuel combustion byproducts, from storm water runoff, Tree and bush debris from logging operations.

*Volatile organic compounds (VOCs)*

Chlorinated solvents, which are dense non-aqueous phase liquids (DNAPLs), may fall to the bottom of reservoirs, since they don't mix well with water and are denser. Polychlorinated biphenyl (PCBs). Trichloroethylene. Perchlorate

Various chemical compounds found in personal hygiene and cosmetic products

- Drug pollution involving pharmaceutical drugs and their metabolites.
- Inorganic water pollutants include
- Acidity caused by industrial discharges (especially sulfur dioxide from power plants)
- Ammonia from food processing waste

- Chemical waste as industrial by-products
- Fertilizers containing nutrients--nitrates and phosphates—which are found in stormwater runoff from agriculture, as well as commercial and residential use[16]
- Heavy metals from motor vehicles (via urban stormwater runoff)[16][17] and acid mine drainage

Silt (sediment) in runoff from construction sites, logging, slash and burn practices or land clearing sites.

### Microbiological pollutant

Microbiological pollution is caused by wide range of microorganisms like bacteria, viruses , protozo, helminths can cause serious diseases that can lead to death.

### Radioactive pollutant

Radioactive contamination, also called radiological contamination, is the deposition of, or presence of radioactive substances on surfaces or within solids, liquids or gases, where their presence is unintended or undesirable. E.g uranium, radium, thorium.

### Water borne pathogens

Waterborne diseases are caused by pathogenic microorganisms that most commonly are transmitted in contaminated fresh water. Although the vast majority of bacteria are either harmless or beneficial, a few pathogenic bacteria can cause disease. [Coli form bacteria](#), which are not an actual cause of disease, are commonly used as a [bacterial indicator](#) of water pollution. Other microorganisms sometimes found in surface waters that have caused human health problems include:

- [Burkholderia pseudomallei](#)
- [Cryptosporidium parvum](#)
- [Giardia lamblia](#)
- [Salmonella](#)
- [Norovirus](#) and other viruses
- [Parasitic worms](#) including the [Schistosoma](#) type

High levels of pathogens may result from on-site [sanitation](#) systems ([septic tanks](#), [pit latrines](#)) or inadequately treated [sewage](#) discharges. This can be caused by a sewage plant designed with less than [secondary treatment](#) (more typical in less-developed countries). In developed countries, older cities with aging infrastructure may have leaky sewage collection

systems (pipes, pumps, valves), which can cause [sanitary sewer overflows](#). Some cities also have [combined sewers](#), which may discharge untreated sewage during rain storms.

### BACTERIAL EXAMINATION OF WATER

The bacteriological examination of water is performed routinely by water utilities to ensure a safe supply of water for drinking, industrial and other domestic uses. The examination is intended to identify water sources which have been contaminated with potential disease causing microorganisms. Such contamination generally occurs either directly by human or animal feces, or indirectly through improperly treated sewage or improperly functioning sewage treatment systems. The organisms of prime concern are the intestinal pathogens, particularly those that cause typhoid fever and bacillary dysentery. In order to determine whether water has been contaminated by fecal material, a series of tests are used to demonstrate the presence or absence of coliforms. The coliform group is comprised of Gram-negative, nonspore-forming, aerobic to facultatively anaerobic rods, which ferment lactose to acid and gas. Two organisms in this group include *E. coli* and *Enterobacter aerogenes*; however, the only true fecal coliform is *E. coli*, which is found only in fecal material from warm-blooded animals. The presence of this organism in a water supply is evidence of recent fecal contamination and is sufficient to order the water supply closed until tests no longer detect *E. coli*. The three principal tests used for bacterial examinations are

- Presumptive test
- Confirmative test
- Complete test

### Standard water analysis

#### The Presumptive test

In the presumptive test, a series of lactose broth tubes are inoculated with measured amounts of the water sample. Gas production in any one of the tubes is presumptive evidence of the presence of coliforms. The most probable number (MPN) of coliforms in 100 ml of the water sample can be estimated by the number of positive tubes.

#### The confirmed test

If any of the tubes inoculated with the water sample produce gas, the water is presumed to be unsafe. In order to confirm the presence of coliforms, it is necessary to inoculate EMB (eosin methylene blue) agar plates from a positive presumptive tube. The methylene blue in EMB agar inhibits Gram-positive organisms and allows the Gram-negative coliforms to grow. Coliforms produce colonies with dark centers. *E. coli* and *E. aerogenes* can be distinguished from one another by the size and color of the colonies. *E. coli* colonies are small and have a green metallic sheen, whereas *E. aerogenes* forms large pinkish colonies. If only *E. coli* or if both

E. coli and E. aerogenes appear on the EMB plate, the test is considered positive. If only E. aerogenes appears on the EMB plate, the test is considered negative. The reasons for these interpretations are that, as previously stated, E. coli is an indicator of fecal contamination, since it is not normally found in water or soil, whereas E. aerogenes is widely distributed in nature outside of the intestinal tract.

### **The completed test**

The completed test is made using the organisms which grow on the confirmed test media. These organisms are used to inoculate a nutrient agar slant and a tube of lactose broth. After 24 hours at 37°C, the lactose broth is checked for the production of gas, and a Gram stain is made from organisms on the nutrient agar slant. If the organism is a Gram-negative, nonspore-forming rod and produces gas in the lactose tube, then it is positive that coliforms are present in the water sample.

The water sample is inoculated in three tubes of lactose broth with 10 ml, three tubes with 1.0 ml and three tubes with 0.1 ml. Incubate all tubes at 37°C for 24 hours. Observe the number of tubes at each dilution that show gas production in 24 hrs. Reincubate for an additional 24 hours at 37°C. Inoculate an EMB plate with material from a tube containing gas. Invert and incubate the plate at 37°C for 24 hours. Observe EMB agar plates. A positive confirmed test is indicated by small colonies with dark centres and a green metallic sheen (E. coli). Inoculate a lactose broth tube and a nutrient agar slant with organisms from the EMB plate. Incubate the broth tube and agar slant at 37°C for 24 hours

**KARPAGAM ACADEMY OF HIGHER EDUCATION**

CLASS: I MSc MB

COURSE NAME: ENVIRONMENTAL AND AGRICULTURAL MICROBIOLOGY

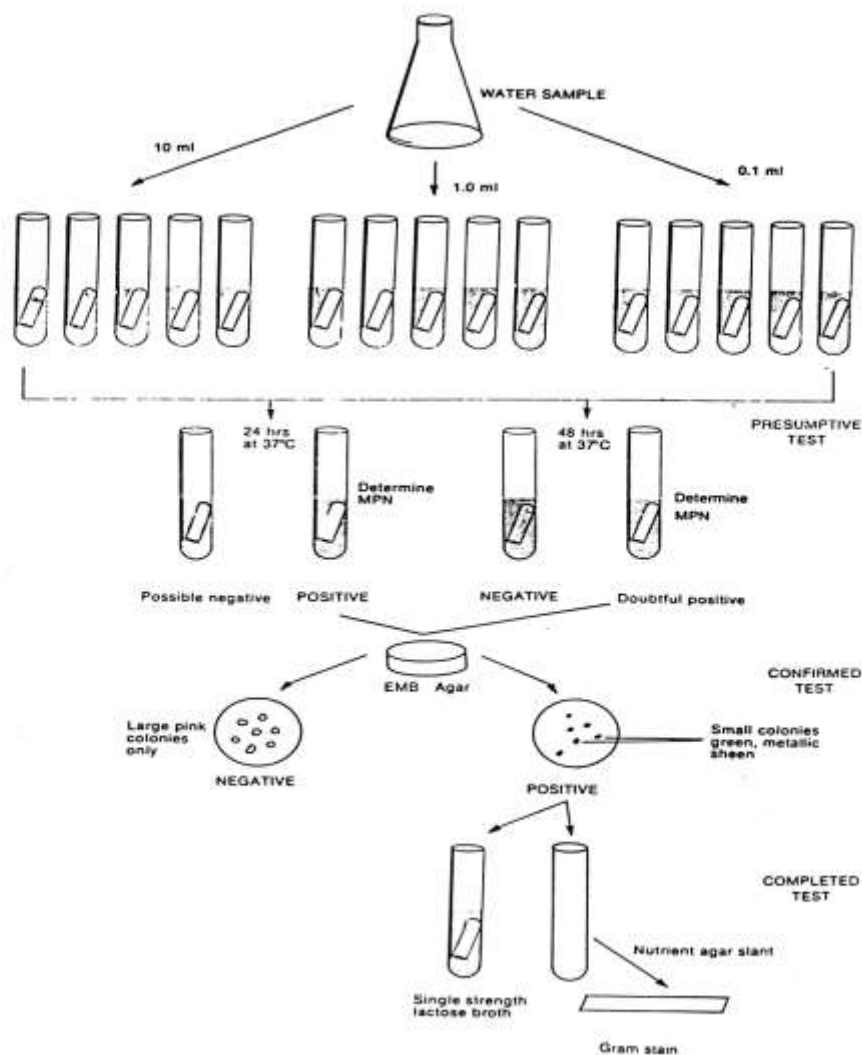
COURSE CODE: 17MBU204

UNIT: I

BATCH-2017-2019

**MPN DETERMINATION FROM MULTIPLE TUBE TEST**

NUMBER OF TUBES GIVING POSITIVE REACTION OUT OF			MPN Index per 100 ml.	95 PERCENT CONFIDENCE LIMITS	
3 of 10 ml. each	3 of 1 ml. each	3 of 0.1 ml. each		Lower	Upper
0	0	1	3	<0.5	9
0	1	0	3	<0.5	13
1	0	0	4	<0.5	20
1	0	1	7	1	21
1	1	0	7	1	23
1	1	1	11	3	36
1	2	0	11	3	36
2	0	0	9	1	36
2	0	1	11	3	37
2	1	0	15	3	44
2	1	1	20	7	89
2	2	0	21	4	47
2	2	1	28	10	150
3	0	0	23	4	120
3	0	1	39	7	130
3	0	2	64	15	380
3	1	0	43	7	210
3	1	1	75	14	230
3	1	2	120	30	380
3	2	0	93	15	380
3	2	1	150	30	440
3	2	2	210	35	470
3	3	0	240	36	1,300
3	3	1	460	71	2,400
3	3	2	1,100	150	4,800



### Indicator organism

Cabelli (1977) noted that the best indicator organism should be the one whose densities correlate best with health hazards associated with one or several given types of pollution sources. The requirements for an indicator as follows:

- The indicator should be consistently and exclusively associated with the source of the pathogens.
- It must be present in sufficient numbers to provide an accurate density estimate whenever the level of each of the pathogens is such that the risk of illness is unacceptable.



- It should approach the resistance to disinfectants and environmental stress, including toxic materials deposited therein, of the most resistant pathogen potentially present at significant levels in the sources.
- It should be quantifiable in recreational waters by reasonably facile and in expensive methods and with considerable accuracy, precision, and specificity.

Indicator organisms indicate that fecal pollution and presences of microbial pathogens. Total and fecal coliforms, and the enterococci - fecal streptococci are important indicator organisms. Coliform bacteria include all aerobic and facultative anaerobic, gram-negative, nonspore-forming, rod-shaped bacteria that ferment lactose with gas formation. There are three groupings of coliform bacteria used as standards: total coliforms (TC), fecal coliforms (FC) and *Escherichia coli*. Total coliforms are the broadest grouping including *Escherichia*, *Enterobacter*, *Klebsiella*, and *Citrobacter*. These are found naturally in the soil, as well as in feces. Fecal coliforms are the next widest grouping, which includes many species of bacteria commonly found in the human intestinal tract. Usually between 60% and 90% of total coliforms are fecal coliforms. *E. coli* are a particular species of bacteria that may or may not be pathogenic but are ubiquitous in the human intestinal tract. Generally more than 90% of the fecal coliform are *Escherichia coli*.

### **Microbiology of sewage**

Wastewater, by its nature, is teeming with microbes. Many of these microbes are necessary for the degradation and stabilization of organic matter and thus are beneficial. On the other hand, wastewater may also contain pathogenic or potentially pathogenic microorganisms, which pose a threat to health. Microbes play an extremely important role in sewage treatment. It is largely through biological digestion that sewage is converted from a highly contaminated, infectious liquid into a relatively stable, inert sludge and a harmless effluent needing only chlorination before it may be discharged into a receiving stream, leaching bed, or other disposal area. There are two biological processes involved in sewage treatment.

Aerobic digestion is exemplified by the activated sludge process, in which the wastes from primary settling tanks are thoroughly aerated until active masses of microorganisms settle out as sludge, leaving a clear effluent of relatively low organic content. A portion of the sludge is returned and mixed with the incoming raw sewage, while the remainder is pumped to digester tanks. Anaerobic digestion is a slower process, which is typified by large digestion tanks, septic tanks, and cesspools. The main focus of wastewater treatment plants is to reduce the BOD (biochemical oxygen demand) and COD (chemical oxygen demand) in the effluent discharged to natural waters, meeting state and federal discharge criteria. Wastewater treatment plants are designed to function as "microbiology farms", where bacteria and other microorganisms are fed oxygen and organic waste

### **Characteristics of Sewage:**

Characterization of sewage is essential for an effective and economical waste management programme. It helps in the choice of treatment methods deciding the extent of treatment, assessing the beneficial uses of wastes and utilizing the waste purification capacity of

natural bodies of water in a planned and controlled manner. The wastes are generally characterized as follows:

**(i) Physical characteristics:** The physical characteristics are colour, odour, turbidity and temperature.

**Colour:** Fresh sewage is yellowish green or light brown. It is detected by naked eye.

**Odour:** Fresh sewage is odorless, In 3 to 4 hours, it becomes stale due to exhaust of oxygen in the sewage, mainly due to decomposition of sewage. It is measured by Threshold odour number (TON).

**Turbidity:** Sewage is generally turbid. It becomes more turbid due to floating matters like floating paper, grease, match sticks, fluid skins etc. Turbidity increases as sewage becomes stronger. Turbidity is measured by turbidity meter.

**Temperature:** The observation of temperature of sewage is useful in indicating solubility of oxygen, which affects transfer capacity of aeration equipment in aerobic systems and rate of biological activity. Normal temperature of sewage is higher than that of water. Raw temperature of sewage under Indian conditions is between 15-35°C, mostly 20°C.

**(ii) Chemical characteristics:** Chemical characteristics of sewage help us to find the stage of sewage decomposition, its strength and type of treatment required for safe disposal.

**pH:** The hydrogen ion concentration expressed as pH, it is a valuable parameter in the operation of biological units. Generally pH of raw sewage is in range of 5.5 to 8.0.

**Solid matter:** Sewage water contains 0.05 to 0.1% of total solids. They are present in four forms

- (a) Suspend solids
- (b) Dissolved solids
- (c) colloidal solids
- (d) settle able solids
- (e) Organic matter
- (f) Inorganic matter.

**Chloride content:**

Chloride present in sewage from kitchens, urinals, bathrooms & industries. The normal limit is 120 mg/l. The maximum permissible limit is 250mg/l.

**Nitrogen content:** The presence of nitrogen indicates presence of organic matters. This exists in the form of nitrates, free  $\text{NH}_3$  and aluminoides. Nitrate indicates intermediate stage of decomposition. Hence it helps to find the amount of treatment to be done. Natural oxidation prevents nitrates and nitrites.

**Dissolved oxygen:** Amount of oxygen gas dissolved in sewage water is called as dissolved oxygen. It has to be noted while discharging sewage into stream water. Dissolved content should be more than 4 ppm, else the fishes die and thus affects aquatic cycle. Fresh sewage contains DO in certain amount that gets depleted due to aerobic decomposition. When temperature increases, DO reduces. It is determined by winkler's method

**. Biochemical oxygen demand and eutrophication**

Organic material in wastewater originates from microorganisms, plants, animals, and synthetic organic compounds. Organic materials enter wastewater in human wastes, paper products, detergents, cosmetics, and foods. They are typically a combination of carbon, hydrogen, oxygen and nitrogen and may contain other elements.

The oxidation of organic materials in the environment can have profound effects on the maintenance of aquatic life and the aesthetic quality of waters. Biochemical oxidation reactions involve the conversion of organic material using oxygen and nutrients into carbon dioxide, water and new cells. The equation that expresses this is:

**Organic material + O<sub>2</sub> + nutrients → CO<sub>2</sub> + H<sub>2</sub>O + new cells + nutrients + energy**

It can be seen from this equation that organisms use oxygen to breakdown carbon-based materials for assimilation into new cell mass and energy. A common measure of this oxygen use is biochemical oxygen demand (BOD). BOD is the amount of oxygen used in the metabolism of biodegradable organics. If water with a large amount of BOD is discharged into the environment, it can deplete the natural oxygen resources. Heterotrophic bacteria utilize deposited organics and oxygen at rates that exceed the oxygen-transfer rates across the water surface. This can cause anaerobic conditions, which leads to noxious odors. It can also be detrimental to aquatic life by reducing dissolved oxygen concentrations to levels that cause fish to suffocate. The end result is an overall degradation of water quality.

Wastewater often contains large amounts of the nutrients, particularly nitrogen and phosphorous, which are essential for growth of all organisms and are typically limiting in the environment. Nitrogen is a complex element existing in both organic and inorganic forms. The forms of most interest from a water quality perspective are organic nitrogen, ammonia, nitrite, and nitrate. Phosphorous is found in synthetic detergents and is used for corrosion control in water supplies.

The introduction of large concentrations of these nutrients from untreated or improperly treated wastewater can lead to eutrophication. Eutrophication is the process by which bodies of water become rich in mineral and organic nutrients causing plant life, especially algae, to proliferate, then die and decompose thereby reducing the dissolved oxygen content and often killing off other organisms.

**Chemical oxygen demand (COD):** The amount of oxygen required to oxidize the organic matter present in sewage (both biologically active and inactive)

Generally COD is greater than BOD. Thus BOD/COD is always less than 1.

**.(iii) Biological characteristics:** The bacterial characteristics of sewage are due to the presence of micro-organisms, which include bacteria and other living micro-organisms such as algae, fungi, protozoa etc.

**Pathogens:** it Creates harm to humans, animals, crops.

**Non-pathogens:** it does not produce harm.

**Aerobic bacteria:** it survives in the presence of oxygen.

**Anaerobic bacteria:** Flourish in absence of oxygen.

**Facultative bacteria:** Survive with or without oxygen.

Most of the microorganisms help in decomposition of sewage.

### **Sewage Treatment:**

Sewage, before being disposed of either in river or streams or on land, has to be treated for making it safe. The degree of treatment required depends on the characteristics of sewage & source disposal. Sewage can be treated in different ways.

The treatment process are often classified as

- (i) Preliminary treatment
- (ii) Primary treatment
- (iii) Secondary treatment
- (iv) Tertiary/final treatment (sometimes).

(i) **Preliminary treatment:** It consists of separating the floating materials like dead animals, tree branches, paper, and pieces of wood etc. and also heavy settleable inorganic solids. It helps in removing oils and greases etc from sewage. This reduces BOD of waste water by about 15 to 30%. The processes used are

- (a) Screening: To remove floating papers, rags, clothes etc.
- (b) Grit chamber/Detritus sand: To remove grit and sand
- (c) Skimming tanks: To remove oils and greases

(ii) **Primary Treatment:** It consists of removing large suspended organic solids. This is usually done by sedimentation in settling basins. The liquid effluent from primary treatment often contains a large amount of suspended organic material and has high BOD (about 60% of original). The organic solids, which are separated out in sedimentation tanks are stabilized by anaerobic decomposition in digestion tank or incinerated. The residue is used for landfills or soil conditioners.

**Secondary Treatment:**

Secondary treatment is biological process of very fine suspended matter, colloids and dissolved solids in sewage that comes from primary sedimentation tank.

The treatment stabilizes and makes the sewage completely harmless.

The unit process of secondary treatment are biological oxidation and synthesis through sewage filter or activated sludge process, converting sewage into heavier and bulkier and then allowing it to settle in secondary sedimentation tank.

The separated sewage sludge is decomposed anaerobically in sludge tank and the digested sludge is disposed off separately in sludge drying beds.

Difference between primary treatment and secondary treatment of sewage

**(i) Primary treatment:**

It is evident that the sewage as it arrives at the treatment plant would initially undergo primary treatment for the removal of heavy suspended matter such as solids, kitchen refuse, cloth, wastepaper etc.

Inorganic matter like sand, grit and other floating matter.

The primary treatment involves subjecting sewage subsequently to unit processes such as screening. Screening is the removal of grit and other floating matter and the remaining solids are removed through sedimentation process in primary sedimentation tank or clarifier. The primary treatment removes the physical impurities present in sewage along with solid matter. Sometimes preliminary treatment is also termed along with the primary treatment.

**(ii) Secondary Treatment:**

Secondary treatment involves further treatment of the effluent coming from the primary sedimentation tank. This is generally accomplished through biological decomposition of organic matter, under aerobic or anaerobic conditions. Bacteria get decomposed to fine organic matter, to produce clearer effluent.

(i) Aerobic biological unit: Under aerobic conditions eg: filters, aeration tanks, oxidation ponds, aerated lagoons

(ii) Anaerobic biological unit: Under anaerobic conditions eg: anaerobic lagoons, septic tanks etc.

**Benefits of sewage treatment:**

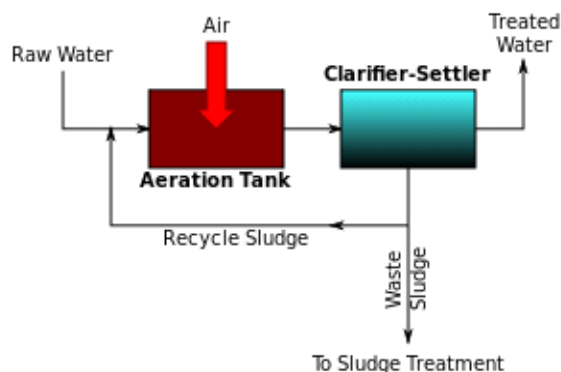
Save money by recycling a portion of waste water for use around garden.

Limit the impact of house waste on environment by becoming more self sufficient.

Protects precious source of ground water and saves rainwater in dams by recycling.

Reduce impact on municipal sewage system by installing domestic treatment system, particularly grey water treatment system.

Methods of sewage treatment



### Activated sludge

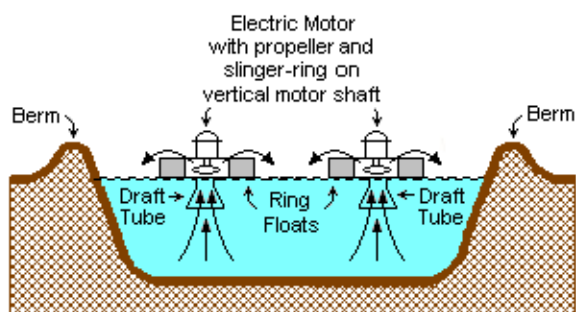
Activated sludge plants encompass a variety of mechanisms and processes that use dissolved oxygen to promote the growth of biological floc that substantially removes organic material. Biological floc, as mentioned above, is an ecosystem of living biota that subsists on nutrients from the inflowing primary settling tank (or clarifier) effluent. These mostly carbonaceous dissolved solids undergo aeration to be broken down and biologically oxidized or converted to carbon dioxide. Likewise, nitrogenous dissolved solids (amino acids, ammonia, etc.) are also oxidized by the floc to nitrites, nitrates, and, in some processes, to nitrogen gas through denitrification. While denitrification is encouraged in some treatment processes, in many suspended aeration plants denitrification will impair the settling of the floc and lead to poor quality effluent. In either case, the settled floc is both recycled to the inflowing primary effluent to regrow, or is partially 'wasted' (or diverted) to solids dewatering, or digesting, and then dewatering. This many times takes the form of the floating brown foam, Nocardia. While this so called 'sewage fungus' (it isn't really a fungus) is the best known, there are many different fungi and protists that can overpopulate the floc and cause process upsets. Additionally, certain incoming chemical species, such as a heavy pesticide, a heavy metal (eg.: plating company effluent) load, or extreme pH, can kill the biota of an activated sludge reactor ecosystem. Such problems are tested for, and if caught in time, can be neutralized.

### **Aerobic granular sludge**

Activated sludge systems can be transformed into aerobic granular sludge systems (aerobic granulation) which enhance the benefits of activated sludge, like increased biomass retention due to high sludge settlability.

### **Surface-aerated basins**

Many small municipal sewage systems in the United States (1 million gal./day or less) use aerated lagoons. Most biological oxidation processes for treating industrial wastewaters have in common the use of oxygen (or air) and microbial action. Surface-aerated basins achieve 80 to 90 percent removal of BOD with retention times of 1 to 10 days. The basins may range in depth from 1.5 to 5.0 metres and use motor-driven aerators floating on the surface of the wastewater. In an aerated basin system, the aerators provide two functions: they transfer air into the basins required by the biological oxidation reactions, and they provide the mixing required for dispersing the air and for contacting the reactants (that is, oxygen, wastewater and microbes). Typically, the floating surface aerators are rated to deliver the amount of air equivalent to 1.8 to 2.7 kg O<sub>2</sub>/kW·h. However, they do not provide as good mixing as is normally achieved in activated sludge systems and therefore aerated basins do not achieve the same performance level as activated sludge units. Biological oxidation processes are sensitive to temperature and, between 0 °C and 40 °C, the rate of biological reactions increase with temperature. Most surface aerated vessels operate at between 4 °C and 32 °C.



**A TYPICAL SURFACE - AERATED BASIN**

Note: The ring floats are tethered to posts on the berms.

### **Filter beds**

Trickling filter beds are used where the settled sewage liquor is spread onto the surface of a bed made up of coke (carbonized coal), limestone chips or specially fabricated plastic media. Such media must have large surface areas to support the biofilms that form. The liquor is typically distributed through perforated spray arms. The distributed liquor trickles through the

bed and is collected in drains at the base. These drains also provide a source of air which percolates up through the bed, keeping it aerobic. Biological films of bacteria, protozoa and fungi form on the media's surfaces and eat or otherwise reduce the organic content. This biofilm is often grazed by insect larvae, snails, and worms which help maintain an optimal thickness. Overloading of beds increases the thickness of the film leading to clogging of the filter media and ponding on the surface. Recent advances in media and process micro-biology design overcome many issues with trickling filter designs.

### **Biological aerated filters**

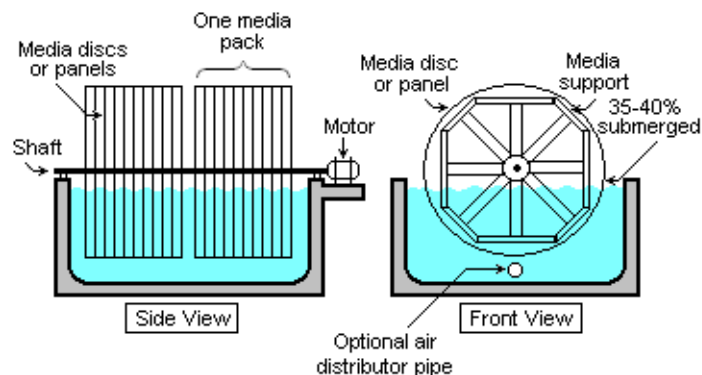
Biological Aerated (or Anoxic) Filter (BAF) or Biofilters combine filtration with biological carbon reduction, nitrification or denitrification. BAF usually includes a reactor filled with a filter media. The media is either in suspension or supported by a gravel layer at the foot of the filter. The dual purpose of this media is to support highly active biomass that is attached to it and to filter suspended solids. Carbon reduction and ammonia conversion occurs in aerobic mode and sometime achieved in a single reactor while nitrate conversion occurs in anoxic mode. BAF is operated either in upflow or downflow configuration depending on design specified by manufacturer.

### **Rotating biological contactors**

Rotating biological contactors (RBCs) are mechanical secondary treatment systems, which are robust and capable of withstanding surges in organic load. RBCs were first installed in Germany in 1960 and have since been developed and refined into a reliable operating unit. The rotating disks support the growth of bacteria and micro-organisms present in the sewage, which break down and stabilize organic pollutants. To be successful, micro-organisms need both oxygen to live and food to grow. Oxygen is obtained from the atmosphere as the disks rotate. As the micro-organisms grow, they build up on the media until they are sloughed off due to shear forces provided by the rotating discs in the sewage. Effluent from the RBC is then passed through final clarifiers where the micro-organisms in suspension settle as a sludge. The sludge is withdrawn from the clarifier for further treatment.

A functionally similar biological filtering system has become popular as part of home aquarium filtration and purification. The aquarium water is drawn up out of the tank and then cascaded over a freely spinning corrugated fiber-mesh wheel before passing through a media filter and back into the aquarium. The spinning mesh wheel develops a biofilm coating of microorganisms that feed on the suspended wastes in the aquarium water and are also exposed to the atmosphere as the wheel rotates. This is especially good at removing waste urea and ammonia urinated into the aquarium water by the fish and other animals.





### **Membrane bioreactors**

Membrane bioreactors (MBR) combine activated sludge treatment with a membrane liquid-solid separation process. The membrane component uses low pressure microfiltration or ultrafiltration membranes and eliminates the need for clarification and tertiary filtration. The membranes are typically immersed in the aeration tank; however, some applications utilize a separate membrane tank. One of the key benefits of an MBR system is that it effectively overcomes the limitations associated with poor settling of sludge in conventional activated sludge (CAS) processes. The technology permits bioreactor operation with considerably higher mixed liquor suspended solids (MLSS) concentration than CAS systems, which are limited by sludge settling. The process is typically operated at MLSS in the range of 8,000–12,000 mg/L, while CAS are operated in the range of 2,000–3,000 mg/L. The elevated biomass concentration in the MBR process allows for very effective removal of both soluble and particulate biodegradable materials at higher loading rates. Thus increased sludge retention times, usually exceeding 15 days, ensure complete nitrification even in extremely cold weather.

The cost of building and operating an MBR is often higher than conventional methods of sewage treatment. Membrane filters can be blinded with grease or abraded by suspended grit and lack a clarifier's flexibility to pass peak flows. The technology has become increasingly popular for reliably pretreated waste streams and has gained wider acceptance where infiltration and inflow have been controlled, however, and the life-cycle costs have been steadily decreasing. The small footprint of MBR systems, and the high quality effluent produced, make them particularly useful for water reuse applications.

### **Secondary sedimentation**

The final step in the secondary treatment stage is to settle out the biological floc or filter material through a secondary clarifier and to produce sewage water containing low levels of organic material and suspended matter.

### **Tertiary treatment**

The purpose of tertiary treatment is to provide a final treatment stage to further improve the effluent quality before it is discharged to the receiving environment (sea, river, lake, wet

lands, ground, etc.). More than one tertiary treatment process may be used at any treatment plant. If disinfection is practiced, it is always the final process. It is also called "effluent polishing."

### **Filtration**

Sand filtration removes much of the residual suspended matter. Filtration over activated carbon, also called carbon adsorption, removes residual toxins.

### **Lagooning**

Lagooning provides settlement and further biological improvement through storage in large man-made ponds or lagoons. These lagoons are highly aerobic and colonization by native macrophytes, especially reeds, is often encouraged. Small filter feeding invertebrates such as *Daphnia* and species of *Rotifera* greatly assist in treatment by removing fine particulates.

### **Nutrient removal**

Wastewater may contain high levels of the nutrients nitrogen and phosphorus. Excessive release to the environment can lead to a buildup of nutrients, called eutrophication, which can in turn encourage the overgrowth of weeds, algae, and cyanobacteria (blue-green algae). This may cause an algal bloom, a rapid growth in the population of algae. The algae numbers are unsustainable and eventually most of them die. The decomposition of the algae by bacteria uses up so much of the oxygen in the water that most or all of the animals die, which creates more organic matter for the bacteria to decompose. In addition to causing deoxygenation, some algal species produce toxins that contaminate drinking water supplies. Different treatment processes are required to remove nitrogen and phosphorus.

### **Nitrogen removal**

The removal of nitrogen is effected through the biological oxidation of nitrogen from ammonia to nitrate (nitrification), followed by denitrification, the reduction of nitrate to nitrogen gas. Nitrogen gas is released to the atmosphere and thus removed from the water.

Nitrification itself is a two-step aerobic process, each step facilitated by a different type of bacteria. The oxidation of ammonia ( $\text{NH}_3$ ) to nitrite ( $\text{NO}_2^-$ ) is most often facilitated by *Nitrosomonas* spp. ("nitroso" referring to the formation of a nitroso functional group). Nitrite oxidation to nitrate ( $\text{NO}_3^-$ ), though traditionally believed to be facilitated by *Nitrobacter* spp. (nitro referring the formation of a nitro functional group), is now known to be facilitated in the environment almost exclusively by *Nitrospira* spp.

Denitrification requires anoxic conditions to encourage the appropriate biological communities to form. It is facilitated by a wide diversity of bacteria. Sand filters, lagooning and reed beds can all be used to reduce nitrogen, but the activated sludge process (if designed well) can do the job the most easily. Since denitrification is the reduction of nitrate to dinitrogen gas, an electron donor is needed. This can be, depending on the wastewater, organic matter (from faeces), sulfide, or an added donor like methanol. The sludge in the anoxic tanks (denitrification tanks) must be

mixed well (mixture of recirculated mixed liquor, return activated sludge [RAS], and raw influent) e.g. by using submersible mixers in order to achieve the desired denitrification.

### **Phosphorus removal**

Phosphorus can be removed biologically in a process called enhanced biological phosphorus removal. In this process, specific bacteria, called polyphosphate-accumulating organisms (PAOs), are selectively enriched and accumulate large quantities of phosphorus within their cells (up to 20 percent of their mass). When the biomass enriched in these bacteria is separated from the treated water, these biosolids have a high fertilizer value. Phosphorus removal can also be achieved by chemical precipitation, usually with salts of iron (e.g. ferric chloride), aluminum (e.g. alum), or lime. This may lead to excessive sludge production as hydroxides precipitates and the added chemicals can be expensive. Chemical phosphorus removal requires significantly smaller equipment footprint than biological removal, is easier to operate and is often more reliable than biological phosphorus removal.

### **Disinfection**

The purpose of disinfection in the treatment of waste water is to substantially reduce the number of microorganisms in the water to be discharged back into the environment for the later use of drinking, bathing, irrigation, etc. The effectiveness of disinfection depends on the quality of the water being treated (e.g., cloudiness, pH, etc.), the type of disinfection being used, the disinfectant dosage (concentration and time), and other environmental variables. Cloudy water will be treated less successfully, since solid matter can shield organisms, especially from ultraviolet light or if contact times are low. Generally, short contact times, low doses and high flows all militate against effective disinfection. Common methods of disinfection include ozone, chlorine, ultraviolet light, or sodium hypochlorite. Chloramine, which is used for drinking water, is not used in the treatment of waste water because of its persistence. After multiple steps of disinfection, the treated water is ready to be released back into the water cycle by means of the nearest body of water or agriculture. Afterwards, the water can be transferred to reserves for everyday human uses.

Chlorination remains the most common form of waste water disinfection in North America due to its low cost and long-term history of effectiveness. One disadvantage is that chlorination of residual organic material can generate chlorinated-organic compounds that may be carcinogenic or harmful to the environment. Residual chlorine or chloramines may also be capable of chlorinating organic material in the natural aquatic environment. Further, because residual chlorine is toxic to aquatic species, the treated effluent must also be chemically dechlorinated, adding to the complexity and cost of treatment.

Ultraviolet (UV) light can be used instead of chlorine, iodine, or other chemicals. Because no chemicals are used, the treated water has no adverse effect on organisms that later consume it, as may be the case with other methods. UV radiation causes damage to the genetic structure of bacteria, viruses, and other pathogens, making them incapable of reproduction. The key disadvantages of UV disinfection are the need for frequent lamp maintenance and replacement and the need for a highly treated effluent to ensure that the target microorganisms

are not shielded from the UV radiation (i.e., any solids present in the treated effluent may protect microorganisms from the UV light). In the United Kingdom, UV light is becoming the most common means of disinfection because of the concerns about the impacts of chlorine in chlorinating residual organics in the wastewater and in chlorinating organics in the receiving water. Some sewage treatment systems in Canada and the US also use UV light for their effluent water disinfection.

Ozone (O<sub>3</sub>) is generated by passing oxygen (O<sub>2</sub>) through a high voltage potential resulting in a third oxygen atom becoming attached and forming O<sub>3</sub>. Ozone is very unstable and reactive and oxidizes most organic material it comes in contact with, thereby destroying many pathogenic microorganisms. Ozone is considered to be safer than chlorine because, unlike chlorine which has to be stored on site (highly poisonous in the event of an accidental release), ozone is generated onsite as needed. Ozonation also produces fewer disinfection by-products than chlorination. A disadvantage of ozone disinfection is the high cost of the ozone generation equipment and the requirements for special operators.

**Benefits of sewage treatment:**

- Save money by recycling a portion of waste water for use around garden.
- Limit the impact of house waste on environment by becoming more self sufficient.
- Protects precious source of ground water and saves rainwater in dams by recycling.
- Reduce impact on municipal sewage system by installing domestic treatment system, particularly grey water treatment system.

## Unit I

\_\_\_\_\_ filters provide a high surface area to grow a biomass

\_\_\_\_\_ is a semiconductor photo catalyst.

\_\_\_\_\_ virus causes whooping cough.

\_\_\_\_\_ is a semiconductor photo catalyst.

\_\_\_\_\_ are relatively more abundant than the vegetative cells in the air

\_\_\_\_\_ is an occupational disease

\_\_\_\_\_ can be a source of infectious diseases

Air borne infections are transmitted mainly by

Air doesn't have a \_\_ flora

Airborne particles are a major cause of \_\_\_\_\_ allergies in humans.

Average salinity of seawater

Bacteriological examination of water usually employs

*Chlorella pyrenoidosa* is usually found in

Copper is used in water treatment as a

Droplet nuclei are significant in the transmission of diseases of the

Ecological region at the lowest level of a body of water such as an ocean or a lake

Effective air sanitizing is done by

Elemental sulphur to sulphuric acid oxidised by -----

Farmer's lung caused by exposure to spores of thermophilic \_\_\_\_\_

Fomites are

Formation of----- is crucial step in anaerobic digestion

HEPA filters are typically rated as \_\_\_\_\_ effective in removing dust.

In a lake the combined littoral and limnetic zone is known as

In Lemon sampler air is drawn at the rate of \_\_\_\_\_ per minute and dispersed

Laminar airflow developed by \_\_\_\_\_.

Lilton large volume air sampler is an example for \_\_\_\_\_.

Main photosynthetic body of the lake

Marine ecosystems cover approximately \_\_\_\_\_ of the Earth's surface

Microbes in air can be enumerated by

Microorganisms found attached to the rock surface are referred to as

Of the different atmospheric layers \_\_\_\_\_ is characterized by a heavy load of microorganisms

Profoundal zone is

Relative humidity for survival of the microorganism is between -----

Schmutzdecke is a hypogeal biological layer formed on surface of slow sand filter by

Slit sampler can collect upto \_\_\_\_\_ % of the water droplet particles sprayed into air

Sludge conditioning is accomplished by which of the following

Spores of \_\_\_\_\_ travel over a thousand kilometers.

The amount of carbon dioxide present in the atmosphere is near to

The dominant genera of common saprophytic fungi in indoor air is

The filtering medium of the tank becomes coated with a microbial flora, the \_\_\_\_\_ film

The most commonly efficient substrate used as a carbon source in denitrification during sewage treatment

The optimum rate of relative humidity for the survival of the most microorganisms is

Viruses survive in the atmosphere at low temperature from

Which of the following can be seen in marine environment?

Which of the following is not an aerobic process?

Which of the following is not common in marine environment?

Zone near shore area where sunlight penetrates the sediment and allows aquatic plants to grow

Zoogeal film formed in the trickling filter consists of

Which of the following is the type of endosymbiosis

Which of the following microorganism grows well at temperatures above boiling point of water

Which of the following method is used for removal of suspended materials from waste water

Most of the indicator organisms for detection of disease occurrence level in drinking water belongs to

Which among the following microbes is not a prime concern for deterioration of water quality in drinking water?

Which of the following test is used as presumptive test for enumeration of coliform in water samples?

Which of the following promotes the biological transformation of dissolved organic matter to microbial

Inorganic nutrients are removed by biological means refer as which of the following treatment process

In industrial processing plants, which of the following is the principle factor of treating waste water

Along with inorganic and organic nutrients which of the following compounds are removed through

KARPAGAM ACADEMY OF HIGHER EDUCATION  
DEPARTMENT OF MICROBIOLOGY  
ENVIRONMENTAL AND AGRICULTURAL MICROBIOLOGY

**Opt 1**

Carbon  
Sodium hypochloride solution  
*Varicella*  
Sodium hypochloride solution  
Spores  
Brucellosis  
Droplets  
Aerobes from person to person  
Indigenous  
Gastrointestinal  
15 ppt  
Total count  
Activated sludge process  
Disinfectant  
Digestive system  
Limnetic zone  
Gamma radiation  
Algae  
Fungi  
Insect vectors  
Hydrogen  
90  
Profundal zone  
20-25litre  
Whittaker  
Sieve sampler  
Littoral zone

7%

Settle plate method  
Epiplon  
Troposphere  
Open surface of water body  
25-45 percent  
Fungi  
85%  
Thickening  
*Clostridium perfringens*  
0.02%  
Aspergillus

Biofilm  
Methanol  
40-80%  
8 to 32°C  
Halophiles  
Activated sludge process  
Luminous bacteria  
Littoral zone  
Bacteria  
Commensalisms  
Halobacterium  
Filtration  
Actinobacteria  
Legionella  
Most probable number  
Primary  
Primary  
Removal of microbes  
Heavy and trace metals



OGY

## Opt 2

Diatom

Resorcinol

*Influenza*

Resorcinol

Infectious dust

Pulmonary disease

Aerosols

Inhaling spores or hyphal fragments from soil or dead vegetation

Aerotoxins

Urinary tract

25 ppt

Multiple tube method

Sludge compost

Indicator

Nervous system

Littoral zone

UV radiation

Bacteria

Bacteria

Inanimate objects

Carbon dioxide

99.92%

Euphotic zone

25-30 litre

Whitfield

Impingement

Limnetic zone

71%

Pour plate method

Epizootic

Stratosphere

Sub-surface zone

40-80 percent

Bacteria

100%

Elutriation

*Puccinia graminis*

0.03%

Fusarium

Zoogloal film

Oxygen

60-80%

7 to 24°C

Barophiles

Sludge digestion

Psychrophilic bacteria

Limnetic zone

Algae

cooperation

Methanococcus jannaschii

Purification

Bacilli

Shigella

Heterocoliformcount

Secondary

Secondary

Removal of organics

Lignocellulosic

### Opt 3

Aerated  
Triethylene glycol  
*Bordetella pertussis*  
Triethylene glycol  
Aerosols  
Pneumonitis  
Dust  
Drinking contaminated water  
Normal  
Respiratory  
35 ppt  
Membrane filters count  
Trickling filter  
Coagulant  
Reproductive system  
Profoundal zone  
Beta radiation  
Fungi  
Actinomyces  
Animate objects  
Water  
99.97%  
Metalimnion  
30-35litre  
Tyndall  
Electrostatic precipitation  
Profoundal zone

Spread plate method  
Epixylon  
Lithosphere  
Deepest zone  
40-60 percent  
Protozoa  
95%  
Chemical conditioning  
*Sarcina lutea*  
0.04%  
Penicillium

### Opt 4

Micro  
Titanium dioxide  
*Rubella*  
Titanium dioxide  
Droplets  
Meningitis  
Flocs  
Objects such as handkerchiefs that are cc  
None of the above  
Eye  
45 ppt  
Plate count  
Oxidation pond  
Flocculants  
Respiratory system  
Benthic zone  
Gamma radiation  
Viruses  
Viruses  
Biological vectors  
Acetate  
90.99%  
Epilimnion  
35-40litre  
Koch  
Centrifugal action  
Paleic zone

17%

Streak plate method  
Epilithon  
Atmosphere  
Side zone  
50-70 percent  
Algae  
75%  
Diluting with water  
*Micrococcus luteus*  
0.05%  
Mucor

77%

.Neustonic  
Glucose  
50-80%  
6 to 18°C  
Psychrophiles  
Trickling filter  
Thermophilic bacteria  
Paleic zone  
Protozoa  
mutualism  
Pyrococcus furiosus  
sedimentation  
Coliform  
Vibrio parahaemolyticus  
Aerobic colony count  
Tertiary  
Tertiary  
Removal of solids  
Suspended matters

Algal bloom  
Sucrose  
30-80%  
2 to 6°C  
Hydrophiles  
Oxidation pond  
Barophilic bacteria  
Profoundal zone  
Algal bloom  
predation  
Bacillus  
settlement  
Firmicutes  
Vibrio vulnificus  
colony forming unit  
Quaternary  
Quaternary  
Removal of liquids  
Floating materials

17MBP204

contaminated with respiratory secretations

Disinfectant



## Answer

Aerated  
Titanium dioxide  
*Bordetella pertussis*  
Titanium dioxide  
Spores  
Brucellosis  
Aerosols  
Aerobes from person to person  
Normal  
Respiratory  
35 ppt  
Multiple tube method  
Activated sludge process  
Disinfectant  
Respiratory system  
Benthic zone  
UV radiation  
Bacteria  
Actinomycetes  
Inanimate objects  
Acetate  
99.97%  
Epilimnion  
20-25litre  
Whitfield  
Electrostatic precipitation  
Limnetic zone

71%

Settle plate method  
Epipeplon  
Troposphere  
Deepest zone  
40-80 percent  
Bacteria  
85%  
Thickening  
*Clostridium perfringens*  
0.04%  
Penicillium

Zoogloal film  
Methanol  
40-80%  
6 to 18°C  
Halophiles  
Trickling filter  
Luminous bacteria  
Littoral zone  
Bacteria  
Commensalism  
Pyrococcus furiosis  
Sedimentation  
Coliform  
Shigella  
Most probable number  
Secondary  
Tertiary  
Removal of organics  
Heavy and trace metals



UNIT-II  
SYLLABUS

Infections – types – methods – infectious disease cycle. Definitions of Epidemics, Endemics, Pandemics and investigation of epidemics and control. Definition of pathogens, Saprophytes and Commensals. Quality control in microbiology lab.

**Infection**

**Infection** is the invasion of an organism's body tissues by disease-causing agents, their multiplication, and the reaction of host tissues to these organisms and the toxins they produce. **Infectious** disease, also known as transmissible disease or communicable disease, is illness resulting from an **infection**.

A primary infection is the first time you are exposed to and infected by a pathogen. During a primary infection, your body has no innate defenses against the organism, such as antibodies.

A secondary infection can occur when a different infection, known as the primary infection, makes a person more susceptible to disease. It is called a secondary infection because it occurs either after or because of another infection.

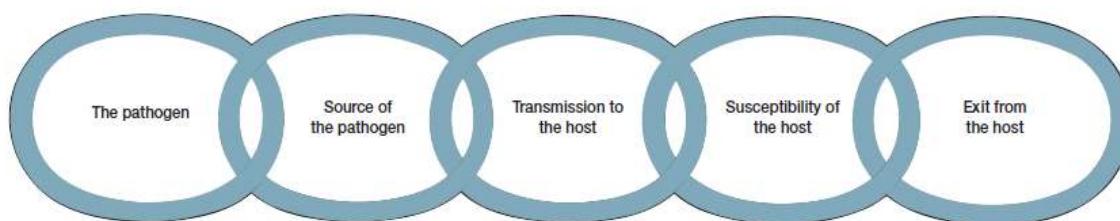
A second infection that follows recovery from a previous infection by the same causative agent.

Iatrogenic infections are those infections transmitted during medical treatment and care.

A hospital-acquired infection (HAI), also known as a nosocomial infection, is an infection that is acquired in a hospital or other health care facility.

**The Infectious Disease Cycle**

The **infectious disease cycle** or **chain of infection** represents these events in the form of an intriguing epidemiological mystery story



### **What Pathogen Caused the Disease?**

The first link in the infectious disease cycle is the pathogen. After an infectious disease has been recognized in a population, epidemiologists must correlate the disease outbreak with a specific pathogen. The disease's exact cause must be discovered. This is where Koch's postulates, and modifications of them, are used to determine the etiology or cause of an infectious disease. At this point the clinical or diagnostic microbiology laboratory enters the investigation. Its purpose is to isolate and identify the pathogen that caused the disease and to determine the pathogen's susceptibility to antimicrobial agents or methods that may assist in its eradication.

Many pathogens can cause infectious diseases in humans and will be discussed in detail in chapters 38 to 40. Often these pathogens are transmissible from one individual to another. A **communicable disease** is an illness caused by a pathogen or its products that has been transmitted from an infected person or a reservoir, either directly or indirectly. Pathogens have the potential to produce disease (pathogenicity); this potential is a function of such factors as the number of pathogens, their virulence, and the nature and magnitude of host defenses.

### **What Was the Source and/or Reservoir of the Pathogen?**

The source and/or reservoir of a pathogen is the second link in the infectious disease cycle. Identifying the source and/or reservoir is an important aspect of epidemiology. If the source or reservoir of the infection can be eliminated or controlled, the infectious disease cycle itself will be interrupted and transmission of the pathogen will be prevented.

A **source** is the location from which the pathogen is immediately transmitted to the host, either directly through the environment or indirectly through an intermediate agent. The source can be either animate (e.g., humans or animals) or inanimate (e.g., water, soil, or food). The **period of infectivity** is the time during which the source is infectious or is disseminating the pathogen.

The **reservoir** is the site or natural environmental location in which the pathogen is normally found living and from which infection of the host can occur. Thus a reservoir sometimes functions as a source. Reservoirs also can be animate or inanimate.

Much of the time, human hosts are the most important animate sources of the pathogen and are called carriers. A **carrier** is an infected individual who is a potential source of infection for others. Carriers play an important role in the epidemiology of disease.

Four types of carriers are recognized:

1. An **active carrier** is an individual who has an overt clinical case of the disease.
2. A **convalescent carrier** is an individual who has recovered from the infectious disease but continues to harbor large numbers of the pathogen.
3. A **healthy carrier** is an individual who harbors the pathogen but is not ill.
4. An **incubatory carrier** is an individual who is incubating the pathogen in large numbers but is not yet ill.

Convalescent, healthy, and incubatory carriers may harbor the pathogen for only a brief period (hours, days, or weeks) and then are called **casual, acute, or transient carriers**. If they harbor the pathogen for long periods (months, years, or life), they are called **chronic carriers**.

As noted earlier, infectious diseases called zoonoses occur in animals and are occasionally transmitted to humans; thus these animals also can serve as reservoirs. Humans contract the pathogen by several mechanisms: coming into direct contact with diseased animal flesh (tularemia); drinking contaminated cow's milk (tuberculosis and brucellosis); inhaling dust particles contaminated by animal excreta or products (Q fever, anthrax); or eating insufficiently cooked infected flesh (anthrax, trichinosis). In addition, being bitten by arthropod **vectors** (organisms that spread disease from one host to another) such as mosquitoes, ticks, fleas, mites, or biting flies (equine encephalomyelitis and malaria, Lyme disease, Rocky Mountain spotted fever, plague, scrub typhus, and tularemia); or being bitten by a diseased animal (rabies) can lead to infection.

### **How Was the Pathogen Transmitted?**

To maintain an active infectious disease in a human population, the pathogen must be transmitted from one host or source to another. Transmission is the third link in the infectious disease cycle and occurs by four main routes: airborne, contact, vehicle, and vector-borne.

#### **Airborne Transmission**

Because air is not a suitable medium for the growth of a pathogen, any pathogen that is airborne must have originated from a source such as humans, other animals, plants, soil, food, or water. In **airborne transmission** the pathogen is truly suspended in the air and travels over a meter or more from the source to the host. The

pathogen can be contained within droplet nuclei or dust.

**Droplet nuclei** are small particles, 1 to 4  $\mu$ m in diameter, that result from the evaporation of larger particles (10  $\mu$ m or more in diameter) called droplets. Droplet nuclei can remain airborne for hours or days and travel long distances. When animals or humans are the source of the airborne pathogen, it usually is propelled from the respiratory tract into the air by an individual's coughing, sneezing, or vocalization. For example, enormous numbers of moisture droplets are aerosoled during a typical sneeze. Each droplet is about 10  $\mu$ m

in diameter and initially moves about 100 m/second or more than 200 mi/hour!

Dust also is an important route of airborne transmission. At times a pathogen adheres to dust particles and contributes to the number of airborne pathogens when the dust is resuspended by some disturbance. A pathogen that can survive for relatively long periods in or on dust creates an epidemiological problem, particularly in hospitals, where dust can be the source of hospital acquired infections.

### **Contact Transmission**

**Contact transmission** implies the coming together or touching of the source or reservoir of the pathogen and the host. Contact can be direct, indirect, or by droplet spread. Direct contact implies an actual physical interaction with the infectious source. This route is frequently called person-to-person contact. Person-to-person transmission occurs primarily by touching, kissing, or sexual contact (sexually transmitted diseases); by contact

with oral secretions or body lesions (herpes and boils); by nursing mothers (staphylococcal infections); and through the placenta (AIDS, syphilis). Some infectious pathogens also can be transmitted by direct contact with animals or animal products (*Salmonella* and *Campylobacter*).

Indirect contact refers to the transmission of the pathogen from the source to the host through an intermediary—most often an inanimate object. The intermediary is usually contaminated by an animate source. Common examples of intermediary inanimate objects include thermometers, eating utensils, drinking cups, and bedding. *Pseudomonas* bacteria are easily transmitted by this route. This mode of transmission is often also considered a form of vehicle transmission (see next section).

In droplet spread the pathogen is carried on particles larger than 5  $\mu$ m. The route is through the air but only for a very short distance—usually less than a meter. Because these particles are

large, they quickly settle out of the air. As a result droplet transmission of a pathogen depends on the proximity of the source and the host. Measles is an example of a droplet-spread disease.

### **Vehicle Transmission**

Inanimate materials or objects involved in pathogen transmission are called **vehicles**. In **common vehicle transmission** a single inanimate vehicle or source serves to spread the pathogen to multiple hosts but does not support its reproduction. Examples include surgical instruments, bedding, and eating utensils. In epidemiology these common vehicles are called **fomites** [s., fomes or fomite]. A single source containing pathogens (blood, drugs, IV fluids) can contaminate a common vehicle that causes multiple infections. Food and water are important common vehicles for many human diseases.

### **Vector-Borne Transmission**

As noted earlier, living transmitters of a pathogen are called vectors. Most vectors are arthropods (insects, ticks, mites, fleas) or vertebrates (dogs, cats, skunks, bats). **Vector-borne transmission** can be either external or internal. In external (mechanical) transmission the pathogen is carried on the body surface of a vector. Carriage is passive, with no growth of the pathogen during transmission. An example would be flies carrying *Shigella* organisms on their feet from a fecal source to a plate of food that a person is eating. In internal transmission the pathogen is carried within the vector. Here it can go into either a harborage or biologic transmission phase.

In **harborage transmission** the pathogen does not undergo morphological or physiological changes within the vector. An example would be the transmission of *Yersinia pestis* (the etiologic agent of plague) by the rat flea from rat to human. **Biologic transmission** implies that the pathogen does go through a morphological or physiological change within the vector. An example would be the developmental sequence of the malarial parasite inside its mosquito vector.

### **Why Was the Host Susceptible to the Pathogen?**

The fourth link in the infectious disease cycle is the host. The susceptibility of the host to a pathogen depends on both the pathogenicity of the organism and the nonspecific and specific defense mechanisms of the host.

**How Did the Pathogen Leave the Host?**

The fifth and last link in the infectious disease cycle is release or exit of the pathogen from the host. It is equally important that the pathogen escapes from its host as it is that the pathogen originally contacts and enters the host. Unless a successful escape occurs, the disease cycle will be interrupted and the pathogenic species will not be perpetuated. Escape can be active or passive, although often a combination of the two occurs. Active escape takes place when a pathogen actively moves to a portal of exit and leaves the host. Examples include the many parasitic helminths that migrate through the body of their host, eventually reaching the surface and exiting. Passive escape occurs when a pathogen or its progeny leaves the host in feces, urine, droplets, saliva, or desquamated cells. Microorganisms usually employ passive escape mechanisms.

**Endemic:** a disease that exists permanently in a particular region or population. Malaria is a constant worry in parts of Africa

**Epidemic:** An outbreak of disease that attacks many peoples at about the same time and may spread through one or several communities

**Pandemic:** When an epidemic spreads throughout the world

An **epidemic** is the slow spread of infectious disease to a large number of people in a given population within a short period of time, usually two weeks or less. For example, in meningococcal infections, an attack rate in excess of 15 cases per 100,000 people for two consecutive weeks is considered an epidemic.

Epidemics of infectious disease are generally caused by several factors including a change in the ecology of the host population (e.g. increased stress or increase in the density of a vector species), a genetic change in the pathogen reservoir or the introduction of an emerging pathogen to a host population (by movement of pathogen or host). Generally, an epidemic occurs when host immunity to either an established pathogen or newly emerging novel pathogen is suddenly reduced below that found in the endemic equilibrium and the transmission threshold is exceeded.

An epidemic may be restricted to one location; however, if it spreads to other countries or continents and affects a substantial number of people, it may be termed a pandemic.<sup>[1]</sup> The declaration of an epidemic usually requires a good understanding of a baseline rate of incidence;

epidemics for certain diseases, such as influenza, are defined as reaching some defined increase in incidence above this baseline. A few cases of a very rare disease may be classified as an epidemic, while many cases of a common disease (such as the common cold) would not.

In epidemiology, an infection is said to be **endemic** (from Greek ἐν *en* "in, within" and δῆμος *demos* "people") in a population when that infection is maintained in the population without the need for external inputs. For example, chickenpox is endemic (steady state) in the UK, but malaria is not. Every year, there are a few cases of malaria reported in the UK, but these do not lead to sustained transmission in the population due to the lack of a suitable vector (mosquitoes of the genus *Anopheles*).

A **pandemic** (from Greek πᾶν *pan* "all" and δῆμος *demos* "people") is an epidemic of infectious disease that has spread through human populations across a large region; for instance multiple continents, or even worldwide. A widespread endemic disease that is stable in terms of how many people are getting sick from it is not a pandemic. Further, flu pandemics generally exclude recurrences of seasonal flu. Throughout history there have been a number of pandemics, such as smallpox and tuberculosis. One of the most devastating pandemics was the Black Death, killing over 75 million people in 1350. The most recent pandemics include the HIV pandemic as well as the 1918 and 2009 H1N1 pandemics.

For an infection that relies on person-to-person transmission to be endemic, each person who becomes infected with the disease must pass it on to one other person on average. Assuming a completely susceptible population, that means that the basic reproduction number ( $R_0$ ) of the infection must equal 1. In a population with some immune individuals, the basic reproduction number multiplied by the proportion of susceptible individuals in the population ( $S$ ) must be 1. This takes account of the probability of each individual to whom the disease may be transmitted actually being susceptible to it, effectively discounting the immune sector of the population.

**Parasites** are plants or animals that live on or in a host getting their nutrients from that host. A **host** is an organism that supports a parasite. Sometimes the host is harmed by the parasite, and



sometimes the relationship is neutral. But the host never benefits from the arrangement. When the parasite does have a negative impact on the host, it doesn't often kill the host directly, but the stressors that come with having parasites can kill.

**Ectoparasites** are parasites that live outside the body. In animals, they live on the skin and can cause itching and rashes. **Endoparasites** are parasites that live inside the body. For instance, they may live in the blood system, muscles, liver, brain, or digestive systems of animals.

Parasites are not one-size-fits-all. There are several main categories of parasites that can affect animals and plants. Probably the most-studied parasites are the ones that affect humans. Broadly grouped, they include protozoa, helminths, and arthropods. More familiar, less mysterious names are lice, ticks, mites, bed bugs, flukes, and tapeworms.

**Saprophytes** may refer to

- Saprotroph, a term used for organisms which obtain nutrients from dead organic matter (this term commonly applies to fungi)
- Saprophytes are more generally plants, fungi, or micro-organisms more accurately called myco-heterotrophs because they actually parasitize fungi, rather than dead organic matter directly. They live on dead or decomposing matter.

**commensal**

1. living on or within another organism, and deriving benefit without harming or benefiting the host individual.
2. a parasitic organism that causes no harm to the host.

**Pathogen**

In biology, a **pathogen** (Greek: *πάθος* *pathos* “suffering, passion” and *-γενής* *-genēs* “producer of”) in the oldest and broadest sense is anything that can produce disease, a term which came into use in the 1880s. Typically the term is used to describe an infectious agent such as



a virus, bacterium, prion, fungus, viroid, or parasite that causes disease in its host. The host may be a human, an animal, a plant, a fungus, or even another micro-organism.

There are several substrates including *pathways* where the pathogens can invade a host. The principal pathways have different episodic time frames, but soil contamination has the longest or most persistent potential for harboring a pathogen. Diseases caused by organisms in humans are known as pathogenic diseases.

**Pathogenicity** is the potential disease-causing capacity of pathogens. Pathogenicity is related to virulence in meaning, but some authorities have come to distinguish it as a *qualitative* term, whereas the latter is *quantitative*. By this standard, an organism may be said to be pathogenic or non-pathogenic in a particular context, but not "more pathogenic" than another. Such comparisons are described instead in terms of relative virulence. Pathogenicity is also distinct from the transmissibility of the virus, which quantifies the risk of infection.

A pathogen may be described in terms of its ability to produce toxins, enter tissue, colonize, hijack nutrients, and its ability to immune suppress the host.

## **QUALITY CONTROL IN MICROBIOLOGY LAB**

### **Laboratory solution**

- Integrated controls of fume hoods, monitoring devices and value-added services
- Demand controlled ventilation of the laboratory rooms
- Controls and conditioning of the supply air in the primary plant
- Operation and monitoring of the facilities on management level
- Fast and reliable fire detectors sensing smoke, heat, flames and CO at an early stage
- Tightly controlled differential pressure to protect people from toxic substances and preventing cross-contamination
- Safe evacuation independent of the cause with clear automated audio and visual commands and opening of escape routes
- Integrated and flexible access control systems preventing unauthorized entry, reduce risk of contamination or product tampering and combine several sources of information (access control, HR records, historical access trends...)

## **KARPAGAM ACADEMY OF HIGHER EDUCATION**

**CLASS: I M.Sc MB**

**COURSE NAME: MEDICAL BACTERIOLOGY**

**COURSE CODE: 17MBP202**

**UNIT: II**

**BATCH-2017-2019**

- Intelligent video surveillance reliably monitors personnel flow, processes and procedures
- Integrated RFID functionality with Smart Access Cards for multiple tasks (e.g. encrypting emails, paying lunch in the cafeteria...)
- All can be integrated into a Danger Management System
- Performance testing and record keeping to document compliance of your laboratories, fume hoods and bio safety
- The solution supports requirements of the European standard EN 14175
- Compliant with global GxP standards as well as local regulations
- Application of regulatory compliance such as Good Laboratory Practices (GLP) and Electronic Records and Electronic Signatures (ER/ES)
- Guarantee of efficient and effective validation including user training and services during operation as well as maintaining the validated status.

**Possible Questions**

**Part B (Two marks)**

1. Define infection.
2. Define disease.
3. Define symptoms.
4. Define pathogen.
5. What is a parasite?
6. Define saprophytes.
7. Explain the commensals.
8. Define epidemic.
9. Define endemic
10. Define pandemic.

**Part C (Eight marks)**

1. Explain the role of investigation of epidemic.
2. Explain in details about the types of carriers.
3. Comment on primary, secondary and re infection.
4. Write about the importance of quality control?
5. Explain role of QA.
6. Give the role of QC.
7. Explain in detail about the QC and microbiology.
8. Comment on infectious disease cycle.
9. Explain the types of infections.
10. What are the methods of infection?
11. Give the various sources of infection.
12. What are the steps in infectious disease cycle?

**KARPAGAM ACADEMY OF HIGHER EDUCATION**  
**M.Sc. DEGREE EXAMINATION, APRIL 2018**  
**SECOND SEMESTER**  
**MEDICAL BACTERIOLOGY [17MBP202]**

Unit II Question	Opt 1	Opt 2	Opt 3	Opt 4
In Greek 'pathos means _____.	Suffering	violence	disease	infection
The lodgement and multiplication of a parasite	disease	infection	immunity	parasitism
Initial infection with a parasite in a host is termed	primary	secondary	re-infection	nosocomial
Subsequent infection by the same parasite in the	Primary	Secondary	Re-infection	Iatrogenic
When a new parasite sets up an infection in a host	Primary	Secondary	Re-infection	Iatrogenic
Infection or sepsis at localized sites is called	Primary	Secondary	Focal	Iatrogenic
In a patient already suffering from a disease, a re	Cross	Focal	Re-infection	Nosocomial
Cross infection occurring in hospitals are called	Cross	Focal	Re-infection	
Physicians induced infections are termed	Iatrogenic	Focal	Nosocomial	Re-infection
When clinical effects are not apparent it is called	Atypical	Inapparent	Subclinical	Clinical
_____ infection is the one in which the type	Endogenous	Exogenous	Inapparent	Clinical
Some parasites, following infection may remain	Endogenous	Exogenous	Latent	Atypical
A person who harbours the pathogenic microorganism	Patient	Carrier	Healthy person	Immunodeficient
A person one who harbours the pathogen but has	Healthy carrier	Convalescent	Contact carrier	Paradoxical carrier
A person who have recovered from the disease	Healthy	Convalescent	Contact	Paradoxical
The _____ carrier state lasts than six months	Acute	Temporary	Chronic	Healthy
The term _____ carrier is applied to a person	Acute	Temporary	Contact	Paradoxical
The _____ carrier state lasts for several years.	Acute or chronic	Temporary	Contact	Paradoxical
The term _____ carrier refers to a person who	Healthy	Convalescent	Contact	Paradoxical
Infectious diseases transmitted from animals to	Zoonosis	Anoosis	Xanthosis	Phytosis
When the pathogen multiplies in the body of the	Mechanical	Biological	Healthy	Contact
Some pathogens are able to cross the placental	Congenital	Intracellular	Vertical	Horizontal
_____ is generally employed to refer to the	Infection	Immunity	Pathogenicity	Virulence
_____ is applied to the same property in a	Infection	Immunity	Pathogenicity	Virulence
_____ is the science that evaluates the occurrence	Epidemiology	Oncology	Infection	Physiology
An individual who practices epidemiology is an	Epidemiologist	Scientist	Investigator	Environmental
A _____ is an impairment of the normal state	Health	Disease	Infection	Immunity
_____ is the condition in which the organism is	Health	Disease	Infection	Immunity
When a disease occurs occasionally and at irregular	Epidemic	Endemic	Sporadic	Pandemic
When the disease occurs at a steady low-level for	Epidemic	Endemic	Sporadic	Pandemic
_____ disease gradually increase in the occurrence	hyperendemic	Epidemic	Endemic	Pandemic
An _____ is a sudden increase in the occurrence	Epidemic	Endemic	sporadic	Pandemic
The first case in an epidemic is called	index case	infection	disease	outbreak
A sudden unexpected occurrence of a disease in	index case	Infection	disease	outbreak
A _____ is an increase in disease occurrence	epidemic	Endemic	Pandemic	Sporadic
The factors that influence the frequency of a disease	epizootic	Zootiology	Epidemiology	Entamology
Moderate prevalence of a disease in animals is termed	epizootic	enzootic	panzootic	zoonoses
A sudden outbreak of disease in animals is called	epizootic	enzootic	panzotic	zoonoses
A wide dissemination of animals is called	epizootic	enzootic	panzootic	zoonoses
Animal disease that can be transmitted to humans	epizootic	enzootic	panzootic	zoonoses
A _____ period is the period between pathogen	incubation	survival	lag	log
The _____ is the period in which there is an	incubation	prodromal	survival period	death

The _____ represents the events in the form of	infectious	disease	infection	none
_____ is an illness caused by a pathogen or its	communicable	epidemic	epidemic	none
The _____ is the time during which the source	incubation	the period	predormant	none
The water used in the lab is tested by _____	Quarentum	GTL	Materials	Dispatch
The Goods purchased is stored at _____	Dispatch	Materials	Quarentum	Stock section
The water used in laboratory is purified by _____	Catridge	Pad	Sinted gla	Earthern ware
The monitoring of the lab environment is done	QA	QC	GTL	QB
The microbial load of lab environment is tested	Settle plate	Pour plate	Spread plate	Streak plate.
The AHU stands for _____	Aerosol handling	Air handling	Atmospheric	Auto handling
_____ controls the microbes in air.	Air pressure	Aerosol	Atmospheric	oxygen
The circulating air is filtered in lab by _____	Pad	Candle	HEPA	Catridge
The discard materials to be _____ before disposal	Dissuaded	Dispenced	Decontam	sterilized
Quality control checks the quality of the product	QA	QC	GTL	QB
The proper disposal of biologicals helps to prevent	Epidemic	Endemic	Pandemic	Randamic
There is no single reliable test available to detect	Antibiotic	Antiseptic	Disinfectant	Diluent.
In the Rideal walker test typhoid bacilli is tested	Phenol	Boron	Acid	Alcohol
_____ is a product ketane and formaldehyde	HCL	BPL	TNT	SDS
QA stands for _____	Quality assurance	Quality assurance	Quality assurance	Quality assurance

[illegible]

[illegible]

[illegible]



[illegible]

[illegible]

Opt 5	Opt 6	Answer
		Suffering
		infection
		primary
		Re-infection
		Secondary
		Focal
		Cross
		Nosocomial
		Iatrogenic
		Inapparent
		Inapparent
		Latent
nt person		Carrier
rier		Healthy carrier
		Convalescent
		Temporary
		Contact
		Acute or chronic
		Paradoxical
		Zoonosis
		Biological vector
		Vertical
		Pathogenicity
		Virulence
		Epidemiology
st		Epidemiologist
		Disease
		Infection
		Endemic
		Endemic
		hyperendemic
		Pandemic
		index case
		outbreak
		Pandemic
		epizootiology
		enzootic
		panzotic
		zoonoses
		zoonoses
		incubation
		prodromal stage

		infectious disease cycle
		communicable disease
		predormal stage
		GTL
		Quarentum section
		Catridge
		QC
		Settle plate
mit		Air handling unit
		Air pressure
		HEPA
		Decontaminated
		QA
		Epidemic
		Disinfectants
		Phenol
		BPL
on.		Quality assurance

[illegible]

[illegible]

[illegible]

[illegible]



[illegible]

**UNIT-III**  
**SYLLABUS**

Gram positive organisms: Morphology, cultural characteristics, antigenic property, pathogenicity, laboratory diagnosis and treatment. *Staphylococcus* sp., *Streptococcus* sp., *Bacillus* sp., *Corynebacterium* sp., *Clostridium* sp. Acid Fast organism - *Mycobacterium* sp.

**Introduction to Gram positive organisms**

Gram-positive bacteria are those that are stained dark blue or violet by Gram staining. This is in contrast to Gram-negative bacteria, which cannot retain the crystal violet stain, instead taking up the counterstain (safranin or fuchsin) and appearing red or pink. Gram-positive organisms are able to retain the crystal violet stain because of their thick peptidoglycan layer, which is superficial to the cell membrane. This is in contrast to Gram-negative bacteria, which may have a thick or thin peptidoglycan layer that is located between two cell membranes.

***Staphylococcus* Sp.,****Morphology, cultural characteristics of *Staphylococcus***

*Staphylococcus aureus* on Columbia agar with 5% defibrinated sheep blood (Bio-Rad™). Individual colonies on agar are round, convex, and 1-4 mm in diameter with a sharp border. On blood agar plates, colonies of *Staphylococcus aureus* are frequently surrounded by zones of clear beta-hemolysis. The golden appearance of colonies of some strains is the etymological root of the bacteria's name; aureus meaning "golden" in Latin.

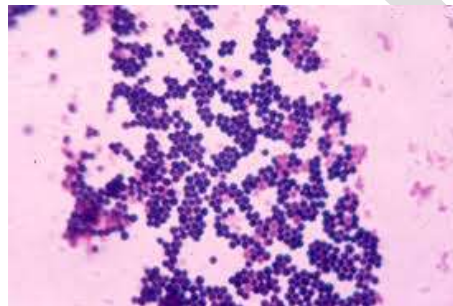
Methicillin-resistant strains of *Staphylococcus aureus* (i.e. MRSA) often have only weak or no beta-hemolysis and special cultivation media with oxacillin, mannitol and NaCl for their isolation are used. MRSA is able to grow on this media and produce colonies of certain color, depending on used pH indicator.

**Antigenic property of *Staphylococcus*****Toxins (hemolysins) – cytolytic, membrane-damaging toxins**

- Alpha toxin (hemolysin) – 34 kD protein; principal hemolysin expressed by human strains of *S. aureus*. Toxin monomer binds to cell surface heptamer formation transmembrane channels. Hydrophobic molecule that inserts within the cell membrane of

susceptible cells, forming pores. Most active against rabbit erythrocytes, but also active against human platelets. Inject alpha toxin IV -> hemolysis, dermonecrosis, lethality

- Beta toxin (hemolysin) produced commonly by animal strains of *S. aureus* and only by 10 – 20% of human isolates. Beta toxin is a sphingomyelinase C enzyme – catalyzes hydrolysis of membrane phospholipids.
- Gamma toxin (hemolysin). Mode of action – unknown.
- Delta toxin (hemolysin) is produced by most human strains of *S. aureus*. 10,000 to 100,000X less toxic than alpha toxin. Has detergent-like properties.



**Microscopic view of *Staphylococcus***

### **Pathogenicity of *Staphylococcus***

Extracellular virulence factors:

#### **Enzymes:**

- Coagulases:
  - A. bound (**clumping factor**)
  - B. free (**coagulase-reacting factor**)
- Hyaluronidase: “spreading factor” of *S. aureus*
- Nucleases: *S. aureus*; Cleaves DNA (Dnase) and RNA (Rnase)
- Fibrinolysin: staphylokinase
- Lipases: esterases
- Penicillinase

#### **Exotoxins:**

**Cytotoxins** (hemolysins): cytopathic and cytolytic for a broad range of affected cells, including erythrocytes, leukocytes, macrophages, hepatocytes, lymphocytes, lymphoblasts, fibroblasts, neutrophils and platelets

- Alpha toxin
- Beta toxin: sphingomyelinase C (phospholipase)
- Delta toxin: detergent-like activity
- Gamma toxin: hemolytic activity
- Leukocidin
- Enterotoxins (A to E)
- Exfoliative toxin (epidermolytic toxin or exfoliatin) (A and B)
- Toxic shock syndrome toxin-1 (TSST-1) (formerly pyrogenic exotoxin C)
- Somatic virulence factors:
- Slime layer (capsule)

**Protein A:** binds Fc receptors of IgG , **Teichoic acid:** binds fibronectin

### **Laboratory diagnosis**

Depending upon the type of infection present, an appropriate specimen is obtained accordingly and sent to the laboratory for definitive identification by using biochemical or enzyme-based tests. A Gram stain is first performed to guide the way, which should show typical Gram-positive bacteria, cocci, in clusters. Second, the isolate is cultured on mannitol salt agar, which is a selective medium with 7–9% NaCl that allows *S. aureus* to grow, producing yellow-colored colonies as a result of mannitol fermentation and subsequent drop in the medium's pH. Furthermore, for differentiation on the species level, catalase (positive for all *Staphylococcus* species), coagulase (fibrin clot formation, positive for *S. aureus*), DNase (zone of clearance on Dnase agar), lipase (a yellow color and rancid odor smell), and phosphatase (a pink color) tests are all done. For staphylococcal food poisoning, phage typing can be performed to determine whether the staphylococci recovered from the food were the source of infection.

### **Treatment and Prevention:**

- Drain infected area
- Deep/metastatic infections: semi-synthetic penicillins; cephalosporins, erythromycin or clindamycin
- Endocarditis: semi-synthetic penicillin plus an aminoglycoside
- Carrier status prevents complete control
- Proper hygiene, segregation of carriers from highly susceptible individuals

- Good aseptic techniques when handling surgical instruments
- Control of nosocomial infections

### ***Streptococcus Sp.,***

#### **Morphology of *Streptococcus***

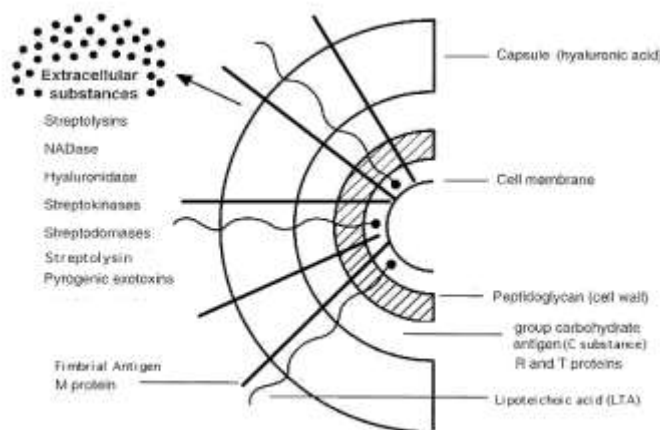
*Streptococci* are Gram-positive, nonmotile, nonsporeforming, catalase-negative cocci that occur in pairs or chains. Older cultures may lose their Gram-positive character. Most streptococci are facultative anaerobes, and some are obligate (strict) anaerobes. Most require enriched media (blood agar). Group A streptococci have a hyaluronic acid capsule.



**Microscopic view of *Streptococcus***

#### ***Classification and Antigenic Types***

Streptococci are classified on the basis of colony morphology, hemolysis, biochemical reactions, and (most definitively) serologic specificity. They are divided into three groups by the type of hemolysis on blood agar:  $\beta$ -hemolytic (clear, complete lysis of red cells),  $\alpha$  hemolytic (incomplete, green hemolysis), and  $\gamma$  hemolytic (no hemolysis). Serologic grouping is based on antigenic differences in cell wall carbohydrates (groups A to V), in cell wall pili-associated protein, and in the polysaccharide capsule in group B streptococci.



**Pathogenicity of *Streptococcus***

Group A streptococci are model extracellular gram-positive pathogens responsible for pharyngitis, impetigo, rheumatic fever, and acute glomerulonephritis. A resurgence of invasive streptococcal diseases and rheumatic fever has appeared in outbreaks over the past 10 years, with a predominant M1 serotype as well as others identified with the outbreaks. emm (M protein) gene sequencing has changed serotyping, and new virulence genes and new virulence regulatory networks have been defined. The emm gene superfamily has expanded to include antiphagocytic molecules and immunoglobulin-binding proteins with common structural features. At least nine superantigens have been characterized, all of which may contribute to toxic streptococcal syndrome. An emerging theme is the dichotomy between skin and throat strains in their epidemiology and genetic makeup. Eleven adhesions have been reported, and surface plasmin-binding proteins have been defined. The strong resistance of the group A *Streptococcus* to phagocytosis is related to factor H and fibrinogen binding by M protein and to disarming complement component C5a by the C5a peptidase. Molecular mimicry appears to play a role in autoimmune mechanisms involved in rheumatic fever, while nephritis strain-associated proteins may lead to immune-mediated acute glomerulonephritis. Vaccine strategies have focused on recombinant M protein and C5a peptidase vaccines, and mucosal vaccine delivery systems are under investigation.

**Laboratory diagnosis of *Streptococcus***

Infective stages may be present in CSF, joint aspirates, blood, abscesses, aerosols, faeces, and urine.

**Treatment**

Treatment of abscesses usually does not need antibiotic therapy; appropriate drainage is usually sufficient. Proper antibiotic therapy is required for more serious infections.

***Bacillus Sp.,*****Morphology of *Bacillus***

The word *bacillus* (plural *bacilli*) may be used to describe any rod-shaped bacterium, and such bacilli are found in many different taxonomic groups of bacteria. However, the name *Bacillus*, capitalized and italicized, refers to a specific genus of bacteria. The name *Bacilli*, capitalized but

not italicized, can also refer to a more specific taxonomic class of bacteria that includes two orders, one of which contains the genus *Bacillus*. Bacilli are usually solitary, but can combine to form diplobacilli, streptobacilli, and palisades.

### **Pathogenicity of *Bacillus***

*B. anthracis* possesses a capsule that is antiphagocytic and is essential for full virulence. The organism also produces three plasmid-coded exotoxins: edema factor, a calmodulin- dependent adenylate cyclase, causes elevation of intracellular cAMP, and is responsible for the severe edema usually seen in *B. anthracis* infections; lethal toxin is responsible for tissue necrosis; protective antigen (so named because of its use in producing protective anthrax vaccines) mediates cell entry of edema factor and lethal toxin.



**Microscopic view of *Bacillus***

### **Laboratory diagnosis**

The diagnosis of type based on morphology, affinity dye (sometimes very difficult to determine because some Gram-positive species appear only in old cultures a few hours), the study of respiratory type and the identification of a spore. As pointed out Logan and Turnbull, it is essential to establish that the suspect colonies are made up of gram-positive bacteria, sporulated and capable of growing in aerobically.

### **Prevention and treatment**

A number of anthrax vaccines have been developed for preventive use in livestock and humans. Infections with *B. anthracis* can be treated with  $\beta$ -lactam antibiotics such as penicillin, and others which are active against Gram-positive bacteria.<sup>[19]</sup> Penicillin-resistant *B. anthracis* can be treated with fluoroquinolones such as ciprofloxacin or tetracycline antibiotics such as oxycycline.

### ***Corynebacterium Sp.,***

#### **Morphology of Corneybacterim**

*Corynebacterium diphtheriae* is a pathogenic bacterium that causes diphtheria. It is also known as the **Klebs-Löffler bacillus**, because it was discovered in 1884 by German bacteriologists Edwin Klebs (1834 – 1912) and Friedrich Löffler (1852 – 1915). Four subspecies are recognized: *C. diphtheriae mitis*, *C. diphtheriae intermedius*, *C. diphtheriae gravis*, and *C. diphtheriae belfanti*. The four subspecies differ slightly in their colonial morphology and biochemical properties, such as the ability to metabolize certain nutrients, but all may be toxigenic (and therefore cause diphtheria) or non-toxigenic.

*Corynebacterium diphtheriae* produces Diphtheria toxin which alters protein function in the host by inactivating elongation factor (EF-2). This causes pharyngitis and 'pseudomembrane' in the throat. The diphtheria toxin gene is encoded by a bacteriophage found in toxigenic strains, integrated into the bacterial chromosome.

#### **Culture characteristic**

In order to accurately identify *C. diphtheriae*, a Gram stain is performed to show gram-positive, highly pleomorphic organisms with no particular arrangement. Special stains like Albert's stain and Ponder's stain are used to demonstrate the metachromatic granules formed in the polar regions. The granules are called as polar granules, Babes Ernst Granules, Volutin, etc. An enrichment medium, such as Löffler's medium, is used to preferentially grow *C. diphtheriae*. After that, use a differential plate known as tellurite agar, which allows all *Corynebacteria* (including *C. diphtheriae*) to reduce tellurite to metallic tellurium. The tellurite reduction is colorimetrically indicated by brown colonies for most *Corneybacteria* species or by a black halo around the *C. diphtheriae* colonies.



**Microscopic view of Corneybacterium**



**Antigenic Property**

*Corynebacterium diphtheriae* is a nonmotile, noncapsulated, club-shaped, Gram-positive bacillus. Toxigenic strains are lysogenic for one of a family of corynebacteriophages that carry the structural gene for diphtheria toxin, *tox*. *Corynebacterium diphtheriae* is classified into biotypes (mitis, intermedius, and gravis) according to colony morphology, as well as into lysotypes based upon corynebacteriophage sensitivity. Most strains require nicotinic and pantothenic acids for growth; some also require thiamine, biotin, or pimelic acid. For optimal production of diphtheria toxin, the medium should be supplemented with amino acids and must be deferrated.

**Pathogenesis *Corynebacterium***

Asymptomatic nasopharyngeal carriage is common in regions where diphtheria is endemic. In susceptible individuals, toxigenic strains cause disease by multiplying and secreting diphtheria toxin in either nasopharyngeal or skin lesions. The diphtheritic lesion is often covered by a pseudomembrane composed of fibrin, bacteria, and inflammatory cells. Diphtheria toxin can be proteolytically cleaved into two fragments: an N-terminal fragment A (catalytic domain), and fragment B (transmembrane and receptor binding domains). Fragment A catalyzes the NAD<sup>+</sup>-dependent ADP-ribosylation of elongation factor 2, thereby inhibiting protein synthesis in eukaryotic cells. Fragment B binds to the cell surface receptor and facilitates the delivery of fragment A to the cytosol.

**Diagnosis**

Clinical diagnosis depends upon culture-proven toxigenic *C. diphtheriae* infection of the skin, nose, or throat combined with clinical signs of nasopharyngeal diphtheria (e.g., sore throat, dysphagia, bloody nasal discharge, pseudomembrane).

**Control**

Immunization with diphtheria toxoid is extraordinarily effective. Diphtheria patients must be promptly treated with antitoxin to neutralize circulating diphtheria toxin.

## ***Clostridium Sp.,***

### **Morphology of Clostridium**

Most Clostridium species decompose proteins or form toxins and some do both. Their natural habitat is the soil or intestinal tract as saprophytes. The important pathogenic species are:

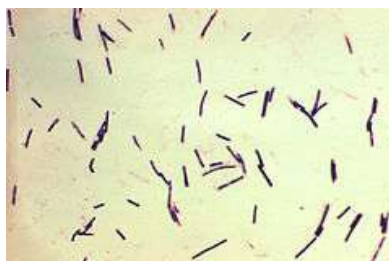
- *Clostridium botulinum*: Causes botulism
- *Clostridium tetani*: Causes tetanus
- *Clostridium perfringens*: Causes gas gangrene
- Large anaerobic gram positive motile rods.
- The spore is usually wider than the rods.
- Spores are placed centrally, terminally, or subterminally according to the genus.

### **Cultural characteristics**

Anaerobic culture conditions are established by one of the following:

Agar plates or culture tubes are placed in air tight jar from which air is removed and replaced by N and CO<sub>2</sub>.

- Fluid media contain either:
- Fresh animal tissue (chopped meat)
- Reducing agent (Thioglycolate)



**Gram's staining view of *Clostridium tetani***

### **Colony forms**

*Clostridium perfringens*: Large raised colonies with entire margins.

*Clostridium tetani* : Smaller colonies with fine filaments.

Most Clostridia produce a zone of hemolysis on blood agar.

### **Growth characteristics of anaerobic microorganisms are:**

- Unable to utilize O<sub>2</sub> as the final oxygen acceptor.
- Lack of cytochrome and cytochrome oxidase.

- Unable to break down hydrogen peroxide  $H_2O_2$  because they lack catalase or peroxidase so  $H_2O_2$  will accumulate to toxic conc. in the presence of  $O_2$ .

***Clostridium botulinum***

It causes botulism, infant's botulism, and rarely wound infection. It is found in soil and animal feces. The spores are subterminal highly resistant to heat. They resist boiling 3-5 hours. This resistance is diminished at acidic pH and salt. It produces toxin during life and autolysis of bacteria.

**Pathogenesis of *Clostridium***

Botulism is intoxication. It results from ingestion of food in which *Clostridium botulinum* spores germinate and produce toxins under anaerobic conditions. These foods are spiced, smoked vacuum-packed, or canned alkaline foods (if eaten without smoking). The toxin acts by blocking the release of acetyl choline at synapses and neuromuscular junctions causing flaccid paralysis. Patients who recover don't develop an antitoxin in the blood.

**Symptoms[ within 18 – 24 hours ]**

- Visual disturbances
- Inability to swallow
- Speech difficulty
- Respiratory paralysis or cardiac arrest

**Lab diagnosis**

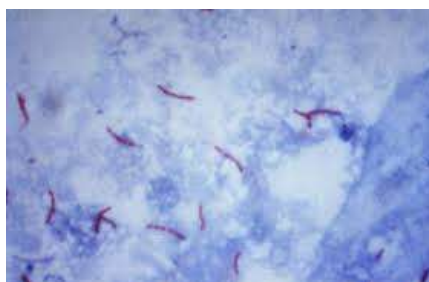
- Toxin can be detected in the patient serum and left over food.
- Mice are injected with the specimen and then neutralized by injections of antitoxin.
- Culture of food remains of its growth test for toxin production.
- Toxin is tested by hemoagglutination or radioimmunoassay (RIS).

**Treatment**

- IV administration of antitoxin (trivalent antitoxin of types A, B, and E).
- Adequate ventilation by mechanical respirator. This will reduce mortality from 65% to 25%
- Infant botulism is recovered with supportive therapy alone.

***Mycobacterium Sp.,*****Morphology of Mycobacterium**

Typical organisms: In tissue, tubercle bacilli are thin straight rods with variable morphology from one species to another. Mycobacteria cannot be classified as gram +ve or -ve. They are characterized by 'acid-fastness' i.e. 'acid-alcohol' quickly decolorizes all bacteria except the mycobacteria, acid-fastness depends on the integrity of the waxy envelope. The Ziehl-Neelsen technique of staining is employed for identification of acid-fast bacteria.



**Microscopic view of *Mycobacterium***

**Cultural characteristic of *Mycobacterium***

There are three general formulations that can be used for both the nonselective and the selective media:-

1. Semi-synthetic agar media (eg, Middlebrook 7H10 and 7H11) contain salts, vitamins, cofactors, oleic acid, albumin, catalase, glycerol, glucose, and malachite green. Large inocula yield growth on these media in several weeks. These media may be less sensitive than other media for primary isolation of mycobacteria.
2. Inspissated egg media (eg, Lowenstein-Jensen) contain salts, glycerol, and complex organic substances (eg, fresh eggs, egg yolks, potato flour, and other ingredients). Malachite green is included to inhibit other bacteria. Small inocula in specimens from patients will grow on these media in 3-6 weeks. These media with added antibiotics are used as selective media.
3. Broth media: broth media (eg, Middlebrook 7H9 and 7H12) support the proliferation of small inocula. Mycobacteria grow in clumps or masses because of the hydrophobic character of the cell surface, and added antibiotics.

**Growth characteristics:**

- Mycobacteria are obligate aerobes.
- Increased  $\text{CO}_2$  tension enhances growth.
- Biochemical activities are not characteristics, and the growth rate is much slower than that of most bacteria.
- Saprophytic forms tend to grow more rapidly, to proliferate well at 22-33 °C To produce more pigment, and to be less acid-fast than pathogenic forms.

**Pathogenesis**

Mycobacteria in droplets are inhaled and reach the alveoli. The disease results from establishment and proliferation of virulent organisms and interactions with the host. Resistance and hypersensitivity of the host greatly influence the development of the disease.

**Diagnostic laboratory tests**

A positive tuberculin test does not prove the presence of active disease due to tubercle bacilli.

- A. Specimens: consist of fresh sputum, gastric washings, urine, pleural fluid, CSF, joint fluid, biopsy material, blood, or other suspected material.
- B. Decontamination and Concentration of Specimens: Specimens from sputum with NaOH, neutralized with buffer, and concentrated by centrifugation. Used for acid-fast stains and for culture.
- C. Smears:
  - Examined for acid-fast bacilli by Ziehl-Neelsen staining.
  - Antigen Detection, serology and anti-gene detection (PCR)
  - The polymerase chain reaction holds great promise for the rapid and direct detection of M. tuberculosis in clinical specimens- the PCR test is approved for this use.

**Antigen Detection, serology and anti-gene detection (PCR)**

The polymerase chain reaction holds great promise for the rapid and direct detection of M.tuberculosis in clinical specimens- the PCR test is approved for this use.

**Treatment**

- Prompt and effective treatment of patients with active tuberculosis
- Drug treatment of asymptomatic tuberculin-positive persons (eg, children)-receive immunosuppressive drugs.

## KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: I M.Sc MB

COURSE NAME: MEDICAL BACTERIOLOGY

COURSE CODE: 17MBP202

UNIT: III

BATCH-2017-2019

- Nonspecific factors may reduce host resistance include starvation, gastrectomy, and suppression of cellular immunity by drugs.
- Immunization: Various living avirulent tubercle bacilli, particularly BCG (Bacillus Calmette-Guerin, an attenuated bovine organism). Vaccination is a substitute for primary infection with virulent tubercle bacilli without the danger inherent in the latter given to children.
- The eradication of tuberculosis in cattle and the pasteurization of milk have greatly reduced M.bovis infections.

**Possible Questions**

**Part B (Two marks)**

1. Define pyogen.
2. Write about the morphology of *S.aureus*?
3. What are the cultural characteristics of *Staphylococcus*?
4. Write about the morphology of *Corynebacterium*?
5. Write about the morphology of *Streptococcus*?
6. Give the morphology of *Bacillus*.
7. Give the morphology of *Clostridium*.
8. Write about the morphology of *Mycobacterium*?
9. Comment on the biochemical property of *Streptococcus*.
10. Comment on the biochemical property of *Bacillus*.
11. Explain the antigenic property of *Bacillus*.

**Part C (Eight marks)**

1. Comment on the biochemical property of *Staphylococcus*.
2. Discuss the antigenic property of *Staphylococcus*.
3. Laboratory diagnosis of *S.aureus*.
4. Comment on the biochemical property of *Corynebacterium*.
5. Discuss the antigenic property of *Corynebacterium*.
6. Laboratory diagnosis of *Corynebacterium*.
7. Discuss the antigenic property of *Streptococcus*.
8. Laboratory diagnosis of *Streptococcus*.
9. Discuss the cultural characteristics of *Bacillus*.
10. Outline the Laboratory diagnosis of *Bacillus*.
11. Discuss the cultural characteristics of *Clostridium*.

## KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: I M.Sc MB  
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BATCH-2017-2019

12. Comment on the biochemical property of *Clostridium*.
13. Explain the antigenic property of *Clostridium*.
14. Outline the Laboratory diagnosis of *Clostridium*.
15. Comment on the biochemical property of *Mycobacterium*.
16. Discuss the antigenic property of *Mycobacterium*.
17. Write about the Laboratory diagnosis of *Mycobacterium*?



**KARPAGAM ACADEMY OF HIGHER EDUCATION**  
**M.Sc. DEGREE EXAMINATION, APRIL 2018**  
**SECOND SEMESTER**  
**MEDICAL BACTERIOLOGY [17MBP202]**

Unit III Question	Opt 1	Opt 2	Opt 3	Opt 4
_____ species often resemble Staphylococcus	micrococcus	streptococcus	lactococcus	staphylococcus
_____ established the pathogenic role of staphylococcus	pasteur	emil von be	jenner	alexander ogstor
staphylococci can grow in the presence of 10% or more of _____	peptone	beef extract	NaCl	lactose
_____ is the selective medium for isolation of Streptococcus	blood agar	PLET	nutrient agar	crystal violet blood
_____ local infection of superficial layers of skin, especially in children	impetigo	pustule	hemorrhage	meningitis
The _____ test is used for the identification of Staphylococcus	slide coagulase	tube coagulase	Grams test	serum test
Streptococcus pyogenes are more sensitive to _____	amoxycillin	penicillin	erythromycin	bacitracin
_____ the disease common in dockworkers carrying loads of coal	hide porter	gas gangrene	edema	toxemia
_____ strains usually secrete both coagulase and fibrinolysin	micrococcus	streptococcus	staphylococcus	E.coli
Vegetative cells of Bacilli are destroyed at _____ °C	60C	40C	20C	10C
The spores of Bacillus anthracis were isolated from _____	20	30	40	60
Lepra bacilli have been found to remain viable in moist soil for _____	100	80	46	20
The Lepra bacilli seen in large numbers as golgi inclusions in _____	Common diphtheria	Multibacillary	Gas gangrene	Symptomatic diphtheria
_____ was the first effective chemotherapeutic agent for leprosy	rifampicin	clofazimine	ethionamide	dapsone
_____ vaccine was used to prevent leprosy.	BCG	Polio vaccine	Leprosy vaccine	Rabies vaccine
The Lepra bacillus was first observed by _____	Jenner	Behring	Pasteur	Hansen
The diphtheria bacillus was first observed by _____	Pasteur	Hansen	Klebs	Loeffler
Typing in Pneumococcus may be carried out by _____	serum typing	Quellung	Bamboo-stick	stickland
Corynebacterium exists in a _____ morphology	Rod	Cocci	Varied	Spindle shaped
On repeated subculture Pneumococci undergo a _____ change	smooth-rough	rough-smooth	smooth	rough
_____ is always a secondary infection caused by Streptococcus	meningitis	hemorrhage	paralysis	Broncho-pneumonia
The strain used to produce the diphtheria toxin is _____	Bacillus Calmette	Park Williams	Park Williams	Bacillus Calmette
The diagnostically important constant property of Pseudomonas is _____	Bile solubility	serum solubility	symptoms	pathogenicity
The incubation period of Lepra bacilli ranges from _____	5 to 6	2 to 5	4 to 9	1 to 3
The BCG vaccine used to prevent leprosy was suggested by _____	Fernandez	Pasteur	Jenner	Hansen
Prevention of anthrax in animals is aided by _____	prophylaxis	treatment	active immunization	antibiotics
_____ reaction is useful for the primary diagnosis of diphtheria	M'Fadyean	Quellung	Nagler	immunization
Staphylococci are lysed under the influence of the _____	Penicillin	streptomycin	amoxycillin	dapsone
_____ is a typical of Staphylococcal infection	pus	edema	focal suppuration	impetigo
Streptococcal sore throat is commonly called _____	sore throat	Strep. throat	infection	disease
_____ named the strains Staphylococcus aureus and Staphylococcus	Jenner	Behring	Rosenbach	Klebs
Typical Staphylococci are seen in the stained smears as _____	pus	blood	stool	urine
_____ is the selective medium used for the isolation of Staphylococcus	PLET	blood agar	Mac-conkey	PDA
In cultures Bacillus were arranged _____	end to end in a long chain	Bamboo-stick	cluster	thread-like
The _____ of Corynebacterium was described by Von	exotoxin	antitoxin	size	shape
_____ type of complications are most common in diphtheria	fever	headache	paralytic	nausea
Food poisoning by Clostridium perfringens is usually _____	fish	egg	soup	meat
Pneumococci were first noticed by _____	Nagler	Robert Hooke	Pasteur and	Kleb and Loeffler
The toxin produced by virulent strain of diphtheria is _____	exotoxin	endotoxin	antitoxin	toxin
The drug of choice for treating gas gangrene is _____	Penicillin	streptomycin	metranidazole	Amoxycillin
The irregularly stained boat or leaf shaped Clostridium _____	citron bodies	pleomorphic	irregular bodies	boat bodies
The arrangement of diphtheria bacilli at various angles is _____	V shaped	L shaped	Chinese	Bamboo- stick

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Opt 5	Opt 6	Answer
		streptococcus
		alexander ogston
		NaCl
od agar		crystal violet blood agar
		impetigo
		slide coagulase test
		bacitracin
		hide porter's disease
		staphylococcus aureus
		60C
		60
		46
ease		Multibacillary disease
		dapsone
		BCG
		Hansen
		Klebs
		Quellung
		Varied
		smooth-rough
onia		Broncho-pneumonia
8 strain		Park Williams 8 Strain
		Bile solubility
		2 to 5
		Fernandez
		active immunization
		M'Fadyean's
		Penicillin
		focal suppuration
		sore throat
		Rosenbach
		pus
		PLET
		Bamboo-stick
		antitoxin
		paralytic
		meat
		Pasteur and Sternberg
		exotoxin
		metranidazole
		pleomorphs
		Chinese



[illegible]

[illegible]



[illegible]

[illegible]

[illegible]

**UNIT-IV**  
**SYLLABUS**

Gram negative organisms: Morphology, cultural characteristics, antigenic property, pathogenicity, laboratory diagnosis and treatment. *E.coli*, *Klebsiella* sp., *Proteus* sp., *Pseudomonas* sp., *Vibrio* sp., *Salmonella* sp., *Shigella* sp., *Spirillum* and spirochetes- *Treponema* sp., *Leptospira* sp; *Neisseria* sp. and *Haemophilus* sp.

***Escherichia coli*****Morphology:**

- *Escherichia coli* commonly abbreviated *E. coli* is a Gram-negative, rod-shaped bacterium that is commonly found in the lower intestine of warm-blooded organisms (endotherms).
- Strains that possess flagella are motile. The flagella have a peritrichous arrangement
- Capsules or microcapsules made of acidic polysaccharides .They may vary in their size. Capsules detected by light microscopy .Microcapsules by serological or chemical techniques



**Fig: Gram negative rods- *E.coli***

**Cultural Characteristics:**

- a. *E. coli* is Gram-negative, facultative anaerobic and non-sporulating. Cells are typically rod-shaped, and are about 2.0 microns ( $\mu\text{m}$ ) long and 0.5  $\mu\text{m}$  in diameter, with a cell volume of 0.6 – 0.7 ( $\mu\text{m}$ ).
- b. Ferments simple sugars such as glucose to form lactic, acetic, and formic acids.
- c. The optimum pH for growth is 6.0 to 8.0. However, growth can occur as low as pH 4.3 and as high as 9 to 10 pH

- d. Optimal growth temperature is 37°C
- e. After 18–24 h of incubation at 37°C, large (2–3 mm), circular, convex, and non pigmented colonies on nutrient and blood agar (Large thick greyish white moist smooth opaque or partially translucent discs )
- f. Some strains produce  $\beta$  hemolysis (hemolysin)
- g. Grow as large red colonies on MacConkey agar



**Fig: Blood agar** (smooth opaque)



**Fig: MacConkey agar** (large red colonies)

**Antigenic structure:**

- a. Approximately 170 different O antigens have been delineated and some of these are cross-reactive with *Shigella*, *Salmonella* and *Klebsiella*.
- b. Motile strains possess H (flagellar) antigens that can be used for epidemiologic purposes.
- c. *Escherichia* also possess K (capsular) antigens similar to the Vi antigen of *Salmonella*.
- d. Enterotoxigenic strains may also display colonization factor antigens (CFA/I, CFA/II).

**Pathogenesis:**

The pathogenic *E. coli* within each pathotype may be further classified as virotypes, based on the virulence genes that they possess. A virotype is a particular combination of virulence genes. Important virulence factors encoded by these genes include fimbrial adhesins, enterotoxins, cytotoxins, capsule, and lipopolysaccharide, or LPS. Pathogenic *E. coli* may also be differentiated by serotyping, based on antigenic differences in the O antigen of the LPS, in the flagellar or H antigens, and the fimbrial or F antigens.

Pathogenic infections include:

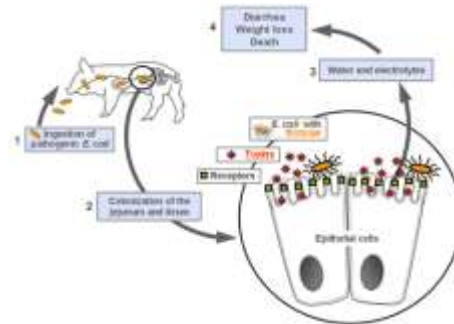
- a. Enteropathogenic (EPEC)
- b. Enteroinvasive (EIEC)
- c. Enterotoxigenic (ETEC)
- d. Vero cytotoxigenic (VTEC)



e. Diffusely adherent (DAEC)

f. Uropathogenic (UPEC)

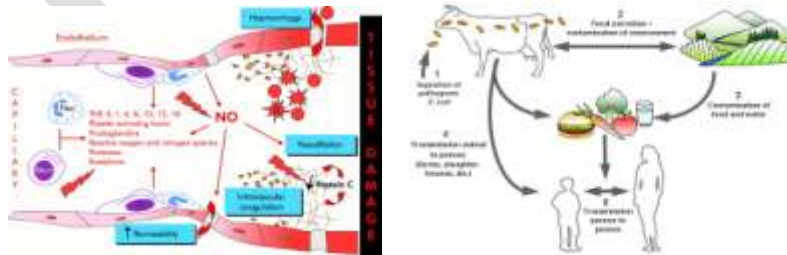
### Enteropathogenic *Escherichia coli* (EPEC)



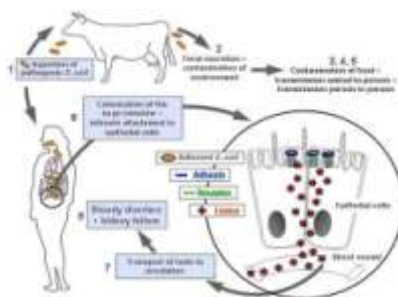
Pathogenic bacteria contaminating the environment are ingested by susceptible animals and enter the intestinal tract (1). These bacteria possess fimbrial adhesins which mediate adherence to specific receptors on the intestinal epithelial cells (2). Resulting bacterial colonization is found mostly on the jejunal and or ileal mucosa. The adherent bacteria produce enterotoxins which stimulate water and electrolyte loss into the intestinal lumen (3), leading to dehydration and possibly death, and a decreased weight gain in surviving animals (4).

### EIEC (Entero invasive *Escherichia coli*)

EIEC strains are invasive pathogens. The first step in this process is the attachment to the host cell. This induces rearrangements in the cytoskeleton of the cells and eventually leads to phagocytosis of the bacteria. The invasion plasmid antigen (Ipa) D is believed to be involved in adhesion. IpaB and IpaC seem to be essential for phagocytosis and for rupture of the phagocytic vesicle. Intercellular spread, which again involves continuous reorganization of the host cell actin filaments, is mediated by two proteins, IcsA (also called VirG) and IcsB, and ultimately leads to cell death.

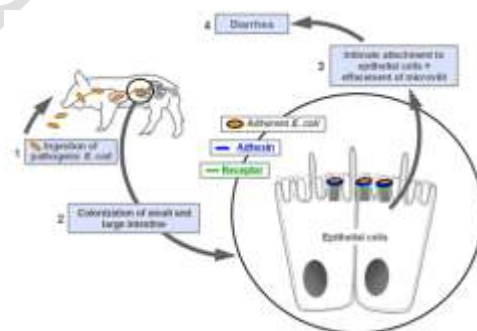


### VTEC (Verotoxigenic *Escherichia coli*)



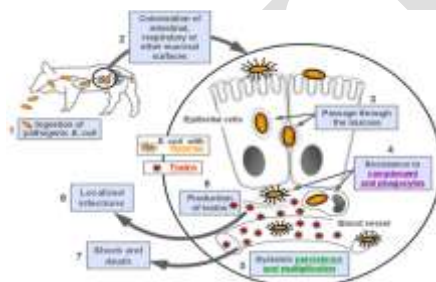
Potentially pathogenic bacteria are ingested by cattle and other ruminants (1) and colonize the intestinal tract, but do not cause any disease in these animals. The bacteria are excreted in the feces and contaminate the environment, including the drinking and swimming water of the human population (2). There may also be contamination of foods such as fruits, vegetables, sprouts, lettuce, and raw milk and juice (3). There may be contamination of the carcass at slaughter, and bacteria will be mixed into ground beef. Persons in direct contact with animals, who are working on farms or in slaughter-houses, may also be contaminated by the bacteria (4). There may also be spread of bacteria from person to person (5). In humans, these bacteria colonize mostly the large intestine and cause similar attaching and effacing lesions to those described for AEEC (6). Bacteria produce their own specific receptor which is injected into the host epithelial cell via a syringe-like bacterial apparatus. A bacterial adhesin then mediates a very intimate attachment of the bacteria to the cell receptors and bacterial signals stimulate effacement of the microvilli, or brush border, and reorganization of the cell cytoskeleton. The adherent bacteria produce a toxin which is transported across the epithelial cells to the circulation (7). This toxin acts on the endothelial cells of blood vessels, resulting in nonbloody to bloody diarrhea and abdominal cramps (8). There may be a complication of hemolytic uremic syndrome which may lead to acute kidney failure, especially in children.

#### **Diffusely adherent *Escherichia coli* (DEAC)**



Pathogenic bacteria contaminating the environment are ingested by susceptible animals and enter the intestinal tract (1). Focal to extensive bacterial colonization of small and large intestine is observed (2). Bacteria produce their own specific receptor which is injected into the host epithelial cell via a syringe-like bacterial apparatus. A bacterial adhesin then mediates a very intimate attachment of the bacteria to the cell receptors and bacterial signals stimulate effacement of the microvilli, or brush border, and reorganization of the cell cytoskeleton (3). The adherent bacteria also stimulate epithelial cell degeneration, and infiltration of PMN's in lamina propria. These cell changes may lead to the appearance of diarrhea (4).

### **Uropathogenic *Escherichia coli* (UPEC)**



Potentially pathogenic bacteria contaminating the environment are ingested by susceptible animals and enter the intestinal tract or enter via the respiratory tract (chickens) (1). These bacteria are considered to be opportunistic pathogens, as they remain as part of the normal microflora and colonize intestinal, respiratory or other mucosal surfaces, possibly due to fimbrial adhesins (2). When the animal is weakened, such as following a viral infection, due to ingestion of mycotoxins, or when a newborn has not received enough colostrum, bacteria pass more readily through the mucosa to the circulation (3). These internalized bacteria can resist the lethal effects of complement and phagocytes (4) and persist and multiply in the system (5 also in part due to the production of aerobactin. The production of toxins by the bacteria may contribute to tissue damage (6). Release of endotoxins by dead bacteria, may trigger cytokine responses leading to shock and death of the animal (7). In localized infections, there may be bacterial interaction with extracellular matrices, leading to pneumonia, serositis, mastitis, urinary tract infection, etc. (8).

### **Clinical Features:**

- a. Urinary tract infection- cystitis, pyelonephritis
- b. Wound infection- appendicitis, peritonitis

- c. Neonatal septicemia and meningitis
- d. E.coli-associated diarrheal disease

1. Enteropathogenic E.coli (EPEC)

- causes outbreaks of self-limiting infantile diarrhea
- they also cause severe diarrhea in adults
- antibiotic treatment shortens the duration of illness and cures diarrhea

2. Enteroinvasive E.coli (EIEC)

- Non-motile, non-lactose fermenting E.coli invades the mucosa of the ileum and colon, and causes shigellosis-like dysentery in children in developing countries

3. Enterotoxigenic E.coli (ETEC)

- Colonization factor of the organism promotes adherence to epithelial cells of small intestine followed by release of enterotoxin which causes toxin-mediated watery diarrhea in infants and young adults.
- It is an important cause of traveller's diarrhea
- Antibiotic prophylaxis can be effective but may increase drug resistance

4. Enterohaemorrhagic E.coli (EHEC)

- Cytotoxic verotoxin-producing E.coli serotype O157:H7 causes haemorrhagic colitis (severe form of diarrhea), and hemolytic uremic syndrome characterized by acute renal failure, hemolytic anemia and low platelet count

5. Enteraggressive E.coli (EAEC)

- Adhere to human intestinal mucosal cells and produce ST-like toxin and hemolysin, and causes acute and chronic diarrhea in persons in developing countries
- Produce food-borne illness in developed countries

**Laboratory diagnosis:**

- **Specimen:** Urine, pus, blood, stool, body fluid
- **Smear:** Gram-negative rods
- **Culture:** Lactose-fermenting mucoid colonies on MacConkey agar and some strains are hemolytic on blood agar.
- **Biochemical reaction:** Produce indole from tryptophan-containing peptone water. Reduce nitrate to nitrite.

- **Serology:** For serotyping (Epidemiologic information)

**Treatment:**

- a. Base on antibiotic sensitivity pattern countries and travellers to these countries
- b. Antibiotic therapy is not generally recommended unless disease becomes life-threatening.  
Oral rehydration is the best treatment.
- c. New vaccines against fimbrial antigens are possible.

**Prevention and control:**

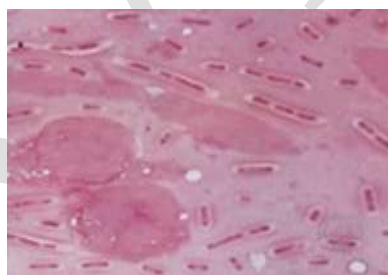
- **Sanitary:** As with other fecal-oral diseases, proper food handling and personal hygiene are the best means for preventing infection.

**Immunological:** New vaccines against fimbrial antigens are possible.

***Klebsiella pneumoniae***

**Morphology:**

- a. Gram negative rod ,encapsulated, non-motile, non-spore forming, facultative anaerobic
- b. opportunistic pathogen belonging to the Enterobacteriaceae
- c. Reservoirs -Humans (normal flora of the skin, nasopharynx, oropharynx and GI tract), animals, water,soil
- d. Transmission by direct contact,fecal-oral,contaminated fomites

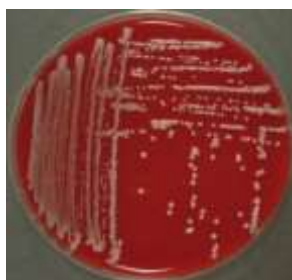


**Fig: *K.pneumoniae* Gram-negative, short rods with parallel sides and rounded ends.**

**Cultural Characteristics:**

- a. *K. pneumoniae* consists of straight rods 1 to 2  $\mu\text{m}$  (micrometres) in length with a thick, surrounding capsule. When cultured, this species produces a distinctive yeasty odor and bacterial colonies have a viscous/mucoid appearance.
- b. In Nutrient agar– mucoid, circular, convex, small colonies

- c. MacConkey agar– mucoid, rose pink
- d. Biochemical reactions:  
IMViC: - - - + TSI: Acid butt/acid slant with gas production\
- e. *K. pneumoniae* is lactose fermenting, H<sub>2</sub>S- and indole-negative, has a positive Voges-Proskauer (VP) reaction, is capable of growth in KCN and using citrate as a sole carbon source, and is incapable of growth at 10°C.



**Fig: *K.pneumoniae* on blood agar showed medium sized, grey colonies, which cause no alteration of the blood.**



**Fig: *K.pneumoniae* on Mac Conkey agar plates showing Lactose fermenting colonies.**

#### **Antigenic structure:**

Members of the *Klebsiella* genus typically express 2 types of antigens on their cell surface. The first, O antigen, is a component of the lipopolysaccharide (LPS), of which 9 varieties exist. The second is K antigen, a capsular polysaccharide with more than 80 varieties.<sup>[3]</sup> Both contribute to pathogenicity and form the basis for serogrouping

#### **Pathogenesis:**

This pathogen possesses many virulence factors that allow it to go undetected by the host's immune system and cause infection in a variety of ways. Firstly, this species uses ferric-siderophore receptors of the host to activate their enterobactin-mediated iron-sequestering system, allowing for bacterial growth. Their thick polysaccharide capsule prevents ingestion by

phagocytes and their somatic antigens from being detected by the host's antibodies. Also, serum *complement* activation is more difficult with the thick lipopolysaccharide capsule it possesses (Greenwood *et al.*, 2002). In fact, *K. pneumoniae* avoids damage by complement proteins by the extreme length of the molecules comprising the capsule, essentially allowing the lytic C5b-9 (complement) complex to form too far away from the membrane. This prevents opsonization and *membrane attack complex* (MAC) insertion, which leads to lysis of the bacterium .

**Clinical Features:**

Second most common cause of lobar pneumonia and pulmonary abscesses primarily caused by *K. pneumoniae*

- a. wound infections (primarily if burned, caused by all species of *Klebsiella*)
- b. cystitis (primarily if urinary catheter, caused by all species of *Klebsiella*)
- c. second most common cause of septicemia caused by all species of *Klebsiella*

Associated pneumonia

- a. Frequently associated with
  - i. Necrotic destruction of alveolar spaces
  - ii. Production of blood-tinged sputum
- b. Can also cause wound, soft tissue, and urinary tract infections

**Laboratory diagnosis:**

The diagnosis of the infection is done in two ways

- Gram stain and culture
- Biochemical tests is required to identify the species

**Treatment:**

- third generation cephalosporins
- fluoroquinolones

**Prevention and control:**

- Although prevention of hospital acquired infections is difficult, meticulous hand washing best way to minimize transmission.

As yet, vaccines or hyperimmune sera are not available



*Proteus vulgaris*

**Morphology:**

- a. Gram negative rod, motile, non-spore forming, non-encapsulated, facultative anaerobic
- b. Opportunistic pathogen
- c. Reservoirs -Humans (normal flora of the GI tract), water, soil
- d. Transmission - Fecal-oral, direct contact, contaminated water.



**Fig: *Proteus vulgaris*, a gram-negative bacterium is demonstrated by the red/pink colouration from the gram stain**

**Cultural Characteristics:**

- a. The genus *Proteus* is classified in the **enteric bacteria**,
- b. Gram-negative rods and are **facultative anaerobes**:
- c. they ferment sugars in anaerobic conditions but can use a wide range of organic molecules in aerobic conditions.
- d. The cells are highly motile and often **swarm** across the surface of agar plates. Swarming gives rise to a very thin film of bacteria on the agar surface, but swarming periods are interspersed with periods when the cells stop and undergo a cycle of growth and division so that the colony has a distinct zonation, clearly
- e. It has the ability to degrade urea to ammonia, by production of the enzyme **urease**. This distinguishes them from the other enterics and is used in a simple diagnostic test.



**Fig: Circular, smooth, entire, opaque colonies of *Proteus vulgaris* on a nutrient agar plate**





**Clinical Features:**

Wound infections

- bronchopneumonia
- cystitis and urolithiasis
- septicemia

**Laboratory diagnosis:**

**Specimen:** Urine, pus, blood, ear discharge

**Smear:** Gram-negative rods

**Culture:** Produce characteristic swarming growth over the surface of blood agar.

Ditching of culture media prevents spread of proteus species. Non-lactose fermenting colonies in mac conkey agar. Proteus species have a characteristic smell.

**Biochemical reaction:**

Proteus spp..... Urease positive

P. vulgaris..... Indole positive

**Serology:** Cross react with Weil-felix test

**Treatment:**

- Ciprofloxacin
- Ceftazidime
- Netilmicin
- Sulbactam or Cefoperazo
- Meropenem
- Piperacillin/tazobactam
- Unasyn

Antibiotics should be introduced in much higher doses than "normal" when P. vulgaris has infected the sinus or respiratory tissues. I.E.- Ciprofloxacin should be introduced at a level of at least 2000 mg per day orally in such a situation, rather than the "standard" 1000 mg per day.

**Prevention and control:**

- a. **Sanitary:** Frequent hand-washing by staff and a general awareness of microbial presence can reduce hospital-acquired infections. Disinfectants are not always effective.

- b. **Immunological:** There is the possibility of anti-serum or vaccine against these organisms but none are currently in use.

**Chemotherapeutic:** Moderate or broad spectrum antibiotics are generally useful. Susceptibility tests should be performed when appropriate.

### ***Pseudomonas aeruginosa***

#### **Morphology:**

- Gram negative rod, encapsulated, motile, non-spore forming, obligate aerobic bacteria 0.5 to 0.8  $\mu\text{m}$  by 1.5 to 3.0  $\mu\text{m}$ .
- opportunistic pathogen
- Reservoirs - humans (normal flora of the GI tract), water, soil
- Transmission - direct contact, droplet nuclei, contaminated water, contaminated soil, contaminated fomites



**Fig: Gram stain of *Pseudomonas aeruginosa* cells**

#### **Cultural Characteristics:**

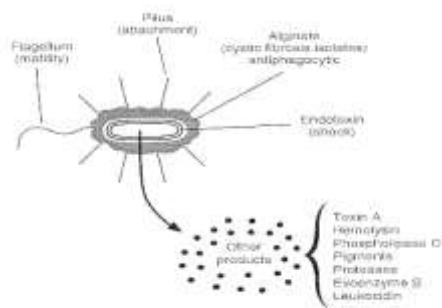
- Pseudomonads are Gram negative rods.
- They are motile, nonfermentative aerobes
- Can utilize acetate for carbon and ammonium sulphate for nitrogen.
- Many species are resistant to high salt, dyes, weak antiseptics most antibiotics.
- P. aeruginosa* optimally at 37 °C, and it is able to grow at temperatures as high as 42°C.



**Fig: *Pseudomonas aeruginosa* in cetrimide agar**

**Antigenic structure:**

- Exotoxin A
- Exoenzyme S



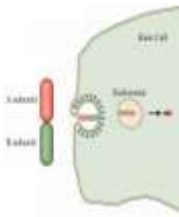
**Fig :Antigenic structure of *P aeruginosa***

The cell envelope of *P aeruginosa*, which is similar to that of other Gram-negative bacteria, consists of three layers: the inner or cytoplasmic membrane, the peptidoglycan layer, and the outer membrane. The outer membrane is composed of phospholipid, protein, and lipopolysaccharide (LPS). The LPS of *P aeruginosa* is less toxic than that of other Gram-negative rods. The LPS of most strains of *P aeruginosa* contains heptose, 2-keto-3-deoxyoctonic acid, and hydroxy fatty acids, in addition to side-chain and core polysaccharides. Recent evidence suggests that the LPS of a large percentage of strains isolated from patients with cystic fibrosis may have little or no polysaccharide side chain (O antigen), and that this finding correlates with the polyagglutinability of these strains with typing sera.

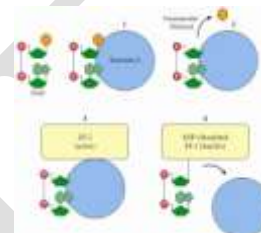
**Pathogenesis**

*P. aeruginosa* is infamously known for its ingenious mode of infection. Once this pathogen enters its host, it releases an exotoxin known as A-B toxin. This toxin is composed of two units, namely: A and B. Toxin B binds to the cell and is internalized; the A subunit, which is bound to the B subunit, has toxic activity and is also internalized. Exotoxin A then binds to a coenzyme inside the cell called *nicotinamide adenine dinucleotide* (NAD); NAD is involved in many cellular oxidation-reduction reactions. The binding of exotoxin releases the nicotinamide from *adenine dinucleotide* (ADP-ribose). This ADP-ribose unit stays attached to the A subunit. Exotoxin A transfers ADP-ribose to Elongation Factor-2, a protein involved in the translation and elongation of proteins. This, in turn, blocks protein synthesis in host cells, causing

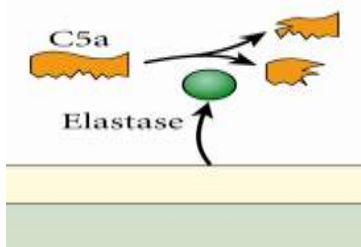
damaging to target tissues. Another way *P. aeruginosa* evades the immune system is by producing specialized microbial factors that inactivate the complement cascade. Recall that the complement system is a biochemical cascade that helps or 'complements' the ability of antibodies to clear pathogens from an organism in innate immunity. These enzymes known as *elastases* cleaves and destroys complement proteins, specifically C3a and C5a, resulting in a reduction in the local immune response to *P. aeruginosa* and favouring the establishment of infection.



**Fig: A-B toxin entry into host cell.**



**Fig: *Pseudomonas* exotoxin A; ADP ribosylation of Elongation Factor 2 (EF-2) interferes with translation**



**Fig: schematic depicting elastase enzyme being secreted from *P. aeruginosa* and breaking down clinical features:**

#### ***In Healthy***

- Endophthalmitis, keratitis and corneal ulcers (primarily if contact lenses)
- Otitis externa ("swimmer's ear")

#### ***In Immunocompromized***

- Second most common cause of acute infectious endocarditis
- Wound infections (primarily if burned)
- Tracheobronchitis and bronchopneumonia (primarily if intubated)
- Chronic bronchopneumonia and severe progressive pulmonary abscesses (primarily if cystic fibrosis)
- Cystitis and pyelonephritis (primarily if catheterized)

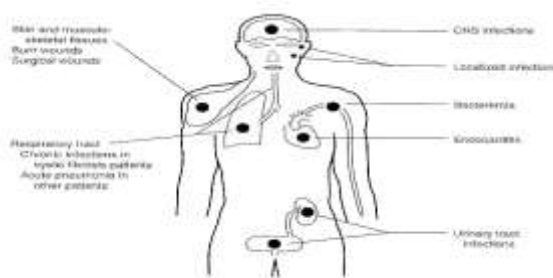
- Meningitis (primarily if external ventricular drainage catheter) - septicemia

**Laboratory diagnosis:**

*P aeruginosa* depends on its isolation and laboratory identification. It grows well on most laboratory media and commonly is isolated on blood agar plates or eosin-methylthionine blue agar. It is identified on the basis of its Gram morphology, inability to ferment lactose, a positive oxidase reaction, its fruity odor, and its ability to grow at 42° C. Fluorescence under ultraviolet radiation helps in early identification of *P aeruginosa* colonies and also is useful in suggesting its presence in wounds. Other pseudomonads are identified by specific laboratory tests.

**Treatment –**

- Extended spectrum penicillins in conjunction with aminoglycosides (due to high antibiotic resistance)

**Prevention and control:**

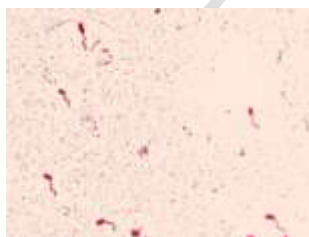
The spread of *P aeruginosa* can best be controlled by observing proper isolation procedures, aseptic technique, and careful cleaning and monitoring of respirators, catheters, and other instruments. Topical therapy of burn wounds with antibacterial agents such as mafenide or silver sulfadiazine, coupled with surgical debridement, has dramatically reduced the incidence of *P aeruginosa* sepsis in burn patients.

*Pseudomonas aeruginosa* is frequently resistant to many commonly used antibiotics. Although many strains are susceptible to gentamicin, tobramycin, colistin, and amikacin, resistant forms have developed, making susceptibility testing essential. The combination of gentamicin and carbenicillin is frequently used to treat severe *Pseudomonas* infections, especially in patients with leukopenia. Several types of vaccines are being tested, but none is currently available for general use.

### *Vibrio cholerae*

#### Morphology:

- Gram negative curved rod (comma shaped), motile, non-spore forming, non-encapsulated, facultative anaerobic, facultative alkaliphilic bacteria.
- Obligate isotonic (may only survive in isotonic environments)
- Obligate pathogen
- Reservoirs - humans (not normal flora), water
- Transmission - fecal-oral, contaminated water, contaminated food



**Fig: Vibrio cholerae. Leifson flagella stain**

#### Cultural Characteristics:

- V. cholerae* is also motile due to its polar flagellum and makes ATP (an energy molecule) by aerobic respiration if oxygen is present, but is also capable of switching to fermentation - *facultative anaerobe*.
- Species belonging to the genus *Vibrio* are distinguished from *Enterobacteria* by their flagella, as well as being oxidase positive.
- They grow in temperatures around 37°C and can survive in conditions as low as 25°C.
- V. cholerae* generally require saltwater to grow properly, but a glucose medium is usually enough for their energy needs.

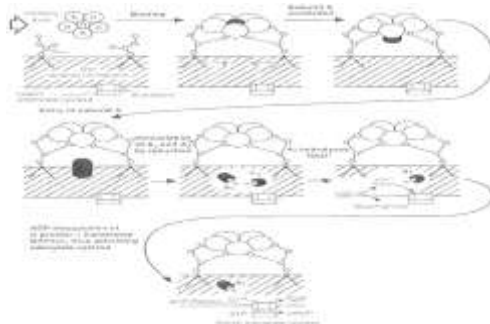


**Fig: Vibrio cholerae colonies in TCBS(Thiosulfate Citrate Bile Sucrose) agar**



**Antigenic structure:**

- Cholera toxin
- LPS



**Fig: Mechanism of action of cholera enterotoxin**

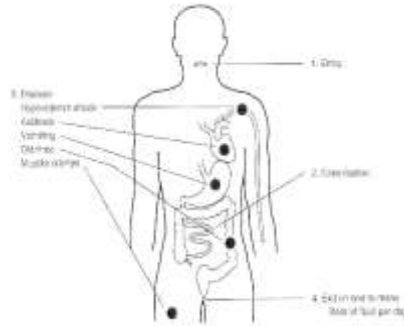
The enterotoxin works by activating adenylate cyclase in the epithelial cells. More specifically, it inhibits GTPase enzyme activity so that GDP (an inhibitory molecule) cannot replace the activated G protein which has GTP bound to it in its active state during signal transduction. The activated G protein goes on to activate adenylate cyclase, producing large amounts of another chemical compound called cAMP. cAMP then activates protein kinase A, an enzyme that induces several different cellular responses, including the release of ions. cAMP also opens plasma membrane calcium channels, so that large amounts of calcium are released into the intestines, leading to an increase in water loss. Cholera toxin modifies the G protein by adding an ADP-ribosyl group to it. This prevents the enzyme GTPase, as mentioned earlier, from hydrolyzing the activated the G protein to a deactivated state which has GDP bound to it, as opposed to GTP. As a result, if the G protein is constantly active, there is persistent activation of adenylate cyclase and, in turn, a nonregulated rise of intracellular cAMP.

**Pathogenesis:**

Cholera is transmitted by the fecal-oral route. Vibrios are sensitive to acid, and most die in the stomach. Surviving virulent organisms may adhere to and colonize the small bowel, where they secrete the potent cholera enterotoxin (CT, also called “cholera toxin”). This toxin binds to the plasma membrane of intestinal epithelial cells and releases an enzymatically active subunit that causes a rise in cyclic adenosine 5<sup>1</sup>-monophosphate (cAMP) production. The resulting high



intracellular cAMP level causes massive secretion of electrolytes and water into the intestinal lumen.



**Treatment:**

Treatment of cholera consists essentially of replacing fluid and electrolytes. Formerly, this was accomplished intravenously, using costly sterile pyrogen-free intravenous solutions. The patient's fluid losses were conveniently measured by the use of buckets, graduated in half-liter volumes, kept underneath an appropriate hole in an army-type cot on which the patient was resting. Antibiotics such as tetracycline, to which the vibrios are generally sensitive, are useful adjuncts in treatment. They shorten the period of infection with the cholera vibrios, thus reducing the continuous source of cholera enterotoxin; this results in a substantial saving of replacement fluids and a markedly briefer hospitalization.

**Prevention and control:**

Control by sanitation is effective but not feasible in endemic areas. A good vaccine has not yet been developed. A parenteral vaccine of whole killed bacteria has been used widely, but is relatively ineffective and is not generally recommended. An experimental oral vaccine of killed whole cells and toxin B-subunit protein is less than ideal. Living attenuated genetically engineered mutants are promising, but such strains can cause limited diarrhea as a side effect. Antibiotic prophylaxis is feasible for small groups over short periods.

***Salmonella enterica (typhi)*****Morphology:**

- Gram negative rod, encapsulated, motile, non-spore forming, facultative anaerobic, facultative intracellular, facultative alkaliphilic bacteria.
- Obligate pathogen
- Reservoirs - Humans (only reservoir, not normal flora)
- Transmission - direct contact, fecal-oral, contaminated water, contaminated food



**Fig: *Salmonella typhi* gram negative rods**

**Cultural Characteristics:**

- Coliform bacilli (enteric rods)
- Motile gram-negative facultative anaerobes
- Non-lactose fermenting
- Resistant to bile salts
- H<sub>2</sub>S producing

**Antigenic structure:**

As with all *Enterobacteriaceae*, the genus *Salmonella* has three kinds of major antigens with diagnostic or identifying applications: somatic, surface, and flagellar.

**Somatic (O) or Cell Wall Antigens**

Somatic antigens are heat stable and alcohol resistant. Cross-absorption studies individualize a large number of antigenic factors, 67 of which are used for serological identification. O factors labeled with the same number are closely related, although not always antigenically identical.

**Surface (Envelope) Antigens**

Surface antigens, commonly observed in other genera of enteric bacteria (e.g., *Escherichia coli* and *Klebsiella*), may be found in some *Salmonella* serovars. Surface antigens in *Salmonella* may mask O antigens, and the bacteria will not be agglutinated with O antisera. One specific surface antigen is well known: the Vi antigen. The Vi antigen occurs in only three *Salmonella* serovars (out of about 2,200): Typhi, Paratyphi C, and Dublin. Strains of these three serovars may or may not have the Vi antigen.

**Flagellar (H) Antigens**

Flagellar antigens are heat-labile proteins. Mixing salmonella cells with flagella-specific antisera gives a characteristic pattern of agglutination (bacteria are loosely attached to each other by their flagella and can be dissociated by shaking). Also, anti-flagellar antibodies can immobilize bacteria with corresponding H antigens.

**Pathogenesis:****Enteric Fevers**

- a. *S. typhi* causes **typhoid fever**

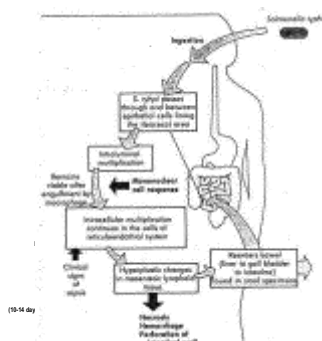
*S. paratyphi A, B* (*S. schottmuelleri*) and *C* (*S. hirschfeldii*) cause milder form of enteric fever

- b. **Infectious dose** = 106 CFU
- c. **Fecal-oral route of transmission**
  - i. Person-to-person spread by chronic carrier
  - ii. Fecally-contaminated food or water
- d. **10-14 days incubation period**
- e. Initially signs of **sepsis/bacteremia** with **sustained fever** (delirium) for > one week before abdominal pain and **gastrointestinal symptoms**
- f. **Invasiveness**
  - i. Pass through intestinal epithelial cells in ileocecal region, infect the regional lymphatic system, invade the bloodstream, and infect other parts of the reticuloendothelial system
  - ii. Organisms are phagocytosed by macrophages and monocytes, but survive, multiply and are transported to the liver, spleen, and bone marrow where they continue to replicate
  - iii. Second week: organisms reenter bloodstream and cause prolonged bacteremia; biliary tree and other organs are infected; gradually increasing sustained fever likely from endotoxemia
  - iv. Second to third week: bacteria colonize gallbladder, reinfect intestinal tract with diarrheal symptoms and possible necrosis of the Peyer's patches

**Clinical Features:**

***Typhoid Fever***

- "Enteric fever"
- Enterocolitis (high fever, headache, abdominal pain, vomiting and watery diarrhea) and mesenteric lymphadenitis ("mock appendicitis") " abdominal rash ("rose spots"), hepatosplenomegaly and generalized lymphadenomegaly
- caused by phagocytosis of *Salmonella Typhi* by macrophages of the gut-associated lymphoid tissue ("GALT") " survival of *Salmonella typhi* within the macrophages " dissemination of *Salmonella typhi* in virtually every lymphoid organ



**Fig: Pathogenesis of salmonellosis (*Progression of Enteric Fever - Typhoid fever*)**

### **Laboratory diagnosis:**

The diagnosis of salmonellosis requires bacteriologic isolation of the organisms from appropriate clinical specimens. Laboratory identification of the genus *Salmonella* is done by biochemical tests; the serologic type is confirmed by serologic testing. Feces, blood, or other specimens should be plated on several nonselective and selective agar media (blood, MacConkey, eosin-methylene blue, bismuth sulfite, *Salmonella-Shigella*, and brilliant green agars) as well as into enrichment broth such as selenite or tetrathionate. Any growth in enrichment broth is subsequently subcultured onto the various agars. The biochemical reactions of suspicious colonies are then determined on triple sugar iron agar and lysine-iron agar, and a presumptive identification is made. Biochemical identification of salmonellae has been simplified by systems that permit the rapid testing of 10–20 different biochemical parameters simultaneously. The presumptive biochemical identification of *Salmonella* then can be confirmed by antigenic analysis of O and H antigens using polyvalent and specific antisera. Fortunately, approximately 95% of all clinical isolates can be identified with the available group A-E typing antisera. *Salmonella* isolates then should be sent to a central or reference laboratory for more comprehensive serologic testing and confirmation.

### **Treatment:**

Enteric fever and bacteremia require antibiotic treatment: chloramphenicol, ampicillin, trimethoprim-sulfamethoxazole. Surgical drainage of metastatic abscesses may be required

**Prevention and control:**

Effective vaccines exist for typhoid fever but not for non-typhoidal salmonellosis. Those diseases are controlled by hygienic slaughtering practices and thorough cooking and refrigeration of food.

- a. **Antibiotics to avoid carrier state**
- b. **Identify & treat carriers of *S. typhi* & *S. paratyphi***
- c. **Vaccination can reduce risk of disease for travellers in endemic areas**

***Shigella dysenteriae*****Morphology:**

- Gram negative rod, non-encapsulated, non-motile, non-spore forming, facultative anaerobic intracellular
- Obligate pathogen
- Reservoirs - Humans (only reservoir, not normal flora)
- Transmission- direct contact, fecal-oral, vectorial (flies), contaminated water, contaminated food.



**Fig: *Shigella dysenteriae* cultured in Gram stain**

**Cultural Characteristics:**

- Coliform bacilli (enteric rods)
- Nonmotile gram-negative facultative anaerobes
- Does not ferment lactose
- Gas is not produced from glucose fermentation
- IMViC is -+--
- Does not produce lysine decarboxylase

- H<sub>2</sub>S and urease negative
- Four species
  - i. *Shigella sonnei* (most common in industrial world)
  - ii. *Shigella flexneri* (most common in developing countries)
  - iii. *Shigella boydii*
  - iv. *Shigella dysenteriae*
- Non-lactose fermenting
- Resistant to bile salts



**Fig: *Shigella dysenteriae* Non lactose fermenting colonies in Mac Conkey Agar plate**

**Antigenic structure:**

Shiga toxin causes hemorrhagic bacillary dysentery and hemolytic-uremic syndrome

- Enterotoxigenic, neurotoxic and cytotoxic
- Encoded by chromosomal genes
- Two domain (A-B) structure
- Similar to the Shiga-like toxin of enterohemorrhagic *E. coli* (EHEC)

NOTE: except that Shiga-like toxin is encoded by lysogenic bacteriophage

**Pathogenesis:**

***Shigellosis***

**Two-stage disease:**

➤ **Early stage:**

- **Watery diarrhea** attributed to the **enterotoxigenic activity of Shiga toxin** following ingestion and **noninvasive colonization**, multiplication, and production of enterotoxin in the **small intestine**
- **Fever** attributed to **neurotoxic activity** of toxin

➤ **Second stage:**

- Adherence to and tissue **invasion of large intestine** with typical symptoms of **dysentery**
- **Cytotoxic activity** of Shiga toxin increases severity

**Enterotoxigenic Effect:**

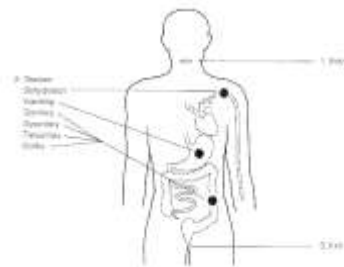
- Adheres to **small intestine receptors**
- **Blocks absorption** (uptake) of **electrolytes, glucose, and amino acids** from the intestinal lumen

**Note:** This contrasts with the effects of **cholera toxin** (*Vibrio cholerae*) and labile toxin (**LT**) of enterotoxigenic *E. coli* (ETEC) which act by **blocking absorption of Na<sup>+</sup>**, but also cause **hypersecretion of water and ions** of Cl<sup>-</sup>, K<sup>+</sup> (low potassium = hypokalemia), and HCO<sub>3</sub><sup>-</sup> (loss of bicarbonate buffering capacity leads to metabolic acidosis) out of the intestine and into the lumen

**Cytotoxic Effect:**

- B subunit of Shiga toxin binds host cell glycolipid
- A domain is internalized via receptor-mediated endocytosis (coated pits)
- Causes irreversible inactivation of the 60S ribosomal subunit, thereby causing:
  - Inhibition of protein synthesis
  - Cell death
  - Microvasculature damage to the intestine
  - Hemorrhage (blood & fecal leukocytes in stool)

**Neurotoxic Effect:** Fever, abdominal cramping are considered signs of neurotoxicity



**Fig: Pathogenesis of shigellosis in humans**



**Clinical Features:**

***Bacillary Dysentery***

- low-grade fever, abdominal cramps, abdominal pain, vomiting and purulent hemorrhagic diarrheaspontaneously resolves in < 1 week
- primarily occurs in children and elderly
- analogous to hemorrhagic colitis
- caused by Shigella infection of the GI tract " production and secretion of shiga toxin " necrosis of the enterocytes
- Some cases were accompanied by hemolytic uremic syndrome (HUS).

**Laboratory diagnosis:**

- **Specimens:** fresh stool, mucus flecks, and rectal swabs. Large numbers of fecal leukocytes and some RBC may often be seen microscopically.
- **Culture:** differential and selective media as used for salmonellae.

**Treatment:**

- broad spectrum penicillins in conjunction with oral fluid and electrolyte replacement (if bacillary dysentery)
- broad spectrum penicillins in conjunction with careful oral fluid and electrolyte replacement (if hemolytic-uremic syndrome, due to occlusion of the glomeruli)

**Prevention and control:**

Humans are the only reservoir for shigellae.

- Transmission of shigellae: water, food, fingers, feces, and flies.
- Most cases occur in children under 10 years of age.
- Prevention and control of dysentery:
  - Sanitary control of water, food and milk; sewage disposal; and fly control.
  - Isolation of patients and disinfection of excreta.
  - Detection of subclinical cases and carriers.

### *Treponema pallidum*

#### Morphology:

- Gram negative spirochete (helically-coiled cell), motile, non-spore forming, non-encapsulated microaerophilic bacteria, 6 to 15  $\mu\text{m}$  long and 0.1 to 0.2  $\mu\text{m}$  wide.
- obligate intracellular pathogen
- Reservoirs -Humans (only reservoir, not normal flora)
- Transmission - direct contact, sexual, perinatal
- Too thin to be seen with light microscopy in specimens stained with Gram stain or Giemsa stain
- Motile spirochetes can be seen with **darkfield microscopy**
- Staining with **anti-treponemal antibodies labeled with fluorescent dyes**



**Fig: Darkfield Microscopy of *Treponema pallidum***

#### Cultural Characteristics:

- The *Treponema* are motile, helically coiled organisms having a corkscrew-like shape,.
- They stain very poorly because their thickness approaches the resolution of the light microscope.
- Treponema* are delicate organisms requiring pH in the range 7.2 to 7.4, temperatures in the range 30°C to 37°C and a microaerophilic environment.
- The structure of these organisms is somewhat different: the cells have a coating of glycosamino-glycans, which may be host-derived, and the outer membrane covers the three flagella that provide motility.
- In addition, the cells have a high lipid content (cardiolipin, cholesterol), which is unusual for most bacteria. Cardiolipin elicits "Wassermann" antibodies that are diagnostic for syphilis.
- Multiplication is by binary transverse fission.

g. Treponemes have not yet been cultured in vitro.

**Antigenic structure:**

- Outer membrane proteins promote adherence
- Hyaluronidase may facilitate perivascular infiltration
- Antiphagocytic coating of fibronectin
- Tissue destruction and lesions are primarily result of host's immune response (immunopathology)

**Pathogenesis:**

Humans are the only natural host for *T pallidum* subsp *pallidum*, and infection occurs through sexual contact. The organisms penetrate mucous membranes or enter minuscule breaks in the skin. In women the initial lesion is usually on the labia, the walls of the vagina, or the cervix; in men it is on the shaft or glans of the penis. A chancre also may occur on lips, tongue, tonsils, anus, or other skin areas. The observation, made in a number of in vitro studies, that *T pallidum* subsp *pallidum* and subsp *pertenue* specifically attach to numerous cell types is believed to reflect the ability of these bacteria to infect diverse tissues and organs. To disseminate away from the site of initial entry, organisms must traverse the viscous ground substance between tissue cells. There is evidence that *Treponema pallidum* subsp *pallidum* elaborates an enzyme capable of degrading hyaluronic acid within the ground substance, thereby potentially facilitating hematogenous dissemination of organisms.

**Clinical Features:*****Primary Syphilis***

- a single small painless depressed ulcer with elevated margins ("chancre") at the site of initial infection, fever, headache, anorexia and local lymphadenomegaly
- primarily occurs on the external genitalia, periorally (if oral intercourse) or perianally (if anal intercourse)
- occurs 3-6 weeks after initial infection
- spontaneously resolves in 3-6 weeks
- caused by *Treponema pallidum* infection of the skin
- may progress to secondary syphilis

***Secondary Syphilis***

- small flat erythematous rashes of the palms and soles, small painless papules (“condyloma lata”) of the groin and axilla, and generalized lymphadenomegaly
- occurs 12-18 weeks after initial infection
- spontaneously resolves in 3-6 weeks
- caused by *Treponema pallidum* septicemia
- may progress to tertiary syphilis

***Tertiary Syphilis***

- nodular well circumscribed caseating granulomas (“gummas”) of the skin, liver and bone, obliterative endarteritis of the vasa vasorum leading to aortic aneurysm (“cardiovascular syphilis”), meningitis, obliterative endarteritis of the cerebral arteries leading to cerebral infarct, and permanent central neuronal damage leading to general paresis and tabes dorsalis (“neurosyphilis”)
- occurs 3-15 years after initial infection
- occurs in 30% of untreated patients
- caused by *Treponema pallidum* accumulation in tissues

***Early Congenital Syphilis***

- small flat erythematous rashes of the palms and soles, condylomalata of the groin and axilla, osteitis, rhinitis (snuffles”), hepatosplenomegaly and generalized lymphadenomegaly
- occurs immediately after birth
- spontaneously resolves in 1-3 weeks
- caused by intrauterine *Treponema pallidum* infection "

***Treponema pallidum septicemia***

- may progress to late congenital syphilis

***Late Congenital Syphilis***

- gummas (see above) of the cartilage of the nose, the bone of the hard palate and the teeth leading to deformation of the face (“bulldog facies”), gummas of the tibia and fibula leading to deformation of the legs (“saber shins”), and neurosyphilis

- occurs 1-3 years after birth
- caused by *Treponema pallidum* accumulation in tissues

**Laboratory diagnosis:**

**Tests:** After the examination, a blood test for syphilis will be done. Besides this you may be tested for other sexually transmitted infections, including HIV.

**Blood test:**

Infection with syphilis causes your body to make antibodies against the syphilis bacteria. When your blood is tested, it may show the antibodies that are present. A positive result means that you either have the infection or have had it in the past (the antibodies persist in the body for years; even after successfully treatment of an infection). If the blood test is negative, it does not necessarily mean that you are not infected. The antibodies against syphilis bacteria may not be detected for up to three months after infection. Your doctor may advise repeat test after three months to confirm the diagnosis. Blood test for syphilis is done in every pregnant woman as the infection can affect the baby (it can result in death of the foetus or newborn baby or cause other complications). The test is usually done at weeks 11-20 of pregnancy. The common blood tests done for syphilis include:

- RPR (rapid plasma reagin).
- VDRL (venereal disease research laboratory).
- FTA-ABS (fluorescent treponemal antibody absorption) or MHA-TP (microhemagglutination assay for *T pallidum*).

**Swab:** If the patient has sores the doctor will take a sample from the sore and examine it under a microscope (perform a dark-field microscope examination). The test is useful in the primary and also sometimes in the secondary phase of infection.

**Spinal fluid examination:** During the tertiary phase, the examination of a sample of spinal fluid obtained by spinal puncture may be done to check for infection and to measure the success of treatment.

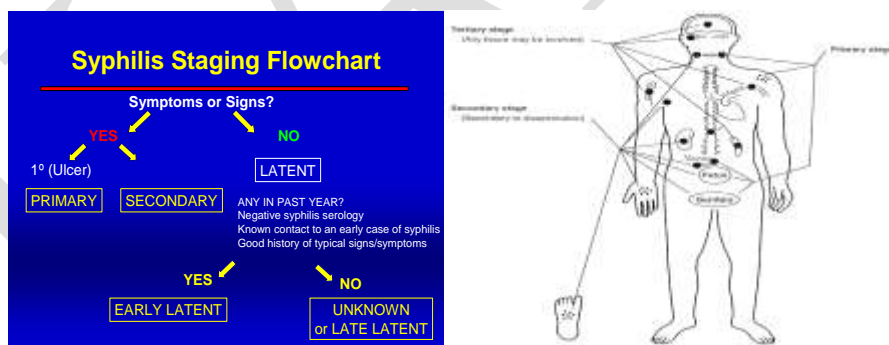
**Treatment:**

- a. Recommended regimen:
  - i. Benzathine penicillin G 2.4 million units IM once
- b. Non-pregnant penicillin-allergic adults \*

- c. Data to support the use of alternatives to penicillin are limited and if used, close follow-up is essential
  - i. Doxycycline 100mg orally twice daily for two weeks or
  - j. Tetracycline 500mg orally 4 times a day for two weeks or
  - k. Adherence is poor (i.e., dosing and gastrointestinal effects)
  - l. Ceftriaxone 1 g IM daily x 8-10 d or
  - m. (Azithromycin 2 g po)...not recommended in CA
- d. Efficacy in HIV + persons not studied so use with caution

**Prevention and control:**

- a. Sanitary: As with other sexually transmitted diseases (STDs), use of a condom helps prevent infection.
- b. Immunological: None are available.
- c. Chemotherapeutic: Benzathine penicillin (long acting) or penicillin G are the drugs of choice. One must be aware of a possible Jarisch-Herxheimer reaction following treatment of secondary or tertiary syphilis, however. The rapid release of treponemal antigens after lysis by penicillin can cause hypersensitivity reactions in some persons.



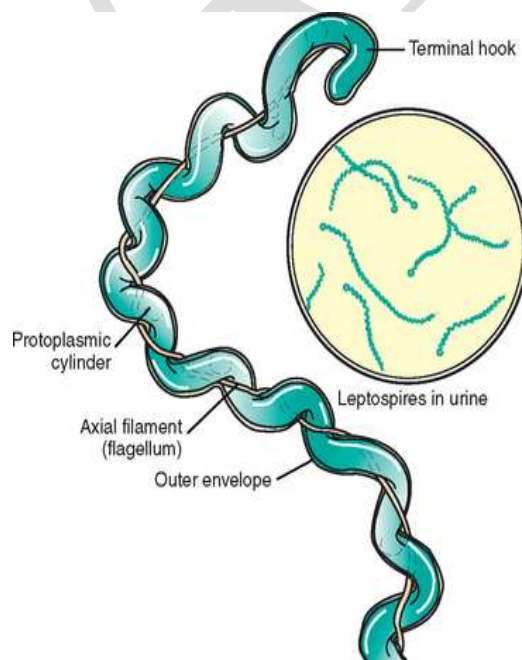
**Fig: Clinical manifestations of syphilis**

***Leptospira Sp.,***

Leptospirosis is a zoonosis of worldwide distribution. It is caused by spirochetes of the genus *Leptospira*. The traditional classification system is based on biochemical and serologic specificity to differentiate between the pathogenic species, *Leptospira interrogans*, and the free-

living nonpathogenic species, *Leptospira biflexa*. The species are further broken down to more than 200 serovars of *L interrogans* and more than 60 serovars of *L biflexa*. The serovars are further organized into serogroups of *L interrogans* and serogroups of *L biflexa*. The serogroups are based on shared antigenicity and are primarily for laboratory use. A second classification system is based on DNA–DNA hybridization studies, which have demonstrated a high degree of heterogeneity within the two species of the traditional classification. Phylogenetic analysis based on 16S rRNA gene sequencing indicates that there are three clades of leptospires, pathogens, saprophytes, and some of uncertain pathogenicity. The 19 species (13 pathogenic and six saprophytic) do not correspond to the species in the traditional serologic classification. Indeed, some serovars in the traditional classification occur in multiple species in the molecular classification, and the serologic classification cannot be used to predict the molecular classification. Under the new classification, the species are further subdivided into 24 serogroups and 250 serovars based on the surface lipopolysaccharide.

*Leptospira* (Greek *leptos*, "fine, thin" and Latin *spira*, "coil") is a genus of spirochaete bacteria, including a small number of pathogenic and saprophytic species. *Leptospira* was first observed in 1907 in kidney tissue slices of a leptospirosis victim who was described as having died of "yellow fever."

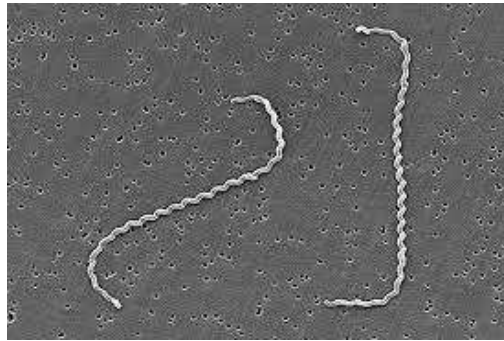


**Fig: Morphology of *Leptospira***



### **Morphology**

- Spiral-shaped bacteria
- Delicate, flexible, helical rods
- Actively motile and hooked ends
- 6-20  $\mu\text{m}$  long and 0.1  $\mu\text{m}$  in diameter with a wavelength of about 0.5  $\mu\text{m}$ .
- They are so thin, live *Leptospira* are best observed by darkfield microscopy.



**Fig: *Leptospira* under dark field microscope**

### **Cultural characteristics**

- Temperature:
  - Optimum temperature range: 28-30°C; extreme range: 11-42°C
  - Growth at 11-13°C has been proposed as a phenotypic test for *L. biflexa*
  - Pathogens grow in mammalian host at febrile body temperature; in chick embryos and young chicks at 40-42°C
- pH range: 6.5-8.4
- Growth:
  - It is an obligate anaerobe
  - Leptospirae grow best under aerobic conditions at 28-30°C in semisolid medium (eg, Ellinghausen-McCullough-Johnson-Harris EMJH) in 10 mL test tubes with 0.1% agar and 5-fluorouracil
  - Leptospira strain grow slowly, Colonies can take from 3-7 days to 3 weeks to appear
  - Routinely grow in liquid media at 30°C with a doubling time of 6-8h under optimum condition



- Leptonema grows rapidly in medium reach maximum density on incubation for 18-72h at 30°C

- Growth Requirements:

Leptospirae derive energy from oxidation of long-chain fatty acids and cannot use amino acids or carbohydrates as major energy sources. Ammonium salts are a main source of nitrogen. Leptospirae can survive for weeks in water, particularly at alkaline pH.

**Antigenic Structure:**

The main strains (“serovars”) of *L interrogans* isolated from humans or animals in different parts of the world are all serologically related and exhibit crossreactivity in serologic tests. This indicates considerable overlapping in antigenic structure, and quantitative tests and antibody absorption studies are necessary for a specific serologic diagnosis. The outer envelope contains large amounts of lipopolysaccharide of antigenic structure that is variable from one strain to another. This variation forms the basis for the serologic classification of the *Leptospira* species. It also determines the specificity of the human immune response to leptospirae.

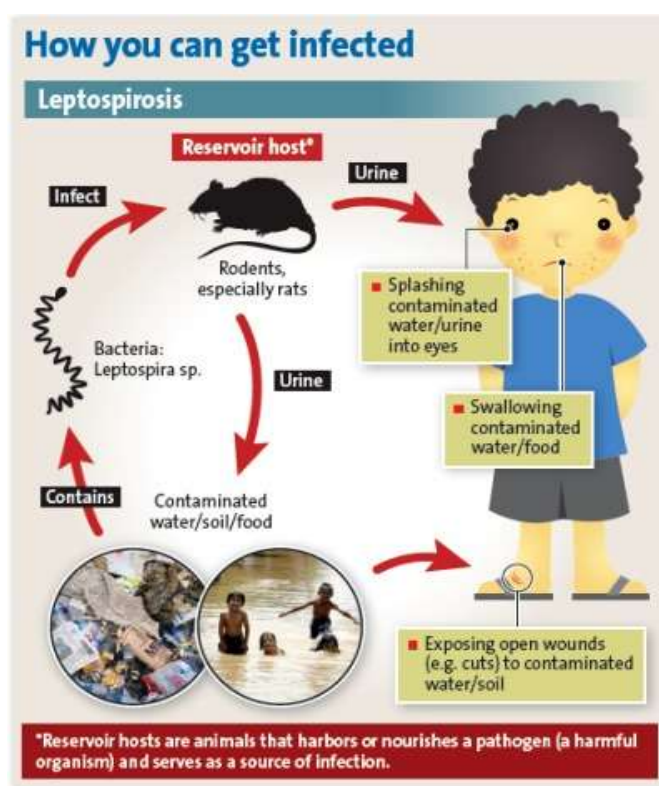
**Principal Leptospiral Diseases**

<i>Leptospira</i> Serogroups	Source of Infection	Disease in Humans	Clinical Findings	Distribution
Autumnalis	?	Pretibial fever or Ft. Bragg fever	Fever, rash over tibia	United States, Japan
Ballum	Mice	—	Fever, rash, jaundice	United States, Europe, Israel
Bovis	Cattle, voles	—	Fever, prostration	United States, Israel, Australia
Canicola	Dog urine	Infectious jaundice	Influenza-like illness, aseptic meningitis	Worldwide
Grippotyphosa	Rodents, water	Marsh fever	Fever, prostration, aseptic meningitis	Europe, United States, Africa
Hebdomadis	Rats, mice	7-day fever	Fever, jaundice	Japan, Europe
Icterohaemorrhagiae	Rat urine, water	Weil disease	Jaundice, hemorrhages, aseptic meningitis	Worldwide
Mitis	Swine	Swineherd's disease	Aseptic meningitis	Australia
Pomona	Swine, cattle	Swineherd's disease	Fever, prostration, aseptic meningitis	Europe, United States, Australia

**Pathogenesis and Clinical Findings**

Human infection usually results from leptospirae, often in bodies of water, entering the body through breaks in the skin (cuts and abrasions) and mucous membranes (mouth, nose, conjunctivae). Ingestion is considered to be less important. After an incubation period of 1–2 weeks, there is a variable febrile onset during which spirochetes are present in the bloodstream. They then establish themselves in the parenchymatous organs (particularly liver and kidneys),

producing hemorrhage and necrosis of tissue and resulting in dysfunction of those organs (jaundice, hemorrhage, nitrogen retention). The illness is often biphasic. After initial improvement, the second phase develops when the IgM antibody titer rises. It manifests itself often as “aseptic meningitis” with an intense headache, stiff neck, and pleocytosis of the CSF. Nephritis and hepatitis may also recur, and there may be skin, muscle, and eye lesions. The degree and distribution of organ involvement vary in the different diseases produced by different leptospirae in various parts of the world (see Table 24-1). Many infections are mild or subclinical. Hepatitis is frequent in patients with leptospirosis.



**Fig: Mode of Transmission**

Kidney involvement in many animal species is chronic and results in the shedding of large numbers of leptospirae in the urine; this is probably the main source of environmental contamination resulting in infection of humans. Human urine also may contain spirochetes in the second and third weeks of disease. Agglutinating, complement-fixing, and lytic antibodies develop during the infection. Serum from convalescent patients protects experimental animals against an otherwise fatal infection. The immunity resulting from infection in humans and animals appears to be serovar specific.

**Diagnostic Laboratory Tests****A. Specimens**

Specimens consist of aseptically collected blood in a heparin tube, CSF, or tissues for microscopic examination and culture. Urine should be collected using great care to avoid contamination. Serum is collected for agglutination tests.

**B. Microscopic Examination**

Dark-field examination or thick smears stained by the Giemsa technique occasionally show leptospirae in fresh blood from early infections. Results of dark-field examination of centrifuged urine may also be positive. Fluorescein-conjugated antibodies or other immunohistochemical techniques can be used also.

**C. Culture**

Whole fresh blood or urine can be cultured in a semisolid medium. Because of inhibitory substances in blood, only 1 or 2 drops should be placed in each of five tubes containing 5 or 10 mL of medium. Up to 0.5 mL of CSF can be used. One drop of undiluted urine can be used followed by 1 drop each of 10-fold serially diluted urine for a total of four tubes. Tissue approximately 5 mm in diameter should be crushed and used as the inoculum. Growth is slow, and cultures should be kept for at least 8 weeks.

**D. Serology**

The diagnosis of leptospirosis in most cases is confirmed serologically. Agglutinating antibodies first appear 5–7 days after infection and develop slowly, reaching a peak at 5–8 weeks. Very high titers may be attained ( $>1:10,000$ ). The reference laboratory standard for detection of leptospiral antibody uses microscopic agglutination of live organisms, which can be hazardous. The test is highly sensitive, but it is difficult to standardize; the end point is 50% agglutination, which is difficult to determine. Agglutination of the live suspensions is most specific for the serovar of the infecting leptospire. Agglutination tests are generally performed only in reference laboratories. Paired sera that show a significant change in titer or a single serum with high-titer agglutinins plus a compatible clinical illness can be diagnostic. Because of the difficulty in performing the definitive agglutination tests, a variety of other tests have been developed for use primarily as screening tests.

**Immunity**

Serovar-specific immunity follows infection, but reinfection with different serovars may occur.

### **Treatment**

Treatment of mild leptospirosis should be with oral doxycycline, ampicillin, or amoxicillin.

Treatment of moderate or severe disease should be with intravenous penicillin or ampicillin.

### **Epidemiology, Prevention, and Control**

The leptospires are essentially animal infections; human infection is only accidental, occurring after contact with water or other materials contaminated with the excreta of animal hosts. Rats, mice, wild rodents, dogs, swine, and cattle are the principal sources of human infection. They excrete leptospirae in urine both during the active illness and during the asymptomatic carrier state. Leptospirae remain viable in stagnant water for several weeks; drinking, swimming, bathing, or food contamination may lead to human infection. Persons most likely to come in contact with water contaminated by rats (eg, miners, sewer workers, farmers, and fishermen) run the greatest risk of infection. Children acquire the infection from dogs more frequently than adults do. Control consists of preventing exposure to potentially contaminated water and reducing contamination by rodent control. Doxycycline, 200 mg orally once weekly during heavy exposure, is effective prophylaxis. Dogs can receive distemper–hepatitis–leptospirosis vaccinations.

### ***Neisseria Sp.***

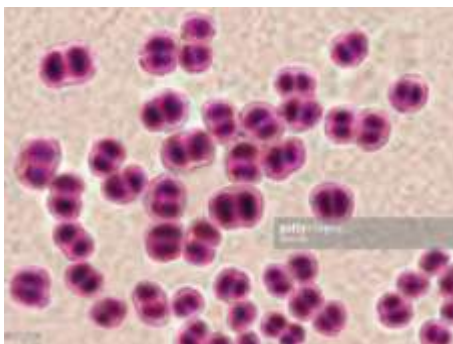
The neisseriae are gram-negative cocci that usually occur in pairs (diplococci). *Neisseria gonorrhoeae* (gonococci) and *Neisseria meningitidis* (meningococci) are pathogenic for humans and typically are found associated with or inside polymorphonuclear cells. Some neisseriae are normal inhabitants of the human respiratory tract, rarely if ever cause disease, and occur extracellularly.

Gonococci and meningococci are closely related, with 70% DNA homology, and are differentiated by a few laboratory tests and specific characteristics: Meningococci have polysaccharide capsules but gonococci do not, and meningococci rarely have plasmids but most gonococci do. Most importantly, the two species are differentiated by the usual clinical presentations of the diseases they cause: Meningococci typically are found in the upper

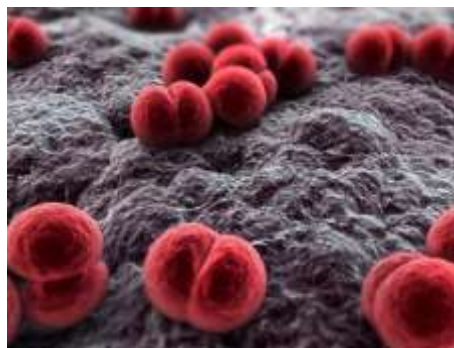
respiratory tract and cause meningitis, but gonococci cause genital infections. The clinical spectra of the diseases caused by gonococci and meningococci overlap, however.

**Morphology :****A. Typical Organisms**

The typical *Neisseria* is a gram-negative, nonmotile diplococcus, approximately 0.8  $\mu\text{m}$  in diameter. Individual cocci are kidney shaped; when the organisms occur in pairs, the flat or concave sides are adjacent.



**Fig: Grams staining**



**Fig: Electron microscopy**

**B. Culture**

In 48 hours on enriched media (eg, modified Thayer-Martin, Martin-Lewis, GC-Lect, and New York City), gonococci and meningococci form convex, glistening, elevated, mucoid colonies 1–5 mm in diameter. Colonies are transparent or opaque, nonpigmented, and nonhemolytic. *Neisseria fl avescens*, *Neisseria cinerea*, *Neisseria subfl ava*, and *Neisseria lactamica* may have yellow pigmentation. *Neisseria sicca* produces opaque, brittle, wrinkled colonies. *Moraxella catarrhalis* produces nonpigmented or pinkish gray opaque colonies.

**C. Growth Characteristics**

The neisseriae grow best under aerobic conditions, but some grow in an anaerobic environment. They have complex growth requirements. Most neisseriae oxidize carbohydrates, producing acid but not gas, and their carbohydrate patterns are a means of distinguishing them (see Table 20-1 ). The neisseriae produce oxidase and give positive oxidase reactions; the oxidase test is a key test for identifying them. When bacteria are spotted on a filter paper soaked with tetramethylparaphenylenediamine hydrochloride (oxidase), the neisseriae rapidly turn dark purple.

Meningococci and gonococci grow best on media containing complex organic substances such as heated blood, hemin, and animal proteins and in an atmosphere containing 5% CO<sub>2</sub> (eg, candle jar). Growth is inhibited by some toxic constituents of the medium (eg, fatty acids or salts). The organisms are rapidly killed by drying, sunlight, moist heat, and many disinfectants. They produce autolytic enzymes that result in rapid swelling and lysis in vitro at 25°C and at an alkaline pH.

#### **Antigenic Heterogeneity of *Neisseria gonorrhoeae***

Antigen	Number of Types
Pilin	Hundreds
Por (protein) (U.S. system)	PorA with 18 subtypes PorB with 28 subtypes
Opa (protein II)	Many (perhaps hundreds)
Rmp (protein III)	One
Lipooligosaccharide	Eight or more
Fbp (iron-binding protein)	One
Lip (H8)	One
IgA1 protease	Two

#### **Pathogenesis, Pathology, and Clinical Findings**

Gonococci exhibit several morphologic types of colonies (see earlier discussion), but only piliated bacteria appear to be virulent. Opa protein expression varies depending on the type of infection. Gonococci that form opaque colonies are isolated from men with symptomatic urethritis and from uterine cervical cultures at midcycle. Gonococci that form transparent colonies are frequently isolated from men with asymptomatic urethral infection; from menstruating women; and from patients with invasive forms of gonorrhea, including salpingitis and disseminated infection. Antigenic variation of surface proteins during infection allows the organism to circumvent host immune response.

Gonococci attack mucous membranes of the genitourinary tract, eye, rectum, and throat, producing acute suppuration that may lead to tissue invasion; this is followed by chronic inflammation and fibrosis. Men usually have urethritis, with yellow, creamy pus and painful urination.

The process may extend to the epididymis. As suppuration subsides in untreated infection, fibrosis occurs, sometimes leading to urethral strictures. Urethral infection in men can be



asymptomatic. In women, the primary infection is in the endocervix and extends to the urethra and vagina, giving rise to mucopurulent discharge. It may then progress to the uterine tubes, causing salpingitis, fibrosis, and obliteration of the tubes. Infertility occurs in 20% of women with gonococcal salpingitis. Chronic gonococcal cervicitis and proctitis are often asymptomatic. Gonococcal bacteremia leads to skin lesions (especially hemorrhagic papules and pustules) on the hands, forearms, feet, and legs and to tenosynovitis and suppurative arthritis, usually of the knees, ankles, and wrists. Gonococci can be cultured from blood or joint fluid of only 30% of patients with gonococcal arthritis. Gonococcal endocarditis is an uncommon but severe infection. Gonococci sometimes cause meningitis and eye infections in adults; these have manifestations similar to those caused by meningococci.

Complement deficiency is frequently found in patients with gonococcal bacteremia. Patients with bacteremia, especially if recurrent, should be tested for total hemolytic complement activity. Gonococcal ophthalmia neonatorum, an infection of the eye in newborns, is acquired during passage through an infected birth canal. The initial conjunctivitis rapidly progresses and, if untreated, results in blindness. To prevent gonococcal ophthalmia neonatorum, instillation of tetracycline, erythromycin, or silver nitrate into the conjunctival sac of newborns is compulsory in the United States. Gonococci that produce localized infection are often serum sensitive (ie, killed by antibody and complement).

### **Diagnostic Laboratory Tests**

#### **A. Specimens**

Pus and secretions are taken from the urethra, cervix, rectum, conjunctiva, throat, or synovial fluid for culture and smear. Blood culture is necessary in systemic illness, but a special culture system is helpful because gonococci (and meningococci) may be susceptible to the polyanethol sulfonate present in standard blood culture media.

#### **B. Smears**

Gram-stained smears of urethral or endocervical exudates reveal many diplococci within pus cells. These give a presumptive diagnosis. Stained smears of the urethral exudates from men have a sensitivity of about 90% and a specificity of 99%. Stained smears of endocervical exudates have a sensitivity of about 50% and a specificity of about 95% when examined by an experienced microscopist. Additional diagnostic testing of urethral exudates from men is not

necessary when the stain result is positive, but nucleic acid amplification tests (NAATs) or cultures should be done for women. Stained smears of conjunctival exudates can also be diagnostic, but those of specimens from the throat or rectum are generally not helpful.

### **C. Culture**

Immediately after collection, pus or mucus is streaked on enriched selective medium (eg, modified Thayer-Martin medium [MTM]) and incubated in an atmosphere containing 5% CO<sub>2</sub> (candle extinction jar) at 37°C. To avoid overgrowth by contaminants, the selective medium contains antimicrobial drugs (eg, vancomycin, 3 µg/mL; colistin, 7.5 µg/mL; amphotericin B, 1 µg/mL; and trimethoprim, 3 µg/mL). If immediate incubation is not possible, the specimen should be placed in a CO<sub>2</sub>-containing transport-culture system. Forty-eight hours after culture, the organisms can be quickly identified by their appearance on a Gram-stained smear; by oxidase positivity; and by coagglutination, immunofluorescence staining, or other laboratory tests. The species of subcultured bacteria may be determined by oxidation of specific carbohydrates (see Table 20-1). Matrix-assisted laser desorption ionization-time of flight mass spectrometry (MALDI-TOF MS) has potential to provide rapid (same-day) identification of cultured isolates. The gonococcal isolates from anatomic sites other than the genital tract or from children should be identified as to species using two different confirmatory tests because of the legal and social implications of a positive culture result.

### **D. Nucleic Acid Amplification Tests**

Several Food and Drug Administration–cleared nucleic acid amplification assays are available for direct detection of *N gonorrhoeae* in genitourinary specimens, and these are the preferred tests from these sources. In general, these assays have excellent sensitivity and specificity in symptomatic, high-prevalence populations. Advantages include better detection, more rapid results, and the ability to use urine as a specimen source. Disadvantages include poor specificity of some assays because of cross-reactivity with nongonococcal *Neisseria* species. These assays are not recommended for use for the diagnosis of extragenital gonococcal infections or for infection in children. NAATs are not recommended as tests of cure because nucleic acid may persist in patient specimens for up to 3 weeks after successful treatment.



**E. Serology**

Serum and genital fluid contain immunoglobulin G (IgG) and IgA antibodies against gonococcal pili, outer membrane proteins, and LPS. Some IgM of human sera is bactericidal for gonococci in vitro. In infected individuals, antibodies to gonococcal pili and outer membrane proteins can be detected by immunoblotting, radioimmunoassay, and ELISA (enzyme-linked immunosorbent assay) tests. However, these tests are not useful as diagnostic aids for several reasons, including gonococcal antigenic heterogeneity, the delay in development of antibodies in acute infection, and a high background level of antibodies in the sexually active population.

**Immunity**

Repeated gonococcal infections are common. Protective immunity to reinfection does not appear to develop as part of the disease process, because of the antigenic variety of gonococci. Although antibodies can be demonstrated, including the IgA and IgG on mucosal surfaces, they are either highly strain specific or have little protective ability.

**Treatment**

Since the development and widespread use of penicillin, gonococcal resistance to penicillin has gradually risen, owing to the selection of chromosomal mutants, so that many strains now require high concentrations of penicillin G for inhibition ( $\text{MIC} \geq 2 \mu\text{g/mL}$ ). Penicillinase-producing *N gonorrhoeae* (PPNG) also have increased in prevalence. Chromosomally mediated resistance to tetracycline ( $\text{MIC} \geq 2 \mu\text{g/mL}$ ) is common. High-level resistance to tetracycline ( $\text{MIC} \geq 32 \mu\text{g/mL}$ ) also occurs. Spectinomycin resistance as well as resistance to fluoroquinolones has been noted. Single-dose fluoroquinolone treatment was recommended for treatment of gonococcal infections from 1993 until 2006. Since 2006, rates of quinolone resistance among gonococcal isolates have exceeded 5% in men who have sex with men and in heterosexual men. Because of the problems with antimicrobial resistance in *N gonorrhoeae*, the Centers for Disease Control and Prevention (CDC) recommends that patients with uncomplicated genital or rectal infections be treated with ceftriaxone (250 mg) given intramuscularly as a single dose or 400 mg of oral cefixime as a single dose. Additional therapy with 1 g of azithromycin orally in a single dose or with 100 mg of doxycycline orally twice a day for 7 days is recommended for possible concomitant chlamydial infections. Azithromycin has been found to be safe and effective in pregnant women, but doxycycline is contraindicated. Modifications of these therapies are

recommended for other types of *N gonorrhoeae* infection. See the CDC's website for the 2010 updated treatment guidelines. Because other sexually transmitted diseases may have been acquired at the same time as gonorrhea, steps must also be taken to diagnose and treat these diseases (see discussions of chlamydiae, syphilis, and so on).

### **Epidemiology, Prevention, and Control**

Gonorrhea is worldwide in distribution. In the United States, its incidence rose steadily from 1955 until the late 1970s, when the incidence was between 400 and 500 cases per 100,000 populations. Between 1975 and 1997, there was a 74% decline in the rate of reported gonococcal infections. Thereafter, the rates plateaued for 10 years, decreased from 2006–2009, but increased by 2.8% between 2009 and 2010. Gonorrhea is exclusively transmitted by sexual contact, often by women and men with asymptomatic infections. The infectivity of the organism is such that the chance of acquiring infection from a single exposure to an infected sexual partner is 20–30% for men and even greater for women. The infection rate can be reduced by avoiding multiple sexual partners, rapidly eradicating gonococci from infected individuals by means of early diagnosis and treatment, and finding cases and contacts through education and screening of populations at high risk. Mechanical prophylaxis (condoms) provides partial protection. Chemoprophylaxis is of limited value because of the rise in antibiotic resistance of the gonococcus.

Gonococcal ophthalmia neonatorum is prevented by local application of 0.5% erythromycin ophthalmic ointment or 1% tetracycline ointment to the conjunctiva of newborns. Although instillation of silver nitrate solution is also effective and is the classic method for preventing ophthalmia neonatorum, silver nitrate is difficult to store and causes conjunctival irritation; its use has largely been replaced by use of erythromycin or tetracycline ointment.

### ***Haemophilus Sp.,***

This is a group of small, gram-negative, pleomorphic bacteria that require enriched media, usually containing blood or its derivatives, for isolation. *Haemophilus influenzae* type b is an important human pathogen; *Haemophilus ducreyi*, a sexually transmitted pathogen, causes chancroid; other *Haemophilus* species are among the normal microbiota of mucous membranes and only occasionally cause disease.

***Haemophilus influenza***

*Haemophilus infl uenzae* is found on the mucous membranes of the upper respiratory tract in humans. It is an important cause of meningitis in children and causes upper and lower respiratory tract infections in children and adults.

**Morphology and Identifi cation****A. Typical Organisms**

In specimens from acute infections, the organisms are short (1.5 µm) coccoid bacilli, sometimes occurring in pairs or short chains. In cultures, the morphology depends both on the length of incubation and on the medium. At 6–8 hours in rich medium, the small coccobacillary forms predominate. Later there are longer rods, lysed bacteria, and very pleomorphic forms. Organisms in young cultures (6–18 hours) on enriched medium have a defi nite capsule. Th e capsule is the antigen used for “typing” *H infl uenzae*.

**B. Culture**

On chocolate agar, flat, grayish brown colonies with diameters of 1–2 mm are present after 24 hours of incubation. IsoVitaleX in media enhances growth. *H infl uenzae* does not grow on sheep blood agar except around colonies of staphylococci (“satellite phenomenon”). *Haemophilus haemolyticus* and *Haemophilus parahaemolyticus* are hemolytic variants of *H infl uenzae* and *Haemophilus parainfluenzae*, respectively.

**C. Growth Characteristics**

Identifi cation of organisms of the *Haemophilus* group depends partly on demonstrating the need for certain growth factors called X and V. Factor X acts physiologically as hemin; factor V can be replaced by nicotinamide adenine nucleotide (NAD) or other coenzymes. Colonies of staphylococci on sheep blood agar cause the release of NAD, yielding the satellite growth

phenomenon. Carbohydrates are fermented poorly and irregularly. In addition to serotyping on the basis of capsular polysaccharides, *H influenzae* and *H parainfluenzae* can be biotyped on the basis of the production of indole, ornithine decarboxylase and urease. Most of the invasive infections caused by *H influenzae* belong to biotypes I and II (there are a total of eight).

#### **D. Variation**

In addition to morphologic variation, *H influenzae* has a marked tendency to lose its capsule and the associated type specificity. Nonencapsulated variant colonies lack iridescence.

#### **E. Transformation**

Under proper experimental circumstances, the DNA extracted from a given type of *H influenzae* is capable of transferring that type specificity to other cells (transformation). Resistance to ampicillin and chloramphenicol is controlled by genes on transmissible plasmids.

#### **Antigenic Structure**

Encapsulated *H influenzae* contains **capsular polysaccharides** (molecular weight >150,000) of one of six types (a–f). The capsular antigen of type b is a polyribitol ribose phosphate (PRP). Encapsulated *H influenzae* can be typed by slide agglutination, coagglutination with staphylococci, or agglutination of latex particles coated with type-specific antibodies. A capsule swelling test with specific antiserum is analogous to the quellung test for pneumococci. Typing can also be done by immunofluorescence. Most *H influenzae* organisms in the normal microbiota of the upper respiratory tract are not encapsulated. The somatic antigens of *H influenzae* consist of outer membrane proteins. Lipooligosaccharides (endotoxins) share many structures with those of neisseriae.

#### **Pathogenesis**

*H influenzae* produces no exotoxin. The nonencapsulated organism is a regular member of the normal respiratory microbiota of humans. The capsule is antiphagocytic in the absence of specific anticapsular antibodies. The polyribose phosphate capsule of type b *H influenzae* is the major virulence factor. The carrier rate in the upper respiratory tract for *H influenzae* type b was 2–4% in the prevaccine era and is now less than 1%. The carrier rate for nontypeable *H influenzae* is 50–80% or higher. Type b *H influenzae* causes meningitis, pneumonia and empyema, epiglottitis, cellulitis, septic arthritis, and occasionally other forms of invasive infection. Nontypeable *H influenzae* tends to cause chronic bronchitis, otitis media, sinusitis, and

conjunctivitis after breakdown of normal host defense mechanisms. The carrier rate for the encapsulated types a and c to f is low (1–2%), and these capsular types rarely cause disease. Although type b can cause chronic bronchitis, otitis media, sinusitis, and conjunctivitis, it does so much less commonly than nontypeable *H influenzae*. Similarly, nontypeable *H influenzae* only occasionally causes invasive disease (~5% of cases). The blood of many persons older than age 3–5 years is bactericidal for *H influenzae*, and clinical infections are less frequent in such individuals. However, bactericidal antibodies have been absent from 25% of adults in the United States, and clinical infections have occurred in adults.

### **Clinical Findings**

*H influenzae* type b enters by way of the respiratory tract. There may be local extension with involvement of the sinuses or the middle ear. *H influenzae*, mostly nontypeable, and pneumococci are two of the most common etiologic agents of bacterial otitis media and acute sinusitis. Encapsulated organisms may reach the bloodstream and be carried to the meninges or, less frequently, may establish themselves in the joints to produce septic arthritis. Before the use of the conjugate vaccine, *H influenzae* type b was the most common cause of bacterial meningitis in children age 5 months to 5 years in the United States. Clinically, it resembles other forms of childhood meningitis, and diagnosis rests on bacteriologic demonstration of the organism. Occasionally, a fulminating obstructive laryngotracheitis with swollen, cherry-red epiglottitis develops in infants and requires prompt tracheostomy or intubation as a lifesaving procedure. Pneumonitis and epiglottitis caused by *H influenza* may follow upper respiratory tract infections in small children and old or debilitated people. Adults may have bronchitis or pneumonia caused by *H influenzae*.

### **Diagnostic Laboratory Tests**

#### **A. Specimens**

Specimens consist of expectorated sputum and other types of respiratory specimens, pus, blood, and spinal fluid for smears and cultures depending on the source of the infection.

#### **B. Direct Identification**

Commercial kits are available for immunologic detection of *H influenzae* antigens in spinal fluid. A positive test result indicates that the fluid contains high concentrations of specific polysaccharide from *H influenzae* type b. These antigen detection tests generally are not more

sensitive than a Gram stain and therefore are not widely used, especially because the incidence of *H influenzae* meningitis is so low.

### **C. Culture**

Specimens are grown on IsoVitaleX-enriched chocolate agar until typical colonies appear. *H influenzae* is differentiated from related gram-negative bacilli by its requirements for X and V factors and by its lack of hemolysis on blood agar. Tests for X (heme) and V (nicotinamide-adenine dinucleotide) factor requirements can be done in several ways. The *Haemophilus* species that require V factor grow around paper strips or disks containing V factor placed on the surface of agar that has been autoclaved before the blood was added (V factor is heat labile). Alternatively, a strip containing X factor can be placed in parallel with one containing V factor on agar deficient in these nutrients. Growth of *Haemophilus* in the area between the strips indicates requirement for both factors. A better test for X factor requirement is based on the inability of *H influenzae* (and a few other *Haemophilus* species) to synthesize heme from  $\delta$ -aminolevulinic acid. The inoculum is incubated with the  $\delta$ -aminolevulinic acid. *Haemophilus* organisms that do not require X factor synthesize protoporphobilinogen, porphyrins, protoporphyrin IX, and heme. The presence of red fluorescence under ultraviolet light (~360 nm) indicates the presence of porphyrins and a positive test result. *Haemophilus* species that synthesize porphyrins (and thus heme) are not *H influenzae*.

### **Immunity**

Infants younger than age 3 months may have serum antibodies transmitted from their mothers. During this time, *H influenzae* infection is rare, but subsequently, the antibodies are lost. Children often acquire *H influenzae* infections, which are usually asymptomatic but may be in the form of respiratory disease or meningitis. *H influenzae* was the most common cause of bacterial meningitis in children from 5 months to 5 years of age until the early 1990s when the conjugate vaccines became available. By age 3–5 years, many unimmunized children have naturally acquired anti-PRP antibodies that promote complement-dependent bactericidal killing and phagocytosis. Immunization of children with *H influenzae* type b conjugate vaccine induces the same antibodies. There is a correlation between the presence of bactericidal antibodies and resistance to major *H influenzae* type b infections. However, it is not known whether these



antibodies alone account for immunity. Pneumonia or arthritis caused by infection with *H influenzae* can develop in adults with such antibodies.

### **Treatment**

The mortality rate for individuals with untreated *H influenza* meningitis may be up to 90%. Many strains of *H influenza* type b are susceptible to ampicillin, but up to 25% produce  $\beta$ -lactamase under control of a transmissible plasmid and are resistant. Essentially all strains are susceptible to the third generation cephalosporins. Cefotaxime given intravenously gives excellent results. Prompt diagnosis and antimicrobial therapy are essential to minimize late neurologic and intellectual impairment. Prominent among late complications of *H influenzae* type b meningitis is the development of a localized subdural accumulation of fluid that requires surgical drainage.

### **Epidemiology, Prevention, and Control**

Encapsulated *H influenzae* type b is transmitted from person to person by the respiratory route. *H influenzae* type b disease can be prevented by administration of ***Haemophilus b* conjugate vaccine** to children. Currently, two conjugate vaccines are available for use: PRP-OMPC (polysaccharide linked to outer membrane protein complex), the outer membrane protein complex of *Neisseria meningitidis* serogroup B, and PRP-T, which uses tetanus toxoid. Beginning at age 2 months, all children should be immunized with one of the conjugate vaccines. Depending on which vaccine product is chosen, the series consists of three doses at 2, 4, and 6 months of age or two doses given at 2 and 4 months of age. An additional booster dose is given sometime between 12 and 15 months of age. Both conjugate vaccines can be given at the time of other vaccine administration such as DTaP (diphtheria, tetanus, and acellular pertussis). Widespread use of *H influenza* type b vaccine has reduced the incidence of *H influenza* type b meningitis in children by more than 95%. The vaccine reduces the carrier rates for *H influenzae* type b. Contact with patients with *H influenzae* type b clinical infection poses little risk for adults but presents a definite risk for nonimmune siblings and other nonimmune children younger than age 4 years who are close contacts. Prophylaxis with rifampin is recommended for such children.

**Possible Questions**

**Part B (Two marks)**

1. Write about the morphology of *E.coli*?
2. Comment on the biochemical property of *E.coli*.
3. Give the morphology of *Klebsiella*.
4. Comment on the biochemical property of *Klebsiella*.
5. Write about the morphology of *Proteus*?
6. Comment on the biochemical property of *Proteus*.
7. Discuss the cultural characteristics of *Klebsiella*.
8. Give the morphology of *Pseudomonas*.
9. Write about the morphology of *Vibrio*?
10. Give the morphology of *Salmonella*.
11. . Comment on the biochemical property of *Salmonella*.
12. Write about the morphology of *Shigella*?
13. Give the morphology of *Treponema*.
14. . Comment on the biochemical property of *Treponema*.
15. Write about Laboratory diagnosis of *Proteus*?
16. Give the morphology of *Haemophilus*.
17. Discuss the cultural characteristics of *Pseudomonas*.

**Part C (Eight marks)**

1. Discuss the cultural characteristics of *E.coli*.
2. Discuss the antigenic property of *E.coli*.
3. Write about Laboratory diagnosis of *E.coli*?
4. Comment on the biochemical property of *Pseudomonas*.
5. Explain the antigenic property of *Pseudomonas*.
6. Outline the Laboratory diagnosis of *Pseudomonas*.
7. Explain the antigenic property of *Klebsiella*.
8. Outline the Laboratory diagnosis of *Klebsiella*.
9. Comment on the biochemical property of *Vibrio*.
10. Discuss the cultural characteristics of *Vibrio*.
11. Discuss the antigenic property of *Vibrio*.
12. Write about Laboratory diagnosis of *Vibrio*?



## KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: I M. Sc MB  
COURSE CODE: 17MBP202

COURSE NAME: MEDICAL BACTERIOLOGY  
UNIT: IV  
BATCH-2017-2019

13. Discuss the cultural characteristics of *Proteus*.
14. Discuss the cultural characteristics of *Salmonella*
15. Discuss the antigenic property of *Proteus*.
16. Explain the antigenic property of *Salmonella*.
17. Outline the Laboratory diagnosis of *Salmonella*.
18. Comment on the biochemical property of *Shigella*.
19. Discuss the cultural characteristics of *Shigella*.
20. Discuss the antigenic property of *Shigella*.
21. Write about Laboratory diagnosis of *Shigella*?
22. Discuss the cultural characteristics of *Treponema*.
23. Explain the antigenic property of *Treponema*.
24. Outline the Laboratory diagnosis of *Treponema*.
25. Write about the morphology of *Neisseria*?
26. Comment on the biochemical property of *Neisseria*.
27. Discuss the cultural characteristics of *Neisseria*.
28. Discuss the antigenic property of *Neisseria*.
29. Write about Laboratory diagnosis of *Neisseria*?
30. Discuss the cultural characteristics of *Haemophilus*.
31. Comment on the biochemical property of *Haemophilus*
32. Explain the antigenic property of *Haemophilus*.
33. Outline the Laboratory diagnosis of *Haemophilus*

**KARPAGAM ACADEMY OF HIGHER EDUCATION**  
**M.Sc. DEGREE EXAMINATION, APRIL 2018**  
**SECOND SEMESTER**  
**MEDICAL BACTERIOLOGY [17MBP202]**

Unit IV Question	Opt 1	Opt 2	Opt 3	Opt 4
Vibrio cholerae shows _____ result for indole	negative	positive	neutral	no reaction
CLED stands for _____ agar .	cystine lact	crystalvio	citrate lact	cultural lactose
Strains of V.cholerae O1 is subdivided into Ina	V.cholerae	Hikojima	panama	Ogawa
Widal test is performed for the serological diag	V.cholerae	Salmonell	Klebsiella	Pseudomonas
E.coli is an _____ in humans	Pathogen	predator	Parasite	commensal
E.coli exhibits IMViC_____	.++--	--++	.+--	++++
The K antigen in E.coli is composed of _____	Protein	lipid		carbohydrate
_____ is known as travelers diarrhea	EPEC	ETEC	EHEC	EAEC
EHEC is also known as _____	EPEC	EAEC	VTEC	EXEC
SIDS is seen in case of _____	E.coli	Klebsiella	Proteus	Pseudomonas
Klebsiella is _____	Non motil	motile and	Non motil	motile and non
Klebsiella exhibits _____ colonies	Dry	mucoid	Pale	diffuse
K. pneumoniae is also known as _____	Jansen's b	Koch's ba	Friedlande	Escherich's bac
Klebsiella exhibits IMViC_____	++--	--++	+++	----
The tribe proteae are _____	Fermentor	. non ferm	Late ferme	early fermentor
The proteae is classified into _____ genera.	One	two	three	Four
Proteus exhibits _____ motility.	Swarming	no	Fish in str	Darting
The predominant aerobic bacterial flora of the l	Non sporin	non acid f	viruses	Gram negative
The clinical picture of dysentery is exhibited by	Mycobact	Pseudomo	Klebsiella	Shigella
Shigella is _____	Flagellate	sporing	capsulated	Non motile
The selective medium used for Shigella is _____	Deoxycho	EMB	MSA	Martin Thayer
The Shigella culture filtrates demonstrates _____	Hypersens	Lytic	Chemotox	Neurotoxicity
The minimum infective dose for outcome of Sh	10-50 bac	10-100 ba	100-1000	1-10 bacilli
Bacillary dysentery has an incubation period of _____	6 hours	1 day	1-7 days	more than 7 day
The main features of bacillary dysentery are _____	Rice water	presence c	Abdomina	Loose scanty fe
The infection with Salmonella is characterized _____	Malaise	gastric ulc	Septicemi	Enteric fever
Salmonella is known as _____ bacilli.	Eberth gaf	Shiga	Friedlande	Escherich
Salmonella typhi is the causative agent of _____	Typhoid f	paratypho	Enteric fe	Malaise
The incubation period of Salmonella typhi is _____	6 hours	1 day	1-7 days	7-14 days
The infective dose for Salmonella typhi is _____	1-10 bacil	100000 ba	10000000	10000 bacilli
Vibrio is _____ rods.	Helical	Elongated	Twisted	Curved
Vibrio cholerae was first isolated by _____	Pasteur	Koch	Paccini	Boyd
Vibrio is _____	Motile	Non motil	Slime	Capsulated.
Vibrio cholerae are _____ rods.	Gram posi	Non motil	Spore forr	curved, Cylindr
_____ Is used as transport medium f	Alcohol m	Acid	sea water	V R Medium
Vibrio colonies may be easily identified by _____	Biochemic	String test	Cultural c	Coombs test
Heiberg classified Vibrios into _____ groups ba	2	4	6	8
The route of infection with Vibrio is by _____	Oral	respiratory	Ingestion	inhalation
Pseudomonas is motile by _____ flagella.	polar	bipolar	peritricho	Atrichous
Vibrio is motile by _____ flagella.	Atrichous	peritricho	polar	Lopotrichous.
Glycocalyx is composed of _____	Protein	lipid	Polysacch	carbohydrate
Pseudomonas produces _____ pigme	Ruby	lucosin	Pyocynani	Verdin

Pyocyanin is a _____ colored pigment	Blue	green	. Red	yellow
Pyocyanin is soluble in _____	Acid	Base	chloroform	ether
Fluorescein is _____ colored pigment.	Greenish y	Green	red	blue
Pyorubin is _____ colored pigment	yellow	Green	red	blue
Pyomelanin is _____ colored pigment.	brown	red	Green	yellow
<i>Pseudomonas aeruginosa</i> produces _____	Pyocyanin	melanin	rubin	verdin
The term 'blue pus' is associated with _____	<i>Proteus</i>	<i>Pseudomo</i>	<i>E.coli</i>	<i>Vibrio</i>
_____ is used as selective media for Pseud	Citrimide	EMB	DCA	MSA
enteric fever is caused by _____	Salmonell	S. paraty	S. enterica	Proteus
EHEC strains are able to secrete _____	verotoxin	exotoxin	endotoxin	exfoliate toxin
_____ isolated influenza bacillus.	Andrews &	Koch	Boyd	Pasteur
The accessory factors required by H. influenza	X and Y	X and V	X and Z	Y and Z
_____ enzyme aids the invasion of Pseudo	pectinase	elastase	protease	amylase
_____ is the drug of choice for <i>Pseudom</i>	Chloramip	Bacitracin	ceftazidim	Streptomycin
selective media for <i>Pseudomonas aeruginosa</i> is	Mac conkey	blood agar	PLET	Dettol agar
. <i>T. pallidum</i> causes _____	Syphilis	typhoid	Tuberculo	pertusis
<i>T. pallidum</i> are highly sensitive to _____	Acid	Antiseptic	drying	antibiotic
<i>Pseudomonas</i> mainly causes _____	Primary in	secondary	re- infectio	nosocomial infe
<b>Unit V</b>				
The common post operator consequence in hosp	Fever	gangrene	cold	sore
Semelweis was able to control _____ in h	puerperal	meningitis	cholera	diarrhoea
Lister overcome surgical infection by spraying	acid	base	charcoal	phenol
The concept of asepsis _____ the incidence	reduce	elevate	. increase	improve
The incidence of hospital infection has been rep	10-20%	12-20%	2-12%	10-15%
In hospital environment the normal flora is rep	Drug resis	common	Nosocomi	saprophyte
Hospital acquired infection is also called as	Nominal	Neutral	Normal	Nosocomial
Hospital acquired infection are typically	Exogenous	Endogeno	Epigenous	Eugenous
_____ is diagnostic intervention in the	Primary in	re infectio	post infect	Intragenic infec
The opportunity of a microorganism to infect p	Diet	immune	Invasive	Infection
The hospital environment is heavily laden with	Commens	Contamin	Pathogen	Normal flora
The blister caused in bed return patient is	Bed sore	Bedbug	Bedding	Bed wet
The slightest lapse in asepsis in hospital leads	Invention	Infection	Interaction	Innovatoin
_____ is the important cause of hospital in	E.coli	Treponem	HIV	Streptococcus p
Staphylococcus of drug resistant belong to phag	80/81	60/61	10/10/	44/10
The drug resistance is _____ m	Phage	Plasmid	Phasmid	cosmid
_____ can grow in disinfectan	E.coli	Klebsiella	Pseudomo	Proteus
_____ spores can survive in cotton fo	Tetanus	E.coli	Klebsiella	Bacillus
HIV is transmitted through _____ prod	Sputum	Urine	Blood	Stool
Viral infection are transmitted through	Pus	Blood	CSF	Swab
_____ the pathogen causes oral thrush.	Candida	E.coli	Klebsiella	Cryptococcus
Stitch abscesses is _____ infection.	Brain	Wound	. CSF	Pus
Streptococcus wound infection manifest within	Month	Year	Week	Day
Clostridial wound infection manifest within a	Month	Year	Week	Day
<i>Pseudomonas</i> cause infection in _____	Burns	Wound	Brain	Blood
Neonatal tetanus have occurred due to the use o	Blood	Body	Umblical	Brain
Cathetrization cause _____ infection	UTI	RTI	CTI	systemic
About _____ of patient UTI common	10 percent	2percent	5percent	7percent
<i>E.coli</i> and <i>Proteus</i> cause _____ infection.	Mixed	single	. combined	complicated

[illegible]

[illegible]

Opt 5	Opt 6	Answer
		positive
electrolyte deficient		cystine lactose electrolyte deficient
		Ogawa
		<i>Salmonella</i>
		Parasite
		.++--
		Polysaccharide
		ETEC
		VTEC
		<i>E.coli</i>
capsulated		Non motile and capsulated
		muroid
acilli		Friedlander's bacilli
		--++
as		. non fermentors
		three
		Swarming
bacilli		Gram negative bacilli
		<i>Shigella</i>
		Non motile
		Deoxycholate citrate agar
		Neurotoxicity
		10-100 bacilli
days		1-7 days
feces		Loose scanty feces
		Enteric fever
		Eberth gaffky
		Typhoid fever
		7-14 days
		100000000 bacilli
		Curved
		Koch
		Motile
clinical.		curved, Cylindrical.
		V R Medium
		String test
		6
		Oral
		polar
		polar
		Polysaccharide
		Pyocyanin

		Blue
		chloroform , Water
		Greenish yellow
		red
		brown
		Pyocyanin
		<i>Pseudomonas</i>
		Citrimide agar
		Salmonella typhi
		verotoxin
		Andrews and Laidlaw
		X and V
		elastase
		Chloramiphenicol
		Dettol agar
		Syphilis
		drying
ection		nosocomial infection
		Fever
		puerperal sepsis
		phenol
		reduce
		2-12%
		Drug resistant
		Nosocomial
		Exogenous
tion		Iatrogenic infection
		immune
		Contaminants
		Bed sore
		Infection
pyogenes.		Streptococcus pyogenes.
		80/81
		Phage
		<i>Pseudomonas</i>
		Tetanus
		Blood
		Blood
		Candida
		Wound
		Day
		Day
		Burns
		Umbilical cord
		UTI
		2percent
		Mixed

[illegible]



[illegible]

**UNIT-V**  
**SYLLABUS**

Nosocomial infection – Urinary tract infection, Respiratory tract infection, Sexually transmitted disease – Immunoprophylaxis – Antimicrobial chemotherapy, antibiotics, second line drugs. Vaccines.

**Nosocomial infections:**

Nosocomial infections are infections acquired in hospitals and other healthcare facilities. To be classified as a nosocomial infection, the patient must have been admitted for reasons other than the infection. He or she must also have shown no signs of active or incubating infection.

These infections occur:

- up to 48 hours after hospital admission
- up to 3 days after discharge
- up to 30 days after an operation
- in a healthcare facility when a patient was admitted for reasons other than the

infection

In the United States, it has been estimated that 9.2 out of every 100 patients acquire a nosocomial infection

Nosocomial infections are caused by pathogens that easily spread through the body. Many hospital patients have compromised immune systems, so they are less able to fight off infections. In some cases, patients develop infections due to poor conditions at a hospital or a healthcare facility, or due to hospital staff not following proper procedures.

Some patients acquire nosocomial infections by interacting with other patients. Others encounter bacteria, fungi, parasites, or viruses in their hospital environment.

Symptoms of nosocomial infections vary by type. They include inflammation, discharge, fever, and abscesses. Patients may experience pain and irritation at the infection site, and many experience visible symptoms.

**1. Urinary tract infections**

## 2. Respiratory tract infections

### **Urinary tract infections:**

A urinary tract infection (UTI) is an infection that affects part of the urinary tract. When it affects the lower urinary tract it is known as a bladder infection (cystitis) and when it affects the upper urinary tract it is known as kidney infection (pyelonephritis). Symptoms from a lower urinary tract include pain with urination, frequent urination, and feeling the need to urinate despite having an empty bladder. Symptoms of a kidney infection include fever and flank pain usually in addition to the symptoms of a lower UTI. Rarely the urine may appear bloody. In the very old and the very young, symptoms may be vague or non-specific.

The most common cause of infection is *Escherichia coli*, though other bacteria or fungi may rarely be the cause. Risk factors include female anatomy, sexual intercourse, diabetes, obesity, and family history. Although sexual intercourse is a risk factor, UTIs are not classified as sexually transmitted infections (STIs). Kidney infection, if it occurs, usually follows a bladder infection but may also result from a blood-borne infection. Diagnosis in young healthy women can be based on symptoms alone. In those with vague symptoms, diagnosis can be difficult because bacteria may be present without there being an infection. In complicated cases or if treatment fails, a urine culture may be useful.

### **Respiratory tract infection:**

Respiratory tract infection refers to any of a number of infectious diseases involving the respiratory tract. An infection of this type is normally further classified as an upper respiratory tract infection (URI or URTI) or a lower respiratory tract infection (LRI or LRTI). Lower respiratory infections, such as pneumonia, tend to be far more serious conditions than upper respiratory infections, such as the common cold.

### **Upper respiratory tract infection**

Although some disagreement exists on the exact boundary between the upper and lower respiratory tracts, the upper respiratory tract is generally considered to be the airway above the glottis or vocal cords. This includes the nose, sinuses, pharynx, and larynx. Typical infections of the upper respiratory tract include tonsillitis, pharyngitis, laryngitis, sinusitis, otitis media,

certain types of influenza, and the common cold. Symptoms of URIs can include cough, sore throat, runny nose, nasal congestion, headache, low grade fever, facial pressure and sneezing.

### **Lower respiratory tract infection**

The lower respiratory tract consists of the trachea (wind pipe), bronchial tubes, the bronchioles, and the lungs.

Lower respiratory tract infections are generally more serious than upper respiratory infections. LRIs are the leading cause of death among all infectious diseases. The two most common LRIs are bronchitis and pneumonia. Influenza affects both the upper and lower respiratory tracts, but more dangerous strains such as the highly pernicious H5N1 tend to bind to receptors deep in the lungs.

### **Immunoprophylaxis**

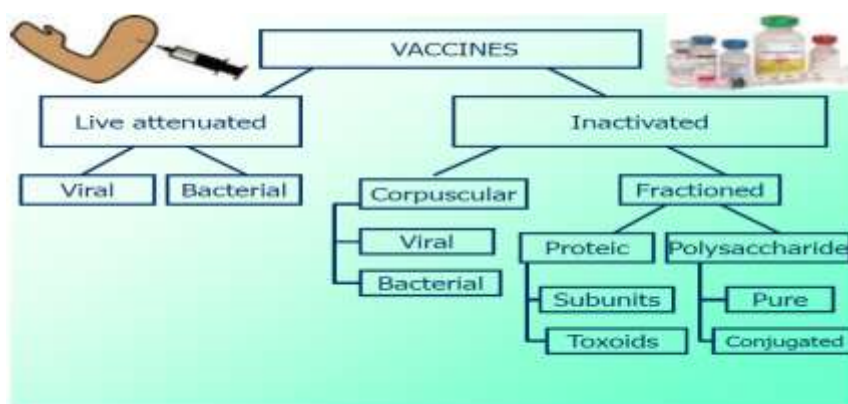
Immunoprophylaxis is an antiepidemic measure (of public health) taken in order to prevent the spreading of infectious diseases via immunization of the susceptible groups of the population.

### **Main targets**

- Reducing the incidence (VHB, pertussis, mumps, rubella)
- Liquidation of the morbidity (eliminating the disease from certain territories –diphtheria, polio, measles)
- Eradication of the disease (smallpox)

### **Discovery of Vaccination (Edward Jenner, 1796)**

- Edward Jenner (1749-1823) was a country doctor in Gloucestershire county in the West of England. He observed that people who get cowpox often develop less severe disease and survive smallpox outbreaks.
- Jenner inoculated a young boy (James Phipps) with material from hand sores of a milkmaid Sarah Nelmes. Six weeks later, after the boy recovered from cowpox, he was re-inoculated with the smallpox virus. – The boy survived ...
- The term "Vaccination" was introduced by Jenner (from the Latin *Vacca*, and *Vaccinia* virus) and later adopted for immunization against any disease (Pasteur).



## Immunization

### Types of Immunizations

1. **Active** – exposure to antigen with the host generating protective immunity.

- Objective: provide long lasting immunity against future exposures

2. **Passive** – administration of humoral and/or cellular factors that provide immunity for the host.

- Objective: provide temporary immediate protection against an imminent or ongoing exposure/threat
- “Herd” immunity in preventing spread of infection
- occurs when the vaccination of a significant portion of a population (or “herd”) provides a measure of protection for individuals who have not developed immunity.

### Active Immunization

2 Historical active vaccine approaches:

- **Attenuated** pathogen – ex. Rabies vaccine
- **Killed** pathogens – ex. Anthrax vaccine

### Age and Timing of Immunizations

**Children** under 2 yr are limited in producing antibodies to bacterial capsular polysaccharides.

- Limited response to T-independent antigens
- Can be overcome partially by chemical link to carrier protein
- Can assist maturation of response using multiple vaccinations

Recommended Immunization Schedule for persons age 0-18 years

Vaccine	Birth	1 mo	2 mo	4 mo	6 mo	9 mo	12 mo	15 mo	18 mo	19-23 mo	2-3 yrs	4-6 yrs	7-10 yrs	11-12 yrs	13-15 yrs	16-18 yrs
Hepatitis B <sup>1</sup> (HepB)	1st dose	2nd dose					3rd dose									
Rotavirus <sup>2</sup> (RV) RV1 (2-dose series); RV5 (3-dose series)			1st dose	2nd dose	See footnote 2											
Diphtheria, tetanus & acellular pertussis <sup>3</sup> (DTaP; <7 yrs)			1st dose	2nd dose	3rd dose			4th dose				5th dose				
Tetanus, diphtheria & acellular pertussis <sup>4</sup> (Tdap; ≥7 yrs)														(Tdap)		
Haemophilus influenzae type b <sup>5</sup> (Hib)			1st dose	2nd dose	See footnote 5		3rd or 4th dose (see footnote 5)									
Pneumococcal conjugate (PCV13)			1st dose	2nd dose	3rd dose		4th dose									
Pneumococcal polysaccharide (PPSV23)																
Poliovirus <sup>7</sup> (IPV)			1st dose	2nd dose			3rd dose					4th dose				
Influenza <sup>8</sup> (IV; LAIV) 2 doses for some; see footnote 8							Annual vaccination (IV only)				Annual vaccination (IV or LAIV)					
Measles, mumps, rubella <sup>9</sup> (MMR)							1st dose					2nd dose				
Varicella <sup>10</sup> (VAR)							1st dose					2nd dose				
Hepatitis A <sup>11</sup> (HepA)							2-dose series, see footnote 11									
Human Papillomavirus <sup>12</sup> (HPV) (HPV2: females only; HPV4: males and females)														(3-dose series)		
Meningococcal <sup>13</sup> (HibMenCY: ≥6 wks; MCIV4-D ≥9 mos; MCIV4-CRM: ≥2 yrs)							See footnote 13							1st dose		Booster

Range of recommended ages for all children
Range of recommended ages for catch-up immunization
Range of recommended ages for certain high-risk groups
Range of recommended ages during which catch-up is encouraged and for certain high-risk groups
Not routinely recommended

## Vaccines in Selected Populations: Medical Indications

**Figure 2. Vaccines that might be indicated for adults based on medical and other indications<sup>1</sup>**

Figure 2. Vaccines that might be indicated for adults based on medical and other indications											
VACCINE ▼	INDICATION ►	Pregnancy	Immuno-compromising conditions (excluding human immunodeficiency virus [HIV]) <sup>1,2,3,4,5,6</sup>	HIV infection CD4+ T lymphocyte count <sup>4,5,7,8,9</sup>	Men who have sex with men (MSM)	Kidney failure, end-stage renal disease, receipt of hemodialysis	Heart disease, chronic lung disease, chronic alcoholism	Asplenia (including elective splenectomy and persistent complement component deficiencies) <sup>1,10</sup>	Chronic liver disease	Diabetes	Healthcare personnel
Influenza <sup>11</sup>			1 dose IIV annually	< 200 cells/μL	≥ 200 cells/μL	1 dose IIV or LAIV annually		1 dose IIV annually			1 dose IIV or LAIV annually
Tetanus, diphtheria, pertussis (Td/Tdap) <sup>12</sup>		1 dose Tdap each pregnancy	Substitute 1-time dose of Tdap for Td booster; then boost with Td every 10 yrs								
Varicella <sup>13</sup>		Contraindicated						2 doses			
Human papillomavirus (HPV) Female <sup>14</sup>			3 doses through age 26 yrs					3 doses through age 26 yrs			
Human papillomavirus (HPV) Male <sup>15</sup>			3 doses through age 26 yrs					3 doses through age 21 yrs			
Zoster <sup>16</sup>		Contraindicated						1 dose			
Measles, mumps, rubella (MMR) <sup>17</sup>		Contraindicated						1 or 2 doses			
Pneumococcal 13-valent conjugate (PCV13) <sup>18</sup>								1 dose			
Pneumococcal polysaccharide (PPSV23) <sup>19,20</sup>								1 or 2 doses			
Meningococcal <sup>21,22</sup>								1 or more doses			
Hepatitis A <sup>23,24</sup>								2 doses			
Hepatitis B <sup>25,26</sup>								3 doses			
Haemophilus influenzae type b (Hib) <sup>27</sup>			per RBC recipients only					1 or 3 doses			

<sup>1</sup> Covered by the Vaccine Injury Compensation Program

For all persons in this category who meet the age requirements and who lack documentation of vaccination or have no evidence of previous infection, either vaccine recommended regardless of prior episode of disease

Recommended if some other risk factor is present (e.g., on the basis of medical condition, lifestyle, or other indications)

No recommendation

<sup>1</sup>Covered by the Vaccine Access Compensation Program. For all persons in this category who meet the age requirements and who lack documentation of vaccination or have no evidence of previous infection, zoster vaccine recommended regardless of prior episode of zoster
Recommended if some other risk factor is present (e.g., on the basis of medical, occupational, lifestyle, or other indications)
No recommendation

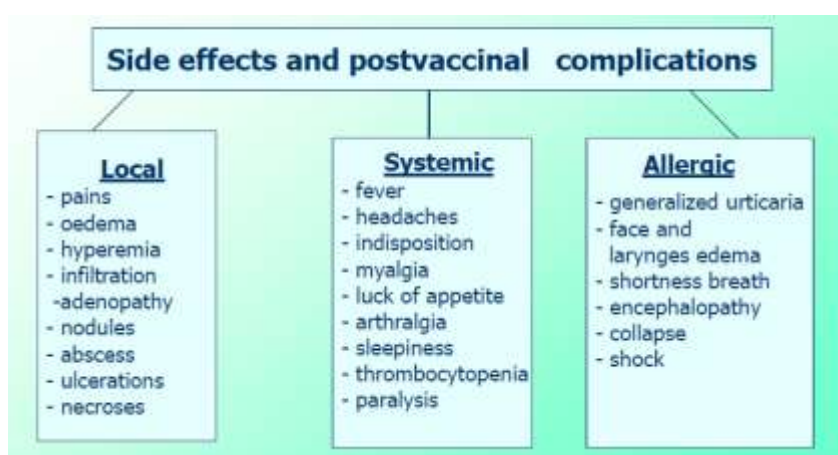
**General characteristic of the vaccines used for the immunoprophylaxis of infectious diseases included in the schedule**

- Viral hepatitis B – inactivated vaccine, proteic fractioned (HBsAg), plasmatic, biotechnologic
- Tuberculosis – live attenuated vaccine, BCG
- Diphtheria, Tetanus Pertussis – associated vaccine DTP, DTPa, DT, Td

- *Polio – live attenuated vaccine (OPV), Corpuscular inactivated vaccine (IPV)*
- *Measles, Mumps, Rubella – live attenuated vaccine (MMR)*
- *Haemophilus influenza type b (Hib) – inactivated vaccine, fractioned polysaccharide*

### **The role of immunoprophylaxis**

- Immunoprophylaxis of over 30 infectious diseases:  
smallpox, diphtheria, tetanus, pertussis, polio, measles, mumps, chickenpox, Haemophilus influenzae type b infection, VHA, VHB, TB, meningococcal infection, pneumococcal infection, influenza, typhoid fever, cholera, rabies, tick encephalitis, anthrax, yellow fever, rotaviral infection, tularemia etc.
- Infectious diseases in the prevention of which immunoprophylaxis holds the main role are called vaccine preventable diseases.
- Immunoprophylaxis as an individual protection: rabies, yellow fever etc.



### **Measure of reducing the frequency of side effects and postvaccinal complications**

- selection of the persons for the vaccination
- observance of the immunization rules
- precocious registration and medical assistance
- evidence, epidemiological investigation and case analysis
- population information

### **Vaccines and Antibiotics**

**Antibiotics** and **vaccines** are both used to fight germs but they work in different ways. While vaccines are used to prevent disease, antibiotics are used to treat diseases that have already



occurred. In addition, antibiotics do not work on viruses or viral illnesses such as common cold or flu.

### **Definitions**

**Antibiotics** are compounds that are effective in treating infections caused by organisms such as bacteria, fungi and protozoa. Antibiotics are mostly small molecules, less than 2000 Daltons.

**Vaccines** are compounds that are used to provide immunity to a particular disease. Vaccines are usually dead or inactivated organism or compounds purified from them.

### **Differences in Sources**

**Antibiotics** can be derived from natural, semi-synthetic and synthetic sources and source of vaccines include live or inactivated microbes, toxins, antigens, etc.

**Vaccines** are usually derived from the very germs the vaccine is designed to protect against. A vaccine typically contains an agent that resembles a disease-causing microorganism, and is often made from weakened or killed forms of the microbe. The agent stimulates the body's immune system to recognize the agent as foreign, destroy it, and "remember" it, so that the immune system can more easily recognize and destroy any of these microorganisms that it later encounters.

### **History**

Even before the concept of germs and diseases was understood, people in Egypt, India and the natives in America used molds to treat certain infections. The first breakthrough in **antibiotics** came with the discovery of penicillin by Alexander Fleming in 1928. This was followed by the discovery of sulfa drugs, streptomycin, tetracycline, and many others antibiotics to combat different microbes and diseases.

The earliest reports of **vaccines** seem to have originated from India and China in the 17th century and recorded in Ayurvedic texts. The first description of a successful vaccination procedure came from Dr. Emmanuel Timoni in 1724, followed by Edward Jenner's independent description, half a century later, of a method for vaccinating humans against small pox. This technique was further developed by Louis Pasteur during the 19th century to produce vaccines against anthrax and rabies. Since then attempts have been made to develop more vaccines against many more diseases.



## **Different Types of Antibiotics and Vaccines**

### **Types of Antibiotics**

Classification according to effect on Bacteria

Antibiotics are mainly of two types, those that kill bacteria (bactericidal) and those that inhibit bacterial growth (Bacteriostatic). These compounds are classified according to their structure and mechanism of action, for instance antibiotics can target bacterial cell wall, cell membrane, or interferes with the bacterial enzymes or important processes such as protein synthesis.

### **Classification based on source**

Besides this classification, antibiotics are also grouped into natural, semi-synthetic and synthetic types depending on whether it is derived from living organisms, like aminoglycosides, modified compounds like beta-lactams — e.g., penicillin — or purely synthetic, such as sulfonamides, quinolones and oxazolidinones.

### **Classification based on bacteria spectrum**

Narrow spectrum antibiotics affect particular bacteria whereas large spectrum antibiotics affect a wide range of bacteria. In the recent years, antibiotics have been classified into three classes, cyclic lipopeptides, oxazolidinones and glycyclcyclines. The former two are targeted at gram-positive infections whereas the last one is a broad spectrum antibiotic, treating many different types of bacteria.

### **Types of Vaccines**

Vaccines are of different types-live and attenuated, inactivated subunit, toxoid, conjugate, DNA, recombinant vector vaccines and other experimental vaccines.

**Live, attenuated vaccines** are weakened microbes that help cause lifelong immunity by eliciting a strong immune response. A huge disadvantage of this type of vaccine is that because the virus is live, it can mutate and cause severe reactions in people with a weak immune system. Another limitation of this vaccine is that it has to be refrigerated to stay potent. Examples for this type include vaccines against chicken pox, measles and mumps.

**Inactivated vaccines** are dead microbes and safer than live vaccines, though these elicit a weaker immune response, and often have to be followed by booster shots. TheDTap and Tdap vaccines are inactivated vaccines.

**Subunit vaccines** include only subunits or antigens or epitopes (1 to 20) that can evoke an immune response. Example of this type includes vaccine against hepatitis C virus.

**Toxoid vaccines** are used in case of infections where organisms secrete harmful toxins in the body of the host. Vaccines with “detoxified” toxins are used in this type.

**Conjugate vaccines** are used for bacteria that possess a polysaccharide coating that is not immunogenic or recognized by the immune system. In these vaccines, an antigen is added to a polysaccharide coating to enable the body to produce an immune response against it.

**Recombinant vector vaccines** use the physiology of one organism and DNA of another to target complex infections.

**DNA vaccines** are developed by inserting the infective agent’s DNA into human or animal cell. The immune system is thus able to recognize and develop immunity against the organism’s proteins. Though, this is still at the experimental stage, the effect of these types of vaccines promises to last longer and can be easily stored.

Other experimental vaccines include Dendritic cell vaccines, and T-cell receptor peptide vaccines.

### **Administration of Vaccines vs. Antibiotics**

**Antibiotics** are usually given orally, intravenously or topically. The course may last from a minimum of 3-5 days or longer depending on the type and severity of the infection.

A large number of **vaccines** and their **booster shots** are usually scheduled before the age of two for children. In the United States, routine vaccinations for children include those against hepatitis A, B, polio, mumps, measles, rubella, diphtheria, pertussis, tetanus, chickenpox, rotavirus, influenza, meningococcal disease and pneumonia. This routine might differ in other countries and is continually being updated. Vaccinations for other infections such as shingles, HPV are also available.

### **Side effects**

Though **antibiotics** are not considered unsafe, these compounds may cause certain adverse reactions. These include, fever, nausea, diarrhoea and allergic reactions. Antibiotics may cause severe reactions when taken in combination with another drug or alcohol. Antibiotics also tend to kill the "good" bacteria, whose presence in the body — especially the gut — is important for health.

# KARPAGAM ACADEMY OF HIGHER EDUCATION

CLASS: I M.Sc MB  
COURSE CODE: 17MBP202

COURSE NAME: MEDICAL BACTERIOLOGY  
UNIT: V  
BATCH-2017-2019

## Vaccine safety

There have been many disputes, over the effectiveness, and ethical and safety aspects of using **vaccines** in the past. For example, a study published in June 2014 in the Canadian Medical Association Journal found that the combination measles–mumps–rubella–varicella (MMRV) vaccine doubles the risk of febrile seizures in toddlers when compared with administration of separate MMR and varicella vaccines (MMR+V).

Under the National Childhood Vaccine Injury Act (NCVIA), federal law requires that Vaccine Information Statements (VIS) be distributed to patients or their parents whenever certain vaccines are administered. The CDC maintains that vaccines now produced meet very high safety standards so that the overall benefit and protection vaccines offer against diseases far outweighs any adverse reactions it might have in some individuals.

## Comparison chart

Antibiotics versus Vaccines comparison chart		
	Antibiotics	Vaccines
<b>Definition</b>	Antibiotics are small molecules or compounds that are effective in treating infections caused by organisms such as bacteria, fungi and protozoa.	Vaccines are dead or inactivated organisms or compounds that are used to provide immunity to a particular infection or disease.
<b>Types</b>	Antibiotics are classified according to their structure and mechanism of action into 3 classes: cyclic lipopeptides, oxazolidinones & glycyclines. The first 2 are targeted at Gram positive infections and the last one is a broad spectrum antibiotic	Vaccines are of different types-live and attenuated (vaccines against chicken pox), inactivated (BCG vaccine), subunit (Hepatitis C), toxoid, conjugate, DNA , recombinant vector vaccines and other experimental vaccines.
<b>Side effects</b>	Some antibiotics may have side effects like diarrhea, nausea and allergic reactions.	Some vaccines may cause allergic reactions.
<b>Source</b>	Antibiotics can be derived from natural, semi-synthetic and synthetic sources.	Sources of vaccines include live or inactivated microbes, toxins, antigens, etc.

**Phage typing** is a method used for detecting single strains of bacteria. It is used to trace the source of outbreaks of infections. The viruses that infect bacteria are called bacteriophages ("phages" for short) and some of these can only infect a single strain of bacteria. These phages are used to identify different strains of bacteria within a single species.

A culture of the strain is grown in the agar and dried. A grid is drawn on the base of the petri dish to mark out different regions. Inoculation of each square of the grid is done by a different phage. The phage drops are allowed to dry and are incubated: The susceptible phage regions will show a circular clearing where the bacteria have been lysed, and this is used in differentiation.

**Bacteriocins** are proteinaceous toxins produced by bacteria to inhibit the growth of similar or closely related bacterial strain(s). They are similar to yeast and paramecium killing factors, and are structurally, functionally, and ecologically diverse. Applications of bacteriocins are being tested to assess their application as narrow-spectrum antibiotics.

Bacteriocins were first discovered by A. Gratia in 1925. He was involved in the process of searching for ways to kill bacteria, which also resulted in the development of antibiotics and the discovery of bacteriophage, all within a span of a few years. He called his first discovery a *colicine* because it killed *E. coli*.

**Possible Questions**

**Part B (Two marks)**

1. What is meant by Nosocomial?
2. Define pyrogen.
3. Write about type of UTI.
4. Define UTI.
5. Define RTI.
6. Define STD.
7. Define phage typing
8. Define bacteriocin typing.
9. Define vaccines.
10. Define antibiotics.

**Part C (Eight marks)**

1. What is generation of antibiotics?
2. Explain immunoprophylaxis.
3. Explain Nosocomial infection.
4. Comment on sexually transmitted disease.
5. Outline the symptoms of Respiratory tract infection.
6. Explain vaccination schedule.
7. What is antibiogram?
8. Write about the descending UTI?
9. Explain the ascending UTI.
10. Write about renal TB?

**KARPAGAM ACADEMY OF HIGHER EDUCATION**  
**M.Sc. DEGREE EXAMINATION, APRIL 2018**  
**SECOND SEMESTER**  
**MEDICAL BACTERIOLOGY [17MBP202]**

Unit V Question	Opt 1	Opt 2	Opt 3	Opt 4
The common post operator consequence in hospital	Fever	gangrene	cold	sore
Semelweis was able to control _____ in hospital	puerperal	meningitis	cholera	diarrhoea
Lister overcome surgical infection by spraying _____	acid	base	charcoal	phenol
The concept of asepsis _____ the incidence of infection	reduce	elevate	. increase	improve
The incidence of hospital infection has been reported as _____	10-20%	12-20%	2-12%	10-15%
In hospital environment the normal flora is represented by _____	Drug resis	common	Nosocomi	saprophyte
Hospital acquired infection is also called as _____	Nominal	Neutral	Normal	Nosocomial
Hospital acquired infection are typically _____	Exogenous	Endogenous	Epigenous	Eugenous
_____ is diagnostic intervention in the hospital	Primary in	re infection	post infect	Iatrogenic infec
The opportunity of a microorganism to infect patient is _____	Diet	immune	Invasive	Infection
The hospital environment is heavily laden with _____	Commens	Contamin	Pathogen	Normal flora
The blister caused in bed return patient is _____	Bed sore	Bedbug	Bedding	Bed wet
The slightest lapse in asepsis in hospital leads to _____	Invention	Infection	Interaction	Innovatoin
_____ is the important cause of hospital infection	E.coli	Treponem	HIV	Streptococcus p
Staphylococcus of drug resistant belong to phage _____	80/81	60/61	10/10/	44/10
The drug resistance is _____ mediated	Phage	Plasmid	Phasmid	cosmid
_____ can grow in disinfectant	E.coli	Klebsiella	Pseudomo	Proteus
_____ spores can survive in cotton for _____	Tetanus	E.coli	Klebsiella	Bacillus
HIV is transmitted through _____ product	Sputum	Urine	Blood	Stool
Viral infection are transmitted through _____	Pus	Blood	CSF	Swab
_____ the pathogen causes oral thrush.	Candida	E.coli	Klebsiella	Cryptococcus
Stitch abscesses is _____ infection.	Brain	Wound	. CSF	Pus
Streptococcus wound infection manifest within _____	Month	Year	Week	Day
Clostridial wound infection manifest within a _____	Month	Year	Week	Day
Pseudomonas cause infection in _____	Burns	Wound	Brain	Blood
Neonatal tetanus have occurred due to the use of _____	Blood	Body	Umblical	Brain
Cathetrization cause _____ infection	UTI	RTI	CTI	systemic
About _____ of patient UTI common	10 percent	2percent	5percent	7percent
E.coli and Proteus cause _____ infection.	Mixed	single	. combined	complicated
_____ catheter are used in proper closed _____	French	Glass	Indwelling	Rubber
Pulmonary ventilation may lead to nosocomial _____	Pneumoni	. Bleeding	Abscesses	Fever
Multiplication of bacteria in blood called _____	Bacteria	Bacteremi	Viremia	Septicemia
Multiplication of virus in blood called _____	Bacteria	Bacteremi	Viremia	Septicemia
viral infection are transmitted through _____	. Fungemi	Bacteremi	Viremia	Septicemia
The liberation of toxin in blood is called _____	Fungemia	Bacteremi	Viremia	Toximia
Pus filled cavity called as _____	Abscesses	Lesion	Necrosis	Fever
Programmed cell death is called as _____	Abscesses	. Lesion	Necrosis	Fever
Stool sample must be transported within _____	1 hour	2 hours	3 hours	4 hours
Fever inducing agent is called as _____	Pyrogen	Pyogen	Phelm	Parotid
Phlebitis sets in with consequent _____	Bacteria	Bacteremi	Viremia	Septicemia
Staphylococcus epidermidis bacteremia is seen _____	Skin	Catheter	Heart valv	Inhaler
Many hospital infection occur as _____	Epidemic	Endemic	Pandemic	Randamic

[illegible]

[illegible]



[illegible]

[illegible]

[illegible]

Opt 5	Opt 6	Answer
		Fever
		puerperal sepsis
		phenol
		reduce
		2-12%
		Drug resistant
		Nosocomial
		Exogenous
tion		Iatrogenic infection
		immune
		Contaminants
		Bed sore
		Infection
pyogenes.		Streptococcus pyogenes.
		80/81
		Phage
		Pseudomonas
		Tetanus
		Blood
		Blood
		Candida
		Wound
		Day
		Day
		Burns
		Umbilical cord
		UTI
		2percent
		Mixed
		Indwelling
		Pneumonia
		Bacteremia
		Viremia
		Viremia
		Toxemia
		Abscesses
		Necrosis
		2 hours
		Pyrogen
		Bacteremia
		Skin
		Endemic

[illegible]

[illegible]

[illegible]

[illegible]



[illegible]