**MICROBES**

About 2/3 organisms on Earth are so small that they can only be seen using a microscope. These organisms are known as ‘microorganisms’ or ‘microbes’ whose millions of species inhabit the Earth. A human body consists of more microbes than cells and they form the ‘human microbiome’. The microbes are like tiny chemical processors that keep the life cycles of the planet turning. They also play key roles in nutrient cycling, biodegradation, climate change, food spoilage, cause and control of diseases, preparation of medicines, making of biofuels and in food industries.

### Bacteria

**All around us**

Bacteria, single-celled prokaryotes, were the first organisms to appear on Earth. They are considered as invisible backbone of all life systems. They can be found in soil, water, hot springs, ice & glaciers, radioactive waste, deep in the Earth’s crust, plants, animals and humans - from high up in the stratosphere to deep down in oceans. Average size (diameter) of most bacteria is between 0.2 to 2.0 μm & they can be easily viewed with compound microscope.

### Virus

**Harmful, but also useful**

Everyday, we breathe in thousands of viruses. These viruses are useful and harmless while only a few make us sick. They help the immune system to identify pathogens. They are the smallest of all the microbes. Most viruses vary in diameter from 20 to 400 nm. They can be viewed with an electron microscope. Viruses exist both as living and non-living. They can replicate only upon finding a host cell.

### Fungi

**Not just mushrooms**

Fungi can be single-celled or have a complex cellular organization e.g. mushrooms. They are eukaryotes and mainly live in soil or on plant material. Fungal cell consists of membrane-bound nucleus with genetic material, cytoplasmic organelles and lack chloroplast. Many fungi have bright colours due to presence of red, green or black coloured pigments. Diameter of most fungi ranges from 2 to 10 μm. They can be observed under a compound microscope.

### Protozoa

**Universal microbes**

Protozoa are single-celled eukaryotes and exist as free-living organisms or as parasites e.g. *Plasmodium falciparum*. They live in moist habitats like fresh water, marine environment and soil. Their size ranges from 10 to 100 μm in diameter e.g. Amoeba which can change its shape & Paramoecium with its fixed shape and complex structure. They can be viewed under compound & simple microscope.

### Algae

**Photosynthetic microbes**

In humid climatic conditions, green velvety layer is seen on walls and rocks which is called as algae. These eukaryotes can exist as single cells or in clusters. Algae are mostly found in fresh and sea water, soil, leaves, bark or land animals. Algal cells contain chloroplast & are found in different colours like green, brown, red or yellow. Algal cells range from 0.5-5 μm in diameter to 85 μm in length. They can be viewed under compound microscope.

### Archaea

**Life in extremes**

Archaea are single-celled, slow growing prokaryotes and similar to bacteria. They can be seen as filaments or in clusters with spherical, rod, spiral, lobed or irregular shapes. They are known for living in extreme environments like super-hot and freezing climates; acidic, alkaline, salty conditions; deep in oceans & places with high gamma or UV radiation. They are usually less than 1 μm long and can be viewed with an electron microscope.

### Prions

**Abnormal Proteins**

Prions are not cells but misfolded proteins which can replicate on their own. They cause many neuro-degenerative diseases like Mad Cow disease in livestock and CJD in humans. These proteins do not multiply in the host organism that they infect. Instead, they affect the brain structure by making the normal protein folding into abnormal prion form. They can be viewed under electron microscope.

### Spread of microbes

- **Droplet contact**
  - Coughing or sneezing on another person.
- **Direct physical contact**
  - Touching an infected person.
  - Touching contaminated soil or water.
- **Airborne transmission**
  - Through microbes present in air.
- **Fecal oral transmission**
  - Intake of contaminated food or water.
- **Contamination**
  - By unclean intravenous syringe, organ transplant or blood transfusion.

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**Department of Science & Technology**
- Government of India
**Virus**

Virus contains nucleic acid, either DNA or RNA (but not both), and a protein coat. Virus, in this form is non-infective and known as a ‘virus particle’. When a virus is in its infective form, it is known as a ‘virion’.

Virus can be considered neither as living nor nonliving. It cannot replicate on its own but can replicate if it finds suitable living organism.

The capacity of any microorganism (bacteria, fungi or virus) to cause damage in a host is referred to as ‘pathogenicity’. The degree of damage caused by the microorganism is known as ‘virulence’.

Viruses mostly have rod or filament shape. Some viruses are as long as 1 μm in diameter. Viruses exist only to make more viruses.

**Structure of Enveloped Virus**

- Envelope projections
- Lipid layer
- Viral DNA or RNA
- Protein capsid / Nucleocapsid
- Viral tegument

**Structure of Non-enveloped Virus**

- Viral RNA or DNA
- Bacteriophage
- Bacterial cell
- Viral genome injected into cell

**Stages of virus infecting a cell (Lytic cycle)**

1. A virus particle gets attached to the cell (host cell).
2. The virus particle enters into the host cell by breaking the cell's outer membrane.
3. Virion releases DNA or RNA to use enzymes & genetic material of host cell for its replication.
4. New virus particles are formed.
5. The new particles break free from host cell. In this process, either the host cell gets killed or continuously makes new virus particles.

**Phagocytosis**

Phagocytosis is a process by which phagocytes e.g., amoeba or WBCs, ingest or engulf other cells or particles. Phagocytic name comes from the Greek word 'phagein' means 'to eat' and 'cytosis' means cell.

The classification of virus is based on the organism it infects. If a virus infects a bacterium, it is called as ‘Bacteriophage’ or ‘phage’. Bacteriophage actually means ‘bacteria eater’. Depending upon the host cell, there is ‘plant virus’, ‘animal virus’ and ‘human virus’.

**An outbreak**

An outbreak is a sudden increase in number of cases of a disease, e.g. Nipah virus, Chikungunya.

An epidemic is a disease that is ‘affecting many persons at the same time, and spreading from person to person in a locality where the disease is not permanently prevalent’. It occurs at the level of a region or community, e.g. Plague, Smallpox.

A pandemic is an epidemic that has spread over a large area, that is, it is ‘prevalent throughout an entire country, continent, or the whole world’. It is a world widespread of a new disease, e.g. H1N1, COVID-19

The word ‘demic’ comes from Greek word ‘demos’ meaning ‘people of district’.

**Did you know?**

Certain viruses are beneficial to us!

Viral infections at a young age helps immune system to develop properly and provide protection against future infections. e.g., presence of harmless virus in saliva eliminates harmful bacteria, if any.
COVID-19

Coronaviruses (family Coronaviridae) are a group of RNA viruses that cause diseases in mammals and birds. COVID-19 is a new infectious disease (CO stands for Corona, VI for Virus, and D for Disease and 19 for the year 2019). COVID-19 disease was called as novel (meaning ‘new’) coronavirus as these type of coronaviruses have not been seen in humans before.

According to WHO, the official names of disease and virus are both different. The disease is called Coronavirus Disease (COVID-19) while virus is called Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). Coronavirus structure has lipid outer membrane layer with club-shaped glycoprotein spikes. The envelope gives the virus a crown-like or coronal appearance, hence the name.

Transmission

Respiratory infections can be transmitted through droplets of different sizes. When the droplet particles are bigger than 5-10 μm in diameter they are referred to as respiratory droplets. When they are smaller than 5 μm in diameter, they are referred to as droplet nuclei. According to current evidence, COVID-19 virus is primarily transmitted between people through respiratory droplets and contact routes.

In a study, it was found that people touch their face 23 times in an hour without even realizing it.

Distance <6 feet
- Coughs, sneezes, exhales, talks
- Human population
- Infected individual
- Droplets fall on surface of objects
- Upon touching the surface, droplets reach on hand
- The infection starts spreading in the body & person becomes infected
- If hand is not cleaned properly infectious droplets may enter cells of respiratory tract through eyes, nose or mouth.

Families
- They are inanimate objects that aid transmission of an infectious agent from person to person e.g. dust particle, ATM machine, mobile phone etc.
- Depending upon the type of surface, temperature or humidity in environment, coronaviruses may persist on surfaces for a few hours to several days.

Spread of an infectious disease

The spread of a disease depends upon its transmission among individuals. Transmission occurs through two major ways:

Symptomatic transmission refers to transmission of a disease from individuals who experience signs & symptoms.

Asymptomatic transmission refers to transmission of a disease from individuals who do not show any signs & symptoms. These individuals are called as ‘carriers’ or ‘silent spreaders’, as they unknowingly play a major role in spreading the disease.

A typical pathway of spread of an infectious disease amongst human beings

Mutations: Like spelling error in a word

Mutations are essential to evolution & occur due to various environmental factors. Every organism to survive in the fittest form undergoes mutation. If the mutation has a positive effect on an organism then it is called as adaptation.

Parental strain
- RNA
- Mutation
- Variant
- Change in RNA, spike protein & virus behaviour
- New strain
- Every cell consists either DNA or RNA or both. Mutations are permanent alterations (change) to any gene sequence.
**Preventive Measures**

Microbes are present on all surfaces of the hand, specially under the nails. Many diseases, infections and conditions are spread by not washing hands properly.

### Soap

Washing hands thoroughly with soap & water for 60 seconds removes microorganisms, dirt & grease. This includes washing the back of hands, in between fingers and under the nails.

The outer membrane of virus (or any microorganism) breaks due polar and non-polar ends of soap molecule.

### Sanitizers

Alcohol-based hand sanitizers contain 60-95% ethyl alcohol, isopropyl alcohol or n-propanol or a combination of them. Mostly all gel-based hand sanitizers contain chlorhexidine or benzalkonium chloride with glycerol and hydrogen peroxide.

How do hand sanitizers protect against infections?

Washing hands with alcohol-based sanitizer for more than 30 seconds kills most microorganisms by denaturing proteins and dissolving lipid membranes (except for virus which lacks envelope). Gel-based sanitizers lack this effectiveness. Alcohol-based sanitizers should be used by children under adult supervision only.

Sanitizers are not effective in presence of dirt, grease or harmful chemicals like pesticides & heavy metals on the hands.

### Bleach

Bleach oxidizes & destroys virus proteins and genetic material. It works effectively when used with minimum of 0.1% sodium hypochlorite (NaClO) concentration is used and left on surface for 10 minutes.

### Hydrogen Peroxide

Hydrogen peroxide with minimum 0.5% concentration of peroxide, oxidizes & destroys virus proteins and genetic material. It has been proven effective when left on a surface for 10 minutes.

### PPE

PPE is specialized clothing worn as a control measure for infection prevention.

- **Head cover**
  - Protect the hair and scalp from airborne contaminates.

- **Face shield and goggles**
  - Protect mucous membranes of eyes, nose and mouth from infection.

- **Masks**
  - Protect the crucial airway passage. It is advisable to not reuse single-use masks & follow standard protocols of wearing & removing the mask.

- **Gloves**
  - Nitrile (synthetic) or latex (natural rubber) gloves helps to stay safe from surface contamination. Comparatively, nitrile gloves are less allergic and more resistant against chemicals.

- **Coverall/gown**
  - A fluid- and air-resistant woven plastic fibre provides 360° protection to the whole body from infection.

- **Shoe covers**
  - They are made up of impermeable fabric to facilitate protection and decontamination.

- **Triple layer medical mask/surgical mask**
  - A fluid-resistant disposable mask prevents wearer from spreading the infection while coughing / sneezing / talking.

- **N-95 Respirator**
  - More efficient than surgical mask, has high filtration efficiency & can screen out 95% of small airborne particles (min. size of 0.3µ).

- **Non-medical cloth mask (3 layered or more)**
  - It is advisable to use tightly woven material like 100% cotton for better efficiency.

Why wearing valve mask is not advisable?

Valve mask filters air only during inhalation while during exhalation the valve opens out and allows unfiltered air to come out. So, chances of an asymptomatic carrier or person with coronavirus infecting others become very high.

### HAZMAT suit

A HAZMAT suit is short for HAZardous MATerial suit, designed to protect against harmful biological, chemical agents. This whole-body suit is a form of PPE. They are classified into 4 levels - A, B, C & D; with A giving highest level of protection.
SYMPTOMS & EARLY DETECTION

The onset of coronavirus is sudden. For symptomatic and asymptomatic individuals, incubation period ranges between 1-14 days and may even go up to 24 days. Mild cases take about 2 weeks to recover but for severe cases, it may take up to 6 weeks. Since this virus is mutating, continuous research is going on to study the changes in transmissibility, virulence and symptoms.

Mucohylineasis, a rare fungal infection is sometimes observed in patients with low immunity & co-morbid conditions. This infection starts in nasal area, throat, then spreads into the entire body.

Common Symptoms of SARS-CoV-2
- Conjunctivitis
- Fever
- Headache
- Shortness of breath
- Loss of smell & taste
- Dry cough
- Aches & pain
- Fatigue

GI tract complications

Symptoms vary from person to person in occurrence and severity

Detection
The most common symptom of any type of infection is fever. It is caused as pyrogens (fever inducing agents) are released in the body. These pyrogens trigger the hypothalamus (thermostat of our body) which increases the body temperature. Fever can be detected by thermal imaging systems or non-contact infrared thermometer (NCIT).

Thermal Imaging System
The system includes an infrared thermal camera and may have a temperature reference source. It measures the skin temperature of the person without being physically close.

Non-Contact Infrared Thermometers (NCITs)
NCITs use reduces the risk of spreading disease. Normal temperature of human body is 98.6°F. Some studies have shown that normal body temperature can range from 97°F to 99°F. It measures mid to long wave infrared radiation and converts it into temperature.

It is advisable to hold the thermometer sensing area perpendicular to forehead & instruct the person to remain stationary during measurement.

Oximeter

An oximeter uses small beams of infrared light to measure the oxygen saturation (SpO2) of the blood and the pulse rate (PR) when placed on a fingertip. SpO2 gives information about the amount of oxygen carried in the blood in percentage. Pulse rate is the number of heart beats per minute. In normal conditions, SpO2 levels are between 95% to 100%. Lower levels are seen in individuals living at high altitudes or those having lung problem. It is advisable the consult the doctor immediately in case of any abnormal reading in oximeter.

Thermal images do not show
- Structural problems in body
- Details about diagnostic diseases
- This method is non-invasive & radiation free.
Immunity is defined as an organism’s ability to protect itself from an unknown antigen. It is usually acquired naturally, but can also be induced by vaccination.

**Antigen and Antibody**

- **Antigen** (Ag) - A particle, foreign to human body, whose presence in the body triggers immune response, produced by antibodies.
- **Antibody** (Ab) - Protective proteins produced naturally by the immune system in response to antigens.

**Herd Immunity**

Also known as community immunity, this form immunity occurs when large portion of population becomes immune to an infectious disease. Herd immunity tends to limit the spread of disease.

This level of immunity is achieved when a population is immune either through vaccination or immunity developed through previous infection.

**Have you heard of cytokine storm?**

Cytokines are proteins which as part of the immune system, regulate the body’s response to a disease and also act as messengers for immune system.

**Immunity Boosters**

- Some self-care measures during COVID-19 pandemic
  - Drink warm water throughout the day.
  - Daily practice of Yoga, Pranayama and meditation for at least 30 minutes as advised by Ministry of Ayush
  - Spices like Haldi (Turmeric), Jeera (Cumin), Dhania (Coriander) and Lahsun (Garlic) are recommended in cooking.

Due to delay in release of cytokines, cells secrete high levels of cytokines which cannot identify the difference between normal and virus infected cells. This phenomenon of release in abnormally high quantity of cytokine proteins is considered as Cytokine storm.
ANTIGEN DETECTION TESTS

Detection of COVID-19 antigen is based on molecular techniques like Reverse Transcription Polymerase Chain Reaction (RT-PCR) & Rapid Antigen Test. These scientific techniques involve the study of antigen or DNA / RNA isolated from a cell.

**DNA (Deoxyribonucleic Acid)**
It is a molecule that humans and most organisms use to store information in form of genetic code. It is formed from two strands that bind together forming a helix shape.

**RNA (Ribonucleic Acid)**
In humans, RNA’s main function is to convert information stored in DNA to proteins. Some viruses use RNA instead of DNA to store their genetic code, including the SARS-CoV-2.

**Viral Load**
It is the measure of total number of viral particles inside the individual. High viral load indicates that replication of virus in the cells is at higher rate.

**Transcription**
Transcription is the process where information in DNA is synthesized into RNA. While in reverse transcription, it is opposite.

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**RT-PCR Test**
1. A small piece of gauze /absorbent material attached to a stick (swab) is used for collecting samples.
2. Sample is treated with chemicals & enzymes that remove proteins, fats & other molecules, leaving RNA intact.
3. This purified RNA is mixture of a person’s genetic material & viral RNA (if present).
4. The enzyme Reverse Transcriptase converts the RNA into DNA.
5. DNA along with other chemicals and fluorescent dyes are added in PCR machine.
6. New identical copies of DNA are created. Dyes bind to DNA as it gets copied.

**Result**
The amount of light produced by fluorescent dye equals to amount of virus present.
High intensity of light (fluorescence) → more amount of virus

New identical copies of DNA created in PCR machine

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**Rapid Antigen Test**

**Nasopharyngeal/ oropharyngeal sterile swab collection**

**Result**
This test detects the coronavirus (antigen). The control line, regardless of positive or negative result will display colour change.

**Precautionary measures**
If sample is taken in early or late phase of infection, the results will be negative. Distribution of virus across respiratory tract varies from person to person. The virus may only be detectable in sputum or nasopharyngeal swab but not necessarily at both locations at the same time. Most COVID-19 Rapid Antigen Test kits are stored between 15°C to 30°C & out of direct sunlight. RT-PCR kits are generally stored at −20°C in a laboratory (temperature constant) freezer and protected from direct sunlight.
ANTIBODY DETECTION TESTS

The immune system of a person infected by SARS-CoV-2 will produce Immunoglobulin M (IgM) and Immunoglobulin G (IgG) antibodies to fight against it. The IgM antibodies are produced in 4-7 days while IgG antibodies are produced between 10-14 days. The antibody test detects the antibodies to the virus and not the virus. The molecular tests for detecting these antibodies are Enzyme Linked Immunoabsorbent Assay (ELISA) and Lateral Flow Antibody Immunoassay.

Antibody tests are critical for assessing the spread of the virus and the level of herd immunity in the population. These tests can also identify asymptomatic people who are ‘carriers’ or silent spreaders of the infection.

ELISA Antibody Test

1. This is one of the wells of ELISA plate. Antigen specific to SARS-CoV-2 (in red) is coated at the bottom of the well.
2. Patient’s blood or serum sample (which may contain antibodies to SARS-CoV-2) is added to the well.
3. If sample has antibodies to SARS-CoV-2, it will form Ag-Ab complex. Extra components are washed out.
4. Laboratory-produced antibodies and enzymes are added.
5. These antibodies attach to the Ag-Ab complex and form a second layer. Excess antibody is washed out.
6. Special chemicals are added which will react with the Ag-Ab complex to initiate colour change.
7. Colour change indicates +ve result → Ab present.

Result

A positive result indicates that sample has antibodies to SARS-CoV-2 virus. Colour change (positive result) can be viewed with unaided eyes & ELISA reader machine is used for quantification.

Lateral Flow Antibody Immunoassay

A drop of patient’s blood (from prick on middle or index finger) / plasma / serum can be used as sample. In each cassette/stick, there is a control antibody with colloidal gold marker. This test is also known as ‘Colloidal Gold Immunochromatography’. Control labels can be carbon or latex depending upon the type of test.

The sample & buffer moves along the membrane through capillary force. If antibodies IgG or IgM against SARS-CoV-2 are present in the sample they bind with gold plated antibody on conjugate pad.

In presence of SARS-CoV-2 IgG or IgM antibodies, an IgG-IgG / IgM-IgM complex will be formed, resulting in colour change on test lines (observed in form of pink line).

Result

This test detects antibodies IgG and IgM alone or both together. The control line, regardless of positive or negative result will display colour change.

Most SARS-CoV-2 Antibody test kits are stored between 2°C-30°C.

Limitations

ELISA test sometimes gives positive result for unrelated proteins. A positive test result must be confirmed by another method. The Immunoassay is for qualitative testing. For further studies, quantitative methods should be used. Negative results may be due to low concentration of antibodies, difference in temperature and humidity.

ELISA Antibody test kits are generally stored at a temperature between 2°C and 8°C.
VACCINES

A vaccine helps the body's immune system to recognize and fight pathogens like harmful virus or bacteria and keeps us safe from the diseases they cause. Vaccines have protected people against more than 25 life-threatening diseases. Different types of vaccines work in different ways to offer protection. The vaccines help to produce adaptive immune response and 'immunological memory' against the pathogen.

- **Monovalent vaccine** - Single strain of a single antigen (e.g. Measles)
- **Polyvalent vaccine** - Two or more strains of same antigen (e.g. OPV, Oral Polio Vaccine)
- **Combination vaccines** - Two or more strains of different antigen (e.g. MMR, Measles, Mumps, Rubella).

**Vaccination** - Process of introducing vaccine in an individual to produce immunity against specific disease.

**Immunization** - A process by which a person becomes protected against a disease through vaccination.

Components of a vaccine: Antigens, Stabilizers, Adjuvants, Antibiotics, Preservatives

**Potential COVID-19 vaccines**

- **Inactivated / weakened virus vaccines**
  - Virus does not cause disease but generates immune response.

- **mRNA vaccines**
  - Genetically modified RNA or DNA generate protein to trigger immune response.

- **Vector vaccines**
  - Virus, genetically engineered, produces coronavirus proteins to generate immune response.

- **Protein subunit vaccines**
  - Harmless fragments of proteins mimic COVID-19 virus to trigger immune response.

**Vaccine efficacy**

Natural infection or vaccination do not always provide lifelong immunity. Vaccination is scheduled when individuals are most susceptible to get vaccine-preventable disease. No vaccine is 100% effective, some people are not immune even after vaccination while for many the 'immunological memory' decreases over a period of time.

Vaccine storage depends upon its type. DTap or Conshield vaccines have to be stored between 2 to 8°C while chickenpox vaccines have to be stored between -50 to -8°C.

**Vaccine Effectiveness** is measured with regularly assessing and confirming the effectiveness of a vaccine on people with co-morbid conditions under real world conditions.

**Booster Dose**: An additional dose of a vaccine needed to increase the body's immunity to a particular disease at a time when the effective initial vaccine may start to wear off, e.g., Tetanus & diphtheria vaccine is recommended for adults every 10 years.

**Stages Of Vaccine Development**

**Exploratory and clinical stage**
- This stage is pre-clinical laboratory research which involves in vitro & in vivo analysis.
- **Identification of pathogen**
- **DNA/RNA isolation**
- **Amplification of DNA through PCR**
- **Recombinant DNA**

**Approval for clinical trial from CDSCO (Central Drugs Standard Control Organization), Govt. of India.**

**Phase I trial**
- The first trial to assess the effect of vaccine in group of 20-80 adult human volunteers.

**Phase II trial**
- If the first trial is successful, the second trial involves hundreds of individuals.

**Phase III trial**
- After successful completion of second trial, the vaccine is tested on thousands of individuals.
- After successful completion of phase III trial, the application is sent for getting license.
- All the research, data and results of vaccine development are presented for review at CDSCO.

**CDSCO**
- Once the vaccine is approved from the committee, CDSCO provides the license.
- The vaccine is then available for all individuals.

**Phase IV trial**
- These trials begin after the vaccine is released for immunization to these studies continuously check vaccine's safety, efficacy etc.
ANTIMICROBIALS

Antimicrobials are used for treatment when an individual gets infected by bacteria, virus, parasite or fungus. Most antimicrobials are easily available, cost effective and safe to use. But, the overuse and misuse of antimicrobials have resulted in microbes which are resistant to them leading to loss of their efficacy. There are four types of antimicrobials: antibiotics, antivirals, antiparasitics and antifungals.

**Antibiotics or Antibacterials**

Antibiotics can cure many types of bacterial infections. They either kill the bacteria or stop them from replicating. It is advisable to take antibiotics as prescribed by the doctor. Even after symptoms disappear, the course of antibiotic should be completed as it prevents the development of resistant bacteria. An antibiotic can cure many bacterial infections of wide range. But, they don’t work against viral infections like flu or common cold.

Bacteria are highly adaptable organisms and over use or misuse of antibiotics will make bacteria resistant to it. e.g. penicillin.

**Penicillin: An accidental discovery**

In 1928, Alexander Fleming noted that in his petri dish containing culture of Staphylococcus bacteria, there was growth of blue-green mold called Penicillium notatum. There was a clear ring surrounding the mould with no bacterial growth on it. This way, first antibiotic was discovered. After further research, penicillin antibiotic was made available to individuals in 1942.

**Drug and Medicine: Thin line of difference**

Drug is a substance that affects how the body works. It can include medicines or nicotine.

- Drugs can be harmful or helpful.
- Medicine is a drug used for treatment, diagnosis or prevention of a disease.

All medicines are drugs but not all drugs can be medicines.

**How does antibiotic resistance occur?**

- There are many types of bacteria in our body and very few are resistant to antibiotics.
- When antibiotics kill the harmful bacteria, they also kill some of the good bacteria which protect the body. The antibiotic-resistant bacteria remain unaffected.
- These antibiotic-resistant bacteria then grow and multiply.
- Some antibiotic-resistant bacteria transfer their resistance ability to other bacteria.

The last new class of antibiotics to be approved was daptomycin which was discovered in 1987.

**Antivirals**

Antiviral drugs are available in pills, liquid, powder or as intravenous liquid. These drugs are more difficult to develop as compared to antibiotics.

An antibiotic can treat many bacterial infections, an antiviral drug cannot do the same. An antiviral drug is specific to specific to viral infection. A few antiviral drugs available are for influenza, HIV, herpes, and hepatitis B and C.

Like bacteria, viruses also mutate over time and develop resistance to antiviral drugs.

**Antifungals**

Also known as an antymycotic medication or fungicide or fungistatic, they are used to treat and prevent mycosis or fungal infections such as athlete’s foot, ringworm, candidiasis, serious systemic infections such as cryptococcal meningitis etc.

**Antiparasitics**

Antiparasitics are used for treatment of parasitic diseases, such as those caused by helminths, amoeba, ectoparasites, parasitic fungi and protozoa and many more. Examples of parasitic infections are stomach & gut worms (threadworm, hookworm), skin mites (scabies), hair & body lice (head lice and crab lice), malaria (female anopheles mosquito).

**What are Superbugs?**

Microorganisms which becomes resistant to the drug that is used for their treatment are called superbugs. Certain bacteria and fungi are called superbugs because they infect humans, animals and crops more as compared to other microorganisms. The term ‘superbug’ was coined by the media. In scientific terminology it is referred to as ‘Multidrug-Resistant’ (MDR) infectious organism.