

PROFESSIONAL TRAINING- I REPORT

Submitted in partial fulfilment of the requirements for the award of bachelor of
technology degree in biomedical engineering

By

Nikkhilla Chowdary . S

(41240033)



DEPARTMENT OF BIOMEDICAL ENGINEERING

SCHOOL OF BIO AND CHEMICAL ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with grade "A++" by NAAC

JEPPIAR NAGAR, RAJIV GANDHI SALAI, CHENNAI -600 119

OCTOBER – 2023



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DEPARTMENT OF BIOMEDICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this professional training report is the bonafide work of Nikkhilla Chowdary . S (41240033) who has completed the training program in "SATHYABAMA RESEARCH PARK" under "CENTER FOR DRUG DISCOVERY AND DEVELOPMENT" as a part of professional development under our supervision from 20.09.2023 to 25.09.2023.


Internal guide


External guide


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Exploring Bioanalytical Tools and Techniques for Drug Discovery

CERTIFICATE

This is to certify that S. Nikkhilla Chowdary has attended the Training session on “**Exploring Bioanalytical Tools and Techniques for Drug Discovery**” from 20th to 25th September 2023 jointly organized by the Department of Biomedical Engineering and Centre for Drug Discovery and Development, Sathyabama Institute of Science and Technology.

Dr. Krupakar Parthasarathy
Convener

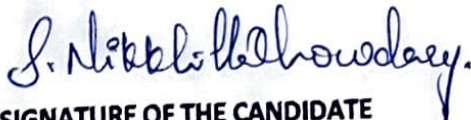
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Dr. M. Radhakrishnan
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DECLARATION

I Nikkhilla Chowdary . S hereby declare that the professional training report completed by me during my professional training at **Sathyabama Research Park** under the guidance of **Dr. A. Sabarivani , M.Tech., Ph. D.** and **Ms. Sindu Divakaran** is submitted in partial fulfilments of the requirements for the award of Degree in Bachelor of Technology in Biomedical Engineering.


SIGNATURE OF THE CANDIDATE

DATE: 03.10.2023

PLACE : CHENNAI.

ACKNOWLEDGEMENT

I wish to express my most sincere and profound gratitude to our beloved **Founder Chancellor Col. Dr. JEPPIAR, M.A. ,B.L., Ph. D.**, for providing me an opportunity to educate myself.

I am also pleased to acknowledge sincere thanks to our **Chancellor Dr. MARIAZEENA JOHNSON, B.E., M.B.A., M.Phil., PhD.** and **President Dr. MARIE JOHNSON, B.E., M.B.A., M.Phil., PhD.** and our beloved **Vice President Mr. J. ARUL SELVAN, Ms. MARIA BERNADETTE TAMILARASI, Ms. MARIA CATHERINE JAYAPRIYA** of Sathyabama Institute of Science and Technology, Chennai, for their unwavering support to carry out my research work.

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I would like to extend my thanks to **Dr. B.SHEELA RANI ,M.S., Ph.D.**, Director (research), Our Dean of school of Bio and Chemical sciences **DR. RAMESH KUMAR, M.Sc., Ph.D.** our head of the department **Dr. T. Sudhakar M.Sc., Ph.D.**, and our professional training guides **Ms. SINDU DIVAKARAN** and **Dr. A .SABARIVANI , M. Tech., Ph.D.** Thank you for being a part of this educational journey with us.

I am genuinely thankful for the opportunity offered by the Head of **CENTER OF DRUG DISCOVERY AND DEVELOPMENT Dr. KRUPAKAR PARTHASARATHY** sir at **SATHYABAMA RESEARCH PARK** and also to the staff who taught us about the various machineries in the laboratory with lot of patience.

I also wish to express my thanks to all the Teaching and Non-Teaching staff members of the department of biomedical engineering who were helpful in many ways for the completion of the report.

ABSTRACT

This report provides a comprehensive overview of my internship experience in the field of Exploring Bioloanatical Tools and Techniques For Drug Delivery, which comes under Drug Discovery and Development, located in Sathyabama Research Park , Chennai from 20.09.2023 to 25.09.2023.

This internship taught us many things which are related to the equipments used in the drug discovery process and also in the bio laboratories. And also about the different bacterial culture and also about the many process about the regarding the drug formation .

They also taught us how a Biomedical engineers supports in Drug Discovery . This internship increased our interest regarding this research. We got to know many interesting things which are not in our daily lectures . And also we got to know about the recent research's going on in our college research park and also about the current affairs about the researches going on around the world under they Biomedical field and also under the Drug delivery field .

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I.INTRODUCTION

1.1 . OVERVIEW

This report document tells about the journey of my 5 days internship program which was done at **SATHYABAMA RESEARCH PARK** under **DRUG DISCOVERY AND DEVELOPMENT** .This tells regarding the instruments what we have seen there and also about the research going on in that field. We have seen many of the bio equipment like Hot air oven, incubator, autoclave, centrifuge, fermenter , PCR and RT-PCR. We got the basic knowledge about the research field .

This internship taught us many of the topics like virology, gut microbiology, and also about synthetic dyes , chromatography , biofilms , organ on a chip .And also about the present research undergoing is this steam. They had collected the biofilms from various parts of word and testing on that bacteria recently they took from the Antarctic ocean and testing on it.

And also a new thought painting an art using the natural pigment extracted from a bacterium streptomycetes . And also we saw the bacterium culture grown in the specific temperature condition . And also got to know about the use of biomedical engineering in the field of drug discovery.

II. STERILIZATION and DISINFECTION EQUIPMENT

What is **STERILIZATION** ?

Sterilization is a process or technique used to completely eliminate or kill all forms of microbial life, including bacteria, viruses, fungi, and spores, from a particular object, surface, substance, or environment. The primary goal of sterilization is to ensure that no potentially harmful microorganisms remain that could cause infections or spoilage.

Sterilization is crucial in various fields, including healthcare, pharmaceuticals, food processing, and laboratory research, to prevent the spread of infections and to ensure the safety and efficacy of products and procedures. The choice of sterilization method depends on the nature of the materials being sterilized and the specific requirements of the application.

What is **DISINFECTION** ?

Disinfection is the process of reducing the number of harmful microorganisms, such as bacteria, viruses, and fungi, on surfaces, objects, or in the environment to a level that is considered safe for public health. Unlike sterilization, which aims to eliminate all microorganisms, disinfection typically targets the most pathogenic or harmful ones, while some non-pathogenic microbes may survive.

Disinfection methods are used to control the spread of infections, reduce the risk of disease transmission, and maintain sanitary conditions. The choice of disinfection method depends on the specific application, the type of microorganisms targeted, and the level of disinfection required.

2.1 . AUTOCLAVE

An autoclave is a specialized piece of equipment used for sterilization by applying heat, pressure, and steam to effectively kill or eliminate all forms of microorganisms, including bacteria, viruses, fungi, and spores. Autoclaves are widely used in various industries, including healthcare, research laboratories, pharmaceutical manufacturing, and the food industry, to ensure that instruments, equipment, and materials are free from harmful pathogens. Autoclaves work by subjecting objects or substances to high-pressure steam at elevated temperatures. The combination of heat and pressure is effective at destroying microorganisms and their spores.



Fig: 1.1 . Autoclave .

Typical operating conditions for autoclaves involve temperatures ranging from 121°C to 134°C (250°F to 273°F) and pressure levels from 15 to 30 pounds per square inch (psi). These conditions can be adjusted based on the specific sterilization requirements. The sterilization process involves several stages, including heating,

sterilization, and cooling. During the heating phase, the autoclave raises the temperature and pressure to the desired levels. The sterilization phase maintains these conditions for a specified duration, effectively killing the microorganisms. The cooling phase rapidly reduces temperature and pressure to safe levels, allowing the sterilized items to be safely removed.

STERILIZER	TEMPERATURE	PRESSURE	TIME
Steam Autoclave	121° C (250 ° F)	15 psi	15 min
- Unwrapped Items - Lightly Wrapped Items - Totally Wrapped Items	121° C (270 ° F) 132° C (270 ° F) 132° C (270 ° F)	30 psi 30 psi 30 psi	3 min 8 min 10 min
Dry Heat Wrapped	170° C (340 ° F)		60 min
Chemical Vapor	132° C (270 ° F)	20-40 psi	20 min
Ethylene Oxide	Ambient		8-10 hr

Fig : 1.2 .

Autoclaves come in various sizes and configurations. They can range from small tabletop autoclaves used in dental offices and laboratories to large industrial autoclaves used in pharmaceutical manufacturing and food processing. Some autoclaves are designed for specific purposes, such as sterilizing medical instruments or laboratory glassware. Autoclaves are used for sterilizing a wide range of items, including surgical instruments, laboratory equipment, media, glassware, textiles, and certain types of waste. They are crucial in healthcare settings to prevent the spread of infections and ensure patient safety.

Vertical autoclaves and **horizontal autoclaves** are two common types of autoclaves used for sterilization and other applications. They differ in their design and the orientation in which items are loaded into them.

When it comes to **Orientation**

- **Vertical Autoclave:** In a vertical autoclave, the chamber is oriented vertically, with the door on top and the chamber below. Items to be sterilized are typically loaded onto removable trays or shelves that are stacked vertically within the chamber.
- **Horizontal Autoclave:** In a horizontal autoclave, the chamber is oriented horizontally, with the door on the front or side. Items to be sterilized are loaded onto racks or trays that are placed horizontally inside the chamber.

Application:

- **Vertical Autoclave:** Vertical autoclaves are commonly used for sterilizing liquids in containers like glassware and media bottles. They are also used for smaller instruments and laboratory equipment.
- **Horizontal Autoclave:** Horizontal autoclaves are often preferred for sterilizing larger items such as surgical instruments, bedding, and laboratory apparatus that cannot easily fit into a vertical autoclave.

The choice between a vertical and horizontal autoclave depends on the specific needs of the application, the types of items to be sterilized, the available space, and user preferences. Both types are effective at achieving sterilization, but their design and loading methods make them better suited for different types of equipment and situations .



Fig : 1.3 . Horizontal autoclave and Vertical autoclave.

2.2. HOT AIR OVEN

A hot air oven is a laboratory and industrial equipment used for sterilization and various other applications that require controlled heating. It operates by circulating hot, dry air within an enclosed chamber to achieve and maintain specific temperatures. Hot air ovens are commonly used in research laboratories, clinical settings, pharmaceutical manufacturing, and industries that require precise and uniform heating.

This equipment contains an electric heating element and a thermostat or digital temperature controller, allowing users to set and maintain specific temperatures. To ensure consistent heating, a fan or blower circulates the hot air throughout the chamber, preventing temperature variations and hot spots. The interior chamber is typically made of stainless steel for easy cleaning and resistance to corrosion. Shelves or racks inside the oven provide ample space for loading items, such as glassware, samples, or equipment.

A secure door with a viewing window seals the chamber and allows users to monitor the process without opening the oven. Timers are often integrated, enabling users to set the duration of heating or drying cycles. Hot air ovens find applications in sterilization, drying, heat treatment, and stability testing across various industries, including pharmaceuticals and food processing, due to their precise temperature control and reliability.



Fig: 2.1. Hot Air Oven

Hot air ovens are used to sterilize laboratory glassware, equipment, and instruments. Ensuring that these items are free from microbial contamination is vital in drug discovery to maintain the integrity of experiments and ensure that test results are not compromised. After washing and cleaning laboratory glassware, it is essential to eliminate any residual moisture. Hot air ovens are used to efficiently dry glassware, preventing water-related issues that could affect experimental outcomes. Researchers use hot air ovens to gently and precisely dry these samples, ensuring they are moisture-free and ready for analysis.

Hot air ovens are employed for stability testing of pharmaceutical products and drug formulations. They provide controlled temperature conditions over time, allowing researchers to assess the stability and shelf life of potential drug candidates. Some drug compounds and excipients require accurate measurement of their moisture content. Hot air ovens are used to remove moisture from samples, enabling researchers to calculate moisture content accurately. These ovens simulate long-term storage conditions by exposing formulations to controlled heat, helping researchers make informed decisions about potential drug candidates. In the development of drug delivery systems, hot air ovens are utilized for various purposes, including heat-shrinking polymer films, curing adhesives, or processing polymer-based drug carriers.

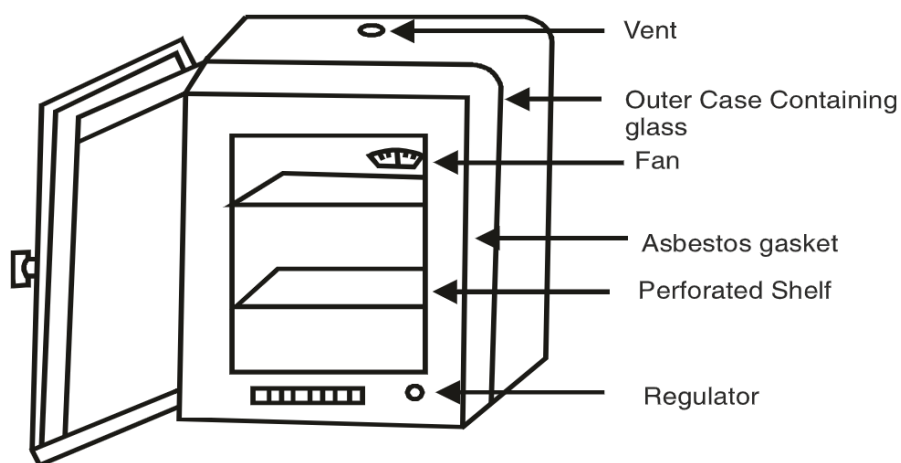


Fig. Hot air oven

Fig: 2 .2

2.3. ULTRAVIOLET CHAMBER

An ultraviolet (UV) chamber, also known as a UV chamber or UV sterilizer, is a specialized piece of equipment that uses ultraviolet light to disinfect or sterilize various objects, surfaces, or liquids. UV chambers are commonly used in laboratory settings, healthcare facilities, water treatment plants, and industries where maintaining a sterile environment or preventing the spread of pathogens is essential.

UV chambers primarily use UV-C light, a specific wavelength of ultraviolet light (between 200 and 280 nanometers), which is highly effective at inactivating microorganisms, including bacteria, viruses, and fungi. The primary function of a UV chamber is to sterilize or disinfect items placed inside it. When microorganisms are exposed to UV-C light, their DNA and RNA absorb the UV energy, which damages their genetic material, preventing them from reproducing and rendering them noninfectious.



Fig: 3.1. UV Chamber

UV chambers are commonly used in laboratories to sterilize equipment like pipettes, glassware, and laboratory instruments to prevent contamination of

experiments and cultures. In pharmaceutical and biotechnology manufacturing, UV chambers are used to sterilize air in cleanrooms and to disinfect surfaces and equipment to prevent contamination during drug production. Some UV chambers are designed for air purification. They use UV-C lamps to sterilize the air by inactivating airborne pathogens like bacteria and viruses, improving indoor air quality.

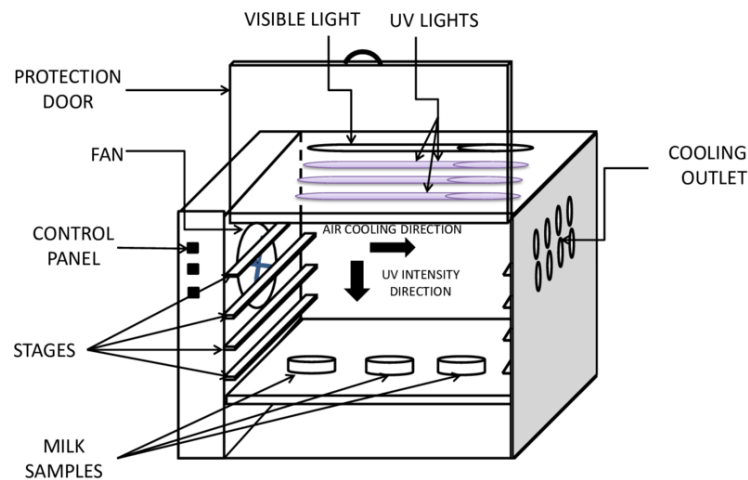


Fig: 3.3 .

Pharmaceutical companies that produce drug delivery devices, such as syringes, inhalers, or transdermal patches, may use UV chambers to sterilize manufacturing equipment and cleanrooms. This helps prevent contamination during the production process, ensuring the final products are sterile and safe for patients. UV chambers can be employed for quality control purposes in drug delivery manufacturing. Manufacturers can use UV chambers to assess the sterility of samples from production batches, ensuring that the drug delivery systems meet regulatory requirements and are safe for use.

UV chambers play a crucial role in maintaining sterility and preventing contamination in various industries, from healthcare to pharmaceuticals, by using ultraviolet light to disinfect surfaces and equipment.

III. LABORATORY EQUIPMENT

Laboratory equipment refers to the various tools, instruments, apparatuses, and devices used in scientific research, experimentation, analysis, and testing within laboratory settings. These equipment items are essential for conducting experiments, making measurements, collecting data, and performing various scientific procedures. Laboratory equipment can vary widely depending on the specific field of science, research objectives, and the nature of experiments being conducted. Common examples of laboratory equipment include microscopes, centrifuges, spectrophotometers, pipettes, Bunsen burners, incubators, autoclaves, balances, and a wide range of specialized instruments and apparatuses tailored to specific scientific disciplines. These tools help scientists and researchers carry out experiments, analyze samples, and advance knowledge in various scientific fields, including biology, chemistry, physics, medicine, environmental science, and many others.

3.1. INCUBATOR

An incubator is a laboratory device designed to provide a controlled and stable environment for the growth and cultivation of microorganisms, cells, or tissues. It is an essential tool in microbiology, cell biology, and various life sciences disciplines. Incubators maintain precise temperature, humidity, and often CO₂ levels to create ideal conditions for the growth and study of biological samples. They are used for tasks like bacterial culture, cell culture, fermentation, and other experiments that require controlled and consistent environmental conditions to promote cell or microbial growth and research. Incubators come in various sizes and configurations, including benchtop and large-capacity floor models, to accommodate different research needs

The main use of an incubator is to provide a controlled environment for the growth and cultivation of microorganisms, cells, or tissues in laboratory settings. In drug discovery, incubators are used to cultivate and maintain cell cultures, including cancer cells, stem cells, and other relevant cell lines, to study drug effects, toxicity, and cellular responses, providing valuable insights into drug development and efficacy.

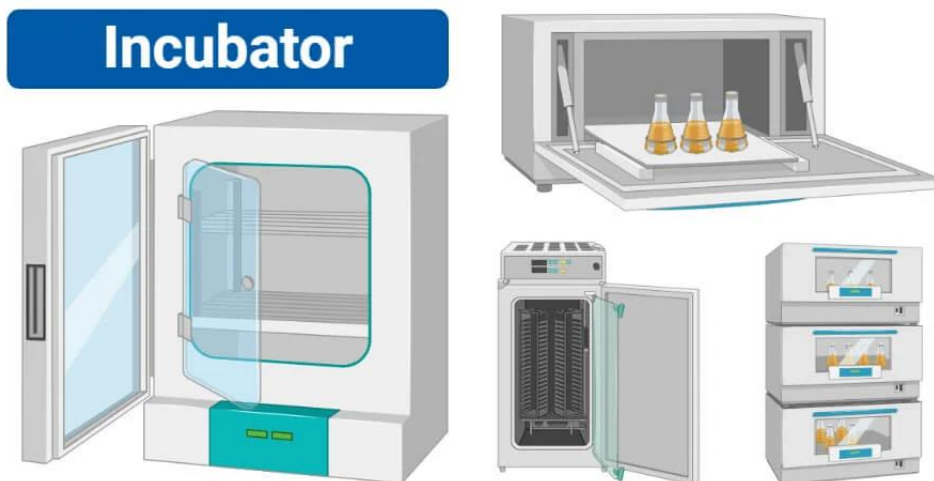


Fig:.4.1. Incubator

Incubators in the context of drug delivery typically refer to equipment used for various processes in pharmaceutical and biotechnological research and development rather than the actual delivery of drugs to patients. Here are some processes performed by incubators in drug discovery and development: Researchers may use incubators to develop and test various drug formulations, ensuring that they remain stable and effective under different environmental conditions. For drug delivery systems, incubators may be used to conduct drug release studies. These studies examine how drugs are released from delivery systems over time under controlled conditions, mimicking physiological environments. Incubators provide a stable and controlled environment for conducting biological assays that are crucial in drug discovery, such as enzyme-linked immunosorbent assays (ELISAs) and cell viability assays.

Incubators are versatile tools in drug discovery and development, ensuring controlled conditions for a wide range of processes, from cell culture and stability testing to drug formulation and release studies, ultimately contributing to the development of safe and effective pharmaceutical products and drug delivery systems.

3.2 . LAMINAR AIR FLOW

Laminar airflow (LAF) is a controlled airflow system used in various industries, including pharmaceuticals, healthcare, electronics manufacturing, and laboratories. It is designed to maintain a sterile or clean environment by directing air in a unidirectional,

parallel flow to minimize the risk of contamination and to protect sensitive processes, equipment, or products from airborne particles, dust, and microorganism.

It is commonly used in drug discovery laboratories, especially in areas where maintaining sterility and preventing contamination are essential. Laminar airflow systems are used to create a controlled environment that minimizes the presence of airborne contaminants, such as dust, particles, and microorganisms. This is crucial in drug discovery laboratories where experiments require aseptic conditions and the prevention of cross-contamination between samples.



Fig.5.1 Laminar Air Flow

LAF hoods or cabinets provide a sterile workspace for activities like cell culture, microbiological testing, and the preparation of sterile drug formulations. They ensure that the air entering the workspace is free from contaminants and pathogens. Laminar airflow systems protect sensitive samples, cell cultures, and reagents from contamination. This is especially important when working with cell lines, tissues, or biological materials, as any contamination can compromise experimental results. In drug discovery, LAF systems are used for the aseptic preparation of drug formulations, ensuring that the final product remains sterile and free from contaminants.

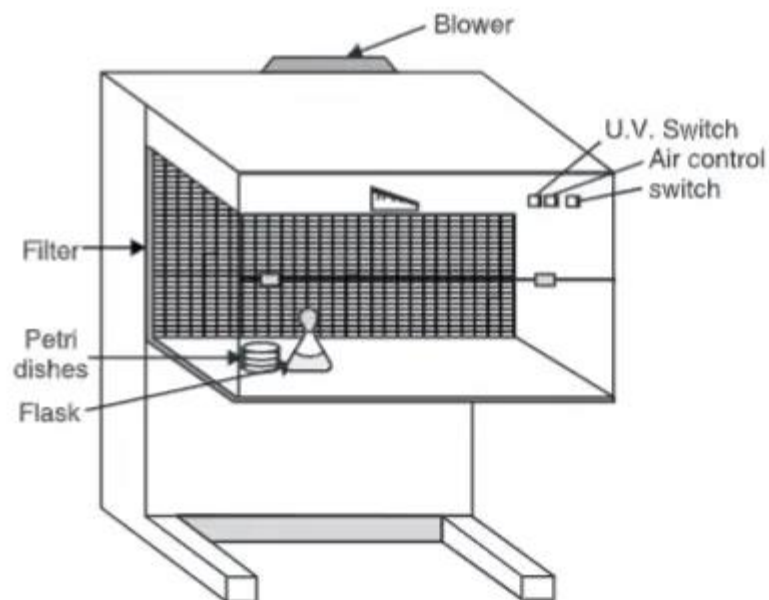


Fig.5.2.

It helps in maintaining particle-free environments by removing airborne particles and maintaining a continuous flow of filtered air that sweeps away any potential contaminants. In drug discovery facilities that require cleanrooms, laminar airflow is used to create ISO-classified clean environments to meet strict regulatory standards. laminar airflow plays a crucial role in ensuring the integrity of drug discovery experiments, maintaining the sterility of drug formulations, and protecting sensitive biological samples. It helps create controlled and contamination-free environments.

3.3. FREEZE DRYER

A freeze dryer, also known as a lyophilizer, is a specialized piece of equipment used in various industries, including pharmaceuticals, food processing, and research, to remove moisture from substances while preserving their structure and integrity. The primary purpose of a freeze dryer is to freeze a material and then remove the ice or water content through a process called sublimation, where ice transitions directly from a solid to a vapor without passing through the liquid phase. This process allows for the preservation of perishable materials, such as foods, pharmaceuticals, and biological samples, for long-term storage or transport.



Fig. 6.1 Freeze Dryer

Freeze dryers are used to create stable drug formulations by removing water or solvents from drug compounds. This enhances the drug's stability and shelf life, especially for medications that are sensitive to heat and moisture. biological samples such as proteins, enzymes, antibodies, and tissues can be freeze-dried to preserve their biological activity for long-term storage and analysis. This is critical for research involving drug-target interactions and biomarker discovery.

Many vaccines are freeze-dried to increase their stability and ease of storage and transport. This process allows vaccines to be stored at higher temperatures without losing efficacy, which is particularly important for global distribution. Freeze drying is used for the production of various pharmaceutical products, including antibiotics, antiviral drugs, and biologics. It ensures the stability of these products and allows for extended storage. Freeze drying is used to create microencapsulated drug formulations. In this process, drug particles are encapsulated in a protective matrix, enhancing drug delivery and controlled release properties.

The freeze-drying process involves several stages:

- **Freezing:** The material is frozen to a very low temperature, causing the water or solvent within it to solidify.

- **Primary Drying (Sublimation):** Under reduced pressure, the frozen water or solvent transitions directly from a solid to a gas (sublimation) without passing through the liquid phase. This stage removes the majority of the moisture.
- **Secondary Drying (Desorption):** Remaining bound water molecules are removed through desorption at slightly higher temperatures and lower pressures. This stage further reduces moisture content.

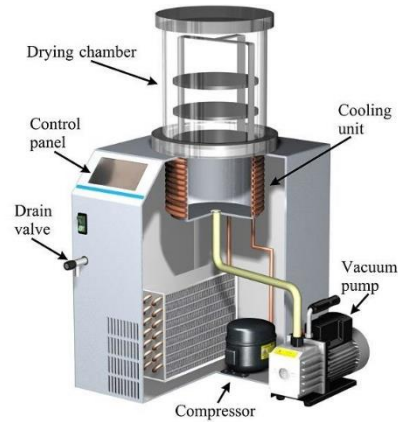


Fig.6.2

3.4. CENTRIFUGE

A centrifuge is a laboratory instrument used to separate components of a heterogeneous mixture based on their density and sedimentation properties. It operates on the principle of centrifugal force, which causes denser particles or substances to move outward and settle at the bottom of a rotating container. Centrifuges are widely used in various scientific and industrial applications, including in drug discovery and pharmaceutical research. Centrifuges have a rotor, which is the rotating component that holds the sample tubes or containers. Rotors come in various designs, including fixed-angle and swinging-bucket types, to accommodate different sample types and applications. Centrifuges can achieve a range of rotational speeds, allowing researchers to select the optimal speed for their specific separation needs. Speed is typically measured in revolutions per minute (RPM) or relative centrifugal force (RCF), expressed in units of gravity (g). Some centrifuges are equipped with temperature control features to maintain samples at a specific temperature during centrifugation. This is crucial for applications involving temperature-sensitive samples. Centrifuges are designed with safety features such as lid locks and imbalance detection systems to ensure safe operation, especially at high speeds.



Fig.7.1 Centrifuge

Uses of Centrifuges in Drug Discovery:

- **Cell Separation:** Centrifugation is used to separate cells and cellular components, such as organelles and nuclei, from suspensions or homogenates. This is vital in cell culture work and cellular biology research.
- **Protein Purification:** Centrifuges are employed in the purification of proteins and biomolecules. They help separate proteins of interest from cell lysates, culture supernatants, or crude extracts.
- **Isolation of Biomolecules:** Centrifugation is used to isolate DNA, RNA, and other biomolecules from complex biological samples. It aids in nucleic acid extraction and purification processes.
- **Density Gradient Centrifugation:** Researchers use density gradient centrifugation to separate particles or substances with different densities, such as organelles, viruses, or subcellular components, based on their sedimentation rates.
- **Sample Concentration:** Centrifuges are used to concentrate samples by pelleting suspended particles or molecules at the bottom of the sample tube, allowing for the removal of excess liquid.
- **Quality Control:** In pharmaceutical manufacturing, centrifugation is employed for quality control purposes, such as checking the uniformity of drug formulations and verifying the presence of particulate matter.

- **Clinical Diagnostics:** Centrifuges are used in clinical laboratories for the separation of blood components, such as red blood cells, plasma, and serum, for diagnostic purposes.
- **Pharmaceutical Research:** In drug discovery and development, centrifugation is utilized for various applications, including formulation development, stability testing, and drug delivery research.

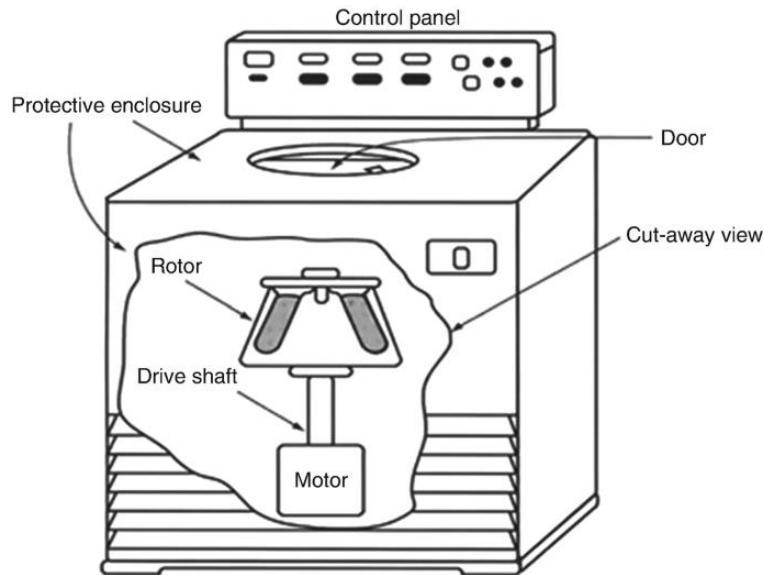
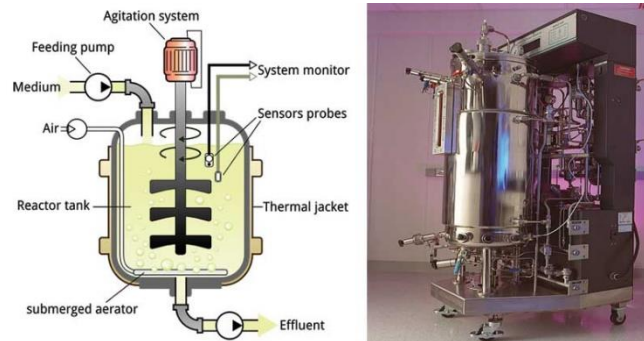


Fig.7.2

3.5. FERMENTER

A fermenter, also known as a bioreactor or fermentation tank, is a specialized vessel or container used in biotechnology and industrial microbiology to culture and grow microorganisms such as bacteria, yeast, fungi, or algae. Fermenters provide a controlled environment for microbial fermentation processes, where microorganisms convert raw materials (substrates) into desired products, which can include various chemicals, pharmaceuticals, biofuels, enzymes, and more. These vessels are essential in a wide range of industries, including pharmaceuticals, food and beverage, biofuels, and biotechnology research. Fermenters are designed to maintain a sterile environment to prevent contamination by unwanted microorganisms during the fermentation process.

Temperature is carefully controlled within the fermenter to provide an optimal growth environment for the specific microorganisms being cultured. pH levels are monitored and adjusted as needed to ensure the optimal pH for the microbial culture. Different microorganisms have varying pH requirements for growth and product formation. Fermenters supply nutrients, including carbon sources, nitrogen, vitamins, and minerals, to support microbial growth and product formation. Modern fermenters often include advanced monitoring and control systems that allow for precise control of parameters like temperature, pH, dissolved oxygen levels, and agitation speed.



Many biologic drugs, such as monoclonal antibodies, vaccines, and therapeutic proteins, are produced using fermenters. These systems provide the optimal conditions for the growth and expression of genetically engineered cells or microorganisms that produce these drugs. Fermenters are used in the production of vaccines. They enable the large-scale cultivation of viruses or bacteria used as vaccine antigens, allowing for the production of vaccines on a commercial scale. In drug delivery research, fermenters can be used to cultivate cells or microorganisms for the production of drug delivery systems, such as liposomes, nanoparticles, or microspheres. These systems are designed to deliver drugs to specific targets or improve drug release characteristics.

Fermenters can be employed to produce large quantities of cells or microorganisms for biological assays and testing. This is especially important in drug discovery when testing the efficacy and safety of drug candidates. Fermenters are used for the large-scale production of enzymes used in drug delivery systems. Enzymes can play a role in drug formulation, improving drug release, or enhancing drug stability. In biopharmaceutical research, fermenters are used for the expression of therapeutic proteins, allowing for the production of biologics that can be administered through various drug delivery routes, such as injections or infusions.

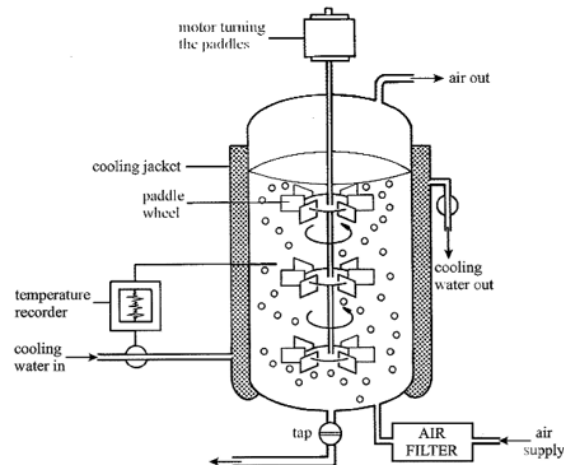


Fig.8.2.

3.6 PCR and RT-PCR

PCR stands for **Polymerase Chain Reaction**. It is a molecular biology technique used to amplify or make millions of copies of a specific DNA sequence. PCR is a fundamental tool in genetics, genomics, and various fields of biomedical research, including medicine and forensics. The technique was first developed in the 1980s by Kary Mullis and has since become an essential method in molecular biology and diagnostics.

Here's how PCR works:

- **Denaturation:** The PCR reaction begins by heating the DNA sample to a high temperature (typically around 94-98°C). This step causes the DNA double helix to separate (denature) into two single strands by breaking the hydrogen bonds between the complementary base pairs (adenine-thymine and guanine-cytosine).
- **Annealing:** The reaction temperature is then lowered to a specific temperature (typically around 50-65°C). At this temperature, short DNA sequences called primers that are designed to be complementary to the regions flanking the target DNA sequence bind (anneal) to their complementary sequences on the single-stranded DNA template.
- **Extension:** An enzyme called DNA polymerase is used to synthesize a new DNA strand complementary to the template strand. This enzyme extends the primers, creating a copy of the target DNA sequence. This step usually occurs at a temperature around 72°C.
- **Repeat:** The denaturation, annealing, and extension steps are repeated in a cycle. Each cycle approximately doubles the amount of DNA present, resulting in exponential amplification of the target sequence

After multiple cycles (usually 20-40 cycles), PCR can produce a significant amount of the desired DNA sequence, even if it was initially present in only trace amounts.



Fig.9.1.PCR

Real-time polymerase chain reaction (real-time PCR), also known as quantitative PCR (qPCR), is a sophisticated variation of the traditional PCR technique. It allows researchers to monitor the amplification of DNA in real-time as it occurs, providing quantitative information about the initial amount of the target DNA sequence. Real-time PCR is widely used in molecular biology, genetics, clinical diagnostics, and various fields of research.

Real-time PCR uses fluorescent probes or dyes that bind to the amplified DNA during the reaction. These probes emit fluorescence when they bind to the target DNA, allowing real-time detection of the amplification process.

. Here's how RT-PCR works:

- **Sample Preparation:** The process begins with the extraction of nucleic acids (DNA or RNA) from the biological sample of interest. This can include cells, tissues, blood, saliva, or other sources containing the genetic material to be analyzed.

- **Reverse Transcription (for RNA):** If the target of interest is RNA (e.g., mRNA), a reverse transcription (RT) step is performed to convert RNA into complementary DNA (cDNA) using an enzyme called reverse transcriptase. This step is essential because PCR typically amplifies DNA, not RNA.
- **Primer Design:** Specific primers are designed for the target DNA or cDNA sequence. Primers are short, single-stranded DNA sequences that are complementary to the regions flanking the target sequence. One primer binds to the forward strand, and the other binds to the reverse strand of the target DNA.
- **Fluorescent Probes or DNA-binding Dyes:** Real-time PCR uses fluorescent probes or DNA-binding dyes that emit fluorescence when they bind to the amplified DNA during the reaction. Commonly used probes include TaqMan probes and SYBR Green dye.
- **PCR Amplification:** The PCR reaction is set up, typically in a thermocycler or a real-time PCR instrument. The reaction mixture includes the template DNA or cDNA, primers, DNA polymerase enzyme, nucleotides (A, T, C, G), and the fluorescent probe or dye. The reaction goes through a series of cycles, each consisting of three main steps:
 - **Denaturation**
 - **Annealing**
 - **Extension**
- **Fluorescence Detection:** As the DNA amplification proceeds, the fluorescent probes or dyes in the reaction mixture bind to the newly synthesized DNA strands. When the probes or dyes bind to the amplified DNA, they emit fluorescence, which is detected in real-time by a fluorescence detector in the PCR instrument.
- **Data Analysis:** The real-time PCR instrument continuously monitors the fluorescence intensity during each cycle of the reaction. The fluorescence signal is plotted on a graph, and the threshold cycle (Ct) is determined, which is the cycle at which the fluorescence signal reaches a defined threshold. The Ct value is inversely proportional to the initial amount of the target DNA or cDNA in the sample. Lower



Ct values indicate higher initial target concentrations.

ial target

Fig. 9.2. RT-PCR

IV. CUTTING-EDGE TECHNOLOGIES

Cutting-edge technology, in a general sense, refers to the latest and most advanced technological innovations, tools, or methods that are at the forefront of their respective fields. These technologies often represent the leading edge of scientific and engineering progress, and they have the potential to bring about significant advancements, transformations, and improvements in various industries and aspects of society. Cutting-edge technologies typically push the boundaries of what is currently possible and may offer novel solutions to existing problems or create entirely new possibilities. They are characterized by their innovation, efficiency, and potential for substantial impact. Examples of cutting-edge technologies include artificial intelligence, quantum computing, advanced robotics, nanotechnology, renewable energy solutions, and biotechnology breakthroughs, among others. These technologies are continually evolving as researchers and engineers push the limits of scientific knowledge and technological capabilities, making them essential drivers of progress and innovation in our rapidly changing world.

4.1. 3D BIOPRINTING

3D bioprinting is an emerging and cutting-edge technology that combines three-dimensional printing with biotechnology to create complex biological structures, tissues, and even organs. It offers the ability to fabricate living tissues with precise control over cell placement, allowing for the creation of functional and customized biological constructs.

How 3D Bioprinting Works:

- **Bioinks:** 3D bioprinting uses specialized materials called "bioinks" that typically consist of living cells, biomaterials (such as hydrogels), and bioactive compounds. These bioinks are loaded into the 3D printer's cartridges.
- **Layer-by-Layer Printing:** The 3D bioprinter deposits layers of bioink onto a substrate or scaffold material in a controlled and precise manner, following a digital blueprint or design. The printer's nozzle or extruder moves in three dimensions, allowing for the creation of complex structures.
- **Cell Viability:** Maintaining the viability and functionality of the living cells within the bioink is critical. Careful attention is paid to factors like temperature, pH, and oxygen levels during the printing process to ensure cell survival and function.

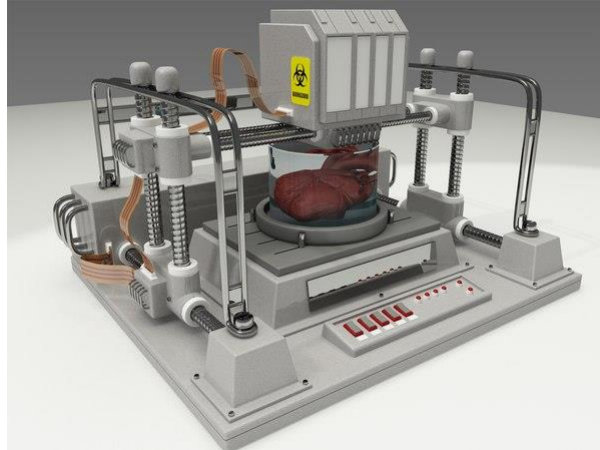


Fig. 10.1 3D Bioprinting machine

Applications of 3D Bioprinting:

- Tissue Engineering
- Drug Testing
- Disease Modeling
- Personalized Medicine
- Cosmetic Testing
- Research and Education

Materials used:

•**Bioinks:** These are the materials used for 3D bioprinting and typically consist of cells (such as stem cells or specialized tissue cells) suspended in a hydrogel or other biocompatible matrix.

•**Scaffold Materials:** In addition to bioinks, bioprinters often use structural support materials that can be removed after printing to create hollow structures or channels.

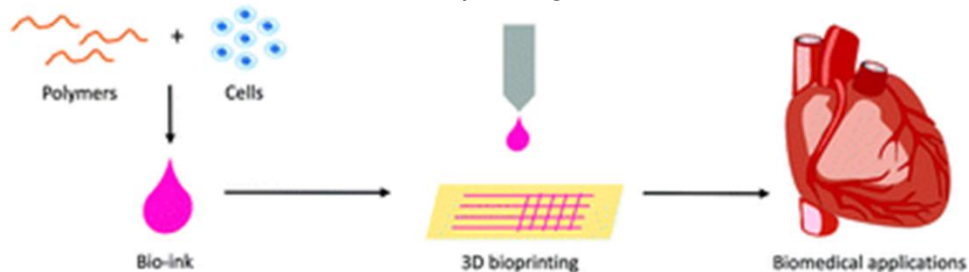


Fig.10.2

Bioprinting Techniques:

- Inkjet Bioprinting:** This method uses inkjet printer technology to deposit droplets of bioink onto a substrate.
- Extrusion Bioprinting:** It involves the controlled extrusion of bioink through a nozzle, similar to Fused Deposition Modeling (FDM) 3D printing.
- Laser-Assisted Bioprinting:** High-precision lasers are used to selectively deposit bioink onto a substrate.

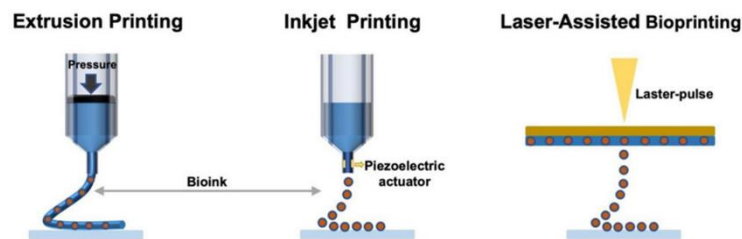
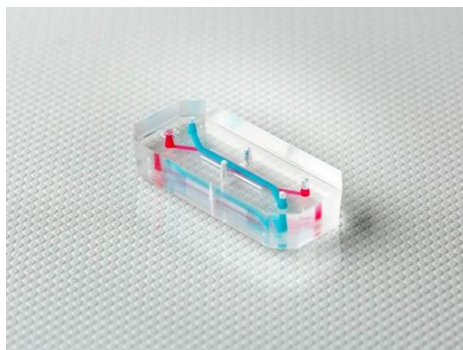


Fig.10.3.

4.2.ORGAN ON A CHIP

An "organ-on-a-chip" is a microfluidic device that mimics the structure and function of a specific organ or tissue within the human body. These innovative platforms are designed to replicate the physiological and mechanical aspects of organs in a controlled, miniaturized system. Organ-on-a-chip technology is a groundbreaking development in biomedical research and has numerous applications in drug testing, disease modeling, and personalized medicine.

Organ-on-a-chip devices are typically small and microscale, often the size of a credit card. Despite their small size, they replicate the key structural and functional elements of an organ or tissue. Human cells, such as organ-specific cell types or stem cells, are cultured within the chip to recreate the cellular environment and interactions found in the actual organ. Sensors and imaging techniques are often integrated into the chip to monitor cell behavior, responses to stimuli, and physiological changes in real-time.



Firstly the process of drug testing and Drug development is notoriously slow and expensive – it can take up to 10 years and cost more to bring a new compound from the lab bench to market. A major cause of this inefficiency is the traditional reliance on testing drugs in animals before they are tested in humans. Animal models often do not accurately reflect human physiology, meaning that drugs that appear to be safe and effective in animals frequently turn out to be harmful or ineffective in humans. This mismatch in biology causes many useless or toxic drugs to advance through clinical trials at great expense, while potentially effective compounds never make it to market.

As the result “Organs-on-Chips” (Organ Chips) a microfluidic culture devices that recapitulate the complex structures and functions of living human organs. These microdevices are composed of a clear flexible polymer about the size of a USB memory stick that contains hollow microfluidic channels lined with living human organ cells and human blood vessel cells. These living, three-dimensional cross-sections of human organs provide a window into their inner workings and the effects that drugs can have on them without involving animals

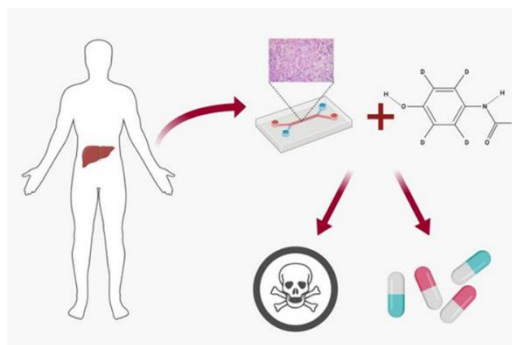


Fig. 11.2.

V . THEORETICAL CONCEPT

5.1 . VIROLOGY

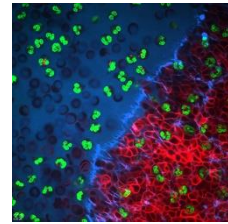


Fig.12.1

Virology is the field of science dedicated to the study of viruses, which are infectious agents consisting of genetic material (either DNA or RNA) enclosed in a protein coat. Virologists explore various aspects of viruses, including their structure, replication mechanisms, interactions with host organisms, and role in causing diseases. Understanding virology is essential for developing vaccines and antiviral treatments, tracking and controlling viral outbreaks, and advancing our knowledge of molecular biology. It also plays a critical role in fields such as epidemiology, public health, and biotechnology, making it a vital discipline with far-reaching implications for human health and scientific research.

In virology, researchers categorize viruses based on criteria like genetic makeup and replication methods. They investigate how viruses infect host cells, replicate within them, and cause diseases. Moreover, virology informs the development of diagnostic tools and antiviral therapies, contributing significantly to the fields of medicine, agriculture, and biotechnology. Understanding viral evolution and zoonotic transmission, where viruses jump between animal and human hosts, is crucial for preventing and managing emerging infectious diseases.

Virology has far-reaching implications in medicine, agriculture, environmental science, and biotechnology. Viruses can cause diseases in humans, animals, and plants, and they also play essential roles in ecosystems as well as in biotechnological applications, such as gene therapy and the use of viral vectors for genetic engineering. Understanding viruses at the molecular and cellular levels is crucial for combating viral diseases, developing vaccines, and advancing scientific knowledge.

5.2.GUT MICROBIOLOGY

Gut microbiology is a branch of microbiology that focuses on studying the diverse community of microorganisms inhabiting the human gastrointestinal tract, particularly the intestines. This complex ecosystem, often referred to as the gut microbiota or gut microbiome, consists of bacteria, viruses, fungi, and other microorganisms.

The gut microbiota is incredibly diverse, with thousands of different species of microorganisms residing in the human gut. Bacteria are the predominant members, but viruses (bacteriophages), archaea, fungi, and other microbes are also present. The gut microbiota plays crucial roles in human health, including aiding in digestion, synthesizing vitamins, training the immune system, and metabolizing dietary components that the human body cannot digest on its own.

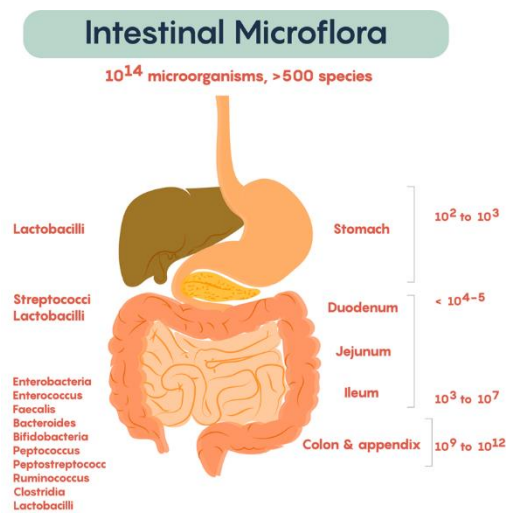


Fig.13.1

5.3 . BIOFILMS

A biofilm is a complex and organized community of microorganisms, such as bacteria, fungi, algae, and protozoa, that adhere to surfaces and are embedded in a slimy, extracellular matrix composed of proteins, polysaccharides, and DNA. These microorganisms form biofilms in various natural and man-made environments, including water bodies, pipes, medical devices, and living tissues. Biofilms are characterized by their structured and cooperative lifestyle, which differs from the planktonic (free-floating) form of these microorganisms. Here are some features of biofilms:

- **Adhesion:** Microorganisms in a biofilm adhere to surfaces, which can be biotic (living) or abiotic (non-living), using adhesins or other surface attachment mechanisms.
- **Extracellular Matrix:** Biofilms are surrounded by an extracellular matrix, often referred to as a "slime" or "biofilm matrix." This matrix provides structural support and protection for the microorganisms within the biofilm.
- **Cooperative Behavior:** Biofilm microorganisms exhibit cooperative behavior, with different species or strains working together for mutual benefit. They can share nutrients and provide protection against environmental stressors.
- **Increased Resistance:** Biofilms are highly resistant to antimicrobial agents, including antibiotics, disinfectants, and the host immune system. This resistance is due to the protective matrix and altered gene expression of microorganisms within the biofilm.
- **Persistence:** Biofilms are often persistent and difficult to eradicate. They can colonize various surfaces, leading to fouling in industrial settings, biofouling in water systems, and chronic infections in medical contexts.
- **Heterogeneity:** Biofilms are heterogeneous structures with varying microenvironments. This heterogeneity can result in gradients of nutrients, oxygen, and pH within the biofilm.
- **Role in Infections:** Biofilms are associated with various infections, including dental plaque on teeth, chronic wounds, urinary tract infections, and infections associated with medical devices like catheters and implants.
- **Environmental Impact:** Biofilms play essential roles in natural ecosystems, where they are involved in nutrient cycling, water purification, and the degradation of organic matter.

- **Research and Industry:** Understanding biofilms is critical in various fields, including medicine, environmental science, and industry (e.g., water treatment and biofilm control in pipelines).
- **Control and Prevention:** Strategies for controlling or preventing biofilm formation include using antimicrobial coatings, improving hygiene practices, and developing treatments that disrupt the biofilm matrix or target biofilm-specific genes.

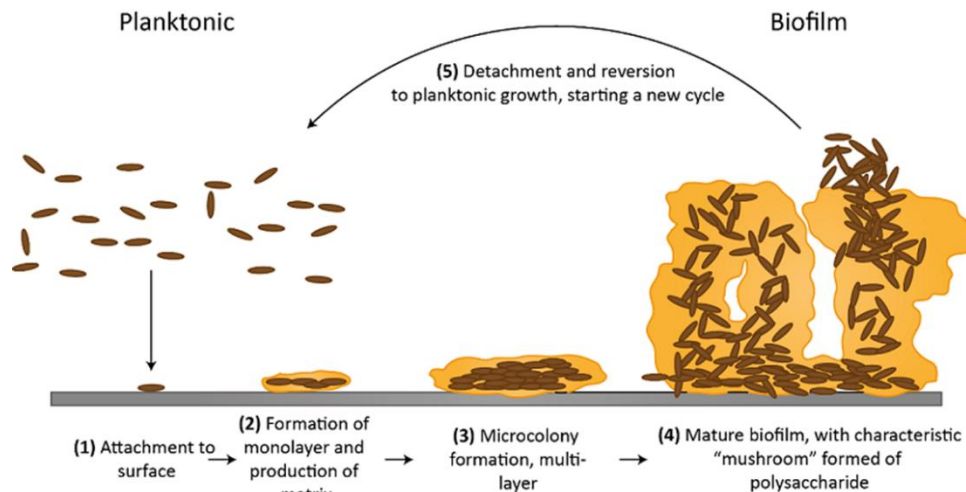


Fig.14.1

5.4.ACTINOMYCETES

Actinomycetes are a group of microorganisms that belong to the phylum Actinobacteria. They are known for their unique characteristics, including their filamentous and branching growth pattern, as well as their ability to produce a wide range of bioactive compounds. Actinomycetes play essential roles in various ecological, industrial, and medical contexts.

Actinomycetes are characterized by their filamentous and branching growth, which gives them a somewhat fungal appearance. They typically form a network of hyphae (filaments) in their growth structures. Actinomycetes are found in diverse environments, including soil, water, and aquatic sediments. They are particularly abundant in soil, where they contribute to the decomposition of organic matter.

Actinomycetes are aerobic organisms, meaning they require oxygen for growth and metabolism. They are also chemoorganotrophic, which means they obtain energy from organic compounds. One of the most notable features of actinomycetes is their ability to

produce a vast array of secondary metabolites, including antibiotics, antifungals, anticancer

agents, immunosuppressants, and enzymes.
Actinomycetes colonies on SCN agar

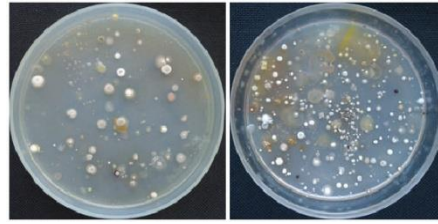


Fig.15.1.

VII.CONCLUSION

Over all the experience of this internship was very helpful to me .I got to know many additional topics .I have learnt about many of the instruments used in the bio laboratory. And also the basic things about the research , bacterial culture and also about the various bacteria's ,their growth and their specific temperature .I also got to know about the current researches going on on the topics of virology , drug discovery ,biofilms, organ on a chip and also on 3D printing. The staff were very friendly and they took us to the laboratories and taught us about the working of instruments .Totally this internshp was very useful and helpful to me .

VIII.REFERENCE

1. <https://www.bmes.org/>
2. <https://www.nibib.nih.gov/>

3. **<https://biomedical-engineering-online.biomedcentral.com/>**
4. <https://www.thermofisher.com/>
5. <https://www.agilent.com/>
6. <https://www.perkinelmer.com/>
7. <https://www.waters.com/>
8. <https://www.bio-rad.com/>

