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RESEARCH TRENDS IN SCIENCE AND TECHNOLOGY VOLUME II

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PREFACE

In the ever-evolving landscape of science and technology, knowledge is a beacon that illuminates the path to progress. The pursuit of understanding and innovation has been the driving force behind the remarkable advancements that have shaped the world we live in today. As we embark on a new era, it becomes increasingly crucial to navigate through the diverse and dynamic currents of research to discern the trends that will define our future.

"Research Trends in Science and Technology" represents a collective effort to explore and elucidate the cutting-edge developments that are shaping the fields of science and technology. This book is an assembly of insightful chapters contributed by leading experts, researchers, and visionaries, all of whom share a common passion for unraveling the mysteries of the universe and harnessing the power of technology for the betterment of humanity.

In this volume, we delve into a broad spectrum of disciplines, ranging from fundamental sciences such as physics, chemistry, and biology to the transformative fields of artificial intelligence, nanotechnology, and biotechnology. By curating a diverse selection of research trends, we aim to showcase the interdisciplinary nature of modern scientific inquiry and the interconnectedness of technological breakthroughs.

We believe that knowledge should be shared and disseminated freely, fostering a collaborative spirit that transcends geographical and disciplinary boundaries. As such, "Research Trends in Science and Technology" serves as a platform for disseminating the latest discoveries, ideas, and perspectives that shape the course of human progress.

We extend our heartfelt gratitude to all the contributors who have dedicated their expertise and passion to enrich this compilation. Their invaluable insights and visionary outlooks have made this endeavor possible.

We hope that this book will inspire readers, whether they are students, researchers, policymakers, or curious minds, to embrace the spirit of inquiry and embark on their own explorations. By staying attuned to the latest research trends and leveraging collective knowledge, we can collectively chart a course towards a more sustainable, equitable, and innovative future.

Editors

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HARNESSING THE POWER OF 2D NANOMATERIALS FOR FLEXIBLE SOLAR CELL APPLICATIONS

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Abstract:

Renewable energy technologies, particularly solar cells, have gained attention due to their potential in various applications. Graphene, a 2D nanomaterial with high electrical conductivity, carrier mobility, and mechanical flexibility, is a popular option for flexible solar cells. Other 2D nanomaterials with potential include transition metal dichalcogenides, black phosphorus, and metal-organic frameworks. The study aims to explore the synthesis, characterization, and device integration of these materials for flexible solar cell applications. By understanding light, charge carriers, and 2D nanomaterials, high-performance flexible solar cells can be optimized and designed. This study will contribute to the existing knowledge and guide future development of flexible solar cell technology.

Keywords: Nanomaterial's, Flexible solar cell, Materials, Energy.

Introduction:

The need for renewable energy sources, especially solar cells, has increased as a result of this. Wearable electronics, intelligent textiles, and mobile power generation are just some of the potential areas of application for flexible solar cells. The production process, efficiency, and adaptability of conventional materials all have their drawbacks. 2D nanomaterials have attracted attention because of their potential use in flexible solar cells due to their unusual physical and chemical properties. The transparent electrodes and charge transport layers of flexible solar cells are well suited for graphene, a thoroughly studied 2D nanomaterial. In addition to graphene, other 2D nanomaterials with great potential for flexible solar cells include transition metal dichalcogenides (TMDs), black phosphorus, and metal-organic frameworks (MOFs). Discovering more about these materials and how they might be used will pave the way for cutting-edge solar cell designs that break with convention. High-performance flexible solar cells

can be optimized and designed with a deeper knowledge of the fundamental principles driving interactions between light, charge carriers, and 2D nanomaterials.

Experimental method

The synthesis of nanomaterial's in 2D for flexible solar cells, various synthesis methods can be employed depending on the specific material. Here are general approaches for synthesizing some commonly used 2D nanomaterials:

1. **Graphene:**
    a) Mechanical Exfoliation: This method involves peeling off thin layers of graphene from a bulk graphite using adhesive tape or a sticky substrate. It produces high-quality graphene flakes but is labor-intensive and low-yield.
    b) Chemical Vapor Deposition (CVD): In CVD, a carbon-containing precursor gas (e.g., methane) is decomposed on a metal catalyst surface (e.g., copper or nickel) to grow graphene. The process allows for large-scale synthesis and control over the number of layers.
    c) Epitaxial Growth: Graphene can be synthesized through epitaxial growth on metal substrates like silicon carbide (SiC) by heating them in a controlled environment. This method provides high-quality and large-area graphene.
2. **Transition Metal Dichalcogenides (TMDs):**
    a) Chemical Vapor Deposition (CVD): TMDs like MoS2 and WS2 can be synthesized by introducing metal and sulfur precursor gases into a high-temperature furnace. The reaction leads to the formation of TMD films on a substrate.
    b) Sulfurization: In this method, a metal precursor (e.g., molybdenum or tungsten) is deposited onto a substrate, followed by heating in a sulfur-rich environment. The metal precursor reacts with sulfur to form TMDs.

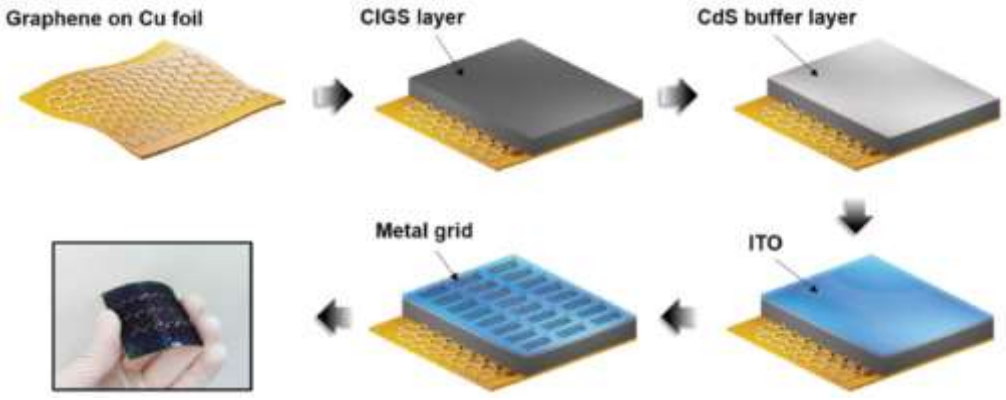

Figure 1: Flexible CIGS cell construction on a graphene/Cu substrate, depicted in schematic form

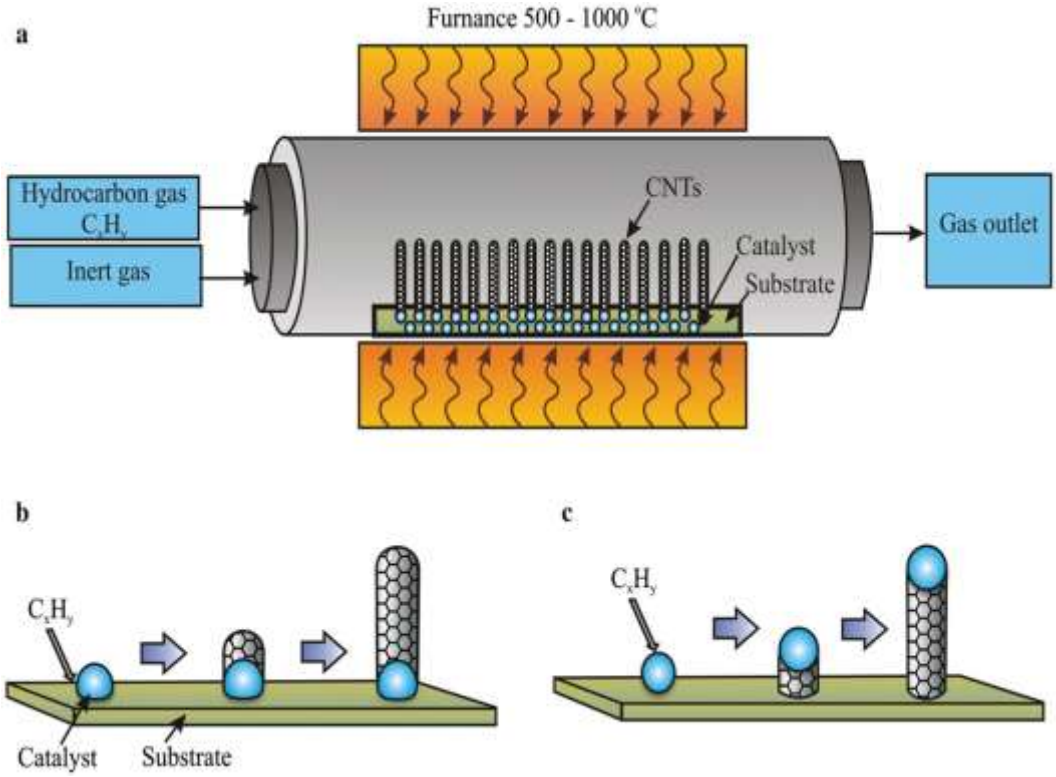

Figure 2: Chemical vapor deposition (CVD) depicted in a simplified diagram. (a). CVD reactor for CNTs production, simplified schematic; (b). basic expansion

3. **Liquid-Phase Exfoliation:** Black phosphorus can be exfoliated into thin flakes by immersing bulk black phosphorus in a solvent and applying ultrasonication or mechanical stirring. The exfoliated flakes can be collected by centrifugation or filtration.
4. **Metal-Organic Frameworks (MOFs):** MOFs can be synthesized by combining metal ions and organic ligands in a solvent under high-temperature and high-pressure conditions. The reaction promotes the self-assembly of the components into crystalline MOF structures.

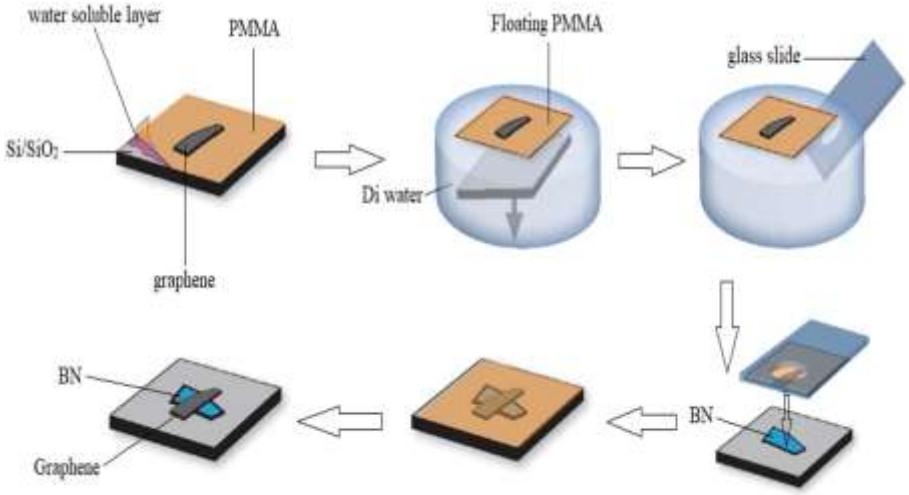

Figure 3: Mechanical Exfoliation process.

After synthesizing the 2D nanomaterials, they can be transferred onto flexible substrates to create flexible solar cells. Techniques such as drop-casting, spin-coating, or inkjet printing can be used for deposition. The flexible substrates, such as polymer films or metal foils, should be pre-treated and coated with suitable adhesion-promoting layers if required. Additionally, transparent conductive electrodes, active layers, and encapsulation layers are fabricated on the flexible substrates to complete the flexible solar cell device.

Characterization of 2D nanomaterial's

1. Structural Analysis: X-ray diffraction (XRD) can be used to determine the crystal structure and phase purity of the synthesized nanomaterials.
2. Morphological Analysis: Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) can be employed to examine the morphology, size, and distribution of the nanomaterials.
3. Chemical Composition: Techniques like X-ray photoelectron spectroscopy (XPS) or energy-dispersive X-ray spectroscopy (EDS) can be utilized to analyze the elemental composition and chemical states of the nanomaterials.
4. Optical Properties: UV-Vis spectroscopy can be performed to investigate the absorption and optical properties of the nanomaterials.

Fabrication of flexible solar cell devices

1. Substrate Preparation: Flexible substrates such as polymer films or metal foils can be cleaned, pre-treated, and coated with appropriate adhesion-promoting layers if necessary.
2. Nanomaterial Deposition: The synthesized 2D nanomaterials can be transferred onto the flexible substrates using methods like drop-casting, spin-coating, or inkjet printing.
3. Electrode Formation: Transparent conductive electrodes can be created by depositing a thin layer of materials like graphene or conducting polymers using techniques such as vacuum deposition or chemical vapor deposition.
4. Active Layer Deposition: The active layer, typically composed of a light-absorbing material like a perovskite or an organic semiconductor, can be deposited on the electrodes using techniques like spin-coating, vapor deposition, or inkjet printing.
5. Device Encapsulation: To protect the active layer and ensure long-term stability, the flexible solar cell devices can be encapsulated using suitable barrier materials and sealing techniques.

Performance characterization of flexible solar cells

1. Current-Voltage Measurements: The current-voltage (I-V) characteristics of the fabricated solar cells can be measured using a solar simulator and a source meter to

determine parameters such as short-circuit current (Isc), open-circuit voltage (Voc), fill factor (FF), and power conversion efficiency (PCE).

2. External Quantum Efficiency (EQE): The EQE measurements can be performed to analyze the spectral response and light absorption efficiency of the solar cells across a range of wavelengths.
3. Stability Testing: The long-term stability of the flexible solar cells can be evaluated by subjecting them to environmental factors such as temperature, humidity, and light exposure over extended periods.

Analysis and optimization

1. Device Characterization: Additional characterization techniques such as impedance spectroscopy, transient photocurrent/photovoltage measurements, and capacitance-voltage measurements can be employed to gain insights into the charge transport, recombination dynamics, and interface properties of the solar cells.
2. Performance Optimization: The fabrication parameters, including nanomaterial synthesis conditions, device architecture, and interface engineering, can be systematically varied and optimized to improve the overall performance and efficiency ofthe flexible solar cells.

Data analysis and interpretation

1. The collected experimental data, including I-V curves, EQE spectra, stability measurements, and additional characterization results, can be analyzed to understand the performance and behavior of the fabricated flexible solar cells.
2. Statistical analysis and comparison between different nanomaterials or device architectures can be conducted to identify trends, correlations, and potential areas for improvement.
3. Theoretical modeling and simulation studies can be performed to support the experimental findings and gain further insights into the underlying mechanisms governing the device operation.

Result and Discussion:

The experimental results and analysis should be summarized, highlighting the performance achievements, limitations, and potential future directions. The obtained findings can be compared with existing literature and discussed in the context of previous research on nanomaterials in 2D for flexible solar cell applications. Key challenges, unresolved issues, and potential strategies for further enhancing the efficiency, stability, and scalability of the flexible solar cells can be identified and discussed. It is important to note that the specific experimental

methods and techniques may vary depending on the chosen nanomaterials, solar cell architecture, and research objectives. Therefore, it is recommended to adapt and optimize the experimental procedures according to the specific requirements of the study.

Conclusion:

In this study, the authors investigate the feasibility of using 2D nanomaterials in flexible solar cells. Transparent electrodes and charge transport layers that use graphene, TMDs, black phosphorus, and metal-organic frameworks (MOFs) have showed promise. The light they absorb is very efficient, and they may be used with flexible substrates. Black phosphorus's high charge carrier mobility and tunability make it a promising material for use in flexible solar cells. Flexible solar cell devices made from these nanomaterials have been successfully fabricated employing processes including deposition and device encapsulation. Efficiency, spectrum responsiveness, and durability can be gleaned from performance characterization techniques such current-voltage measurements, external quantum efficiency analysis, and stability testing. To improve performance and efficiency, however, it is necessary to refine synthesis techniques, interface engineering, and device topologies. Flexible solar cell technologies that are efficient, sustainable, and commercially feasible are within reach thanks to ongoing research and development.

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RENEWABLE ENERGY TECHNOLOGIES USED IN INDIA

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Abstract:

Technologies for producing energy from renewable sources have become an essential part of India's energy mix, helping to achieve the nation's goals for sustainable development while reducing the negative consequences of climate change. This abstract offers a summary of renewable energy technologies in India, emphasizing their importance, present state, and potential in the future.

Keywords: Renewable energy, India, Solar energy, Wind energy, Hydroelectric power, Biomass energy, Geothermal energy, Challenges.

Introduction:

According to the Energy Policy Act of 2005, renewable energy is defined as "Electric energy generated from solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), geothermal, municipal solid waste, or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project." The technologies listed here are in line with this definition.

How does solar system integration work? What is it? In order to integrate solar systems into the electrical grid while retaining grid efficiency, security, and dependability, technologies and techniques must be developed. India's energy sector has shifted its focus to renewable energy technology as it works to meet its increasing energy needs, lessen its reliance on fossil fuels, and combat climate change. India has set out on an ambitious quest to greatly boost the deployment of renewable energy sources as part of its commitment to sustainable development. An overview of the significance of renewable energy technologies in India is given in this introduction, together with information on the country's initiatives to encourage their use and the advantages they may provide. India, one of the most populated nations on earth with a developing economy, faces a major energy crisis. A wide and dependable energy mix is necessary to meet the

population's energy needs and maintain economic growth. India has traditionally relied largely on fossil fuels, especially coal, to meet its energy needs. However, this reliance has aided in air pollution, greenhouse gas emissions, and environmental damage, prompting a shift to cleaner and more sustainable energy sources.

Technologies utilizing renewable energy provide a workable answer to these problems. Solar, Wind, Hydro, Biomass, and Geothermal energy are just a few of the numerous renewable energy sources available in India. Utilizing these resources can increase energy security, lower carbon emissions, and generate new job opportunities in addition to offering a clean and sustainable energy supply.

A] Solar energy technologies used in India:

India has seen a strong uptake in solar energy technologies as it works to harness its plentiful solar resources and promote clean and sustainable energy sources. In India, a variety of solar technologies are being used to harness the energy of the sun and produce electricity. Some of the main solar energy technologies in use in India are as follows:

1] Solar Photovoltaic (PV) systems: The most extensively used solar energy technology in India is solar PV. It includes employing solar panels made of photovoltaic cells to convert sunlight directly into electricity. When exposed to sunlight, these cells produce an electric current that can be utilized for a variety of tasks, such as grid-connected power generation, off-grid electrification, and solar pumping for agricultural uses. Solar PV installations, including both rooftop and utility-scale solar power systems, have increased significantly in India.

2] Concentrated Solar Power (CSP): In CSP technology, sunlight is focused onto a receiver by means of mirrors or lenses, which then transfers heat to a working fluid. A steam turbine or other heat engine uses this heat to produce power. Although India has comparatively few CSP installations compared to solar PV, the nation has started programmes to investigate and utilize the technology's potential. With the integration of CSP with thermal energy storage, electricity may be produced even when there is no sunlight, ensuring grid stability and dispatch able power.

3] Solar thermal systems: The main goal of solar thermal technology is to collect solar energy and use it for heating. This includes solar water heating systems, which use heat from the sun that is absorbed by solar collectors to warm water for use in household, commercial, and industrial applications. In India, solar thermal systems are highly common, notably for heating water in homes, hotels, and businesses. They assist lessen reliance on fossil fuels by providing a more energy-efficient alternative to traditional water heating techniques.

4] Floating solar power plants: India has embraced the concept of floating solar power plants thanks to its extensive network of water bodies, including lakes, reservoirs, and canals. Solar

panels are installed on floating structures in these installations, usually on water surfaces. Due to the cooling effect of water, floating solar plants have an increased energy output and require less area than conventional solar farms. India has put in place a number of floating solar projects, including Kerala's installation of the largest floating solar power plant in the world.

5] Solar-powered irrigation systems: Solar energy is used in rural agricultural areas to power irrigation systems. There is no need for grid electricity or diesel generators because solar pumps are utilized to extract water from wells, rivers, or canals. Solar-powered irrigation systems enable higher agricultural productivity and lessen reliance on traditional energy sources by giving farmers dependable access to water for irrigation.

B] Wind energy technologies used in India:

India has seen substantial growth and development in wind energy technologies, making it one of the top nations in terms of installed wind power capacity. The nation uses a variety of wind energy technology to harness the energy of the wind and produce electricity. Several of the main wind energy innovations employed in India are listed below:

1] Onshore wind turbines: In India, onshore wind turbines are the most prevalent and commonly used wind energy technique. Large rotor blades are used in these turbines to catch the wind's kinetic energy and turn it into rotational motion. A generator located inside the turbine subsequently converts the motion into power. In areas with good wind conditions, like coastal areas, hilly terrains, and broad plains, onshore wind farms are often created. India has a large number of onshore wind farms spread across many states, which considerably increases its wind energy capacity.

2] Offshore wind turbines: In India, offshore wind energy is a developing technology. Utilizing the stronger and more reliable offshore winds, offshore wind turbines are erected in coastal seas. Compared to onshore turbines, these turbines are often larger in size and produce more electricity. Pilot projects are now ongoing as part of India's efforts to investigate and exploit its offshore wind potential. India's future use of renewable energy is anticipated to be significantly influenced by offshore wind energy, which will add to the country's clean energy production potential.

3] Hybrid wind-solar systems: In India, hybrid energy systems that combine solar and wind energy have attracted interest. These systems combine solar panels and wind turbines into one project, maximizing energy production and utilizing resources to the fullest potential. Due to the fact that wind and solar resources frequently complement one another, hybrid systems that use both of them can provide power more steadily and consistently. In India, hybrid wind-solar

projects are being constructed, adding to the country's diverse and well-balanced mix of renewable energy.

4] Repowering of wind farms: Repowering entails replacing or changing out older, less effective wind turbines for more modern, more sophisticated models. Repowering makes use of the existing grid connections and infrastructure to boost energy generation capacity while also improving efficiency. Repowering operations are being carried out to improve the performance of India's numerous older wind turbines and maximize the use of wind resources. Repowering wind farms results in higher wind energy output overall and uses less land than new installations.

5] Distributed wind power: Smaller wind turbines positioned close to energy consumption points, such as industrial, commercial, or residential structures, are referred to as distributed wind power. These turbines are frequently employed to satisfy local electricity demand or balance off certain sites' energy usage. The benefit of distributed wind power is decentralized generation, which lowers transmission losses and encourages energy independence. Distributed wind power systems are being used in India in a number of industries, including agricultural applications, rural electrification, and decentralized power generation for remote places.

C] Hydro power energy technologies used in India:

India has historically used hydropower energy technology to harness the power of moving water and produce electricity. The nation's wide variety of rivers, streams, and water resources make it ideal for the implementation of several hydro generating methods. Some of the main hydropower energy technologies employed in India includes the following:

1] Large-scale hydroelectric power plants: Large-scale hydroelectric power facilities are constructed on rivers and produce energy by harnessing the force of moving water. The majority of these facilities are made up of dams that build reservoirs to store water, which is subsequently released through turbines to generate energy. India has created numerous sizable hydroelectric projects, including the Sardar Sarovar Dam in Gujarat and the Tehri Dam in Uttarakhand. These initiatives greatly increase India's ability to produce electricity and offer a consistent and dependable supply of power.

2] Small-scale hydroelectric power plants: Small-scale or tiny hydroelectric power plants are built on rivers or streams with lower water flow rates and are intended for reduced capacity generating. In particular, these plants are more suited for decentralized power generation in remote or hilly places. Small hydro projects have been created throughout India to fulfil regional electrification needs while utilizing the power of local water resources. These initiatives frequently have fewer negative effects on the environment and offer chances for community involvement.

3] Pumped storage hydroelectric power plants: Hydroelectric power facilities with pumped storage have two reservoirs that are at various altitudes. Water is pumped from the lower reservoir to the upper reservoir when there is little demand for energy. When there is a strong demand for energy, water from the higher reservoir is discharged through turbines to produce electricity. Pumped storage systems are used to store energy, stabilize grids, and balance sporadic renewable energy sources. The Koyna Hydroelectric Project in Maharashtra is one of a few pumped storage projects in India.

4] Run-of-the-river hydroelectric power plants: Large dams and reservoirs are not built for run-of-the-river hydroelectric power plants. Instead, these facilities redirect some of the river's flow via a penstock or canal, where it subsequently goes through turbines to produce energy. Run-of-the-river projects allow for continuous water flow downstream, which has a lower environmental impact than massive dams. These initiatives are useful for rivers with a steady flow and are frequently used in hilly areas. The Nathpa Jhakri Hydroelectric Power Station in Himachal Pradesh is one of many run-of-the-river hydroelectric plants in India.

5] Micro and pico hydro power systems: Small-scale hydroelectric facilities called micro and pico hydro power systems are intended for off-grid or rural sites. Pico hydro systems are even smaller, typically producing less than 5 kilowatts of power, whereas micro hydro systems typically have a capacity between a few and several hundred kilowatts. In rural areas with poor grid connectivity, agricultural operations, and remote locations, these systems offer electricity. Many locations in India have installed micro and pico hydro systems, notably in steep and hilly terrain.

D] Biomass energy technologies used in India:

India uses a lot of biomass energy technologies to turn organic waste into useful energy sources, offering a sustainable and renewable energy alternative. India has been able to utilise a variety of biomass energy methods thanks to its sizable agricultural industry and plentiful biomass supplies. Some of the main biomass energy methods employed in India includes the following:

1] Biomass power plants: Burning biomass feedstocks such agricultural waste, crop waste, forestry waste, and special energy crops, biomass power plants produce electricity. Typically, biomass is used in these power plants' boilers as the fuel source, which generates high-pressure steam that powers turbines attached to electrical generators. By utilizing locally accessible biomass resources for electricity production, biomass power plants play a critical role in India's renewable energy sector, particularly in rural areas.

2] Biogas plants: Anaerobic digestion of organic materials, such as animal manure, agricultural waste, and organic kitchen waste, is a key component of biogas technology. Methane and carbon

dioxide are combined to create biogas, a clean fuel that can be used for energy production, heating, and cooking. In India, biogas facilities, often referred to as digesters, are widely used, especially in rural regions. These facilities offer a practical method for handling organic waste while supplying renewable energy for home and small-scale industrial uses.

3] Biomass gasification: Syngas, a combustible gas, is produced from solid biomass feedstocks using biomass gasification technology. This gas has a number of uses, including the manufacture of biofuels, thermal heating, and power. In order to create a gas that is high in hydrogen and carbon monoxide, biomass is partially burned in a controlled environment during the process of gasification. India has put biomass gasification projects into action, primarily for decentralized power generation and giving distant and off-grid areas access to electricity.

4] Biomass cookstoves: Cooking with biomass fuels like wood, agricultural waste, and cow dung is efficient and healthy thanks to biomass cookstoves, which are especially widespread in rural areas. In India, improved biomass cookstoves are being marketed to address indoor air pollution, health issues, and fuel consumption. These cookstoves are made with better combustion efficiency and lower emissions. These cookstoves aid in the preservation of biomass resources and lessen the environmental damage caused by conventional cooking techniques.

5] Biomass briquetting: Using biomass briquetting technology, loose biomass leftovers are transformed into compact, homogenous briquettes that may be utilised as a solid fuel for industrial processes like heating and cooking. Without the use of binders or chemicals, biomass resources are compressed under high pressure to create biomass briquettes. Utilising biomass residues effectively and efficiently is made possible by this method. In India, biomass briquetting has gained popularity as a way to reduce biomass waste and encourage the use of renewable energy sources.

E] Geothermal energy technologies used in India:

Earth's internal heat and hot water are converted into geothermal energy. Several sources, whether on or near the surface or thousands of feet below it, can be used to access geothermal resources. Geothermal systems transport heat away from these areas to places where it may be utilised for thermal or electrical energy production more effectively. The following three uses of geothermal energy are typical:

1] In place of ambient air, geothermal heat pumps employ the ground, groundwater, or surface water as a heat source and heat sink. The typical temperature range for resources is 40° to 100°F (4° to 38°C).

2] Direct-use application systems employ hot water to directly heat or cool a place. Low- to moderate-temperature hydrothermal resources respond best to this method.

3] Geothermal power plants that use steam and binary use the heat from geothermal resources to power turbines to generate electricity.

India has been actively exploring and utilizing geothermal energy technologies to harness its vast geothermal resources. Although the development of geothermal energy in India is still in its early stages, several initiatives and projects have been undertaken. Here is some of the geothermal energy technologies used or being explored in India:

1] **Direct use**: Geothermal energy is used directly for various applications such as space heating, industrial processes, and agricultural activities. In India, direct use of geothermal energy is primarily focused on hot springs and geothermal wells. The water from hot springs is utilized for bathing, therapeutic purposes, and tourism.

2] Geothermal power generation: India has been making efforts to use its geothermal resources to produce electricity. The Puga Valley in Ladakh, Tattapani in Chhattisgarh, and Manikaran in Himachal Pradesh are just a few of the geothermal provinces that the nation has identified as having great potential. Drilling wells to gain access to heated subterranean reservoirs and using the heat to generate electricity using different technologies including binary cycle, flash steam, and organic Rankine cycle systems are all part of the development of geothermal power plants.

3] Enhanced Geothermal Systems (EGS): Additionally, India is investigating the possibilities of enhanced geothermal systems, which entail the construction of artificial geothermal reservoirs in regions with limited access to natural heat sources. EGS uses deep wells that are drilled and water injection to fracture hot rock formations. The water is then forced into the fissures, where it absorbs heat and creates steam that is used to generate power.

4] Geothermal heating and cooling systems: In India, geothermal heat pumps are being used more and more for heating and cooling. These systems offer effective cooling during the summer and heating during the winter by taking use of the ground's constant temperature. Buildings that are residential, commercial, or institutional can use geothermal heat pumps.

5] Geothermal research and development: Geothermal research and development is a major focus for the Indian government, academic institutions, and private businesses. To harness geothermal energy, these initiatives involve resource evaluation, feasibility studies, exploration, drilling techniques, and technological development efficiently and sustainably.

F] Challenges in renewable energy technologies in India

While renewable energy technologies offer numerous benefits, there are several challenges that need to be addressed for their widespread adoption and efficient integration into the energy system. Here are some of the key challenges in renewable energy technologies:

1] Cost and economic viability: In comparison to more traditional, fossil fuel-based technologies, the upfront expenses of renewable energy sources, such as solar panels and wind turbines, can be higher. Although costs have decreased over time, the initial expenditure might still be a challenge, particularly for developing nations. For some renewable energy sources, achieving economic viability and cost parity with alternatives to fossil fuels is still a challenge.

2] Intermittency and grid integration: Many renewable energy sources, like solar and wind, are intermittent, which means that the weather affects when they are available. The erratic nature of the electricity supply from renewable sources makes grid integration and stability difficult. To guarantee a dependable and consistent power supply, effective grid management, energy storage options, and cutting-edge forecasting methodologies are required.

3] Limited grid infrastructure: In order to handle the increasing generation capacity and allow the transmission of electricity, the expansion of renewable energy requires a sufficient and durable grid infrastructure. It can be difficult to connect renewable energy projects to the grid in many areas, especially in isolated or rural ones, where the current grid infrastructure may be insufficient or nonexistent.

4] Land and resource constraints: Large-scale solar and wind farms, for example, need a lot of land to be installed in order to function. Finding ideal places for renewable energy projects can be difficult in nations or areas with a shortage of available land. The availability of other resources, such as water for hydropower or biomass feedstock for bioenergy, may also be limited.

5] Policy and regulatory framework: The adoption of renewable energy technology may be hampered by a lack of enabling policies and inconsistent regulatory frameworks. To foster an environment that is favourable for investment and market expansion, clear and consistent rules are essential. These include feed-in tariffs, tax incentives, and renewable energy targets. For the private sector to participate, it is crucial to guarantee policy stability and overcome administrative barriers.

6] Environmental considerations: Even though renewable energy sources are typically seen as ecologically favourable; some technologies nonetheless might have an effect. Large hydropower projects, for instance, have the potential to destroy habitat and change river ecosystems, while biomass energy production raises questions about the sustainability of the feedstock supply. The task of balancing the use of renewable energy with environmental preservation and avoiding potential ecological repercussions requires careful attention.

7] Skill development and workforce transition: Even though renewable energy sources are often considered to be environmentally friendly, certain technologies may nevertheless have an

impact. Large hydropower projects, for example, have the potential to alter river ecosystems and damage habitat, and the production of biomass energy raises concerns about the sustainability of the feedstock supply. Careful consideration must be given to the challenge of balancing the usage of renewable energy with environmental preservation and avoiding potential ecological consequences.

Addressing these challenges requires a multi-faceted approach involving technological advancements, supportive policies, market mechanisms, and international collaborations. Continued research and innovation, along with government support and public awareness, are crucial for overcoming these challenges and realizing the full potential of renewable energy technologies. It's crucial to remember that India's renewable energy sector is continually evolving thanks to the introduction of cutting-edge innovations and technologies. Because of the government's emphasis on this type of energy and its pro-green policies, which have allowed for enormous growth in the industry, India is currently one of the top countries for the deployment of renewable energy. To encourage the development of renewable energy technology, the Indian government has implemented a number of policies and incentives, including financial support, tax cuts, and regulatory frameworks. Partnerships with international organizations and support from various stakeholders have helped to advance the nation's use of renewable energy.

Conclusion:

In conclusion, renewable energy technologies are essential to India's goals for energy security and sustainable development. A favorable climate for the acceptance and spread of solar, wind, hydro, biomass, and geothermal energy is created in the nation by the abundance of renewable resources, supported by innovative policies, and geothermal energy. India can lower its carbon footprint, improve energy availability, and support international efforts to address climate change by making the transition to a cleaner, more sustainable energy future.

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CERVICAL CANCER AND ITS TREATMENT STRATEGIES

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Abstract:

Cancer is caused by a complex and poorly understood combination of genetic and environmental factors. It is still the world's greatest cause of death, killing almost 6 million people each year. Cervical cancer is a disorder in which healthy cells on the cervix's surface alter, grow out of control, and create a mass of cells known as a tumour. The triggering factors include, HPV Infection, immune system, genetic factors and socio-economic factors. Cervical cancer treatment is determined by a number of criteria, including the type and stage of the cancer, the size of the tumour, potential adverse effects, and the patient's overall health. Here we focus on the treatment strategies including surgery, radiation therapy, chemotherapy, targeted therapy against cervical cancer. Moreover, immunotherapy, a type of biologic therapy, is becoming popular and helps the body's natural defences fight cancer.

Introduction:

The abnormal proliferation of cells in our body that can lead to death is known as cancer. Normal cells are generally invaded and destroyed by cancer cells. Cancer is a fatal illness that can attack anyone at any age and in any section of the body. Cancer is caused by a complex and poorly understood combination of genetic and environmental factors. It is still the world's greatest cause of death, killing almost 6 million people each year. Around 3500 persons per million dies from cancer each year around the world [1–4].

Humans and animals both benefit from the presence of the plant kingdom. India is the world's greatest producer of medicinal plants and is appropriately known as the "World's Botanical Garden." Medicinal plants are estimated to number over 8000 species, accounting for almost half of all higher flowering plant species in India. To put it another way, there are around 400 families [1].

Types of Cancer

Based on where cancer starts, there are four main varieties.

- **Carcinomas:** Carcinoma is a cancer that begins the skin or tissue covers the exterior surfaces of internal organs and glands and progresses to solid tumours. Cervical and prostate cancers are examples of carcinomas.
- **Sarcomas:** Sarcomas are cancers that form in the body's supporting and connecting tissues, such as fat, muscle, lymph vessels, bone, joints, and blood vessels.
- **Leukaemia's:** it is blood cancer that arises when healthy blood cells begin to change and multiply in an uncontrollable manner. Acute and chronic lymphocytic leukaemia, acute and chronic myeloid leukaemia,
- **Lymphomas:** Lymphoma is a cancer that starts in the lymphatic system and spreads to other parts of the body. It included Hodgkin lymphoma and non-Hodgkin lymphoma.

Risk factors for cancer

- Use of tobacco.
- Abuse of alcohol.
- Aging
- Ancestral history
- Dietary factors, such as a lack of fruits and vegetables.
- Obesity and being overweight
- Physical immobility.
- Exposure to a certain chemical
- Chronic infections with *Helicobacter pylori*, hepatitis B and C viruses, and certain kinds of human papillomavirus (HPV).
- Ionizing and non-ionizing radiation, as well as other environmental and occupational hazard [2-5].

Cervical cancer

The cervix is the lowest, thin portion of the uterus that links to the vagina and creates the birth canal with the vagina. Cervical cancer is a disorder in which healthy cells on the cervix's surface alter, grow out of control, and create a mass of cells known as a tumour. Cervical dysplasia is a period in which the alterations in the cells are aberrant but not precancerous. Cervical cancer occurs when precancerous cells transform into cancer cells and spread further into the cervix or other tissues and organs. Cervical cancer is the third most malignancy among women globally, behind breast and colorectal cancers, with an anticipated 5,70,000 women diagnosed with the disease and 3,11,000 fatalities recorded by 2018, and a projected 6,04,127 women diagnosed with the disease and 3,41,831 women dying by 2020 [5,6].

HPV is a family of sexually transmitted viruses that causes 90% of cervical cancer in women by the age of 45. The majority of cervical cancer cases are caused by HPV infection, with HPV-16 and HPV-18 being the most carcinogenic subtypes, accounting for nearly 50% and 10% of cases, respectively [7].

Types of cervical cancer

Cervical cancer is divided into two categories based on the type of cell in which it begins.

- **Squamous cell carcinoma:** These tumours begin in the cells that line the cervix's outer surface, accounting for 80 % to 90 % of all cervical malignancies.
- **Adenocarcinoma:** These tumours begin cells that line the lower birth canal in the interior region of the cervix, accounting for 10% to 20% of all cervical cancers [8,9].

Symptoms:

Precancerous cells do not cause any symptoms; however early-stage cervical cancer is when symptoms do arise. The severity of the symptoms increases when the cancer spreads to other places of the body. A symptom could potentially be caused by a medical disease other than cancer. The following are the signs of cervical cancer that have been observed:

- Blood splotches
- Menstrual bleeding
- Increased vaginal discharge.
- Pain during a sexual encounter
- Bleeding following menopause
- Unknown cause of recurrent pelvic and/or back discomfort [10-12].

Triggering factors of cervical cancer

The triggering factors that contribute to the development of cervical cancer are as follows:

- **HPV infection:** The most major risk factor for cervical cancer is human papillomavirus infection. There are 100 distinct varieties of HPV. Cervical cancer is most commonly related with HPV16 and HPV18 strains. Sex at a young age or having several sex partners are both high risk factors for HPV infection.
- **Immune system deficiency:** Immune system deficiency caused by corticosteroid therapy and organ transplantation increases the risk of getting cervical cancer. Due to a weakened immune system, the human immunodeficiency virus, which causes acquired immune deficiency virus, has the potential to cause cervical cancer.
- **Herpes:** Women who have a genetic herpes problem are more likely to get cervical cancer.

- **Smoking:** Women who smoke on a regular basis are twice as likely as women who do not smoke to acquire cervical cancer.
- **Age:** Cervical cancer rarely develops in women under the age of 20. Between the ages of late teenage years and mid-30s, the risk increases. Women over the age of 50 are still at risk of acquiring cervical cancer and should be screened on a regular basis.
- **Socioeconomic factors:** Women who do not have access to cervical cancer screening are more likely to get the disease.
- **Oral contraceptives:** it an often known as birth control pills, have been linked to an increased risk of cervical cancer.
- **Diethylstilbesterol exposure:** Women who are exposed to diethylstilbesterol are at an increased risk of acquiring cervical cancer [13-16].

Diagnosis:

The process of diagnosing an illness, condition, or injury based on its indications and symptoms is known as diagnosis. Early detection of cancer frequently results in the best chance of a cure. The following factors are taken into account when selecting a diagnostic test:

- Results of earlier medical tests
- Suspected cancer type
- Age and general health
- Signs and symptoms.

Cervical cancer is diagnosed using the following tests:

- **Pap test:** During this test, the examiner scrapes the outside and inside of the cervix, collecting cell samples for examination. Because the cells can be coated by mucous or blood, dried out, or cluster together on the slide, traditional Pap tests can be difficult to diagnose. Improved Pap tests have made detecting malignant cells much easier.
    - After removing blood and mucus, the liquid-based cytology test ThinPrep or SurePath deposits a thin layer of cells onto the slide.
    - AutoPap is a type of computer screening that employs a computer to scan a sample for malignant cells.
- **HPV test:** HPV testing is done on cells obtained from the cervix and vagina, the same test sample as Pap testing. The sample is used to screen for the presence of HPV strains related to the development of cervical cancer.
- **Visual inspection with acetic acid (VIA):** The VIA screening test is simple and clear to perform with just a few tools and the naked eye. A dilution of white vinegar is

administered to the cervix in this procedure, and abnormalities that turn white when exposed to vinegar are screened.

- **Bimanual pelvic examination and sterile speculum examination:** In this diagnostic, the patient's cervix, uterus, vagina, ovaries, and other adjacent organs are evaluated for any abnormalities. The doctor uses a speculum to keep the vaginal walls open and screens within the vagina to see the cervix and check for any external changes to the vulva.
- **Colposcopy:** Colposcopy is a screening technique that employs a colposcope to magnify cervix and vaginal cells in the same way that a microscope does. It is comparable to a speculum examination in that it provides an illuminated and magnified image of the vaginal and cervix tissues.
- **Biopsy:** Biopsy is a procedure that involves the removal of a small amount of tissue for examination under a microscope in order to make a definitive diagnosis. After the biopsy, there may be some bleeding and other discharges that produce discomfort comparable to menstrual cramps. There are numerous sorts of biopsies; one popular way is to use a tool to pinch off small bits of cervical tissue. Other types include:
    - **Endocervical curettage (ECC):** It's used when there's a need to check an area inside the cervix's entrance that can't be screened during a colposcopy. In this examination, a spoon-shaped device called a curette scrapes a little piece of tissue from inside the cervical aperture.
    - **LEEP:** An electric current was supplied through a fine wire hook that was used to extract tissues for laboratory testing.
    - **Conization (a cone biopsy):** A cone-shaped portion of tissue from the cervix is removed for examination.
- **Pelvic examination under anaesthesia:** This procedure involves re-examining the pelvic area while the patient is sedated to check for cancer spread to other organs such as the uterus, vagina, bladder, or rectum.
- **CT scan:** A CT scan uses X-rays from various angles to acquire photographs of the inside of the body, which are then combined into a detailed, 3-dimensional image that displays any abnormalities or tumours, as well as their size.
- **Magnetic resonance imaging (MRI):** An MRI employs a magnetic field to provide detailed images of the body, which can be used to determine the size of a tumour [17-19].

Cervical cancer stages:

Table 1: Various stages of cervical cancer

Stage	Description
I	Cancer has spread from cervix lining deeper tissue, but it still presents in the uterus and has not moved to other regions body stage.
II	Cancer has spread to neighbouring locations such as the vaginal area or tissues around the cervix, but still contained inside the pelvic area.
III	The tumour spread to the pelvic wall and has affected the bottom third of the vaginal wall.
IV	The cancer has spread throughout the body, including the bladder, rectum, and other organs.

Treatment for cervical cancer

Cervical cancer treatment determined by a number of criteria, including the type and stage of the cancer, the size of the tumour, potential adverse effects, and the patient's overall health. Surgery, radiation therapy, chemotherapy, or a combination of one or two techniques are among the treatment methods.

Surgery

During a surgery, the tumour and some healthy tissue surrounding the tumour are removed. The surgical procedure includes

- Conization.
- Radical Trachelectomy
- Total Hysterectomy.
- Radical Hysterectomy:
- Bilateral Salpingo-Oophorectomy
- Pelvic exenteration

Radiation therapy

Radiation therapy can be used instead of or after surgery to eliminate any cancer cells that remain in the area in the early stages of cervical cancer. High-energy rays are used in radiation therapy to eliminate cancer cells. Only the cells in the treated area are affected. Radiation therapy is utilised in a variety of ways.

- **External radiation Therapy:** Radiation is directed at the pelvis or other regions where the cancer has spread using a big equipment.

- **Internal Radiation Therapy:** A radioactive material is loaded into a tiny tube that is inserted into the vagina.

Systemic therapy

Systemic treatment is the employment of drugs to kill cancer cells. This treatment is given intravenously to reach cancer cells all across the body. An intravenous tube is inserted into a vein using a needle, or it can be taken orally as a pill or capsule. Systemic medicines used to treat cervical cancer: Chemotherapy, Targeted therapy and Immunotherapy.

These therapies can be used alone, in combination with surgery and radiation, or as part of a combinational treatment plan.

Chemotherapy

Chemotherapy is the use of chemicals to kill cancer cells and prevent them from multiplying. A patient may receive one medicine at a time or a mixture of pharmaceuticals given at the same time for a predetermined amount of time in this therapy. Intravenously given medicines are used to treat cervical cancer.

- Cisplatin, Paclitaxel, and Carboplatin are single-agent chemotherapy drugs that are frequently administered in combination with radiation therapy.
- In the treatment of advanced or recurrent cervical cancer, platinum-based chemotherapy, such as cisplatin / paclitaxel, carboplatin / paclitaxel, or topotecan / paclitaxel in conjunction with bevacizumab, is employed.

Adverse effects of chemotherapy

Chemotherapy adverse effects vary depending on the individual and the dose administered, and they last for the duration of treatment.

- Chemotherapy reduces the number of healthy blood cells in the body, making Infections are more common, and bruising and bleeding, as well as weariness and weakness, are more likely.
- Hearing loss and renal damage are unusual side effects of some medications.
- Hair loss, nausea and vomiting, exhaustion, diarrhoea, and mouth and lip sores are among symptoms [20-23].

Table 2: Cervical Cancer Drugs that have been Approved

Approved Chemopreventive drugs	Approved Chemotherapeutic drugs	Drug Combinations
1. Cervarix 2. Gardasil 9 3. Gardasil 4. Recombinant Papillomavirus Nonavalent Vaccine 5. Recombinant Human Papillomavirus Quadrivalent Vaccine 6. Recombinant Human Papillomavirus Bivalent Vaccine	1. Avastin (Bevacizumab) 2. Bevacizumab 3. Bleomycin Sulfate 4. Hycamtin (Topotecan Hydrochloride) 5. Keytruda (Pembrolizumab) 6. Mvasi (Bevacizumab) 7. Pembrolizumab 8. Tisotumab Vedotin-tftv 9. Tivdak (Tisotumab Vedotin-tftv) 10. Topotecan Hydrochloride 11. Zirabev (Bevacizumab)	1. Carboplatin-Taxol 2. Gemcitabine-Cisplatin

Targeted therapy:

In this treatment focuses on the genes, proteins, and tissues that are important in cancer development and survival, stopping cancer cells from spreading and harming healthy cells. With platinum-based chemotherapy combined with the targeted medication Bevacizumab (Avastin).

- Bevacizumab-awwb (Mvasi) and Bevacizumab-bvzr (Zirabev), two more medications that are comparable to Bevacizumab, have been approved by the FDA to treat cervical cancer.

Immunotherapy:

Immunotherapy is a type of biologic therapy that helps the body's natural defences fight cancer.

- The immune checkpoint inhibitor pembrolizumab (Keytruda) is used to treat cervical cancer.
- Skin rashes, flu-like symptoms, diarrhoea, and weight fluctuations are all common immunotherapy adverse effects [23].

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ECONOMIC GROWTH AND LITERCY IN INDIA

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Abstract:

In India there are so many problems like Unemployment, poverty, and unequal distribution of wealth. Low literacy rate can face all these problems. Further literacy reduces the economic and inequality and reduce the income disparity, which India faces today. This chapter attempts to study on economic growth and literacy in India which are related to each other. Literacy rate is one of the key indicators of the economic situation in a country as increased literacy rate leads to enhancement of a country's human capital. Increased literacy rate also leads to decreased pollution growth.

Keywords: Economic growth (GDP), Literacy rate, Human Resource.

Introduction:

India occupies second rank among the world's populated countries. However, age group 15 -64 is considered 65% population and 30% of population under the age of 15, India's population is very young. When literacy rate of India is increased its impact on increasing growth rate increasing the economy of country and decreasing the population growth. Literacy rate increases there is need to create jobs. Strong policies to create the employment. Today, India faces the unemployment problems, if strong and effective measures to create employment are not taken then increase in the labor problem.

This chapter attempts to study the relationship between the literacy, economy growth, population growth and GDP.

Research methodology:

Study of data divided in following parts, the main part is important of literacy in economy growth, Second effect of literacy on population growth and effect of literacy on GDP. Data collected from online sources.

Economy growth and literacy

For economy growth literacy is important key. Economic resources are economic property and economic property is human resource. By increasing the literacy rate of a population enhanced the population, its growth rate, skills, living standard and the working

capacity of labor force. Thus, economic growth of country depends on the literacy rate. Effective utilization of human resources becomes very important for economic progress of the country. Thus, our country growth the literacy rate plays a very important growth.

Importantace of literacy in India's economic growth

Economic growth (GDP) and the population growth (TFR) are strongly correlated with each other and thus increase literacy rate will leads to an increased level of GDP and same time maintains of population growth. India is a much diversified country socially; there lie key challenges which have to be given their due priority as these are the potentially decisive areas of improvement. The most important of human resources of India is its working population. The low rate female working population is one of indicators of human capital being underutilized in India.

Even though India is now becoming an industrial economy, majority of people living rural area there is dividation of population in urban area and rural area. Main source of income is by and large only agricultural sector. Agricultural contribution in GDP is low as compared to urban area. This can be seen due to low literacy rate. So the urban –rural income gap is another challenge in India. This can be done inclusive growth in agricultural sector, handloom sector and micro industrial sector. India has huge diversity culture, language and genetics. Indian society has been classified in to scheduled caste, scheduled tribe and backward class. Scheduled caste and scheduled tribe (SC/ST) population are generally with lower literacy level. So, the per capital income is lower as compare to the national average. This population has to given special attention to increase literacy rate and providing job.

Challenges to literacy and solutions in it

A country with the highest growth rate in the number of engineers produced also has the maximum school dropouts. This is one of the stark contrasts of the Indian education system. Many children, mostly in the rural areas, have no access to schools at all. A survey conducted by EEA shows that 25% of teachers in government schools will absent on any given day and only 50% are actively engaged in teaching. Infrastructure of government schools remains one of the main deterrents from educating the improvised children across the rural and urban India. Most of the government schools lack basic amenities like a black board in a class and toilet for the school. All these factors have contributed to the sluggish growth of literacy in India. This can be seen from the fact that though literacy rate was always on the rise in India, the number of illiterates was never on decline due to the population growth rate being more than the literacy growth rate.

But there have been positives in the literacy growth story of India. Schemes such as Sarve Siksha Abhiyan and National Literacy Mission have brought in a lot of development across the government schools in India. The mid-day meal scheme, originally started in Tamil Nadu, has been able to drive the school enrollments up. Most of southern states, Kerala and Tamil nadu, have achieved considerable amount of success in driving up their literacy rates and states which have to address the problem of school education have to address the challenges of educating the poor students. This in-turn requires for the appropriate measures being taken to improve the state government schools. which will then automatically increase the number of the students attending these schools.

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NANOTECHNOLOGY IN DAY-TO-DAY LIFE

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Abstract:

Nanotechnology has permeated every aspect of modern life during the past 10 to 15 years. It is one branch of material science that directly relates to the fields of physics, mechanical engineering, bioengineering, and chemical engineering. It also aids in the establishment of numerous professions that examine the micro-level properties of materials. Nanoparticles are employed in many different industries, including the food industry, pharmacy, medicine, and cosmetics. They are also found in commonly used dietary supplements, hygiene products, and packaging materials. Nano synthetic materials may exhibit unique properties that set them apart from bulk materials. Because of their superfluous linkages with similar compartments in the biological process, the unique characteristics of nanomaterials not only confer considerable advantages but also toxicity. With its atomic-scale capabilities, which control a large portion of the dynamics in the natural and physical worlds, nanotechnology has the potential to develop humanity like never before. This chapter examines the uses of nanotechnology in the fields of pharmaceutical science, Food and nutrition, Agriculture, Health care, catalysis and environmental cleanup. In this chapter, the most recent nanotechnology applications that have an impact on several facets of human existence are described.

Keywords: Nanotechnology, Applications, nano medicines, nano emulsions, nano catalysis.

Introduction:

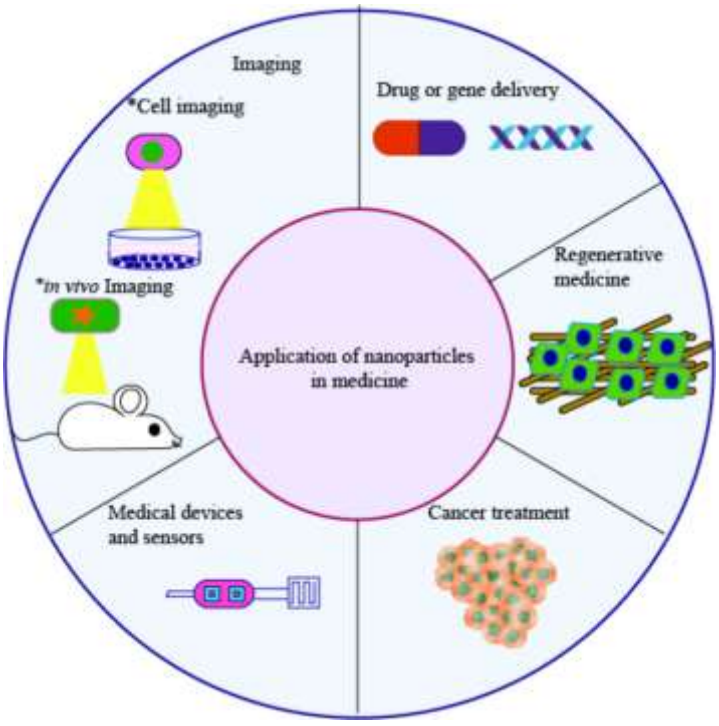
The term "nano" refers to a wide range of technological and scientific disciplines, procedures, and characteristics at the nano- or microscale. A tiny word called "nano" has garnered a great deal of interest, research, and attention during the past few decades. Every part of how we think about science and technology has been significantly altered, and it will undoubtedly continue to surprise us in both our daily lives and the wider world in the future (Sanchez and Livage, 1990; Yang *et al.,* 1998; Brinker *et al.,* 1999; Eychmuller, 2000; Ratner and Ratner; 2003; Rao *et al.,* 2004). The importance of nanotechnology has grown recently due to the wide range of applications it has in various fields of science and technology, including

chemistry, physics, material science, biology, medicine, management, and the environment, among others. This has resulted in a close connection between nanotechnology and our daily lives. Nanoscience is a cutting-edge method that is being used more frequently and is gaining importance in a wide range of industries. Today's nanoscience is a synthesis of top down engineering methods with bottom up chemistry. For creating, modifying, and visualizing nanoscale materials and structures, new concepts and methods are proliferating. Since nanoscience is interdisciplinary, it necessitates the collaboration of scientists from other fields, including chemistry, physics, material science, engineering, and biology. These disciplines' cooperation will make it possible to tackle even the most difficult scientific issues. Around the past ten years, nanoscience research has grown significantly all around the world. The worlds scientific, economic, government, and industrial communities all agree that nanoscience will play a crucial role in the creation of new technologies. The potential and significance of nanoscience and nanotechnology are elevated by the possibility that material properties such as physical, chemical and biological vary considerably at nanoscale from those found in bulk material (Hu *et al.,* 1999). Spectacular changes in a material's properties are possible when its dimensions are shrunk below 100 nm. Materials may be nanostructured in order to accomplish a certain performance or to provide them with other characteristics in addition to alterations specifically linked to size and structure. At sizes ranging from 1 to 50 nm, these macromolecules and particles made up of a limited number of molecules exhibit distinctive physicochemical characteristics (Whitesides, 2005). The discovery of novel nanoscale materials, phenomena and processes as well as the development of state-of-the-art, theoretical and experimental research methodologies have opened up new possibilities for the development of inventive nanostructured materials and nano systems. Regarding its uses in agriculture, electronics, medical, energy, and other fields, nanoscale research and nanotechnology are currently undergoing a lot of developments and will continue to do so. An accelerating rate of innovation is being demonstrated here (Ghorbanpour *et al.,* 2015; Mansoori *et al.,* 2005; Mansoori *et al.,* 2007; Ghorbanpour and Hatami, 2015). The development of cutting-edge theoretical and experimental research approaches along with the discovery of novel nanoscale material phenomena and processes have created new opportunities for the creation of creative nanostructured materials and nano systems. (Lee *et al.,* 2010). The most recent uses of nanotechnology that have an impact on various facets of human existence are covered in this chapter.

Application of nanotechnology:

1. Nanotechnology in pharmaceuticals and medicinal science

The field of study known as "nanomedicine" combines drugs or diagnostic agents with nanotechnology to improve the ability to target specific cells or tissues. These materials are safe to ingest because they are produced at the nanoscale level. One of the many constructive aspects of nanotechnology is the development of nano sized systems, which are particularly important because they affect pharmacokinetic and pharmacodynamic properties such as bioavailability, solubility, reduced toxicity and drug release capacity and may lead to the development of some important drug systems. Nanosized medicines are better than other dosage systems based on their high surface area, which improves solubility, bioavailability, rate of bio availabilities, rapidly acting medicinal products, low required dosages and decreased patient variability. This has led to the development of a range of planned, targeted medication delivery systems, improving patient compliance, efficacy, and safety (Karn *et al.,* 2009; Arredouani *et al.,* 2004; Bopp and Lettieri, 2008; Ahmed *et al.,* 2012; Al-Bastaki, 2004; Silva *et al.,* 2011).



Nanotechnology in Medicines and Pharmacy (Zarei-Behjani *et al.*, 2022)

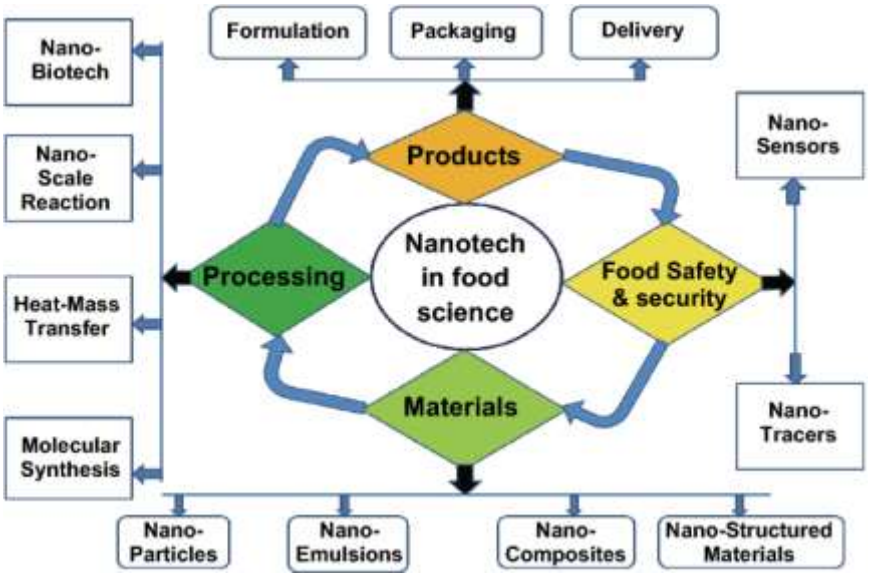
Nanomaterials are utilised in the medical sector to identify, manage, and prevent disease. Better, safer drugs, tissue-focused activities, and individualized nano-medicines are all being developed as a result of nanoparticle technology. This technology is used to clean surfaces and personal protection equipment in preparation for the coronavirus illness pandemic of 2019. Nanoparticles may deliver medications to the precise location needed, significantly enhancing

their efficacy and limiting their toxicity to other body parts (Raina *et al.,* 2021; Rastegari *et al.,* 2021; Wallace *et al.,* 2012). Nanotechnology and nano-drugs have recently made a lot of progress. With the help of remarkable advancements in nano-medicine, the drug has reached a new level with important medical effects (Vishwakarma *et al.,* 2013). The enormous applications of nanotechnology in medicine require further investigation. In the field of medicine, there is a lot of continuing study into the best practices and techniques, especially in the fields of nephrology, cardiovascular disease, therapeutic genes, and cancer therapy. The effectiveness of conventional therapy has significantly advanced, and encouraging developments have been made in nanotechnology and nanoparticle quality (Keskinbora and Jameel, 2018).

2. Nanotechnology in food

Food is an item with nutritional value. In order to provide energy and support life, it is consumed by an organism that is subsequently broken down by internal metabolic processes. Nanotechnologies have a wide impact on nearly every aspect of food and agriculture, which includes the security of foods, disease control systems, new molecular and cell biology instruments, novel materials for detecting pathogens and protecting the environment. Food nanotechnology has given rise to advancements in food technology which have increased the quality and quantity of foods made while at the same time making it more easy to evaluate safety, particularly with regards to the additives. This contemporary technology is utilized to boost the safety of the food manufacturing sectors through processing and shipment of food products using sensors designed to identify pollutants and pathogens. One of the primary uses of nanotechnology in the food business is also thought to be encapsulation and delivery systems, which transport, shield, and distribute functional food ingredients to particular locations of action (Srividhya and Chellaram, 2012; Archana and Chellaram, 2012; Abbas *et al.,* 2009). Recent developments in nanotechnology and related sectors made it possible to carry out a wide range of nutritional research on dairy products preparation, preservation and packaging as well as the development of functional foods. Furthermore, those who are most impacted by the development of nanotechnology are those who produce food and dairy products, farmers, and consumers (Duncan, 2011; Chau *et al.*, 2007; Losche 1997; Chinnan and Park, 1995; Janaswamy and Chandrasekaran, 2005; Charych *et al.,* 1996). Nanotechnology is crucial to the food packaging industry because it not only improves packaging material but also enhances food safety by warning consumers about food contamination and bacterial contamination, producing stronger flavours and colours, mending packaging tears, and releasing preservatives to prolong packaged shelf life. The most important ingredients in medicines, vitamins, antimicrobials, antioxidants, preservatives, flavorings, colours and additives are currently accessible nanomaterials such as

nano dispersions and nano capsules. These materials have made medicine and food more accessible to the human race. (Sundarraj, *et al.*, 2014).

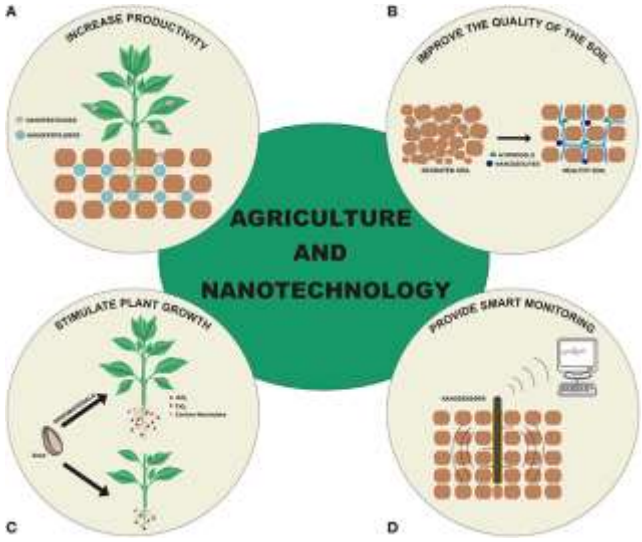


Nanotechnology in Food (Selvaraj *et al.*, 2020)

3. Nanotechnology in agriculture

Nanomaterials play an important role in agricultural research, by being used for the manufacture of fertilizers and as a way to provide plants with nutrients they need. This can be ensured by using nanoscale fertilizer inputs, nanoscale additives, nanoscale coatings, or nanomaterials as fertilizers host materials. This modern technology has also made progress in other areas of agriculture, such as reproductive science and technology, the conversion of food and agricultural wastes into energy and other useful byproducts through enzymatic nano bioprocessing, the prevention of disease, and the treatment of plants using various novel nanoscale devices. Metal and metal oxide nanoparticles (NPs) with precisely controlled size, morphologies, and physical-chemical properties, like magnetic, fluorescence, and photocatalytic degradation effects, have made it possible to develop novel sensors, reverse agrochemical degradation, and restore degraded soil. These organizations have played an active part in developing technologies to enhance agricultural practices of the future. Nanomaterial properties such as rigidity, permeability, crystallinity, thermal stability, solubility, and biodegradability have substantially improved the formulation and efficacy of nano insecticides. These properties have also improved the dispersion and wettability of agricultural formulations, as well as reduced organic solvent runoff (Sharon *et al.*, 2010; Mukhopadhyay, 2014; Parisi *et al.*, 2015; Cozzens *et al.*, 2013). In the future “smart” agricultural systems would be created using special features of nanoscale devices. Instruments that can identify plant health problems in advance of the farmer's knowledge could be applied. Such technologies may be capable of adapting to different

situations and by acting in accordance with the necessary corrective measures, responding to them. In that instance, they will let the farmer know about the problem. In this approach, smart devices will act as a preventative and the early warning system. Other uses of nano-materials in agriculture focus on reducing the use of plant protection chemicals, reducing nutrient losses from fertilizer, and boosting yields through improved nutrient management strategies. Machines used in agriculture are yet another key area where nanotechnology is being used. In order to increase stability against corrosion and ultraviolet radiation, nanoparticles may be applied to glass, agricultural equipment, tools, and even machine body coatings. In addition to all of these uses, nano technological tools and devices, like nano capsules, nanoparticles, and even viral capsids, are illustrations of potential uses for the diagnosis and treatment of diseases, improved nutrient uptake by plants, delivery of active ingredients to specific sites and water treatment procedures. Target-specific nanoparticles can lessen the amount of toxins released into the environment and damage to unintended plant tissues (Owolade *et al.*, 2008; Pal *et al.*, 2007; Park *et al.*, 2006; Pérez-de-Luque and Rubiales, 2009; Prasad *et al.*, 2011; Prasad *et al.*, 2012).

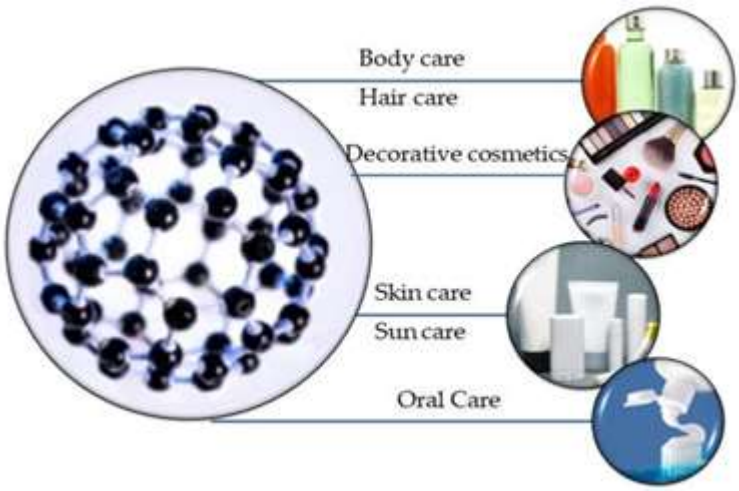


Nanotechnology in agriculture (Fraceto *et al.*, 2016)

4. Nanotechnology in cosmetics

The cosmetics industry is using nanotechnology by developing nanoparticles to improve the efficacy and bioavailability of active compounds in cosmetics, sunscreens, anti-aging creams, moisturizers, and scents. (Kaul *et al.*, 2018). Several nano-delivering methods are utilised in cosmetic preparations to include necessary ingredients. This helps the efficient delivery of active substances through the skin. Nanotechnology based products facilitate quick and efficient skin absorption. The active ingredients are adsorbed on the surface of nanoparticles acting as delivery vehicles. In order to optimize the benefits of the shape and size dependent activities of nanoparticles and to improve the effects of cosmetic products, cosmetics may contain

nanoparticles of different morphologies and chemical compositions. In the manufacture of cosmetic products, a variety of metal and metal oxide nanoparticles, such as silver nanoparticles (AgNPs), gold nanoparticles (AuNPs), titanium dioxide nanoparticles (TiO_2NPs), zinc oxide nanoparticles (ZnONPs), iron oxide nanoparticles (Fe_2O_3NPs), and carbon-based nanoparticles are used. (Boxall *et al.,* 2007; Sioutas *et al.,* 2005). The use of nanoparticles in cosmetic goods can operate as transporters for active substances, consistency-improving components, and active ingredients themselves, enhancing the efficacy of cosmetic products. Additionally, due to their extensive antibacterial properties and ability to serve as a preservative, silver nanoparticles are widely used in cosmetic compositions. Because the lotions with silver nanoparticles have antibacterial properties, they can be used to disinfect cuts and skin (You *et al.,* 2012). These nanoparticles can be used into cosmetics to give them new qualities. There are many different kinds of nano-materials, each with unique properties and potential uses. The various types of nano-materials utilized in cosmetics include nano capsules, dendrimers, nano emulsions, nano-liposomes, and nano-hydroxyapatite materials. These materials are used in cosmetic products for a range of uses, e.g. oral care, protection carriers and the distribution of components through skin.

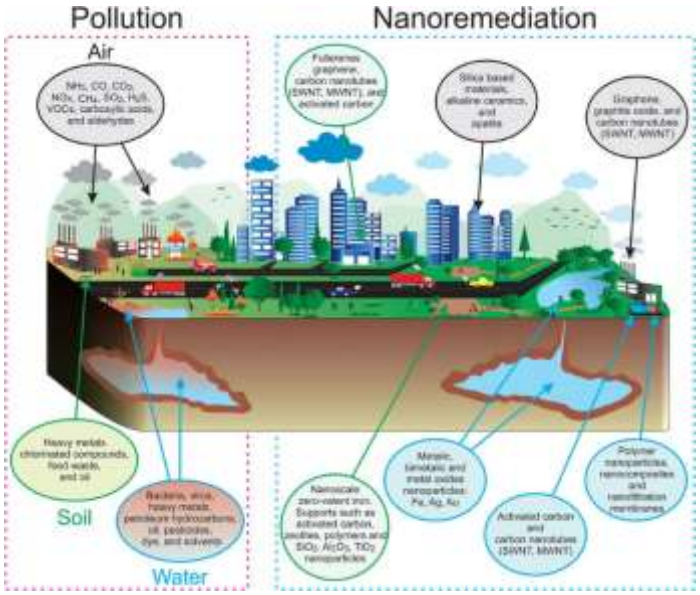


Nanotechnology in cosmetics (Fytianos *et al.*, 2020)

5. Nanotechnology in environmental remediation

From the past few decades, highly poisonous chemical compounds have been created and released into the environment in order to be used directly or indirectly over a lengthy period of time. Among these elements are some pesticides, fuels, polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) (Jones *et al.,* 2007). One of the most significant scientific movements nowadays and one of the essential technologies of the twenty-first century is nanotechnology (Zhang and Elliot, 2006). When it comes to cleaning up pollution,

nanotechnology may be a really effective instrument. Numerous studies suggest that adding nanoparticles to traditional treatment could improve the effectiveness of removing pollutants such as organic compounds. Nanotechnology applications in the field of environmental science are divided into four categories: regeneration, protection, maintenance and enhancement. Rectification is the category with the fastest growth rate among these four, while protection and maintenance account for the majority of environmental science applications. However, the smallest portion amongst the nanotechnology application is in the environmental improvement. There have been several contaminated sites where nanoscale materials have been used, and early reports indicate success. Through effective control and contamination prevention, nanotechnology can also help the environment. Numerous nanotechnology applications for environmental treatment have been successfully tested in experimental settings. The majority of these uses, however, require field validation of their efficacy and safety (Dang *et al.*, 2015).



Nanotechnology in Environmental Remediation (Del Prado-Audelo *et al.*, 2021)

6. Nanotechnology for energy saving

Nowadays, the major sources of energy which meet human needs and enable people to carry out their activities are fossil fuels, mineral oils, Nuclear Power Plants or Hydropower. Most of the time, these pose a serious threat to human life and harm ecology. They also cost a lot of money, harm ecologically sensitive places, contribute to global warming, ozone layer loss, biosphere and geosphere destruction and ecological disaster. Since nanotechnology has emerged in recent years, there are now technologies for efficiently and cheaply supplying and saving energy (De la Rubia *et al.*, 2000). Nanotechnology has enabled the study of nanoscale issues so as to identify methods for improving energy performance or capacity in a manner that is more advantageous than obtaining it from bulk materials. By strengthening the capacity of production

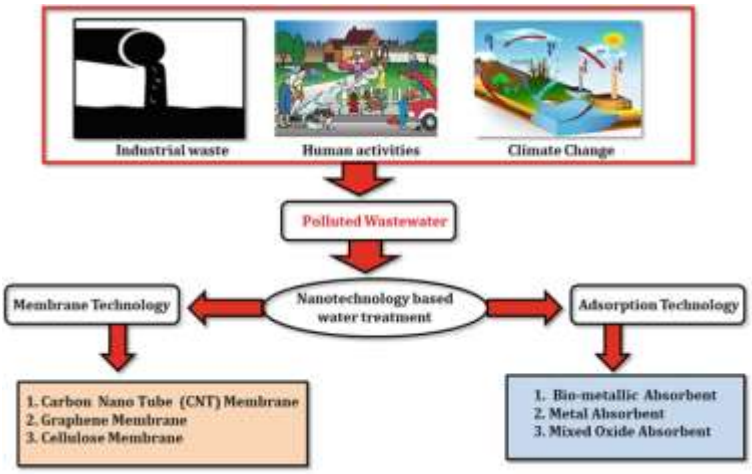
through an environmentally friendly way, it will help to ensure a long term global power supply and prevent energy loss. (Epstein and Malloy, 2009). In order to improve efficiency and reduce costs of production and thus consume more energy, the predominant source of energy is replaced by a number of forms of energy such as electricity, heating or heat. Nanotechnology has a singular ability to create materials with unique atomic configurations, which has broadened the scope of its uses. Energy transmission systems offer a faster and more efficient way to transfer energy from production sources to consumers, one area where nanotechnology is being applied in the energy sector. In this regard, nanotechnologies may offer more effective methods for fuel transportation, potentially slowing the rise in demand for long-distance liquid fuel shipments through the use of construction materials made from nanoparticles that may be stronger and occupy less volume than our current materials, thereby lowering the footprints required for the construction and maintenance of pipelines and electricity transmission lines (Nelson and Owen, 2003). Owing to their extraordinary properties at the nanoscale, which caused their innovations to have an impact on every link in the value-added chain in the energy sector, nanomaterials are presently being used to produce and develop new potentials for competent, reasonable, and environmentally friendly energy sources for both conventional (fossil and nuclear fuels) and renewable energies (sun, wind, water, tides, or biomass). Nanotechnologies thus provide the potential to increase energy efficiency in all industrial sectors, as well as economically leverage renewable energies through new technological developments and improved production methods.

Nanotechnology for saving energy (Nasrollahzadeh *et al.*, 2019)

7. Nanotechnology for water treatment

Modern developments suggest that a number of problems pertaining to water quality might be resolved or significantly decline, which led to the growth of nanotechnology. The use of innovative approaches for the production of new nanomaterials to desalinate water is one of the most interesting and promising technologies. In order to make waste water treatment

efficient, fast and economically feasible, various research teams in the field of material science are using certain nano particles that target analyte. Nanotechnology based waste water treatment effectively removes impurities and aids the recycling process to obtain purified water, which results in a reduction in labour, time, costs to industry and resolves a number of environmental problems. Palladium and titanium oxide nanoparticles are two examples of metallic/metal oxide nanoparticles that are utilized as nano sensors to analyze organic and inorganic contaminants in water systems. There are three different categories of wastewater treatment: primary, secondary, and tertiary. In order to effectively remove pollutants from water systems, nanomaterials are chosen in accordance with the type of treatment and level of purification. Nanotechnologies have also been shown to be capable of removing deposits, chemical effluents and particles that are charged. In desalination, salt removal, brackish water treatment, Industrial Water Treatment and Reuse, Product Dissociations in Industry or Water Slicing Processes a new pressure driven membrane technique known as nanofiltration has been applied. Carbon nanotubes, a special type of nanomaterials, can be used to remove many contaminants including organic and inorganic compounds, oil, turbidity, microbials as well as viruses. Negatively charged pollutants including viruses, bacteria, and organic and inorganic colloids are also removed more quickly than with traditional filters using nano fibrous alumina filters and other nanofiber materials. For treating wastewater, which is essential to humans, nanotechnology research and development offers an innovative and promising technology.

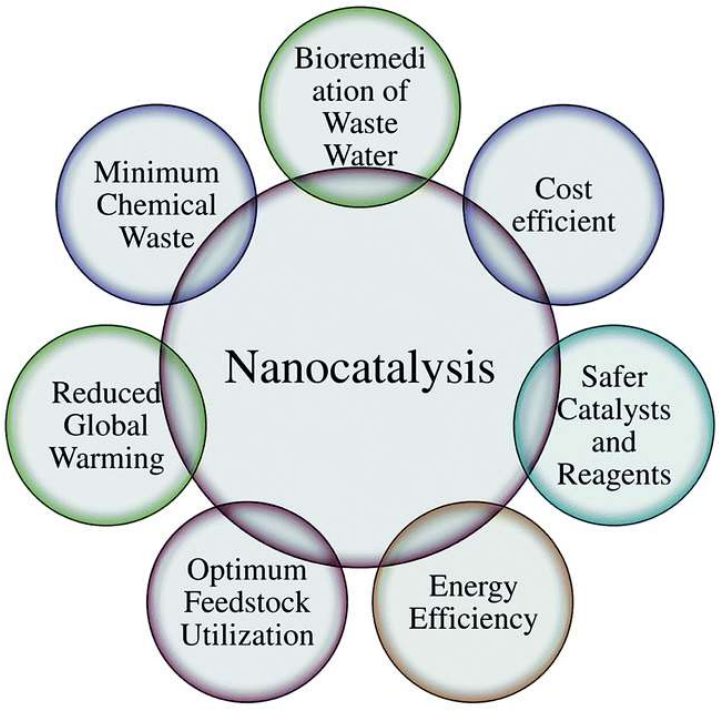


Nanotechnology for Water Treatment (Chaturvedi *et al.*, 2020)

8. Nanotechnology in catalysis

The researchers face a problem with the time consuming process of separating catalyst from its reactants, recycling them and using them again. It is anticipated that nanotechnology would lessen the financial burden of this issue (Johnson *et al.*, 1999). In the rapidly expanding subject of nano catalysis, which includes metals, semiconductors, metal oxides, and composite

nanostructures, nanomaterials are used as catalysts in a wide range of processes. In recent years, nanotechnology research has attracted attention for the potential to make catalysts that are 100% sensitive and have an extraordinary amount of activity but also low energy consumption and long life. Only a careful control of each nano component size, shape, locational distribution, surface composition, electric structure, temperature stability and chemical resistance will be able to achieve this. (Pan *et al.,* 2007). The impact of nanotechnology on catalyst technology is significant. The structure, type, morphology, and most significantly size of a substance all affects its ability to reduce activation energy and hence speed up a chemical process. As far as nanotechnology is concerned, the size of the catalyst is of particular importance because all reactions and transformations take place on its surface, which means that the size of the catalyst will increase its surface area. In the field of nanotechnology, consideration is given to nanoscale systems with a high surface area to volume ratio. The most significant improvement of nanotechnology in catalysis is the achievement of large surface area, which gives rise to fast reactions, high yields and synergistic effects that lead to better cost effectiveness. As was previously indicated, the creation of atomically small catalysts (nanometer scale) increases catalytic activity (Chen *et al.,* 2013).



Nanotechnology in Catalysis (Sharma *et al.*, 2015)

As an illustration, gold nanoparticles are nearly inert at the macroscopic level but are catalytically active at the nanoscale. The unique morphology and size properties of catalysts at the nanoscale also support energy-saving activities, enhancing turnover frequency,

straightforward separations, and extended lifetimes. They can therefore be employed as a major component in green chemistry. In fact, the selectivity, activity, durability, and recoverability procedures of superior nano catalysts exhibit exceptional performance (Chen *et al.*, 2007). High levels of recyclability, stability, and lifetimes are further significant advantages that nanotechnology has brought to catalyst performance. These give a clear picture of the economic traits of a catalyst. The capacity to be reused for additional chemical processes is a crucial property of nano catalysts that considerably lowers the cost of the catalytic process. Because of this, one of the most important properties of nano catalysts is how easily they can be separated from a reaction mixture, allowing them to be reused. This results in a product of higher quality. In fact, nano catalysts exhibit various reusability and recyclable qualities due to their huge surface areas and strong reactivities. Hence, they are often suggested as suitable alternatives to bulk catalytic materials in the context of catalyst processes (Santiso *et al.*, 2008).

Conclusion:

The field of nanotechnology is considered as being exceedingly permissive and revolutionizing science. In the realms of food and agriculture, building materials, mechanical, medical, and electrical engineering, nanotechnology has the potential to open up a whole new world. The field of nanotechnology has advanced significantly in recent years. In the coming years, practically everyone on the earth will experience some impact from nanotechnology if it keeps developing at its current rate. All facets of our existence, including agriculture, aerospace, energy, defence, materials science, environmental science, and medicine, are beginning to benefit from research and advancements in the subject of nanotechnology. A growing number of researchers, including scientists, doctors, government organizations, venture capitalists, and politicians, are looking into the potential applications of nanotechnology. In addition, nanotechnology and nanomaterials are a rapidly expanding field of study where new properties of materials at the nanoscale can be used for industrial purposes. A number of promising developments already exist that have the potential to alter the service life and life-cycle cost of infrastructure construction to create a new world in the future.

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BIOTECHNOLOGY AND ITS APPLICATIONS

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Abstract:

Biotechnology is the use of biology to develop novel organisms, procedures, and products with the intention of improving society and human health. Biotechnology, also known as biotech, has been a part of human culture ever since domesticated plants and animals were first brought into existence as well as the discovery of fermentation. A multidisciplinary field known as biotechnology makes use of living things or their parts to create goods and procedures that are advantageous to human society. It has advanced significantly recently and is influenced by a wide range of scientific fields, including engineering, molecular biology, genetics, and biochemistry. Numerous facets of our lives, such as healthcare, agriculture, business, and the environment, have been significantly impacted by biotechnology. As a result, there is now greater food security. Additionally, biotechnology has made it possible to manufacture eco-friendly and sustainable products and materials. Biotechnology is a technology of hope because it holds the potential to raise living standards, protect the environment, and improve human health. The main objective of this essay is to provide readers with a comprehensive overview of biotechnology, including an explanation of its definitions, varieties, and main applications. This essay will look at the fundamental concepts underlying biotechnology as well as its numerous specialised fields. Also covered in-depth will be the most significant applications of biotechnology in the fields of healthcare, agriculture, business, and the environment. The chapter's ultimate objective is to increase understanding of biotechnology and its social impacts while also highlighting potential areas for additional research and study.

Keywords: Biotechnology, History, Types of biotechnology, Applications

Introduction:

Modern biotech applications most frequently use genetic engineering, also known as recombinant DNA technology. In genetic engineering, the genetic cell structures are changed or engaged. Every cell in an animal or a plant contains genes that produce proteins. These proteins dictate the characteristics of the organism. Genes can be changed or interacted with by scientists to improve the traits of an organism or create an entirely new one. These modified and novel organisms could produce crops with higher yields or greater drought resistance, which would be advantageous to humans[1]. Genetic engineering also makes controversial advancements like animal cloning and genetic modification possible. The broad field of biotechnology has a significant impact on modern life. Cells or compounds made from cells have been used in technology for a number of uses since many years ago. It is known as the "technology of hope" and has a vast array of uses that influence environmental sustainability, animal welfare, and human health. The cornerstone of biotechnology is the use of living things or components of living things, such as cells, enzymes, and proteins, to create new products or processes. The many different techniques and tactics used in biotechnology have many different applications[2].

Utilizing science and engineering, biotechnology transforms materials containing biological agents. Examples of biological agents that are used to produce drugs, foods, and biochemicals that are used in warfare include enzymes, plant cells, and microbes. It has uses in biotechnological fields like nanotechnology, cloning, gene therapy, recombinant DNA technology, embryonic stem cell research, biofuels, and biobanks. Biotechnology has aided in improving the nutritional value of crops and increasing crop yields in the agricultural sector. Genetically modified crops that are resistant to pests and can thrive in challenging environmental conditions, like drought, have also been made possible by biotechnology[3]. In addition, Reversebreeding methods are also used to accelerate breeding and create new cultiva rsto meet changing climate demands. Plant biotechnology is being used to address the growing needs for food security, socioeconomic development, conservation, diversification, and sustainable use of plant genetic resources as cornerstones of the agricultural industry of the future. In the industrial sector, biotechnology has sparked the creation of novel, environmentally responsible products and materials[4].

Among other things, biotechnology has made it possible to produce biofuels, bioplastics, and enzymes for use in laundry detergents[5]. Additionally, biotechnology has the potential to address some of the most important global problems, like pollution and climate change. New biodegradable materials, contaminated site cleanup, and the production of sustainable energy sources can all be accomplished using biotechnology. The field of biotechnology, which is

dynamic and rapidly evolving, has the potential to find solutions to some of the most pressing societal problems[6]. It has changed a number of industries and sparked the creation of fresh goods and procedures that have enhanced food security, enhanced human health, and made the world more sustainable[7].

Definitions of biotechnology

The use of biology in problem-solving and product development is known as biotechnology. The use of genetic engineering to produce therapeutic proteins and other medications is the most well-known application of biotechnology[8]. The agricultural revolution ushered in biotechnology at least 6,000 years ago. This early era was characterized by the use of unaltered living things or the selective breeding of them to alter their genetic makeup. Around the same time, people learned how to create cheese, bread, and alcohol using the biological process of fermentation. People also began modifying the genetic make-up of domesticated plants and animals through selective breeding. Biotechnology is a broad field that involves using a variety of tools and technologies to either work with living cells or molecules derived from them for applications aimed at improving human welfare. Living things, cells, or component parts are used in the production of goods in this fusion of biological science and engineering[9].

There are many different ways to define biotechnology. Here, it would be appropriate to define the OECD (Organization for Economic Co-operation and Development). In order to produce knowledge, products, and services, it is said that "biotechnology is an interdisciplinary branch of science and technology that deals with the transformation of living and inanimate matter by the use of living organisms, their parts, or products derived from them, as well as creation of models of biological processes." Three generations of biotechnology have been proposed, starting with the (at first, unintentional) use of whole organisms in fermentation, such as in brewing. In the first half of the twentieth century, the second generation developed culture and extractive techniques by taking advantage of greater microbiological understanding (e.g., for the production of antibiotics from fungi)[10]. Restrictions enzymes and monoclonal antibodies were isolated and used in the third generation, which dates to the 1970s.

Modern biotechnology is one tool that can be used to address the challenge that this growth presents. It has also helped to (a) create a more environmentally friendly environment, (b) improve safety and health, (c) reduce the amount of water needed for manufacturing processes, (d) reduce industrial waste, and (e) help with pollution remediation[11]. Generally speaking, biotechnology uses either living organisms or biological products to develop new goods for use in a variety of pharmaceutical, medical, agricultural, and environmental applications, with the ultimate goal of advancing humankind[12]. Examples include the

production of recombinant proteins, resistant crops, vegetables, higher-producing animals that can produce milk, and an endless list of other products. according to applications, The primary branches of biotechnology are A biotechnology used in agricultural processes is called "green biotechnology," Industrial biotechnology, also referred to as white biotechnology, is the process of using cells to produce goods that are useful for the industrial sector[13]. It has been used in numerous industrial processes in various ways, most notably when biocatalysts are used in manufacturing processes. Medical biotechnology, also known as red biotechnology, is the application of engineering and technology principles to the study of biological or living systems. In order to discover and use marine biodiversity as a source for new products, blue biotechnology, also known as marine biotechnology, bioprospects the using marine organisms' environments, molecular biology, and microbial ecology to achieve positive advancements for humanity[14]**.**

History of biotechnology

People have used biological processes to improve their quality of life since the earliest agricultural communities. About 6,000 years ago, humans were the first to utilize the biological processes of microorganisms to produce bread, alcoholic beverages, cheese, and preserve dairy products. However, such procedures are not included in the modern definition of biotechnology, which was originally used to refer to the molecular and cellular technologies that first emerged in the 1960s and 1970s[15]. The foundation of the field of biotechnology, which has been expanding over the past few decades, is the utilization of biological systems and processes to generate useful products and services. Engineer Karl Ereky from Hungary is credited with coining the term "biotechnology" in 1919. However, the origins of biotechnology can be traced to prehistoric times when people used fermentation to make bread, wine, and other alcoholic beverages as well as food[16]. The origins of biotechnology can be traced to the middle of the 20th century, when researchers started using genetic engineering to modify organisms at the molecular level. One of the initial innovations was Watson and Crick's discovery of the DNA structure in 1953, which set the stage for understanding the genetic code[17].

Significance of biotechnology

In a variety of fields, including agriculture, medicine, and environmental science, biotechnology is a rapidly expanding academic discipline that has emerged as a major force for advancement and innovation[18]. Utilizing scientific and engineering principles, biotechnology creates new goods and procedures based on living things, their components, and their interactions with the environment. The creation of novel medications and treatments is one of the major fields where biotechnology has had a significant impact. Nevertheless, the field has

advanced significantly over the past century in ways that affect how living things' genes and biomolecules work[19]. Modern biotechnology uses a variety of scientific and technological fields, including molecular biology, bionics, chemistry, genomics, genetic engineering, informatics, and nanotechnology. As a result, biotechnology has made it possible to develop novel drugs and treatments for a number of previously incurable diseases, including cancer and genetic disorders. Scientists are able to create customized treatments for individual patients using biotechnology methods, which results in better outcomes and higher quality[20].

Aside from medicine, biotechnology is also essential to agriculture, where it helps to boost crop yields and enhance the nutrient content of food. Farmers can grow crops that are less water and fertilizer-intensive, pest and disease-resistant, and require less water through the use of biotechnology[21]. This is advantageous to the environment and ensures a steady and sustainable food supply for a population that is expanding worldwide. Environmental science is a significant area where biotechnology is changing things. New technologies for the production of renewable energy, like biofuels, and for the cleanup of contaminated sites are being developed using biotechnology[22]. By enabling researchers to better understand the genetics and behavior of organisms and to create new conservation strategies, biotechnology is also being used to study and protect biodiversity. In the coming decades, the world will likely face a number of challenges, such as climate change and the emergence of new diseases, and biotechnology is likely to play an increasingly significant role in finding solutions. It is crucial that academic researchers and students continue to research and innovate in this area[23].

Types of biotechnology

A broad range of technologies and applications are included in the diverse and rapidly developing field of biotechnology. At its core, biotechnology is the use of living things or parts of them to create novel goods and procedures that have the potential to improve the environment, agriculture, human health, and many other fields. Biotechnology comes in a variety of forms, such as environmental, industrial, medical, and agricultural biotechnology. Medical biotechnology refers to the application of biotechnology to the creation of novel medications, vaccines, and therapeutics for the treatment of diseases[24]. Agricultural biotechnology is focused on creating new methods for enhancing crops and producing food, such as genetically modified plants. Industrial biotechnology refers to the use of biotechnology to create novel goods and procedures for industrial applications, such as the production of biofuels[25].

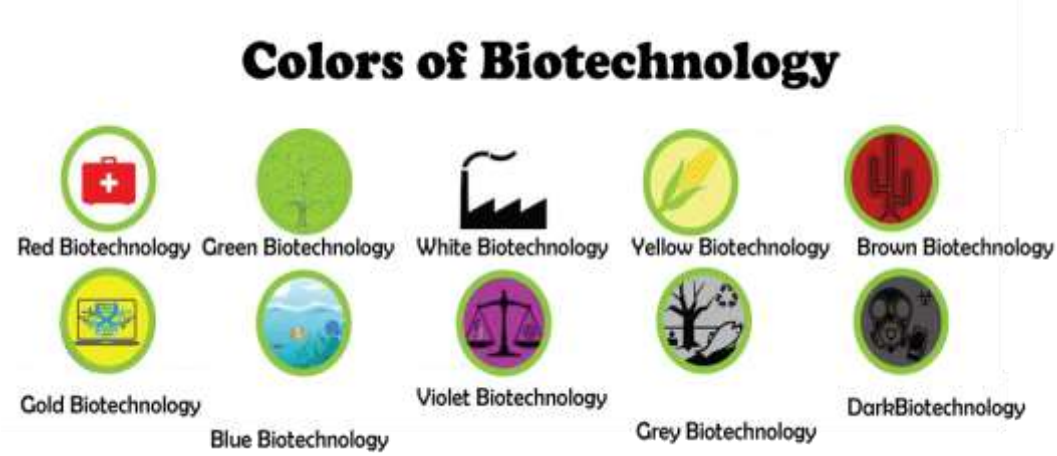
Understanding the various types of biotechnology is crucial for the creation of fresh, original solutions to difficult problems because each type of biotechnology presents different opportunities and challenges. While there are other methods for classifying biotechnology, the

most popular one is by using a color code. This system aims to make it easier to remember and arrange the various biotechnology fields. There are many fields within biotechnology, and each one is divided by a distinct color that represents a different aspect of biotechnology[26].

The science of biotechnology is divided into subdisciplines that are color-coded in accordance with popular uses and applications.

1. **Green biotechnology:** "Green biotechnology" refers to any biotechnology used in the agricultural sector. Genetically modifying pest-resistant plants is one of the field's active research areas (in order to reduce the usage of chemical pesticides).
2. **White biotechnology:** White biotechnology is also known as industrial biotechnology or "industrial biotech." This phrase applies to any form of industrial biotechnology. For example, some companies use microbes to create specialized chemicals or enzymes.
3. **Blue biotechnology:** Blue biotechnology uses marine-based organisms for a range of industrial and commercial uses. One example is the production of biofuel from photosynthetic algae.
4. **Dark Biotechnology**: Biological terrorism or biological weapons are examplesof dark biotech nology. Examples include genetically modifying viruses to be used as weapons and the production of toxins by microorganisms.
5. **Yellow biotechnology**: This term refers to any biotechnological applications used in the food industry. It's interesting to note that even though many of these examples have a long history—some of them go back hundreds or even thousands of years—they are still in use on a more extensive, industrial scale. Examples include making cheese, brewing beer, and baking bread.
6. **Violet Biotechnology**: Violet Biotechnology is the term used to describe the legal subset of biotechnology. The field focuses on protecting intellectual property rights and the safe use of biotechnology.
7. **Red biotechnology**: Red biotechnology is any form of biotechnology used in pharmaceuticals or medicine. The creation of antibiotics from various mold species (or other microorganisms) is one well-known use of red biotechnology.
8. **Brown biotechnology**: This phrase refers to biotechnology applications in dry, drought-stricken areas, such as the creation of drought-resistant crops.
9. **Bioinformatics:** Bioinformatics is a term that is also used to refer to "computational biology" and "gold biotechnology." Briefly put, bioinformatics use computer techniques to hunt for solutions to biological issues.

10. **Gray biotechnology:** "Gray biotechnology" refers to any form of biotechnology used for environmental purposes. One classic example is the technique known as "bioremediation," which employs anaerobic microorganisms to degrade and remove toxic substances.



Applications of biotechnology

Applications in industry

Utilizing microorganisms to create industrial products is known as industrial biotechnology. Several examples are as follows:

- Reduction of operational costs and chemical emissions through fermentation and the use of enzymes and microbes in the production of chemicals;
- Biofuels that produce combustible fuel from renewable crops like corn rather than from natural, non-renewable fossil fuel resources like oil and petroleum; and
- Biodegradable clothing and textiles made from living organisms' proteins, such as spider silk proteins.

Applications in medicine

The goal of medical biotechnology, also referred to as biopharma, is to treat patients better and fight and prevent disease. The modern pharmaceutical industry is based on biotechnology and biomedical research. Among the uses are the following:

- Research on stem cells that aids in the replacement or repair of damaged or dead cells;
- Development of antibiotics;
- Gene treatments for illnesses like leukemia;
- Study of potentially harmful pathogens and the antibodies that can combat them;
- 3d printing or lab-grown bones and organs;
- **Stem Cell Therapy**: Since stem cells can differentiate into any type of cell in the body, they are an important therapeutic tool for treating illnesses and wounds. The mass production of stem cells and the ability to change their characteristics for particular uses are both made

possible by biotechnology.

- **Biotechnology**; Biotechnology has significantly improved healthcare and has become a necessary instrument in the field of medicine. Here are some ideas for a research study about how biotechnology is being used in medicine:
- **Gene therapy:** Gene therapy is a method for treating or preventing disease that includes inserting genes into cells. Numerous techniques, like as electroporation or non-viral ones like viral vectors, can be used to accomplish this. Cystic fibrosis, muscular dystrophy, and certain cancers are among the conditions that have been the focus of gene therapy.
- **Recombinant Protein Production**Recombinant proteins may now be produced on a big scale and are therefore usable as medicines thanks to biotechnology. By genetically altering yeast, mammalian, or bacterial cells to express a particular protein, recombinant proteins are created. Recombinant protein-based medicines, such as insulin for diabetes, growth hormone for problems of growth, and clotting factors for hemophilia, are a few examples.
- **Genome Editing**: Medicine has undergone a revolutionary change as a result of genetic code manipulation. The modification of genes in cells or creatures using genome editing tools like CRISPR-Cas9 has the potential to treat genetic abnormalities, cancer, and infectious diseases.
- **Personalized Medicine:** The development of customized medicine, which adapts treatment to a patient's particular genetic profile, is made possible by advances in biotechnology. Techniques like genetic testing and pharmacogenomics, which examine how a person's genes affect their reaction to medications, can be used to do this.

Application of biotechnology in food processing

Processing food using biotechnological techniques has a number of advantages, including:

- Improved food storage
- Better food
- Losses are kept to a minimum while food quality is preserved.
- Genetically modified crops reduce soil erosion, the need for pesticides, and environmental pollution.
- Environmental pollution can be decreased by biotechnology.
- Food products' nutritional value may be improved by it.
- It can enhance food flavor and make undesirable food ingredients more palatable.
- Food security can be improved by reducing food losses.
- Biosensors can be used to spot the first indications of crop disease.

Applications in agriculture

Through genetic engineering, agricultural biotechnology improves the productivity of agriculture, boosts nutrient content, and lowers food insecurity. The following are some instances of agricultural biotechnology:

- Drought-tolerant plants;
- Least space-resistant plants;
- Meat produced in laboratories or by 3d printers;
- Grains free of gluten and suitable for celiac patients;
- Producing healthier, larger livestock and crops through selective breeding; and
- Adding extra nutrients to food through nutrient supplementation can help with diets and medical treatments.
- **Genetically modified crops:** Plants that have been genetically changed to have a particular feature, such as resistance to pests, diseases, or herbicides, are known as genetically modified crops. Farmers all around the world have embraced this technique, which has been demonstrated to offer major economic and environmental advantages[27]. According to some research, GM crops can reduce greenhouse gas emissions by up to 22%, reduce pesticide use by up to 37%, and improve agricultural yields by up to 25%.
- **The use of microbial inoculants**: The addition of living microorganisms to soil or seeds, known as microbial inoculants, can improve the health and growth of plants. These bacteria can enhance soil fertility, encourage nutrient uptake, boost resistance to pests and illnesses, and raise disease resistance.
- **Molecular breeding:** The selection of beneficial traits in plants is made possible by the use of molecular markers, such as disease resistance or drought tolerance. Breeders may now produce new crop varieties more rapidly, precisely, and effectively thanks to this technology[28].

Biomaterials and biopolymers based on biotechnology

Biopolymers and biomaterials are widely used in treatments and medicine because of their biocompatibility and safety. They are made up of the following:

- Systems for administering drugs, like insulin.
- Produced are antibiotics like penicillin as well as screening tools like the elisa assay for detecting antibodies or antigens.
- Skin grafting, implants, and dressings and adhesives for wounds.
- Tissue regeneration and wound recovery.

Applications for environment solutions

Biotechnology applications have significant potential fo addressing environmental challenges by providing innovative and sustainable solutions for various sectors such as agriculture, industry, and waste management[29].

- Waste like plastic is broken down in soil and water by plastic-eating bacteria.
- GMO foods reduce food waste and maintain freshness longer.
- The American chestnut tree is one endangered species that genetic restoration aims to save.
- Cover crops, like corn, are used as biofuels in place of conventional fuel sources, which emit greenhouse gases during extraction and use.
- **Bioremediation:** Bioremediation is a procedure that uses living organisms to clean up pollution in the environment. It is a long-term and cost-effective solution that may be tailored to remediate specific toxins in a given environment. Bioremediation can be done in place, decreasing the expense and environmental impact of hazardous waste transfer. Overall, bioremediation is a significant environmental biotechnology tool with the potential to be employed on a global scale to solve a wide range of environmental problems[30].
- **Phytoremediation:** Phytoremediation is a green and sustainable biotechnology tool that use plants to remove, degrade, or immobilise contaminants from contaminated soil, water, or air. It can be used to remediate a variety of contaminants, including heavy metals, organic pollutants, herbicides, and explosives. Specific plant species are used in the procedure because they can tolerate high amounts of pollutants and accumulate them in their tissues. The toxins can subsequently be eliminated by harvesting the plants or letting them decay naturally[31].
- **Biogas production**: Biogas technology is an essential biotechnology technique because it may reduce greenhouse gas emissions, provide renewable energy, and provide economic benefits to farmers and other stakeholders. Biogas is created through anaerobic digestion, which involves microorganisms breaking down organic waste in the absence of oxygen. The ultimate result of this process is a gas mixture containing methane, carbon dioxide, and other gases that can be utilised to generate energy, heat homes, and cook food. Biogas technology has several advantages over other renewable energy sources, including the flexibility to utilise a variety of organic waste, the ability to minimise greenhouse gas emissions, and the ability to provide a reliable source of electricity in remote locations.

Applications in skin-care preparations

A significant category of cosmetics is skin care products. Cleaning is the first step in facial care, and soap and water is still one of the most efficient methods. However, if heavy

makeup needs to be removed or if the skin is sensitive to soap, cleansing creams and lotions are helpful. They primarily contain oil as their active ingredient, which serves as a solvent and is combined with water to form an emulsion (a mixture of liquids in which one is suspended as droplets in another). One of the oldest beauty aids, cold cream, was originally made by beating water into mixtures of natural fats like lard or almond oil. However, modern preparations use mineral oil along with an emulsifier to help the oil dissolve in water. Emollients (softening creams) and night creams are thicker, cold creams designed to be massaged into the skin. They frequently leave a thick film on the face overnight, preventing water loss from the skin during that time.

Using hand creams and lotions can help prevent or lessen the dryness and roughness that come from being exposed to things like household detergents, the sun, wind, and dry environments. Similar to facial creams, they work primarily by replenishing lost water and forming an oil film to stop further moisture loss while the body's natural healing processes fix the damage.

General applications

Biotechnology is a fast evolving discipline with applications that go beyond the conventional fields of the environment, medicine, and agriculture. Industrial biotechnology is one such use, which uses enzymes, bacteria, and other biological agents to manufacture chemicals, fuels, and materials in a more sustainable and efficient manner. Biotechnology can also be utilised to improve food output and quality by developing genetically engineered crops, as well as food processing and preservation. Furthermore, biotechnology can assist in addressing energy concerns by producing sustainable energy sources such as biofuels and biogas, which can reduce reliance on fossil fuels and ameliorate climate change. In forensic science, biotechnology can be used to identify persons through DNA analysis as well as detect and analyse biological evidence.

What benefits does biotechnology offer?

- Production using biotechnology provides a number of benefits and solutions to serious issues. The following are the main ones:
- To stop the catastrophic effects of climate change and environmental harm, reduce pollution and waste;
- Developing food products that are more nutritious, durable, and sustainable in order to fight food insecurity;
- Changing a child's genome to treat diseases before the child is even born;
- Creating medical treatments that will improve the wellbeing and longevity of people,

animals, and plants; and

- Lowering the price of agricultural supplies like pesticides while boosting crop yields and profits.

What drawbacks does biotechnology have?

Biotechnology also has drawbacks and can be abused. The following list includes the main drawbacks:

Bioterrorist activity: There is a chance that pathogens and epidemics could emerge and be used to infect people in a conflict zone.

Less biodiversity: The natural gene pool of species may become smaller as a result of monoculture or the cultivation of a small number of genetically modified crops, decreasing their resistance to environmental change and their capacity to adapt.

Loss of soil fertility: Bio-enhanced plants produce more crops while requiring more nutrients from the soil. This can deplete soil of its beneficial nutrients, destroy farmland, and necessitate the use of fertilizers that are harmful to the environment in order to make up for the deficiency in nutrients.

High costs: Products based on biotechnology are frequently more expensive than comparable conventional goods, and their price increases could affect many different industries.

Ethical considerations: A variety of ethical concerns are brought up by gene manipulation, including the genetic engineering of people.

Conclusion:

The main objective of this essay is to provide readers with a comprehensive overview of biotechnology, including an explanation of its definitions, varieties, and main applications. This essay will look at the fundamental concepts underlying biotechnology as well as its numerous specialised fields. The application of biology to the creation of new things organisms, processes, and products with the goal of enhancing society and human health is known as biotechnology Biotechnology has had a profound impact on human life, revolutionising healthcare, agriculture, industry, and environmental management. However, biotechnology's future prospects are even more bright. The merger of biotechnology and information technology is driving the development of personalised medicine, in which therapies are tailored to the genetic makeup of the particular patient, resulting in superior health results. Advances in gene editing and synthetic biology have the potential to produce novel and more effective medicines for diseases while also boosting crop yields and sustainability. Furthermore, biotechnology has the potential to contribute to the creation of sustainable biofuels, bioplastics, and other renewable resources, lowering reliance on fossil fuels and mitigating environmental pollution. The ongoing expansion

and development of biotechnology holds immense promise for addressing some of humanity's most serious concerns in the twenty-first century. Biotechnology will play a critical role in determining the future of our planet, from producing novel diagnostic tools and cures for diseases to optimising agricultural output and sustainability. The potential for further advancements is tremendous, and biotechnology's continuous research could hold the key to improving the quality of life for people all around the world.

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CRISPR-CAS: UNLOCKING THE GENETIC FRONTIER – APPLICATIONS AND INNOVATIONS

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Introduction:

The CRISPR-Cas9 system is a revolutionary gene-editing tool that has transformed the field of biotechnology and genetic engineering. CRISPR stands for "Clustered Regularly Interspaced Short Palindromic Repeats," and Cas9 is an enzyme that plays a crucial role in the system.

The CRISPR-Cas9 system was originally discovered as part of the bacterial immune system, where it serves as a defense mechanism against viral infections. It allows bacteria to recognize and target specific viral DNA sequences and destroy the invading viruses.

The key components of the CRISPR-Cas9 system are as follows:

1. Guide RNA (gRNA): This is a small RNA molecule that guides the Cas9 enzyme to the target DNA sequence. The gRNA contains a sequence that is complementary to the target DNA, ensuring that the Cas9 enzyme binds to the correct location.
2. Cas9 protein: Cas9 is an RNA-guided endonuclease, meaning it can cut DNA at a specific site designated by the guide RNA. Once the Cas9 protein is guided to the target DNA by the gRNA, it creates a double-strand break in the DNA.

The process of using the CRISPR-Cas9 system for gene editing can be summarized in the following steps:

1. Designing the gRNA: Scientists design a guide RNA specific to the DNA sequence they want to modify. The gRNA is synthesized in the lab.
2. Delivery of CRISPR-Cas9 components: The Cas9 protein and the gRNA are delivered into the target cells, typically using viral vectors or other delivery methods.
3. Target recognition and DNA cleavage: The gRNA guides the Cas9 protein to the desired DNA sequence within the cell's genome. The Cas9 enzyme then cuts the DNA at the targeted site, creating a double-strand break.

4. DNA repair: Once the DNA is cut, the cell's natural repair mechanisms come into play. There are two main repair pathways: Non-Homologous End Joining (NHEJ) and Homology-Directed Repair (HDR).
5. NHEJ: This repair pathway rejoins the broken ends of DNA, often resulting in small insertions or deletions (indels). These indels can disrupt the gene's function.
6. HDR: This repair pathway uses a DNA template to repair the double-strand break accurately. Researchers can use a custom DNA template to introduce specific changes to the target gene during HDR.

The ability to precisely edit DNA sequences using the CRISPR-Cas9 system has significant implications for various fields, including agriculture, medicine, and basic research. It has the potential to correct genetic mutations responsible for inherited diseases, create disease models for research purposes, and develop genetically modified organisms with improved traits. However, ethical considerations and safety concerns surrounding the use of CRISPR-Cas9 in human germline editing remain subjects of ongoing debate and regulation.

Applications:

The CRISPR-Cas9 system has opened up numerous exciting applications across various fields due to its ability to precisely edit DNA sequences. Here are some of the key applications of the CRISPR-Cas9 system:

A. Gene editing and genetic engineering

The CRISPR-Cas9 system has revolutionized the field of gene editing and genetic engineering due to its simplicity, precision, and efficiency. It allows scientists to make targeted modifications to specific genes within an organism's DNA, enabling a wide range of applications in both basic research and practical applications. Here's how the CRISPR-Cas9 system is used in gene editing and genetic engineering:

1. Targeted gene modification: The CRISPR-Cas9 system can be programmed to target specific DNA sequences in the genome. By designing a guide RNA (gRNA) that is complementary to the target gene sequence, the Cas9 enzyme can be directed to that location. Once at the target site, Cas9 creates a double-strand break in the DNA, which triggers the cell's natural repair mechanisms.
2. Gene knockout: When the double-strand break is repaired through the error-prone Non-Homologous End Joining (NHEJ) pathway, small insertions or deletions (indels) are often introduced. These indels can disrupt the reading frame of the gene, resulting in a non-functional or "knocked out" gene. Gene knockout is valuable for studying gene function and understanding the consequences of gene loss.

3. Gene insertion: In addition to creating double-strand breaks, researchers can also provide a custom DNA template along with the CRISPR-Cas9 components. This template can be used to insert specific DNA sequences at the target site during the repair process, enabling precise gene insertion or "knocking in" of desired sequences.
4. Gene correction: CRISPR-Cas9 can be used to correct disease-causing genetic mutations. By introducing a DNA template that carries the correct version of the gene, the repair process can incorporate this template, leading to the correction of the mutated gene sequence.
5. Gene regulation: CRISPR-Cas9 can also be employed as a tool for gene regulation, without modifying the DNA sequence itself. Researchers have developed variations of the CRISPR-Cas9 system, such as deactivated Cas9 (dCas9) fused to specific transcriptional regulators. These fusion proteins can be guided to target genes to either activate or suppress their expression.
6. Multiplex gene editing: The CRISPR-Cas9 system allows researchers to target multiple genes simultaneously. By designing multiple gRNAs, different genes can be edited in a single experiment, making it possible to study gene interactions and complex genetic pathways.
7. Transgenic organisms: CRISPR-Cas9 is used to create transgenic organisms by introducing specific genetic modifications. This has applications in agriculture, where researchers can engineer crops with desirable traits, and in biotechnology, where transgenic animals may produce therapeutic proteins.
8. Model organism development: The ability to easily manipulate genes using CRISPR-Cas9 has enhanced the development of model organisms for studying human diseases and biological processes. This has implications for drug discovery and understanding disease mechanisms.

Ethical and safety considerations:

While the CRISPR-Cas9 system offers tremendous potential, there are ethical and safety considerations, particularly when it comes to human germline editing. The use of CRISPR-Cas9 in human embryos or reproductive cells raises complex ethical issues and remains subject to extensive debate and regulation.

The versatility and ease of use of the CRISPR-Cas9 system have accelerated research in gene editing and genetic engineering, paving the way for groundbreaking discoveries and potential medical advancements. However, it is essential to proceed with caution and adhere to ethical guidelines while harnessing the power of this technology.

B. Disease Modeling

The CRISPR-Cas9 system has become a powerful tool in disease modeling, enabling researchers to create accurate and relevant models of various human diseases. By using this gene-editing technology, scientists can introduce specific genetic mutations or alterations into cells or model organisms, mimicking the genetic basis of diseases observed in humans. Disease modeling with CRISPR-Cas9 offers several significant advantages for studying disease mechanisms, drug development, and potential therapeutic interventions. Here's how the CRISPR-Cas9 system is utilized in disease modeling:

1. Generating disease-relevant cell lines: CRISPR-Cas9 is used to introduce disease-specific genetic mutations or modifications into human cell lines. These modified cell lines, known as cellular disease models, provide researchers with a controlled system to study disease-associated biological processes in a simplified and scalable environment.
2. Creating animal disease models: CRISPR-Cas9 can be employed to generate genetically modified animals that carry specific disease-causing mutations or alterations. These animal models, such as mice, rats, or zebrafish, closely mimic human disease conditions and offer insights into disease progression and potential therapeutic targets.
3. Studying disease mechanisms: Disease models created using CRISPR-Cas9 provide valuable insights into the molecular and cellular mechanisms underlying the development and progression of diseases. By comparing diseased cells or organisms with their healthy counterparts, researchers can identify critical pathways and molecular targets involved in the disease.
4. Drug discovery and development: Disease models serve as crucial tools in drug discovery and development. By using CRISPR-Cas9 to create disease-specific cellular or animal models, researchers can screen potential drug candidates and evaluate their efficacy in correcting or mitigating disease-related molecular defects.
5. Personalized medicine: CRISPR-Cas9 has the potential to revolutionize personalized medicine by using patient-derived cells to create disease models. This approach allows researchers to understand disease mechanisms at an individual level and identify personalized treatment strategies.
6. Investigating drug resistance: Disease models created with CRISPR-Cas9 are valuable for studying drug resistance mechanisms. By engineering specific mutations found in drug-resistant patients, researchers can assess the effectiveness of existing therapies and design new treatment strategies.

7. High-throughput screening: CRISPR-Cas9 enables high-throughput screening of large numbers of genes to identify those that influence disease-related processes. This approach helps identify potential therapeutic targets or genes responsible for disease susceptibility.
8. Studying complex multifactorial diseases: CRISPR-Cas9 allows researchers to introduce multiple genetic modifications or edit multiple genes simultaneously. This capability is particularly beneficial for studying complex multifactorial diseases, where multiple genes may interact to influence disease susceptibility and progression.

C. Functional genomics

Functional genomics aims to understand the functions and interactions of genes within an organism's genome. CRISPR-Cas9 enables scientists to systematically manipulate and study gene functions, allowing them to uncover the roles of specific genes in various biological processes. Here's how the CRISPR-Cas9 system is used in functional genomics:

1. Gene knockout screens: CRISPR-Cas9 is utilized to systematically disrupt or "knock out" individual genes in a large-scale manner. By targeting different genes one by one, researchers can observe the effects of gene loss on cellular or organismal phenotypes. These screens help identify genes essential for specific processes and provide insights into gene function.
2. Genetic interaction studies: CRISPR-Cas9 allows for the simultaneous knockout of multiple genes in a single experiment, making it possible to study genetic interactions. By examining the combined effects of gene loss, researchers can uncover synergistic or antagonistic relationships between genes, shedding light on complex biological pathways.
3. Gain-of-function studies: In addition to gene knockout, CRISPR-Cas9 can be used to introduce specific genetic mutations or alterations, mimicking gain-of-function scenarios. These manipulations help researchers understand how particular gene alterations influence cellular behavior and biological processes.
4. transcriptional regulation studies: CRISPR-Cas9 can be used with deactivated Cas9 (dCas9) fused to transcriptional activators or repressors. By targeting dCas9 to specific genes' regulatory regions, researchers can modulate gene expression, leading to the activation or suppression of gene function. This approach allows the study of gene regulatory networks.
5. Non-coding RNA research: CRISPR-Cas9 can be applied to investigate the functions of non-coding RNAs, such as microRNAs and long non-coding RNAs. By targeting and modifying these RNA molecules, researchers can study their roles in gene regulation and cellular processes.

6. Mapping functional elements in the genome: CRISPR-Cas9 has been used to create large-scale deletions or inversions in the genome, enabling researchers to map functional elements, such as enhancers or promoters, and identify their roles in gene regulation.
7. Studying disease-relevant pathways: Functional genomics using CRISPR-Cas9 allows researchers to explore the roles of specific genes and pathways in disease development and progression. By creating disease-specific models, researchers can dissect the molecular mechanisms underlying various diseases.
8. Screening for drug targets: CRISPR-Cas9 has been employed in high-throughput screening to identify potential drug targets. By systematically targeting genes and observing their effects on disease-related phenotypes, researchers can discover novel therapeutic targets.

D. Drug Discovery

The CRISPR-Cas9 system has emerged as a powerful tool in drug discovery, significantly accelerating the process of identifying potential drug targets and evaluating drug candidates. It offers researchers the ability to perform precise and systematic genetic manipulations, providing valuable insights into disease mechanisms and potential therapeutic interventions. Here's how the CRISPR-Cas9 system is used in drug discovery:

1. Validation of drug targets: One of the crucial steps in drug discovery is identifying and validating potential drug targets—genes or proteins implicated in disease processes. CRISPR-Cas9 allows researchers to systematically knockout or inhibit specific genes to evaluate their impact on disease-related phenotypes. This helps confirm whether the target gene is essential for the disease's development or progression, providing confidence in its suitability for drug development.
2. Functional genomics screens: CRISPR-Cas9 enables large-scale knockout or activation screens, allowing researchers to study the functions of thousands of genes simultaneously. By observing changes in cellular behavior or disease-relevant phenotypes, scientists can identify genes that play critical roles in specific diseases, suggesting potential drug targets.
3. Unbiased drug target discovery: CRISPR-Cas9 can be applied in unbiased screens to explore previously unknown drug targets. These screens do not rely on prior knowledge of potential targets, making it possible to discover novel pathways or mechanisms relevant to a disease.
4. Disease modeling: CRISPR-Cas9 facilitates the creation of disease-relevant cellular and animal models, which can be used to test the efficacy of drug candidates. These models

allow researchers to assess the impact of potential drugs on disease-related processes and provide valuable preclinical data.

5. Mechanism of action studies: In addition to identifying drug targets, CRISPR-Cas9 can help researchers understand the mechanisms of action of potential drug candidates. By introducing genetic alterations in cells treated with a drug, researchers can determine which genes are essential for the drug's effect, providing insights into how the drug works.
6. Drug resistance studies: CRISPR-Cas9 is used to investigate mechanisms of drug resistance. By creating genetic modifications associated with drug resistance, researchers can study how these changes impact drug efficacy and explore strategies to overcome resistance.
7. Personalized medicine: CRISPR-Cas9 technology can be applied in conjunction with patient-derived cells to create disease models tailored to an individual's genetic background. This approach enables researchers to study drug responses in a personalized manner and develop personalized treatment strategies.
8. Toxicity testing: CRISPR-Cas9 can be used to investigate potential drug toxicities. By knocking out specific genes involved in drug metabolism or cellular responses to drugs, researchers can assess potential adverse effects of drug candidates.

E. Agriculture and food security

The CRISPR-Cas system holds significant promise for agriculture and food security by enabling precise and targeted genetic modifications in crops and livestock. This technology offers several applications that can enhance agricultural productivity, improve crop resilience to environmental stresses, and contribute to global food security. Here are some key ways the CRISPR-Cas system is being utilized in agriculture and food security:

1. Crop improvement: CRISPR-Cas9 allows researchers to edit the DNA of crops to introduce desirable traits, such as increased yield, improved nutritional content, and enhanced resistance to diseases, pests, and environmental stresses like drought, heat, and salinity. These genetic modifications can help create crops that are better adapted to changing environmental conditions and can lead to increased agricultural productivity.
2. Disease resistance: The CRISPR-Cas system can be used to introduce genetic modifications that confer resistance to plant diseases. By targeting and disabling specific genes in the crop's genome, researchers can create plants that are less susceptible to infections, reducing the need for chemical pesticides and minimizing crop losses.

3. Improved nutritional content: CRISPR-Cas9 can be used to enhance the nutritional quality of crops by modifying genes involved in nutrient synthesis or metabolism. For example, researchers have explored using CRISPR to increase the levels of essential vitamins, minerals, and other nutrients in staple crops, addressing malnutrition and nutrient deficiencies.
4. Accelerated breeding: Traditional plant breeding can be a time-consuming process that relies on crossing and selecting desired traits over several generations. CRISPR-Cas9 can expedite this process by directly introducing specific genetic changes in a single generation, leading to faster crop improvement.
5. Non-GMO approach: Unlike traditional genetically modified organisms (GMOs), which often involve introducing foreign genes, the CRISPR-Cas system can create targeted genetic modifications without introducing genes from unrelated species. This non-GMO approach may make it more socially acceptable and easier to navigate regulatory pathways for crop improvement.
6. Functional genomics: The CRISPR-Cas system is valuable in functional genomics studies in plants, allowing researchers to systematically study the functions of various plant genes, pathways, and regulatory elements. This research can lead to a better understanding of plant biology and help identify new targets for crop improvement.
7. Livestock improvement: CRISPR-Cas9 has the potential to enhance livestock breeding programs by introducing genetic modifications that improve animal health, welfare, and productivity. For example, it can be used to create livestock with increased disease resistance or improved growth rates.
8. Conservation of plant biodiversity: The CRISPR-Cas system can be applied in conservation efforts to protect and restore endangered plant species. By creating disease-resistant or stress-tolerant varieties, researchers can contribute to preserving plant biodiversity.

Despite the promising applications of CRISPR-Cas9 in agriculture and food security, some challenges remain, such as regulatory considerations, public acceptance, and ethical concerns. Ensuring responsible use and adherence to appropriate safety measures are essential to harness the potential benefits of this technology while addressing any associated risks.

Livestock improvement

The CRISPR-Cas system has opened up exciting possibilities for improving livestock through precise genetic modifications. By using CRISPR-Cas9 technology, researchers can introduce specific genetic changes in livestock animals, resulting in improvements in animal

health, welfare, and productivity. Here are some key applications of the CRISPR-Cas system in livestock improvement:

1. Disease Resistance: CRISPR-Cas9 can be used to create livestock animals with enhanced disease resistance. By targeting and disabling specific genes related to susceptibility to certain diseases, researchers can produce animals that are more resistant to infections, reducing the need for antibiotics and improving overall herd health.
2. Improved Growth and Productivity: Researchers can use CRISPR-Cas9 to modify genes associated with growth and productivity in livestock. This includes enhancing muscle development, feed efficiency, and reproductive traits, which can lead to increased meat, milk, or egg production.
3. Hornless Cattle: In the dairy industry, the removal of horns from cattle is a common practice to reduce injuries and improve safety. Using CRISPR-Cas9, researchers can introduce genetic modifications that result in naturally hornless cattle, eliminating the need for physical dehorning procedures.
4. Environmental Adaptation: CRISPR-Cas9 offers the potential to improve livestock's ability to adapt to various environmental conditions. By targeting genes associated with stress tolerance, heat resistance, or cold adaptation, researchers can develop livestock that are better suited to challenging climatic conditions.
5. Disease Models: CRISPR-Cas9 can be used to create disease models in livestock animals, allowing researchers to study the genetic basis of specific diseases. These models can be valuable for understanding disease mechanisms, testing potential treatments, and advancing biomedical research.
6. Reproductive Technologies: CRISPR-Cas9 can enhance assisted reproductive technologies in livestock breeding. For example, it can be used to modify genes related to fertility and reproductive traits, leading to improved breeding outcomes and increased genetic diversity.
7. Animal Welfare: CRISPR-Cas9 has the potential to improve animal welfare by introducing genetic changes that promote healthier and less stressful living conditions. For instance, researchers can modify genes associated with stress responses or pain sensitivity, leading to better welfare outcomes for the animals.
8. Disease Eradication: In some cases, CRISPR-Cas9 can be used to introduce genetic changes that eliminate specific diseases from a livestock population. This approach could help eradicate heritable diseases and reduce economic losses associated with disease outbreaks.

F. Biomedical therapies

The CRISPR-Cas system holds tremendous potential for biomedical therapies, particularly in the field of gene therapy. Gene therapy aims to treat or cure genetic diseases by modifying the patient's genetic material. CRISPR-Cas9 technology allows for precise and targeted editing of genes, making it a promising tool for developing novel therapeutic approaches. Here are some key applications of CRISPR-Cas in biomedical therapies:

1. Gene Editing to Correct Mutations: CRISPR-Cas9 can be used to correct disease-causing mutations in the patient's DNA. By delivering the CRISPR-Cas9 components to the target cells, the mutated gene can be replaced or repaired with the correct version, potentially restoring normal cellular function and treating the underlying cause of the genetic disease.
2. Gene Therapy for Monogenic Disorders: Monogenic disorders are caused by mutations in a single gene. CRISPR-Cas9 provides a potential avenue for treating these conditions by precisely editing the defective gene. Diseases like cystic fibrosis, sickle cell anemia, and certain types of muscular dystrophy are among the targets for gene therapy using CRISPR-Cas9.
3. Modulation of Gene Expression: CRISPR-Cas9 can also be utilized to regulate gene expression without modifying the DNA sequence. By using deactivated Cas9 (dCas9) fused to transcriptional activators or repressors, specific genes can be turned on or off, offering therapeutic opportunities for diseases where gene expression dysregulation plays a role.
4. CAR-T Cell Therapy: CRISPR-Cas9 can be employed to enhance the effectiveness of chimeric antigen receptor T-cell (CAR-T) therapy, a promising immunotherapy approach for certain cancers. CRISPR-Cas9 can edit the T cells to improve their tumor-targeting capabilities and reduce the risk of side effects.
5. Immune System Engineering: CRISPR-Cas9 can be used to modify immune cells to enhance their ability to recognize and attack cancer cells or pathogens. This could lead to personalized immunotherapies with improved therapeutic outcomes.
6. Antiviral Therapies: CRISPR-Cas9 has potential applications in developing antiviral therapies. It can be used to target and edit viral DNA or RNA sequences, potentially disrupting viral replication and offering new strategies to combat viral infections.
7. In Vivo Gene Editing: Researchers are exploring the use of CRISPR-Cas9 to perform gene editing directly inside the patient's body. This approach aims to deliver CRISPR

components to specific tissues or organs, providing a non-invasive and potentially more effective method for gene therapy.

8. Cell Replacement Therapies: CRISPR-Cas9 can aid in the development of cell replacement therapies by modifying stem cells or other cell types to replace damaged or dysfunctional cells in the patient's body.

G. Cancer research

The CRISPR-Cas system has become an important tool in cancer research, offering valuable insights into the underlying mechanisms of cancer development and progression. Researchers are using CRISPR-Cas9 technology to study cancer-related genes, pathways, and therapeutic targets. Here are some key applications of CRISPR-Cas in cancer research:

1. Cancer Gene Identification: CRISPR-Cas9 is used in large-scale knockout screens to identify genes that play critical roles in cancer. By systematically targeting and disabling individual genes, researchers can observe the effects on cancer cell growth, metastasis, and response to treatments. This approach helps identify new oncogenes and tumor suppressor genes.
2. Functional Analysis of Cancer Genes: CRISPR-Cas9 allows researchers to study the functions of specific cancer-related genes. By knocking out or activating these genes, scientists can better understand their roles in cancer development and identify potential therapeutic targets.
3. Drug Resistance Mechanisms: CRISPR-Cas9 is used to study drug resistance in cancer cells. Researchers can create genetic modifications associated with drug resistance to investigate the underlying mechanisms and develop strategies to overcome resistance.
4. Immune Checkpoint Regulation: CRISPR-Cas9 is utilized to study immune checkpoint molecules, which play a critical role in cancer immune evasion. Researchers can manipulate these molecules to understand their impact on the tumor microenvironment and explore combination therapies for enhancing the immune response against cancer.
5. Personalized Cancer Therapies: CRISPR-Cas9 can be applied to create patient-specific cancer models to study tumor biology and assess individual responses to treatments. This personalized approach holds promise for tailoring cancer therapies to each patient's specific genomic profile.
6. Genome-Wide Functional Screens: CRISPR-Cas9 enables genome-wide screens to identify genes or non-coding elements involved in cancer progression and drug responses. These screens help uncover new biomarkers and potential therapeutic targets.

7. Synthetic Lethality Studies: CRISPR-Cas9 is used to investigate synthetic lethality, a phenomenon where the simultaneous loss of two specific genes leads to cell death. Identifying synthetic lethal interactions can uncover vulnerabilities in cancer cells and suggest new therapeutic approaches.
8. Cancer Vaccine Development: CRISPR-Cas9 is employed in cancer vaccine research to edit cancer cells and present specific tumor antigens to the immune system. This approach aims to trigger an immune response against cancer cells and develop personalized cancer vaccines.
9. Modeling Tumor Heterogeneity: CRISPR-Cas9 is used to create tumor models that recapitulate the genetic heterogeneity observed in cancer patients. By generating models with multiple genetic alterations, researchers can study tumor evolution and identify potential combination therapies.

H. Infectious disease research

The CRISPR-Cas system has proven to be a valuable tool in infectious disease research, offering new opportunities to study pathogens, develop diagnostics, and potentially develop novel therapies. Researchers are utilizing CRISPR-Cas technology in various ways to understand infectious diseases and combat them effectively. Here are some key applications of CRISPR-Cas in infectious disease research:

1. Pathogen Detection: CRISPR-Cas-based diagnostic tests, such as SHERLOCK and DETECTR, offer rapid and sensitive detection of infectious agents. These tests leverage the CRISPR-Cas system's ability to target and cleave specific DNA or RNA sequences unique to pathogens, providing a cost-effective and portable platform for diagnostics.
2. Viral Genome Characterization: CRISPR-Cas9 is used to study the genomes of viruses, including those with high mutation rates like RNA viruses (e.g., influenza and SARS-CoV-2). This information aids in understanding viral evolution, transmission patterns, and drug resistance mechanisms.
3. Antiviral Therapies: CRISPR-Cas systems can be engineered to target and cleave viral DNA or RNA, potentially inhibiting viral replication and infection. CRISPR-based antiviral therapies are under investigation as a new approach to combat viral infections.
4. Drug Target Identification: CRISPR-Cas9 is employed in functional genomics screens to identify host genes that are crucial for viral replication or infection. These genes can serve as potential targets for antiviral drugs.

5. Viral Evolution Studies: CRISPR-Cas systems can be used to track the evolution of viruses in real-time. By capturing viral sequences and comparing them over time, researchers can gain insights into viral adaptation and transmission dynamics.
6. Understanding Host-Pathogen Interactions: CRISPR-Cas9 is utilized to manipulate genes in host cells to study how pathogens interact with and evade the host immune response. This helps researchers understand the mechanisms underlying infections and identify potential therapeutic targets.
7. Viral Vectors in Gene Therapy: CRISPR-Cas9 is used in conjunction with viral vectors to deliver gene-editing components for gene therapy. This approach is being explored for treating genetic diseases, including those with an infectious component.
8. Vaccine Development: CRISPR-Cas9 technology is used to engineer attenuated or disabled viral strains for vaccine development. By modifying viral genomes, researchers can create safer and more effective vaccines.
9. Drug Resistance Studies: CRISPR-Cas9 is employed to study drug resistance in infectious agents. Researchers can create genetic modifications associated with drug resistance to investigate the underlying mechanisms and develop strategies to overcome resistance.

I. Environmental applications

The CRISPR-Cas system has potential applications in environmental research and conservation efforts. By leveraging its gene-editing capabilities, CRISPR-Cas can be used to address ecological challenges, restore ecosystems, and aid in the conservation of threatened species. Here are some key environmental applications of CRISPR-Cas:

Environmental Monitoring: CRISPR-Cas-based diagnostic tools can be developed to detect specific environmental pollutants, pathogens, or invasive species. These tests can provide rapid and accurate information about the health of ecosystems and aid in early detection and response to environmental threats.

1. Conservation Genetics: CRISPR-Cas9 can be used to study the genetic diversity of endangered species. By analyzing and manipulating specific genes, researchers can better understand the population structure and develop conservation strategies to preserve genetic variability.
2. De-extinction Efforts: CRISPR-Cas technology has been proposed as a potential tool for de-extinction—bringing back extinct species by editing the genomes of related living species. Although still a speculative concept with ethical considerations, CRISPR-Cas could play a role in restoring lost biodiversity.

3. Invasive Species Management: CRISPR-Cas9 could be utilized to control invasive species that threaten native ecosystems. By editing genes essential for the invasiveness of a species, researchers may reduce its ability to thrive and spread.
4. Genetic Engineering for Ecological Restoration: CRISPR-Cas technology can be applied to engineer organisms to assist in ecological restoration efforts. For example, researchers may modify plants to better tolerate adverse environmental conditions or to enhance their role in ecosystem services, such as carbon sequestration or soil remediation.
5. Disease Control in Wildlife: CRISPR-Cas can be used to target and control infectious diseases affecting wildlife populations. By editing specific genes in pathogens or vectors, researchers can potentially limit the spread of diseases among animals.
6. Climate Change Adaptation: CRISPR-Cas may play a role in enhancing the resilience of organisms to the effects of climate change. By editing genes that govern stress responses or adaptation mechanisms, researchers may develop organisms better suited to changing environmental conditions.
7. Biocontrol of Pests: CRISPR-Cas technology can be used to develop biocontrol agents that target specific pests or invasive species. By manipulating genes in these agents, researchers can increase their effectiveness in controlling pest populations.
8. Conservation of Endangered Species: CRISPR-Cas9 can be used to modify genes in cultured cells from endangered species, potentially aiding in assisted reproductive techniques and conserving genetic diversity.

Risk associated with CRISPR – Cas system

While the CRISPR-Cas system offers promising applications in various fields, including gene editing, agriculture, and medicine, it also comes with several risks and ethical concerns. Some of the key risks associated with CRISPR-Cas technology are as follows:

1. Off-Target Effects: One of the primary concerns with CRISPR-Cas9 is the potential for off-target effects. The Cas9 enzyme may unintentionally target and edit DNA sequences that are similar but not identical to the intended target. These off-target edits could lead to unintended and potentially harmful genetic changes.
2. Mosaicism: In some cases, CRISPR-Cas9 editing can result in mosaicism, where different cells within an organism have different genetic changes. This genetic variability could lead to unpredictable outcomes and complicate the interpretation of experimental results.

3. Incomplete Editing: CRISPR-Cas9 editing may not be 100% efficient, and some cells may remain unedited or partially edited. This could result in incomplete therapeutic outcomes or the persistence of disease-causing mutations.
4. Immune Response: The introduction of CRISPR components, such as Cas9 and guide RNA, into the body could trigger an immune response. This immune reaction may reduce the effectiveness of CRISPR-based therapies or cause adverse effects.
5. Ethical Considerations: The ability to edit the human germline (eggs, sperm, and embryos) using CRISPR-Cas technology raises ethical concerns. Germline editing has implications for future generations, and there are widespread debates about the ethical, social, and moral implications of making heritable genetic changes.
6. Unintended Consequences: Genetic modifications made using CRISPR-Cas technology may have unforeseen consequences, especially when multiple genes or regulatory elements are edited simultaneously. These unintended effects could impact the organism's health or ecological balance.
7. Horizontal Gene Transfer: CRISPR-Cas systems can be naturally present in certain bacteria and other organisms. The introduction of these systems into other species, such as in gene-edited organisms, raises concerns about horizontal gene transfer, potentially leading to unintended spread of genetic modifications.
8. Environmental Risks: The use of CRISPR-Cas technology in agriculture and ecological restoration could have unintended consequences on the environment. For example, gene-edited organisms could interact with native species or disrupt ecosystems, leading to ecological imbalances.
9. Inequality and Accessibility: The widespread use of CRISPR-Cas technology may raise concerns about unequal access to its benefits, especially in the context of gene therapies. Ethical considerations are crucial to ensure that this technology is accessible, affordable, and equitable.

As CRISPR-Cas technology continues to advance, addressing these risks is essential for responsible and safe applications. Scientists, policymakers, and society must work together to develop robust guidelines, regulations, and ethical frameworks to ensure the responsible use of this powerful tool. Extensive preclinical research, transparent reporting of results, and adherence to ethical principles are critical to mitigate the risks and maximize the benefits of CRISPR-Cas technology.

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MOLECULAR RECOGNITION OF BIOMOLECULES BY SMALL MOLECULE BASED SYNTHETIC RECEPTORS

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Abstract:

The recognition of biomolecules such as amino acids, peptides in water by synthetic receptors remains challenging. The recognition of biomolecules which not only have key roles in many biochemical pathways, as well as having pharmacological and biotechnological applications. Taking inspiration in nature many researchers have developed and applied a variety of different synthetic receptors, for selective recognition of amino acids, small peptides and proteins. In this chapter, we discuss selected examples of synthetic receptors for recognition of amino acids and peptides, based on non-covalent interactions in physiological conditions.

Introduction:

Amino acids are the basic building blocks of small peptides and proteins. The development of artificial receptors that can bind specific amino acids with high affinity and selectivity under physiological conditions constitutes a first step towards the development of multivalent, sequence specific receptors for peptides. However, the selective binding of free amino acids already presents a difficult task since some side chains of amino acids are very similar to each other.

Furthermore, design and synthesis of selective and high-affinity receptors for peptides are recognized to be very difficult in water. The practical difficulties related to the solubility of synthetic organic receptors. Therefore, to improve their solubility in aqueous solution further functionalization may require. The solvation of these biomolecules by water reduced the directional and strong interactions with receptor based on hydrogen bonding, which are frequently and successfully employed in organic solvents. However, the field has progressed significantly in recent years (Peczuh *et al.,* 2000) and it is now possible to design small synthetic receptors which function in aqueous solutions (Webb *et al.,* 1993). This has opened the way for prospective applications in proteomics (Zhong *et al.,* 2002), medical diagnostics (Schneider *et al.,* 2000), and drug delivery (Dong *et al.,* 1999).

1. Amino acid recognition by synthetic receptor based on electrostatic interaction

To achieve amino acid recognition in aqueous media, researchers have used ionic interactions to enhance the binding affinity of simple hydrogen bonding motifs. Positively charged receptors have been developed based on molecules containing guanidinium, imidazolium, and viologen groups.

1.1 Receptors based on guanidinium groups

(Schmuck, 1999) reported a class of guanidinium receptors for binding N-acetyl-α-amino acids in aqueous media. 2-(Guanidiniocarbonyl)pyrrole receptor (Fig. 1) was designed in such a way that the guanidinium cation binds to the oxo anions and pyrrole also forms a hydrogen bond to the bound carboxylate via a N-H···O hydrogen bonding interaction. Receptor binds N-acetyl-α-amino acid carboxylates in 40% H_2O–DMSO with binding constants ranging from K_a = 360 to 1700 M^{-1} depending on the structure of the amino acid side chain. For example, N-acetyl-phenylalanine is bound much stronger than the corresponding alanine or lysine derivatives. Molecular modeling calculations indicated that the differences in complex stability among the various amino acids were due to secondary interactions of the side chains with the receptor. For example, cation-π interactions between the aryl group in phenylalanine and the acylguanidinium unit of stabilize the complex. The positively charged ammonium group in lysine decreases the binding affinity due to unfavorable electrostatic interactions with the positively charged guanidinium group. Later Schmuck *et al.* also reported N'-alkylated guanidiniocarbonyl pyrroles that efficiently binds amino acid carboxylates in water (bis-tris-buffer, 3 mM at pH = 6.1) (Schmuck *et al.*, 2003). Additional binding interactions of the side chain attached to the N' of the guanidiniocarbonyl pyrrole with the backside of the substrate improved the complex stability and also increased the recognition selectivity. N-acetyl-L-valine (K_a = 1750 M^{-1}) was bound nearly two times better than N-acetyl-L-alanine (K_a = 1000 M^{-1}). Most likely the larger side chain of valine allows for more stabilizing interactions with the receptor than the small methyl group of alanine. A series of guanidiniocarbonylpyridine receptors were evaluated for binding N-acetyl-amino acids in aqueous DMSO (Schmuck & Machon, 2005). However, the electrostatic repulsion between the pyridine nitrogen lone pair and the bound carboxylate makes anion binding less efficient than with the analogous pyrrole receptors. A later prototype was bis-cationic guanidiniocarbonylpyrrole receptor, which efficiently binds N-acetyl alanine carboxylate with log K_a = 3.9 in water (bis–tris-buffer, 4.7 mM, pH = 6.0) (Schmuck, & Graupner, 2005). Due to the increased charge density in this dication, the binding constant is five times larger than for the parent guanidiniocarbonyl pyrrole monocation (log K_a = 3.2). A tris-cationic receptor binds amino acid carboxylates efficiently with $K_a > 10^3$ M^{-1} in water solely based on electrostatic interactions (Schmuck, & Geiger, 2005).

Notably, it binds N-acetyl-L-alanine carboxylate very strongly with a association constant of $K_a \geq 10^5$ M^{-1} in 40% water in DMSO (v/v). Furthermore, shows an unexpected cooperative 2:1 complex formation with N-acetyl glutamate but not aspartate in 90% water/DMSO (v/v). Hence the tris-cation is capable of differentiating between structurally similar glutamate and aspartate. The smaller distance between the two carboxylates in aspartate compared to glutamate might prevent the formation of 2:1 complexes due to steric/electrostatic repulsions.

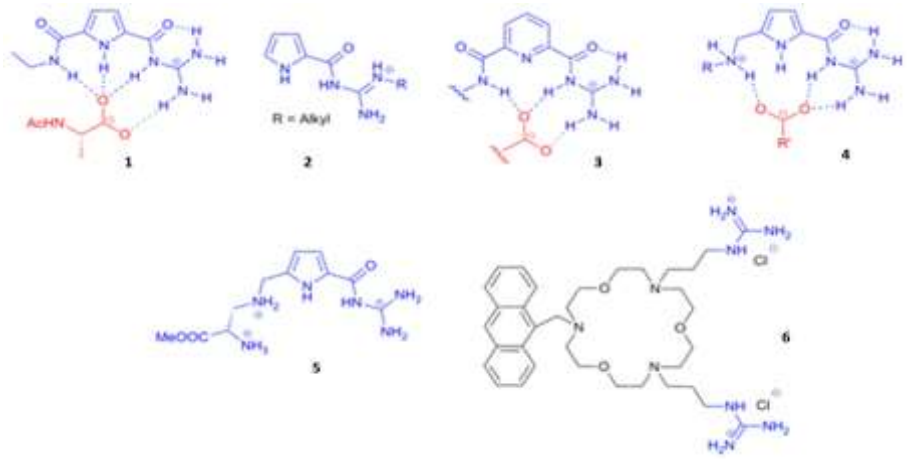

Figure 1: Receptors based on guanidinium groups

Suzuki *et al.* (2002) reported a fluorescent receptor based on triaza-18-crown-6 ether combined with two guanidinium groups which could bind several amino acids in aqueous methanol (pH 9.5) and showed fluorescence enhancement response by a photoinduced electron transfer (PET) mechanism. The binding site for the ammonium cation, the triaza-18-crown-6 ether unit, was connected to two guanidinium groups which function as a carboxylate binding site. The anthracene unit was used as a fluorescent reporter for amino acid sensing. The fluorescence response of receptor is GABA > lysine > n-$BuNH_3^+$, as only GABA and lysine have both a carboxylate and an ammonium group and thus interact with both binding sites, whereas the *n*-butylammonium cation can only bind to the crown ether moiety.

1.2 Receptors based on imidazolium groups

Lan *et al.* (2010) reported 1,1'-binaphthyl-based imidazolium receptors (Fig. 2) for highly selective recognition of tryptophan via synergistic effects of multiple hydrogen bonding and electrostatic interactions in aqueous solutions (pH 7.4). The binding affinity and selectivity of the structurally open cleft-like receptor (*R*)-**7** with L-Trp ($K_a = 1.73 \times 10^4$ M^{-1}) was larger than homologues (*R*)-. These results demonstrated that the C-2 hydrogen atom of the imidazolium ring plays a key role. The methylation of the C-2 hydrogen of the imidazolium nucleus of (*R*)-showed negligible changes in the fluorescence spectra. The macrocyclic (*R*)- exhibits a remarkable chiral recognition capability for the two enantiomers of tryptophan with a K_D/K_L of 6.2 despite an inferior selectivity towards a variety of aromatic amino acids.

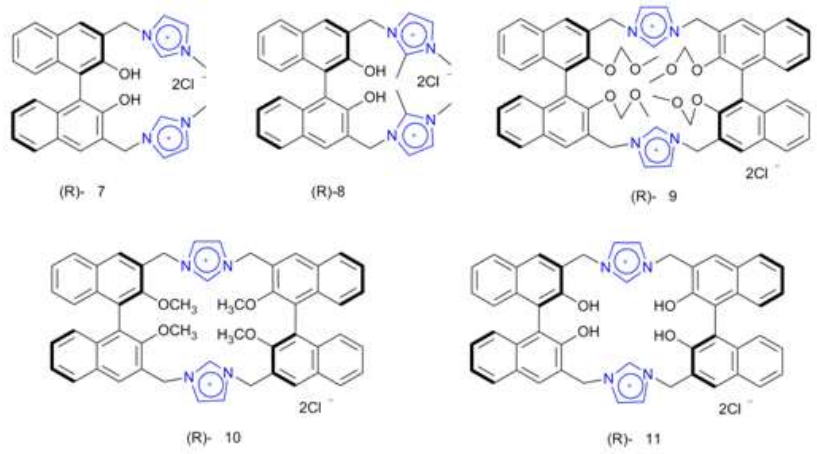

Figure 2: Receptors based on imidazolium groups

1.3 Receptors based on viologen groups

Ramaiah *et al.* (2007) reported a novel donor-acceptor conjugate (Fig. 3) for the selective recognition of Trp in aqueous medium. The viologen-linked pyrene forms a novel fluorescent intramolecular charge-transfer (ICT) complex in the aqueous medium and was tested for recognition of different amino acids. Upon addition of Trp, a decrease in the ICT fluorescence intensity at 475 nm was observed along with a concomitant increase in the pyrene fluorescence at 400 nm. This fluorescence change was due to 1:1 complexation between the conjugate and Trp with an association constant of K_a = 1300 M^{-1}. Significantly weak association was observed for Phe (K_a = 73 M^{-1}) and Tyr (K_a = 52 M^{-1}), whereas other amino acids under similar conditions exhibited negligible changes in both the absorption and the fluorescence properties. These results indicate that the conjugate interacts selectively with Trp and alters the π-stacking, electrostatic, and donor-acceptor interactions that favor the intramolecular ICT complex. Interestingly, the selectivity of the conjugate toward Trp was observed even in the presence of equimolar amounts of other amino acids.

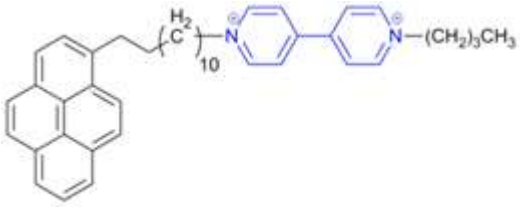

Figure 3: Receptor based on a viologen group

2. Amino acid recognition mediated mainly by hydrogen bonding

(Chan *et al.* 2005) investigated the binding affinities of a cholic-acid-based fluorescent neutral receptor (Fig. 4) toward amino acids in a CH_3OH/H_2O system (1:1, 0.01 M HEPES buffer, pH = 7.4). The emission spectrum of was quenched by ca. 20% upon the addition of with L-aspartate, glutamate, N-acetyl-L-aspartate and N-acetyl-L-glutamate. The preorganization of

permits three points binding with the guests leading to a more selective complexation with acidic amino acids. The synthetic host bearing four convergent functionalities strongly binds glutamate via multiple hydrogen bonds with a binding constant of $(5.57 \pm 0.88) \times 10^6\ M^{-1}$.

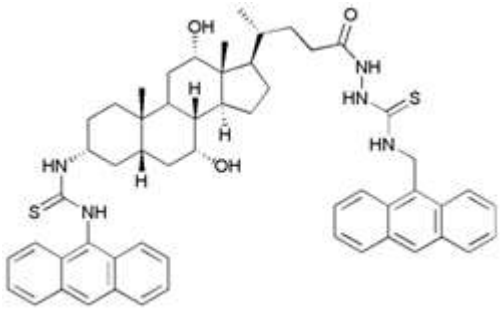

Figure 4: Receptor mainly based on hydrogen bonding

3. Amino acid recognition mediated by metal coordination

The most common applications of synthetic receptors for amino acids are either membrane transport or chemical sensing. The most straightforward way to associate reversibly with an underivatized α-amino acid in water is to use a synthetic receptor that incorporates a metal center that can chelate to the amino nitrogen and the carboxyl oxygen.

3.1 Receptors based on Cu-complexes

(Fabbrizzi *et al.,* 2003) reported an off–on "chemosensing ensemble" for selective recognition of histidine over other natural amino acids using an indicator-displacement assay (IDAs). Coumarin 343, fluorescein, and eosin Y were used as the fluorescent indicators. The indicator was bound by coordination to the $(Cu^{2+}{}_2$ (Fig. 5) receptor complex at pH = 7, which quenched its emission. The added analyte displaced the indicator and restored its full fluorescence. But the $(Cu^{2+}{}_2$/coumarin ensemble does not discriminate His from glycine (Gly). However, the fluorescein-containing ensemble satisfactorily discriminated His with full recovery of fluorescence. The highest sensing selectivity was observed for the $(Cu^{2+}{}_2$/eosin Y ensemble. The observed trend of stability of other amino acids (Gly > alanine (Ala) > phenylalanine (Phe) > valine (Val) > Leu > proline (Pro) seems to be related to the increasing steric repulsive effects exerted by the substituent. Anslyn et al. reported coordinatively unsaturated metal complexes to discriminate His from other zwitterionic α-amino acids by means of an IDA using 5(6)-carboxyfluorescein as an indicator. The titrations of complexes into solutions of the indicator caused a visual color change from a bright yellow green to a dark yellow brown in buffered $MeOH/H_2O$ (3:1) solution. The colorimetric recognition of His was achieved by using this IDA method, which appears to owe its selectivity to a unique process involving disruption of the host complex to form a 2:1 His/Cu^{2+} complex rather than simple indicator displacement.

(Anslyn *et al.,* 2005) also reported an operationally simple colorimetric recognition method based on competitive dynamic metal coordination in H_2O/MeOH (1:1) solutions.[32] A chromophoric ligand, pyrocatechol violet (PV), was used in this indicator displacement assay to effectively compete with the amino acid guest for open coordination sites on (S,S)-Cu^{2+}. Titration of (S,S)-Cu^{2+} with PV gave a 1:1 complex with a shift in λ_{max} from 445 to 645 nm, resulting in a change in color from pale yellow to intense blue. The reversal of the spectral change was observed upon addition of amino acids to the (S,S)-Cu^{2+}/PV complex, signaling PV displacement. The relationship between enantiomeric excess and absorbance in 1:1 MeOH/H_2O (50 mM HEPES buffer pH=7.0) was remarkably linear, demonstrating uniform sensitivity over the entire enantiomeric excess range. Enantiomeric excess curves for Leu generated with both (S,S)-Cu^{2+} and (R,R)-Cu^{2+} exhibit a near mirror image relationship.

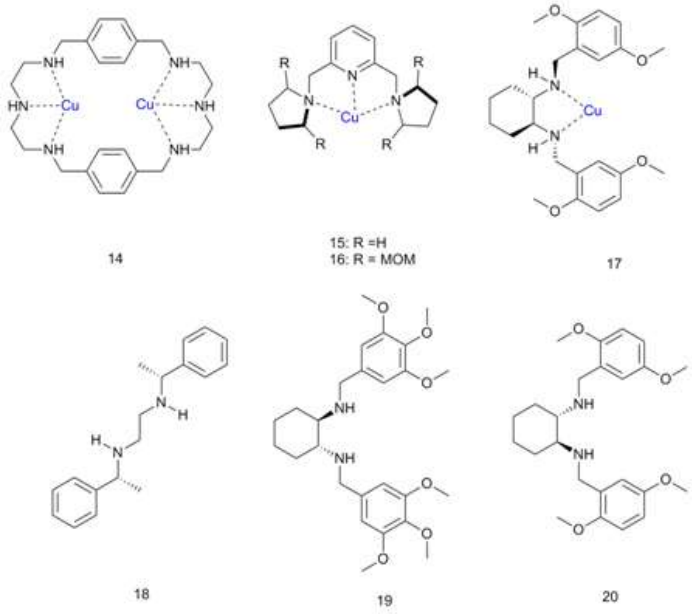

Figure 5: Copper containing receptors for amino acid recognition based on indicator-displacement assays

In further work, Anslyn *et al.,* (2006) reported the discrimination of enantiomeric and structurally similar amino acids through a series of IDAs based on dynamic metal coordination. Upon Cu^{2+} coordination, the indicators pyrocatechol violet (PCV), chromoxane cyanin R (CCR) and chrome azurole S (CAS) undergo large red shifts in their absorbance spectra, providing a highly sensitive colorimetric output. The enantioselectivity exhibited in each IDA was found to be a common property of the chiral receptor, as the complexes –Cu^{2+} and –Cu^{2+} prefers L configurations while –Cu^{2+} favors D configurations. Since free CAS and Cu^{2+}-bound CAS are yellow and blue, respectively, the ratio of bound to free indicator, which depends on the stability of the receptor–amino acid complex, could be assessed by visual inspection (1:1 MeOH:H_2O, 50

mM HEPES buffer, pH = 7.8). All of the IDAs exhibited a relative chemoselective order for complex stability of Trp > Phe > Leu ~ Val > tert-leucine (Tle).

3.2 Receptors based on Rh-complexes

(Severin *et al.,* 2005) reported an array of IDAs for colorimetric identification of the twenty natural amino acids. Organometallic Cp*Rh complex (Fig. 6) was employed as the receptor unit and the dyes gallocyanine, xylenol orange, and calcein blue were employed as the indicators for these IDAs. A key component of the sensor array was the utilization of a variable pH to change the selectivity of the sensing ensemble. The absorption at 750 nm of an IDA composed of gallocyanine was used to classify the amino acids as either high-affinity (consisting of His, Cys, Met, Asp, Asn, ΔA (750 nm) < 0.06) or low affinity (the remaining 15 amino acids (0.55 > DA(750 nm) > 0.06). Each member of the first group was analyzed by four IDAs (using two different dyes, xylenol orange, and calcein blue, and two different pH values), and each member of the second group was analyzed by five IDAs (gallocyanine as the indicator, at five different pH values). Linear discriminant analysis (LDA) and principal component analysis (PCA) were performed for the identification of the amino acids. The amino acids were well separated with the only overlap found for valine and isoleucine. The sole cyclic amino acid, proline, was well separated from the rest amino acids and closely related analytes such as leucine and isoleucine were clearly distinguishable.

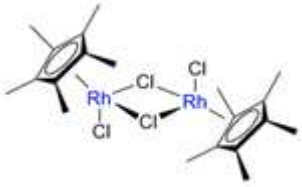

Figure 6: Rhodium containing receptor for amino acid recognition based on indicator-displacement assays

3.3 Receptors based on Au-complexes

(Yang *et al.,* 2005) reported a ‘‘chemosensing ensemble’’ method for the detection of cysteine and homocysteine in water (MeOH 1%). A complex of Au^{+} and a 2-deoxyribose functionalized rhodamine hydroxylamine was used for this purpose. In the presence of Au^{+} only Cys and Hcy induced significant enhancements in fluorescence intensities (Fig. 7). The recognition of Cys was attributed to binding of the Cys thiol to the Au^{+}-bound probe. The corresponding binding constant was $K_a = 6.65 \times 10^3\ M^{-1}$ and detection of Cys was possible even at the 100 nM level. The binding of Cys to $–Au^{+}$ also caused a red coloration (log ε^{530} nm = 4.512 $M^{-1}\ cm^{-1}$) that could be viewed with the naked eye. No other amino acids exhibited similar color changes with $–Au^{+}$ under the same conditions.

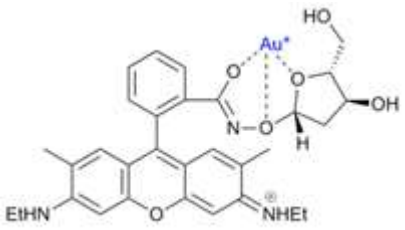

Figure 7: Au^{+} containing receptor for amino acid recognition

Synthetic receptors for peptides

Peptides have diverse chemical structures presenting a variety of different functional groups (amide backbone, side chain functional groups) which can be used as binding sites. Thus various noncovalent interactions such as H-bonding, metal coordination, salt bridges, hydrophobic stacking, or π-π interactions can be exploited for peptide recognition. Interactions with the functional groups in the amino acid side chains are of special interest as this not only increases the binding affinity, but also can render the recognition process selective. One of the ultimate goals is to develop molecular design algorithms that lead to a synthetic receptor for any specific peptide sequence. The following sections systematically discuss synthetic receptors for peptides based on hydrophobic interactions, electrostatic interactions, and metal coordination.

4. Peptide recognition mediated by hydrophobic interactions

The driving force for the molecular interaction of two nonpolar molecules in water is often an increase in the entropy of the solvent upon complex formation. Nonpolar molecules in water disturb the H-bonded network of bulk water molecules. The water molecules at the surface of a nonpolar organic molecule are restricted in their orientation as they find neighbouring water molecules only in one direction, away from the organic molecule. Hence they have a higher degree of order compared to water molecules in the bulk phase. The number of such unfavourable water molecules directly depends on the surface area of the organic molecule. The larger the solvent exposed surface the more water molecules are affected. When two organic molecules aggregate the overall solvent exposed surface area is reduced and hence a number of formerly ordered solvent molecules are released into the bulk phase. This is an entropically favourable process. Often, the van der Waals interactions between the two organic molecules have the same strength as the van der Waals interactions with the water molecules. Hence, the change in enthalpy for complex formation due to the hydrophobic effect is usually relatively small. Molecular association in water due to the hydrophobic effect is comparatively insensitive to molecular shape. However, binding selectivity can be imparted if the receptor molecule possesses a hydrophobic cavity that forces a size filter on the binding partner. Alternatively,

substrate selectivity can be achieved if the hydrophobic binding site is augmented by salt bridges or a network of highly directional H-bonds.

4.1 Cyclodextrin-based receptors

Cyclodextrins are a class of cyclic oligosaccharides consisting of six to eight D-glucose units linked by α-1,4-glycosidic bonds. Cyclodextrins form stable inclusion complexes with many organic molecules in water, and they are well known to encapsulate the hydrophobic side chains of the amino acids phenylalanine, tyrosine, and tryptophan, respectively (Fig. 8) (Breslow *et al.,* 1992). There have been several reports of cyclodextrin (CD)-based receptors for the sequence-selective recognition of peptides containing hydrophobic amino acids in water.

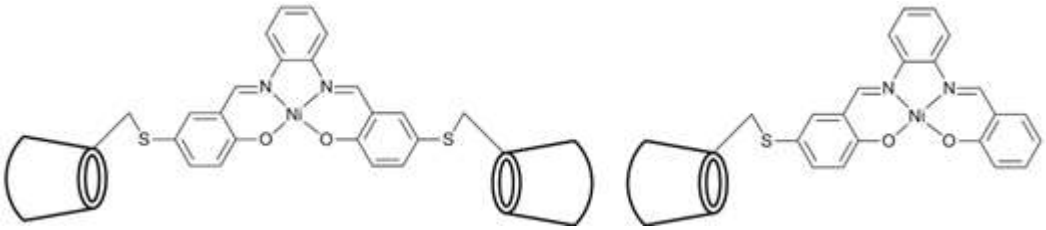

Figure 8: Cyclodextrin- nickel salophen complexes for recognition of L-Phe-D-Pro containing peptides in water

Still *et al.* (1996) used a combinatorial approach to investigate the binding properties of β-cyclodextrin hosts to di- and tripeptides.[45] They screened two orange-colored nickel salophen based hosts with two or one β-cyclodextrin moiety, respectively, against a tripeptide library synthesized on a solid support (a hydrophilic poly(ethyleneglycol)polystyrene (TentaGel). The general structure of the library was AA^3-AA^2-AA^1-$NH(CH_2)_2$-TentaGel, prepared by split-mix synthesis using 29 different amino acids at each position providing a library size of $29^3 = 24389$ tripeptides. Both receptors showed remarkable selectivity for binding certain peptides in water at pH 7. The screening results showed that the two receptors favor peptides containing either the L-Phe-D-Pro or the D-Phe-L-Pro dipeptide unit. Subsequent ^{1}H NMR titration studies of H_2N-L-Phe-D-Pro-$CONHCH_3$ and H_2N-L-Phe-L-Pro-$CONHCH_3$ with unsubstitued β-cyclodextrin in D_2O revealed a binding constant of 180 ± 20 M^{-1} for the s-trans conformer of L-Phe-D-Pro. With the help of molecular modeling the authors concluded that hydrophobic encapsulation of the phenyl ring by the cavity, together with interactions of the proline ring with the rim of the cyclodextrin, account for the high stability of the complex.

Extending this work, (Breslow *et al.,* 1998) later on reported β-cyclodextrin dimers (Fig. 9) and studied their binding properties with several peptides in aqueous buffer (0.2 M pH 9.0 $NaHCO_3/Na_2CO_3$) at 25°C. Host having a short disulfide linkage on the primary cyclodextrin face binds the simple dipeptide Trp-Trp ($K_1 = 1200 \pm 400$ M^{-1}) better than the other dimers. For example, dimer contains a longer link between the primary faces of the two cyclodextrins and

binds significantly weaker to Trp-Trp (96 ± 2 M^{-1}). This affinity is similar to the affinity for a cyclic peptide **a** (98 ± 4 M^{-1}). Breslow et al. also prepared dimers with different linkers connecting the two cyclodextrins via their secondary face. In agreement with the earlier work on host, also there was a large affinity for peptides such as **a** (K_1 = 2590 M^{-1}; K_2 = 1120) and **d** (K_1 = 1100 M^{-1}; K_2 = 114 M^{-1}) having two L-Phe-D-Pro units. However, did not bind to Trp-Trp, or peptide **b** (with a Trp-Gly-Trp sequence) or peptide **c** (with a Phe-Gly-Phe sequence). Similarly, dimers and prefer to bind peptide **a** compared to peptides Trp-Trp or Phe-Phe. Hence, the selectivity of these hosts depends on both the lengths of the linkers and their mode of attachment within the cyclodextrin dimers (primary or secondary face).

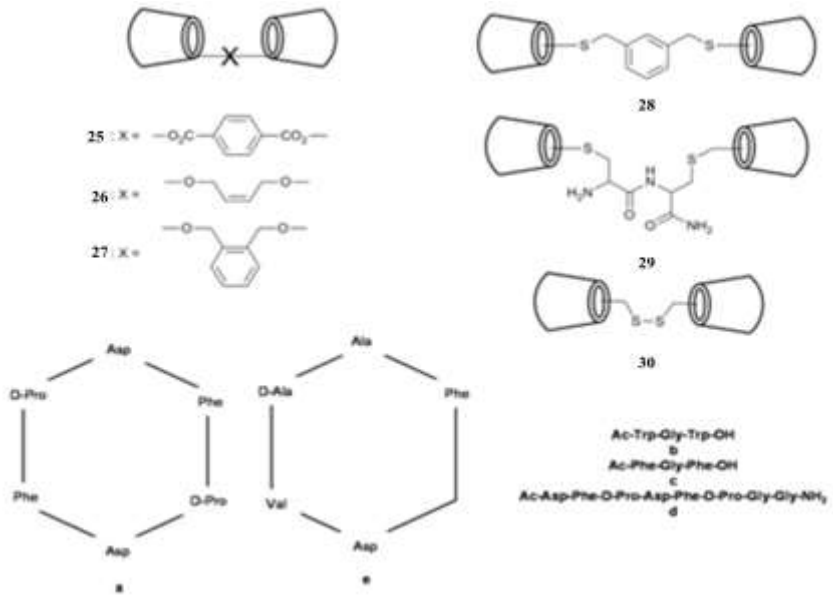

Figure 9: Cyclodextrin based peptide receptors and different peptides used as substrates

Liu *et al.,* (2004) reported bridged oxamide bis(2-benzoic) carboxyl linked bis(β-cyclodextrin), the corresponding copper(II) and nickel(II) complexes (Fig. 10) and their binding properties with some oligopeptides in Tris-HCl buffer solution (pH 7.4). Mainly aliphatic oligopeptides such as Leu-Gly, Gly-Leu, Gly-Pro, Glu-Glu, Gly-Gly, Gly-Gly-Gly, and Glu-Cys-Gly were tested as substrates. All these peptides form 1:1 inclusion complexes with the hosts. Host strongly binds Glu-Cys-Gly with a binding constant of K = 6850 M^{-1}. This strong binding was interpreted as a cooperative interaction with the two β- cyclodextrin cavities. In contrast, Glu-Glu contains three carboxylate groups and is hence more hydrophilic, thus showing poorer binding with (K_a = 135 M^{-1}). Furthermore, these hosts could differentiate between the two isomeric dipeptides Leu-Gly and Gly-Leu. The former peptide has a more linear conformation which fits better into the two cyclodextrin cavities than the Leu-Gly dipeptide that possessed a large isobutyl branch. The longer tripeptide Gly-Gly-Gly fits even better as it perfectly spans the distance between the two CD cavities within the host.

Later the same authors incorporated a fluorescent pyridine-2,6-dicarboxamide linker between two β-cyclodextrins and studied its complexation behavior with some aliphatic oligopeptides in aqueous buffer solution at two different pH values, namely 2.0 and 7.2, respectively. The 2,6-disubstituted pyridine group in the linker acted as an effective binding motif for the peptide carboxylate fragment (Liu *et al.,* 2004). Binding was strongest for Gly-

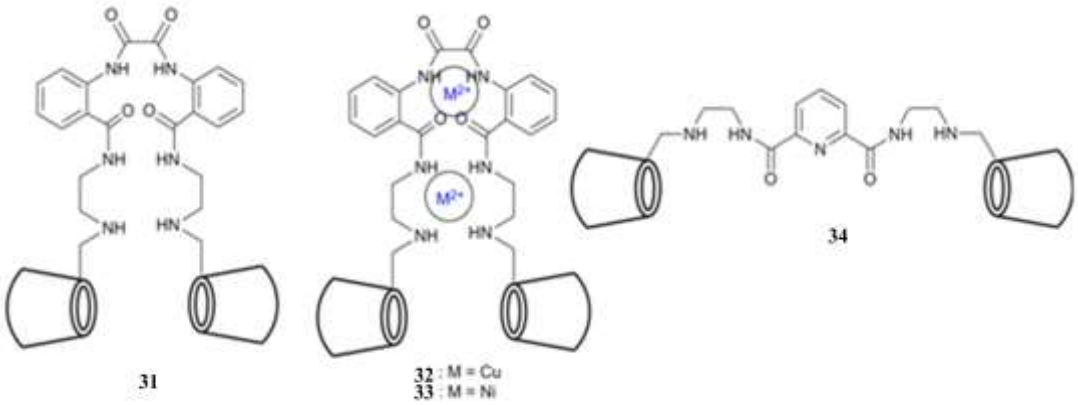

Figure 10: Bis-cyclodextrin receptors used for binding dipeptides

Leu (K_a = 1208 M^{-1}) at neutral pH and affinity decreased in acid. In neutral media the host adopts an extended conformation and the peptide guests bind into the two cavities of the host. In acidic media, the protonated pyridinium ring can partially bind into one cyclodextrin cavity, so that guest binding occurs only with the remaining free cavitiy.

Conclusion:

The goal of obtaining strong and selective binding of amino acids or peptides by artificial receptors has fascinated many research groups over the years. Each group developed a different approach which has led to an extensive set of artificial receptors but in many ways the field is still in its infancy. Only in recent years has it become possible to produce synthetic receptors that operate efficiently in water and now the challenge is to augment the basic recognition process with performance features that enable practical outcomes. The recognition of amino acids utilizing indicator-displacement assays, metal cation coordination or specific reactions (*e.g.*, imine formation) has been achieved. Due to the similarity in structure and reactivity of some amino acids, it is still challenging to develop receptors that can discriminate them with high selectively and sensitivity. For example, it is still difficult to distinguish the three biological important thiols Cys, Hcy and GSH in certain biomedical samples. However, progress to date has been encouraging and indicates that improved amino acid receptors will soon be developed.

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CHEMICALLY MODIFIED PLANT MATERIALS USING BIOADSORBENTS

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Abstract:

This study examines the role that chemically tailored biosorbents play in removing sulfur dioxide from plant materials. It only acknowledged a small number of biosorbents and their accountability. It was found that altering biosorbents is necessary to increase their capacity. Numerous biosorbents are made primarily of plant materials, which are crucial for the reduction of costs. Adsorption technology has been successfully employed for controlling water pollution. The Adsorption phenomenon, which has been studied using adsorbents modified with potassium permanganate, is greatly influenced by the surface chemistry, surface modification, nature of the adsorbate, and adsorbent. According to the results of the current studies, the most effective plants for removing sulfur dioxide are *Citrus limetta*, *Abelmoschus esculentus*, Hevea brasilensis, Hibiscussabdariffa, *Bacopa monnieri*, Aloe barbadensis Miller, Psidiumguajava, *Nelumbo nucifera*, Fenugreek, and Amaranthus. It is necessary to conduct large-scale research on the biosorption progression elimination of sulfur dioxide from plant materials because, despite the various biosorption studies, the majority of the works reported were laboratory-based.

Keywords: Adsorption, Adsorbent, Bioadsorbents, Plant materials.

Introduction:

High traffic areas cause air pollution issues as human activity rises. Freight transportation and logistical activities are the main contributors to pollution from road transportation. Also contributing to the high production of gas pollutions, especially SO_2 gas, are the industrial sector, high fossil fuel consumption, and large urban populations. A significant portion of China's declining air quality is caused by SO_2. When sulfur-containing elements in fossil fuels like coal and petroleum are oxidized during the combustion process, SO_2 is produced. At a taste threshold of 0.35-1.05 ppm and an odor threshold of 0.67-4.75 ppm, SO_2 concentration in the air can be detected. The WHO recommends that daily SO_2 concentrations not exceed 20 g/m3.

A substance is moved from the liquid phase to the solid phase through the accumulation and transport process known as biosorption. It is a physically-chemically autonomous metabolic process with mechanisms like absorption, precipitation, adsorption, ion exchange, and surface complexity. Agricultural waste materials are the leftover by-products from a variety of agricultural operations. The effectiveness of non-conventional agricultural waste materials for reducing air pollutants depends on their accessibility, affordability, environmental friendliness, nature, particle size, and the concentration of adsorbent and adsorbate[1-4]. Pectin and cellulose are abundant in agricultural waste. In recent studies, agricultural waste by-products were successfully used to remove chromium, arsenic, and fluoride ions[5,6]. Taking those studies into account, research has been done using agricultural wastes that have been treated with potassium permanganate[7]. The farm wastes that were examined *Citrus limetta*, *Abelmoschus esculentus*, *Hevea Brasiliensis*, *Hibiscus sabdariffa*, and *Bacopa monnieri* Psidium guajava, Aloe barbadensis Miller, *Nelumbo nucifera*, Fenugreek, and Amaranthus.

There are many disadvantages to conventional methods for removing heavy metals, including ineffectiveness and high costs. Ions biosorbed on the surfaces and active sites of biosorbents during the biosorption of heavy metals. This study looked into the connection between removal efficiency and the following variables: pH, temperature, biosorbent dosage, retention time, and functional groups. The goal of this work is to establish ideal circumstances for the biosorption reaction. Additionally, by introducing different kinds of biosorbents, expressed the benefits and preparation method for each one. Not all biosorption isotherm models have been discussed in various chapters; instead, different types of biosorption isotherm, kinetics, and thermodynamic models have been described, and crucial process data has been organized for easy access to the tables.

Humans are most commonly affected by SO_2 gas pollutants through irritation of the respiratory system, which can lead to symptoms like coughing, mucus production, difficulty breathing, decreased lung function, chest tightness, changes in lung defenses, and even chronic lung disease for longer-term exposure to high SO_2 concentrations. Through both homogeneous and heterogeneous processes, SO_2 gas oxidized in the atmosphere to produce sulfate compounds. The intermediates (HSO3) in this process quickly combine with atmospheric water vapor to form sulfuric acid aerosol. Because of this process, SO_2 gas is more likely to become acidic, which can damage mucous membranes in the nose, throat, and other respiratory tracts leading to the lungs. An effort should be made to reduce SO_2 gas pollution to the environment in order to lessen the negative effects caused by SO_2 gas.

Selection of the adsorbent

***Bacopa monnieri*:** Ayurvedic practitioners have used the medicinal plant bacopa (*Bacopa monnieri*) for centuries. It is often referred to as Brahmi. The common name for this plant, which is collected, is *Bacopa monnieri*. In marshy areas, it is extensively grown. These plant leaves contain bacapasides I–XII, terpenoids, and alkaloids[8].

Chemical modification of *Bacopa monnieri*: The collected leaves and flowers of the *Bacopa monnieri* plant are crushed, air dried, and sealed in bottles[9]. following cleaning, washing, and color removal. Potassium permanganate is used to modify the surface of the dried *Bacopa monnieri* leaves because it is a good oxidizer and increases the surface's functional groups that contain oxygen. FTIR analysis reveals prominent bands at 3266.82cm^{-1}, 2915.04 cm^{-1}, 1685.78 cm^{-1}, 1500.35 cm^{-1}, 1416.76 cm^{-1}, 1222.65 cm^{-1}, 1145.51 cm^{-1}, 1010.52 cm^{-1}, 840.812 cm^{-1}, 713.533 cm^{-1} indicating the presence of various functional groups NH_2, OH, alcohol, aldehyde groups. The finger print region contains numerous peaks that facilitate the adsorption of sulfur dioxide molecules from aqueous solutions. The modified *Bacopa monnieri* leaves don't do much work, so it is tested for adsorption.

***Hibiscus sabdariffa* (Roselle):** commonly referred to as "Gongura," which comes in two varieties: green- and red-stemmed varieties. Sandalwood can grow in both clay and sandy soils. The growth of Gangura is suitable for loamy soils. We gather gangura leaves from the garden.

Chemical modification of Gongura: The leaves were sundried, washed after cleaning. For structure modification, these leaves are treated with 0.01 m Potassium Permanganate[10]. The modification was made to add more oxidizing groups, which could result in the adsorption of sulfur dioxide. An FTIR analysis of gongura leaves revealed the presence of acid groups, acetylated oxime and imine groups, aldehydes, alkanes, phenols, and ketones.

***Citrus limetta*:** Lemongrass is a common name for it. It belongs to the grass family and has a variety of medicinal properties[11]. It has antiseptic properties and it is good insect repellent. After initial purification, 0.01N potassium permanganate was applied to the lemongrass leaves before being used in the study. The FTIR studies that were not treated with potassium permanganate revealed a number of absorption peaks that were complex in nature and contained carbonyl, hydroxyl, and amino groups. Using modified lemongrass as an adsorbent, synthetic dye molecules can be created from wastewater by trapping them. In order to remove methyl blue, lead ions from wastewater, and the dye methylene red, lemongrass powder is used as an adsorbent in tannery water treatment. Taking these factors into account, it has also been used to remove sulfur dioxide from aqueous solutions.

***Abelmoschus esculentus* (lady finger):** Most typical in India. Tropical and subtropical climates support its growth. It contains proteins, minerals, and vitamins[12]. Since they are a great source of iodine, they can be used to treat goitre. Congo red, Cr(VI) azo dyes, dye removal, the creation of zerovalent iron nanoparticles, and fluoride removal are just a few of the uses for ladyfingers. Taking this into account, Abelmoschus esculent has been successfully used to study its sulfur dioxide adsorption capacity. Abelmoschus is procured from the neighborhood market, cleaned, dried, and powdered, then treated with 0.01N potassium permanganate for adsorption studies.

***Aloe barbadensismiller* (Aloe vera):** The genius of Aloe is Aloe vera. It is a 500-variety green perennial plant that is widely cultivated. From a nearby garden, aloe vera was harvested. Aloe vera has been used to treat wastewater and remove dyes, heavy metals, and other contaminants from aqueous media[13]. Considering that justification. After being cleaned and dusted with Aloe Vera leaves that have been dried, Aloe Vera is treated with 0.01 N Potassium Permanganate and used for further research.

***Nelumbo nucifera* (Lotus):** Lotus root powder *Nelumbo nucifera* is the scientific name for the aquatic plant species known as the lotus, which is native to India and has submerged root systems[14]. Swamps, lakeshores, and riverbanks are where they thrive. They also thrive in contaminated water. Lotus root powder has been researched for reducing sulfur dioxide pollution taking that into account. Modified polysaccharides are found in lotus roots and are used for drug delivery. Lotus roots were altered to improve adsorption, and these modified roots were investigated as protonated amine-modified lotus, modified for the removal of chromium (CrVI), reactive radium (Ra), and cadmium (Cd). Potassium permanganate is applied to lotus root to increase the active sites for sulfur dioxide adsorption.

***Hevea Brasiliensis* (Rubber leaves):** The local garden is where rubber leaves are gathered. They were then ground into powders, dried, and crushed[15]. Surface modifications are made to these powders using a 0.001 N potassium permanganate solution. Rubber leaves are employed as an adsorbent for the removal of methylene blue, copper, lead, and chromium as well as the adsorption of toxic Pb (ii) ions by chemically treated rubber, organic acid-modified rubber, phosphoric acid-treated rubber, and hydrogel. Numerous studies that supported the use of rubber leaf as a bioadsorbent have been conducted.

Amaranthus (Thotakura (red)): Amaranthus is a perennial plant and they are summerweedds and are known as pigweeds They contain various pigments that range from maroon to crimson[16]. These Amaranthus leaves are gathered in the summer from the surrounding areas because they are widely cultivated there and are regarded as waste plants. Considering the potentialof agro-waste materialleaves were cut, dried and made into powder.

Potassium permanganate has been used to treat this powder. It is a brand-new adsorbent that hasn't undergone extensive research.

Fenugreek (Methi): Vitamin K, calcium, vitamin E, riboflavin, and folic acid are among the vitamins found in fenugreek or methi leaves[17]. They are very effective for a variety of illnesses. These leaves have not been the subject of many studies. These leaves screen out for the adsorption of sulfur dioxide, according to the studies that have been conducted so far.

Psidium guajava **(Guava):** A traditional plant is the guava. Tropical and subtropical regions are where it grows. Numerous studies[18] use guava leaves as adsorbents. Based on the innate wisdom of guava leaves, sulfur dioxide has been removed using 0.01N potassium permanganate.

Biosorption: Using distilled water, a stock solution of 100 ppm sodium metabisulphite is created. 100ml of a 40 ppm sulfur dioxide aqueous solution was used for batch adsorption studies. Adsorbent (1 gm) is added to bottles. The West-Geek method using a spectrophotometer to determine a solution's starting and ending concentration[19]. Calculated is the amount of sulfur dioxide removed as a percentage.

Bacopa monnieri **(Bramhi):** Brahmi's polymeric nature and the presence of Baco residues I cause adsorption[20]. The bonds were broken with the aid of potassium permanganate. Brahmi or bio adsorbent has more active sites with more oxidizing groups as a result of the bond breaking on its surface. The removal of sulfur dioxide molecules from an aqueous solution of sulfur dioxide can be attributed to the intricate surface mechanism. For a sulfur dioxide concentration of 40 ppm in an aqueous solution, Brahmi removes 50% of the gas.

Hibiscus sabdariffa **(Roselle) Gongura:** Remove 52% of the percentage Highly fibrous and polymeric in nature, gongura. Due to the presence of C=C and N-H bonds, it is oxidized by manganate (Ill) ions. The oxidizing agent's oxygen reacts with the sulfur dioxide's acidity and is then absorbed by other surfaces of the gingular eave that are active. Following the biosorption process is the reaction.

Aloe barbadensismiller **(Aloe vera):** Modified Aloevera leaves remove 40% of sulfur dioxide from an aqueous solution. When Aloevera is treated with chemicals, it is discovered from earlier studies that the specific surface of acid, base, and oxidizing agent increases, aiding in the adsorption. These mesopores were studied using the Barrett-Jaine- Helenda method.

Nelumbo nucifera **seed powder:** 40% of sulfur dioxide is removed using lotus seed powder. There have been numerous studies on lotus seeds for direct use, but none of them used chemical modification. The more active groups on the treated surface enable successful adsorption.

Hevea Brasiliensis**(Rubber leaves):** Sulfur dioxide was 52% more effectively absorbed on modified rubber leaves. This green adsorbent holds promise for effective adsorption. Sulfur

dioxide and rubber leaves may bind as a result of physical or chemical forces. According to studies, 12% of methi leaves, 3% of thotakura leaves, and 1% of guava leaves adsorb.

Results and Discussions:

With potassium permanganate-modified ladyfingers, 68% of the sulfur dioxide is removed. Hemicellulose, lignin, and pectin are the main components of ladyfinger. The hydroxyl groups that connect the molecules of cellulose together to form the ladyfingers are made of. Potassium permanganate alters and modifies these intricate, structural behaviors of functional groups. Numerous bonds that were already present are broken as a result of chemical modifications, creating more active sites. Sulfur dioxide molecules from an aqueous solution were able to be adsorbed because there were more oxygen-containing groups in addition to active sites. With lemongrass modified with potassium permanganate, 75% of the sulfur dioxide is removed. Given that lemongrass has a variety of functional groups, potassium permanganate has modified its polymeric nature. This modification has increased the number of active sites on the surface and may have made nascent oxygen groups more reactive, causing the oxidation of sulfur dioxide and the adsorption process.

Conclusion:

This study examines the role that chemically tailored biosorbents play in removing sulfur dioxide from plant materials. It only acknowledged a small number of biosorbents and their accountability. It was found that altering biosorbents is necessary to increase their capacity. Numerous biosorbents are made primarily of plant materials, which are crucial for the reduction of costs. Utilizing screening tests, the ability of potassium permanganate modified plant-based adsorbents to remove sulfur dioxide from aqueous medium was examined. Aloe barbadensis, *Citrus limetta*, *Abelmoschus esculentus*, Hevea brasilensis, *Hibiscus sabdariffa*, *Bacopa monnieri*, Psidium guajava, *Nelumbo nucifera*, Fenugreek, and Amaranthus are some examples of plant species. With the help of these screening techniques, we were able to evaluate the performance of the modified biosorbents in advance of further study.

There is a need to conduct large-scale research on the biosorption process for removing sulfur dioxide from plant materials because, despite the various biosorption studies, the majority of the works reported were laboratory-based. Although plant charcoal has potential as an adsorbent for SO_2 gas, more research is needed to determine how it can be used to remove other pollutants, such as gases, heavy metals, or organic compounds. It may be suggested to optimize the carbonization process's temperature, methods, and activation or modification. It's also important to note that inexpensive adsorbent needs to have its recovery assessed in order to be

used on a large scale and commercialized. In the end, it's crucial that this material can be used in actual contaminated environments.

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USE OF REMOTE SENSING TECHNIQUE IN AGRICULTURE

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Abstract:

Agriculture field plays crucial role in food supply to us. But there are many issues disturbing agriproducts. Climate change, water shortage, improper value of agriproducts in market, population growth, low-income levels are the key factors influencing agriculture field. In such situation remote sensing can be the best tool to agriculture field. Various applications of remote sensing play a vital role to detect problems in agriculture and gives insight to overcome these problems. This review article discusses role of remote sensing in agriculture field.

Keywords: Agriculture, remote sensing, sensors, vegetation cover, soil mapping

Introduction:

In 1960 A.D. Fischer devised the term remote sensing. Remote sensing is defined as the art and science of gathering information about objects or areas from a distance without having physical contact with objects or areas being investigated. Use of electromagnetic spectrum is the principle used in remote sensing. It is the science and technology of making inferences about material objects from measurement made at a distance without coming into physical contact with the object under study. It is a tool to monitor the earth's resources using space technology in addition to ground observations. Such examinations can be carried out using ground-based instruments as well as sensors or cameras mounted on ships, aircraft, satellites, or other spacecraft (Prabhakar *et al.*, 2011). This collection of basic data involves monitoring of crop growth, soil moisture condition, irrigation drainage and outburst of pest, disease infection. Remote sensing collects data without destroying the crop, which can be used to provide vital information for precision agriculture.

Types of remote sensing

There are two main types of remote sensing, passive remote sensing, and active remote sensing.

Passive remote sensing depends on natural energy bounced by the target. It makes use of seasons that detects the reflected/emitted electromagnetic radiation by natural sources. Active remote sensing: It makes the use of seasons that detects reflected responses from object that are

irradiated from artificially generated energy sources. In this remote sensing, instruments operate with their own source of emission or light.

Remote sensing platforms

There are three main types of remote sensing platforms. These are the vehicles that carry remote sensors to collect data from a distance.

1. **Airborne platforms:** These remote sensing vehicles operate in Earth's atmosphere. These include airplanes, helicopters, and drones.
2. **Ground borne platforms:** These are remote sensing vehicles that operate on the Earth's surface. Infrared thermometer, spectral radiometer, pilot balloons, & radars are some of the ground based remote sensing tools.
3. **Space borne platforms:** These are remote sensing vehicles that operate in space. These include satellites, which are the most used space platforms for remote sensing. The satellites are subdivided into two classes. (a) Polar orbiting satellites-These satellites operate at an altitude between 550 &1600 km along an inclined circular place over t5he poles. LANDSAT (USA), SPOT (France), & IRS (India) series are some of the remote sensing satellites. (b) Geostationary satellites- These are satellites that orbit the Earth at an altitude of approximately 36,000 km. The INSAT series satellites are launched from India for the above purpose.

Sensors used in remote sensing

a. **Photography:** It is the most used sensing systems. The film records the energy reaching in at the time in the visible and near infrared ranges of the spectrum. The range of any individual system is governed by a particular film characteristics and use of films.
b. **Line scan and related system:** It uses the visible and near infrared portion of the spectrum. In this system a mirror is rotated parallel to the direction of the movement of the aircraft or satellite. The mirror reflects the radiation received on to a detector and the data are recorded.
c. **Microwave system:** Microwave radiation is emitted from the earth's surface is very small quantities. These microwaves are used by microwave sensors in a wavelength of about 1 mm to 1000 mm. The sensors record the microwave radiation through complex antennae. These are used in weather satellites (Ray, 2016).

Basics of agriculture remote sensing

Using remote sensing farmers observe their fields to assess the condition of crops. Observing the colors of leaves or the overall appearances of plants can determine the plant's condition. Remotely sensed images taken from satellites and aircraft provide important

information to assess field conditions without physically touching them. Exploring Information from remotely sensed images allows farmers to treat only affected areas of their field. Remote sensing is very important tool for farmers. Energy from sunlight is called the electromagnetic spectrum shown in fig.1.

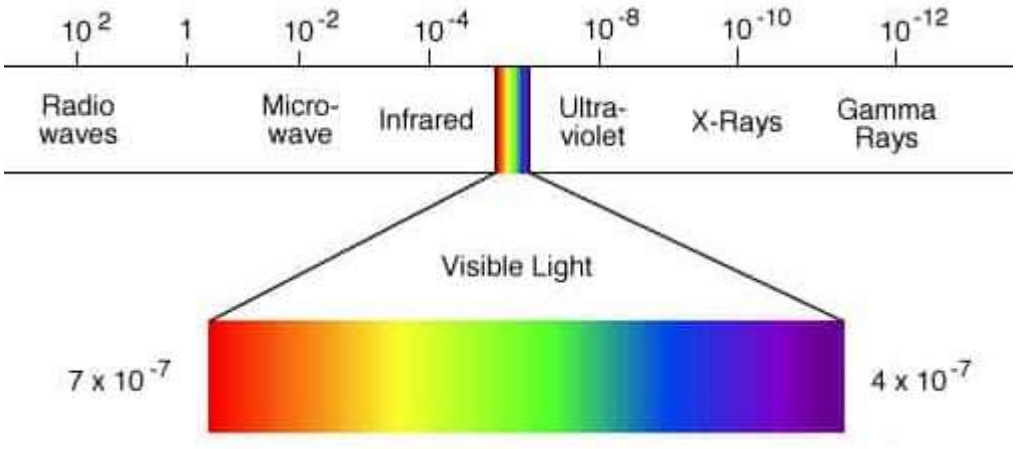

Figure 1: Electromagnetic spectrum (Wikimedia Commons, 2019)

Wavelengths used in agricultural remote sensing cover only a small region of the electromagnetic spectrum. In a satellite remote sensing process used in agriculture. This process is depicted in fig.2.

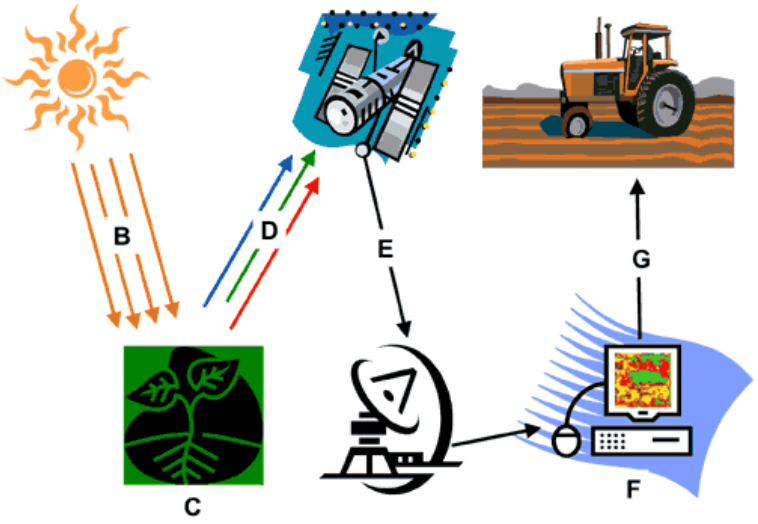

Figure 2: Satellite remote sensing process (Anna Jakomulska *et al.*, 2002)

Electromagnetic energy from Sun strikes the plants. A portion of this energy is transmitted through the leaves. Reflected energy is detected by the sensor on the satellite. The data is then transmitted to the ground station. The data is analyzed and displayed on field maps. Alterations in leaf colors, textures, shapes or even how the leaves are attached to plants, determine how much energy will be reflected, absorbed, or transmitted. Spectral signatures of an individual plant are obtained by using the relationship between reflected, absorbed, and

transmitted energy. The radiation reflected as a function of the wavelength is called the spectral signature of the surface as indicated in fig. 3.

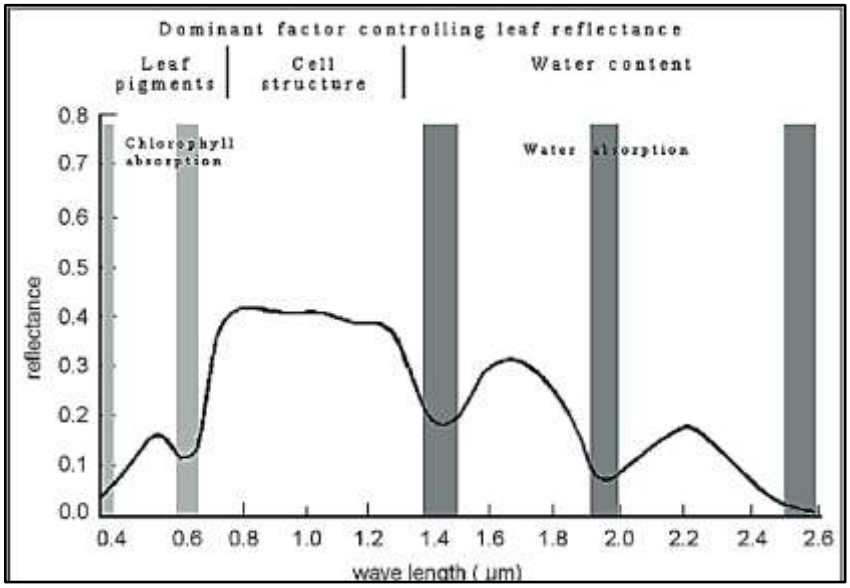

Figure 3: Spectral signature of planets (mcbburney.wixsite.com)

Spectral signatures are unique to plant species. The spectral signatures of unhealthy plants appear changed from those of healthy plants. Interpretation of the reflectance values at various wavelengths of energy can be used to evaluate crop health (Nowatzki *et al.*, 2017).

Remote Sensing in agriculture

Most researchers have focused on the use of data for classification of land cover types with crop types in agricultural applications during early stages of satellite remote sensing. In recent years, focus was on characterization of plant biophysical properties. Remote sensing of agricultural canopies has provided valuable insights into various agronomical parameters. It provides repeated information for providing valuable information for precision agricultural applications without destructive sampling of the crop (P. Shanmugapriya et al.,2019). Some agronomical parameters have been discussed here.

Monitoring of vegetation cover

Vegetation cover indicates the percentage of soil which is covered by green vegetation. Remote sensing is an outstanding technique to monitor the earth's surface cover. The Normalized Difference Vegetation Index (NDVI) is the most accurate method of digital processing of spatial visualization in the presentation of vegetation. Main fact used in this technique is that the plants show a high reflectivity in the wavelength range near the red wavelength range. NDVI values are in the range of -1 to +1. Positive result indicates the cell has a plant cover and the negative values indicate the non-green surface parameters (Allawai and Ahmed, 2020).

Crop condition assessment

Remote sensing gives us timely spectral information about the crops. This information provides physiological information of plants. Physiological changes are reflected in spectral characteristics of plants. Evaluation of crop condition will help monitoring of the crop at frequent intervals. Remote sensing is perfectly suited for crop condition monitoring. The condition of the crop depends on moisture stress due to drought, nutrient stress due to insufficient availability in the soil, flooding, saltiness, disease, and pest doses (Ray, 2016).

Nutrient and water status

Remote sensing gives water status over the land to farmers. Nutrient and water stress management can be done using remote sensing applications. Using this technique farmers can reduce cultivation cost and proper use of fertilizer to increase the yield. The spectral reflectance in visible region of electromagnetic spectrum can give intuition of diseased and healthy crops. Remote sensing also gives us the soil moisture availability in the field. Remote sensing has been playing a major role in understanding the crop soil characteristics. Such information when linked with GPS will provide promising results which are more helpful in precision farming (Shanmugapriya *et al.,* 2019; Sinha *et al.,* 2018).

Soil mapping

Remote sensing plays an important role in soil mapping. Through soil mapping, farmers can get information about ideal soil for the crop and know irrigation requirement for the crops. This information helps in precision agriculture (Priya and Raman Kumar, 2020).

Weed identification and management

Remote sensing united with precision agriculture is a hopeful technology in nowadays. Some methods for weed detection are very time– consuming and labor–intensive. However, image–based remote sensing has potential applications in weed detection for site– specific weed management. Difference in the spectral reflectance properties between weeds and crop, remote sensing technology helps us to identify the weeds in the crop (Shanmugapriya *et al.,* 2019).

Detection of plant stress

The chlorophyll and other pigments react to the visible radiation. Infra-red region is a region of high reflectance. Using remote sensing technology, we can identify stressed and non-stressed leaves. Water stress, nutrient stress, and disease outbreak lead to reduction in plant pigment in red band. The reflectance measured in the visible and near infra-red bands indicates plant health (Ray, 2016).

Atmospheric dynamics

Use of meteorological satellites in weather forecasting is the tool given by remote sensing. These satellites are used to measure cloud cover, wind, moisture, temperature, and wind

speed. Variation in canopy temperature is used to determine water availability in the field. The use of remote sensing data for drought assessment plays a significant role in agriculture. NDVI produced by NOAA-AVHRR data is used to assess and monitor droughts at the district level, allowing timely preventive and corrective measures to be taken (Adhikary *et al.,* 2022).

Crop evapo-transpiration

Crop productivity is influenced by soil moisture. Soil moisture depends on temperatures and rainfall. The relationship between water stress and a plant's thermal characteristics is described by vegetation indices such as Crop Water Stress Index, Surface Temperature, Water Deficit Index, and Stress Index. Evapo-transpiration estimates are crucial for evaluating irrigation scheduling, calculating water and energy balances, determining crop water stress indexes, and determining climatological and meteorological conditions. Temperature influences soil water availability and crop evapo-transpiration which is essential in assessing crop water stress (Saju Adhikary *et al.,* 2022).

Crop yield and production forecasting

Remote sensing plays vital role forecasting crop yields. Statistical– empirical relationships between yield and vegetation indices gives forecasting of crop yields. The information on production of crops before the harvest is significant for national food policy planning. Crop yield depends on factors such as crop variety, water and nutrient status of field, influence by weeds, pest and disease infestation, weather parameters. The spectral response curve is dependent on these factors. Nature of the spectral response curve indicates the crop condition and its performance (Shanmugapriya *et al.,* 2019).

Precision agriculture

Remote sensing technology is a key factor of precision farming and is being used by number of scientists, engineers, and large-scale crop growers. It gives information about cultivation of healthy crops which guarantee farmers to harvest crop after an ideal period (Shanmugapriya *et al.,* 2019).

Conclusions:

With population growth in the world the natural resources and agriculture food resources are not adequate. Most of the farmers do their farming without the help of technology. Many natural factors such as less rainfall, temperature, floods, plant diseases etc. hamper agriculture produce. Farmers should get information about how to increase agriculture produce by proper knowledge of the factors affecting their crops, yield. This is possible by using remote sensing technique in agriculture. It is necessary to obtain reliable data on not only the types of resources, but also the quality, quantity, and location of the resources. Remote sensing is an important tool in improving the present system of agriculture.

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HETEROJUNCTION SOLAR CELLS

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Increasing demand for energy

The requirement of energy has been exponentially increasing day by day as it is the main pillar for the national development as well as the need, convenience and betterment of largely growing modern civilization. Several forms of energy resources such as fossil fuels, wind power, photovoltaic, nuclear energy and hydro-energy are being used in the world to fulfill the respective requirements. The large share is occupied by the energy from fossil fuels containing a high percentage of carbon like petroleum fuels and coal for the transport and electricity purposes as both of it are widely consumptive across the world.

Need of renewable source of energy

The current rate of consumption of energy implies that with an increase in time, the dependence of humanity on the conventional energy sources will become more and more intensive. Fossil fuels take millions of years to form and hence they are considered to be non-renewable energy resources. Fossil fuels are known as viable reserves which are being expended much faster as compared to the new ones being made. Several environmental concerns are associated with the use of fossil fuels. The consumption of fossil fuel produces a significant amount of atmospheric CO_2 per year which is one of the greenhouse gases that contributing continuously towards the acid rain and global warming. Several international agencies have shown that CO_2 emissions have been increasing significantly since the dawn of the 20^{th} century.

If this situation remains continue, it is possible that the consequences will be desperate changes to the earth's climate. China, United States and India were the three largest CO_2 emitting countries in 2009 [1]. While U.S. emissions are relatively static from year to year, Chinese and Indian emissions are growing exponentially. Thereby, the overall emissions of CO_2 are expected to continue to grow as the economies of developing countries require more energy. On the basis of present rate of emission of CO_2, Intergovernmental Panel on Climate Change (IPCC) has determined the expected rise in the planet’s average temperature which will be the increase of 4 °C per year provided if it is possible to stabilize the current value of CO_2 emission of 29 Gt/yr [2].

The alternative sources of energy will become more dominant as the fossil fuels may turn run out, sooner or later. Unlike fossil fuels, the alternatives for energy sources are needed to be

renewable as well as sustainable, non-polluting, climate-safe and environment friendly too. With the exponentially growing energy consumption and environmental crisis, development and application of renewable energy has become a matter of great necessity. The search for alternatives to energy sources now has become a worldwide movement. Several groups are working in many countries with different ways to replace the conventional sources of energy. Nuclear energy, which was initially in the close proximity as a solution towards alternative energy source, has now developed to a scale where waste management, risks of accidents and activity related to terrorism have framed it an imperfect alternative to fossil fuels.

With respect to the today's environmental and geopolitical reference, it is indeed an utmost requirement for a renewable source of energy. The sources of energy regarding petroleum fuel are running low and soon they will be out of the run with the current rate of utilization. Besides that, the inevitable pollution arising out of fossil fuels is also a growing concern which could cause drastic changes in world's climate.

Renewable sources of energy

The concerns regarding growing population of the world and the fast-developing countries such as India and China will demand the supply of abundant as well as clean and cheap sources of energy over the coming decades. The Most obvious and easily available sources of alternative energy which are renewable and have lower carbon emissions are natural sources such as the sun, wind, and water. The energy from the sun in the form of sunlight can be turned into heat or electricity. The motion of wind and rivers produces kinetic energy which can also be harnessed into electricity. All these natural sources hold the ability for producing pollution free and sustainable alternatives of energy.

Solar energy spectrum

Solar energy is an important form of renewable energy source and alternative to fossil fuels. It is a radiant form of energy needs to be harnessed using a range of photovoltaic technologies such as photovoltaics, solar heating, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis. Photovoltaics combined with other green technologies such as wind, hydroelectric, solar thermal and geothermal power can be a solution to overcome the concerns regarding alternative for a renewable source of energy and thereby greenhouse effect and global warming. The magnitude of solar energy available at the earth surface is several times excess as compared to the energy required to fulfill the need of current rate of consumption of energy.

The solar energy spectrum is shown in Fig. 1.1. The intensity, spectral distribution and radiant power per unit area of the sunlight reaching to the earth is significantly influenced by the atmospheric scattering and absorption due to gases. The infrared radiation is absorbed by water vapor, carbon monoxide, methane and hydrocarbons. Whereas, in ultra-violet region, absorption

is caused by oxygen and ozone gases [3]. Such an influence modifies the solar spectrum which is quantified in terms of air mass (AM) index. It is a measure of decrease in power of light as it passes through the atmosphere.

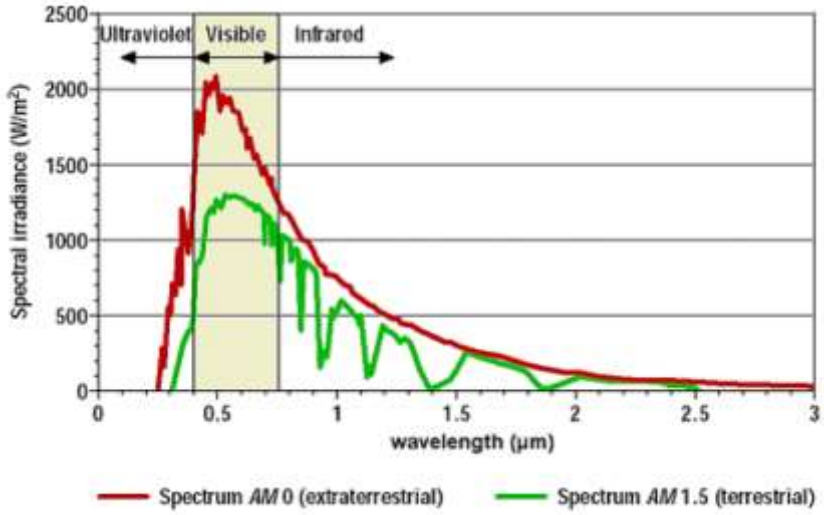

Figure 1.1: Solar energy spectrum

It is defined as,

$$AM_x = \frac{1}{cos\theta} \quad (1)$$

where θ is the angle of incidence as shown in Fig. 1.2.

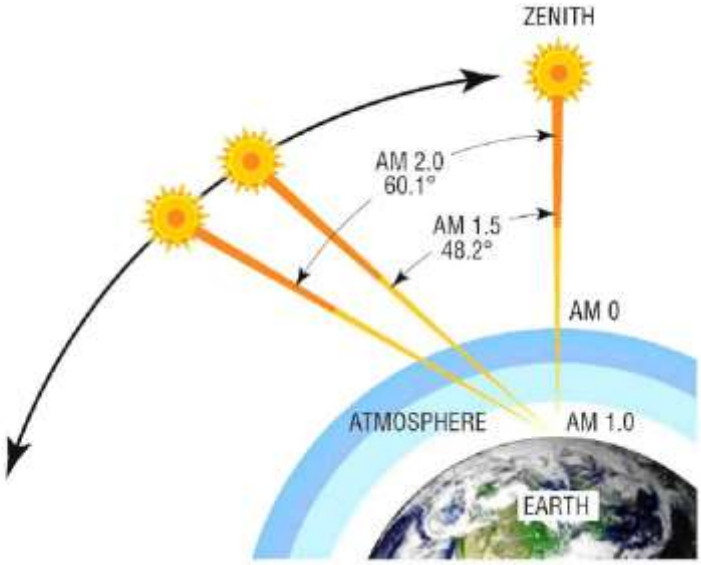

Figure 1.2: Air mass index

AM0 represents the solar spectrum outside the atmosphere and it is used for space application. When the sun is exactly above the observer's zenith, it is denoted by AM1.0. AM1.5 corresponds to the incident solar spectrum at 48.2° and it is used for conventional terrestrial applications. AM2 is referred to an incident angle of 60°. AM1.5 spectrum equals the power of 1000 W/m^2 and it is the standard intensity used to study the solar cell performance.

The major challenge is to design such a technology or devices which are efficient in converting the sunlight into electricity and other forms of energy with the use of earth-abundant, non-toxic, sustainable and pollution free raw materials so that it can be fabricated at the low cost of production. Although many researchers groups are working hard on photovoltaic systems to harness the energy from the sun with the highest efficiency, still they have to go a long way to exploit with several attempts to make it compatible all the way to serve for the humanity and development.

Solar cell

Concept

The solar cell is basically a device consisting of a *p*-*n* junction diode that converts the energy of sunlight directly into electricity. The conversion of radiation energy into electrical energy is known as the photovoltaic effect. The basic process comprising the photovoltaic effect is as follows

(i) Generation of the charge carriers due to the absorption of photons in the materials that form a junction

(ii) Separation of those photo-generated charge carriers in the junction and

(iii) Collection of the photo-generated charge carriers at the terminals of the junction

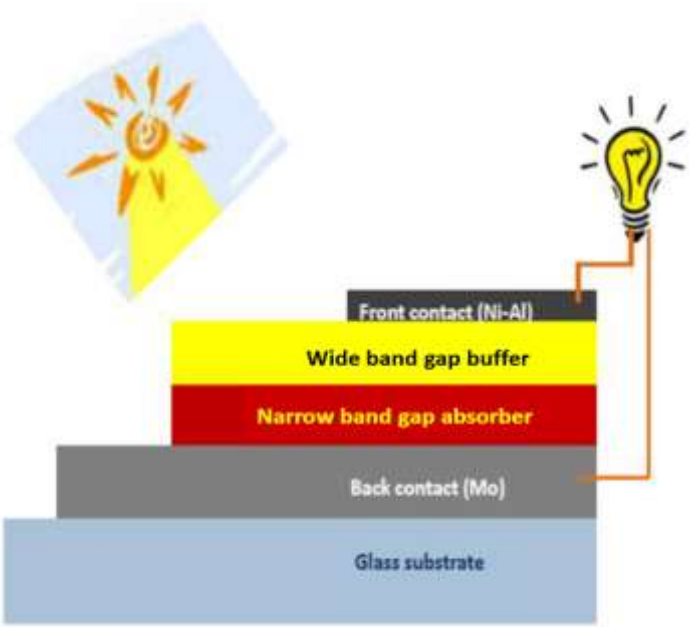

Figure 1.3: Schematic diagram of heterojunction solar cell

A schematic diagram of heterojunction solar cell is shown in Fig. 1.3. It consists of a junction of narrow band gap absorber layer (*p*-type), a wide band gap buffer layer (*n*-type) and contacts to carry the current to external circuit.

In general, the solar cell is equivalent to the diode in a dark and source of current when illuminated. When a *p*-*n* junction diode is illuminated or exposed to light, photons with energy

greater than the optical band gap of the semiconductor are absorbed and electron-hole pairs are generated in both, *p*-side and *n*-side of the junction. The electron and holes which are produced nearby the junction migrate to the space charge region by diffusion process due to concentration gradients. The space charge region causes a separation of electrons and holes creating a built-in electric field at the *p*-*n* junction interface. This built-in electric field produces a drift current thereby offers a very low resistance to the flow of minority carriers. The flow of minority charge carriers facilitates the traveling of electrons towards *n*-type region and holes towards the *p*-type region, constituting the current when connected across to a load resistor. The prime requirements for a solar cell are the matching of optical band gap to the solar spectrum, high absorption coefficient as well as the high mobility and lifetime of charge carriers.

Development in solar cells

According to the materials used for the fabrication, development of solar cell is broadly categorized into generations as follows.

First Generation Solar cells

The first-generation solar cells were limited to the use of high-quality single crystal like crystalline silicon (Si). In 1954, the first-ever *p*-*n* junction solar cell using Si was successfully fabricated by Chapin and Fuller. Earlier, the fabrication of solar cells was intended to fulfill the extraterrestrial requirements like power requirement for space applications with no concern regarding the fabrication cost. Later, the technology was used for development of terrestrial applications.

Crystalline Silicon solar cells are further divided into mono-crystalline and polycrystalline Si solar cells. Mono-crystalline solar cells are prepared using Czochralski method in which single crystals were drawn out of the melt followed by slicing into thin wafers of around 200 μm. Mono-crystalline Si solar cell exhibited the highest efficiency of 24.4% [4], however due to extremely high cost of manufacturing multi-crystalline Si solar cells were developed. Multi-crystalline solar cells are fabricated using different ways. Usually, the Si wafers are sliced out of the bars which are cut from the Si cast block. The doping is done in same way as that of the mono-crystalline solar cells. Due to the formation of large sized grains, the efficiencies are higher in case of multi-crystalline Si solar cells. Currently, the commercial modules prepared using multi-crystalline Si showing a highest efficiency of 21.9%. [5].

Second Generation Solar cells

The drawback of the first-generation solar cells such as high cost of production motivated the researchers to move towards second generation solar cells. The fabrication of solar cells was aimed to achieve high efficiency with the reduction in production cost using the material in thin film form. The consumption of material to be used for the fabrication of solar cell was reduced to ~2 μm from 200 μm (crystalline Si) using thin film approach which led to significant cost reduction. Instead of crystalline Si, direct band gap semiconductors such as amorphous Silicon

(a-Si), Cadmium Telluride (CdTe), Gallium Arsenide (GaAs), Copper Indium Gallium Selenide (CIGS) were used to prepare solar cells.

Amorphous silicon solar cells are relatively cheaper and they can be deposited at low temperature on the variety of substrates including glass and metals. The absorption coefficient of a-Si is higher than crystalline Si which allows the fabrication with lower thickness thereby decreasing the amount of raw material and the overall production cost. The fabrication a-Si solar cells can be carried out at a low temperature of ~300 ºC allowing the uniform deposition over a large area. Plasma enhanced chemical vapor deposition and glow discharge methods are usually used to deposit a-Si. Highest efficiency of 12.69% has been achieved with amorphous silicon solar cells [6].

CdTe is a direct band gap material having a band gap of 1.45 eV. It has a very high absorption coefficient for visible light causing an absorber layer with a relatively low thickness in the order of micrometers. In spite of abundance and low production cost, scarcity of tellurium and high toxicity of cadmium are major drawbacks for CdTe solar cells, which have limited the fabrication of solar cells. Current record efficiency of 22.1% is exhibited by the research-scale device of CdTe solar cell [7].

The use of Gallium Arsenide for solar cell offers some advantages over crystalline Silicon. The band gap of GaAs is 1.42 eV which is close to optimum for solar cell spectrum. Further, the theoretical conversion efficiency is close to 31%. In addition to that, the absorption coefficient of GaAs is higher than that of the Si, thereby relatively lower thickness is required for the absorption. However, the cost of GaAs is quite higher than that of the Si which has restricted the fabrication of GaAs solar cells for spacecraft and military applications. The highest efficiency solar cell based on GaAs achieved a highest efficiency of 28.8% [8].

Copper Indium Gallium Selenide (CIGS) Solar Cells are collecting worldwide attention due to the generation of solar power with high efficiency. It is a direct band gap material with high absorption coefficient of ~10^5 cm^{-1} which requires minimum thickness to absorb the photons. The theoretical efficiency limit for CIGS is 29%, however, the current world-record CIGS cell exhibited an efficiency of 22.6% [9] due to which it has become a strong alternative to other high efficient absorber materials like a-Si, GaAs and CdTe.

Current status

In an ideal case, the material to be used as an absorber layer for the fabrication of solar cell must be composed of earth-abundant elements, having direct optical band gap suitable for the photovoltaic purpose which enables large-scale production with minimal cost of fabrication. In addition to that, the material should not be toxic. Currently, two most commonly used absorber materials such as CdTe and CIGS, which are binary and quaternary chalcogenides, respectively, have achieved an efficiency of more than 22% and these are the dominant alternatives in the domain of thin film solar cells. However, both the materials are subjected to

serious concerns regarding the scarcity and toxicity. In CIGS, the constituent elements such as Indium (In) and Gallium (Ga) are having very limited natural resources and hence they may encounter a scarcity near in future thereby the high cost of fabrication will not allow the use of it for a terrestrial application. In case of CdTe, Cadmium is the most toxic material which may cause the concerns related to environment and health issues, further, disposal of Cadmium is also a major problem.

In this context, the kesterite chalcogenides such as $Cu_2ZnSnSe_4$, Cu_2ZnSnS_4, and $Cu_2ZnSn(S,Se)_4$, which are composed of earth-abundant constituent elements such as Cu, Zn, Sn, S, and Se are cheaper and relatively less toxic, could be the strong alternatives to replace these chalcopyrite absorbers facing issues regarding scarcity and toxicity.

The configuration of interfaces in thin film solar cells

The thin film technology may be the most promising alternative for the future prospects of renewable sources of energy. The technology requires a very small thickness of constituent material to be used for the fabrication of thin film solar cells with direct band gap absorber materials. It provides a sophisticated and economic approach as it minimizes the manufacturing cost, reduces mass of elements, fabrication on SLG or flexible substrates. The technology avails the fabrication of thin film solar cells with different configuration or alignment of interfaces regarding the deploying of *p*-*n* junction diode used for the formation of built-in electric field or potential barrier which separates the photo-generated charge carriers contributing for the flow of current.

Homojunction solar cells

Homojunction solar cells are consisting of *p*-*n* junction having a same base semiconductor material which is *n*-type doped on one side and *p*-type doped on another [*n*-Si/*p*-Si]. The thicknesses of *p*-type and *n*-type regions are ~300 μm and ~0.3 μm, respectively. The performance of homojunction solar cells is affected by the loss due to surface recombination which is one of possible reasons for poor performance of homojunction solar cells.

Heterojunction solar cells

In heterojunction solar cells, the semiconductor materials used for *p*-*n* junction are different, ex. *p*-$Cu_2ZnSnSe_4$/*n*-CdS. It offers a choice to select the material according to the requirement to serve the purpose of the *p*-*n* junction with desirable band offset.

The *n*-type material to be used as a buffer layer can be a semiconductor having a band gap of 2.5-3.0 eV which acts as a transparent layer to the incident solar radiation. However, the lattice mismatch between the *p*-type and *n*-type semiconductor materials may cause interface recombination loss. It creates localized interface states which are responsible for the increase in reverse saturation current and reduces the open circuit voltage.

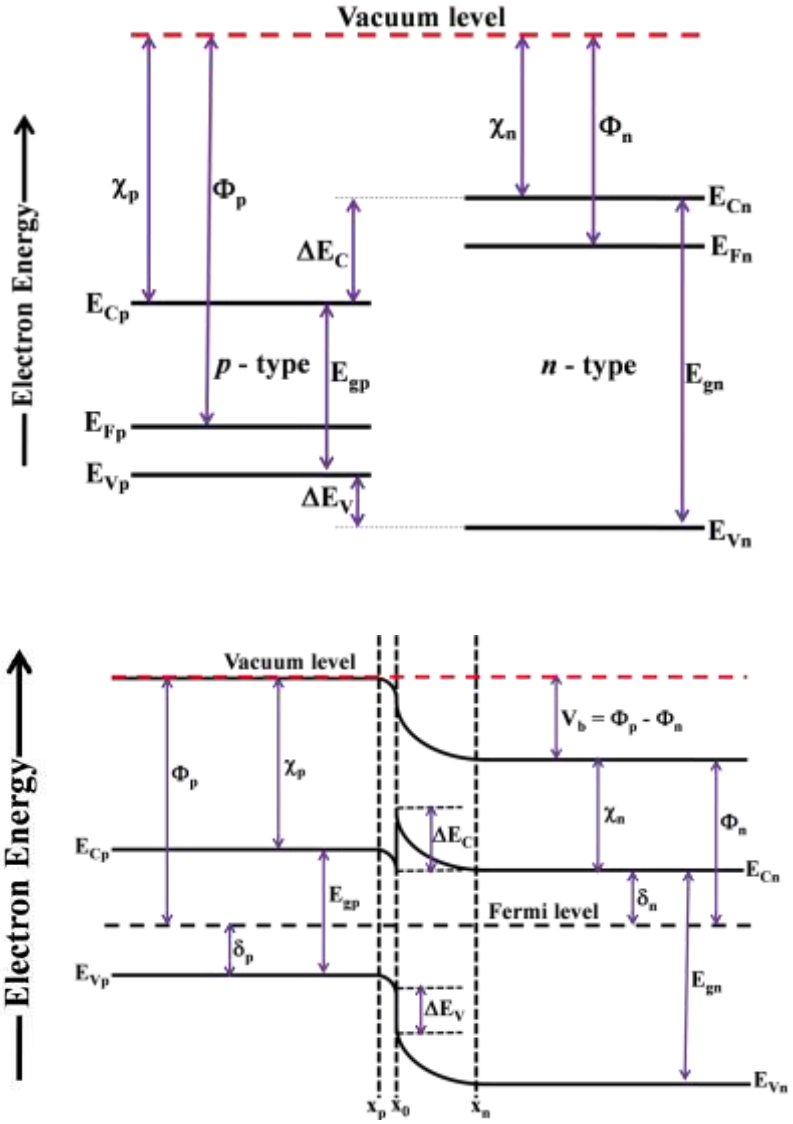

Figure 1.6: Energy band diagram of (a) isolated semiconductors and (b) an ideal *p-n* heterojunction at thermal equilibrium

In addition to lattice match, electron affinity and coefficient of thermal expansion should also be compatible. The band diagram of *p*-type and *n*-type materials constituting a heterojunction, before and after the junction is shown in Fig.1.6. The energy band diagram is based on Anderson model [10]. Let us assume that *p*-type and *n*-type semiconductor materials, having band gaps Eg_p and Eg_n, respectively, are to be brought into contact to form a heterojunction. The work function and electron affinity are labeled as ϕ and χ, respectively. The work function (ϕ) is the energy required to remove an electron from Fermi level to reach vacuum level as indicated in the band diagram. Whereas, electron affinity is a difference between the energy of conduction band edge (Ec) and vacuum level. ΔE_c denotes an energy difference between conduction band edges of *p*-type and *n*-type materials. Similarly, ΔE_v is the difference between the energies of valence band edges. Vacuum level denotes the energy occupied by a free electron which has left the atom and hence outside the atom (i.e. in a vacuum).

When the junction is formed, at thermal equilibrium, the Fermi levels on both sides of the junction coincide. The vacuum level everywhere is parallel to band edges and is continuous.
The total built-in potential V_b is given by [11,12]

$$V_b = \Phi_p - \Phi_n \quad (1.2)$$

$$V_b = V_{bp} + V_{bn} \quad (1.3)$$

where V_{bp} and V_{bn} are the portions of built-in potential on the *p*- side and *n*-side of the junction respectively.

$$eV_{bi} = eV_{bp} + eV_{bn} \quad (1.4)$$

$$= Eg_p - \delta_n - \delta_p + \Delta E_C \quad (1.5)$$

where δ is the energy difference between equilibrium Fermi level and band edges.
The conduction and valence band discontinuities ΔE_C and ΔE_V respectively are given by

$$\Delta E_C = \chi_p - \chi_n \quad (1.6)$$

$$\text{and } \Delta E_V = (Eg_n - Eg_p) - \Delta E_C \quad (1.7)$$

Schottky barrier junction

It is potential barrier arises when a metal is brought into a contact with the semiconductor. It develops a rectifying contact between a semiconductor and metal causing electron flow from semiconductor to metal resulting in a depletion layer in the semiconductor. The internal field formed at the junction causes a collection of photo-excited charge carriers, contributing towards the flow of electric current in the external circuit.

Buried homojunction

Buried homojunctions are consisting of a wide band gap *p*-type semiconductor material forming a heterojunction with smaller band gap *p*-type material which forms a junction with the *n*-type material having a similar band gap. Such an approach is used to minimize the surface recombination losses due to lattice mismatch by forming p^+-*p* junction offering a lattice match at the interface. Example of buried homojunction is *p*+-GaAlAs/*p*-GaAs/*n*-GaAs.

p-i-n junction

This configuration is similar to semiconductor-insulator-semiconductor (SIS) junction, however, the regions are differently doped. It has an undoped or intrinsic semiconductor region sandwiched in between heavily doped *p*-type and *n*-type semiconductors. The transport of photo-generated charge carriers occurs by the drift due to the electric field exists throughout i-region. Usually, this type of junctions is made out of amorphous silicon.

Semiconductor-electrolyte junction

It consists of an interface between a semiconductor and an electrolyte. It is based on photo-electrolysis and photo-electrochemical process. Photo-electrolysis at the semiconductor-

liquid junction facilitates the dissociation of electrolyte to form redox species. In the photo-electrochemical process, upon the photo-excitation at one surface, an oxidation reaction occurs. A process of reduction taking place at another surface causes a flow of electrons in the external circuit.

Fundamentals of solar cell

The performance of solar cells is mainly dependent on the *p-n* junction formed by the differently doped semiconductor materials constituting an absorber and buffer layers. Besides that, the materials used as a front and back contacts are also important for the flow of charge carriers to the external circuit. Hence, it is indeed essential to discuss the properties of materials to be used for the fabrication of solar cell.

Semiconductors

Usually, the absorber layers as well as the buffer layers used for the fabrication of solar cell are composed of a semiconductor material. The process of conversion of solar energy into electricity is based on the formation of the electron-hole pair in a semiconductor material constituting an absorber layer. The properties of semiconductor influencing the performance of absorber layer are discussed here.

Energy bands

When an electron of an isolated atom having discrete energy levels, approaches to form a crystal, because of atomic interaction, the energy levels will split causing a closely spaced separate energy levels. This results in a continuous energy band with a certain energy band gap. A band gap is an energy range where no electron states can exist due to the quantization of energy. This band gap is an important parameter for the absorber layer in a solar cell. Semiconductors are having a smaller band gap in between metal and insulator. The lower energy band called valence band and the upper one is called conduction band. The electrons in the outermost shell of an atom are called as valence electrons. The energy band occupied by these valance electrons is called valence band. It may be either completely filled or partially filled with electrons but can never be empty. The electrons which have left the valence band are conduction electrons and the band occupied by them is called conduction band. It could be either empty or partially filled.

Intrinsic and extrinsic semiconductors

A semiconductor in which electrons and holes generated from impurities are much smaller than thermally activated electrons and holes is called an intrinsic semiconductor. In another way, intrinsic semiconductors are the materials in its extremely pure form; it does not contain any impurity. Hence, in an intrinsic semiconductor, numbers of electrons are equal to the number of holes resulting in the position of Fermi level in the middle of the forbidden energy gap.

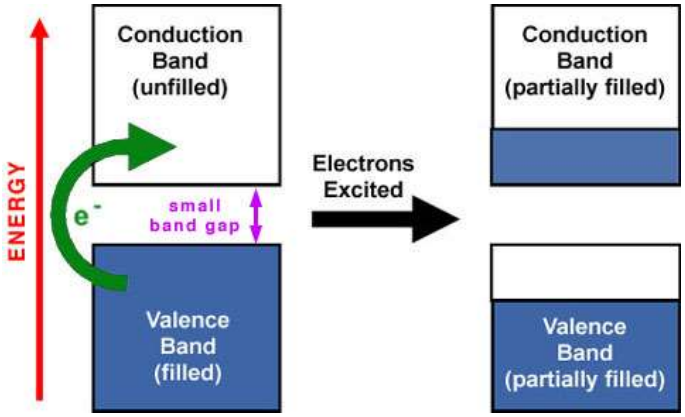

Figure 1.7: Valance band and conduction band in semiconductors

However, in extrinsic semiconductors, the electron and holes are produced by adding small quantities of impurities. Depending upon the material used as a dopant, an extrinsic semiconductor is further divided into a *p*-type and *n*-type semiconductor. In *n*-type semiconductors, electrons are majority charge carriers and holes are minority charge carriers which cause upward shift in Fermi energy level towards the bottom of the conduction band. Whereas, in *p*-type, holes are in majority and electrons constitutes the minority carriers resulting in a downward shift in Fermi energy level towards the top of the valence band.

Mobility

In a semiconductor material, the electron moves randomly in all directions due to thermal energy. After traveling a certain distance, the electrons will colloid with a lattice atom or an impurity atom. Mobility is a measure of the ease of carrier motion, caused by drift within a semiconductor. The carrier mobility varies inversely with the amount of scattering taking place within the semiconductor, in other words, an increase in motion-impeding collisions results in a decrease of mobility. The average time between two successive collisions is called mean free time (τ_c). The scattering of charge carriers affecting the mobility takes place due to following mechanisms

i. Phonon (lattice) scattering
ii. Ionized impurity scattering
iii. Scattering by neutral impurity atoms and defects
iv. Carrier-carrier scattering
v. Piezoelectric scattering

Out of the scattering mechanisms mentioned, scattering caused by phonon and ionized impurity dominates the performance of the device made out of semiconductors. Phonon scattering refers to the collisions between the charge carriers and the thermally induced lattice atoms. The Coulomb force of attraction or repulsion between the charged carriers and the ionized donors and/or acceptors leads to ionized impurity scattering.

Drift and diffusion

The flow of current across the semiconductor can be categorized into two components, drift current and diffusion current. Drift is associated with the movement of charged particles influenced by the applied electric field, whereas diffusion is the movement of electrons and holes in response to the concentration gradient.

When *p*-type and *n*-type materials are put in contact with each other, the carriers flow under the driving force caused by the concentration gradient of majority charge carriers and it will continue until chemical potential on both the sides reaches to an equilibrium i.e. position of Fermi level becomes equal or same in both the semiconductors. Eventually, the free carriers will be depleted in the vicinity of the junction leaving the behind the ionized atoms which creates a depletion region containing fixed and immobile ions. Because of this charge separation, an electric field across the junction develops even when the junction is not biased by any externals means. It is known as junction potential or potential barrier which discontinues the further flow of majority charge carriers, provided, it remains unbiased externally. The electric field or potential barrier developed across the junction opposes the diffusion of majority charge carriers and offers a very low resistance to the flow of minority charge carriers which facilitates the separation of charge carriers upon illumination, thereby electron move towards *n*-type and holes moves towards the *p*-type region.

Optical absorption

The optical properties of semiconductors constituting a solar cell are of considerable importance. It is essential that on the absorption of a photon, the electron should be promoted to the conduction band where it is free to move through the lattice and carry a current. The spectrum of solar energy spreads light from ultraviolet to infrared region having a bandwidth of 300 nm to 3000 nm. If the semiconductor is illuminated with light, when the energy of a photon ($h\nu$) is less than the band gap of semiconductor material, the incident light will transmit through the material. The photons with energy equal to band gap of the semiconductor will be absorbed and that will results in the excitation of an electron from the valence band to the conduction band, which in-turn creates an electron-hole pair. When the energy of the photon ($h\nu$) is excess to band gap (E_g), it causes an additional kinetic energy which dissipates as heat in the semiconductor. The absorption of photons is quantified by the term ‘absorption coefficient’. The larger the absorption coefficient more will be the possibility of photons to be absorbed in a short distance. The semiconductors with smaller absorption coefficients require more distance to be travelled by the photons to get absorbed.

Direct and indirect band gap

In the context of the absorption of incident light, semiconductor materials are categorized as direct band gap and indirect band gap semiconductors. Fig.1.8 shows the difference between direct and indirect band gap semiconductors. Absorption of a photon is

associated with the change in momentum of electrons at the absorption of photons. For direct band gap semiconductors, the top of valence band aligns with the bottom of the conduction band in k (momentum) space, Ex. GaAs. Such an alignment enhances the absorption coefficient due to which the thickness of semiconductor required for the absorption of photons can be reduced to certain micrometers which in-turn reduces the cost of production. Whereas, in case of indirect band gap semiconductor, the top of the valence band is shifted or misaligns with the bottom of the conduction band, Ex. Si. This misalignment results in an increase in energy required for the absorption of a photon by means of phonon or energy due to lattice vibration and the transition is called phonon-assisted transition. Such a semiconductor requires relatively more thickness for the absorption of the photon as compared to the direct band gap semiconductors.

In direct band gap semiconductors: $\boldsymbol{E_c = E_v + h\nu}$

In indirect band gap semiconductors: $\boldsymbol{E_c = E_v + h\nu + E_{phonon}}$ (phonon assisted transition)

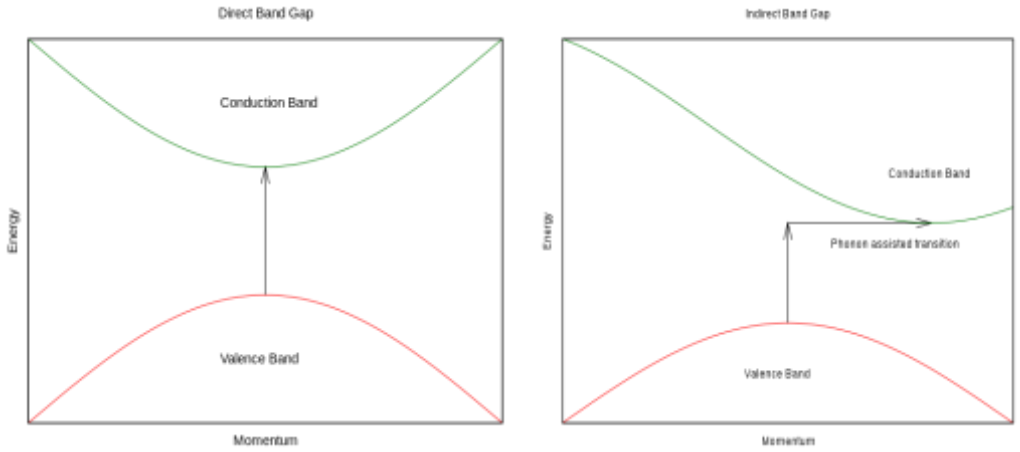

Figure 1.8: Direct and indirect band gap semiconductors

Criteria for the absorber (*p*-type), buffer layer (*n*-type) and contacts

Property		**Criteria**
Cost and Availability	**:**	The material should be cheaper and earth-abundant to minimize the cost of production at commercial scale.
Toxicity	**:**	The material should not be toxic.
Optical	**:**	The absorber should be having a direct band gap in the range 1.0 to 1.5 eV with high absorption (10^4 cm^{-1}). The buffer layer material should have a large optical band gap (~3 eV) so that it behaves like a transparent layer for the incident light to reach the junction.
Electrical	**:**	The absorber should possess *p*-type conductivity whereas the buffer layer has to be *n*-type to form a *p*-*n* junction (preferable heterojunction).
Electrical contacts	**:**	The material to be used as an electrical contact to ensure the flow of charge carriers to the external load should possess low resistance.

Photovoltaic parameters

When the *p-n* junction is illuminated with light, electron-hole pairs are generated in the semiconductor materials and thereby it causes an increase in the concentration of minority charge carriers which leads to the flow of minority charge carriers through the depletion region. The photo-generated electron and holes constitute a flow from *p*-type to *n*-type region and vice-versa, respectively. The electron-hole pairs are also generated outside of the depletion region but only those which are at the distance of the diffusion length contributes towards the generation of current and rest of them lose their existence upon recombination. Since *p*-type semiconductor material has a quite higher coefficient of absorption compared to *n*-type, the photons participating in the generation of photo-current are absorbed in the depletion region of absorber layer [13].

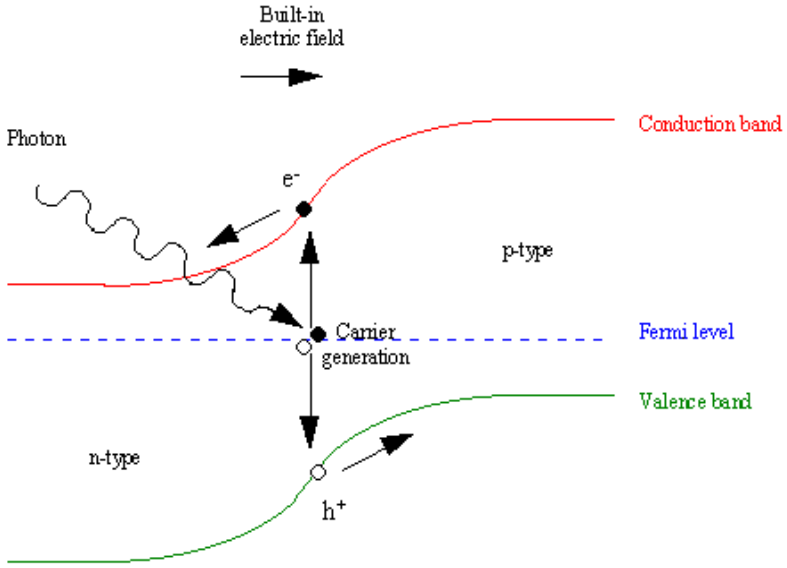

Figure 1.9: *p-n* junction when illuminated with light

The photovoltaic parameters are generally evaluated under standard atmospheric test condition such as air mass index (AM) of 1.5 with an incident power density of 1000 W/m^2 and a temperature of 25 °C.

Current-voltage characteristic

The current-voltage characteristic of a *p-n* junction under the dark and illuminated condition is schematically shown in figure 1.10. The terms *J* and *V* represent current density and voltage, respectively. Furthermore, J_o is labeled as saturation current density [14] under a dark condition which is a counterpart for J_{sc}, short circuit current under illumination and J_{ph} is the photo-generated current.

Current-voltage characteristic under dark:

$$J_{dark} = J_o\left(e^{\frac{qV}{kT}} - 1\right) \qquad (1.8)$$

where q is the electron charge, V is the applied voltage, k is the Boltzmann's constant and T is the temperature.

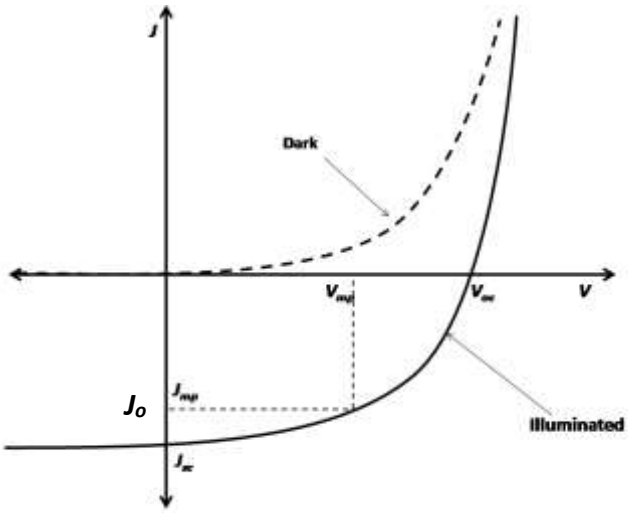

Figure 1.10: Current-voltage characteristic under dark and illuminated conditions

Current-voltage characteristic under illumination:

$$J_{light} = J_{dark} - J_{ph} = J_o\left(e^{\frac{qV}{kT}} - 1\right) - J_{ph} \quad (1.9)$$

Diffusion length (L_D)

When an electron is generated outside the depletion region as a result of absorption of a photon, it does not have a sufficient lifetime to reach the depletion region to get separate out further. Diffusion length determines the probability of collection of electrons in the depletion region. Diffusion length reduces due to the presence of deep defects or lattice defects such as dislocations and grain boundaries.

$$L_D = \sqrt{\frac{kT\mu_e\tau}{q}} \quad (1.10)$$

where μ_e is the mobility of electron and τ is the lifetime of electrons.

Short circuit current (J_{sc})

It is the current that flows through the external circuit when the electrodes of the solar cell are short-circuited and no voltage is applied. The electron-hole pairs which are generated in the depletion region contribute towards short circuit current. Loss of short circuit current may occur due to recombination at the surface as well as in the bulk of the semiconductor.

Open circuit voltage (V_{oc})

It is the voltage at which no current flows through the external circuit. For an ideal solar cell, the open circuit voltage value can be obtained by adjusting the total current to zero and it is given by equation (1.11). It is desirable for a solar cell to have V_{oc} as large as possible for a good performance.

When J_{diode}, the net current flowing through the *p-n* junction diode is equal to zero, $J_{ph}=J_{sc}$

$$V_{oc} = \frac{AkT}{q} ln\left(\frac{J_{sc}}{J_o} + 1\right) \quad (1.11)$$

where *A* is an ideality factor for a diode, *k* is the Boltzmann's constant and *q* is the electron charge.

Fill factor (FF)

Fill factor is the ratio of maximum power deliverable by a solar cell and the product of open circuit voltage (V_{oc}) and short-circuit current (J_{sc}). Fill factor is influenced by series resistance, shunt resistance and voltage dependence of the photo-generated current (J_{ph}). It is given as

$$FF = \frac{J_{mp}V_{mp}}{J_{sc}V_{oc}} \quad (1.12)$$

Power conversion efficiency (η)

Power conversion efficiency is the ratio of maximum power extracted to the power of incident light (P_{in}).

$$\eta = \frac{J_{sc}V_{oc}\,FF}{P_{in}} \quad (1.13)$$

Series resistance and shunt resistance

There are several parameters affecting the performance of solar cell out of which series resistance and shunt resistance are most common parasitic resistances. Series resistance (R_s) is influenced by movement of charge carrier through the electrodes for metal contact. It causes a reduction in fill factor and excessively high value reduces the short circuit current as well.

On the other hand, shunt resistance (R_{sh}) occurs due to manufacturing defect. Low shunt resistance may cause an alternative path for photo-generated current thereby minimizes the amount of current flowing through the junction resulting in degraded photovoltaic performance. In ideal case, series resistance and shunt resistance should be zero and infinite, respectively.

Series resistance (R_s) and shunt resistance (R_{sh}) can be determined from I-V characteristic as shown in Fig. 1.11 using following relations

$$\left(\frac{\Delta I}{\Delta V}\right)_{I=0} = \frac{1}{R_s} \quad (1.14)$$

$$\left(\frac{\Delta I}{\Delta V}\right)_{V=0} = \frac{1}{R_{sh}} \quad (1.15)$$

Limitations to efficiency

There are several limitations for a solar cell device to acquire a high efficiency, however, the major constraint arises from the poor match between the spectral distribution of incident sunlight and the band gap of given absorber material. This mismatch suggests an inability of a semiconductor to absorb photons with energy below and above the band gap energy. Furthermore, even if the electrons are generated in the bottom of conduction band and hole in the

top of the valence band, open circuit voltage will always remain smaller than the energy band gap. Due to this reason, a *p-n* junction fails to utilize the maximum voltage.

The parameters governing the performance of a solar cell like open circuit voltage (V_{oc}) and short-circuit current (J_{sc}) are largely influenced by the band gap of the semiconductor. A smaller band gap semiconductor material will result in larger open circuit voltage than a wider one; however, it has a smaller short circuit current due to relatively poor absorption of a photon which in-turn limits the efficiency. Similarly wide band gap material will have smaller open circuit voltage and large short circuit current resulting in constrained efficiency [14].

Furthermore, the presence of energy traps, recombination, series and shunt resistance are also responsible for the limited performance of solar cell device. Series resistance (R_s) arises as a result of the resistance of the different layers constituting the device. Shunt resistance (R_{sh}) occurs due to short circuit paths through the device. The loss due to reflection is also responsible for the degradation of solar cell performance. To overcome this, antireflection coatings are being used.

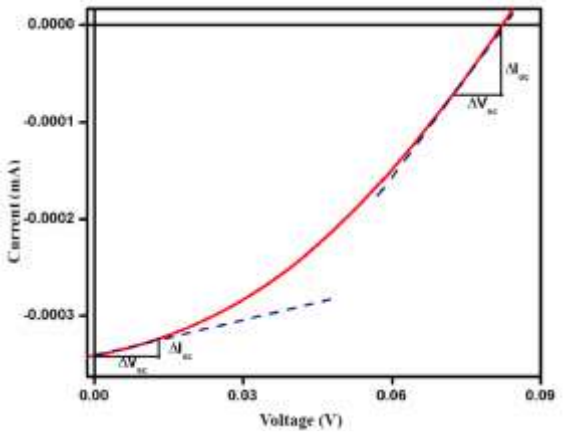

Figure 1.11: Estimation of series resistance and shunt resistance from I-V characteritics

Defects

Defects play an important role towards determining the type of conductivity of the semiconductor as well as the performance of the device. I_2-II-IV-VI_4 compound absorber layers are strongly affected by the presence of point defects. The defects may exist in the absorber layer in isolated form or in the form of clusters consisting of a combination of acceptor and donor defects; however, their existence affects the properties of the material in different ways. Isolated defects contribute towards the formation of energy levels in the band gap, whereas defect clusters may modify band gap, electron affinity and other electronic properties [16].

The type of conductivity is decided by the combined effect of all the point defects existed in the material and population of those defects influenced by their energy of formation. For example, in case of CZTSe, the shallow defect V_{Cu} (Cu vacancy) requires the lowest energy for the formation which is an acceptor defect. Hence the conductivity of CZTSe material, governed by a large population of $V_{Cu,}$ results in *p*-type with the aid of other acceptor defects such as Cu_{Zn}

antisite. As shallow defects are responsible for the intrinsic *p*-type conductivity, there are deep defects which are detrimental to the performance of the solar cell. This deep defect acts as a recombination center affecting the parameters governing the performance of a device such as short circuit current (J_{sc}).

Loss due to recombination

The loss due to recombination is significant as it affects the lifetime of minority charge carrier and their mobility. The charge carriers generated in the depletion region and within proximity of depletion region having enough diffusion length are collected as a photo-generated current. However, when the diffusion length is not long enough, the charge carriers lose their entity upon recombination which acts as a detrimental phenomenon. The surface recombination at the front and back surface degrades the short circuit current.

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TRAFFIC ENFORCEMENT VEHICLE TO DETECT MOTORING OFFENSES AND SPEED CAMERA

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Abstract:

Vehicle speed location is utilized to gauge the speed of the moving vehicle utilizing picture and video handling procedures. With no camera alignments video is caught and investigated for speed progressively. By utilizing outline deduction and veiling strategies, moving vehicles are fragmented out.

Keywords: History of Camera, Working of Camera, Basic Principals involved in Speed Cameras, Introducing the Doppler Effect, Vehicle Speed Detection by Lidar, Communication and Public Awareness, Different Type Cameras Advantages of Speed Cameras, Future Technologies.

Introduction:

Despite the fact that there is acceptable street security execution the quantity of individuals slaughtered and harmed on our streets remain unsuitably high. So, the streets technique was distributed or acquainted with help the new loss decrease targets. The street wellbeing system incorporates all types of innovation dependent on the designing and instruction and requirement and perceives that there are various components that lead to car accidents and losses. The principal reason is speed of vehicle. We use traffic signals and other traffic director to diminish the speed. One among them is speed cameras.

Speed cameras on metropolitan and rustic streets, typically positioned to get violators of the specified speed limit for that street. The speed cameras, the exclusively to recognize and arraign those drivers that pass by the them when surpass the specified speed limit.

From the outset this appeared to be sensible that the street clients don't surpass as far as possible should be something to be thankful for in light of the fact that it builds street security, lessens mishaps and ensure other street clients and people on foot.

So speed limits are smart thought. To uphold these speed limit; laws are passed making speed an offense and signs are raised were off to demonstrate the most extreme admissible paces. The police can't be wherever to uphold as far as possible thus implementation cameras

workmanship chief to accomplish this work; on one who has an ounce of Commons sense, the purposely pass through speed camera all together fined and punished.

So almost everybody log jam for the speed Camera. We at last have an answer for the speeding issue. Presently in the event that we are to accept that speed cameras are the best way to make driver's log jam, and they work productively, at that point we would expect there to be an incredible number of these each were and that day would be profoundly obvious and recognizable to make a drivers delayed down.

Speed cameras are constantly taken cover behind trees, street signs and regularly the primary sign that one is going through a speed camera point is the ruler marks painted on the carriageway or glimmer of the camera that it goes off.

Speed cameras were presented in west London in 1992 and following their achievement in decreasing rate related accidents and wounds their utilization extended to numerous different regions of Great Britain. The hardware is costly to purchase, work and keep up and their help in arraignment strategies additionally much significant organization costs. Notwithstanding and the expense are little contrasted with the advantages of society and the economy.

Speed cameras are prescribed under use to diminish street setbacks. Since these cameras save lives of street clients the speed camera is otherwise called" wellbeing cameras".

Speed camera utilizes the essential standard of Doppler Effect and RADAR innovations. We can examine the Doppler Effect in these speed cameras and other working in these cameras.

Figure 1: Speed detection camera

History

The Dutch Company Gasometer BV, which was established in 1958 created the Gasometer. The main Radar for use with street traffic in 1971.The first portable speed traffic camera in 1982.Speed camera was presented in West London in 1992. Following their achievement in decreasing velocity was extended to numerous different territories in Great Britain.

Speed cameras were presented in west London in 1992 and following their achievement in lessening speed related accidents and wounds their utilization extended to numerous different

territories of Great Britain. The hardware is costly to purchase, work and keep up and their help in indictment methodology additionally much considerable organization costs. Notwithstanding and the expense are little contrasted with the advantages of society and the economy.

Figure 2: Automated speed camera

Why are speed cameras where they are?

- Areas where accidents frequently occur
- Areas where speeding is one of the main causes for accidents
- Areas where human police control is difficult

Working

Vehicle is in speeding, as it passes by a programmed radar speeding is recognized, computerized image of the vehicle is takenPicture is shipped off public treatment centerRegistration of the vehicle is contrasted with, data sets of taken and leased vehicles Fine is sent.

This speed location framework sounds fascinating and is by all accounts exceptionally productive in upholding as far as possible. Yet, how can it work? Peruse on to know the working of this framework. Envision that a vehicle is speeding by a road where the speed camera is introduced. As it experiences the programmed radar, as far as possible is distinguished and on the off chance that it surpasses, an advanced picture of this vehicle is caught, which is then cryptic and sent online (adsl association) with a public treatment place. It is here that the picture is encoded and the vehicle's enrollment number is brought with other related information like speed, time, and so on This information is contrasted and the data set of leased and taken vehicles. The cops take over from this stage and the fine is collected on the vehicle proprietor.

Figure 3: Working of speed cameras

Basic principles involved in speed cameras

RADAR utilizes electromagnetic waves to distinguish objects. It gives data about speed, distance of articles. It utilizes Doppler Effect to decide vehicle speed.

Speed cameras on metropolitan and rustic streets, generally positioned to get violators of the specified speed limit for that street. The speed cameras, the exclusively to distinguish and indict those drivers that pass by the them when surpass the specified speed limit.

From the outset this appeared to be sensible that the street clients don't surpass as far as possible should be something worth being thankful for on the grounds that it expands street security, decreases mishaps and ensure other street clients and people on foot.

Introducing the DOPPLER effect

The rule of DOPPLER impact is notable in the investigation of soundDoppler is the speaker of DOPPLER impact and thus the name. The rule of speed camera is the DOPPLER impact and radar innovations

The gadget that is the original RADAR isn't fit for deciding the speed of the distinguished item. This was restricted to estimating the development of reverberation on the screen, which gave a somewhat incorrect outcome.

As an illustration consider the vehicle that makes a sound with a fixed recurrence. At the point when you are in the vehicle, you will not notification any variety in the recurrence of the motor sound. Anyway, you remain along the edge of the street and tune in to the vehicle when it drives past under indistinguishable condition you will see that the recurrence of the motors sound increments as the vehicle comes ever closer declines as the vehicle goes past you.

It involves normal experience that the pitch of the note seems to change when either source or spectators or both are moving comparative with one another. Either the source or the eyewitnesses or both move comparative with and one another, the obvious pitch delivered by the sounding body has all the earmarks of being higher than real pitch. Similarly, when the source moving towards the eyewitnesses or the onlookers moving away from this source or both moving

away from one another the obvious pitch will have all the earmarks of being lower than the genuine pitch of the sounding body. The clear change in pitch because of relative movement among source and onlooker is known as the Doppler's guideline.

For instance: if a railroad motor moving quick with its whistle blowing is moving toward a spectator, the pitch seems to turn out to be more. The pitch of the note seems to turn out to be less similarly as the motor moves from the onlooker on the stage.

Doppler effect: the rule of this impact is notable in the investigation of sound. It is realized that if the wellspring of sound, emanating a note of recurrence 'v' is move with a consistent speed 'V' comparative with a spectators, it is discovered that the onlookers p Perceives a sound having the recurrence v' which varies from 'v', being more prominent or more modest as indicated by the source is move towards or away from eyewitnesses. This marvel in sound was first clarified by Doppler and thus the name Doppler impact. In any case, Fizeau indicated that a similar impact on light.

Hence if the wellspring of light is moving with a frequency saw in the Spectroscope marginally not quite the same as the first frequency.

The principle of speed camera that is the Doppler's effect can be described by the formula:

$$fM = 2vfE\cos(\alpha/c)$$

Where,

fM if the frequency of the received signal

v is the speed of vehicles

fE if the frequency of transmitted signal

α is the angle between the transmitted signal and path along which the vehicle travels

$c$is propagation speed of the signal in the air.

From this we can find that imparting a fixed recurrence sign towards the vehicle and afterward estimating the productivity of the returning sign the can the conclude the speed of the vehicle.

The chief utilized for Radar in speed camera, despite the fact that they share little practically speaking with the frameworks depicted.

It ought to be referenced that the affectability of the RADAR increments as the point between the pillars and the way of the vehicle diminishes. Thus the aerials of speed cameras situated corresponding to the streets instead of across them! This is likewise the motivation behind why just a few sorts of RADAR can work along twists, since the point between the pillars and the vehicle constantly changes, making blunder the estimation.

From theory to practice

Since we have perceived how the Doppler Effect can be utilized to quantify the speed of the vehicles, we will investigate the business applications that are found along the edge of the street.

The essential of each speed camera is a SHF generator, which can send the shafts in explicit ways. From the past area we realize that the affectability of the gadget is straightforwardly of corresponding to the recurrence of the pillars. The specific recurrence relies upon the producer, which is by and large between 2 GHz and 15 GHz. The force of oscillators isn't extremely high (typically under 10 mw), however the impact a force yield is expanded using the directional aerials.

The collector for the reflected sign is regularly founded on a shottky diode a, arranged at the point of convergence of the flying what capacities as a blender of sent and reflected sign. The yield sign of the beneficiary is intensified, adapted by a simple circuit and afterward gave to the estimation segment, which is just a recurrence counter.

The sign from the recurrence counter goes to the microchip that ascertains the speed and sends it to show. It likewise checks if the deliberate speed surpasses the preset worth and cautions the cop who are close by that of wrongdoers has quite recently passed or it actuates the camera or glimmer weapon. So, the fundamental rule behind a high recurrence speed locator isn't exceptionally intricate.

So speed limits are smart thought. To implement these speed limit; laws are passed making speed an offense and signs are raised were off to demonstrate the greatest allowable velocities. The police can't be wherever to implement as far as possible thus authorization cameras craftsmanship chief to accomplish this work; on one who has an ounce of Commons sense, the intentionally pass through speed camera all together fined and punished.

So almost everybody log jam for the speed Camera. We at long last have an answer for the speeding issue. Presently in the event that we are to accept that speed cameras are the best way to make driver's stoppage, and they work productively, at that point we would expect there to be an extraordinary number of these each were and that day would be profoundly obvious and recognizable to make a drivers delayed down. Speed cameras are constantly holed up behind trees, street signs and regularly the primary sign that one is going through a speed camera point is the ruler marks painted on the carriageway or glimmer of the camera that it go.

How well does it work

Since we know how everything functions. The may consider how solid the estimations made by these gadgets are. We will see the issue from a specialized perspective to find that what the restrictions of SHF speed cameras are.

- **Operating during the rain or mist:**

Interestingly the RADAR functions admirably during a downpour or fog. For instance RADAR is utilized broadly to help the setting down of planes in terrible climate. When all is said in done, when it downpours it descends vertically which is correct points to the RADAR shaft, achieving a Doppler impact of nothing (cos 90=0 soFm=0). Weighty downpour that descends at the points because of solid whirlwind can't resource for the sign to clamor proportion of the recipient and forestalls its right activity. For this situation they processor will just dismissed the estimations.

Since fog doesn't move concerning RADAR radiates it will be basically undetectable to the collector and the estimations are totally unaffected.

- **Measurement Range:**

The separation from which the RADAR can gauge the speed of a vehicle relies upon two factors: the force of SHF oscillators and the affectability of the finder. We definitely realize that they oscillators, power are by and large low and that the utilization of a directional aeronautical expands the communicated power. The most concerning issue of the identifier is a sign to commotion proportion. In this segment the affectability can be improved using an airborne. While the primary Radars could just take estimations up to 20 meters, the more up to date models with the ultras delicate finders are equipped for taking an estimations up to a few hundred meters, so a long time before they can be seen from the vehicle.

- **Reaction time:**

Similarly, as in other hardware that utilization recurrence counters the speed cameras additionally require a specific chance to take an estimation. Moreover, most gadgets currently take a few estimations so quickly, making it conceivable to dismiss any potentially incorrect estimations.

More seasoned models needed by about a large portion of one moment to take a dependable estimation. Current models respond with in 10th of a second, so any drivers who overlooks speed breaking point will have minimal possibility of stay away from a fine subsequent to seeing a speed camera. Once in a while the RADAR hardware likewise contains the Ds, which utilizes unique calculations with the brief timeframe, making incredibly quick readings conceivable.

- **Continuous transmission:**

Rather than your opinion in the wake of perusing the hypothetical part, RADAR doesn't have to have its oscillators working ceaselessly. It just should be dynamic long enough to balance out and take an estimation. Real RADAR hardware deals with the arbitrary premise or is enacted just when a vehicle draws close to by.

- **Discrimination:**

At the point when a few vehicles going at various velocities experience at the RADAR radiates the subsequent Doppler signal contains a combination of signs at various recurrence. Most of current gadgets can't separate these segments and reject the estimation as flawed. There are anyway fresher frameworks that Dsp, which can gauge the speed of the few vehicles at the same time. So now just those vehicles at the same time end up being in' shadow ' of other can escape from the speed cameras. The bottom line is that speed cameras have become so exact and solid that it has gotten very hard to sidestep them.

On the wrong side of the law

Humanity, and particularly homo vehicles, carry on so that when he runs over a deterrent he will take a stab at everything to get round of it. Speed cameras are no special case for this and various boffins have added to the improvement of counter measures.

There are two sorts of 'enemies of radars'. Sticking gadgets and locators. The sticking gadgets are essentially being SHF oscillators, which are utilized to impart ' take ' sign the to speed camera, making the estimation come up short and forestalling the legitimate examination of the recurrence. Other than the way that these gadgets are generally in successful, the electronic circuit in the radar can distinguish such the sticking signs and tell the police. A sticking gadget is accordingly a definite fire route and to get captured.

A finder then again comprises of the straightforward SHF recipient, and by definition this can't be identified. In USA they are sold in huge amounts. On the Internet they are promptly accessible. These are moderately straightforward circuit containing a microwave indicator an alert. It isn't hard to plan the broadband indicator the frequencies somewhere in the range of 2 and 10 GHz, which is the reach where the vast majority of present day gadget work.

Nonetheless, if the oscillators of the speed camera are set to a recurrence that is outside the reach covered by the indicator, or it utilizes an optical laser, at that point you will undoubtedly get captured.

In the subsequent issue is that to recognize something, there first ought to be something to identify. More seasoned RADAR hardware communicated persistently, which made undertaking basic, yet fresher models just send irregularly, either arbitrarily or in short blasts decreasing the opportunity of distinguishing the gadgets. A few models are seriously clever and possibly come right into it when a vehicle goes inside the reach. These 'Green shots ', as they are known due to the shape and shading, have an optical finder on the top that can in a real sense see the vehicle coming.

When there is development before the gadget it gets a move on. This carries us to the third issue: a RADAR finder will detect the shaft right then and there.

And yet the speed camera is now tackling its job. From that it follows that in the time taken by the driver to make a proper move, the RADAR or will as of now have taken four or five estimations.

The identifier is made more troublesome by the way that thin shafts are used, making for a little location zone. A few clients of RADAR locators have seen that the shaft can likewise be distinguished when reflected off different vehicles ahead and have readily utilized this property.

What's more, presently last issue: most RADAR gear can take estimations of drawing closer and subsiding however the affectability of most locator is Limited to one heading to be ready for in the in the end the vehicles ought to in this manner have an indicator at both the front and back.

Vehicle speed detection by lidar

It doesn't utilize Doppler Effect. This framework computes the distance at which the item is and from the adjustment in distance observed in a particular time slip by. The frequencies here are higher and trickier to stick.

Radar utilizes electromagnetic waves to identify articles and give data (speed, distance, and so forth) about them. It utilizes Doppler Effect to decide the vehicle's speed. They compute and scale the variety of recurrence between the got and sent radio waves (reverberation). The recurrence will be lower if the item is moving endlessly and is higher in the event that it is drawing nearer. Thus, in light of the degree of reverberation, it is conceivable to choose the speed of the moving article. The above innovation has become old now and can be effectively stuck. Presently, there's another one called LIDAR (Light Detection and Ranging), which doesn't utilize Doppler impact. This framework computes the distance at which the item is and from the adjustment in distance observed in a particular time pass, it is not difficult to decide the speed. The frequencies here are higher and trickier to stick. Speed cameras are an extraordinary shelter in speed requirement, in this manner decreasing the quantity of street mishaps, making the streets more secure for people on foot and other blameless street clients.

Types of cameras

- Gastro meter speed cameras
- Peak traffic speed cameras
- Speed spike cameras
- Travel speed cameras
- Specs system speed cameras

1. Gastrometer speed cameras

Producer of the UK's red light camera. Red light camera was initially utilized measure red light offences.

Figure 4: Gastro meter speed cameras

2. Peak traffic speed cameras

Established in 1990 and situated in the Netherlands. It utilizes either circles inside the street surface or radar

Figure 5: Peak traffic speed cameras

3. Speed spike

These new kind of cameras correspondence with one another by means of the GPS Satellite Network. It can follow vehicle utilizing number plate acknowledgment. Permit two cameras to 'converse with' one another.

4. Truvelo speed cameras

This framework is intended to take photos of the front of a passing vehicle. This permits the image taken to show the driver of the vehicle also. It utilizes an infrared blaze which delivers no noticeable 'streak' to the moving toward drive.

5. Specs system speed cameras

Speed infringement Detection Deterrent, SVDD is the computerized mind which the SPECS framework depends on. It comprises of two camcorders each fitted with infra red illuminators. It enables to work 24hrs 7days every week.

Communications and public awareness

The need for public communications

A key goal was to guarantee that individuals are made completely mindful of the speed cameras are for street security purposes and isn't for the raise of income. In spite of the fact that speeding prompts more crashes, passing’s and wounds, a few reporters contend against speed

camera requirement by guaranteeing that the speeding isn't risky in light of the fact that speed limit are discretionary and acceptable drivers has are better ready to judge what is protected in given conditions. Alternately there are a bigger number of government officials and street security, climate and motoring associations that help endeavors to lessen speeding and they are steady of speed camera.

We should make individuals mindful of the speeding and advantages of speed cameras. We should make mindfulness in the neighborhood level, public level and furthermore in government level. We should make association with the nearby and public and government associations to make mindfulness about these speeding and setbacks because of speeding. There are numerous exposure crusades, for instance called 'THINK!' which incorporates messages about the dangers and different results of speeding.

Different names of speed cameras

- Traffic enforcement camera
- Road safety camera
- Road rule camera
- Photo radar
- Photo enforcement
- Red light camera

Advantages of speed camera

- Speed costs lives
- Economic benefit
- Speed camera’s are a tax on the rich
- Good for environment
- High speed is bad for communities and other type of exercise

Criticisms of speed cameras

They cause mishaps since individual’s brake from 40 to 30mph. Speed isn't the fundamental driver of death. Nations without speed cameras have lower demise rates. A traffic implementation camera (likewise A traffic authorization camera (additionally red light camera, street security camera, street rule camera, photograph radar, photograph requirement, speed camera, Gatos, wellbeing camera, transport path camera, streak for money, Safe-T-Cam, contingent upon use) is a camera which might be mounted alongside or over a street or introduced in a requirement vehicle to recognize motoring offenses, including speeding, vehicles experiencing a red traffic signal, vehicles experiencing a tollgate without paying, unapproved utilization of a transport path, or for recording vehicles inside a clog charge territory. It could be connected to a computerized tagging framework.

An overall audit of studies found that speed cameras prompted a decrease of "11% to 44% for deadly and genuine injury crashes". The UK Department for Transport assessed that cameras had prompted a 22% decrease in close to home injury crashes and 42% less individuals being murdered or genuinely harmed at camera destinations. The British Medical Journal as of late detailed that speed cameras were viable at diminishing mishaps and wounds in their region and suggested more extensive arrangement. A LSE concentrate in 2017 found that "adding another 1,000 cameras to British streets could set aside to 190 lives every year, diminish up to 1,130 crashes and alleviate 330 genuine wounds."

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The most recent programmed number-plate acknowledgment frameworks can be utilized for the discovery of normal paces and raise worries over loss of protection and the potential for governments to build up mass observation of vehicle developments and accordingly by affiliation additionally the development of the vehicle's proprietor. Vehicles proprietors are frequently legally necessary to distinguish the driver of the vehicle and a case was taken to the European Court of Human Rights which found that common liberties were not being penetrated. A few gatherings, for example, the American Civil Liberties Union in the US, guarantee that "the regular utilization of speed traps as an income source additionally undermines the authenticity of wellbeing endeavors.

Future technologies

A speed camera intended to find speeding drivers. The resource camera ought to have the option to select driver's who are not wearing. Character closely following. Can likewise note number plates and perceive vehicles with obsolete expense circle and no protection.

Speed detection camera system using image processing techniques on video streams

It presents another Speed Detection Camera System (SDCS) that is appropriate as a radar elective. SDCS utilizes a few picture handling methods on video transfer in on the web - caught from single camera-or disconnected mode, which makes SDCS fit for computing the speed of moving articles evading the conventional radars' issues. SDCS offers an en-costly option in contrast to customary radars with a similar precision or stunningly better. SDCS cycles can be isolated into four progressive stages; first stage is Objects recognition stage. Which utilizes a crossover calculation dependent on joining a versatile foundation deduction procedure with a three-outline differencing calculation which approves the significant downside of utilizing just versatile foundation deduction? The subsequent stage is Objects following, which comprises of three progressive activities, Object division, Object marking, and Object jog extraction. Articles following activity mulls over the various potential situations of the moving item like; Simple following, object has left the scene, object has entered the scene, object cross by another article, and item leaves and another enters the scene. Third stage is speed figuring stage, which is determined from the quantity of edges devoured by the item to pass-by the scene. The last stage is Capturing Object's Picture stage, which catches the picture of items that disregard as far as possible. SDCS is actualized and tried in numerous investigations; it demonstrated to have accomplished an acceptable execution.

Real-time vehicle speed detection algorithm using motion vector technique

Reconnaissance camcorder checking framework has acquired a great deal of interest among the exploration local area particularly in observing vehicle speed.

Aside from vehicle speed discovery, this calculation can be utilized to screen the traffic condition along the street or expressway. The current reconnaissance camcorders are infrequently used to gauge the vehicle speed and gauge the vehicle.

A MATLAB calculation is proposed and created to connect the created calculation with constant video grouping and pictures. Improvement of vehicle speed location calculation depends on the vector-esteemed capacity and movement vector method that appraises the speed of moving vehicle.

Conclusion:

Presently we might want to accept that implementation cameras are there for our on great and make our streets more secure. All in all speed camera are seen to be smart thought since they ensure guiltless street clients and walkers. Albeit these cameras lessens mishaps and ensures the

blameless street clients, the manner by which the speed cameras are at present utilized isn't to make the driver delayed down, submit to as far as possible and make the street safe yet to get and punish the violators who may some way or another have eased back down on the off chance that they have seen as the cameras ahead of time .for example speed camera , as, right now sent, are not all that legitimate .

These cameras were profoundly obvious then nobody would go by them surpassing as far as possible and they would tackle their work. Utilized as they shrouded away, they are punished and contribute little to street wellbeing straightforwardly just creating income to pay for their establishment and upkeep.

Regardless of almost 4000 driver got, more than one every moment all things considered, not one single mishap but rather was accounted for by the police which recently indicated that, speedier offer a little towards improving street security yet do a horrendous part to produce income for the nearby police and neighborhood specialists. In spite of the fact that street security tacticians are acquainted with lessen the quantity of individuals slaughtered and genuine harmed that is to help new loss decrease biggest. So on using the procedures in the correct manner, we can lessen 40% it of mishaps.

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