BIOTECHNOLOGY IN EVERYDAY LIFE

Abstract

Biotechnology is becoming an integral part of our daily existence, shaping the life we live, work and interact with the world. It explores how advancements in biotechnology have seamlessly integrated into various aspects of our daily lives, from healthcare, agriculture and food production, environmental sustainability, etc. This topic highlights the transformation impact of biotechnological applications, emphasizing their role in improving human well being, addressing global challenges and shaping the future of modern living.

Keywords: Biotechnology, Everyday life, Human well-being, Advancements, Environmental engineering.

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Biotechnology is an essential, challenging and interesting industry to be a part of and helps to lead the way for how we live healthy and prosperous lives. Biotechnology plays a huge role in our day to day life, from the clothes we wear, the food we eat to how we produce them, the medicine we take to treat our bodies, and even the fuel we use for our vehicle. Biotechnology is a field which is growing rapidly, but we must realize that it's just a tip of an iceberg that has been revealed and is yet to be explored further.

I. WHAT IS BIOTECHNOLOGY?

Biotechnology means, genetic manipulation of living things by human beings to make most desirable products by using various techniques. It is the use of biology to the creation of novel goods, processes, and living things with the goal of enhancing society and human health.

Biotechnology, often referred to as biotech, has a longstanding presence dating back to the inception of human civilization. It is a multidisciplinary domain that amalgamates natural sciences and engineering sciences with the goal of achieving improved utilization of organisms, cells, their components, and molecular counterparts for the development of various products and services. (**IUPAC Goldbook., 2014.**)

According to the American Chemical Society's definition, biotechnology is the utilization of biological organisms, systems, or procedures across different industries to gain insights into the science of life and enhance the value of materials and organisms, including pharmaceuticals, agricultural crops, and livestock.(**Biotechnologyportal.acs.org, 2013*).*** The term Biotechnology was coined by Karl ereky in 1919.

Uses of Biotechnology in Everyday Life: Biotechnology is a rapidly advancing discipline with substantial potential to address emerging global issues and enhance the quality of life worldwide. It has exerted a profound influence on various facets of society, ranging from agriculture to healthcare. The applications of biotechnology are multifaceted and have resulted in the creation of critical products such as life-saving medications, biofuels, genetically modified crops with enhanced attributes, the production of biodegradable plastics, and the utilization of microorganisms for environmental remediation in contaminated areas.

In today's world it has become integrated with our lives and has proved to make our lives easier and aids to make the best from the least. Biotechnology has become a part of our day to day life in many ways which includes the following,

II. BIOFUEL

Biofuels are sustainable fuel alternatives that come from plants and goods derived from plants. Cars are the primary application for biofuels. Biofuels come in two primary varieties.

Bioethanol is a sensible replacement for gasoline that is mostly created by the fermentation of sugar in cellulose. The primary sources of starch are sugarcane, tapioca, maize, and other sources.

Conversely, the primary source of biodiesel is oil crops like soybean, rapeseed, palm, and jatropha. In diesel-powered engines and vehicles, it serves as a diesel alternative. This proves to be more ecofriendly than the former one and is found to emit less unburned carbon.

Biofuel is generally used in vehicles in a blended form with petrol and diesel. This way of using biofuels are useful in reducing the carbon level emission. Thereby, enabling to have a strict control on greenhouse gas emissions. Biotechnology can be used in biofuel production by either developing more efficient enzymes to break down solid biomass or engineering robust microbes that are capable of producing usable biofuel directly. In either way, it proves to improvise our life.

1. **Biotechnologies for First-Generation Biofuels:** Edible energy crops like sugar-based (sugarcane, sugar beet, and sorghum), starch-based (corn, wheat, and barley), and oil-based (rapeseed, sunflower, and canola) are used to make first generation biofuels.

   The plant varieties utilized in the first-generation biofuel production process were chosen based on their agronomic qualities that are pertinent to the production of food and/or feed, not on qualities that make them suitable as feedstocks for the biofuel production process. The process of choosing cultivars with higher biomass per hectare, higher oil content (for biodiesel crops) or fermentable sugar content (for ethanol crops), or better processing qualities that make them easier to convert to biofuels is accelerated by biotechnology. An essential role is played by the field of genomics, which is the study of an organism's entire genetic makeup, or its genome. Several first-generation feedstocks, including soybean, sorghum, and maize, have already had their genome sequences examined and published. Other than genomics, a few other biotechnologies come in handy as well, like genetic editing and marker assisted selection.

   An essential step in the process of making ethanol from biomass is the fermentation of sugar. Saccharomyces cerevisiae, one of the most widely used industrial fermentation microorganisms, is yeast. Starchy materials like the starch in maize cannot be directly fermented by it. Using enzymes known as amylases, the biomass must first be hydrolyzed into fermentable sugars. A large number of the enzymes that are currently sold commercially, such as amylases, are made by genetically altered microorganisms. Research is still being done to create genetic yeast strains that are efficient enough to make amylases on their own, allowing for the combination of the fermentation and hydrolysis processes.

2. **Biotechnologies for Second-Generation Biofuels:** Second-generation biofuels pertain to energy generated from non-food crops, which encompass agricultural residues, forest residues, and solid wastes.

   The primary components of lignocellulosic biomass are hemicellulose, which contains a combination of hexose and pentose sugars, polysaccharides, and cellulose, which is made up of hexose sugars. The use of lignocellulosic biomass in the manufacture of biofuel is more complex than the synthesis of ethanol from first-generation biofuels due to the stability of the polysaccharides and the difficulty of Saccharomyces cerevisiae to ferment the pentose sugars. Enzymes or acid must first hydrolyze the polysaccharides in lignocellulosic biomass in order to turn it into biofuels. Numerous biotechnology-based strategies are being employed to address these issues, such as the creation of strains of Pentose sugars can be readily fermented by Saccharomyces cerevisiae, different yeast species can be employed that naturally ferment pentose sugars, and enzymes that can degrade cellulose and hemicellulose into simple sugars can be engineered.

The main source of lignocellulosic biomass for second-generation biofuels, aside from forestry, agriculture, and other byproducts, is probably "dedicated biomass feedstocks," which include some perennial grasses like switch grass, miscanthus, bamboo, sweet sorghum, tall fescue, kochia, wheat grass, and forest tree species. In an attempt to produce plants with desirable traits for the production of second-generation biofuel, efforts are being made to employ genomics, genetic modification, and other biotechnologies. Examples of these traits include plants that produce more cellulose or biomass overall, produce less lignin, which cannot be broken down into liquid biofuel, or produce their own enzymes for cellulose and/or lignin degradation.

3. **Plant Biotechnology and Biofuels:** According to estimates from the US Department of Agriculture (USDA) and DOE (2005), one billion dry tons of biomass must be produced annually in order to replace 30% of transportation fuels with biofuels. This amount of biomass may be generated by 2050 with practical technical advancements and still meet the need for food, fiber, and exports, according to a USDA research. The majority of the biomass would come from growing perennial energy crops and crop wastes. **(Ragauskas, A.J., et al., 2006).**

Therefore, the challenge for biotechnology is to design crops with an appropriate set of chemical and physical features for energy production while also significantly increasing crop output.

- **Increasing Plant Yield:** Increasing the efficiency of light uptake during photosynthesis can help plants develop more rapidly. The most successful methods have entailed inserting photosynthetic bacterial genes into plants without changing the degree of gene activity specific to the plant. Manipulation of genes involved in nitrogen metabolism—a crucial component of proteins and DNA—was another burgeoning biotech application.

- **Raising Plant protection to Abiotic Stress:** The main factor causing crop loss globally is abiotic stress, which lowers average yields by more than 50%. Additional losses occur as a result of insect and pathogen attacks. Thus, the development of stress-resistant crops and the provision of pest- and disease-resistant plants are at the core of many agricultural improvement programs, involving both traditional breeding and cutting-edge biotechnological techniques (Vinocur, B. & Altman, A., 2005). For instance, transgenic rice that has the chloroplastic glutamine synthase gene (GS2) overexpressed exhibits improved resistance to excessive salinity in the soil. Plant productivity will be fundamentally impacted by such measures.

III. VACCINES

A vaccine is a biological product administered to individuals to enhance their immune system's defense against pathogens, which can encompass bacteria, viruses, or fungi.

Typically, vaccines consist of a specific pathogen that has been attenuated, antigenic components of that pathogen, its inactivated form, or commonly a protein located on the surface of a cell or viral particle that can be identified and targeted by antibodies within the immune system.

Vaccines are employed to activate the body's immune system to combat pathogens when they invade. This is accomplished by introducing a weakened form of the disease-causing pathogen into the body, thereby priming the body's defense mechanisms. The weakened pathogens are obtained using biotechnological methods, such as cultivating antigenic proteins in genetically engineered crops.

The advancement of vaccines is intricately linked to biotechnology. Modern biotechnological methods, including genetic engineering and cell culture, play a pivotal role in expediting the efficient and cost-effective development of vaccines. Recombinant DNA technology enables the production of antigens from a specific pathogen in a relatively non-pathogenic host cell, such as E. coli or yeast, eliminating the need for direct harvesting from the original pathogen.

Furthermore, commercial vaccine production incorporates a facet of biotechnology known as bioprocessing, encompassing both upstream and downstream processes. In the case of protein-based vaccines, the genetic code encoding the protein can be incorporated into a plasmid, which is subsequently introduced into the host cell (such as E. coli or mammalian cells). This host cell then translates the gene into the corresponding protein. The resultant protein is harvested, purified, and processed into a vaccine formulation. The production of protein-based vaccines is relatively more intricate, demanding additional steps and applications. However, it can yield a comparatively higher antigen titer and enhanced efficacy compared to other vaccine production methods.

- The classic vaccinations contain either attenuated or dead microorganisms, which when injected into the body cause an immunological reaction. Biotechnology's amazing advancements and breakthroughs have completely transformed the field of biomedicines. The first recombinant vaccine to be cloned and generated in Saccharomyces cerevisiae was recombinant Hepatitis B surface antigen (HBsAg), which is being utilized as an HBV vaccination all over the world. Vaccines containing deoxyribonucleic acid (DNA) are essentially genetically modified DNA that, upon injection, produces antigen and stimulates a potent immune response. Reverse genetics, messenger RNA (mRNA) vaccines, and reverse vaccinology are platforms that are used in the creation of vaccinations and have demonstrated encouraging outcomes. Biotechnology has revolutionized the field of vaccination and increased the time required to dedicate to research to find cures for diseases that are already prevalent and others that are on the rise for the benefit of humankind.

- After the development of Recombinant DNA Technology, a branch of biotechnology, notable improvements in human health were noted. From the synthesis of safe proteins, antibodies, and gene therapy, RDT transformed several facets of biological research.[**Khan S et al., 2016**]. **Recombinant Sub-Unit Vaccine**

New avenues for therapies were made possible by the discovery of gene cloning. Cloning antigenic protein (fragment) or its subtype and cloning it into an animal or another expression system to transcribe it is a valuable procedure. The body is given the expressed protein that has been purified to stimulate the immune system. [Burnette W N. 1991]

Using cloning techniques, Maurrice Hellmen and his team created the first recombinant vaccination, known as recombinant Hepatitis B surface antigen (HBsAg). Following the purification of HBsAg from infected HBV carrier serum, Saccharomyces cerevisiae (Baker's yeast) was cloned and expressed. Using yeast culture, the HBsAg sub-type adw was produced and purified. The mice, chimpanzees, and monkeys that received the vaccinations were shielded from illness following an HBV adw and ady subtype challenge. **[Mc Aleer etal., 1984**].

1. **DNA Vaccines:** DNA vaccines are fundamentally composed of genetically engineered DNA. When administered through injection, they generate antigens and stimulate a robust immune response. The gene responsible for triggering the immunogenic response is pinpointed, cloned, and subsequently expressed within the host by direct injection. DNA vaccines possess a greater capacity to induce immune responses compared to conventional live attenuated or inactivated vaccines. [Alarcon J B etal., 1999).

   The term "DNA vaccines" was first coined in 1990, when plasmid DNA was injected into muscle or skin, resulting in an immune response against both viral and non-viral antigens. At that time, DNA vaccines were seen as holding significant promise for the future. [**Tang D c etal., 1992**]

2. **mRNA Vaccines:** Introducing a segment of mRNA that correlates to a viral protein is how mRNA vaccines function. When someone receives an mRNA vaccination, they are not exposed to the virus and cannot contract the infection via the vaccine. The inserted mRNA contributes to the viral protein's synthesis. The immune system produces specialized proteins known as antibodies in reaction to the proteins, which it detects as foreign antigens. By quickly identifying specific viruses or other pathogens, adhering to them, and designating the pathogens for elimination, antibodies shield the body against infection. Once created, antibodies against a given disease remain in the body for the rest of one's life, making it easier to fight off an infection's second onslaught and shielding the body from health complications. We refer to these antibodies as memory cells. These memory cells are in charge of the pathogen's elimination and the quick response to the illness.

IV. BIOREMEDIATION

Within the field of biotechnology, bioremediation involves using living organisms such as bacteria and microorganisms to remove and process poisons, pollutants, and other contaminants from soil, water, and other environments.

Bioremediation is grounded in the principle of encouraging the proliferation of specific microorganisms capable of utilizing substances like oil, solvents, and pesticides as their sources of nutrition and energy. These microorganisms effectively transform the contaminants into non-hazardous by-products, thereby contributing to the creation of a more environmentally secure setting.

It requires a combination of the important factors like right temperature, nutrients, and foods. The absence or relative deficiency of these elements may prolong the cleanup of contaminants thus making it less effective.

The time involved in the process of bioremediation is variable and may vary anywhere from several months to years for the completion of the task. The factors which has influence over the process includes the size of the contaminated area, temperature, the concentration of contaminants, soil density, and whether bioremediation will occur in-situ or ex-situ.

The three types of bioremediation are:

1. **Biostimulation:** As implied by the name, the procedure begins with the stimulation of the microorganisms. Prior to the process, the contaminated soil is mixed with specific nutrients and other essential components, either in liquid or gas form. This encourages the growth of microbes, which enables the microbes to remove toxins effectively and quickly. Through the use of chemicals or nutrients that can activate them, microbes are encouraged to start the remediation process.

2. **Bioaugmentation:** Sometimes the pollutants must be extracted using microorganisms. Take municipal wastewater as an example. Bioaugmentation is the procedure used in these unique situations. One significant disadvantage of this is that it restricts the proliferation of microorganisms throughout the process of eliminating the specific pollutant. Its primary application is soil pollution cleanup. The way this procedure operates is by introducing germs to the afflicted area's surface and allowing them to proliferate.

3. **Intrinsic Bioremediation:** Given that pollutants and toxins are almost always present in soil and water biomes, these are the biomes where intrinsic bioremediation is most effective. The utilization of intrinsic bioremediation is more prevalent in subterranean environments, such as subterranean petroleum tanks. Toxins and pollutants can seep in through these leaks and pollute the gasoline, although it is difficult to identify leaks in such places.

   By utilizing the native microbiome, the bacteria transform harmful substances into innocuous ones and eliminate the poisons from the tanks.

V. ENVIRONMENTAL ENGINEERING

The application of science and engineering principles to enhance the environment and provide clean water, air, and land for human habitation as well as other organisms, as well as to clean up contaminated locations, is known as environmental engineering.

Environmental engineers utilize the fundamentals of engineering, soil science, biotechnology, and chemistry to develop strategies for addressing environmental challenges. Their contributions lead to enhancements in recycling, waste management, public health, as well as the effective control of water and air pollution.

Bioremediation offers a potentially cost-effective and environmentally friendly alternative to existing physico-chemical remediation methods. Nevertheless, naturally occurring bacteria cannot transform heavy metals like mercury into non-toxic forms. Global annual estimates for mercury emissions released into the environment amount to thousands of tons per year. Mercury (Hg) is among the most highly toxic heavy metals, and pollution from this element poses a significant environmental concern, impacting all environmental systems, including soil, water, and air, even at low concentrations. [**Attwaters, 2023, Ballabio C etal., 2021, Munthe J etal., 2019**] while the remediation cost is in the thousands of dollars per pound. Mercury is released into the environment as a result of human activities and natural events. Finding new bioremediation technologies is an urgent need. Environmental engineering and biotechnology are two important fields that can work together to solve some of the most tormenting environmental challenges. One of these challenges is waste water treatment, which involves removing pollutants and contaminants from water sources. Biological agents called bioremediators are employed in bioremediation to clean up contaminated locations. Typical prime bioremediators include bacteria, algae, fungus, and archaea.

Biological treatment of wastewater is cost effective and sustainable. The genetically engineered biological organisms enhance the pollutant removal rate from wastewater and helps in maintaining the water quality of the discharge. A genetically engineered bacteria, *Pseudomonas putida* is used for cleaning up of oil spills by digesting the hydrocarbons of crude oil. Through biotechnology or genetic engineering, a stronger protein with the intended function is introduced into bacteria to improve the desired feature, resulting in genetically altered germs. Using genetically modified bacteria, fungi, and algae, biodegradation of oil spills, halobenzoates, naphthalenes, toluenes, trichloroethylene, octanes, xylenes, etc., has been achieved. Because bioengineered microbes can swiftly adapt to new toxins they encounter or co-metabolize, they are more potent than naturally occurring ones and can destroy contaminants faster. Genetic engineering is a worthwhile endeavor that will eventually improve human health and the environment. Genes to improve mercury accumulation and resistance can be incorporated into bacteria through genetic engineering.

VI. PEST RESISTANT CROPS

The never-ending process of multiplication of living organisms sets off an increasing demand food production with a limited source and area. Biotechnology has enabled us in producing effective crops which has high yield with desirable quality. Controlling pest has been a great challenge to all the agriculturists and farmers.

Biotechnology has provided a number of methods for producing crops that are naturally resistant to pests. The gram-positive, spore-forming bacteria Bacillus thuringiensis is mostly found in soil. It generates harmful proteins for insects. To defend their plants from pests, organic farmers cultivate this bacterium in a solution and spray it on the plants.

The use of Bacillus thuringiensis dates back to 1996, when the bacterium's genes were first isolated in modest amounts. This made it easier for plant cells to produce cry proteins, which aid in the death of pests. The agricultural yields were mostly destroyed by pests like the Colorado potato beetle, tobacco and cotton budworm, pink bollworm, and European and southwestern corn borer. It turns out that Bacillus thuringiensis is resistant to these pests.

Crops that have Bacillus thuringiensis genes incorporated into them are naturally resistant to pests, which reduces the need for chemical dusting and spraying. Bt crops are transgenic plants that, in order to defend themselves against pests, release a toxin similar to that produced by the Bacillus thuringiensis bacteria inside the plant cell. The bacteria makes particular proteins referred to as "cry." proteins" that have been shown to be hazardous to insects. Bt crops include corn, cotton, brinjal, and other vegetables.

The poisonous cry protein found in the transgenic plants crystallizes in the digestive tract of insects, eventually causing them to perish. On the other hand, it has no negative impacts on people.

1. **Some Examples of BT Crops:** GMO field crops include Bt-potatoes, Bt-corn, Bt-sweet corn, Roundup Ready soybeans, Roundup Ready Corn, and Liberty Link corn.

2. **BT Cotton:** The Bt cotton variety is genetically modified by introducing the Bt gene to shield the plants from the bollworm, a predominant cotton pest. As a result of the Bt gene's presence, the worms residing on the leaves of Bt cotton exhibit decreased activity and drowsiness, resulting in reduced harm to the plants.

3. **BT Brinjal:** Bt brinjal is also created through genetic modification, involving the introduction of a crystal protein gene, cry 1 Ac, sourced from the bacterium Bacillus thuringiensis. The development of Bt brinjal aimed to confer resistance against lepidopteran insects. The proteins generated by the Bt genes adhere to receptors on the insect's membrane, causing the formation of pores in the membranes. This disruption interferes with the insect's digestive process, ultimately resulting in its demise.

VII. BIOTECHNOLOGY IN ALCOHOLIC BEVERAGES

Making alcohol is one of the most fundamental applications of biotechnology. People all throughout the world drink alcohol on a daily basis in varying quantities. For instance, brewer's yeast, water, barley, and a specific flavoring are used to make beer.

Enzymes first transform the starch in the barley into sugar, which is subsequently fermented. After that, the sugars are broken down by the brewer's yeast to create carbon dioxide and alcohol. Microbes and enzymes are common instruments in industrial biotechnology.

Alcoholic fermentation is the anaerobic transformation of the monosaccharides , fructose and glucose into ethanol and carbon dioxide. The process is conducted by yeasts and a few bacteria (for eg, *Zymomonas mobilis*). Through the metabolism of hexose, the process of alcoholic fermentation replenishes the NAD+ that was taken up during glycolysis and gives yeast an energy boost of two ATP molecules.

In grape juice fermentation, *Saccharomyces cerevisiae* (Species of yeast), primarily directs the pyruvate for the production of ethanol to regenerate NAD+ consumed by the process of glycolysis. This process is referred to as alcoholic fermentation.

VIII. BIOTECHNOLOGY IN TEXTILE INDUSTRIES

Biotechnology, which is the use of living things or their byproducts to carry out particular tasks or create goods, has the potential to completely transform the textile sector by making it possible to develop new materials and procedures with special qualities and advantages. Here are some instances of how biotechnology is used in the textile industry. Biotechnology is used in textile industries in the following possible ways,

1. The bacteria Acetobacter xylinum is used to make chitin and cellulose fibers, which are spun into a range of textiles. As a result, natural fibers are produced, which can take the place of synthetic ones.

2. Textile dyeing is enhanced by the application of biotechnology. Natural dyes like indigo, which are used to color fabrics, can be made by bacteria. By enhancing the colorfastness and vibrancy of dyes with enzymes, we can reduce the need for harsh chemicals.

3. Microorganisms can be utilized to remove dyes from textiles through the process of biodegradation, notwithstanding their utility in textile dyeing. One useful bacterium for biodegrading azo dyes, which are frequently used in the textile industry, is Pseudomonas putida.

4. Natural fibers, like cotton and wool, can be softened and given a better drape by using enzymes, which will make them more wearable and cozy.

5. The process of shrinking woven materials, or eliminating starch, in the textile manufacturing process is known as textile desizing. Enzymes are employed in this procedure, which uses biotechnology, to break down the starch molecules into smaller sugars. Enzymatic desizing is the term for this, and it's thought to be a more environmentally friendly option than the current chemical desizing techniques. Since microorganisms can be used to manufacture the enzymes used in enzymatic desizing through fermentation, the procedure is a type of biotechnology. The reason enzymes are used is because they can break down starch molecules only, without causing harm to the fabric.

6. The scouring procedure, which entails cleaning fabrics of impurities like oils, grime, and waxes, also makes use of biotechnology. In this procedure, specific kinds of pollutants are broken down and eliminated using enzymes. For example, lipases are used to break down fat or oil-based impurities, whereas proteases can be used to break down protein-based impurities like blood and sweat stains. Because they are biodegradable and generate less byproducts from wastewater, microbial scouring agents have been found to be more environmentally benign than typical chemical scouring agents.

7. By applying unique coatings or treatments, biotechnology can be utilized to produce fabrics that are water-repellent. Fabrics can be made naturally water-proof by using enzymes to build hydrophobic surfaces or by using bacteria to make self-assembling peptides that form a water-repellent coating on the fabric's surface.

8. The environmental impact of textile production and disposal can be lessened by the use of biodegradable finishes for textiles. Biodegradable polymers, such polylactic acid (PLA), which can be utilized to make a range of finishes, can be made by bacteria.

9. Biotechnology can be applied to enhance the sustainability of the textile industry as well as to create new materials. Bacteria can be employed to create biodegradable substitutes for synthetic fibers or to break down and recycle textile waste.

Concerns about genetically modified organisms, potential misuse or abuse, and potential effects on biodiversity and the environment are only a few ethical issues that may arise from the use of biotechnology in textiles. It is critical that the textile sector takes these moral concerns into account and responds to them responsibly.

Although there are few obstacles and restrictions to the application of biotechnology in textiles, there are many potential advantages. Specialized tools and knowledge are needed for the manufacture of biotechnology-based materials, which can also be more costly than ordinary fibers. Another issue can be the dependability and scalability of biotechnology-based procedures.

Although the application of biotechnology in textiles is still in its infancy, it is expected that the field will see further advancements and changes in the years to come. Future applications of biotechnology in textiles could involve the creation of novel, useful, and sustainable materials as well as the incorporation of sensors and electronics into textiles, and the application of biotechnology to enhance the sustainability and efficiency of the textile production process in an environmentally beneficial way.

All things considered, the application of biotechnology to the textile industry holds promise for the development of novel materials and sustainable production techniques. It is imperative to meticulously evaluate the plausible hazards and ramifications of biotechnology, and to guarantee its conscientious and principled application.

IX. BIOTECHNOLOGY IN FORENSIC SCIENCE

Forensic biotechnology entails the scientific examination and exploration of genomic data to pinpoint specific indicators of criminal acts. Forensic scientists utilize biotechnology to gather trace evidence, such as blood, bones, skin, hair, semen samples, and more, from crime scenes. Genetic fingerprinting or DNA profiling plays a pivotal role in modern forensics.

The information derived from forensic biotechnology is employed by the legal system to make vital determinations regarding the nature of crimes and the individuals involved. Given its ability to discern unique genetic markers, this field has also found application in establishing parenthood and other familial characteristics. Initially, forensic biotechnology relied on fundamental genetic techniques like DNA fingerprinting. Nevertheless, recent advancements in genomics, transcriptomics, and proteomics have significantly heightened the sensitivity and reliability of forensic sciences. These advancements enable the extraction of valuable information from even the smallest sample amounts (such as blood, hair, or other bodily tissues) in a timely manner, a process that would have previously taken months or years to accomplish.

X. INVITRO FERTILIZATION/ TEST TUBE BABY

In recent times we have observed several couples who are unable to bear children because of minor bodily problems. This is the place where in vitro fertilization (IVF) plays a vital role in bringing fruitfulness in life to such couples.

The procedure of fusing a man's sperm and a woman's egg in a lab setting is known as in vitro fertilization, or IVF. It means outside the body in vitro. The union of the sperm and the egg is known as fertilization.

The fertilized egg is then cultured for 2–6 days and allowed to be divided 2-4 times inside a test tube (thereby getting the name test tube baby also). These fertilized eggs are then planted to the mother's uterus where they can be developed normally.

An egg and sperm cell are surgically manipulated for successful fertilization in order to produce a test-tube baby, which is the offspring of successful human reproduction that takes place through means other than sexual contact between a man and a woman. The word, which originally referred to infants produced via the first kind of artificial insemination, has now been used to include infants born via in vitro fertilization, which is the process of fertilizing an egg outside of a woman's body. The word has been the subject of debate and discussion about the morality of reproductive technologies like artificial insemination and in vitro fertilization since its introduction in the media and scientific literature in the 20th century. The scientific community and the general public both recognize that we are capable of manipulating the human embryo based on the evolution of these concepts over time.

XI. GENE EDITING

Genome editing, also known as gene editing, comprises a set of techniques that provide scientists with the capability to modify an organism's DNA. These methods enable the addition, removal, or alteration of genetic material at specific locations within the genome.

Gene editing holds significant promise for preventing and treating human diseases. Currently, it is utilized in animal model cells within research laboratories to gain insights into various diseases. Scientists are actively assessing the safety and efficacy of this approach for human use. Research and clinical trials are exploring its potential applications in a wide range of diseases, including single-gene disorders like cystic fibrosis, hemophilia, and sickle cell anemia, as well as more complex conditions such as cancer, mental illness, heart disease, and HIV infection.

Most alterations introduced through genome editing are confined to somatic cells, which are distinct from germline cells (egg and sperm cells). These changes are limited to specific tissues and do not transfer to subsequent generations. However, modifications made to genes in egg or sperm cells or in the genes of an embryo could be inherited by future generations. The use of germline cell and embryo genome editing raises numerous ethical concerns, including whether it should be permissible to employ this technology to enhance typical human traits, such as height or intelligence. Due to ethical and safety considerations, germline cell and embryo genome editing are currently prohibited in the United States and numerous other countries.

Some Recent Research in Biotechnology

- Researchers have pioneered a groundbreaking three-dimensional (3D) bioprinting technology designed to eradicate cancer cells through the action of immune cells, marking the world's inaugural achievement in this field.
- A multidisciplinary investigation, spearheaded by researchers at the Centro Nacional de Investigaciones Cardiovasculares (CNIC), introduces an innovative approach to evaluating the structural and electrophysiological alterations, referred to as atrial remodeling, occurring within the hearts of patients afflicted with atrial fibrillation, a prevalent type of cardiac arrhythmia.
- Modern plant biotechnology has emerged as a new era in the realm of science and technology, focusing on various aspects such as the synthesis of secondary metabolites, enhancements in valuable plant genetics, germplasm preservation, and the creation of substantial quantities of disease-resistant and novel plant varieties.

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