NAME: ESAN FAITH

DEPARTMENT: PHARMACOLOGY

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COURSE TITLE INTRODUCTION TO BIOTECHNOLOGY

INTRODUCTION

The field of medical biotechnology is experiencing rapid growth in recent years, leading to the development of several innovative techniques for preventing, diagnosing, and treating diseases. Novel methodologies, including [polymerase chain reaction](https://www.sciencedirect.com/topics/medicine-and-dentistry/polymerase-chain-reaction), gene sequencing, [fluorescence in situ hybridization](https://www.sciencedirect.com/topics/medicine-and-dentistry/fluorescence-in-situ-hybridization), microarrays, cell culture, gene silencing using interference RNA, and [genome editing](https://www.sciencedirect.com/topics/medicine-and-dentistry/genome-editing), have significantly contributed towards improving health science, such as the sequencing of the human genome, use of stem cells for [regenerative medicine](https://www.sciencedirect.com/topics/medicine-and-dentistry/regenerative-medicine), tissue engineering, development of antibiotics, and the generation of [monoclonal antibodies](https://www.sciencedirect.com/topics/medicine-and-dentistry/monoclonal-antibody) for therapy. This chapter will summarize and update important techniques used and the products generated using these tools in the field of medical biotechnology. If the current growth rate continues, medical biotechnology will soon become a major pillar of health science.

**THE APPLICATIONS OF MEDICAL BIOTECHNOLOGY IN MEDICINE**

**BIOPHARMACEUTICAL**

Through advanced methods in biotechnology, biopharmaceuticals were produced safely and quickly for treating illnesses. Furthermore, biopharmaceuticals do not contain any chemicals and use targeted organisms to synthesize the medicine successfully. Big molecules of proteins are the typical origin of biopharmaceuticals. When they are inside the human body, they target dangerous and hidden parts of the disease and obliterate them. Today, scientists and researchers are aiming to extend and develop biopharmaceutical medicines which can be used to fight diseases related to heart, hepatitis and cancer.

**PHARMACOGENOMICS**

Pharmacogenomics is the technique that leverages the person’s heredity information to choose the best biotechnological medicine for their illness. This studies the body system’s response to certain medications. To put it simply, this is the combination of advances in pharmaceuticals along with genomics. The end goal of this application is to improve medicines that are specifically targeted to a person in lieu with his genetic makeup to ensure effective treatment of illness. The end goal of this branch of medical science is to effectively produce biotechnological medicines which are placed in the patient’s body in accordance with his genetical makeup.

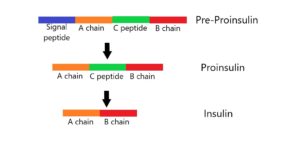
With the use of pharmacogenomics, medical companies can produce medicines that depend on the proteins, compounds, and RNA particles based on the chosen qualities and infections applicable.  Synthesized medicines are almost guaranteed to improve remedial effects, in addition to diminishing harm to other nearby cells. With the knowledge of the person’s hereditary inclinations, specialists can ascertain how well the patient’s body can prepare and process a medication and decide the correct amount of medication doses. As a result, an accurate prescription will be given, and the chance of overdose is mitigated

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**RAPID DEPLOYMENT OF VACCINES**

A global pandemic is a real issue and has always proven its powerful grip on humanity. Through Biotechnology, scientists and researchers can quickly pinpoint precursors or markers that can cause severe illnesses and diseases. As a result, they can synthesize vaccines quickly against any dangerous pandemic sickness. In[a study on vaccines and biotechnology](https://www.ncbi.nlm.nih.gov/pubmed/15380644), researchers found a great decline in illnesses when patients were administered with a vaccine produced through biotechnology.

**1) Genetically Engineered Insulin:** Earlier, [diabetes](https://www.toppr.com/guides/essays/essay-on-diabetes/) was treated using insulin from the pancreas of slaughtered pigs and cattle. Do you think this insulin causes any side-effects in humans? Yes! Insulin from animal sources induces allergies and other unwanted immune reactions in humans. This is why there was a need to isolate human insulin. Is there a way to do this? What if we can use [bacteria](https://www.toppr.com/bytes/humans-and-bacteria/) to produce human insulin? Not only can we grow bacteria in large amounts, but we can also mass-produce human insulin!Insulin consists of two short, polypeptide chains – chain A and B, linked via disulfide bridges. Insulin is produced as a ‘prohormone’ in mammals (including humans). This prohormone has an extra peptide, the **C peptide,**which needs to be removed to give rise to mature insulin.



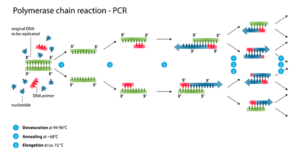
Maturation of Insulin.

The major challenge while generating human insulin is to assemble insulin into its mature form. An American company called ‘Eli Lilly’ overcame this hurdle in 1983. They prepared two DNA sequences that correspond to the A and B chains of human insulin. They then incorporated these sequences into plasmids of *E.* Coli to generate insulin chains. Further, they produced the chains separately, extracted and combined them by creating disulfide bonds to give rise to human insulin.

**2) Gene Therapy:**If a child is born with a genetic defect, is there a way to correct that defect? Yes, there is, with [gene](https://www.toppr.com/guides/biology/the-molecular-basis-of-inheritance/gene-expression/) therapy! Gene therapy is a biotechnology application involving a collection of methods that can correct a gene defect in a child or an embryo. It involves inserting a normal gene into the person’s [cells](https://www.toppr.com/guides/biology/the-fundamental-unit-of-life/structure-of-cell/) or tissues to compensate for the non-functional gene. Let’s understand how this works. In 1990, the first clinical gene therapy was applied to treat a 4-year old girl with a deficiency in the [enzyme](https://www.toppr.com/guides/biology/biomolecules/enzymes/) adenosine deaminase (ADA). This disorder is due to the lack of the gene for ADA, which is an enzyme important for the function of the immune system. Bone marrow transplantation helps cure this disorder in some cases. Enzyme replacement therapy, which involves injecting the patient with functional ADA, is also effective in some cases. However, both these procedures are not completely curative. In gene therapy, [blood](https://www.toppr.com/guides/biology/body-fluids-and-circulation/blood/) lymphocytes of the patient are grown in a culture outside the body. Subsequently, a functional ADA cDNA is incorporated into these lymphocytes and re-introduced into the patient. This alleviates the symptoms of the disorder. However, the patient requires periodic infusions of these genetically-engineered lymphocytes, since these cells are not immortal. A permanent cure for this could be to introduce the gene producing ADA from marrow cells into cells at early embryonic stages of life.

**3) Molecular Diagnosis:** We all know that early diagnosis of a [disease](https://www.toppr.com/guides/biology/human-health-and-diseases/types-of-diseases/) is important to effectively treat the disease. Early detection is not possible using conventional methods like serum and urine analysis. Let’s look at some biotechnology applications that help in early diagnosis of diseases.

i) Polymerase Chain Reaction (PCR):Normally, we can detect a pathogen (bacteria, [virus](https://www.toppr.com/guides/biology/biological-classification/viruses-viroids-and-lichens/) etc.) only when the disease symptoms start to appear. However, by this time, the pathogen concentration in the body is very high! Is there a way to detect pathogens at initial stages of the disease when their concentrations are low? Yes, using a technique called PCR. PCR involves amplification of the nucleic acid in the pathogen allowing us to detect the pathogen at very low concentration. Today, we use PCR routinely to detect HIV in suspected AIDS patients and to detect gene mutations in suspected cancer patients.



Steps in Polymerase Chain Reaction (PCR) [Source: thebalance]

ii) Enzyme-Linked Immunosorbent Assay (ELISA):The basic principle of ELISA is antigen-antibody reactions. ELISA can diagnose infections by detecting the presence of antigens (proteins of the pathogen) in the patient serum or by detecting the antibodies produced against the pathogen.

iii) In Situ Hybridisation: This technique involves tagging a single-stranded DNA or RNA with a radioactive molecule (probe). This then hybridizes with its complementary DNA in a clone of cells. On detection using autoradiography, the clone with the mutated gene will not appear on the photographic film because the probe is not complementary to the mutated gene.

Human Cloning

Many hopes and fears emerged in the human societies since scientists developed a new method for

replication of the sheep called dolly. Biotechnologists transferred genetic content of one somatic cell into one

germ cell that its genetic content was removed. This caused creation of entities very similar to dolly. This

technology has very broad market in livestock proliferation of specific characteristics such high milk or

appropriate meat. However, this issue extends to human cloning and has raised many concerns in different

countries. Producing organisms or organs of the human embryo root cells is related to this topic and involves its

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**HUMAN CLONING**: Many hopes and fears emerged in the human societies since scientists developed a new method for replication of the sheep called dolly. Biotechnologists transferred genetic content of one somatic cell into one germ cell that its genetic content was removed. This caused creation of entities very similar to dolly. This technology has very broad market in livestock proliferation of specific characteristics such high milk or appropriate meat. However, this issue extends to human cloning and has raised many concerns in different countries. Producing organisms or organs of the human embryo root cells is related to this topic and involves its own pros and cons.

**BIOLOGICAL CHIPS:** Bio-chips such as DNAChips are among new and deceptive applications of biotechnology. In one of these applications, scientists could use DNA str strands to produce chips in which information processing speed compared with their very small size is more than conventional chips. Other applications of bio-chips are two cases of DNAChips and DNAMicroarray Information.

**DNA CHIPS:** Biotechnologist in this technology establish 20 to 80 nucleotide DNA fragments with different sequences with a fine arrangement of points (less than 300 microns) on a suitable substrate( Less than 300 microns) (such as nitrocellulose or some metals and plastics). Next, unknown DNA samples with the fixed points are put together to make hybridization reaction conditions. Unknown DNA sequence can be found if hybridization reactions occur between known and unknown sequences of each Oligonucleotides. Therefore, this technique is also used to determine protein expression.

**DNA** **MICROARRAY**:In this technology , cDNA probe with a length of 500 -5000 base on solid appropriate media is consolidated. Then these fixed points are subjected to unknown DNA samples. Both methods applications in diagnostics, Pharmacogenomics and Toxicogenomics are too similar

**CONCLUSIONS**  Today, advances in molecular biology are not comparable to any other era. Development of biotechnology and genetic engineering led to the development of other sciences such as medicine, microbiology, agriculture and livestock. Today, production of DNA vaccines and recombinant vaccines are important steps towards the prevention of vaccine-preventable diseases. In cases where there is a genetic defect in the production of hormones or enzymes, new bio-pharmaceutical methods are very clear and promising. Future of biotechnology and pharmaceutical will be very promising. One can hope that many diseases and genetic defects will be treated