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PHARMACOLOGY

PHA210

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Question : Discuss in details the aspect of medical biotechnology

MEDICAL BIOTECHNOLOGY

Medical biotechnology is a branch of medicine that uses living cells and cell materials to research, and then produce pharmaceutical and diagnosing products. These products help treat and prevent diseases. From the Ebola vaccine to mapping human DNA to agricultural impacts, medial biotechnology is making huge advancements and helping millions of people.

Some of the most recent uses of biological tech is work in genetic testing, drug treatments, and artificial tissue growth. Tissue engineering is a top scientific branch, which is often named as “regenerative medicine” mistakenly, which uses the combination of engineering principles and the knowledge of cell biology and materials sciences to improve or replace the functions of tissues and organs. This field provides a variety of options from repairing the damaged tissues through building new organs for transplant surgeries. Apart from the regenerative medicine, tissue engineering, additional to the use of stem cell culturing and differentiation techniques, is taking the advantage of using biodegradable and biosafe materials such as polyesters and collagen to form versatile structures called “scaffolds.” Recently, by the developments of stem cell technology, it became possible to generate a tissue or an organ from the patient himself/herself without using these materials that pose a great opportunity to tackle the problems we face today, like the cancellation of the transplant. In the future, by means of improvements in tissue engineering industry, it is foreseen to establish their organ banks from the healthy citizens and to test the effects of drugs on tissues and multiorgan systems, which end up with the personalized medicine.

WONDERS OF MEDICAL BIOTECHNOLOGY

1) Genetically Engineered Insulin

Earlier, diabetes was treated using insulin from the pancreas of slaughtered pigs and cattle. And this insulin had its side effect. Insulin from animal sources induces allergies and other unwanted immune reactions in humans. This is why there was a need to isolate 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.

Biotechnology applications was the 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

Gene therapy, or the use of genetic entities after manipulation for disease management, is derived from advances in genetics, molecular biology, clinical medicine, and human genomics. Molecular medicine, the application of molecular biological techniques to disease treatment and diagnosis, is derived from the development of human organ transplantation, pharmacotherapy, and elucidation of the human genome. The promise of gene therapy, permanent reversal or amelioration of disease symptoms without dependence on a long-lasting intake of drugs, has come within reach because of these conceptual and technical advances in molecular biology. The incidents came at a time when technical advances in the manipulation of DNA had led to widespread testing of gene-based therapies.

Gene therapy is generally categorized as either in vivo, in which the gene is delivered

directly into recipient cells in the site of target, or ex vivo, in which the gene of interest is inserted in vitro into a targeted cell population (usually stem cells or fibroblasts) and the cells are delivered to the desired site in vivo. These two gene delivery strategies are usually termed “in vivo gene delivery” and “cell-mediated gene delivery,” respectively. Since the beginning of the first gene therapy (clinical trial), i.e., approximately 25 years ago, the field of human gene therapy has gone through numerous successions of ups and downs. Gene therapy has made a profound impact not only in the treatment of genetic disease such as sickle cell anemia as single gene disorder but also open new vistas in neurological diseases, cardiovascular diseases, and cancer; hence, we have started looking at human diseases as a whole.

In 1990, the first clinical gene therapy was applied to treat a 4-year old girl with a deficiency in the enzyme 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 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 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 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.

Biotechnology applications

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.

4.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.

5. Rapid development 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, researchers found a great decline in illnesses when patients were administered with a vaccine produced through biotechnology.