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**Assignment**

**Questions**: Discuss in details the aspects of medical biotechnology.

**Answer**:

**Medicine Biotechnology**

In medicine, modern biotechnology has many applications in areas such as pharmaceutical drug discoveries and production, pharmacogenomics, and genetic testing (or genetic screening). Pharmacogenomics (a combination of pharmacology and genomics) is the technology that analyses how genetic makeup affects an individual's response to drugs. The Researchers in the field investigate the influence of genetic variation on drug responses in patients by correlating gene expression or single-nucleotide polymorphisms with a drug's efficacy or toxicity. The purpose of pharmacogenomics is to develop rational means to optimize drug therapy, with respect to the patients' genotype, to ensure maximum efficacy with minimal adverse effects. Such approaches promise the advent of "personalized medicine"; in which drugs and drug combinations are optimized for each individual's unique genetic makeup.

Biotechnology has contributed to the discovery and manufacturing of traditional small molecule pharmaceutical drugs as well as drugs that are the product of biotechnology – biopharmaceutics. Modern biotechnology can be used to manufacture existing medicines relatively easily and cheaply. The first genetically engineered products were medicines designed to treat human diseases. To cite one example, in 1978 Genentech developed synthetic humanized insulin by joining its gene with a plasmid vector inserted into the bacterium Escherichia coli. Insulin, widely used for the treatment of diabetes, was previously extracted from the pancreas of abattoir animals (cattle or pigs). The genetically engineered bacteria are able to produce large quantities of synthetic human insulin at relatively low cost. Biotechnology has also enabled emerging therapeutics like gene therapy. The application of biotechnology to basic science (for example through the Human Genome Project) has also dramatically improved our understanding of biology and as our scientific knowledge of normal and disease biology has increased, our ability to develop new medicines to treat previously untreatable diseases has increased as well.

**Genetic testing**

Genetic testing allows the genetic diagnosis of vulnerabilities to inherited diseases, and can also be used to determine a child's parentage (genetic mother and father) or in general a person's ancestry. In addition to studying chromosomes to the level of individual genes, genetic testing in a broader sense includes biochemical tests for the possible presence of genetic diseases, or mutant forms of genes associated with increased risk of developing genetic disorders. Genetic testing identifies changes in chromosomes, genes, or proteins. The field usually leads to the development of new drugs and treatments, novel to the field.

Examples:

* **Vaccines**

Vaccines are chemicals that stimulate the body’s immune system to better fight pathogens when they attack the body. They achieve this by inserting attenuated (weakened) versions of the disease into the body’s bloodstream. This causes the body to react as if it was under attack from the non-attenuated version of the disease. The body combats the weakened pathogens and through the process takes note of the cell structure of the pathogens and has some cell ‘remember’ the disease and store away the information within the body.

When the individual becomes exposed to the actual disease, the body of the individual immediately recognizes it and quickly forms a defence against it since it already has some information on it. This translates to quicker healing and less time being symptomatic. The attenuated disease pathogens are extracted using biotechnological techniques such as growing the antigenic proteins in genetically engineered crops. An example is the development of an anti-lymphoma vaccine using genetically engineered tobacco plants made to exhibit RNA (A similar chemical to DNA) from malignant (actively cancerous) B-cells.

* **Antibiotics**

Strides have been made in the development of antibiotics that combat pathogens for humans. Many plants are grown and genetically engineered to produce the antibodies. The method is more cost effective than using cells or extracting these antibodies from animals as the plants can produce these antibodies in larger quantities.

**Biotechnology Applications in Medicine**

You may have already learnt about Recombinant DNA (rDNA) technology. This biotechnology application is very important in healthcare because it allows for the mass production of safe and more effective medicines. It also prevents undesirable immune responses which are common with medical products from non-human sources. Currently, about 30 recombinant therapeutics have been approved for human use worldwide, and 12 of these are presently being marketed in India. Let’s take a look at some of the applications.

1. **Genetically Engineered Insulin**

Earlier, 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 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 disulphide 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.

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 disulphide bonds to give rise to human insulin.

1. **Gene Therapy**

If a child is born with a genetic defect, is there a way to correct that defect? Yes, there is, with gene 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 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 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.

1. **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.

* **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.

* **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.

* **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.

**Recombinant DNA**

Recombinant DNA (rDNA) molecules are DNA molecules formed by laboratory methods of genetic recombination (such as molecular cloning) to bring together genetic material from multiple sources, creating sequences that would not otherwise be found in the genome. Recombinant DNA is the general name for a piece of DNA that has been created by combining at least two strands. Recombinant DNA is possible because DNA molecules from all organisms share the same chemical structure, and differ only in the nucleotide sequence within that identical overall structure. Recombinant DNA molecules are sometimes called chimeric DNA, because they can be made of material from two different species, like the mythical chimera. R-DNA technology uses palindromic sequences and leads to the production of sticky and blunt ends.

The DNA sequences used in the construction of recombinant DNA molecules can originate from any species. For example, plant DNA may be joined to bacterial DNA, or human DNA may be joined with fungal DNA. In addition, DNA sequences that do not occur anywhere in nature may be created by the chemical synthesis of DNA, and incorporated into recombinant molecules. Using recombinant DNA technology and synthetic DNA, literally any DNA sequence may be created and introduced into any of a very wide range of living organisms. Proteins that can result from the expression of recombinant DNA within living cells are termed recombinant proteins. When recombinant DNA encoding a protein is introduced into a host organism, the recombinant protein is not necessarily produced. Expression of foreign proteins requires the use of specialized expression vectors and often necessitates significant restructuring by foreign coding sequences. Recombinant DNA differs from genetic recombination in that the former results from artificial methods in the test tube, while the latter is a normal biological process that results in the remixing of existing DNA sequences in essentially all organisms.

**Biomedicine or biopharmaceutical**

Biopharmaceuticals are proteins (including antibodies), nucleic acids (DNA, RNA or antiseme and oligonucleotides) used for treatment or diagnostic purposes (in vivo) with a biological source. Human recombinant insulin was the first approved treatment. The greatest biotechnology legacy of the twentieth century was Alexander Fleming’s discovery of penicillin. However, biosynthesis insulin was the first biopharmaceutical material made by recombinant DNA technology in 1982 that entered the market. In the late 1990s, many developments in the field of production and pharmaceutical process occurred including recombinant DNA and hybridomas technologies.

**High Impact List of Articles**

* Summary of Journal of Medical Physics and Applied Sciences

Author(s): Mohamed Emmanuel

Journal of Medical Physics and Applied Sciences, 2020

* The Subspecialty of Medical Toxicology

Author(s): Konstantin Mikhaylovitch B

Journal of Medical Toxicology and Clinical Forensic Medicine, 2020

* Editor’s Note: A World Urging for Medical Help

Author(s): Laura Cercenelli

Journal of Medical Research and Health Education, 2020

* Recent Trends in Biology and Medical

Author(s): Abdelmonem Awad Mustafa Hegaz

Journal of Biology and Medical Research, 2020

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Author(s): Zarishnyak Natalya Vladimirovna, Kulbaisov Amyrzhan Magazhanovich and Vybornova Ekaterina Vladislavovna

Health Science Journal, 2020

* Comparative Analysis of Encryption Techniques for Sharing Data in IoMT Devices

Author(s): M Asad Bilal and Sidra Hameed

American Journal of Computer Science and Information Technology, 2020