First Chapter Lesson-8: Bioinformatics and Genetic Engineering

At the end of this lesson-

- 1. You will be able to explain Bioinformatics.
- 2. You will be able to explain the application area or uses of Bioinformatics.
- 3. You will be able to explain Genetic Engineering.
- 4. You will be able to explain the application area or uses of Genetic Engineering.

Bioinformatics:

Bioinformatics is an interdisciplinary field that develops methods and software tools for understanding biological data, in particular when the data sets are large and complex.

As an interdisciplinary field of science, bioinformatics combines computer science, statistics, mathematics, and engineering to analyze and interpret biological data.

In other words, Bioinformatics is a science of solving biological problem using a mathematical and computational approach.

Various biological analyses result in exponential amounts of biological data and it becomes very hard to analyze them using manual means. This is where Computer Science comes to the rescue. Various computational techniques are used to analyze hunks of biological data more accurately and efficiently by means of automated processes. Hence, bioinformatics can be considered as a field of data science for solving problems in biology and medicine.

In bioinformatics, the data obtained through gene and DNA studies are stored in the database. Subsequently, analyzing these data using computer science, statistics, mathematics and engineering knowledge, various biological problems are solved and new tools are created.

The biological data used in Bioinformatics are-

- DNA
- Gene
- Amino Acid
- Nucleic Acid etc.

Donald Knuth, a computer scientist at Stanford University, first came up with the idea of bioinformatics.

Purpose of bioinformatics:

1. To properly understand biological processes using pattern recognition, data mining, visualization etc. That is, generating knowledge by searching for gene information.

2. Gain knowledge of the effects of genes as a cause of disease.

3. To improve the quality of medicine and to invent new drugs.

Bioinformatics Tools perform three steps:

A bioinformatics tool has the following three main functions in analyzing any biological data in bioinformatics –

1. Determines protein sequence from DNA sequence

2. Determines protein structure from protein sequence

3. Determines protein function from protein structure

Uses of Bioinformatics:

- Microbial Genome
- Molecular Medicine
- Personalized Medicine
- Preventive Medicine
- Gene Therapy
- Comparative studies
- Climate Change studies
- Biotechnology
- Drug Development
- Veterinary Science
- Agriculture

- Bio-weapon development

Bioinformatics is used in the following research areas:

- Sequence alignment
- DNA Analysis
- Gene Finding
- Drug Design
- Drug Invention
- Protein Structure

Some Open-Source Software's used in Bioinformatics:

- Bioconductor
- BioPerl
- BioJS
- Biopython
- BioJava
- BioRuby
- Biclipse
- EMBOSS
- Taverna Workbench
- UGENE
- T Bio
- Orange

Some add-on in Bioinformatics:

- Apache Taverna
- UGENE
- GenoCAD

Genetic Engineering:

Cells are the smallest unit of organism, animal or plant. The center of life of a cell is called the nucleus. Inside the nucleus, there are certain objects called chromosomes. The chromosomes again have a chain-like structure called DNA (Deoxyribo Nucleic Acid). This DNA is divided into many parts. One specific part is called a gene. These genes carry different properties of animals or plants. That is, how the animal or plant develops, the shape of the shape is stored in the DNA sequence of the cell.

Genetic engineering, also called Genetic modification or Genetic manipulation, is the direct manipulation of an organism's genes using biotechnology. It is a set of technologies used to change the genetic makeup of cells, including the transfer of genes within and across species boundaries to produce improved or novel organisms.

In other words, Genetic engineering is a process that alters the genetic structure of an organism by either removing or introducing DNA. Genetic engineering takes the gene directly from one organism and delivers it to the other. This is much faster, can be used to insert any genes from any organism and prevents other undesirable genes from also being added.

An organism that is generated through genetic engineering is considered to be genetically modified (GM) and the resulting entity is a genetically modified organism (GMO).

Process of Genetic Engineering:

Creating a GMO is a multi-step process. They are-

- Genetic engineers must first choose what gene they wish to insert into the organism.
- New DNA is obtained by either isolating and copying the genetic material of interest using recombinant DNA methods or by artificially synthesizing the DNA.
- A construct is usually created and used to insert this DNA into the host organism. As well as inserting genes, the process can be used to remove, or "knock out", genes.

- The new DNA can be inserted randomly, or targeted to a specific part of the genome.

The first recombinant DNA molecule was made by Paul Berg in 1972 by combining DNA from the monkey virus SV40 with the lambda virus.

How does genetic engineering work?

To help explain the process of genetic engineering we have taken the example of insulin, a protein that helps regulate the sugar levels in our blood.

- Normally insulin is produced in the pancreas, but in people with type 1 diabetes there is a problem with insulin production.
- People with diabetes therefore have to inject insulin to control their blood sugar levels.
- Genetic engineering has been used to produce a type of insulin, very similar to our own, from yeast and bacteria like E. Coli.
- This genetically modified insulin, 'Humulin' was licensed for human use in 1982.

Uses of Genetic Engineering:

- To produce insulin
- To produce human growth hormone
- To produce vaccines
- To produce genetically modified food
- To produce genetically modified livestock
- To develop Important tools for natural scientists

Lesson Evaluation-

Knowledge Based Questions:

- a. What is bioinformatics?
- a. What is genetic engineering?

Comprehension Based Questions:

- b. Explain the technology used to produce advanced varieties of crops.
- b. "Diabetes Patients are being benefited by recent trends of Information Technology" – Explain.
- b. Explain the data used in bioinformatics.
- b. "Database is used in bioinformatics" -explain.

Creative Questions:

Read the stem and answer the following questions:

Mr. Mokhles is a fish specialist by profession. He uses new technology to meet the shortage of fish in the country and produces new species of fish.

c) Describe the technology of fish production as mentioned in the stem.

Read the stem and answer the following questions:

Mr. Shafiq researched with litchi in his laboratory in order to keep the tradition of Dinajpur and preserved its results. He has set up a machine at the entrance of the laboratory where if the authorized person keep looking for a particular time can enter.

d) Which technology did Mr. Shafiq use for his research work? Analyze it's application areas.

Read the stem and answer the following questions:

Dr. Khalil is researching with a technology to discover more crop producing rice to meet the country's food shortage. His assistant tries to get information about his research from a computer without his permission.

c) Explain the technology used by Dr. Khalil's research.

Multiple Choice Questions:

1. Which of the following is used in bioinformatics?

a) SQL b) LISP c) CLISP d) PROLOG

2. Which is the feature of bioinformatics?

a) Storing small data b) Combination of biological data

c) Use of nanotechnology d) Technology dependent security

3. The application of computer technology to the management of biological information is-

a) Bioinformatics b) Genetic engineering c) Cryosurgery d) Biometrics

4. What is used for gene finding studies?

a) Bioinformatics b) Genetic engineering c) Cryosurgery d) Biometrics

5. Which technology is used to discover the causes of various complex diseases?

a) Bioinformatics b) Genetic engineering c) Cryosurgery d) Biometrics

6. The things related to Bioinformatics are-

i. Biology ii. Statistics iii. Computer Science

Which one is correct?

a) i & ii b) i & iii c) ii & iii d) i, ii & iii

7. Application areas of Bioinformatics are-

i. Biotechnology ii. Creating germ-weapons iii. Aerospace Research

Which one is correct?

a) i & ii b) i & iii c) ii & iii d) i, ii & iii

8. What is the technique of DNA manipulation of an animal?

a) Bioinformatics b) Genetic engineering c) Nanotechnology d) Biometrics

9. Through Genetic Engineering –

i. New genomes of organisms can be discovered

ii. Insulin can be made commercially

iii. Very easy to identify the person

Which one is correct?

a) i & ii b) i & iii c) ii & iii d) i, ii & iii

10. The steps for recombinant DNA technology are-

i. DNA selection ii. Carrier selection of DNA iii. DNA fragmentation

Which one is correct?

a) i & ii b) i & iii c) ii & iii d) i, ii & iii

11. Which one is application area of genetic engineering?

a) Medical b) Security c) Sport d) Software

12. What is the technique of creating new types of chromosomes?

a) Bioinformatics b) Genetic engineering c) Cryosurgery d) Biometrics

13. Which technology is used in high yielding crop production?

a) Bioinformatics b) Genetic engineering c) Nanotechnology d) Biometrics

14. Who is the father of Genetic engineering?

a) Jack Williamson b) Paul berg c) Stanley Cohen d) Marshal McLuhan

15. Genetic engineering successfully applied in –

i. Industries ii. Medical field iii. the field of agriculture

Which one is correct?

a) i & ii b) i & iii c) ii & iii d) i, ii & iii