42 Biotechnology and its Applications

- **Biotechnology and its application** : Biotechnology is the most exciting and revolutionary science of this century this is one of the applied biological field.
- **Application of Biotechnology :** In general biotechnology has applications in four major industrial areas including (1) Health care (medical) (2) Crop production and agriculture (3) Non-food (industrial) uses of crops and other products (4) Environmental uses.
- **Biotechnological Applications in Agricutture :** There are following three options in order to increase the food production.

  (1) Agro - chemical based agriculture (2) Organic agricalture (3) Genetically engineered Crop based agricalture.
- The world population has topped 6 billion people and is predicted to double in the next 50 years. Ensuring an adequate food supply for this becoming population is going to be a major challenge in the years to come.
- The green revolution succeeded in tripling the food supply but yet it is not enough to feed the growing human population.
- The increased production have not only been due to the use of improved crop varieties but also due to use of agrochemicals like fertilizers and pesticides and pollution can occur.
- Features exibits in genetically modified plants :

  (1) **Pest resistance :** Growing pest resistance plant can help to eliminate the application of chemical pesticides and reduce the cost of bringing a crop to market.

  (2) **Herbicide Tolerance** : Crop plants genetically - engineered to be resistant to very powerful herbicide, could help to prevent environmental damage by reducing the amount of herbicides needed.

  (3) **Disease Resistance** : These are many viruses, fungi and bacteria that cause plant diseases. GM Plants are resistance to these diseases.

  (4) Cold, drought, salt and heat tolerance.

  (5) With enhanced nutritional value of food.
- **Genetically Modified Organisms** : A Genetically modified organism is an organism whose genetic material has been altered using genetic engineering technique.
- **Advantage of GMO method** : The main advantage of utilizing this technique in agriculture is possibility to increase productivity through the use of newer varieties that possess property as resistance to pest.
- **Introduction of specific charatars for pest resistance :**
- Imparting the property of pest resistance through the transfer of gene from *Bacillus thuringiensis* (Bt) into target plant through modern biotech method is presently considered to be one of the most advanced application of biotechnology.
- Bt cotton is a genetically modified crop that contains a foreign gene isolated from *Bacillus thuringinesis*.
- This bacterial gene produces toxic insecticidal crystalline protein destroys boll worms.
- Actually, *Bacillus thuringiensis* produces this toxic protein in an inactive form, but when an insects ingets this inactive protein, it is converted into an active form of toxin due to the alkaline pH of gut which solubilises the crystals.

- This activated toxin binds to the surface of midgut epithelial cells and creates pores that causes death of the insect. The toxin is coded by a gene named cry and hence, toxin is termed an cry protein.

- **Biotechnological Applications in Medicine :**

- Most development in biotechnology originated for their potential applications in health care.

- In medicinal field, biotechnology techniques are used frequently in diagnosing and treating different diseases.

- The field of biotechnology has introduced techniques like gene theropy, recombinant DNA technology and polymerase chain reaction which use genes and DNA molecules to diagnose diseases and insert new and healthy genes in the body which replace the damaged gene or DNA.

(1) Which type of science is biotechnology from centuries ?

(A) Exciting (B) Revolutionary

(C) A and B both (D) Healthy

(2) The world population has topped ..... .

(A) more than 12 billions (B) more than 8 billions

(C) more than 7 billions (D) more than 6 billions

(3) How many times food supply has increased due to green revolution ?

(A) Two times (B) Three times (C) Many times (D) None of the above

(4) The use of which thing is very expensive in developing countries ?

(A) Agriculture based on agrochemicals (B) Organic agriculture

(C) Genetic engineered crop based agriculture (D) None of the above

(5) What is the main advantage of utilizing genetically modified organisms technique ?

(A) Irrigation (B) Pest control (C) In agriculture (D) None of the above

(6) Bt stands for ..... .

(A) Biotechnology (B) *Bacillus thuringiensis*

(C) Biologically trained plant (D) None of the above

(7) Inactive toxin, is converted into toxin form due to

(A) Alkaline pH (B) Enzymes (C) Neutral pH (D) Acidic pH

(8) By which type of gene toxin protein is produced ?

(A) Cry gene (B) Bt gene (C) Cyr gene (D) Toxic gene

(9) Which hormone, regulates sugar metabolism in human ?

(A) Insulin (B) Crystal (C) Albumin (D) Testosterone

Answers : 1 (C), 2 (D), 3 (B), 4 (A), 5 (C), 6 (B), 7 (A), 8 (A), 9 (A)

- **Genetically Engineered Insulin :**

- Insulin, a hormone, regulates sugar metabolism in haman and it is of immense value to diabetics.

- Insulin is produced by the B-cells of islets of langerhans of pancreas.

- **Human Insulins :**

- Human insulin contains 51 amino acids, arranged in two poly peptide chains. The chain A has 21 amino acids while B has 30 amino acids.

- Both are held together by disulfide bonds.

- In 1980 recombinant DNA technology was used to produce human insulin in bacteria (E.Coli) which is called Humulin. Normally insulin is synthesized as proinsulin which has an extra stretch called the C peptide.
- This C peptide is not found in mature insulin.
- In 1983, Eli Lilly company of United states has produced two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of E.Coli to produce insulin chains.
- **Gene-therapy :**
- Gene-therapy is a technique of biotechnology which is to treat and diagnise diseases like cancer, parkinson's disease etc.
- Gene-therapy may be defined in broad general term as introdution of a normal functional gene into cells, in order to replace defective or mutated gene.''
- **Significance of gene-therapy :**

(1) Identification of the gene that play the keyrole in the development of a genetic disorder.

(2) Determination of the role of its product in health and disease.

(3) Isolation and Cloning of gene.

(4) Development of an approach for gene theropy.

- **Types of Gene-therapy**

(1) Germ line gene-therapy :

- In germ line gene theropy, germ cells, i.e sperms or eggs are modified by introduction of functional gene, which are ordinarily integrated into their genomes. Therefore, change due to therapy would be heritable.

(2) Somatic cell gene theropy :

- In somatic cell gene therapy the gene is introduced only in somatic cells, especially of those tissue in which expression of the concerned gene is critical for health. Expression of the introduced gene relieves or eliminate symptoms of the disorder.

Gene therapy treatment :

(1) Exvivo : Exvivo means 'outside the body'. Cells from the patients' blood or bone marrow are removed and grown in the laboratory.

(2) Invivo : Invivo, which means ' inside the body'. No cells are removed from the patient's body.

- **Transgenic Animals :** The dependence of man on animals such as cattle, sheep, poultry, pig and fish for various purposes (milk, meat, eggs, wool etc.) is well known.
- With the advent of modern biotechnology, it is now possible to carry out manipulation at the genetic level to get the desired characteristics in animals.
- **Tranrgenesis / Transgenic animals :** Transgenesis refers to be the phenomenon of introduction of exogenous DNA into the genome of an animal to create and maintain a stable heritable character. The foreign DNA that is introduced is called transgene. And the animal whose genome is altered by adding one or more transgenes is said to be transgenic animals.

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(10) From where insulin is produced ?

(A) α - cells of islets of langerhans of pancreas (B) From liver

(C) β - cells of islets of langerhans of pancreas (D) None of the above

(11) How many amino acids are present in human insulin ?

(A) 51 (B) 49 (C) 90 (D) 61

(12) How many amino acids are present in the polypeptide chain A ?

(A) 25 (B) 22 (C) 29 (D) 21

(13) How many amino acids are present in the polypeptide chain B ?

(A) 50 (B) 19 (C) 30 (D) 25

(14) Change due to which therapy would be heritable ?

(A) Somatic cell gene therapy (B) Exvivo gene therapy

(C) Germ line gene therapy (D) Invivo gene therapy

(16) Transgene means ..... .

(A) Foreign DNA (B) External DNA

(C) Internal DNA (D) Any Gene

(17) Which animal is being developed for use in testing the safety of polio vaccine ?

(A) Mice (B) Rabbit (C) Pig (D) Chick

(18) In which year the first transgenic cow was developed ?

(A) 1997 (B) 1979 (C) 1799 (D) 1977

(19) Which animal is associated with the production of milk for human babies ?

(A) Buffalo (B) Cow (C) Goat (D) Sheep

(20) Which product is useful for human being produced by transgenic cow ?

(A) Milk for human babies (B) Trapa natans (C) Meat (D) Leather

(21) What was the amount of protein per litre in the milk of transgenic cow ?

(A) 2.4 gm (B) 0.25 gm (C) 250 gm (D) 24 gm

Answers : (10-C), (11-A), (12-D), (13-C), (14-C),(15-C), (16-A), (17-A), (18-A), (19-B), (20-A), (21-A)

- **Ethical Issues :**
- Ethics includes 'moral principle' that control or influence a person's behavior. It includes a set of standards by which a community regulates its behaviour and decides as to which activity is legitimate and which is not.
- Bioethics may be viewed as a set of standards that may be used to regulate our activities in relation to the biological world. Now-a-days, biotechnology, particularly recombinant DNA technology, is used for exploitation of the biological world by various ways.
- **Biopatent :**
- Patents for bioscientific researches are called biopatents.
- A patent is granted for :

(1) An invention , including a product

(2) An improvement in an earlier invention

(3) The process of generating product

(4) A concept or design

- **Biopiracy :** When big organization and multinational companies exploit patent biological resources or bioresources of other nations without proper authorization from the countries concern; such exploitation is called biopiracy.
- While developing nations are poor in technology and finacial resources, but quite rich in biodiversity and traditional knowledge related to bioresources.
- By modernizing the methods, they become more prosperous. Thus it is necessary to bring awarness regarding biopiracy and to stop it.
- A plant *Pentadiplandra brazzeana* of west Africa, produces a protein called brazzein.
- **Biosafety :**
- Biosafety is the prevention of large scale loss of biological integrity; focusing both on ecology and human health.

  Recombinant DNA technology enables man to combine DNA sequences from different sources to create functional DNA molecules with novel properties.
- These molecules are expressed in genetically modified organisms (GMO), Which are then used in biomedical, agricultural and environmental areas.

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(22) Biopatents are awarded for ..... .

(A) Specific DNA sequences (B) Strains of micro organisms

(C) The proteins encoded by DNA sequence (D) A, B and C

(23) According to which act biopatent is awarded in India ?

(A) Indian Patent Act (B) Indian Institute of Pharma

(C) Indian Biotech Company (D) None of the above

(24) The awarded duration of biopatent is of ..... .

(A) 5 years (B) 1 year (C) Lifetime (D) 7 years

(25) In which of the folowing plant a brazzein protein is produced ?

(A) *Pentadiplandra brazzeana* (B) *Zamia pygmea*

(C) *Cucurbita pepo* (D) *Datura fastuosa*

(26) Which ethics includes in ethical issues ?

(A) Independancy (B) moral issues (C) A and B both (D) None of the above

(27) When human beings use animals in biotechnology ..... .

(A) It is biothical issue (B) Only exploits animals for the benifit of selfish nature of human

(C) A and B both (D) None of above

(28) A biopatent is granted for ?

(A) An invention ot chemistry (B) Patents granted to a bioresearcher

(C) An astrologist for research in space (D) All of the above

(29) In which year Indian patent Act was introduced in India ?

(A) 1979 (B) 1989 (C) 1970 (D) 1999

(30) The brazzein protein is approximately ..... as sweet as sugar ?

(A) 250 times (B) 2000 times (C) 400 times (D) 300 times

(31) Which disease treatment can be done by brazzein protein ?

(A) Plague (B) Cancer (C) Parkinson's disease (D) Diabetes

(32) From the following country which has obtained a patent for brazzein and fused it in maize ?

(A) India (B) America (C) Canada (D) Australia

(33) Who can have supreme control over, if a single biopatent covers all patents of a plant like Brassica?

(A) Some individual (B) A country (C) institute (D) All of the above

(34) Biopiracy means ..... .

(A) stealing of bioresource without proper authorization.

(B) exploitation of bioresources without authentic permission from country

(C) organization and multinational companies exploit those organisms which can be used to derive commercial benefits

(D) all of the above

Answer : (22- D), (23-A), (24-A), (25-A), (26-B), (27-C), (28-B), (29-C), (30-B), (31-D), (32-B), (33-D), (34-D)

- **A - Statement, R - Reason**

Read the given statements and select the correct option.

(A) Both A and B is correct, R is description of A.

(B) Both A and R is correct, but R ios not description of A.

(C) A is correct, R is wrong.

(D) A is wrong, R is correct.

(35) Statement A : To eliminate the application of chemical pesticides.

Reason B : Pest resistance plant can be grown.

(A) (B) (C) (D)

(36) Statement A : Causes death of insects.

Reason R : It is converted into an active form of toxin due to the alkaline pH of gut which solubilises the crystal protein.

(A) (B) (C) (D)

(37) Statement A : Bacterial gene produces a toxic insecticidal crystalline protein.

Reason R : It provides nutrition to bollworms.

(A) (B) (C) (D)

(38) Statement A : Insulin is one type of enzyme.

Reason R : Insulin regulates sugar metabolism in human.

(A) (B) (C) (D)

(39) Statement A : Human insulin contarins 51 amino acids.

Reason R : The chain A has 30 amino acids, while B has 21 amino acids.

(A) (B) (C) (D)

(40) Statement A : C peptide is not found in mature insulin.

Reason R : Insulin is synthesized as proinsulin.

(A) (B) (C) (D)

(41) Statement A : The foreign DNA is introduced in animals.
Reason R : One can get desired characteristics in animals.
(A) (B) (C) (D)

(42) Statement A : Cells from the patient's blood are removed in Exvivo.
Reason R : The desired gene is delivered to cells in the patient's body.
(A) (B) (C) (D)

(43) Statement A : A plant of west Africa, produces a protein called brazzein. This protein is approximately two thousand times as sweet as sugar.
Reason R : By consuming this protein diabetes increases.
(A) (B) (C) (D)

Answers : (35-A), (36-A), (37-C), (38-D), (39-C), (40-B), (41-A), (42-B), (43-C)

- **True-False (T - F) type questions**

(44) Select the correct option for Bt cotton.
(i) Bt cotton is a gentically modified crop.
(ii) That contains a foreign gene isolated from *Bacillus thuringiensis*.
(iii) *Bacillus thuringiensis* produces this toxic protein in an active form.
(iv) This toxic protein is known as cry protein.
(A) TTTT (B) TTFT (C) TTTF (D) TTFF

(45) Select the correct option for human insulin.
(i) Human insulin contains 51 amino acids.
(ii) The chain A has 30 amino acids.
(iii) The chain B has 21 amino acids.
(iv) Both chains combined by creating peptide bonds to form human insulin.
(A) TTTT (B) TFFT (C) TFFF (D) TFTF

(46) Select the correct option for Ethical issues.
(i) Use of animals in biotechnology causes great suffering to them.
(ii) Introduction of a transgene from one species into another species violates the integrity of species.
(iii) Biotechnology exploits animals only for the benefit of human indicator.
(iv) Biotechnology may pose unforeseen risks to the environment, including risk to biodiversity.
(A) TFTT (B) TFFT (C) TTTF (D) TTTT

(47) Select the correct option for biopiracy.
(i) Africa obtained a patent for germplasm of our basmati rice.
(ii) Biomolecules of many plants are patented in other countries.
(iii) Isolate useful genes and then obtain patent for them.
(iv) Pirate or steal the traditional knowledge and publish the same as a new finding.
(A) TTTT (B) FTTT (C) FTFT (D) FTTF

(48) Select the correct option for risks due to genetically modified plants.
(i) Production of toxic or allergic metabolites.
(ii) Unexpected new susceptibilities to pathogens.

(iii) Transmission of new traits to related sexually compatible weed species.

(iv) The ecosystem may be disturbed by altered reactions.

(A) TTFT (B) TTFF (C) FTTF (D) TTTT

Answers : (44-B), (45-B), (46-D), (47-B), (48-D)

(49)

Column - I	**Column - II**	
(i) Germline gene therapy	(p) Introduction of exogenous DNA into the genome of animals	(A) (i-q) (ii-s) (iii-p) (iv-r)
(ii) Somatic cell gene	(q) The functional gene is incorporated into Genome of germ cells	(B) (i-q) (ii-s) (iii-r) (iv-p)
(iii) Transgenesis	(r) First human insulin was produced	(C) (i-r) (ii-p) (iii-s) (iv-q)
(iv) Eli Lilly	(s) The gene is introduced only in somatic cells, especially of those tissues in which expression of the concerned gene is critical for health.	(D) (i-s) (ii-q) (iii-p) (iv-r)

(50)

Column - I	**Column - II**	
(i) Lepidoptera	(p) Beetles	(A) (i-p) (ii-q) (iii-r) (iv-s)
(ii) Coleoptera	(q) Aphids	(B) (i-q) (ii-s) (iii-p) (iv-r)
(iii) Orthoptera	(r) Bollworms	(C) (i-r) (ii-p) (iii-s) (iv-q)
(iv) Homoptera	(s) Grasshoppers	(D) (i-s) (ii-r) (iii-p) (iv-q)

(51)

Column - I	**Column - II**	
(i) Gene therapy	(p) Pirate the traditional knowledge and publish the same as a new finding	(A) (i-q) (ii-s) (iii-p) (iv-r)
(ii) Bio patent	(q) To extract gene and cloning	(B) (i-r) (ii-q) (iii-s) (iv-p)
(iii) Transgenic animals	(r) Brazzein	(C) (i-q) (ii-r) (iii-p) (iv-s)
(iv) Biopiracy	(s) It was used to test the safety of the polio vaccine	(D) (i-q) (ii-r) (iii-s) (iv-p)

Answers : (49-A), (50-C), (51-D)

(52) Which option is correct for X and Y in this diagram ?

(A) X = C - Peptide Y - disulfied bond

(B) X = B chain of insulin

Y = A chain of insulin

(C) X - A chain of insulin

Y = B chain of insulin

(D) X = disulfied bond

Y = C - peptide

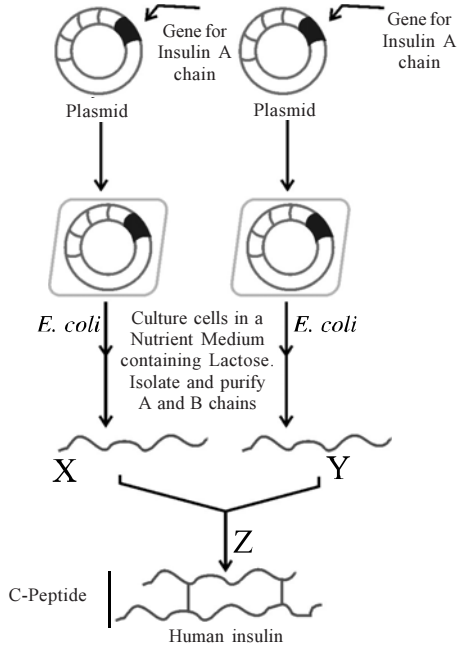
(53) What is the function of Z in given diagram ?

(A) It regulates sugar metabolism in human.

(B) Ioining of chain A and B of insulin.

(C) Synthesis of proinsulin.

(D) Breaking of chain A and B of insulin.



Production of human insulin

Answers : 52 (C), 53 (B)

- **Questions for NEET**

(54) Animal cell culture technique used maximally used these days ..... .

(A) to prepare edible proteins (B) to prepare insulin

(C) for interferon production (D) for vaccine production

(55) Which is the main reactant in elisa test for detection of virus ?

(A) RNAase (B) Alkaline phosphatase (C) Catalase (D) DNA probe

(56) In future 'Golden rice' developed through transgene approach is enriched with ..... .

(A) pest resistance (B) high lysine content

(C) high protein content (D) high vitamin A content

(57) Norman Borlaug is credited for which revolution ?

(A) white revolution (B) Green revolution (C) Yellow revolution (D) Blue revolution

(58) For what Bacillus thuringiensis is used ?

(A) To prepare biofertilizer (B) Biometal technique

(C) Bio mineralization (D) Bio pest - resistance plant

(59) In developing countries for treatment of night blindness useful genetically modified plant ..... .

(A) Tomato (B) Starlink maize (C) Bt soyabean (D) Golden rice

(60) ..... microorganism is useful to transfer foreign DNA into target plant.

(A) Meloidogyne incognita (B) Agrobacterium tumefaciens

(C) Penicillium notatum (D) Trichoderma harzianum

(61) In India genetically modified brinjal is produced for what ?

(A) To make pest resistance (B) To increase life resistance

(C) To increase mineral level (D) Drought resistance

(62) What can be used for production of ethanol in brewery ?

(A) Cornmill (B) Ground gram (C) Soyabean (D) Molasses

(63) The highest numbers of transgenic animals ?

(A) Fish (B) Cow (C) Rat (D) Pig

(64) Why continuous feeding of sugar in medium is needed in fed batch fermentation ?

(A) For production of methane (B) For production of antibiotics

(C) To activate enzymes (D) For dissolution of sewage

(65) By introducing fragments of m-RNA in genetically modified plant, it can be made resistance to ..... .

(A) bollworms (B) aschelminthes

(C) white rust (D) bacterial blight

(66) Find true statements for organic farming ?

(a) Use of genetically modified plant like Bt cotton.

(b) Use of only natural elements like compost.

(c) No use of chemical pesticides and urea.

(d) Production of vegetables having vitamins and minerals.

(A) b, c and d (B) b and c (C) c and d (D) a and b

(67) For development of What Human Genome project was introduce in biology ?

(A) Biotechnology (B) Biomonitoring (C) Bioinformatics (D) Biosystematics

(68) In genetic engineering by which method organisms can be developed ?

(A) Recombinant DNA (B) X - ray diffraction

(C) Heavier isotope labeling (D) Hybridization

Answers : (54-D), (55-B), (56-D), (57-B), (58-D), (59-D), (60-B), (61-A), (62-D), (63-C), (64-C), (65-C), (66- C), (67-C), (68-A)

Applications of Biotechnology

Ethical issues

Biopiracy

- It is exploitation of bioresources of a country by organisations and multinationals for commercial exploitation with or without patent but without any Access and Benefit Sharing Agreement (ABA).
- Some nations are developing laws to prevent such unauthorised exploitation of their bioresources and traditional knowledge.

Biopatent

- It is an official licence to use a particular biological material for commercial exploitation like (i) A strain of microorganism (ii) GM plant animal (iii) DNA sequence (iv) Biotechnological procedure (v) Production process. (vi) Product and (vii) Product application.
- Biopatents are going to give not only increased economic benefits to holders, but will also provide a spurt in research.

Biotechnlogical application in agriculture

- Genetically modified crops (GM crops) or Transgenic plants : GM crops contain and express one or more useful foreign genes or transgenes (e.g. Bt cotton, golden rice, Flaver Savr tomato)
- GM plants have been useful in many ways :
  - Growing GM crops can help to reduce the use of chemical pesticides.
  - GM crops are more tolerant to abiotic stresses (cold, drought, salt, heat etc.).
  - They have helped to reduce post-harvestlosses.
  - Increased efficiency of mineral usage by plants prevents early exhaustion of fertility of soil.
  - GM plants enhance nutritional value of food. e.g., vitamin A enriched rice.
  - Herbicides (weed killers) do not harm the GM crops.
  - Plant biologists are working to create genetically engineered plants having resistance to these deseases.
  - GM plants have been used to create alternative resources to industries in the form of starches, fuels and pharmaceuticals (molecular farming.)

Biotechnological application in medicine

- Recombinant DNA technology is engaged in production of newer and safer therapeutic drugs, called recombinant drugs. These drugs do not induce immunological reactions as some other drugs obtained from nonhuman sources (e.g., insulin from animals).
- A large number of human genes encoding pharmaceutically valuable proteins have been cloned and expressed in microorganisms.
- Gene theraphy is a collection of methods that allows correction of a gene defect that has been diagnosed in a child/embryo. Here genes are inserted into a person's cells and tissues to treat a disease.

Production of transgenic animals

- These are animals which have been genetically modified by incorporating foreign and other specific genes through recombinant DNA technology. A number of animals have been genetically modified,e.g., rats, rabbits, pigs, sheep, cows, fish. 95% of them are transgenic mice.
- Some of the important uses of transgenic animals are as follows :
  - Transgenic animals enable scientists to study the working of genes, their regulation, effect on normal body functions and development.
  - Transgenic animals are used to study how genes take part in development of diseases.
  - The important bilogical products being harvested by this method are protein α-1 antitrypsin for treating emphysema, tissue, plasminogen activator (goat), blood clotting factors VIII and IX (sheep) and loctoferrin (cow).
  - Transgenic animals are the best for checking the safety of vaccines before their use in humans.
  - Trasgenic animals are used in studying the effect of toxic chemicals.

Biotechnological application in industry

Mostly microorganisms are used in many industries to produce alcohol, enzymes, vaccines, vitamins, antibiotics, organic acids etc.