Science and Technology

for

Civil Services Examinations

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Science and Technology for Civil Services Examinations

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Preface

If you ever happen to be walking down the streets of places where preparation for Civil Services is done, it will not be uncommon for you to come across or make the acquaintance of 'several' starry eyed yet completely committed IAS aspirants. Yet, 'several' would be an understatement given the number that runs into lakhs! But when we say committed, we mean it; these young men and women are ready to sacrifice almost all their youthful follows including sleep, comfort and even a semblance of a normal life to achieve one goal—IAS!

Sadly, this dream remains a distant one for a large majority of these aspirants in spite of the endless hours of study and sleep forsaken nights. When we tried to unravel WHY, the responses were almost synchronous:

"The subject was so vast that there was too much to cover and I could never complete it."

"I read so much but could not retain it."

"I studied something but was quizzed on something else in the exam."

"I kept reading but did not attempt to solve the past year papers or give a mock exam."

"Subscribing to several sources of information/preparation such as a coaching class, the internet and books was futile; after all there are only 24 hours in a day."

"My almirah was full of too many books,but I could barely complete a few."

And while the candid answers stated above clearly gave us a challenging problem—we did not attempt to solve it. We instead focused on a holistic solution—the synchronizing of effort i.e. Learning and Positive Results!

It is with this aim that we—PrepMate collaborated with Cengage India—are continuously striving to develop a comprehensive learning model that is a combination of online and offline so as to effectively address the issues that most aspirants grapple with.

About the Online–Offline Learning Model

The learning model initiates the process with a series of books targeted at cracking the UPSC exam. The books stand apart from others available because of the following unique features:

- We use a conceptual approach, simple language, explain concepts with diagrams, cite sufficient examples, pose pertinent questions in a reader friendly format—to ensure that the contents of these books can be read and assimilated in a time-bound manner.
- The content is specially designed taking into account the trend in UPSC exams in recent years. We have also included the previous years' questions (with solutions) after every chapter.

- The Practice Questions at the end of each chapter are exhaustive to provide sufficient preparation to crack the exams.
- We have tried to encapsulate all that is required to be learnt for a particular subject into a single book.

Usually, an aspirant purchases a book, but never gets a chance to contact the authors. We believe that the contact among aspirants and authors is important for learning and motivation of the aspirants. That is precisely why we have developed an application and a web portal to answer your queries and provide you with continuous support during your preparation.

It is through this online system that we provide the following services:

1. Videos covering important and difficult topics
2. Daily prelims quiz
3. Assistance in interview preparation
4. Regular updates
5. Daily current affairs
6. Monthly current affairs magazine
7. Radio news analysis
8. Educational videos
9. Previous years' papers and solutions
10. Free study materials

Looking forward to being your partner in the journey towards achieving your dream!

In case you have any specific queries or constructive feedback you can always share the same with us via e-mail at info@prepmate.in.

PrepMate

Acknowledgements

"We cannot accomplish all that we want to do without working together"

The complete UPSC learning module by Prepmate has been the culmination of more than a year of ideation and brain storming with a lot of people. It is only natural that we should gratefully acknowledge their valuable contribution sincerely. Nirmal Singla, Ramnik Jindal, Sharat Gupta, Subhash Singla and Vijay Singla—thank you for your continuous support and motivation.

We would also like to thank Maninder Mann, Rajinder Paul Singla and Sundeep Singh Garha who helped us in first conceiving and later developing the synergistic online–offline model of the project—without you we would be missing our competitive edge.

Implementation of strategy can more often than not prove challenging and the development of the online module did prove to be tougher than we had envisaged. But our technical team was focused on enabling our dream and delivering the best and they surely did. With a specific mention to the testing of both the website and the application,we would like to thank Parth, Tanvir and Surabhi who did their job patiently and effectively in spite of the road blocks.

Our videos and books could not have been possible without the help of our graphics design team—Sandeep, Manjeet, Sukhjinder, Roshni and Uday toiled endlessly to ensure the best designed audio-visuals.

It is an understatement to state that the sourcing and reviewing of existing content and the generation of missing content was the most crucial part of this project and the backbone of our Learning Module. This would just not have been possible without our team of content contributors: Isha Gupta, Shelly Jindal, Gurdeep, Surabhi, Shantnu, Tanvir, Anmol, Kriti, Tanya, Sahil, Suraj and Dilshad, who left no stone unturned in their pursuit of excellence—your pivotal contributions are gratefully acknowledged.

We would like to extend a special thanks to our staff members Geeta, Jitender, Manoj and Pinki, who helped us in the most laborious job i.e. typing through the several manuscripts of our books—your contribution is sincerely appreciated.

It is imperative that we thank Isha Gupta, Shelly Jindal, Anjum Diwan, Rajesh Goel, Shikha Sharma and Ravinder Indoura, for their critical yet constructive feedback that identified and subsequently rectified the errors that crept in during the development process. We will never be able to thank them enough for this—you fortified the very foundation of our model.

We sincerely acknowledge the initiatives and support from the entire editorial team of Cengage India in the process of publishing this book.

PrepMate

List of Videos

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3.	Nuclear Fusion Research
4.	Satellite Orbit
5.	Fracking
6.	Electromagnetic Spectrum
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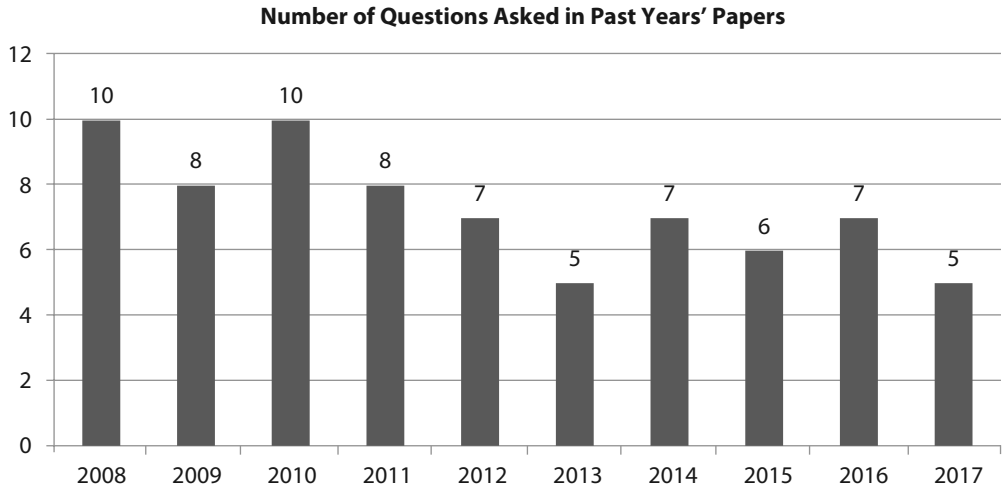
8.	Nanotechnology
9.	Large Hadron Collider
10.	Internet of Things

Chapter-wise Break Up of Previous Year's Questions (Prelims)

Topic	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	Total
Biotechnology	02		01	01	02	03	01	02			12
Nuclear Research		01				01	01			01	04
Space Research		02	01	01			02	02	02	04	14
Defence				01					02	02	05
Sources of Energy		01	01	02	02	01	01	02	01		11
Laser							01				01
Electromagnetic Radiation						01		02	02	02	07
Superconductors											00
Nanotechnology			01	01						01	03
Advancement in Fundamental Physics	02		01		01	01		01			06
Information Technology		01					01				02
Advances in Information Technology		01									01
Communication Technology		01	01				01	01	01		05
Lighting Systems	01										01
Miscellaneous				01							01
Total	**05**	**07**	**06**	**07**	**05**	**07**	**08**	**10**	**08**	**10**	**73**


Number of Questions Asked in Past Years' Papers
12
10
8
6
4
2
0
10
8
10
8
7
5
7
6
7
5
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

Chapter 1 BIOTECHNOLOGY

1 BIOTECHNOLOGY

The word 'biotechnology' is made up of two words: 'bio' and 'technology'. 'Bio' means life and 'technology' means application or harnessing of science for a specific purpose. Therefore, the term 'biotechnology' refers to modification or use of any living organism for any useful purpose.

The term 'biotechnology' is largely believed to have been coined in 1919 by the Hungarian engineer, Károly Ereky. In the late twentieth and early twenty-first centuries, biotechnology has expanded to include new and diverse sciences which we will discuss in this chapter.

2 APPLICATIONS OF BIOTECHNOLOGY

Green Biotechnology

The use of biotechnology in the field of agriculture is called green biotechnology. One of the important applications under green biotechnology is the development of transgenic plants.

What are transgenic plants? In a transgenic crop plant, one or more genes are artificially inserted instead of the plant acquiring such genes through pollination. The inserted gene sequence (transgene) may come either from another unrelated plant or from a completely different species. Plants containing transgenes are often called genetically modified (GM)crops.

For instance, *Bacillus thuringiensis* (Bt) cotton is a transgenic crop in which the 'Cry1Ac' gene of Bt is introduced to make the crop pest-resistant. After the introduction of this gene, the cotton crop starts producing its own pesticide. The Bt trait has been believed to save the cotton plant from the pest, which is popularly known as 'ball worm'.

Bacillus thuringiensis (Bt) is a soil-dwelling bacterium, commonly used as a biological pesticide. It also occurs naturally in the gut of moths and butterflies, on leaf surfaces, etc. It is deliberately used in flour mills and in grain-storage facilities.

Why should we make transgenic crop plants? A plant breeder tries to accumulate a combination of genes in a crop plant so as to make it useful and more productive as far as possible.

Desirable genes may provide the following features:

1. **Increased crop production:** Transgenic plants, which have been developed to produce higher yields, are tolerant to diseases, drought, etc., Such crop attributes have facilitated increased crop production.
2. **Improved nutritional value:** Transgenic plants with higher nutritional value have been produced. For instance, golden rice is a transgenic variety of rice, with genes for the synthesis of beta-carotene (β-carotene) taken from daffodil plant and inserted into rice. The β-carotene is converted into vitamin A. Thus, golden rice helps in preventing nutritional blindness in people, which occurs due to the deficiency of vitamin A, and is also responsible for the normal functioning of the immune system. The golden rice is called so because the rice grain is pale yellow in colour, instead of pearly white. The colour is due to the presence of β-carotene.
3. **Increased shelf life:** Transgenic plants have been developed with longer shelf life, which makes storage and transportation of produce easier.
4. **Environmental benefits:** Transgenic varieties rely on reduced consumption of pesticides. Consequently, there is less pesticide residues in foods, reduction of pesticide leaching into groundwater, and minimization of the farm worker's exposure to hazardous products.

Comparison with traditional plant breeding Traditional plant breeding has been limited to artificially crossing plants within the same species or with closely related species to bring different genes together through selective or mutation breeding techniques. For example, a gene for protein in soya bean could not be transferred to a completely different crop such as wheat using traditional techniques.

Transgenic technology enables plant breeders to bring the useful genes together in one plant from a wide range of living sources. Thus, it expands the possibilities beyond the limitations imposed by traditional cross-pollination and selection techniques.

How are transgenic plants developed? Transgenic plants are the plants that have been genetically engineered, a breeding approach that uses recombinant DNA techniques to create plants with desired characteristics. Genetic engineering is the process by which scientists modify the genome (the complete set of genes or genetic material present in a cell or organism) of an organism. Creation of genetically modified organisms requires recombinant DNA.

This technology provides the means for identifying and isolating the genes controlling specific characteristics in one kind of organism, and for moving copies of those genes into another different organism, which will also have those characteristics. This powerful tool enables the plant breeders to generate more useful and productive crop and animal varieties containing new combinations of genes.

In other words, transgenic plants are obtained through recombinant DNA technology or genetic engineering. The recombinant DNA technology is a technology through which a foreign gene of an organism is inserted into a host organism to produce desired qualities in the host organism. Such a foreign gene may be acquired even from an organism which is unrelated to the host organism.

Red Biotechnology

The use of biotechnology in the field of medicine is called red biotechnology. Red biotechnology is used in the following medical processes:

1. **Gene therapy:** It is a subdivision of red biotechnology that deals with the diagnosis and treatment of genetic diseases and other diseases which are related to genetic makeup of an individual. Modern life science considers important role of genetic makeup in diseases even associated with heart or cancer. In gene therapy, the treatment revolves around the manipulation or replacement of defective genes. It may also involve insertion of missing genes.
2. **Pharmacogenomics:** This field is a combination of genetics and pharmaceuticals. Pharmacogenomics analyses how a genetic makeup affects an individual's response to drugs. It deals with the influence of genetic variation of drug response in patients by correlating gene expression with the efficacy or toxicity of a drug.

   Pharmacogenomics offers new possibilities in the design and production of drugs and how they can be adapted to each individual and their genetic makeup. Specifically, applications in pharmacogenomics have resulted in the development of custom drugs, accurate dosages for different individuals, etc.
3. **Genetic testing (or genetic screening):** Genetic testing allows for the diagnosis of genetic vulnerabilities leading 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.

   Genetic testing, in a broader sense, includes biochemical tests for the possible presence of genetic diseases or changes that are associated with inherited disorders, or mutant forms of genes associated with increased risk of developing genetic disorders. Since genetic testing revelations may lead to psychological problems, genetic testing is often accompanied by genetic counselling.
4. **Drug administration:** Biotechnology has contributed to the discovery and manufacturing of pharmaceutical drugs as well as drugs that are the product of biotechnology, which are called biopharmaceutics.

   Biopharmaceutics examines the interrelationship of the physical/chemical properties of the drug, the dosage form (drug product) and the manner of drug administration on the rate and extent of drug absorption. Thus, the field of biopharmaceutics has helped in enhancing the therapeutic effect of a drug.

   Biotechnology has also helped in field of pharmacokinetics. It is described as what the body does to a drug, refers to the movement of drug into, through, and out of the body—the time course from its absorption to excretion.
5. **Virotherapy:** It is a medical treatment that uses biotechnology to convert viruses into therapeutic agents. The viruses are genetically modified to treat diseases. There are three main branches of virotherapy: anti-cancer oncolytic viruses, viral vectors for gene therapy and viral immunotherapy.

Can Biotechnology Control Dengue and Chikungunya?

Trials are underway to develop transgenic *Aedes aegypti* variety in Jalna, Maharashtra which will help in controlling dengue and chikungunya.

How Will This New Variety Reduce Disease?

Aedes aegypti vector mosquitoes, responsible for spreading dengue and chikungunya among other diseases, are engineered through advanced biotechnology to be self-limiting—in other words, genetically modified so that their offspring will die.

Why Are Transgenic Mosquitoes Certain to Work?

The 'friendly Aedes' (modified *Aedes aegypti*) has already been trademarked by Oxitec (the research unit of Oxford University). These are transgenic male mosquitoes with a self-limiting gene inserted through advanced genetics. Banking upon the male's natural instinct to mate with a wild female, the OX513A strain is inherited by the offspring, causing the larvae to die before they mature to become adult mosquitoes.

White Biotechnology

The use of biotechnology in industry is regarded as white biotechnology. It helps to improve industrial processes and create new industrial products.

The uses of white biotechnology are mentioned below:

1. Biotechnology is used to develop microorganisms which can increase the rate of fermentation of organic matter in order to convert it into alcohol, acids and biomass.
2. It is used to enhance oil recovery from its well. Genetically modified organisms by consuming dense hydrocarbons can reduce the surface tension of the oil to a greater extent and hence facilitate easy recovery of oil.
3. It is used to produce microorganisms which can act as preservatives for perishable products.
4. It is used to produce biofuels which are a renewable source of energy.

Use of Biological Processes for Extraction of Natural Resources

The following biological processes can be used for the extraction of natural resources:

1. **Biosorption:** It is a property of certain types of inactive, dead, microbial biomass to bind and concentrate heavy metals from even very dilute aqueous solutions.

2. **Biomining:** It is an approach for the extraction of desired minerals from ores with the help of living organisms.

   Biomining can be undertaken through microbes (microbial mining) or plants (phytomining).

   Microorganisms are used to leach out the minerals, rather than the traditional methods of extreme heat or toxic chemicals, which have a deleterious effect on the environment.

   Phytomining is an approach in which mining is done with the help of plants. For instance, some plants absorb copper compounds through their roots. As a result, copper compounds remain concentrated in their roots. The plants can be burned to produce an ash that contains copper.

Blue Biotechnology

Blue biotechnology deals with aquatic environment (along with marine organisms) to generate new sources of energy, develop new drugs, extract useful resources or develop new varieties of marine organisms.

Uses of blue biotechnology Biotechnology can be used to develop microorganisms to clean waterbodies. For instance, oil spills can occur both over land as well as over waterbodies. Oil spills over waterbodies are more dangerous as the oil layer prevents the penetration of sunlight, leading to reduction of photosynthesis activity. Consequently, availability of oxygen in the waterbodies is reduced, leading to the death of marine animals.

Oil zapper is a mixture of five types of bacteria which feed on hydrocarbon compounds present in the crude oil. The hazardous hydrocarbon waste generated by oil refineries is known as oil sludge.

Oil zapper converts hydrocarbons into CO_2 and H_2O. Oil zapping bacteria are immobilised and packed into polythene bags. The shelf-life of oil zapper is three months. Oil zapper is used to clean oil spills.

Biotechnology can create transgenic aquatic organisms with desirable features. Transgenic aquatic organisms are the ones in which a foreign gene is added to the organisms to produce the desired qualities in them.

Uses of Biotechnology in Environment

Bioremediation

It refers to the cleaning of environment with the help of living organisms. Living organisms range from microorganisms to different species of plants. For example, bacteria help in the decomposition of organic waste and certain plant species such as mustard helps in the absorption of poisonous elements such as selenium.

Bioremediation usually takes a longer time period. However, bioremediation effectively discriminates between pollutants and the required nutrients.

Strategies of bioremediation are mentioned below:

In situ bioremediation techniques It refers to the treatment of waste at its site. These techniques not only assist in the degradation of adsorbed fuel residuals, but also assist in the degradation of volatile organic compounds. In situ bioremediation techniques include biosparging, bioventing, bioaugmentation and bioculture.

1. **Biosparging:** It is an in situ remediation technology that uses indigenous microorganisms to biodegrade organic constituents in the saturated zone. In biosparging, air (or oxygen) and nutrients are injected at high pressure to increase the biological activity of the indigenous microorganisms and to enhance their decomposition activity.
2. **Bioventing:** It is an in situ remediation technology that uses microorganisms to biodegrade organic constituents adsorbed in soils in the unsaturated zone. Bioventing enhances the activity of indigenous bacteria and simulates the natural in situ biodegradation of hydrocarbons in the soil by inducing air or oxygen flow at low pressure into the unsaturated zone and, if necessary, by adding nutrients. In conventional bioventing systems, oxygen is delivered by an electric blower to subsurface wells.

Saturated zone requires injection of air and nutrients at high pressure and unsaturated zone requires injection of air and nutrients at low pressure.

3. **Bioaugmentation:** In this technology, the microorganisms are imported to the contaminated site to carry out degradation of organic waste. For instance, oil zapper (explained earlier).
4. **Bioculture:** It is a bacterial formulation to improve waste degradation in septic tanks and eliminate odours due to organic buildup. Bioculture refers to the use of blend of bacteria that collectively produce enzymes for the degradation of fats, oils, proteins, starch and carbohydrates.

Ex Situ bioremediation techniques Ex situ refers to the transfer of contaminated material for treatment to some other site. Ex situ bioremediation techniques include land farming and biopile.

1. **Land farming:** In this technique, the contaminated soil is spread over a prepared bed. The soil is periodically tilled to stimulate the growth of microorganisms for degradation of organic waste.
2. **Biopile:** It is a hybrid of land farming and composting. Excavated soils are spread over a prepared bed, formed into compost piles and enclosed for treatment.

Moisture, heat, nutrients, oxygen, and pH are controlled to enhance biodegradation. An irrigation/ nutrient system is used to pass air and nutrients through the soil. Soil piles can be up to the height of 20 feet. They may be covered with plastic to control runoff, evaporation and to promote solar heating.

Treatment time is typically three to six months, after which the excavated material is either returned to its original location or disposed off.

The treatment area is generally covered or contained with an impermeable lining to minimise the risk of contaminants leaching into the uncontaminated soil.

Bioremediation Techniques

1. **Phytoremediation:** It means the use of plants to remove contaminants from soil and water. Neem plant is used for phytoremediation as it absorbs poisonous elements and reduces the growth of harmful microorganisms.
2. **Phytoextraction:** It is a subprocess of phytoremediation in which plants remove dangerous elements or compounds from soil or water, mostly heavy metals, metals that have a high density and are toxic to organisms even at relatively low concentrations.
3. **Mycoremediation:** It involves the use of fungus such as *mycelia* to decontaminate an area. *Mycorrhiza* is another type of fungus which is used for bioremediation. It also has other important uses in agriculture.

   '*Mycor*'–'*rhiza*' literally means 'fungus'–'root'. It exists in mutually beneficial relationship with plant roots. These fungi develop on plant roots and extend far into the soil. Thereafter, these fungi act as extensions of root systems and are in fact more effective in nutrient and water absorption than the roots themselves. Mycorrhiza also protects plants against pathogens and toxic substances present in the soil. The fungus also facilitates restoration and helps in revegetation of disturbed mined lands.

What Is Synthetic Biology?

It is an emerging science through which new life forms can potentially be made in labs and existing life forms, such as bacteria and other microbes, are altered to produce specific proteins or chemically useful products.

Possible Benefits of Synthetic Biology

Synthetic biology in microbial systems holds promise for the production of drugs, vaccines, fuel components and other chemicals. Microorganisms have also been constructed to act as sensors that can detect a toxin in vitro (outside a living organism) or in vivo (inside a living organism).

3 DRAWBACKS OF BIOTECHNOLOGY

1. Biotechnology can be used to develop Weapons of Mass Destruction (WMD). Biological weapons of mass destruction are cheap and easy to build. Moreover, these weapons have devastating effect only on living organisms and does not affect infrastructure.
2. Biotechnology can bring back certain extinct forms of life which may lead to some unpredictable and harmful consequences. For instance, Smallpox virus can be regenerated and left in the environment to infect people.

3. Biotechnology may have a negative effect on biodiversity. At present, few plant and animal species are focus of research leading to ignorance of other species. The focus on few species may lead to their growth and can have a negative effect (even extinction) on remaining species.
4. Biotechnology is used to develop plant varieties with terminator genes. A terminator gene in a genetically modified crop plant stops the plant from releasing fertile seed. Hence, the farmer is again required to purchase the seeds in the next cropping season. The practice of incorporating terminator gene trait in some seed varieties is adopted by multinational companies (MNCs) to enhance their sale of seeds. This terminator trait may cross-pollinate with local varieties and may affect the continuity of agriculture.

4 CLONING

It is a process of asexual reproduction in which the offspring or the progeny is an exact replica of the single parent donor who has contributed the genetic material. Cloning is a process, where each cell is equipped with genetic information of an organism, which has the ability to develop into full organism.

In contrast, in sexual reproduction, the progeny inherits genetic material in equal amount from both the parents.

Cloning in animals is used to produce duplicates of animals. First successfully cloned animal was a sheep called Dolly in the year 1997 at Roslin Institute of Technology, Scotland. Since then, a large number of animals have been cloned.

The following are India's achievements in animal cloning:

1. **Samrupa:** In 2009, the world's first cloned buffalo calf, named Samrupa, was developed by National Dairy Research Institute (NDRI) in Karnal, Haryana. But unlike Dolly, the first mammal cloned 13 years ago, who lived for seven years, Samrupa succumbed to a lung infection just five days after it was born.
2. **Garima:** It was the world's second cloned buffalo at NDRI in Karnal, Haryana. It was developed in 2009 and survived for more than two years. It died because of heart failure in 2011.
3. **Cirb Gaurav:** In 2016, the scientists at the Central Institute for Research on Buffaloes (CIRB) in Hisar, Haryana, cloned a buffalo offspring named 'Cirb Gaurav'.

Human Cloning

The process of creating a genetically identical copy of a human being, human cell or human tissue is called human cloning.

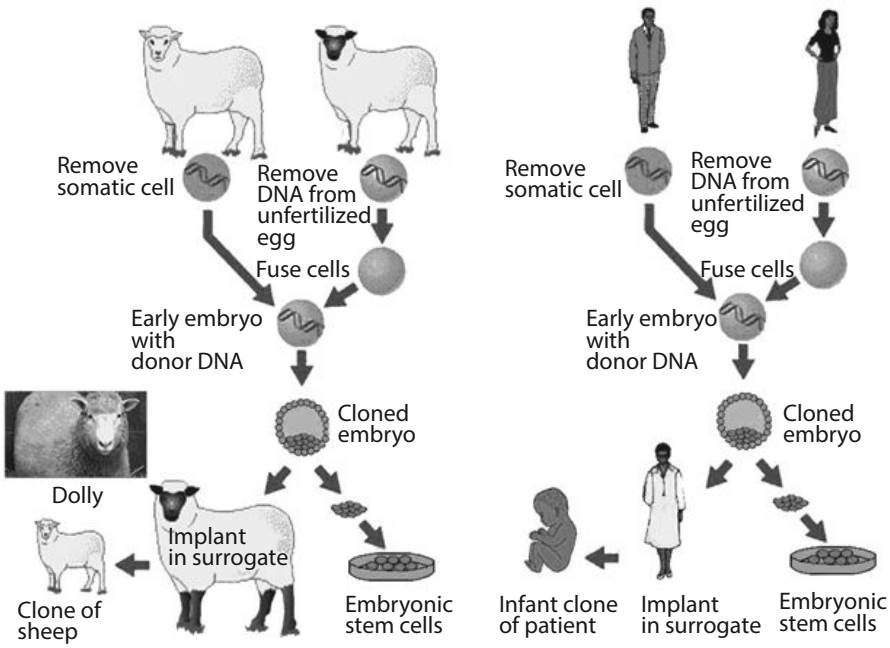
Process of Cloning

Human cloning is performed by somatic cell (any cell in the body other than sperm and egg, the two types of reproductive cells) nucleus transfer to an enucleated egg (an egg cell whose nucleus has been removed). The egg so obtained is thereafter, stimulated by electric shock and chemicals to initiate division. Within a week, this single cell becomes a ball of mass having around 150 unspecialised cells.

This stage of development is called 'blastocyst'. The blastocyst is inserted into the uterus of a surrogate mother to complete the process of embryonic development.

There are two types of cloning: reproductive and therapeutic. The difference between the two is listed below:

1. In reproductive cloning, the newly created embryo is placed back into the uterus, where it can develop into an individual. Reproductive cloning is the production of a genetic duplicate of an existing organism. A human clone would be a genetic copy of an existing person.
2. Therapeutic cloning involves the replication of human embryos in order to harvest stem cells for medical uses. In therapeutic cloning, an embryo is created in a similar manner, but the resulting 'cloned' cells are stored in the lab; they are not implanted into a female's uterus. We will learn about the stem cells later in this chapter.



Concerns over Reproductive Human Cloning

Reproductive human cloning is opposed on various ethical grounds.

1. It may undermine society's respect for human life. It may happen that clones are treated as secondary race or even as slaves.
2. It may affect the social institutions such as marriage and family. Single parent may go for reproductive cloning. Thus, the institution of marriage may be affected.

Children born out of reproductive cloning may be treated secondary in the family. A cloned son of a man would be his identical twin. This would create a set of very complicated family relations. Thus, the institution of family may be affected.

3. Reproductive Cloning (RC) may create a global security concern. Nations or even terrorist organizations may create cloned armies.
4. The RC may emphasize on infusing desirable trait in clones. This may promote the concept of 'designer babies', babies who are genetically engineered to exhibit desirable characteristics.
5. Experiments and research on cloning require working on embryos. This is opposed because according to some religious organizations, life begins at conception.

How Is RC Different from Surrogacy?

1. **Process:** In case of cloning, a somatic cell is taken from a donor and is used to create an embryo. This child is born of a single parent and carries his/her DNA only.

   In an In Vitro Fertilization (IVF) or test tube baby, an egg fertilized by a sperm (creating a zygote) is transferred into the uterus. It creates a progeny similar to normal conception. The child carries the DNA of both his/her parents.
2. **Uniqueness of progeny:** Biologically, a child from IVF is a unique human (unless he/she has an identical twin), while a cloned child is genetically identical to his/her parents.
3. **Lifespan:** Shortened lifespan has been reported in many cases of animal cloning. The progeny born out of IVF leads a normal life.
4. **Ethical issues:** The ethical issues with IVF are not questioned as much as RC. Both IVF and RC help infertile couples and same sex couples with their parenting rights.

   This in turn has led to commercialization of IVF and creation of 'contract mothers'. Many conservatives also believe that it is a commodification of children, where the social perception of motherhood and fatherhood changes and turns the baby into a commodity.

5 STEM CELLS

Stem cells are the raw materials for other body cells. They are considered raw materials, because all other cells with specialised functions are generated from these cells.

In other words, stem cells are unspecialised cells which have not yet developed into mature, specialised cells. These cells have the ability to develop into different, specialised body cells.

Stem cells have the following two important properties:

1. **Ability of self-renewal:** The ability of stem cells to go through numerous cycles of cell division while maintaining the undifferentiated state is called self-renewal.

   Under the right conditions in the body or a laboratory, stem cells divide to form more cells called daughter cells.

These daughter cells either become new stem cells (self-renewal) or become specialised cells (differentiation) with a more specific function. No other cell in the body has the natural ability to generate new cell types.

2. **Ability to specialise:** The stem cells have the capacity to differentiate into specialised cell types. They have the ability to specialise into various body cells types such as blood cells, brain cells, heart muscle or bone.

Sources of Stem Cells

Stem cells are obtained from the following various sources:

1. **Embryonic stem cells:** These stem cells come from embryos, three to five days after conception. At this stage, an embryo is called a blastocyst and has around 150 cells.

   These stem cells are pluripotent stem cells, meaning they can divide into more stem cells or can become any type of cell in the body. Thus, these stem cells can be used to regenerate or repair diseased tissues and organs.

2. **Adult stem cells:** These stem cells are found in small numbers in most adult tissues, such as bone marrow or fat. Compared to embryonic stem cells, adult stem cells have a limited ability to specialise into various cells of the body.

   For instance, bone marrow stem cells may be able to create bone or heart muscle cells, but not nerve cells. The research involving use of adult stem cells is undergoing clinical trials to test its usefulness and safety in people. For example, adult stem cells are currently being tested in people with neurological or heart disease.

   Scientists have also successfully transformed regular adult cells into stem cells using genetic reprogramming. By altering the genes in the adult cells, researchers can reprogramme the cells to act similarly as embryonic stem cells. These stem cells are called induced pluripotent stem cells.

   However, researchers are yet to know if these reprogrammed cells will cause adverse effects in humans.

3. **Perinatal stem cells:** Perinatal means relating to time, usually a number of weeks, immediately before and after birth. Researchers have discovered stem cells in amniotic fluid in addition to umbilical cord blood stem cells. These stem cells also have the ability to change into specialised cells. Clinical trials are undertaken to understand the potential of amniotic fluid stem cells.

Totipotent, Pluripotent and Multipotent Cells

Totipotent cells can be specialised into all cell types in a body with the addition of extra-embryonic or placental cells. Embryonic cells within the first two cell divisions after fertilization are the only cells that are totipotent.

Pluripotent cells can be specialised into all the cell types that make up the body; embryonic stem cells are considered pluripotent.

Multipotent cells can be developed into more than one cell type, but their ability to specialise is more limited than pluripotent cells. Adult stem cells and umbilical cord blood stem cells are considered multipotent.

Uses of Stem Cells

Stem cells have the following applications:

1. **Increased understanding of how diseases occur:** By watching stem cells mature into cells in bones, heart muscles, nerves and other organs and tissue, researchers and doctors may better understand how diseases and conditions develop.
2. **Generate healthy cells to replace diseased cells (regenerative medicine):** Stem cells can be guided to become specific cells that can be used to regenerate and repair diseased or damaged tissues in people.

   People who might benefit from stem cell therapies include those with spinal cord injuries, Type 1 diabetes, Parkinson's disease, Alzheimer's disease, heart disease, burns, cancer and osteoarthritis.
3. **Test new drugs for safety and effectiveness:** Before using new drugs in people, some types of stem cells are useful to test the safety and quality of investigational drugs.

   For testing of new drugs, the cells are programmed to acquire properties of the type of cells to be tested. For instance, nerve cells could be generated to test a new drug for a nerve disease. Tests could show whether the new drug had any effect on the cells and whether the cells were harmed.

Ethical Issues in the Use of Stem Cells

Embryonic stem cells are obtained from early-stage embryos—a group of cells that forms when a woman's egg is fertilised with a man's sperm. Thus, the use of embryos to obtain stem cells is opposed by some religious bodies which believe that life begins immediately after fertilization.

Problems with the Use of Adult Stem Cells

Adult stem cells have limited ability to specialise, which limits how adult stem cells can be used to treat diseases.

Adult stem cells are also more likely to contain abnormalities such as toxins, or from errors acquired by the cells during replication.

6 DNA FINGERPRINTING

DNA fingerprinting refers to identifying complete (or partial) set of genetic information of a particular individual. It is essentially a DNA-based identification system that relies on genetic differences among individuals or organisms. A sample of blood, saliva, semen, vaginal lubrication or other appropriate fluid or tissue from personal items can be used for DNA fingerprinting.

Like fingerprints, every human has unique DNA; unlike fingerprints which can be surgically altered, one cannot change the DNA. The DNA fingerprinting is also known as DNA analysis or DNA profiling.

What is DNA?

Deoxyribonucleic acid (DNA) is the genetic material typically found in all living cells of humans as well as animals and plants. It invariably contains hereditary data passed on from parent to children which is unique to each person (except in the case of identical twins). This makes DNA profiling a reliable and unique personal identification tool.

Applications of DNA Fingerprinting

1. **Identification of criminals:** DNA analysis of hair, bodily fluids, skin, etc., obtained from a crime scene is used to compare with the DNA analysis of suspects to identify the actual criminals.
2. **Claim over dead body:** DNA fingerprinting is used to identify the unrecognizable dead body.
3. **Paternity:** Paternity can be established with certainty with DNA analysis.
4. **Effective drugs:** Drugs can be developed which are more effective for a particular genetic disposition.
5. **Treatment of genetic vulnerability:** Genetic vulnerabilities can be identified beforehand and can be prevented. For instance, if a person has a genetic tendency for hypertension, then preventive steps can be taken to prevent the occurrence of hypertension.
6. **Wildlife management:** The more the genetic makeup of plant and animal population is understood, the better conservation and management plans can be formulated.

Concerns over DNA Fingerprinting

1. The information about gene pool can lead to preference for designer babies and ignore the genes which are of undesirable characteristics, thus reducing genetic diversity.
2. Genetic privacy of individuals will be violated. It can have multiple repercussions. For instance, a person with a particular genetic vulnerability may be looked down upon socially.
3. Genetic information can be misused for commercial purposes. For instance, medical institutions will start offering medical packages based on DNA analysis.
4. Genetic information may be used to create weapons of mass destructions which may lead to ethnic cleansing of a particular community.

DNA Based Technology (Use and Regulation) Bill, 2017

After a gap of two years, the Law Commission of India released a revised draft of the Bill that is now called, 'The DNA Based Technology (Use and Regulation) Bill, 2017' with some very important changes.

Objective of the New Law

The proposed law seeks to establish regulatory institutions and standards for DNA testing and supervise the activities of all laboratories authorised to carry out such tests.

What Does the Bill Propose?

The Bill seeks to set up two new institutions—a DNA Profiling Board and a DNA Data Bank.

DNA Profiling Board

The Board, with 11 members, is supposed to be the regulatory authority that will grant accreditation to DNA laboratories and lay down guidelines, standards and procedures for their functioning.

It will also be the authority to make recommendations on ethical and human rights, including privacy issues related to DNA testing.

DNA Data Bank

A national data bank of DNA profiles is proposed to be set up, along with regional data banks in every state, or one for two or more states, as required. The national data bank is proposed to be set up at Hyderabad, possibly because the Centre for DNA Fingerprinting and Diagnostics, the premier DNA laboratory, is located there.

All regional DNA data banks will be mandated to share their information with the national data bank.

Certain DNA Profiling Board-accredited labs would be authorised to carry out DNA testing and analysis. These are the only places to which DNA samples, picked up from a crime scene, for example, blood stain, can be referred for analysis.

Data from the analysis will have to be shared with the nearest regional DNA data bank which will store it and share it with the national data bank.

The data banks will maintain five sets of databases—DNA samples picked up from crime scenes, from suspects or under trials and from offenders, missing persons and unidentified dead bodies.

Other Provisions

The Bill has introduced a new provision that explicitly prohibits the collection of any 'bodily substance' from an arrested individual (for the purpose of DNA test) without his/her consent, except if the individual is arrested for certain specific offences. However, if the consent 'is refused without good cause' and a magistrate is satisfied with the need for a DNA test, he/she can order the arrested person to give a sample.

Misuse of data will lead to a prison term of up to three years and a fine up to ₹1 lakh.

Objections Against the Bill

There are chances, however remote, that a wrong match is generated. If the DNA result is taken as the ultimate evidence, no recourse will be available to an individual who has been wrongly matched.

More frequently asserted are the privacy-related objections. Questions, such as whose DNA can be collected and under what circumstances, whether the consent of the individual is required, who can access the database, to what uses the DNA information can be put apart from identifying an individual and the circumstances under which a record can be deleted, have been raised repeatedly.

It has been pointed out that information like ancestry or susceptibility to a disease or other genetic traits, is liable to be misused.

It has also been argued that DNA tests have not led to an improvement in conviction rates, in countries where they are already being followed.

7 GENE THERAPY

Gene therapy is a medical technique that manipulates genes to treat or prevent a disease. Gene therapy research is focused on the following approaches:

- Replacing a gene responsible for disease with a healthy gene.
- Inactivating or 'knocking out' a gene that is functioning improperly.
- Introducing a new gene into the body to help fight a disease.

In future, this technique may allow doctors to treat a disorder by manipulating a gene into a patient's cells instead of using drugs or surgery. Gene therapy is a treatment option for a number of diseases (including inherited disorders, some types of cancer and certain viral infections).

Use of Vector to Introduce a Gene

Usually, a gene that is inserted directly into a cell does not function on its own. Instead, a carrier called a vector is genetically engineered to deliver the gene. Certain viruses such as retrovirus are often used as vectors, because they can deliver the new gene by infecting the cell. The viruses are modified so that they cannot cause disease when inserted into people.

The vector can be injected, or given intravenously (by IV), directly into a specific tissue in the body, where it is taken up by individual cells. Alternately, a sample of the patient's cells can be removed and exposed to the vector in a laboratory setting. The cells containing the vector are then returned to the patient. If the treatment is successful, the new gene delivered by the vector will make a functioning protein.

Concerns over Gene Therapy

1. **Short-lived nature of treatment:** Before gene therapy can become a permanent cure for a condition, the therapeutic DNA introduced into the target cells must remain functional and the cells containing the therapeutic DNA must be stable. Problems with integrating therapeutic DNA into the genome

and the rapidly dividing nature of many cells prevent it from achieving long-term benefits. Patients undergoing gene therapy often require multiple treatments.

2. **Immune response:** Depending upon the number of times a foreign object is introduced into our body, the immune system is stimulated to attack the invader. As a result, the gene therapy might activate the response of our immune system. Even our immune system reduces the effectiveness of gene therapy.
3. **Multi-gene disorders:** Some commonly occurring disorders such as heart disease, high blood pressure, Alzheimer's disease, arthritis and diabetes are affected by variations in multiple genes, which complicate the use of gene therapy.

Presently, the technique remains risky. It is not yet proven to be safe and effective. Gene therapy is currently being tested only for the treatment of diseases that have no other cures.

8 DNA OR THIRD GENERATION VACCINES

DNA vaccines are also called third generation vaccines. These vaccines are made up of a small, circular piece of bacterial DNA (called a plasmid) that has been genetically engineered to produce one or two specific proteins (antigens) from a pathogen.

In the DNA vaccine, a piece of bacterial DNA (plasmid) carrying antigen is directly given to us and our body absorbs the DNA into our genetic system. Our body then replicates the production of plasmid carrying antigen. This release of antigen by our own DNA activates our immune system. Like any vaccine, the immune system will then recognize the bacteria or virus in the future—hopefully preventing illness.

What Are the Advantages of DNA Vaccines?

1. **Require short time span for development:** Quick changes can be easily brought in gene-based vaccine than bacteria- or virus-based. Such changes are important to deal with strains of bacteria or virus that are constantly mutating.
2. **DNA vaccines are easy to transport and store:** DNA is a very stable molecule and does not need to be stored at low temperatures, making transportation and storage cheaper and easier than conventional vaccines.
3. **Less risk to those who are making the vaccine:** Conventional vaccines require raising up the infectious bacteria or virus. Thus, there is a risk (even though small) to those who make the vaccines, whereas making of DNA vaccines is less risky

What Are the Disadvantages of DNA Vaccines?

So far, no DNA vaccine has been licensed for use in humans. Although some DNA vaccines are now in clinical trials, none are licensed for use.

First Generation Vaccines

These vaccines consist of infectious organisms, either in mild or dead form. The first generation vaccines are still widely used today.

Live and mild/attenuated forms produce both humoral (antibody) and cellular immune responses. For example, oral polio virus vaccine uses polio virus in mild form. When we take the vaccine, our body reacts as if it is affected by actual virus. Consequently, our immune system gets activated and T-killer cells attack the polio virus. Thereafter, when there is any actual attack of polio virus, then our immune system is already developed to handle such an attack.

The only problem with these vaccines is that the actual pathogen in these vaccines may assume a dangerous form.

Dead pathogen vaccines do generate an antibody response, but they do not generate cellular responses (no T-killer response). Depending on the disease, antibody production may or may not be enough to ward off an infection. The advantage of using killed pathogen vaccine is that there is no chance of infection from the vaccine.

T-killer cells are T-lymphocytes (a type of white blood cell); these cells kill other cells that are infected (particularly with viruses), or cells that are damaged in other ways.

Second Generation Vaccines

The second generation vaccines were created in order to minimise the risks of having the pathogen revert to a dangerous form.

The way these vaccines work is that they do not contain the whole organism, but rather contain only subunits. Subunits may consist of the toxins that the pathogen uses for infecting the body. A great example for the second generation vaccine is DTP vaccine. The second generation vaccines can generate antibody response but not T-killer response.

9 GENETICALLY MODIFIED ORGANISMS

Genetically Modified Organisms (GMOs) are organisms whose genetic materials have been altered using genetic engineering techniques to provide the organisms with certain special characteristics. GMOs can include plants, animals and even microorganisms.

We have learnt that genetic modification can lead to various benefits. GMO research in animals is at the nascent stage. However, it has attained some success in plants. Many genetically modified plant varieties have been developed.

Some of the popular genetically modified crops are mentioned below:

1. **Golden rice:** We have already discussed this earlier. At present, research about golden rice is going on. It is not yet commercially cultivated.
2. **Bt cotton:** We have already discussed that Bt cotton is a transgenic crop in which 'Cry1 AC' gene of Bacillus thuringiensis is introduced to make the crop pest-resistant. After the introduction of this gene, the cotton crop starts producing its own pesticide. The Bt trait is believed to save the cotton plant from the pest popularly known as ball worm.
3. **Bt brinjal and Bt mustard:** Bt brinjal and Bt mustard have been developed on the lines of Bt cotton. These crops are also transgenic in nature in which 'Cry1 AC' gene of Bacillus thuringiensis is introduced to make the crop pest-resistant.

Position of Genetically Modified Crops in India

At present, commercial cultivation of edible, genetically modified (GM) crops such as Bt brinjal and Bt mustard is not allowed because of the following reasons:

1. Presently, research is not enough to understand the impact of Bt food crops on human health. The regular consumption of such varieties may have long-term repercussions on health.
2. Bt trait food crop may cross-pollinate with local wild weeds to make them super weeds which would then require large amount of pesticides for elimination.
3. Moreover, there is a strong opposition from some groups for the cultivation of GM crops. Farmer groups oppose the cultivation of GM crops, because promotion of sale of GM crops would hamper the sale of non-GM crops. NGOs such as Greenpeace stringently oppose the cultivation of GM crops.

On the other hand, commercial cultivation of non-edible Bt crop is allowed. For instance, Bt cotton crop is cultivated at many places in India.

GM Mustard (DMH-11)

Mustard is a self-pollinating crop. Hence, it is difficult to develop a hybrid of mustard. In other words, it is difficult to cross-pollinate mustard crop. In the year 2016, researchers of the Delhi University have genetically modified an Indian mustard (Varuna) and an East-European mustard in order to cross-pollinate them. After cross-pollinating these genetically modified mustard varieties, the new variety of mustard developed was named Dhara mustard hybrid (DMH)-11.

Researchers have sought permission for the following:

1. To commercially release DMH-11 and
2. To use the two GM parental lines, Indian and East-European, for developing new hybrids.

Benefits claimed from DMH-11include:

1. DMH-11 yields about 30% more than the traditional reference mustard variety.
2. It helps in boosting edible mustard oil production thus, reducing huge import bill for edible oil.
3. GM mustard is resistant to herbicides.

Views of Government on GM Mustard

Our government has given the required permission to the researchers to develop GM mustard. The Genetic Engineering Appraisal Committee (GEAC) is the government agency responsible for granting permission for research on genetically engineered organisms and products.

Views of Supreme Court on GM Mustard

The Supreme Court has stayed permission to develop GM mustard. It holds that the approval for GM mustard has been given without consulting people. Moreover, it holds that denying citizens a voice in this matter is all the more serious considering that no labelling regime is in place in India. Without proper labelling, citizens will not get to know whether they consume food made from GM mustard. Example, blood stain can be referred for analysis.

Genetic Engineering Appraisal Committee

The Genetic Engineering Appraisal Committee (GEAC) was formed under Environment Protection Act, 1986 and functions under the Ministry of Environment, Forest and Climate Change (MoEFCC). It gives approval for the cultivation of GM crops.

The functioning of GEAC has the following loopholes:

1. The GEAC is not an autonomous body as it functions under MoEFCC. Thus, while granting approval for genetically modified crops, the GEAC may come under pressure from MoEFCC.
2. Moreover, the GEAC does not possess independent research capabilities. It gives approval based on the research report furnished by the MNCs that seek approval for the cultivation of genetically modified crops.

There is a need to set-up Biotechnology Regulatory Authority of India (BRAI) which would be an autonomous body. Moreover, the BRAI shall possess independent research facilities to verify the claim made by the MNCs for a particular GM crop. These research facilities shall also be able to assess long-term impact of GM crop on health and environment.

10 INTERDISCIPLINARY DEPENDENCY OF BIOTECHNOLOGY

Biotechnology is dependent on many disciplines and techniques for accumulation of data, its organization and analysis. Some of these disciplines are mentioned below:

Biological Engineering

Biological Engineering is an interdisciplinary area focusing on the application of engineering principles to analyse biological systems and solve problems relating to biological systems with human-designed machines, structures, processes and instrumentation.

In many cases, currently available knowledge is inadequate to support the engineering design of biological processes. Hence, greater fundamental knowledge of biology and its potential applications remain as a focus of biological engineering.

Examples of bioengineering include:

- Artificial hips, knees and other joints.
- Ultrasound, MRI and other medical imaging techniques.
- Using engineered organisms for chemical and pharmaceutical manufacturing.

Biomimetics

Biomimetics, also known as biomimicry, is the usage and implementation of concepts and principles from nature to create new materials, devices and systems.

This adaptation of methods and systems found in nature into man made products is desirable, because living organisms have evolved well-adapted structures and materials over geological time through natural selection. Moreover, human beings have looked at nature for answers to problems throughout our existence. Nature has solved engineering problems such as self-healing abilities, environmental exposure tolerance and resistance, harnessing solar energy, etc.

A simple example of biomimetics is inspiration to develop Velcro tape on lines of hooks on bur fruits.

Velcro tape

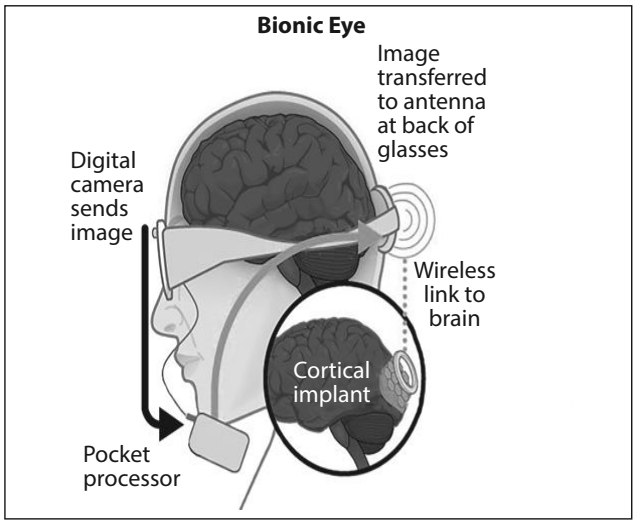
Bionics

Bionics can mean different things to different people. It started as a term for the application of principles of biology to engineering. Now it is used more to describe a method to engineer organs that can replace diseased or non-functional human organs. In future, it could also be a way to design machines that can mimic biological behaviour. Thus, the term bionics is related to biomimetics. Bionics is distinct from bioengineering (or biotechnology), which is based on the use of actual living organisms.

Under the traditional method, well-fitting limbs such as wooden leg or a glass eye was made for persons who had lost legs or eyes. Bionic technology does not stop at making well-fitting prostheses. The term 'bio' in the word, 'bionic' refers to artificial eye or limbs such as legs or arms which can carry out functions like the normal limbs.

Example of bionic eye Bionic eye is an artificial device that has been developed to restore vision. The device includes, among other things, a small video camera, a transmitter mounted on a pair of glasses and an implant in the brain which works as a wireless link between the transmitter and the brain.

This new surgically implanted assistive device provides an option for patients who have lost their sight, for which there are no approved treatments.



Bioinformatics

The recent flood of data from biology and the need for its organization has given rise to a new field namely, bioinformatics, which combines the elements of Biology and Computer Science. Think about the data generated by more than three billion nitrogen pairs in human body which is responsible for gene sequences in an individual!

Bioinformatics begins with conceptualizing biological processes and systems, and then applying 'informatics' techniques (derived from disciplines such as Applied Mathematics, Computer Science and Statistics) to understand and organise the information associated with these processes and systems, on a large-scale.

Practice Questions

1. Which of the following benefits may be reaped from transgenic crops?

1. Increased shelf life
2. Higher crop production
3. Higher nutritional value

Select the correct answer using the codes given below:

(a) 1 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

2. Consider the following statements with reference to 'gene testing':

1. Gene testing can be used to determine a person's ancestry.
2. Gene testing may help in preventing genetic disorders.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

3. Which one of the following techniques can be used to establish the paternity of a child?

(a) Protein analysis
(b) Chromosome counting
(c) Quantitative analysis of DNA
(d) DNA fingerprinting

4. The application of biotechnology to make industrial processes more efficient is called:

(a) Green biotechnology
(b) Blue biotechnology
(c) White biotechnology
(d) Red biotechnology

5. Consider the following statements regarding stem cells:

1. In our day to day lives, stem cells regularly replace dead cells from our body tissues.
2. Stem cells help in understanding the occurrence of degenerative diseases.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

6. Consider the following statements regarding traditional plant breeding:

1. Traditional plant breeding cannot be carried among interspecies.
2. Traditional plant breeding is carried through recombinant DNA technology.

Which of the statements given above is/are correct?

(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

7. The term 'Cirb Gaurav' is used in the context of:

(a) A cloned monkey offspring
(b) First cloned human offspring
(c) A cloned buffalo offspring
(d) First cloned sheep offspring

8. Which of the following are ex situ bioremediation techniques:

1. Bioaugmentation
2. Biopile
3. Land farming

Select the correct answer using the codes given below:
(a) 1 and 2 only (b) 2 and 3 only
(c) 3 only (d) 1, 2 and 3

9. Consider the following statements regarding golden rice:
1. The golden yellow colour of the rice is due to the presence of high protein in the rice.
2. The golden rice is fortified with proteins in order to eliminate protein deficiency.

Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

10. Consider the following statements regarding cloning:
1. World's first cloned animal was Dolly, the sheep.
2. The first case of human cloning was recorded in Germany in 2004.

Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

11. Consider the following statements with regard to DNA analysis:
1. DNA fingerprinting has become an important test to establish the paternity and identity of criminals of rape cases.
2. Dried blood and semen are adequate for DNA analysis.

Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

12. The term 'virotherapy' refers to:
(a) A virus that is used to treat leukemia
(b) A medical treatment to kill foreign virus that may cause some disease
(c) A medical treatment that converts viruses into therapeutic agents
(d) A medical treatment that is used to cure any genetic disorder

13. Consider the following statements:
1. If scientists could locate and extract the DNA out of a lock of Einstein's hair, another Einstein could be produced by cloning.
2. The DNA extracted from the cell of an embryo at an early stage of development can be transferred to denucleated egg which in turn can be implanted into the uterus of a surrogate mother to give birth to an identical offspring.

Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

14. Consider the following statements:
1. Phytomining is an approach in which mining is done with the help of plants.
2. Biosorption is an approach in which extraction of desired minerals from ores is done with the help of living organisms.

Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

15. Stem cell therapy (SCT) is not useful for the treatment of which one of the following ailments?
(a) Kidney-related ailments
(b) Hypertension
(c) Liver damage
(d) Vision impairment

16. The term 'biomimetics' is sometimes seen in the news with reference to:
(a) Implementation of concepts from nature to create new materials, devices and systems.
(b) Use of rare earth metals to create artificial body parts which can function like real parts.
(c) Implementation of cloning technique to create exact replica of physical devices.
(d) Use of biotechnology principles in day-to-day life for a comfortable living.

17. With reference to the latest developments in stem cell research, consider the following statements:
1. The only source of human stem cells is the embryo at the blastocyst stage.
2. The stem cells can be derived without causing destruction to blastocysts.
3. The stem cells can automatically regenerate themselves.

Which of the statements given above is/are correct?
(a) 1 and 2 only (b) 1, 2 and 3
(c) 1 only (d) 3 only

18. With reference to 'biological engineering', consider the following statements:
1. It is an interdisciplinary area focusing on the application of engineering principles to analyse biological systems and solve problems related to biological systems.
2. Greater fundamental knowledge of biology and its potential applications are pre-requisites for biological engineering.

Which of the statements given above is/are correct?
(a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

PERFECTING PAST PRELIMS

1. Mon 863 is a variety of maize. It was in the news for which of the following reasons? **(2010)**

(a) It is a genetically modified dwarf variety which is resistant to drought.
(b) It is a genetically modified variety which is pest-resistant.
(c) It is a genetically modified variety with ten times higher protein content than the regular maize crop.
(d) It is a genetically modified variety used exclusively for biofuel production.

2. Genetically modified 'golden rice' has been engineered to meet human nutritional requirements. Which one of the following statements best qualifies golden rice? **(2010)**

(a) The grains have been fortified with genes to provide three times higher grain yield per acre than other high yielding varieties.
(b) Its grains contain pro-vitamin A which upon ingestion is converted into vitamin A in the human body
(c) Its modified genes causing the synthesis of all the nine essential amino acids.
(d) Its modified genes cause fortification of rice grains with vitamin D.

3. A genetically engineered form of brinjal, known as the Bt-brinjal, has been developed. The objective of this is **(2011)**

(a) To make it pest-resistant
(b) To improve its taste and nutritive qualities
(c) To make it drought-resistant
(d) To make its shelf life longer

4. What are the reasons for the people's resistance to the introduction of Bt brinjal in India? **(2012)**

1. Bt brinjal has been created by inserting a gene from a soil fungus into its genome.
2. The seeds of Bt brinjal are terminator seeds and therefore, the farmers have to buy the seeds before every season from the seed companies.
3. There is an apprehension that the consumption of Bt brinjal may have adverse impact on health.
4. There is some concern that the introduction of Bt brinjal may have adverse effect on biodiversity.

Which of the statements given above is/are correct?

(a) 1, 2 and 3 only
(b) 2 and 3 only
(c) 3 and 4 only
(d) 1, 2, 3 and 4

5. With reference to 'stem cells', frequently in the news, which of the following statements is/are correct? **(2012)**

1. Stem cells can be derived from mammals only.

2. Stem cells can be used for screening new drugs.
3. Stem cells can be used for medical therapies.

Select the correct answer using the codes given below:
(a) 1 and 2 only (b) 2 and 3 only
(c) 3 only (d) 1, 2 and 3

6. Other than resistance to pests, what are the prospects for which genetically engineered plants have been created? **(2012)**

1. To enable them to withstand drought.
2. To increase the nutritive value of the produce.
3. To enable them to grow and do photosynthesis in spaceships and space stations.
4. To increase their shelf life.

Select the correct answer using the codes given below:
(a) 1 and 2 only (b) 3 and 4 only
(c) 1, 2 and 4 only (d) 1, 2, 3 and 4

7. Recombinant DNA technology (Genetic Engineering) allows genes to be transferred: **(2013)**

1. Across different species of plants.
2. From animals to plants.
3. From microorganisms to higher organisms.

Select the correct answer using the codes given below:
(a) 1 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

8. Mycorrhizal biotechnology has been used in rehabilitating degraded sites because mycorrhiza enables the plants to: **(2013)**

1. Resist drought and increase absorptive area.
2. Tolerate extremes of pH.
3. Resist disease infestation.

Select the correct answer using the codes given below:
(a) 1 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

9. Consider the following techniques/ phenomena:

1. Budding and grafting in fruit plants.
2. Cytoplasmic male sterility.
3. Gene silencing.

Which of the above is/are used to create transgenic crops? **(2014)**
(a) 1 only (b) 2 and 3
(c) 1 and 3 (d) None

10. The Genetic Engineering Appraisal Committee is constituted under the: **(2015)**

(a) Food Safety and Standards Act, 2006.
(b) Geographical Indications of Goods (Registration and Protection) Act, 1999.
(c) Environment (Protection) Act, 1986.
(d) Wildlife (Protection) Act, 1972.

11. What is the application of somatic cell nuclear transfer technology? **(2017)**

(a) Production of biolarvicides.
(b) Manufacture of biodegradable plastics.

(c) Reproductive cloning of animals.
(d) Production of organisms that are free of diseases.

12. With reference to agriculture in India, how can the technique of 'genome sequencing', often seen in the news, be used in the immediate future? **(2017)**

1. Genome sequencing can be used to identify genetic markers for disease resistance and drought tolerance in various crop plants.
2. This technique helps in reducing the time required to develop new varieties of crop plants.
3. It can be used to decipher the host–pathogen relationships in crops.

Select the correct answer using the codes given below:

(a) 1 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2 and 3

ANSWER KEYS

Practice Questions

1. (d)	**2.** (c)	**3.** (d)	**4.** (c)	**5.** (c)
6. (d)	**7.** (c)	**8.** (b)	**9.** (d)	**10.** (a)
11. (c)	**12.** (c)	**13.** (b)	**14.** (a)	**15.** (b)
16. (a)	**17.** (d)	**18.** (c)		

Perfecting Past Prelims

1. (b)	**2.** (b)	**3.** (a)	**4.** (c)	**5.** (b)
6. (c)	**7.** (d)	**8.** (d)	**9.** (b)	**10.** (c)
11. (c)	**12.** (d)			

Solutions for

Practice Questions and Perfecting Past Prelims