# Contents of Study Kit for (IFos) Pre General Studies Paper 1

## SCIENCE & TECHNOLOGY

# SAMPLE CHAPTERS OF THIS BOOKLET

# ATOMIC RESEARCH

**Ques. 1 : Critically evaluate the India's Nuclear energy programme?**

**Ans.** India's nuclear research programme aims to develop and utilise nuclear energy for peaceful purposes such as power generation, applications in agriculture, medical sciences, industry and other areas, India is today globally acknowledged as one of the advanced countries nuclear technology. The country is self-reliant and excels in the expertise covering the complete nuclear cycle from exploration and mining to power generation and from applications of nuclear technology to waste management and other safety issues.

The main objective of India's nuclear energy programme, as defined in the Atomic Energy Act of 1948, is the development, control and use of nuclear energy for peaceful purposes and development of various nuclear applications. The programme has laid great emphasis on 'self-reliance' and 'indigenisation from its very beginning'. Apart from being a potentials source of electricity that could satisfy our requirement for next 300 years, nuclear energy research has various other crucial applications important for our socio-economic development as also for our defence requirements.

Although nuclear armament has not been the. thrust area of India's nuclear programme, India did visualise a need to adopt a more comprehensive approach to security - encompassing economic strength, internal cohesion and technological upgradation -in the emerging global scenario. India remains a firm and consistent proponent of general and complete global nuclear disarmament; as against any discriminatory doctrine in this regard. India's policy on disarmament also takes into account changes that have taken. place in the world, especially in the 1990s onwards. The nuclear tests of May 1998 do not dilute India's commitment to the long held objective of nuclear disarmament. This sets the country apart from other nuclear weapon states, which reject global nuclear disarmament proposals because they refuse to visualise their security without nuclear weapons. As a. nuclear weapon state, India is even more conscious of its responsibility in this regard and, as in the past, initiatives in pursuit of global nuclear disarmament continue to be taken by India.

India's nuclear weapon capability is meant only for self-defence and seeks only to ensure that India's security, independence and integrity are not threatened in future. India's nuclear doctrine is based on maintaining a minimum credible deterrence and a no-first-use policy as opposed to nuclear war fighting or warning doctrines. It is, therefore, natural for India to take initiatives that aim to reduce the threat-of break-out of nuclear war and also to take initiatives that promote peaceful and more meaningful applications of nuclear technology.

**Ques. 2 : Comment on the following in not more than 50 words each:**

**i) Department of Atomic Energy**
**ii) BARC, Treombay**
**iii) IGCAR, Kalpakkam**
**iv) NPC**
**v) IRE, Mumbai**
**vi) NFC, Hyderabad**
**vii) HWB**
**viii) Atomic Minerals Division**
**ix) BRIT**

**Ans.**

**I) DEPARTMENT OF ATOMIC ENERGY (DAE)**

The executive agency for all activities pertaining to atomic energy in the country is the DAE, which was setup in 1954. Policies pertaining to the

functioning of DAE are laid down by the Atomic Energy Commission (AEC) which was set up in 1948. The DAE has always been under the charge of the Prime Minister himself. The activities of DAE are primarily in the area of nuclear power generation, R&D in atomic energy and the applications in industries; mineral sector etc. These activities are carried out by its constituent units, public sector undertakings and by R&D institutions which are given financial assistance by the DAE. DAE has comprehensive capabilities to design, construct, operate and maintain related-fuel cycle facilities, and many such facilities are operational all over the country.

### II) Bhabha Atomic Research Centre, Trombay

This is the premier research centre of the DAE, set up in 1957. It carries out research in areas of reactor engineering, reactor physics, nuclear chemistry, water chemistry, computer technology, nuclear applications etc. It works in close co-operation with the Nuclear Power Corporation in its rapid indigenisation requirements. The research reactors of BARC, Trombay, especially the indigenously built Dhruva, have given the necessary infrastructural base for advances in nuclear science and technology.

### III) Indira Gandhi Centre for Atomic Research, Kalpakkam

This is the other multi-disciplinary nuclear R&D centre, set up in 1971. It is dedicated to R&D related to fast reactor technology and associated fuel cycles, material sciences, radiochemistry, fuel reprocessing and sodium technology. The centre is also engaged in basic research related to material sciences and applied research in the sphere of non-destructive technology, advanced instrumentation and materials.

### IV) Nuclear Power Corporation (NPC)

Formerly called Nuclear Power Board, it is responsible for design, construction and operation of nuclear power stations. The NPC has already gained an operating experience of around 100 'reactor-years'. India's safety standards in power-generation and plant operation are in keeping with those recommended by the International Atomic Energy Agency (IAEA) and the International Commission on Radiological Protection (ICRP). A national network of environmental radiation monitoring stations is being set up which will monitor and help in detecting unusal radiation releases, as part of a global. Environments radiation monitoring network. Five such stations are operational at present, at Mumbai, Tarapore, Kalpakkam, Kolkata and Indore.

### V) Indian Rare Earth Limited

Founded in 1950, it is responsible for processing and producing thorium and other radioactive elements found in sands of Kerala and Orissa:

### VI) Nuclear Fuel Complex

It fabricates fuel and structural components for all operating power reactors and thorium blankets and structural components for FBTR. In the recent past, NFC developed special alloys for use in the space programme also which was a major milestone in import substitution. NFC along with IREL has succeeded in producing pure zirconia crystal popularly known as American diamonds.

### VII) Heavy Water Board

It designs, builds and operates its own heavy water plants which not only meet the country's requirements but have also given us export capability.

### VIII) Atomic Minerals Division

It is responsible for surveying and prospecting of nuclear mineral resources in the country.

### IX) The Board for Radiation and Isotope Technology (BRIT)

It is responsible for keeping pace with the state-of-the-art developments in isotope applications in Industry, research and medicine.

## ORGANISATIONAL SET UP

Atomic Energy Commission

Atomic Regulatory Board

Department of Atomic Energy

| RD Organisations Industrial Facilities | PSUs Aided Insititutions (By DAE) |
|---|---|
| • Bhabha Atomic Research Centre (BARC), Mumbai | • Nuclear Power Corporation of India (NPCIL) Mumbai |
| • Heavy Water Board (HWB), Mumbai | • Tata Institute of Fundamental Research (TIFR), Mumbai |
| • Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, (TN) | • India Rare Earths Ltd. (IRE), Mumbai |
| • Nuclear Fuel Complex (NFC), Hyderanad | • Saha Institute of Nuclear Physics (SINP), Kolkata |
| • Board of Radiation and Isotope Technology (BRIT), Mumbai | • Uranium Corporation of India Ltd. (UCIL), Jaduguda, Jharkhand |
| • Centre for Advanced Technology (CAT), Indore | • Institute of Plasma Research, Ahemdabad |
| • Variable Energy Cyclotron Centre (VECC), Kolkata | • Tata Memorial Centre, Mumbai |
| | • Institute of Physics, Bhubneshwar |
| | • Electronics Corporation Ltd. (EICL) Hyderabad |
| | • Institute of Mathematical Sciences, Chennai |

**Ques. 3 : What do you understand by Nuclear energy?**

**Ans.** Energy released during a nuclear reaction in accordance with the mass-energy equation is called nuclear energy. All matter is composed of atoms. Each atom has a nucleus composed of neutrons and protons (except the simplest, single proton nucleus of ordinary hydrogen). Every nucleus of every atom, except hydrogen would fly apart but for the binding energy within the nucleus. It is this binding energy that, when released slowly and under control, produces heat that can power steam-driven electricity generators in nuclear power plants. And it is this binding energy that, when released all at once, produces, the destructive impact in a nuclear bomb.

Theoretically, we can obtain nuclear energy from almost any substance but this is not practical because the energy needed, for triggering the released binding energy via breaking the nucleus apart, would be more than the energy released by the process. Thus, practically nuclear energy can be obtained only from some elements which are called fissile or radioactive elements, which undergo radioactivity readily i.e. which are easily broken apart-thereby releasing energy in the form of heat.

**Ques. 4 : Discuss in brief the types of nuclear reactions?**

**Ans.** Nuclear energy is produced by two types of nuclear reactions - nuclear fission and nuclear fusion.

Nuclear Fission: It is a nuclear reaction in which a heavy atomic nucleus is split into two approximately equal nuclei, thereby, releasing very large amount of binding energy resulting mainly in the form of heat. Moreover, this split also ejects several neutrons, each of which in turn can strike other atomic nuclei to trigger further splits and cause further releaser of energy. For .example, U-235, an isotope of uranium, has an unstable nucleus which is easily broken apart when hit by a neutron. It splits into two equal sized nuclei - krypton and, barium and releases great deal of energy and neutrons. These neutrons further trigger the fission of other nuclei. It is called nuclear fission chain reaction and is the basis of energy release in nuclear reactors and nuclear bombs. For example, Pu 239 an iso-

tope of plutonium is used in nuclear bomb tests wherein its nucleus splits and releases enormous amount of explosive energy. However, there are problems associated with fission energy. Fission actually involves a series of nuclear changes following the major heat-yielding split. At each step in the series, energy is given off in the form of radioactive particles and rays, some highly dangerous. This radioactive waste must be safety stored and disposed of otherwise it can be lethal to living beings. Another problem is that the nuclear reactor itself becomes radioactive over its useful life of around 30 years; after which it must be dismantled and its parts must be handled like radioactive waste. This is both risky and costly.

Nuclear Fusion, it is a nuclear reaction in which light atomic nuclei fuse together to form a single heavy nucleus, with the release of large quantum of energy. The mass of single nucleus formed is less than the total initial mass of the nuclei as the difference is converted into energy. In fusion, hydrogen isotopes are fused to form helium, with the release of enormous quantities of energy.

**Ques. 5 : Briefly discuss the advantages of Fusion energy mechanism over Fission energy?**

**Ans.** Fusion energy Mechanism has many advantages over Fission energy.

i)The principal raw material is an hydrogen isotope deuterium. As hydrogen is a constituent of water which is available in plenty on earth is a renewable/ inexhaustible raw material as compared to fissile raw materials like uranium, plutonium, thorium etc.

ii)The end product of fusion reaction is energy and helium which is a harmless and stable gas and is environment friendly. Thus, there is no problem of radioactive fall out that is associated 'with fusion' reaction.

iii)A fusion reactor, by its very nature, cannot explode, and is thus safer than a fission reactor.

**Ques. 6 : Discuss in brief the Fusion energy Mechanism?**

**Ans.** Fusion requires the forcing together of hydrogen isotopes to form helium nuclei. This requires energy to overcome nuclear repulsion but after that happens, far more energy is released than was needed to start it. Before we can release the energy of nuclear fusion, we must put nuclei in the condition to fuse. This requires expanding energy for two purposes: (i) to separate the nuclei from their surrounding electrons, so the nuclei can be brought close together. The stripped-apart substance is a dense mixture of nuclei and free electrons; it is called plasma and (ii) to slam the nuclei together so violently that they stick together (fuse). These steps can be achieved at a temperature of 100 million degrees Celsius. (Nuclear fusion is called a thermonuclear reaction). This temperature exists all the time - in the interiors of the sun and other stars - and there are ways of producing it on earth, by electromagnetic and laser devices. But in what kind of container can we heat plasma to 100 million degrees Celsius without destroying the container itself? Even the element with the highest melting point, tungsten, melts at a mere 3410° C and vaporises at 5660° C.

Scientists and engineers are working on a different approach not to let the superheated plasma touch the sides of the container. This would be done by surrounding the container with a strong magnetic field that repels the plasma (which responds to magnetism) and focus it away from the sides into the centre of the container. There, hopefully, it can attain fusion temperature long enough to be a steady source of energy. Fusion has in fact been achieved in this way number of times in experimental fusion reactors for a fraction of a second. Three of these types - the magnetic bottle, tokamak and stellarator - operate on the same principle, the magnetic containment (bottling) and compression of plasma.

The tokamak designed by the soviet physicist Lev Artsimovich, who in 1968 demonstrated his

toroidal magnetic chamber for which tokamak is an acronym - in Russian is a toroid-shaped hollow chamber operating on magnetic principles with adaptations for its special functions.

A hydrogen bomb is literally a one-shot nuclear fusion reactor. It consists of two main parts: (1) a source of deuterium and tritium and (2) a heating device to achieve 100 million degrees Celsius. This heating device is another bomb, or several, of the fission type.

**Ques. 7 : State the principle underlying functioning of Nuclear Power reactors?**

**Ans.** A nuclear power reactor is only a source of heat, the heat being produced when the Uranium Atom Splits (fissions). The heat produces steam which drives the turbo generator and produces electricity.

The natural uranium the fuel used in this reactor, consists of two kinds of isotopes of Uranium, namely U-238 and. U-235 in the ratio of 139:1. It is the less abundant U-235 isotope that fissions and produces energy.

When a U-235 atom called enriched uranium is struck by a slow (or thermal) neutron, it will split into two or more fragments. Splitting is accompanied by tremendous release of energy in the form of heat, radio-activity and two or three fast neutrons. These fast neutrons which flyout of the split atom at high speeds, are made to slow down (thermalised) so that they have high probability to hit other u-235 atoms which in turn releases more energy and further sets of neutrons and fissions. Attainment of such self- sustained splitting of uranium atom is called a 'Chain Reaction'. At this stage, the Reactor is said to have attained 'Criticality'. The slowing down of neutrons is achieved by the 'Moderator' which is 'Heavy Water'.

Mankind will get the cheapest energy source once the toughest scientific and technical problem of thermonuclear fusion is controlled in fusion reactors. In a thermonuclear reaction, high-powered laser guns are bombarded over droplets of deuterium/tritium mass resulting in the release of tons of degrees of temperature which can be tapped for producing electricity. The BARC has already set up the centre for Advanced Technology at Indore in Madhya Pradesh to conduct thermo-nuclear research to develop technologies for applied areas. It will concentrate on application of lasers and accelerators in thermo-nuclear reactions to fabricate a workable fusion reactor.

### Ü *Nuclear Reactor in India*

Nuclear reactor is an assembly in which a nuclear fission chain reaction is maintained and controlled for producing nuclear energy, radioactive nuclides, or artificial elements. The nuclear fuel used in reactor is a fissile material, commonly U-235, which undergoes fission producing two nuclei of approximately equal mass along with two to three neutrons and considerable amount of energy. These neutrons cause further fissions so that a chain reaction develops; in order that reaction should not get out of control, it is regulated by neutron absorbers - the control rods made of graphite or beryllium - which allow only sufficient free neutrons to exist in the reactor core to maintain the reaction at constant level. The fuel is usually mixed with a moderator, which slows down the fast neutrons emitted during fission so that they are more likely to cause further fissions of fuel than they are captured by the U-235 nuclei.

All current reactors used to feed electricity to their national grids are thermal reactors, which raise steam to drive a steam turbine, which in turn drives an electric generator. A coolant (e.g. pressurised water, gas etc.) is present in the reactor which transfers the heat from the nuclear reaction to the steam raising plant.

The most widely used type is now the pressurised heavy water reactor (PHWRs), In this heavy water (D2 O), used as coolant, is kept under pressure to avoid it from boiling while allowing it to attain high temperature. Heat thus absorbed is

then transferred to other water (in steam-raising plant).which converts into steam and drives a steam turbine which in turn drives an electric generator.

**Ques. 8 : What is fast Breeder Reactor? Discuss its advantages.**

**Ans.** A nuclear reactor that produces (breeds) the same kind of fissile materials as it burns is called a breeder reactor. Like U-235: plutonium (pu-239) can also sustain a chain reaction. Breeder reactors while using plutonium as, a fuel can produce more pu-239 than it consumes by converting non-fissionable u-238, that predominates in natural uranium ore. With fast neutrons the chance of absorptions by u-238 are less and hence these reactors do not use moderator to slow down neutrons. So these are called fast breeder reactors (FBRs). But FBRs need special heat removal systems such as liquid sodium or steam coolants in view of their higher power density.

**ADVANTAGES OF FBRS**

i)In PHWRs nuclear chain is slowed down by moderators whereas in FBRs this reaction is sustained by fast neutrons;

ii)higher efficiency of conversion-ratio of fresh fuel produced to fuel consumed, is 1.2 to 1.6 in FBR and 0.5 in PHWRs; and

iii)radioactivity released into atmosphere is less.

**Ques. 9 : Briefly discuss the Nuclear fuel cycle?**

**Ans.** The nuclear power programme has a number of ancillary operations which form a Nuclear Fuel Cycle. The Front-End of the cycle includes mineral exploration, mining and processing of ore, and fabrication of fuel.

The Back-End of cycle covers reprocessing of spent Uranium fuel and management of nuclear waste.

India has acquired comprehensive capability in PHWR design, construction and operation of associated plants covering the entire fuel cycle of nuclear power programme based on PHWR. This includes production of heavy water.

The Department of Atomic Energy organizations contributing to Front-End of Nuclear-Fuel Cycle Programme are Atomic Minerals Directorate for Research and Exploration (AMD). Hyderabad, Jaduguda (Jharkhand). Nuclear Fuel Complex (NFC) Hyderabad, and Heavy Water Board (HWB). Mumbai. BARC and IGCAR administer the Back-end of the cycle.

**Ques. 10 : Give an account of the Atomic Minerals in India?**

**Ans.** Atomic Minerals Division is a very important component of the Department of Atomic Energy in India. The Atomic Minerals Division continues to enlarge the resource base of uranium and other nuclear raw materials namely thorium, zirconium, titanium, beryllium and rare earth elements by carrying out airborne and ground surveys, exploratory and evaluation drilling and underground mining in different parts of the country. For exploration of uranium Air-borne survey and Remote Sensing were conducted from which new uranium reserves were known.

The search for favourable localities for uranium mine-realisation in the peninsular shield culminated in the discovery of Jaduguda deposits in Singhbhum District of Jharkhand. In Singhbhum District, uranium deposits are also found in Turamdih, Mohuldih, Bagjata, Garadih and Kanyalika. As a result of the extensive survey work carried out so far, it has been estimated that India's total uranium reserves are about 73,000 tonnes. India's thorium resources contained in the monazite beach sand as well as some inland deposits, are estimated at about 5 lakh tonnes, the largest in the world. During recent explorations, promising uranium occurrences were located in Andhra Pradesh, Meghalaya, Uttar Pradesh, Rajasthan, Madhya Pradesh and Karnataka. Potential tracts of heavy mineral concentration were identified along the east coast in Srikakulam and East Godavari Districts of

Andhra Pradesh.

The locations where promising indications of uranium reserves have been noticed recently are:

1.Meghalaya - Near Domiasiat in the West Khasi Hills District and also in Wahkyn.

2.Andhra Pradesh - Some areas in Nalgonda, Guntur, Cuddapah and Chittoor Districts (Lambapur-Vellapur, Koppunuru and Tumrnalapalle).

3.Uttar Pradesh - Naktu-Kudar in. Sonbhadra District.

4.Gujarat - Garumal in Panchmahals District.

5.Rajasthan - Putholi in Chittorgarh District.

6.Karnataka - Gogi in Gulbarga District.

At present, Jaduguda, Bhatin and Narwapahar mines are meeting the uranium needs of the Nuclear Power Programme. The natural uranium from these mines is processed as yellowcake and sent to Nuclear Fuel Complex for fuel fabrication.

Ilmenite, Rutile, Zircon, Leucoxene and Monazite, declared as scheduled minerals under the Atomic Energy Act, are mined from the coastal areas of Kerala, Tamil Nadu and Orissa.

Availability of Thorium in India and the ways it is utilized.

Thorium is processed from beach sands of Kerala, Tamil Nadu, Orissa and Andhra Pradesh. Indian Thorium is considered to be of high grade. India has five times more thorium than uranium and the energy content in thorium reserves is about 4000 times the energy that can be generated from uranium.

Thorium by itself is not a nuclear fuel but it turns into U-233 an excellent nuclear fuel - when bombarded by neutrons inside a reactor. The u-233 is chemically separated from irradiated thorium and is called thorium derived uranium.

BARC made a beginning 40 years ago when it introduced thorium rods in the Canadian - built CIRUS reactor and then chemically processed it to separate u-233.

BARC is also working on a scheme to introduce thorium along with uranium - plutonium mixed oxide (MOX) into one of the operating pressurised heavy water reactors (PHWR).

As a part of the thorium utilisation programme, U-233 separated from irradiated thorium and fabricated into fuel elements, has also been used for flux flattening in the initial cores of the Kakrapara reactors. Work is progressing on the design of an Advanced Heavy Water Reactor (AHWR) which will make use of thorium as fuel.

**Ques. 11 : Give an account of U-233 fuel?**

**Ans.** One of the significant advances is the Indian nuclear establishment's break- through in developing U-233 fuel, an area in which Indian nuclear scientists have a lead, world-wide. U-233, the best isotope of uranium for power generation, does not occur in nature. It has been obtained by Indian researchers at Kalpakkam, first in the research reactors and later by putting a thorium blanket on the core of the Fast Breeder Test Reactor (FBTR). U-233 fuel is now being used in running a research reactor at IGCAR, Kalpakkam, called KAMINI which is the first reactor in the world fuelled by this isotope of uranium. The achievements are of special importance for India because this country has immense supplies of thorium, which by itself cannot be used as fuel in N- reactors. On the other hand, India's uranium reserves are limited.

With the BARC - Kalpakkam team deciding to use thorium in some of the thermal reactors as a blanket covering their core, on an experimental basis, a new vista in the use of thorium as a fuel in N-power development opens up. Hitherto, it was presumed that thorium could be used to give u-233 only in fast breeders. But the result obtained already in covering the core of thermal N-reactors with thorium has changed the outlook.

There are already u-233 fuelled research reactors working - one at BARC (PURNIMA-II) and

another at Kalpakkam (KAMIN I). Both are moderated by light water. The core of Purnima II, fuelled by U-233, is now being modified in the light of experience already gained. This reactor needs 300 grams of u-233 as against 20 tonnes of natural uranium for the heavy water moderated thermal reactors which now predominate in India. U-233 has also been obtained by reprocessing the thorium rods irradiated in Cirus and Dhruva research reactors. Now, from laboratory scale, the development has moved on to a larger scale, due to BARC improving its capability for reprocessing waste fuels obtained from thermal reactors. A new type of solvent extraction equipment called Calmix has been developed for the reprocessing. Yet another important lead for India, perhaps the only developing country in the world which has acquired this capability.

### Ques. 12 : Give an account of the Fuel Fabrication in India?

**Ans.** The indigenous element is high in the field of fuel fabrication. The first fuel element was fabricated in 1959 on the basis of research carried out at BARC. The fuel fabrication plant at Trombay produces fuel elements for the research reactors. Research on new fuels and materials is also conducted here. The thorium oxide pellets for the FBR were also fabricated at Trombay. The fuel made of mixed uranium-plutonium carbide for the FBTR was also developed here.

The Nuclear Fuel Complex, set up in 1971 at Hyderabad, manufactures on an industrial scale nuclear fuel assemblies for PHWRs and boiling water reactors and zicaloy structural materials. It also manufactures components required for advanced reactors such as PFBR.

The Advanced Fuel Fabrication Facility of BARC at Tarapur has fabricated the mixed oxide fuel bundles for Tarapur.

### Ü *India's Nuclear Energy Programme*

***Present Context***

India is 1/6th of humanity. Its energy demand are to grow ten-fold in coming 4 to 5 decades. Considering sustainability of energy resources in meeting increasing demands, to support economic development, it points to inevitability of nuclear power, a global nuclear renaissance is a reality.

To realise this potential DAE provides synergy between science and technology development and establishes an organic linkage between Laboratory and industry. The network of its organisation has enabled department to plan and successfully execute a comprehensive programme in areas of nuclear science involving chain of activities viz., research, development, demonstration and deployment of technologies. This approach has been a crucial factor in building a self-reliant capability in all aspects of the nuclear fuel cycle.

### Ques. 13 : Briefly discuss the Vision 2020 of DAE?

**Ans.** It aims-at setting up of about 20,000 MWe of nuclear power capacity by 2020 A.D. The present nuclear power capacity in the country is 2720 MWe. In order to meet the goal of generating 20,000 MWe from nuclear plants by 2020. Two main thrust areas have been identified.

1. Generation of own resources by NPC by seeking resources/investments other than budgetary support. It was highlighted that the government is committed to budgetary support, on a reduced basis, only up to 11th Plan. The NPC feels that its own resources and borrowings will be enough to support of 3000 MWe per annum.
2. Expansion of new technology being used in the Koodankulam.
3. India Nuclear Programme: Our Nuclear Programme is unique. It encompasses the complete range of activities that characterise advanced nuclear power including generation of electricity, advanced research and strategic programme.

The manner of development of our programme

has been envisaged is predicted on our modest Uranium resources and vast reserves of thorium. The 3-Stage programme of. PHWR, FBR and thorium based reactors will be integrated into one.

**Ques. 14 : Discuss in brief the First Stage of India's Nuclear Energy Programme?**

**Ans.** Pressurised Heavy Water Reactors for the Indian Nuclear Power Programme, that took off in the sixties, PHWR was the reactor of choice for the first stage of the programme. However, to gain operational experience, initially an atomic power station consisting of two boiling water reactors (BWR) was set up at Tarapur, Maharashtra. This was a turnkey project of the General Electric of USA. Commissioned in 1969, the station is still in operation.

The first two PHWRs, at Rawatbhata, Rajasthan, started commercial production in 1973 and 1981. The first unit (RAPS-1) was built with the help of the Atomic Energy of Canada Ltd. (AECL). However, the second unit was completed with the indigenous research and development endeavour and the support of the Indian industry. This success followed commissioning of the two 220 MWe reactors at Kalpakkam near Chennai, Tamil Nadu, in the years 1984 and 1986. Later, the design of the 220 MWe.

PHWR was standardised and two reactors of this design were commissioned at Narora, Uttar Pradesh, in 1991 and 1992.

The design standardisation has markedly reduced gestation period of new reactors. This technology of PHWR reached commercial maturity with the commissioning of two 220MWe PHWRs at Kakrapar (Gujarat) in 1993 and 1995. In the year 2000, four state-of-the-art 220 MWe PHWRs, two each at Kaiga (Karnataka) and Rawatbhata (Rajasthan) came on line. The reactor design of 220 MWe PHWR, was successfully scaled up to 540 MWe. Two reactors of this scaled up design have been successfully commissioned at Tarapur, in the years 2005 and 2006. The gestation period of reactors has also been reduced drastically. The growing experience of NPCIL in nuclear technology, has resulted in improving performance of its nuclear power plants, and drastically reducing the gestation period of reactors. The nuclear power generation has risen from 3000 million units in the year 1981-82 to 20,000 million units for year 2008.

Ongoing Projects: A total capacity of 3380 megawatt is under construction. It comprises two 220 MWe pressurised water reactors each at Rawatbhata (RAPS-5&6) and Kaiga (Kaiga-3&4), two pressurised water reactors of 1000 MWs each and one 500 MWe prototype fast breeder reactor (PFBR) at Kalpakkam.

New Projects: The Government of India has also given, in principle, site approvals for setting up 8 additional nuclear power reactors aggregating 6800 MWe. These will consist of 700 MWe. PHWRs and 1000 MWe Light Water Reactors to be located at Kudankulam (Tamil Nadu), Kakrapar (Gujarat), Rawatbhata (Rajasthan) and Jaitapur (Maharashtra). DAE has an ambitious nuclear power programme that aims at achieving an installed nuclear power capacity of 20,000 MWe by the year 2020, through internal resources and external collaborations.

**Ques. 15 : Briefly discuss the Second Stage of India's Nuclear Energy Programme?**

**Ans.**

***Fast Breeder Reactor Programme***

The second stage of nuclear power generation envisages setting up of fast breeder reactors (FBRs) backed by reprocessing plants and plutonium-based fuel fabrication plants. These fast breeder systems produce more fuel than what they consume. FBRs can increase fuel utilisation by about sixty times of what is possible with PHWRs.

IGCAR started the breeder programme with the setting up of a Fast Breeder Test Reactor (FBTR) at Kalpakkam, Tamil Nadu in October 1985. This reactor, operating with indigenously developed mixed uranium-plutonium carbide fuel has achieved its technology objectives.

Based on the experience gained with the FBTR, the Bharatiya Nabhikiya Vidyut Nigam Ltd. (BHAVINI-formed in October 2003) is constructing a 500 megawatt Prototype Fast Breeder Reactor (PFBR) at Kalpakkam, Tamil Nadu. It is a pool type reactor using a mixed oxide of uranium and plutonium as fuel, the design and technology of which were developed at IGCAR. The PFBR is expected to go critical in September 2012. The FBR

programme is poised to enhance the electricity potential in India through available uranium-metal resources by a factor of about 100.

The thrust of the R&D programme at IGCAR is oriented towards the design validation of PFBR in the first instance, and subsequently, the design optimisation for future FBRs, to reduce the cost.

***Fast Reactor Fuel Fabrication***

The Mark-I mixed carbide fuel core, with high plutonium content, has been developed for the first time in the world. Fabrication of Mark-II core is progressing at Trombay. A number of PFBR MOX fuel elements for making experimental PFBR subassembly, for irradiation in FBTR, have been fabricated by BARC.

***Fast Reactor Fuel Reprocessing***

For reprocessing of FBTR fuel, the lead Mini Cell, known as Compact Reprocessing facility for Advanced fuels in Lead cells (CORAL) has been commissioned at Kalpakkam. It is aimed at establishing the fast reactor reprocessing process flow sheet. For reprocessing of fuel from fast breeders, IOCAR is setting up the Fast Reactor Fuel. Reprocessing Plant (FRFRP). A comprehensive procedure has also been evolved at the Centre for the recovery of uranium and plutonium and separation of the radioactive fission products from the spent fuel solutions.

***Fast Reactor Technology Development***

Under the technology development programme, IGCAR is pursuing engineering related research & development such as thermal hydraulic and structural mechanics studies, development of components such as control and safety rod drive-mechanism and various test facilities such as Sodium Water Reaction Test Facility and Steam Generator Test Facility.

# BIOTECHNOLOGY

## Meaning, Scope and Organisational Set Up

### A. Concept

Biotechnology is the use of complete living cells or part of living cells to produce new or improved products of service systems. According to the U.S. National Science Foundation Biotechnology consists of "the controlled use of biological agents, such as, micro-organisms or cellular components, for beneficial use." The European Federation of Biotechnology define "Biotechnology as the integrated use of biochemistry, microbiology, molecular biology and engineering sciences in order to achieve technological application of the capabilities of micro-organisms, cultured tissues/cells and part thereof". In the modern context, an illustration of biotechnology would be the practice, for centuries, of fermentation of wine into alcohol using micro-organisms.

### B. Background

The crucial advance in biotechnology that laid the foundation took place in 1972 when the first successful venture namely direct insertion of foreign DNA, the genetic material, in a host organism was carried out in the U.S.A. The technique was termed recombinant DNA (rDNA) technique. This in effect opened up immense possibilities of direct manipulation of the genetic material, the blueprint of all living organisms, to produce chemicals and other products needed by man. This pioneering work resulted in the award of the Noble prize to Professor Paul Berg of Stanford University and others. The rDNA technique along with "cell fusion" -or "hybridoma" technology constitutes broadly the areas of modern biotechnology. The cell fusion technique was developed in 1971 by Dr. Milsein Kohler and Jeme. As a reaction to an antigen the host organism produces what are called antibodies. This is basically a defence mechanism. The

cell fusion technique has immense potentialities for specific diseases arising out of viral, bacterial and other microbial infection. A distinction is made between 'non-gene biotechnology' and 'gene biotechnology': the former works with whole cells, tissues or even individual organisms; the latter deals with transfer of genes from one organism to another or genetic engineering. Non-gene biotechnology is a more popular practice, and plant tissue culture, hybrid seed production, microbial fermentation, production of hybridoma antibodies are widespread biotechnology practices in our Country.

## C. Organisation And Manpower

In 1982, Government of India setup the National Biotechnology Board which was replaced by a separate Department of Biotechnology (DBT) in the Ministry of Science and Technology in 1986. This was in recognition of the need for a focal point in the administration and structure of the government for planning promotion and co-ordination of biotechnological programme. The main responsibilities of the Department of biotechnology are:

i)To evolve integrated plans and programmes in biotechnology;

ii)To identify specific R&D programmes in biotechnology and biotechnology related manufacturing;

iii)Establishment of infrastructure support at the national level;

iv )To act as an agent of the Government for import of new recombinant DNA based biotechnological processes, products and technology;

v)To evolve bio-safety guidelines for laboratory research production and applications;

vi)To initiate scientific and technical, efforts related to biotechnology;

vii)Programmes of manpower development in the areas of biotechnology;

viii)Establishment of international centre for genetic engineering and biotechnology,

## D. Institutions

1.Centre for DNA Fingerprinting and Diagnostics (CDFD), Hyderabad: CDFD provides service for DNA fingerprinting, diagnostics, bioinformatics and automated genome analysis and undertakes research and developments in the area of genetics, molecular and cellular biology, molecular pathogenesis and bioinformatics.

2.Institute of Bio Resources and Sustainable Development (IBSD), Imphal (Manipur): IBSD has been established with to develop utillse the rich bio-resources of the North-Eastern region of the country through the application of modern tools of biology and biotechnology. The institute works on medicinal, horticultural, microbial, insect and aquatic resources as well as eco restoration.

3.Institute of Life Science (IIS), Bhubaneshwar: The Institute of life sciences has been established to conduct basic and applied research in frontiers areas of life sciences, to promote interaction among scientists, conduct inter-disciplinary research and for dissemination of scientific knowledge.

4.National Institute of Immunology (NII), New Delhi: NII's primary responsibility is to help create the scientific base for innovations of relevance for the development of the nation. Its main areas of research are infection and immunity, molecular design, gene regulation and reproduction and development.

5.National Centre for Plant Genome Research (NCPGR), JNU, New Delhi: NCPGR works in core research area of plant genomics covering structural, functional and application components of genomics. The institute has been working on nutritional genomics of potato, structural and functional genomics of chickpea.

6.National Brain Research Centre (NBRC), Gurgaon: NBRC undertakes basic research to understand brain function in diseases

and normal conditions. NBRC has established networking centres with 35 foreign institutions like NIMH, USA for research co-operation and training.

7.National Centre for Cell Sciences (NCCS), Pune: NCCS undertakes research and development at the cutting edge of cell sciences, teaching, training in addition to providing services as a national repository for cell lines and hybridomas. NCCS has developed technologies for preservation and revival of bone marrow stem cells which led to a successful transplantation in a neuroblastoma patient.

8.International Centre for Genetic Engineering and Biotechnology (ICGEB), New Delhi: ICGEB focuses on basic research in human diseases and agriculture, especially to look at problems of the Indian subcontinent. IGCEB has 'state-of-art' facilities and it will be a National facility to be used by scientific community. It has developed technology for hepatitis C disgnostic kit and a malaria vaccine program is progressing as per time Schedule.

9.Bharat Immunological and Biological Corporation Limited (BIBCOL), Bulandshahr: BIBCOL, a public sector undertaking has the most modern manufacturing unit based on good manufacturing practice requirements as specified by WHO and US Federal standards.

10.Biotechnology parks and incubators: The Biotechnology Parks and Biotech Incubation Centres established provide a good template for the promotion of Biotech startup companies and the promotion of Public Private Partnerships. Biotech Park and incubation Centres have been established at Lucknow, UP and Shapoorji Pallonji Biotech Park, Genome Valley, Hyderabad (AP). The other projects approved for Himachal Pradesh, Karnataka and Kerala for setting up of biotech incubation/pilot plant facilities are at various stages of development.

### (E) National Bio Resource Development Board (NBDB)

Following the Finance Minister's Budget Speech, 1999, a National Bio Resource Development Board (NBDB) has been set up under the chairmanship of Minister of Science and Technology. NBDB shall decide the broad policy framework for effective application of biotechnological and related scientific approaches for R&D and sustainable utilisation of bio-resources, especially for development of new products and processes. It shall develop a scientific plan of action for contribution to the economic prosperity of the nation through accelerated research and development using the modern tools of biosciences. The NBDB shall adopt both resource based and region- based approaches. It shall also be involved in training, capacity building and awareness generation in bio-resources.

A National steering committee has been constituted to support the activities of the board; the board has identified 3 priorities:

1.Preparation of digitised inventories of plant, animal, microbial and marine resources.

2.R&D projects, programmes support, establishment of centres of excellence, training activities and demonstrations, for the development of bio resources of special areas such as North-eastern region, Himalayan region, coastal and land ecosystems, desert region etc.

3.Knowledge empowerment and human resource training would be a priority for the board.

### Ques. 1 : Give an account of the techniques of Biotechnology?

**Ans.** The main techniques of biotechnology are - genetic engineering, cell culture, tissue culture, bio-processing, protein engineering, monoclonal antibody production and biosensor technology. As has been recognised all over the world, in the last fifteen years, there has been

revolution in the field of Biotechnology as evidenced through new discoveries and inventions in the areas of isolation and manipulation of genes, better understanding of biological molecules, the advent of recombinant DNA technique enabling the genes to be transferred between organisms to produce scare proteins of plant and animal origin as also human growth factors and hormones.

**Ques. 2 : Discuss in brief the Genetic engineering?**

**Ans. Genetic Engineering :** The utilisation of genetic machinery of life for production of any special substance is called gene technology or genetic engineering. The genetic modification of micro- organisms, so vital for their utilisation in the production of useful biochemical, can be brought about by simple recombination or by complex genetic manipulations. Some of the techniques are:

Isolation of Genes: Appropriate sequence of genes is directly obtained from genome of normal cell or from other cells. This is made possible by cleavage and denaturation of DNA extracted from the cells.

Synthesis of Genes: This is done by chemical methods. Dr. Hargobind Khurana reported this in 1970.

Recombinant DNA: Breakage of DNA molecule at two desired places to isolate a specific DNA fragment and then inserting it in another DNA molecule at a desired position results in a new gene product which is called as recombinant DNA (r-DNA). The receiving organism is said to be transgenic. Using this technique we can isolate and clone single copy of a gene or a DNA molecule into an indefinite number of copies, all identical.

Gene Cloning: Isolation of gene and replication of a single copy of gene or DNA segment into an infinite number of copies, all identical, is known as gene cloning. This becomes possible because vectors like plasmids and phages reproduce in their usual style even after insertion of foreign DNA. This inserted DNA will also replicate faithfully with parent DNA. Recently extensive use of newly discovered polymerase chain reaction (PCR) has also been made for gene technology.

**Ques. 3 : What is Tissue Culture?**

**Ans. Tissue Culture :** Tissue culture is the technology of artificially growing micro-organisms or cells or tissues or organs to the desired genetic purity with properties such as high yield and disease resistance.

The microbes in culture are used in recombinant DNA technology and in a variety of industrial processes, plant cells and tissues are used for a variety of genetic manipulations. For example another culture is used for haploid breeding; gametic and somatic cell/tissue cultures are used for tapping gametoclonal and somaclonal variations or for production of artificial seeds. Transformation of protoplast in culture leads to production of useful transgenic plants. Embryo culture technique has also helped extending the range of distant hybridisation for plant breeding purposes. Animal cells are used for multiplication of superior livestock using a variety of techniques like Cloning of superior embryonic cells, transformation of cultured cells leading to the production of transgenic animals and in vitro fertilisation and transfer of embryos to surrogate mothers.

**Ques. 4 : Briefly discuss microbial biotechnology?**

**Ans. Microbial Biotechnology :** Micro organisms have been harnessed by man for the production of useful materials. The latest initiatives in Microbial Biotechnology have been taken in the following matters:

i)Rehabilitation of degraded land such as alkaline soil, mine dumps and dump from metallurgical factories, utilising microbial supports.

ii)Dissolution of pyretic shells by microbial

methods to liberate entrapped noble metals like gold, silver etc. through the process of bio-techning of low and lean grade orders.

iii)Degradation of polyphenolic compounds using microbial approaches.

iv)Standardisation of shuttling vectors for E-coli and streptomyces having capabilities of accepting chester genes of Ansamycines.

v)Strengthening of microbial teaching and research in identified universities.

vi)Development of fungicides to contain fungal infections in plants and vegetables.

vii)Development of microbial enzymes active in extreme temperatures, novel antibiotics and bioactive proteins and other bio-molecules for industrial use.

**Ques. 5 : Briefly discuss the concept of Human Genetics?**

**Ans. Human Genetics :** Genetic diseases have posed a serious threat to the health in the Indian population. This has led to an increased demand for genetic counselling and screening tests both for carrier detection and for identifying pregnancy at risk. Currently prenatal diagnosis is possible for most chromosomal disorder and many major congenital malformations.

Diagnostic services are being provided to Thalassemia affected families and prenatal diagnosis of pregnant women in those families. In AIIMS, New Delhi investigations relating to haemophilia are carried out in various families affected by the disease and prenatal diagnosis had helped in identifying the foetus that carries the disease in pregnant women in those families. In North-east, Sickle-Cell anaemia was traced in certain tribal populations through screening of blood samples for Haemoglobin-E in those persons. Based on the haematological results, it has been possible to construct a linear discriminate function to identify suffering individuals with an error probability of less than 5%.

Formation of gene is a very complex issue. Scientists have not achieved full control over their formation. Indian Scientists have developed good expertise to understand gene structure and therefore, it would be possible to identify genetic defects.

Genes consists of DNA. Each gene has a different sequence of bases. Each sequence has coded information that ultimately leads to the production of a specific protein. These molecules govern several life processes. Specific clinical trials are under way in case of a few selected genetic disorders. Gene therapy is being tried only in terminal cases or where there is no other avenue for survival. It is hoped that gene therapy will become a serious option in about 5 to 10 years.

**Ques. 6 : What is DNA fingerprinting? Discuss its importance?**

**Ans. DNA Fingerprinting :** DNA finger printing technique was first developed by ALEC JEFFREYS in 1985- 86 in UK. DNA finger printing is a technique, by which an individual can be identified at molecular level; the technique identifies the repeating sequences in the DNA that are unique to a particular individual.

DNA is the basic genetic material. It not only carries a blue print for our life, but also varies significantly from one person to another. What DNA fingerprinting does is to look inside DNA, regions of DNA that show a great deal of variations from one person to another. These regions account for a small proposition of our genetic material, but the variations are such that we can locate these regions, highlight and identify them using DNA probes and obtain a pattern, a series of bands or stripes on X-ray film. These DNA patterns / sequences are essentially unique to an individual, except in case of identical twins who have the same DNA.

The samples required for DNA fingerprinting examination are drop of blood, semen, saliva,

and any body part such as bones, tissue, skull teeth, hair with root etc.

DNA fingerprinting has revolutionised forensic medicine and its applications now, encompass broad areas. The technology has made it possible to identify the source of biological samples at scenes of crime. This will resolve disputes of maternity paternity, identification of mutilated remains, identifications of rape/murder, identification of missing child, exchange of babies in hospital words, forensic wildlife, investigate family relationships in animals, protection of farmers rights and biodiversity (technology was used to prove the genetic distinctiveness of Indian Basmati rice composed to Pakistani variety).

Latent of fingerprint was discovered by Sir William Hesschel, a British revenue office in British India in 1860. Latent fingerprint is the identification of the individual by the impression of the fingers. While DNA fingerprinting is the identification of an individual, by the genetic markers, which are present on chromosomes. Latent fingerprints can be distorted by surgery. Latent fingerprint despite its limitations has come to be a handy tool in crime investigation over the last 140 years.

In India, DNA fingerprinting using B Km probe has been developed by Dr. Lalji Singh at Centre for Cell and Molecular Biology (CCMB), Hyderabad. DNA fingerprinting tests are performed at centre for DNA fingerprinting and diagnostics (CDFD). Hyderabad, a new DNA typing laboratory has been established Central Forensic Science Laboratory at Kolkata by the Bureau of Police Research and Development. Thus, the country has two DNA typing facilities.

**Ques. 7 : What is Hybridoma?**

**Ans. Hybridoma :** Hybridoma is a cell produced by" fusion of an antibody- producing cell and a mycloma cell (tumour of B-lymphocyte). The technique of fusing mycloma cell with antibody-producing cell is called somatic cell hybridisation. Kohler and Milstein were awarded Nobel Prize in medicine in 1984 for the development of 'hybridoma'. The value of hybridomas was not appreciated until monoclonal antibodies were regularly produced in rodents for diagnostics.

**Ques. 8 : What is Monolonal antibodies? Point out its uses?**

**Ans.** Monoclonal antibodies are:

•Antibodies of exceptional purity and specificity

•Components of immune system

•Able to recognize and bind to a specific antigen.

Monoclonal antibodies (m Ab) are antibodies* that are identical because they are produced by one type of immune cell, all clones of a single parent cell.

***Production***

If a foreign substance (an antigen) is injected into a vertebrate such as a mouse or a human, some of the immune systems B-cells will turn into plasma cells and start to produce antibodies that bind to that antigen. Each B-cell produces only one kind of antibody, but different B-cells will produce structurally different antibodies that bind to different parts ("epitopes") of the antigen. This natural mixture of antibodies is known, as polyclonal antibodies.

To produce m Ab, B-cells from the spleen of an animals which have been challenged with antigen are removed. These b-cells are then fused myeloma cells (myeloma is a B-cell cancer/ tumour). The fused hybrid cells (hybridomas), being cancer cells, multiply rapidly and produce large amounts of antibodies. From the hybridomas, we can obtain a number of different colonies but each colony produces only one type of antibody (hence MONOCLONAL). Among the various types of antibodies, the variety that effectively bind with antigen is then picked out.

***Uses***

Monoclonal antibodies are widely used as diagnostic and research reagents. They are

currently utilized in many diagnostic procedures including:

•Measuring protein and drug levels in serum

•Typing tissue and blood

•Identifying infectious agents

•Identifying the specific cells involved in immune response

•Identifying tumour antigens and auto-antibodies.

**Ques. 9 : What is Artificial Insemination?**

**Ans. Artificial Inseminations :** Artificial Insemination (AI) is the artificial introduction of semen into the reproductive tract of female.

Depending upon the location of sperm insemination, Artificial Insemination is of different types:

a)Intra-cervical: semen placed into the cervical canal

b)Intra-uterine: semen inseminated inside the uterine cavity

c)Intra-follicular: semen introduced in the ovarian follicle

d)Intra tubal: semen placed in the fallopian tube.

Of the 4 different forms of Artificial Insemination, intrauterine insemination (IUI) is the most commonly used form.

**Ques. 10 : Discuss in brief the Artificial Insemination in animals?**

**Ans. Artificial insemination in animals :** Modern techniques for AI were first developed for the dairy cattle industry to allow many cows to .be impregnated with the-sperm of a bull for improved milk production, Now AI is used in various animals like horses, swine, pedigreed dogs, honey bees etc to propagate desirable characteristics of one male to many females or to overcome breeding problems.

In Artificial Insemination, the semen that is going to be inseminated is first collected, then frozen and later transported to the female's location. To allow the sperm to remain viable during the time before and after it is frozen, the semen is mixed in with a solution containing glycerol, in order to allow the semen from a donor to impregnate more female, an "extender" solution is added-to the donor semen so that insemination is possible with fewer sperms. Antibiotics such as streptomycin diseases, (sexually- transmitted diseases)

**Ques. 11 : What do you understand by Human Artificial Insemination?**

**Ans. Human Artificial insemination :** In humans, Artificial Insemination is usually part of an infertility treatment. The sperms are either of husband (artificial insemination by husband, AIH) or donor (artificial insemination by donor, AID).

In its simplest form, the women's menstrual cycle is closely observed and just when an ovum is released, semen from donor is place in women's reproductive tract. If the procedure is successful, she conceives and bears a baby, making her both the genetic and gestational mother.

Artificial Insemination is recommended when these are structural abnormalities in women, moderate male factor infertility, cervical mucus insufficiency, hostile cervical mucus etc.

Artificial Insemination is advantageous over invasive procedures like In Vitro fertilisation (IVF) as it is less invasive, relatively uncomplicated, and economical. Artificial Insemination however has resulted in debated revolving around surrogate parenting. Legal issues have arisen in cases where the gestational (and possibly genetic) mother decides to keep the child. Also, there have been debates over thoughts of sperm donors. Some also argue that conceiving a baby without sexual intercourse is not ethical.

**Ques. 12 : Briefly discuss the In vitro**

**fertilization?**

**Ans. In Vitro Fertilisation (Test Tube Baby):** 'In vitro' in Latin means 'in glass' refers to the test tubes, But in 'in vitro' fertilisation neither glass or test tubes are being used, this term (in vitro) is used generally for lab procedures.

In Vitro Fertilization (IVF) is a major treatment in infertility when all other methods of achieving conception have failed. IVF is a technique in which egg cells are fertilized outside the woman's body.

In this technique, ova (eggs) are removed from woman's ovary and sperms are allowed to fertilize them in a fluid medium. The fertilized egg (zygote) is then transferred to the female's uterus to establish a successful pregnancy.

The first ever 'test-tube baby' Lousie Brown was born on July 25, 1978 by this technique. This technique was developed to overcome infertility due to problems of fallopian tube, but is now the most successful method to overcome infertility cost considerations are the major drawback of this technique.

**Ques. 13 : Give an account of Embryo Transfer?**

**Ans. Embryo Transfer :** Embryo transfer refers to a step in process of In Vitro Fertilization (IVF) where one or several embryos are placed into the uterus (womb) of female in order to establish a pregnancy. In IVF, fertilisation between egg and sperm occurs outside female body. Once, fertilization occurs, the resulting embryo has to be transferred back into womb for its development. This method of transfer of fertilized egg is called embryo transfer.

Embryo can be transferred as either "fresh" from fertilized egg cells of same menstrual cycle or "frozen" (i.e.) they have been generated in a preceding cycle and then cryopreserved. Before the embryo is implanted inside the womb it must be-ensured that the uterine wrong (endometrium) is appropriately prepared. The embryo's are generally transferred 3 days after fertilization. The procedure of embryo transfer is preferred with the aid of ultrasound to allow for precise placement.

The Science and Technology project on Embryo Transfer Technology being implemented in mission mode since 1987 had been successfully completed. The embryo recovery in cattle and buffalo and establishment of embryo transfer and related techniques had come close to the international standards. The four Regional Centres and 25 State Level Centres would provide the infrastructure for training and actual application/ utilisation of this technology. A stock of superior germplasm has beer established to provide 100 embryo free of cost to the milk co-operative societies to benefits the farmers. A large number of scientists have been trained and the expertise has been developed in the areas of super ovulation, embryo splitting, cryopreservation etc. The technology packages generated under this project will be transferred to the National Dairy Development Mission and the National Bull Production Programme. Considerable progress was made on embryo sexing, splitting and in vitro fertilization and maturation other activities in the area of animal birth control vaccine, TALSUR; establishment of the genetically superior stock of cattle; improvement in the growth rate of poultry broilers, development of immuno-diagnostics are under implementation with promising results. The open nucleus breeding system (ONBS) for production of crossbreed Sahiwal Bulls in under progress and the first batch of bulls is expected soon.

**Ques. 14 : What is Recombinant DNA technique? Point out its uses?**

**Ans. Recombinant DNA** : Recombinant DNA is any DNA molecule that has been manipu-

lated by in vitro procedures to create a novel sequence. The recombinant molecule produced may have a modified base sequence or contain sequences from two or more different genes or organisms. They are usually introduced into an organism to create a novel protein or R NA molecule that alters the properties of the organism.

Major recombinant DNA techniques include site-directed mutagenesis, doming and polymerase chain reaction (PCR). Key enzymes required for recombinant DNA work are type II restriction enzymes: DNA Ligase, DNA polymerase, reverse transcriptase and ON.A phosphatase.

Some of the uses of recombinant DNA techniques are:

•To done genes

•To knock out a gene in an organism

•To create: anti-sense RNAs in an organism so as to interfere with gene expression.

•To add a gene(s) to an organism to engineer a new or modified metabolic pathway.

## Ques. 15 : What is proteome?

**Ans. Proteome :** 'Proteome' means protein complement expressed by a genome, the proteome all the expressed genes or proteins of a genome., A cell type may display numerous sub proteomes under different growing conditions, nutrition status, health or disease "Proteomics" is the use of quantitative measurements of the level of a protein or gene expression to characterize biological processes to decipher the mechanism and control of gene expression. Proteome research / proteomics is the best path between genome and function studies.

### ¨ Glossary of Biotech Terms

1.Antibody: is a protein secreted by B-Lymphocytes in response to an antigen.

2.Antigen: is a foreign substance that induces the formation of antibody.

3.Myeloma: is a tumour of B-lymphocyte cells arising in the bone marrow,

4.Bacteriophage: a virus that infects bacteria; also called a phage.

5.Biocatalyst: An enzyme that activates or speeds up a chemical reaction.

6.Biocatalyst: is a container used for bioprocessing.

7.Bio Processing: A technique in which microorganisms, living cells or their components are used to produce a desired end product. Bio processing of biotech products consists of 2 major processing steps:

1. Up streaming process: refers to the culturing of micro erg an isms to create a bulk bio product. This processing is typically done using cell culture or fermentation.
2. Down streaming process: refers to reparation and processing of bulk bio product into a form suitable for its end-use. Typically, this step involves separation, purification and sterilisation.

8.Callus: A duster of undifferentiated plant cells that have the capacity to regenerate a whole plant in some species. This term is used in tissue culture technique.

9.Clone: a cell or collection of cells containing identical genetic material. Clones are produced from a single parent cell.

10.DNA typing: more popularly called as DNA fingerprinting.

11.DNA probe: A molecule that has been labelled with a radioactive isotope, dye or enzyme and is used to locate a particular portion of a DNA molecule.

12.DNA sequence: .The order of nucleotide bases in the DNA molecule.

13.In vitro: performed in a test tube or other laboratory apparatus.

14.In vivo: in the living organism.

15.Interferon: A protein produced naturally by the cells of our body. It increases the resistance

of surrounding cells to attacks by viruses.

16. Interleukin: A protein produced naturally by our bodies to stimulate our immune systems.

17. Gene Amplification: The increase, within a cell, of the number of copies of a given gene.

18. Genome: The total hereditary.-material of a cell.

19. Gene Mapping: determining the relative locations of genes on a chromosome.

20. Plasmid: A small circular piece of DNA found outside the chromosome in bacteria. Plasmids are the principal tools for inserting new genetic information into micro organisms or plants.

21. Vector: The agent used to carry new DNA into a cell, viruses or plasmids are often used as vectors.

22. Transposon: A mobile genetic element that can move from one location in the gene and reinsert at another site.

23. Restriction Enzymes: Bacterial enzymes that cleave DNA at very specific location,

24. Protein Engineering: A technique used on production of proteins with new or artificial amino acid sequences.

25. Polymerase Chain Reaction (PCR): A technique for quickly making many copies of a specific segment of DNA.

26. Anti-Sense Technology: The use of an RNA molecule to block gene expression by interfering with protein production. This technique is used commercially in tomatoes to slow ripening for better shipping and longer shelf life.

27. Gene Expression: The physical manifestation of the information contained in a gene,

28. Pleuripotent Stem Cells: are the multi-potential cell populations capable of developing into various specialized cells and tissues of body such as muscle cells, nerve cells, fiver cells blood cells etc.

29. Stem Cell Lines/Colonies: A stem cell line is a self-replenishing colony of embryonic cells.

# Applications of Biotechnology

1. Medicine (Health Care)

- Prevention
  - Vaccine
  - Gene therapy
  - Genetic counselling
- Diagnosis
  - Diagnostic kits and pathological kits
  - DNA probes
  - Monoclonal antibodies
- Therapeutics
  - Antibiotics
  - Hormones
  - Interferon
  - Dotting factor
  - Usokinase
  - Transcription factor based drugs
  - Digonucleotide antisense drugs
  - Drug delivery systems.
  - Other
  - DNA fingerprinting and Applications auto antibody finger-printing
  - Fertility control (oral pills)

2. Agriculture

- Productivity
  - (1) Photosynthesis improver
  - (2) Transgenic plants
  - (3) Tissue culture
  - (4) Bio fertilisers
- Diversity
  - Hybrid seeds
  - Synthetic/Artificial seeds
- Resistance
  - Disease, drought, pest resistant varieties
- Allied Areas
  - (1) Seribiotechnology
  - (2) Aquaculture
  - (3) Animal husbandry
  - (4) Food biotechnology

3. Environment and Energy
- Bioremediation
- Bio indicators
- Biodegradation
- Biomass production
- Bio fuels

4. Industry
- Fermentation products
- Mining (Bioleaching)
- Vaccines
- Steroids
- Chemicals
- Vitamins

5. Biotech Instruments
- Biosensors
- Cell analyser
- DNA/peptide synthesisers