BTY 304 MEDICAL & INDUSTRIAL BIOTECHNOLOGY

UNIT 1

Topic : Role of Biotechnology in helath

Biotechnology is a broad field that deals with the exploitation of living organisms to develop products beneficial for sustainable development. It harnesses cellular and molecular processes to develop products and technologies that could help in improving human life on earth. It has a variety of applications that focus on human welfare. Let us have an overview of major Biotechnology applications and its scope in today's scenario.

Biotechnology Applications

Biotechnology is widely used in different fields such as medicine, agriculture, food processing, etc. to produce useful products for human benefits.

The major biotechnology applications are discussed below in detail.

Biotechnology Applications in Medicine

Biotechnology has a variety of applications in the field of medicine. Some of the biotechnology applications in medicine include the following:

Recombinant Insulin

Insulin is required by diabetic patients to remove excess sugar from the blood. Diabetic patients have a very low level of insulin or no insulin produced by the body. Therefore, they need external insulin to control blood glucose levels.

Later it was discovered that the insulin produced by the pancreas of the pigs can be used by humans. But there were not enough pigs to provide the quantities of insulin required. This led to the cloning of the human insulin gene.

The specific gene sequence that codes for human insulin were introduced in *E.coli bacteria*. The gene sequence altered the genetic composition of the *E.coli* cells. Within 24 hours several *E.coli* bacteria containing the recombinant human insulin gene were produced. The recombinant human insulin was isolated from *E.coli* cells.

Gene Therapy

Gene Therapy holds the most promising answer to the problem of genetic diseases. Gene therapy is used to treat genetic disorders usually by the insertion of a normal gene or correct gene for the defective or inactive gene into an individual with the help of vectors such as retrovirus, adenovirus, and herpes simplex virus.

The normal gene replaces the defective or inactive gene and carries out its functions. The therapy has the highest chances of developing a permanent cure if introduced in the earliest stages of life.

Detailed Insight: Gene Therapy

Molecular Diagnosis

Medical diagnosis is another application of biotechnology in the health sector. Many times the pathogen concentration increases by the time the disease is diagnosed. Hence, early diagnosis and knowledge of pathophysiology are essential for an effective cure. This can be achieved with the help of techniques such as Recombinant DNA Technology, Polymerase Chain Reaction (PCR) and Enzyme-Linked Immunosorbent Assay (ELISA), etc.

Pharmacogenomics

Pharmacogenomics has led to the production of drugs that are best suited to an individual's genetic makeup. It can be applied in diseases such as cancer, depression, HIV, asthma, etc.

Edible Vaccines

Vaccines are obtained by animals and cell cultures. These vaccines contain inactivated pathogens.

The transgenic plants can produce antigens that can be used as edible vaccines. Antigenic proteins from several pathogens can be expressed in plants such as tomato and banana. Transgenic sugarbeet can treat foot and mouth disease of animals, transgenic banana and tomato can cure diseases such as cholera and hepatitis B.

Importance of Biotechnology in Human Life

Biotechnology plays a very important role in human welfare and has revolutionized mankind since its existence. It contributes much towards the human welfare and their health needs.

A few of them are listed below:

Biotechnology In Agriculture

The application of biotechnology in the agriculture field helps in improving food quality, quantity, and processing. Bio-fertilizers and bio-pesticides are eco-friendly sources for agriculture, which contain living microorganisms that help in promoting growth by increasing the supply or availability of primary nutrients. Farmers choose biotech crops to increase the yield and lower production costs.

Biotechnology in Medicine

In the field of medicines, biotechnology is widely used in the development of several innovative techniques for diagnosing, treating and preventing diseases. It helps in providing effective treatments and prevention measures for different diseases through its inventions of novel drugs and recombinant vaccines.

Therapeutic proteins have a greater effect against a variety of non-communicable diseases, which were responsible for over 50-60% of deaths in developing countries.

With the help of modern biotechnology, many diagnostic tools have been introduced for the detection of diseases in a quick and accurate manner.

Biotechnology in Flora and Fauna

Biotechnology develops the process of **micropropagation** system, a new method of plant breeding for producing many new plant species and new varieties with highly desirable characteristics.

Productions of genetically engineered plants with highly desirable characteristics have been very effective. These crops result from the alteration in the genetic makeup of the crops and this modification leads to a number of potential advantages including the production of crops, quality of crops, increased nutritional qualities of food crops, improved taste, texture or appearance of food, reduced dependence on fertilizers, pesticides and other agrochemicals and lot more.

Biotechnology has a wide application in animal husbandry. Several transgenic animals were produced to transfer the growth hormones and improve the efficiency of egg, meat and milk production.

Biotechnology in Environment

Biotechnology is also involved in controlling environmental pollution through biodegradation of potential pollutants, recycling of wastes and other waste treatment technologies.

Biotechnology plays a major role in monitoring and controlling environmental pollution through biological applications including bioremediation, biomonitoring, biotreatment and biodegradation of all solid, liquid and gaseous wastes. Apart from these, there are many other biotechnological treatments applied to monitor the different components of the environment.

Biotechnology in Human Health and their Welfare

Biotechnology has been playing a dynamic role in improving the challenges regarding human health and welfare. There are many more research and investigation processes carried out for improving future technologies.

Biotechnology has played a significant role in improving human health by producing enriched **nutrients** in food products such as Golden Rice, potatoes, maize, groundnuts, soybean etc.

Topic : Hepatitis vaccine-B development

A plasma-derived Hepatitis B (HepB) vaccine was first licensed for use in the United States in 1981. The vaccine was safe and effective but was not well accepted, possibly because of unsubstantiated fears of transmission of live HBV and other blood-borne pathogens. Recombinant HepB vaccines replaced plasma-derived HepB vaccines beginning in 1986. Plasma-derived HepB vaccines are no longer used in the United States.

Hepatitis B Virus (HBV)

HBV is a small, double-stranded DNA virus in the family Hepadnaviridae. Serologic markers for HBV infection include HBsAg, antibody to HBsAg (anti-HBs), immunoglobulin class M (IgM) antibodies to hepatitis B core antigen (IgM anti-HBc), and immunoglobulin class G (IgG) anti-HBc (IgG anti-HBc). At least one serologic marker is present during the different phases of infection. Hepatitis B e antigen (HBeAg) can be detected in persons with acute or chronic HBV infection; the presence of HBeAg correlates with viral replication, high viral levels of HBV DNA, and high infectivity; antibody to HBeAg (anti-HBe) usually correlates with the decrease of replicating virus, although reversion to HBeAg positivity can occur.

HBV has been classified by two separate systems: serologic subtype and genotype. Nine serologic subtypes based on the heterogeneity of HBsAg have been described. Ten HBV genotypes, designated A through J, have been described. HBV serotypes and genotypes vary geographically. HBV genotypes are associated with the modes of HBV transmission (vertical versus horizontal) and with the risk of certain outcomes of chronic infection, such as cirrhosis and hepatocellular carcinoma (HCC). For example, in Alaska, HBV genotype F is associated with HCC in children as well as adults younger than age 30 years, while in Asia as

well as Alaska, HBV genotype C has been associated with a significantly higher risk of HCC than other genotypes. Infection or immunization with one HBV genotype generally confers immunity to all genotypes.

HBV remains infectious for at least 7 days on environmental surfaces and is transmissible in the absence of visible blood.

Pathogenesis

HBV is transmitted by parenteral or mucosal exposure to HBsAg-positive body fluids from persons who have acute or chronic HBV infection. It replicates in hepatocytes through a unique reverse transcription process.

Hepatitis B Vaccine

The first recombinant HepB vaccine, Recombivax HB, was licensed in the United States in 1986. A second recombinant vaccine, Engerix-B, was licensed in 1989. Recombivax HB and Engerix-B are available in both pediatric and adult formulations. A third recombinant vaccine with a novel adjuvant, Heplisav-B, was licensed in 2017 for use in adults age 18 years or older. HBV infection cannot result from use of the recombinant vaccine since no potentially infectious viral DNA or complete viral particles are produced in the recombinant system.

There are two combination vaccines that contain HepB vaccine. DTaP-HepB-IPV (Pediarix) is licensed for children age 6 weeks through 6 years. HepA-HepB (Twinrix) is licensed for persons age 18 years or older. A third combination vaccine, DTaP-IPV-Hib-HepB (Vaxelis), is licensed in the United States.

Hepatitis B Vaccine Characteristics

- Administered by intramuscular injection
- Contain yeast protein
- Contain aluminum adjuvant (Engerix-B and Recombivax HB) or synthetic adjuvant (Heplisav-B)
- Some presentations contain latex
- Ingredients in combination vaccines differ; all contain antibiotics

Characteristics

Recombinant HepB vaccine is produced by inserting a plasmid containing the gene for HBsAg into yeast (Saccharomyces cerevisiae or *Hansenula polymorpha*); HepB vaccines contain yeast protein. HepB vaccines are administered by intramuscular injection. Each dose of HepB vaccine contains aluminum as an adjuvant or, for Heplisav-B, a small synthetic immunostimulatory oligodeoxynucleotide 1018 adjuvant. Each dose of DTaP-HepB-IPV contains antibiotics neomycin and polymyxin B; each dose of DTaP-IPV-Hib-HepB

contains neomycin, polymyxin B, and streptomycin; each dose of HepA-HepB contains neomycin. HepB vaccines contain no preservative. Presentations of HepB vaccines contain latex rubber. Specific ingredients in combination vaccines containing HepB vaccine differ.

Recombivax HB and Engerix-B are available in both pediatric and adult formulations and are typically administered as a 3-dose series on a 0, 1, 6 month schedule. Although their antigen content differs, the two vaccines are interchangeable except for a 2-dose series for adolescents age 11 through 15 years, for which only Recombivax HB is approved. Heplisav-B is administered as a 2-dose series on a 0, 1 month schedule and is approved for persons age 18 years or older.

Hepatitis B Vaccination Schedule

- Infants: See Hepatitis B vaccine schedule for infants
- Adolescents: All children and adolescents through age 18 years not previously vaccinated
    - 3-dose series at 0, 1, 6 months
    - Adolescents age 11 through 15 years may use 2-dose series of Recombivax HB separated by 4 to 6 months
- Adults: All unvaccinated adults at risk for or requesting protection from HBV infection
    - 2-dose series at 0 and 1 month (Heplisav-B) or 3-dose series at 0, 1 and 6 months (Engerix-B and Recombivax HB)
    - 3-dose series at 0, 1 and 6 months (Twinrix)
    - 3-dose series with doses at 0, 7, 21-30 days, and booster 12 months after dose 1 (Twinrix, accelerated)

Vaccination Schedule and Use

Infants and Children

HepB vaccination is recommended for all medically stable infants weighing at least 2,000 grams within 24 hours of birth. Only single-component vaccine should be used for the birth dose and doses administered before age 6 weeks. The usual schedule is 0, 1 through 2, and 6 through 18 months.

All pregnant women found to be HBsAg-positive should have their sera tested for HBV DNA. If HBV DNA levels are greater than 200,000 IU/mL, Tenofovir (preferable) or lamivudine should be administered to the pregnant woman starting at the beginning of the third trimester and continued one to three months after birth. Infants born to mothers who are HBsAg-positive should receive the HepB vaccine birth dose and HBIG within 12 hours of birth. HepB vaccine and HBIG should be administered in separate limbs. For infants weighing less than 2,000 grams, the birth dose should not be counted as part of the vaccine series

because of potentially reduced immunogenicity; 3 additional doses of vaccine (for a total of 4 doses) should be administered beginning when the infant reaches age 1 month. Infants whose mothers are HBsAg-positive should receive the last dose by age 6 months but not before age 24 weeks.

Infants born to mothers whose HBsAg status is unknown should receive the HepB birth dose within 12 hours of birth. Infants weighing less than 2,000 grams should also receive HBIG within 12 hours of birth. The mother's HBsAg status should be assessed as soon as possible. If the mother is determined to be HBsAg-positive, infants weighing at least 2,000 grams should also receive HBIG as soon as possible but no later than age 7 days. As with infants born to HBsAg-positive mothers, for infants weighing less than 2,000 grams, the birth dose should not be counted as part of the vaccine series because of potentially reduced immunogenicity; 3 additional doses of vaccine (for a total of 4 doses) should be administered beginning when the infant reaches age 1 month. Infants with mothers whose HBsAg status is unknown should receive the last dose by age 6 months but not before age 24 weeks.

Preterm infants weighing less than 2,000 grams have a decreased response to HepB vaccine administered before 1 month of age. However, by chronologic age 1-month preterm infants, regardless of initial birth weight or gestational age, are as likely to respond as adequately as full-term infants. Preterm infants of low birth weight whose mothers are HBsAg-negative can receive the first dose of HepB vaccine at chronologic age 1 month. Preterm infants discharged from the hospital before chronologic age 1 month can receive HepB vaccine at discharge if they are medically stable and have gained weight consistently, even if they are less than 2,000 grams.

The third HepB dose must be administered at least 8 weeks after the second dose, and at least 16 weeks after the first dose. The minimum interval between the first and second dose is 4 weeks

UNIT-II

Topic: pcr amplification diagnosis in foresenic medicine

Polymerase chain reaction (**PCR**) is a common laboratory technique used to make many copies (millions or billions!) of a particular region of DNA. This DNA region can be anything the experimenter is interested in. For example, it might be a gene whose function a researcher wants to understand, or a genetic marker used by forensic scientists to match crime scene DNA with suspects.

Typically, the goal of PCR is to make enough of the target DNA region that it can be analyzed or used in some other way. For instance, DNA amplified by PCR may be sent for sequencing, visualized by gel electrophoresis, or cloned into a plasmid for further experiments.

PCR is used in many areas of biology and medicine, including molecular biology research, medical diagnostics, and even some branches of ecology.

Taq polymerase

Like DNA replication in an organism, PCR requires a DNA polymerase enzyme that makes new strands of DNA, using existing strands as templates. The DNA polymerase typically used in PCR is called ***Taq* polymerase**, after the heat-tolerant bacterium from which it was isolated (***T****hermus* ***aq****uaticus*).

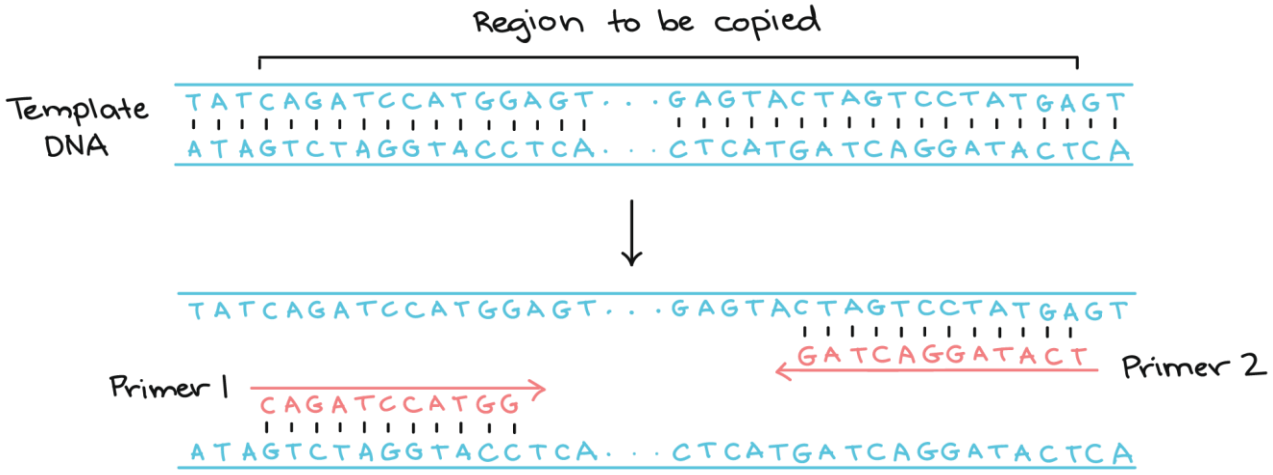
T. aquaticus lives in hot springs and hydrothermal vents. Its DNA polymerase is very heat-stable and is most active around (a temperature at which a human or *E. coli* DNA polymerase would be nonfunctional). This heat-stability makes Taq polymerase ideal for PCR. As we'll see, high temperature is used repeatedly in PCR to **denature** the template DNA, or separate its strands

PCR primers

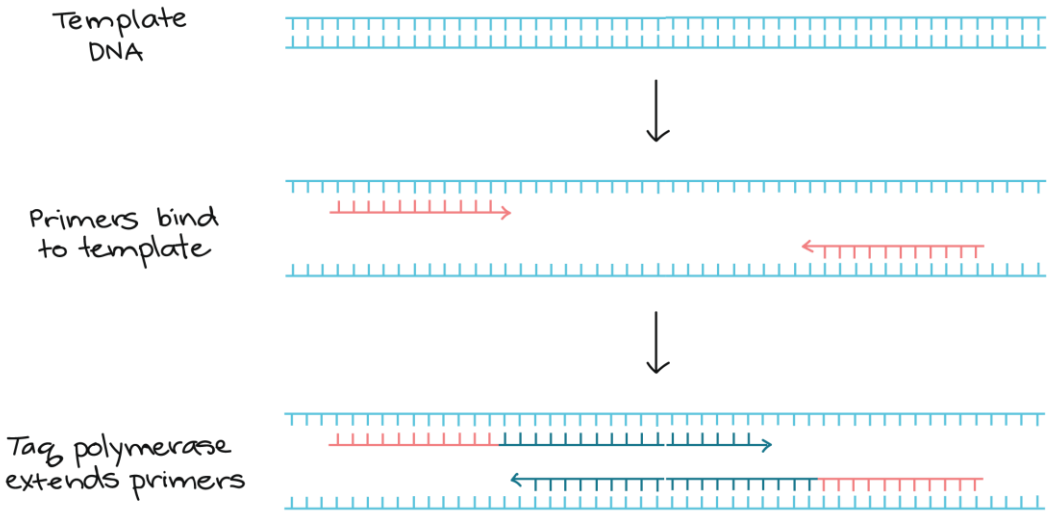
Like other DNA polymerases, *Taq* polymerase can only make DNA if it's given a **primer**, a short sequence of nucleotides that provides a starting point for DNA synthesis. In a PCR reaction, the experimenter determines the region of DNA that will be copied, or amplified, by the primers she or he chooses.

PCR primers are short pieces of single-stranded DNA, usually around nucleotides in length. Two primers are used in each PCR reaction, and they are designed so that they flank the target region (region that should

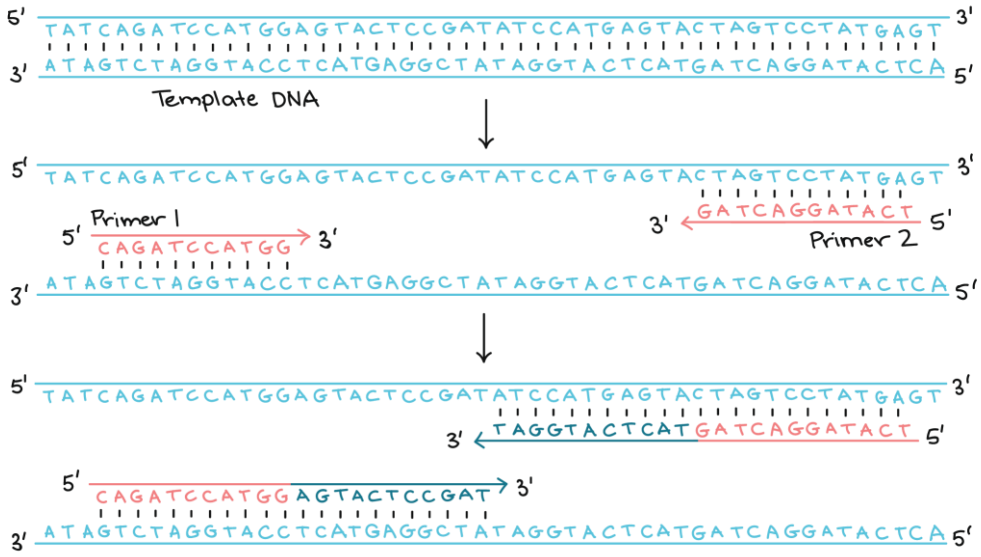
be copied). That is, they are given sequences that will make them bind to opposite strands of the template DNA, just at the edges of the region to be copied. The primers bind to the template by complementary base pairing.



When the primers are bound to the template, they can be extended by the polymerase, and the region that lies between them will get copied.



More detailed diagram showing DNA and primer directionality



The steps of PCR

The key ingredients of a PCR reaction are *Taq* polymerase, primers, template DNA, and nucleotides (DNA building blocks). The ingredients are assembled in a tube, along with cofactors needed by the enzyme, and are put through repeated cycles of heating and cooling that allow DNA to be synthesized.

The basic steps are:

1.Denaturation ( ): Heat the reaction strongly to separate, or denature, the DNA strands. This provides single-stranded template for the next step.

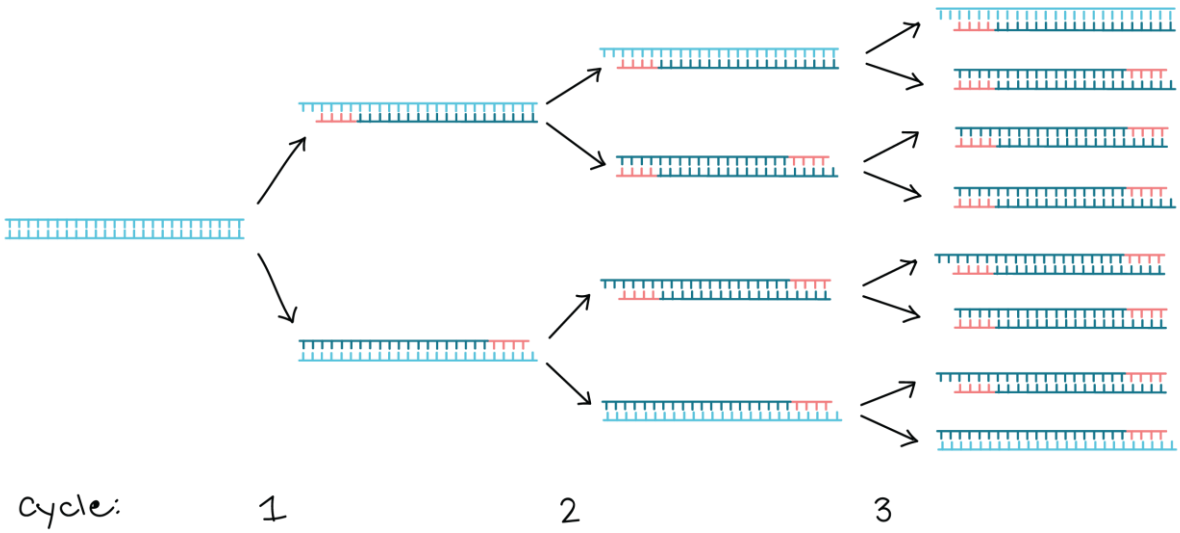
2.Annealing ( ): Cool the reaction so the primers can bind to their complementary sequences on the single-stranded template DNA.

3.Extension ( ): Raise the reaction temperatures so *Taq* polymerase extends the primers, synthesizing new strands of DNA.

This cycle repeats times in a typical PCR reaction, which generally takes hours, depending on the length of the DNA region being copied. If the reaction is efficient (works well), the target region can go from just one or a few copies to billions

That's because it's not just the original DNA that's used as a template each time. Instead, the new DNA that's made in one round can serve as a template in the next round of DNA synthesis. There are many copies of the primers and many molecules of *Taq* polymerase floating around in the reaction, so the number of

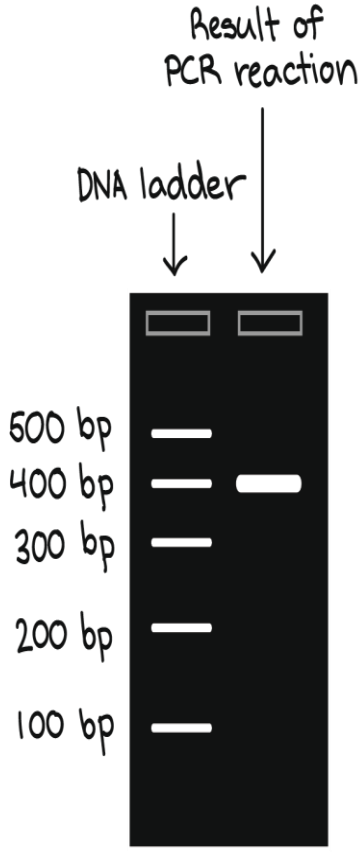
DNA molecules can roughly double in each round of cycling. This pattern of exponential growth is shown in the image below.



Using gel electrophoresis to visualize the results of PCR

The results of a PCR reaction are usually visualized (made visible) using gel electrophoresis. **Gel electrophoresis** is a technique in which fragments of DNA are pulled through a gel matrix by an electric current, and it separates DNA fragments according to size. A standard, or DNA ladder, is typically included so that the size of the fragments in the PCR sample can be determined.

DNA fragments of the same length form a "band" on the gel, which can be seen by eye if the gel is stained with a DNA-binding dye. For example, a PCR reaction producing a base pair (bp) fragment would look like this on a gel:



A DNA band contains many, many copies of the target DNA region, not just one or a few copies. Because DNA is microscopic, lots of copies of it must be present before we can see it by eye. This is a big part of why PCR is an important tool: it produces enough copies of a DNA sequence that we can see or manipulate that region of DNA.

Applications of PCR

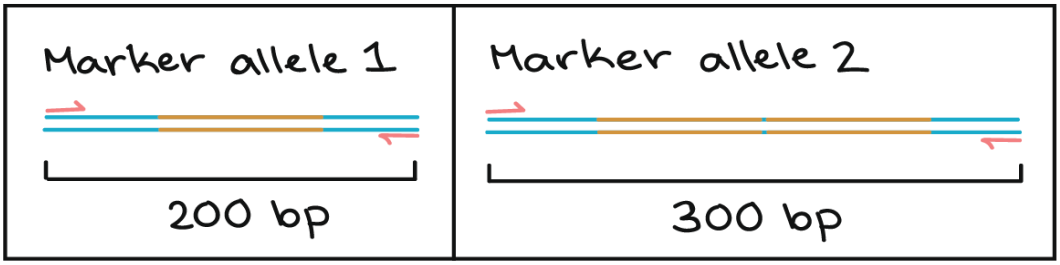
Using PCR, a DNA sequence can be amplified millions or billions of times, producing enough DNA copies to be analyzed using other techniques. For instance, the DNA may be visualized by gel electrophoresis, sent for sequencing, or digested with restriction enzymes and cloned into a plasmid.

PCR is used in many research labs, and it also has practical applications in forensics, genetic testing, and diagnostics. For instance, PCR is used to amplify genes associated with genetic disorders from the DNA of patients (or from fetal DNA, in the case of prenatal testing). PCR can also be used to test for a bacterium or DNA virus in a patient's body: if the pathogen is present, it may be possible to amplify regions of its DNA from a blood or tissue sample.

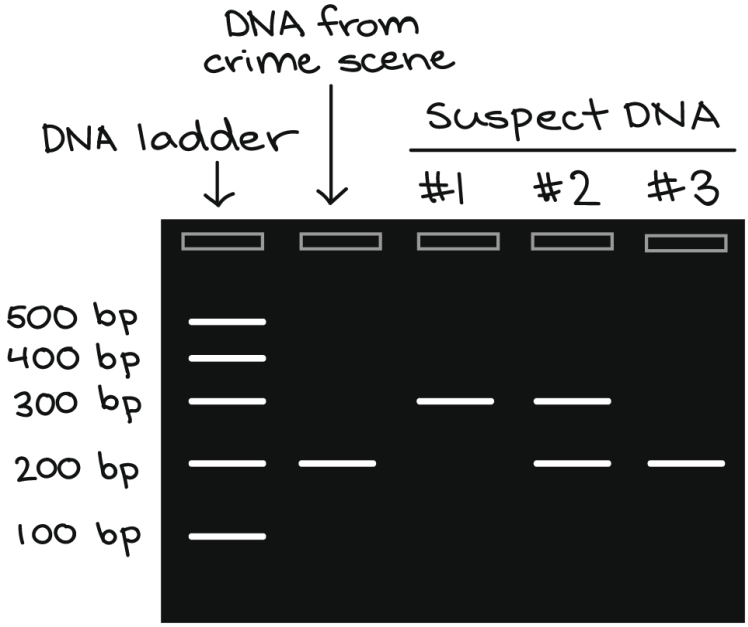
Sample problem: PCR in forensics

Suppose that you are working in a forensics lab. You have just received a DNA sample from a hair left at a crime scene, along with DNA samples from three possible suspects. Your job is to examine a particular genetic marker and see whether any of the three suspects matches the hair DNA for this marker.

The marker comes in two alleles, or versions. One contains a single repeat (brown region below), while the other contains two copies of the repeat. In a PCR reaction with primers that flank the repeat region, the first allele produces a DNA fragment, while the second produces a DNA fragment:



You perform PCR on the four DNA samples and visualize the results by gel electrophoresis, as shown below:

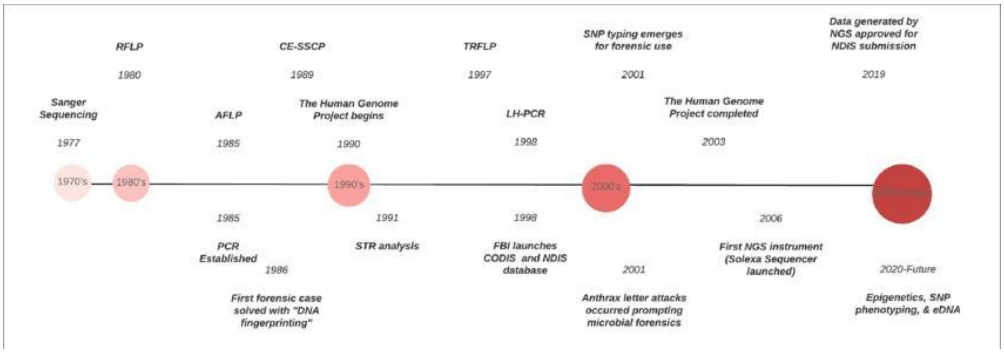


Forensic Applications of PCR: DNA Profiling and Analysis

Forensic genetics is the use of genetic tools and scientific methods to solve legal cases, both criminal and civil. The principle of Locard's Exchange suggests that every contact leaves a trace, making any evidence crucial in forensic analysis. Biological evidence found at crime scenes can include cellular material or cell-

free DNA, and as genetic technologies have advanced, these methods have been applied to both human and non-human genetic analyses. While these techniques can be used for any genome, the existence of databases and standard guidelines has made human DNA typing the preferred method.

The rapid progress of forensic DNA typing can be attributed to the numerous advancements in molecular biology technologies that have occurred within a relatively short timeframe.



Overview of Forensic DNA Analysis

The techniques used for DNA fingerprinting include Restriction Fragment Length Polymorphism (RFLP) and PCR-based Variable Number Tandem Repeat (VNTR) or Short Tandem Repeat (STR) determination. While RFLP was the first approach used, it is not commonly used due to its time-consuming nature and requirement for high-quality DNA.

VNTR and STR have since been developed and are more commonly used due to their sensitivity and less time-consuming procedures. Both methods use PCR to amplify a small amount of DNA. VNTR is composed of 17-19bp repeat sequences while STR consists of 2-4bp repeat sequences.

Several different STRs are amplified by PCR and analyzed by DNA sequencing, which is currently the most commonly used method in forensic science. However, it requires expensive facilities and precision techniques.

Organization of DNA into Chromosomes

In every human nucleated cell, there are two complete copies of the genome. The human genome comprises around 3.2 billion base pairs (BPs) of information, which are arranged into 23 pairs of chromosomes. Each individual inherits one set of chromosomes from each parent, resulting in a total of 46 chromosomes.

The human genome can be classified into different types based on its structure and function.

- Firstly, there are regions of DNA that encode and regulate protein synthesis, which are called genes. The human genome is estimated to contain between 20,000 to 25,000 genes, which make up only 1.5% of the genome.
- Secondly, there are noncoding regions of genetic sequence that make up 23.5% of the genome. These regions do not encode proteins but instead play a role in regulating gene expression through enhancers, promoters, repressors, and polyadenylation signals.

- Finally, approximately 75% of the genome is extragenic DNA, which is composed of repetitive DNA. This includes 50% interspersed repeats, which consist of short interspersed elements, long interspersed elements, long terminal repeats, and DNA transposons, and 45% tandem repeats, which consist of satellite DNA, minisatellite DNA, and microsatellite DNA.

:current strategies development of vaccine hiv malaria tuberclosis

AIDS

In the early 1980s when HIV was discovered, the success of the recombinant hepatitis B virus vaccine produced in yeast led to the belief that all that was needed to make a viral vaccine was a recombinant subunit of the viral envelope. Unfortunately this has not been the case with HIV, one of the most difficult and challenging viruses discovered so far. The subunit vaccines derived from the HIV envelope were developed, tested in phase I and phase II clinical studies, and in the mid 1990s were ready to enter phase III efficacy studies; however, *in vitro* studies demonstrated that the antibodies induced by the vaccines only neutralized the virus strain used to make the vaccine and did not neutralize divergent viruses or primary viruses isolated from patients12,13. Therefore, phase III trials were postponed. A few years later VaxGen performed an efficacy trial using a vaccine composed of a mixture of the recombinant subunits from two clade B viruses adjuvanted with alum. This trial was performed in approximately 5,000 high-risk volunteers mainly comprising men who have sex with men14. A similar study with a vaccine composed of a mixture of clade B and clade E envelopes (AIDSVAX B/E) was started in Thailand on approximately 2,500 drug users15. The negative results of these trials were perhaps not surprising given the great antigenic diversity of the virus and the inability of the vaccines to induce antibodies able to neutralize primary isolates. The failure of the antibody-based vaccine encouraged the scientific community to focus on T-cell-mediated immunity. It had been shown that $CD8^+$ T cells against broadly conserved epitopes could be induced in non-human primates and that these were able to blunt the peak of viraemia during primary infection and maintain a low viral load for a long time after infection12. The enthusiasm for T-cell-based vaccines led to the design of the STEP trial, an efficacy study involving 3,000 people who were immunized either with a non-replicating adenovirus 5 (MRKAd5 HIV-1) expressing Gag/Pol/Nef or placebo. The failure of this T-cell vaccine to prevent infection or to control viral load, as had been observed in non-human primates16, was disappointing, leading many in the field of HIV research to question the feasibility of an HIV vaccine17. It was therefore encouraging when the results of the RV144 trial were reported in the autumn of 2009. This trial was based on a prime–boost regime: priming with a canarypox expressing the subtype B HIV Gag, Pro and the subtype E gp120 (ALVAC-HIV) and boosting with the alum adjuvanted mix of gp120 AIDSVAX B/E. Conducted in 16,000 heterosexuals in Thailand, this trial yielded a modest 31% prevention of HIV infection18. Although some researchers question whether such a low efficacy is meaningful, for many the RV144 trial has renewed the hope of developing an HIV vaccine, and attempts are now being made to plan for a trial to

confirm, and perhaps improve on, the results by organizing new efficacy trials based on prime–boost regimes. If successful, these new efforts could provide licensable vaccines within this decade. In the meantime, an expanded phase II trial based on a multiclade DNA priming and adenovirus 5 boost is also being conducted by the NIH Vaccine

The results of three failed and one marginally successful trial could be interpreted to mean that antibodies alone or $CD8^+$ T cells alone are not effective, and that a combination of both antibodies and T cells offers marginal protection against disease. However, the immune responses underlying this protection are likely to be extraordinarily complex and only amenable to systems analysis. A comparison of the immune networks induced by various prime–boost and conventional regimes could lead to the identification of signatures of immunogenicity and possibly, in the future, of protection. Because no protective vaccines exist for HIV it is not currently possible to define correlates of protection. Thus, at the moment, we are restricted to measuring defined end points such as specific $CD4^+$ and $CD8^+$ T cells and pathogen load, which can act as useful surrogates.

Some preliminary studies are encouraging. For instance, RNA expression profiles of whole blood before and after challenge in rhesus macaques vaccinated with replicating adenovirus type 5 expressing either HIV envelope protein, simian immunodeficiency virus (SIV) Gag, or SIV Nef, followed by an HIV gp140 boost were able to identify expression signatures that distinguish vaccinated from control animals19. In another prime–boost study carried out in macaques, systems analysis of RNA expression profiling of PBMCs and lymph nodes identified network signatures that predicted the magnitude of specific $CD4^+$ and $CD8^+$ T-cell responses and were associated with decreased viral load (Fig. 1 and D. E. Zak *et al.*, unpublished observations). More information may also be obtained by following up some of the clinical studies that have already been performed. For instance, a subset of infected people from the STEP trial was followed for 2 years. Analysis revealed some decrease in viral load in people that carry the HLA alleles B27, B57 and B58 that are associated with more protective $CD8^+$ responses20. An additional observation that is still not explained is that the people that had high titres of antiadenovirus antibodies and were not circumcised were found to have an increased risk of infection16. Preliminary systems analysis has demonstrated that high antibody titres are associated with decreased transcription of a number of antiviral innate immune pathways

Tuberculosis

In the case of *Mycobacterium tuberculosis*, a vaccine is available and still used to vaccinate newborns in countries with a high risk of tuberculosis infection. The vaccine was formulated a century ago and consists of Bacillus Calmette–Guerin (BCG), an attenuated strain of *Mycobacterium bovis*23,24. Although the overall efficacy of BCG is controversial, most agree that the vaccine is able to prevent disseminated disease

and mortality in newborns and children. However, it is not able to prevent chronic infection nor to protect against pulmonary tuberculosis in adults. As a consequence, *M. tuberculosis* establishes a latent chronic infection that reactivates when there is a decrease in immune surveillance, for example in aged people, in individuals with genetic immune defects, and in those whose medication blunts their immune responses, such as a patients treated with antibodies against tumour necrosis factor-α. Immune suppression caused by HIV has become an extremely important factor in the reactivation of tuberculosis25, and in the 15 million people co-infected by HIV and tuberculosis it is the major cause of mortality in this population26. Altogether, approximately two billion people carry a latent tuberculosis infection and approximately 10% will progress to active disease at some time. There are 12 vaccines against tuberculosis currently in clinical trials. Several of them are subunit vaccines consisting of recombinant antigens such as the Mtb72F fusion protein or the Ag85B-ESAT-6 fusion protein delivered with the adjuvant AS02, the Ag85-TB10.4 fusion protein delivered with the adjuvant IC31 (ref. 27), the fusion of Ag85B-ESAT-6-Rv2660c and a variety of antigens delivered via DNA or viral vectors25,28. Other subunit vaccines identified by reverse vaccinology have been shown to boost BCG immunity in preclinical studies29. These subunit vaccines could be used to boost BCG vaccination in infants in the hope of preventing chronic infection. These vaccines could also be used in adolescents and adults to boost immunity induced by BCG or natural infection to delay or avoid reactivation. Another approach to improving tuberculosis vaccines is to re-engineer BCG to achieve better priming30. For example, the rBCG30 strain was engineered to overexpress antigen 85B to make it more immunogenic. Indeed, in clinical trials rBCG30 was found to induce better $CD4^+$ responses against Ag85B compared to wild-type BCG. Another engineered BCG strain was designed to engage the class I antigen presentation pathway based on the assumption that $CD8^+$ T cells are important for protection by killing tuberculosis-infected cells; this strain was therefore engineered to express the cytolysin of *Listeria monocytogenes*, a protein that enables the mycobacterium to escape from the vacuole to the cytosol, where it can be presented via class I antigen presentation pathway. The vaccine strain rBCGDUreC:Hly also has an inactivated urease gene that allows better acidification of the vacuole and improves the release of the bacterium. Preclinical studies demonstrated that this vaccine was more attenuated and more protective than BCG; it is now being tested in phase I clinical studies.

It is interesting that after a century of tuberculosis vaccine development, and after immunizing more than 3 billion people with BCG, we still know very little about immunity to *M. tuberculosis*. We still do not know why BCG induces protection, why immunity does not prevent persistent infection, what immune response would be needed to achieve sterile immunity or to prevent reactivation of latent infection. None of these questions has been answered using conventional technologies. Progress in this field will require a more comprehensive approach, such as systems biology, to test and compare different vaccines in the field and to dissect the mechanisms associated with protection. Information about immunity to tuberculosis can also be

obtained by studying infected individuals. Two recent studies[31,32] used systems approaches to compare the transcripts in the blood of individuals with active infection to those of individuals who were latently infected. This investigation identified subsets of genes that correlated with the extent of the disease[31]. Although these signatures are not related to tuberculosis vaccine efficacy or immunogenicity, identification of the pathways associated with tuberculosis disease progression may help to define pathways that can be targeted in new vaccines.

Malaria

It has been known since 1967 that immunization with irradiated sporozoites can protect mice from infection with *Plasmodium berghei*[33]. It was subsequently found that humans immunized with the bites of >1,000 irradiated sporozoite-carrying mosquitoes were 100% protected from infection when challenged within 9 weeks[34]. Natural infection in endemic areas also results in protection. This is why malaria causes very severe disease and mortality in infants, children and in naive adults, but causes only mild disease in adults living in endemic areas[35,36]. The observed immunity, however, does not last indefinitely because immune people who live abroad for a period of time become susceptible again to severe malaria when they travel back to endemic countries[37].

The immunity provided by complex antigens such as irradiated sporozoites and natural infection has been very difficult to replicate using purified antigens. The best results have been obtained using the circumsporozoite protein, the most abundant antigen on the surface of the sporozoites. This protein is known to induce antibodies that inhibit the invasion of hepatocytes by sporozoites and to induce T-cell responses capable of killing infected liver cells. The antigen was expressed in a viral-like particle known as RTS,S[38]. The particle comprises 189 amino acids of the circumsporozoite antigen containing the repeat and terminal region fused to the 226 amino acids of the hepatitis B surface antigen (RTS) and the non-fused hepatitis B surface antigen.

Because the immunogenicity of RTS,S was found to be better than any recombinant circumsporozoite antigen previously expressed, it was mixed with different adjuvants and eventually used to immunize adult volunteers that were then challenged with infected mosquito bites. Surprisingly, of the three groups immunized with the RTS,S antigen, the groups receiving vaccines adjuvanted with alum plus monophosphoryl lipid A (MPL) (AS04)[39] or with the oil in water emulsion AS03 were not protected, whereas the group receiving the vaccine adjuvanted with the oil in water emulsion plus MPL and QS21 (AS02) were 86% protected from infection[40]. Interestingly, no relevant differences in antibody titres or T-cell immunity were observed between the protected group and the non-protected groups, indicating that the quality rather than the quantity of B and T cells was the key for protection. Unfortunately, at the time of this

challenge study systems biology approaches were not yet available and the tools to evaluate the quality of the immune responses were limited, so that the development of the RTS,S vaccine continued empirically, without knowing why it had been so efficacious.The vaccine was therefore tested in several clinical trials in adults and infants where it showed short-term efficacy in preventing infection ranging from 34% to 66%, and protection of 30% against clinical malaria41,42. The vaccine was then reformulated with a different adjuvant containing liposomes plus MPL and QS21 (AS01) and tested for efficacy; it induced short-term protection of 56% (ref. 43) during the first 8 months that decreased to 45% at 15 months44. Subjects are currently being enrolled for phase III efficacy trials that are expected to provide data for registration of the vaccine for use in infants and children within the next 4 years

UNIT – 3

Environmental Pollution and types control of Environmental Pollution ?

Environmental pollution is the contamination of the biological components of the Earth, which adversely impacts standard ecological processes. Any unnatural and damaging transformations in all the dimensions (like physical, chemical, and biological factors of any constituent of the **ecosystem**) which can cause dangerous effects on mixed forms of life and belongings are called environmental pollution.

Types of Environmental Pollution

Majorly, ***7 types of environmental pollution*** can occur on the Earth. A detailed illustration can be extracted from the types of pollution PDF for better understanding. The given pollution types have specific causes, effects, and control measures indicated further in this article.

1. Air pollution
2. Water pollution
3. Soil pollution
4. Thermal Pollution
5. Noise pollution
6. Light Pollution
7. Land Pollution.

Air Pollution

Pollutants such as carbon monoxide, chlorofluorocarbons (CFCs), dust, mold spores, nitrogen oxides, pollen, and sulfur dioxide, cause air pollution. **Air pollution** is caused by solid particles and gases present in the atmosphere.

Causes:

Coal, dry grass, dry-farm waste, and leaves utilized as domestic fuels in villages also generate harmful gases in the atmosphere.

Some additional sources of Air Pollution are:

- Automobile pollution

- Burning of garbage
- Decayed plants and animals
- Indoor air pollution
- Industrial air pollution
- Radioactive elements.

Effects:

The major effects of environmental pollution of the air are that it increases the risk of heart disease in humans and causes diseases of the lungs and respiratory systems. It can also lead to asthma and bronchitis. It can also affect the environment as it increases greenhouse gases.

Control Measures:

Households and industries should operate with better-design equipment and smokeless fuels to lessen air pollution.

- Afforestation or planting more trees should be encouraged to maintain a balance in the ecosystem and manage the effect caused by the rising greenhouse gases.
- The government also took initiatives to control air pollution, including the National ambient air quality standards (NAAQS) and the National air quality monitoring program (NAMP).

Water Pollution

Water pollution is caused when toxic materials, including chemical contaminants, discharges of untreated waste, and sewage, are thrown into rivers, lakes, and oceans.

Causes:

The **sources of water pollution** include farming methodologies with excess fertilizers and pesticides that also degrade the water bodies.

Environmental Pollution of water has the following causes:

- Agricultural pollutants are dumped into the water bodies.
- Disposal of radioactive substances into seawater.
- Industrial effluents enter oceans.
- Trading of marine.

- Offshore oil rigs.
- Recreational sports.
- Sewage is disposed of into the sea by rivers.

Effects:

The effect of water pollution is that it can cause Minamata disease in humans and dropsy disease in fishes when the amount of mercury increases in water. It also leads to biological magnification (concentration of toxic chemicals increases) and eutrophication (overabundance of nutrients).

Control Measures:

Water consumption must be minimized or reduced by revising the strategies involved in controlling the environmental pollution of water. Wastewater should be treated well to be reused.

Soil Pollution

Environmental Pollution of Soil is caused when concentrations of toxic substances or contaminants increase and accumulate on the soil surface.

Causes of Soil Pollution:

The contaminants that cause **soil** pollution are:

- Inorganic ions and metals
- Salts (e.g., carbonates, nitrates, phosphates, sulfates)
- Organic compounds (such as alcohols, DNA, fatty acids, hydrocarbons, lipids, proteins, PAHs, etc.).

Effects:

The effects of soil pollution are that it reduces soil fertility and increases salinity. It results in the blocking of drains, thereby releasing foul odors and gases.

Control Measures:

To control the environmental pollution of soil, we must stop plastic usage. The use of plastic should be reduced to prevent soil pollution, and sewage should be appropriately treated before its utilization as fertilizer on cultivated grounds.

Thermal Pollution

Thermal pollution is the degradation of the quality of water that counters the surrounding water temperature by any procedure.

Causes:

This environmental pollution is caused when industrial factories and power plants use water as a coolant. Boilers from industries, coal fire power plants, crude oil refineries, nuclear and electric power plants, and steel melting factories are some of the causes of thermal pollution.

Effects of Thermal Pollution:

The effects of thermal pollution are that it decreases the amount of dissolved oxygen in the water, kills several species of invertebrates and fishes, along with destroying their eggs laid in the water bodies.

Control Measures:

Thermal environmental pollution can be prevented using a few scientific approaches, like cooling ponds or buildings and constructing artificial lakes. These lakes are man-made water sources that provide a possible alternative for cooling power plants.

Noise Pollution

Noise pollution is an unwanted sound that induces terrible discomfort in the ears. Sound is counted in decibels (dB); the noise of about 90 dB causes auricular weakness, while sound levels exceeding 100 dB can cause permanent hearing loss.

Causes:

Noise pollution is caused by the sound of the ship's water bothering whales' navigation system and even eradicating aquatic species.

- The factories' machines generate whistling, grinding, and thundering sounds.
- Exploding rocks and earth, drilling tube wells, heavy earth-moving machinery, and ventilation fans at construction locations cause this type of pollution.

- Other causes of this environmental pollution are the sound of automobile horns and the high sound of loudspeakers.

Effects:

Noise pollution can cause high BP, stress-related ailments, interfere with speech, result in hearing loss, disbalance in sleep, and lost productivity.

Control Measures:

Noise pollution can be decreased by properly maintaining roadside vehicles and using soundproof equipment in noisy places. Horns should be used minimally on roads. Automobiles and industrial equipment must be fitted with silencers to avoid excessive noise.

Light Pollution

The extra light in the night sky causes light pollution, also known as photo pollution, and is commonly witnessed in urban settlements. This type of environmental pollution makes it problematic to distinguish between day and night as it destroys the ecosystem.

Causes:

It is caused by artificial indoor or outdoor light, street lighting, advertisement and exhibition lighting, security lights, luminous sporting platforms, etc. Light pollution washes out starlight in the night sky, interrupts astronomical analysis, interferes with ecosystems, wastes a tremendous amount of energy, and has damaging health effects on living organisms.

Effects:

Environmental pollution of Light can affect the rhythmic patterns of wildlife, increases the amount of carbon dioxide, cause irritability in the sleep cycle, and blur the appearance of stars in the night sky.

Control Measures:

- Lights should be turned off whenever unused, especially at night.
- The overutilization of indoor lights should be minimized.
- Lights should be pointed towards the ground whenever you are going outside your home.

Environmental Pollution of Land

Land pollution makes a particular area of land unfit in its usefulness, geography, and capability to sustain life forms. It arises when there is improper or no treatment of waste and garbage that ultimately introduces chemicals on the land surface.

Causes of Land Pollution:

The causes of environmental pollution of land comprise the following:

- Biomedical waste
- Chemical fertilizers
- Garbage
- Industrial waste
- Mineral exploitation
- Pesticides
- Urban commercial and domestic waste.

Effects:

Land pollution affects soil quality and makes it unsuitable for agriculture. This may cause a deterioration in food availability. It may also lead to **climate change**, instant **floods**, and irregular rainfall. This type of environmental pollution can cause many species to get endangered or extinct.

Control Measures:

Proper sewage treatment should be done before employing them on land areas. Better agricultural practices must be followed to prevent this environmental pollution.

- Organic fertilizers, an incorporated pest management technique, and crop rotation can all be used by farmers.
- The 3 R's should be embraced by all households – reduce, reuse, and recycle, to generate less waste.
- People should use products as much as possible to generate less waste individually.
- We should pick materials that can be easily recycled, for instance, paper, glass, plastics, and electronic items, and transform them into new products.

Causes of Environmental Pollution

The leading cause of environmental pollution is a pollutant. It is a substance that causes various types of pollution. A contaminant causes harmful effects or uneasiness in the organisms.

- **Which Gas is the Main Pollutant Responsible for Global Warming?**
- **What are the Main Pollutants responsible for Causing the Greenhouse Effect, Acid Rain, and Ozone Layer Depletion?**

Depending on whether they remain consistent in the environment, there can be persistent or non-persistent types of pollutants. Other pollutants that are the **causes of Pollution** are:

According to their existence in nature:

- Quantitative Pollutants: For example – Carbon Dioxide or CO2
- Qualitative Pollutants: For example – Fungicides, herbicides, pesticides, insecticides, etc.

Environmental Pollution Causes – According to origin:

- Natural Pollutants: For example – Ash, combustion gases, salt spray, soot, sulfur dioxide, and so on.
- Man-made Pollutants: For example – Carbon Monoxide (CO), Lead (Pb), Nitrogen Dioxide, Ozone (O3), Particulate Matter (PM), and more.

According to the nature of disposal:

- Biodegradable Pollutants: For example – Agriculture residues, cloth, food waste, fecal matter, green waste, human waste, paper waste, sewage, vegetable stuff, etc.
- Non-biodegradable Pollutants: For example – Arsenic, DDT, plastics, polythene bags, mercury, metal pieces such as aluminum cans, glass objects, iron products, silver foils, synthetic fibers, and so on.

Effects of Environmental Pollution

Environmental pollution can be hazardous for all living beings. Air pollution can lead to multiple diseases, such as skin, nose, and throat irritation, wheezing, coughing, respiratory concerns, etc.

- Air pollution can cause asthma, heart attacks, and other respiratory difficulties.

- Air pollution can also lead to global warming, acid rain, and depletion of the ozone layer.
- The environmental pollution of water can destroy aquatic life and even cause diseases like typhoid and Jaundice when consumed by humans.
- Contaminated water has negligibly dissolved oxygen (DO) and hence becomes unfit for drinking.
- Soil or land pollution can disrupt the life of microorganisms underground and affect the quality of plants grown.

Environmental Pollution Control Measures

Adopting some necessary measures can control various types of environmental pollution. Managing pollution is required for the safety of humans and other living creatures.

- Plastic use should be prohibited as the environment takes years to decompose plastic.
- Unnecessary usage of indoor and outdoor lights should be avoided.
- Crackers should be banned as they pollute the environment to a large extent.
- Environmental Pollution can be controlled by using reusable materials that should be promoted aggressively and recycled for future use.
- More and more individuals should prefer public transport as it uses less gas and energy.
- Fans should be used more than air conditioners as it operates with less energy and electricity.

BIOREMEDIATION

Bioremediation is defined as use of biological processes to degrade, break down, transform, and/or essentially remove contaminants or impairments of quality from soil and water.

Bioremediation is a natural process which relies on bacteria, fungi, and plants to alter contaminants as these organisms carry out their normal life functions. Metabolic processes of these organisms are capable of using chemical contaminants as an energy source, rendering the contaminants harmless or less toxic products in most cases. This paper summarizes the general processes of bioremediation within the soil environment, focusing on biodegradation of petroleum hydrocarbons. The effect of soil conditions on rate of biodegradation of hydrocarbons is addressed. Further, limitations and potential of both ***ex situ*** and ***in situ*** bioremediation as viable alternatives to conventional remediation are explained and addressed.

Many substances known to have toxic properties have been introduced into the environment through human activity. These substances range in degree of toxicity and danger to human health. Many of these substances either immediately or ultimately come in contact with and are sequestered by soil. Conventional methods to remove, reduce, or mitigate toxic substances introduced into soil or ground water via anthropogenic

activities and processes include pump and treat systems, soil vapor extraction, incineration, and containment. Utility of each of these conventional methods of treatment of contaminated soil and/or water suffers from recognizable drawbacks and may involve some level of risk

contaminants. Bioremediation has been demonstrated and is being used as an effective means of mitigating:

- hydrocarbons
- halogenated organic solvents
- halogenated organic compounds
- non-chlorinated pesticides and herbicides
- nitrogen compounds
- metals (lead, mercury, chromium)
- radionuclides

Bioremediation technology exploits various naturally occurring mitigation processes: **natural attenuation, biostimulation**, and **bioaugmentation**. Bioremediation which occurs without human intervention other than monitoring is often called **natural attenuation**. This natural attenuation relies on natural conditions and behavior of soil microorganisms that are indigenous to soil. **Biostimulation** also utilizes indigenous microbial populations to remediate contaminated soils. **Biostimulation** consists of adding nutrients and other substances to soil to catalyze natural attenuation processes. **Bioaugmentation** involves introduction of exogenic microorganisms (sourced from outside the soil environment) capable of detoxifying a particular contaminant, sometimes employing genetically altered microorganisms

Types of Bioremediation

Bioremediation is of three types –

1) Biostimulation

As the name suggests, the bacteria is stimulated to initiate the process. The contaminated soil is first mixed with special nutrients substances including other vital components either in the form of liquid or gas. It stimulates the growth of microbes thus resulting in efficient and quick removal of contaminants by microbes and other bacterias.

2.Bioaugmentation

At times, there are certain sites where microorganisms are required to extract the contaminants. For

example – municipal wastewater. In these special cases, the process of bioaugmentation is used. There's only one major drawback in this process. It almost becomes impossible to control the growth of microorganisms in the process of removing the particular contaminant.

3.Intrinsic Bioremediation

The process of intrinsic bioremediation is most effective in the soil and water because of these two biomes which always have a high probability of being full of contaminants and toxins. The process of intrinsic bioremediation is mostly used in underground places like underground petroleum tanks. In such place, it is difficult to detect a leakage and contaminants and toxins can find their way to enter through these leaks and contaminate the petrol. Thus, only microorganisms can remove the toxins and clean the tanks.

Other methods of Waste Management

Incineration

This is a process where wastes and other unwanted substances are burnt. During combustion, the organic waste turns into ash, flue gas, and heat. The inorganic constituents of the waste remain in the form of an ash. It is also termed as thermal treatment.

Phytoremediation

In this scenario, plants are directly used to clean up or contain contaminants in the soil. This method of bioremediation will help mitigate the environmental problem without the need to excavate the contaminant material and dispose of it elsewhere.

Phytoremediation = Phyto (Plant) + Remedium (Restoring balance or Remediation)

During bioremediation, microbes utilize chemical contaminants in the soil as an energy source and, through oxidation-reduction reactions, metabolize the target contaminant into useable energy for microbes. By-products (metabolites) released back into the environment are typically in a less toxic form than the parent contaminants. For example, petroleum hydrocarbons can be

degraded by microorganisms in the presence of oxygen through aerobic respiration. The hydrocarbon loses electrons and is oxidized while oxygen gains electrons and is reduced. The result is formation of carbon dioxide and water (Nester et al., 2001). When oxygen is limited in supply or absent, as in saturated or anaerobic soils or lake sediment, anaerobic (without oxygen) respiration prevails. Generally, inorganic compounds such as nitrate, sulfate, ferric iron, manganese, or carbon dioxide serve as terminal electron acceptors to facilitate biodegradation

Three primary ingredients for bioremediation are: 1) presence of a contaminant, 2) an electron acceptor, and 3) presence of microorganisms that are capable of degrading the specific contaminant. Generally, a contaminant is more easily and quickly degraded if it is a naturally occurring compound in the environment, or chemically similar to a naturally occurring compound, because microorganisms capable of its biodegradation are more likely to have evolved (State of Mississippi, Department of Environmental Quality, 1998). Petroleum hydrocarbons are naturally occurring chemicals; therefore, microorganisms which are capable of attenuating or degrading hydrocarbons exist in the environment. Development of biodegradation technologies of synthetic chemicals such DDT is dependent on outcomes of research that searches for natural or genetically improved strains of microorganisms to degrade such contaminants into less toxic forms.

Topic : Biomass productionomass Definition (Energy Source)

Biomass is the fuel developed from organic matter waste of living organisms like plant waste, animal waste, forest waste, and municipal wastes.

In biological terms, the word biomass refers to the organic plant matter, which is converted into fuel and used as an energy source. Biomass fuel is considered to be of great importance as it plays the role of a renewable and sustainable source of energy. For example, biomass is used for the production of electricity. Due to this, biomass is capable of replacing fossil fuels.

Organic materials which can be recycled like wood, agricultural wastes, and municipal wastes serve as excellent sources to produce biomass fuel. The biomass can be burnt directly and later converted into methane and ethanol biofuels. Biomass's chemical composition includes hydrogen, carbon, nitrogen, oxygen, certain alkali atoms, alkaline earth metals and heavy metals

Introduction to Biomass

Biomass energy refers to energy produced from organic matter. It is found in the form of living or recently living organisms, organic mass and waste. The energy produced from biomass is called bioenergy. Materials used to produce this bioenergy refers to feedstock which is mostly plant animal material. Different types of feedstocks have different physical compositions but Carbon, water and organic volatiles are common in all. Biomass can be defined as the organic life and mass means weight, so biomass means the total quantity or the weight of organisms in a given area or volume. Now, we are familiar with biomass and biomass definition.

Types of Biomass

Biomass comes from a variety of sources. Some of the different types of biomass example are:

1. **Agricultural Residues**

These are the Biomass sources or materials that are left in an agricultural field or orchard after the cro harvesting. The residues include stubble like leaves, stems, stalks, and seed pods. These residues are used as biomass for bioenergy production.

2. **Animal Waste**

Animal waste is an important source of nutrients and renewable energy and is a valuable biomass feedstock. Animal waste has chemical energy stored in it just like plants and when it is burnt, it releases bioenergy in the form of heat and fuel. Animal wastes are generally the excreted materials from living animals and can also include hay, straw, organic debris and wood shavings.

3. **Forestry Residues**

It is the residue which is left over from logging operations that may include branches, tree tops, sawdust and stumps. These can be obtained in two forms including primary forestry residues and secondary forestry residues. Forest residues comprise of branches, tops and unmerchantable wood left after cleaning, final felling or thinning of forest stands. These are some of the important Biomass examples.

4. **Wood Wastes**

It is the portion of the waste stream which comprises discarded wood products, stumps, whole trees or pruned branches obtained during park or street maintenance. Therefore, a vast portion of wood waste can be collected to use as biomass and bioenergy production.

5. **Industrial Wastes**

It is defined as the waste which is generated by manufacturing or industrial processes. It includes a variety of waste including dirt, gravel, cafeteria garbage, concrete and masonry, scrap metals, oil solvents, trash, chemicals, wood, weed grass, trees, etc. A careful selection of the industrial waste to generate bioenergy is advised for prevention to bad impact on human health.

6. **Municipal Solid Wastes and Sewage**

Also known as trash or garbage, it is the everyday items that we use and throw away such as grass clippings, furniture, clothing, newspapers, appliances, paint, batteries, product packaging, kitchen waste, etc. Sewage sludge is a type of wastewater produced from a sewer or treatment plant. All of these are used as biomass feedstock for bioenergy production.

Biomass Conversion Process

For bioenergy production from biomass, multiple biomass conversion processes are used:

1. **Combustion:**

Feedstock is burnt in the presence of air to release heat. Eg: heating wood

2. **Gasification:**

It is the process of using heat, pressure and partial combustion to convert feedstock into combustible gas mixture called syngas (can be used as natural gas/electricity/other uses).

3. **Pyrolysis:**

The process of heating feedstock in high temperature in the absence of oxygen. As oxygen is not present, organic material does not combust and it converts into 3 forms: bio oil (solid), bio-char (solid) and syngas.

4. **Anaerobic Digestion or Biodigestion:**

Here, the feedstock is burnt which then gets converted into biogas with the help of bacteria in the absence of oxygen. The residue is called digestate and is a great fertilizer.

5. **Fermentation:**

The process of converting feedstock or the plant glucose into an alcohol called ethanol by utilization of yeast. Ethanol produced is a biofuel that can be used in the automotive industry.

Disadvantages of Biomass

Biomass usage is highly environment-friendly and budget-friendly, also depending upon the feedstocks and technology type used. Some of the disadvantages of using biomass are discussed in the following points:

- Since the combustion process results in high carbon dioxide emissions leading to harmful impact on humans whereas waste energy biomass production process releases less carbon dioxide, being environment-friendly.
- Biomass production, due to lack of awareness and appropriate measures, especially among poor regions, may result in serious health hazards or risks to human health.

- Depending on the resources used, deforestation, land degradation and assaultation can be the major problems associated with biomass production.

Topic: MicroBiological Treatment of Waste Water

Biological wastewater treatment is an important and integral step of wastewater treatment system and it treats wastewater coming from either residential buildings orindustries etc. It is oftencalled as SecondaryTreatment process whichis used to remove any contaminants that left over after primary treatment. Chemicaltreatment ofwaste water makes use ofchemicals to react withpollutants present in the wastewater and where as biological treatment uses microorganisms to degrade wastewater contaminants. This treatment rely on bacteria, nematodes, algae, fungi, protozoa, rotifers to break down unstable organic wastes using normal cellular processes to stable inorganic forms. Based on the process, biological treatment of wastewatermethodsaremajorlyclassifiedintotwotypesandareasfollows:

1. BiologicalAerobicTreatment(inpresenceofoxygen)
2. BiologicalAnaerobicTreatment(inabsenceofoxygen)

1. Biological Aerobic Treatment: Aerobic wastewater treatment is a biological process that takes place in the presence of oxygen. It is the rapid and the most efficient biological waste treatment which remove up to 98% of organic contaminants. This process causes effective breakdown of organic pollutants and yields a cleaner water effluent than anaerobic treatment. Aerobic biological treatment processes include many processes such as activated sludge process, trickling filter, aerated lagoons and oxidation ponds etc. Activated sludge processis the most widely used process for domestic and industrial wastewater. Aerobic biologicaltreatmentwillremainefficientandstableinallconditions.

a. Activated Sludge Process: The activated sludge process is the most widely used biological waste treatment in secondary stage of wastewater treatment. An activated sludge process refers to a multi-chamber reactor unit that makes use of highly concentrated microorganisms to degrade organics and remove nutrients from wastewater to produce a high-quality effluent. In this method, the sewage containing organic matter with the microorganisms is aerated (by a mechanical aerator) inanaerationtank. This process speeds up waste decomposition. Aeration inanactivated sludge process is based on pumpingair into a tank, whichpromotes themicrobialgrowthinthewastewater.Theeffluentfromtheaerationtank

b. Trickling filters: This is the second commonly using type of aerobic treatment which is also called as percolating or sprinkling filters. These filters are commonly used to remove compounds such as

ammonia from the water after primary treatment.Thesecondaryeffluentthatsettleswilleitherenteradigest

c. **Oxidation Pond:**The ponds involve an interaction between bacteria, algae and other organisms which feed on the organic matter received from primary effluent. These ponds are also productive, because it generates effluent that can be used for other applications. Overall the process is slow and requires large areas of land. Typically oxidation ponds are used in areas with small populations where land is readily available.

2. **Biological Anaerobic Treatment:**This treatment process is effectively utilized to treat high strength waste water and it employs organisms that function in the absence of oxygen and it will typically treat high-strength waste water to a level that will permit discharge to a municipalsewer system. Here, the amount ofsludge produced is very small when we compared to aerobic treatment. Anaerobic treatment is a slow process and it occurs in many different stages. Anaerobic digestion is biological process which is used in wastewater treatment plants for sludge degradation and stabilization. Once the process is completed, thewastewater can undergo many additional treatments. This process is accepted because it is able to stabilize the water with little biomass production. Biogas is produced as the bacteria feed off the biodegradable material in the anaerobic process. Overall, the process converts about 40% to 60% of the organic solids to methane(CH4)and carbon dioxide(CO2).

Finally,the type of biological treatments selected—whether aerobic or an aerobic
Depends on a many range off actors

UNIT-IV

Renewable energy

Renewable energy is energy that comes from a source that won't run out. They are natural and self-replenishing, and usually have a low- or zero-carbon footprint.

Examples of renewable energy sources include wind power, solar power, bioenergy (organic matter burned as a fuel) and hydroelectric, including tidal energy.

Burning fossil fuels to create electricity has long been a major contributor in the emission of **greenhouse gases** into our atmosphere, so these renewable sources are considered vital in the race to tackle climate change

The most common renewable energy sources

Wind

Wind power is the largest producer of renewable electricity in both the UK and the US. **Onshore and offshore wind farms** generate electricity by spinning the blades of **wind turbines**. The turbines convert the kinetic energy of the spinning blades into electric energy by turning a drive shaft and gear box, which is connected to a generator. Electricity is then converted into higher voltages and fed into the national grid.

Solar

Sunlight is one of the planet's most freely available energy resources, which you'd assume would make it the number one source of renewable energy But of course, the amount of sunlight we get can vary greatly depending on location, season and time of day.

Solar power generates electricity by capturing sunlight on solar panels in a joint chemical and physical reaction, known as the 'photovoltaic effect' (or PV).

Hydroelectric

Hydro power is created using the movement of flowing or falling water.Hydroelectric power plants are found at dams and generate electricity through underwater turbines that turn a generator. Hydro power also encompasses wave and tidal power, which rely on ocean forces to generate electricity at the mouths of large bodies of water, using similar technology.

Bioenergy

Electricity can be generated when **organic matter is burned as a fuel source**. These fuels are known as biomass and include anything from plants to timber to food waste. Carbon dioxide (CO_2) is emitted when bioenergy is made, but these fuel sources are considered renewable because they can be regrown and absorb as much carbon as they emit across their lifespans.

What are non-renewable energy sources?

Fossil fuels, such as coal, natural gas and oil, are examples of non-renewable energy sources. These sources can occur naturally, but they are finite in their amount.

A disadvantage of non-renewable energy sources is thatthey often take hundreds of thousands of years to form, and have to be extracted from the earth and burned in order to create the energy that generates electricity. They also emit harmful greenhouse gases like CO_2 when they're burned

What are the benefits of renewable energy?

There are several reasons why harnessing the power of renewable energy sources is so important for our future.

As they're in much more plentiful supply, compared to fossil fuels, governments across the world are looking to develop renewables to exclusively power their nations.

Perhaps most importantly, renewables produce little or no harmful emissions when used, so the clean energy they provide will play a crucial role in preventing further global warming. It's why so many of our net zero goals in the future hinge on increasing their use today.

Examples of Renewable Energy

We can define renewable energy as those energies which can never be depleted. The importance of renewable energy is invaluable. These types of energy sources are different from fossil fuels, such as oil, coal, and natural gas. Some examples of renewable energy sources are:

- Wind energy
- Geothermal energy
- Hydropower
- Biomass energy

Sources of Renewable Energy

The sources could sustain for a longer period of time and can easily be renewed often. Sustainable sources are biomass, nuclear power, geothermal, wind energy, solar power, tidal power, and wave power.

The sources of renewable energy are known to be less polluting and therefore the whole world is looking forward to new carbon emission norms, where carbon will play a major role in developing new factories and industries. They will be rated according to the carbon emission and the products that they are producing will be rated accordingly.

Types of Renewable Energy

1. **Solar Energy:** The radiant light and heat energy from the sun is harnessed with the use of solar collectors. These solar collectors are of various types such as photovoltaics, concentrator photovoltaics, solar heating, (CSP) concentrated solar power, artificial photosynthesis, and solar architecture. This collected solar energy is then used to provide light, heat, and different other forms of electricity.
2. **Wind Energy:** The energy we get from winds is known as wind energy. For this, windmills have been used for hundreds of years to pump out water from the ground. We use large tall wind turbines that allow winds to generate electricity. The natural airflow on the surface of the earth is used to run the wind turbines. The modern-day wind turbines range from about 600 Kilowatt to 5 Megawatts, for commercial purposes these are rated with an output power of 1.5 to 3 Megawatts. The most preferred locations for these wind turbines to be installed are the areas which and strong and have constant

airflows on offshore and sites that are at high altitudes. The power generated from wind energy in 2015 met 4% of global energy consumption.

3. **Hydroelectricity:** According to statistics, hydroelectricity generated around 16.6% of the global energy resources and constituted about 70% of all renewable electricity. This energy is another alternative source of energy that is generated by the construction of dams and reservoirs on the flowing water, the kinetic energy from the flowing water is used to run the turbines which generate electricity. Tidal power converts the energy of tides and Wave power which captures the energy from the surface of the ocean waves for power generation. These two forms of hydropower also have huge potential in electric power generation.
4. **Geothermal Energy:** It is the energy that is generated from the thermal energy which is stored in the earth. The heat energy is captured from sources such as hot springs and volcanoes and this heat is directly used by industries for heating the water and other purposes.
5. **Biomass Energy:** This type of energy is derived from biomass which is a type of biological material derived from living organisms and plant-derived materials which are called lignocellulosic biomass. Biomass can be directly used via combustion to produce heat and indirectly it can be used to convert to biofuels. Biomass can be converted to other usable forms of energy such as transportation fuels like ethanol, biodiesel, and methane gas.

What is Ozone Layer Depletion?

Ozone layer depletion is the thinning of the ozone layer present in the upper atmosphere. This happens when the chlorine and bromine atoms in the atmosphere come in contact with ozone and destroy the ozone molecules. One chlorine can destroy 100,000 molecules of ozone. It is destroyed more quickly than it is created.

Some compounds release chlorine and bromine on exposure to high ultraviolet light, which then contributes to ozone layer depletion. Such compounds are known as Ozone Depleting Substances (ODS).

The ozone-depleting substances that contain chlorine include chlorofluorocarbon, carbon tetrachloride, hydrochlorofluorocarbons, and methyl chloroform. Whereas, the ozone-depleting substances that contain bromine are halons, methyl bromide, and hydro bromofluorocarbons.

Chlorofluorocarbons are the most abundant ozone-depleting substance. It is only when the chlorine atom reacts with some other molecule, it does not react with ozone.

Montreal Protocol was proposed in 1987 to stop the use, production and import of ozone-depleting substances and minimise their concentration in the atmosphere to protect the ozone layer of the earth.

Causes of Ozone Layer Depletion

Ozone layer depletion is a major concern and is associated with a number of factors. The main causes responsible for the depletion of the ozone layer are listed below:

Chlorofluorocarbons

Chlorofluorocarbons or CFCs are the main cause of ozone layer depletion. These are released by solvents, spray aerosols, refrigerators, air-conditioners, etc.

The molecules of chlorofluorocarbons in the stratosphere are broken down by ultraviolet radiations and release chlorine atoms. These atoms react with ozone and destroy it.

Unregulated Rocket Launches

Researches say that the unregulated launching of rockets results in much more depletion of the ozone layer than the CFCs do. If not controlled, this might result in a huge loss of the ozone layer by the year 2050.

Nitrogenous Compounds

The nitrogenous compounds such as NO_2, NO, N_2O are highly responsible for the depletion of the ozone layer.

Natural Causes

The ozone layer has been found to be depleted by certain natural processes such as Sun-spots and stratospheric winds. But it does not cause more than 1-2% of the ozone layer depletion.

The volcanic eruptions are also responsible for the depletion of the ozone layer.

Ozone Depleting Substances (ODS)

"Ozone-depleting substances are the substances such as chlorofluorocarbons, halons, carbon tetrachloride, hydrofluorocarbons, etc. that are responsible for the depletion of the ozone layer."

Effects Of Ozone Layer Depletion

The depletion of the ozone layer has harmful effects on the environment. Let us see the major effects of ozone layer depletion on man and environment.

Effects on Human Health

Humans will be directly exposed to the harmful ultraviolet radiation of the sun due to the depletion of the ozone layer. This might result in serious health issues among humans, such as skin diseases, cancer, sunburns, cataract, quick ageing and weak immune system.

Effects on Animals

Direct exposure to ultraviolet radiations leads to skin and eye cancer in animals.

Effects on the Environment

Strong ultraviolet rays may lead to minimal growth, flowering and photosynthesis in plants. The forests also have to bear the harmful effects of the ultraviolet rays.

The greenhouse effect

The exchange of incoming and outgoing radiation that warms the Earth is often referred to as the greenhouse effect because a greenhouse works in much the same way.

Incoming UV radiation easily passes through the glass walls of a greenhouse and is absorbed by the plants and hard surfaces inside. Weaker IR radiation, however, has difficulty passing through the glass walls and is trapped inside, thus warming the greenhouse. This effect lets tropical plants thrive inside a greenhouse, even during a cold winter.

A similar phenomenon takes place in a car parked outside on a cold, sunny day. Incoming solar radiation warms the car's interior, but outgoing thermal radiation is trapped inside the car's closed windows.