Biology 30
Biotechnology Examples

Genetic Engineering

- Genetic engineering is the process of manually adding new DNA to an organism. The goal is to add one or more new traits that are not already found in that organism. Genetic engineering works by physically removing a gene from one organism and inserting it into another, giving it the ability to express the trait encoded by that gene. It is like taking a single recipe out of a cookbook and placing it into another cookbook.
- Examples of genetically engineered (transgenic) organisms currently on the market include plants with resistance to some insects, plants that can tolerate herbicides, and crops with modified oil content.

(Source: http://agbiosafety.unl.edu/basic_genetics.shtml)

Synthetic Biology

- Advances in scientific techniques have enabled scientists to make new sequences of DNA from scratch. By combining these advances with the principles of modern engineering, scientists can now use computers and laboratory chemicals to design organisms that do new things--like produce biofuels or excrete the precursors of medical drugs. To many people, this is the essence of synthetic biology.
- In other words, synthetic biology is the design and construction of new biological entities such as enzymes, genetic circuits, and cells or the redesign of existing biological systems. The element that distinguishes synthetic biology from traditional molecular and cellular biology is the focus on the design and construction of core components (parts of enzymes, genetic circuits, metabolic pathways, etc.) that can be modeled, understood, and tuned to meet specific performance criteria, and the assembly of these smaller parts and devices into larger integrated systems to solve specific problems.

(Source: https://www.ebrc.org/what-is-synbio)

- For examples visit: https://www.bio.org/articles/current-uses-synthetic-biology

Gene Therapy

- Gene therapy is an experimental technique that uses genes to treat or prevent disease. In the future, this technique may allow doctors to treat a disorder by inserting a gene into a patient's cells instead of using drugs or surgery. Researchers are testing several approaches to gene therapy, including:
    - Replacing a mutated gene that causes disease with a healthy copy of the gene.
    - Inactivating, or "knocking out," a mutated gene that is functioning improperly.
    - Introducing a new gene into the body to help fight a disease.
- Although gene therapy is a promising treatment option for a number of diseases (including inherited disorders, some types of cancer, and certain viral infections), the technique remains risky and is still under study to make sure that it will be safe and effective. Gene therapy is currently only being tested for the treatment of diseases that have no other cures.

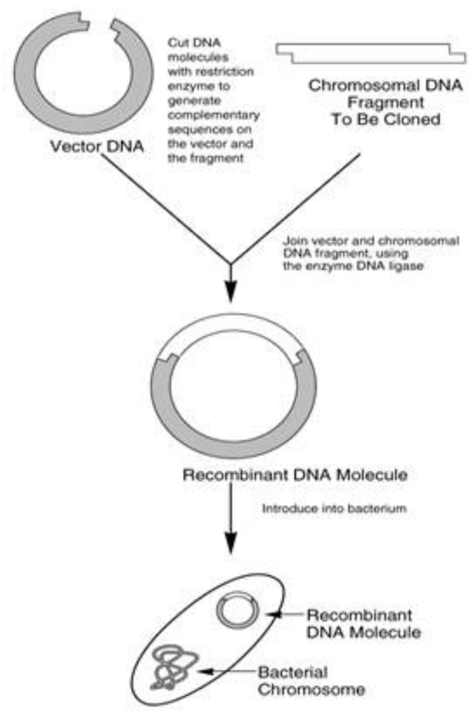
(Source: https://ghr.nlm.nih.gov/primer/therapy/genetherapy)

Genetic Screening

- Genetic testing and screening can help you find out of your baby could develop certain genetic conditions (passed on through your genes). This is usually done when there is a family history of a major health problem that is likely to be passed on to the baby.
- Genetic testing helps to find out if a person's genes or chromosomes may be linked to a health condition; it can also identify changes in a person's genes. The procedure can be done before a pregnancy, during a pregnancy, or later in life.
- Genetic testing is not available for every condition. It is also not usually possible unless the gene change is already known in the family. Lastly, results of the testing are not always clear. Because of these and other limitations with genetic testing, and because not all health conditions are genetic, a "normal" result does not guarantee that a child will be healthy.

(Source: https://www.canada.ca/en/public-health/services/fertility/genetic-testing-screening.html)

Recombinant DNA Technology



- Recombinant DNA (or rDNA) is made by combining DNA from two or more sources. In practice, the process often involves combining the DNA of different organisms. The process depends on the ability to cut and re-join DNA molecules at points which are identified by specific sequences of nucleotide bases called restriction sites. DNA fragments are cut out of their normal position in the chromosome using restriction enzymes (also called restriction endonucleases) and then inserted into other chromosomes or DNA molecules using enzymes called ligases.
- **Example: Production of Insulin** – Genetic engineering processes can make human insulin. Human insulin DNA is placed into the DNA of a second organism. The host organism becomes an insulin-producing factory. People with diabetes (called diabetics) do not correctly produce or use their insulin protein. The insulin protein helps control how much sugar is in your bloodstream. Millions of diabetics need to take insulin. Insulin from cows and pigs has been used since the early 1900s to treat diabetes. Now human insulin protein can be mass-produced through genetic engineering processes – DNA put into a bacteria that will then produce insulin.

(Source: http://www.iptv.org/exploremore/ge/what/insulin.cfm)

Assistive Reproductive Technology (ART)

- ART includes all fertility treatments in which both eggs and embryos are handled. In general, ART procedures involve surgically removing eggs from a woman's ovaries, combining them with sperm in the laboratory, and returning them to the woman's body or donating them to another woman. They do NOT include treatments in which only sperm are handled (i.e., intrauterine—or artificial—insemination) or procedures in which a woman takes medicine only to stimulate egg production without the intention of having eggs retrieved.
- The main type of ART is in vitro fertilization (IVF). This is when fertilization occurs outside of the body, in the laboratory.

(Source: https://www.cdc.gov/reproductivehealth/infertility/)

Human Genome Project

- The Human Genome Project (HGP) was the international, collaborative research program whose goal was the complete mapping and understanding of all the genes of human beings. All our genes together are known as our "genome."
- The hereditary material of all multi-cellular organisms is the famous double helix of deoxyribonucleic acid (DNA), which contains all of our genes. DNA, in turn, is made up of four chemical bases, pairs of which form the "rungs" of the twisted, ladder-shaped DNA molecules. All genes are made up of stretches of these four bases, arranged in different ways and in different lengths. HGP researchers have deciphered the human genome in three major ways: determining the order, or "sequence," of all the bases in our genome's DNA; making maps that show the locations of genes for major sections of all our chromosomes; and producing what are called linkage maps, complex versions of the type originated in early *Drosophila* research, through which inherited traits (such as those for genetic disease) can be tracked over generations.
- The HGP has revealed that there are probably about 20,500 human genes. The completed human sequence can now identify their locations. This ultimate product of the HGP has given the world a resource of detailed information about the structure, organization and function of the complete set of human genes. This information can be thought of as the basic set of inheritable "instructions" for the development and function of a human being.

(Source: https://www.genome.gov/12011238/an-overview-of-the-human-genome-project/)

- Of special note in the HGP was the fact that there was so much collaboration between international scientists to make this happen. Without this level of collaboration, a project as ambitious as this would not have been possible.
- The Human Genome Project was a publicly funded project that brought scientists together from across the globe. Support and funding from the Department of Energy and US National Institutes of Health and later in the UK from the Medical Research Council and Wellcome Trust enabled the project to run on a huge scale. The labs from these organisations then joined with collaborators across six countries to take on the massive task of sequencing the first human genome.
- Everyone involved was keen that the project was a joint effort. This was in part because it was concerning the ‘human’ genome, not the ‘American’ or ‘British’ genome, but also because they needed worldwide support as the project itself would end up costing a huge $3 billion over 13 years (although their initial goal was 15 years). The Human Genome Project provided an excellent opportunity to encourage international cooperation in biological science, setting standards in techniques and technologies across the globe to influence future medical research.

(Source: http://www.yourgenome.org/stories/who-was-involved-in-the-human-genome-project)

Antibodies and Resistance

- Antibiotic medications are used to kill bacteria, which can cause illness and disease. They have made a major contribution to human health. Many diseases that once killed people can now be treated effectively with antibiotics. However, some bacteria have become resistant to commonly used antibiotics.
- Antibiotic resistant bacteria are bacteria that are not controlled or killed by antibiotics. They are able to survive and even multiply in the presence of an antibiotic. Most infection-causing bacteria can become resistant to at least some antibiotics. Bacteria that are resistant to many antibiotics are known as multi-resistant organisms (MRO).
- Antibiotic resistance is a serious public health problem. It can be prevented by minimising unnecessary prescribing and overprescribing of antibiotics, the correct use of prescribed antibiotics, and good hygiene and infection control.

- Some bacteria have developed resistance to antibiotics that were once commonly used to treat them. For example, Staphylococcus aureus ('golden staph' or MRSA) and Neisseria gonorrhoeae (the cause of gonorrhoea) are now almost always resistant to benzyl penicillin. In the past, these infections were usually controlled by penicillin.
- The most important ways to prevent antibiotic resistance are:
    - Minimise unnecessary prescribing and overprescribing of antibiotics. This occurs when people expect doctors to prescribe antibiotics for a viral illness (antibiotics do not work against viruses) or when antibiotics are prescribed for conditions that do not require them.
    - Complete the entire course of any prescribed antibiotic so that it can be fully effective and not breed resistance.
    - Practise good hygiene such as hand-washing and use appropriate infection control procedures.

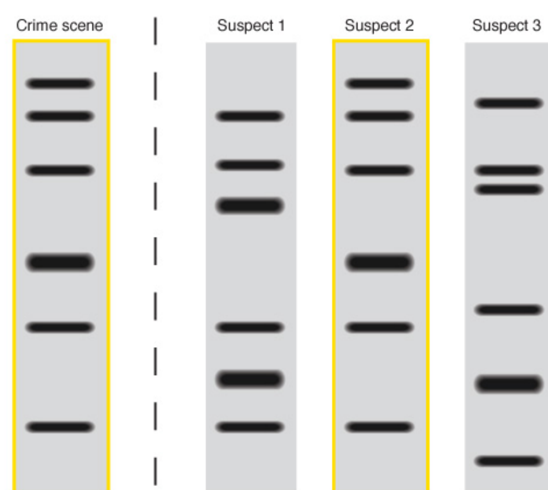
(Source: https://www.betterhealth.vic.gov.au/health/conditionsandtreatments/antibiotic-resistant-bacteria)

- According to the World Health Organization, more antibiotics are fed to farmed animals than are used to treat disease in human patients. Doctors overprescribe antibiotics, but huge amounts of antibiotics are used in fish farming and other intensive animal agriculture, up to four times the amount used in human medicine. Why? "Suboptimum growth to slaughter weight caused by unsanitary conditions can be compensated with the addition of antibiotics to feed." Instead of relieving any stressful overcrowded unhygienic conditions, it may be cheaper to just dose the animals with drugs.
- In this way, factory farms are driving the growth of antibiotic-resistant organisms that cause human diseases. "This may help bolster the industry's bottom line, but in the process, bacteria are developing antimicrobial resistance, which affects human health."
- The FDA reports that 80% of antimicrobial drugs in the United States are used in food animals, mainly to promote growth in this kind of high-density production. This can select for antibiotic-resistant bacteria like methicillin-resistant *Staph aureus*, or MRSA, considered a serious threat in the United States.

(Source: https://nutritionfacts.org/2016/03/10/antibiotic-resistant-superbugs-in-meat/)

DNA Fingerprinting

- DNA fingerprinting is a laboratory technique used to establish a link between biological evidence and a suspect in a criminal investigation. A DNA sample taken from a crime scene is compared with a DNA sample from a suspect. If the two DNA profiles are a match, then the evidence came from that suspect. Conversely, if the two DNA profiles do not match, then the evidence cannot have come from the suspect. DNA fingerprinting is also used to establish paternity.



(Source: https://geneed.nlm.nih.gov/topic_subtopic.php?sid=38)