These notes explain the **why** behind every concept, not just the what. They include **analogies**, **real-life examples**, and explanations of **common mistakes**. Use these alongside your revision notes for full understanding.

B6 Life on Earth — Past, Present and Future

Life on Earth has existed for approximately 3.5 billion years. For most of that time, the only life was single-celled. Complex multicellular life only appeared about 600 million years ago. Understanding how life evolved and how it is currently threatened helps us appreciate what is at stake with today's biodiversity crisis.

Selective Breeding — Humans Shaping Evolution

For thousands of years, farmers have been unconsciously practising artificial selection. By choosing which individuals to breed from, they have directed the evolution of domesticated species far faster than natural selection would. Modern wheat produces 10 times more grain than its wild ancestors. Modern dairy cows produce 10 times more milk than cows 100 years ago.

■ **Why does this happen?** The downside of selective breeding is reduced genetic diversity. Modern commercial crops are often genetically near-identical. If a new pathogen or pest evolves to attack one plant, it can attack them all. The Irish Potato Famine (1845-49) was largely caused by the fact that Irish potatoes were almost entirely one variety — when a new potato blight arrived, it destroyed virtually the entire crop, causing the deaths of over 1 million people.

Genetic Engineering — Precision at the Molecular Level

Genetic engineering allows specific genes to be cut from one organism's DNA and inserted into another's — regardless of how distantly related the two species are. This is fundamentally different from selective breeding, which can only work with variation that already exists in a species.

Step 1	**Identify the gene**	Find the DNA sequence coding for the desired protein (e.g. human insulin gene)
Step 2	**Cut out the gene**	Use restriction enzymes — molecular scissors that cut DNA at specific sequences
Step 3	**Prepare the vector**	Cut open a bacterial plasmid with the same restriction enzyme, creating sticky ends
Step 4	**Insert the gene**	Mix the gene and plasmid — sticky ends join. Use ligase to seal the joins
Step 5	**Transform bacteria**	Introduce the recombinant plasmid into bacteria. Bacteria now carry the human gene
Step 6	**Express the gene**	Bacteria reproduce and produce the human protein (e.g. insulin) in large quantities

Selective breeding	Humans choosing individuals with desired traits to breed — speeds up evolution of useful characteristics
Genetic engineering	Direct transfer of a gene from one organism to another using molecular tools

Restriction enzyme	Enzyme that cuts DNA at specific sequences — used to cut out genes
Ligase	Enzyme that joins DNA strands — used to seal genes into plasmids
GM organism	Genetically modified organism — contains a gene from a different species
Clone	Genetically identical copy of an organism