Evolution in Present Times

Principles of evolution are very relevant in the modern world. They are, for example, used in:

- The resolution of legal issues by DNA fingerprinting
- Tracing the origins of diseases and development of treatments
- Selective breeding of plants and animals
- Understanding the resistance of insects to insecticides
- Modern warfare; the use of pathogens and mutagens as weaponry

An argument posed against evolution is that we cannot say that it happens because we cannot *see* it happening. However, evolution is **always happening** and, while for many species (such as humans) it is an extremely slow process occurring over many thousands of years, it is observable. Evolutionary change can be:

- Demonstrated in a laboratory using life forms that reproduce very rapidly, such as single-celled organisms and some invertebrates
- Witnessed as the result of the breeding of new varieties of plants and animals by artificial selection
- Observed where the TB bacterium develops a resistance to TB drugs, or insects develop resistance to insecticides
- Seen in the adaptation of HIV to drugs
- Shown by the development of new species of plants as a result of polyploidy and hybridisation

Why can using antibiotics and insecticides be risky?

Pathogenic organisms, such as bacteria and insects, can **evolve quickly**. This is because of:

- Natural variation
- Mutations, which occur often because of the rapid breeding of the organisms

In the process of evolving, they can become resistant to chemicals intended to kill them. The antibiotics or insecticides are therefore no longer useful.

Resistance to antibiotics in bacteria:

Antibiotics are important as they help fight infections caused by bacteria. Incorrect use of antibiotics, however, is a serious issue. This is because bacteria can become resistant to the antibiotics, rendering them useless.

An example of this is that drugs such as penicillin, which were once very powerful, are now ineffective against new drug-resistant strains of bacteria (like those that cause tuberculosis and staphylococcal infections. Some bacteria are now resistant to almost all known antibiotics; these bacteria, which carry resistant genes, are called multi-drug resistant or 'superbugs'.

Antibiotic resistance is the ability of a bacterium to survive the effects of antibiotics and continue to live and reproduce.

Development of Resistance:

- A patient with a bacterial infection begins a 5 day course of antibiotics
- After 3 days, the person begins to feel better and stops taking the antibiotics. This can lead to the development of antibiotic resistance in the following ways:
    - As a result of natural variation
    - Chance mutations
    - Bacteria reproduce rapidly, therefore those with a resistant gene could form a new resistant population
- Using an antibiotic incorrectly can cause the rapid evolution of a strain of bacteria resistant to antibiotics

Development of resistant strains of TB:

Tuberculosis is a chronic bacterial infection caused by *Myobacterium tuberculosis*. Antibiotic treatment was developed about 50 years ago, and this resulted in the incidence, frequency and mortality rates of humans with TB declined rapidly.

However, TB has become more common again:

- Many patients fail to complete their full course of antibiotics and TB bacteria that are resistant to the drugs survive
- The antibiotic exerted an **environmental pressure** on the bacterium
- Natural genetic variation means that some TB bacteria are less susceptible to the antibiotics, and these survive the shortened treatment
- This resistant trait is passed on to new generations and soon most bacteria are resistant and the patients develop TB again
- Most of the TB bacteria population was made up of this resistant strain
    - To manage this, patients were given two medications at once
    - This was done with the hope that the bacteria would not become resistant to both
- However, the bacteria did become resistant to both, and **multidrug-resistant TB (MDR-TB)** evolved
- This is extremely dangerous as it can bring about the rise of **extensively drug-resistant TB (XDR-TB)** which needs aggressive treatment, made up of 5 drugs combined
- XDR-TB is very dangerous and highly fatal

The emergence of MDR-TB and XDR-TB is a result of incomplete treatments and the evolutionary process at work.

Resistance to insecticides in pest insects:

Pest insects are a great problem to humans as they:

- Destroy food crops, e.g. locusts
- Act as vectors of disease-causing pathogens, e.g. mosquitoes

In order to manage these problems, humans developed insecticides to destroy the insects. However, a specific insecticide will not be effective for long, as the insects will ultimately develop a resistance to it. As a result, crop losses and the prevalence of diseases like malaria increase. By 1990, more than 500 species were resistant to at least one type of pesticide.

Development of resistance to DDT in insects:

DDT is a strong nerve poison, which was widely used to:

- Kill pest insects in agriculture and forestry
- Control human diseases with insect vectors, such as malaria (transmitted by mosquitoes)

Use of DDT was initially very successful. However, resistance developed in the following ways:

- The insect population had genetic variability, and a few individuals had a trait allowing them to detoxify DDT, making them resistant to it
- DDT acts as a selective force, with only the individuals resistant to it surviving. The resistance trait is passed on to the next generations
- Repeated used of DDT results in the development of DDT-resistant populations with an altered genotype

This is a good example of evolution by natural selection: the best adapted survive, while the less adapted die.

In the early 1970s, most industrialised nations banned the use of DDT because of the environmental impacts of it and its breakdown products. With the selective pressure of DDT removed, insect populations that are not resistant to DDT have re-emerged. In South Africa, spraying with low doses of DDT has been renewed and is proving effective against malaria mosquitoes.