

How biotechnology helps to identify criminals criminology essay

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Have you ever wondered how the police are able to identify suspects from just a single strand of hair, skin fibres or fingerprints that they leave behind? Without the use of modern biotechnology, it will be difficult to do so. In this brochure, you will be introduced to one of the methodology that forensic scientists used to identify criminals, and that is Polymerase Chain Reaction (PCR).

Why it works

Human DNA sequences contains short tandem repeats (STRs) that do not code for proteins and differs greatly from person to person and most importantly they are unique, hence these STRs can be used to identify criminals. These STRs are amplified by polymerase chain reaction, then separated by gel electrophoresis with the suspect's DNA and identified by using DNA Probes.

What is DNA

DNA is a double helix molecule, (i. e. two strands twisted around each other in a helical structure). A single strand of the DNA consists of a sequence of four different types of molecules call nucleotides.

They are namely, adenine (A), thymine (T), guanine (G) and cytosine (C). Each nucleotide will always bind to another specific nucleotide. (T always to A and G always to C) and vice versa. This is known as complementary base pairing.

Each strand of the DNA runs in one direction. One of them run in the 5 prime direction and the other in the 3 prime direction. These directions are named

due to the orientation of the carbon atoms on the DNA. The two strands of DNA are anti parallel when they are bonded together so that the 5 prime end of one strand matches the 3 prime end of the other.

What is Polymerase Chain Reaction

PCR is a method that create millions of copies of a target DNA strand known as the Amplification Site. This method makes use of the same enzyme (DNA polymerase) but another variant that are used to replicate DNA in our body. It is however, performed in a laboratory environment by repeated cycles of heating and cooling.

In order to amplify the DNA for analysis, the two strands have to first be separated or denatured. After which a molecule known as the primer, attaches itself to a location toward the 5 prime end of the target amplification site. The primer is usually made up of 20 nucleotides.

Lastly an enzyme, DNA polymerase (Taq Polymerase), attaches itself to the primer. This enzyme is able to synthesize nucleotides to a growing DNA strand. It uses the original DNA as a template and moves along the single strand to create a new strand of complementary nucleotides based on the complementary base pairing rule. (E. g., the original strand contains the sequence GACTG, and then it will generate another strand with the sequence CTGAC.)

At the end of the process, the original strands of DNA are separated and copied by DNA polymerase, and two identical DNA strands are being created.

In PCR, primers are made so that only the targets of DNA amplification are produced. In order to copy both DNA strands for the amplification site, 2 primers are needed, one for each strand.

Taq polymerase

The variant of enzyme of the DNA polymerase, used in PCR is the Taq polymerase, which is stable at temperatures as high as 95°C, and hence it is able to withstand the heat when DNA is being denatured. Furthermore, at higher temperatures, the chances of a primer binding to a non-target DNA sequence is much lower with the enzyme's optimal temperature of 72°C, which is way higher than the original DNA polymerase in our body

The PCR Process

The strands of DNA are denatured by heating them to about 90-95°C for about 30 to 60 seconds to be separated, so that the primers cannot bind to the target DNA.

The mixture is cooled to about 50-70°C, a temperature which DNA will form its double helix structure. In this step, the 2 primers will bind to each of the target DNA strands at the 5 prime end of the target of amplification. An excess of primers are added to make sure that the primers anneal to the amplification site, so as to prevent it from reattaching to each other. This step takes about 20 seconds.

The temperature is then raised to about 72-75°C, which is the optimum temperature for Taq polymerase to work. It will start to extend the complementary strand of DNA, which takes about 60 seconds.

After the first cycle, two complete copies of the target DNA is produced

Figure 1: PCR Process Figure 2: Replication

The second time it is repeated, both the original DNA and the newly synthesized strands are copied, resulting in four copies of the target DNA. The third time it is repeated, eight copies are made and so on (Refer to figure 2). It can be observed that the amplification increases exponentially at 2^n , where n is the number of cycles. This cycle is repeated for about 20 to 30 times which usually take 2-3 hours. At the end of the process around one million to one billion of copies of the target sequence of the DNA are produced.

The entire process is done on a PCR Machine which is a thermal cycler to change temperature very quickly so that the reactions can take place. The figure on the left illustrates what happens in the thermal cycler

Figure 3: Thermal Cycling Graph