Genetic fingerprinting (A2)

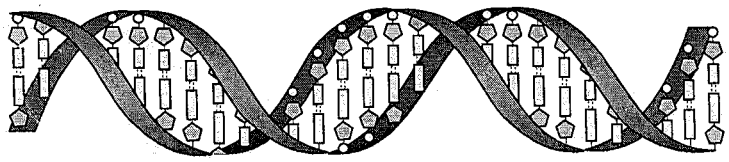
the principle and method.

Genetic fingerprinting is the most high profile and widely used application of the electrophoresis of nucleic acid.

DNA (deoxyribonucleic acid) is the biological macromolecule that is contained within the chromosomes of cells.

It is a two-stranded polymer and each strand is composed of a sugar (deoxyribose)-phosphate backbone, with a cyclic organic base attached to each sugar residue.

The strands are held together by hydrogen bonds between the organic bases and twine around each other in a helical fashion.



structure of DNA.

All DNA molecules contain the same molecular backbones, and the same four bases.

They differ only in their overall length (even the shortest has many thousand units in its chain) and in the order in which the bases are arranged along the backbone.

Genes are sections of a DNA molecule that become templates for the synthesis of strands of RNA (ribonucleic acid) which in turn form the code that translates into the arrangement of amino acids along the chains of the enzymes and other protein molecules in the organism.

Of the DNA contained within the chromosomes, only about 10% is used in the genes. This small portion of 'useful' DNA will be almost identical in most members of a particular species. And much will be identical for different species too.

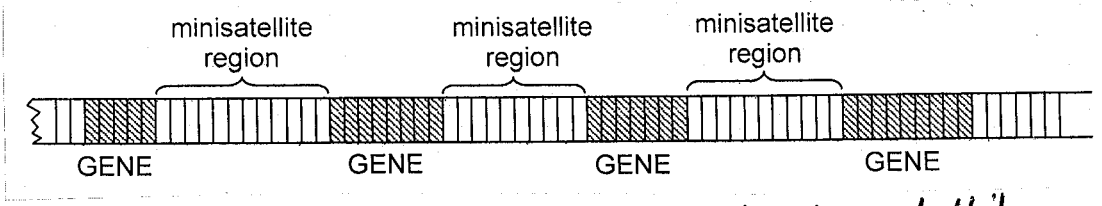
Any large change in this genetic material would be mirrored by a change in the amino acid sequence of the final protein, which would affect their efficiency as enzymes and could prove fatal to the organism.

The other 90% of chromosomal DNA (the 'useless' DNA) lies between the genes, and is highly variable in its base sequences. These portions often contain sequences of bases (about 10–50 base-pairs in length) that are repeated several times.

All members of the same species have these repeats, but individuals vary in the number of times each sequence is repeated

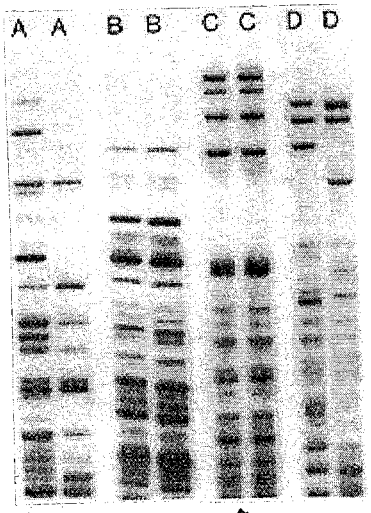
The areas are termed minisatellites, or VNTRs (variable number of tandem repeats).

There are also quite short sequences (2-5 base pairs) that are repeated many times. These are termed short tandem repeats (STRs), or microsatellites.



strand of DNA showing genes and minisatellites.

The key to genetic fingerprinting is that an individual's pattern of VNTRs or STRs is entirely unique – no one else (except an identical twin) will have the same pattern.



DNA from twins

Each individual inherits half their pattern from their mother and half from their father.
Members of a family throughout many generations will have similar minisatellite patterns to each other.

Procedure of genetic fingerprinting

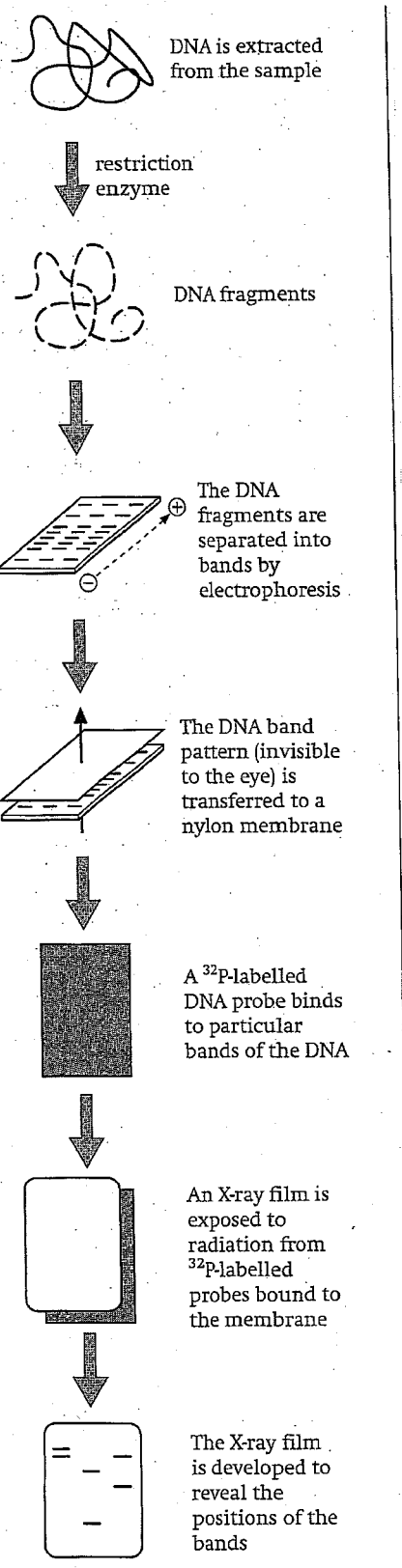
The technique of genetic fingerprinting starts with the extraction of the DNA from a sample of chromosomal material, such as blood (only the white cells contain DNA), hair, inner cheek cells, semen or skin.
The DNA is then broken into fragments by a restriction enzyme.
There is a range of these enzymes available, each one breaking the DNA at several different, but known and specific places. This produces fragments that can now be subjected to electrophoresis.
The samples of DNA to be analysed are placed in wells near the cathode of an agarose gel plate.
Since the phosphate groups along the chains of DNA are negatively charged, all DNA samples will move towards the anode, but the smaller fragments will move faster than the larger ones.

Discovering the positions of the seperated fragments on the developed electropherogram requires a special technique, since the amounts of DNA are so small. Spraying and staining with a dye would give only a faint image.

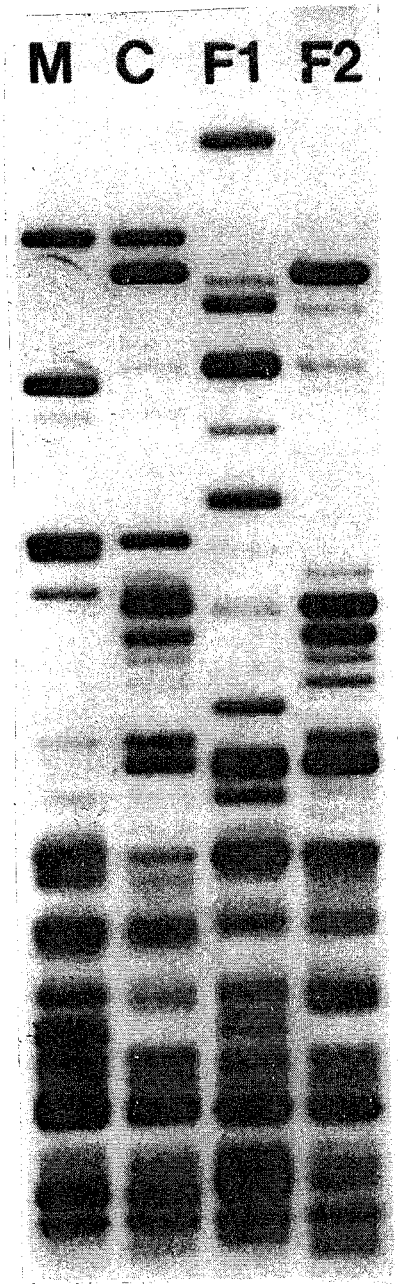
The DNA fragments are transferred from the gel onto a nylon membrane and are broken into single strands by soaking in dilute alkali.

The membrane is then soaked in a solution containing short lengths of DNA identical to the minisatellite sequence, but labelled with radioactive ^{32}P.

The ^{32}P DNA thus sticks to the membrane where the DNA fragments are situated, and if an X-ray sensitive film is placed over the plate, it will record the pattern originally on the gel plate.



The steps in the process of genetic fingerprinting.



genetic fingerprints of a child, C, and its mother, M, and two possible fathers, F1 and F2.

The uses of genetic fingerprinting

Genetic fingerprinting has been used in:

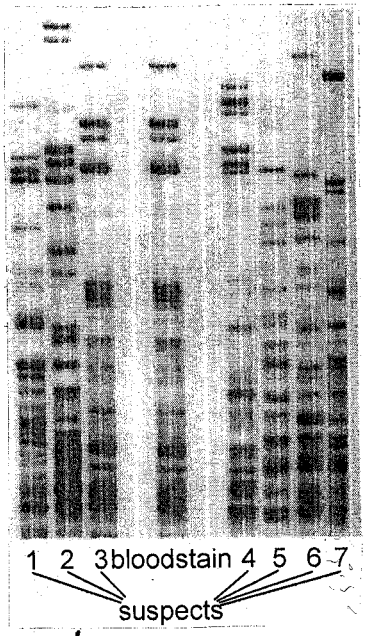
- paternity testing
- establishing other familial relationships - between both the living and the dead.
- establishing the relationship between archaeological artefacts.
- forensic testing
- medicine.

Example

A child inherits one set of chromosomes from its mother, and the other set from its father.
The child's fragments correspond with those of its mother, together with those of possible father F2, but show little correspondance to those of possible father F1.

Example.

In forensic science, genetic fingerprinting is useful because of its ability to exclude suspects, as well as give strong evidence to include one particular suspect. The below shows the DNA fingerprints of seven suspects, and of a bloodstain at the scene of a crime.



DNA fingerprints of seven suspects and blood taken from the scene of a crime.

Exercise

How and Why is electrophoresis used in DNA fingerprinting/profiling?

Workings

Electrophoresis is used to seperate the small fragments of DNA on a gel.

This method seperates the fragments according to their charge and size without altering them in any way.