ROSALIND MIST

DNA fingerprinting

GCSE key words
DNA
Clone
Selective breeding

When Dolly the sheep was born in 1996, it was announced that she was a 'clone' from a female adult sheep. To prove this, the scientists who created Dolly had to have genetic profiling or fingerprinting done by another, independent, group of scientists. This article describes how it was done, and explains other uses of the technique.

Alfred Pasieka/SPL

Dolly with Ian Wilmut who led the team that created her

Topham

Have you ever wondered how the scientists who bred Dolly the sheep could be sure that she was a clone? They had to convince the scientific community that no mistakes had been made, and it was therefore important that more than one group of scientists tested Dolly.

Any organism produced by sexual reproduction is genetically unique (with the exception of identical twins) and this means the DNA packed into the chromosomes is different in each individual. Some years ago Sir Alec Jeffreys, a professor at the University of Leicester, developed a method for spotting unique features of an organism's DNA. His method formed the basis for genetic fingerprinting or profiling (see Box 1 and Figure 1), which was the technique used to check Dolly's genetic origin.

HOW DOLLY WAS TESTED

Human DNA is unique to the individual, but what about sheep DNA? The first thing to do was to compare DNA samples from several sheep to see whether sheep DNA is also unique. The team compared the DNA fingerprints of 12 different sheep. About 38% of the DNA bands in any two animals were similar. If the match between samples from Dolly and the donor ewe was much better than this, they were very likely to be related.

Dr Esther Signer, a member of the group at the University of Leicester which tested Dolly, said, 'We compared the DNA found in Dolly's blood with the DNA from the mammary cells of the donor ewe and with a sample of the original cells that had been implanted in the surrogate mother.' They found that there were no differences between the three samples. 'The chances of two unrelated sheep having such a good match were estimated at about 1 in 1600 million,' said Esther.

The group also had to consider the possibility that Dolly was a daughter sheep rather than a clone. Dolly's mother was pregnant when the mammary cells were taken. There was a small possibility that a foetal cell had travelled through the blood system to her mammary glands and been collected there by the scientists.

If she was a daughter, Dolly would have had about half her DNA from the donor sheep and the other half from a father sheep. As Dolly's DNA fingerprint was so similar to that of the donor ewe, Esther's team had to work out what the chance was that a 'normal' offspring could have had such a great resemblance. 'The probability was very small, 1 in 3 million,' said Esther.

NOT JUST SHEEP AND PEOPLE

DNA fingerprinting isn't just used to test the paternity of people, or even of 'cloned' sheep. The technique has been used for other purposes too.

Suppose you want to breed a prize pig, or one that will taste better than other pigs. You have a

BOX 1 GENETIC PROFILING

Everyone's DNA has the same molecular structures. The differences between the DNA of individual organisms lie in the order of the base pairs. There are so many millions of base pairs in DNA that every person has a different sequence except identical twins, nature's 'clones'.

Since these patterns are unique to an individual they are called DNA fingerprints. Unlike traditional fingerprints they can also show whether people are related.

Each person, animal or plant can be identified solely by the sequence of their base pairs. However, because there are so many millions of base pairs, this task would be very time-consuming. Alec Jeffreys found a short-cut making use of repeating patterns in DNA.

These patterns do not give an individual 'fingerprint', but they are able to show whether two DNA samples are from the same person, related people, or non-related people (or other organisms). Scientists use a small number of sequences of DNA that are known to vary a great deal among individuals, and analyse these to get a certain probability of a match.

Figure 1 *How DNA fingerprinting works*

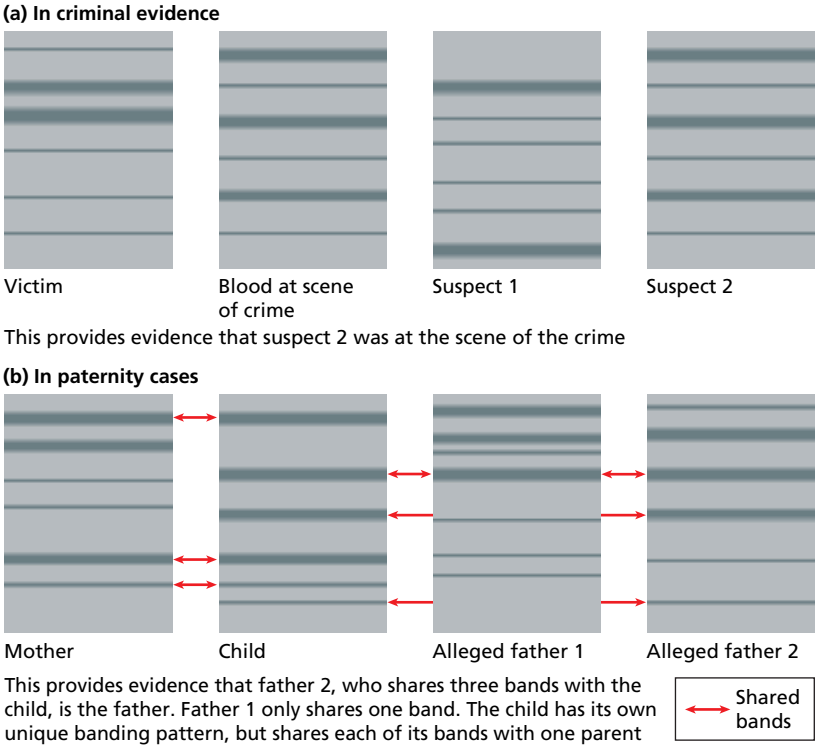
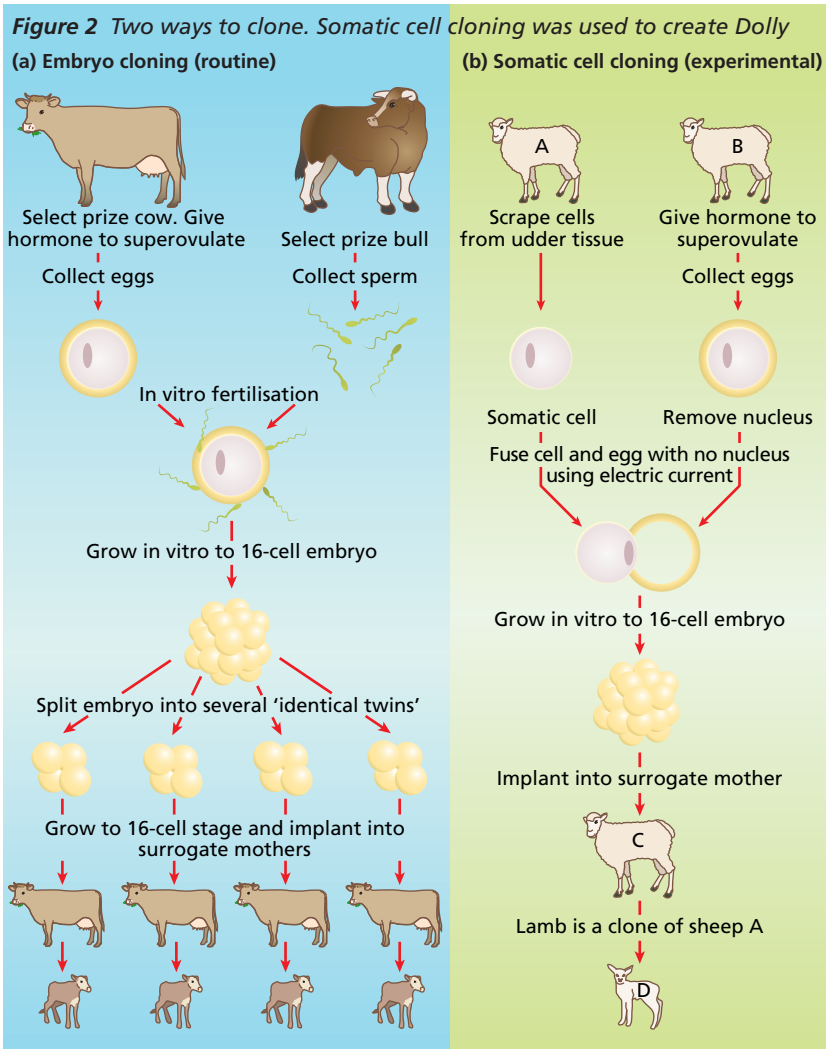


Figure 2 *Two ways to clone. Somatic cell cloning was used to create Dolly*



Leicester University

Leicester University

***Left**: Esther Signer's work on DNA has involved her in identifying the parentage of piglets (**below**) as well as that of Dolly, and of peregrine falcons*

sow, and you need a prize-winning father. You take your sow to be mated with the prize boar (or maybe you opt for artificial insemination). Sixteen weeks later, a fine litter of piglets is born. They grow up. However, as they grow, you are not quite sure about them — they are not what you expected. You begin to wonder whether the father was the boar you paid to use. What can you do?

Well, you can call in a DNA fingerprinting expert and see what they say. In the case of the pigs, Dr Signer discovered that somehow there had been a mix-up at the pig-breeding company. The test tubes containing the semen had not been labelled correctly, and the wrong pig had fathered the litter. You might think this is a lot of trouble to go to for a pig, but getting a prime porker can be an expensive business!

FORENSIC SCIENCE

You probably know that the police can use DNA as part of their forensic evidence in crime scenes, but did you know that they have used it to trap wild-bird smugglers and breeders?

In 2000, the RSPB (Royal Society for the Protection of Birds) suspected that some peregrine falcons it had found at a man's house were not all they seemed. The peregrine falcon is a protected species, but the man claimed his birds had been bred in captivity, and were not illegal wild birds. The RSPB suspected that he had taken them from the wild and called in the team at Leicester to investigate.

Esther got to work with the fingerprinting techniques and compared the DNA of the questionable chicks to that of the adult birds the breeder claimed to be the parents. The chick DNA profiles should have been a mix of the bands seen in their parents' profiles, but — you've guessed it — the matches were far from perfect. Using this evidence, the man was convicted under CITES (Control on International Trade in Endangered Species).

This was one of many cases brought by the RSPB using DNA evidence which have had a dramatic effect. 'Before DNA fingerprinting, we couldn't prove that birds were not reared in captivity,' said the RSPB spokesman. 'Thanks to DNA typing, there has been a significant drop in the numbers of people taking birds from the wild'.

***Rosalind Mist** runs sciZmic, a national network of science clubs based at Science Centres such as Explore@Bristol. **Esther Signer** is a geneticist at the University of Leicester.*

BOX 2 WEBSITES

http://www.dnai.org provides all sorts of animations, including those associated with the polymerase chain reaction used to copy DNA (see back cover), as well as video clips and historical background on many genetic topics. DNA fingerprinting itself is soon to be added to the site.

http://www.rspb.org.uk has information on how to watch and learn about wild birds.

http://www.cites.int explains CITES and the work it does to prevent trade in endangered species.