

## Biological systems: Biotechnology - Cloning

### Links to curriculum learning outcomes:

#### Biotechnology – Fourth (SCN 4- 13c):

- *I can debate the moral and ethical issues associated with some controversial biological procedures.*

### Teachers' Notes

#### Cloning

These teachers' notes are designed to provide you with all the information you need to teach a lesson on cloning using the slide show. These notes describe the different types of cloning and give arguments for and against it to help you with a bioethical discussion. They explain the types of cloning in more detail than you will need for pupils at this level but they may help answer any complicated questions and they will be useful for your background knowledge. There are also notes under each slide to help you explain them.

The learning outcomes of the slide show are for pupils to understand:

- Cloning is a process that creates genetically identical copies of organisms
- Dolly the Sheep was cloned
- The process of nuclear transfer that was used to clone Dolly
- To be able to debate the moral and ethical issues associated with cloning

To start off the lesson, you could ask the children what they know about cloning. Can they explain what it is or think of any examples.

Some examples and points for discussion are:

- Dolly the Sheep
- From fiction, Mini Me – a clone of Doctor Evil (although his reduced size is hard to explain)
- Identical twins are technically clones
  
- Cloning is a process that creates genetically identical copies of organisms

DNA cloning: As well as whole organism cloning, there is molecular cloning or recombinant DNA technology, which is a procedure used to isolate a defined sequence of DNA and obtain lots of copies of it. This procedure is in common use in biology laboratories. When scientists want to study a fragment of DNA from a particular organism they cut it out, using restriction enzymes. It is transferred into a self-replicating element, such as a bacterial plasmid and then propagated in a foreign host cell. Lots of copies of the gene of interest can be grown in the foreign host cell

and then used to study the function of the gene. Although it is the most commonly used type of cloning, this procedure is rather too advanced for younger pupils.

Reproductive cloning: is the technology used to create an entire organism, which has the same nuclear DNA. Dolly the sheep was created by reproductive cloning technology, by a process called somatic cell nuclear transfer, which is described later.

Therapeutic cloning: also known as embryo cloning, refers to the production of human embryos to be used in research or treatment. Stem cells are removed from the embryos, which are used to study human development and for treating diseases. Stem cells generate virtually all types of specialised cells in the human body, which is why they are so useful to biomedical researchers. They are extracted from the embryo after 5 days of cell division, at which point the embryo is known as a blastocyst.

Many researchers hope that stem cell treatment will provide replacement cells to treat heart disease, Alzheimer's, cancer and other diseases in the future. The extraction process destroys the embryo itself so there are lots of ethical concerns associated with this treatment.

In the slide show cloning is defined as creating a genetically identical copy of an organism. Genetically identical means having exactly the same DNA; the DNA in the nucleus of cloned cells is identical to the DNA from the organism the nucleus was taken from. Reproductive cloning is the focal point of the slide show. Molecular and therapeutic cloning are not covered as they are too advanced for pupils at this level. You may want to tell pupils that there are other types of cloning for discussion purposes later on though.

You may want to ask or remind pupils what an organism is. An organism can simply be described as anything living, e.g. animals, plants, fungi and micro organisms

- Dolly the Sheep was cloned

Dolly was the first mammal to be successfully cloned from an adult cell, in 1996. She was made and lived in the Roslin Institute in Edinburgh for all her life. She was not actually the first animal ever to be cloned; she was just the first mammal to be cloned using somatic cell nuclear transfer. The first ever animal to be cloned was a tadpole in 1952.

Since Dolly, lots of animals have been cloned using somatic cell nuclear transfer, including sheep, goats, cows, mice, pigs, cats, rabbits and a gaur (a large, dark-coated bovine animal, which look like water buffalo from the front and domestic cow from the back).

- The process of nuclear transfer that was used to clone Dolly

Dolly was cloned using somatic cell nuclear transfer. A somatic cell is a cell of the body, which is not a sperm or egg cell. The slides in the PowerPoint have images to accompany the explanation to try to help pupils visualise the procedure.

## Somatic Cell Nuclear Transfer

1. A somatic cell from the mammary gland of a Finn Dorset adult ewe was isolated.
2. The nucleus was extracted and the rest of the cell was discarded.
3. An egg cell from a Scottish Blackface ewe was isolated.
4. The nucleus was removed & discarded.
5. The nucleus from the somatic cell was inserted into the enucleated egg cell (egg cell without a nucleus).
6. After insertion into the egg, the host cell reprogrammed the somatic cell nucleus.
7. The egg cell was stimulated with a shock so it began to divide.
8. After lots of cell divisions in culture, once the single cell had formed a blastocyst (an early stage embryo with about 100 cells), it was implanted into a Scottish Blackface surrogate mother and the surrogate mother carried the embryo through pregnancy.
9. Dolly was born to her surrogate mother 148 days later.

Steps 6 and 7 of the process have been omitted from the slides and some of the explanations have been simplified.

As the pictures show, the ewe the egg cell was taken from and the surrogate mother both have black faces. They are from the Scottish Blackface breed of sheep. The Finn Dorset sheep, from which the nucleus was extracted, had a white face. When Dolly was born with a white face this proved that she was a clone of the Finn Dorset ewe (shown in Slide 8).

## Somatic Cell Nuclear Transfer technology

There are lots of limitations to the somatic cell nuclear transfer procedure because it is very risky. In the case of Dolly, 277 eggs were used but only 29 viable embryos were created. From these viable embryos, only three survived until birth and only one into adulthood.

At the moment the procedure cannot be automated so it has to be performed manually under a microscope. This means it is very resource intensive. The biochemistry involved in the reprogramming of the differentiated somatic nucleus and activating the recipient egg (Step 6 and 7) are not very well understood.

It is not clear whether it will be possible to clone humans that will develop to term using this procedure in the foreseeable future. However, due to the difficulty, uncertainty and associated ethical issues, most researchers are opposed to human reproductive cloning anyway.

## Dolly's life and the speculation surrounding her death

Dolly lived until she was six years old and in her lifetime gave birth to six healthy lambs. At the age of five, Dolly developed arthritis and began walking stiffly. This was successfully treated using anti-inflammatory drugs. However, on February 14<sup>th</sup> 2003, when Dolly was six she was euthanised because she had contracted a

progressive lung disease. Post-mortem examination found she had a lung disease called Jaagsiekte, which is fairly common among sheep, caused by the retrovirus JSRV.

There was a lot of speculation surrounding Dolly's death because the average life expectancy of a Finn Dorset sheep is about 11 to 12 years. Scientists at Roslin claim there is no connection between Dolly being a clone and her early death, pointing out that lung diseases like Jaagsiekte are particularly dangerous for sheep kept indoors. For security reasons Dolly had to sleep indoors. However, some scientists think that her death is related to the fact that the sheep she was cloned from was 6, so when she was born she had a genetic age of 6.

Her remains were preserved when she died and are kept at the Royal Museum on Chamber Street in Edinburgh.

### **Bioethical discussion**

- To be able to debate the moral and ethical issues associated with cloning

Once pupils have grasped a basic understanding of cloning, they should be able to form an opinion about the ethics surrounding the issue, which they can share with their classmates. Cloning is a really good topic to have a bioethical discussion about because of its increasing use and controversy.

The slides at the end of the PowerPoint are designed for a bioethical discussion (Slide 12 – 15).

The questions in Slide 12 aim to encourage the children to think about the issues surrounding cloning and to introduce a discussion.

Slide 13 gives three arguments for cloning (numbers 1, 4 & 6) and three against (numbers 2, 3 & 5). Ask the children to get into small groups of about 3 or 4 and put these statements into the 'for' and 'against' columns on the next slide. Alternatively if you have a SMART board you could do this as a class activity if you prefer. Get pupils to discuss the arguments in their groups or as a class and think of as many more to add to the list as possible. If pupils have been working in groups, once they have had time to discuss some of the issues, get a member of each group to stand up and justify one of their arguments for and one against. There are lots of arguments for and against cloning listed on the next page to help you; you may want to tell the pupils about some of these as they might not think of them on their own.

Slide 14 is a class activity to do once you have finished the discussion. Click through the pictures and get them to stand up when they think it is wrong to clone the animal in the picture. Make sure the pupils know that there is no right or wrong answer. However, to make their opinions more credible they should be able to back them up with reasonable arguments.

### Arguments against cloning:

- It is unnatural - it is going against nature.
- It is trying to create an artificial world where everything is produced the way humans want it to be.
- It is very risky – it is ‘playing with life.’
- Unsuccessful attempts have been made to clone many animals, like monkeys, chicken, dogs and horses meaning embryos have been unnecessarily lost.
- The somatic cell nuclear transfer process is very inefficient and not very well understood (only about 1 or 2 viable offspring are produced from every 100 experiments).
- For clones that do survive, about 30% are affected with ‘large-offspring’ syndrome and other debilitating conditions. They often die early because they contract infections and other complications.
- The impact cloning may have on psychological development is an important consideration in regards to human cloning. Intellect and mood are not as crucial to the animals that have already been cloned as they are to humans. Human cloning could therefore potentially be very dangerous and ethically irresponsible.

### Arguments for cloning:

#### Reproductive cloning

- Although the process of cloning is not properly understood yet, scientists are improving it all the time. Like anything in science, lots of work is involved in the early stages of development in order for techniques to be properly understood. Once techniques are properly understood, they can be improved.
- Cloning could be used to save endangered species or animals that are difficult to breed from. In 2001, a clone of a baby mouflon, an endangered wild sheep, was born in Italy. It is now living in a wildlife centre in Sardinia. The African bongo antelope, the Sumatran tiger and the giant panda are endangered species, often with low reproductive success in captivity, that are all potential targets for cloning.
- Cloning animals that have gone extinct may become possible in the future.
- Cloning could be used to develop efficient ways to reliably reproduce animals with special qualities, e.g. animals that produce drugs or animals that have been genetically altered to serve as models for studying human disease.
- Cloning meat for human consumption enhances the ability to produce the best quality meat. This will help farmers whose livelihood depends on farming by increasing their profits. It will also prevent wasting the lives of low productivity animals and guarantee that the meat produced is healthier.

- Cloning enables males that have been castrated to produce offspring. On 14<sup>th</sup> April 2005, Italian researchers announced the first clone produced from a sterile horse was healthy and thriving. The Arabian colt, Pieraz 2, was a clone of the world champion endurance racehorse, Pieraz. Pieraz 2 is able to produce offspring and is only used for breeding purposes. It has also been suggested that cloning could be used similarly for assisted reproduction in humans.

#### DNA cloning,

- which involves isolating a defined sequence of DNA and obtaining lots of copies of it, has dramatically advanced scientists understanding of the function of different genes in our bodies. This has improved their understanding of the way our bodies work and genetic diseases greatly. Gene therapy is a technique that involves supplying a functional gene to cells lacking that function with the aim to correct a genetic disorder or acquired disease. Although this type of therapy has already been used for treatment in disease it has not proved very successful, in fact some cases have even resulted in the death of patients receiving gene therapy. This treatment is now very heavily regulated. However, this technique could potentially be used for therapy in the future once techniques have been improved. DNA cloning also underpins a vast array of technologies associated with many aspects of our lives (forensics, medical diagnosis and treatments, GM and agriculture, biotechnology and drug production, and ecological conservation).  
(If you tell your pupils about this argument you should draw their attention to the fact that this procedure is achieved by another type of cloning that differs from reproductive cloning.)

#### Therapeutic cloning,

- which involves the removal of cells that are pluripotent, has lots of potential benefits. Pluripotent cells can give rise to all types of cell in the body, apart from the embryo. This means they can potentially treat diseases in any body organ or tissue by replacing damaged and dysfunctional cells. Therapeutic cloning treatment therefore avoids the risk of immunological rejection because the patients own genetic material is used. Immunological rejection is one of the major problems associated with organ transplants, along with the huge shortage of available organs. Therapeutic cloning has the potential to dramatically reduce the wait time for organ transplants as well as eliminating the immunological rejection concerns.  
(If you tell your pupils about this argument you should draw their attention to the fact that this procedure is also achieved by nuclear transfer but not reproductive cloning.)

### **Cloning worksheet**

At the end of the slide show there is an activity/worksheet, which gives the description of the process that was used to clone Dolly on one slide (Slide 18 -20). Depending on what you want to do with you class will determine which slides you use. You may also want to change the order of the slides around to do this before the bioethical discussion.

If you want to do it as an activity you could print out the worksheet with the pictures and arrows on (slide 18) and get them to put the right descriptions in, in the right places. Slide 19 could be printed out too or projected on the board at the front while they are doing it. It could be done as a class activity to get them more involved and to interact with each other. If preferred you could just print out the worksheet (slide 20) so they have a copy of the explanation of the process to refer back to.