



Faith & Genetics

Transgenics

Genetically-Modified Organisms (GMOs)

What makes a gene a uniquely human gene? As mentioned earlier, genes of all living creatures are composed primarily of DNA. DNA, the actual chemical, is the same in bacteria, oak trees, mold, trout, and humans. So how do we differentiate between your DNA that found in an oak tree? Recall that genes contain information to make proteins. The order of DNA subunits determines the order of protein subunits. Certain genes, that is, certain patterns of DNA subunits, exist only in certain species. However, some genes have the same subunits whether they are found in humans or other species. For example, two of the three allelic variants of the human gene determining blood types encode the enzyme that puts the sugars on red blood cells. That gene is nearly identical to the gene for the enzyme in chimpanzees. Nevertheless, some genes are unique to a particular species. The exact particular pattern of subunits is not found in other species. Even in these cases, there may be patterns that are close, if not identical. For example, some genes involved in development are similar in yeast, fruit flies, tiny soil worms, zebrafish and, yes, humans.

A transgenic organism is one that contains a gene from another species in every cell in its body. That is, the transgenic organism's genome has been altered. Transgenetic organisms may not appear to be different from normal organisms of that species. For example, transferring a human ABO blood type gene into a chimpanzee makes that chimpanzee technically transgenic but the genes are essentially the same. But what if we transfer into a pig a gene that allows a jellyfish to glow? The result would be a transgenic organism that has changed in some detectable way because pig genomes do not contain genes for glowing!



Zucchini's filled with orange (or oranges covered in zucchini skin?) don't really exist, but this illustration shows the principles of transgenics at work: mixing together the genetic identities of two or more species.

How is a gene transferred into an organism to create a transgenic organism? First, the desired gene from one species must be isolated. Then it can be injected directly into an egg of another species, where it will be incorporated into the genome as a germline modification. The egg is then fertilized by a sperm, implanted into a maternal host and allowed to develop. When offspring are born, they will carry the new gene in every cell of their bodies. This process has been used in mice for almost 30 years. The only problem with this process is that the inserted gene cannot be inserted into the genome very precisely yet. In fact, it may end up anywhere in the genome, on any of the chromosomes. As a result, it may not function correctly in its location.

A second method of creating transgenic organisms is to use a virus to introduce the new gene. Most of the virus genome is removed and replaced with the desired gene. The virus is then injected into an egg. Because the virus used normally inserts its genetic material into the genome of cells it infects, the new gene gets inserted into the genome along with this viral genetic material. This is the method that was used to produce the first transgenic primate, named ANDi, a rhesus monkey that had a jellyfish gene in each cell of his body. In 2001, scientists at the Oregon Regional Primate Center injected 224 rhesus monkey egg cells with the jellyfish gene. The egg cells were then fertilized with rhesus monkey sperm. In vitro fertilization is not an efficient process and only about half of the injected cells began to develop. Forty reached the stage at which they could be implanted. These 40 embryos were transplanted into the uteruses of 20 female rhesus monkeys. Five of the monkeys became pregnant. From the five pregnancies, 3 monkeys were born alive. One of those monkeys, ANDi, was found to have the jellyfish gene in each of his cells, but the gene was not functioning. In jellyfish, the gene contains the information for the green fluorescent protein which allows the jellyfish to glow. ANDi did not glow.

If this process actually works, and transgenic non-human primates are produced, two issues arise. If transgenic non-human primates can be produced, there is no theoretical barrier to producing transgenic humans. The process would essentially be the same. A transgenic human would not only contain a new gene from another species in every cell of his or her body, he or she would transmit that gene to any offspring. This modification is called germline modification because it affects not only the individual being modified, but also that individual's offspring.



The human genome shows perfect identity with 99% of the chimpanzee genome. In the genetic sense, chimpanzees can be considered our closest genetic relatives. But if our genes are so similar, why do we seem so remarkably different from our primate genetic cousins? We humans are far more sophisticated in our ability to build cities and develop political systems, write great literature and music. Our technology is hardly matched by anything else in the Animal Kingdom, and perhaps most importantly, we have self-reflective consciousness. What is it, then, that this 1% can tell us about our differences? Scientists have recently discovered 49 regions in uniquely human DNA that show faster nucleotide substitution than the rates of normal genetic evolution would predict. These regions are appropriately named Human Accelerated Regions (HARs). Within these regions scientists have found genes involved in the development of speech, overall brain volume, manual dexterity required for tool use and making, digestion of starch and lactose required in agricultural societies, and so on. As this exciting new area of research reaches deeper into our genome, we see that the differences between chimpanzees and humans are significant, even if based on only a small amount of our overall genetic material. That 1% does not seem so insignificant after all.

Animal Cloning

Finally, let's talk about cloning. A number of mammals have been cloned, including mice, sheep, cats, and mules. The process by which they were cloned is called somatic cell nuclear transfer or SCNT. Everything except egg cells and sperm are considered somatic cells. Describing the technique is fairly simple, getting it to work is trickier. In somatic cell nuclear transfer, the nucleus containing its genome is removed from an egg cell. Then a somatic cell (that is, not a sperm or egg cell) is removed from a donor. Its nucleus containing its genome is removed from the somatic donor cell and inserted into the egg cell



whose own nucleus has been removed. An electrical current is applied to activate the newly nucleated egg, which may then begin to divide and produce an embryo. The embryo is implanted into the uterus of a surrogate mother and, if it fully develops, it becomes an individual genetically identical to the individual who donated the somatic nucleus. No primates have yet been cloned using this method due to some technical difficulties. But theoretically, this method could be used to clone primates, including humans.