Genetically-Modified Organisms (GMOs): Modification within a Species

In the past, before modern genetic technologies became available, genetic modification of organisms came about through inbreeding of a species over many generations. For example, improvements in crop resistance to insect damage were developed in this way. Genetic material such as DNA can also be exchanged naturally between organisms of the same or similar species, such as bacteria, resulting in genetic modification. For example, viruses, which are smaller than bacteria and usually must live in a cell to survive, can infect bacteria and incorporate some of their DNA into their bacterial host (some viruses have a molecule similar to DNA known as RNA, which can function in a similar way to DNA). This can result in changes in the bacterium's resistance to antibiotics. In more complex organisms, such infected cells usually die from the infection without passing the viral DNA to the next generation. **Genetically-modified organisms** or **GMOs** may be organisms that have been modified in the laboratory through the insertion of a mutation of a gene of the same species associated with a desired trait that would take generations to breed into the species by conventional methods.

Please note: definitions of terms that are in boldface in the text as well as other terms can be found in the Glossary.

This has become a common and sometimes controversial technology in agriculture and animal husbandry where the results of introducing such GMOs can result in environmental imbalance and instability, and socioeconomic disruption. Use of GMOs in agriculture can result in the replacement of natural strains of plants by genetically modified strains. While the GM strains may carry desired characteristics, such as resistance to certain fungi or bacteria, the GM strain may also be less hardy in other respects over time. In addition, companies that produce GM strains have been known to gain a monopoly on the production of such plants in specific localities, resulting in economic and cultural damage and the loss of livelihood especially among some indigenous peoples.

Transgenic Organisms

Today, genetic technology allows us to take DNA from one species into the genome of another, resulting in a **transgenic organism**. Attaching DNA from one individual or species to a virus and injecting the virus into the recipient cell of another individual or species is one of the most efficient ways to introduce a new foreign gene into a cell. Before injection, most of the virus genome is removed and replaced with the desired gene. The virus is then injected into the cell of a new individual. Because the type of virus used normally inserts its genetic material into the genome of cells it infects, the new gene gets inserted into the genome along with any remaining viral genetic material. If this is done to the germ cells, such as the sperm or the egg, this DNA from another species will likely be transferred to offspring and will be present in all cells of those offspring. To date, although viruses insert DNA more efficiently into cells, they cannot insert the foreign DNA very precisely into the recipient genome yet. In fact, the foreign DNA may end up anywhere in the genome, on any of the chromosomes. As a result, it may not function correctly in its location or it may function in an abnormal way because of its proximity to other genes. The development of some cancers, including leukemia, has been associated with abnormal gene placements on chromosomes.

Difference between Hybrids and Chimeras

When large amounts of DNA are combined between species, additional ethical concerns arise. Recently, there has been controversy in the United Kingdom over whether it is morally acceptable to combine human and non-human cells to produce a unique organism. In such an organism, called a **chimera**, cells of each species would exist side-by-side but function together for the health of the whole hybrid organism.

By contrast, when large amounts of DNA from one species such as a human are injected into the nucleus of an early embryo of a non-human species, all of the subsequent cells of that developing organism will have DNA from both species and the organism is considered to be a **hybrid** of both species.

Such combining of human and non-human DNA into one organism brings up basic ethical issues about what is means to be a human being.

Example of a Transgenic Organism

In 2001 scientists at the Oregon Regional Primate Center produced the first transgenic primate, named ANDi, a rhesus monkey that had a jellyfish gene in each cell of his body. They injected 224 rhesus monkey egg cells with the jellyfish gene. The egg cells were then fertilized with rhesus monkey sperm by **in vitro fertilization**. Forty fertilized eggs reached the stage at which they could be implanted. These 40 embryos were transplanted into the uteri of 20 female rhesus monkeys. Five of the monkeys became pregnant. From the five pregnancies, three 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 that allows the jellyfish to glow. But ANDi did not glow.

Can/Will Transgenic Humans Be Developed?

If this process eventually works, and transgenic non-human primates are produced, there is no theoretical barrier to producing transgenic humans. 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.

Why Does Almost the Same DNA In Primates and Humans Result In Very Different Creatures?

The DNA in the human genome shows perfect identity with 99% of the chimpanzee genome. But if our genes are so similar chemically, why do we seem so remarkably different? We humans can build cities and develop political systems, write great literature and music. Perhaps most importantly, we have self-reflective consciousness. What is it, then, that this small 1% genetic difference can tell us about the difference between us and chimpanzees? Perhaps other factors affect the functioning of these genes in the two species. However, scientists also have recently discovered 49 regions in human DNA (called Human Accelerated Regions or HARs) that show faster nucleotide substitution than the rates of normal genetic evolution would predict. Within these regions scientists have found genes involved in advanced functioning such as 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% may not be 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. The 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 (that is, a female of the same species but not the biological donor of the egg) 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 technical difficulties. But theoretically, this method could be used to clone primates, including humans.

The Need for Greater Reflection on the Implications of Transgenic Research

Transgenics is a particularly difficult area of science and research for many people, including Christians. Much of the research is carried out with the goal of developing better plants, animals, or medical therapies. However, the research often moves ahead without sufficient reflection on the short- and long-term consequences of transgenic organisms and their products on ourselves, and on the environment in which we live and for which we are responsible. Since we believe that caring for Creation is our God-given mandate as human beings, it is our responsibility to advocate for careful reflection on the purpose of all transgenic research and the benefits and risks of transgenic organisms and their products on all aspects of the created order.