“MEATY, BT, BIG & BOUNCY” — WHO REMASTERED THIS MESS?

Why Genetic Engineering, Bt Corn, and Other GMO Food Crops Don't Mix

We know that heavy use of pesticides by farmers is a problem. Pesticides harm beneficial insects at the same time they're killing pests. They drift via the air to contaminate nearby properties and people. They contaminate groundwater, streams, and rivers via rainwater and irrigation runoff. They also harm farmers and farm workers. And as regular consumers of food, it's likely that none of us are too enthusiastic that we're regularly eating our meals with a small serving of pesticide residue on the side. Waiter! What's this organophosphate doing in my soup??

Instead of spraying pesticides all over our farm fields, wouldn't if be cool if someone could find a natural substance with low human and environmental toxicity and incorporate it directly into plants, thus making crops naturally resistant to pests?

INTRODUCING BACILLUS THURINGIENSIS – GENETICALLY ENGINEERED BT CORN AND OTHER CROPS

Bt corn, Bt cotton, and Bt potatoes are genetically engineered plants that incorporate Bt, a natural toxin from the microorganism Bacillus thuringiensis that is deadly to many pest species but has low toxicity for most benign organisms, beneficial predators, and humans. Wow, great—we can stop using all those lethal chemical pesticides! Unfortunately, there's more to the story...

The main idea behind genetically engineered (GE) Bt crops is that they eliminate the need for conventional farmers—those who have traditionally used chemical pesticides—to apply insecticides to their crops, which is better for the environment and cheaper for the farmer. But Bt is not a new approach dreamed up in the bowels of one the agribusiness corporations. Bt spray has been used for decades for pest control and has been a particularly important tool for organic farmers, who aren't allowed to use the highly toxic arsenal of chemical pesticides used by "conventional farmers." What's new is that the genetic engineers have figured out how to embed the genetic characteristics of the Bt toxin directly into some plants—primarily corn, cotton, and potatoes—so that they become naturally resistant to pests.

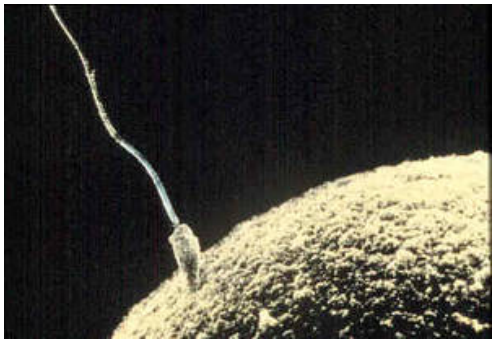
In the past, Bt has been applied topically to plants to control pests, but as with any other pesticide, rain eventually washes it off and the Bt spray must be applied again, running up the farmer's costs and labor. Since the Bt corn and cotton have the Bt toxin embedded as part of the genetically engineered plant's cells, the wash-off problem is eliminated.

THE PROBLEM WITH BT CROPS

All that sounds good in theory, but there is a big problem with Bt crops. Prior use of Bt by farmers has always been on an as-needed basis and in combination with other insect control techniques. This intermittent use has prevented insects from developing resistance to Bt. With Bt corn and cotton, the insects are constantly exposed, and it is thus inevitable that insect will develop resistance to Bt. (Resistance is not a phenomenon specific to Bt—insects develop resistance to regularly applied chemical pesticides, too.)

There are a couple of aspects to the development of resistance in genetically engineered Bt crops. First, the obvious way: Insects eating Bt crops are constantly being exposed to the pesticide and, over time, subsequent generations of the insects will eventually become resistant. But there is another factor: Because crops grow unevenly in nature's differing conditions and because expression of the Bt gene is not uniform throughout the plant, some pests will get a "sub-lethal dose" of Bt toxin, which will facilitate the development of resistance in the same way that pathogenic bacteria become resistant when a patient fails to complete the full course of an antibiotic.

Human Cloning, Part 1 - Making Babies the Natural Way

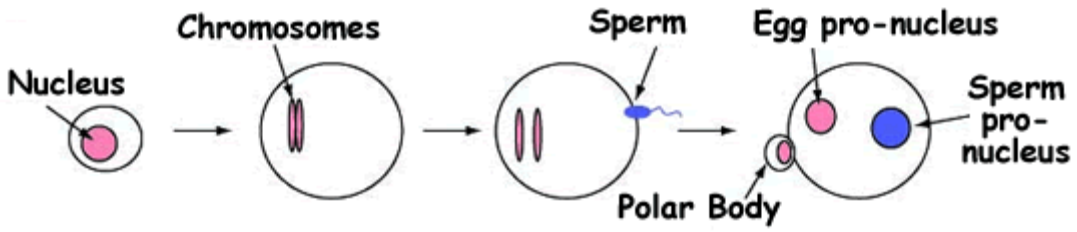


Few people can have escaped the newspaper headlines over the past few months. The fertility doctor Panos Zavos claimed to have cloned a human baby, while a team of researchers in South Korea also presented their clones to the world. So what's the difference between these stories? And are we really going to see cloned babies peering out from their prams in the near future? In this first article we will spy on the earliest moments of life: how an egg and sperm make a ball of cells that eventually become a baby. Then we can ask if, and how, these processes can be bypassed by cloning.

The first thing to understand is how babies are made - no sniggering at the back, please! To do this, we need to know a bit about eggs and sperm. Eggs are relatively large cells and contain lots of biological goodies required for early development. They are also rather unusual in that they are frozen in the act of dividing their DNA from a full set of chromosomes to half a set (see *figure 1*, below). This division is important because the sperm also carries half a set: together they make up a full set in the new baby.

At the moment of fertilisation the sperm enters the egg, and things start getting exciting (at least, in biological terms). The following descriptions show what happens in mouse development: we currently do not know whether human development is exactly the same, but it is likely that many events are similar. When the sperm goes in, it reactivates the division process in the egg, causing the arrested chromosome half-sets to separate. The unwanted chromosomes are booted out and form a little cell called the polar body, with no further part to play in the unfolding developmental drama (see *figure 1*, below). The remaining egg chromosomes organise into a ball-like structure termed a pronucleus. At the same time, proteins in the egg begin to unpack the sperm DNA, expanding it to form another pronucleus (see *figure 1,* below).

Egg formation and Fertilisation



1. An early egg cell.

Humans carry 23 pairs of chromosomes. We inherit one half of each pair from our mothers, and the other half from our fathers. These half-sets of chromosomes are produced in a special form of cell division called meiosis which produces eggs and sperm.

2. A mature egg.

In this egg, for simplicity, only one pair of chromosomes is shown (in pink). The process of cell division remains frozen until the egg is fertilised by a sperm

3. Fertilisation.

When a sperm penetrates the egg it kick starts the completion of meiosis. One of each pair of the egg's chromosomes is randomly ejected from the cell to form a structure called a polar body. The remaining chromosomes form the egg pro-nucleus.

4. One cell embryo.

The half-sets of chromosomes from the sperm are unpacked to form the sperm pro-nucleus. As each pro-nucleus contains half the normal chromosome number, together they produce a cell with a full complement of genetic material.

Figure 1 - The formation of a mature egg and a single celled embryo.

But strange things happen to the sperm DNA: it is stripped of methylation, a special molecular tag that helps the cell to use its genes properly. In the first few hours of development other dynamic changes happen to the sperm pronucleus, especially alterations in the DNA packing proteins within it. These changes in methylation and packing proteins are termed "epigenetic modifications", as they affect the DNA without actually changing the underlying DNA sequence - only the tags and markers around it. Epigenetic marks are important because they tell the cell which genes to use in different types of cells. This is crucial because all our cells contain essentially the same DNA (and therefore the same genes): it is the different patterns of gene usage that give all our cell types their distinct characteristics. Some epigenetic marks act as silencing signals for genes, while some have an activating effect. For example, in a liver cell, liver-type genes would have activating marks while muscle genes would have silencing marks. Conversely, in a muscle cell the muscle-specific genes have activating tags whereas the liver genes are silenced.

Many epigenetic changes take place while the embryo is still a single cell, and these mainly occur within the sperm pronucleus. These molecular upheavals are essential for reprogramming the sperm, so it can be used correctly in the next steps of development. But the

epigenetic adventures don't stop at the one-cell stage. The new embryo divides into two cells, then four, then eight and so on until it is a ball of around a hundred cells (see *figure 2*). Throughout this flurry of activity, more molecular tags are removed from the DNA while other epigenetic modification patterns are established. Eventually, after 4 to 5 days, the ball of cells begins to take shape. A cavity forms and fills with fluid, pushing the cells outwards until the ball is almost hollow and looks rather like a football. We call this a "blastocyst". But the blastocyst is not quite hollow, because lurking on one side is a small clump of cells, somewhat obviously named the "inner cell mass". It is from this unpromising cluster that we all grew: these are the stem cells of the embryo. It is also clear at this stage that there are distinct epigenetic differences between the outer cells and the inner cell mass.

Better babies?

Why genetic enhancement is too unlikely to worry about

By Steven Pinker, 6/1/2003

THIS YEAR, THE 50th ANNIVERSARY of the discovery of the structure of DNA has kindled many debates about the implications of that knowledge for the human condition. Arguably the most emotionally charged is the debate over the prospect of human genetic enhancement, or ''designer babies.'' It's only a matter of time, many say, before parents will improve their children's intelligence and personality by having suitable genes inserted into them shortly after conception.

A few commentators have welcomed genetic enhancement as the latest step forward in the age-old struggle to improve human life. But many more are appalled. They warn that it is a Faustian grab at divine powers that will never be used wisely by us mortals. They worry that it will spawn the ultimate form of inequality, a genetic caste system. In his book ''Our Posthuman Future'' (just released in paperback), the conservative thinker Francis Fukuyama warns that genetic enhancement will change human nature itself and corrode the notion of a common humanity that undergirds the social order. Bill McKibben, writing from the political left, raises similar concerns in his new jeremiad ''Enough: Staying Human in an Engineered Age.''

But whether they welcome or decry it, almost everyone agrees that genetic enhancement is inevitable if research proceeds on its current course. Genetic enhancement is a major concern of the President's Council on Bioethics; its chairman, Leon Kass, and several of its members, including Fukuyama, are outspoken worriers.

As it happens, some kinds of genetic enhancement are already here. Anyone who has been turned down for a date has been a victim of the human drive to exert control over half the genes of one's future children.

And it is already possible to test embryos conceived in vitro and select those that are free of genetic defects such as cystic fibrosis.

But when it comes to direct genetic enhancement-engineering babies so they will carry genes for desirable traits-there are many reasons to be skeptical. Not only is genetic enhancement not inevitable, it is not particularly likely in our lifetimes. This skepticism arises from three sources: futurology and its limits, the science of behavioral genetics, and human nature itself.

The history of the future should make us raise an eyebrow whenever the experts tell us how we will live 10, 20, or 50 years from now. Not long ago, we were assured that by the turn of the century we would live in domed cities, commute by jet-pack, and clean our homes with nuclear-powered vacuum cleaners wielded by robot maids. More recently we were promised the paperless office, interactive television, the Internet refrigerator, and the end of bricks-and-mortar retail. It's not just that these developments have not yet happened. Many of them, like domed cities, never will happen. Even in mundane cases, technological progress is far from inexorable. Air travel, for example, is barely faster or more comfortable today than it was when commercial jets were introduced 50 years ago.

Why are technological predictions usually wrong? Many futurologists write as if current progress can be extrapolated indefinitely-committing the fallacy of climbing trees to get to the moon. They routinely underestimate how much has to go right for a development to change our lives. It takes more than a single ''eureka!'' It takes a large number of more boring discoveries, together with the psychological and sociological imponderables that make people adopt some invention en masse. Who could have predicted that the videophones of the 1960s would sink like a stone while the text messaging of the 1990s would become a teenage craze?

Finally, futurologists tend to focus their fantasies on the benefits of a new technology, whereas actual users weigh both the benefits and the costs. Do you really want to take the time to install software upgrades on your refrigerator, or reboot it when it crashes?

Many prognosticators assume that we are currently discovering single genes for mathematical giftedness, musical talent, athletic prowess, and the like. The reality is very different. The Achilles heel of genetic enhancement will be the rarity of single genes with consistent beneficial effects.

Behavioral genetics has uncovered a paradox. We know that tens of thousands of genes working together have a large effect on the mind. Studies show that identical twins (who share all their genes) are more similar than fraternal twins (who share half of those genes that vary from person to person), who in turn are more similar than adopted siblings (who share even fewer of the varying genes). Adoption studies show that children tend to resemble their biological relatives in personality and intelligence more than they resemble their adoptive relatives.

But these are the effects of sharing an entire genome, or half of one. The effects of a *single* gene are much harder to show. Geneticists have failed to find single genes that consistently cause schizophrenia, autism, or manic-depressive disorder, even though these conditions are substantially heritable. And if we can't find a gene for schizophrenia, we're even less likely to find one for humor, musical talent, or likeability, because it's easier to disrupt a complex system with a single defective part than to improve it by adding a single beneficial one. The 1998 report of a gene that was correlated with a 4-point advantage in IQ was recently withdrawn because it did not replicate in a larger sample-a common fate for putative single-gene discoveries.

So don't hold your breath for the literary-creativity gene or the musical-talent gene. The human brain is not a bag of traits with one gene for each trait. Neural development is a staggeringly complex process guided by many genes interacting in feedback loops. The effect of one gene and the effect of a second gene don't produce the sum of their effects when they're simultaneously at work. The *pattern* of expression of genes (when they are turned on or off by proteins and other signals) is as important as which genes are present.

Even when genes should be at their most predictable-in identical twins, who share all their genes, and hence all the interactions among their genes-there are no foregone conclusions about anyone's traits or behavior. Identical twins reared together, who share not only their genes but most of their environment, are imperfectly correlated in personality measures like extroversion and neuroticism. The correlations, to be sure, are much larger than those for fraternal twins or unrelated people, but they are seldom greater than .5. This tells us there is an enormous role for chance in the development of a human being.

It gets worse. Most genes have multiple effects, and evolution selects those genes that achieve the best compromise between positive and negative impacts. Take the most famous case of genetic enhancement on record: the mice that were given extra copies of the NMDA receptor, which is critical to learning and memory. These poster mice did learn mazes more quickly-but they also turned out to be hypersensitive to pain. Closer to home, there is a gene in humans that may be correlated with a 10-point boost in IQ. But it is also associated with a 10-percent chance of developing torsion dystonia, which can confine the sufferer to a wheelchair with uncontrollable muscle spasms.

So even if genetic enhancement could work in principle, the problem is how to get there from here. How can scientists try out different genes to enhance the minds of babies given that many of those genes could have terrible side effects?

Genetic enhancement faces another problem: Most traits are desirable at intermediate values. Wallis Simpson said that you can't be too rich or too thin, but other traits don't work that way. Take aggressiveness. Parents don't want their children to be punching bags or doormats, but they don't want Attila the Hun, either. Most want their children to face life with

confidence rather than sitting at home cowering in fear, but they don't want a reckless daredevil out of ''Jackass.'' So even if a gene had some consistent effect, whether the effect was desirable would depend on what the other tens of thousands of genes in that child are doing.

The third obstacle to re-engineering human nature comes from human nature itself. We are often told that it's only human for parents to give their children every possible advantage. Stereotypical yuppies who play Mozart to their pregnant bellies and bombard their newborns with flash cards would stop at nothing, it is said, to give their children the ultimate head start in life.

But while parents may have a strong desire to help their children, they have an even stronger desire *not to hurt* their children. Playing Mozart may not make a fetus smarter, but it probably won't make it stupider or harm it in other ways. Not so for genetic enhancement. It is not obvious that even the most overinvested parent would accept a small risk of retardation in exchange for a moderate chance of improvement.

Rights and Wrongs

Should parents be allowed to custom build their children?
Will it lead to happier parents and children?
Will it lead to healthier people?
Will it lead to more beautiful people?
Will it lead to there being more differences between rich and poor people?

Should scientists tamper with the genes of unborn children to cure genetic disease?
Is it right?
Is it unnatural?

These are all questions about whether the technology to create designer babies is right or wrong?

Here are some points of view both for and against custom building babies.

Arguments for creating designer babies

Some couples are not able to have children because their children will have a genetic disease and die before they are born or when they are very young. Techniques used to change the genetic make-up of the embryo allow these parents to have a child.

If we want the best for our children why shouldn't we design our own babies? Using genetic techniques we can help prevent certain genetic diseases. This both saves the children from suffering and reduces the cost and emotional strain of looking after an ill child. Will this lead to happier children and parents?

Spare part children? In a few cases where parents have had one child with a serious blood disease, they have used IVF to select embryos so that they can have a second child that can act as a future, tailor-made blood or bone marrow donor. In these cases when the child is born he or she will be healthy and can help their older brother or sister stay well.

Arguments against creating designer babies

But is this right? In these cases, parents and doctors are creating a child to act as an organ-donating factory. How will the child feel? The child may feel that they were only born to be a help to their older brother or sister. Children should be loved and cherished for themselves and not what they can do for others.

These genetic techniques are very expensive. Why should only rich people be able to eradicate genetic diseases? This could lead to imbalances between rich and poor people.

Will we breed a race of super-humans who look down on those without genetic enhancements? Even today people who are born with disabilities face intolerance. Will discrimination against people already born with disabilities increase?

We could get carried away 'correcting' perfectly healthy babies. Once we start to eliminate embryos because they have the gene for a disease, what is to stop us from picking babies for their physical or psychological traits?

At the moment we can screen human embryos to choose only those embryos without the 'bad' genes. But is it right to add new artificial genes, or take away other genes? These genetic changes will be permanent and be contained in every single cell of the baby.

Alterations made by genetic engineering would be passed on from one generation to the next. What right have parents to choose what genetic characteristics are best for their children, and their children's children. Will the children react against the genetic changes that their parents have chosen for them?

Who is responsible for genetic modification of a child? The parents? The doctors? Or the Government?

Is it right to experiment on babies?

Animal studies have shown that this type of genetic engineering is unpredictable. There is a huge risk that we may produce physical changes, or even change the child's personality. Mice whose genes had been changed to make them more muscular, unexpectedly became very timid compared to other non-genetically engineered mice!

However, some scientists think they will become more certain about how a gene will act if it is engineered into a person or an animal.

Will future humans have animal genes added to them to give them superhuman abilities? This really could happen. Human genes have been engineered into animals for years.