# "Extreme Science"

Science is the *"systematic study of the nature and behavior of the material and physical universe, based on observation, experiment, and measurement, and the formulation of laws to describe these facts in general terms."*

Something that is extreme is *"exceeding what is usual or reasonable."*

– Collins English Dictionary, 2003

**What, then, is *extreme science*? Please respond using your own words.**

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**Read the description of the four situations that may be considered extreme. Discuss each situation with your group, then choose <u>2</u> of them and respond to <u>all of the questions</u> on a separate sheet of paper. Use your own opinions over the opinions of your group.**

<u>Experiment 1:</u>

1. What is the benefit of this experiment?
2. What are the risks of this experiment?
3. Is this an example of "extreme science?" Is the experiment worth doing?
4. Would you volunteer to participate in this study? Why or why not?

<u>Experiment 2:</u>

5. What is the benefit of this experiment?
6. What are the risks of this experiment?
7. Is this an example of "extreme science?" Is the experiment worth doing?
8. Would you volunteer to participate in this study? Why or why not?

<u>Overall:</u>

9. How do you feel about these experiments being done on other animals? Specifically, how do you feel about each of the 4 experiments being done on mice? On dogs?
10. How did our experiment with mice compare to these experiments? Were we performing an extreme experiment?

**Staple additional pages behind this one and write your name, date, and grade at the top of this page.**

# Separating Twins

**The Experiment:** Split up twins after birth—and then control every aspect of their environments.

**The Premise:**
In the quest to solve the debate between nature and nurture, researchers have one obvious resource: identical twins, two people whose genes are nearly 100 percent the same. But twins almost always grow up together, in essentially the same environment. A few studies have been able to track twins separated at a young age, usually by adoption. But it's impossible to control all the ways that the lives of even separated twins are still related. If scientists could control the siblings from the start, they could construct a rigorously designed study. It would be one of the least ethical studies imaginable, but it might be the only way (short of cloning humans for research, which is arguably even less ethical) that we'd ever solve some big questions about genetics and upbringing.

**How it Works:**
Expectant mothers of twins would need to be recruited ahead of time so the environments of each sibling could differ from the moment of birth. After choosing what factors to investigate, researchers could construct test homes for the children, ensuring that every aspect of their upbringing, from diet to climate, was controlled and measured.

**The Payoff:**
Several sciences would benefit enormously, but none more than psychology, in which the role of upbringing has long been particularly hazy. Developmental psychologists could arrive at some unprecedented insights into personality—finally explaining, for example, why twins raised together can turn out completely different, while those raised apart can wind up very alike.

—Erin Biba

# Brain Sampling

**The Experiment:** Remove brain cells from a live subject to analyze which genes are switched on and which are off.

**The Premise:**
You might donate blood or hair for scientific research, but how about a tiny slice of your brain—while you're still alive? Medical ethics wouldn't let you consent to that even if you wanted to, and for good reason: It's an invasive surgery with serious risks. But if enough healthy patients agreed, it could help answer a huge question: How does nurture affect nature, and vice versa? Although scientists recognize in principle that our environment can alter our DNA, they have few documented examples of how these changes happen and with what consequences.

Animal studies suggest the consequences could be profound. A 2004 McGill University study of lab rats found that certain maternal behaviors can silence a gene in the hippocampi of their pups, leaving them less able to handle stress hormones. In 2009, a McGill-led team got a hint of a similar effect in humans: In the brains of dead people who had been abused as children and then committed suicide, the same gene was largely inhibited. But what about in living brains? When does the shift happen? With brain sampling, we might come to understand the real mental toll of child abuse and a great deal more.

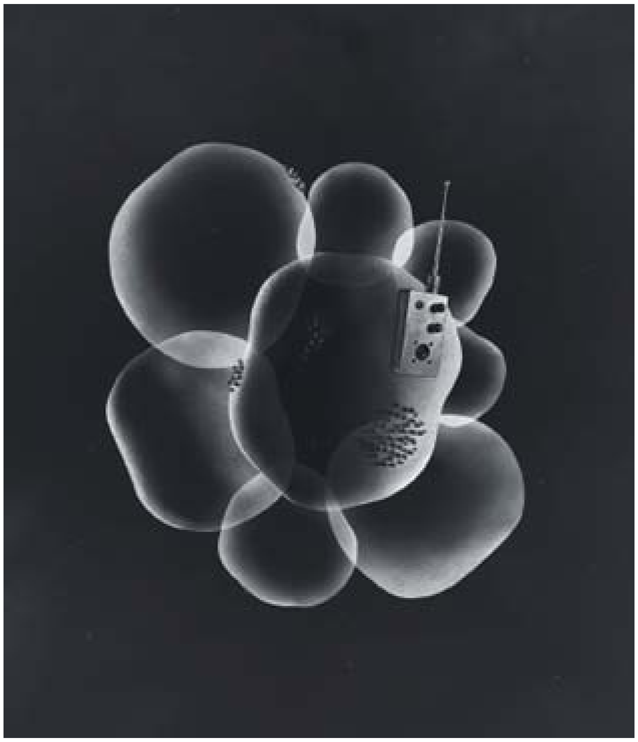
**How it Works:**
Researchers would obtain brain cells just as a surgeon does when conducting a biopsy: After lightly sedating the patient, they would attach a head ring with four pins, using local anesthetic to numb the skin. A surgeon would make an incision a few millimeters wide in the scalp, drill a small hole through the skull, and insert a biopsy needle to grab a tiny bit of tissue. A thin slice would be sufficient, since you need only a few micrograms of DNA. Assuming no infection or surgical error, damage to the brain would be minimal.

**The Payoff:**
Such an experiment might answer some deep questions about how we learn. Does reading turn on genes for higher-level thinking? Does spending lots of time at a batting cage alter the motor center of the brain? By correlating experiences with the DNA in our heads, we could better understand how the lives we lead wind up tinkering with the genes we inherited.

—Sharon Begley

**Seven Creepy Experiments That Could Teach Us So Much (If They Weren't So Wrong)**

Wired Magazine -- July 15, 2011



# Embryo Mapping

**The Experiment:** Insert a tracking agent into a human embryo to monitor its development.

**The Premise:**
These days, expectant mothers undergo elaborate tests to make sure their baby is normal. So, would any of them allow scientists to exploit their future offspring as a science project? Not likely. But without that sort of radical experimentation, we may never fully understand the great mystery of human development: how a tiny clump of cells transforms into a fully formed human being. Today researchers have the tools to answer that question, thanks to new technology that allows for the tracking of cells' genetic activity over time. If ethics weren't an issue, all they would need was a willing subject—a mother who would let them use her embryo as a guinea pig.

**How it Works:**
To trace the activity of different genes within an embryonic cell, researchers could use a man-made virus to insert a "reporter" gene (green fluorescent protein, for example) that was visually detectable. As that cell divided and differentiated, researchers could actually observe how genes turned on and off at various points in development. This would let them see which developmental switches transform embryonic stem cells into hundreds of types of specialized adult cells—lung, liver, heart, brain, and so on.

**The Payoff:**
A fully mapped embryo would give us, for the first time, a front-row seat for the making of a human being. That information could help us direct stem cells to repair cellular damage and treat disease (say, by inserting a healthy pool of neurons into the brain of a patient with Parkinson's disease). Comparing the details of human embryonic development to that of other species—similar mapping has already been done on mice, for example—might also reveal the differences in genetic expression that contribute to complex human attributes such as language. But the risks of human embryo mapping are too great to even consider performing it. Not only would the mapping process risk destroying the child, the virus used to insert the reporter gene might disrupt the embryo's DNA and lead, ironically, to developmental defects.

—Jennifer Kahn

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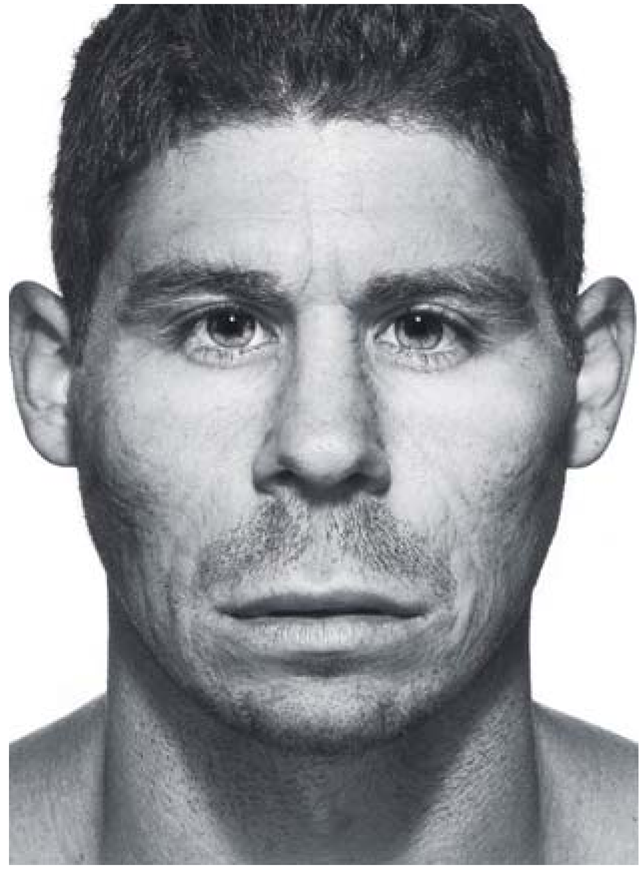
# Ape Man



**The Experiment:** Cross-breed a human with a chimpanzee.

**The Premise:**
The great biologist Stephen Jay Gould called it "the most potentially interesting and ethically unacceptable experiment I can imagine." The idea? Mating a human with a chimp. His interest in this monstrosity grew out of his work with snails, closely related species of which can display wide variation in shell architecture. Gould attributed this diversity to a few master genes, which turn on and off the different shell genes. Perhaps, he speculated, the large visible differences between humans and apes were also a factor of developmental timing. He pointed out that adult humans have physical traits, such as larger craniums and wide-set eyes, that resemble infant chimpanzees, a phenomenon known as neoteny—the retention of juvenile traits in adults. Gould theorized that over the course of evolution, a tendency toward neoteny might have helped give rise to human beings. By watching the development of a half-human, half-chimp, researchers could explore this theory in a firsthand (and truly creepy) way.

**How it Works:**
It would probably be frighteningly easy: The same techniques used for in vitro fertilization would likely yield a viable hybrid human-chimp embryo. (Researchers have already spanned a comparable genetic gap in breeding a rhesus monkey with a baboon.) Chimps have 24 pairs of chromosomes, and humans 23, but this is not an absolute barrier to breeding. The offspring would likely have an odd number of chromosomes, though, which might make them unable to reproduce themselves. As for the birth, it could be done the natural way. Chimpanzees are born slightly smaller than humans, on average—around 4 pounds—so the embryo would probably be grown in a human uterus.

**The Payoff:**
Gould's idea about neoteny remains controversial, to say the least. "It got a lot of scrutiny and has been disproved in many ways," says Daniel Lieberman, a Harvard professor of human evolutionary biology. But Alexander Harcourt, professor of anthropology at UC Davis, regards neoteny as "still a viable concept." This forbidden experiment would help to resolve that debate and, in a broader sense, illuminate how two species with such similar genomes could be so different. Its outcome would take biologists deep into the origin of the species we care about most: ourselves. Let's just hope we can find a less disturbing route to get there.

—Jerry Adler