

**What is a gene?** A segment of DNA that contains instructions to make a specific protein molecule; the basic biological unit of heredity.

**What is gene expression?** The process by which information encoded in a gene is converted to a protein product that determines an organism's characteristics and functioning.

**What is epigenetics?** Epigenetics refers to genetic factors that change an organism's appearance or biological functions without changing the actual DNA sequence. In other words, gene expression changes but the genes themselves don't. Epigenetics adds an additional level of complexity to the genetic code.

#### What actually happens at the molecular level?

Epigenetics refers to the addition or deletion of a methyl group to a DNA base, turning the gene on or off, or to packaging of the chromatin structure by silencing or opening regions of the genome by winding or unwinding the DNA around histones.

**What can cause epigenetic changes?** Interactions we have with our environment can cause epigenetic changes that affect how our genes work. These interactions include behaviors like smoking, eating, drinking, exercise, and exposure to natural and manufactured chemicals in air, water, and food.

**How common are these changes?** Epigenetic changes are more common than mutations that change the actual structure of the DNA.

**Can epigenetics changes be passed from generation to generations?** Yes. Epigenetic changes caused by environmental exposures can be transmitted down several generations. The lives of our ancestors can directly affect our health. We can be more susceptible to a disease because of our ancestors' exposure or behavior. Our grandchildren can be less healthy because of the choices we make or what we are involuntarily exposed to.

**An Analogy:** *If genes are the hardware, epigenetics is the software that determines what that hardware does.*



#### Some Examples from the Research:

- A study followed 100 women who were in the last three months of pregnancy, were near the World Trade Center on 9/11, and subsequently developed post-traumatic stress disorder. The women had abnormally low levels of the stress hormone cortisol in their saliva a year later, and so did their babies.
- In an isolated Swedish population who depended on a good harvest for adequate food supply, men whose paternal grandfathers had more than enough to eat just before puberty had a higher than average risk of dying from diabetes.
- A deletion of part of a chromosome is likely to cause a birth defect. A deletion of a particular section of Chromosome 15 inherited from the mother results in Angelman's Syndrome, but when the same Chromosome 15 deletion is in the copy inherited from the father, the baby has Prader Willi Syndrome, an entirely different disease. Epigenetics appears to be how the cell knows whether the chromosome was inherited from the mother or father.
- Your decision to smoke can affect the life expectancy of your descendants.

## The Dutch Hunger Winter & Epigenetics



From November 1944 until May 1945 the Nazis blockaded areas of Netherlands, cutting off food supplies which led to severe rationing and mass malnutrition. This period came to be known as the Dutch “Hunger Winter,” and over 18,000 people died. Individuals who were conceived during the Dutch Hunger Winter had normal access to food throughout their lives. Long-term studies showed that they had an increased risk of glucose intolerance, coronary heart disease, obesity, schizophrenia, breast cancer, and drug addiction. The studies suggest that restriction of the mother’s calories during gestation can lead to a variety of diseases in adulthood.

The actress Audrey Hepburn, 16 years old at the time, was living in one of the blockaded areas and resorted to eating tulip bulbs and making bread from grass because of the food shortage. As a result, she suffered from jaundice, anaemia, respiratory problems and chronic blood disorders.

She survived the experience and went on to become an international figure renowned for her beauty, grace, and talent. She was very thin - her waist was 20” - and was described as elfin or waif-like. She also suffered from frail health and depression throughout her life and was diagnosed with a very rare form of cancer at age 63. She died a few months later.

In *The Epigenetics Revolution* (2011), Dr. Nessa Carey hypothesizes that Hepburn’s slim figure and health problems were a result of epigenetic changes brought about by food deprivation and starvation during an important period of development.



## What You Can Do for Your Health

While genetic mutations tend to be irreversible, epigenetic changes are inherently reversible. Drugs and diet have the potential to restore normal epigenetic status and research suggests that diseases caused by epigenetic aberrations may be treatable and preventable. As researchers continue to learn more about the connections between health and epigenetics, you can decrease your overall disease risk through:

- *Preventative health care, including screenings and vaccinations*
- *Eating a lowfat, high fiber diet*
- *Getting regular exercise*
- *Maintaining an appropriate weight*
- *Managing stress*

## Where to Learn More

1. **The Ghost in Our Genes**, a BBC Horizon documentary  
<http://video.google.com/videoplay?docid=1128045835761675934#>
2. **Toxipedia.org** ([www.toxipedia.org](http://www.toxipedia.org))
3. **Ethical Implications of Epigenetics Research**. Rothstein, M., et al. 2009.  
<http://www.ncbi.nlm.nih.gov/pubmed/19274047>
4. **The Ghost in Our Genes: Legal and Ethical Implications of Epigenetics**. Rothstein, M., et al. 2009.  
<http://ssrn.com/abstract=1140443>
5. **Learn.Genetics™ from the University of Utah** (<http://learn.genetics.utah.edu/>)