

Genes, Behavior, the Environment, and Health



Yesterday

- People observed for thousands of years that diseases run in families, but it was only with 20th century genetic discoveries that we began to understand how specific genes affect health.
- Research showed that some diseases, including cystic fibrosis, Duchenne muscular dystrophy, and sickle cell disease, are caused by changes in a single gene. However, it became apparent that multiple genes, acting in concert, confer risk for other complex diseases including diabetes and hypertension, psychiatric disorders like schizophrenia and depression, and alcohol and drug dependence.
- Genes alone were not the whole story. Identical twins who had exactly the same genetic makeup but who were raised in different families sometimes developed different diseases or health outcomes. These types of findings suggested that our living conditions or environments were also very important contributors to health and disease.

Today

- The now completed mapping of the entire human genome (<http://www.genome.gov/10001772>) gives researchers powerful tools to identify genetic contributions to health and disease.
- We know that genes alone do not cause many common diseases like heart disease, diabetes, cancer and depression, as well as alcohol, tobacco and other drug addictions. Rather, many genes influence our risk of developing diseases, and whether or not that risk actually leads to disease depends on a lifetime of complex interactions between our genes and our environments. Similarly, certain environments or experiences that are known to increase our chances of physical or mental health problems are especially risky for people who also have a particularly vulnerable genetic make-up.
- Major stressful events, such as job loss, divorce, abuse, or caring for a seriously ill family member, may lead to depression. Research on gene-environment interactions show that children experiencing highly stressful environments are more likely to become depressed as adults if they also have a particular version of a gene that influences the level of the brain chemical, serotonin. Individuals experiencing high levels of stress as children, but devoid of this genetic variation aren't as likely to become depressed.
- This same serotonin-related gene may be involved in alcohol consumption. NIH researchers revealed that female monkeys with a particular version of the gene prefer to drink alcohol more than monkeys with a different version of the gene. If the monkeys with the version of the gene that prefer alcohol are reared in groups of other young monkeys rather than by their mothers, they show an even greater preference for alcohol and drink more of it when they are young adults. This is an example of how a genetic risk is made worse by specific conditions during early stages of development. These monkey studies, in which researchers can better control the environment, allow us to pinpoint more specifically how gene-environment interactions lead to disorders and diseases in an animal model that closely resembles humans.
- Scientists doing research on rats discovered that the behavior of rat moms toward their newborn pups – how they nurse, lick and groom the pups – changes the lifelong responses of those offspring to stress. The mothers' behaviors change the activity of genes in their offspring's brains – specifically, genes that are involved in the response to stress hormones.
- Toxic environments also contribute to influencing our behavior. Studies with children have shown that cumulative exposure to lead contributes to risk for delinquent behavior. Exposures to certain pesticides and industrial chemicals increase the risk of developing attention deficit hyperactivity disorder in children. Animals similarly exposed also show abnormal patterns in the developing brain. Moreover,

different strains of rodents show different outcomes from similar chemical exposures, indicating that genetic differences can influence the response to an environmental exposure.

- More and more studies are showing that gene-environment interactions during early development may have long lasting effects on health that do not show up until adulthood.

In order to develop successful treatments for the many disorders caused by gene/environment interactions, the NIH launched the Genes and Environment Initiative (<http://gei.nih.gov/>) and the Genetic Association Information Network (<http://www.genome.gov/19518664>) to explore and catalogue how genes and environment interact to influence the occurrence of common diseases.

Tomorrow

- The identification of subsets of individuals with high disease risks due to particular combinations of genetic variations and environmental exposures or stressors will allow development of more targeted screening, interventions, and preventative strategies, as well as more effective maintenance of health.
- Prevention of neurological disease and behavioral dysfunction caused by chemical exposures can be implemented by identifying and eliminating exposures to chemicals that cause risk, especially for those with known genetic susceptibility.
- We can develop more personalized, and therefore more effective behavioral treatments like changing social support, improving diet and exercise habits, or helping to cope with stress, to counteract higher risks for disease among those with certain genetic vulnerabilities or to enhance the effects of other genetic factors that offer protection against health problems.
- Knowledge gained from research on gene-environment interactions can also be used by policymakers to design more “user-friendly” living conditions that delay or prevent the genetic risks of disease from being realized.

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