



Every summer, on the first weekend in August, thousands of twins converge on Twinsburg, Ohio, a small town named by identical twin brothers nearly two centuries ago. They come, two by two, for the Twins Days Festival, the world's largest gathering of twins.

Twins are not the only people who are regular festival visitors. There are also several groups of scientists. To these scientists, identical twins

offer a precious opportunity to untangle the influence of genes and the environment. Although identical twins look exactly alike to most people, they differ in many small ways, and these differences increase with age. For example, one may develop wrinkles on her face, but the other does not. They may also differ in more dramatic ways. One may die of cancer at age 50 and the other may live a healthy life until 85. Because identical twins share virtually the same genes, it has been



Twins gather at the Twins Days Festival in Twinsburg, Ohio, USA.

thought that differences between twins are due to environmental factors.

Lately, however, studies of identical twins have led scientists who are working on the cutting edge of genetics research to a different and radical new conclusion: Genes and the environment are not the only fundamental forces at work. According to recent research, a third factor also comes into play: the epigenome. (The prefix *epi-* means "above.") A genome is a complete set

of genes, which is composed of DNA. The epigenome ("above the genes") controls genes. It is a complex set of biochemical controls, called tags, that does not alter genes but can turn genes on or off. Epigenetics is the study of epigenomes and how they shape who we are. (See Figure 1 on page 152.)

To understand epigenetics, think of our DNA as a script¹ for a play. Every actor—in this case, every gene—has the same script. However, each actor has a different role to play and different words to say. Like a play script, epigenetic tags can determine the role that each cell plays. For example, even though every cell contains the same DNA, one may become a muscle cell and another may become a skin cell. These epigenetic tags can also control which genes are turned on, or expressed, and which are turned off, or suppressed. This is a normal part of development. Some epigenetic changes, however, are anything but normal. For example, an epigenetic change may turn off a gene for proper cell growth, leading to cancer or obesity.

Scientists are not entirely sure why these harmful epigenetic changes occur, but they are sure that the environment plays a big part. The environment includes your physical surroundings as well as what you eat, drink, and do. Scientists believe that your behavioral choices can lead to epigenetic changes. These choices include your diet, whether you smoke, or even how much time you spend in the sun. Epigenetic changes may also be caused by factors you cannot always control, such as toxins in your environment or high stress. These changes explain why identical twins grow more different as they age. Their environments, behaviors, and life experiences are not exactly the same.

None of this was terribly surprising to scientists at the Twins Days Festival, who have long known that the environment and behavioral choices have an impact on health. What has astonished scientists is that these effects could be passed on to the next generation. This was surprising because genes and the environment had

¹ *script*: all of the words that actors say in a play, written down in the form of a book

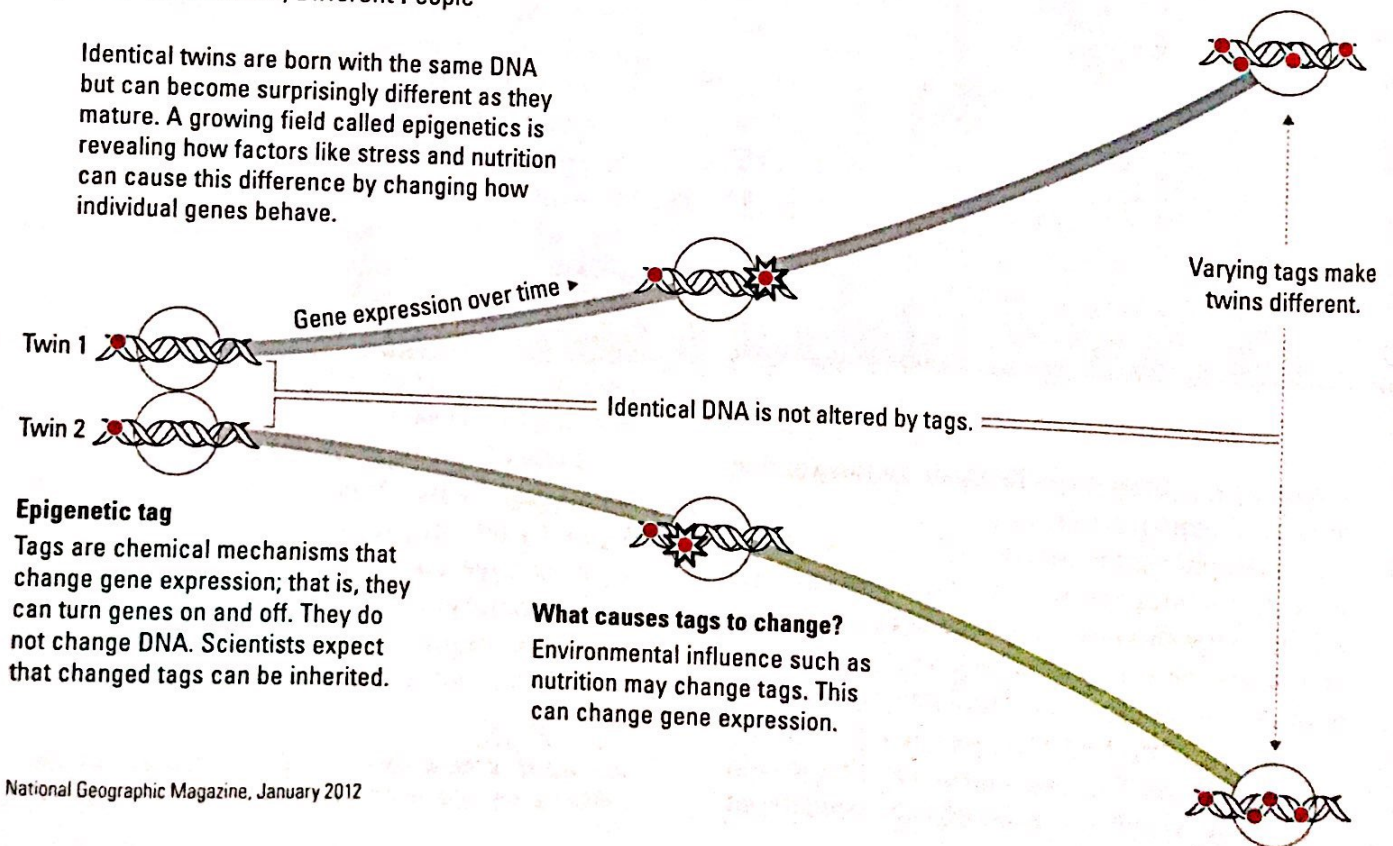
always been considered complementary but independent factors. However, with the discovery of the epigenome they were forced to conclude that these two factors are not completely independent after all. For example, if epigenetic changes lead to obesity in parents, they may pass this change on to their children. This was seen in a study of several generations of residents in an isolated part of Sweden. This surprised scientists because they had always believed that the choices made by one generation would not affect the next generation.

It turns out this is not the case. Although the environment cannot alter the genetic code, it can change gene expression—the position of the on-off switch—in future generations. This means that it is not just the choices that a mother makes during pregnancy that are significant for the child's future health. The choices that both the mother and father make are important, and long before they start a family. As a famous quote states, "You are what you eat." It seems that you may also be what your mother, father, and even grandparents ate . . . and drank, and smoked.

AN EARLY STUDY IN EPIGENETICS

A story that is on the cutting edge of modern science began in an isolated part of northern Sweden in the 19th century. This area of the country had unpredictable harvests through the first half of the century. In years that the harvest failed, the population went hungry. However, the good years were very good. The same people who went hungry during bad harvests overate significantly during the good years. A Swedish scientist wondered about the long-term effects of these eating patterns. He studied the harvest and health records of the area. He was astonished by what he found. Boys who overate during the good years produced children and grandchildren who died about six years earlier than the children and grandchildren of those who had very little to eat. Other scientists found the same result for girls. The scientists were forced to conclude that just one season of overeating could have a negative impact that continued for generations. In other words, environmental conditions altered gene expression, establishing new traits within a generation.

Figure 1. Same Genes, Different People



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READING COMPREHENSION

Big Picture

- A** Choose the best answer for each of the following questions.
- Which sentence expresses the main idea of paragraph 2?
 - The first sentence
 - The third sentence
 - The last sentence
 - What is the main idea of paragraph 3?
 - Epigenetics may explain what genes and environment alone cannot explain.
 - The epigenome is more important than either genes or the environment.
 - Epigenetics is a study of identical twins and the environment.
 - What is the purpose of paragraph 4?
 - To give a definition of the epigenome
 - To prove that epigenetic processes cause cancer
 - To explain how epigenetic processes control genes
 - What is the main idea of paragraph 5?
 - Identical twins do not really have identical genes.
 - Smoking and stress can alter your genes.
 - The environment and behavior can lead to epigenetic changes.
 - What is the main idea of paragraph 6?
 - The impact of people's choices may extend beyond their own lives to future generations.
 - Fathers need to be careful about diet because their choices affect their health.
 - Epigenetics can affect your environment and the environment of your children.

- B** Number these events to show the correct order, according to the reading.
- Gene expression changes.
 - Person experiences environmental factors (such as stress) and makes behavioral choices (such as smoking).
 - Changes occur in a person's health (such as obesity or cancer).
 - Epigenetic changes occur; that is, changes occur in tags on genes.

Close-Up

- A** Decide which of the following statements are true or false according to Reading 2 and the short extra reading, "An Early Study in Epigenetics," on page 152. Write *T* (True) or *F* (False) next to each one.
- Identical twins are completely identical.
 - Epigenetic tags control gene expression.
 - Epigenetic changes can lead to disease.
 - The environment can alter your genes.
 - Epigenetic changes can be inherited.
 - The Swedish study showed that epigenetic changes are limited to the next generation.

- B** Work with a partner or in a small group. Change the false statements in Exercise A to make them true.

VOCABULARY PRACTICE

Academic Vocabulary

A Find the words in bold in Reading 1. Use the context and the sentences below to help you match each word to its definition.

- | | |
|---|---|
| _____ 1. Engineers hope that the new roads will untangle (Par. 2) the terrible traffic in the city. | a. useful or beneficial together |
| _____ 2. The statement that "all men are created equal" was a radical (Par. 3) idea in the 18th century. It was not generally accepted until much later. | b. far away and separate from other things |
| _____ 3. Many scientists believe that human activity can alter (Par. 3) our climate. In particular, they believe it is getting warmer. | c. stopped something from happening or developing |
| _____ 4. He suppressed (Par. 4) his anger until the end of the meeting, but then he lost his temper and began to shout. | d. extremely different and new |
| _____ 5. Obesity (Par. 4) is a huge problem in the United States. More than 35 percent of adults are extremely overweight. | e. the state of being extremely fat |
| _____ 6. Many parents complain that the responsibilities of work and family create a lot of stress (Par. 5) in their lives. | f. change |
| _____ 7. The company hired two new employees with complementary (Par. 6) skills. One was good at writing and the other knew a lot about technology. | g. continuous feelings of worry about work or personal problems |
| _____ 8. It is difficult for workers to reach the new factory because it is far from the city in a very isolated (Par. 6) area. | h. separate out things or ideas so they become less complicated |

B Choose an academic word from the box to complete each of the following sentences. Notice and learn the words in bold because they often appear with the academic words.

alter	isolated	radical	suppress
complementary	obesity	stress	untangle

1. We have to finish the project by next week, so everyone in the office is **under** a lot of _____.
2. Unfortunately, the _____ **rate** is rising every year. The number of children who are overweight is of special concern.
3. Genetics and the environment have _____ **roles** in determining our health.
4. After our parents died, we had to _____ the financial **mess** that they had left. Their bank and insurance records were disorganized and incomplete.
5. The accident took place in a(n) _____ **area**, so it took a long time for the police to arrive.
6. The new president has made some _____ **changes** in the company. Things are going to be very different from now on.
7. She couldn't _____ her **smile** when she read the good news.
8. These ideas will **fundamentally** _____ how we teach math and science.

Multiword Vocabulary

A Find the words in bold in Reading 2. Then write the words that come before and/or after them to complete the multiword vocabulary.

1. on _____ **edge** (Par. 3)
2. _____ **into play** (Par. 3)
3. _____ **case** (Par. 4)
4. _____ **but** (Par. 4)
5. have an _____ (Par. 6)
6. _____ **on to** (Par. 6)
7. were forced _____ (Par. 6)
8. _____ **all** (Par. 6)

B Complete the following sentences with the correct multiword vocabulary from Exercise A. Use the information in parentheses to help you. In some cases, you need to change the verb form.

1. The scientists at the university work _____ (involved in the most exciting new developments) of genetic research.
2. Some behavior, such as smoking and overeating, may _____ (have an effect on) future generations.
3. I looked everywhere for my earring—at home, in the car, at my office—but could not find it. I _____ (decide that something is true based on evidence that you don't really want to accept) that I had lost it.
4. Everyone thought it was going to rain today, but it turned out to be a nice day _____ (in spite of what was expected).
5. Many factors _____ (have an effect or become important) when voters have to decide which candidate they prefer.
6. The teacher promised the instructions for the assignment would be clear and easy to follow, but I found that they were _____ (not in any way) clear.
7. Hair color is one trait that parents can _____ (give) their children.
8. On January 1, we will have to follow a new law. I am usually in favor of laws that support small businesses, but _____ (in this situation), I am not.

Use the Vocabulary

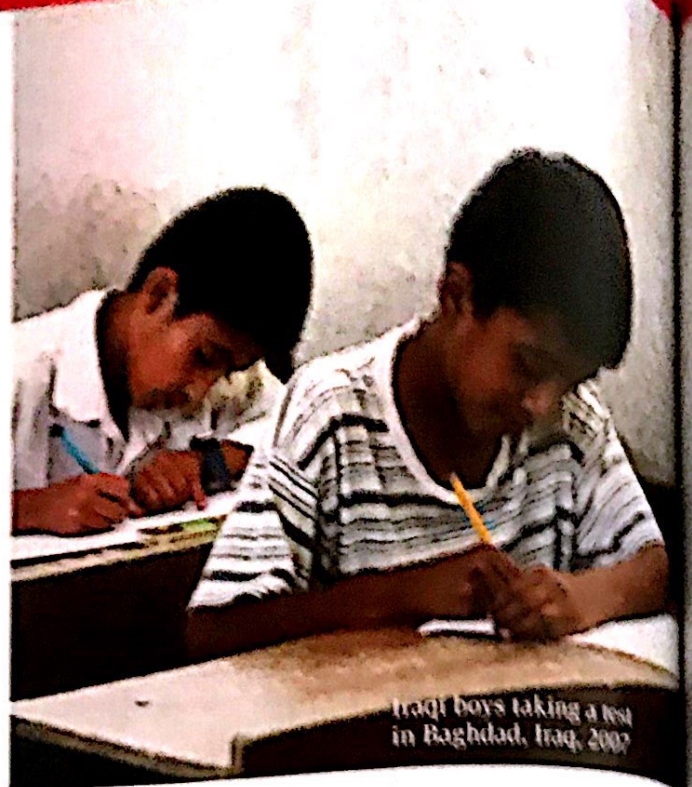
Write answers to the following questions. Use the words in bold in your answers. Then share your answers with a partner.

1. What basic ideas and values do you want to **pass on to** your children? What factors do you think **come into play** when children and teenagers make important decisions? Do these factors change when they are **under stress**?

Vocabulary Review

A Complete the reading with the vocabulary below that you have studied in the unit.

after all	inherit from
comes into play	next phase
complementary roles	pass on
consistent with	radical changes
fundamentally alter	were forced to conclude



Throughout much of the 20th century, scientists and education experts tried to determine the contributions of genes and the environment to intelligence. The answer is important for decisions about education. For example, if the environment can _____ intelligence, the government should make an effort to improve the environment in which children learn. However, if intelligence is something we _____ our parents, then it may not be worthwhile to try to improve the learning environment. After years of research, scientists _____ that about 75 percent of intelligence is genetic.

However, during the _____ of intelligence research came a surprise. New results were not _____ the earlier studies. The new studies showed that the two factors are not in opposition _____. Instead, scientists began to see them as playing _____ in explaining intelligence. They now believe that parents do _____ genes for intelligence to their children. However, the genetic portion of intelligence is only potential intelligence. Experts currently believe that genes define the limits of intelligence, but then the environment _____. The environment determines if a person will be able to reach those limits. This insight could lead to _____ in how we approach education.

B Compare answers to Exercise A with a partner. Then discuss the following question.

How do you think this new research could change our approach to education?

C Complete the following sentences in a way that shows that you understand the meaning of the words in bold.

1. It's hard to be an **only child** because _____
2. When I speak in English, I sometimes **get into trouble** when _____
3. He chose to live **on his own** because _____
4. If you are **under** a lot of **stress** at work, you should _____



Reading Skill

Relating Supplementary Material to the Text

In academic textbooks, authors often supplement the primary material in the text with information in textboxes or sidebars. These supplements generally contain information that will add to your understanding of the main text. When you read this extra material, try to determine its purpose and how important it is.

This supplementary material can serve several functions:

- Provide historical context for the primary material
- Offer statistical support for primary material in the form of tables or graphs
- Focus on a scientific study that is relevant to the primary material
- Offer interesting information that is related to the topic of the text
- Provide a more personal perspective on the primary material

- A** Review the supplementary material “An Early Study in Epigenetics” on page 152. What do you think the general purpose of this material is? _____
- B** Read the following statements from the main text. Check (✓) the ones that are discussed and supported in the supplementary material in the box on page 152.
- _____ 1. Twins share virtually the same genes. (Par. 2)
 - _____ 2. Even though every cell contains the same DNA, one may become a muscle cell and another may become a skin cell. (Par. 4)
 - _____ 3. Scientists believe that your behavioral choices can lead to epigenetic changes. (Par. 5)
 - _____ 4. What has astonished scientists is that these effects could be passed on to the next generation. (Par. 6)
 - _____ 5. The choices that a mother makes during pregnancy are significant for the child’s future health. (Par. 7)