

▶ MAIN IDEA

Environmental factors influence gene expression, resulting in different cell types.

Most multicellular organisms begin as a single fertilized egg cell, or zygote, which grows and divides into two cells. This process of growth and division repeats over and over. Cell differentiation is the process by which unspecialized cells develop into their mature forms and functions. Gene expression is responsible for the differentiation of cells. Gene expression is affected by both the internal and external environment. An organism's internal environment includes all the factors within the organism and its cells. The external environment refers to any factors outside the organism.

As cells grow and divide, subtle differences become more evident as distinct cell types are formed. During embryonic development, cell differentiation and cell growth form tissues and organs in a process called morphogenesis. **FIGURE 6.3** shows the morphogenesis of embryonic eyes through the differentiation of cells.

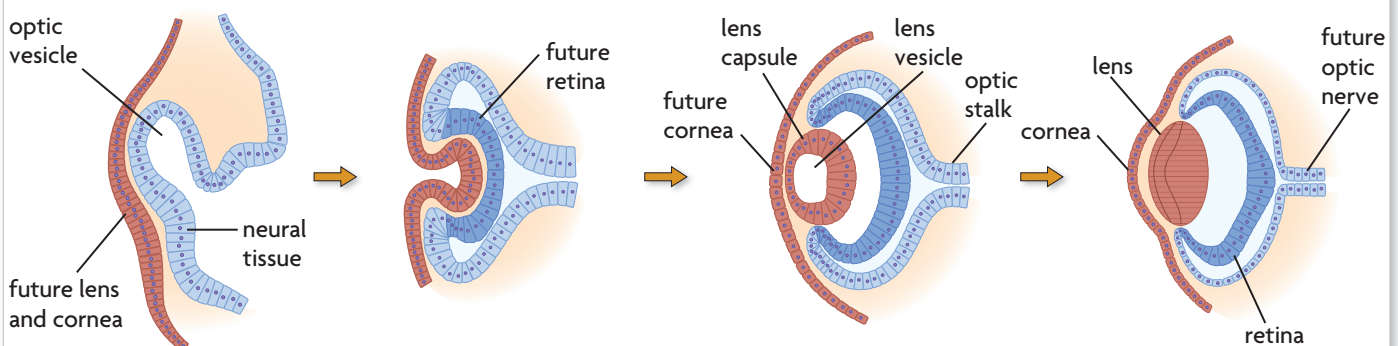
Internal Factors

The differentiation of embryonic cells is based on several internal factors. First, the genetic make-up of the zygote provides the organism with many instructions for differentiation. A zygote's genetic make-up includes all the genes that can be expressed within any cell of the organism, even after the organism has grown and developed. Genes that are expressed in the cells of a developing organism initiate cell differentiation.

Even before an egg cell is fertilized, the internal environment of the egg cell promotes differentiation. Proteins, mRNA, organelles, and other substances in the egg cell cytoplasm are not spread evenly throughout the egg cell. After fertilization, as the zygote divides, the molecules in the cytoplasm are distributed unevenly among the different cells of the developing embryo. These molecules regulate gene expression in each cell and help determine what type of cell it will become.

FIGURE 6.3 DIFFERENTIATING EMBRYONIC EYES

The eyes of human embryos begin to develop about 22 days after the egg cell is fertilized to become a zygote. The cells that form eye tissue differentiate due to chemical signals from nearby cells.



Each cell in a developing embryo is influenced by other cells around it. In the developing eyes, for example, cells close to the optic vesicle are influenced to thicken and fold inward. These changes eventually lead to the development of the lens and cornea. Cells influence and communicate with each other by sending and receiving molecules that act as signals. Signals may also come from molecules embedded in the cell membrane. Signal molecules are proteins that induce a cell to follow a specific developmental path by causing a change in its gene expression. Signal molecules cause the expression of certain genes to be turned on or off. Some signal molecules can affect genes by preventing a gene from transcribing genetic information to mRNA. Gene expression also can be controlled after translation has occurred. For example, a protein may be produced by translation and then broken down by enzymes.

External Factors

Factors in an organism's external environment also can affect gene expression. For example, temperature can influence gene expression in some organisms. The *C* gene in Himalayan rabbits is involved in development of the black color of fur, skin, and eyes. When the external temperature is above 35°C, the central parts of the rabbit's body are over 30°C, and the gene is inactive. No pigments are produced, and the fur color is white. Below 20°C, the outer parts of the rabbit—such as the ears, tail, feet, and tip of the nose—are cooler, and the gene is expressed. These body parts are black.

The presence of drugs and chemicals in an organism's external environment can also affect gene expression and cell differentiation. When magnesium chloride is present in the environment of certain fish embryos, they develop one eye instead of two. In the 1960s, the drug thalidomide was found to cause severe arm and leg deformities in human embryos. Children born from mothers who took this drug often had shortened and malformed limbs.

Light affects gene expression in *Vanessa* butterflies. If the immature caterpillars are placed in red light, the wings that develop in the adult butterflies are brightly colored. When the caterpillars are placed in green light, the adults have dark wings. Under blue light or in darkness, the wings are a pale color.

Identify Name two internal and two external factors that affect gene expression.



SELF-CHECK Online
HMHSscience.com

GO ONLINE

8.6 Formative Assessment

REVIEWING MAIN IDEAS

1. What is a **promoter**?
2. In eukaryotic cells, genes each have a specific combination of regulatory DNA sequences. How do these combinations help cells carry out specialized jobs?

CRITICAL THINKING

3. **Predict** Suppose a bacterium had a mutated repressor protein that could not bind to the *lac* operator. How might this affect regulation of the **operon**?
4. **Summarize** What are the three major steps involved in mRNA processing?

CONNECT TO

DNA

5. DNA is loosely organized in areas where RNA polymerase is transcribing genes. What might you infer about a region of DNA that was loosely organized in muscle cells but tightly coiled in lung cells?