Factors Affecting Cell Growth

Many factors influence cell growth and division, including cell size. A typical animal cell only grows to a size of 10–20 micrometers. Cell size is often expressed as a comparison of two quantities: surface area and volume. A cell's surface area-to-volume ratio is the relationship between the surface area of a cell's membrane and the inner volume of a cell.

Problem Solving

Calculating Cell Size

A ratio is a comparison of two numbers. For example, suppose there are 25 students in a class—10 boys and 15 girls. The ratio of boys to girls is 10 to 15. We can express this ratio in one of three ways:

$$10 \text{ to } 15 \qquad 10{:}15 \qquad \frac{10}{15}$$

A ratio can be reduced, just like any other fraction. Ratios are reduced by determining the lowest common denominator. In the example above, the greatest common factor is 5.

$$\frac{10}{15} = \frac{2}{3} = 2{:}3$$

SAMPLE PROBLEM

Study this sample problem for Cell A.

FIGURE 5: Cells are measured by their surface area and volume.

Calculate the surface area-to-volume ratio for Cell A.

1. Surface area = length × width × number of sides = 1 × 1 × 6 = 6.
2. Volume = length × width × height = 1 × 1 × 1 = 1.
3. Surface area-to-volume ratio = 6:1.

SOLVE

Calculate the surface area-to-volume ratio for Cell B and Cell C.

1. Calculate the surface area of Cell B and Cell C.
2. Calculate the volume of Cell B and Cell C.
3. Calculate the surface area-to-volume ratio for Cell B and Cell C.

Explain Describe the pattern you observe in the surface area-to-volume ratios as the cell gets larger.

Explore Online

Hands-On Lab

Modeling Cell Surface Area-to-Volume Ratio Use model cells to investigate how a cell's size affects its ability to transport materials across the membrane and maintain homeostasis.

Cell Size

Recall that oxygen, nutrients, and wastes move across the cell membrane, or the surface of the cell. Some diffuse passively across the membrane, while others are transported actively via specialized proteins. No matter how materials move across the membrane, they must be transported in adequate amounts and with adequate speed to maintain homeostasis. If there is not enough surface area for materials to cross into and out of the cell, the cell may not be able to absorb materials or expel wastes effectively. To maintain a suitable cell size, growth and division must be coordinated.

Explain Make a claim for why cells must divide, rather than grow larger. Explain how surface area and volume, as well as transport across the cell membrane, are related to cell size and homeostasis.

Regulating Cell Division

Like other cellular processes, the cell cycle must be regulated. The cell cycle is regulated by both internal and external factors that work together to control when and how often a cell divides. Internal factors come from inside the cell and include several types of molecules found in the cytoplasm. External factors come from outside the cell, either from nearby cells or from another part of the organism's body.

An external factor that regulates the cell cycle can be either a physical signal or a chemical signal. One example of a physical signal—cell-to-cell contact—can be observed in a single layer culture of mammalian cells. Individual cells will divide in these cultures until they touch other cells. At this point, they stop dividing. Scientists are not yet sure what causes this to happen. One hypothesis is that receptors on the surfaces of neighboring cells bind to each other, causing the cell's cytoskeletons to form structures that can block growth signals. Many cells also release chemical signals that can stimulate the growth of other cells. For example, growth factors are a broad group of proteins that stimulate cell division.

When external factors bind to their receptors on a cell's surface, they can trigger internal factors that affect the cell cycle. Two well-studied kinds of internal factors are kinases and cyclins. A kinase is an enzyme that, when activated, transfers a phosphate group from ATP to a specific target molecule. This action typically increases the energy of the target molecule, changes its shape, or both. Your cells have many types of kinases, and they are almost always present in the cell. Those kinases that help control the cell cycle are activated by cyclins. Cyclins are a group of proteins that are rapidly made and destroyed at certain points in the cell cycle. These two factors help a cell advance to different stages of the cell cycle when they bind to each other. This cyclin-kinase interaction plays an important role in cell cycle checkpoints, ensuring that cells start and stop dividing at appropriate times.

Model Create a graphic organizer to describe the different factors that influence cell division. Include information related to the cell cycle, rates of cell division, cell size, and internal and external factors.

Apoptosis

Some cells are programmed to die at a predetermined time in their life cycle or after a certain number of cell divisions. Programmed cell death is known as apoptosis, and it occurs when internal or external signals activate genes that help produce self-destructive enzymes. Apoptosis may occur in cells with damaged DNA or in cells that are harmful to, or simply no longer needed by, the body. Normally immune system cells ignore other cells in the body, but some immune cells are specialized to recognize apoptotic cells. These cells very tidily gobble up the apoptotic cell and recycle its chemical parts for use in building other molecules. Apoptosis is also an important process in normal embryological development in animals, including humans.

Collaborate Human embryos have webbed digits (fingers and toes) early in their development. The cells between the digits undergo apoptosis during later stages of development. With a partner, draw a model to show how apoptosis leads to changes in the structure of digits during later stages of development.

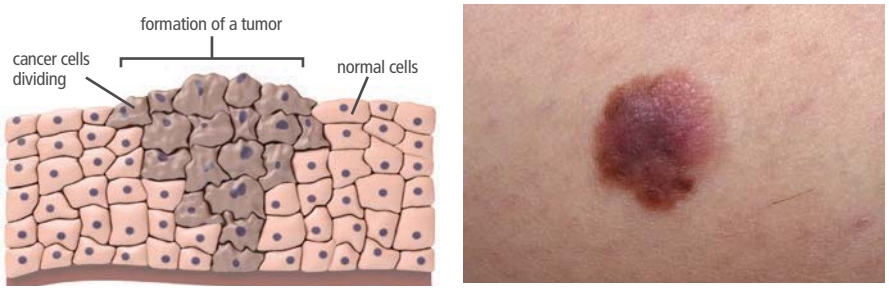
FIGURE 6: In early stages of development, human embryos have webbing between their fingers and toes.

Cancer

Cancer is the common name for a class of diseases characterized by uncontrolled cell division. It arises when regulation of the cell cycle is disrupted. Because they do not respond to factors regulating growth, cancer cells divide more often than healthy cells. This results in the formation of disorganized clumps of cells called tumors. Some tumors can be removed successfully if they remain localized. However, some cells break away and are carried to other places in the body where they create new tumors in a process called metastasis. Cancer cells are hazardous because they do not perform normal cell functions. For example, in the lungs, cancer cells do not develop into healthy lung tissue and do not properly carry out gas exchange.

Cells become cancerous when mutations occur in sections of DNA that code for regulatory factors. Some mutations are caused by radiation or chemical exposure while others are inherited. Substances that promote or produce cancerous growth are called carcinogens. These include tobacco smoke and certain air pollutants. Some cancers are inherited when the abnormal gene that causes the cancer is passed on from generation to generation.

FIGURE 7: Normal animal cells respond to external factors and stop dividing when they touch each other. Cancer cells fail to respond to these factors. The cancerous growth shown here is a form of skin cancer called melanoma.



Explain Describe the differences in the normal cells and the cancerous cells shown in Figure 7.

Analyze A sensory neuron serving the toe of a giraffe has an average length of nearly 4.6 meters. Use what you have learned about cell surface area and volume to explain how this cell can function properly.