10.4
Cell Differentiation
THINK ABOUT IT

The human body contains hundreds of different cell types, and every one of them develops from the single cell that starts the process. How do the cells get to be so different from each other?
From One Cell to Many

How do cells become specialized for different functions?

During the development of an organism, cells differentiate into many types of cells.
All organisms start life as just one cell.

Most multicellular organisms pass through an early stage of development called an **embryo**, which gradually develops into an adult organism.
During development, an organism’s cells become more differentiated and specialized for particular functions.

For example, a plant has specialized cells in its roots, stems, and leaves.
Defining Differentiation

The process by which cells become specialized is known as differentiation.

During development, cells differentiate into many different types and become specialized to perform certain tasks.

Differentiated cells carry out the jobs that multicellular organisms need to stay alive.
Mapping Differentiation: patterns

There are two patterns of cell differentiation.

In some organisms, a cell’s role is determined at a specific point in development. All cells have a predetermined specialization.

In the worm *C. elegans*, daughter cells from each cell division follow a specific path toward a role as a particular kind of cell.
Differentiation in Mammals

Other organisms have generic cells that have many possibilities for differentiation. Individual cells do NOT necessarily have a predetermined outcome.

Example: Cell differentiation in mammals is controlled by a number of interacting factors in the embryo.

Adult cells generally reach a point at which their differentiation is complete and they can no longer become other types of cells.

Mammalian cell differentiation:
1) many factors control it
2) adult cells reach a point when they can no longer differentiate.
Stem Cells and Development

What are stem cells?

The unspecialized cells from which differentiated cells develop are known as stem cells.
One of the most important questions in biology is how all of the specialized, differentiated cell types in the body are formed from just a single cell.

Biologists say that the beginning cells in an organism are totipotent, literally able to do everything, to form all the tissues of the body.

Only the fertilized egg and the cells produced by the first few cell divisions of embryonic development are truly totipotent.
Human Development

After about four days of development, a human embryo forms into a **blastocyst**, a hollow ball of cells with a cluster of cells inside known as the inner cell mass.

The cells of the inner cell mass are said to be **pluripotent**, which means that they are capable of developing into many, but not all, of the body's cell types.

Draw a blastocyst in your notes. Label the inner cell mass as having pluripotent cells.
Lesson Overview

Cell Differentiation

- Blastocyst
- Inner cell mass
- Embryonic stem cells in a culture
- Neuron
- Fat cell
- Macrophage
- Smooth muscle cell
Stem Cells

**RECALL:** Stem cells are unspecialized cells from which differentiated cells develop.

There are two types of stem cells: embryonic and adult stem cells.
Embryonic Stem Cells

Embryonic stem cells are found in the inner cells mass of the early embryo.

Embryonic stem cells are pluripotent.

Researchers have grown stem cells isolated from human embryos in culture. Their experiments confirmed that embryonic stem cells have the capacity to produce most cell types in the human body.
Adult Stem Cells

Adult organisms contain some types of stem cells.

Adult stem cells are multipotent. They can produce many types of differentiated cells.

Adult stem cells of a given organ or tissue typically produce only the types of cells that are unique to that tissue.
Fill in the following **stem cell vocab chart**

<table>
<thead>
<tr>
<th>Name</th>
<th>Age/stage</th>
<th>Degree of differentiation ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Youngest/embryonic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium/embryonic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oldest/adult</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Summary Questions:

What is cell differentiation?
What is cell specialization?
What are the two “patterns” for differentiation?
What is an embryo?
What is a blastocyst?
What are stem cells?
What are the three types of stem cells? Describe each in terms of age and ability to differentiate
What are some possible **benefits and issues** associated with stem cell research?

Stem cells offer the potential benefit of using undifferentiated cells to **repair or replace badly damaged cells and tissues**.

Human embryonic stem cell research is **controversial** because the arguments for it and against it both involve ethical issues of life and death.

Make a T-CHART about stem-cell use in your notes. Title the two columns “benefits” and “drawbacks”. Based on your current understanding of stem cells, write at least two items in each column.
Potential Benefits

Stem cell research may lead to new ways to repair the cellular damage that results from heart attack, stroke, and spinal cord injuries.

One example is the approach to reversing heart attack damage illustrated below.
Ethical Issues

Most techniques for harvesting, or gathering, embryonic stem cells cause destruction of the embryo.

Government funding of embryonic stem cell research is an important political issue.

Groups seeking to protect embryos oppose such research as unethical.

Other groups support this research as essential to saving human lives and so view it as unethical to restrict the research.