Chapter One: Cell Differentiation and Resulting Cell Types

**Introduction:**

Cells are the basic unit of all life, and have a variety of types, along with a variety of functions. They are all formed by the genome of a fertilized egg, and are derived from a less specialized cell in a process which can be referred to as cell differentiation. Multicellular organisms are able to carry out this process. Following the fusion of two gametes (one from a mother one from a father) to form a zygote, the zygote quickly begins to differentiate into many different cells. This process also happens with adult stem cells where the stem cells divide into specialized daughter cells with different functions. There are even stem cells that can differentiate into any cell of the body and these are referred to as pluripotent cells. There are vast applications of these cells but also ethical issues have arose as a result as well. These cells have such a variety of uses because there is such a vast amount of cells in the body that they can differentiate into. Research of these stem cells has resulted in the opening of an entirely new route of medicine. That is, the stem cells can be used to completely regenerate damaged or mutated tissues, even before birth. This of course has made the use of stem cells an ethical issue and one that is far from being solved. We will be going through the categories of these cells that stem cells differentiate into and their functions within the body.

**History:**

Before looking at the different cell types, it is important to gain an understanding of how they were discovered. Robert Hooke was the one who first discovered the cell, and did so in 1665. However, Hooke only observed dead cells. Anton van Leeuwenhoek was the first to observe a cell in its living state when he observed it under a microscope in 1674. Following these two observations, many other discoveries in regards to the structure of the cell emerged.

**Modern Cell Theory:**

What has arose from these discoveries is what is known as Modern Cell Theory. Modern Cell Theory has six basic principles. The six being that all known living things are made up of cells, the cell is the structural and functional unit of all living things, all cells are the result of cell division (no spontaneous generation), cells contain genetic information which is passed to other cells during division, all cells have roughly the same chemical composition, and all energy flow of life occurs within cells. Before these principles were set, Theodor Schwann’s observations of cells are what formed the basic understanding. The first of these observations was that the cell is the unit of structure, physiology, and organization in living things, which is still the modern understanding. The second was that the cell retains a dual existence as a distinct entity and a building block in the construction of organisms, which also still holds true with today’s understanding. His third and final statement on cells was that cells form by free-cell formation, similar to the formation of crystals. Meaning that cells are the result of spontaneous generation (spontaneous generation means that something is able to arise from nothing or simply appear out of thin air). However, this third statement on cells has been disproven. This belief was popularly held until the late 19th century. Experiments such as leaving out dirty underwear and wheat grain and mixed in a bucket, and then in a few weeks it would result in mice, were the basis of why spontaneous generation was believed to be true. Nevertheless, in 1668, this was disproven by Francesco Redi. Redi was able to successfully dispute spontaneous generation by showing that meat left exposed to air did not just magically turn into maggots. He used three different slices of meat, two of which were covered, one which was left exposed to air. His hypothesis was that flies laid eggs on the meat, and as a result, maggots developed from the eggs. His hypothesis was supported when only the meat left exposed to the air resulted in maggots, as the flies did not lay eggs on the covered slices of meat. Additionally supporting his hypothesis, he removed the covering from one of the slices of meat, and as expected, maggots resulted as the flies were then able to lay their eggs. All that being said, the idea of spontaneous generation has been replaced with part of modern cell theory which states that all cells are the result of cell division (cells come from other cells).

**Cell Types:**

From development, cells in the body differentiate into a variety of cell types. These cell types (besides stem cells) are bone cells, blood cells, muscle cells, fat cells, skin cells, nerve cells, endothelial cells, and sex cells. We will explore the details of each of these cell types.

**Bone Cells:**

* Osteoblasts
  + Contain a central nucleus and are found on the surface of bone.
  + Their main purpose is to make proteins composing the matrix, without these cells, the matrix of bone would not exist.
  + Come from a precursor cell also capable of differentiating into fat cells.
  + Secrete substances which activate osteoclasts (see following)
  + After finished making bone matrix, they differentiate into osteocytes, (see following), lining cells, or will disintegrate.
* Osteoclasts
  + Have many nuclei, and are formed from fusion of the precursors found in blood and bone marrow.
  + Their main purpose is to degrade bone, and following degradation undergo ‘cell suicide’.
* Osteocytes
  + Central cells of bone, they live inside the bone and contain long branches.
  + Their main purpose is to regulate the growth of bone

**Muscle Cells:**

* Skeletal muscle
  + Under voluntary control, are widely distributed, are striated, and contain many nuclei.
* Cardiac Muscle
  + Strictly found in the heart, are striated, specialized to pump blood, and are involuntary.
  + Rhythm of the heartbeat is determined by specialized pacemaker cardiac cells.
* Smooth Muscle
  + Found in organs, blood vessels, and bronchioles.
  + Contains no striations and their main purpose is to move substances through the body.

**Adipose Cell:**

* White adipocyte
  + Have large fat droplets, small cytoplasm, and flattened nuclei
* Brown adipocyte
  + Varying size of fat droplets, large cytoplasm, and round nuclei

Both types of adipose cells contain enzymes which hydrolyze triglycerides to generate fatty acids and glycerol to be used in different processes of the body.

**Skin Cells:**

* Keratinocytes: Serve as body’s first line of protection from the elements and pathogens, also function in thermoregulation via sweat and also house hair follicles and oil glands. Keratinocytes contain four layers:
  + Stratum corneum (dead and hardened cells without nuclei)
  + Stratum granulosum (contains basophilic granules, and secretes waxy material into intracellular spaces)
  + Stratum spinulosum (has desmosomes which link the keratinocytes together)
  + Stratum basale (regenerative layer, bottom layer, and the new cell as a result of division migrates towards the top)

**Nerve Cells:**

* Nerve cells serve as providing stimulus throughout the body. That is, when you stub you toe or get pinched, nerves cells are responsible for the sensation. Nerve cells contain a body, surrounded by what are called dendrites, and then contain a long axon traveling away from the neuron. The axon contacts either another nerve cell or a tissue in the body via its axon terminal. Following a stimulus, the nerve cell sends an impulse along its axon and when the impulse reaches the terminus, neurotransmitters are released and received by the tissue which will then experience that stimulus.

**Endothelial Cells:**

* Endothelial cells are for a single cell thick layer creating the blood vessels. These blood vessels include arteries, arterioles, venules, veins, and capillaries. That being said, their function is to regulate blood flow throughout the body. The endothelial cells are also able to form new blood vessels and facilitate the flow of plasma and its cells within the vessels. The barrier that endothelial cells generate is very important as it effectively separates the blood from the rest of the body tissues, but is also permeable to nutrients needing to reach the blood.

**Sex Cells:**

* Produced in a process called meiosis which is the cell division resulting in cells containing 23 chromosomes (cells generated from mitosis have 46). Sex cells allow for reproduction in humans via fertilization of the female sex cell (ova) by the male sex cell (spermatozoa). This results in a cell called a zygote, which then is able to develop into an embryo.

**References:**

Bailey, Regina. “Biology Basics: What Are Sex Cells?” *ThoughtCo*, www.thoughtco.com/sex-cells-meaning-373386.

“Bone Cells.” *ASBMR educational materials*, depts.washington.edu/bonebio/ASBMRed/cells.html.

“Cell Differentiation and Tissue.” *Nature.* 22 Mar. 2014.

<https://www.nature.com/scitable/topicpage/cell-differentiation-and-tissue-14046412>

“Functions of Endothelial Cells .” *Endothelial Cells and Functions*, www.lonza.com/campaigns/bioresearch/endothelium-cells-and-functions.aspx.

“History of Cell Biology.” *Bitesize Bio*, 6 Mar. 2015, bitesizebio.com/166/history-of-cell-biology/.

“Human Muscle Cell Types | Interactive Anatomy Guide.” *Innerbody*, www.innerbody.com/image/musc01.html.

Microscope, Through the. “-9 Spontaneous generation was an attractive theory to many people, but was ultimately disproven.” *Through the Microscope Main News RSS*, www.microbiologytext.com/5th\_ed/book/displayarticle/aid/27.

<http://www.microbiologytext.com/5th_ed/book/displayarticle/aid/27>

“Nerve Cell Structure .” *Nerve Cell*, hyperphysics.phy-astr.gsu.edu/hbase/Biology/nervecell.html.

“Structure of normal skin.” *Structure of normal skin | DermNet New Zealand*, www.dermnetnz.org/topics/the-structure-of-normal-skin.

The Editors of Encyclopædia Britannica. “Adipose cell.” *Encyclopædia Britannica*, Encyclopædia Britannica, inc., 22 Dec. 2015, www.britannica.com/science/adipose-cell.

“What is Cell Differentiation?” *BiologyWise*.

<https://biologywise.com/cell-differentiation>