Specialized Cells: An Introduction & Exercise
BIO 201 Cell & Molecular Biology

Similar to the homework, the exercise below will not be collected, but is meant to help you better understand specialized cells and will hopefully pull together some of our discussions from the semester in one place to reinforce the concepts.

An Introduction

During the development of multicellular organisms and later in the adult organism, stem cells divide and give rise to many different cell types with specialized functions. The process by which the cells specialize is called differentiation. As cells develop further down a differentiation pathway, they often lose the ability (1) to give rise to alternate cell types and (2) to divide. At this point the cells are committed to that differentiation pathway and, when they completely lose their ability to divide, they are referred to as terminally differentiated. Stem cells, on the other hand, often have unlimited potential to divide giving rise to additional stem cells as well as cells that differentiate into specialized cells. Thus, stem cells are not considered a specialized, differentiated cell.

An Exercise

Consider a specialized cell found in a multicellular organism.
   Example: RBC (see also document online)

   • Think about where this cell is located
     In which organism or group of organisms can the cell be found (e.g. humans, mammals, plants, etc.)? Vertebrates
     In what location is the cell found in the organism (e.g. organ/tissue)? Connective tissue: circulating in blood

   • Identify specialized cellular features of the cell.
     These might include structures, organelles, genes and their products, etc. Clearly explain why these are considered specialized features and not features commonly found in most cells. What is their role in the cell?

     Note: Although you may relate the features to the physiology of the organism, the specialized features you choose must be cellular in nature and you must describe the molecular or cellular basis of the feature. For example, you might explain the intermediate filaments that are specifically found in neurons and how they determine the polarity of these cells, but stating that neurons conduct nerve impulses says little about the cell itself.

     Another common error is to indicate a feature of your cell that is actually a characteristic of another cell with which the first cell interacts (e.g. a hormone receptor on the target cell when discussing a hormone producing cell) or a feature that has to do with tissue or organ structure (e.g. synaptic cleft is a structure, a space, that arises between a neuron and another cell)
Some of the specialized cellular features you identify may not be able to be described at the molecular level, either because that information is not yet known or the complexity is higher than the level of this course. Here are two examples that would be difficult to describe at the molecular level: (1) The loss of an organelle may have occurred during the differentiation process, so the molecular details may have occurred previously and actually be a feature of a progenitor cell. (2) An abundance of an organelle may be an important feature, but since the organelles are no different than those of other cells you would need to describe how they are maintained at that elevated level to actually describe the specialized feature. Identifying the molecular mechanisms that allow that cell to have such an abundance might be a difficult task or may not yet be completely understood.

Example: The following are simply notes but could be compiled into an answer made of complete sentences.

Hemoglobin
- a protein that carries oxygen and carbon dioxide (carbaminohemoglobin)
- this function is important to gas exchange in the respiratory system
- only found in RBC

Biconcave shape
- supported by the cell cortex
- this shape provides: flexibility to squeeze through capillaries, ability to stack with other RBCs as they pass through the capillaries, increased surface area for gas exchange
- although the cell cortex is found in other cells, in RBCs the cortex is organized in such a way to support the specialized shape of the RBC
- only RBC have this shape

Carbonic anhydrase
- an enzyme that catalyzes the formation of carbonic acid from carbon dioxide & water (1st rxn)
- carbonic acid then quickly dissociates to form bicarbonate (2nd rxn)
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  \begin{align*}
  \text{CO}_2 + \text{H}_2\text{O} & \rightarrow \text{H}_2\text{CO}_3^- + \text{H}^+ \\
  \text{H}_2\text{CO}_3 & \rightarrow \text{H}^+ + \text{HCO}_3^-
  \end{align*}
  \]
- this specialized feature of RBC’s increases the ability of the blood to carry carbon dioxide as well as producing bicarbonate which is a major buffer in the blood
- although this enzyme is found in other cells it is not found in all cells and contributes to the specific function of red blood cells