

A conceptual framework for the core concept of Cell Membrane

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Abstract

The core concepts of physiology are descriptions of phenomena that have great explanatory power in every area of physiology. They are "big ideas" that are comprised of many smaller ideas. The process of "unpacking" a core concept yields a hierarchically arranged statement of the sub-ideas that we have called a conceptual framework (CF). Our goal has been to produce CFs that will facilitate teaching and learning physiology.

We have unpacked three of the core concepts (*homeostasis, flow down gradients, and cell-cell communication*) and validated the resulting conceptual frameworks with feedback from the physiology teaching community; this work has been reported in *Advances in Physiology Education*.

Here we present our conceptual framework for the core concept of *cell membrane*. We have chosen to describe both the structure of the membrane and the functions of the various components making up the membrane. Cells and their membranes are, of course, present in every part of the organism.

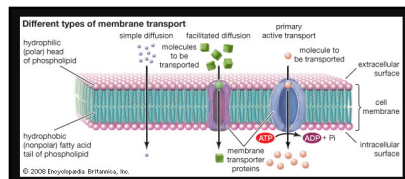
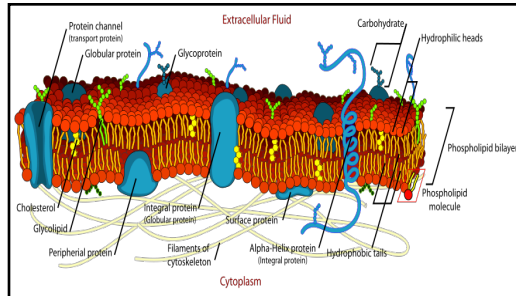
Preliminary feedback from a small number of physiology teachers suggest that our unpacking has captured those ideas that can be used as a tool by both teachers of physiology and their students.

What do we mean by the core concept of Cell Membrane?

Cell plasma membranes are complex structures that determine what substances enter or leave the cell. They are essential for cell signaling, transport, and other processes (Michael and McFarland, 2011).

In unpacking this core concept, we have elected to describe both the structure of the membrane (a lipid bilayer in which proteins are embedded or attached) and the functions that these components generate. Both of these sets of ideas are covered in physiology courses and textbooks.

A visual representation of Cell Membrane



PLEASE HELP US TO VALIDATE THE CELL MEMBRANE CONCEPTUAL FRAMEWORK BY TAKING A COPY OF THE SURVEY, RATING THE IMPORTANCE OF EACH ITEM, AND RETURNING IT TO US USING THE SELF-ADDRESSED ENVELOPE.

THANKS FOR YOUR ASSISTANCE!

Joel Michael and Harold Modell

CONCEPTUAL FRAMEWORK FOR CELL MEMBRANE		Number of 5/4/3/2/1
CM1	The cell membrane is a lipoprotein bilayer.	8/1/1/0/0
CM1.1	The bilayer consists of two layers of phospholipid molecules, each with a polar head (hydrophilic) and two non-polar (hydrophobic) tails.	8/2/0/0/0
CM1.2	The cell membrane includes a number of different types of molecules, including proteins (the fluid mosaic model).	8/2/0/0/0
CM1.2.1	Some proteins are embedded in and span the membrane.	5/3/0/0/1
CM1.2.2	Some proteins are attached to either the interior or exterior of the membrane.	3/3/2/0/1
CM2	The cell membrane participates in a variety of mechanisms that maintain the integrity of cells and make possible the specialized function of any cell.	10/0/0/0/0
CM2.1	The cell membrane creates a closed space that contains the biochemical "machinery" needed for the cell to live and reproduce.	8/1/1/0/0
CM2.2	The cell membrane helps to determine solute concentrations inside the cell to preserve the viability of the cell and the continuation of its specialized functions.	9/1/0/0/0
CM2.2.1	Lipid soluble molecules (O ₂ , CO ₂ , urea) can passively diffuse across the membrane through the lipid portion of the membrane.	6/3/0/0/1
CM2.2.2	Water and water-soluble substances (ions, most organic molecules) can only cross the membrane via mechanisms that involve membrane proteins.	7/3/0/0/0
CM2.2.2.1	Water and some ions traverse the membrane by passive diffusion down an energy (osmotic or electrochemical) gradient through fluid filled channels (membrane spanning proteins).	8/1/1/0/0
CM2.2.2.2	Some substances (e.g., ions, glucose, amino acids) traverse the membrane passively down a gradient via carrier molecules (proteins) in the membrane.	8/1/1/0/0
CM2.2.2.3	Some substances traverse the membrane against a concentration gradient using ATPase powered pumps (primary active transport).	7/2/1/0/0
CM2.2.2.4	Some substances traverse the membrane against a concentration gradient using membrane transporters that move one species across the membrane against a concentration gradient and one species along a concentration gradient generally created by an ATPase located on a different location on the cell membrane (secondary active transport).	6/3/1/0/0
CM2.2.2.5	The membrane also participates in the processes of endocytosis and exocytosis, energy-requiring processes that move things across the membrane in vesicles.	5/3/1/1/0

Ratings selected by respondents to survey
 5=Essential/4=Important/3=Moderately Important
 2=Slightly Important/1=NOT Important

		CCM2.2.2.6	Some cell membranes have connections to adjacent cells (gap junctions) that allow movement of substances from one cell to another along an electrochemical gradient.	4/4/2/0/0
	CM2.3		The cell membrane participates in cell-to-cell communication.	10/0/0/0/0
		CM2.3.1	Some cell membranes contain voltage-gated ion channels (proteins).	8/1/1/0/0
		CM2.3.2	Some cell membranes contain ligand-gated ion channels (proteins). When ligands are bound to the receptor site, the ion channel opens or closes.	8/1/1/0/0
		CM2.3.3	Some cell membranes contain receptors (proteins) that, when bound to a ligand, activates a second messenger system within the cell.	8/1/1/0/0
		CM2.3.4	Some cell membranes contain enzymes (e.g., acetylcholinesterase) that remove a ligand from the cell receptor site.	3/3/3/1/0
	CM2.4		Some cell membranes help maintain the integrity of tissues (e.g., epithelium) by forming junctions between cells.	5/5/0/0/0
		CM2.4.1	Tight junctions form between certain cells (e.g., epithelial cells) near the apical side of the cell.	3/4/2/1/0
		CM2.4.1.1	Tight junctions limit the passage of various substances (molecules, ions, water) through the space between cells.	4/3/2/1/0
		CM2.4.1.2	They block the movement of membrane components within the fluid mosaic from the apical to the basolateral side of the cell.	4/1/3/2/0
		CM2.4.2	Adherens junctions and desmosomes provide strong mechanical attachments between adjacent cells.	4/3/1/2/0
	CM2.5		The membranes of some cells (e.g., lymphocytes) contain proteins that serve as cell recognition proteins and participate in the organism's immune system	3/5/1/0/1

Conclusions

The *cell membrane* core concept is as ubiquitous as are cells in the body. If students understand this core concept and can apply it where it is appropriate, learning the physiology of the body will be greatly facilitated.

We have developed a 27 item hierarchical conceptual framework with items at four levels. Although this is still a work in progress, the preliminary feedback we have received (N=10) suggests that we are on the right track. Every item received a majority of ratings of 4 (important) or 5 (Essential). Further, it appears that the perceived importance of an item is a function of its position in the hierarchy; the lower the item is in the hierarchy, the less important it is thought to be. Finally, it does not appear that the importance of items is a function of the kind of institution at which the respondent teaches.

We should note that there are many different ways in which a pedagogically useful core concept can be written. We are continuing to seek additional feedback to validate our core concept.

References

Michael and McFarland. (2011). The core principles ("big ideas") of physiology: Results of faculty surveys. *Adv Physiol Educ* 35: 336-341.

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Michael et al (2017). Validating a conceptual framework for the core concept of "cell-cell communication." *Adv Physiol Educ* 41: 260-265.