Introduction to Cell Biology

"All human beings by nature stretch themselves out toward knowing"

Aristotle,
***METAPHYSICS* (translated by Sachs J), 2nd edition**
(Green Lion Press, Santa Fe 2002)

What's cell biology

- Etymology: **βίος** – life; **λόγος** – word, concept, speaking, opinion, reason

↓

speaking about cell life

- Part of biology studying biological processes under the cell context (how the cell is structured, and how it acts)
- Biological process – a chain of biochemical reactions occurring in a well defined sequence
- Descriptive part (analytical cell biology) – morphological organization of the cell (cell organelles and other morphological elements) – microscopic approach (LM, EM)
- Functional part (integrative cell biology) – how cell morphological elements act (by themselves and by cross-talking in-between) to assure cell survival and their doing the best

Cell definition

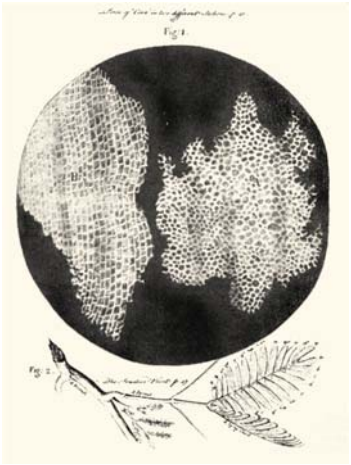
The cell is the structural and functional elementary unit of all living organisms,

conserving the features of the organism,

having the ability of self-control, self-regulation, and self-reproduction,

being the result of a long time of evolution

A little bit of history



http://en.wikipedia.org/wiki/Robert_Hooke

- The word *cell* comes from the Latin *cellula*, a small room, and was chosen by Robert Hooke, in 1665, when he compared the cork cells he saw to the small rooms monks lived in
- The cell theory, first developed in 1839 by Matthias Jakob Schleiden and Theodor Schwann, completed by Rudolf Virchow, in 1858

  - all organisms are composed of one or more cells
  - all cells come from preexisting cells (***omnis cellula e cellula***)
  - vital functions of an organism occur within cells
  - all cells contain the hereditary information necessary for regulating cell functions and for transmitting information to the next generation of cells.

What's the reason to study the cell

- Cell definition – an answer?
- Live phenomenon – no live outside a cell
- Physiology *vs*. pathology
- Any medical act – accommodated by the body's cells

The Corollary:

The cell must be known, understood and respected!

But, this is not easy at all 

Cell diversity

(*cell classifications*)

- According to their morphological complexity
  - – Prokaryotic cells
  - – Eukaryotic cells

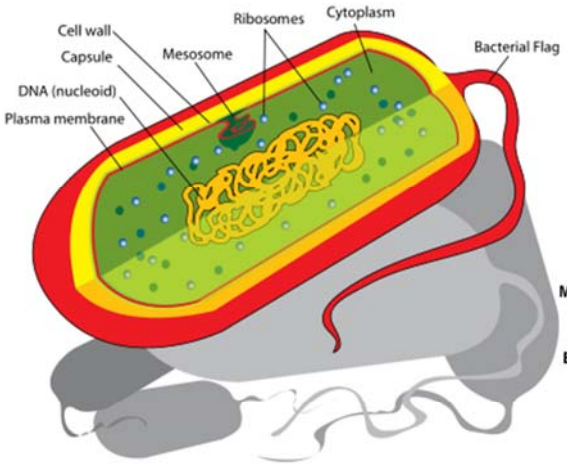
Cell diversity

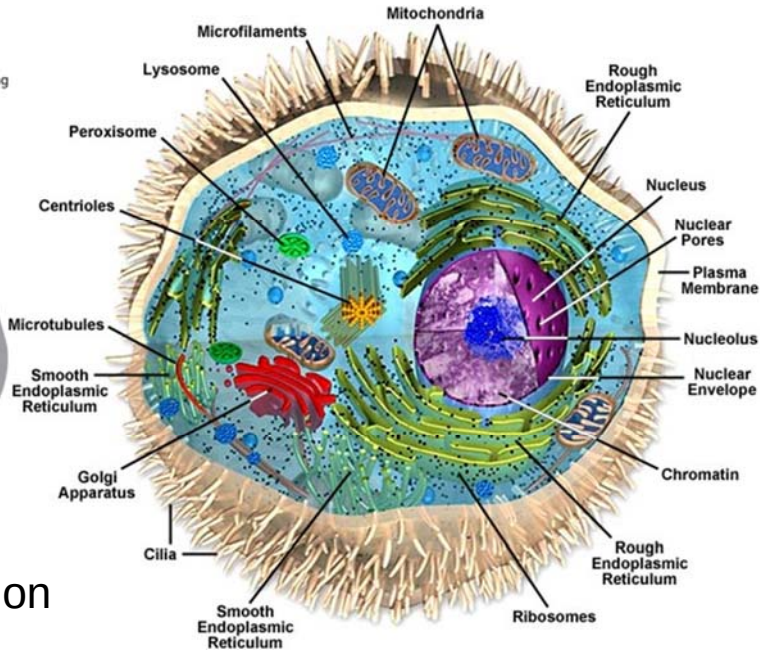
- prokaryotic

No membrane bound organelle

- eukaryotic

Several membrane bound organelle





Definition of organelle notion

Prokaryotic / Eukaryotic

Features	Prokaryotes	Eukaryotes
Typical organisms	bacteria, archaea	protists, fungi, plants, animals
Typical size	~ 0.1-10 µm	~ 10-150 µm (sperm cells, apart from the tail, are smaller, egg cell/ovum is 150 µm in diameter)
Type of nucleus	nucleoid region; no real nucleus	real nucleus with nuclear envelope
DNA	circular (usually)	linear molecules (chromosomes) with histone proteins
RNA-/protein-synthesis	coupled in cytoplasm	RNA-synthesis inside the nucleus, protein synthesis in cytoplasm and some organelles
Ribosomes	50S+30S	60S+40S
Cytoplasmatic structure	very few structures (ribosome), no membrane bound organelles	highly structured in organelles by endomembranes (nucleus, nuclear envelope, endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes, mitochondria) and organelles without endomembranes (ribosome, cytoskeleton, proteasome, apoptosome)
Cell movement	flagella made of flagellin	flagella and cilia made of tubulin, cytoskeleton
Mitochondria	none	one to several dozen (though some lack mitochondria)
Chloroplasts	none	in algae and plants
Organization	usually single cells	single cells, colonies, higher multicellular organisms with specialized cells
Cell division	Binary fission (simple division)	mitosis, meiosis (steps in germ cell differentiation)

Cell diversity

(*classifications for eukaryotic cells*)

- According to the kingdom they belong
  - Plant (vegetal) cells
  - Animal cells
- According their differentiation
  - epithelial cells
  - muscle cells
  - nerve cells
  - mesenchymal cells

Organism's cellularity

- Some organisms, such as bacteria, are unicellular (consist of a single cell)
- Other organisms, such as humans, are multicellular
- Humans have an estimated 100 trillion (10^{14} cells)
- Average cell size: 10 µm
- Average cell mass: 1 nanogram
- Cell volume: 80µm^3 – 8000µm^3
- The largest known cell is an ostrich egg
- The largest cell in human beings is the egg cell (150µm in diameter)

Cell dimension

The structure of the course

- Introduction to cell biology (1 lecture)
- Molecular organization of the cell membrane (2 lectures)
- Cell membrane functioning as an integrative system (2 lectures)
  - Membrane transport (1 lecture)
  - Cell signaling (1 lecture)
- Ribosome and protein biosynthesis (1 lecture)
- Endoplasmic reticulum (1 lecture)
- The Golgi apparatus and cell secretion (1 lecture)
- The cytoskeleton (1 lecture)
- Cell junctions (1 lecture)
- Lysosome, peroxisome (1 lecture)
- Mitochondria (1 lecture)
- The nucleus (1 lecture)
- The cell cycle and cell division (1 lecture)

Lectures' organization

- Definition of terms, concepts, notions (organelle, other morphological elements)
- Morphology of the organelle/element
  - Structural features (light microscopy look)*
  - Ultrastructural features (electron microscopy look)
- Functions of the organelle/elements and mechanisms of action toward the molecular level of understanding

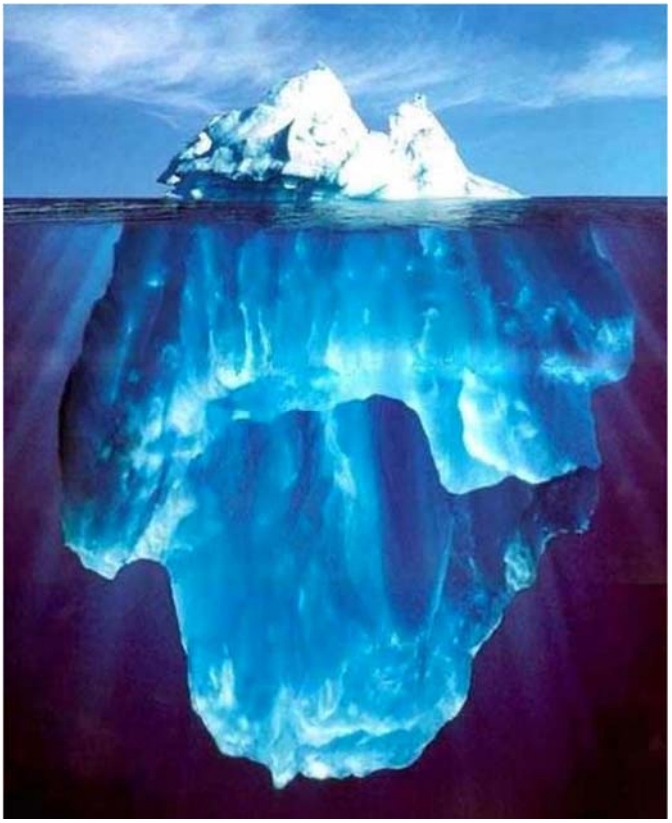
* STED (***ST****imulated* ***E****mission* ***D****epletion*) microscopy

— Stefan W. Hell – The Nobel Prize in Chemistry 2014: "***for the development of super-resolved fluorescence microscopy***"

Warning

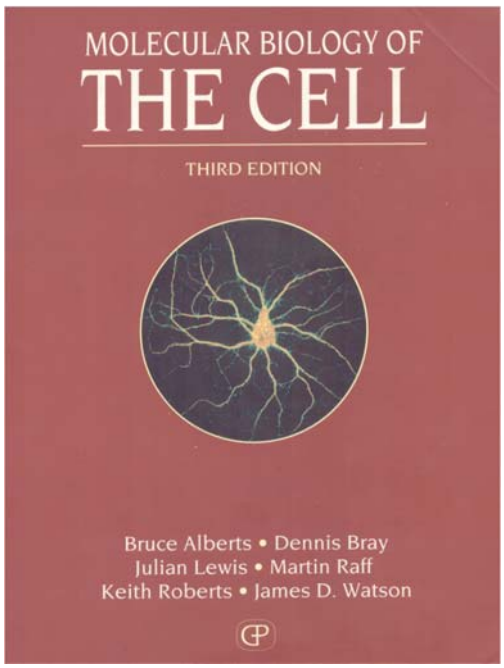
Enhancement of knowledge in cell biology

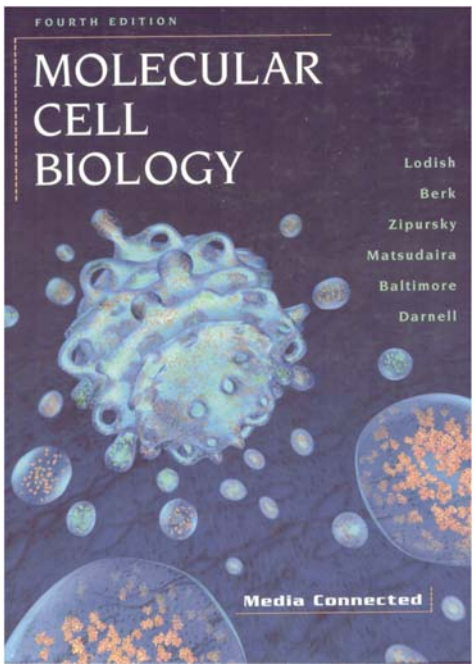
An answer got ...



... Several questions arise!

Reference textbooks





http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=mboc4

http://www.whfreeman.com/lodish4e/

Good luck in the cell study

- What's the target?

To think in the same terms such as a cell "is thinking" (to think in the cell manner)

Molecular Organization of Cell Membrane

A walk from molecules to a functional biostructure

Cell Membrane

- Definition

An ultrastructure

separating

connecting

the cell to the environment

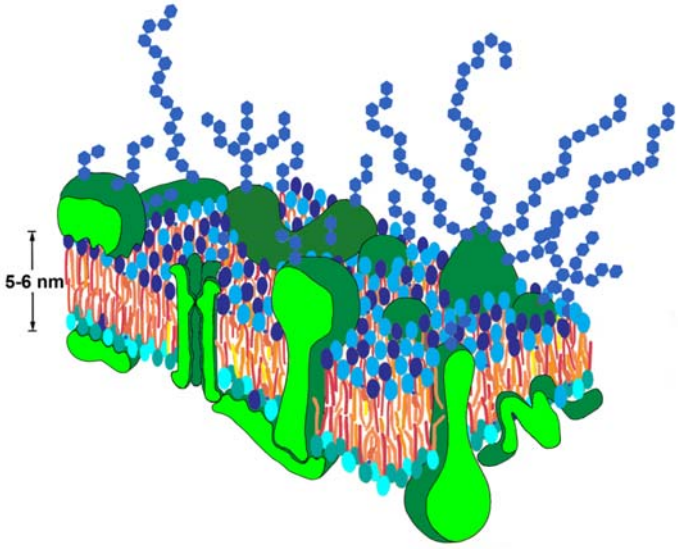
Coarse chemical composition

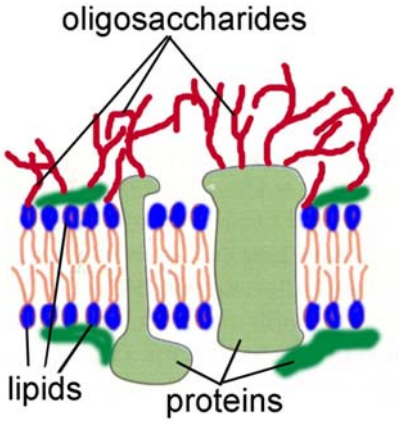
- Water: 20-30%
- Dry material: 70-80%
  - Minerals: ~1%
  - Organic compounds: ~99%
    - Lipids: 40-50%
    - Proteins: 50-60%
    - Sugar components: 1-10%

Why so low amount of water?

Mosaic Fluid Model
for Molecular Assembly of Biomembranes

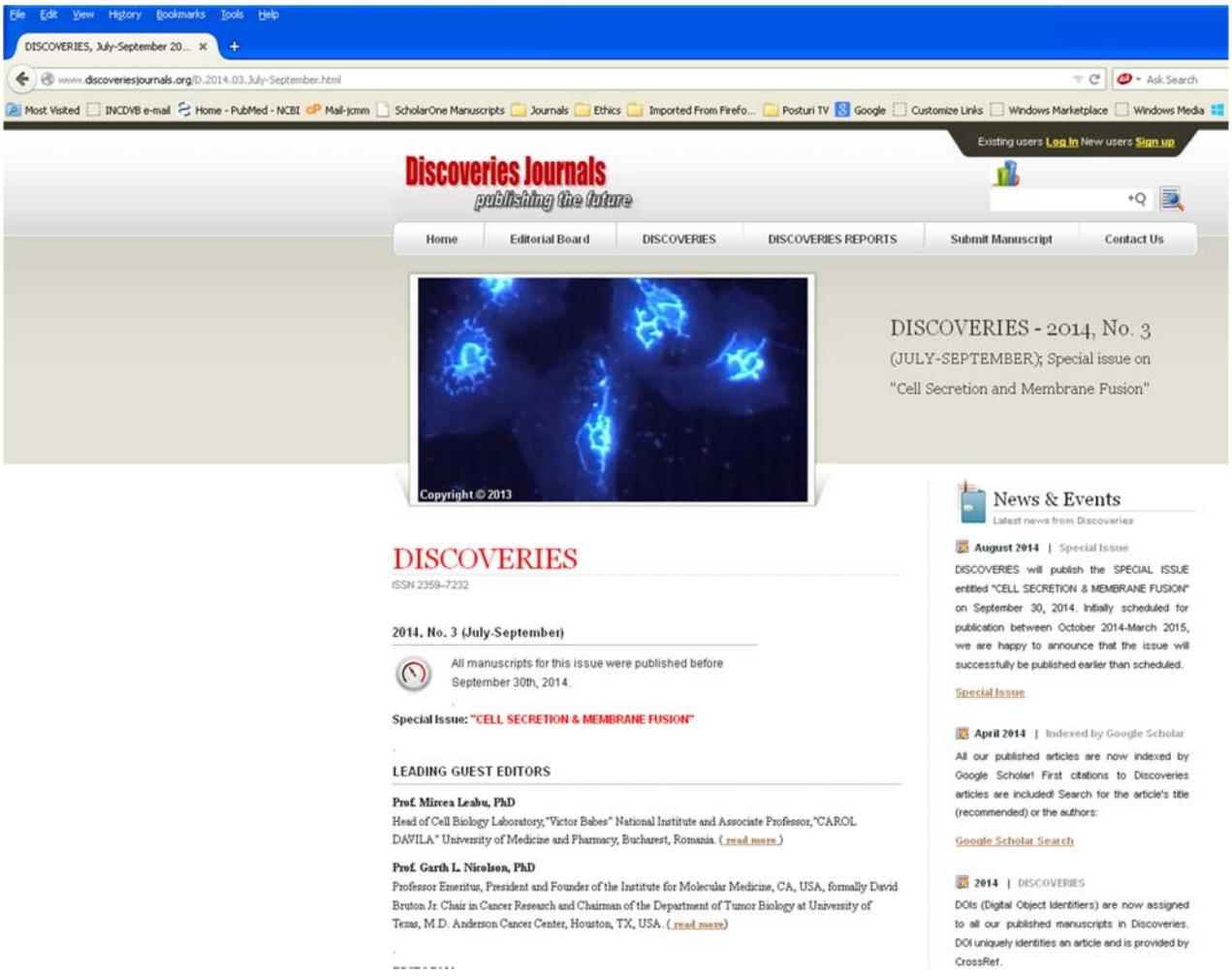
Singer SJ, Nicolson GL (1972) The fluid mosaic model of the structure of cell membranes. *Science*. 175: 720-731.





Cell Membrane Functions

1. ***Barrier***
2. ***Metabolic***



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DISCOVERIES - 2014, No. 3
(JULY-SEPTEMBER); Special issue on
"Cell Secretion and Membrane Fusion"

DISCOVERIES
ISSN 2359-7232

2014, No. 3 (July-September)

All manuscripts for this issue were published before September 30th, 2014.

Special Issue: "CELL SECRETION & MEMBRANE FUSION"

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August 2014 | Special Issue
DISCOVERIES will publish the SPECIAL ISSUE entitled "CELL SECRETION & MEMBRANE FUSION" on September 30, 2014. Initially scheduled for publication between October 2014-March 2015, we are happy to announce that the issue will successfully be published earlier than scheduled.
Special Issue

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DISCOVERIES 2014, Jul-Sep, 2(3): e30
DOI: 10.15190/d.2014.22

EDITORIAL

Cell secretion and membrane fusion: highly significant phenomena in the life of a cell

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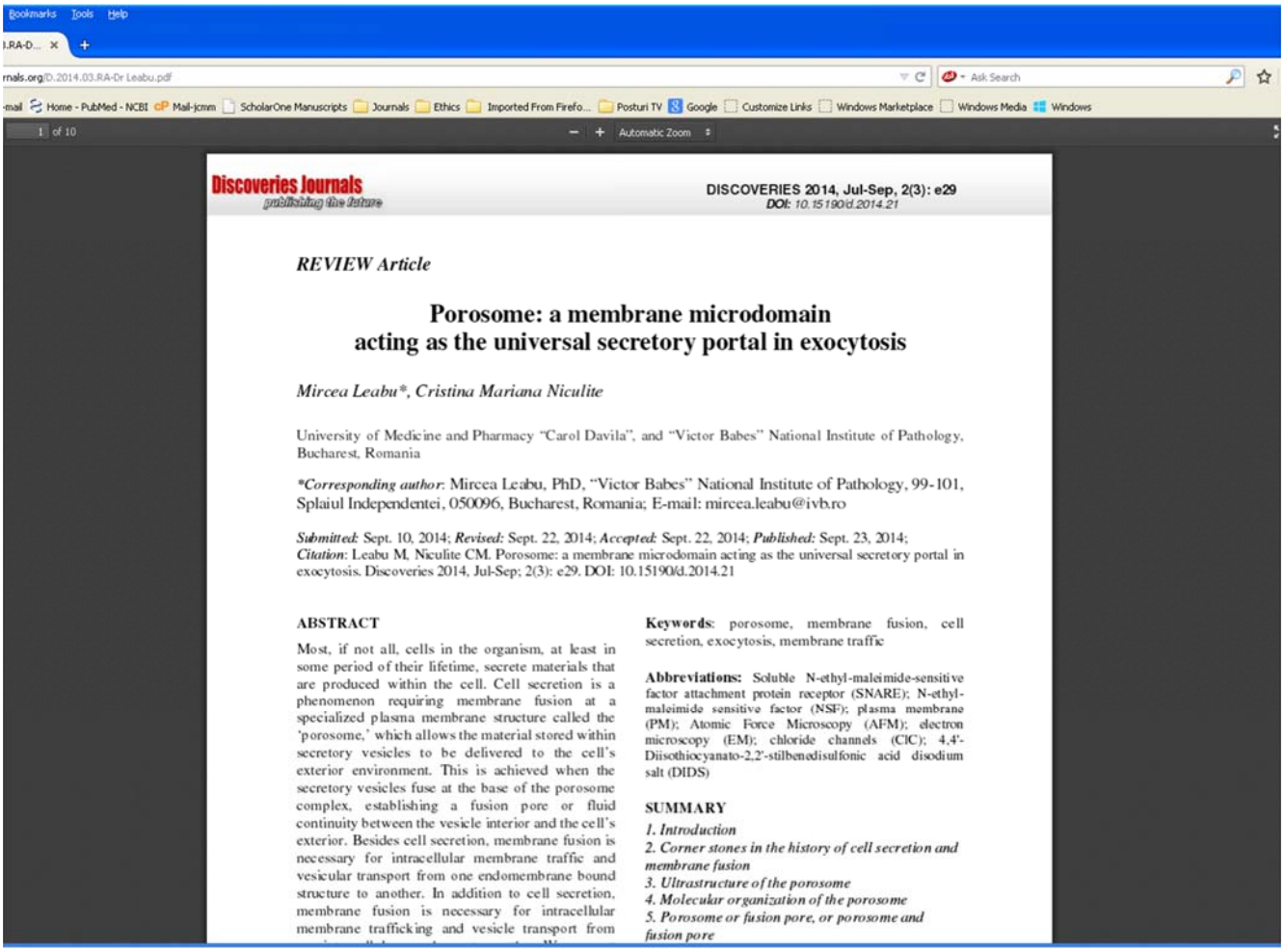
Submitted: Sept. 10, 2014; ***Revised:*** Sept. 14, 2014; ***Accepted:*** Sept. 17, 2014; ***Published:*** Sept. 18, 2014;
Citation: Leabu M, Nicolson GL. Cell Secretion and membrane fusion: highly significant phenomena in the life of a cell. Discoveries 2014, Jul-Sep; 2(3): e30. DOI: 10.15190/d.2014.22

Keywords: cell secretion, membrane fusion, porosome, exosomes, electron microscopy, cancer, mathematical approach, secretory vesicle, science history

Introduction

Is there any cell that does not secrete something necessary for maintenance of the organism? Secretion involves membrane fusion, which is every cell's existence, and they must be very well coordinated and controlled. Membrane trafficking, which involves vesicular budding of the source membrane, directed transport and eventually fusion with the target membrane is a very specific process. All of these processes depend, in particular, on basic principals of biological membrane structure and dynamics, a topic that was reviewed recently in this journal[1].



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DISCOVERIES 2014, Jul-Sep, 2(3): e29
DOI: 10.15190/d.2014.21

REVIEW Article

Porosome: a membrane microdomain acting as the universal secretory portal in exocytosis

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Submitted: Sept. 10, 2014; *Revised*: Sept. 22, 2014; *Accepted*: Sept. 22, 2014; *Published*: Sept. 23, 2014;
Citation: Leabu M, Niculite CM. Porosome: a membrane microdomain acting as the universal secretory portal in exocytosis. Discoveries 2014, Jul-Sep; 2(3): e29. DOI: 10.15190/d.2014.21

ABSTRACT

Most, if not all, cells in the organism, at least in some period of their lifetime, secrete materials that are produced within the cell. Cell secretion is a phenomenon requiring membrane fusion at a specialized plasma membrane structure called the 'porosome,' which allows the material stored within secretory vesicles to be delivered to the cell's exterior environment. This is achieved when the secretory vesicles fuse at the base of the porosome complex, establishing a fusion pore or fluid continuity between the vesicle interior and the cell's exterior. Besides cell secretion, membrane fusion is necessary for intracellular membrane traffic and vesicular transport from one endomembrane bound structure to another. In addition to cell secretion, membrane fusion is necessary for intracellular membrane trafficking and vesicle transport from

Keywords: porosome, membrane fusion, cell secretion, exocytosis, membrane traffic

Abbreviations: Soluble N-ethyl-maleimide-sensitive factor attachment protein receptor (SNARE); N-ethyl-maleimide sensitive factor (NSF); plasma membrane (PM); Atomic Force Microscopy (AFM); electron microscopy (EM); chloride channels (ClC); 4,4'-Diisothiocyanato-2,2'-stilbenedisulfonic acid disodium salt (DIDS)

SUMMARY

Physical, chemical and biological features of cell membranes

- Heterogeneity
- Asymmetry
- Two-dimensional fluidity

- *Which components are responsible for these features?*
- *What's the biological significance of these features?*