Plasma Membrane and the Great Wall of China

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BIO 219 / Cell Biology
Final Research Paper
3 May 2016
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Living Architecture Research Report written for
Wheaton Journal of Cell Biology Research
BIO 219 / Cell Biology
Wheaton College, Norton Massachusetts
3 May 2016

Rule to Build By
To conduct multiple activities simultaneously, subdivide spaces and assign different functions to each space. (Morris & Staudinger, 2016)

What
Human-built structure: the Great Wall of China is consisted of different subspaces which have different functions in order to perform multiple tasks simultaneously.

Biological structure: the plasma membrane has divided its space into subspaces in order to conduct different activities at the same time, which can achieve optimal efficiency.

How
Plasma membrane is one of the important structures in cells, because it can maintain its internal environment, sense the external environment, and control the flow of molecules into and out of the cell (Plopper, 2013). The building blocks of plasma membrane are phospholipids, which will form a bilayer with polar hydrophilic head facing the aqueous environment inside and outside the cell and hydrophobic tails inside (see Figure 1). The plasma membrane consists of phospholipid bilayer, transmembrane proteins, interior protein network, and cell-surface makers (Raven, 2013). Because the hydrophobic tails of phospholipids are concentrated interior of the cell, which will repel hydrophilic molecules, phospholipid serves as semipermeable barriers and can also separate aqueous environment with the cell itself. Very small natural molecules, such as oxygen and carbon dioxide, can diffuse easily through plasma membrane; other molecules, such as hydrophobic molecules and water can also diffuse directly through membrane, while sugar, ions, proteins, polar organic molecules, and other large molecules cannot diffuse directly thought the plasma membrane (see Figure 2). In this situation, a protein channel is usually required. Semipermeable barriers can help cells to maintain a chemical imbalance, which is essential to support life. For example, the sodium potassium pump is an ion channel that moves sodium and potassium ions across the membrane, forming a concentration gradient, to assist the production of ATP.

There are six kinds of transmembrane proteins that are on the plasma membrane (see Figure 3): transporter, enzyme, cell-surface receptor, cell-surface identity marker, cell-to-cell adhesion and attachment to the cytoskeleton (Raven, 2013). Transporters are integral proteins that assist in the movement of substances by facilitated diffusion or active transport. Facilitated diffusion is the transport of molecules that down with their concentration gradient which do not require cellular energy, while active transport is the transport of molecules that up with their concentration gradient which need cellular energy, ATP. Different transporter proteins can only recognize specific molecules, regulating the molecules that pass through the protein, which
makes the plasma membrane a selectively semipermeable barrier. In 1972, SJ Singer and GL Nicolson devised the fluid mosaic model, which shows the plasma membrane is like fluid that is constantly moving, providing cells with flexibility that can change its shape based on its environment (see Figure 4) (Plopper, 2013).

On the plasma membrane of a cell, there are lots of activities happening simultaneously. Transport proteins and ion channels are assisting cells to move molecules up or down their concentration gradients; secretory vesicles on the exocytic pathway release molecules to the surrounding environment by merging with the plasma membrane, while other proteins, such as major histocompatibility complex, provide cell identity markers to immune system to recognize foreign cells (Janeway CA Jr, Travers P, Walport M, et al. 2001). Moreover, the cell has divided its plasma membrane into different regions, which have different roles. For example, the single unit of nerve system is neuron. Each neuron is consisted of cell body, axon, and dendrites. Cell body is the location where most organelles are contained. Axon is a cable-like structure, whose plasma membrane region can carry the maximum action potential conduction, and part of which, called axon hillock, contains the region of plasma membrane that is the most sensitive to voltage. Branches of axons, also called synapses, are the regions where most exocytosis happens, because nerve cells conduct signals to the other nerve cells by neurotransmitters (Matus, 2001). Dendrites are the region where the nerve cell has the maximum number of synaptic input. All of those functions are carried by plasma membrane of a single neuron. The only difference is that the plasma membrane is divided into subspaces where different functions are performed, which illustrates the rule-to-build-by.

The Great Wall of China is a series of fortifications that mainly made of stones, which can date back to the 7th century BCE (travelchinaguide.com). The Great Wall is typically built on an east-to-west line, whose main function is to defend against the invasion of various nomadic groups of the Eurasian Steppe (see Figure 5). Qin Shi Huang, the first emperor of China about 2200 years ago, built the earliest systematic Great Wall. The remaining part of the Great Wall was mainly built in the Ming Dynasty (1368-1644). After the establishment of the Qing Dynasty (1644-1912), the Great Wall was abandoned, because people who established this dynasty were actually from the Eurasian Steppe. At that time, maintaining the function of the Great Wall was unnecessary. Beside the function of protection the Mainland China, the Great Wall also has many other functions, such as border control, regulation of trade, and the control of immigration and emigration. The Great Wall was built on different structures (see Figure 6), including barbican entrance (Wengcheng), horse road, water spout, stone missile hole, drainage ditch, shooting hole, and watch hole (travelchinaguide.com). Each structure has different functions, in order to fulfill the whole function as the Great Wall. Barbican entrance controls and monitors the people and trade that pass through the border; watch hole is responsible to identity the foreign invaders, while other structures mainly serve as notification and protection. The Great Wall is divided into different subspaces in order to perform different functions, which illustrates the rule-to-build-by.

Why

Because cells are the fundamental unit of life, it will conduct most of the functions that essential to life. Human skin cell only has a diameter of 30 um (Genetic Science Learning Center, 2014), in order to fulfill all the function cells should have optimal efficiency. Subdividing spaces and assign them to different functions can not only make sure cells are working with optimal efficiently but also maximize the ability of the cell to perform its
specialized role in a multicellular organism. Tendency of increasing efficiency is favored by the Natural Selection Theory (Henday, A.P., Kinnison, M.T., Heino, M., Day, T. et al. 2011).

Similar to the plasma membrane, as a huge and complex architecture, the Great Wall has many different functions, in order to fulfill those functions, space and structure of the Great Wall should be arranged efficiently and easy to regulate and control by the authority.

Structurally, both plasma membrane and the Great Wall share some similarities. Both of those structures are barriers, controlling and monitoring molecules in and out. Plasma membrane is a selectively semipermeable barrier that control specific movement of molecules via transport proteins, while the entrance of the Great Wall also control trade and people that in or out the mainland China. Both structures can also protect themselves. Phospholipids of plasma membrane protect cell from foreign molecules in the aqueous environment, while stone missile hole, drainage ditch, shooting hole, and watch hole of the Great Wall can monitor and defense themselves from the invasion of foreigners. However, plasma membrane is fluid and the Great Wall is a solid barrier. Both structurally and functionally, plasma membrane and the Great Wall have lots of similarities, which lead them to share the same rule to build by. Both structures subdivide their spaces to subspaces in order to fulfill different but important functions, improving the efficiency of both structures.

**Figures**

![Figure1](commons.wikimedia.org/wiki/File:Cell_membrane_detailed_diagram_4.svg. 2015)

**Figure1.** Basic structure of plasma membrane. The building blocks of the plasma membrane is phospholipid bilayer and plasma membrane also contains proteins, such as protein channels. (Figure from:commons.wikimedia.org/wiki/File:Cell_membrane_detailed_diagram_4.svg. 2015)
Figure 2. Phospholipid bilayers have varying permeability to solutes. Small molecules can diffuse easily through the plasma membrane while large molecules, ions, and polar molecules require protein channels. (Figure 4-5, Principles of Cell Biology. Jones & Bartlett Learning. 2013)

Figure 3. Functions of Plasma Membrane Proteins There are six kinds of plasma membrane proteins on the plasma membrane, which serves different functions. (Figure 5.5 Biology: 10th Edition. McGraw Hill. 2013)
Figure 4. The evolution of the fluid-mosaic model. The fluid-mosaic model indicates that the plasma membrane is flexible and in constantly moving. (Figure 4–6 Principles of Cell Biology. Jones & Bartlett Learning. 2013)
Figure 5. Construction of the Great Wall during Chinese history. The Great Wall of China was built on east-to-west line, which has more than 2000 years of history, in order to protect the mainland China from the invasion of nomadic groups. (Dörrbecker, M. 2008)
**Figure 6.** Different structures that construct the Great Wall in China. The Great Wall is consisted of six different structures, which serve different functions in order to fulfill its overall functions (Figure from https://www.travelchinaguide.com/china_great_wall/construction/).

**Reference**


