Painting at the Molecular Level

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Molecular Painting (MP) is concerned with the surface modification of biomembranes. Possibly an article beginning with the words "surface modification of biomembranes..." will not be considered as a potentially exciting read. However, it does become more intriguing when one considers that every cell in our bodies is encompassed by a biomembrane, and yet despite this huge mass of it in all of us, as well as every other living organism, still relatively little is understood about it in terms of biophysics and mechanics, the components found within and the functions of these associated components.

The biomembrane of a cell, or plasma membrane as it is also sometimes known, is a relatively rigid, yet essentially fluid mass of fatty-acid based components known as phospholipids. This layer of phospholipids is impregnated with other biological molecules called proteins. A simple analogy would be to imagine a bowl of thick soup with croutons floating in it. The surface of the soup is the membrane. The croutons are the proteins, which carry out various functions on behalf of the cell. Just as a crouton is connected to both the air and the soup at the same time, some proteins span across the entire membrane, connecting the inside and outside of the cell. Typically, such trans-membrane proteins have a pore through their centre, through which nutrient molecules can travel, such as salts or sugars for example, much in the same way that the crouton will become soggy with time as soup soaks into it (see Figure 1, H). This is mostly controlled by a self-regulating, passive process known as diffusion. There are other proteins which don't have pores but can flip around from one side of the membrane to the other by an active process which requires energy input from the cell. Usually these active mechanisms excrete or internalise larger components which need to be carefully regulated. Other kinds of proteins and mechanisms also exist.

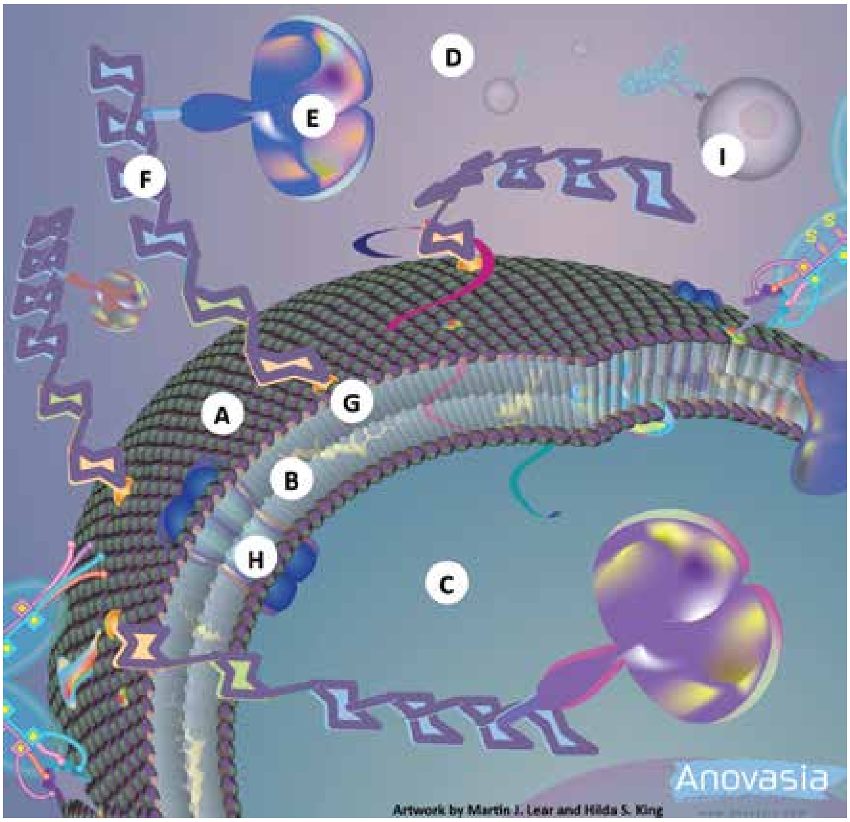

Figure 1: The biomembrane of a cell. (A) Hydrophilic head of phospholipid. (B) Hydrophobic tail of phospholipid. (C) Inside the cell. (D) Outside the cell. (E) The functional part of a Molecular Painting agent. (F) The hydrophilic spacer region of a Molecular Painting agent. (G) The hydrophobic prong region of a Molecular Painting agent that anchors into the membrane. (H) A trans-membrane protein with a central pore for transport of molecules in and out of the cell. (I) A virus or membrane vesicle engineered with a Molecular Painting agent anchored onto its surface. 1Modified version of cover art from the e-book "GPI Membrane Anchors – the much needed link"

The basic phospholipid elements of the membrane have a water repelling component known as the hydrophobic tail. This part causes a double layer to be formed whereby all the tails accumulate in the centre of the membrane's layer. The other, water-liking part or hydrophilic head points outwards to both the watery surroundings of the rest of the body on one side, and the inside of the cell on the other. The resulting bi-layer is a stable, continuous sheet surrounding the entire cell (see Figure 1, A-D).