

What role does the cell membrane play in the body's response to caffeine?

If you are like most people, you consume a significant amount of caffeine every day. More than 90% of North Americans and Europeans drink coffee or tea to get their “caffeine fix.” Coffee and tea plants contain caffeine as a defense against the insects that eat them. Caffeine acts as an insecticide in plant parts that are particularly vulnerable to insect attacks, such as seeds, young seedlings, and leaves. But it is not as toxic to humans.

Legend has it that almost 5,000 years ago, a Chinese emperor found out by accident that a pleasant beverage could be made by boiling tea leaves. About 1,000 years ago, monks living in what is now Ethiopia found that roasting coffee seeds (also called “beans”) gave a similarly pleasant effect and that the beverage kept them awake during long periods of prayer. Caffeine is now the most widely consumed psychoactive molecule in the world, but unlike other psychoactive drugs, it is not subject to government regulation.

Most people know from personal experience what caffeine does to the body because it keeps us awake. It affects the brain. In fact, it is often given to premature babies in the hospital nursery when they stop breathing. But it also affects other parts of the body—for example, it increases urination and speeds up the heart. How does this molecule work?

The key to understanding caffeine's action is to understand how it interacts with the cell membrane. The membrane is the structural boundary between the inside of a cell and the surrounding environment. The cell membrane physically separates the cell cytoplasm from its surroundings and helps maintain chemical differences between these two environments. The same can be said of the membranes that surround cell organelles, separating them from the cytoplasmic environment.

When caffeine arrives at a cell in the body, it first encounters the cell membrane. The properties of this membrane determine whether and how the cell will react to caffeine. Will it cross the membrane boundary and enter the cell? What determines whether it crosses the membrane? If it does not, how can caffeine's interactions with membrane components lead to changes in cell function?