Spoke

Solving Solubility with Science

Nutrient Absorption

In this Brief we discuss how the degree to which a particular nutrient is water or oil soluble impacts the way it is digested and absorbed.

Technical Brief

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Introduction to Solubility

We get the nutrients we need from our food. Obvious, right? But how are those nutrients liberated from the food we eat or drink in a way they can be absorbed through our gut? That, it turns out, is a very complicated process and is different for each nutrient, depending on whether the nutrient is soluble in water or not. The following is a simplified but useful explanation of nutrient absorption. For a detailed discussion of solubility in our future Technical Briefs. Sign up to receive our latest Technical Briefs here.

We call water soluble molecules "hydrophilic" (literally, water-loving) and non-water-soluble molecules "lipophilic" (fat-loving). Lipophilic molecules are soluble in lipids, like fats or oils.

For any nutrient to be absorbed, that is get across our gut wall and into our bloodstream, it must first be digested, which is the process of breaking food down into single or small groups of molecules. This is necessary because, for obvious reasons, the wall of our intestine will only allow very small things to pass through it.

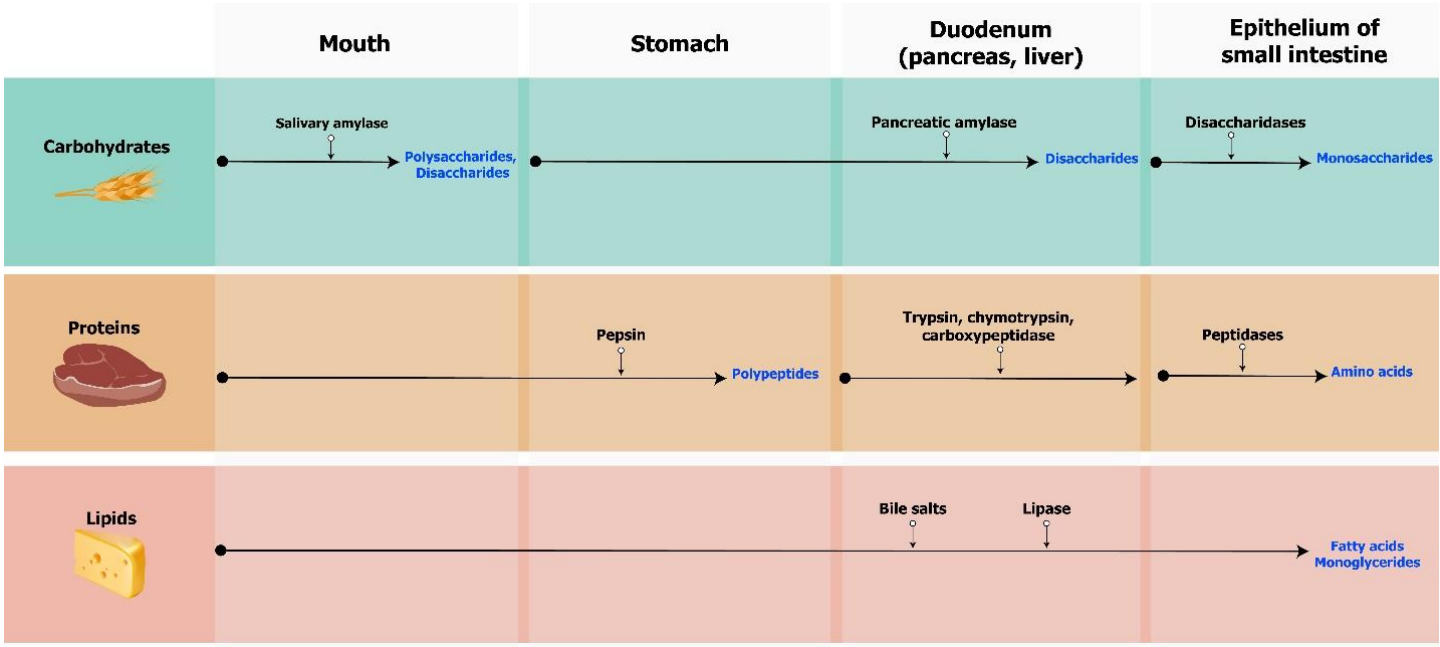
Digestion starts the moment you put something into your mouth. By chewing, we are mechanically tearing down the food's structure, making the nutrients more accessible for the next step, chemical digestion. Chemical digestion begins in our mouth, with enzymes found in our saliva (Fig. 1).

Enzymes are large molecules our body makes that help speed up chemical reactions. As food passes into our stomach, digestion is further accomplished with additional enzymes, emulsifiers from our gall bladder, and acid secreted by our stomach lining. Still more enzymes digest our food as it passes further through our digestive tract. Each enzyme has a specific kind of molecule it helps to break down; sugars and proteins for example are digested using different enzymes. As in the mouth, the food is mechanically mixed throughout the digestive tract to help the enzymes do their job.

Once food is broken down into small enough pieces (molecules or small groups of molecules) it is time for them to be absorbed. There are five general ways nutrients are transported across the specialized cells that line our gut, called "enterocytes." A detailed explanation of those mechanisms will be the subject of another Technical Brief but for now, suffice it to say that within those five transport mechanisms, hydrophilic and lipophilic molecules are processed very differently.

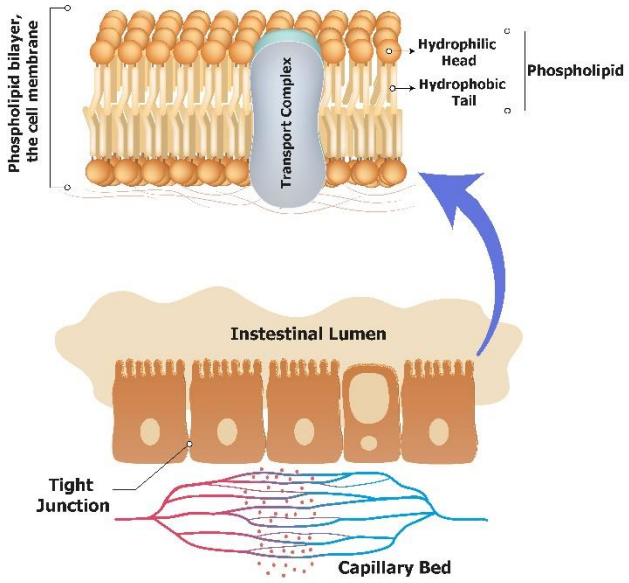
Each enterocyte is surrounded by a membrane, made up mostly of phospholipids, a class of molecules that have

Fig. 1



two parts: a small hydrophilic "head" and a bulkier lipophilic "tail." Because of this two-part structure, phospholipids naturally arrange themselves to form a bi-layer where the middle of the membrane is very lipophilic (Fig 2).

Fig. 2



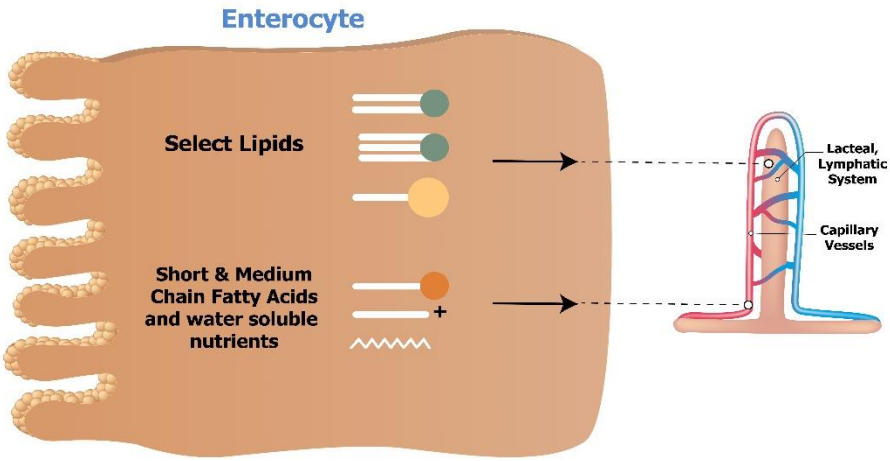
Hydrophilic Nutrients

Because they are not easily dissolved in a lipophilic membrane, the water-soluble nutrients must be actively transported across the enterocyte cell membrane. Living organisms accomplish this with special transport molecules that are embedded in the membrane. These transport molecules provide hydrophilic tunnels that allow the water-soluble molecules to pass through the membrane. Depending on the nutrient, energy may or may not be needed for the trip across the membrane, referred to as active and passive transport respectively. One might think small water-soluble molecules could squeeze in between cells and get across that way, but cells in the intestinal lining are bound together by tight junctions which prevents this. Thus, the only way for a water-soluble nutrient to get into our blood stream is to pass through the apical (side facing the inside of our gut) surface of the enterocyte aided by transport molecules and into to the capillary bed surrounding our gut (Fig 3).

Lipophilic Nutrients

Lipophilic nutrients, on the other hand, can mingle with and pass through the cell membrane, often without the aid of transport molecules. To optimize this process our digestive tract first emulsifies the lipids in the gut and it is the emulsion droplets, or similar smaller structures called micelles, that actually present to the enterocyte cell membrane and pass through. A future Brief will provide detailed explanation of emulsions and how they are formed. Once in the cell, depending on their size and content, the fatty droplets either pass through to the capillaries or into our lymphatic system. Importantly, nutrients that pass from the gut to the capillaries immediately go to the liver where they may be chemically altered, the so-called first pass phenomenon. This is why the concentration of a nutrient or active ingredient taken orally may be reduced before it even reaches the general circulation. Molecules that are transported via the lymphatic system avoid first pass metabolism. Learning how to leverage these different pathways is a very active area of pharmaceutical research.

Fig. 3



Conclusion

As we can see, solubility plays a major role in how a nutrient is digested, absorbed and metabolized. Water soluble molecules need to be transported through the enterocyte and go directly to the liver for further modification. Lipid soluble nutrients cross the enterocyte with the aid of endogenous (molecules we manufacture in our body) emulsifiers and, while many go to the liver, some avoid first pass metabolism by using the lymphatic channel.

Importantly, many beneficial nutrients that we would want to take as supplements are lipophilic but, even though lipophilic nutrients can be efficiently digested, incorporating them into acceptable consumer products can be difficult. So, what can we do to make taking them easier and more effective? The first task is to get them into a product that we want to use, one that tastes good, is affordable and contains the proper amount of the nutrient. Spoke Sciences has technologies that do just this – we solve the solubility problem. Please contact us if you would like to learn more.