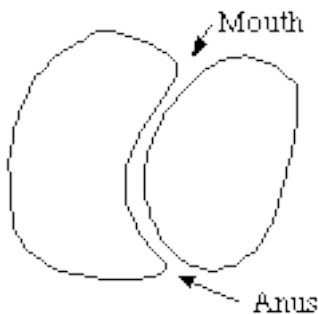


(Annie Dillard: from "Heaven and Earth in Jest", in *Pilgrim at Tinker Creek*, Harper and Row, Publishers, 1974, pp. 5,6.)

Ask Gale Rhodes for a copy of the Dillard excerpt

Water Bugs, Metabolism, and Mystery
Gale Rhodes

Like the giant water bug, which injects enzymes and reduces the macroscopic and macromolecular organization of its prey to a mixture of building-block molecules (amino acids from proteins, sugars from starches and membrane carbohydrates, fatty acids from membrane lipids and stored fats, salts from bone), many animals perform stage-one catabolism externally. Think of the spider. In fact, think of yourself. Your digestive tract is, topologically speaking, outside your body. A simplified cross-section of a mammalian body is shown below. Note that the digestive tract is continuous with the body's outer surface.



Mammalian Body Plan in Cross Section (Topologist's View)

Because the cell can conserve none of the chemical energy from the Stage-I breakdown of molecules (hydrolysis of polymers to building blocks), there is no advantage, and some disadvantage, to bringing all this stuff inside for digestion. So it is hydrolyzed to a relatively small number of building blocks, then drawn into cells, where further oxidative instead of hydrolytic dismantling can occur in a compartment equipped to conserve the abundant energy released. The cell needs fewer transport systems this way, because the myriad molecules of the live organism give way to only 30 or 40 building blocks. The reduction of perhaps 10,000 different proteins to 20 amino acids, which in turn can be absorbed by an even smaller number of transport proteins, strikingly exemplifies the typical converging nature of

degradative pathways. (By the way, another advantage is that some of those froggy proteins may be toxic, but the digested building blocks are reliably benign.)

This reduction also points dramatically to our kinship with all of life. If the giant water bug latched onto you or me, the resulting mixture would be indistinguishable from frog soup. In imagining the myriad forms life builds from this soup, we see an essential simplicity beneath the multitude of living forms on the earth. It is when my mind runs back and forth between such simplicity and such complexity that I feel I am blindly touching the hem that Dillard describes.

For all our knowledge of it, this force—call it life or nature or God or what you will—this extravagant force that pours intricate living forms over the face of the earth, remains purest mystery. As you explore the details of metabolism and learn to follow a little of its logic, it will seem at times that we know so overwhelmingly much. But I hope it will also become clearer how little of the whole endeavor we understand, how halting and partial our attempts to increase our knowledge. Even if there are, as Dillard puts it, "bars and doors" set against our knowing it all, it appears that we are nowhere near reaching them; the potential joy of learning still seems boundless. Perhaps the most difficult (and subtle) obstacle is the sheer complexity of life. If so, the limits of our knowledge are not solid barriers at all. Instead they are resilient but persistently entangling webs of ambiguity, indecision, and confusion in the face of nature's profusion.

As an example of that complexity, imagine trying to design a set of digestive enzymes for the water bug. Simple: you just want to hydrolyze everything in sight, right? Not quite: everything except the skin. Why waste the skin? Well, imagine how much of the meal would be lost in the waters of the pond if the enzymes so much as perforated the skin. At first glance, the water bug's approach seems blunt and heavy handed. But those enzymes, bulls in the china shop of froggy macromolecules, handle the proteins and carbohydrates of the skin with kid gloves. Using the impressive specificity of enzyme action, the water bug wastes the skin to save the rest of the meal.

Of course, in the end, the skin is not wasted. It too will find its way into other life. It may dart away backwards in a crayfish or rise to the surface in the petals of a pond lily. Or if a hungry nymph munches the skin, what was once earthbound frog may fly far away in the delicate wing of a dragonfly.