JOANNE STUBBE: If you look at the vitamin bottle, you have all these vitamins you eat, like, what do they call them? Biotin, riboflavin, pyridoxal.

So all of those small, organic molecules, and they all have chemical reactivity and they interact with the protein and allow the protein to do chemistry that can't normally be carried out by just the amino acid side chains of the protein in the active site of the enzyme.

So the vitamins you eat are not actually what's interacting with the protein, they need to be modified. So they are the precursors to what are called co-factors that, again, expand the repertoire of what's found in enzymatic systems.

So you have a whole bunch of organic co-factors that actually can be made spontaneously. If you throw in some simple molecules like cyanide and stuff, these things all self-assemble, so they're all from the primordial soup.

And in fact, many of these vitamins can do chemistry without any enzyme at all. But they can't do it specifically. And they can't do it rapidly.

So we have all these organic molecules that can self-assemble that expand the repertoire, but if you look at a vitamin bottle, you will see minerals. And that's one thing that I think most biochemistry courses don't talk about, is metals.

And it's now proposed that between 35% and 50% of all the proteins in our body have metals that are essential for function. And so these minerals that you eat, iron or zinc or calcium, all play a central role, again, in expanding.

They all help in many cases facilitate chemical transformations, and in the way we can understand by understanding basic chemical principles.

So the vitamin bottle, we come back to over and over again through the course of the semester, because all the enzymes in metabolic pathways have different kinds of co-factors that are required to make the enzymes function.