

What are you made of? Look at your hands. Draw one palm across the other. Feel the density of your tissues, the bones, musculature, and sinuous ligaments. What gives your tissues substance and form? You have probably been told that your body is composed of trillions of living cells. But what are your cells made of? What is the stuff of life?

Those of us hailed by contemporary technoscience are likely familiar with the notion that proteins are the molecular building blocks of life. But what is a protein?¹ And why do we care so much about the molecular constitution of our bodies? Proteins are remarkably prominent actors in our everyday explanations of life and health. We so often hear that “you are what you eat.” When you are hungry, what is it you are looking for? You don’t have to be an athlete, nutritionist, or dieter to know that protein-rich foods satisfy your hunger. If you live in the relative privilege of North America or Europe you are unlikely to escape a consumer culture that finds you constantly on the lookout for ways to improve your body and your health. Maybe you compulsively read the nutrition labels on packaged food at the supermarket, those little charts that fractionate foods according to chemical composition, listing the amounts of fat, salt, sugar, cholesterol, and protein you are about to consume. How many grams of protein are in that package of tofu? Or that slice of processed cheese?

Proteins, we are told, provide sustenance. Yet scientists also figure proteins as the enzymes that catalyze life-sustaining chemistry; the substances that transduce signals within and between cells; the molecules that transcribe, translate, and rewrite DNA to produce more proteins; and the materials that provide the dynamic—continually cycling, growing, and retracting—architectural support for cellular life. The evolutionary stories we tell ourselves about the origins of life and the adaptations of organisms rely on knowledge of heritable changes in DNA that affect the molecular constitution of proteins.

Pharmaceutical advertisements animate the specific chemistry of drugs to show you how they bind to proteins and intervene in your physiological processes at the molecular scale.² In the twenty-first century, life and living bodies have been rendered thoroughly molecular, and proteins now share the stage with DNA and other molecules as pivotal actors in our stories about cellular life.³

This propensity to parse the world into molecular components has a long history that extends back to ancient philosophers who postulated that the worldly stuff we could see and feel had an unseen "inner constitution"; matter, it was thought, was made up of subvisible atoms or particles.⁴ For centuries scientists in a range of disciplines have expended great effort refining techniques to make matter visible, tangible, and workable at the molecular scale. The vindication of atomic theories of matter and the allure of mechanistic explanations of life in the nineteenth and twentieth centuries have swept researchers up in efforts to see through the obscuring density of cells and tissues. Researchers seek chemical and physical explanations to deepen their mechanistic understanding of living processes.⁵ It is through their concerted efforts that the stuff of life has *come to matter* at the molecular scale.⁶ This book is about the practitioners who *render life molecular*.

Who knows about proteins? Who can tell us what they look like and what they are up to in a cell? Life science researchers in the multiple and overlapping disciplines of cell biology, molecular genetics, and genomics care a great deal about the activities of proteins and other molecules in the cell, but they generally do not have the tools or techniques to make protein structures visible at the atomic scale. One group of researchers who call themselves "protein crystallographers" are especially interested in resolving the precise atomic configuration of protein molecules. They want to be able to see proteins and intervene in cellular processes at the molecular scale. In order to make proteins visible, tangible, and workable in their laboratories, these researchers build three-dimensional models in a wide range of media. This book is a study of the remarkable techniques and media forms that crystallographers and other protein modelers have developed to make visible otherwise imperceptible molecular phenomena. It examines protein crystallography as a practice and a culture, tracking how these practitioners gather data, conduct experiments, test hypotheses, and demonstrate results.

Protein crystallographers face significant challenges in their efforts to build sound models of things they cannot otherwise see. What remains for them unseen, intangible, and unimaginable? And how do they fill in the gaps between

a perceptible world of aggregate substances (like cells, tissues, and bodies) and the largely imperceptible realm of molecular phenomena? This book explores the remarkable ways that they confront the limits of what they can see and what they can know. It documents how they hone their sensibilities and intuitions, and the creative ways that they engage their bodies in the production and dissemination of visual facts. And, by tracking both expert researchers and their more novice students, it inquires into the ways that modelers teach their students what they see, feel, imagine, and know about molecular life.

These modelers craft the models that are defining the material substructure of living bodies today. Their models come to stand as authoritative descriptions of the molecular world. The facts these practitioners craft in their laboratories are also the facts of life that many others come to live by.⁷ These are the facts that experts rely on to tell us what our bodies are made of, what makes us tick, what makes us sick, and what might make us better. The explanations of life many of us have come to rely on, including the evolutionary stories we tell ourselves about the origins of life, hinge on knowledge of the molecular structures of proteins.⁸ Scholars in feminist theory and science studies have shown that it is crucial to pay close attention to the techniques and practices that shape matter and materiality.⁹ Protein modelers are the scientists to watch in order to see what forms of life and what materialities are coming to matter in the twenty-first-century life sciences.

And yet, the forms of life coming to matter in the hands of these practitioners are perhaps not what we might expect from a discipline grounded in mechanistic approaches to life. This book examines a range of phenomena that are not easy to see, especially if one just reads the texts scientists write. It amplifies forms of life in the laboratory that are muted in other accounts. It pays close attention to what modelers see, say, feel, imagine, and know about molecules, and in the process, reveals a marvelous range of ways that proteinacious life is rendered in their laboratories. Modelers, it turns out, cultivate intimate relationships with their molecules as they get themselves caught up in the involving work of molecular visualization. It is in the energetically and emotionally charged space of the laboratory that protein modelers confront living matter as an unruly, wily substance. This account tunes in to the *affective entanglements of inquiry* in the laboratory to document the extraordinary ways that modelers' lively renderings of molecular life disrupt conventional, mechanistic accounts. This book argues that these modelers are shifting the contours of the contemporary biological imagination and reconfiguring the nature of living substance. Throughout, it asks: What is molecular life becoming in their hands?