No Pre-set Answers: The Joy of Thinking and Uncovering Hidden Molecular Teamwork

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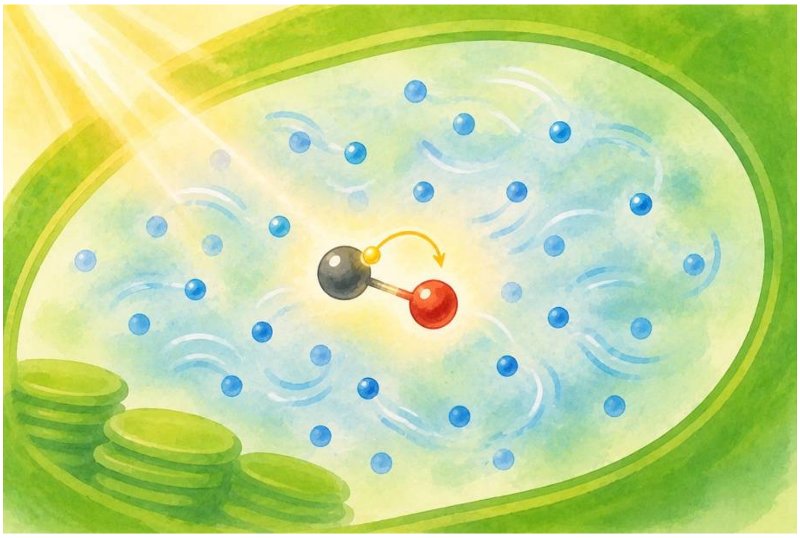

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I am currently conducting theoretical research in a graduate school quantum chemistry lab, using computers and mathematical equations to unravel the movements of tiny, invisible molecules. Specifically, I study how individual molecules move when chemical reactions occur in environments surrounded by large numbers of molecules, such as water.

Although I am engaged in this kind of research now, when I was in elementary and middle school, I was completely absorbed in something entirely different. Influenced by my father, who was interested in IT and engineering, I attended lessons where I built robots out of LEGO blocks and learned programming to develop my own web services. In those classes, after learning the basic rules of coding, we were encouraged to engage in creative work: freely imagining what we wanted to build and combining elements to bring it to life. I found that incredibly fun, and back then, I vaguely imagined pursuing a career in information technology.

Partly because of that, I never felt insecure about math or science in school; on the contrary, I found joy in understanding new things and solving difficult problems on my own. Although I couldn’t imagine my future job yet, I loved expressing my thoughts through forms like words, formulas, or programming code, so I decided to pursue a career in science.

However, once I entered high school, I began to doubt my path, wondering, “Is a career in IT really what I want?” I realized that rather than creating things like apps or robots through engineering, I was more drawn to science—deeply understanding and explaining the mechanisms of the natural world.

During a high school Inquiry class, a special experiment deeply moved me. Our task was to find the perfect catalyst (a substance that aids a reaction) to break down caffeine. Instead of following a pre-set answer, I could freely adjust the type and amount of the catalyst. Seeing unexpected, interesting results felt like discovering hidden treasure. This true joy of thinking for myself—rather than just going through the motions—made me realize for the first time: “I want to pursue a career in research.”

At university, a unique system allowed me to explore various fields before choosing my major. That was when I encountered quantum chemistry, the study of the microscopic structures of atoms and molecules.

In high school chemistry, I had to simply memorize phenomena, like “mixing these liquids turns them a beautiful blue,” with the explanation “that’s just how it is.” I wasn’t drawn to it. However, in university quantum chemistry, I learned that analyzing the spectrum—the breakdown of light emitted by a substance—could explain the fundamental reason behind that color using math and words. I was incredibly excited that the secrets of color could be understood through microscopic rules governing molecules.

This was exactly where I found the joy of thinking, understanding, and expressing thoughts through equations or code — the very things I loved since middle school. That is why I chose my current theoretical research lab to study these mechanisms myself.

Currently, I am researching how molecules move at the very moment a chemical reaction occurs.

When we think of chemical reactions, we tend to focus only on the reacting molecules. But in reality, those molecules exist in a crowded environment, surrounded by many other molecules, such as water or proteins. And the movements of the key molecules and the surrounding environment strongly influence one another.

However, calculating the movements of every single one of the countless surrounding molecules is extremely difficult, even with modern computers. So, instead of looking at the surrounding molecules individually, I am trying to find a new method to understand how they collectively facilitate the reaction.

Specifically, I am currently focusing on photosynthesis in plants. During photosynthesis, a reaction occurs the moment light strikes, causing electrons within molecules to move to a different location. This electron transfer is a crucial first step in converting light energy into energy that plants can use.

What's fascinating is that this reaction doesn't proceed solely through the action of the main molecule. As the electron moves, the surrounding proteins and water molecules also gradually change their shape and orientation in response to this change. It's as if teammates are shifting their positions in sync with the main player's movements, supporting the reaction so it proceeds smoothly.

I am attempting to use mathematical equations to uncover the rules governing this “molecular teamwork.”

Living organisms, including plants, use tiny molecular movements in surprisingly clever ways. Photosynthesis is not always more efficient than artificial solar cells, but the way plants guide electrons and surrounding molecules after light is absorbed may still teach us useful ideas for future energy-efficient technologies.

As a child, I was thrilled by the process of writing programming code. Now, I am trying to understand the wonderful mechanisms created by nature through mathematical equations and words, while deciphering the movements of molecules that are invisible to the naked eye.

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I used ChatGPT to help revise the English expressions in this essay and to create the image.