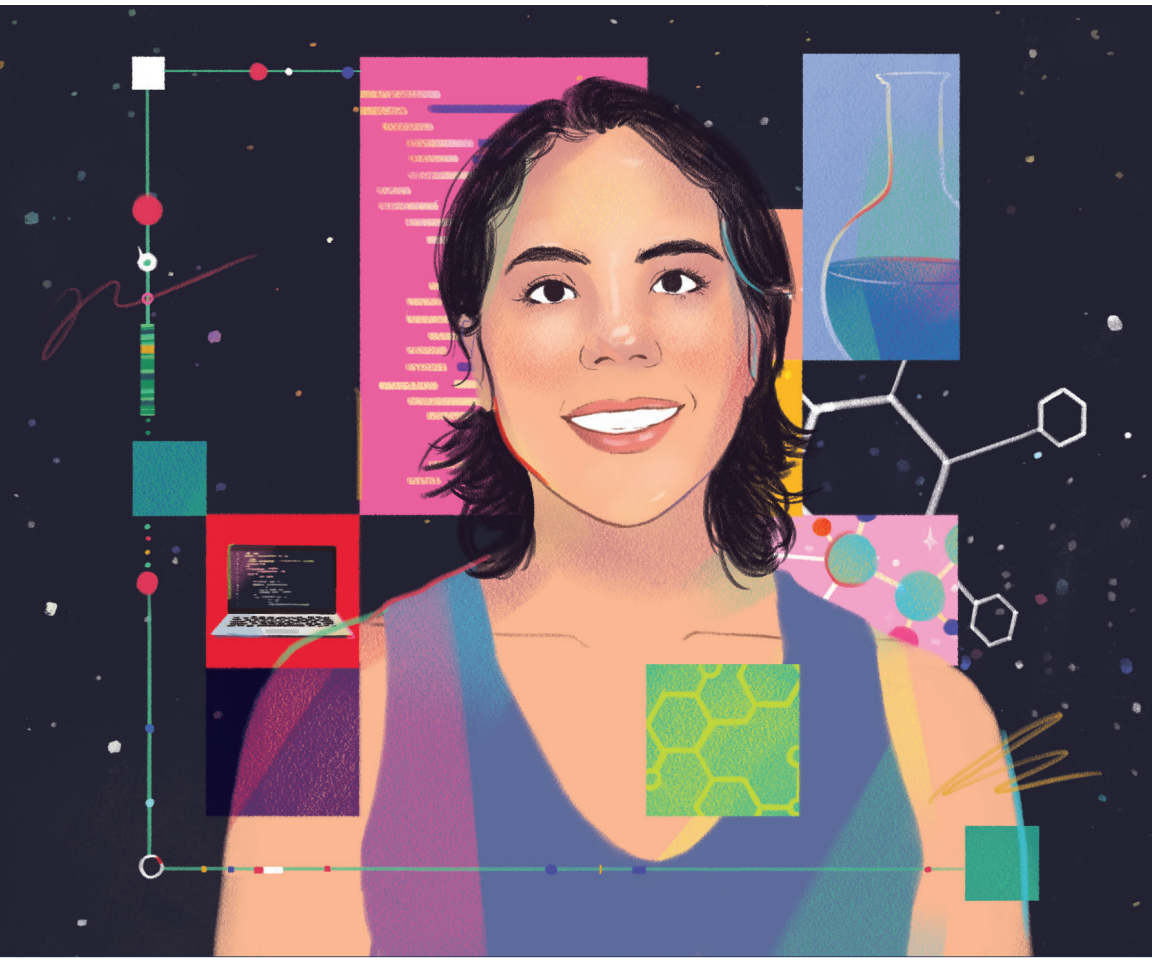
Science Journeys



MELISSA RAMIREZ

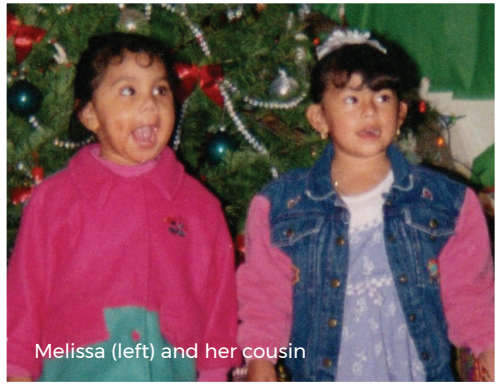
presents

Building New Molecules: Chemistry in the Lab and at the Computer

MEET

Melissa Ramirez

ORGANIC CHEMIST



Melissa (left) and her cousin

Melissa, a first-generation Mexican American, was born in Los Angeles. She grew up in Pasadena and attended Marshall Fundamental School, which is only 2 miles away from Caltech, from sixth to 12th grade. She became interested in chemistry through her participation in summer high school programs, which included the California State Summer School for Mathematics and Science at UC Santa Cruz, and Caltech's Summer Research Connection. The ability to use chemistry to explain why certain fish light up—a natural phenomenon known as bioluminescence—first sparked Melissa's interest in this area.

Currently, Melissa is a Caltech Presidential Postdoctoral Scholar in the laboratory of Brian Stoltz, who is the Victor and Elizabeth Atkins Professor of Chemistry and a Heritage Medical Research Institute Investigator. Melissa's research centers on combining computation and synthetic chemistry to construct new organic molecules with the potential to improve human health. Melissa is excited to train the next generation of chemists and will become a faculty member at the University of Minnesota, Twin Cities, in January 2025.

When she is not setting up a reaction or working at the computer, Melissa enjoys running and loves exercising with her Peloton bike and rower. She also enjoys taking high-intensity interval training classes at a local studio and trying new restaurants in the Pasadena and LA areas.

Explore THE Science

Organic chemistry affects our lives every day, from the food we eat to the shampoo we use. Organic molecules are all around us. They can be found in plants, drinks, and even our clothing. Finding new ways to synthesize, or make, new organic molecules in the laboratory is an important area of research that can provide new medicines and other desirable compounds. Many of the medicines you see in the drug store are developed through organic synthesis.

As computers have advanced over the years, they have become a powerful tool for inventing new chemical reactions that generate valuable organic molecules. Computational models—computer representations of something that exists in the real world—make it possible for chemists to predict the outcome of a reaction before performing an experiment in the laboratory. Computation can also allow chemists to study "highly reactive molecules," or molecules that oftentimes cannot be observed in the lab.

As an organic chemist, Melissa Ramirez uses computation and experimentation to construct and explore new organic molecules and to find better ways of synthesizing existing ones. Her research at Caltech focuses on developing new chemical reactions that generate spirocycles, which are important building blocks for new medicinal molecules.

Join Melissa on this journey to explore how organic chemistry affects our world and to learn why she came back home to Pasadena to develop new chemistry.

Terms TO Know

- **Chemical reaction:** A process that occurs when one or more molecules change in structure to form a new product.
- **Cycloaddition reaction:** A type of chemical reaction in which the final product is a ring structure.
- **Reaction Mechanism:** The sequence of elementary steps by which a chemical reaction occurs.
- **Transition state:** A temporary structure that is generated during a reaction; a point of no return from which the reaction must proceed. This state is so fleeting that it cannot be observed experimentally.
- **Chiral molecule:** A specific type of molecule that is nonsuperimposable on its mirror image—meaning there is no way for the molecule and its mirror image to be placed on top of each other with all points lining up.
- **Pair of enantiomers:** A chiral molecule and the molecule represented by its mirror image.
- **Catalyst:** A substance that speeds up a chemical reaction, or lowers the temperature or pressure needed to start one, without itself being consumed during the reaction.

Continue THE Conversation

Polymers are large, chain-like molecules made of hundreds or thousands of smaller, repeating molecular units called **monomers**. Monomers are typically connected by covalent chemical bonds. Many polymers occur naturally—cellulose in plants and human hair, for example—but scientists and others also create polymers, often for useful purposes. These are called **synthetic** polymers.

Monomers are joined together to create synthetic polymers in a chemical process called polymerization. Observe polymerization by creating milk plastic. You will need: 1 cup of dairy milk, 4 teaspoons of white vinegar, a mug, paper towels, a nonmetal bowl, a nonmetal spoon, a strainer, a coffee filter, and a stovetop or microwave.

- Heat the milk until steaming, then pour it into the bowl.
- Add vinegar, then stir.
- Pour the mixture through the strainer lined with the coffee filter to separate out the clumps. Use the spoon to press out more liquid.
- Scoop the dough onto paper towels and squeeze out even more liquid.
- Roll, knead, and shape the resulting dough, called casein plastic. It will harden as it dries.

WHAT HAPPENED?

Milk contains a protein called casein. When you heated the milk and added vinegar (an acid), the casein molecules (monomers) unfolded and reorganized into a long chain, a polymer.

— adapted from Boston Children's Museum

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