“A lot of people call me a ‘border-walker,’” says Dr. Kimberly Tanner, director and founder of SEPAL, a learning and research center on the San Francisco State University campus. Tanner started her academic work as a research scientist studying neurobiology, but along the way became interested in science education. Neurobiology focuses, in part, on how the brain works, and “learning is a big part of that,” Tanner says. Today, she, her colleagues, and her students at the Science Education Partnership Assessment Laboratory (SEPAL) in Hensill Hall, study how people teach and learn science. For good measure, she also applies their collective findings in her own classrooms.
In late 2003, Tanner took a job as a biology education researcher at SF State. She wanted to investigate what people of all ages think about biology and, in particular, what common misconceptions they held. Founding SEPAL was a first step, and by design, undergraduates, graduate students, and K-12 teachers working in community schools would join in the research studies. Tanner’s goal was to partner scientists and working teachers, then to investigate how their interactions influence two kinds of teaching: K-12 science education; and the university’s own approach to teaching science and preparing science teachers. An additional goal was to understand how novices—including young children, non-science majors, and elementary school teachers—think about biological organisms and concepts.

Tanner’s broad research and teaching experience has enabled her to probe the roots of student misconceptions about biology and other sciences. According to Tanner, SF State is on “the cutting edge” of understanding and improving biology education. Her colleagues in the biology department realized that teaching and learning biology are important enough subjects to justify devoting an entire faculty position to their study. Tanner’s broad research and teaching experience has enabled her to probe the roots of student misconceptions about biology and other sciences. Tanner believes that “the more we know how people are thinking about [a science], the more insights we can get into how to teach it.”

For most people, Tanner pictures “biological school knowledge” and “life knowledge” as existing in separate mental repositories like silos full of grain. But effective science instruction, she says, should result in one giant silo where all of this knowledge is both stored and interconnected. According to Tanner, science teachers must manage to tell the story of a scientific field or particular science concept in a way that “connects it to real life.” This in turn, she says, will change the way people think about the world and themselves. To illustrate, Tanner cites photosynthesis as a classic example of “common disconnect.” Students may study the principle of photosynthesis year after year, she explains, yet still fail to grasp the basic fact that plants remove and utilize carbon from the air. Students often learn formulas and equations without linking them to the phenomena they see all around themselves. Thus they may misperceive that plant growth emanates mainly from soil, water, or another source, rather than from the air that we all breathe. “It’s the perfect example of how

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people have learned photosynthesis over and over again, and they have no idea, fundamentally, of what it means,” says Tanner—that plants have the incredibly special ability to take carbon out of the air and to combine it into the biological compounds that support virtually all living things, directly or indirectly. Another common misconception involves learning and the brain. Students are not aware that, Tanner says, that when they learn, changes actually take place inside their brains. When asked what happens during learning, high school students often respond with answers such as, “I see the world in a different way,” or “I feel better about myself.” They think of learning, in other words, as a psychological process rather than a biological phenomenon. “But if you are thinking biologically,” Tanner says, “you should say, ‘When something happens to an organism, then something changes inside of it, too.’” Most students come away from the last biology class they’re ever going to take unable to associate learning with physical changes in the brain. Yet studies by psychologist Carol Dweck and others show that understanding the link between learning and brain changes empowers students and gives them a sense of control over their own learning. They do better at school, Tanner explains, than those who think of their minds as fixed. “Everything we know about biology, neurobiology, and learning is that the brain is very plastic. You can change it. And you can learn to an organism, then something changes inside of it, too.” Most students come away from the last biology class they’re ever going to take unable to associate learning with physical changes in the brain. Yet studies by psychologist Carol Dweck and others show that understanding the link between learning and brain changes empowers students and gives them a sense of control over their own learning. They do better at school, Tanner explains, than those who think of their minds as fixed. “Everything we know about biology, neurobiology, and learning is that the brain is very plastic. You can change it. And you can learn to.

Tanner describes another misconception involving how children think about weather—a subject one student majoring in meteorology explored in the SEPAL lab. Young students asked to talk about weather—from a meteorologist’s perspective—often reject the fact that plants have the incredibly special ability to take carbon out of the air and to combine it into the biological compounds that support virtually all living things, directly or indirectly. Another common misconception involves learning and the brain. Students are not aware that, Tanner says, that when they learn, changes actually take place inside their brains. When asked what happens during learning, high school students often respond with answers such as, “I see the world in a different way,” or “I feel better about myself.” They think of learning, in other words, as a psychological process rather than a biological phenomenon. “But if you are thinking biologically,” Tanner says, “you should say, ‘When something happens to an organism, then something changes inside of it, too.’” Most students come away from the last biology class they’re ever going to take unable to associate learning with physical changes in the brain. Yet studies by psychologist Carol Dweck and others show that understanding the link between learning and brain changes empowers students and gives them a sense of control over their own learning. They do better at school, Tanner explains, than those who think of their minds as fixed. “Everything we know about biology, neurobiology, and learning is that the brain is very plastic. You can change it. And you can learn to an organism, then something changes inside of it, too.” Most students come away from the last biology class they’re ever going to take unable to associate learning with physical changes in the brain. Yet studies by psychologist Carol Dweck and others show that understanding the link between learning and brain changes empowers students and gives them a sense of control over their own learning. They do better at school, Tanner explains, than those who think of their minds as fixed. “Everything we know about biology, neurobiology, and learning is that the brain is very plastic. You can change it. And you can learn to.

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