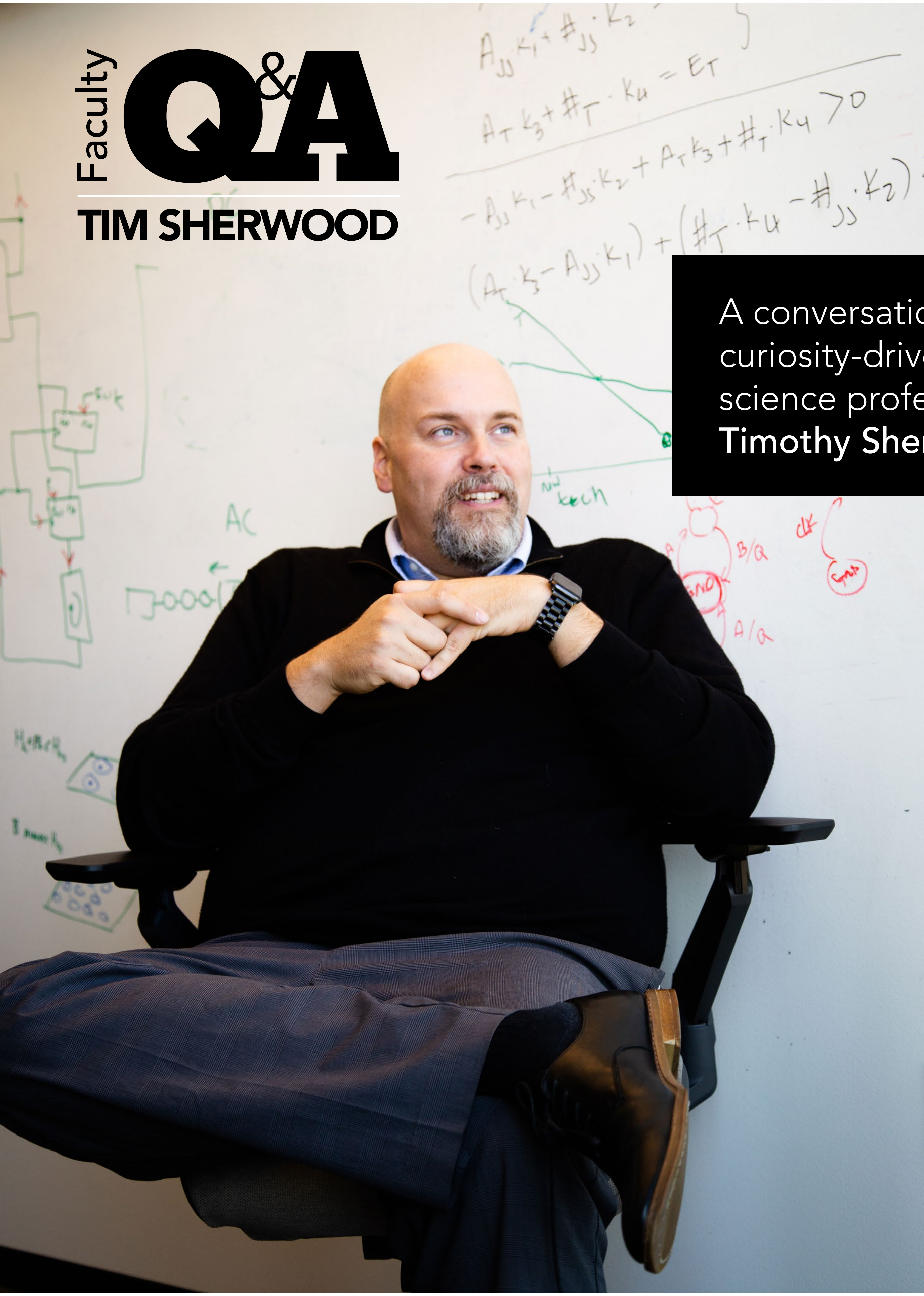
# Faculty Q&A

## TIM SHERWOOD



A conversation with dynamic, curiosity-driven computer science professor **Timothy Sherwood**.

**Turn the page to read some of his thoughts on temporal logic, the importance of communication and representation, curiosity-driven research, and more.**

# Faculty Q&A
## TIM SHERWOOD

***Timothy Sherwood*** *is a busy man on campus. The engaging UC Santa Barbara computer science professor leads a full research agenda focused on cybersecurity and energy-efficient computing, mentors about six graduate students at a time, and runs a program with Associate Vice Chancellor for Diversity, Equity and Inclusion* ***Sharon Tettegah*** *aimed at creating a new interdisciplinary, student-driven foundation for understanding issues of personal significance through a diverse lens. He recently spent five years as Associate Vice Chancellor for Research and, in September, began his tenure as interim dean of the College of Creative Studies, while still teaching an introductory class on computer architecture to about 130 students. We spoke with him in August.*

***Convergence:*** *Can you talk a bit about your recent research on what is referred to as* temporal logic?

**TS:** Any time you do arithmetic, whether as a machine or as a human, you need a way to represent a number. As humans, we use the written digits zero to nine and then string them together to represent a number. A computer represents a number in a similar way but uses only one or zero. Here, instead, we're representing the number as an amount of time that has passed. So, you might have two signals that are like a pulse. There's an event, and you encode the value as the time elapsed between some reference time and when that event happens. One event might be encoded as three and another event that occurred closer to the reference time as a two. That's the basic idea.

Now, you need to do arithmetic. So, you define arithmetic partially based on your system of representation. For instance, as a human, we have rules for how to carry values in addition, etc. A computer does arithmetic in an analogous way. But when you're dealing with these time-encoded values, you do arithmetic in a very different way. One of the interesting things is that, in this encoding system, some operations become easy and some become hard, and some of the things that become easy are bioinfomatics and certain signal-processing applications, which lots of people care about.

**C**: *Have there been further advances in this area? If so, are they related to improving the energy efficiency of computing?*

**TS:** We've been doing some work related to how you can do more general machine-learning operations incredibly efficiently this way, which may be closer to how your brain works. Your brain doesn't calculate by storing ones and zeroes; it does it some other way that we don't fully understand, but it seems clear that spikes interacting over time is part of the story. Clearly, the brain is doing something right, as it is hard to think of a more efficient "computing system." So, here we have a spiking network that does arithmetic, and we know the rules of this new way of doing arithmetic, which is closer to how the brain works than the traditional way of doing computation with zeroes and ones. We now have preliminary data showing that this approach is even more computationally powerful than we thought it was. For example, we can use this logic to approximate arbitrary functions, which, in turn, implies new ways to perform machine-learning operations and points toward new and even-more-energy-efficient ways of performing computation. Given how much energy is used each day by computer hardware, this type of logic has a great deal of potential — plus, I just think it is so interesting to find this completely new way of looking at things.

**C:** *Mention cybersecurity, and many people probably think first of software, but you have a reputation for your work on defending against attacks that occur via hardware. Can you explain?*

**TS:** Fifteen years ago, my PhD students had a simple curiosity-driven question, which was, how *exactly* does information flow through hardware? It's a good question, and we didn't know the answer. After a lot of work, it turned out that you can define it mathematically at the hardware level far more cleanly than you could ever hope to at the software level. In that work, we discovered all kinds of security vulnerabilities, including some that hadn't been invented yet. Several years later, these two huge vulnerabilities came along, Spectre and Meltdown, which were a very big deal and caused hardware companies to lose billions of dollars. Digging into our curiosity-driven question had made us the only people in town who knew how to reason through something like that, so suddenly it went from, 'This is an interesting little thing' to 'Oh my gosh, can you help us?'"

**C:** *That kind of "just wondering" about a question reminds me of when UCSB materials professor* ***Carlos Levi*** *described our interim COE dean,* ***Tresa Pollock,*** *as an especially "creative" scientist. Does that word resonate for you?*

**TS:** It does, and creativity is something people have mentioned in awards I've gotten. I think that curiosity-driven research in engineering is not given enough consideration, and yes, we're very problem-driven people, and at the end of the day, every one of my students wants to solve real problems to make the world better. But at the same time, you have to be open to these curiosity-driven questions. Sometimes they don't go anywhere, but they can also go someplace really interesting. There are projects that result from just wanting to look behind this door to know what's back there. And it turns out that behind that door are a whole bunch of other interesting doors, and you just keep pushing and they keep giving, and you push some more, and then one day you find that you're in this whole undiscovered area where no one has been before. Gosh, what an amazing feeling that is! You get to help define some whole new space for people to explore.

**C:** *You have been involved in addressing issues of diversity, equity, and inclusion (DEI) on campus, including starting the Sustaining Engagement & Enrichment in Data Science (SEEDS) program with UCSB's Vice Chancellor for DEI,* ***Sharon Tettegah.*** *Can you talk about the aims and importance of those efforts?*

**TS:** Representation is one of the most important questions we should be addressing as engineers. My field, computer science, is a powerful lens for viewing the world. It reveals hidden truths in data, giving you the ability to learn things no one else can. So, a critical question is, *who gets to look through that lens, and what problems do we use it to address?* As engineers at such an important research-intensive university, we have a responsibility not only to provide access to what we already know how to do on the problems we already look at, but also to help others turn this lens on the problems they care about and the issues that are impacting their communities — and we have a particular responsibility to those who have been systematically marginalized and disenfranchised.

Doing that takes humility, first and foremost. I have to realize that my life experience does not equip me even to have all the questions, let alone the answers to everyone's problems. One of the things I see that we need to do is empower more people to be engaged in defining what are "important" questions and identifying what we need to do to understand them better and ultimately address them.

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**C:** *Can you talk a little about the importance of graduate students to the success of your lab, which has produced a considerable amount of award-winning research?*

**TS:** Probably the most important thing is that what we do in my lab is possible only because of our outstanding PhD students and our faculty collaborators, such as computer science professors **Jonathan Balkind** and **Ben Hardekopf,** and electrical and computer engineering professor **Dmitri Strukov.** My group consists of about six PhD students and a professional researcher, which allows me to spend a lot of one-on-one time with my students. I think that's central to how you come up with really interesting "out-there" stuff. And it allows them to take their ideas and really develop and drive them. I just help to facilitate their vision.

**C:** The writing on your UCSB web page is friendly and light in style, conversational and clear. Is that by design?

**TS:** Yes, absolutely, and it is a result, first, of my desire to share. If you come up with something cool in your lab and it just stays there, it never does anyone any good, so communication is really important. Part of what we're here to do is to share our understanding with the world, and with a broader audience — not just with people who already have PhDs in my subdiscipline.

The writing in my lab is something I take seriously. Although I'm constantly wondering if I'm wasting everyone's time by emphasizing communication, when I talk to my former PhD students about the skills they learned in my lab that have served them well, they are very clear that one of those things is how to communicate their work. They tell me that it has been incredibly powerful in their careers: to be able to communicate with diverse audiences what it is they're doing, why they're doing it, and why it's important.