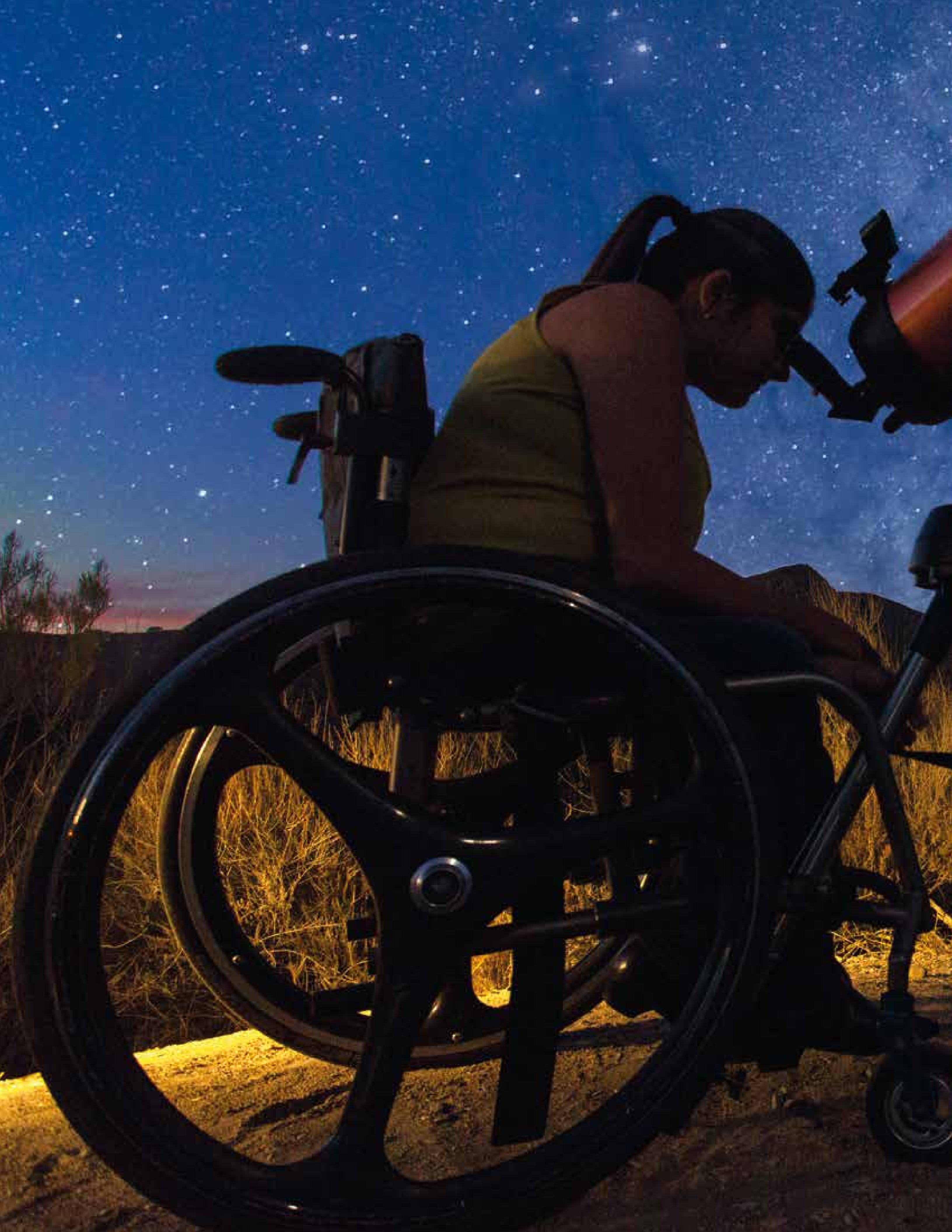
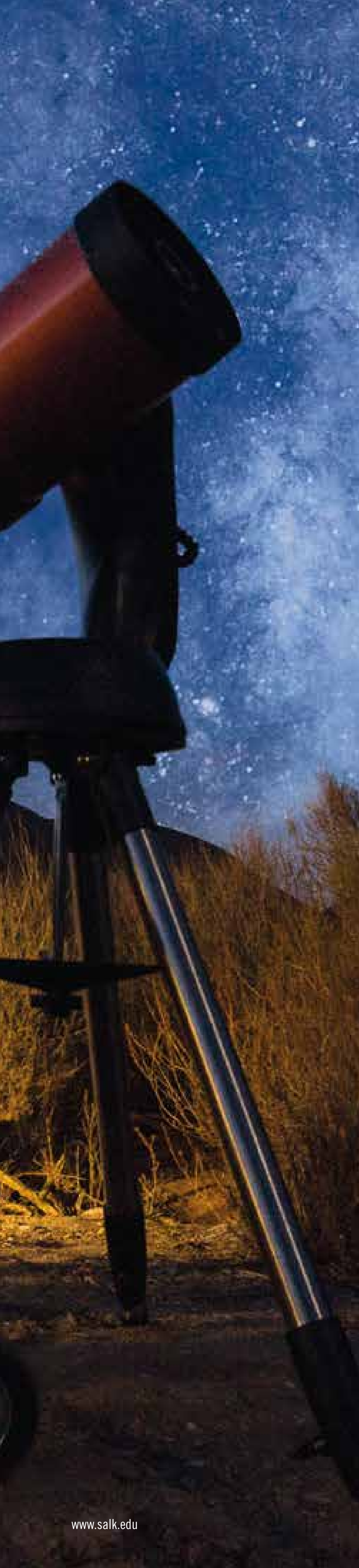




» **View video:** www.salk.edu/insidesalk/dec14/wildani

Next generation: Avani Wildani

Lines of code in fuschia, teal and yellow run across a computer screen next to an office window overlooking the ocean at the Salk Institute. Similar colors—glossy teal and purple—streak the brown hair of the young woman who types alternately at a desktop and laptop, both adorned with images of galaxies. Strewn around her desk are tins of tea and half-rolled posters showing illustrations of what look like virtual donuts.

Avani Wildani, a computer scientist in the Computational Neurobiology Laboratory under **Tatyana Sharpee**, is constructing geometric forms from massive amounts of biological data, with the hopes of finding large-scale patterns in nature. By constraining the data in three-dimensional space, representations emerge—shapes like donuts and spheres—that can lead to a better understanding of complex processes.

"I was always interested in what information means for the mind," says Wildani. "And computer science is the rock I come back to in order to understand that."

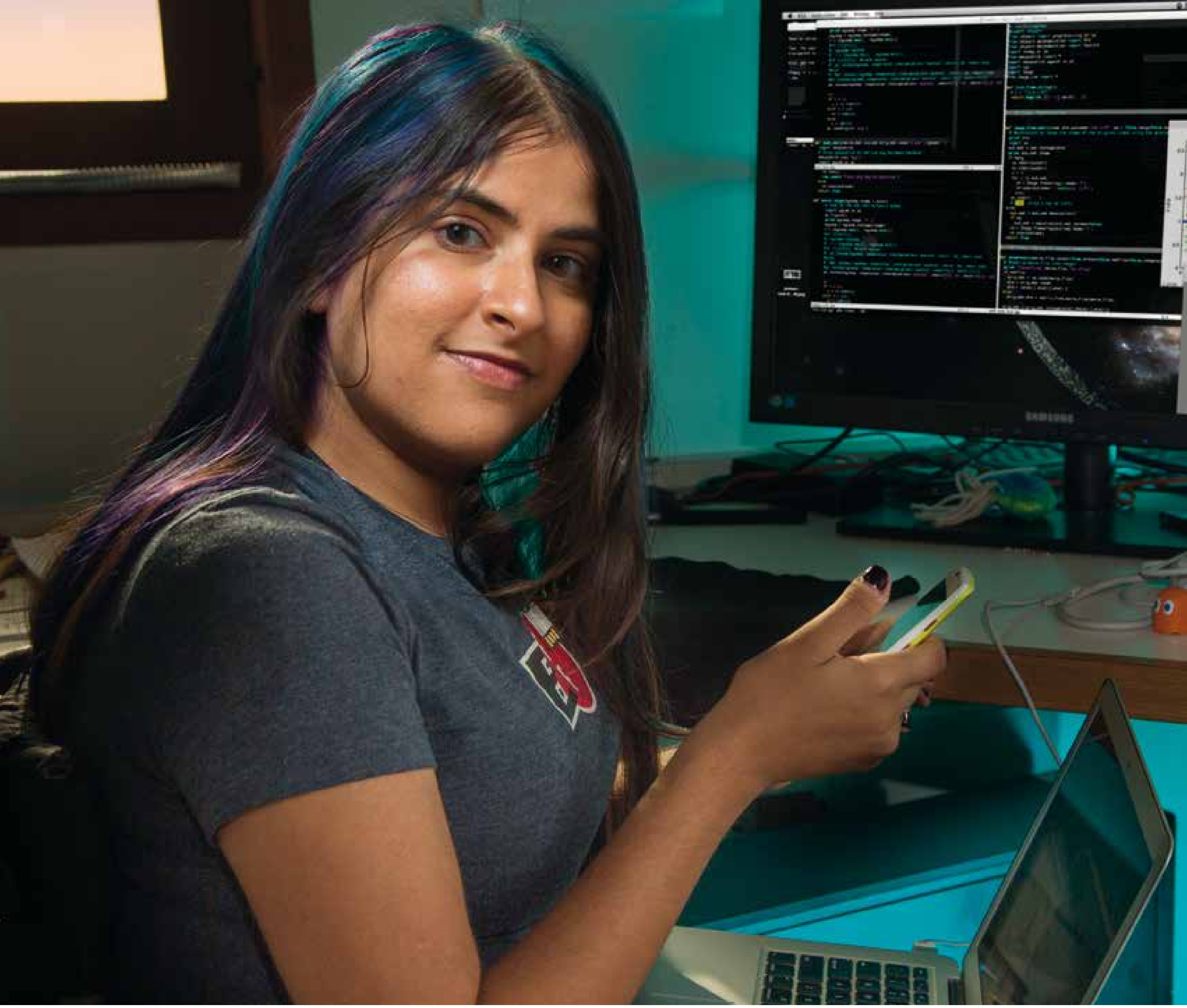
Wildani has juggled interests in biology, computer science and art throughout her life. At age three and under her father's encouragement, she used the programming language LOGO and an early home computer system, Texas Instruments' TI99, to program simple lines and shapes. (She still uses a version of that program today to teach basic computer science.) Wildani wanted to be a physician like her father, but she was born with brittle bone disease, a genetic disorder that requires the use of a wheelchair and has resulted in, on occasion, broken fingers from brushing her hair. Her father realized that the physical demands of medicine wouldn't be a good fit and steered her toward computer science at a young age.

In grade school, Wildani coded math game programs to help tutor her younger brother (now a medical school student) and her sister (now an artist) and wrote a version of the Paint program on an Apple IIe while in high school. Despite her aptitude in computer science, her interest in biology persisted. But a transformative lecture she attended while a junior in high school planted the seed of more serious interest in computer science.

"The lecturer had some very big questions and he'd get to the answers in just a few steps," Wildani recalls. "He showed how, given a small, understandable set of commands, he could do pretty much every set of computation there is. That really blew my mind."

At Harvey Mudd College, she began with a focus on biochemistry and art, but the lecture had made such a deep impression on her she switched to computer science and math at the end of her freshman year.

She started her graduate studies in biological machine learning at the University of New Mexico, where her group correlated massive amounts of data from fMRI studies of schizophrenic patients to reveal four subsets of the disease phenotype (for example, a history of drug abuse in patients resulted in a specific manifestation of schizophrenia). Funding for the project ran out abruptly, so Wildani transferred to the University of California, Santa Cruz to again make a shift: she began to study storage systems, which would later give her a unique perspective on the brain.



In storage systems, Wildani explains, researchers want to increase two abilities: availability—getting the data quickly whenever you want—and reliability—keeping data around when units fail.

"We have a good model for how information should be stored in a large distributed set of computers—how information moves around and is saved even as disks die," she said. "Since we know how to do this in computers, I started to ask those same questions about the brain."

It was an unusual idea. Generally, computer scientists try to figure out how principles in biology can help make new computer models, for example, neural networks. But Wildani was interested in also looking in the other direction: asking what computer science can teach researchers about phrasing biological questions in a different, and potentially helpful, way. While the rest of her classmates went to work for industry jobs in storage, she was drawn to academic research to pursue this and other ideas.

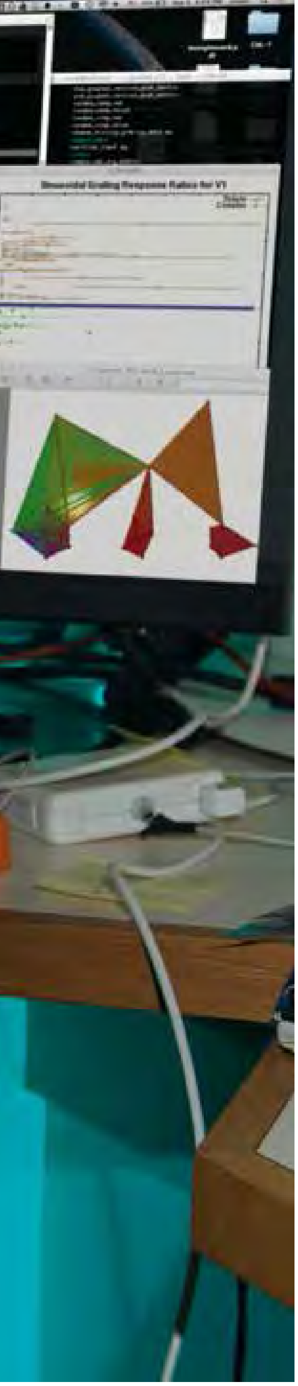
All of her interests—how systems store and process data, biomedicine, machine learning, and even the spatial reasoning in art—culminated in her work at the Salk Institute, where she continues to ask what computer science can teach us about biology and vice versa, particularly in relation to the brain.

"Avani brings a unique and enthusiastic perspective to the field," says Sharpee, associate professor in Salk's Computational Neurobiology Laboratory. "Her intelligence and creative synthesis of different facets of computer science make her well poised to bring a new understanding to biological data."

In the area of neuroscience, Wildani aims to trace how information moves through the brain. Despite an abundance of experimental biological data, two major challenges emerge: the data tends to be "noisy" (with errors) and also hard to compare, since recording methodologies can vary slightly.

By transforming experimental data into a virtual surface—where each data point is plotted in relation to the other data points in its set—Wildani and other computer scientists are able to minimize noise and get the most out of data that biologists collect.

For example, Wildani is making two sets of maps from vision experiments, tracing the



> "This work is a first step toward a better model of object recognition in the brain, which could in turn lead to treatments for visual agnosia, an ailment that prevents stroke victims from being able to recognize objects or faces." —Avani Wildani

signals from neurons to see which clusters fire in response to different types of images. In one set of maps, she is charting the electrical responses of visual cortex neurons. In the second set, she is charting the stimuli themselves, which consist of nature-based and artificial scenes.

By mapping these sets into shapes, Wildani will be able to compare data within and across experiments to pull out the larger patterns that show how signals are transmitted between single and groups of neurons. "When plotted correctly, connectivity between data points stay the same, allowing us to create shapes that accurately reflect the data when compared across sets," says Wildani.

A practical application of this work would be to build robots with better machine vision or to develop better treatments for those with vision impairment. "This work is a first step toward a better model of object recognition in the brain, which could in turn lead to treatments for visual agnosia, an ailment that prevents stroke victims from being able to recognize objects or faces," she says.

The far-out notion of this work would be to reverse-engineer the brain. For example, researchers could establish a crude type of "mind-reading" where, just by looking at the neural spike response, researchers could reconstruct what the stimuli were (e.g., an image of a forest).

The science-fiction concept of deconstructing the brain well enough to transfer consciousness into a virtual reality environment is one idea she enjoys. "It would be so cool if we could 'upload our brains' and live entirely in a virtual reality. I would love that," she says.

Nevertheless, the physical world keeps her busy. A preoccupation with shapes and space diffuse into her hobbies. She uses charcoal and pencils to sketch portraits of family and friends, one way she gives her mind a break. "When I'm drawing, I can relax and zone out on the negative space on the paper. Eventually, a picture comes out of it," she says.

She is also an avid stargazer, building a telescope from scratch and grinding the mirror herself to get the parabolic shape just right. In addition, she kayaks and enjoys experimenting with classic cocktail recipes (the "Aviation" is her favorite).

Wildani also believes in giving back professionally. She is particularly interested in supporting women in the Science, Technology, Engineering and Mathematics (STEM) fields in two big ways. The first is in her involvement with the Anita Borg Institute's Grace Hopper conference, an initiative to celebrate women in computer science. She works with the conference to attract younger attendees and to help establish early professional support for women starting out in computer science.

Secondly, Wildani is developing an upcoming website dubbed Project Hypatia, named for the ancient Greek female philosopher and mathematician. The website—open to all genders—will showcase female first-authored papers and encourage multiple reading groups. "By having strong examples to look up to, I hope this site convinces women that they 'belong' in the field," says Wildani. She herself says she has been fortunate to have many female mentors and peers and hopes the website can provide a similarly supportive community.

"It's important to get young women interested in STEM fields in middle school and high school—that's a time when we start to lose them," she says. "But the support needs to continue well into all stages of the career path."

Wildani has also promoted science to elementary students through the Salk's Education Outreach program. She was a featured scientist in the program's SciChat initiative, where researchers give Skype presentations to classrooms throughout San Diego County. For her SciChat, Wildani explained how data from neurons could lead to a way to develop more intuitive robotic vision and answered students' questions about how objects and animals of all sorts see. Just like the lecture at Harvey Mudd that opened her eyes to the possibilities of computer science, she hopes that promoting science through many different kinds of venues will spark others' interest.

"I love helping people develop an interest in science and being party to the fascinating questions they come up with," says Wildani. "I hope to encourage all inquiring minds to tackle problems in the rich boundary between computer science and biology."