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Scientific interests, personal chemistry, and mentoring styles go into choosing an adviser. The best way to know if a match will work is to try it out.

Back when Dan Stamper-Kurn, now a physics professor at the University of California (UC), Berkeley, headed to graduate school at MIT, he got two bits of advice that were “right on.” A researcher with whom he had explored the effects of urban heat islands on energy use told him to work “in the most fundamental science” possible so as to gain a strong foundation. The other piece of advice came from a graduate student, who told him, “Don’t work for a jerk.”

Since then Stamper-Kurn, whose research focuses on ultracold atoms, has mentored dozens of PhD students. Choosing an adviser is the most important decision a graduate student makes, he says. The relationship continues after a student gets their PhD. It is personal. It has a power dynamic. And both parties need each other for their careers.

Yet adviser–advisee relationships tend to form with minimal information. The process involves institutional structures,

funding, individual initiative, trial projects to sample research interest and work styles, and compatibility. “There is no formula,” says Stamper-Kurn. “I have to think it will be possible to turn [the student] into a kick-ass scientist.”

Open houses and pizza lunches

At many US universities, the admissions process paves the way for pairing faculty with PhD students. Faculty members are polled to see who wants to take on new students, and applicants are asked to list their areas of interest. The aim is to engineer an incoming class whose interests roughly line up with the available research spots.



PROSPECTIVE GRADUATE STUDENTS at the Louisiana State University physics department’s 2017 open house, which coincided with a local St Patrick’s Day parade. Now working on their physics PhDs at LSU are Tej Poudel Chhetri (far left), Thomas Ruland (red shirt), Frank McKay (light blue shirt), and Scott Mullen (maroon shirt). Madeleine Miora (second from right) earned her master’s at LSU; the other students went to other universities.

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GROUP DYNAMICS can be an important factor in choosing a research adviser. At the University of Illinois at Urbana-Champaign, Jessie Shelton (right front) and other professors in high-energy theoretical physics hold joint group meetings.

Prospective students and advisers meet during campus visits. That's how Rachel Nguyen, now a second-year graduate student in dark-matter theory at the University of Illinois at Urbana-Champaign (UIUC), found her adviser. "I had a large list of universities I was interested in, and for each one that I was accepted to I tried to identify several professors that I thought I would be happy working with," she says. The person who became her adviser was not on her spreadsheet—he was a new hire and was not yet featured on the department's website. "His interests matched mine, so the department put him on my schedule for visitors' weekend," she says. Afterward, he followed up with email messages and a Skype call.

Rachel Malecek didn't know what research area she wanted to pursue. At the Louisiana State University (LSU) physics department's open house in spring 2017, she attended talks by several professors and chatted with them and their students. "I'd never considered nuclear as an option because I hadn't had a class as an

undergraduate," she says. "But from the short talks, it sounded cool. The nuclear-physics group seemed like a nice, tight-knit group." Malecek later sent an email to one of the nuclear physicists and asked if he was looking for graduate students. He was, and she joined his group.

Once students are accepted to UC Berkeley, Stamper-Kurn reaches out to those who express interest in atomic, molecular, and optical physics. "I encourage them to come to our open house. I show them around the labs and talk to them about Berkeley and our group." At Berkeley and other state schools, departmentally funded fellowships are scarcer than at some of the private schools that the students may be looking at, he says. "One tool I have in my arsenal is to offer students a spot in my group right off." If they want to do research and not have to work as a teaching assistant, he says, "that can be a powerful incentive."

Faculty members who want to take on students typically present departmental talks. For first-year students in the Yale

University physics department, for example, Friday pizza lunch is a *de facto* required class. "Students learn about potential advisers, and it gives them a sense of research in the department," says Sarah Demers, whose group focuses on using muons and tau leptons to investigate physics beyond the standard model. "It's a great recruiting opportunity."

Some departments offer rotations, in which students join different research groups for up to a semester each. Official rotation programs are rare in physics—they are common in biology and chemistry—but often students can create their own rotation schedules. The physics department at UC Berkeley, for example, encourages students to do that. Heather Gray is an assistant professor at the campus who studies the Higgs boson. "In high-energy physics, we work in enormous collaborations," she notes. "The rotations are an opportunity to see if the personalities work together. The PhD is long, and there is no purpose in being in a group where you are unhappy."

"Motivation any day"

So what do faculty look for in advisees? Passion and excitement about the specific research topic are often critical. "I don't look for just experience and talent," says MIT's Nergis Mavalvala, who works on the Laser Interferometer Gravitational-Wave Observatory. "I look for interest. I can teach a student the tools of my trade, but I can't teach them to be excited about what I do."

Professors also look for dedication, motivation, creativity, a willingness to ask questions, the ability to recognize when a line of inquiry hits a wall. Frank Würthwein of UC San Diego searches for new high-energy phenomena at the Large Hadron Collider. "Each faculty member has a different set of criteria," he says. Theorists are more interested in what students know, he observes, while experimentalists are typically more interested in what skills they have. He pays attention to the questions students ask and to whether they are self-critical.

Würthwein likens his group to a small business, in which his investment in students should pay off. "There is real money in the game," he says. "I want to make sure students are productive."

David Gerdes, physics chair at the

University of Michigan, asks prospective students, “What are your goals? What is your perfect day?” Some students are software oriented, some like analyzing data, some want to fiddle with lasers or other hardware, some like higher-level interpretation. Sussing out a student’s interests is important to match them with a project, Gerdes says. “There’s an axis of skills and abilities, and an axis of motivation, persistence, and enthusiasm. Ideally, someone has both. But if I have to pick, I’d pick motivation any day.”

A common approach for faculty is to invite students to work with them on a provisional basis so both parties can test the fit. Lars Bildsten, director of the Kavli Institute for Theoretical Physics at UC Santa Barbara, says that to onboard students he works with them intensely, usually after their first year of graduate school. “By the end of the summer, I’ll say ‘yes, great,’ or ‘no, this isn’t working.’” A no is better earlier than later, he notes, and usually it’s no surprise to the student. “If they don’t have that fire in the belly for the specific research problem, it comes through quickly,” says Bildsten. Usually, he adds, the student finds a research area, adviser, and group that are a better fit.

James Sethna, a Cornell University theorist in statistical physics, says he works with students for a summer or semester before committing to take them on for their PhD. “It’s not just how smart they are, or how much overlap of interest we have. It’s also personal chemistry.” Theory tends to attract more students than departments can support, he notes, so student initiative is important. “The ones who are aggressive end up getting more attention.” But Sethna says he avoids snap judgments. He recalls one student whose persona was “very nonthreatening. You didn’t find out how really amazingly smart she is until you worked with her for a while. I was really pleased I didn’t make the decision right away. I grew to appreciate how talented she was.”

Elements of style

Grades and GRE scores, many professors say, are not a factor for taking on a student. For one thing, by the time students are in a position to join a research group, they have been admitted to the department. Getting into Harvard University is competitive, so students’ grades have to be good, notes Melissa Franklin, who



MEMBERS OF THE AXION DARK MATTER EXPERIMENT lower the deep cryogenic detector into the bore of a superconducting magnet. Shown are ADMX lead scientist Leslie Rosenberg (yellow hat), graduate students Nick Du (white hat) and Michael Hotz (green hat), and Cliff Plesha (no hat) and another undergraduate (orange hat), all of the University of Washington.

studies proton–proton collisions at the Large Hadron Collider. Professors look at research experience and letters of recommendation, she says.

Karen Daniels, a soft-condensed-matter experimental physicist at North Carolina State University, says that for her, “grades and prior lab experience are just part of the picture.” She has mentored students who had good grades and others who had mediocre grades;

students with skills in electronics, coding, and writing prose and others who lacked those skills. “It’s hard to predict which students will emerge with a rewarding PhD,” she says. “It’s best correlated with whether they want to work on the skills they need. If so, they will be successful.”

Professors, for their part, have different mentoring styles. They can be hands on or let students flounder. They may in-

sist that students be in the lab on weekends and evenings. "It's fascinating to see how people gravitate to work with one sort of professor or another," says Franklin. In looking for a good fit, she says, "I ask students, 'What book are you reading now?' You can get a sense of who they are intellectually."

Group dynamics is precious, says Yale's Demers. "Graduate school is a challenge, and the relationships among students, postdocs, and myself have to be functional." And, she adds, "I want students who are kind and respectful. I don't want arrogant or overconfident. I want someone who sees doing a PhD as not a waste of time, regardless of what they end up doing."

Sometimes faculty members don't have much choice about whom to take on. "I am a recruiter," Demers says. "I don't have people banging on my door. When the new class is admitted, I go to them." Likewise, Vernita Gordon at the University of Texas (UT) at Austin says her department has a tough time wooing would-be biophysicists. And Jeffrey Wilkes, a professor emeritus who works in high-energy neutrino and cosmic-ray astrophysics at the University of Washington, says he's taken on "mediocre students because I needed someone, and no one was available who I thought would do the best job."

Attracting students can be especially hard for new faculty, who urgently need students but haven't yet built up a reputation for either their research or their mentoring style. But assistant professors also have advantages, says Jack Ritchie, chair of physics at UT Austin. Graduate students can find them less intimidating, he notes. "And young faculty often work in hot new areas."

Vladan Vuletić, an MIT professor who creates and studies entangled many-body states, says he relies heavily on the students and postdocs in his group to assess whether potential recruits would fit in well. "Peers are a really good judge," he says. "Students may be less shy and show their knowledge and personality."

Whisper networks

For students, too, talking to other students can be helpful in selecting a research adviser and group. LSU's Malecek says senior graduate students "gave me the inside scoop on their advisers." Karmela Padavić-Callaghan, who recently earned

her PhD in condensed-matter theory at UIUC, says she knew when she entered graduate school that she wanted to be a theorist, and she knew the field was male dominated and competitive. "I didn't want to work with someone who would make me feel small if I didn't know things," she says. She chatted with graduate students because "they don't have a reason to lie. They warn you, and if you ignore those warnings, it's not ideal." She sought out a research group mainly based on topic, but it was also important to find a female adviser "for the shared lived experience."

Women tend to be less assertive, she notes, and they are more likely to have family responsibilities than men. Students from other countries may be accustomed to more formal and deferential interactions with senior scientists, continues Padavić-Callaghan, who is originally from Croatia. As a result, women and international students "may not have as much of a shot at getting into certain groups, even if they are interested in the research and have great skills." Such cultural issues "can be a big factor in what a student ends up doing during their PhD," she says.

"I had spoken to graduate students who seemed burned out," says Mariel Pettee, who will graduate next spring from Demers's group at Yale. "I wanted to pick a place where I could be happy as a whole adult."

Sergio Cantu, an American of Mexican heritage, joined Vuletić's lab after spending a year at MIT in a bridge program that helps students from underrepresented groups transition to graduate school. "I shopped around," says Cantu. "But I kept going back to him because he was welcoming. And once I started working in his lab, I noticed he would say things like 'your lab' and 'your experiment.' That gave me ownership and made me feel empowered."

When it doesn't work out

No reliable statistics exist, but several faculty members interviewed for this story estimated that 10–20% of PhD students switch groups. The main reasons are that students find a topic they are more excited about, they clash with their adviser, or their adviser runs out of funding. When the switch happens relatively early, say by the end of the second year, it tends to go smoothly, students and fac-

ulty members report. Switching later is trickier, and it often adds time to finishing a degree.

Joel Moore, a theorist who studies quantum materials at UC Berkeley, says that one of the hardest things he's had to do was tell a student after six months that it wasn't working out because they weren't making enough progress. "They were still excited about the project, but I felt I was not the right adviser for them to succeed."

"I've asked someone to leave," says a professor who didn't want to be named to protect the student. "It had become toxic. The student had alienated almost everyone in the group."

Sonia Paban, a cosmologist and particle theorist at UT Austin, says that ousting a student is "not a decision [made] in one day. It's a process." Harold Johnson, now a third-year graduate student, switched to Paban's group from an astronomy group because both the research and the work environment were more inspiring to him. When Johnson approached Paban about joining, he says, "she gave me some work to read, and I knew I wanted to be her student."

Transitions are not always easy, says MIT's Mavalvala. "They are not always mutual. If a student needs a new research group, they can typically work as a teaching assistant to tide them over, so they don't feel trapped." She has never asked a student to leave her group. "When I get to the place where I think a student is not working out, I force myself to write down their strengths and weaknesses," she says. "And then I try to point them in the direction of their strengths."

When their chosen group doesn't work out, some students leave with a master's degree. Those that stay may have a hard time finding a new adviser. But, says Mavalvala, "the stigma goes in both directions. It's not just the student who is tainted. If there is a pattern, the faculty member gets a reputation for being hard to work with."

Senior faculty members say that students who have had trouble working with someone should work with tenured professors. "When young, an adviser should focus on finding students that can be beneficial to their research," says Cornell's Sethna. "After they get tenure and are secure, they can aim in large part to benefit the students."

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