When graduate student Alyssa Ward took a science-policy internship, she expected to learn about policy — not to unearth gaps in her biomedical training. She was compiling a bibliography about the reproducibility of experiments, and one of the papers, a meta-analysis, found that scientists routinely fail to explain how they choose the number of samples to use in a study. “My surprise was not about the omission — it was because I had no clue how, or when, to calculate sample size,” Ward says. Nor had she ever been taught about major categories of experimental design, or the limitations of $P$ values. (Although they can help to judge the strength of scientific evidence, $P$ values do not — as many think — estimate the likelihood that a hypothesis is true.)

Ward’s PhD programme required her to take courses in research ethics, but she already knew not to make up data. Instead, she wanted to know how to plan unbiased experiments and conduct rigorous analyses. “Mistakes are more important than misconduct,” she says. “I wanted a course on mistakes.” So she designed one.

After her internship, she convinced the head of her graduate programme at Johns Hopkins School of Medicine in Baltimore, Maryland, to let her pilot a 7-week course called ‘Method, Logic and Experimental Design’ for first-year graduate students. Next year, an expanded version of this course will roll out across multiple Hopkins programmes and be required for many trainees.

Scientific irreproducibility — the inability to repeat others’ experiments and reach the same conclusion — is a growing concern. Much blame is placed on weak experimental and analytical practices that cause researchers to inadvertently favour exciting hypotheses. A Nature survey this year (Nature 533, 452–454; 2016) found that 87% of more than 1,500 researchers named poor experimental design as a cause of irreproducibility; 89% blamed flaws in statistical analysis. Yet few early-career researchers receive formal instruction on these topics. Indeed, when Ward tried to recruit faculty members to lecture for her course, several declined because they had not received such training themselves.

Early-career scientists cannot expect to learn everything they need to know in their own laboratories, or even departments, says Alison Gammie, who administers research training programmes at the US National Institutes of Health (NIH) in Bethesda, Maryland. “Science is changing at an incredible rate, and the current principal investigators and investigators were trained in a different era,” she says. Because many of the available training opportunities are new and not well known, scientists who want to improve their analytical skills must take the initiative to seek — or create — the resources they require (see ‘The learning hunt’). Several researchers have supplied relevant advice in the form of books, articles and webcasts. David Glass, a director at the Novartis Institutes for BioMedical Research in Cambridge, Massachusetts, converted a short...
Searching. Seek discipline-specific training. It seemed odd that we weren’t teaching grad students how to actually perform science, he says.

David Vaux, a cell biologist at the Walter and Eliza Hall Institute of Medical Research in Melbourne, Australia, has also penned articles in this vein. An experiment designed to probe alternative explanations can be more powerful than using statistics to ferret out differences between groups, Vaux notes. For example, researchers can engineer a mouse or cell so that a gene can be turned off selectively. Such discipline-focused courses are not always available, but faculty members are generally sympathetic when students ask for help, says Randall Reed, a molecular biologist who acted as the faculty sponsor for the course Ward designed. “She was more successful than I would have been in engaging faculty and getting them to participate.”

Ward spoke to more than a dozen faculty members in an attempt to find guest lecturers for her course. But recruiting professors was easier than pitching content at the appropriate level, she says. “We’re looking for the magic that is general enough to help everyone but specific enough so that students know how to apply it.” She found a solution in copious extra-credit assignments that, for example, required graduate students to work out how to validate reagents in their own labs. Plans for subsequent years include a series of online lectures supplemented with in-person discussions and projects tailored to specific disciplines.

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Help with experimental design and analysis is more accessible than many researchers realize. The 60 or so research institutions that receive funding as hubs for the NIH Clinical and Translational Science Awards programme often also provide statistical advice. The Center for Open Science in Charlottesville, Virginia, offers free statistical consultations along with webinars and short tutorials on techniques such as pre-registration, a bias-thwarting strategy that requires researchers to formally document analysis plans before collecting results. And the CHDI Foundation, a non-profit drug-development organization targeting Huntington’s disease, has assembled a panel of experts on protocol and statistics that anyone in that research community can engage.

But many scientists do not know how to work with statisticians effectively, says Andrew Vickers, a biostatistician at Memorial Sloan Kettering Cancer Center in New York City. For example, it is best to approach a statistician about analysis early, ideally before collecting data. At Vanderbilt University in Nashville, Tennessee, a course for second-year graduate students teaches them how to work with statisticians. Students bring data from their lab to the university’s “walk-in statistician clinic,” and learn how to balance statistical exploration and rigour. But most importantly, they learn that the stats clinic exists — course designer and pharmacologist Joey Barnett hopes that this message will reach their principal investigators, too. “If they are good students they will act as a vector and deliver this to their mentor.” Barnett has also observed that trainees learn to seek resources beyond their labs after taking the course.

Getting to Class

Most research universities offer courses in applied statistics and, increasingly, in data analysis. These can be useful, but trainees may find themselves lumped in with economics or business students with very different core interests. “Scientists learn skills better when they are taught in a domain-specific way than when you shuttle them off to math and computer science departments,” says Ethan White, an ecologist at the University of Florida, Gainesville, who has designed courses in quantitative methods.

“Help with experimental design and analysis is more accessible than many researchers realize.”