



Agricultural Research

Career Advice

Internships Offer Undergrads Full-Time Research Immersion

Sarah Addou stared hard at her computer screen, willing the code in front of her to

compile properly. "When you don't have any experience writing code, it's a steep learning curve," she recalls today, 8 years after that summer internship experience at **Cold Spring Harbor Laboratory** (CSHL) in New York state.

Like many undergraduates, Addou got her first real experience with professional-grade research tools during that summer internship. She was studying genetics at **University College London** at the time. Combined with a class she later took in bioinformatics, her CSHL internship helped her decide to pursue a M.Sc. and a Ph.D. in bioinformatics. Now, she's a database programmer at the **Institute of Cancer Research** in Suffolk, U.K. "I think I would have done bioinformatics anyway," she says, "but [the internship] gave me a taste" of real research.

Addou's experience isn't unique. Summer internships give many undergraduates a chance to experience research full-time, often surrounded by facilities and people they don't have access to during the year.

Full-contact research

At summer research programs such as the one at CSHL, students can spend 24 hours a day, 7 days a week thinking about and doing research under the supervision of full-time researchers, says **F. Gerald Plumley**, internship director at the **Bermuda Institute of Ocean Sciences** (BIOS) in St. George's. It is a level of commitment that even the most hard-pressed undergrads at major research labs are not expected to show when classes are in session.

The CSHL **program** is homegrown, but others have support from national funding bodies such as the U.S. National Science Foundation (NSF) or NASA. NSF's popular and long-running **Research Experiences for Undergraduates** (REU) program funds nearly 500 sites, which average about nine students each, according to coordinator Corby Horvis. Not all of the sites are at exotic locations, but program managers at NSF "tend to reward proposals that give students front-line experiences" with top-notch equipment and researchers, Horvis says.

Students apply to individual REU sites, which include a Department of Defense-funded **supercomputing project** at the University of Maine, Orono, conservation biology at the **Chicago Botanic Garden**, and a **polar science project** in Svalbard, Norway. Private foundations and national laboratories offer similar internships outside the REU framework. Site directors, typically researchers or professors, are responsible for matching students with mentors. In addition to one-on-one research advising with a working scientist, many sites offer supplemental activities such as weekly lectures and practical workshops on how to write up and present research or apply to graduate school.

Formal programs typically last 10 to 12 weeks and provide a stipend covering basic living expenses and travel to and from the site. Remote sites, such as the **Arecibo Observatory** in Puerto Rico, offer housing to students, and others offer assistance arranging summer housing before students arrive, says Laura Kushner, now an engineer who works at **NASA Ames Research Center** in Moffett Field, California. Kushner spent a summer at Arecibo, another at Kitt Peak National Observatory (KPNO) in Tucson, Arizona, and a third summer at Ames while she was an undergraduate physics major at the University of Washington.

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Many students use summer internships as a springboard for graduate research in the sciences, but instead, NSF says the main goal of its REUs is to attract a diverse array of students: "Many go on to grad school but that's not necessarily the goal," says REU program officer Lisa Rom. "We need lawyers who understand science, too."

Testing the waters



Carmen Denman, an undergraduate at Oregon State University, heads out to collect water samples for her research project on bacteria abundance. She did the project during an internship with the Bermuda Institute of Ocean Sciences.

Undergrads must take responsibility for the success of their summer projects, says Carmen Denman, an undergraduate at Oregon State University, Corvallis, who just completed the BIOS program. She says that one of the big challenges of her program was learning to teach herself how to independently solve problems in the lab. "There's not always someone to ask" for help, she says. To complete her project on bacteria abundances in the sea around Bermuda, Denman had to master and refine several laboratory protocols. It's important that undergrads not shy away from "making [protocols] your own and making them work," she says.

Such intense experiences can be challenging, but they may also be the best ways to explore professional-level research as an undergraduate. At Addou's home institution, the only bioinformatics class available to genetics students "wouldn't really teach me how to program," she says.

Bioinformatics was actually Addou's third choice of topics when she applied to the program at CSHL. But when she was accepted, she says, she thought, "It is a very prestigious place to be ... that can only help with my future career." She also thought it would be a fun summer, but "it ended up being a lot of work, a lot of stress." She's quick to add that the students and scientists with whom she worked were "friendly and easygoing" but that her programming project dominated her summer. Undergraduates can expect to work on original research at most summer internships, notes Plumley, adding that BIOS supervisors regularly assign summer students to experiments that "come right off of our NSF grants, and we literally don't know the answers that the students are going to get."

Such work may be useful experience, but in an ideal scenario it can also result in a poster for presentation at a conference or even a contribution to a publication. Kushner presented results from her summer programs at subsequent meetings of the

American Astronomical Society (AAS). These follow-up events are a way of maximizing the networking value of summer internships, according to Kenneth Mighell, site director of KPNO. Mighell encourages his REU students to attend the AAS meeting every year following their REU.

Who you end up working with can be unpredictable. "My supervisor was a busy person," says Addou, "so I was working more closely with people who worked on his team." Ad hoc arrangements are not uncommon at summer research programs. Undergrads in some programs have been surprised to discover that their supervisors would be skipping town for a week or two during the summer. Students then must rely on collaborators or other undergrads to keep their projects on schedule.

For Addou, it was the other undergraduates that made the experience enjoyable, and she continues to keep up with some of them. "They often become lifelong friends because they start their careers at the same time," Rom adds.

Denman is enthusiastic about the intensity of her experience measuring bacteria abundances at sea. "This wasn't an internship to come to Bermuda to see the beaches," she says. "Prior to it, I was working in a smallpox/biomedical lab. Now I am so thrilled to have found my real passion in marine science/microbial ecology." It was a good way to get her feet wet, she says, before deciding which field she wanted to pursue in graduate school.

The payoff

In addition to giving students a taste of science and some new technical skills, summer internships offer benefits such as practice communicating the results of your research to other scientists. At BIOS, Plumley says, students "give weekly seminars, and we teach them to get their data into a format they can present in real-time, rather than just letting everything accumulate."

The connections students make with peers and senior scientists during their internships are a big part of the payoff, too. Supervisors will later serve as references, can introduce students to other helpful colleagues, and may provide long-distance advice on future research. Denman says that during her time at BIOS, she met "professors from [the] Massachusetts Institute of Technology and [the] Woods Hole Oceanographic Institute and [the] Scripps Institute of Oceanography. ... You don't just run into those people at the dinner table." When she graduates, she plans to apply for graduate studies with some of those professors.

Those professors are likely to pay extra attention to applications from students with a good summer research internship. Plumley points out that many laboratory class experiments are "canned," the results known in advance. Graduate admissions committees value original research experience and take letters from research supervisors quite seriously, because those people can offer insight into a student's potential that transcripts cannot. "We're treating them like they were first-year graduate students," Plumley adds. "The projects are smaller, but we're training them how to go to graduate school so when they do apply they'll be able to write a stronger resumé."

A big lesson is learning to deal with uncertainty. Because the projects are original, "we don't guarantee success," says Plumley. "A lot of things haven't worked out here," agrees Denman, but that is the reality of research. Sometimes equipment breaks down and sometimes DNA doesn't. "But I'm taking this project home with me to my lab."

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