Four years has become the magic number for many graduate programmes in the United States and Europe. Eugene Russo explains the logic behind the maths.

As a prospective graduate student five years ago, Amy Caudy was interested in the new Watson School of Biological Sciences at Cold Spring Harbor Laboratory (CSHL) in New York state. Her reasons: CSHL's reputation, the small class size and an innovative curriculum. The school's insistence that students complete their PhDs within four years, unusually fast for life-sciences students in the United States, wasn't much of a factor. "But at a certain point in graduate school it became a major factor," Caudy chuckles.

US graduate programmes, especially in life sciences, have grown excruciatingly long in recent decades. Eight years is not unusual. According to Jim Voytuk, senior programme officer at the US National Academy of Sciences, the average time to PhD since the 1970s has increased by nearly a year in chemistry and physics and nearly 18 months in the biosciences. In 1973–82, the average in biosciences was 6.3 years; for 1993–2002, the average was 7.7 years. In physics, time to degree increased from 6.6 to 7.4 years, in chemistry from 5.8 to 6.7 years.

In the United Kingdom, the trend is up from three years to three-and-a-half or four. With financial commitments from the Medical Research Council (MRC) and the Wellcome Trust, the number of four-year programmes is rising. The rest of Europe (where students spend longer than Britain's standard three years as undergraduates) is following suit. The 'Bologna process', led by the European Union, aims to standardize graduate studies by 2010, with four-year doctoral programmes as one aim, according to Iain Cameron, head of postgraduate training at the UK Engineering and Physical Sciences Research Council.

Ironically, the new European ideas are modelled on the US system, where four- or five-year programmes often stretch much longer. The way the Watson School's first six students gained PhDs in an average of four years may provide lessons for other institutions. The lengthening in Britain, meanwhile, has provided a model in which students are given more freedom to explore different lab environments and to research fresh disciplines.

Some people suggest that the entire area needs to be rethought. "It's important that the graduate and postdoctoral period are thought about as a combined training period, which is often not the case," says James William Nelson, a professor of cellular physiology at Stanford Medical School and former senior associate dean of graduate and postdoctoral education.

Amy Caudy: the four-year PhD programme works "because people are beating on you to drag you out the door and get you to progress".

COLD SPRING HARBOR LABORATORY

Students need to consider where their aspirations lie, Nelson suggests. If academia is not the ultimate objective, doing a postdoc should not be a given; nor should staying on at graduate school, waiting to get a paper in *Nature* or *Science*.

SHARPER FOCUS ON CAREER

Many programmes are working to shorten the early stages, such as courses and oral tests, says Keith Yamamoto, vice-dean for research at the medical school of the University of California, San Francisco. But it is the later research that takes so much time. "If we can instil a sharper focus on what they want to be coming out of graduate school with, I think people will discover that they can acquire those tools in four years," says Yamamoto.

Science students should think about their careers the way business students think about theirs, says Raymond Clark, co-chair of the policy committee for the US National Postdoctoral Association. "Look to leverage the greatest advantage in your direction," he says. "It's your career you need to be concerned about, not your mentor's." If your mentor doesn't support you, you need to find a new one, Clark advises (see *Nature* **422,** 784–785; 2003).

Nelson says that graduate students should keep three aims in mind: scholarship, or being able to define a problem; training as experimentalists; and critical thinking skills to interpret data and the literature.

Finding the right lab is crucial to accomplishing all

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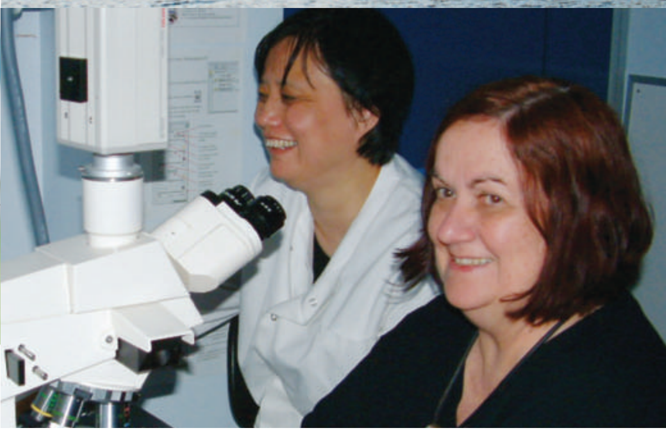

BEN MUDGE

Anne Mudge (with colleague Lili Cheng, left): lab rotation system works better than matching students to supervisors. Above, Cold Spring Harbor.

three. At the Watson School, Caudy and her classmates went through three six-week lab rotations, a crucial facet of the educational experience at many other institutions, including the European Molecular Biology Laboratory in Heidelberg. Importantly, she says, the rotations were not open-ended, as in many programmes. Students can't fall into the trap of thinking that if they just stay a few more weeks, they will complete a task — then find themselves in the same place a year later. "The school works because of people like the dean, Lilian Gann, who are beating on you to drag you out the door at the end of your six weeks and get you to progress," says Caudy.

At University College London's four-year MRC-funded PhD programme in molecular cell biology, started in 1993, programme director Anne Mudge cites newly instituted lab rotations as a major improvement. In the previous system, studentships were allocated to supervisors, who were then matched up with students. "Students were sort of obliged to go to the person who had the studentship as opposed to being driven by interests," says Mudge. "Sometimes that matched up well, but sometimes it didn't." Programme graduate Nic Tapon, now at the charity Cancer Research UK, says the rotations provided insight into lab dynamics, and gave some sense of where he would be happy.

The Watson School pushes students, providing both an academic and a research adviser. Crucially, say Caudy and Gann, it is the school, not the student, that schedules thesis committee meetings with busy faculty members. "It saves time and aggravation," says Gann.

In part, though, the Watson School is able to stick to four years because it takes only a few students a year, and offers structured supervision so that they don't fall behind. Replicating that environment at larger universities may be difficult. Also, Watson's small class size can mean sacrificing some options; students' curricula are pretty well set. For instance, there is no maths department, so a student interested in statistics would have to either go without or look elsewhere.

Clark encourages students hoping for jobs and for fairly short graduate and postdoc experiences to opt for cutting-edge fields such as bioinformatics, nanotechnology or biodefence. Caudy, now a postdoc at Washington University in St Louis, got lucky: she chose RNA interference (RNAi). She started graduate research in 1999, just as the technique exploded on the scene, and she contributed to key RNAi papers.

PRESSURE TO PUBLISH

But shorter study means fewer publications, a concern for students in the job market. Mudge recognizes the difficulty of getting a solid piece of research done within four years. "Everything has to go well," she says.

In Europe, hanging around a lab for years is hard because the funding isn't there. And in some countries, other requirements complicate and lengthen the PhD process. In Finland, for example, PhD students must first complete a master's, which pushes the average time to a PhD to nearly eight years. Some Finnish scientists opt instead to do MD/PhDs even though they don't intend to practise medicine, because they can begin thesis research earlier than in an MSc. Students, postdocs and faculty members at a planning retreat for the University of Oulu's Biocenter last month agreed that four years is a good goal for a PhD — but wondered whether it is attainable, given the growing pressure to complete a PhD with more and better publications.

"Time will have to tell if it'd be better to stick around for another six months and have that next paper," says Caudy, who has segued into immunology as a postdoc at Washington University. "It'll be interesting to see in three to four years from now where people end up." ■

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