key piece of evidence. In his *Impact Médecine* article, he repeats the original Saint-Antoine Hospital diagnosis that the two patients died from herpes virus lesions, a condition common in AIDS patients. The immunological reaction to the vaccinia virus, he writes, can be explained by the presence of inactivated vaccinia virus in the area of skin where the patient was injected.

Although Zagury appears confident that his treatment is safe, changes were made to ensure that it was safer, according to Picard. In a radio interview on Europe 1, she conceded that the vaccine may be "dangerous to a patient who no longer has immune defenses.... This is the reason why as soon as the first accident occurred, we stopped all intramuscular and subcutaneous injections." Patients instead received the preparation by intravenous perfusion, while researchers sought to improve vaccinia inactivation methods.

Luc Montagnier, the Pasteur Institute researcher who discovered the AIDS virus, is worried by the research. He kept out of the controversy over Zagury's experiments in the past, but after hearing about the possible vaccinia infection he says he now believes that the experiments should be "interrupted forthwith." "We have carried out in vitro experiments that demonstrate the potential harmfulness of this virus when it is not opposed by the immune system," Montagnier told *Science*.

Montagnier stressed that his concerns are not influenced by past disputes between himself and Gallo, who coauthored the *Lancet* article with Zagury. Gallo's lab at NIH provided some reagents for Zagury's experiments and the genetically engineered virus was supplied by Bernard Moss of the National Institute for Allergy and Infectious Diseases. Moss, who says he had not been informed of the deaths by Zagury, had no part in planning or monitoring the experiments. For that reason, he says, he agreed to supply the vaccinia virus only on condition that "it was an official request from the French government and if the [NIH] Office for Protection from Research Risks would take responsibility."

The dangers of giving live vaccinia to immunodeficient individuals were recognized when the virus was used in the smallpox vaccination campaign, says Moss, and Zagury had assured him that his technique inactivated the virus. But "if Zagury's patients really have developed vaccinia necrosis," says Moss, "you can surmise that Zagury's method of killing the virus was not effective."

■ ALEXANDER DOROZYNSKI AND ALUN ANDERSON

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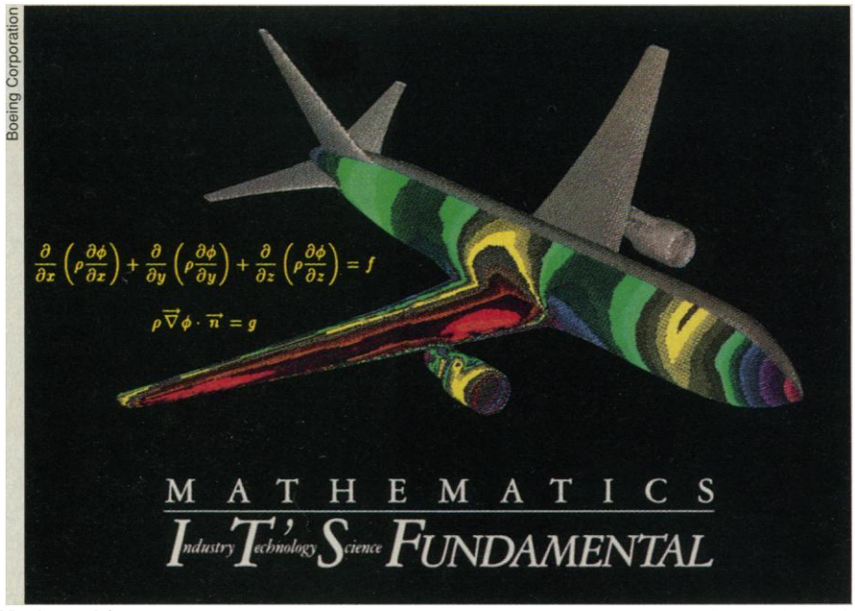

Math problem. *Part of a poster to promote Mathematics Awareness Week, which is taking place this week; mathematicians with new Ph.D.s are most aware of the tight job market.*

Math Ph.D.s: Bleak Picture

MATHEMATICIANS ARE USING WORDS LIKE "disaster" and "catastrophe" to describe the academic job market this year for Ph.D.s in mathematics. Political and economic factors have conspired to create an apparent glut of applicants for a sharply reduced number of jobs. Departments have been flooded with applications, and some mathematicians are worried that hundreds of those job seekers may not find employment. And for a field in which fewer than 1000 new Ph.D.s and a comparable number of recent doctorates go on the job market each year, unemployment figures like that could be calamitous.

"It looks really bad," says Sheldon Axler of Michigan State University. In telephone interviews with *Science*, Axler and others paint a bleak picture of well-qualified Ph.D.s who would normally have had several offers by now but who have yet to get so much as an interview. "There are many, many people out there who are extremely talented... and aren't getting a nibble," says Paul Sally of the University of Chicago.

To be fair, the picture is somewhat clouded by a lack of hard information. Nearly all the news is anecdotal, spread by word of mouth. Even the American Mathematical Society (AMS), which collects retrospective data on the employment of new Ph.D.s, has no hard evidence. "It's hard to get the data," admits executive director William Jaco, who adds that his organization is scrambling to survey the current market.

But the anecdotes are at least consistent. While there are pockets of hiring—the Berkeley math department, for example, is doing a normal amount of hiring—many other schools that would ordinarily be looking to fill several positions have only one or two, and some have none at all. Much of this is due to budget crises that have put a damper on hiring at state universities from Massachusetts to California. Many private schools also find themselves financially strapped by the current recession and reduced enrollments.

On top of this is an unexpected influx of mathematicians from the Soviet Union and Eastern Europe, as well as a large number of Chinese students now looking to remain in the United States. The Russians are a special strain on the market. As many as 300 have sought employment in the United States in the last 2 years. Many are at the very top of their profession, making them too attractive for math departments to resist. Some schools have hired one senior Soviet at the cost of two junior positions.

Another part of the problem is carry-over from last year. Although nearly everyone on the market then wound up with a job—the AMS survey of the 1989-90 crop of Ph.D.s shows a normal unemployment rate of aprroximately 2%—many took less-than-desirable 1-year positions, putting that many more people on the market this year.

Some students have simply opted not to graduate this year. "We quite deliberately allowed a number of our students who could have finished this year to take a sixth year rather than go on the market," says Peter May, chairman of the mathematics department at the University of Chicago. "We

Mathematician, Heal Thyself

It happens something like this: employer X makes an offer to applicant A, who would rather work for employer Y; Y, meanwhile, has made an offer to applicant B, who, naturally, would rather work for X. Unless the employers insist on immediate answers, the upshot is a kind of gridlock in the job market.

Reports are that the mathematics community, which has faced this quandary annually, feels that this year is especially bad. Sort of like Rio at rush hour, almost no one is getting where they want—not quickly, anyway. Donald Lewis, a mathematician at the University of Michigan, would alleviate the annual suffering of applicants and employers alike. Writing on the job market in the April issue of the *Notices of the American Mathematical Society*, Lewis suggests a method for rationalizing at least part of the hiring season.

Lewis proposes that the AMS run a matching program for university postdocs and fellowships provided by the National Science Foundation and other institutions. "Many new doctorates will not consider other offers until the postdoctoral competition is over," he writes. Filling those positions in mid-February would expedite the rest of the academic hiring season.

Lewis' proposal has two things going for it. First, it's a method the medical community has used for nearly 40 years in what's now called the National Resident Matching Program (see *Science*, 14 December 1990, p. 1524). Second, it involves a surprisingly nice mathematical problem known as the stable marriage problem.

In its simplest form, the stable marriage problem goes like this: the mathematician must assign an equal number of men and women to mates, each of them having first ranked his or her possible partners in order of preference. The overall result of all this matchmaking is considered unstable if there is any pair who prefer each other to the partners they've been assigned. That would be unstable because it stands to reason that such a couple would leave their assigned partners in the lurch, destabilizing the neatly matched pairs.

At first glance it might seem that achieving a stable matching—in which no one's wayward glances are reciprocated—is impossible. But, surprisingly, stable matchings do exist: It is possible to find overall pairings in which all partners are satisfied. The second mathematical surprise is that it's not necessary to sort through all possible matchings to find one that's stable. There are algorithms that work much more quickly.

That's extremely important when what's at stake isn't just *Seven Brides for Seven Brothers* but an entire job market. Even with just 10 couples, there are more than 3 million possible matchings; for 100 couples the number is astronomically large—and by the time you get to 1000 couples, even astronomical numbers begin to look tiny.

So how does math come to the rescue? One possible algorithm begins when each "man" (who could be a potential employer) proposes to the "woman" (a job candidate, say) at the top of his list. Each woman who has received a proposal tentatively accepts the best offer and sends notice to all men lower on her list not to bother her in the future. The process then repeats, with each man who is not currently engaged proposing to the woman at the top of his now-edited list, and the women responding as before. In particular, a woman can break an engagement if a better offer comes along. The process necessarily terminates, because the men propose at most once to each woman. The result is stable because each man has, in effect, been rejected by all women on his list above his final partner. One nice thing about this system is that all it requires is a preference list from each participant.

And indeed, with suitable modifications, this is the algorithm used by the National Resident Matching Program—with hospitals taking the men's role. That's significant, because the algorithm favors the men in a surprising way: Each man winds up with his best possible partner among all stable matchings, meaning that no man ever has any reason to suggest any other way of solving the problem. That's not true of the women, who would prefer that *they* do the proposing. This asymmetry has been a source of controversy in the medical community, but it's not surprising that the hospitals have kept the upper hand.

Mathematicians have been trying to resolve this dilemma by mapping out a middle ground between the "male-dominated" algorithm and its "female-dominated" counterpart. In 1985 Robert Irving at the University of Glasgow, Paul Leather at Salford College of Technology in England , and Dan Gusfield at the University of California at Davis came up with an efficient algorithm that produces a stable matching with a minimum amount of total "dissatisfaction." (Each person's dissatisfaction is measured by how far down his list his partner is.) However, even this algorithm has one version that favors the men and another that favors the women. A truly egalitarian stable matching would minimize not only total dissatisfaction but also the difference between the men's and the women's dissatisfaction. Such a matching must exist but, Gusfield notes, there is as yet no efficient algorithm for finding one.

It remains to be seen whether Lewis' proposal will catch on with mathematicians as it has in the medical community. But with more and more mathematicians groaning over headaches in the job market, a dose of algorithmic matchmaking could be just what the doctor ordered. ■ **B.C.**

don't know that it'll be better next year, but it does seem rather unlikely to be worse."

Meanwhile, departments have been deluged with applications: 500 at the University of Chicago, 700 at Penn State, 850 at Michigan State, and a mind-boggling 1800 at UCLA—where a hiring freeze only thawed out in late March (even so, UCLA has permission to hire only 3 or 4 temporary positions, instead of the 8-10 positions originally anticipated). The huge number of applications—a result of combining desperation with word-processing capabilities—has put a heavy burden on departments' screening processes.

Indeed, the ratio of applications to job openings is one area in which the AMS, which runs an annual employment register, does have some firm figures. The ratio of applicants to positions in the AMS register has swung from 1:2 in the mid-'80s to nearly 3:1 this year: the number of applicants has gone from 214 in 1985 to 486 in 1991, while the number of positions has dropped from 444 to 166. However, the AMS register represents only a fraction of the job market, which includes nearly 1000 new Ph.D.s and a similar number looking for a second, third, or fourth job.

All this is at odds with forecasts of an impending shortage of mathematicians. The two are not necessarily contradictory, though. Most mathematicians expect the hiring pendulum to swing in the other direction in the next 5 to 10 years, as faculty hired in the '50s and '60s begin to retire. But that doesn't offer much comfort to all those newly minted Ph.D.s who are entering the market now. ■ **BARRY CIPRA**