

Protection Agency considers to be well-suited for testing for neurological toxicity because its nervous system is highly susceptible to toxic damage. The Duke researchers exposed the animals to the pesticides DEET and permethrin—chemicals meant to protect soldiers from malaria and other insect-borne diseases—and to an anti-nerve gas agent widely used in the Gulf War called pyridostigmine bromide, both individually and then in all possible combinations. The doses were equivalent to three times what Gulf War veterans should have been exposed to.

The symptoms the animals developed as a result of these exposures varied but were reminiscent of the headaches, fatigue, gastrointestinal problems, and other symptoms reported by the Gulf War veterans. While hens given just one chemical showed no ill effects, any two chemicals made them become weak, short of breath, and unable to fly correctly. They lost weight, stumbled frequently, and had tremors. And some of the chickens exposed to all three chemicals became paralyzed or died. Microscopic studies of the animals' nerves sometimes revealed swollen and damaged nerve endings, Abou-Donia says. Adds Haley: "There were not

only clinical effects, there were enzymatic and neurological effects."

The researchers hypothesize that the multiple chemicals overwhelmed the animals' ability to neutralize them. The enzyme butyrylcholinesterase, which circulates in the blood, breaks down a variety of nitrogen-containing organic compounds, including the three substances tested. But the anti-nerve gas drug, in particular, can monopolize the enzyme, possibly preventing it from dealing with the insecticides. Those chemicals could then sneak into the brain, causing damage they would not produce on their own, the researchers suggest.

The big question, of course, is whether something similar happens in humans exposed to the Gulf War chemicals. In fact, earlier studies had not found nerve damage in ill Gulf War veterans. But recently, Goran Jamal of the University of Glasgow, Scotland, using more sensitive tests, has found subtle differences in nerve function between unaffected and affected individuals, evidence that has convinced Spencer that his group should also start looking for these changes. Spencer cautions, however, that there is currently no way of telling whether those

changes are due to Gulf War chemical exposures: "We have no idea whether symptomatic subjects had special exposure, or any exposure, to pyridostigmine bromide."

To pin down any link between multiple chemical exposures and Gulf War symptoms, Haley, Thomas Kurt, also of Southwestern, and their colleagues have examined Gulf War veterans themselves. In the first phase of the work, they devised comprehensive surveys, including both a detailed questionnaire about Gulf War chemical exposures and symptoms, and found a psychological test to assess if any of the symptoms the veterans report might have a psychological, instead of a physical, basis. They then performed extensive neurological tests on 26 individuals who met their criteria for Gulf War syndrome, as well as on 20 controls, to see if they showed signs of the same kind of damage the chemicals induced in the chickens. If the work pans out, it could provide some consolation for Gulf War veterans, who have long been dismayed by a lack of explanation for their problems. But it would also be a sobering finding for agencies that regulate toxic substances.

—Elizabeth Pennisi

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## MICROBIOLOGY CAREERS

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### ASM Report Sees a Mixed Future

With federal research budgets shrinking and managed care squeezing medical costs, graduate students planning a career in biomedicine would be justified in wondering whether they are likely to find any jobs. Now one group of graduate students—microbiologists—and their future employers and educators have at least some idea of the employment prospects in their chosen field.

After a year-long effort, the American Society for Microbiology (ASM) this week released the first firm data on future demand for microbiologists: a survey of 1849 employers of microbiologists—from medical centers, clinical laboratories, and pharmaceutical companies to food manufacturers, universities, and government agencies.\* Employers were asked to assess job prospects in their field over the next 3 years. Their answer: Yes, there is a future in microbiology, but not necessarily the future that microbiologists-in-training may have envisioned. And that, in turn, may have implications for the training programs themselves.

The good news is that overall, the number of doctoral-level jobs for microbiologists is projected to grow at a rate of 6% annually. "This certainly goes against the [conventional wisdom] about the need to downsize

Ph.D. programs across the board," says Gail Cassell, chair of microbiology at the University of Alabama, Birmingham, and a past president of ASM. The caveat is that much of the growth will be in nontraditional positions, outside the basic research arena, and students today are not always receiving training for the kinds of jobs that will be most widely available.

For some, this will mean jobs teaching in undergraduate and community-college classrooms; for others it will mean positions in such fast-growing biotech disciplines as molecular immunology, bioremediation, industrial microbiology, and anti-microbial chemotherapy. Industrial employers were most bullish about employment prospects, with 57% forecasting increased hiring, but they also told the surveyors that future hires must be more flexible and less specialized in their abilities than their predecessors were.

By contrast, employers in clinical-medical centers and the government forecast more belt-tightening ahead. They predict that the type of bench research most familiar to experienced microbiologists will not be expanding very much in the immediate future. In addition, more than half the jobs likely to emerge outside industry will be postdoctoral fellowships rather than permanent jobs. Indeed, despite the study's relatively sunny outlook, ASM found that 68% of academic managers surveyed said their

students were encountering difficulty in finding a job.

The shift toward industry, some observers say, is a double-edged sword. ASM officials are pleased to see industry picking up the employment slack just when it's needed most. But some worry about putting all their eggs in one employment basket. Says Rockefeller University virologist Stephen Morse, "While the biotech sector is a good thing, I personally worry about how sustained it will be, because it's highly dependent on the interest of venture capitalists and chance events. If it's blown off course—and that could happen at any time—we would have to change our rosy view."

Still, despite the worries, the shift in job patterns means that the universities training future microbiologists may have to revise their programs, says John McGowan, director of the division of extramural activities at the National Institute of Allergy and Infectious Diseases and a participant in some of the survey's focus groups: "Scientists training young researchers need to recognize that not all students should go into the kinds of research posts they traditionally might have." But he adds there's no point in trying to fight the employment trends. "Science, like Wall Street, is a smart market," McGowan says. "People move to the jobs."

—Louis Jacobson

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\* The survey results will be available after 1 May on the ASM home page (<http://www.asmta.org/pasrc/empoutlk.htm>).

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