

with backgrounds in plant sciences or engineering, are solving such problems as how to minimize the use of herbicides to kill the leaves on potato plants, a procedure that will soon be prohibited by law throughout Europe. Other projects include ways to remove sugar beet from the ground mechanically without the accompanying soil; closed greenhouse systems for automated nutrient and water application; and robotics systems for picking cucumbers and tomatoes.

Academic research can plug some of the gaps left by the drive for industrialization. Jean Dénarié, director of research at the Laboratory of Molecular Biology of Plant-Microbe Interactions in Toulouse, France, is eager to point out that "the use of plant science to develop sustainable and ecologically sound agriculture is not always linked to the development of an industrial agriculture". For example, says Dénarié, white clover is a useful nitrogen-fixing plant to sow in pastures, but the market for these seeds is small and companies are not interested in developing or selling the product. Dénarié's institute receives funding from CNRS, the national basic research organization, and from INRA, France's applied agricultural research organization, which supports a diversity of research projects in agronomy. This is in contrast to the United Kingdom, says Dénarié, where he believes "the complexity of agriculture" receives insufficient attention due to overemphasis on genetic engineering and industry-oriented biotechnology.

"In plants, the study of signal transduction is in its infancy... this field should develop very strongly in the coming years", says Dénarié, particularly where such studies are coupled with genetics. This research could also be of huge benefit to medicine, because "plants have an incredible ability to synthesize a huge collection of secondary metabolites, such as potent antioxidants, flavonoids and alkaloids" whose synthetic pathways we do not fully understand but which are useful as therapeutics.

As the result of an initiative by the German federal government to sponsor technology-transfer programs in Cologne, Munich and Heidelberg, Heinz Saedler, acting director of MPIZ, is in the fortunate position of planning new plant research activities. He predicts the importance of "a more delicate analysis of developmental processes and the gene networks controlling them", for which researchers will need to generate "four-dimensional databases" of gene expression in space and time.

Since the late 1980s, Spain has been setting up national biotechnology centres, which include plant research. Angel Mingo-Castel of the Public University of Pamplona is setting up a centre, and describes the familiar problem of trying to attract well-trained PhDs when he is unable to offer permanent contracts. Graduates with degrees in subjects

such as plant biochemistry could alternatively look for positions in industry, but although there are new biotech companies in Spain, very few of these are involved in plant science. However, Mingo-Castel predicts that they will appear in the next five years, because researchers are producing work that needs to be taken to the market: "the technology has to go somewhere". □

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Off-track careers

Ehsan Masood

You've got your PhD, and maybe a year or two of postdoctoral experience. Its decision time. Do you aim for traditional posts at academic institutions, look for the relatively lucrative pastures of the private sector, or even beat a path into the world of entrepreneurship? Many of the traditional employment categories are disappearing fast, opening up new, untried avenues for scientists.

The choice between industry and academic institutions, for example, is no longer a straight question of fertilizer company versus university laboratory, 'boffin' versus 'business'. The just-defeated Conservative government in the United Kingdom was particularly keen to encourage scientists to venture into the world of business through schemes such as 'Biotechnology Means Business' and 'Crusade for Biotechnology', organized by the Department of Trade and Industry in response to a long-held concern that Britain needs to learn how to capture the economic benefits of its research. The government was aware that scientists have ideas but lack commercial training (see *Nature* 381, 635; 1996). Last year it launched a £7 million (\$11 million) scheme offering advice and professional guidance on setting up small businesses.

If business is not your cup of herbal tea, yet you want something different from working in a European laboratory and don't mind taking a pay cut, you might want to head east. Most developing countries are actively engaged in plant-science research, though with a bias towards agriculture. India, Israel, Egypt and Pakistan all have strong plant-sciences sectors.

An alternative is to approach the Consultative Group on International Agriculture Research (CGIAR), an international network of research centres organized by the World Bank in Washington, DC. The CGIAR centres were set up 25 years ago with the bold aim of helping to remove world hunger. They were at the centre of the 'green revolution' of the 1970s, when research and production of high-yielding varieties of crops, together with the liberal use of chemical fertilizers and pesticides, went some way to staving off food shortages.

Individual centres were located according to specific regional needs: for example, the International Rice Research Institute was set

up in the Philippines, the International Center for the Improvement of Wheat and Maize in Mexico, the International Crops Research Institute for the Semi Arid Tropics in Andhra Pradesh, India, and the International Center for Agriculture Research in the Dry Areas in Aleppo, Syria. Heinrich von Loesch, a spokesman for the CGIAR in Washington, says that employment information is posted on individual centres' Web sites, which can be accessed through the CGIAR main site (see Table 3).

Recently, however, the centres have become the subject of controversy. Increasing donor fatigue led last year to a long-awaited restructuring, which resulted in considerable redundancies, particularly to local auxiliary staff. Under the restructuring, centre funding is no longer guaranteed, depending more on the quality of projects that a centre can offer. Though this has drawbacks, it does favour those who can come up with relevant, practical yet innovative research projects.

The centres continue to attract opposition from environmentalist groups, who argue that high-yielding crops contribute to soil degradation. Environmentalists believe that the use of vast quantities of fertilizer is an outmoded method of cultivation. One long-standing critic of the CG system is the organization Genetic Resources Action International (GRAIN), based in Barcelona.

Organizations such as GRAIN, Greenpeace, and the World Wide Fund for Nature are useful examples of a third off-track destination for plant scientists: environmental groups. With the increase in the public profile of issues such as biotechnology in agriculture and native intellectual property rights, environmentalist pressure groups are keener than ever to employ 'experts' for scientific advice.

Duncan McLaren, senior research coordinator at Friends of the Earth, routinely employs PhD-level scientists, either on the campaigns staff or to prepare briefing documents for lobbying local and international environmental meetings. However, he points out that applicants with some background in environmental campaigns are preferred, as most of the work involves strategic planning and literature reviews rather than research. In addition, a thorough understanding of the research process is more of an advantage than a commitment to a narrow subject. "We rarely carry out primary research. But we need people who can understand the relevant literature."

Helen Wallace, head of science at Greenpeace, says that science in her organization is not an open-ended affair but is used to back up campaign messages. "In our campaigns against the release of genetically modified organisms into the environment, we benefit from the input of scientists who know that genetic manipulation is not precise, and are concerned that the risks of genetic pollution cannot be predicted". □

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