Applying Biotechnology to Entomology

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We polled our entomological colleagues at several universities regarding both the current and anticipated uses of biotechnology in their field. The applications that we found would not be surprising to most researchers and will not be cataloged, however, an interesting observation was that productive scientists in every field of entomology, regardless of their age, saw a major impact of biotechnology on their discipline. It is safe to predict that the impact of the new biology on entomology will be enormous.

Administrators often wonder what biotechnology is. A common misconception is that there is one biotechnology, when in fact there are many biotechnologies. When one only addresses procedures involving nucleic acids, a vast array of technologies are available. However, even if the restriction endonucleases, ligases, and other instruments of nucleic acid surgery had not been discovered, application of other discoveries still would have made this the decade of biotechnology. Even the development of hybridoma technology could fully occupy scientists in finding applications in entomology. Biotechnologies have not arrived singly. Like a child in a candy store, today's entomologist is dazzled by the near simultaneous arrival of a variety of new tools from DNA cloning through in vivo nuclear magnetic resonance. These tools not only can be used individually but also can be combined synergistically with each other and with older approaches to address problems in every aspect of entomology.

Acquisition of Positions in Entomology Departments

Al Boyce (entomologist and chancellor emeritus of University of California, Riverside) and Richard Southwood (entomologist and current vice chancellor of Oxford University) have described a window of opportunity for the acquisition of new talent in a university. This opportunity certainly exists in industrial and governmental settings as well. The biotechnologies present such a window of opportunity for courageous administrators to attract additional personnel and resources for biological research. Such an investment in new biology can be justified easily by both short- and long-term goals in governmental, industrial, and university research. The obvious importance of biotechnology to our profession presents a rare opportunity for entomology departments actually to expand. This opportunity must be pursued aggressively.

Unfortunately, far too many administrators have failed to engineer new resources and instead have depleted personnel in older disciplines in order to staff and support the new biotechnologies. These administrators could then point with pride to their accomplishments in increasing strength in biotechnology. These individuals should not be commended for such reorganizations because they missed the entire point of the revolution in biotechnology, seriously hurt our research efforts, and missed an opportunity to revitalize our diminishing national strength in research and development. Their major accomplishment has been in strengthening their own résumés. Rather than replacing existing disciplines, the new technologies will speed advancement in these disciplines and dramatically increase their value. Nowhere is this more clearly demonstrated than in systematics. For the first time it is possible to market the tremendous value of biotic diversity. The value of bionomic and even taxonomic descriptions of this diversity can be demonstrated in terms that even state and federal legislators can understand. However, throughout the world we see positions in classical biology vanishing as administrators congratulate themselves on reorganizations that advance biotechnology. At a time when we can exploit biodiversity in terms of clear improvements in the quality of life, it is disappointing that both this diversity and the scientists capable of describing it are vanishing at an alarming rate.

This problem becomes more intense as peer reviewed research funds become more limited. The resulting increased competition makes high technology projects more attractive. This leads to biotechnologists not wishing to tarnish their proposals by integrating their skills with old technologies.

Role of Entomology in Development of Biotechnology

Insects as Models. Not only will the biotechnologies influence entomology, but entomology has and will play a major role in the development of these technologies. The same advantages of insects that have made them such marvelous model systems for studies in other disciplines certainly apply in biotechnology. As entomologists and members of entomology departments, we must further our contribution to the development of these technologies that we are using and realize that we have an obligation to these new scientists in our midsts.

Location of Insect Biotechnologists. If insects are but models of processes, then why should a scientist specializing in biotechnology be housed in an entomology department? Certainly there is a strong argument for placing individuals interested in similar technologies or fundamental processes together so that they can utilize common equipment and share ideas. There clearly is a need for scientists using insect models to be in technology-oriented molecular biology departments. In contrast, Berta Scharrer has shown that creative ideas come from a diversity of input. Therefore, there also is a strong justification for individuals with skill in the modern biotechnologies to be placed in entomology departments. Arguments about which approach is correct are foolish, for both approaches are important and will yield different scientific benefits. There clearly is a need for scientists who are aware of the new biotechnologies in entomology departments, in addition to scientists who work in technology centers. However, when such people are placed in entomology departments, the administrative commitment of resources, as well as convenient access to specialized libraries and equipment, must be made.

Intellectual Obligation to the Biotechnologist. Biotechnology positions often are sold on the basis of their perceived service to more applied aspects of agricultural research, but it should be realized that the biotechnologies deserve development for their own sake and that individuals engaged in this work may benefit from association with entomologists. The concept of service is well ingrained in many disciplines within entomology departments. Just as we have tolerated or even encouraged entomologists with a crop orientation to have a professional hobby in systematics or ecology, we should understand that some of our new colleagues in biotechnology may delight in a hobby in areas such as developmental or reproductive biology.

Insect biochemists often complain that their contribution to biochemistry is ignored. In part, this is our own fault for not indicating what fundamental principles of biology are addressed by our results

and referring only to insects as a final target rather than a model. We also suffer from publishing only in journals through which we communicate with each other and not with wider disciplines. To acquire recognition in biotechnology, the biotechnologist will have to publish in journals outside of the normal sphere of entomological readership. Entomology departments must support such endeavors and give adequate credit for this through promotions.

Research Support for Biotechnology. Another common administrative error mentioned above is to place biotechnology positions in entomology departments without support. There is the concept that a genetic engineer in a plant pathology or entomology department can exist with fewer facilities than one in a biochemistry department. The situation is, in fact, quite the opposite. The new scientist will lack access to equipment justified by teaching biochemistry courses and to equipment that is shared. If there is not ready access to this equipment, the new scientist will not be able to attract grant support or students. The scientist may also find that remaining in an entomology department is professionally expensive, because he will effectively pay higher overhead than scientists in technology-oriented departments who can share maintenance costs and have a tradition of some overhead return from federal grants. Biotechnologists in entomology departments will have an even greater need for centralized campus facilities supporting peptide sequencing, hybridoma production, oligonucleotide synthesis and sequencing, and support of high resolution nuclear magnetic resonance and mass spectrophotometry than individuals in more homogeneous departments. Thus, administrators who are successful in placing biotechnologists in production departments have an obligation to ensure that adequate resources are available for these individuals. Certainly, depletion of existing entomology budgets is not an adequate way to fund these exciting, but expensive, new technologies. Colleagues in entomology must realize that the new faculty member is paying a professional price to be in an entomology department. The intellectual stimulation must more than offset this price, or the faculty member, and perhaps the position as well, will vanish.

Hiring a Biotechnologist in Entomology. With the great diversity of both of the technologies now at hand and entomology problems to address, it is not possible to say what kind of person should be hired in an entomology department as a biotechnologist. Obviously, the concept that the administrator's duty is done when there is one molecular biologist in each production department is wrong.

Although we cannot define the type of biotechnologist most suited to work in an entomology department, there are several clear errors to avoid. The first error occurs when a department hires a technologist rather than a scientist. In the past, departments have made the error of hiring narrow experts in electron microscopy or computer technology, only to find that the field quickly passes such people by. Thus, it is important to hire a scientist rather than a technologist. A second common error occurs when current faculty see the new faculty member as a person to solve some aspect of their own research problem. Certainly, collaboration is hoped for and local expertise will make it easier for existing faculty to make use of the new technologies. However, if hiring is based on such considerations, the department will either have acquired an expensive technician or a young faculty member who shortly will move on. People must be hired because their own research interests are considered to be of long-term benefit to the field of entomology and to the department.

Conclusion

The biotechnologies often are sold on the basis of providing apparently simple solutions to highly complex problems. The prospects of transferring pesticide-resistance genes to beneficial insects, of developing genetically engineered plants that repel phytophagous insects, of engineering viruses that replace chemical insecticides, of making kits that tell a predator's previous meal or the presence of a pesticide, of causing mosquitoes to disdain human blood meals, and of developing blots that define phylogenetic relationships, are all possible. In glossy print in a company portfolio, these possibilities may raise venture capital or acquire a new academic position, but they will not become reality without a major intellectual and financial investment. Even when such glamorous goals are achieved, they certainly will not solve the major problems in insect resistance, crop protection, ecology, medical entomology, and systematics. There are certain to be dramatic individual successes. The most exciting practical success of the next decade undoubtedly cannot be anticipated. However, far more exciting than these potential glamorous accomplishments will be the tremendous advances in all aspects of entomological research that these technologies allow.

It is certain that a decade from now, practitioners of the new biology will be faced with the charge that they were hired to provide solutions, and like previously hired biologists, they instead are only

providing more fundamental information. Just as before, this fundamental information will be their major contribution. Yet there has been a major change. With support of the biotechnologies, advancement in all fields of entomology will be faster than ever before. With an increasing ability to apply fundamental knowledge to practical problems in a timely fashion, the period between fundamental discovery and practical application will be shorter and shorter. Thanks to the revolution in biotechnology, never has there been a stronger practical justification for fundamental research in entomology.

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