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Degrees of Freedom

Biomedical scientists, whether they reach this editorial via the magazine's front cover or the advertisements at the back, are affected by the harsh reality of today's job market for biomedical Ph.D.'s. How do we fix a system that has created such scientific success but has produced many more Ph.D.'s than the market can bear? Many are demanding change in graduate education. I believe that graduate education in biology should continue to focus on the pursuit of scholarship and basic discovery. Before we change the system, the first step toward elevating the crisis should be to discard the prejudices that force too many Ph.D.'s to compete for dwindling resources and that fuel false expectations of job security.

Search committees are inundated with hundreds of applications for every available position, and young scientists watch even the best of their peers struggle to find jobs. Even a faculty position is no guarantee of funding, as the percentage of awarded grants slides to record low levels. In academic T.E. it is up or out, and principal investigator positions for all trained Ph.D.'s simply do not exist. Basic biomedical research resembles a great pyramid scheme, and latecomers have little chance of a payoff. Nonetheless, the supply of postdoctoral fellows and new graduates continues unabated and unrestricted by graduate programs, in part because these young scientists are needed to fuel the labor-intensive research enterprise and to teach undergraduates.

Although it is obvious that there are too many scientists and too few jobs, there persists a prejudice that Ph.D.'s who choose alternative careers to science represent a failure of the system and the individual. The stigma attached to those who publicly contemplate leaving the research track is a permanent one. In today's cutthroat job market, such a scientist's commitment is questioned and his or her potential to succeed is considered suspect. The job hunt becomes a one-strike-you're-out game, and that strike can be merely questioning the pursuit of an academic career—a sad irony, that given inquiry is so integral to the scientific method. Such prejudices are shortsighted and irresponsible in a constricting job market. For today's cohort of postdoctoral fellows and graduate students in biological sciences, a career outside basic research is not only an alternative but may be a necessity.

Those who leave research science with a Ph.D. should proudly wear that badge of intellectual and personal achievement. The well-trained Ph.D. knows how to rigorously pursue creative solutions to problems beyond the boundaries of existing knowledge. That skill can be applied to a myriad of careers that offer intellectual challenge and provide societal benefits. However, those who leave the womb of academia do not face a certain future. Scientific training does not teach the managerial and interpersonal skills that are so often needed to excel in other careers. It is a harmful prejudice to believe that leaving science is the easy alternative, even if the job of the average nonscientific professional may be more secure than that of the merely above-average scientist.

In the foreseeable future, only truly exceptional (and lucky) Ph.D.'s will find funded positions, and mentors must face the task of counseling fellows and students to seek careers outside academic science. If concern for students' quality of life is not enough motivation, there are selfish justifications for helping young scientists pursue other careers. First, it is in the best interests of those who remain in basic research to reduce competition for limited resources and jobs. Second, those who leave academic science are most likely to be its advocates through their involvement in academic science, science writing, business ventures, and political action. Today's Ph.D.'s and trainees who do not find jobs in basic research will be tomorrow's ambassadors and advocates of science. The graduate-level training of those scientists provides a very high rate of return on investment for biomedical science.

Prejudices emerge most strongly at times when stress and insecurity heighten a society's fears and misunderstandings. The dwindling resources and increasing competition in biomedical research have created such a time. When a student or fellow exercises his or her freedom to pursue different professional interests, it should not be seen as a challenge to the beliefs of those who have chosen to stay in basic research. Those who choose careers outside of science should do so with pride and with the support of their fellow scientists.

Don S. Doering

Don S. Doering received his Ph.D. in biology in 1992 and is now vice president of AquaPharm Technologies Corporation in Columbus, MD.
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Changing Priorities?

We as a nation need to reconsider the respective roles and relationships between national laboratories and research universities during this period of changing national priorities and shrinking financial resources.

I regret that this message did not come through clearly in a news item in which I was quoted (ScienceScope, 26 May, p. 1119). My comments were part of a discussion about the future of the American research enterprise—including research universities, national laboratories, and industrial laboratories—during a 2-day strategic planning meeting of the National Science Board (NSB).

While national Department of Energy laboratories such as Argonne, Brookhaven, and Oak Ridge do cooperate with research universities, their primary focus traditionally has been strongly influenced by their particular national missions. As these missions have shifted and their centrality to the national agenda has diminished, the future of many of these laboratories has become a subject of national concern and debate.

At the NSF planning meeting, I suggested that the primary missions of several of these national laboratories might be redefined to enlarge their extent to which the national laboratories serve as the focal point for large-scale, interdisciplinary, cooperative research by research universities. Fermilab is an excellent example of a high-quality federal laboratory whose primary mission is to support the basic research of university-based scholars. During a time of constrained resources, we need to consider if other national laboratories could enhance their collaborative roles. Without such strategic discussions, there are those who fear that many of these laboratories will shift their missions, becoming direct competitors with research universities for limited research dollars rather than stronger partners in the research enterprise.

James J. Duderstadt
President, University of Michigan, Ann Arbor, MI 48109–1340, USA

In the ScienceScope item “National labs up for grabs?” an opinion is advanced that the Brookhaven National Laboratory (BNL) has outgrown its original purpose of “designing nuclear reactors” and that it could make a major basic research contribution by being aligned with a coalition of universities dedicated to performing basic research and training of scientists.

BNL is, and always has been, aligned with a group of universities, it is making major basic research contributions, and it does a heck of a lot more than designing nuclear reactors. For instance, it operates the National Synchrotron Light Source and it is building the world's largest nuclear physics facility (a relativistic heavy ion accelerator) for basic research.

Associated Universities, Inc. (AUI), founded nearly half a century ago by a consortium of universities to establish BNL, has operated the laboratory in exemplary fashion since that time. Under its charter, AUI is committed in all areas of science to plan, develop, construct, operate, and manage large-scale research facilities that fulfill a national need and serve the scientific community. It is also responsible for the development and maintenance of research programs of the highest quality as well as for the education and technical
training of research personnel and students. The active AUI Board of Trustees, which oversees AUI and the laboratory, has been drawn almost exclusively from university scientists and administrators. At present, the board includes two Nobel Laureates, four National Medal of Science awardees, and many scientists who have received prestigious awards for their research. The members of this distinguished group have given freely of their time and energy because of the high quality of the scientific work being carried out at the laboratory. Also, AUI reaches out to a broad community of active scientists to review (on an annual basis) the quality and progress of its programs at BNL.

BNL, of all the multidisciplinary national laboratories funded by the U.S. Department of Energy, has an unmatched history of interactions with, and service to, the university research community. At present there are more than 4250 research guest users and collaborators associated with the laboratory.

**Ernest M. Henley**  
Chairman, Board of Trustees,  
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**Nuclear Waste Storage at Yucca Mountain**

Regarding the News & Comment article "Blowup at Yucca Mountain" by Gary Taubes (30 June, p. 1836), geologic storage originally was conceived for the storage of wastes from the fission process, not for the fissile material itself. In most of the world this is still the envisaged goal for geologic storage. However, in the 1970s, the United States decided to put not just the remnants of the fission process underground but also the spent fuel, which contained plutonium. Geologic storage also is being considered for the permanent disposition of large amounts of highly enriched spent uranium fuel from research reactors and national defense reactors. More recently, the Department of Energy (DOE) has been considering geologic storage of the many tons of weapons plutonium from the weapons stockpile reductions as well. Our paper, discussed in Taubes's article, does not attack the geologic storage of all types of nuclear waste at a site such as Yucca Mountain; it addresses the criticality safety of storing fissile material that originally was not intended to be present.

Upon finishing the first draft of our paper, we felt the need for external feed-

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initial emplacement site after the containment is breached. It seems to us that repository designers are acknowledging the possibility of dispersion by including heavy metallic containment around the waste and by debating its thickness in the context of required containment time. Containment breaching followed by dispersion is one of nature’s inevitable steps, which Art Forster referred to as “miraculous.”

The article includes a statement by National Academy of Sciences staffer Matthew Bunn implying that the validity of our paper probably cannot be proved one way or the other, but that the paper nevertheless does political damage. We believe that the possibility of positive feedback for wet and dry systems is readily amenable to analysis and definitive conclusions and that the yield from such systems also can be calculated to at least a factor of 10 and probably a factor of 3. If consensus cannot be reached by analysis, experiments to resolve the issues also are possible.

The position of Los Alamos and Livermore that the study of low-probability underground supercriticality incidents with substantial yield is irrelevant and unimportant contradicts the process of establishing standard practice criteria for dealing with low-probability accidents involving nuclear material in other contexts. An important, well-established criticality requirement for nuclear weapons design is that of one-point safety. This means that if an implosion were to be initiated at a single point rather than uniformly around the fissile material, the nuclear yield would be negligible. For nuclear reactors, we have the requirements of negative reactivity temperature coefficient and negative reactivity coolant void coefficient. All modern reactor designs and most operating reactors adhere to these criteria. An exception is the Chernobyl reactor design, for which the negative coolant void coefficient criterion was ignored. For geologic storage, we have no such criticality guidelines. Because our paper identifies criticality dangers not recognized before, such as dry and wet positive reactivity underground, and points out the substantial nuclear yield possible, we believe it should become part of the basis for establishing the criticality criteria which would be required for geologic storage of fissile material.

At present, the only criteria are that the $k_{\text{eff}}$ criterion will be lowered considerably, (ii) that the possibility of positive feedback will not be acceptable, (iii) that the 10,000-year limit will be removed, and (iv) that the addition of neutron poisons to control criticality will only be employed with caution because of the possibility of separation of poison and fissile material as different chemical species.

Charles D. Bowman
Francesco Venneri
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Notes
1. The effective operating constant ($k_{\text{eff}}$) is 1 for a continuous chain reaction, as in an operating reactor. For $k_{\text{eff}}$ less than 1, the chain reaction decays away and is not sustained. For $k_{\text{eff}} = 0.95$, about 20 fissions occur before the chain terminates.

Malathion and Alternatives
The opening paragraph of the article “New compounds make light of insects” by Robert F. Service (Research News, 12 May, p. 806) describes spraying in Califor-

Here’s a handful of simple RESOURCES from Sweden.

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Uppsala, Sweden. (And the rest of the world)
nia with the insecticide Malathion in what we believe is a prejudicial tone.

The Malathion and bait mixture is applied as discrete droplets averaging more than 400 micrometers in diameter which fall directly to the ground. Two different California governors convened panels of outside health experts to review the use of Malathion and bait in urban areas. Neither panel identified any specific health risk associated with our use of the materials. Health reports (1) submitted to the program are reviewed by the California Department of Health Services. To date, they have not found any indication of increased health problems associated with the Malathion and bait sprays. The facts hardly describe a situation in which helicopters "spew dense clouds of a necessary evil," aside from the philosophical problem of defining "a necessary evil."

The California Department of Health Services and Food and Agriculture, the U.S. Department of Agriculture, and local health officials have been working together to allay the fears of citizens living within areas that have been sprayed with Malathion and bait as part of a fruit fly eradication program. Our goal is to provide accurate information about the program and to reduce the anxiety of the citizens. The California Department of Food and Agriculture has been funding research to find alternatives to Malathion for use in our fruit fly eradication programs since 1984, which is hardly "scrambling for alternatives."

We applaud the remainder of the article, which draws attention to an exciting new area of pest control research that is funded in part by our department. Whether the dyes phloxine B and uranine live up to their potential, the topic is drawing considerable attention and we should see usable results in the near future.

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Response: I am glad Chrisman et al. approve of the focus of the news article, which was on new pest control technologies. The drive for those technologies is fueled in large part by public dissatisfaction with Malathion, as documented in the news article. The article did not imply there was scientific evidence showing that Malathion was harmful to people, but instead reported that many Californians believe it to be a threat to people. That is the explanation of the phrase "necessary evil," which can be found in the second sentence of the article: "evil in the eyes of many Californians." Finding safe and effective alternatives to Malathion is also a process that takes many years. And though the authors are correct in pointing out that such efforts have been under way for years, to date no such alternative has been found.—Robert F. Service
Mutations Not Sufficient for Carcinogenesis?

In their report "Mismatch repair deficiency in phenotypically normal human cells" (5 May, p. 738), Ramon Parsons et al. report a subset of patients with hereditary nonpolyposis colorectal cancer who have a profound defect in mismatch repair and a consequent high mutation frequency in all tissues examined, yet who have few tumors. Parsons et al. point out that one interpretation of this observation is that mutations per se may not be sufficient for a high rate of tumorigenesis. A similar conclusion has been drawn from a consideration of the evidence for sunlight-induced skin cancer (1). The diseases xeroderma pigmentosum (XP) and photosensitive trichothiodystrophy (TTD) can arise from mutations in the same gene. Both types of patient have photosensitive skin, and their cells are indistinguishable in that they show pronounced hypermutability and hypersensitivity when exposed to ultraviolet light. Yet only XP patients exhibit the pronounced freckling and high incidence of skin cancer expected on the basis of a simplistic view of the somatic mutation theory of cancer.

Parsons et al. suggest that exogenous mutagens are carcinogenic because they kill cells and thus trigger active regeneration of tissues in addition to inducing mutations. This argument does not, however, explain the XP-TTD paradox, because hypersensitivity to cell killing (at least as measured in vitro) is similar in both diseases. Perhaps the time has come to look more rigorously at the evidence that mutation induction constitutes a rate-limiting step in carcinogenesis.

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References

Corrections and Clarifications

The news article "The culture of credit" by Jon Cohen (23 June, p. 1706) described the Nobel Prize-winning work of Phillip Sharp and Richard Roberts as the discovery of "gene splicing"; it should have used the term "split genes" instead. The third sentence of the caption for the diagram on page 1706 should have read, "After a gene is 'transcribed' into RNA (2), the regions corresponding to introns are snipped out (3)." The credit for that diagram should have noted that it referred only to the top panel of the diagram.

The Research News article by Wade Roush "Cell movement tale told by bacterial tail protein" (7 July, p. 30) should have stated that in experiments on the IcsA protein by Marcia Goldberg and Julie Theriot, the protein was expressed uniformly over the surface of a mutant Escherichia coli organism, not concentrated at one end.

In the Book Reviews of 7 July (p. 109), the caption accompanying the photograph of the sculpture of Albert Einstein on the grounds of the National Academy of Sciences should have noted that the sculptor was Robert Berks.

In the report "Strain-dependent epithelial defects in mice lacking the EGF receptor" by M. Sibilia and E. F. Wagner (14 July, p. 234), figure 1C on page 235 was printed incorrectly. The correct figure is shown below.

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chromophores in organelles of cells or of aggregates in sensor arrays.

Colloidal and aerosol systems are amenable to the use of RLS. For example, small metal particles have peaks in $C_{abs}$ and $C_{ext}$ at specific wavelengths; these peaks are not the result of absorption by the material but arise from naturally occurring electromagnetic resonances associated with surface plasmon modes. Information on particle size and shape can be obtained even in colloidal and aerosol systems containing particles of very different sizes or particles composed of different materials. Nor is the use of RLS restricted to the visible part of the spectrum; in particular, because many compounds have narrow infrared absorption bands, enhanced light scattering may also occur at these wavelengths. These possibilities are representative of the types of systems in which RLS may make an important contribution. The enhancement of Rayleigh scattering resulting from absorption is a very general phenomenon and therefore may provide important experimental opportunities in a wide range of areas.

REFERENCES


AAAS–Newcomb Cleveland Prize

To Be Awarded for a Report, Research Article, or an Article Published in Science

The AAAS–Newcomb Cleveland Prize is awarded to the author of an outstanding paper published in Science. The value of the prize is $5000; the winner also receives a bronze medal. The current competition period began with the 2 June 1995 issue and ends with the issue of 31 May 1996.

Reports, Research Articles, and Articles that include original research data, theories, or syntheses and are fundamental contributions to basic knowledge or technical achievements of far-reaching consequence are eligible for consideration for the prize. The paper must be a first-time publication of the author’s own work. Reference to pertinent earlier work by the author may be included to give perspective.

Throughout the competition period, readers are invited to nominate papers appearing in the Reports, Research Articles, or Articles sections. Nominations must be typed, and the following information provided: the title of the paper, issue in which it was published, author’s name, and a brief statement of justification for nomination. Nominations should be submitted to the AAAS–Newcomb Cleveland Prize, AAAS, Room 924, 1333 H Street, NW, Washington, DC 20005, and must be received on or before 30 June 1996. Final selection will rest with a panel of distinguished scientists appointed by the editor-in-chief of Science.

The award will be presented at the 1997 AAAS annual meeting. In cases of multiple authorship, the prize will be divided equally between or among the authors.
ures who are likely to be familiar to readers of the 1990s. We are treated to Golden’s en-
counters with many of the era’s key figures in
policy-making for weapons and national se-
curity—Blanpied thoughtfully provides brief
biographical sketches of them—including J.
Robert Oppenheimer, Vannevar Bush, Rob-
ert F. Bacher, James B. Conant, Lee A. Du-
bridge, Karl T. Compton, Theodore von

Golden’s investigation led him to write a
report to the President on 18 December
1950—Blanpied reprints the document—
that a new OSRD was not needed at the
moment, though Golden added that one
might be required in a future emergency to
provide a place for innovative scientists
who might devise radically new weapons
yet feel uncomfortable in a military organi-
ization. He urged that a different initiative
was required—the creation of a regular sci-
ence adviser to the president. Such a person
could bring civilian scientific expertise
more strongly to bear on problems of na-
tional defense and could initiate a new
OSRD should one become necessary. Partly
following Golden’s recommendation, Tru-
man, on 19 April 1951, established a Sci-
ence Advisory Committee in the Office of
Defense Mobilization, to provide advice not
only to the director of the office but to
himself on scientific matters, particularly in
connection with national defense.

Blanpied also reprints the memorandum
that Golden submitted, on 15 February
1951, concerning the new National Science
Foundation (NSF). Here Golden dealt in
part with the pivotal issue of whether the
NSF should conduct military research, an
activity that Vannevar Bush’s original plan
for the agency envisioned it would under-
take. Golden had discovered that the mil-
tary itself was already fostering an enormous
variety of research. He recommended that
the NSF stick to the strictly civilian task of
basic research and training. Policy-making
scientists agreed unanimously with that po-
sition, and the National Science Board
made it the NSF’s own.

Golden was a probing inquirer and lucid
summarizer, and one wishes that Blanpied
had published a broader range of his con-
versational memoranda. The memoranda
Blanpied has chosen to reproduce do illu-
minate the origins of the scientific advisory
system, but only in part. The omitted mem-
oranda reveal in often vivid detail the atti-
dutes toward defense research and civilian
scientists in various military agencies at the
time of the Korean War, including a resis-
tance to civilian experts on the part of
many military officers. They are not only
historically valuable; they also undergirded
Golden’s recommendation for a civilian sci-
ence adviser. What Golden learned about
the military’s resistance to civilian scien-
tists, not to mention about diversity and
competition within defense R&D, signifi-
cantly affected his conclusion that it would
be advantageous for a civilian scientist to
have the president’s ear.

Military possessiveness of research also
disappointed the early fortunes of the Na-
tional Science Foundation. Bush, along
with many of his colleagues, had expected
that once the NSF was created military
agencies such as the Office of Naval Re-
search would turn over the basic research
projects they were sponsoring to the care of
the new civilian agency. Golden endorsed
that expectation, but it quickly became
clear that the military agencies would not
likely cede any research projects (or mon-
ies) of consequence to the foundation. That
refusal, combined with the lack of new
resources for nonmilitary research during the
emergency, left the NSF with little to do
until after the war.

No matter for basic research and training:
Although before the Korean War many
academic scientists might have welcomed
transfers from ONR to NSF, after it most
did not. Defense R&D funding had skyrock-
eted during the conflict and continued ris-
ing after it. Most academic scientists be-
lieved, as did Lee DuBridge, the president of
the California Institute of Technology, that
Congress would not appropriate to NSF the
staple funds that it gave the military and
that their universities would “go broke very
promptly” if they had to rely on that (see
this reviewer’s “Cold War and hot physics:
space, security, and the American state,
1945-1956,” Historical Studies in the Physical
Sciences 20 [no. 2], 259 [1990]).

They are not going broke in the current
post–Cold War circumstances, but they are
worried. For better or for worse, since
World War II military considerations have
been crucial in science policy-making and
the science advisory system. Golden’s mem-
oranda provide a rich perspective on how,
during the Korean emergency, they figured
in shaping the future of both. The full set of
them can be consulted in three presidential
libraries, the Library of Congress, and the
Center for the History of Physics of the
American Institute of Physics.

Daniel J. Keeles
Division of the Humanities
and Social Sciences,
California Institute of Technology,
Pasadena, CA 91125, USA

Books Received

Atlas of Volcanic Landforms on Mars. Carroll
Ann Hodges and Henry J. Moore. U.S. Geologi-
U.S.G.S. Professional Paper 1534.


Publishers' Addresses

Below is information about how to direct orders for books reviewed in this issue. A fuller list of addresses of publishers represented in Science appears in the issue of 26 May 1995, page 1220.

AAAS Directorate for Science and Policy Programs, attn: Bonnie Cassidy, 1333 H St NW, Washington, DC 20005. Phone: 202-326-6600. Fax: 202-289-4950. E-mail: bcasdsy@aaas.org.


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A selection of articles published in 1994/1995

Herpes-Simplex-Virus-Infected Cells Produce a Protein that Binds to TAR DNA Region of the Human Immunodeficiency Virus Type 1 Long Terminal Repeat: Stahl, J.; Wilcox, K.W.; Pitha, P.M.


Role of Protein Phosphorylation in Regulation of Brain L-Glutamate Decarboxylase Activity: Bao, J.; Nathan, B.; Hsu, C.C.; Zhang, Y.; Wu, R.; Wu, J.Y.

Mechanisms of Tax Regulation of Human T Cell Leukemia Virus Type 1 Gene Expression: Franklin, A.A.; Nyborg, J.K.

Apolipoprotein E Genotyping in Turkish Myocardial Infarction Survivors and Healthy Controls: Hergenc, G.; Taga, Y.; Eremek, K.; Cirakoglu, B.

Differential Effects of Corticotropin-Releasing Hormone on Central Dopaminergic and Noradrenergic Neurons: Pan, J.T.; Lookingland, K.J.; Moore, K.E.

New Insights into the Structure and Function of the Thyroid Hormone Receptor: Cheng, S.Y.

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Total RNA was extracted from barley leaves, electrophoresed on duplicate gels, and transferred to S&S Nytran® for 1 hr using alkaline conditions in the S&S TurboBlotter overnight in 20X SSC upward transfer. The blots were hybridized overnight with a 32P-labeled HSP 186 cDNA probe.

Data courtesy of Dietlind Stapel, University of Hannover
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#### Antibodies
The protein kinase C (PKC) family plays a key regulatory role in a number of signal transduction pathways controlling a wide variety of cellular functions including cell proliferation and differentiation. Antibodies to PKCα, β1, β2, δ, and η are available. The Binding Site. Circle 138.

Monoclonal antibodies (mAbs) to PKC isoforms δ, μ, and η, for use in protein immunoblotting and other immunological techniques, have been added to a line of other mAbs to PKC isoforms. Transduction Laboratories. Circle 139.

A polyclonal antibody to the aryl hydrocarbon (dioxin) receptor can be used for immunoprecipitation and protein immunoblotting experiments. Affinity Bioreagents. Circle 140.

#### Ultracentrifuge
The Optima XL-100 Ultracentrifuge is capable of generating 802,400 × g at speeds up to 100,000 rpm. This high speed provides flexibility and versatility, allowing researchers to perform more separations in less time. The floor model ultracentrifuge operates with a wide variety of rotors. It has a vacuum-encased, balance-tolerant induction drive and intuitive microprocessor-based control. Its air-cooled drive replaces liquid refrigerants that are harmful to the environment. An advanced thermoelectric temperature control eliminates the need for a compressor, so the unit requires less power than conventional models. Beckman Instruments. Circle 141.

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#### Fluorescent Protein Gel Stains
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