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The Scientist, July 23, 1990

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The American Association for the Advancement of Science was founded in 1848 and incorporated in 1874. Its objectives are to further the work of scientists, to facilitate cooperation among them, to foster scientific freedom and responsibility, to improve the effectiveness of science in the promotion of human welfare, to advance education in science, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress.
The career path of a scientist in the 1990s may seem a high-wire act with a dotted-line future. Today's successful scientist walks a tenuous line between seeking security in an uncertain funding environment and taking risks in an age of speculative advances. He or she is asked to balance the competing tug of business and academe, of applied and basic research, of authority based on narrow expertise and utility based on multidisciplinary experience. Our special pull-out report on careers, beginning on page 1107, is meant to help scientists navigate their individual high wires. [Image by Guy Billout]

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Careers in Science

Woody Allen once said that a job is an invasion of privacy. To most scientists the invasion is welcome because scientists enjoy the challenges and stimulation of problem-solving. Indeed, it is fortuitous that society considers science valuable because the work of other creative professionals, such as artists, writers, and musicians, is in general not as systematically supported as that of scientists. The idyllic view of a career involving butterfly collecting or looking through telescopes punctuated occasionally with discoveries of the evolution of species or the origin of the Big Bang soon evaporate under the necessity of earning a salary and obtaining laboratory funding. Being a scientist can be lots of fun, but it requires hard work and is not free of anxiety.

To those who are embarking on careers in science and to those who in mid-passage are navigating through the straits that connect an old and a new vocation, this issue of Science presents a careers section that is designed to provide helpful information. The information is episodic and fanciful rather than comprehensive and conventional. By episodic is meant that we have made no attempt to cover every aspect of every scientific discipline and every job type of opportunity within that discipline. We have chosen to provide illustrative examples of jobs, salaries, areas of research, opinions of leading scientists, and guesses as to the hot areas of the future. By fanciful is meant that we present interviews and advice from practitioners of the art of science that provide anecdotal insight rather than tables of documentation, which are often provided in such career analyses. A brief reading of the advice of career scientists shows that there is no monolithic opinion on the straight and narrow path for a young scientist. The many choices of industry versus academia, of physics versus biology, of production versus research, will have to fit personal predilections, but the ideas of those who have been successful in their chosen paths can provide flashes of light that illuminate at least part of the landscape.

An interesting feature of modern careers is that they become more reversible. The flow between industry and academia goes both ways in this era. The flow among disciplines also occurs: physicists have become biologists, chemists may work with ecologists, and mathematicians are useful in all fields. The rapid pace of modern science means that few people today are doing exactly what they were trained to do when they completed their degrees. New instruments, new concepts, and new protocols make yesterday's training obsolete at an alarming rate. The number of scientists applying their powerful methodology to a problem means that problems get solved at breathtaking speeds. Consequently, the scientist of the future who already has a job must keep his or her eyes open for new opportunities. Hence new tools and hot tips are presented to illustrate these developments for individuals looking for new positions and also for those looking for a reorientation of a career.

Because this is the first of what we hope will be an annual event, we feel less prone to be comprehensive. What is left out this year (for example, there is greater emphasis on academia than on industry in this issue) can be balanced by a shift next year. To fill in these holes and to allow you to express indignation if your favorite area was not mentioned, we have included a questionnaire to be filled out by those who would like to help us supplement and expand our coverage next year.

In a tightening job and funding atmosphere, dark fears get exaggerated and inherently silly rumors are believed. Science is going through a tough period but the added information and insight of those who have lived through previous tough eras may be helpful to those who are starting out or changing directions at this point. As one veteran reported, "I have had many worries in my life and most of them never happened."

Despite current vicissitudes, a scientific career is unusually attractive. The rate of technological unemployment among scientists is extremely low, and job security is generally high. There is an enormous range in the type of jobs available, and in most cases the scientist's reward in psychic income is an incalculable fringe benefit. If this issue of Science can be helpful in guiding voyagers into the appropriate harbors, it will have served its purpose.—DANIEL E. KOHLAND, JR.
provide over its lifetime and compared it with two other cases. This seems reasonable because much of the argument is cast in terms of large projects allegedly consuming inordinate fractions of resources that otherwise would be dedicated to the support of individual scientists doing “small science.”

The Department of Energy baseline estimate of the cost of building the SSC is $8.3 billion in “as spent” dollars, that is, in dollars of the year in which they will be spent (1). In 1990 dollars (without escalation), the total is about $7 billion. Upgrades to the detectors over the lifetime of the SSC and additional foreign contributions to the detectors may amount to about $1 billion. If we assume that the SSC will operate for 25 years, the total annual capital cost in 1990 dollars may be taken to be about $320 million.

When the SSC is built, its estimated operating cost in 1990 dollars will be $300 million per year of operation. Let us assume that there will be about 2500 investigators involved every year for the 25 years. (By “investigator” I mean a scientist, generally at the Ph.D. level, who has a responsibility for devising and carrying out research, alone or in a group, and would be considered capable of writing proposals and accepting research funds.) The big detector projects already involve a total of about 2000 investigators continually, and a number of other projects involve small detectors and other experiments.

The salaries and benefits of the scientific investigators who will use the SSC are not included in the above operating and capital costs. We can assume that the average cost of salary and benefits for an investigator will be $100,000 per year in 1990 dollars. The figures lead to an estimate of $350,000 per investigator per year.

This rough estimate of cost per investigator per year is in the range of the equivalent numbers for the General Motors Research Laboratories (GMR), which operate with a budget (including capital expenditures) that over the past few years has been in the range of $185 to $155 million. During this period the laboratories have supported about 500 investigators, with cost per investigator per year in the range of $370,000 to $310,000. GMR is generally engaged in small to medium-small research; investigators work individually or in small teams. There is no equipment comparable in scale to a large accelerator, but there is occasional access, as required, to proving grounds, a large wind tunnel, and manufacturing facilities for tests.

In 1989, the total expenses of the Woods Hole Oceanographic Institution, less those for its education program and for ship refits undertaken on behalf of the National Science Foundation (NSF)—supported oceanographic ship fleet, were about $54 million...
There are 128 members of the scientific staff in five scientific departments, 63 additional members of the technical staff who are considered to be investigators, and four scientists in the Marine Policy Center—for a total of 195 investigators. This gives an estimate of the cost per investigator per year of $277,000, not including the capital cost of the oceanographic ship fleet supported by the Navy and the NSF. The annual ship cost per scientist is $20,000, raising the total cost per investigator per year to slightly less than $300,000.

This rather crude estimate suggests that, on the basis of total cost per investigator per year, the SSC ranks as somewhat larger science than oceanography and about the same size science as a large (but not “big science”) industrial laboratory. Similar estimates for other institutions could be obtained, but it is important that comparisons be made on the basis of total costs of support.

It has been suggested that the investigator count for the SSC is unfair because many of the investigators are not “doing real science,” but are building the accelerator and the detectors and “really doing engineering.” However, accelerator physics and detector physics are recognized by the scientific community as “real physics,” and appear in the journals as such, because they are real physics, and very difficult physics at that. In any case, most experimental scientists spend most of their time preparing and building experiments and only a little time doing them. It is not clear that the division of effort among various kinds of activities is any different in small or big science.

It seems perfectly legitimate for scientists to band together to do science on a scale that is impossible to work at alone or in small groups. This is increasingly the case in many kinds of science. The individual investigator continues to be the key, but there are some things that individuals cannot do alone (and some things that cannot be done in teams); working alone does not necessarily confer a special legitimacy.

ROBERT A. FROSCH
Vice President,
General Motors Corporation,
General Motors Research Laboratories,
30500 Mound Road,
Warren, MI 48090-9035

REFERENCES
Optical Crystallization Work

M. M. Burns, J.-M. Fournier, and J. A. Golovchenko imply in their article of 17 August 1990 (p. 749) that optical crystallization of colloidal particles was their idea. However, we clearly presented the idea of optical crystallization of colloidal particles and demonstrated the concept in a 1985 article (1) and believe that paper should have been so cited. Additionally, our paper suggested the quasicrystal stabilization demonstrated by Burns et al.

We refute the implication of Burns et al. that no previous optical crystallization work had been done and that no optical work had been done on interacting particle systems.

ASLAM CHOWDHURY
BRUCE J. ACKERSON
Department of Physics,
Oklahoma State University,
Stillwater, OK 74074
NOEL A. CLARK
Department of Physics,
Condensed Matter Laboratory,
University of Colorado,
Boulder, CO 80309-0390

REFERENCE

Response: While not wishing to detract from the very fine work of Chowdhury et al. (which we did indeed cite), we must point out that the second reference (1) in their own paper contradicts the main claim of priority in their letter.

MICHAEL M. BURNS
JEAN-MARC FOURNIER
Rowland Institute for Science,
100 Cambridge Parkway,
Cambridge, MA 02142
JENEA. GOLOVCHENKO
Department of Physics,
Lyman Laboratories,
Harvard University,
Cambridge, MA 02138

REFERENCE

Erratum: In the report "Restoration of inactivation in mutants of Shaker potassium channels by a peptide derived from ShakerI by W. N. Zagotta et al. (26 Oct., p. 568), in figure 3A the records labeled "after wash" were mistakenly duplicated in the control records. The correct control records are shown here.
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Latest LSC technology cuts sample and cocktail costs; increases throughput

In the past, liquid scintillation counting used traditional technology to overcome background noise. Now, there’s a new, more sensitive technology – TR-LSC or Time-Resolved Liquid Scintillation Counting – that reduces background noise by an additional 30%-40%, and more. This new patented technology is available only in Packard’s Tri-Carb® liquid scintillation analyzers.

Originally developed for extremely low level counting, TR-LSC technology has now been applied to a broad range of applications. While these don’t always require high sensitivity, additional benefits have been realized. By increasing sensitivity, TR-LSC reduces sample and cocktail consumption while shortening the time required for accurate counts. The benefits? Lower cocktail costs, lower disposal costs, and increased throughput.

How TR-LSC is superior to older technology

Traditional counters are based on two-dimensional pulse analysis: pulse height and pulse counts. They provide a level of sensitivity that’s merely adequate for most applications.

Patented TR-LSC adds a third dimension to pulse analysis: a pulse index that measures over time the afterpulses associated with background. In doing so, TR-LSC clearly distinguishes between beta pulses and background pulses. By identifying, and reducing, background noise, TR-LSC provides a great level of sensitivity (see chart comparing E/B values) and more accurate counts.

Achieve accurate counts on samples as small as 25 μL

Traditional technology limits sensitivity. The improved sensitivity of TR-LSC, however, allows you to achieve accurate DPM results for single and dual label samples in volumes as small as 25 μL. That can add up to substantial savings in sample and cocktail costs.

Slash radioactive waste disposal costs

Counting smaller samples will also reduce radioactive liquid disposal costs, which can be $500 per drum, or higher. While you may not pay this cost directly, your operating budget could be affected. With TR-LSC you can cut operating costs while reducing environmental hazards.

Increase sample throughput by over 80%

Just as TR-LSC reduces the volume of sample and cocktail required for accurate counting, it also reduces the time required for an accurate count. By cutting background in half, high sensitivity TR-LSC lets you count nearly twice the number of vials of a 250-DPM sample, in the time it would take to count a single vial using conventional technology. For lower activity samples, the increase in throughput with TR-LSC is even greater.

Automatic data interpretation, too

Another advanced feature available only with Tri-Carb analyzers is automatic tandem processing. This unique capability processes your counting data automatically using one software program after another – RIA packages, spreadsheets, word processing, or custom-written programs – until the results are printed in whatever format you have specified. All this is done automatically, without operator intervention, for up to 30 users.

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some globular proteins (32)? How drastically can the channel's ion selectivity be manipulated before mutagenesis becomes mutagenocidal? A good probe of the deeper regions of the conduction pore will be the Ba2+ ion, known to act in many K+ channels as a strongly blocking divalent K+ analog (33).

Finally, the quaternary interactions needed to hold the tetramer together must be sorted out. What types of subunit contacts are involved? Is external Ca2+ required for intersubunit stability (34)? These questions will almost certainly require attack directly at the protein level because dead channels tell no tales in site-specific mutagenesis. For this attack, efficient expression systems will be required from which milligrams of functional K+ channel can be purified; functional shaker channels have been expressed in both baculovirus and vaccinia virus (35) systems, but the practical utility of these as biochemical sources requires detailed assessment.

If this past year of K+ channels is any guide, future mechanistic work will be busy and raucoius. But, behind the inevitable excitement and clamor, an unspoken question always will be lurking, without a high-resolution molecular structure, what do we really know?

REFERENCES AND NOTES


AAAS Student Research Awards

As part of an ongoing effort to encourage the development of young scientists and to recognize their achievements in all fields of scientific research, the AAAS will highlight exceptional research by college and university students in a special poster session at the AAAS Annual Meeting, 6-11 February 1992, in Chicago.

Undergraduate students and graduate students who wish to be considered for this distinction can apply by submitting brief abstracts of their research.

For complete instructions on how to submit abstracts, watch for the "Call for Papers" in the 6 September 1991 issue of Science, or write: AAAS Meetings, Dept. SM, 1333 H Street, NW, Washington, DC 20005. (Deadline for abstracts is 1 November 1991.)

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**Metabolic Diseases**

**Osteoporosis**—As an integral member of the osteoporosis research team, you will contribute practically and intellectually to the development/implementation of overall research goals. Apply established expertise to new frontiers of bone research.

**Immunology, Inflammation and Infectious Diseases**

**Cellular Immunology**—Conduct studies to discover novel therapeutics for autoimmune diseases. Flow cytometry analysis of T and B lymphocytes, in vitro T cell activation studies and in vivo modeling.

**Cellular Biochemistry**—Identify and understand cellular processes involved in inflammatory response and develop drug therapies to modulate these processes.

**Microbial Pathogenicity**—Study virulence factors that determine colonization and host immune responses to a novel gastrointestinal pathogen. Biochemistry or Immunology background desirable.

**Infectious Disease Modeling**—Develop new models of disease to evaluate antiinfectives. Study bacterial pathogenesis employing microbiological, biochemical and molecular biology techniques.

**Pulmonary Biology**—Investigate airway disease and dysfunction. Relevant in vivo and in vitro laboratory experience highly desired.

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Research Scientists – Molecular Biology

**Papillomavirus Research**

This individual will contribute to our ongoing program of study in the molecular biology and pathogenesis of human papillomavirus infection. Specific duties include conducting in-depth studies of the virus/host interactions that occur during human papillomavirus infection to define pathogenetic mechanisms and determine potential drug targets. Additionally, you will be involved in establishing cell culture and/or animal model systems. Position requires a PhD and/or MD with a minimum of 2 years’ experience in one or more of the following: molecular biology of the skin; human or bovine papilloma virology; and analysis of human or animal skin biopsies. Code: PR.

**Receptor Gene Cloning**

This individual will conduct research within the beta interferon project group focusing on receptor gene cloning. This position requires a PhD or MD scientist with experience in the field of growth regulation and signal transduction. Candidates should have knowledge of cytokine receptors and experience with cell-based assays. Proficiency in novel designs and construction using modern molecular biology techniques is required. Code: RGC.

**Recombinant Antibody Engineering**

This individual will be involved in the design and construction of recombinant antibodies. Candidates should have a broad knowledge of antibody structure and function as well as computer-aided molecular modeling skills. A PhD plus 2-4 years’ postdoctoral experience required. Industry experience preferred. Code: RAE.

Research Scientists – Cell Biology

**Immunologist**

We currently have an opening for an immunologist with a PhD in cell biology. The principal focus of this work will be on cell functions in inflammatory and autoimmune diseases, and in transplantation through investigations on the molecular mechanisms of cell activation, tolerance, and immune regulation. Position requires a PhD or MD/Scientist with a minimum of 2 years’ postdoctoral experience and demonstrated expertise in examining cell functions in vitro and in vivo. Code: I.

**Vascular Physiology/Pharmacology**

This is an opportunity for a scientist with expertise in vascular physiology and pharmacology to address the needs of our Cardiovascular and Endothelial Cell Biology programs. Specifically, you will develop and apply small animal models of thrombosis and vascular injury/recovery to the evaluation of new drug compounds and help identify novel points of intervention for cardiovascular and inflammatory diseases. A PhD or related degree is required. Experience with tissue histology is helpful. Code: VP.

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This key individual will be responsible for a wide range of duties to include: designing and implementing pharmacology, pharmacokinetic and toxicology studies for regulatory purposes; advising on the preparation of preclinical studies and clinical design; and developing the preclinical development/preclinical support function. Additionally, you will review and present preclinical data as well as write preclinical summaries for INDs, NDA, investigational brochures, protocols and publications. Candidates must possess a PhD in Pharmacology or Toxicology and 10 or more years’ experience of increasing responsibility, including pharmaceutical industry experience in directing preclinical programs. Code: DT.

Process Development

**Protein Chemist**

In a team setting, this individual will develop and optimize purification methods used in the manufacture of recombinantly derived proteins for use as parenteral therapeutics in human clinical trials. You will also create and execute validation studies to support applications to regulatory agencies. Knowledge of physical and biochemistry, specifically in protein chemistry and separations techniques is a must. A PhD in Biochemistry, Chemistry, Immunology or related field, with hands-on experience in protein purification/characterization, and 2-5 years in related postdoctoral research are required. Code: PC.

**Cell Biology**

You will be responsible for research leading to the development and improvement of mammalian cell lines used for production of human therapeutic proteins. This position will also be an integral part of a team investigating methods for optimization of cell culture methods, including culture media development. The ideal candidate will have a PhD in Cellular Biology or Immunology or related field with 3-5 years’ postdoctoral experience. Code: CB.

Research Associate/Associate Scientist

**Protein Chemistry**

We currently have an opening in our Protein Chemistry Department for an individual to prepare, characterize and release high purity protein products for reagent use. You must have a Bachelor’s degree in Life Science and 4-6 years’ experience in lab-scale production and purification of recombinant proteins. Familiarity with bioassay techniques preferred. Molecular Biology experience is a plus. Code: RA.

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developed in competitive social arenas in response to their powerful neighbors (Welch).

The chapters accurately reflect the nature of current archeological research in the eastern United States. Since the late 1970s, well-funded surveys and excavations in areas threatened by construction projects have revolutionized knowledge about prehistoric cultures. This volume simply would not have been possible 10 years ago. Paradoxically, the strength of salvage projects—the opportunity to do otherwise prohibitively expensive work—is closely related to their greatest weakness; most of the authors, like their colleagues elsewhere, must try to make sense out of samples from projects whose location and scope are dictated by the needs of sponsoring agencies. Furthermore, several authors make extensive use of information and specimens from projects conducted many years ago. Despite well-known problems with existing collections, these materials are irreplaceable because modern land use practices have destroyed many sites.

Once again, Bruce Smith has been successful in assembling regional specialists to produce a reference work that will be cited by archeologists for many years to come. These reviews of Mississippian origins in intensively studied parts of the Eastern Woodlands will serve as an impetus for much-needed comparable work elsewhere.

**George R. Milner**
Department of Anthropology, Pennsylvania State University, University Park, PA 16802

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**An Assemblage of Fossils**


The Solnhofen deposits near the German city of Munich are probably the most famous fossil deposits in the world. They yield a unique record of marine and terrestrial life buried nearly 150 million years ago in the fine-grained, limy muds of hypersaline lagoons. Articulated skeletons of fish, flying reptiles, and birds are preserved along with such unusual invertebrate fossils as insects and jellyfish. In many cases there is evidence of soft structures like feathers and the skin of pterosaurs.

This account of the deposits is presented as a revised and updated translation of Solnhofen: Ein Blick in die Erdgeschichte by Werner Barthel. Barthel died in 1978, the year of publication of the German original. The bibliography of the present work lists over 40 references from 1978 or later. These references are widely cited in the text and so influence the discussion that it is clear that Swinburne and Morris have presented us with a new work rather than a revised translation.

The book is divided into eight chapters and has an appendix that includes a complete faunal and floral list for the Solnhofen Plattenkalk. The first two chapters give a brief history of limestone exploitation in the region around Solnhofen and the early development of fossil collections and describe the general geological setting of the region. The next two chapters deal with petrography and environments of deposition. These two chapters may be difficult for readers who lack a geological background. The rest of the book is written in a clear, readable...
That results in the area are widely scattered and that the “unifying concept of molecular similarity remains unstated and largely unrecognized.” The book is meant to be a set of definitive overviews, but their authorship and points of view are diverse, and so the “unifying concept” is still elusive. Nevertheless, it is important to have such a collection.

The background for these 12 essays and hence the readership they will interest are highly varied, but most of the essays are highly mathematical. All the approaches represented are crystallizing at this time because of the availability of computing power to assess their validity and success in prediction, and all are incomplete and under active development. In the first chapter, by the editors, the ideas of matching, ordering, and equivalence classes, expressed as distances in some computed function space, are delineated with the use of measures of proximity and distance to describe similarity. The second chapter illuminates the importance of similarity in the history of chemistry with major similarity concepts such as the periodic classification of the elements.

Chapters 3 and 4 focus on the problems of ordering and retrieving information from databases by means of substructure searches and their relation to physical properties. The discussions are rather technical, and the non-expert would have benefited from examples on how the systems work. Chapters 5 through 8 develop the idea of relating molecular similarity to scalar physical properties, such as boiling or melting points, or to bioactivity data. Chapter 5 is a spirited defense of the value of the correlations possible between physical properties and the mathematical indices derived from graph theory. Well sprinkled with worked-out examples, this is an excellent review for the nonexpert. Chapter 6, for quantum mechanicians, is a mathematical presentation of the use of electronic density functions as molecular descriptors to order relationships in n-dimensional molecular similarity space, reduced to three-dimensional nearest-neighbor graphs for comparing physical properties.

In chapters 9 and 10 the focus is on chemical reactions. In the former we find the use of be- and r-matrices to describe all possible interconversions between two molecules in algebraic rather than graphical form. This affords the idea of a computed chemical distance between any two molecules as a measure of their similarity. Though the concepts are well explained with examples, the authors skate over the difficulty of the n! problem of establishing the canonical matching of related molecules or their r-matrices. Chapter 10 applies these ideas to develop graph transform “kits” to model reaction pathways in biochemistry in order to ascertain what molecular features disallow certain otherwise similar reactions.

Though most of the chapters deal with structure similarities and structure-property relations in two-dimensional systems, the focus of three of them is directly on quantitative structure-activity relationships in drug action and the three-dimensional molecular shape in ligand-receptor interactions. In chapter 7 molecular superposition is defined both by steric volume and charge potential, and the need for conformational analysis in defining similarity is addressed. Chapter 8 deals with the same problem with a focus on the similarity in the contact region of ligand surfaces to identify response similarities at receptors. Chapter 11 codifies the problem in topological terms as domains of convex, concave, and saddle forms on the surface of a ligand. Unlike chapters 7 and 8, however, this chapter is completely theoretical and without illustrative examples or applications. Finally, the last, rather short, chapter in the book describes a fully theoretical approach to a comprehensive mathematical theory of molecular similarity.

It must be noted that the book has an excessive number of mechanical errors, including errors in structures and tables.

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Books Received


