Instructions for Contributors

The Editors of *Science*

Manuscripts submitted to *Science* for consideration for publication can be handled expeditiously if they are prepared in the form described in these instructions.

Submit an original and two duplicates of each manuscript. With the manuscript send a letter of transmittal giving (i) the name(s) of the author(s); (ii) the title of the paper and a one- or two-sentence statement of its main point; (iii) the name, address, and field of interest of four to six persons in North America but outside your institution who you think are qualified to act as referees for your paper; (iv) the names of colleagues who have reviewed your paper for you; (v) the field(s) of interest of readers who you anticipate will wish to read your paper.

Editorial Policies

All papers submitted are considered for publication. The author's membership or lack of membership in the AAAS is not a factor in selection. Papers are accepted with the understanding that they have not been published, submitted, or accepted for publication elsewhere. Authors will usually be notified of acceptance, rejection, or need for revision in 4 to 6 weeks (Reports) or 6 to 10 weeks (Articles).

Types of papers. Five types of signed papers are published: Articles, Reports, Letters, Technical Comments, and Book Reviews. Familiarize yourself with the general form of the type of paper you wish to submit by looking over a recent issue of the journal, and then follow the instructions for that type of paper.

Reviews. Almost all Articles, Reports, and Technical Comments, whether solicited or not, are sent to two or more outside referees for evaluation of their significance and soundness. Forms showing some of the criteria reviewers are expected to consider are available on request.

Editing. Papers are edited to improve the effectiveness of communication between the author and his readers. The most important goal is to eliminate ambiguities. In addition, improvement of sentence structure often permits readers to absorb salient ideas quickly. When editing is extensive, with consequent danger of altered meanings, papers are returned to the author for correction and approval before type is set. Authors are free to make additional changes at this stage.

Proofs. One set of galley proofs or an equivalent is provided for each paper. Keep alterations to a minimum, and mark them only on the galley, not on the manuscript. Extensive alterations may delay publication by 2 to 4 weeks.

Reprints. An order blank for reprints accompanies proofs.

Writing Papers

Organize your material carefully, putting the news of your finding or a statement of the problem first, supporting details and arguments second. Make sure that the significance of your work will be apparent to readers outside your field, even if you feel you are explaining too much to your colleagues. Present each step in terms of the purpose it serves in supporting your finding or solving the problem. Avoid chronological steps, for the purpose of the steps may not be clear to the reader until he finishes reading the paper.

Provide enough details of method and equipment so that another worker can repeat your work, but omit minute and comprehensive details which are generally known or which can be covered by citation of another paper. Use metric units of measure. If measurements were made in English units, give metric equivalents.

Avoid specialized laboratory jargon and abbreviations, but use technical terms as necessary, defining those likely to be known only in your field. Readers will skip a paper they do not understand. They should not be expected to consult a technical dictionary.

Choose the active voice more often than you choose the passive, for the passive voice usually requires more words and often obscures the agent of action. Use first person, not third; do not use first person plural when singular is appropriate. Use a good general style manual, not a specialty style manual. The University of Chicago style manual, the style manual of the American Institute of Physics, and the *Style Manual for Biological Journals*, among others, are appropriate.

Manuscripts

Prepare your manuscript in the form used by *Science*. Use bond paper for the first copy. Submit two duplicates. Double-space title, abstracts, text, signature, address, references (including the lines of a single reference), figure legends, and tables (including titles, columns, headings, body, and footnotes). *Do not use single spacing anywhere.* Put the name of the first author and the page number in the upper right-hand corner of every page.

Paging. Use a separate page for the title; number it page 1. Begin each major section—text, references and notes, and figure legends—on a new sheet. Put each table on a separate sheet. Place figure legends and tables after the references.

Title. Begin the title with a word useful in indexing and information retrieval (not "Effect" or "New").

References and Notes. Number all references to the literature, footnotes, and acknowledgments in a single sequence in the order in which they are cited in the text. Gather all acknowledgments into a single citation, and keep them short ("I thank," not "I wish to thank"). Cite all references and notes but do not cite them in titles or abstracts. Cite several under one number when feasible. Use the "BioSciences Information Service of Biological Abstracts," BIOSIS, with the few suggested revisions in *International List of Periodical Title Word Abbreviations* for abbreviations of journal names. If the journal is not listed there, provide the full name. Use the following forms:

Journal: H. Smith, *Am. J. Physiol.* **98**, 279 (1931).
Book: F. Dachille and R. Roy, *Modern Very High Pressure Techniques* (Butterworth, London, 1961), pp. 163–180.
Chapter: F. Dachille and R. Roy, in *Reactivity of Solids*, J. H. de Boer, Ed. (Elsevier, Amsterdam, 1960), p. 502.

Illustrations. Submit three copies of each diagram, graph, map, or photograph. Cite all illustrations in the text and provide a brief legend, to be set in type, for each. Do not combine line drawings and photographs in one illustration. Do not incorporate the legend in the figure itself. Use India ink and heavy white paper or blue-lined coordinate paper for line drawings and graphs. Use heavier lines for curves than you use for axes. Place labels parallel to the axes, using capital and lower-case letters; put units of measurement in parentheses after the label—for example, Length (m). Plan your figures for the smallest possible printed size consistent with clarity.

Photographs should have a glossy finish, with sharp contrast between black and white areas. Indicate magnification with a scale line on the photograph.

Tables. Type each table on a separate sheet, number it with an Arabic numeral, give it a title, and cite it in the text. Double space throughout. Give each column a heading. Indicate units of measure in parentheses in the heading for each column. Do not change the unit of measure within a column. Do not use vertical rules. Do not use horizontal rules other than those in the heading and at the bottom. A column containing data readily calculated from data given in other columns can usually be omitted; if such a column provides essential data, the columns containing the other data can usually be omitted.

Plan your table for small size. A one-column table may be up to 42 characters wide. Count characters by counting the widest entry in each table column (whether in the body or the heading) and allow three characters for spaces between table columns. A two-column table may be 90 characters wide.

Equations and formulas. Use quadruple spacing around all equations and formulas that are to be set off from the text. Most should be set off. Start them at the left margin. Use the solidus for simple fractions, adding the necessary parentheses. But if braces and brackets are required, use built-up fractions. Identify handwritten symbols in the margin, and give the meaning of all symbols and variables in the text immediately after the equation.

Articles

Articles, both solicited and unsolicited, may range in length from 2000 to 5000 words (up to 20 manuscript pages). Write them clearly in reasonably nontechnical language. Provide a title of one or two lines of up to 26 characters per line and a subtitle consisting of a complete sentence in two lines with a character count between 95 and 105 for the sentence (spaces between words count as one character each). Do not break words at the ends of lines. Write a brief author note, giving your position and address. Do not include acknowledgments. Place title, subtitle, and author note on page 1. Begin the text on page 2.

Insert subheads at appropriate places in the text to mark your main ideas. The set of subheads should show that your ideas are presented in a logical order. Keep subheads short—up to 35 characters and spaces.

Provide a summary at the end.

Do not submit more than one illustration (table or figure) for each four manuscript pages unless you have planned carefully for grouping. With such planning many illustrations can be accommodated in the article. Consult the editorial office for help in planning.

Reports

Short reports of new research results may vary in length from one to seven double-spaced manuscript pages of text, including the bibliography. Short papers receive preferred treatment. Limit illustrative material (both tables and figures) to two items, occupying a total area of no more than half of a published page (30 square inches). A research report should have news value for the scientific community or be of unusual interest to the specialist or of broad interest because of its interdisciplinary nature. It should contain solid research results or reliable theoretical calculations. Speculation should be limited and is permissible only when accompanied by solid work.

Title. Begin the title with an important word (preferably a noun) that identifies your subject. The title may be a conventional one (composed primarily of nouns and adjectives), a sentence (containing a verb), or a structure with a colon (Jupiter: Its Captured Satellites). Limit it to two lines of complete words of no more than 55 characters per line (spaces between words count as one character each). Do not use abbreviations. Type the title in the middle of page 1.

Abstract. Provide an abstract of 45 to 55 words on page 2. The abstract should amplify the title but should not repeat it or phrases in it. Qualifying words for terms used in the title may be used. Tell the results of the work, but not in terms such as "——— was found," "is described," or "is presented."

Text. Begin the text on page 3. Put the news first. Do not refer to unpublished work or discuss your plans for further work. If your paper is a short report of work covered in a longer paper to be published in a specialty journal, you may refer to this paper if it has been accepted. Name the journal. If the manuscript has not been accepted, refer to it as "in preparation." Omit references to private communications. Do not use subheads.

Signature. List the authors on the last page of the text and give a simple mailing address.

Received dates. Each report will be dated the day an acceptable version is received in the editorial office.

Letters

The Letters section provides a forum for discussion of matters of general interest to scientists. Letters are judged only on clarity of expression and interest. Keep them short and to the point; the preferred length is 250 words. The editors frequently shorten letters. See instructions for the preparation of manuscripts.

Technical Comments

Letters concerning technical papers in *Science* are published as Technical Comments at the end of the Reports section. They may add information or point out deficiencies. Reviews are obtained before acceptance.

Book Reviews

The selection of books to be reviewed is made by the editors with the help of advisers in the various specialties; arrangements are then made with reviewers. A sheet of instructions accompanies each book when it is sent to the reviewer.

Cover Photographs

Particularly good photographs that are suitable for use on the cover are desired.

SCIENCE

11 January 1974

Vol. 183, No. 4120

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Preconvention Issue

THE HIGH-SPEED ULTROLAB® DILUTER

The LKB Ultrolab Diluter is one of the fastest and most accurate diluters on the market. It will siphon up a preset volume of a sample liquid and flush it out with a preset volume of a reagent at a rate of up to 1200 times an hour.

The Ultrolab Diluter can also be used as a dispenser, to dispense one or two reagents at the same high rate.

Each pump is permanently preset to deliver 10 different volumes, which can be selected by merely pressing a pushbutton. Three pumps are available to choose from, giving in all a choice of volumes from 10 μl to 3000 μl. These are high-precision pumps, with an accuracy of $\pm 1\%$ and a reproducibility of $\pm 0.5\%$. Tight, leak-free operation is achieved by employing smooth, sapphire pump plungers.

Operation is simple. To change over pumps you just press a button and remove the pump, complete with reagent bottle. You can immediately begin dilution or dispensing for a different type of analysis by plugging in a spare pump with a new type of reagent. A convenient hand pipette and a foot pedal control are available as optional items.

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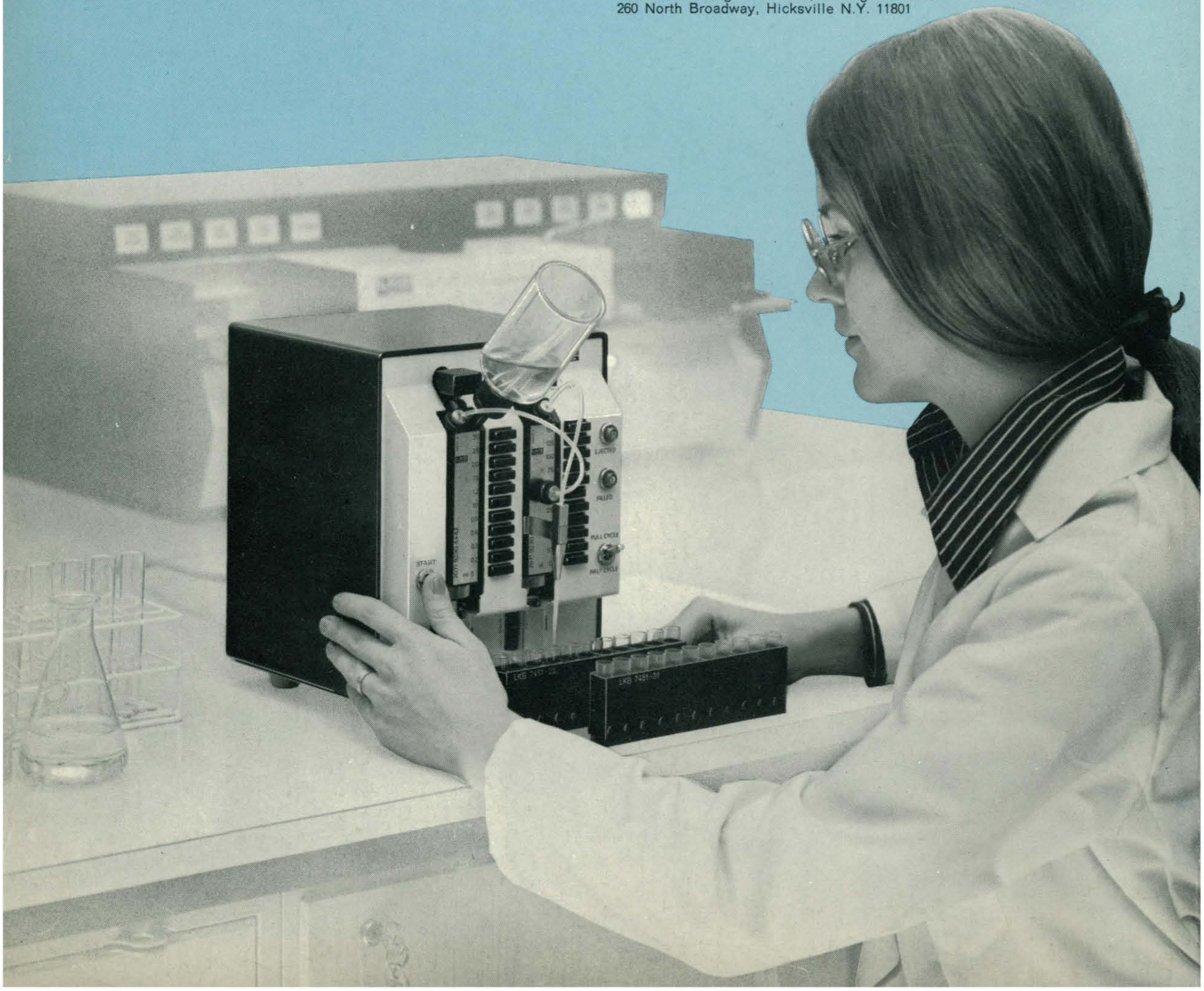

Whatever range you're weighing in, Sartorius top-loaders are best to weigh it on.

Meet the top-loaders that carry a lot of weight, particularly with people who have important weighing work to do — the Sartorius Series 2250 Balances.

These dependable, extremely accurate instruments have net capacities ranging from 160 g to 5000 g, with accuracies from 1 mg to 0.1 g. All 2250's have all-digital readout and huge optical scales with large numerals for easy reading, even under adverse lighting. They have no discernible swing or deviation from the indicated weight, and all models in this series provide mechanical taring. Some models even feature automatic leveling systems, electrical output for external control or print out of results, and special tolerance weighing facilities. In short, there is a Sartorius 2250 top-loader to meet virtually every non-analytical laboratory weighing situation, including direct weighing of unknowns and animals; rapid weighing-in of powders, liquids, granulated materials or fabricated parts; tolerance weighings; even below-balance weighings.

Choosing which model best suits your particular weighing requirements is probably the most serious problem you'll ever encounter with a Sartorius top-loader. The solution to that one is in our comprehensive new balance catalog. For your free copy, just write: Sartorius Division, Brinkmann Instruments, Cantiague Road, Westbury, N.Y. 11590.

sartorius balances

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11 January 1974

Volume 183, No. 4120

SCIENCE

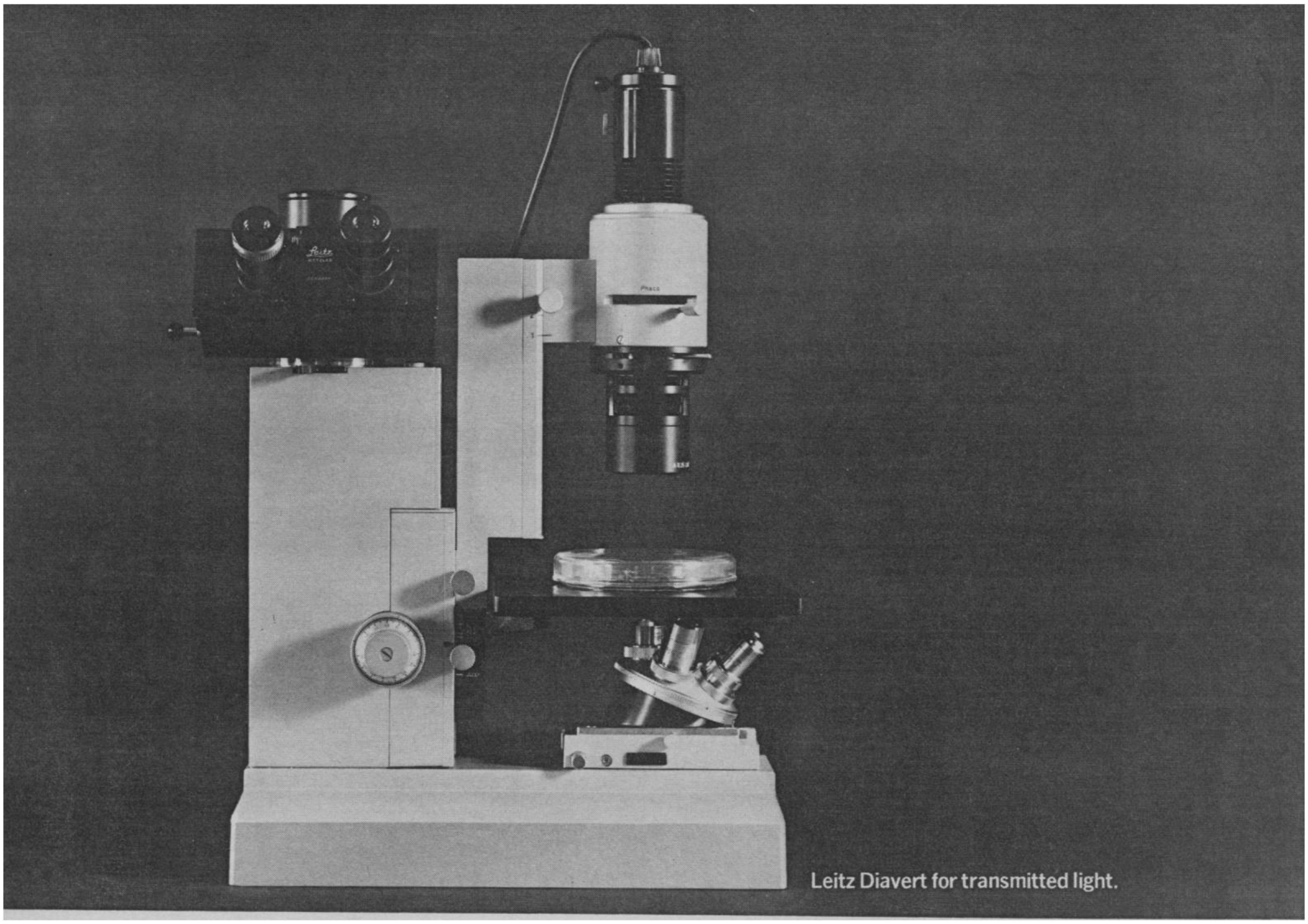
This is the first issue of volume 183.
No 4 January 1974 was published.

SCIENCE is published weekly, except the last week in December, but with an extra issue on the fourth Tuesday in November, by the American Association for the Advancement of Science, 1515 Massachusetts Ave., NW, Washington, D.C. 20005. Now combined with **The Scientific Monthly®**. Second-class postage paid at Washington, D.C. Member rates on request. Annual subscription $30; foreign postage: Americas $4, overseas $6, air lift to Europe $18. Single copies $1 (back issues, $2) except **Guide to Scientific Instruments** which is $4. School year subscriptions: 9 months $22.50; 10 months $25. Provide 6 weeks notice for change of address, giving new and old address and zip codes. Send a recent address label. **Science is indexed in the Reader's Guide to Periodical Literature.**

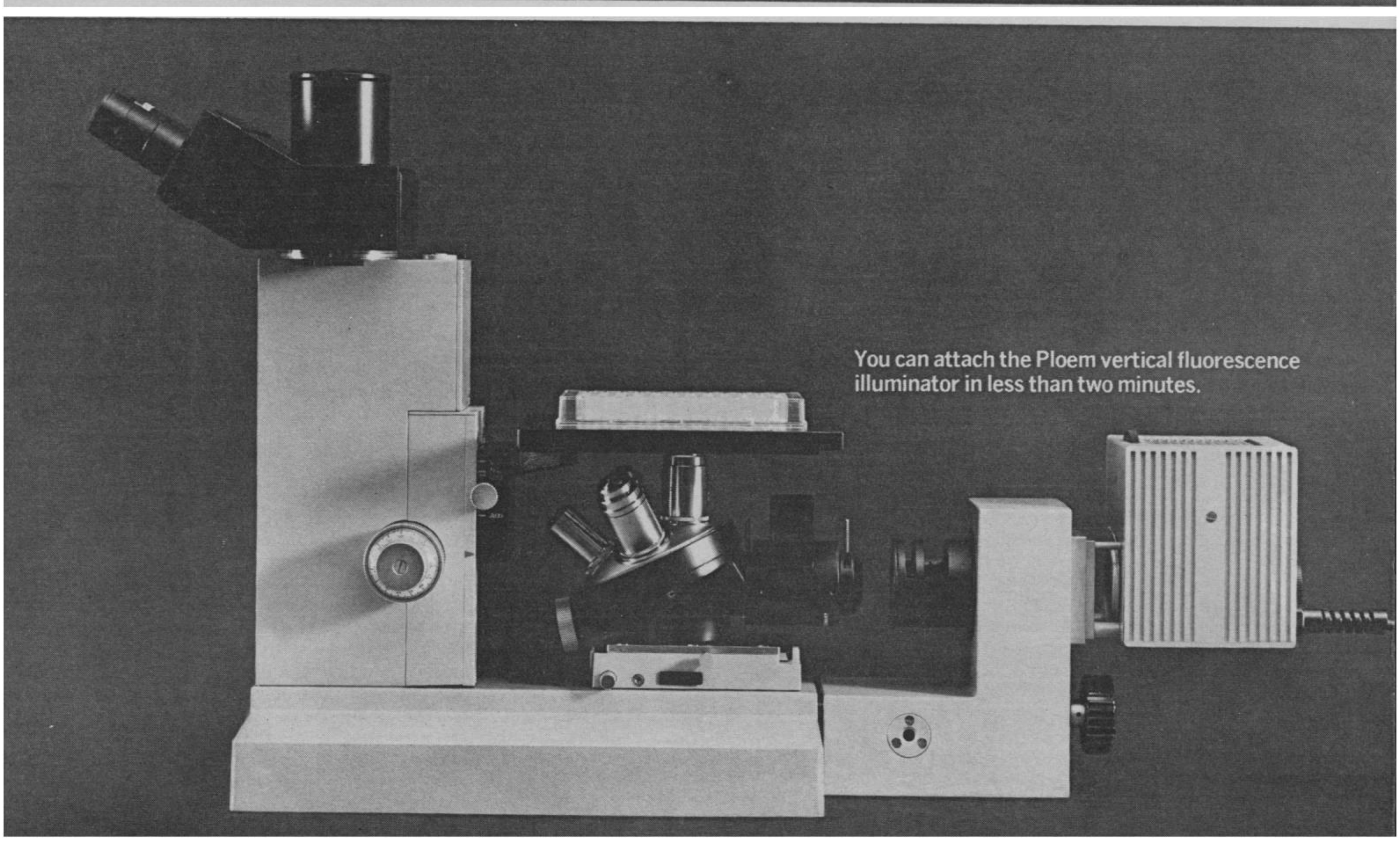
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

COVER

Nomarski interference-contrast micrograph of an aluminum-silicate mixture of stoichiometric mullite composition showing peritectic microstructure formed by slow cooling of a homogenized melt. Interpretation of such microstructures with the aid of diffusion couple technique results in a new SiO_2-Al_2O_3 phase diagram (about × 1200). See page 69. [Ilhan A. Aksay and Joseph A. Pask, Department of Materials Science and Engineering and Inorganic Materials Research Division, Lawrence Berkeley Laboratory, University of California, Berkeley]



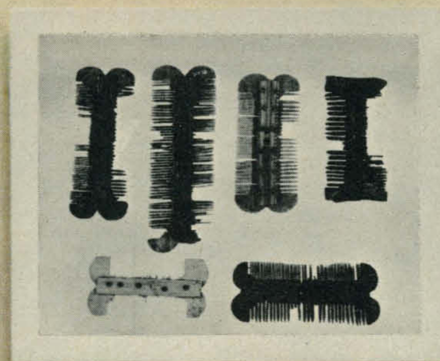
Leitz Diavert for transmitted light.



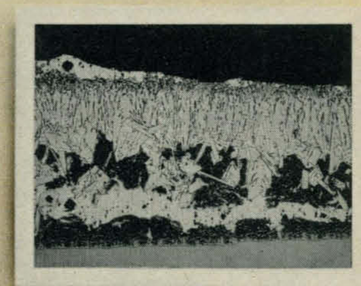
You can attach the Ploem vertical fluorescence illuminator in less than two minutes.

One camera took all of these pictures and delivered them in seconds.

Chromatogram of urological specimen. Type 108.



Bone combs from Middle Ages. Type 52.



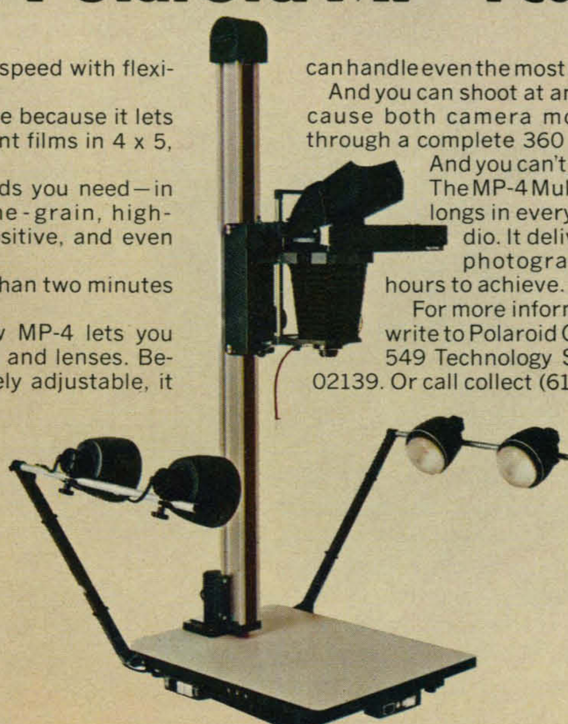
Photomicrograph of experimental galvanized coating. X100. Type 107.

35mm slide of muscle structure. Type 46L.

Damaged automobile piston. Type 55 positive/negative.

Lung with tumor. Type 108.

The new Polaroid MP-4 camera.



It's the one camera that couples speed with flexibility.

It fits practically any job you have because it lets you use 13 different Polaroid instant films in 4 x 5, pack or roll formats.

They give you exactly the records you need—in full color or black and white (fine-grain, high-speed, negative with matching positive, and even black and white transparencies).

And not one of them takes more than two minutes to develop.

The modular design of the new MP-4 lets you interchange cameras, film holders and lenses. Because the light arms are completely adjustable, it can handle even the most difficult lighting situations.

And you can shoot at any angle or perspective because both camera mount and column rotate through a complete 360 degrees.

And you can't go much further than that.

The MP-4 Multipurpose Land camera belongs in every laboratory and photo studio. It delivers in seconds what other photographic processes can take hours to achieve.

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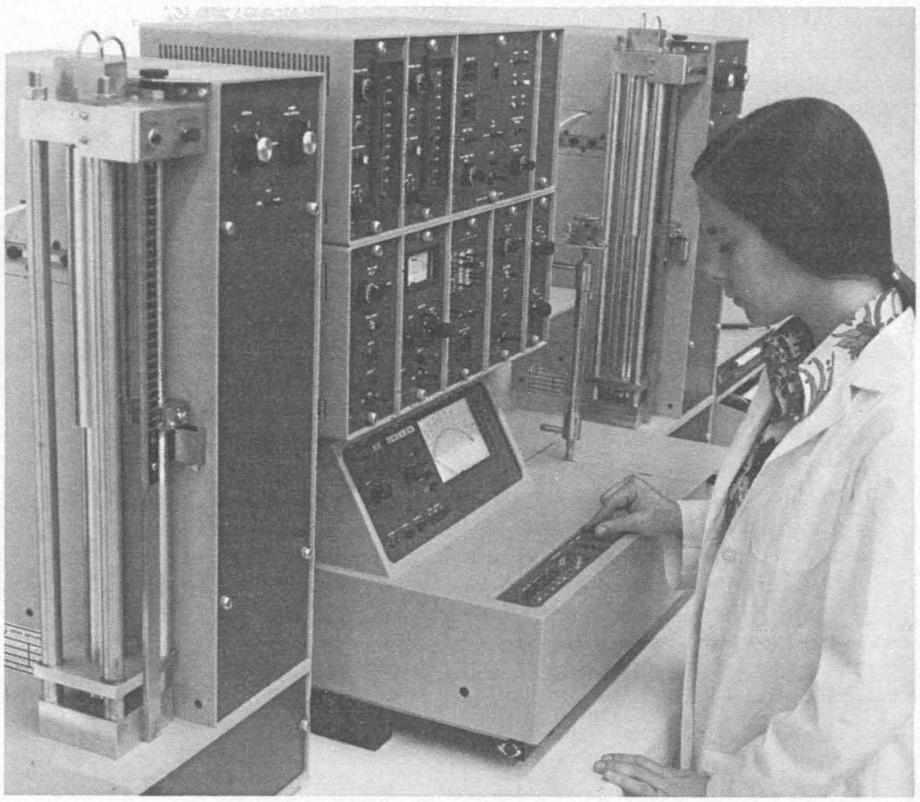

For the most difficult LC analyses... Model 4200

Model 4200 gives you more analytical power for complex samples than any other LC system.

It's the only LC system that provides all these major advantages: 5000 psi injection, 5000 psi pumping system, multilinear solvent/flow programming (MLSP), and a choice of detectors, including Variscan™ the detector that makes it possible to detect and analyze any compound that absorbs in the UV-Vis, from 210 nm to 780 nm.

The precisely controlled high-pressure (5000 psi) pumping system assures accuracy and reproducibility of peak areas and retention times. This system also permits you to utilize the full resolution and speed of MicroPak™—the most efficient LC columns.

For extraordinarily difficult samples, you can set the MLSP to form solvent gradients of virtually any shape—linear, nonlinear, convex or concave, and of any duration from one minute to six-plus days.

Combine Model 4200 with the Variscan UV-Vis detector and you can make LC measurements at the maximum absorption wavelength of compounds that absorb in the entire UV-Vis spectral region from 210 to 780 nm with no sacrifice in efficiency. And, whenever you wish, you can quickly stop flow, push a button, and obtain absorption spectra of individual peaks in your chromatogram.

There's no other LC system anywhere that can even begin to compare with it. Details, including chromatograms and specifications, are yours for the asking.

Just circle Reader Service No.34.

For the most difficult GC analyses... Model 2100

Model 2100 can help you operate easily and efficiently with difficult samples such as you encounter in analyses of drugs of abuse, pesticides, steroids, pharmaceuticals, and other compounds which are metal-sensitive.

Here's why.

Model 2100 has an all-glass system and on-column injection, so sensitive compounds do not contact metal. Negligible dead volume provides superior resolution and sensitivity. The large (3000 cubic inch) U-column oven has uniform heat distribution and precise temperature control, even when temperature programming. And Model 2100 is available with an Automatic Linear Temperature Programmer which automatically provides reproducible column-oven temperature programs.

A solid state dual and differential JFET electrometer is standard on all models. And the ability to run as many as four detectors and four U-columns simultaneously gets you maximum productivity and operating flexibility.

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Varian Instruments for Life Science Research & Analysis

Our E-Line Spectrometer owners are the best advertisement we have.

We don't spend a lot of money advertising our E-Line Spectrometers. We don't need to. Our owners do it for us, by word of mouth, with their consistently glowing recommendations, and for most prospective ESR users, that carries more weight than all the advertising in the world. What do our owners say about us? The most typical comments praise our performance. That's because we make the most sensitive ESR systems in the world. Our owners laud our reliability and versatility, too. And just look at some of the areas they're using spectrometers to investigate.

Organic Chemistry: Free radicals in solution, kinetic studies, triplet states.

Physical Chemistry: molecular structure, relaxation studies, exchange phenomena, quantitative studies.

Inorganic Chemistry: transition elements, electronic wave function.

Analytical Chemistry: impurity studies, drug detection.

Solid State Physics: impurities in semi-conductors, conduction electrons, energy transfer.

Biological Sciences: Nitroxide spin labeling of macromolecules, protein investigations, irradiation damage.

What's more, Varian's E-Line Spectrometers are backed by an on-going program of applications development, the best and most complete such program in the industry. That's something our owners really appreciate.

But don't take our word for all this. If you'd like to hear about our ESR Spectrometers first hand from an E-Line owner, simply call your local Varian salesman. He'll be happy to set it up.

In the meantime, send for a copy of our E-Line Brochure. *Circle Reader Service No. 36.*

Inside the EM-360 NMR Spectrometer

An NMR Spectrometer is only as good as its component parts, and that makes the EM-360 the best low-priced 60-MHz system in the world.

Let's start with the heart of any NMR system, the magnet. We make our own—always have. That's because we feel the magnet is the most important part of an NMR system, and we simply don't trust its manufacture to anyone else. We make them well, too. We're the largest manufacturers of precision electromagnets in the world. Each year we make as many as all the other manufacturers combined. This means we have not only the capability to produce top-quality magnets, but also the expertise that only comes from years of research in the field, and it's all been brought directly to bear on the EM-360. Precise temperature control and magnetic shielding isolate the magnet assembly from environmental changes and insure maximum field stability. The magnet is caster mounted and can be positioned to suit individual requirements. No special services, i.e., cooling water, etc., are required. All you need to activate this magnet is 150 watts of 110 volt ac power.

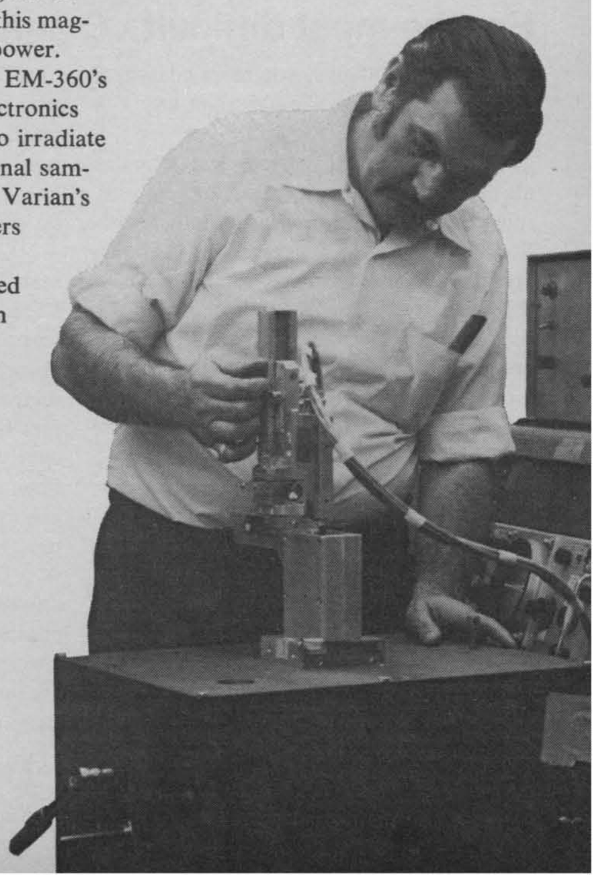
Now let's take a look at the EM-360's radio frequency section, the electronics that supply the rf signals used to irradiate the sample, detect the NMR signal sample, and feed it to the recorder. Varian's been making NMR spectrometers longer than anyone. We made the first one, and we've continued to improve our electronic design ever since. It shows up quite nicely in the simple, efficient integrated circuitry used in the EM-360. On the EM-360, rf field is controlled directly from the console and is continuously variable from 0.005 to 0.5 milligauss. For routine spectra, we've indicated a standard setting. For more exacting work, we've allowed you to take complete control. The EM-360 probe uses a 5-mm sample tube, the same size used by the vast majority of NMR spectrometers.

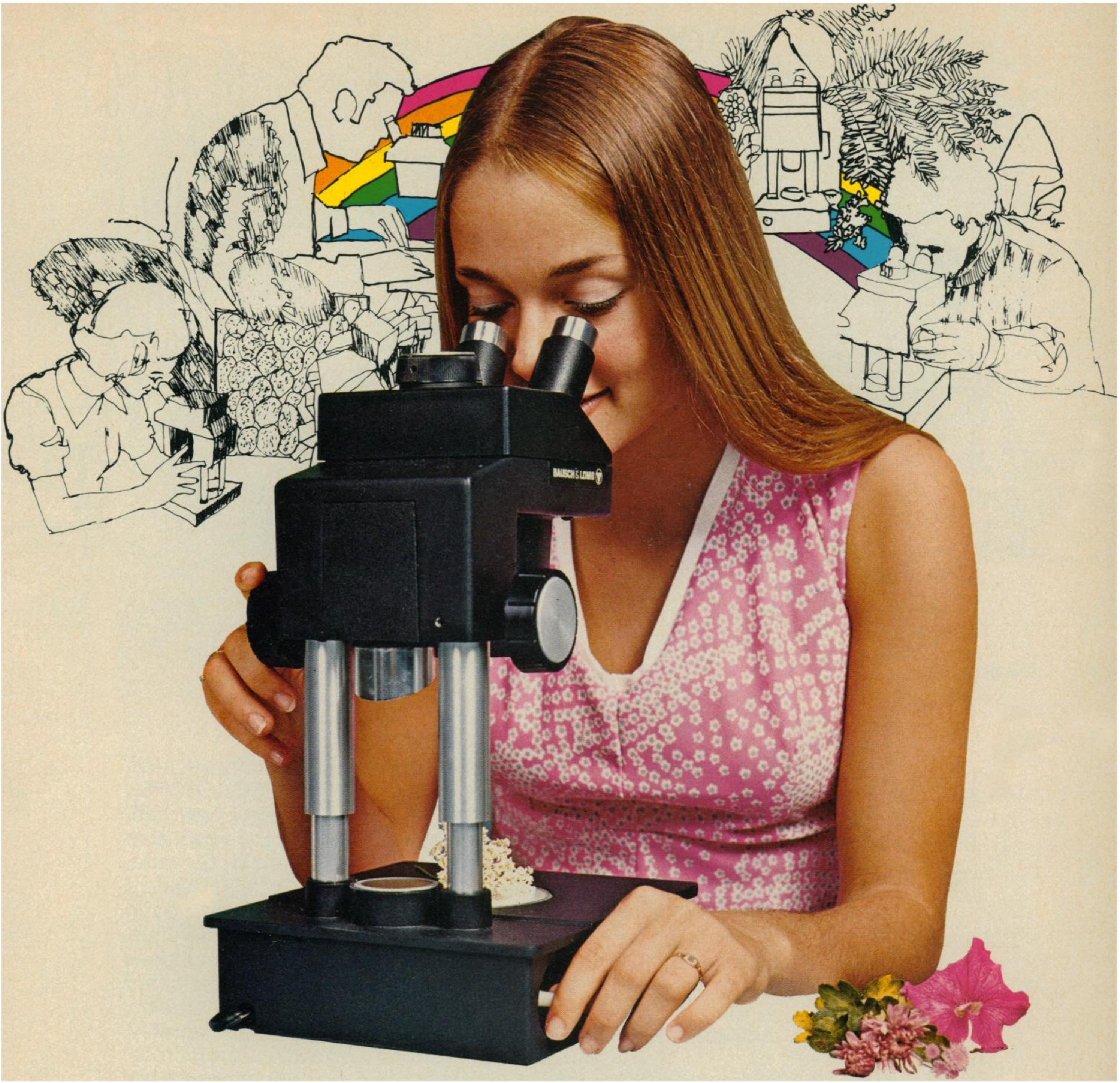
Last, but far from least, the EM-360 uses a big 11 by 17-inch YT recorder to give you the biggest results around.

This has been just a brief look inside the EM-360. Send for a brochure on the system and take a look at the outside, as well. *Reader Service No. 37.*

Varian Associates
Instrument Division,
611 Hansen Way,
Palo Alto, California 94303.

varian





Qtam? Sno

Doesn't anybody in the computer business speak English?

The computer business has created its own language.

"Computerese."

It helps computer people communicate with each other about computers. But it doesn't help them communicate with other people.

We want to make computers easier for you to understand.

Because the difference between the right and wrong way of using them can mean a lot to the profitability of your company.

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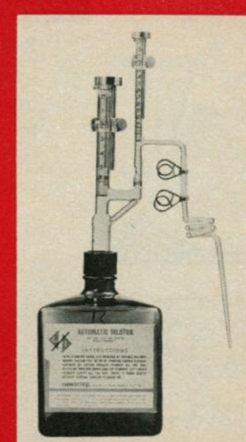
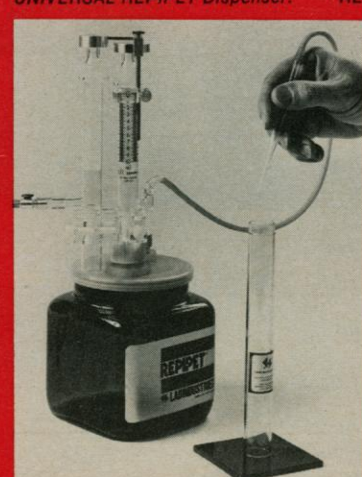
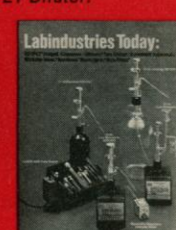
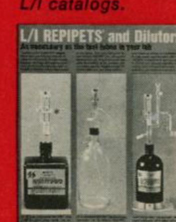

REPIPET Dilutor.

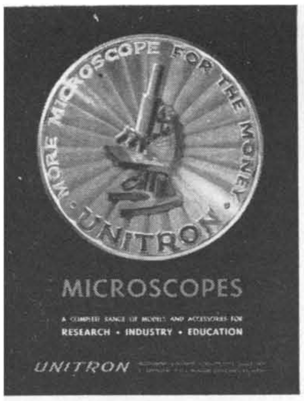


AUTO-REPIPET® Dispensers and Dilutors.



L/I catalogs.





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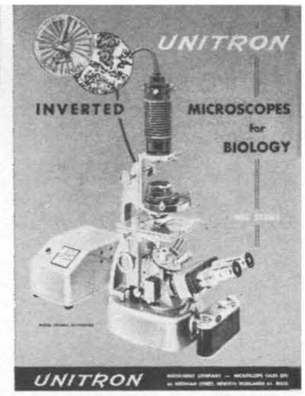

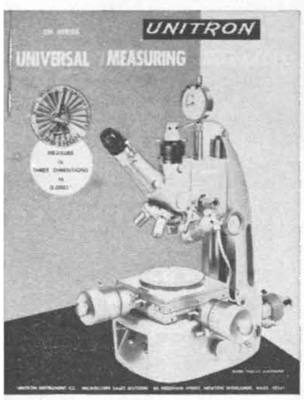

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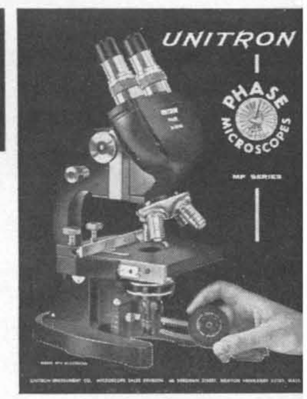

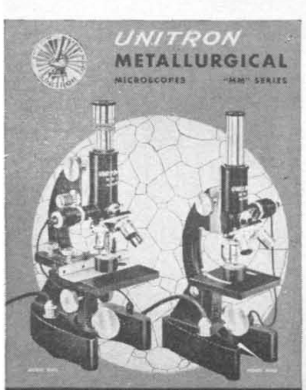

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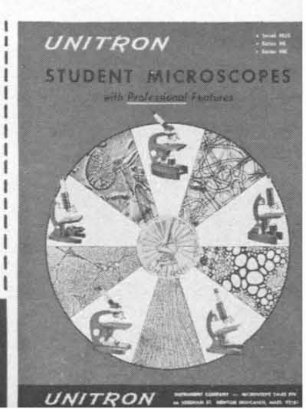

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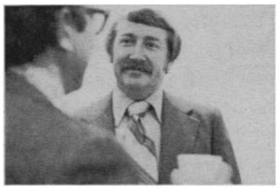
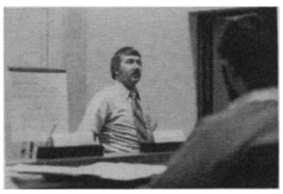
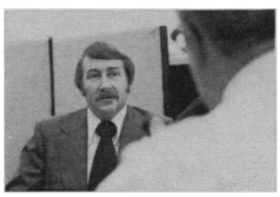
Mr. Sucy, is anyone using microfiche readers in teaching?



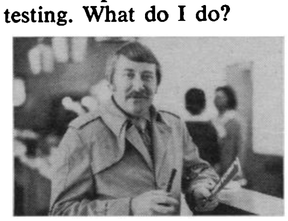
Jim, where can I apply for Federal funding of my research on picture-taking as a guidance tool?



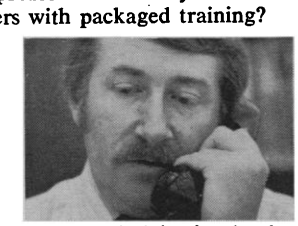
What is the evidence, Jim, for increased retention with audiovisual aids?



Sucy, I need to set up a course in non-destructive testing. What do I do?



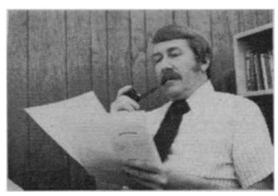
Does Kodak have any suggestions on how our professional society can reach its members with packaged training?



Where can I buy a Kodak visualmaker kit?

Service to education

James G. Sucy is the name. Manager, Education Markets Services, is the title. Address: Eastman Kodak Company, Rochester, N.Y. 14650. Phone: 716-724-4501. Function: to find the person in the best position to field any teacher's question that relates any Kodak product or service to the educational process. "Teacher" covers professor, educator, trainer, instructor–whatever you think it should cover. Patterns discerned in the questions will shape next year's and next decade's Kodak products and services.



What type of programs do you have for military trainers?

Does Kodak have any workshops for teachers?

Can you help me plan a new projection room?

DO YOU HAVE ANY RECOMMENDATIONS ABOUT MAKING SLIDE-TAPE INSTRUCTIONAL UNITS?

Can you give us some information about using microfilm in our school library?

What services does Kodak have for junior high schools?

Do you know of any schools where a student of mine can learn to be a photographer?

Please send me some information about photography at the grade-school level.

HOW DOES KODAK ANALYZE AND PLAN TRAINING PROGRAMS?

I'd like to talk to someone about computer-assisted instruction for our industrial training.

Do you have any information about careers in photography?

Do you have any information to help me start a high school photo club?

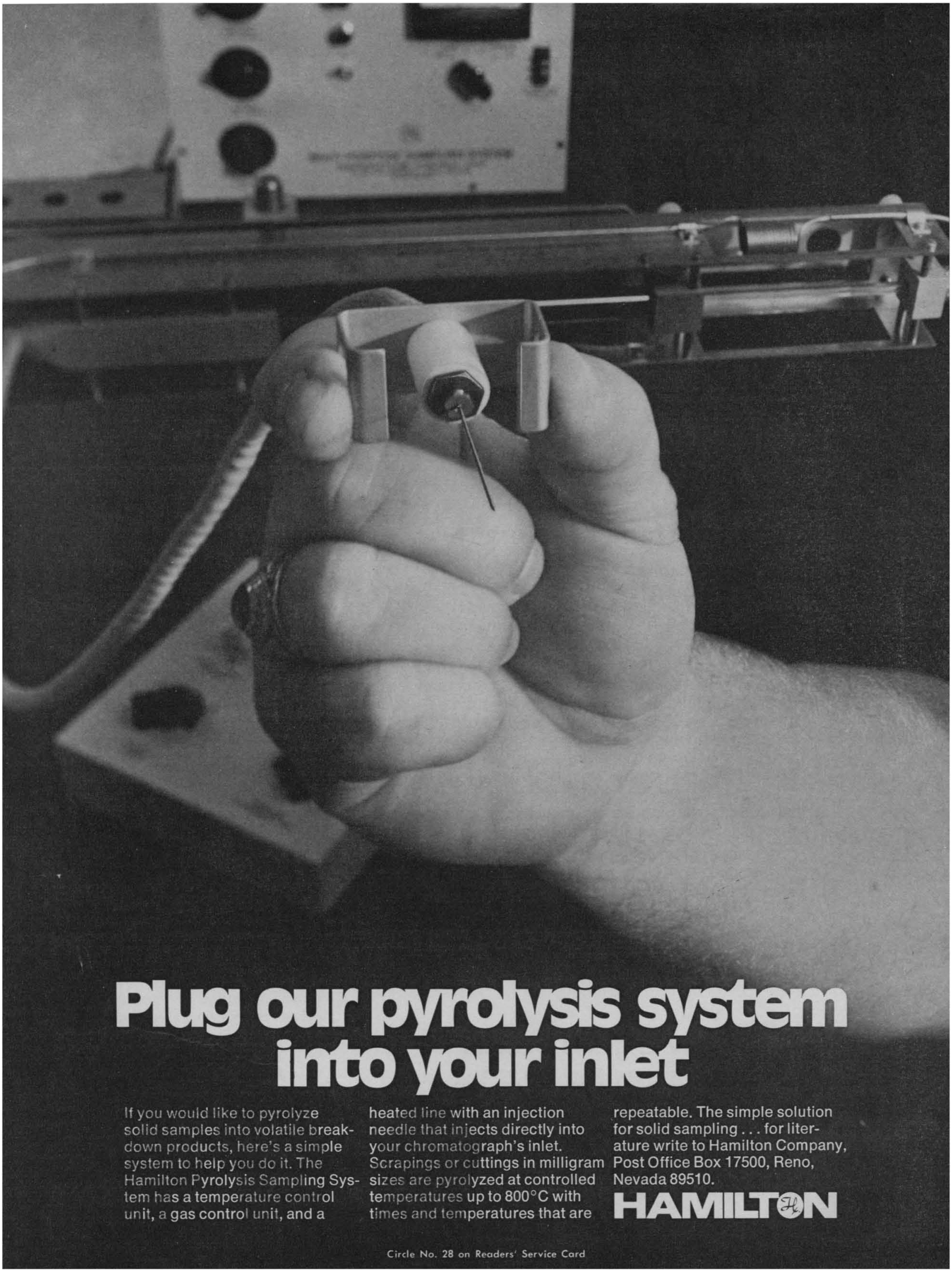
Does Kodak have any films for loan about picture-taking?

Would you send me information about the flexible classrooms in your new education center.

Should I use rear or front projection in our new building?

Our school of dentistry is individualizing. Do you have any information to assist us?

How can I make my own slides for my biology class?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after a lengthy discussion of the fact that a garbage collector can be replaced more easily than, say, a brain surgeon, they say, "Within science some men are more easily replaced than others. . . . It may not be necessary to have 80 percent of the scientific community occupied in producing 15 or 20 percent of the work that is used in significant scientific discoveries, if perhaps only half their number could produce the same work." Thus the fact that some men could be replaced becomes an indication that the work could be done even if these men were removed from the work force *without being replaced*.

Faulty logic is apparent in the introduction of evidence that a great deal of work in physics is not cited at all. Even if "cited" is equivalent to "used," this evidence is irrelevant to the main thesis. To say that some obscure physicists do not contribute is not to deny that many others do contribute. Obviously, in physics as in garbage collecting or sociology, some workers are unproductive, and that was true even when we had one-tenth as many physicists as we have today. It might be more relevant to see if the *percentage* of uncited work has increased as the number of physicists has grown. In any event, because of the way the grant system works, it is unlikely that unproductive physicists absorb much of our research budget.

Many factors that could have a bearing on Cole and Cole's interpretation of their data are either ignored completely or else dismissed by the introduction of some questionable hypothesis.

1) They do not mention that some fields of research are more popular than others. A person working in acoustics will receive fewer citations than a worker in high energy physics.

2) The possibility of more than one "generation of influence" on a paper is dismissed with a hypothesis that a search of further generations would not add many names that "appear more than once." But these names are the very names that the Ortega hypothesis is all about. It seems odd to set out to test a hypothesis concerning the effects of obscure researchers, then to say we do not have to look very far for these effects because these men can be replaced, and finally to say that we could therefore have progress without them or without any replacements for them.

3) Although Ortega specifically re-

ferred to "experimental science," Cole and Cole make no distinction between experimental and theoretical work, and they use the words "work" and "ideas" interchangeably. Consider a 1968 paper by Gell-Mann, Oakes, and Renner (*1*) in the 1971 *Science Citation Index*. It cited 26 papers; *all* were by theorists. A check of the cited papers shows that almost all of the papers cited in them were also by theorists. The only references to experimental work were "second-generation" citations of books or review articles. But review articles were excluded from Cole and Cole's study because they would "distort . . . [their] results." Thus their methods must lead to the conclusion that Gell-Mann *et al.* are not influenced by experimental results!

Recognition of the difference between theory and experiment makes the "Pointilliste" analogy more understandable. We may say that experimentalists fill in points on the canvas, while theorists try to recognize the picture that emerges. Eventually a theorist will say, "Aha, it's a giraffe (or an octet)." Maybe the theorist does not need every point in order to recognize the giraffe; maybe some experimenters fill in more points than others; maybe some workers are filling in some obscure cloud in the background instead of parts of the giraffe. But if too many points are missing, the picture is unrecognizable; theorists are already asking for points that are not being filled in because of budget limitations. It is difficult to decide, before the picture is recognized, which points will be significant, and thus where to place our dwindling resources, but it must be better to base the decision on analysis of the physics rather than on mere numerology.

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References

1. M. Gell-Mann, R. J. Oakes, B. Renner, *Phys. Rev.* **175**, 2195 (1968).

Being intrigued by the hypothesis of Cole and Cole that the "contribution to scientific progress" of an individual can be determined by "citation analysis," I decided to engage in the exercise in ego gratification that this hypothesis suggests. Looking up my own work in the 1972 *Science Citation Index*, I found, among other things, two references to a humorous letter I wrote to the editor of *Physics Today* (*1*) about what physics would have been like if the present mechanisms for research funding and publication had existed in the time of Copernicus and Kepler, making this letter one of my "major contributions to scientific progress" for that year. These references were due to two letters to the editor that were critical of mine. Nevertheless, they provided me with two citations, just as this letter will provide a citation for Cole and Cole. Hence, if a couple of more critical letters are published on the article by Cole and Cole, their work can, by its own standards, be said to have contributed about as much to scientific progress as my joke about Copernicus.

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Department of Physics, Memorial University of Newfoundland, St. Johns, Newfoundland, Canada

References

1. R. J. Yaes, *Phys. Today* **24**, 11 (December 1971).

The criticisms of our article fall into two categories: (i) Citations are an inadequate way to measure the quality of scientific work or intellectual influences on it; and (ii) the conclusions we reach concerning the size of science are not warranted by the data.

First consider the specific criticisms that are made of the use of citations.

1) The number of citations received by an article is dependent upon the "popularity" of the specialty (McGervey). This is only partially true. The sheer size of a field is not, in fact, closely related to the number of citations papers receive. While large specialties have more participants, they also have more literature to draw upon. Papers published in the larger specialty of solid-state physics, for example, do not receive more citations than those published in the smaller specialty of high energy physics. Further, McGervey assumes that the popularity of a specialty has nothing to do with the current opinion by scientists of the relative importance of work done in that specialty. Is acoustics merely a less popular specialty than high energy physics, or does high energy physics, more than acoustics, address a set of questions which are seen by physicists as more central to the advance of physics in general?

2) Experimentalists "fill in points on the canvas, while theorists try to recognize the picture that emerges" (McGervey). Two things are implied here: that experimentalists make many minor (infrequently cited) discoveries that contribute to the syntheses of the theoreticians and that theoreticians frequently do not cite the work of experimentalists that they have used. Important experimental work and technical innovations are frequently cited. For example, the most cited scientist in the 1971 *Science Citation Index* (SCI), O. H. Lowry, is cited for the development of a technique. Also consider the paper by J. H. Christenson *et al.* (*1*) reporting the violation of CP (charge and parity) conservation. In the first 5 years after it was published, this article received a total of 369 citations. Although Christenson, a graduate student at the time, was the first author, the two senior authors, J. W. Cronin and V. L. Fitch, received a total of 261 and 160 citations, respectively, to other papers on which they were the first author. On the matter of influential work going uncited, this certainly happens in *specific* papers. What is important, however, is whether or not there is significant work which received few or no citations in the entire body of literature. One only has to consider the example used by Goudsmit himself. Although Fellgett and Jacquinot are not cited by Becker and Farrar, Fellgett received 33 citations and Jacquinot 42 (not counting self-citations) in the 1972 SCI. These totals would put them in the top 10 to 15 percent of all scientists. Although any one paper may fail to cite a paper that has been influential in its genesis, the critical point, which is missed by Goudsmit, is that the probability of an important paper going uncited in the entire body of literature is low.

3) One of the most frequent criticisms of the use of citation counts to measure the quality of work is that it is impossible to tell the difference between a "positive" and a "negative" citation. This criticism is based upon an incorrect definition of high-quality work. "Correctness" is only one of the criteria we use in evaluating scientific work. Much trivial work is "correct," and much important work turns out in historical retrospect to have been "incorrect." If we take Kuhn's (*2*) argument seriously, then the work of most of the great figures in the history of science was in a sense "incorrect." A paper which is important enough to receive a large number of critical citations is probably a significant contribution. Why would a large number of scientists waste their time pointing out a trivial error? In fact, they do not.

Papers which are trivial and receive critical citations will not accumulate large numbers of citations. Thus, Yaes' letter, which received two critical citations, is not, even by our own rough empirical measure, a significant contribution.

4) Counting citations in an inadequate way to evaluate individual scientists when tenure or other similar decisions are made. We cannot emphasize strongly enough that we totally agree with this point. Nowhere have we ever suggested that citations be used as a basis for rewards. Sociologists use citation analysis to study the *community* of scientists, not individual scientists per se. In any large aggregate of scientists there will be a relatively high correlation between the number of citations received and other methods of evaluation. There will always be individual cases, of course, where the rough statistical measure is inaccurate. Using citation counts to determine the future of a scientist's career would be committing the "fallacy of misplaced concreteness," would be reifying the statistical indicator, and would be grossly unfair to the individuals involved. Although counting citations is indeed a rough way to measure quality and influence, it has allowed us to address a whole range of substantive problems which, heretofore, were not negotiable because there was no adequate measure of research performance. Max Delbruck was well aware of the need at times for adopting less than perfect measures, as long as the scientist is aware that his measures are crude. His "principle of limited sloppiness" (*3*) does not, of course, excuse muddled thinking or poor logic. But his idea shows an acute awareness of the processes by which knowledge advances at various stages in the development of disciplines.

Finally a word about criticism by some natural scientists of work in the sociology of science. When a physicist publicly criticizes the work of another physicist, he is usually advised to be at least somewhat familiar with the literature on the subject of debate. When some natural scientists publicly criticize the work of sociologists of science, they do not appear to be familiar with literature on the topic. The criticisms about citation counts in the letters here are a case in point. There is now a substantial body of literature on the methodological problems involved in using citation counts. Virtually all criticisms raised in these letters have been analyzed in some detail in this literature. Critics of citation analysis have a responsibility to famaliarize themselves with this literature.

The second criticism of our paper suggests that even if most scientists are indeed rarely cited (accepting this indicator of influence as valid), this does not mean that scientific progress would be unaffected by a reduction in the number of scientists. Consider McGervey's implicit assumption that, since all research scientists might contribute some slight piece of relevant knowledge, they are therefore deserving of support. In a world in which resources were unlimited, we too would be in favor of the society supporting anyone who wanted to be a scientist. Science is certainly an intrinsically more interesting and worthwhile endeavor than many others. Unfortunately, we live in a world in which there is a limitation on available resources. In such a situation, rather than bemoan the sad state of science, it is the responsibility of the scientific community to consider how the limited resources we do have can be most effectively utilized.

Nowhere in our article do we suggest that there should be any cutback in the level of spending for scientific research and development. Our findings raise the issue, however, of whether limited resources might best be concentrated in support of the relatively small number of scientists who have the highest probability of making significant discoveries. We hypothesize that such a policy would not bring about a decline in the rate of scientific progress. We do not claim to have proved this conclusively. We claim to have presented enough data in support of hypothesis to merit its further consideration.

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Stony Brook 11790

References

1. J. H. Christenson, J. W. Cronin, V. L. Fitch, R. Turlay, *Phys. Rev. Lett.* **13**, 138 (1964).
2. T. S. Kuhn, *The Structure of Scientific Revolutions* (Univ. of Chicago Press, Chicago, 1962).
3. M. Delbruck, as cited by J. D. Watson, in J. Cairns *et al.*, Eds., *Phage and the Origins of Molecular Biology* (Cold Spring Harbor Laboratory of Quantitative Biology, Cold Spring Harbor, New York, 1966), p. 242.
4. For a bibliography, see *Science Citation Index 1972 Guide & Journal Lists* (Institute for Scientific Information, Philadelphia, 1973), pp. 64–68.

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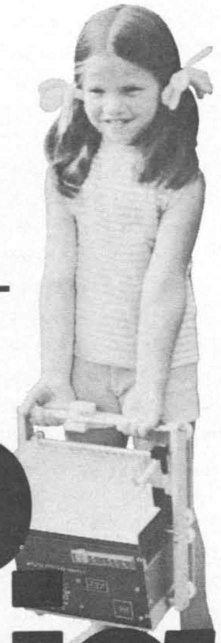

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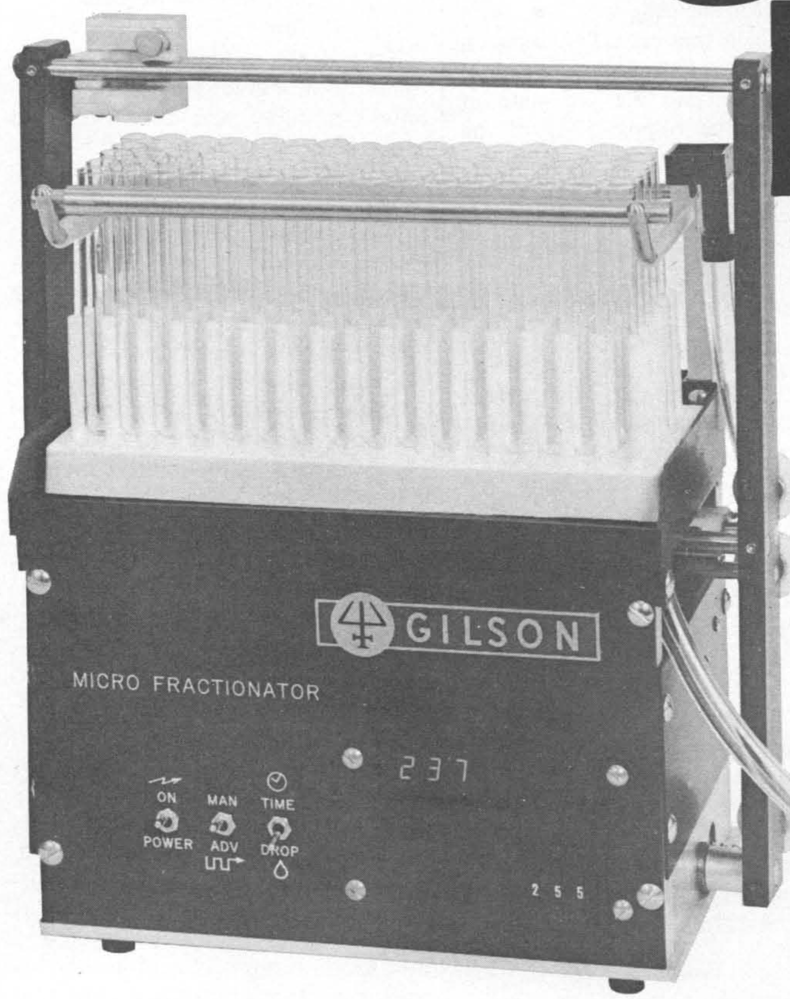

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11 January 1974, Volume 183, Number 4120

SCIENCE

Social Experiments: Promise and Problems

Major experiments with social policy are under way. For example, the Office of Economic Opportunity's 3-year negative income tax experiment in New Jersey is in its final phases. The government is sponsoring a health insurance experiment to see how the use of health services is affected by the extent to which the patient shares the cost of health care and a series of experiments with housing allowances to see how such allowances affect the demand for and the supply of housing. In education, experiments with performance contracting and with new incentives for parents and teachers have been completed.

The new social experiments were responses to the frustration of those considering new policies who found themselves unable to answer the question: How do you know what will happen? The idea sounds simple, but the new tool is exceedingly tricky and hard to use skillfully.

First there are design dilemmas, some of which arise from the conflict between the desire to obtain valid, reliable results and the equally urgent desire to obtain results quickly and at a low cost. Then there are implementation dilemmas. To get a "clean" test of a new policy, it might seem best to have the policy spelled out in great detail in advance and have expert managers follow the rules to the letter. Allowing local communities to innovate as they go along, and perhaps change the whole intent of the policy, would mess up the experiment. On the other hand, if the policy being tested becomes a national program, it will be carried out by people with their own ideas and their own administrative strengths and weaknesses. Thus the "clean" experiment may turn out to be an unreliable predictor of what will really happen.

There are dilemmas attached to evaluation itself. Good evaluation is not possible unless it is built into the original design of the experiment and unless the evaluators are fully familiar with the details of the operation. On the other hand, if the evaluators are involved with the project from the beginning, can they remain objective? There are also timing dilemmas, for if the results of social experiments are to affect decisions, they must be available when the decisions are being made. Unfortunately, politicians rarely get excited enough about a problem to finance an experiment until they are nearly ready to make the decision. Then they want immediate results. But a "quick and dirty" experiment may be worse than none.

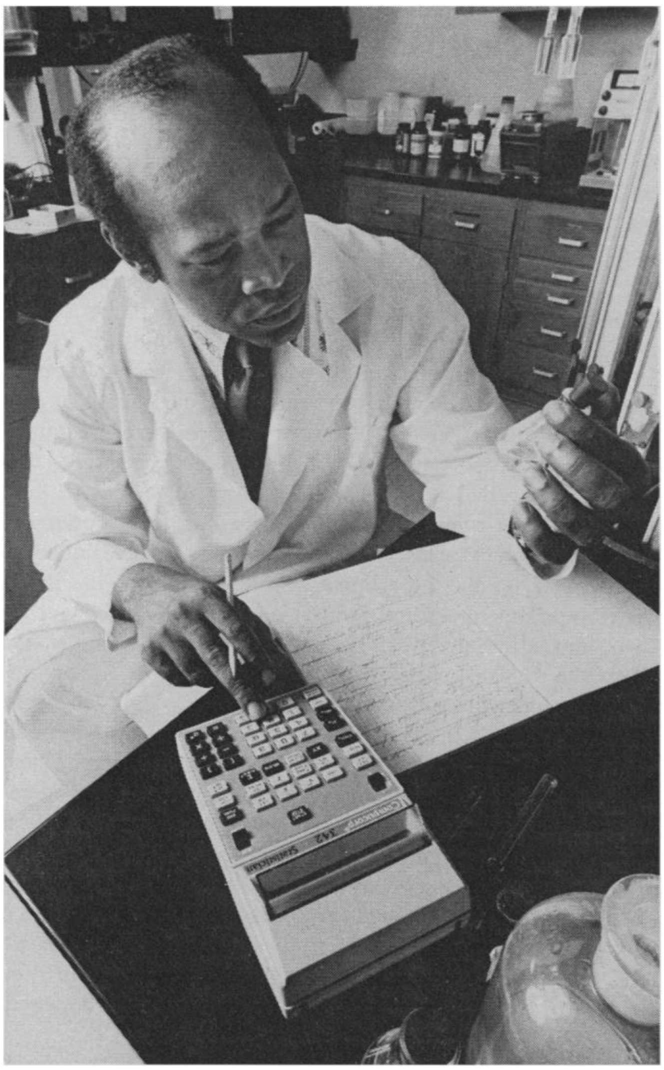
Moreover, there are difficult moral questions associated with experimenting with people. Finally, there is a series of dilemmas having to do with openness of experiments. For example, how can the privacy of the participants in the experiment be protected? If experiments—and indeed other types of social science research—are to continue, a way must be found to protect the privacy of respondents.

It is too soon to draw substantive conclusions from most of these social experiments, but something can be said about the method itself. Clearly experiments are feasible when the treatment is a simple one, such as a change in tax or a payment schedule, and when the outcome is measurable behavior of individuals, such as hours worked or dollars earned. It is still an open question whether more complex experiments are feasible.

Experiments can be an important tool in improving information for decision-making, but we know enough about experimentation now to know how hard it is to do it well. If great care is not taken to make current experiments as useful and as sensible as possible, there may be a reaction against the whole technique, and a potentially useful tool may be taken away.—ALICE M. RIVLIN, *chairman, Panel on Social Experimentation, The Brookings Institution, Washington, D.C. 20036.*

This editorial is adapted from an article in *Evaluation* **1**, No. 2 (1973).

Most of your Bio Med problems can be solved by an unknown.



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PRODUCTS and MATERIALS

Gel Electrophoresis System

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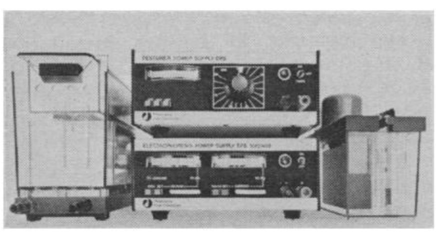

Fig. 1. The Pharmacia gel electrophoresis system includes high-voltage power supplies for the electrophoresis cell apparatus and the gel destainer mounted conveniently.

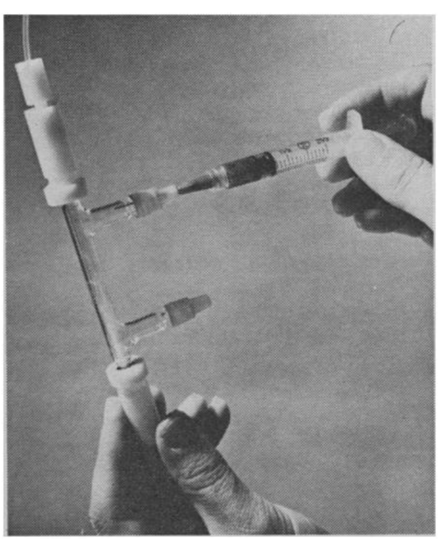

Fig. 2. The Bio-Fiber Cell Culture Kit enables the operator to inject cells through the port into the culture tube where they adhere to semi-porous capillary fibers. They receive nutrient and oxygen through the fibers and grow in densities approximating those in vivo.

Human Cell Culture System

The Bio-Fiber Cell Culture Kit (Fig. 2) allows the growth of human cells in densities comparable to those found in vivo. The system features a small glass tube in which semi-porous fibers serve as artificial blood vessels. The second part is another small tube used as an oxygenator. Nutrient is pumped through the oxygenator, then through the capillary fibers in the cell culture tube. Nutrient and oxygen thus enter the culture area while waste products are removed. Cells are injected through jacket ports in the culture tube. The cells adhere to the fiber surfaces and new cells grow outward, approximating natural tissue growth. Bio-Rad Laboratories. Circle No. 138 on Readers' Service Card.

Blood Flowmeter

Cliniflow (Fig. 3) is designed for ease of operation in clinical applications. The operator dials a calibrated flow factor and adjusts the zero if necessary. Flow rate is displayed directly in milliliters per minute. Range and decimal settings are automatic. The reading unit may be isolated from the patient even if external recording devices are connected. All controls and displays are front-mounted. There is also a model that will simultaneously measure flow and pressure when the input is from a catheter probe. Carolina Medical Electronics, Incorporated. Circle No. 136 on Readers' Service Card.

Fig. 3. Carolina Medical Electronics' Cliniflow blood flowmeter features easy operation, digital display, front-mounted controls, and isolation from the patient.

Scanning Electron Microscope

The Cam-Scan instrument features a horizontally mounted electron column which simplifies cleaning and maintenance. Magnification is variable from 10 to 9000 power with resolution better than 750 angstrom units. The rotating specimen chamber and air lock system allow changing of specimens in 40 seconds. The high vacuum does not deteriorate during specimen change, which prolongs the life of the scintillator and filament and minimizes contamination. Positioning of the specimen is by joystick and tilting and rotation are possible in any direction. A standard half-inch stub accommodates specimens up to 12 millimeters in diameter. The Random Interest Area Selector permits observation at higher magnification of selected areas illuminated with a target patch. Bausch & Lomb, Optical Products Division. Circle No. 139 on Readers' Service Card.

Printing Counter

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Newly offered instrumentation, apparatus, and laboratory materials of interest to researchers in all disciplines in academic, industrial, and government organizations are featured in this space. Emphasis is given to purpose, chief characteristics, and availability of products and materials. Endorsement by *Science* or AAAS is not implied. Additional information may be obtained from the manufacturers or suppliers named by circling the appropriate number on the Readers' Service Card (see pages 18A and 114C) and placing it in the mailbox. Postage is free.—RICHARD G. SOMMER black printing, and programmable "no print" blanking for each digit. The printing cycle is 400 milliseconds. The unit is complete with power supply and demand motor operation controlled by a built-in time-tachometer circuit. Coulbourn Instruments, Incorporated. Circle No. 137 on Readers' Service Card.

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Literature

YSI Temperature Instruments is a four-page catalog of thermometers, thermographs, telemetry and temperature sensing devices for all laboratory and field applications. Yellow Springs Instrument Company. Circle No. 145 on Readers' Service Card.

Electronic Top-Loading Balances describes a line of laboratory devices. The electronic data may be read, recorded, or transmitted for computer analysis. Performance, design specifications, photographs, and schematic drawings are included. Mettler Instrument Corporation. Circle No. 146 on Readers' Service Card.

Chromatography Apparatus Catalog 80A275 is a 28-page brochure that illustrates the Lab-Crest line of columns, end-fittings, and accessories. Fischer & Porter Company. Circle No. 147 on Readers' Service Card.

Microscope Photometer, MPV System describes apparatus for microphotometry including the MPV2 microscope photometer. Applications, accessories, and performance data are illustrated. E. Leitz, Incorporated. Circle No. 148 on Readers' Service Card.

BOOKS RECEIVED

(Continued from page 68)

sistance to Antimalarials. Report of a WHO Scientific Group. World Health Organization, Geneva, 1973 (available from the United Nations Bookshop, New York). 122 pp., illus. Paper, $2.10. World Health Organization Technical Report Series No. 529.

La Chimie des Surfaces. Jacques Oudar. Presses Universitaires de France, Paris, 1973. 172 pp., illus. Paper, 17F. Collection SUP, Le Chimiste, vol. 7.

Chromomycosis. Yousef Al-Doory. Mountain Press, Missoula, Mont., 1972. xii, 204 pp., illus. $10.

Classical Galois Theory. With Examples. Lisl Gaal. Chelsea, New York, ed. 2, 1973. viii, 248 pp., illus. $7.50.

Clinical Nutrition. Proceedings of a symposium, Saltsjöbaden, Sweden, June 1971. J. C. Somogy, Ed. Karger, New York, 1973. viii, 166 pp., illus. Paper, $26. Bibliotheca "Nutritio et Dieta," No. 19, Series of the Institute of Nutrition Research, vol. 19.

The Coastline of Scotland. J. A. Steers. Cambridge University Press, New York, 1973. xvi, 336 pp., illus. + map. $31.50.

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