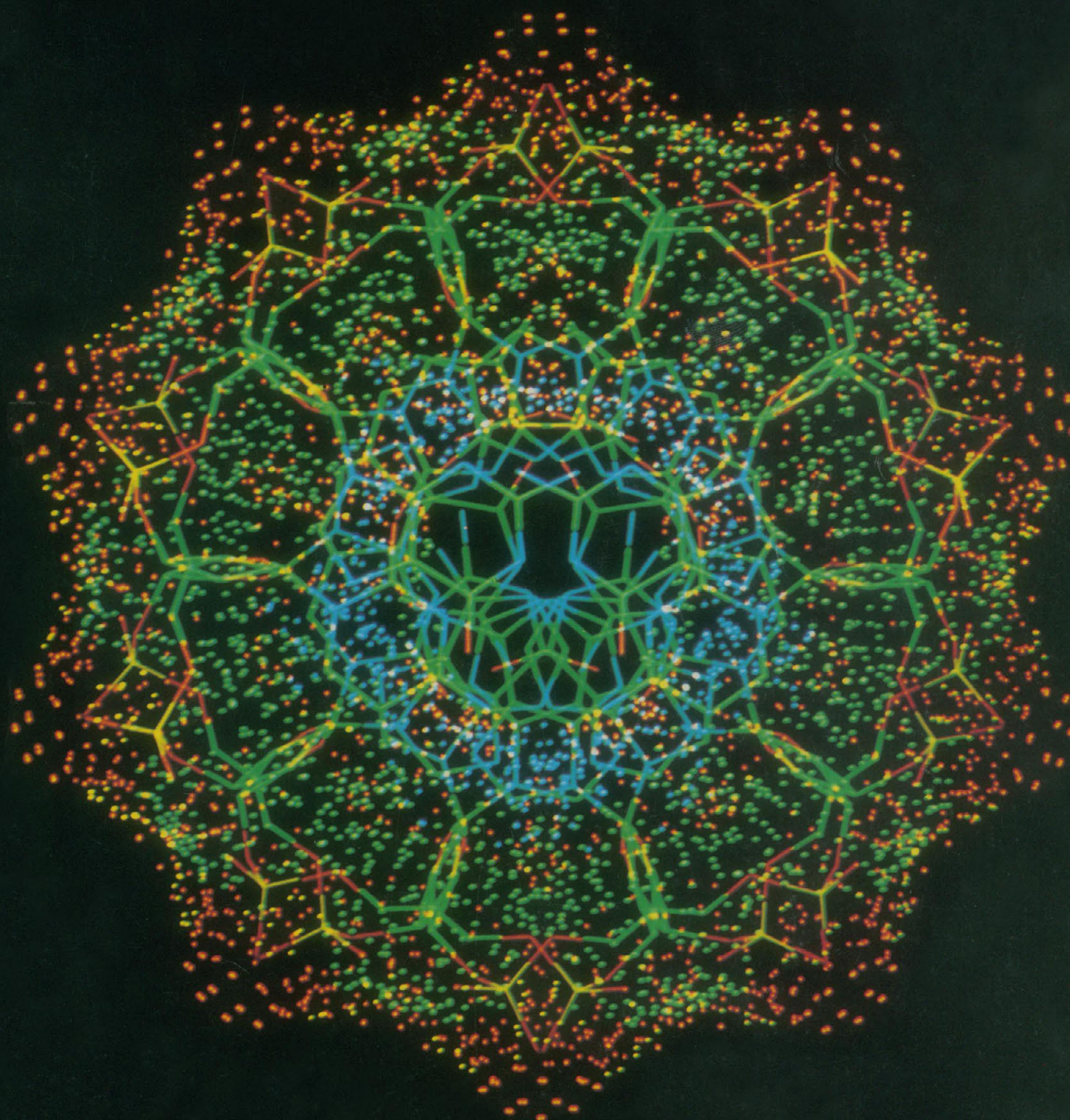


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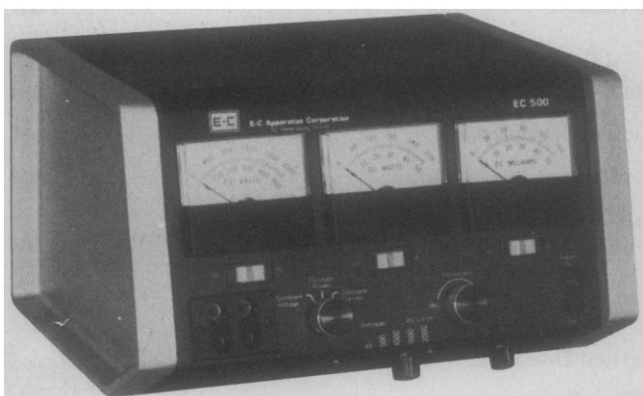
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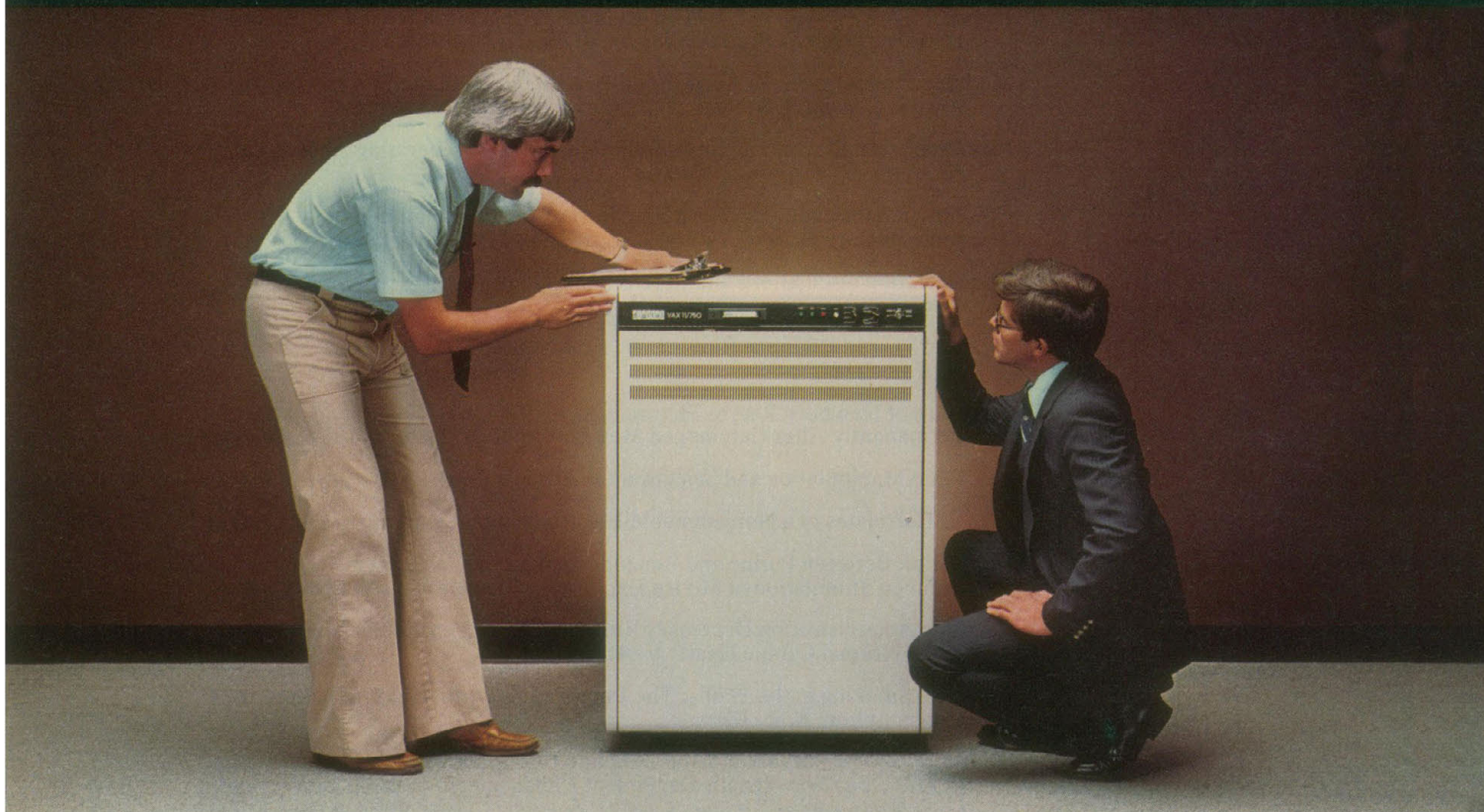
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COVER

View down the axis of double helical DNA photographed directly from real-time, interactive three-dimensional color display. Up to four large molecules may be displayed in color as skeletal models and/or surfaces and their stereochemical interactions studied in three dimensions. See page 661. [Robert Langridge, Computer Graphics Laboratory, University of California, San Francisco]

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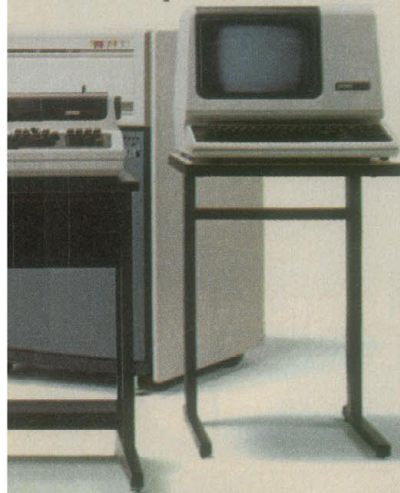
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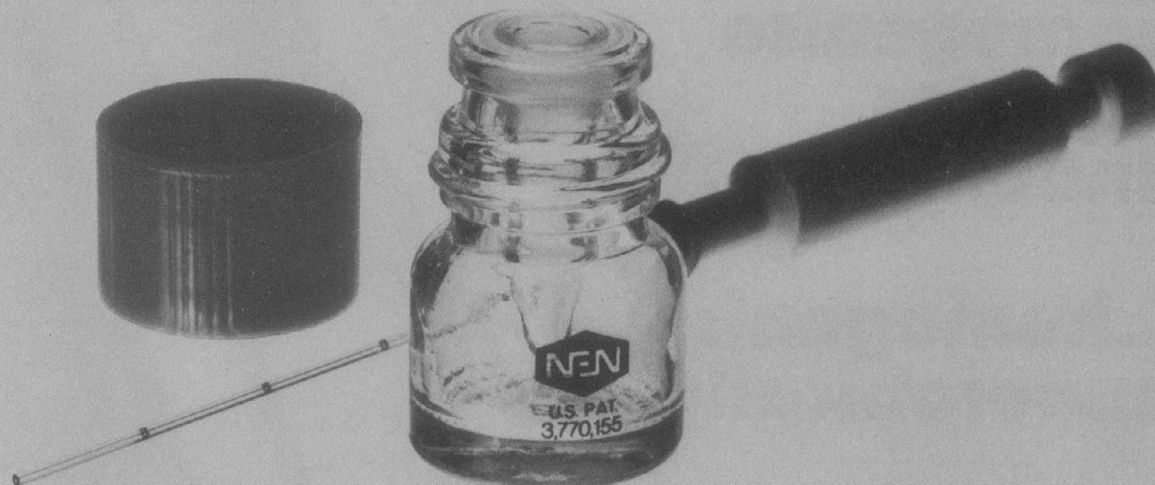
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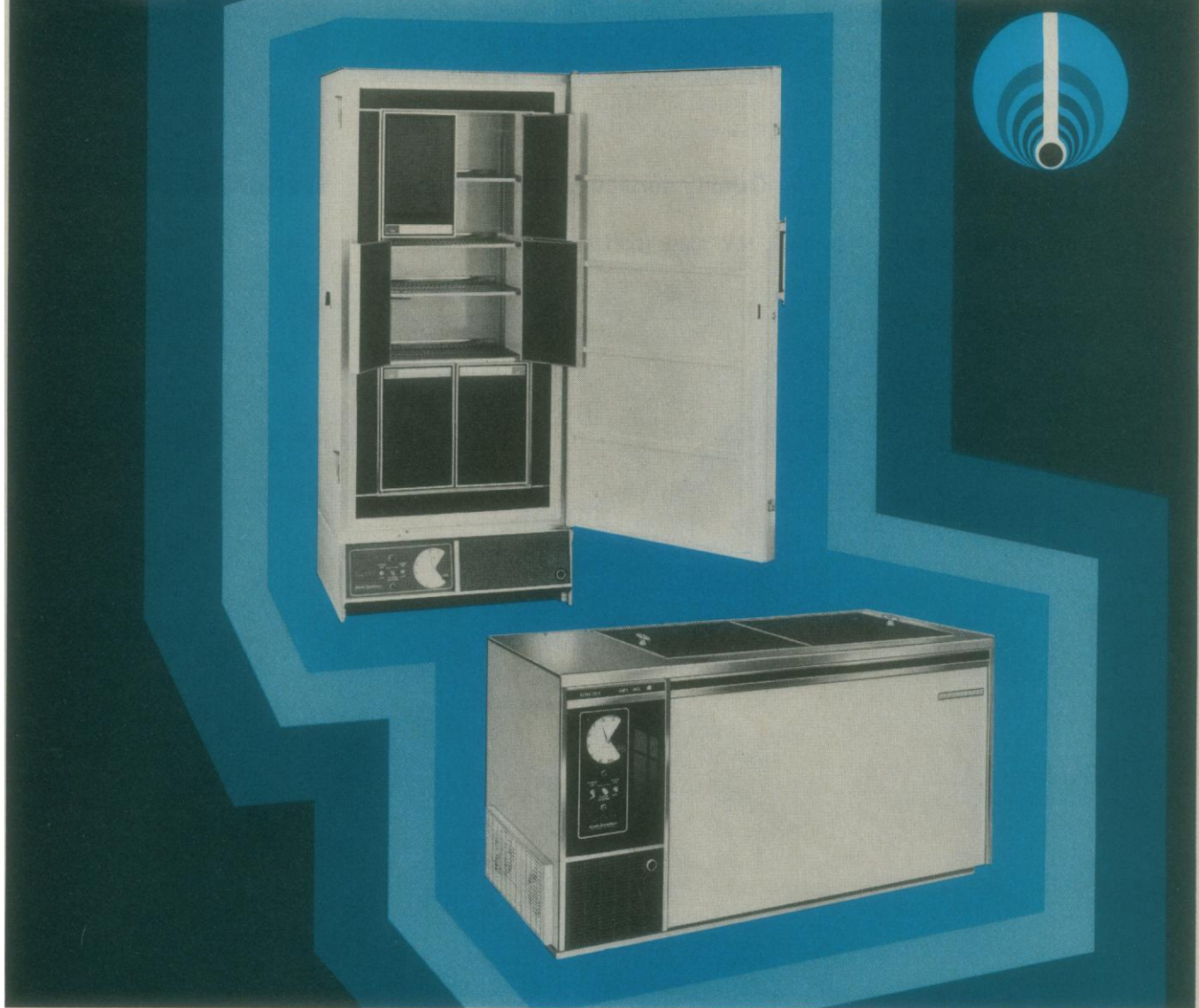
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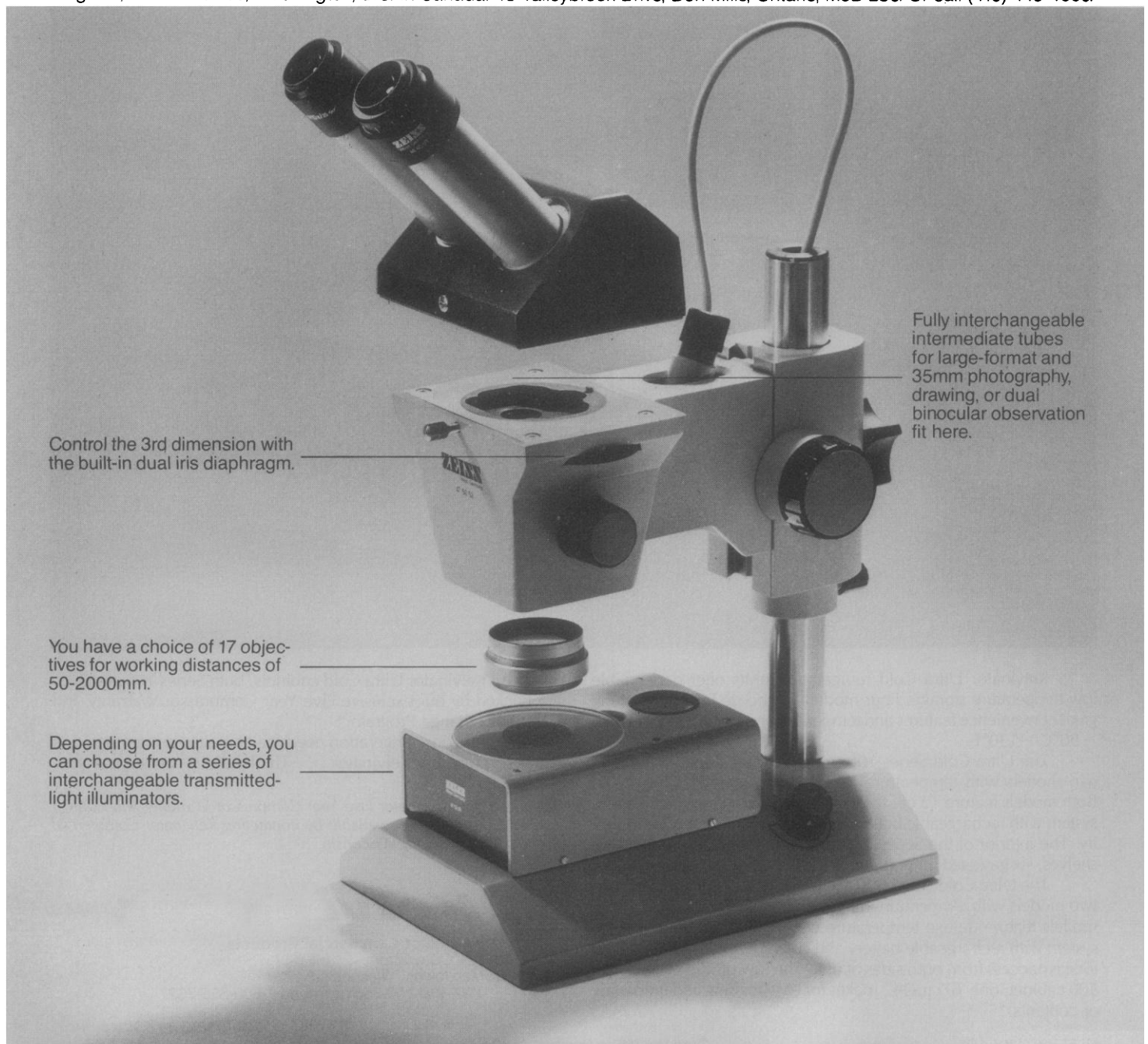
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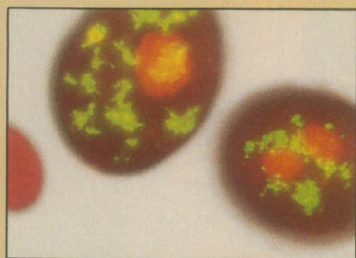


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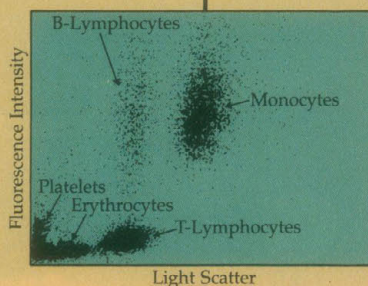


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for the common form of acute lymphoblastic leukemia (ALL) have been produced in rabbits and shown to define a cell surface antigen of non-T, non-B type ALL.

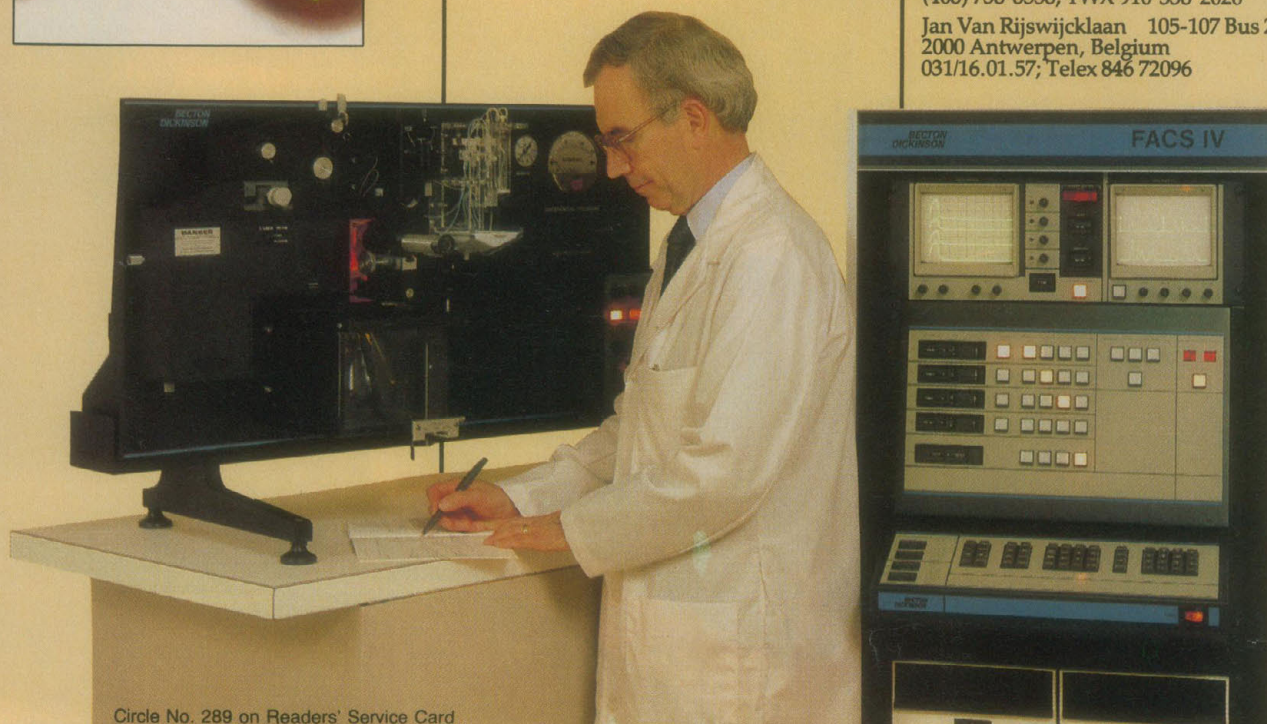
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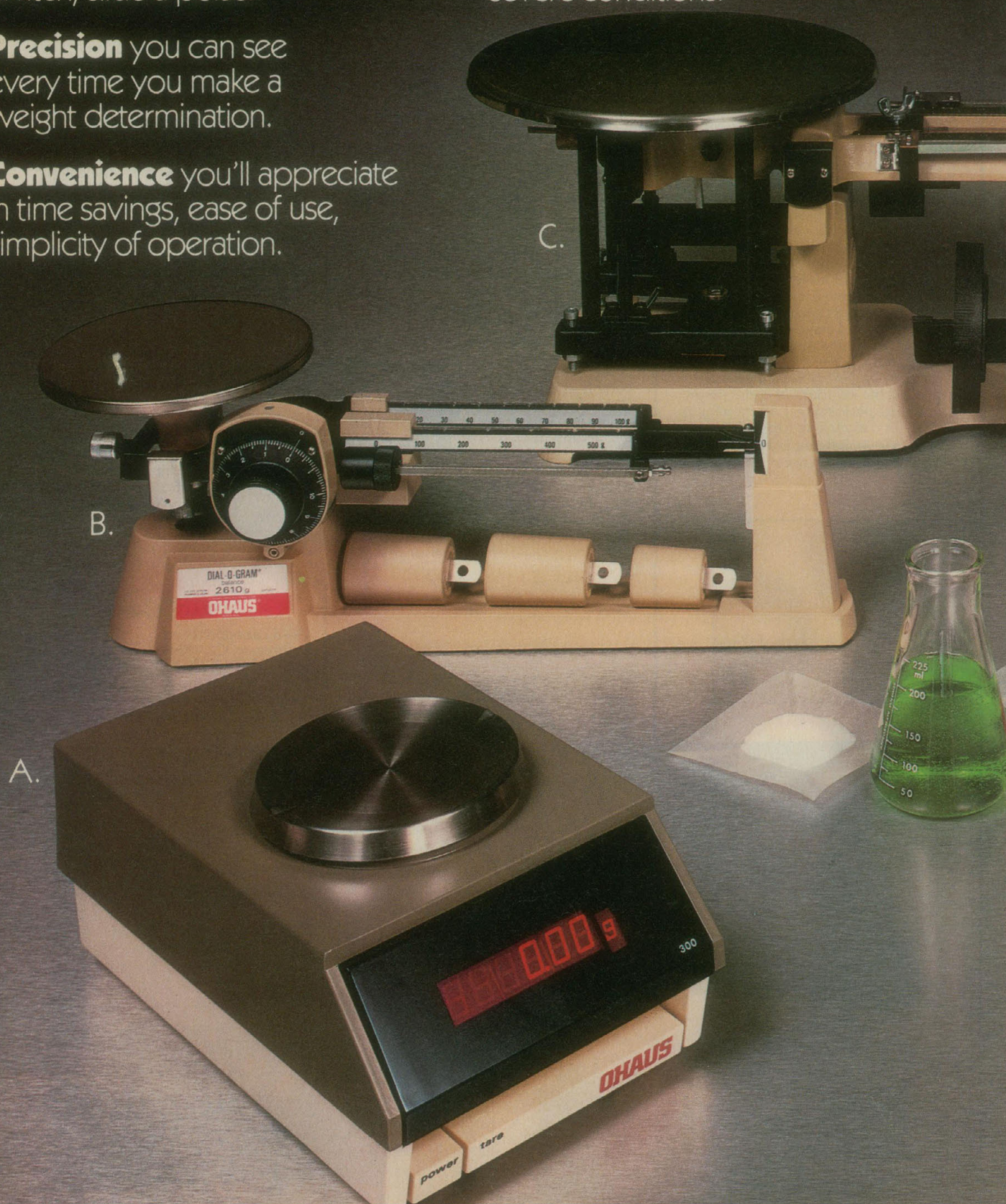
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NATURAL AND EXPERIMENTALLY INDUCED REARRANGEMENT OF NEURONAL CONNECTIONS

Prof. S.S. EASTER Biological Sciences, Univ. of Michigan, 830 North University Ave., Ann Arbor, MI 48109, USA
28 May-8 June, 1981 : Varese, Italy

SPINAL CORD REHABILITATION ENGINEERING

Prof. D.N. GHISTA Michigan Technological Univ., College of Engineering, Houghton, Michigan 49931, USA
11-23 May, 1981 : Stoke Mandeville Hospital, UK

ADVANCES IN BIOL. EFFECTS AND DOSIMETRY OF LOW ENERGY ELECTROMAGNETIC FIELDS

Prof. A. RINDI INFN-LNF - C.P. 13, 00044 Frascati (Roma), Italy
28 March-8 April, 1981 : Erice, Italy

COMPARTMENTATION AND NEUROTRANSMITTER INTERACTION

Prof. H.F. BRADFORD Dept. of Biochemistry, Imperial College, London S.W.7 2AZ, UK
26 July-5 August, 1981 : Hotel Metropole, Powys, Mid-Wales, UK

BEHAVIORAL MEDICINE : WORK, STRESS AND HEALTH

Dr. N. BENSON Univ. of Texas Medical Branch, Galveston, Texas 77550, USA
1-16 August, 1981 : Bonas, Castéra-Verduzan, France

QUANTUM ELECTRODYNAMICS OF STRONG FIELDS

Prof. Dr. W. GREINER Inst. für Theor. Physik, Univ., Robert Mayer Str. 8-10, 6000 Frankfurt/Main, Germany
14-26 June, 1981 : Lahnstein/Rhein, Germany

MAGNETISM IN SOLIDS - SOME CURRENT TOPICS

Prof. A.P. CRACKNELL Carnegie Lab. of Physics, Univ. of Dundee, Dundee DD1 4 HN, Scotland
9-29 August, 1981 : Dundee

FUNDAMENTAL INTERACTIONS

Prof. M. LEVY Phys. Théorique et Hautes Energies, Univ. P. et M. Curie, Tour 16, 4 Pl. Jussieu, 75230 Paris, France
15-31 July, 1981 : Cargèse, Corsica

QUANTUM OPTICS AND EXPERIMENTAL GENERAL RELATIVITY

Prof. P. MEYSTRE Projektgruppe für Laserforschung der Max Planck Gesellschaft, 8046 Garching/Munich, Germany
August 1981 : Kurs- und Kongresshotel Residenz, Bad Windsheim, Germany

EXCITATIONS IN DISORDERED SYSTEMS

Prof. M.F. THORPE Physics Depart., Michigan State Univ., East Lansing, Mich. 48824, USA
23 August-4 September, 1981 : Michigan Univ., USA

CHAOTIC BEHAVIOUR OF DETERMINISTIC SYSTEMS

Prof. R. STORA Division Théorie, CERN, 1211 Genève 23, Suisse
29 June-31 July, 1981 : Les Houches, France

PATTERN RECOGNITION THEORY AND APPLICATION

Dr. J. KITTLER Nuclear Physics Laboratory, Oxford Univ., Keble Road, Oxford OX1 3RH, UK
28 March-11 April, 1981 : Oxford, UK

GAUGE THEORIES IN HIGH ENERGY PHYSICS

Prof. R. STORA Division Théorie, CERN, 1211 Genève 23, Suisse
3 August-11 September, 1981 : Les Houches, France

INTEGRATED OPTICS: PHYSICS AND APPLICATION

Prof. S. MARTELLUCCI Inst. of Physics, Univ. of Naples, Piazza V. Tecchio 80, 80125 Napoli, Italy
17-29 August, 1981 : Erice, Italy

ADVANCES IN LASER SPECTROSCOPY

Prof. H. WALTHER Max-Planck-Gesellschaft, D-8046 Garching bei München, Germany
26 July-8 August, 1981 : Camaiore, Italy

CO-ORDINATION CHEMISTRY ENVIRONMENTS IN PROTEINS AND ENZYMES

Dr. H.B. DUNFORD Dept. of Chemistry, Univ., Edmonton, Alberta, Canada T6G 2G2
23rd August-5th September, 1981 : Banff, Alberta

OPERATION OF COMPLEX WATER RESOURCES SYSTEMS

Prof. E. GUGGINO School Water Resources Managem., 'Ettore Majorana' Centre Scient. Culture, 91016 Erice, Italy
18-29 May, 1981 : Erice, Italy

NEW ADVANCES IN DISTRIBUTED COMPUTER SYSTEMS

Dr. K.G. BEAUCHAMP Computer Services Depart., Univ. of Lancaster, Bailrigg, Lancaster LA1 4YW, UK
15-26 June, 1981 : Bonas, France

SEDIMENT DIAGNOSIS

Dr. A. PARKER Sedimentology Research Lab., Dept. of Geology, University, Whiteknights, Reading, UK
12-25 July, 1981 : Reading, UK

AUTOMATIC PROGRAM CONSTRUCTION

Prof. G. GUIHO Lab. Recherche Informatique, Univ. Paris Sud, Bât. 490, Centre d'Orsay, 91405 Orsay Cedex, France
28 September-10 October, 1981 : Bonas, France

CHEMISTRY OF THE UNPOLLUTED AND POLLUTED TROPOSPHERE

Prof. Dr. H.W. GEORGI Univ., Dept. Meteorology and Geophysics, Feldberg Strasse 47, 6000 Frankfurt, Germany
28 September-10 October, 1981 : Corfu, Greece

THEORIE DES FONCTIONS CONSTRUCTIVE ET GEOMETRIQUE

Dr. G. SABIDUSSI Dept. mathém. et statistique, Univ., C.P. 6128, Succ. A, Montréal, Qué. H3C 3J7, Canada
3-21 August, 1981 : Montréal, Canada

THE USE OF IONIZING RADIATION FOR STUDY OF FAST PROCESSES AND LABILE SPECIES IN CHEMISTRY AND BIOLOGY

Prof. F. BUSI Istituto F.R.A.E./CNR, Via Castagnoli 1, 40126 Bologna, Italy
7-17 September, 1981 : Capri, Italy

COSMOCHEMISTRY - STUDY OF ELEMENTS AND MOLECULES NECESSARY FOR LIFE IN THE EARLY SOLAR SYSTEM

Prof. C. PONNAMPERUMA Lab. Chemical Evolution, Univ. of Maryland, College Park, Md., 20742, USA
1-13 June, 1981 : Maratea, Italy

TARGETING OF DRUGS

Dr. G. GREGORIADIS Clin. Research Centre, Watford Road, Harrow, Middx HA1 3UJ, UK
24 June-5 July, 1981 : Souinion, Greece

POST HARVEST PHYSIOLOGY AND CROP PRESERVATION

Dr. M. LIEBERMAN Lab. Chief, Postharvest Physiology Lab., U.S. Dept. of Agriculture, Beltsville, Md. 20705, USA
28 April-8 May, 1981 : Souinion, Greece

CANCER OF KIDNEY AND PROSTATE: BASIC RESEARCH AND THERAPY

Prof. P.H. SMITH St. James's University, Hospital, Beckett Street, Leeds LS9 7TP, UK
2-12 July, 1981 : Erice, Italy

CURRENT METHODS IN STRUCTURAL MOLECULAR BIOLOGY

Dr. D.B. DAVIES Department of Chemistry, Birkbeck College, Malet Street, London WC1E 7HX, UK
3-16 May, 1981 : Maratea, Italy

BIOMASS UTILIZATION

Dr. H. SOBEL c/o News Inc., P.O. Box 1979, Santa Monica, California 90406, USA
1-12 March, 1981 : Blacksburg, Virginia, USA

ADVANCES IN VERTEBRATE NEUROETHOLOGY

Prof. Dr. J.P. EWERT Dept. of Neuroethology, Univ., Heinrich Plett Str. 40, 3500 Kassel-Oberzwehren, Germany
13-24 August, 1981 : Schlösschen Schönburg, Germany

ARTERIAL POLLUTION

Dr. H. PEETERS Inst. Medical Biology, Alsembergsesteenweg 196, 1180 Brussel, Belgium
30 August-12 September 1981 : Maratea, Italy

EXPERIMENTAL SOCIAL PSYCHOLOGY

Dr. C. FLAMENT Dept. of Psychology, Univ. of Provence, 29 av. R. Schuman, Aix-en-Provence, France
12-31 July, 1981 : Aix-en-Provence, France

CHEMICAL CARCINOGENESIS

Dr. C. NICOLINI c/o Inst. Pharmacology, CNR, Viale Benedetto XV, 2, 16132 Genova Italy
18-31 October 1981 : Erice, Italy

DIAGNOSTIC IMAGING IN MEDICINE

Dr. H.F. DAVIDSON (DAMA-AR), Dept. of the Army, Washington DC 20310, USA
September 1981 : Italy

SOMATIC CELL GENETICS

Dr. C.T. CASKEY Room 544E Baylor College of Medicine, Houston, Texas 77030, USA
31 May-12 June 1981 : Algarve, Portugal

THE USE OF HUMAN CELLS FOR RISK ASSESSMENT BY PHYSICAL AND CHEMICAL AGENTS

Prof. A. CASTELLANI CNEN-CSN Casaccia, P.O. Box 2400, AD. ROME, Italy
20-30 August, 1981 : Castelgandolfo, Italy

BIOCHEMICAL AND BIOLOGICAL MARKERS OF NEOPLASTIC TRANSFORMATION

Prof. P. CHANDRA Molecular Biol. Dept., Univ. Medical School, Theodor Stern Kai 7, D-6000 Frankfurt 70, Germany
1-10 September, 1981 : Crete, Greece

DURABLE RESISTANCE IN CROPS

Prof. F. LAMBERTI Istituto di Patologia Vegetale, Univ. degli Studi di Bari, Via G. Amendola, 165/A, 70126 Bari, Italy
4-18 October, 1981 : Bari, Italy

PHOTORECEPTOR CELLS - MECHANISMS OF PHOTOTRANSDUCTION AND PHOTO RECEPTION

Dr. A. BORSELLINO Istituto di Coermetica e Biofisica del C.N.R., Corso Mazzini 20, 16132 Camogli, Italy
1-10 July, 1981 : Erice, Italy

AGGRESSION IN CHILDREN AND YOUTH

Dr. R.M. KAPLAN Psychology Clinic, San Diego State Univ., San Diego, California 92182, USA
17-28 June, 1981 : Maratea, Italy

LEUKOTRIENES AND PROSTACYCLIN

Prof. F. BERTI Dept. of Pharmacology and Pharmacognosy, Univ. of Milan, Via Vanvitelli 32, 20129 Milan, Italy
10-21 September, 1981 : Erice, Italy

II PHYSICS**COLLECTIVE EXCITATIONS IN SOLIDS**

Prof. B. DI BARTOLO Dept. of Physics, Boston College, Chestnut Hill, Mass. 02167, USA
15-30 June, 1981 : Erice, Italy

ELECTRON CORRELATIONS IN METALS

Prof. Dr. J.T. DEVREESE Dept. Natuurkunde, Univ. Antwerpen, Universiteitsplein 1, B-2610 Wilrijk, Belgium
20-31 July, 1981 : Antwerpen, Belgium

MASS TRANSPORT IN SOLIDS

Dr. C.R.A. CATLOW Dept. of Chemistry, Univ. College London, 20 Gordon Street, London WC1H 0HJ, UK
28 June-11 July, 1981 : Lannion, France

CLASSICAL AND QUANTUM METROLOGY AND FUNDAMENTAL PHYSICAL CONSTANTS

Prof. P.H. CUTLER Depart. Physics, 104 Davey Lab., Pennsylvania State Univ., Univ. Park, Pennsylvania 16802, USA
16-28 November, 1981 : Erice, Italy

THE ORIGIN AND EVOLUTION OF GALAXIES

Dr. B.J.T. JONES Inst. of Astronomy, Madingley Road, Cambridge CB3 0HA, UK
11-23 May, 1981 : Erice, Italy

PHYSICS OF ION-ION AND ELECTRON-ION COLLISIONS

Prof. F. BROUILLARD Inst. de Physique, Science-1, B-1348 Louvain-la-Neuve, Belgium
31 September-12 October, 1981 : Baddeck, Canada

NONLINEAR PHENOMENA AT PHASE TRANSITIONS AND INSTABILITIES

Dr. E. ANDERSON Inst. for Energy Technology, P.O.B. 40, N-2007 Kjeller, Norway
29 March-9 April, 1981 : Geilo, Norway

RELATIVISTIC EFFECTS IN ATOMS, MOLECULES AND SOLIDS

Prof. G.L. MALLI Dept. of Chemistry and Theoretical Sciences, Simon Fraser Univ., Burnaby, B.C. V5A 1S6, Canada
10-21 August, 1981 : Vancouver, Canada

STRUCTURAL ELEMENTS IN PARTICLE PHYSICS & STATISTICAL MECHANICS

Prof. J. HONERKAMP Fakultät für Physik d. Univ. Freiburg, Hermann-Herder-str. 3, 7800 Freiburg, Germany
31 August-11 September, 1981 : Freiburg i.Br., Germany

SUPERNOVAE

Prof. M.J. REES Institute of Astronomy, Madingley Road, Cambridge, CB3 0HA, England
29 June-10 July, 1981 : Cambridge, UK

COMPARATIVE STUDY OF THE PLANETS

Prof. M. FULCHIGNONI Lab. di Astrofisica Spaziale, C.N.R., viale dell'Università 11, 00185 Rome, Italy
14-25 September, 1981 : Vulcano, Italy

NEW DIRECTIONS IN GUIDED WAVE OPTICS

Dr. D.B. OSTROWSKY Lab. Electrooptique, Univ. de Nice, Parc Valrose, 06034 Nice, France
29 June-10 July, 1981 : Cargèse, Corsica, France

III CHEMISTRY, EARTH SC., MATHEMATICS**EARLY EVOLUTION OF THE PLANETS AND THEIR ATMOSPHERE**

SK RUNCORN Physics Dept. University, Newcastle-upon-Tyne NE1 7RU, UK
23 March-3 April, 1981 : Newcastle, UK

MASS TRANSFER WITH CHEMICAL REACTION TO MULTIPHASE SYSTEMS

Dr. E. ALPER Ankara Univ. Fen Fakültesi, Sinaî Kimya Kürsüsü, Beşevler, Ankara, Turkey
10-21 August, 1981 : Izmir, Turkey

STATIC AND DYNAMIC STUDIES OF THE POLYMERIC SOLID STATE

Dr. R.A. PETHRICK Pure & Applied Chemistry Dept., Univ. Strathclyde, Cathedral St., Glasgow, G1 1XL, Scotland
6-18 September, 1981 : Glasgow, UK

APPLICATION OF MODERN DYNAMICS TO CELESTIAL MECHANICS AND ASTRODYNAMICS

Prof. V. SZEBEHELY Dept. of Aerospace Engineering, Univ. of Texas at Austin, Austin, Texas 78712, USA
2-16 August, 1981 : Cortina d'Ampezzo, Italy (?)

INTERFACIAL ASPECTS OF PHASE TRANSFORMATIONS

Dr. R. KERN Mécanismes de la Croissance Cristalline, C. de Lumigny, C.P. 913, 13288 Marseille Cedex 2, France
29 August-9 September, 1981 : Erice, Italy

ORDERED SETS

Dr. I. RIVAL Dept. of Math. & Statistics, Univ., Calgary, Alberta T2N 1N4, Canada
28 August-12 September, 1981 : Banff, Canada

CONTROL AND PROCESSING IN THE BIOSYNTHESIS OF MACROMOLECULES

Prof. Brian F.C. CLARK Dept. of Chemistry, Aarhus Univ., Langelandsgade 140, 8000 Aarhus C, Denmark
30 August-12 September, 1981 : Spetsai, Greece

AIR-SEA-ICE INTERACTION

Dr. N. UNTERSTEINER Office of Ocean Programs, MOAA, 6010 Executive Blvd. Rockville, Md. 20852, USA
21-31 March, 1981 : Bavaria, Germany

AUTOMATIC SPEECH ANALYSIS AND RECOGNITION

Prof. J.P. HATON Centre de Recherche en Informatique, Université de Nancy I, C.O. 140, 54037 Nancy, France
29 June-11 July, 1981 : Bonas, France

IV ENGINEERING AND APPLIED SCIENCES**DYNAMICS OF SOCIAL CONSTRAINT ON LONG-TERM RESOURCE AVAILABILITY**

Prof. D.L. MEADOWS Resource Policy Cent., Dartmouth College, Hanover, NH 03755, USA
Spring 1981 : Copenhagen, Denmark

CATALYST DEACTIVATION

Prof. Dr. J.L.C.C. FIGUEREDO Chemical Engin. Depart., Fac. of Engin., Univ., 4099 Porto CODEX, Portugal
18-29 May, 1981 : Algarve, Portugal

LAMINAR FORCED CONVECTION IN CHANNELS AND BUNDLES APPLIED TO HEAT EXCHANGERS

Prof. Dr. S. KAKAC Dept. Mech. Engin., Univ. Miami, Coral Gables 33124 USA
13-24 July, 1981 : Ankara, Turkey

THEORETICAL FOUNDATIONS OF PROGRAMMING METHODOLOGY

Prof. Dr. F.L. BAUER Inst. für Informatik, Techn. Univ., Postfach 202425, 8000 München 2, Germany
28 July-9 August, 1981 : Marktoberdorf (near Munich)

NITROGEN CERAMICS

Dr. F.L. RILEY Department of Ceramics, Univ. of Leeds, Leeds LS2 9JT, UK
27 July-7 August, 1981 : Univ. of Sussex, UK

SURFACE MOBILITIES ON SOLID MATERIALS

Dr. VU THIEN BINH Univ. Cl. Bernard Lyon I, Phys. Matériaux, L.A. 172, CNRS, 69622 Villeurbanne Cedex, France
7-19 September, 1981 : Les Arcs, France

NUMERICAL METHODS IN GEOMECHANICS

Prof. J.B. MARTINS Univers. do Minho, Engenharia, Pavilhões da Rodovia, 4700 Braga, Portugal
24 August-4 September, 1981 : Vimeiro, Portugal

DATA BASE MANAGEMENT : THEORY AND APPLICATION

Prof. A.B. WHINSTON Purdue Univ., Krannert Building, West Lafayette, IN 47907, USA
1-14 June, 1981 : Estoril, Portugal

ELECTRICAL BREAKDOWN AND DISCHARGES IN GASES

Dr. L.H. LUESSEN Naval Surface Weapons Center, Code F12, Oahglen, Va. 22448, USA
14-28 June, 1981 : Les Arcs, France

TECHNOLOGICAL RISK ASSESSMENT

P. RICCI Electric Power Research Inst., 3412 Hillview Ave., Palo Alto, Ca. 94303, USA
May 1981 : Erice, Italy

TRIBOLOGICAL TECHNOLOGY

Mr. Peter B. SENHOLZI Mechanical Technology Inc., 1656 Homewood Landing Rd, Annapolis, Md. 21401, USA
13-26 September, 1981 : Maratea, Italy

ENVIRONMENTAL IMPACT ASSESSMENT

Prof. B.D. CLARK Depart. Geography, Univ. of Aberdeen, High Street, Old Aberdeen, Aberdeen AB9 2UF, Scotland, UK
30 August-12 September, 1981 : Bonas, France

DETERMINISTIC AND STOCHASTIC SCHEDULING

Dr. J.K. LENSTRA Mathematisch Centrum, Tweede Boerhaavestraat 49, 1091 AL Amsterdam, Netherlands
6-17 July, 1981 : Durham, UK

MATHEMATICAL MODELS AND DESIGN METHODS IN SOLID LIQUID SEPARATION

Dr. A. RUSHTON Department of Chemical Engineering, UMIST, Manchester, Lancs., UK
6-17 July, 1981 : Algarve, Portugal

ENERGY PRODUCTION AND CONSERVATION FROM WASTES

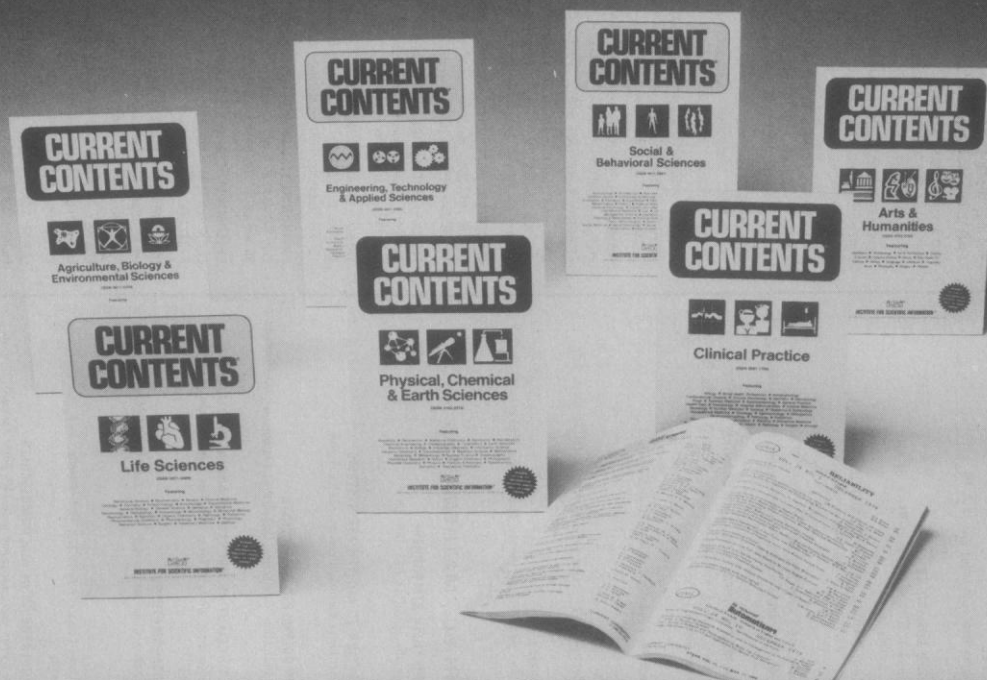
Dr. K. CURI Bogaziçi University, School of Engineering, P.K. 2 - Bebek, Istanbul, Turkey
6-18 July, 1981 : Istanbul, Turkey

LARGE SCALE INTEGRATED CIRCUITS

Prof. L. ESAKI IBM Watson Research Center, P.O. Box 218, Yorktown Heights, N.Y. 10598, USA
14-28 July, 1981 : Erice, Italy

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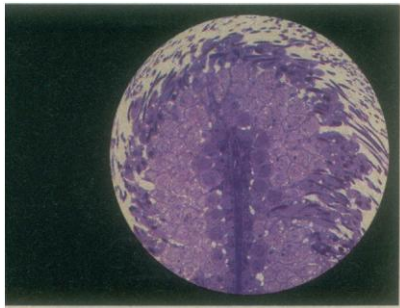
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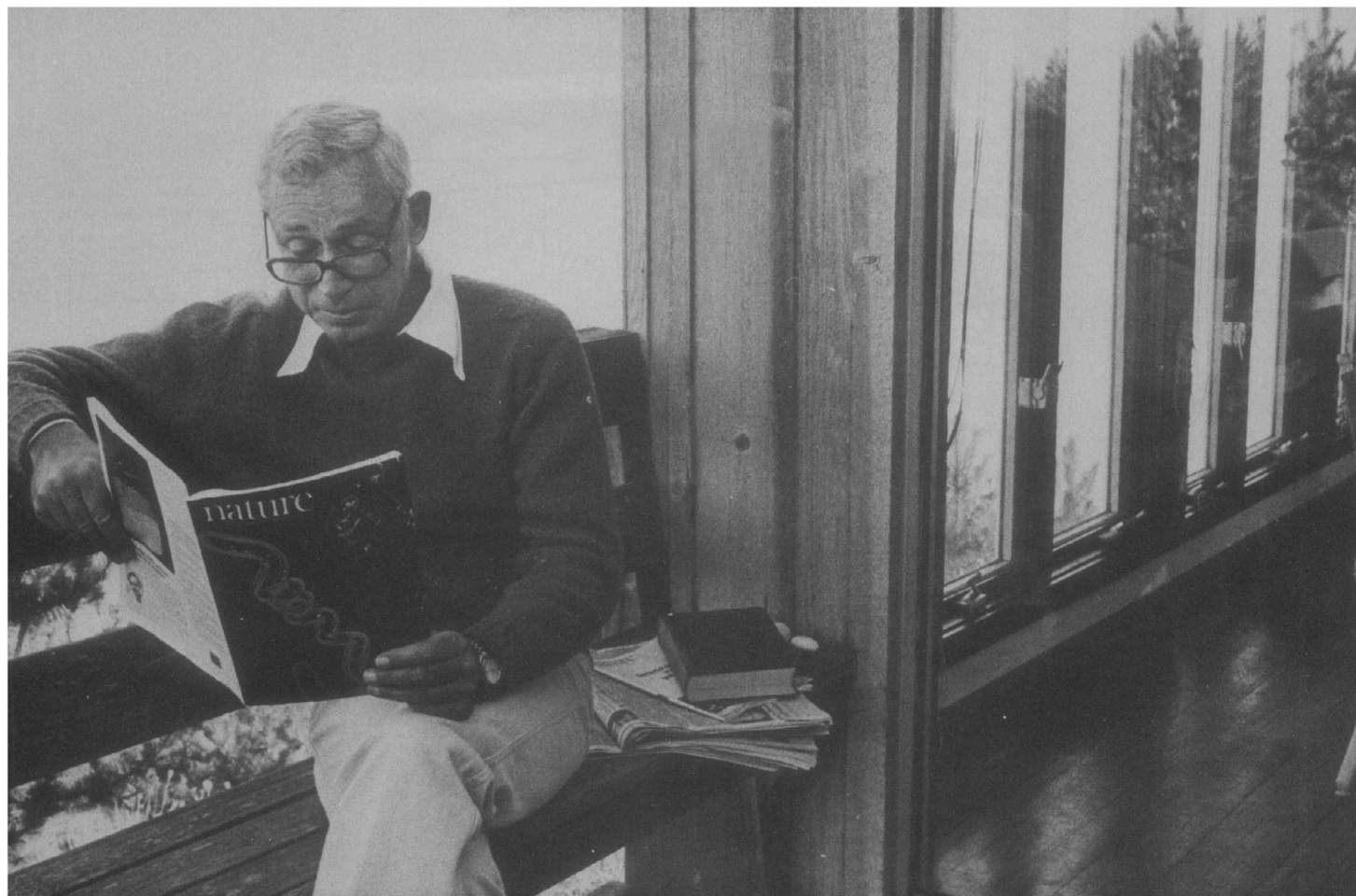
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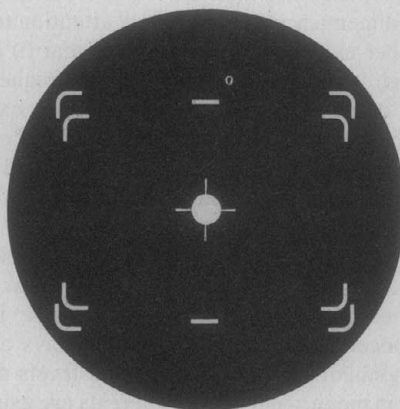
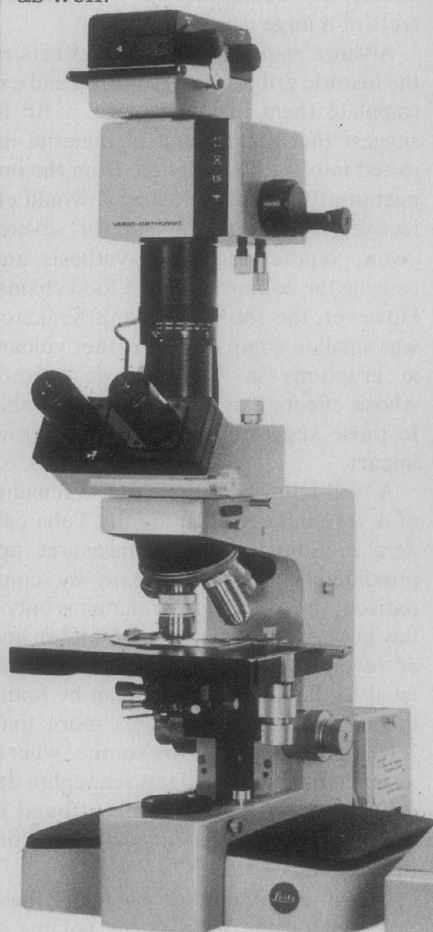
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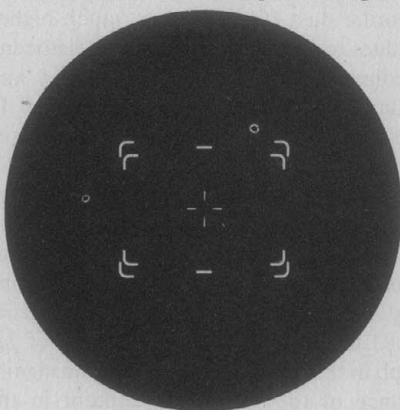
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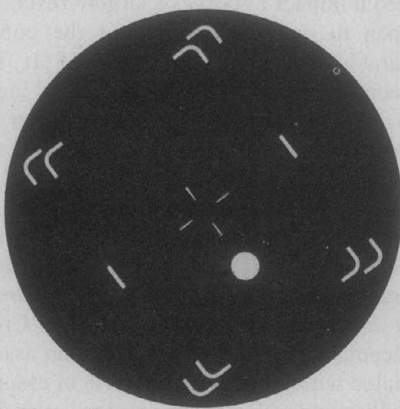
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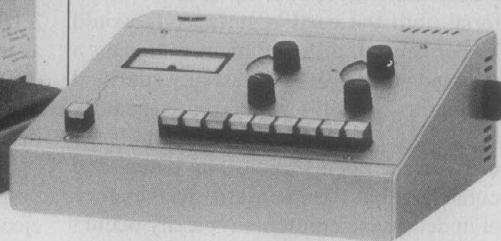
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LETTERS

Asteroid Extinction Hypothesis

A distinguishing feature of the asteroid impact hypothesis presented by Alvarez *et al.* (6 June, p. 1095) for the end-of-Cretaceous biotic crisis is that it is based on direct physical evidence: the distribution of iridium in several Cretaceous-Tertiary sedimentary sections. I draw attention to other evidence which suggests that (i) a high Ir concentration may not be uniquely associated with an extraordinary extraterrestrial event and (ii) the impact of a large asteroid in any case is not likely to have had the dire consequences to life on the earth that they propose.

Crucial to their argument for an asteroid impact at the Cretaceous-Tertiary boundary is the interpretation of the Ir concentration in the boundary clays as anomalously high. Background levels of Ir in modern deep-sea sediments are usually on the order of 0.3 part per billion and can be attributed to the influx of meteoritic dust (1). However, much higher values can occur, even in Pleistocene sediments. For example, Crocket and Kuo (2) reported Ir abundances of 0.11 to 0.71 ppb from nine levels in deep-sea sediment core Eltanin 21-17. The CaCO_3 content of the analyzed bulk samples ranged from 83.0 to 94.9 percent, so that if the bulk Ir contents are recalculated as per weight of insoluble residue, as done by Alvarez *et al.*, they would range from 0.83 to 7.6 ppb, with an average of 2.0 ppb in this core. I suggest that the significance of the 9.1-ppb Ir content in the Gubbio boundary clay, on which the asteroid impact hypothesis largely rests, is open to question in light of the comparable concentration range of Ir in deep-sea sediments of Quaternary age (3), a time period for which neither a large asteroid impact nor massive extinctions have been suggested.

But why should "abnormally" high Ir contents occur at the level of the Cretaceous-Tertiary boundary in stratigraphic sections worldwide? As Alvarez *et al.* and others point out, the Cretaceous-Tertiary boundary is often associated with a hiatus, an interval of essentially nondeposition or erosion, even in pelagic marine sediments. Under a steady influx of Ir-bearing meteoritic material onto the earth's surface, Ir would be concentrated in sediment either by a reduced input of terrestrially derived sediments or by their preferential removal by bottom current activity. The latter mechanism seems plausible when one considers that the extraterrestrial material in deep-sea sediments typically occurs

as spherules from tens of micrometers to several hundred micrometers in size (4)—far in excess of particle sizes of clays (< 2 micrometers) such as those at the Cretaceous-Tertiary boundary in the Italian and Danish sections. The relatively larger size combined with a generally higher density of the cosmic spherules would tend to cause segregation of the meteoritic material from clays in the presence of currents, leading to a highly heterogeneous distribution of Ir in sediments. Thus, the factor of 10 difference in Ir concentration between the Fiskeler in the Danish section and the Gubbio boundary clay could be accounted for. Moreover, Alvarez *et al.* acknowledge the variation in thickness of the Fiskeler, from a few centimeters to as much as 35 centimeters locally (5), which can be interpreted as due to local sedimentary control by bottom current activity.

Clearly more data on the distribution and abundance of Ir in sediments are needed to establish whether high Ir concentrations are uniquely associated with extraordinary extraterrestrial events, or more generally occur locally, perhaps associated with sedimentary conditions which may not coincide in time with biotic crises. But regardless of the eventual outcome of these researches, it is of interest to reconsider the proposed effects of a large asteroid impact.

Alvarez *et al.* consider the effects of the historic eruption of Krakatoa and extrapolate them by a factor of $\sim 10^3$ to suggest that the amount of material injected into the stratosphere from the impact of a 10-kilometer asteroid would effectively shut out sunlight for several years, suppressing photosynthesis and causing the collapse of most food chains. However, the 1883 eruption of Krakatoa was small in comparison to other volcanic eruptions in the geologic record, whose effects may be more comparable to those suggested for a large asteroid impact.

A well-known example of the remains of a very large volcano is the Toba caldera in Sumatra, which measures approximately 100 by 35 km; by comparison, the caldera of Krakatoa is only a few kilometers in diameter. A tephra layer several centimeters thick and correlated to the Toba eruption can be found in deep-sea sediment cores more than 2500 km distant from the source, whereas no distinguishable deep-sea tephra deposit from Krakatoa has been found in sediment cores as close as 200 km from the vent (6).

But it is difficult to compare these eruptions on the basis of the volume of ejecta, which has been calculated in dif-

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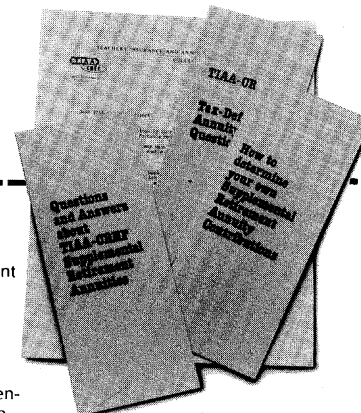
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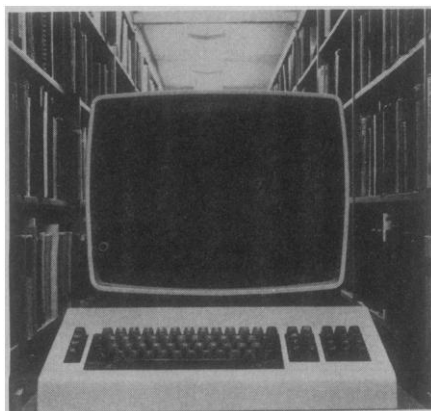
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ferent ways for Toba (6, 7) and Krakatoa (8). A more consistent way to estimate their relative magnitude is to compare the volumes of the calderas and assume that caldera volume is proportional to amount of ejecta put into the atmosphere. The volume of the Toba caldera is estimated to be 2000 km³ (7), and that of the Krakatoa caldera to be 5 km³ (9). The expected sunlight attenuation for Toba, calculated with the same assumptions and values used by Alvarez *et al.* but with the effect of Toba 400 times that of Krakatoa, comes to $\exp(-12) \approx 10^{-5}$. This attenuation factor is not nearly as large as the one postulated by Alvarez *et al.* for the asteroid impact. However, it appears to be more than sufficient to suppress photosynthesis and could presumably have led to at least some of the consequences life on the earth suffered at the end of the Cretaceous according to asteroid impact hypothesis. The pertinent point is that the eruption of Toba occurred 75,000 years ago (10), a time that has yet to be noted for massive extinctions or other extraordinary effects on life. Moreover, there is little reason to believe that the magnitude of the Toba eruption was exceptional; even larger explosive volcanic eruptions probably occurred over geological time.

The two principal points raised here—the first concerning the uniqueness of the association of high Ir concentrations in sediment with large asteroid impacts and the second regarding the proposed effects of such an asteroid impact on life on the earth—are independent of each other. That an asteroid impact occurred at the time of the Cretaceous-Tertiary boundary may in time be substantiated by further geochemical work and stratigraphic studies. However, the lack of evidence for serious consequences to global life from large volcanic eruptions, which may approach the ejecta volume postulated for a large asteroid impact, suggests that the cause of the massive extinctions is not closely related to a drastic reduction in sunlight alone, and an alternative mechanism should be sought [for example, (11)].

DENNIS V. KENT

Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York 10964

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12. I thank J. D. Hays, D. Ninkovich, N. D. Opdyke, and T. Takahashi for constructive comments and the National Science Foundation for support. This is Lamont-Doherty Geological Observatory contribution 3081.

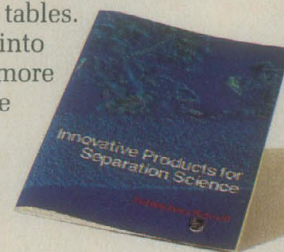
Alvarez *et al.* have studied the elemental composition of the materials that are known to have lain at the earth's surface at the time of the Cretaceous-Tertiary extinction and have concluded from the high abundance of iridium that an extraterrestrial event was involved, probably the impact of an earth-crossing asteroid. They suggest that the extinction itself was due to a complete cessation of photosynthesis caused by the obliteration of sunlight by a stratospheric dust layer that persisted for a few years.

The case made by Alvarez *et al.* for an asteroidal impact is a compelling one. Their argument that the immediate effect on the biosphere was the cessation of photosynthesis is less strong. The possibility that the extinction was due to collapse of the photosynthetic food chain was suggested by Crutzen and Reid (1) and expanded on by Reid *et al.* (2) as one of the potential consequences of a nearby supernova explosion. In the cases considered, however, the magnitude of the reduction in sunlight was on the order of 10 percent at most, in contrast to the reduction by a factor of 10⁷ (approximately 10 percent of full moonlight) suggested by Alvarez *et al.* Such a scenario would cause a total collapse of photosynthesis; it would also have global climatic consequences that might place an even more severe strain on the biosphere.

The decay of the climate system following the extinction of sunlight was investigated by Hunt (3), using a general-circulation model of the atmosphere. His calculations ran for only 50 days after the extinction, at which time the atmosphere still retained weakened jet streams and meridional temperature gradients. After the 2- or 3-year stratospheric residence time for the dust layer, these climatically important features would presumably have essentially disappeared. The scenario suggested by Alvarez *et al.*, however, is not equivalent to extinguishing the sun, since the earth would be blanketed by a hot dust layer capable of producing a powerful greenhouse effect, perhaps analogous to that existing at

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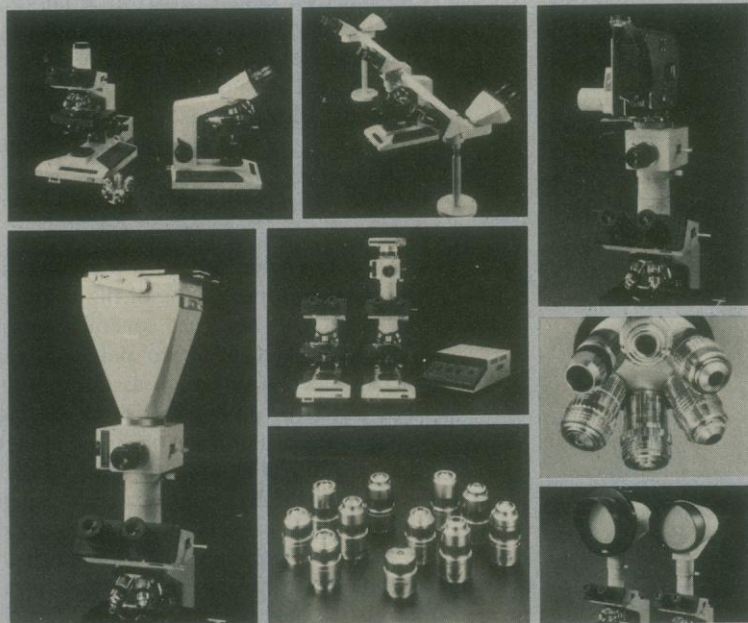
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present on Venus. The radiative balance of the earth under these conditions would depend on such factors as the optical properties of the dust layer in the infrared and its albedo in the visible, but there is little doubt that the climate system would be thrown into a vastly different mode from that of today or that of the Late Cretaceous. The global blanket of dust would largely eliminate the latitudinal temperature gradients that are ultimately responsible for weather. Since the vertical temperature structure of the atmosphere would revert toward stability, convective activity would cease, thereby removing one source of precipitation. Removal of the horizontal temperature gradients would also remove baroclinic instability, thereby eliminating synoptic-scale weather systems, the other major source of precipitation. Extreme drought conditions would thus prevail globally, and the land plants might die from lack of water before they would otherwise die from lack of sunlight.

Under these extreme conditions, the problem becomes not one of explaining the extinction of half the genera living at the time (4), but one of explaining the survival of the other half. It is more likely that the actual scenario was considerably less extreme than that proposed by Alvarez *et al.* The larger particles thrown up by the impact would settle out within a relatively short time, and the residue of fine particles may have been relatively transparent. The fact that the clay layer which presumably resulted from settling of the debris has been seen at locations as far apart as Europe and New Zealand might seem to argue against this, since a fairly long residence time is thought to be required to disperse material in the atmosphere over global distances. This argument is based on observations of the normal atmosphere, however, and it is possible that substantial amounts of debris could have been distributed globally within a short time after the impact, through material thrown into ballistic orbits by the enormous kinetic energy release or by the transient atmospheric disturbance created by the passage of the asteroid.

The small fraction of material remaining in the stratosphere would produce effects similar to those proposed (2) as accompanying the production of NO₂ in the stratosphere by a nearby supernova—that is, a reduction in global temperature by several degrees, a tendency toward drought conditions, and a reduction in photosynthesis that would have its most severe impact on the large herbivorous land animals and their predators. The

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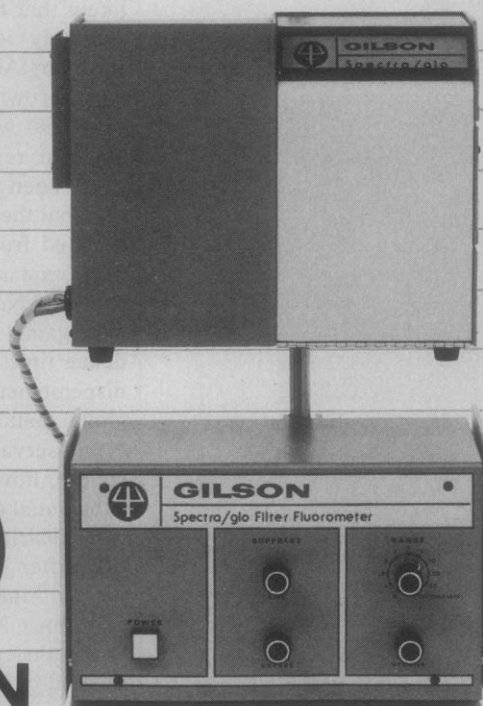
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collapse of the ocean food chain may have been a result of reduced photosynthesis, but it may also have been triggered by overturning of ocean water and crustal fracture due to an oceanic impact.

GEORGE C. REID

*Aeronomy Laboratory,
National Oceanic and Atmospheric
Administration, Boulder, Colorado
80303*

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On page 1099 of their article, Alvarez *et al.* state: "Iridium has been detected (45) in a warm spring on Mount Hood in northern California. . . ." I have not been able to check reference 45 to determine whether an obscure Mount Hood actually exists in northern California. However, many years of living in Oregon and California lead me to believe there is only one Mount Hood, immediately south of the Columbia River and due east of Portland, Oregon.

For many years California sought to claim Crater Lake. Is this now an effort to leapfrog Crater Lake in a move to capture Mount St. Helens, which has superseded Mount Lassen as the most recently active volcano in the conterminous United States?

RANDALL E. BROWN

504 Road 49 North,
Pasco, Washington 99301

The foregoing letters are among the most thought-provoking of the many we have seen in the past several months. The first of Kent's two points is that ocean mechanisms such as bottom current activity could give rise to the high concentrations of Ir we observed at Gubbio, without involving an asteroid collision. While this might be true for a single location, we were unable to devise such a theory to explain the worldwide distribution of this level of Ir, the much higher levels we observed in Denmark, and the still higher integrated amounts we have subsequently seen in a deep-sea core from the north central Pacific. Many other problems arise if one invokes concentration of Ir by bottom currents; we have discussed this in a widely circulated report that is still available from us (1). But the strongest argument against Kent's first suggestion comes from our recent unpublished observation (in collabora-

tion with D. A. Russell) of a distinct Ir enrichment in a nonmarine stratigraphic sequence in Montana, at a level above the highest dinosaur remains and below the lowest Tertiary mammal fauna. This observation seems to eliminate from serious consideration extinction theories that involve the ocean in substantive ways, such as those proposed by Kent and by Gartner (2).

The subtitle of our article was "Experimental results and theoretical interpretation." We feel that the experimental results we published on anomalous Ir concentrations worldwide, plus the Montana results, plus Ganapathy's additional analysis (3) of the Danish Cretaceous-Tertiary boundary material, all confirm our primary theoretical conclusion—that the Cretaceous-Tertiary extinction was initiated by the collision of a large asteroid with the earth, 65 million years ago. Ganapathy found that the relative abundances of several noble metals in the Danish boundary layer matched those in chondritic meteorites and departed in important ways from such measured ratios in all known terrestrial samples. Our independent unpublished measurements (4) involve fewer elements than Ganapathy's, but they agree even more closely with chondritic meteoritic abundances than did his. So we see no escape from the conclusion that a large asteroid hit the earth at exactly the end of the Cretaceous period.

Both Kent and Reid correctly point out that we have not proved the asteroid impact led to the extinction through the "dust-screening" mechanism we favored in our article. Since none of us has had any experience in atmospheric modeling, we are delighted to see that Reid is becoming involved in the problem and will ask the correct questions about what would happen after a large asteroid struck the earth, either in the ocean or on the land. We are familiar with Emiliani's suggestion (5) that the dust cloud we postulated might lead to a "greenhouse effect" that would cause death by hyperthermia, and we appreciate the strength of his arguments. But others have suggested that "turning off the light" would lead to a drastic lowering of global temperatures, thereby freezing living things to death. We understand the delicate balance between the optical and infrared properties of the dust particles that could give rise to large temperature variations in either direction, so we await the results of computer studies that may lead to a definite answer to this question. Kent estimates that the Toba eruption would have ejected about 400 times as much material as Krakatoa did, close to

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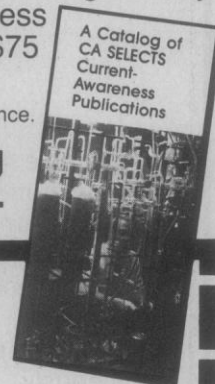
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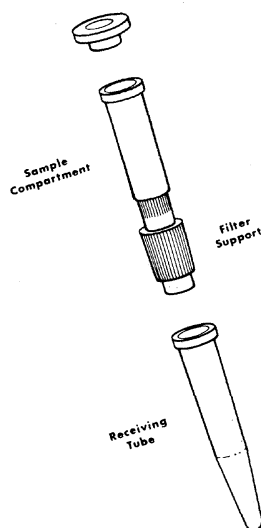
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our estimate of 1000 times Krakatoa for the impact event, although Toba did not produce extinctions. This consideration may make it possible to place a lower limit on the size of extinction-producing events, and we note that if objects substantially smaller than the one we postulate were capable of producing mass extinctions, these would occur more frequently, because of the steep decrease of numbers of asteroids with increasing size. We are prepared to abandon our "darkness hypothesis" when and if some other proposed killing mechanism is shown to fit the geological record better than it does. But we feel our major theoretical conclusion—that the worldwide boundary layer contains the remnants of a large asteroid that somehow triggered the extinction—now rests on a very solid experimental base.

To apologize to Brown and to others who are better proofreaders than we are,

we have all stayed after school and written on the blackboard 100 times, "Mt. Hood is in Oregon."

LUIS W. ALVAREZ

Lawrence Berkeley Laboratory,
University of California,
Berkeley 94720

WALTER ALVAREZ

Department of Geology and Geophysics,
University of California, Berkeley

FRANK ASARO

HELEN V. MICHEL

Lawrence Berkeley Laboratory,
University of California, Berkeley

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Erratum: In the report "Mutagenicity of fly ash particles in *Paramecium*" by J. Smith-Sonneborn *et al.* (9 Jan., p. 180), Tables 1 and 2 are printed incorrectly. Significance lines are missing from both tables and "uninduced" should read "induced" in the sixth, eighth, and ninth entries of the first column in Table 1. The tables are reprinted below as they should have appeared.

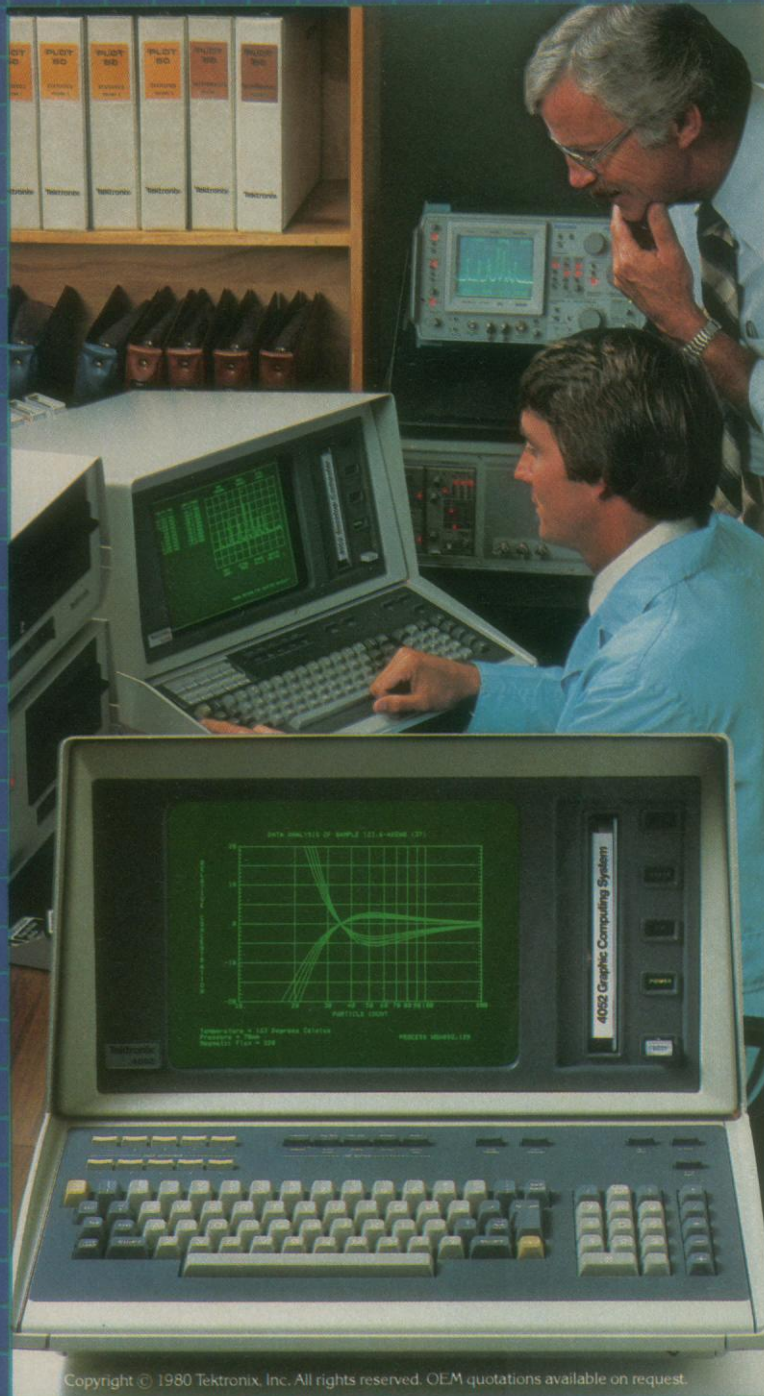
Table 1. Mutagenic effect of fly ash and heat-treated fly ash in *Paramecium*. Values not connected by the same line are significantly different from each other (Wilcoxon matched-pairs signed-ranks test, $\alpha = .05$). The data from six experiments were pooled since the control values for autogamous progeny were not significantly different. Cerophyl is the ryegrass extract used for cultivation of *Paramecium*. Induced S-9 is the Ames liver microsome fraction from rats receiving Arochlor 1254 (polychlorinated biphenyl) to activate the enzymes for conversion of promutagens to mutagenic form; uninduced S-9 is from rats receiving corn oil only (the vehicle for the Arochlor). Glass beads (1 to 3 μm) suspended in either induced or uninduced S-9 were used as a negative control for nonnutritive particles. Kaolinite was also used in one experiment, and the results were the same as those for the glass beads. Benzo[a]pyrene was the positive control for mutagenicity requiring induced S-9. The initial concentration of suspended fly ash was 535 $\mu\text{g}/\text{ml}$. The average number of affected progeny from treated parent cells was 20 percent higher than the average number of affected control progeny. Since one mutation would theoretically yield only 4 affected progeny in 16 autogamous progeny from a treated parent cell (6), the percentages, though low, reflect significant damage.

Substance	Lethal and detrimental cells (%)	Number of progeny examined
Cerophyl	1.01 \pm 0.21	1568
Glass beads + uninduced S-9	1.36 \pm 0.33	1904
Glass beads + induced S-9	1.41 \pm 0.42	1888
Benzo[a]pyrene + uninduced S-9	3.2 \pm 0.39	1440
Fly ash + uninduced S-9	3.7 \pm 0.69	2992
Heated fly ash + induced S-9	3.9 \pm 1.6	1728
Heated fly ash + uninduced S-9	4.6 \pm 1.3	1280
Fly ash + induced S-9	9.3 \pm 1.7	1296
Benzo[a]pyrene + induced S-9	12.5 \pm 5.8	1664

Table 2. Mutagenicity of heat-treated fly ash extracted with HCl or DMSO. Values not connected by the same line are significantly different from each other (pairwise comparisons of proportions, $P < .05$). The concentration of fly ash particles suspended in uninduced S-9 was 1068 $\mu\text{g}/\text{ml}$. The higher than usual value for mutagenicity in the controls can be attributed to the considerable age of the clone used here [micronuclear damage increases with age (12)].

Substance	Lethal cells (%)	Number of progeny examined
Glass beads	3.14 \pm 0.33	624
HCl-extracted particles	4.77 \pm 1.25	960
DMSO-extracted particles	8.21 \pm 2.00	656
Unextracted particles	14.09 \pm 5.29	896

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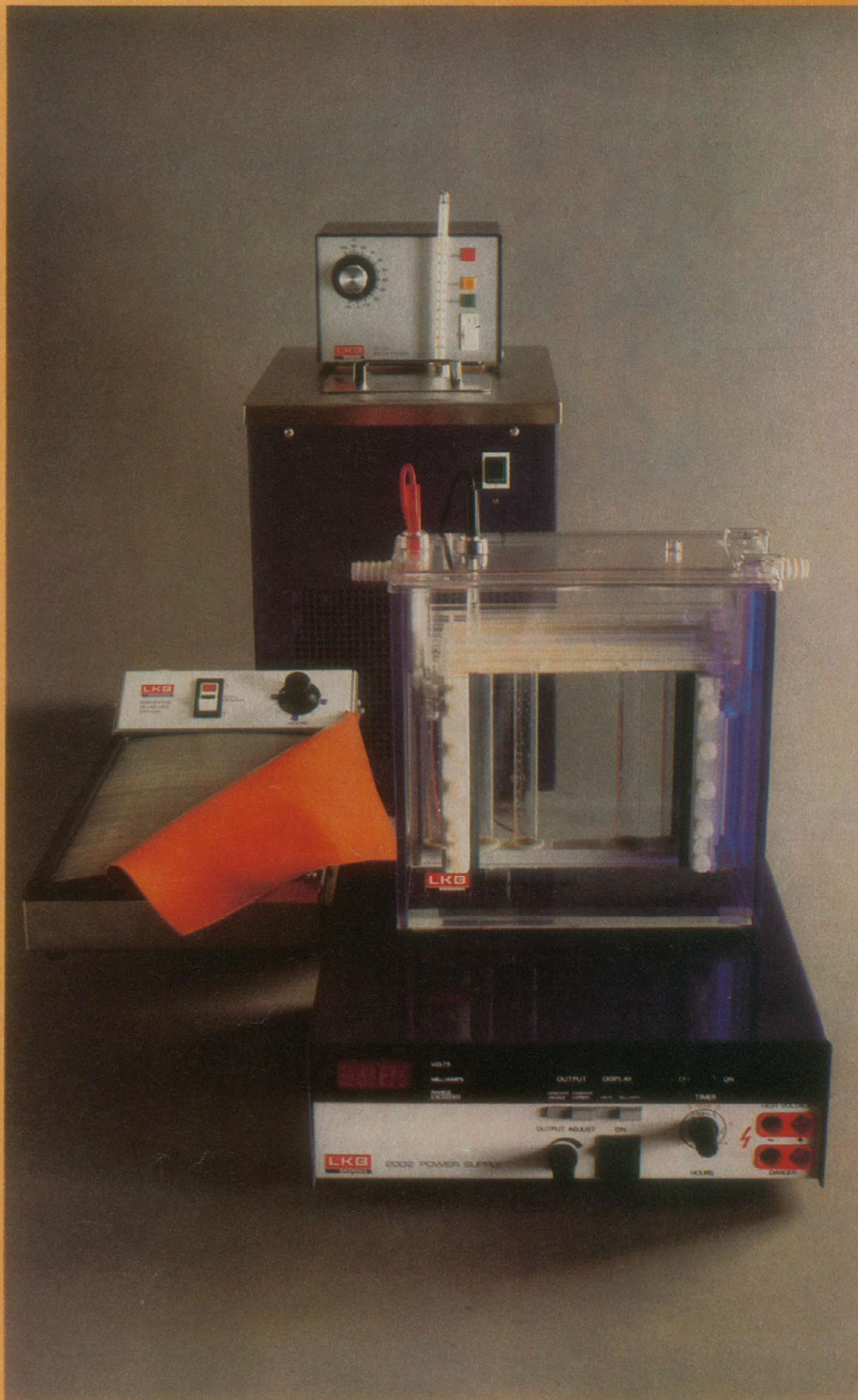
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Usefulness of the Social Sciences

National attention has turned to the productivity, the performance, and even the profitability of science. Measured against such criteria, how will the social sciences fare? Quite well, I believe. Close scrutiny will disclose substantial contributions to economic growth and the public welfare. For instance, numerous well-established industries now market technologies that are derived from social science research: demographic projections, programmed language instruction, standardized educational testing, behavior modification, man-machine system design, political polling, consumer research and market testing, management consulting. Just as medicine draws upon biological research or electronics upon physics, government and management draw upon psychology, economics, demography, geography, and other social sciences.

In addition, the social sciences have vastly extended the observational powers of contemporary societies. Advanced industrial nations are commonly described as information societies in reference to their systematically collected information about the human as well as the physical environment. Human actions and the meanings attached to them constitute the most dynamic and complex of all those environments in which markets sell, banks invest, businesses produce, governments govern, and families plan. Monitoring the ever-changing human environment is a task approached through a variety of tools and disciplines of the social sciences: economic indicators, demographic trends, national statistical systems, historical research, time-series analysis, input-output matrices, developmental psychology, area studies, political geography.

Of course, the public importance of the social sciences, like that of the biological and physical sciences, is not limited to their accomplishments as observational sciences or to a list of industries that market their technologies. It is through theories and intellectual constructs that the sciences realize their greatest potential. In the empirical regularities they reveal, the counterintuitive questions they ask, the contingent associations they discover, and the successive layers of meaning they uncover, the social sciences conceptualize and thereby render accessible to human intelligence a wide array of economic, social, political, and cultural phenomena. Ironically, the social sciences seldom get full credit for their theoretical accomplishments, because the discoveries, once labeled, are quickly absorbed into conventional wisdom. This is easily demonstrated; note the number of social science concepts common to our vocabulary: human capital, gross national product, identity crisis, span of control, the unconscious, price elasticity, acculturation, political party identification reference group, externalities. Obviously, the phenomena revealed through such concepts existed prior to the relevant research, just as DNA, quarks, and the source of the Nile existed prior to their discovery. Yet concepts generated through research are discoveries that make phenomena intelligible and accessible that previously were inaccurately or incompletely understood.

That the tools and concepts of social science work their way into public discourse is a matter of some national importance. Regulatory policy, for example, is seldom discussed without reference to cost-benefit analysis. It is with models from economics and demography that the financial base of Social Security is being examined. Evaluation research is called upon to demonstrate program successes or failures. Game theory provides a vocabulary for looking at shifting international alliances. The current national discussion of productivity will make use of research on topics such as investment and savings behavior, management of complex organizations, competency testing, international labor migration, or human creativity.

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