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Calendar of AMS Meetings

THIS CALENDAR lists all meetings which have been approved by the Council prior to the date this issue of the *Notices* was sent to the press. The summer and annual meetings are joint meetings of the Mathematical Association of America and the American Mathematical Society. The meeting dates which fall rather far in the future are subject to change; this is particularly true of meetings to which no numbers have yet been assigned. *Programs* of the meetings will appear in the issues indicated below. *First* and *supplementary* announcements of the meetings will have appeared in earlier issues.

ABSTRACTS OF PAPERS presented at a meeting of the Society are published in the journal *Abstracts of papers presented to the American Mathematical Society* in the issue corresponding to that of the *Notices* which contains the program of the meeting. Abstracts should be submitted on special forms which are available in many departments of mathematics and from the headquarters office of the Society. Abstracts of papers to be presented at the meeting must be received at the headquarters of the Society in Providence, Rhode Island, on or before the deadline given below for the meeting. Note that the deadline for abstracts for consideration for presentation at special sessions is usually three weeks earlier than that specified below. For additional information consult the meeting announcements and the list of organizers of special sessions.

MEETING #	DATE	PLACE	ABSTRACT DEADLINE	ISSUE
	August 3–11, 1986 (International Congress of Mathematicians)	Berkeley, California	EXPIRED	
828	October 10–11, 1986	Logan, Utah	†August 18	October
829	October 17–18, 1986	Charlotte, North Carolina	†August 20	October
830	October 31–November 1, 1986	Denton, Texas	†August 25	October
831	January 21–24, 1987 (93rd Annual Meeting)	San Antonio, Texas	October 15	January
	April 3–4, 1987	Kent, Ohio		
	April 25–26, 1987	Newark, New Jersey		
	January 6–9, 1988 (94th Annual Meeting)	Atlanta, Georgia		
	August 8–12, 1988 (AMS Centennial Celebration)	Providence, Rhode Island		
	January 11–14, 1989 (95th Annual Meeting)	Phoenix, Arizona		

† Please note change from March 1986 calendar.

DEADLINES

Advertising	(*Aug.* 1986 *Issue*) *June* 17, 1986	(*Oct.* 1986 *Issue*) *Sept.* 3, 1986	(*Nov.* 1986 *Issue*) *Oct.* 1, 1986
News/SMIC	(*Aug.* 1986 *Issue*) *May* 29, 1986	(*Oct.* 1986 *Issue*) *Aug.* 18, 1986	(*Nov.* 1986 *Issue*) *Sept.* 15, 1986

Other Events Sponsored by the Society

May 28, 1986, Symposium on Some Mathematical Questions in Biology, Modeling Circadian Rhythms, Philadelphia, Pennsylvania. Details: March issue.

June 22–August 2, 1986, Joint Summer Research Conferences in the Mathematical Sciences, University of California, Santa Cruz, California. Details: January issue.

July 7–25, 1986, AMS Summer Research Institute on Representations of Finite Groups and Related Topics, Humboldt State University, Arcata, California. Details: March issue.

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Notices: highlights

David Harris, in his feature article on "The Mordell Conjecture," explains the significance of Faltings' proof of the conjecture in relation to other important conjectures in the theory of abelian varieties. Page 443.

The proposed NSF budget for FY 1987 is examined for the areas related to the mathematical sciences and is compared with the actual funding levels over the past ten years. Page 450.

The Board on Mathematical Sciences, in a recent report entitled "Mathematical Sciences: A Unifying and Dynamic Resource," assesses and monitors some trends in pure and applied mathematics. Page 462.

The Treasurer of the AMS reports on the financial status of the Society for 1985. Page 480.

Joseph Buhler's column contains an article by Avner Ash which reviews the software package "Matlab," a high-level language used to manipulate two-dimensional matrices. Page 482.

Kenneth Hoffman, in his Washington Outlook column, recaps the accomplishments of the mathematical community since the issuance of the David Report in 1981. Page 486.

The ICM-86 current schedule of plenary and 45-minute lectures is posted for the August meeting in Berkeley. Page 488.

Peter Lax, Herbert Simon, and Antoni Zygmund are awarded the National Medal of Science for 1986. Page 497.

National Mathematics Awareness Week put mathematics into public view and demonstrated the influence of the mathematical community. Page 509.

The NSF report on graduate science/engineering enrollments alerts the scientific community to the pending shortage of Ph.D.'s. Page 511.

The Mordell Conjecture

David Harris

1. The basic results. On 19 July 1983, the New York Times printed an article [NYT] on the solution by a West German mathematician named Faltings of "one of the outstanding mathematical problems of the century" (in the opinion of Serge Lang). Spencer Bloch of the University of Chicago said that the German's achievement "answers questions that seemed absolutely unanswerable before." The most eye-catching part of Faltings' paper [**Fal**] is a proof of the so-called Mordell Conjecture, a fundamental question in the theory of Diophantine equations.

Until recently, most experts had believed that the Mordell Conjecture would not soon be settled. The Faltings paper is a difficult exercise in algebraic geometry, employing the theory of moduli, the theory of semiabelian varieties, a theory of heights for abelian varieties, and other such abstruse subjects. With this in mind, we are supplying these remarks with the hope they will serve to explain the significance of Faltings' work on the Mordell Conjecture, its relation to the solution of several important conjectures in the theory of abelian varieties, and the historical context.

We begin by listing for reference five basic results, all now proven. We shall refer to these results by these names throughout this article. In the next section, we shall give a general introduction to the problem of solving Diophantine equations. The basic results deal with Diophantine problems such as how many points with integer or rational coordinates lie on a curve. As discussed below, the usual trick of graphing the solutions of an equation transforms the algebraic problem of solving a Diophantine equation into the geometric problem of finding points on its locus of solutions. The rest of this article deals with the problem of integer and rational points on curves. §3 describes the pioneering work of Mordell, Weil, and Siegel in launching the subject. In §4, we describe the early attempts to deal with Mordell's Conjecture, climaxing in the work of the Soviet school. In §5, the work of Faltings is sketched. Finally, in §6, we discuss the problem of effectively using Faltings' work to solve real-world Diophantine equations.

SIEGEL'S THEOREM. *If C is an affine curve defined over a ring R that is finitely generated over $\mathbf{Z}$ and if its genus is ≥ 1, then C has only finitely many points in R.*

More precisely, for an irreducible equation $f(x,y) = 0$ to have infinitely many solutions (x,y) where for a fixed natural number c, cx and cy are integers in some number field, it is necessary and sufficient that the equation can be identically satisfied by two rational functions $x = P(t)$, $y = Q(t)$ of the form

$$P(t) = a_n t^n + a_{n-1} t^{n-1} + \cdots a_{-n} t^{-n},$$
$$Q(t) = b_n t^n + b_{n-1} t^{n-1} + \cdots b_{-n} t^{-n}$$

which are not both constant, which is true if and only if the corresponding projective curve is of genus 0 and has at most two poles for the function $|x| + |y|$.

(Siegel in fact extends this to curves given by $n-1$ equations in n unknowns; cf. [**Si2**]).

The article above is the thirteenth in the series of Special Articles published in *Notices*. The author, David Harris, received his Ph. D. from Harvard University in 1972, under the direction of David Mumford. In the mid-seventies, he survived a five-year-long fight with cancer, thanks to the chemotherapists of the Memorial Sloan Kettering Cancer Center. Since 1979, he has worked for the Department of Defense at Fort George G. Meade, Maryland.

The series of Special Articles was created to provide a place for articles on mathematical subjects of interest to the general membership of the Society. The Editorial Committee of *Notices* is especially interested in the quality of exposition and intends to maintain the highest standards in order to assure that the Special Articles will be accessible to mathematicians in all fields. The articles must be interesting and mathematically sound. They are first refereed for accuracy and (if approved) accepted or rejected on the basis of the breadth of their appeal to the general mathematical public.

Items for this series are solicited and, if accepted, will be paid for at the rate of $250 per page up to a maximum of $750. Manuscripts to be considered for this series should be sent to Ronald L. Graham, Associate Editor for Special Articles, *Notices of the American Mathematical Society*, Post Office Box 6248, Providence, Rhode Island 02940.

Thus, only a very special type of affine curve can have infinitely many integer points on it, and only a very special kind of Diophantine equation of the sort that has locus of zeroes a curve can have infinitely many integer solutions.

THE MORDELL-WEIL THEOREM. *Let K be a field finitely generated over its prime field. Let A be an abelian variety defined over K (i.e., a complete variety defined over K, embeddable in a K-projective space, and having a group structure defined over K). Let A_K be the group of K-rational points. Then A_K is a finitely generated abelian group* (cf. [**We1**]).

As a special case, on elliptic curves defined over K possessing K-rational points, these points form a finitely generated group. Over the rationals, the torsion part of this group can only be one of fifteen finite abelian groups. But, the rational points can have a free infinite abelian part. So, elliptic curves can have infinitely many rational points, but only finitely many integer points (in affine coordinates).

If a projective curve of genus zero has even a single rational point, one can show by elementary means that its rational points are in one-one correspondence with $\mathbf{P}^1(\mathbf{Q})$. So curves of genus zero have either no rational points or infinitely many rational points. Thus, a conic either has no rational points or infinitely many that can be produced from a single one via the method of sweeping lines. On an elliptic curve, there may not be any rational points, but the group structure does allow one in theory to construct all the rational points from finitely many of them via the group action, the so-called chord and tangent method. Faltings work shows that no such method for constructing rational points exists on curves of genus > 1. For more information on the low genus situation, see [**Za1**].

THE MORDELL CONJECTURE FOR NUMBER FIELDS. *Let K be a finite extension of $\mathbf{Q}$. Let X/K be a smooth curve of genus $g \geq 2$. Then the set of K-rational points on X, $X(K)$ is finite* (cf. [**Fa1**]).

(Cassels' paper [**Ca1**] shows that the assumption that X is smooth is not serious. The theories of birational equivalence and absolute irreducibility show that smoothness is not crucial.) Thus, only a very special type of curve can have infinitely many rational points on it and only a very special kind of system of Diophantine equations of the sort that has locus of zeroes a curve can have infinitely many rational solutions.

THE MORDELL CONJECTURE FOR FUNCTION FIELDS. *Let K be a regular extension of the field k of characteristic 0 and let C be a smooth curve of genus ≥ 2 defined over K. Then either its set of rational points $C(K)$ is finite, or C is definable over k and all but a finite number of points in $C(K)$ are in the image of $C(k)$.*

(In characteristic p approximately the same theorem is true, except for curves defined over a finite field, which can have finitely many countable families of rational points (cf. [**Gr1**, **Ma1**, **Pa1**, **Sa2**]).)

This theorem is a function field-theoretic analogue of the Mordell Conjecture for number fields. It was an offshoot of the work of Lang on the restatement of the Mordell Conjecture, and was first proven by Manin and Grauert. The work done by Soviet mathematicians on this theorem led to the ultimate idea of Faltings' proof. This depends on noticing that Mordell's Conjecture follows from:

THE ŠAFAREVIČ CONJECTURE FOR CURVES. *Let K be a finite extension of $\mathbf{Q}$. There are only finitely many isomorphism classes of smooth curves X/K of genus $g \geq 2$ which have good reduction outside a particular finite set of places S of K.*

One may want to take a nonsingular variety defined by equations over $\mathbf{Z}$ and produce a variety over a finite field by reducing the coefficients modulo p. A good reduction is one in which such a method yields a nonsingular variety over the finite field. A variety has good reduction at a prime p if there is some embedding of the variety which has good reduction at p (cf. [**Pa1**, **Fa1**]). This may be related to the idea of testing whether a Diophantine equation has solutions in the integers by testing the necessary condition that it have solutions modulo every prime p.

Also relevant to Faltings' work is the related *Šafarevič Conjecture for Abelian Varieties.* This states that the set of K-isomorphism classes of polarized abelian varieties defined over K of given dimension g and polarization degree $d > 0$ and possessing good reduction outside a finite set of places S is finite. The polarization of an abelian variety involves the way one chooses to embed it in projective space. A refinement of Torelli's theorem can be used to show that if the Šafarevič Conjecture for abelian varieties is true, then so is the one for curves. Faltings established that both these conjectures are true in the course of settling the Mordell Conjecture.

2. The general problem of solving Diophantine equations. Let $f(x_1, x_2, \ldots, x_n)$ be a polynomial in n variables with integer coefficients. Sometimes we will consider such polynomials with coefficients that are integers in a number field. When one seeks solutions of the equation $f(x) = 0$ that are either integers or rationals (or in the number field), the equation is called a *Diophantine equation.* One talks of integral or rational solutions of the Diophantine equation. Solutions with values in a field K are called *K-rational solutions* or *K-rational points.*

A Diophantine equation is *homogeneous* if every term in it has the same degree. In this case, if the vector x is a solution, then so is

cx for every constant c. Thus, for homogeneous equations, it pays to "identify" two solutions that are nonzero multiples of one another, and look only for distinct solutions. For a nonhomogeneous equation of degree d, there is always a related homogeneous equation gotten by adding one more variable to the set of n variables, and throwing into each term of the old equation enough copies of the new variable to make each term have degree d. Then, solutions of the nonhomogeneous equation correspond to solutions of the homogeneous equation for which the new variable has value 1. In practice, one looks for integer solutions in the nonhomogeneous case, and rational solutions in the homogeneous case. The relationship between homogeneous equations in $n + 1$ variables and nonhomogeneous equations in n variables may remind the reader of the relationship between projective geometry and affine geometry (for good reason).

Mathematicians ever since the ancient Greeks have sought to solve particular Diophantine equations, and dreamed of finding a general solution. The most infamous example is Fermat's work on the equations $x^n + y^n = z^n$. Hilbert asked about the existence of a general algorithm for the solution of Diophantine equations. This is Hilbert's so-called Tenth Problem. It was finally solved by Matijasevič in 1970 (cf. [**Da1**]). He showed that no such algorithm can be found that tells whether an equation has a solution in rational integers. It is still unknown if there is an algorithm to tell if an equation has a solution in rational numbers.

A different approach to Diophantine problems attempts to use geometry. Each Diophantine equation defines as its locus of solutions over the complex numbers a certain complex algebraic variety. If the equation is nonhomogeneous, its solutions form an affine variety. If the equation is homogeneous, the solutions lie on a projective variety. The relation described above between a nonhomogeneous equation and its homogeneous version just corresponds to a certain affine variety and the projective variety gotten by taking its closure in the proper projective space (i.e., the projective variety gotten by adding points "at infinity").

The study of solutions of Diophantine equations then becomes the problem of finding integer points and rational points on complex varieties defined by equations with coefficients in number fields. Thus, the equation that Fermat studied is the equation of a nonsingular curve in the projective plane of genus $(n-1)(n-2)/2$. In general an irreducible homogeneous equation of degree n in three variables corresponds to a curve in the projective plane of genus $(n-1)(n-2)/2$ minus a correction for the singular points of the curve. One can hope that geometry may make some Diophantine problems more tractable. The obvious first step is to try to restrict one's attention to Diophantine equations that correspond to curves (or, more generally, to systems of Diophantine equations whose solution sets form curves in higher-dimensional spaces). In this way one is led to restate the problem of solving Diophantine equations as the problem of finding all the rational and integer points on curves. It is with this form of the problem that we are primarily concerned.

A related problem, whose solution is used by Faltings, involves smooth projective varieties defined over finite fields. The numbers of rational points such a variety has in the various finite extension fields can be expressed using a sort of generating function, called the zeta function of the variety. The Weil Conjectures [**We2**] give information about this zeta function that allows it in theory to be computed with enough mechanical work. The last of these Weil Conjectures was finally proven by Deligne in 1973. The Weil Conjectures on abelian varieties are rather simpler to prove (cf. [**La1**]), and are used in a crucial way in Faltings' proof.

3. The work of Mordell, Weil, and Siegel. Let us consider the nonhomogeneous equation $x^2+y^2 = 1$ and the corresponding homogeneous equation $x^2 + y^2 = z^2$. The affine equation clearly has only finitely many integer solutions. The projective variety has infinitely many distinct integer solutions (even after identifying solutions that are nonzero multiples of one another as mentioned before). Namely, the Pythagorean triples give such integer points. The solutions in the projective plane include the solutions of the affine equation as special cases. But they also yield infinitely many rational solutions of the affine equation. Thus, we are led to consider two related but inequivalent problems. The problem of whether the number of integer points on an affine curve is finite we may call *Siegel's Problem*, after the man who solved it. The problem of whether the number of rational points (after identifying those that are nonzero multiples of one another) on a projective curve is finite is called the *Mordell Problem.* Of course, these theoretical problems may not help to find a bound on the number of solutions (even when the number has been proven finite) and certainly may not help us find even one solution. This is called the problem of getting an *effective* solution.

Historically, these problems arose out of the work of Mordell. For the general history of the problems see [**La4**]. In his 1922 paper [**Mo1**], Mordell used direct methods to study rational points on elliptic curves, that is, nonsingular curves of genus 1. In the following year, he wrote the seminal paper [**Mo1**] on the subject. He showed that the rational points on an elliptic curve form a finitely generated group, while the affine curve has only finitely many integer points. He conjectured that affine plane curves of higher genus that are hyperelliptic also have only finitely many integer points, and that smooth projective curves of genus at least 2 always have at most finitely many rational points.

These conjectures proved the inspiration for a continuing stream of research papers lasting to this day. The hyperelliptic conjecture was proven anonymously by Carl Siegel in 1926 [**Si1**]. The conjecture on projective curves of genus at least 2 became the *Mordell Conjecture*, now finally established in Faltings' paper. The proof that the rational points on an elliptic curve form a finitely generated group inspired André Weil to write his first great paper, the proof of the *Mordell-Weil Theorem.* This theorem helped to inspire much of the algebraic geometry and number theory done since it was published in 1928 (cf. [**We1**, **We3**]). Weil's work led to the theory of abelian varieties, combining group theory with algebraic geometry and analysis in a vast generalization of the nineteenth-century theory of elliptic integrals. For more information, see [**La4**, **Za1**].

We may take this opportunity to refer the reader to the sources for more recent work on the problem of rational points on elliptic curves. The basic survey of the subject is [**Ca1**]. Since Cassels' paper, Barry Mazur has done important work using the theory of moduli: see [**Ma2**, **Ma3**, **Ma4**, **Ma5**, **Se1**].

At the heart of Mordell's work was his insight on the usefulness of the theory of heights, as later exemplified in the Thue-Siegel-Roth Theorem. Siegel, in his masterpiece [**Si2**], saw how to put the existing theory of heights together with the Mordell-Weil Theorem and a primitive version of what was to become the theory of abelian varieties to solve what we have called the Siegel Problem. His result, Siegel's Theorem, is quoted above. This paper contains much else of value, including the famous Siegel's Lemma, important to transcendence theory. For more information on Siegel's Theorem see [**La2**, **La4**]. A theory of heights for abelian varieties is central to Faltings' work. Such a theory of heights can be considered a modern version of the famous method of infinite descent introduced by Fermat.

4. Early attempts at the Mordell Conjecture. As the theory of abelian varieties developed, it became increasingly clear that Mordell's Conjecture should be understood as a statement about certain abelian varieties containing curves of genus 2 or more. On such abelian varieties, called Jacobians, one could hope to use the Mordell-Weil Theorem to get information about the rational points of the embedded curves. Such methods date back to Chabauty (cf. [**Ch1**, **Ch2**]) in the 1930s and 1940s, but were made quite concrete by Lang in [**La4**]. One restatement of the Mordell Conjecture by Lang conjectures that a curve lying on an abelian variety has only finitely many points in common with any subgroup of finite type of the abelian variety. He showed that the Mordell Conjecture could also be considered as a conjecture on algebraic families of curves.

Other mathematicians attempted to approach the Mordell Conjecture either through the piecemeal analysis of particular families of curves, or through careful use of the theory of heights. Examples of such work may be found in [**Ca2**, **De2**, **Mo3**, **Mu1**].

The first major breakthrough came in the 1960s with the proof of the function field-theoretic equivalent of the Mordell Conjecture. It is standard operating procedure in algebraic number theory to ask, for any theorem or conjecture over number fields, whether the analogous statement is true for function fields, and vice versa. Such analogies are inspired by general theory about how to prove statements about fields of finite type over prime fields. Néron showed the two Mordell Conjectures establish the corresponding conjecture for any finitely generated field over **Q**. Manin and Grauert both managed to prove the function field analogue of the Mordell Conjecture stated above, without having any clear insight beyond that already in Lang's book [**La4**] on how to proceed in the number-theoretic case. For the details, see [**Gr1**, **Ma1**, **Sa1**].

The work of Manin was a part of a considerable Soviet research effort on the Mordell Conjecture. The central figures were Manin, Šafarevič, Demjanenko, and Parshin. In retrospect, the work of Parshin and Šafarevič (cf. [**Pa1**, **Pa2**, **Sa1**]), centered about the Šafarevič Conjecture stated above and its relationship to the function field version of the Mordell Conjecture, was to be the crucial inspiration for the work done by Faltings fifteen years later. Parshin showed that if the Šafarevič Conjecture could be established, then the Mordell Conjecture could be proven.

More mathematics had to be developed before Parshin's ideas could be applied to the number-theoretic Mordell Conjecture. These included the development of the theory of moduli for abelian varieties and curves and the development of a sophisticated theory of abelian varieties using representation theory. The latter is embodied in the modern theory of Tate modules, as described in [**La1**] and [**Ca1**].

5. A sketch of Faltings' paper. Let K be a finite extension of the rationals **Q** with algebraic closure K^*, A an abelian variety defined over K. Let $\pi = \mathrm{Gal}(K^*/K)$ be the absolute Galois group of K, l a prime. Then π operates on the *Tate module*

$$T_l(A) = \varprojlim A[l^n](K^*).$$

More precisely, $T_l(A)$ is the set of all vectors $(a_1, a_2, \dots, a_n, \dots)$, where $n > 0$, with a_n a K^*-point on A whose order is a power of l, and such that $la_{n+1} = a_n$ for every n, and $la_1 = 0$. Addition of these infinitely long vectors is done componentwise. Then $T_l(A)$ can be made a module over the l-adic integers $\mathbf{Z}_l$.

The Tate group is a torsion-free module over $\mathbf{Z}_l$, and is a module of finite type of dimension $2\dim A$ over $\mathbf{Z}_l$. The Tate module can be extended to a vector space $E_l(A)$ over the l-adic numbers $\mathbf{Q}_l$, $E_l(A) = T_l(A) \otimes_{\mathbf{Z}_l} \mathbf{Q}_l$. This vector space is called the *extended Tate group* and π operates on it. Faltings' basic results are:

(1) The representation of π on $E_l(A)$ is semisimple.

(2) The map $\mathrm{End}_K(A) \otimes_{\mathbf{Z}} \mathbf{Z}_l \to \mathrm{End}_\pi(T_l(A))$ is an isomorphism.

(3) Let S be a finite set of places of K, $d > 0$. Then there are only finitely many isomorphism classes of d-fold polarized abelian varieties over K which have good reductions outside S.

Result (2) says that certain types of well-behaved endomorphisms of $T_l(A)$ correspond to the endomorphisms of A. This settles a version of a conjecture of Tate. For similar results on the use of the Tate module to study maps between abelian varieties, compare Lang's book on abelian varieties [**La1**]. The Šafarevič Conjecture for abelian varieties is (3), and so the Šafarevič Conjecture for curves follows from the theory of Jacobians of curves.

After obtaining the Šafarevič Conjecture, Faltings can now employ Parshin's earlier argument from [**Pa2**] to prove the Mordell Conjecture. We sketch the argument briefly. Suppose X is a smooth curve over K of genus at least 2 and S is a set of places. For each K-rational point x, one can construct a covering $Y(x)$ of X, of genus g', defined over a finite extension of K, which is ramified exactly at x, and so $Y(x)$ has good reduction outside a set T. Here g', T, and the field extension depend only on X and S, but not on x. By Šafarevič's Conjecture, there are only finitely many isomorphism classes of such $Y(x)$. If the set of rational points x were infinite, there would be infinitely many distinct maps from some $Y(x)$ to X. This contradicts a classical result on Riemann surfaces of genus > 1.

The proof of (3) follows from the finiteness of the set of isogeny classes (isogeny = onto homomorphism with finite kernel) of such polarized abelian varieties. This and (1) and (2) follow from similar arguments using heights, the theory of moduli of curves and abelian varieties, and the Weil Conjectures on abelian varieties.

Faltings begins with the theory of semiabelian varieties, which extends the concept of an abelian variety over a field to a variety over a scheme. He discusses some results about the moduli spaces for stable curves and principally polarized abelian varieties. Then, he develops a theory of heights applicable to semiabelian varieties. The basic theorem shows that given a constant c, there are only finitely many isomorphism classes of semiabelian varieties with certain properties whose heights are bounded by c. This *principle of bounded height* may turn out to be the most useful result in Faltings' paper. It is the basis for all his results.

Faltings discusses the behavior of heights under isogenies. Here, the Weil Conjectures are needed. Faltings proves (1) and (2). These are then used to prove that two abelian varieties are isogenous iff their extended Tate modules are isomorphic as π-modules. This settles the *isogeny conjecture*, an important result in itself. Faltings proves (3) from the previous results together with another application of the Weil Conjectures. Finally, one gets the Šafarevič Conjecture for curves, and so—as explained before—the Mordell Conjecture.

6. Some final remarks. Now that the Mordell Conjecture has been solved, one obvious question is: what about those systems of Diophantine equations whose solution sets do not form curves? What can be said about integral and rational points on higher-dimensional varieties? Some early attempts have been made to study such questions. In [**Ch3**] and [**Ch4**], Chatelet studies cubic surfaces. In [**La3**] and [**La5**], there are a series of conjectures extending in various directions the results now known for curves. But any real understanding of the situation in higher dimensions remains a distant goal.

Even more important is the question of the effectiveness of the existing results. By this we mean not merely their theoretical usability to solve Diophantine problems, but their practical applicability. If a problem can be solved only with an impossibly large amount of work, its theoretical solution may not be of any value. Unfortunately, this appears to be the situation with the Siegel Problem, the Mordell Problem, and perhaps the related problem of using the Mordell-Weil Theorem to find the group structure of the rational points on an abelian variety. (There is an unproven algorithm for effectively using the Mordell-Weil Theorem. Its correctness is equivalent to a 1929 conjecture by Weil [**We3**] that remains open.) Quantitative results are difficult to obtain (cf. [**La4**]). The proofs of the Mordell-Weil Theorem and of the Mordell Conjecture are highly nonconstructive. It is hard to estimate the number of rational or integral points or to get generators for the Mordell-Weil group.

In his paper [**Si2**], Siegel states that there should be effective ways to estimate the number of integral points, even if the size of the integral points cannot be estimated. Thus, we might have an idea of the number of integral points, but none of how large a space must be searched to find them exhaustively. In practice, it is not clear that there are practical ways to estimate the number of integral points on a curve. The general consensus among knowledgeable number theorists appears to be that we are a long way from having truly effective means of finding the integral (or rational) points on curves of genus > 1.

Faltings' work is currently highly ineffective. For example, there is no known algorithm for determining whether there are any rational points at all on a curve (the rational point version of the theorem on integer points for which Matijasevič gave a negative answer—so it is hard to have much optimism that such an algorithm will be found). Fermat's Last Theorem is just one example of how hard this problem must be. Assuming there are rational points on a curve, there is no known computable upper bound for the number of rational points. Before Faltings' work, in fact, there was no curve X of genus 2 or more for which it was known that $X(K)$ is finite for all number fields. All this leads to a certain pessimism about the practical usefulness of direct applications of Faltings' work to number theory, despite its considerable theoretical interest. Only time will tell whether this pessimism is justified.

Perhaps the future will show that the ultimate importance of Faltings' work will not lie primarily in settling the Mordell conjecture. To an algebraic geometer, his results on the Šafarevič and Tate conjectures may open the way to significant progress. And perhaps Faltings' work on the theory of heights for abelian varieties will prove even more important. Progress on Diophantine questions may come indirectly. Only time will tell.

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National Science Foundation Budget Request for Fiscal 1987

This article is concerned with material submitted to Congress last February and refers to a reorganization of NSF announced in March 1986.

Since February and March, however, there have been changes in the anticipated budgetary support for Mathematical Sciences Research in fiscal 1987.

Supplementary information available when the June *Notices* was prepared for the printer will be found in the section **NSF News & Reports** later in this issue. EDITOR

Since April 1973, *Notices* has published annually a report outlining the proposals contained in the White House's budget request to the Congress for the needs of the National Science Foundation. This year, details of the NSF budget for FY 1987 were distributed to the public under a cover letter (excerpts below) from Erich Bloch, director of the Foundation. Last year's report in *Notices* appeared in the June 1985 issue, pages 346 to 364.

This year's report differs in several ways from previous ones. We have, again, the usual Tables I to III: Table I indicates what part of the entire NSF budget is allocated to research in the mathematical sciences; Table II shows how the funds for the Division of Mathematical and Physical Sciences (MPS) are apportioned among the Division's several Sections; Table III is an attempt to place the longer-range growth of the Foundation's budget in perspective with regard to the inflation of the past decade or two.

In addition to these more familiar tables, we give figures for the relatively new program supporting supercomputers, the Advanced Scientific Computing (ASC) program is only a year or two old at this point but it shows signs of vigorous growth (last year and this, more is being spent in this program than for the entire Computer Research Section of MPS) and it may not be long before the ASC budget could exceed the budget for research in Mathematical Sciences. A new line has been added this year below Table II giving figures for the ASC program.

In recent years these more general tables and the accompanying commentary have been supplemented by excerpts from the Administration's Budget submission to Congress which describe activities and progress related to research in the Mathematical Sciences, Computer Research, and Science and Engineering Education (SEE). This year we also include the corresponding report from the ASC Office.

There is, however, a difference this year in the emphasis of these reports; no longer do we find details of interest regarding achievements and progress in scientific knowledge, but rather a significant increase in the amount of financial detail concerned with increases, cuts, and the shuffling of funds from one part of the budget to another and from one year to the next.

The good news is that the mathematical sciences are expected to continue to fare better this year and next than in the recent past, although the funds involved are very small (still less than 4% of the entire budget).

The press releases and budget summaries which have been distributed contain little direct information about the effects of the Gramm-Rudman-Hollings limitations on the 1987 NSF budget requests, but there are some rather revealing tables in the four supplementary excerpts that follow. These indicate reductions between

National Science Foundation
Washington, D C 20550
February 7, 1986

I am very pleased to provide ... a summary of the National Science Foundation's fiscal year 1987 budget request, which has been sent to the Congress. The request is for almost $1.7 billion and represents an increase of eight percent over fiscal year 1986.

In a year of dramatic federal budget reductions, the President's budget request for the National Science Foundation contains a moderate, but very important, increase for the basic research and education activities of the Foundation. Science and engineering enrich the lives of all of us, and provide the basis for both economic competitiveness and national defense. Investing in science and engineering research and education is clearly a critical activity that must be maintained under any economic conditions.

Given the extraordinary constraints on the Federal budget, however, it will be difficult to convince the Congress of the need to provide for an increased investment in basic science and engineering. Our balanced program of support for research and education in science and engineering is important to enhancing our nation's economic productivity and our competitive position internationally. As a society and as a government we must look to the future and make the investments necessary to prepare for it.

I hope you find the enclosed summary useful and informative. ...

Sincerely,

Erich Bloch
Director

Table I. National Science Foundation

(Millions of dollars)	1983 Actual	Change	1984 Actual	Change	1985 Actual	Change	1986 Plan	Change	1987 Request
(1) **Mathematical Sciences Research Support**	**$ 34.8**	**18.4%**	**$ 41.2**	**15.8%**	**$ 47.7**	**8.4%**	**$ 51.7**	**15.7%**	**$ 59.8**
(2) Other Research Support (Note A)	960.6	17.9%	1131.0	14.2%	1293.6	3.1%	1334.0	8.4%	1446.3
(3) Education, Information, Foreign Currency Program (Note B)	24.7	169%	66.5	40.9%	93.7	3.8%	97.3	4.4%	101.6
(4) Program Development and Management ("Overhead") (Note C)	65.7	0.9%	66.3	8.6%	72.0	0.7%	72.5	7.6%	78.0
(5) **Totals**	**$1085.8**	**20%**	**$1305.1**	**15.5%**	**$1507.0**	**3.2%**	**$1555.5**	**8.4%**	**$1685.7**
(6) (1) as % of (1) and (2)	3.50%		3.52%		3.56%		3.73%		3.97%
(7) (1) as % of (5)	3.21%		3.16%		3.17%		3.33%		3.55%

Note A. Scientific research and facilities (excluding mathematics and science information). National and special research programs, and national research centers. Support for mathematics has been excluded, cf. items (1) and (3).

Note B. The programs in this group are ones in which there is some support in every field, including mathematics. The foreign currency program involves both cooperative scientific research and the dissemination and translation of foreign scientific publications. Foreign currencies in excess of the normal requirements of the U.S. are used.

Note C. This heading covers the administrative expenses of operating the Foundation; the funds involved are not considered to constitute direct support for individual projects.

Table II. Division of Mathematical and Physical Sciences

Section	1983	Actual	1984	Actual	1985	Actual	1986	Plan	1987	Request
Mathematical Sciences	$ 34.8	(11.5%)	$ 41.2	(11.6%)	$ 47.7	(12.0%)	$ 51.7	(12.6%)	$ 59.8	(13.3%)
Computer Research	29.3	(9.7%)	33.7	(9.5%)	39.1	(9.8%)	40.2	(9.8%)	44.4	(10.0%)
Physics	89.1	(29.5%)	104.4	(29.4%)	115.8	(29.2%)	118.6	(28.9%)	126.6	(28.2%)
Chemistry	67.6	(22.4%)	79.4	(22.4%)	87.6	(22.0%)	89.8	(21.9%)	101.0	(22.5%)
Materials Research	81.1	(26.9%)	96.3	(27.1%)	107.0	(26.9%)	109.6	(26.8%)	117.4	(26.1%)
Totals	$301.9		$355.0		$397.2		$410.0		$449.2	
Advanced Scientific Computing			$ 6.0		$ 41.4		$ 45.2		$ 53.6	

last year's budget requests for FY 1986 and this year's plans for current spending, involving cuts ranging from about 2% for ASC to just over 6% for SEE. On the other hand, the FY 1987 budget requests exceed the FY 1986 planned expenditures by amounts ranging from just over 2% for SEE to about 19% for ASC.

Over the decade and more in which these reports have been prepared for *Notices*, the information on which they have been based has changed almost year-by-year. The detail reported has evolved significantly, the accounting categories have changed regularly, to such an extent that it has often been difficult to present the figures in a form comprehensible to any but professional accountants.

This situation continues. For example, an NSF press release dated March 24, 1986, announces a reorganization involving a new round of "musical chairs" within the Foundation which will involve (1) moving Computer Research out of MPS and moving Astronomy in; (2) creating a new Directorate of Computer and Information Science and Engineering (CISE) to include the Computer Research Section of MPS, the Division of Information Science and Technology (currently in the Directorate of Biological, Behavioral and Social Sciences), the Office of Advanced Scientific Computing (now in the Office of the Director), and "some programs from the Directorate for Engineering"; (3) changing the name of Astronomical, Earth and Ocean Sciences (AAEO), after Astronomy is removed, to Directorate of Geosciences (DOG).

There has been one phenomenon which may not have received adequate coverage in these annual reports on the NSF budgets in *Notices*. For the most part, we have reported what the Foundation says it wants to spend on the various programs which it supports, and what it has actually spent after the year closes. These figures are referred to in the jargon as the "Obligational Authority" for which NSF seeks congressional approval. Those familiar with budgets, and other predictions, can understand that certain inaccuracies are inevitable ("foresight" *vs.* "hindsight") and that what is actually spent during the fiscal year will probably not be what was anticipated.

The various units of NSF appeared to finish each year pretty close to their budgets, usually

Table III. Ten-Year Compilation of the NSF Budget

(Millions of dollars)	1978 Actual	1979 Actual	1980 Actual	1981 Actual	1982 Actual	1983 Actual
(1) Mathematical Sciences Research Support	$ 21.4	$ 22.8	$ 25.0	$ 28.3	$ 30.5	$ 34.8
*1967 dollars**	*10.2*	*9.7*	*9.3*	*9.6*	*10.2*	*11.5*
(2) Other Research Support	702.8	761.0	804.3	873.7	875.7	960.7
1967 dollars	*335.9*	*322.7*	*299.2*	*295.3*	*292.5*	*317.0*
(3) Education, Information, Foreign Currency Program	84.3	88.4	87.7	80.6	29.8	24.6
1967 dollars	*40.3*	*37.5*	*32.6*	*27.2*	*9.9*	*8.1*
(4) Program Development and Management ("Overhead")	48.7	54.7	58.2	59.2	63.2	65.7
1967 dollars	*23.3*	*23.2*	*21.6*	*20.0*	*21.1*	*21.7*
(5) Totals	$857.2	$926.9	$975.2	$1041.8	$999.1	$1085.8
1967 dollars	*409.7*	*393.0*	*362.8*	*352.1*	*333.7*	*358.3*

	1984 Actual	1985 Actual	1986 Plan	1987 Request	Increase 1978 – 1985	Increase 1978 – 1987
(1) Mathematical Sciences Research Support	$ 41.2	$ 47.7	$ 51.7	$ 59.8	123%	179%
1967 dollars	*13.2*	*15.5*			*52%*	
(2) Other Research Support	1131.0	1293.6	1334.0	1446.0	84%	106%
1967 dollars	*364.8*	*419.1*			*25%*	
(3) Education, Information, Foreign Currency Program	66.5	93.7	97.3	101.6	11%	21%
1967 dollars	*21.4*	*30.4*			*−25%*	
(4) Program Development and Management ("Overhead")	66.3	72.0	72.5	78.0	48%	60%
1967 dollars	*21.3*	*23.3*			*0%*	
(5) Totals	$1305.0	$1507.0	$1555.5	$1685.7	76%	97%
1967 dollars	*420.2*	*488.3*			*19%*	

* Current dollars are converted to 1967 dollars using the wholesale/producer index.

with "slide-rule accuracy", as some of us used to say, meaning a deviation of 5% or less from the target, but there has recently been a significant departure from this pattern.

In the first term of the present Administration, the SEE effort was essentially terminated (cf. *Notices*, April 1982, pages 287 to 289). After a decade or so of support at a level of $60 to $80 million a year, in 1982 and 1983 expenditures were reduced to, respectively, $21 and $16 million when there was support for nothing but the Graduate Research Fellowships which had been previously contracted. By 1984, however, the folly of this had apparently been recognized and the Foundation requested over $50 million for education and for 1985 over $75 million, a figure which Congress then raised to $82 million. The SEE Obligational Authority has been at about that level since.

The problem, however, is that SEE has not managed to spend that much money and has consistently "carried over" (or anticipated carrying over) about $30 million each year for the past three years.

It is surely understandable that, when a major program has been abolished and its staff dispersed, it must take years to reconstruct what was there before.

L. K. DURST

The following text was prepared by the staff of the Mathematical Sciences Division of NSF and was submitted to Congress as a part of the Administration's Budget Request for the Fiscal Year 1987.

Mathematical Sciences Subactivity
$59,800,000

Summary of Request

The FY 1987 Budget Request of $59.8 million for the Mathematical Sciences subactivity represents an increase of 11.6% over the FY 1986 Current Plan.

Activity	FY 1985 Actual	FY 1986 Plan	FY 1987 Request
	(Millions of dollars)		
Classical Analysis	$ 4.55	$ 5.02	$ 5.77
Modern Analysis	4.66	5.09	5.86
Geometric Analysis	4.52	4.95	5.69
Topology & Foundations	5.70	6.16	7.08
Algebra & Number Theory	7.91	8.58	9.87
Applied Mathematics	6.42	7.03	8.91
Statistics & Probability	5.60	6.17	7.44
Special Projects	8.37	8.74	9.18
Total	$47.73	$51.74	$59.80

Scientific Overview

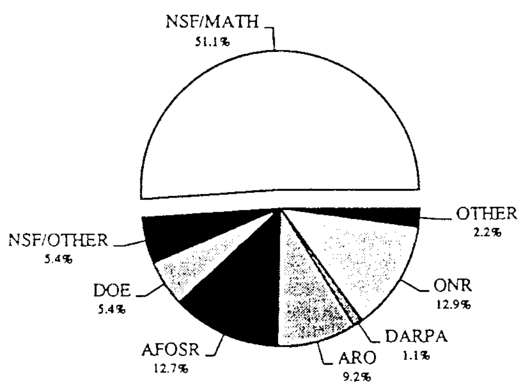
The Mathematical Sciences Subactivity fosters the creation and development of mathematical ideas, methods, and techniques and promotes their use in improving our understanding of physical, biological, engineering, and social phenomena. To achieve these objectives, support provides for significant research in the mathematical sciences, and serves to ensure the continuing vitality and long-range health of the discipline. Each subdiscipline of the mathematical sciences, from those with the sharpest intrinsic focus to those that reach out to other areas of knowledge, is supported in such a way as to encourage their interaction and to provide a healthy balance among them.

The core of the Foundation's program of research support in this area has been the Scientific Research Project Support (SRPS) awards. Within the SRPS activities, significant emphasis has been given to increasing the level of support for the young mathematicians to whom the field owes so much for its vitality. This emphasis has received significant enhancement since FY 1984. The mathematical sciences community recognizes a need for greater opportunities for communication between mathematical scientists in the same or related fields, as well as with scientists in other disciplines. To provide for this need the subactivity has a Special Projects Program which includes funding for research institutes at the University of Minnesota and in Berkeley, California, postdoctoral and visitor support at three other research centers, a program of postdoctoral fellowships, and support for research conferences and workshops. Moreover, researchers are encouraged to join colleagues in obtaining funds for computing equipment that no single project could justify. Activities of this kind will continue to augment the SRPS awards.

During the last few years major structural problems in the support for research have become visible. These problems resulted, in part, from a gradual attrition in support levels over several years. While this attrition was most pronounced in the funding levels for graduate students and postdoctoral associates, it has also affected support for investigators. This problem has been documented in the 1984 report from the National Research Council entitled, *Renewing U.S. Mathematics: Critical Resource for the Future.* As the only Federal agency with responsibility for support of research across the entire spectrum of the mathematical sciences, NSF plays a pivotal role attempting to address these structural problems. The issues are complex, but significant gains have been made since FY 1984. A determined effort, sustained over a period of years, is required to realign support for mathematical sciences research with that of other sciences.

The chart below illustrates the crucial role played by NSF in the Federal support of basic research in the mathematical sciences. Percentages are based on a total Federal expenditure of $92.86 million in FY 1985. For the past decade, the mission-oriented research agencies have focused their support on applied mathematics and statistics. New programs have been aimed at such emerging fields as dynamical systems and discrete mathematics. In all areas of the mathematical sciences, Foundation-supported research generally involves a broader range of topics than the more project-oriented research sponsored by the mission agencies.

Federal Academic Mathematics Funding
FY 1985



NSF coordinates its support of research in the mathematical sciences with its counterpart Federal agencies through the Interagency Committee for Extramural Mathematics Programs. This group meets regularly to share information on policies of support and to discuss areas of emphasis and of unusual scientific opportunity. Extensive day-to-day contact between program officers at various Federal agencies is maintained by telephone and personal visits. Conferences, workshops, and activities at research centers are sometimes supported jointly by the Foundation and one or more of the other agencies.

Changes Between the FY 1986 Budget Request and the FY 1986 Current Plan

	(Millions of dollars)		
Activity	FY 1986 Request	FY 1986 Plan	Percent Change
Classical Analysis	$ 5.36	$ 5.02	−6.3%
Modern Analysis	5.49	5.09	−7.3
Geometric Analysis	5.22	4.95	−5.2
Topology & Foundations	6.63	6.16	−7.1
Algebra & Number Theory	9.11	8.58	−5.8
Applied Mathematics	7.64	7.03	−8.0
Statistics & Probability	6.69	6.17	−7.8
Special Projects	8.55	8.74	+2.2
Total	$54.69	$51.74	−5.4%

The FY 1986 Current Plan is 5.4% below the FY 1986 Budget Request. This decrease results from the unspecified Congressional reduction. The decrease was distributed across the programs in accordance with perceived opportunities and needs. The modest increase in special projects reflects adjustments in support of postdoctoral researchers and equipment.

The FY 1986 Current Plan maintains the Foundation's increases in the support of graduate students and postdoctoral researchers at somewhat more modest levels than originally planned. Where possible, these increases are located in the SRPS programs. The table below describes the position with respect to critical infrastructure items. Maintaining progress on the personnel aspects of the infrastructure was held to have the highest priority. Within the senior investigator category, the emphasis will be on younger investigators. The increase for equipment and access to computers is small in dollars but large in percentage. The increase reflects increasing use of computational equipment in all areas of the mathematical sciences.

	(Millions of dollars)		
	FY 1985 Actual	FY 1986 Request	FY 1986 Plan
Graduate Students	$ 6.04	$ 8.60	$ 7.25
Increase over FY 1985		*42.5%*	*20.1%*
Postdoctoral Researchers	6.23	7.60	7.00
Increase over FY 1985		*22.0%*	*12.4%*
SRPS Senior Investigators	30.03	32.38	32.05
Increase over FY 1985		*7.8%*	*6.7%*
Equipment & Access to Computers	1.72	2.78	2.19
Increase over FY 1985		*61.4%*	*27.2%*

FY 1987 Budget Highlights

	(Millions of dollars)		
Activity	FY 1986 Plan	FY 1987 Request	Percent Change
Classical Analysis	$ 5.02	$ 5.77	14.9%
Modern Analysis	5.09	5.86	15.1
Geometric Analysis	4.95	5.69	15.0
Topology & Foundations	6.2	7.1	14.8
Algebra & Number Theory	8.58	9.87	15.0
Applied Mathematics	7.03	8.91	26.7
Statistics & Probability	6.17	7.44	20.6
Special Projects	8.74	9.18	5.0
Total	$51.74	$59.80	15.6%

The increase of 15.6% for the Mathematical Sciences subactivity is partially in response to the recommendations of the recent report from the National Research Council entitled *Renewing U.S. Mathematics: Critical Resource for the Future* and the subsequent National Science Board resolution on the need to bolster resources for the mathematical sciences. The central role of the mathematical sciences in the computational approach to science and engineering accounts for the remainder of the increase.

The mathematical sciences are engaged in the computational approach to science and engineering in three distinct ways. First, as in most other disciplines, the computer is becoming increasingly important as a tool within the mathematical sciences themselves. Second, mathematical scientists, particularly numerical analysts and computational statisticians, work with scientists and engineers from all disciplines in the integrated development and application of computational mathematical models, algorithms and efficient computational software. Finally, the mathematical sciences provide the necessary theoretical underpinnings for the development of computational methods.

The FY 1987 Budget Request provides $3.0 million for increased support for all three modes of activity with emphasis on the second. These funds have been distributed across the Subactivity according to expected use. The greater involvement of the programs of Applied Mathematics and Statistics and Probability in the area of computational science and engineering results in larger increases for these programs. Funds associated with this computational initiative will be coordinated on a Subactivity-wide basis, with the development of multidisciplinary teams providing a focus for the research supported.

Since FY 1984, the budget of the Mathematical Sciences subactivity has included increments dedicated to the support of graduate students and postdoctoral associates. This emphasis is continued in the FY 1987 Budget Request. The table below summarizes the impact of the request on various items.

	(Millions of dollars)		
	FY 1986 Plan	FY 1987 Request	Percent Change
Graduate Students	$ 7.25	$ 9.90	36.6%
Postdoctoral Researchers	7.00	8.06	15.1
SRPS Senior Investigators	32.05	35.62	11.1
Equipment & Access to Computers	2.19	2.85	30.1

- All support for graduate students will be located in the SRPS programs. The number of graduate students supported will increase from about 750 in FY 1986 to about 875 in FY 1987, and more of the students will be supported as full-time research assistants.
- The increase in funds for postdoctoral researchers will come almost entirely in the SRPS programs. The number of Mathematical Sciences Postdoctoral Research Fellowships awarded by the Special Projects Program will be held constant at 30. The total number of postdoctoral researchers supported is expected to increase from about 240 in FY 1986 to about 255 in FY 1987 while the time supported per postdoctoral researcher increases significantly on SRPS awards.
- Funds for the support of senior investigators include support for the Mathematical Sciences aspects of Foundation-wide activities such as the Presidential Young Investigator awards, Research Opportunities for Women, Research in Undergraduate Institutions, Minority Research Initiation, and the Experimental Program to Stimulate Competitive Research. It is expected that the number of investigators supported will increase from about 1300 in FY 1986 to about 1330 in FY 1987.
- The increase for computer equipment and access to computing facilities is large in percentage, but small in amount. The increase is in response to the increasing need for this resource in all of the areas of the mathematical sciences.

The following text was prepared by the staff of the Computer Research Division of NSF and was submitted to Congress as a part of the material which accompanied the Administration's Budget Request for the Fiscal Year 1987.

Computer Research Subactivity

$44,440,000

Summary of Request

Support for Computer Research is increased by $4.27 million, or 10.6%.

	(Millions of dollars)		
Activity	FY 1985 Actual	FY 1986 Plan	FY 1987 Request
Theoretical Computer Science	$ 4.86	$ 5.15	$ 5.58
Software Systems Science	4.24	4.80	5.47
Software Engineering	3.57	3.85	4.93
Intelligent Systems	5.22	5.35	5.67
Computer Systems Design	3.60	3.50	3.47
Coordinated Experimental Research	15.12	15.10	14.40
Special Projects	1.02	0.92	3.42
Computer Research Equipment	1.49	1.50	1.50
Total	$39.12	$40.17	$44.44

Scientific Overview

The new academic discipline of computer research has its roots in the mathematical sciences, electrical engineering, and logic. The use of computers stimulates the growth of computer research as a discipline; in turn, computer research is building the knowledge base for improving computer technology. Unlike the physical sciences, which deal with the intrinsic properties of physical matter, computer research discovers the concepts and laws governing problem-solving procedures and develops computing systems which test and utilize them. The universe for study consists of strategies and algorithms for solving problems, methods of representing and transforming information, programs for carrying out computation procedures, and machines for executing programs.

Funding patterns in computer research are often difficult to discern because it is common to confuse research in other sciences using computers or applied research on computer technology performed by industry or the mission-oriented agencies with computer research. The computer industry, paced by the constant demand for new or improved products, has concentrated on short-term requirements for most research and development projects. Some basic research is carried out, principally in a few of the largest companies, and companies also provide limited support for academic research. This is mainly in the form of discounts or gifts of equipment but there are also some faculty study contracts, graduate student fellowships or forgivable loans, and a small number of unrestricted departmental grants. The total investment by industry at academic institutions has been increasing but there is heavy emphasis on educational use of computers, concentration of research support at a few selected academic centers, and product orientation.

Both academic and industrial computer research are supported by several agencies and, with the Department of Defense Strategic Computing initiative, Federal investment has risen rapidly. Most Federal programs support directed research that is relevant to their respective missions. As with industrial support, there is concentration at a few academic centers on selected topics. In contrast, NSF responds to unsolicited proposals in all areas of computer research from all research performing institutions. As a result, NSF support is more widely distributed in both subject and locale and plays a unique role in discovering knowledge and strengthening the country's scientific potential.

Changes Between the FY 1986 Budget Request and the FY 1986 Current Plan

	(Millions of dollars)		
Activity	FY 1986 Actual	FY 1986 Plan	Percent Change
Theoretical Computer Science	$ 4.758	$ 5.15	+ 8.4%
Software Systems Science	4.40	4.80	+ 9.1
Software Engineering	3.85	3.88	0
Intelligent Systems	5.40	5.35	− 0.9
Computer Systems Design	4.18	3.50	−16.3
Coordinated Experimental Research	16.30	15.10	− 7.4
Special Projects	1.06	0.92	−13.2
Computer Research Equipment	1.79	1.50	−16.2
Total	$41.73	$40.17	− 3.7%

The FY 1986 Current Plan is 3.7% below the FY 1986 Budget Request. This decrease corresponds to the unspecified Congressional Appropriation reduction. This reduction was not spread evenly across the programs. Increased proposal pressure, coupled with identified needs for more support for research in the foundations of computer science and computer engineering, have led to increases in the more theoretical computer research project support programs and a resulting larger decrease in other programs. The priorities are consistent with plans to emphasize standard research project support over infrastructure support, with substantial reductions being made in the Computer Research Equipment, Special Projects, and Coordinated Experimental Research programs. The reduction to the Computer Systems Design Program reflects growing cooperation and joint sponsorship with other NSF programs such as the Computer Engineering Program within the Design, Manufacturing, and Computer Engineering Subactivity and with the programs of other agencies such as DARPA and DOE.

FY 1987 Budget Highlights

	(Millions of dollars)		
Activity	FY 1986 Plan	FY 1987 Request	Percent Change
Theoretical Computer Science	$ 5.15	$ 5.58	+ 8.3%
Software Systems Science	4.80	5.47	+ 14.0
Software Engineering	3.85	4.93	+ 28.1
Intelligent Systems	5.35	5.67	+ 6.0
Computer Systems Design	3.50	3.47	− 0.9
Coordinated Experimental Research	15.10	14.40	− 4.6
Special Projects	0.92	3.42	+271.7
Computer Research Equipment	1.50	1.50	0
Total	$40.17	$44.44	10.6%

The FY 1987 Request is for an increase of $4.27 million or 10.6%, above the FY 1986 Current Plan.

The Computer Research budget in FY 1987 reflects two new NSF activities.

- Computational Science and Engineering ($1.01 million in the Software Engineering Program Element). This will support 3-5 investigator interdisciplinary research groups, advanced computational facilities, and individual research projects to discover computational methods appropriate for new computer architectures.
- Research on Advanced Computers ($3.0 million; $2.0 million in the Special Projects Program Element and $1.0 million in other program elements). This provides focused resources to study advanced computer concepts and systems. Several areas have been identified that need this type of support including advanced computer architectures, software issues arising from new computer architectures, and information structure, cognition and formal languages. $3.0 million will enable NSF to make a start toward developing these new research directions. The large project portion of this activity, $2.0 million, will be administered through the Special Projects Program Element and $1.0 million will be used to increase the number of smaller faculty and graduate student science research projects in these areas.

Other science research project support will be increased by $1.46 million, or 6.2%, to a total of $25.03 million. This will allow limited expansion of support for research on the foundations of computer science and will provide increased support for young faculty and graduate students in all research areas. These items have very high priority in academic computer research at this time.

Because of the extreme need for faculty research projects and graduate student support, the Coordinated Experimental Research Program Element will be reduced by \$0.7 million to \$14.4 million. This will impose a net decrease of one or two in the number of active CER awards. The total number will drop to about 20 or 21 with three or four new or renewal awards replacing the five active awards terminating in FY 1987.

> The following text was prepared by members of the staff of the Office of Advanced Scientific Computing of NSF and was submitted to Congress as a part of the material which accompanied the Administration's Budget Request for the Fiscal Year 1987.

Advanced Scientific Computing

\$53,630,000

Summary of Request

	(Millions of dollars)		
Activity	FY 1985 Actual	FY 1986 Plan	FY 1987 Request
Advanced Scientific Computing	\$41.40	\$45.23	\$53.63

The FY 1987 Budget Request for Advanced Scientific Computing is \$53.63 million, an increase of \$8.40 million or 18.6% over the Current Plan of \$45.23 million.

Scientific Overview

The Advanced Scientific Computing activity provides high quality access to unique advanced computational facilities for all segments of the science and engineering basic research community.

The specific objectives are:

- To provide the large scale computational resources essential both to the research and to the training of scientists and engineers.
- To extend and develop networks and communications systems which assure access to large scale computing facilities.
- To create computer programs for making software more portable; making operating systems more user-friendly; providing more efficient programs for scientists; and developing means to handle, store and interpret massive amounts of data.

Supercomputers are powerful instruments; they have contributed and will continue to contribute significantly to the advancement of scientific and engineering research. Access to new computational centers for use in basic research activities will increase opportunities (1) for researchers to attack previously intractable problems through the development of complex numerical models; (2) for research communities to collect and analyze data leading to new insights concerning key scientific problems; and (3) for graduate students to obtain training in the use of supercomputers.

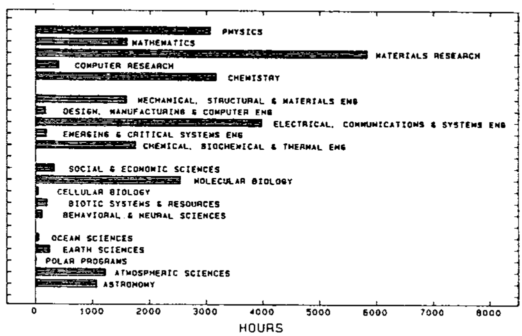
Effective development of supercomputer facilities requires the creation of a national scientific research network (NSFNET). Initially, points of access will be added to existing networks (ARPANET, BITNET, CSNET, MAILNET, MFENET) to provide access for NSF-supported researchers. At first, not all supercomputers will be directly accessible from all networks, but enough paths will be provided to assure effective access. Subsequently it will be necessary to try several experiments to provide information required for the development of NSFNET.

The challenge for NSF is to establish both centers and network access, to make efficient use of existing resources and capacities, and to create facilities dedicated to meeting the computational requirements of the many science and engineering disciplines. The time allocation chart which follows shows NSF experience to date in both the range and the degree of utilization among disciplines.

Supercomputer Allocation

By Program

August 1984 – November 1985



NSF Role

NSF undertakings are consonant with similar activities undertaken or planned by other more mission-oriented Federal agencies, most notably the Department of Energy, Department of Defense, the National Oceanic and Atmospheric Administration, and the National Aeronautics and Space Administration, which support research in weapons development, fusion energy, aerodynamics and atmospheric science. The NSF activity, as it provides advanced computing facilities to the academic basic research community, will make maximum use of the facilities and the knowledge of other Federal agencies.

The centers program focus is on providing large scale computational resources to all scientific and engineering disciplines for basic research requirements via national NSF supercomputer centers. NSF, with considerable supercomputer center experience, particularly in the atmospheric sciences, occupies a key position for creating this new science resource.

The approach of creating an Internet, or network of networks, will ensure connection of the national supercomputer centers and the more than 30 academic institutions of the two supercomputer center consortia with other users of the expanded ARPANET. Steps have been taken to design an interagency plan to interconnect existing individual agency networks. A Networking Working Group has been formed as part of the Federal Coordinating Committee on Science, Engineering, and Technology in order to provide coordination for this effort.

Through a new technologies effort NSF seeks to provide unique supercomputer hardware, and to facilitate engineers' and scientists' access to high powered machines via both user-friendly computer interfaces and improved software. NSF is especially capable of supporting such projects because of its commitments to scientific and engineering disciplines, to computer research, to mathematical development, and to the interface areas among these fields of science.

Changes Between the FY 1986 Budget Request and the FY 1986 Current Plan

	(Millions of dollars)		
Activity	FY 1986 Request	FY 1986 Plan	Percent Change
Advanced Scientific Computing	$46.23	$45.23	−2.16%

A reduction of one million dollars from the FY 1986 Budget Request has been made in the centers program, and the funds reprogrammed to support development of an advanced supercomputer system at the National Center for Atmospheric Research.

FY 1987 Budget Highlights

	(Millions of dollars)		
Activity	FY 1986 Plan	FY 1987 Request	Percent Change
Advanced Scientific Computing	$45.23	$53.63	18.57%

The requested increase will support significant growth of activities at the national centers, and a continuing level of effort in network and experimental technology development.

Background

The plan of the centers program has entailed a two phase approach: 1) to immediately provide time on supercomputers via lease agreements with existing supercomputing facilities, and 2) to replace the lease plan with new national centers. In FY 1985-86, NSF acquired services from six organizations to fill the immediate large scale computational needs of researchers. These centers are located at the University of Minnesota, Colorado State University, Purdue University, Boeing Computer Services, AT&T Bell Labs, and Digital Productions.

NSF is currently establishing three national supercomputer centers: the San Diego Supercomputer Center (University of California at San Diego, CRAY X-MP/48); the National Center for Supercomputing Applications (University of Illinois, CRAY X-MP/24); and the John Von Neumann Center for Scientific Computing (near Princeton University, CYBER 205 interim machine which will be replaced by an ETA 10). A fourth center, the Pittsburgh Center for Advanced Computing in Engineering and the Sciences, is in the process of initiation. In addition to providing supercomputer services to academic researchers, the national centers also encourage collaborative projects among visiting researchers.

During FY 1986 NSF has been working with the Department of Defense agencies, Department of Energy, NASA, and Department of Commerce to develop plans for NSFNET. This will build on the experience of DARPA with ARPANET, NSF with CSNET, and other government and private networks as well as the academic community's network, BITNET. A medium speed "backbone" network connecting the national centers was begun in 1986, ensuring that supercomputer users on campuses with ARPANET connections or members of consortia networks will be able to gain access to all NSF supercomputer centers.

In FY 1986 the experimental systems component of the new technologies effort has focused on a pilot program in interactive graphics and user-friendly, intelligent, and transparent operating interfaces between keyboard and supercomputer. The program also has supported algorithm and software development. In addition, an experimental supercomputer center was opened at Cornell University where access is provided to an advanced parallel system consisting of an IBM 3084 QX mainframe with a number of attached FPS 264 scientific processors. Parallel processing schemes effectively dissect complex mathmatical [*sic*] problems into several independent calculations which can be performed concurrently rather than sequentially, thus providing considerable increases in performance.

FY 1987 Budget Highlights

The Phase I resource center activity will be continued at reduced funding levels. Phase II Centers (Illinois, Princeton, and San Diego) would be maintained at an augmented capabilities level and the John von Neumann Center will carry out the planned upgrade from a CYBER 205 to an ETA 10. The Pittsburgh Center will be undergoing rapid growth. Resource Centers will be supported only when they provide services not readily available at the national centers.

The NSFNET component of the networking program remains essentially the same as in

FY 1986. This level of support allows the continuation of the commitments to the consortia networks, the community wide area networks (especially ARPANET), the NSF "backbone" network, and the existing networking pilot projects, plus limited support for network management and operations. No new networking projects will be begun. The local access component of the networking program will remain the same as in FY 1986, allowing funding of additional campus gateway systems so as to connect an additional 20-30 campuses to the ARPANET.

The new technologies program will upgrade the Cornell center's IBM 3084 to an IBM 3090 in order to provide more supercomputing power to the user. Software technology and training will be furnished to accomodate a larger cross section of scientists and engineers; workshops will be supported to introduce investigators to the unique capabilities afforded by the facility. The request also allows for the possible development of a large scale, massively parallel computer system.

This program will also continue to develop innovative software, numerical methods and graphical techniques to meet the needs of the scientific and engineering communities. Included are user-friendly and transparent interfaces between the user and the computer, transportable computer programs and efficient mathematical and computational methods.

The table which follows displays the funding aspects of these plans for FY 1987 and relates them to prior years.

	(Millions of dollars)		
	FY 1985 Actual	FY 1986 Plan	FY 1987 Request
Centers			
JVNC (Princeton)	$ 8.3	$ 8.0	$11.5
San Diego	4.7	9.1	11.5
Illinois	5.0	7.0	8.5
Pittsburgh	0.0	2.0	4.0
Resource Centers	10.2	3.4	2.3
Subtotal	$28.2	$29.4	$37.8
Networking			
NSFNET	$ 3.7	$ 5.8	$ 6.0
Local Access	2.2	1.0	1.0
Subtotal	$ 5.9	$ 6.8	$ 7.0
New Technologies			
Experimental Center (Cornell)	$ 4.9	$ 6.3	$ 6.2
Experimental Systems	0.9	2.7	2.6
Subtotal	$ 5.8	$ 9.0	$ 8.8

The following text was prepared by the staff of the Science and Engineering Education Directorate of NSF and was submitted to Congress as a part of the Administration's Budget Request for the Fiscal Year 1987.

Science and Engineering Education
$89,000,000

Summary of Request

The FY 1987 Budget Request for Science and Engineering Education (SEE) is $89,000,000, an increase of $1,955,675, or 2.2 per cent over the FY 1986 Current Plan of $87,044,325.

	(Millions of dollars)		
Activity	FY 1985 Actual	FY 1986 Plan	FY 1987 Request
Research Career Development	$27.30	$27.34	$27.30
Teacher Preparation and Enhancement	25.19	27.00	27.00
Materials Development, Research, and Informal Science Education	22.72	25.00	25.00
College Science Instrumentation	5.00	5.50	7.50
Studies and Program Assessment	1.75	2.20	2.20
Total	$81.96	$87.04	$89.00

NSF Role

The responsibility of the Science and Engineering Education (SEE) Activity is to define and fund programs and projects that support the educational aspects of the Foundation's mission. The magnitude of the educational effort in the United States and the long lead times needed for new programs, materials and methods require a continuing and significant involvement in this area. Sustaining this level of commitment, visibility, and continuity expresses the serious national concern with science, mathematics, and engineering education and will draw the best, most creative people into the process.

SEE fulfills this responsibility by conducting leadership activities that inform and/or stimulate other sectors and by support of original work and other merit-based high-leverage activities that serve as prototypes and models of excellence for the Nation. A major objective is to encourage appropriate cooperation among academic scientists, engineers, educators and the private sector for intellectual partnerships as well as for leveraging funds.

The role of SEE is to help insure that:

- a high-quality precollege education in science and mathematics is available to every child in the United States, sufficient to enable those who are interested and talented to pursue technical careers, especially in science and engineering, as well as to provide a base for understanding by all citizens.

- those who select scientific and engineering careers have available the best possible professional education in their discipline. While other NSF programs provide apprenticeship training for the next generation of scientists and engineers through research support, SEE concentrates on the educational structure leading to this stage; that is, the teachers, students, laboratory, and classroom resources that remain important through undergraduate and graduate studies.
- opportunities are available at the college level for interested nonspecialists to broaden their science, mathematics and technology backgrounds. The great majority of students need a technical perspective and understanding to give them insights into and acquaintance with the principles, practices, techniques, and limits of science.
- informal science education programs are available to maintain public awareness of and interest in scientific and technological developments that may affect their lives.

Particular attention is focused on the problems and strategy of assistance to precollege education — the area of greatest complexity and NSF's most urgent responsibility. The scope and complexity of the problems are so great and so diverse that we cannot expect wholly adequate or well-coordinated solutions to emerge spontaneously and totally from local, or even state institutions. Here, a Federal leadership role is particularly critical.

At the precollege level, NSF support is now targeted toward resolving problems of:

- inadequate subject matter competence of current teachers;
- inadequate subject area pre-service teacher preparation;
- classroom materials that are outdated or poorly adapted to the needs of major populations;
- ineffective use of advanced technology;
- poor exchange of information about successful techniques and programs; and
- insufficient opportunities for many talented young men and women to gain experiences that are critical to their early understanding and appreciation of science and mathematics.

A current major reflection of SEE's leadership role is the special emphasis on elementary and middle school levels of education. These are critical stages in the educational process and present problems of great magnitude.

In informal science education, NSF will continue, but not expand, support for "open-air" televison [*sic*] broadcasts, and will increase support to help museums expand their role as a focus and locale for science clubs, hobby groups and other activities that encourage science interest.

At the undergraduate level, NSF has begun to attack the serious problem of deteriorating instrumentation in four-year colleges. Moreover, a special committee of the National Science Board is now completing an in-depth analysis of the problems facing undergraduate education and will recommend an appropriate NSF response.

NSF continues its diverse activities designed to ensure a continuing flow of the best and brightest students into careers in mathematics, science and engineering. This kind of activity has been a hallmark of NSF's role in science and engineering education and will continue to be prominent in its programs into the future.

SEE has a special role in the NSF with regard to increasing the participation of women, minorities and the physically disabled in science and engineering. Better educational opportunities and conditions at all levels are ways to success in this important area, and these are sought by SEE in all phases of its mission.

SEE coordinates its activities closely with other relevant areas of NSF and with other agencies, e.g., NASA, Department of Energy and the Department of Education (DoEd). Such coordination is intended to promote maximum use of expertise in the agencies, to minimize program overlap, and to optimize the use of limited Federal resources. NSF and DoEd, for example, have collaborated in supporting a number of projects, including the International Study of Mathematics and the broadcast series *3-2-1 Contact* and *The Voyage of the Mimi.*

Changes Between the FY 1986 Budget Request and FY 1986 Current Plan

(Millions of dollars)

Activity	FY 1986 Request*	FY 1986 Plan	Percent Change
Research Career Development	$27.30	$27.34	0.2%
Teacher Preparation and Enhancement	25.00	27.00	8.0
Materials Development Research, and Informal Science Education	22.70	25.00	10.1
College Science Instrumentation	5.00	5.50	10.0
Studies and Program Assessment	2.00	2.20	10.0
Total	$82.00	$87.04	6.1%

* Includes $31.45 FY 1985 Deferral plus $50.55 in new obligational authority.

The SEE Activity received an appropriation of $55,550,000 for its activities in FY 1986. This amount represents an increase of $5,000,000 from the FY 1986 Budget Request of $50,550,000. The FY 1985 carryover into FY 1986 was $31,494,598 results from a planned deferral of $31.45 million in the precollege areas and a small additional carryover of $0.04 million in the Research Career Development subactivity. The FY 1986 Current Plan totals $87,044,325 and reflects the net effect of the FY 1985 deferral and carryover and the FY 1986 new obligational authority.

Activity	FY 1986 Request	FY 1987 Plan	Percent Change
	(Millions of dollars)		
Research Career Development	$27.34	$27.30	− 0.2%
Teacher Preparation and Enhancement	27.00	27.00	0
Materials Development, Research, and Informal Science Education	25.00	25.00	0
College Science Instrumentation	5.50	7.50	+36.4
Studies and Program Assessment	2.20	2.20	0
Total	$87.04	$89.00	+ 2.3%

The allocations for the Research Career Development; Materials Development, Research, and Informal Science Education; Teacher Preparation and Enhancement; and Studies and Program Assessment subactivities are unchanged from the FY 1986 Current Plan, enabling them only to maintain their base programs. However, this will include 560 new graduate fellowship awards in Research Career Development, and additional solicitations for proposals targeted at specific problems in science and mathematics in the Nation's elementary and secondary schools.

The FY 1987 SEE budget increase of $2.0 million will be concentrated in the College Science Instrumentation subactivity, bringing it to a level of $7.5 million. Because of the severity of needs in the undergraduate engineering disciplines, $3.0 million will be targeted for strengthening the instructional engineering laboratories in the Nation's colleges and universities. The remaining $4.5 million will be used to continue strengthening the laboratory instruction at four-year colleges as was done in FY 1985 and FY 1986.

Changes in Budget Structure

For better compatibility and administrative efficiency, all precollege teacher program areas are now associated within one subactivity, and informal science education is now associated with materials development and research. Therefore, the former Materials Development and Research subactivity is now termed Materials Development, Research, and Informal Science Education, and the former Teacher Enhancement and Informal Science Education subactivity is now termed Teacher Preparation and Enhancement.

The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

This study by the Board on Mathematical Sciences was conducted under Contract No. DMS-8514639 with the National Science Foundation. Copies available from: The Board on Mathematical Sciences, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.

Mathematical Sciences: A Unifying and Dynamical Resource

Report of the Panel on Mathematical Sciences,
initiated by the National Research Council

Preface

During the summer of 1985, a group of state-of-the-art reviews was initiated by the National Research Council (NRC) at the request of the National Science Foundation. The purpose of these reviews is to assess and monitor world trends, relative strengths, and competitiveness of the United States in rapidly evolving areas of science and technology. Particular emphasis is to be placed on developments that influence the rate at which these fields evolve. Three study areas — cell biology, pure and applied mathematics, and materials science — were chosen for review.

The study on mathematics was conducted by the Panel on Mathematical Sciences under the auspices of the Board on Mathematical Sciences of the NRC's Commission on Physical Sciences, Mathematics, and Resources. The Panel has described major trends in modern mathematics and then illustrated them with a few "vignettes." Through this case-study approach, the Panel illustrates its assertions that we are in a dynamic period of mathematical discovery and that mathematics is the fundamental discipline of science and hence a critical U.S. resource.

International competition and competitiveness are concepts that traditionally are alien to the study of mathematics, in fact, cooperation among individuals of different nations is a vital part of the pursuit of solutions to mathematical problems. Mathematics is intrinsically international, with its own language cutting across barriers of geography and culture. Research and applications in engineering and the physical sciences and, more recently, in business and the social sciences rely increasingly on mathematics for their basic structure, for the modeling of phenomena, and as the basis of new computational directions. Mathematics is a major field of application of the recent powerful computer advances and is the fundamental discipline underpinning both the development of the computer techniques themselves and the applications of these techniques in all fields.

Mathematics has become, even more directly, the language and the foundation of science, technology, and social organization. Indeed, it is a fundamental driving force in the worldwide progress that is altering the economic, political, and social balance among nations. It is essential for the United States to maintain momentum in mathematics if we are to maintain our overall competitiveness in other areas.

The National Research Council, the scientific community, and I are deeply indebted to the panel members, the many colleagues who assisted them, and the able and conscientious reviewers. Thanks also go to Patricia Kenschaft, a mathematician at Montclair State College, for her excellent mathematical editorial work. The chairman is especially grateful to the staff of the Board on Mathematical Sciences, which under the leadership of Frank L. Gilfeather provided throughout the project the support so essential to its successful completion.

Those responsible for guiding science policy in the Congress and the Administration are the primary audience for this report. The report will be useful to other audiences, too: leaders of universities, the mathematical sciences research community, and also those who are inquisitive about the mathematical sciences, about its structure and its current directions.

Phillip A. Griffiths, *Chairman*
Panel on Mathematical Sciences

Executive Summary

Trends. This report emphasizes four major trends in the mathematical sciences:

- Mathematical sciences research is strong worldwide, and the United States is maintaining the leading role.
- Mathematics is unifying internally.
- Applications of mathematics in both traditional and new areas are flourishing and involving more central areas of mathematics.
- Mathematics is the driving force behind new areas of computational science and is in turn profoundly influenced by high-speed computing.

These trends, which demonstrate the vitality of the mathematical sciences as well as the changing nature of this critical discipline are illustrated in a series of six vignettes given in Chapter 3.

There are several corollaries of the trends, which are especially notable in view of the declining U.S. Ph.D. production in mathematical sciences, as seen in the table below. The expanding number and sophistication of tools needed for successful research as areas of mathematics become intertwined now require protracted study often beyond the Ph.D. degree. This corollary development is especially critical for those working at high levels of applications of mathematics. The difficulty in reaching mathematical research frontiers with the requisite deep, broad range of knowledge, without the opportunity for extended study, may partially explain the decreasing Ph.D. production. This decrease will continue if the potential talent does not feel that continuing, as well as entry level, research support will be available.

Some of the vignettes point out that the number of young researchers is of great concern and that considerable talent must be imported to keep the United States in the forefront of mathematical research fields. With the continued resurgence of European mathematics, this cannot be a permanent solution to manpower shortages. While the United States maintains leadership in most areas of mathematics, in some important fields new talent is only sparsely available.

Ph.D. Production and Support. These issues of manpower and infrastructure relate directly to how the United States stands in production of new Ph.D.s and in support of postdoctoral fellowships and graduate students in the sciences generally. The results as summarized below and reported in Chapter 4 (Table 1) are dramatic.

Challenges. Continued concern should be expressed over the decline in the number of Ph.D.s in the mathematical sciences in the United States, and in view of the critical role of mathematics this trend must be reversed. It is essential that the long-range attractiveness of the field and the prospects for success within it be such as to attract able researchers. The competition for students among the various fields of science is keen, and it is critical that mathematics be able to provide sufficient inducements to candidates to maintain its vitality. The figures cited above for Ph.D. production reveal a precarious situation, and we believe that it may be worsening. In addition, if we are to assure the quality of the mathematics enterprise in the United States, the opportunities for postdoctoral training must be significantly expanded.

As we provide sufficient opportunities for young investigators and students, we must also maintain the strength and vitality of senior leadership. That the United States maintains mathematical pre-eminence is due in part to the commitment and investment made in the past to an outstanding group of researchers. Unfortunately, this commitment has been considerably weakened over the past decade as was documented in the 1984 NRC report *Renewing U.S. Mathematics: Critical Resource for the Future* (National Academy Press, Washington, D.C., 1984). The challenge of current policy is to provide greater opportunities for the young while maintaining our current strength in leadership. The two goals are inextricably related.

Introduction

This expository report reviews world trends in mathematics and assesses the position of American mathematics in the world mathematical community. It was written in response to a request from the National Science Foundation to the Board on Mathematical Sciences. Chapter 2 delineates four current trends in the development of the mathematical sciences. Chapter 3 contains six short vignettes, illustrating some of the major efforts in current mathematical research. The topics of the vignettes are:

- D-modules
- Computational Complexity
- Nonlinear Hyperbolic Conservation Laws
- Yang-Mills Equations
- Operator Algebras
- Survival Analysis

The vignettes substantiate the trends and illustrate the excitement and struggle of mathe-

Comparisons of Federal Support for Postdoctoral and Graduate Students in Three Fields of Science

	Chemistry		Physics		Mathematical Sciences	
	1980	1984	1980	1984	1980	1984
Annual Ph.D. Production	1538	1765	862	962	744	698
Postdoctorals (P.D.) federally supported	2255	2473	1210	1150	57	132
Graduate Students (G.S.) federally supported	3700	4118	2900	3348	200	411
Ratio P.D./Ph.D.	1.47	1.40	1.40	1.20	0.08	0.19
Ratio G.S./Ph.D.	2.41	2.33	3.36	3.48	0.27	0.59

Sources: NRC Survey of Doctorate Recipients.
Survey of Graduate Science and Engineering Students and Postdocs, NSF.
Survey of Doctorate Recipients, NSF, unpublished, Table D-32.

matical research, indicating more accurately than could any compilation of areas and results the emphasis and vitality of the discipline. Moreover, since specific research results are the substance of living mathematics, our general observations are made more meaningful through the six vignettes. The report closes with a brief epilogue, which records the key recommendations of the NRC report *Renewing U.S. Mathematics: Critical Resource for the Future* and remarks on the response to and impact of this important report.

Trends

Mathematics is unifying, and it continues to be a dynamic resource in science. Of the many indications of this, the following are outstanding:

- Difficult problems that have been unsolved for many years are now being solved with amazing frequency — a strong confirmation of the vitality of mathematics.
- Mathematics is unifying internally. The division between pure and applied mathematics that developed in the first part of the twentieth century and allowed for the rapid development of new fields is now disappearing. Moveover, the distinctions between traditional areas of specialization have become blurred.
- Traditional areas of applied mathematics are flourishing. Further, significant, deep interactions are occurring directly between core mathematics and other fields, including the natural sciences, engineering, and the social sciences. Increasing interactions are occurring not only with the traditional areas of physics, chemistry, and engineering but also with newer fields such as molecular genetics, business, sociology, information sciences, and studies in policy analysis.
- Mathematics is the underpinning of the revolutionary changes taking place in all scientific and engineering fields as a result of the advent of powerful computers. The development of scientific computing has not only highlighted a host of critical new mathematical problems it has introduced new tools for mathematicians.

With the necessary support, mathematics will continue to flourish, to attract excellent minds, and in the coming years to produce much essential new mathematics on an international basis. The role of any particular country in this development is hard to predict. Mathematical leadership will depend on many factors, primary among them the support that individual nations give to basic sciences in general and mathematical research in particular.

Recent Breakthroughs. Among recurring solutions to previously unsolved problems, several examples merit mentioning. One of them is the program to classify finite groups, which generated a long list of important new efforts. The recent solution of the deep Bieberbach Conjecture in classical function theory showed that the tenacity of a senior individual investigator is still a vital force in mathematics. Finally, the solution of Mordell's Conjecture places mathematicians on the threshold of proving the enticing Fermat's Last Theorem.

Within all areas of mathematics a spectacular number of major but lesser known problems have been solved recently, including problems illustrated in the vignettes in Chapter 3. Further documentation is presented in the forthcoming report of the Board on Mathematical Sciences, *Survey of U.S. Mathematical Sciences*.

Unity of Mathematics. The unification that is taking place within mathematics is obvious to people in the field and will be apparent in the vignettes about D-modules, computational complexity, the Yang-Mills equations, and operator algebras. Unification occurs when there is a confluence of seemingly independent phenomena, motivating cooperative study of the significant underlying patterns. One symptom of this accelerating unification is the increasing difficulty that agencies are having in assigning proposals to their discipline programs, which now substantially overlap. The trend burdens young investigators with a need to pursue increasingly broad training, as is noted in several of the vignettes. In mathematics it is becoming critical to lengthen the training period substantially.

An example of this confluence of areas is the Korteweg-de Vries (KdV) equation $u_t + uu_x + u_{xxx} = 0$ [where u is an unknown function $u(x,t)$ in one space dimension and time], which arises both as the simplest nonlinear dispersive equation in shallow-water wave theory and as the equation of isospectral evolution of the potential in the Schrodinger equation $\psi_{xx} + (k^2 - u)\psi = 0$ of quantum mechanics. The intensive study of the KdV equation during the past quarter century has affected many major areas of mathematics. For example, about a year ago a young Japanese mathematician, using a development in the study of KdV equations initiated a decade ago by the Moscow school, solved a major problem in algebraic geometry that was first discussed more than a century ago by Riemann, a German.

Mathematics and Other Sciences. The symbiotic relationship between mathematics and its areas of application is ever deepening as more areas of science and engineering become almost indistinguishable from subareas of mathematics and this relationship is producing exciting and intriguing new mathematics. Cross-disciplinary collaboration between mathematicians and professionals in other fields is accelerating and deserves encouragement. An important number of interactions between mathematics and science and engineering are not exactly interdisciplinary, but might be more accurately described as resonance phenomena in that advances in one field spur development in another. Examples of this important trend are described in the vignettes on Yang-Mills Equations and Operator Algebras in Chapter 3. The broadening and deepening of these applications, as noted in the vignette on Nonlinear Hyperbolic Conservation Laws, create pressure for mathematicians to pursue significant postdoctoral study. An insightful and illuminating discussion of the interaction of mathematics with science and engineering is given in the 1984 NRC report *Computational Modeling and Mathematics Applied to the Physical Sciences* (National Academy Press, Washington, D.C., 1984).

New Opportunities. The third trend includes the tendency for mathematics to be incorporated into the language not only of science and technology, as has been traditional, but also into new fields of social science. Mathematical models (descriptions of real-world events that use mathematical language) form the basis of econometrics and health policy analysis. The Survival Analysis vignette in Chapter 3 demonstrates this; it examines statistical and mathematical methods used to provide a realistic analysis for problems in medical research, reliability theory, actuarial computations, and demographic studies. Mathematical analyses contribute substantially to decisions about economic and health policies, which in turn have enormous financial and social consequences.

There is no longer any question as to whether mathematical analysis will substantially influence discussions of public policy but only whether it will be used appropriately and effectively. It is essential that those making the decisions understand and influence the assumptions used to form the mathematical model and that mathematicians comprehend the applications sufficiently well that they address and solve the correct problem. In fields where mathematical models are not subject to experimental verification — such as those with the most drastic consequences — it is especially essential that the mathematics be critically scrutinized.

The Role of Computation. Computational mathematics is an integral part of the mathematics discussed in the vignettes about complexity and nonlinear hyperbolic equations, and there are two important observations worthy of emphasis. First, computational methods pervade almost all aspects of science, and mathematics is the foundation of these methods. Today's complex problems, involving computational solutions, range from the design of computer architecture itself through the mathematical modeling of physical, chemical, biological, and engineering processes. Mathematics, the intellectual basis of computational science, has been and will continue to be the key to the dynamic revolution being created by the computer in science and engineering. Second, computational results provide insight for the development of mathematical theory. For example, the behavior of the solutions to the KdV equation mentioned above was first discovered numerically. The mathematical theory, in turn, provides a deeper understanding of the models, revealing phenomena that enable people to analyze and test previous computational results and conceive of new computations that will facilitate further theory.

Core mathematics now consists of three basic operations — computation, abstraction, and generalization. Raw information leading to mathematical discovery comes from concrete examples, and it is increasingly the role of computation to provide such examples, although they are frequently formulated mathematically. Abstraction is the process of distilling the essential features from such examples. Number and space are, respectively, abstractions of the process of counting and of our experience in the physical world, and the mathematical idea of functions similarly abstracts human ideas of measurement and motion. In these contexts, ideas from one manifestation of the abstraction are often relevant in solving problems in seemingly dissimilar situations. Generalization uncovers hidden analogies between abstract patterns of mathematics and frequently extends the range of applicability of such patterns.

Thus in the development of mathematics, periods of computation often alternate with periods of theorizing. During the former, new raw data are generated and horizons expanded. Eventually there is a plethora of information in need of an intellectual framework on the basis of which masses of material can be comprehended simultaneously. As reunification occurs, seemingly disparate examples are often revealed as different aspects of the same phenomenon.

Computation, abstraction, and generalization need each other to be meaningful. Recent mathematics has focused more on concrete problems than on abstractions as it revels in the computing power suddenly available to it, and evidence of a new unification is now appearing. At the same time, our computing power has matured to the point where it can be an enormous asset in the investigation of the still more complex mathematical examples that will inevitably be suggested by pending research. A beautiful amplification of this theme on the development of mathematics is given by Arthur Jaffe in an Appendix to the NRC report, *Renewing U.S. Mathematics: Critical Resource for the Future* (National Academy Press, Washington, D.C., 1984).

A dramatic example of using the computer to gain valuable mathematical insight can be seen on the cover of this report, which represents a problem in the geometry of surfaces of constant mean curvature, a subject with applications to mathematical physics, polymer chemistry, architecture, and other sciences. The existence of a new complete embedded minimal surface with finite topology, the first to be found in more than 200 years, was established using computer-aided graphics. The complex representation of a potential example was analyzed by numerical approximation and three-dimensional computer graphics. An unexpected symmetry was revealed in the surface, which was shown to exist in the equations themselves. Further analysis using both traditional and computational methods established the existence of families of new examples as well as a rich new theory to explain their existence. The ability to create accurate computer images has greatly facilitated communication among scientists. The computer methods developed in this research are proving to be useful in solving problems in related mathematical subjects.

Organization of Mathematics. In addition to these four major directions in mathematics itself, what might be called "The Sociology of Mathematics" reveals how mathematics develops and accentuates the unification within mathematics and its growing interaction with other fields. More and more the mathematical community is now organizing itself by areas of interest instead of fields of traditional study. For example, the Yang-Mills vignette describes how a variety of mathematicians educated in the disparate fields of topology, algebra, differential geometry, algebraic geometry, several complex variables, and partial differential equations is cooperating to solve some exciting equations.

It is well known that some areas of science have become "big science," where research is accomplished by teams frequently gathered around major pieces of scientific equipment or laboratories. Each team consists of at least one senior scientist and many, sometimes a great many, junior investigators, working on related problems. Mathematicians are also often informally grouped around a common research interest such as Yang-Mills equations, operator algebras, or computational complexity. However, such mathematical groups are usually geographically separated, and the analogue of access to a common major piece of scientific equipment is their ability to gather together for sustained periods of collaboration. Furthermore, mathematicians share the scientific community's needs for a means to prepare and motivate potential researchers, from undergraduate through postdoctoral levels. Institutes such as the two National Science Foundation Mathematical Sciences Institutes (Mathematical Sciences Research Institute and Institute for Mathematics and Its Analysis), as well as other institutes, including those supported by Department of Defense agencies and special year projects provide essential opportunities for mathematicians, undergraduate and graduate students, and postgraduates to collaborate.

The vignettes in Chapter 3 illustrate the general patterns discussed above. However, these can give but a small sample of the many endeavors of the entire mathematical community. A more exhaustive, although still selective, survey of the mathematical sciences, *Survey of U.S. Mathematical Sciences*, is currently being prepared under the auspices of the NRC Board on Mathematical Sciences. Together these reports can provide only a glimpse of the scope of current mathematical research. Our choice of specific mathematical topics reflects our effort to select a representative sample of the entire mathematical enterprise.

Language of Mathematics. There is another significant challenge that we must face in our endeavor to explain mathematics to those without years of study in the field. At least three centuries ago, mathematics developed a language of its own, which has become thoroughly distinctive and international. Just as it takes years for an American or Japanese youngster, for example, to become fluent in the spoken language of the other, any aspiring American or Japanese mathematician spends years studying the common language of mathematics. As a result, each can open the other's mathematics books and recognize the topic under discussion (even if totally ignorant of the other's verbal language).

The complex and dynamic language of mathematics that has developed over the past three centuries brings great satisfaction in terms of international understanding for those who are fluent in it, but it presents substantial obstacles to those who have not spent years in its study. On the one hand, the history of mathematics is one of progressively less translatability for nonmathematicians, while, on the other hand, the past few centuries have seen ever-broadening human intellectual endeavors subsumed into the language and models of mathematics. Because of the language barrier between mathematicians and nonmathematicians, the following vignettes cannot describe the technical essence of the fields discussed but will focus only on a field's development and interaction with others.

U.S. Competitive Position. We conclude with a few remarks about the competitive position of the United States with regard to the field of mathematics. First, we emphasize that international cooperation is a long-standing tradition in mathematics. When the vignettes use the words "a Soviet mathematician" or "in the United States," it should be understood that the results being described often depend on a background developed by many investigators in diverse parts of the world.

Although mathematicians, with their specialized international language, view their community as an international one and think relatively little about the comparative ranking of national contributions to their discipline, the writers of this report believe that few would disagree that the United States was dominant mathematically in the decades following World War II. Just as mathematics has become the language of science, technology, and a widening circle of other fields, English has become the verbal language in which most mathematics is explained.

When combined with a federal policy of auxiliary support, the unique American system of combining academic teaching and research at all levels has been a key to our strength. The United States remains attractive to foreign mathematicians because of our relatively high employment opportunities and, more recently, our powerful, relatively accessible computers. We still have a favorable balance of trade from the wonderfully dynamic infusion of immigrants to American mathematics. However, Europe is regaining its former mathematical liveliness, now more on a continental than a national basis. Separately, the Soviet Union, despite its professional isolation and its loss of numerous superb mathematicians, continues its tradition of excellence. The strength of Japan's mathematical community is surging, and there is little doubt that in time major mathematical activity will develop in China.

It is still true that the United States is the world leader in mathematics, but this is surely less so than it was ten or even five years ago. The enthusiastic mathematical activity in other countries has created a tendency toward parity among the major mathematical communities. The fact that half as many U.S. citizens received mathematical sciences Ph.D.s in 1985 as in 1973 bodes ill for our future ability to compete in the world mathematical community (see Table 1 in Chapter 4). Certain areas of mathematics are becoming dependent on foreign-trained researchers as noted, for example, in the vignette on Operator Algebras. It is certain that during the next decade much excellent mathematics will be created. The major questions are, where and by whom.

Vignettes

D-**Modules**. Core mathematics is broadly divided into analysis, algebra, and geometry/topology, although all three subfields include extensive applied mathematics components. (Geometry and topology are not synonymous, but each term is often used for areas in their broad confluence.) However, as the interplay of analysis, algebra, and geometry/topology becomes ever more complicated, even the division of core mathematics into subfields (not to mention its distinction from applied mathematics) seems artificial. Indeed, the essential unity of mathematics is vivid as we review some important recently discovered relationships among these traditional subfields.

Algebraic geometry has been one of the most lively areas of research in algebra during recent decades. It is the study of geometric objects that are the loci of points satisfying polynomial equations in two or more variables, such as the familiar conics from classical geometry. Meanwhile, algebraic topology has become a leading area of geometry. Considerably more general geometric objects than loci of polynomial equations are studied in algebraic topology; in the 1950s and 1960s this was an especially active field and was discussed on a number of occasions in the popular scientific literature.

Any geometric object has a group of symmetries. For example, a cube is invariant under a finite set of rotations. Similarly, a sphere is symmetric under (the infinite set of) all rotations and reflections around its center. A continuous symmetry group, such as the latter example, is called a Lie group. Lie groups can also be viewed as certain groups of matrices with their usual matrix multiplication. This multiplication is not commutative; that is, in general $XY \neq YX$. The set of derivatives along curves through the identity matrix of a particular Lie group can be viewed as an additive set of matrices and is called a Lie algebra. The theory of Lie groups and algebras, one of the great achievements of modern mathematics, originated from questions in differential equations, which has always been central in analysis. But "group" and (of course) "algebra" are quintessentially algebraic notions. Thus Lie theory, based on geometric symmetries and increasingly useful for physicists, incorporates aspects of algebra, analysis, and geometry.

Another place where these three fields meet is in D-modules, which have been developed recently in Japan. A module (with or without the D) is an algebraic structure consisting of a group such as a vector space whose elements can be multiplied by another set of mathematical objects such as matrices. D-modules are modules whose vectors can be multiplied by partial differential operators with analytic coefficients. One motivation for their study was to focus attention on the equations themselves rather than solutions to differential equations. They were investigated using methods of algebraic geometry invented in France in the early 1960s.

The theory of D-modules is also related to the Riemann-Hilbert problem, posed in Germany around the turn of the century. Suppose we have a linear, homogeneous system of n first-order ordinary differential equations for n functions $f_1, \ldots, f_n$ of one complex variable z. It might be written $f' = Af$, where the coefficient A is an n by n matrix whose elements are analytic functions of z. In general the system will have n independent solutions $(f_{11}, \ldots, f_{1n})$, $(f_{21}, \ldots, f_{2n})$, $\ldots$, $(f_{n1}, \ldots, f_{nn})$ such that each solution $(g_1, \ldots, g_n)$ can be written uniquely as a linear combination $g_i = c_1 f_{1i} + c_2 f_{2i} + \cdots + c_n f_{ni}$ for some constants $c_1, \ldots, c_n$. But there may be singularities, points at which one or more of the elements in $A(z)$ tend to infinity or are otherwise irregular. Not only may solutions be undefined at the singularity, but when we follow a curve around the singularity, one solution may be transformed into a different one. Going around the given singularity (and no others) once in a clockwise direction has the effect of transforming a solution by multiplication by an invertable matrix, depending only on the system and not the path traversed. The Riemann-Hilbert problem, a question in analysis, was to show a converse for the theorem just presented — that for any admissible map from a set of singularities into invertible matrices there is a system of n differential equations, as described, such that encircling each singularity changes the solution by the corresponding matrix. The solution, now several decades old, has been extensively generalized.

Mathematicians working in this country and France were investigating ostensibly a quite different area — an area at the intersection of algebraic geometry and algebraic topology that focuses on the concept of duality in geometry. In 1977 researchers in the United States conjectured the existence of a relation between this geometric theory and a fundamental problem from Lie groups. Their conjecture was then proved independently by two pairs of mathematicians, one in France and the other in the Soviet Union. Their proof surprised the mathematical world by using the generalized Riemann-Hilbert results, thus again linking algebra with geometry through differential equations.

Papers about D-modules are impossible to classify into the three traditional fields of analysis, algebra, and geometry/topology, a problem for the editors of *Mathematical Reviews*. It also suggests how very tentative any division of mathematics into subfields may be.

Computational Complexity. An algorithm is a procedure for solving a given class of problems with a specified set of mathematical tools. In classical geometry the tools were straight edge and compass, and the ancient Greeks provided a simple algorithm for trisecting any segment using only these. Their extensive attempts to trisect a general angle were proved futile in the nineteenth century, when it was shown that there can be no such algorithm.

If the tools in algebra are addition, multiplication, division, and taking radicals (square roots, cube roots, etc.), then there is a familiar algorithm for solving any quadratic equation, $ax^2 + bx + c = 0$. However, a question posed by Renaissance Italians was answered when it was proved by Abel, a Norwegian in the early nineteenth century, that there can be no such algorithm for solving equations of degree five or more. The tenth problem posed by Hilbert at the 1900 International Congress of Mathematicians asked whether there is an algorithm for deciding if a general polynomial equation, $f(x_1, \ldots, x_n) = 0$, with integer coefficients has a solution in the positive integers. In the 1960s a Soviet mathematician, strongly incorporating the work of two Americans, proved that there is no such algorithm.

Such decision questions were formerly addressed primarily by logicians, but computers have given new urgency to algorithmic questions. Computers after all operate with only a few primitive tools, and the programs which instruct them are essentially algorithms. For most problems that computers are asked to solve the existence of some algorithm is usually evident; instead, the problem is to find algorithms that are efficient and reliable. The mathematical analysis of these practical considerations has spawned the field now called "complexity theory."

This field measures the complexity of an algorithm by the maximum number $f(n)$ of basic steps that the algorithm needs to solve those cases of the problem requiring n digits in their statement. The theoretically tractable problems, called type P, are those for which there is an algorithm with $f(n)$ growing no faster than some polynomial in n. There are adjustments to this assertion, most notably in the well-publicized linear programming problem discussed below, where the symplex algorithm, though exponentially long in the worst cases, is remarkably efficient in the vast majority of its application.

Each generation of computer scientists has quickly encountered pressing problems that overwhelm available computational resources. Unable to obtain exact answers, they resort to simulation, approximation, and sampling, perhaps by using Monte Carlo techniques. Such approaches are not always appropriate, as when a massive computation is used to make a momentous yes/no decision. In the development of antiballistic missile software during the early 1960s scientists tried to cope with such situations by the simultaneous use of many processors in a multiprocessor environment. It was found that this could result in unpredictable and often serious deterioration in the performance of the system as a whole. This discovery generated a serious study of such anomalies. The resulting work in the mid-1960s provided rigorous bounds for these deleterious effects. Performance guarantees of this type, usually called "worst-case bounds," remain a major focus of algorithmic analysis.

The fundamental class of NP-complete problems was defined in 1971 independently by a Canadian and by a former Soviet citizen who now resides in the United States. This class includes thousands of basic computational problems arising in computer science, mathematics, physics, biology, economics, business, and the social sciences. The NP-complete problems are of equivalent complexity in the sense that if one of them submits to an algorithm of polynomial complexity, then so can all the others. Proving the widespread conviction that no such algorithm exists (that $P \neq NP$) is considered the most fundamental of the open problems in theoretical computer science. It is known that any algorithm for solving an NP-complete problem can be modeled by an appropriate circuit. Until recently the only established lower bounds on circuits for *NP*-complete problems were linear; however, last year a Taiwanese mathematician now living in the United States made a dramatic breakthrough by establishing the conjectured exponential lower bound, but under the assumption that the number of "levels" of the circuit is bounded. Since then a Swedish graduate student in the United States simplified and strengthened these arguments. Almost simultaneously, two Soviet mathematicians independently established an exponential lower bound assuming that the circuit is "monotone," a related but distinct development. This work has been extended by an Israeli doing postdoctoral work in the United States, and many complexity specialists now believe that the tools are finally becoming available to prove the corresponding results for unrestricted circuits, thereby finally settling this fundamental problem.

As the difficulty of *NP*-complete problems was realized, attention shifted to other approaches. These included approximation algorithms, average-case instead of worst-case performance analysis, and randomized algorithms that give a confident guess rather than a firm answer. Timely examples of the latter are the twin problems of deciding if a large integer n is prime or, if it is not, of factoring n. One such algorithm randomly selects an integer k less than n, performs a simple test, and announces either that n is definitely composite or that the problem is still undecided. About three quarters of the possible k's will establish that a composite n is not prime. Thus, performing the test with 100 independent k's that do not prove n to be composite justifies the conclusion that n is prime with a mere one in 4^{100} chance of error.

The study of primes has long been central to number theory, a field that has been pursued for its own splendid beauty but traditionally was considered to have few pragmatic consequences. Recent innovations in cryptography have completely reversed the latter perception. The security of important cryptosystems depends crucially on the belief that the problem of finding the prime factors of a random number with a thousand decimal digits or more is, and will be for decades, a computationally infeasible problem. However faith in this belief is beginning to erode because of some recent unexpected advances in primality testing and factoring. Essentially overnight, a Dutch mathematician produced the currently best factoring algorithm by using the theory of elliptic curves from algebraic geometry, a field mentioned in the previous vignette. It is not yet clear whether this will lead to even more effective algorithms that will undermine the security of these cryptosystems.

This vignette concludes with a discussion of linear programming (LP), a subject that occurs widely in discrete optimization. For example, a linear profit function, possibly depending on a large number of variables, is to be maximized in a region defined by linear constraints. This question is geometrically equivalent to finding the highest point in some high-dimensional convex solid or polyhedron in n-dimensional space, where n can be quite large. The importance of these problems, which have many applications in such varied areas as airline scheduling, meteorology, portfolio management, and telephone traffic routing, was first observed more than 40 years ago by Dantzig in the United States and Kantorovitch in the Soviet Union. Dantzig developed the very effective "simplex algorithm" for solving LP problems, which examines first one vertex and then another, moving along the outside edges of the high-dimensional polyhedron in such a way as to improve the function that is to be optimized at each step until the optimal vertex is reached. Even though these n-dimensional polyhedrons, which typically arise in practical problems, can have exponentially many vertices, over 40 years of experience with the simplex algorithm indicates that only rarely are more than $4n$ or $5n$ vertices tested before the optimum point is attained, despite the fact that pathological examples can be constructed that do indeed require that all vertices be tested.

After the concept of *NP*-completeness was introduced in 1971, researchers struggled without success to find either a polynomial-time algorithm for LP or a proof that it was *NP*-complete. In 1979 the polynomial "ellipsoid algorithm" was produced in the Soviet Union, but the bound on this method grows as n^6, rendering it impractical for large problems, e.g., those having hundreds of thousands of variables. Subsequently, however, the ellipsoid algorithm has had a significant impact in the theory of combinatorial optimization.

In 1984 a young Indian mathematician in the United States made a striking breakthrough when he discovered an iterative method that plunges through the interior of the polyhedron, transforming it nonlinearly at each step so as to stay as far as possible from the boundaries of the changing solid. The number of steps required by this method is on the order of $n^{3.5}$, a significant improvement over the earlier n^6, and a variety of applications have shown that when implemented cleverly, this algorithm seems to perform significantly faster than the simplex algorithm.

Very recent efforts in understanding this new method indicate that an n-dimensional polyhedron can be equipped with a coordinate system that transforms its interior into a certain quasi-hyperbolic geometry so that the trajectories to the optimal vertex form geodesics in this space. Obviously, this area is extremely active worldwide, and much more work is needed before a full understanding can be achieved. Nevertheless, it is already apparent that complexity theory addresses many practical problems and that sophisticated core mathematics, including algebraic geometry, number theory, and geometry, is vital to complexity theory.

Nonlinear Hyperbolic Conservation Laws. The development of both theory and numerical methods for solving nonlinear hyperbolic conservation laws (NLHCLs) has been an exciting area of recent mathematical research. There are many applications of NLHCLs because they describe many important physical systems, including some in aerodynamics, meteorology, water waves, plasma physics, and combustion. In gas dynamics these are the laws of conservation of mass, momentum, and energy.

The major technical obstacle to both solving and analyzing these systems is the fact that their solutions are not smooth, that is, they do not have derivatives of all orders. Many standard approximation procedures require smoothness, and, furthermore, solutions tend to be unique only if certain physical constraints (called entropy conditions) are satisfied. Since there are other important equations in hydrodynamics, relativity, and optics that do not have smooth solutions, NLHCLs are providing a testing ground for innovations with potentially wide applicability.

The first systematic computational attempts to solve NLHCLs, motivated by problems of jet propulsion and in the Manhattan Project, were made in the United States during World War II. John von Neumann and others provided a clear formulation of the problem and introduced several crucial ideas, in particular artificial viscosity (a justifiable technique for smoothing the problem) and a first analysis of stability. These ideas were greatly extended after the war and gave rise to an elegant theory of weak solutions that treated the lack of smoothness without smoothing. In particular, the Lax-Wendroff scheme and its many variants yielded acceptable solutions for many practical problems. However, many other problems remained unsolved, and the theory was incomplete.

In the 1950s the relevance of the Riemann problem, well known to chemists and engineers working with the Riemann shock tube, became fully recognized. The Riemann problem contains the pathology of the general NLHCL problem but is in a more tractable form. An American mathematician gave a mathematical analysis of the Riemann problem, and then a Russian mathematician incorporated the American's analysis into a numerical construction that described the misbehavior of the solutions in a natural way. These developments led to a proof, developed in the United States, that solutions exist for one-dimensional NLHCLs subject to some technical restrictions. This result gave rise to practical algorithms that in turn generated sharper existence results.

The Russian's construction has been generalized in several ways, and dramatic progress has arisen in the last three years from a combination of these ideas. In particular, reliable and efficient solutions of the equations of gas dynamics in any number of space dimensions are now available, and they reveal and explain intricate physical phenomena that previously had been only dimly comprehended. Examples include the disclosure of unexpected complexity in flows involving interacting discontinuities, the discovery of transition criteria from regular to Mach reflection for waves impinging on a surface, and the revelation of instability mechanisms for supersonic jets. Both theory and experiments in NLHCL have been aided by elaborate computations from experiments using new laser technologies.

Recently, much computational activity has been directed toward solving systems of NLHCLs that are structurally more complex than those of gas dynamics, in particular those that arise in combustion theory or in the analysis of flow of porous media — a subject of great relevancy for oil recovery. New methodologies have appeared involving front tracking, mesh refinement, and piecewise parabolic approximations. Some of these are related to higher-order versions of the aforementioned Russian construction.

Many important practical problems remain open. For example, there is as yet no reliable numerical method for solving the equations of combustion theory in more than one space dimension except in the low-Mach-number limit. The newer numerical methods are so complex that computer science questions regarding their implementation, similar to those discussed in the previous vignette, have become crucial. Also, perturbations of NLHCLs, for example by boundary layers, are beginning to be considered.

Why numerical methods fail and why they sometimes succeed so spectacularly are questions that have been studied successfully in recent years, especially through the re-examination of the precise role and possible forms of artificial viscosity. New theoretical tools for understanding practical algorithms and new ideas, such as the notion of variation diminishing schemes, are producing a slow confluence of algorithms rooted in disparate a priori notions of what is important for practical calculations.

New techniques of functional analysis, in particular the compensated compactness method that originated in France, have given new impetus to existence theory, removing some of the earlier limitations. The compensated compactness analysis is significant to the broader context of homogenization and order/disorder phenomena, two other areas in which the French have been involved. In addition, partial existence and stability results have appeared for nonsmooth solutions in more than one space dimension for both convex and nonconvex systems.

The strong interaction between mathematics and practical applications in NLHCL is clear from this account. All the major advances in computation have been anchored in theoretical developments. Indeed, most of the more innovative practical algorithms are due to mathematicians, and more mathematicians have been involved than is apparent. An explosion of knowledge could at this time be safely forecast if there were more high-caliber people active in the field.

However, there are too few people with a combined understanding of the abstruse physical, mathematical, computer science, and related aspects of NLHCLs. Such an understanding requires a broad education in several fields that is not easily available in the United States. One explanation for the strong role played by Israelis in this field may be that in Israel many mathematicians are exposed to engineering problems and to programming during a lengthy military service. In other countries, such as Japan, China, the Soviet Union, and in much of Europe, most students complete algebra by the seventh grade and soon begin calculus, leaving time during secondary school for those with mathematical and technical talent to pursue advanced topics. Given that changes in precollegiate education will take a long time to evolve, the most immediate solutions in the United States would seem to be an extension of the graduate student years through supporting young investigators with adequate postdoctoral fellowships and providing enrichment for talented undergraduate students.

Yang-Mills Equations. In 1954, Yang in the United States and Mills in England constructed a nonlinear version of Maxwell's equations that incorporated a non-Abelian group, typically SU(2), the group of two by two unitary complex matrices with a determinant one. [SU(2) is a three-dimensional Lie group.] This was first conceived as a classical theory transplanted to Lorentz space-time; but when it is used in quantum theory, it is convenient to use Euclidean space-time. The theory has been incorporated into nearly every model of particle physics since the construction in 1975 of instanton solutions and the more recent construction of multi-instanton solutions in four-dimensional space. Shortly thereafter, the Penrose twistor theory was shown to transform an apparently very messy nonlinear system of partial differential equations into an elegant problem in algebraic geometry. Then the equations themselves were noticed to be natural geometric objects.

The Yang-Mills equations depict the curvatures (fields) of connections (potentials) as a principal bundle over a Riemannian manifold. By now, Yang-Mills theory is prominent in pure mathematics. It has already affected subjects as diverse as differential geometry, algebraic geometry, the topology of four-dimensional manifolds, the calculus of variations, nonlinear partial differential equations, index theory (or anomalies), and even the representation of infinite-dimensional groups, and it remains fertile research ground.

The extended impact of Yang-Mills theory does not yet involve the complete equations but concentrates on their role as nonlinear extensions of Laplace's equations, which are well known to be fundamental to earlier mathematics, physics, and engineering. In two variables Laplace's equation is related to the Cauchy-Riemann equations, part of the foundation of complex analysis. One form of the Yang-Mills equations, called the self-dual Yang-Mills equations (SDYM), is a four-variable analogue of the Cauchy-Riemann equations. The instantons are solutions of these equations, and they appear to have properties nearly as basic as solutions of the Cauchy-Riemann equations. The SDYM equations are in turn important in algebra, geometry/topology, and analysis, respectively.

At first glance, the SDYM equations seem absolutely intractable for writing explicit solutions. Even for SU(2), a small essentially non-Abelian Lie group, there are nine first-order equations with twelve unknown dependent variables as well as the four independent variables on the space. There are three extra degrees of freedom, due to gauge symmetries, so it is not surprising that insight from algebraic geometry had to precede progress in topology. The Penrose twistor methods were used to transform these equations in four-dimensional space to a problem concerning holomorphic bundles on a six-dimensional manifold. These methods from algebraic geometry are surprisingly general and can lead in many directions, for example, toward Kac-Moody Lie algebras and models with loop groups.

Learning about the structure of the space of instantons over four-dimensional manifolds has generated profound insight into the topological structure of general four-dimensional manifolds, demonstrating the fundamental value of an equation specific to a low dimension like four. This was helpful to physicists, who have since developed the fundamental intuition of instantons as solitons, the wavelike solutions of KdV and Sine-Gordon that superimpose nonlinearly.

It is interesting to note that mathematicians had been able to deal with the structure of manifolds in dimensions two, three, five, and greater. The Cauchy-Riemann equations are used in two dimensions, geometric methods are employed in three, and mathematicians find five and more dimensions amenable to standard methods of algebraic topology. The gap of the fourth dimension appears to be filled by SDYM theory.

In analysis, one of the key properties of Yang-Mills theory is its conformal invariance. Some of the basic equations about instantons can be formulated in the context of the calculus of variations. The conformal invariance of the theory implies that the variational problem does not satisfy the conditions that are required in order to use the method of direct steepest descent, so helpful in three-dimensional work. The attempt to understand the failure of the steepest descent method for the Yang-Mills problem has led to the development of new variational techniques, which are useful on a variety of problems. It is interesting, and possibly significant, that the three fundamental scale-invariant geometric problems coincide with three basic models of quantum fields: the Yamabe problem (phi-four theory), harmonic maps (sigma models), and the Yang-Mills equations.

In any case, Yang-Mills theory is a beautiful example of the intense bonds between current theoretical physics and all subfields of core mathematics. Yang-Mills theory is a young discipline that will undoubtedly attract many more mathematicians in the near future. Its results to date are primarily due to the efforts of English, American, and Soviet researchers. Although Americans cannot claim to dominate the field, they have certainly contributed significantly to its development. The necessity of extremely broad training, mentioned in the final paragraph of the preceding vignette, also applies to successful research in this field. Increasingly, postdoctoral or protracted study is necessary in order to become a successful researcher in many areas of mathematics.

Operator Algebras. The area of operator algebras is currently very active and provides another excellent example of unexpected interactions between areas of core mathematics and the natural sciences. Quantum physics originated the Heisenberg Uncertainty Principle, which forces consideration of quantities P and Q satisfying $PQ - QP = h/2\pi i$. It motivated a search for appropriate mathematical systems containing infinitely many such noncommuting variables. In the 1920s, M. H. Stone and J. von Neumann demonstrated that such systems require a general theory of algebras of operators on Hilbert spaces, generalizations of finite-dimensional vector spaces. These were studied extensively in the 1930s by F. Murray and von Neumann.

The mathematics of operator algebras is characterized by a profound blend of noncommutative algebra and infinite-dimensional analysis. Although operator algebras exhibit a very rich structure, no serious work following that of Murray and von Neumann appeared until after World War II.

The simplest example of an operator algebra is the entire set of n by n dimensional matrices for a specific n. A general operator algebra is a subset of the bounded linear transformations on a (generally infinite-dimensional) Hilbert space that is closed under addition, multiplication, an adjoint operation, and a suitable limiting process. If the system is closed only for the strongest limiting process, it is called a C^*-algebra. If it also contains the most general limits, it is said to be a von Neumann algebra. The full algebras of all linear transformations on Hilbert spaces of arbitrary dimensions are the building blocks of the simplest operator algebras. However, consideration of proper subalgebras of the universal operator algebra over some Hilbert space reveals far more complex situations. This complexity can be slightly relieved and the study reduced to three basic types of von Neumann algebras simply called Types I, II, and III.

During the early postwar years, both American and French mathematicians made substantial progress in operator algebras, including some important applications to the theory of infinite-dimensional group representations. The French school became relatively inactive by the early 1960s and re-emerged in the mid-1970s when a young mathematician, subsequently a Fields Medalist, began working in the area. During the late 1950s and early 1960s, some Japanese mathematicians entered the field. Simultaneously, numerous theoretical physicists became involved and provided valuable insights derived from their physical applications. It was shown that there exist infinitely many distinct Type II and Type III factors. The latter, especially, remained mysterious because they did not possess the special functionals called traces that were so fundamental to studying the structure of the other two types. When it was discovered that the physically interesting algebras are of Type III and certain classes were explicitly parameterized by physicists, parts of the mystery began to unravel.

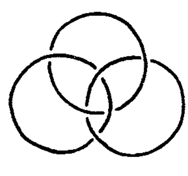
Major international conferences began having a crucial influence on operator algebra theory in the mid-1960s. In the late 1960s, a conference held in the United States removed a key obstacle to analyzing Type III factors by displaying results proved independently by a Japanese mathematician and some Dutch and German physicists. At a subsequent conference, the French Fields Medalist, then a student, was motivated to work on the subject. He opened entirely new vistas by investigations that combined algebra and analysis in new ways and led to the classification of the algebraic structure of Type III factors. In the 1970s, researchers turned toward the geometric aspects of the subject. A new extension theory of C^*-algebras generated a successful synthesis of geometry and algebra, resulting in a unified view of features from these two subjects. At about the same time, the fundamental Atiyah-Singer Index Theorem was extended from locally trivial families to the more general foliations by using operator algebras. Additionally, a Soviet mathematician solved specific cases of a long-standing problem in differential topology concerning smooth deformations by developing powerful new techniques in C^*-algebras.

Recently, an American mathematician, born in New Zealand and educated in Switzerland, has found a totally unexpected connection between three apparently diverse fields–knot theory, the classification of subfactors of Type II factors, and the theory of Hecke algebras. This activity has occurred within the past two years, a catalyst being the fortuitous meeting of the Mathematical Science Research Institute at Berkeley in 1985, sponsored by the National Science Foundation, where experts in operator algebras were meeting concurrently with those in low-dimensional topology, the field that contains knot theory. The excitement of the connection between von Neumann algebras and knot theory may be overshadowed by investigations of its utility to biologists in describing large-scale structures of DNA. A knot is a closed curve in three-space, and a link is a (possibly interlocking) system of knots. Although they can be surprisingly complicated, knots and links can be adequately represented by a projection onto the plane. Two relatively simple examples are:

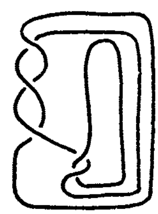
One approach to classifying two mathematical entities in some class is to assign each entity in the class some mathematical label (called an invariant) that coincides on the two entities considered to be the same. Thus a search for appropriate invariants for links began. In the 1920s polynomial invariants were developed by studying the topology of the space remaining when the link is removed from ordinary three-space. The corresponding polynomial for the knot 6_2 above is $1 - 3x + 3x^2 - 3x^3 + x^4$.

Another approach to knots first studied in the 1920s was a mathematical structure called the braid group. Braids can be spliced together thus forming a group, however splicing the top of a braid to its bottom forms a knot or link, and indeed all knots and links may be so formed (in possibly many ways).

The knot 6_2



The link 6_2^3
(also called the Borromean rings)



Although people probably have always used knots, the first known attempt to list and classify them mathematically (as opposed to mechanically) resulted from an erroneous hypothesis of Lord Kelvin in the late nineteenth century that atoms were knotted vortices in the ether. His vain hope of deriving the periodic table by classifying knots stimulated scientific advances entirely different from his vision — in the characteristic but unpredictable manner that pure research, stimulated by attractive ideas, often yields unanticipated harvests quite different from their original intent.

Knot theory considers two knots or links to be the same if one may be deformed without crossing strings until it is identical to the other. It is exceedingly difficult (and obviously fundamental) to decide when two given links are the same. Trial and error methods are rarely satisfactory.

Braids and their invariants have rewarded investigators with considerable valuable insight over the years. However, their connection with operator algebras remained unnoticed until the proof of a deep result about subfactors of Type II factors required an analysis of one representation of the braid group. Coincidentally, almost the same representation, arising from a special case of the Hecke algebras, had been discovered by mathematical physicists in the 1960s as they partially solved the Potts model of statistical mechanics. The connection with operator algebras generated a trace function for the braids that could be used to recover numerical information. The trace of a braid then provided a new (Laurent) polynomial invariant for the associated knot or link. It was more sensitive than the earlier polynomial in that it separated knots that were previously indistinguishable. It could even distinguish knots from their mirror images. Computers can be used to compute this polynomial for many links. For the knot 6_2, it is $x^{-1} - 1 + 2x - 2x^3 - 2x^4 + x^5$ and, for the link 6_2^3, it is $-x^{-3} + 3x^{-2} - 2x^{-1} + 4 - 2x + 3x^2 - x^3$.

Both operator algebra and topology already have produced substantial generalizations of this new invariant that have been used to solve many venerable problems of knot theory. Similar work is expected to shed new light soon on the Potts model, von Neumann algebras, knot theory, statistical mechanics, quantum physics, and possibly even basic structures of life via the DNA application. In any case, these developments emphasize again the eternity of a good mathematical result, the harmony of all mathematics, the unpredictable relationships between fields, and the many bridges across the humanly created gap between core mathematics and basic science.

At present, only a few institutions in the United States offer training in operator algebras. In this area, as with other areas of mathematics, the United States has become increasingly dependent on hiring foreign-trained students and scientists. In addition, some related areas with potential for interaction with engineering have been underemphasized in the United States. This is an ideal time to put a greater effort into providing the correct conditions for new young researchers and strong leadership in the United States in the subject.

Survival Analysis. Since problems in collecting, analyzing, and interpreting data are universal, it is not surprising that people in many countries (including England, France, Scandinavia, the Soviet Union, and the United States) have made significant contributions both to statistics and also to probability, the branch of core mathematics that has until recently provided the major theoretical support for statistics. Expansions in technology have both motivated and enabled the most striking progress in statistics during the past decade. Advances in instrumentation and communication have generated enormously complex sets of data, and the growth of computing power permits the collection and management of such data. The United States has been the unquestioned world leader in statistical computing, mainly because the availability and sophistication of its equipment has been unmatched elsewhere. A further discussion of these developments can be found in the NRC report *Computational Modeling and Mathematics Applied to the Physical Sciences*, and in the forthcoming NRC Board on Mathematical Sciences report, *A Survey of U.S. Mathematical Sciences*.

However, other countries have made significant contributions; a notable example from England is David Cox's proportional hazards model for life history data. Life history analysis is a body of statistical techniques useful in medical research, reliability theory, actuarial computations, and demographic studies. John Graunt initiated this field in 1662 with his invention of life tables for analyzing English mortality data, but recent clinical studies are far more complex. Typically, these begin with patients who have an unpleasant disease (possibly at different stages) being assigned randomly to two or more different treatments; they are then followed until they die or disappear or the study ends. Observers record variables, called covariates, that might affect the survival of the patients, including some that do not change, such as sex and age at diagnosis, and some that do, such as blood pressure and glucose level. Statisticians use these observations to study the relationships between the covariates and the survival time of patients after contracting the disease, and especially the comparative merits of the treatments. One goal may be to predict the effect of different treatment on life expectancy of future sufferers of the disease, another may be to determine which factors prolong the patients' normal functioning as long as possible. Subtleties such as the role of the individuals who are still alive at the end of the study and those who withdraw or disappear complicate the analysis.

One model for the life history of a patient (or piece of equipment) includes a vector $Z(t)$ of covariates that vary (possibly randomly) with time, from zero, when the study begins, to the time T when the study is terminated, and a finite-valued process $Y(t)$ designating the state of the dependent variable. These states might be "alive-and-functioning," "alive-not-functioning," "dead," or "lost." The treatments appear as coordinates of $Z(t)$. Analysis of these models concentrates on the intensity of changes; these intensities correspond to a stochastic process $J(t, y_0, y)$, where $J(t, y_0, y)\,dt$ represents the probability that Y changes from y_0 to y between time t and $t + dt$ assuming a past of $Z(t)$. The life histories of the n patients are regarded as a set of independent observations that can be used to estimate J.

Until the early 1970s, research concentrated on the extremes of either relatively simple situations with few assumptions or vastly more complicated parametric models with heavy assumptions on J. An example of the former is the setting for the product limit estimator for the probability of surviving beyond time t, when no covariants are measured and only questions of life expectancy are of interest. The assumptions of the parametric models were found to be too unrealistic by experts in biostatistics.

In 1973 Cox proposed his "proportional hazards model" for survival-time data, basing his work in part on a model developed during the 1960s at the National Cancer Institute. In this model

$$J(t, \text{Alive}, \text{Dead}) = \exp[\theta^T Z(t)]\lambda(t)$$

where $\lambda \geq 0$ is a (nonrandom) function and θ is a vector of unknown parameters. $J(t, \text{Alive}, \text{Dead})$

can be an essentially arbitrary function of $Z(s)$, $0 \leq s \leq t$.

The attractive features of the Cox model are easily seen if we specialize to fixed covariates. The model permits an arbitrary lifetime distribution for a control population and postulates a linear approximation for the log of the ratio of intensities corresponding to two different values of Z. The effects of the covariates can then be measured in terms of the components of θ.

The inferential procedures proposed by Cox were quickly applied to heart transplant and other data by statisticians and biomedical scientists in the United States. Evidence of these applications appears in numerous citations of the model, mostly in the medical literature. Although the model seemed to give sensible answers in applications, its highly nonlinear nature and the complex probabilistic structure of the data prevented rigorous theoretical analysis for some time.

The theory for the case of time-independent covariates was independently developed in the United States and Denmark in the mid to late 1970s, but these methods could not handle the much more difficult case of time-varying covariates. In 1975, the thesis of a Norwegian student studying in the United States with a United States statistician who emigrated from France showed how to attack the analytic problems in this area. He applied a multivariate counting process framework to both survival analysis models and more general life history models. Most significantly, he exhibited applications to these models of the deep results in continuous time martingales and stochastic integrals, which were introduced by researchers in Japan, the United States, and France. Then others, primarily in The Netherlands, Norway, Denmark, England, and the United States, used these techniques to analyze the heuristic suggestions of Cox and to devise and investigate new inferential procedures in more complicated life history models. Despite their flexibility, the Cox models are still burdened by the questionable assumption that the ratio of intensities for two individuals can be modeled parametrically. It is not clear that the counting process techniques will prove adequate for the analysis of the newer, more flexible, semiparametric models that have been proposed, but they should provide a good starting point.

The analysis of life history data is a rapidly expanding field widely used in a variety of disciplines, including biomedical science, demography, and sociology, fields that reciprocate by continually presenting statisticians with data for which previous methods are inadequate. Although the interaction of theory and application and the international nature of this work are hardly new features of statistics, they have become more prominent recently.

The United States and England are the primary world centers of statistical activity. An important pattern in the field, which is illustrated here, is that foreign scientists and students come to study, lecture, and meet in the United States, and subsequently many of the best remain as citizens or permanent residents.

Review of the David Report

The David Report, a several-year effort by a broad cross section of industry and university scientists, has considerably raised the consciousness of the science community. The principal finding of this 1984 National Research Council report, *Renewing U.S. Mathematics: Critical Resource for the Future* (National Academy Press, Washington, D.C., 1984), was that "federal support for mathematical research is markedly out of balance with support for related fields of science." The Panel on Mathematical Sciences believes that it is important to review the major findings, the subsequent support, and the effect of the critical David Report.

The major findings were as follows:

- Over a 15-year span from 1968 to 1982 constant dollar federal support of mathematics research dropped by over 33 percent.
- During the same period, the number of people in the field doubled in size (the influx from the late 1960s).
- The effects of the resulting paucity of funding are being severely felt at the research universities where almost all basic mathematical research is done.
- Unless corrective action is taken, the health of the nation's mathematical research effort, now still the strongest in the world, will be seriously weakened.
- The central importance of mathematics to science and technology, hence to the economy and defense, makes its continued strength in the United States imperative.
- To address this imbalance, basic needs by 1990 include substantial increases in support for graduate and postdoctoral students, in addition to establishing a greater base of support among young and senior researchers.

Since the David Report appeared in 1984 it has received wide acceptance in the universities and at the federal policy level. The problem seems to be understood. Evidence of this includes:

- The National Science Board (representing all disciplines of science and engineering) passed a resolution "that a concerted effort should be made by all funding agencies to increase support for the mathematical sciences for several years until a proper level of sustaining support has been achieved."
- A subcommittee of the Department of Defense (DOD)-University Forum reported that there had been significant erosion in mathematics support, partially because the growth

of computer science had masked the mathematics funding situation during the 1970s.

- The University Research Initiative, part of the fiscal year 1986 DOD appropriation, states the critical need to address the imbalance that currently exists with respect to mathematics funding.

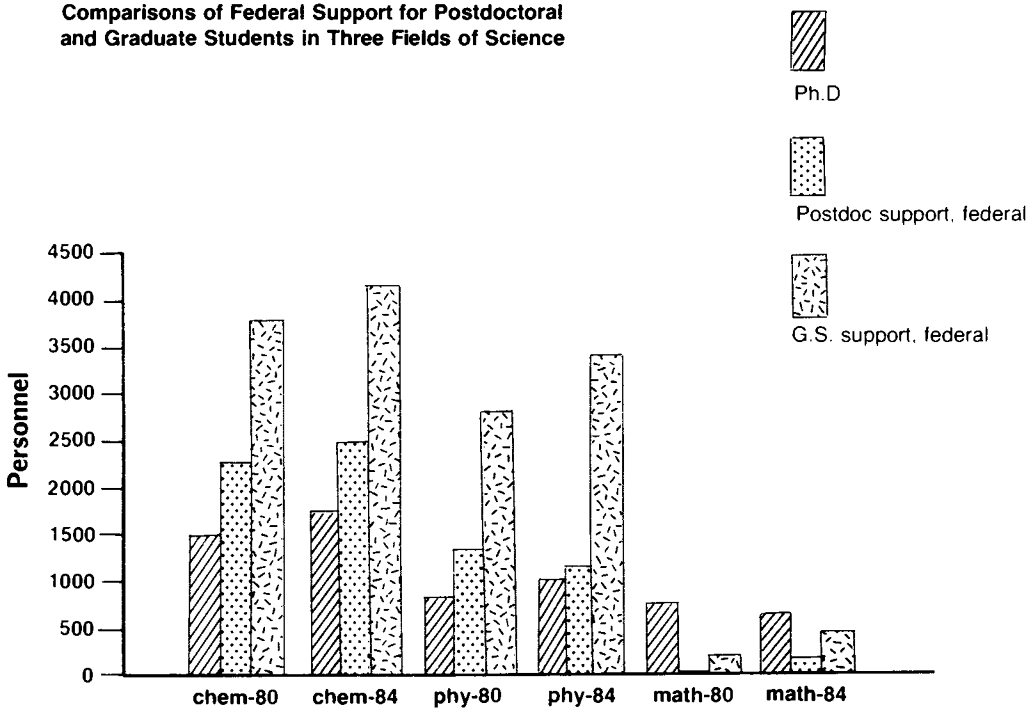
Currently, the federal agencies primarily responsible for mathematics funding are making an effort to redress the problem. However, recent budget constraints severely threaten their efforts. The issue is how to reach this balance of resources between related fields in a climate of overall limited budget enhancements. The difficult burden falls on the agencies which must set priorities in funding research.

Movement toward a proper level of sustaining support in the mathematical sciences for graduate and postdoctoral students, established investigators, and equipment is varied. The only real progress appears to be moderate increases in support for graduate and postdoctoral students, while other investigator support appears static. Even graduate student support progress leaves the discipline in a vastly unfavorable position at a critical time, see Table 1.

The National Science Foundation continues to advocate for additional resources for the mathematical sciences, primarily with a significant cross-disciplinary effort in computational science and engineering. A new mathematics program at Defense Advanced Research Projects Agency (DARPA) is potentially a bright spot. Without this new DARPA program, the current 1986 and 1987 budgets for mathematical sciences research at the DOD agencies would be severely depressed (Table 2). Even with these enhancements, if they remain, and the best intentions of the policy makers, the renewal of U.S. mathematics will require continued resolute effort.

TABLE 1

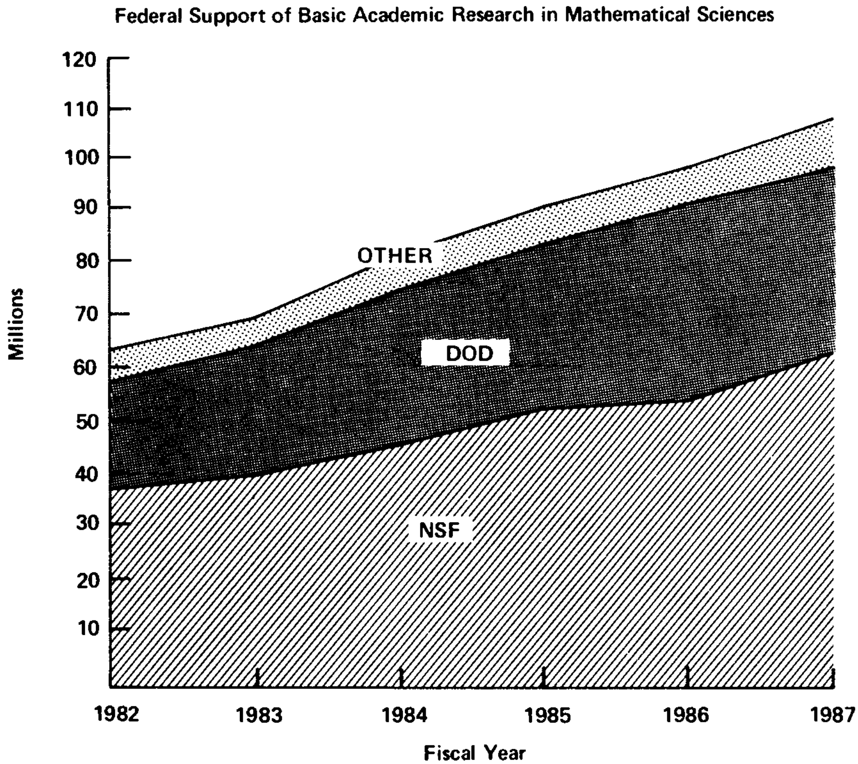
Comparisons of Federal Support for Postdoctoral and Graduate Students in Three Fields of Science



	Chemistry		Physics		Mathematical Sciences	
	1980	1984	1980	1984	1980	1984
University faculty and staff with primary or secondary activity in R&D	9800	9200	9200	9200	7400	7200
Annual Ph.D. Production						
U.S. citizens	1169	1332	611	659	520	407
Total Ph.D.s	1538	1765	862	962	744	698
Postdoctorals federally supported	2255	2473	1210	1150	57	132
Graduate Students federally supported	3700	4118	2900	3348	200	411
Ratio P.D./Ph.D.	1.47	1.40	1.40	1.20	0.08	0.19
Ratio G.S./Ph.D.	2.41	2.33	3.36	3.48	0.27	0.59

Sources: NRC Survey of Doctoral Recipients.
Survey of Graduate Science and Engineering Students and Postdocs, NSF.
Survey of Doctorate Recipients, NSF, unpublished, Table D-32.

TABLE 2



Federal Support of Basic Academic Research in Mathematical Sciences (FY)

	82	83	84	85	86[3)]	87[4)]
NSF[1)]	34.2	37.1	45.6	52.7	57.2	65.5
DOD[2)] (AFOSR, ARO, ONR, DARPA)	23.3	26.5	29.9	32.3	42.4	39.1
Other[2)] (DOE, NASA, NIH)	4.3	4.8	4.9	5.5	5.9	4.8
Total	61.8	68.4	80.4	90.5	104.5	109.4

1) DMS represents about 90%.

2) This is based on estimates of the mathematics extramural component of some programs.

3) These are pre Gramm-Rudman, SDI and University Research Initiative figures. Their eventual effects may cancel each other.

4) The President's budget. Estimates of ultimate program emphasis (see 2) and future effects of URI and SDI make these tentative, especially outside NSF.

Report to the Members of the Society

Report of the Treasurer

I. Introduction

Over the past few years, the Society has experienced both good and bad financial health. The Society earned approximately $470,000 in both 1978 and 1979, or about eight percent of revenues. During the following four years, 1980–1983, the Society lost $2,654,699; in 1984 income of $106,404 was generated. This recovery was largely due to the introduction of cost saving measures and a reconsideration of pricing policies. The recovery has continued into 1985 and will allow the Society to set aside a substantial amount as a contribution to the Future Operations fund. The Long Range Planning Committee of the Executive Committee and Board of Trustees has recommended that the Society build this fund to an amount equal to one year's operating budget. I expect the Society's 1985 audited financial statements to show 1985 income of $1,734,356 before transfers to the Future Operations fund, and $590,598 after transfers to Future Operations. As of December 31, 1985, the Future Operations fund will contain an amount equal to approximately 19% of the 1985 operating expenses. The $590,598 of income remaining is approximately five percent of revenues. It is worth noting that the Society's unrestricted fund balances now approximate their balances in 1980, the first year of the most recent series of deficits, during which such balances decreased to less than one million dollars, a dangerously low level.

I would like to report to you that the financial future of the Society is bright and that no clouds appear on the horizon, but I cannot. The current budget-cutting frenzy in Washington will surely be felt by the institutions which provide the majority of the Society's revenues, and it is only prudent to assume that at some time in the not too distant future the Society will again need to adjust its operations to cope with this problem. The Society's 1986 budget shows an expected excess of revenues over expenses of approximately $300,000 (after reinvestment of investment income in the Future Operations fund). Similar results are being planned for 1987, and it is hoped that this can be achieved through cost cutting and modest price increases.

II. Revenue

I now turn to a description of the Society's revenue, followed by explanations of each category. Revenues to support Society activities in 1985 came from the following sources:

Journals	65%	$7,294,810
Books	9%	1,003,080
Dues	9%	1,045,001
Grants & Contracts	9%	1,063,315
Meetings	2%	242,446
Other	6%	630,328
Totals	100%	$11,278,980

Journals. Although journals provide the largest fraction of revenue, they have been operating at a net loss for the past several years. Costs are under constant scrutiny and cost-saving procedures are implemented where possible, for instance by placing more type on a page, reducing the size of type, using new and cheaper methods of composition, doing in-house printing and using lighter paper to reduce postage costs. As a result of these efforts, journals have been able to support themselves during 1985; and, in spite of continued subscriber erosion, the Trustees expect the 1987 journal prices to increase by only a modest amount.

Books. Included in this category are not only books (monographs or collections of articles) but review volumes and indexes to journals. Books, exclusive of the latter, continue to be financially sound, and selling prices of AMS books compare very favorably with other mathematical books. A vigorous marketing campaign for books is being developed. A successful campaign will increase the number of books being sold and could keep the price of books from rising substantially.

Review volumes and indexes have been a financial burden to the Society. Prices have to be set very high because the costs of producing these extremely large publications are high. The question of whether to publish such volumes is a difficult one; on the one hand the profession needs such publications as research tools; and on the other, the price needed to break even is too high for smaller institutions to pay. In some cases, prices have been set artificially low to address this problem.

Dues. The Society has about 450 institutional members and 20,000 individual members. Of the latter, about 6,000 pay no dues because they are student nominees, emeritus members, or reviewers without convertible currency. Individual member dues are two-tiered to provide some relief to lower paid members. Institutional dues are set, in part, by the number of papers published by authors employed by the institution. Increases in dues for individual members are set annually by a cost-of-living index.

Grants and Contracts. The amount of money available from the federal government has declined substantially over the years. Currently, support is mainly for travel and subsistence for participants in research conferences, institutes, and seminars, plus the Society's cost in preparing and running these conferences. The money received from government agencies is reimbursement only, with no profit to the AMS. The Society does have contracts to perform services for other nonprofit organizations, and this helps to recover some fixed costs.

Meetings. As in prior years, registration and exhibit fees at the two joint meetings were not sufficient to cover expenses. It will therefore be necessary gradually to increase fees over the next few years to bring revenues and expenses into balance.

III. Expenses

The expenses of the Society are not as easily categorized as revenues. Most expenses are assigned to departments, and these are later allocated to specific publications, meetings, or other accounts. The three major expenses of the Society are personnel ($5,520,000 or 58%), buildings and equipment and related accounts ($1,140,000 or 12%), and direct publication costs ($1,230,000 or 13%). The remaining 17% or $1,650,000 is made up of pass-through funds from grants, direct costs, and other general expenses.

IV. Assets and Liabilities

So far, this report has dealt with sources of revenue and applications of expense. Another aspect of the Society's finances is what it owns and owes, or its assets and liabilities. It is estimated that at December 31, 1985, the assets of the Society's operating funds exceeded its liabilities by $1,045,250. The Society's short-term liabilities, those which must be satisfied during 1986, amounted to $8,500,000, and were made up of subscriptions and dues received in advance ($6,750,000) and other obligations.

These liabilities will have to be satisfied with the so-called "current assets" of the Society, consisting of cash and cash equivalent ($3,710,000), accounts receivable ($460,000), inventories ($1,510,000), and other assets ($380,000), together with other income to be received during 1986.

At December 31, 1985, the Society's investment in property and equipment amounts to $3,487,000, consisting of assets with a book value of $4,908,000 and mortgages totaling $1,421,000. The property and equipment consists of land and buildings (original cost $3,394,000) and data processing and other equipment (original cost $4,456,000). From these costs, depreciation of $2,942,000 has been deducted and charged to operations.

Besides the assets mentioned above, the Society has permanently invested funds including endowment funds ($1,554,000) and quasi-endowment funds ($2,329,000). The use of endowment funds is restricted by the funds' donors. The quasi-endowment funds are treated as if they were true endowments with the exception that the restrictions as to use have been made by the Trustees. These funds are held and managed by Rhode Island Hospital Trust National Bank.

F. P. PETERSON

A Matrix Laboratory

Avner Ash
Ohio State University
Department of Mathematics
Columbus, OH

PC-Matlab is a microcomputer version of a collection of matrix routines which has long been available on mainframe computers. It runs on an IBM PC or compatible. Versions for other small computers may become available in the near future. What follows is a description solely of PC-Matlab, version 2.02. For more information, contact The MathWorks, Inc., 158 Woodland Street, Sherborne, MA 01770. Telephone: (617)653-1415.

1. Matlab in the abstract. We can think of Matlab as a very high-level, very specialized programming language. It has only one kind of data structure, two-dimensional matrices. Vectors pass as 1-by-n or n-by-1 matrices, scalars as 1-by-1 matrices, and text as vectors whose components are letters.

There are two types of commands in Matlab: those that deal with matrices (including vectors and scalars) and those that perform peripheral services, such as reading and writing data, creating loops, and managing the memory. Matrix functions implementing state-of-the-art algorithms represent the heart of Matlab.

Arithmetical functions for matrices appear in fairly standard notation. All matrices have complex entries automatically, although real matrices are displayed without their 0 imaginary parts. Arithmetic can also be performed elementwise by preceding the operator sign with a dot. The trigonometric and exponential functions are built in along with functions that round fractions to integers in various ways, find remainders, and use continued fractions to find the best rational approximation to a real number.

Many important functions and decompositions of matrices may be performed in Matlab by issuing just a single command. These include finding the determinant, condition number, rank, and norm of a matrix; finding the inverse, pseudoinverse, null space, range space, and row-reduced echelon form of a matrix; finding the characteristic polynomial and eigenvalues of a matrix; and finding the generalized eigenvalues of A with respect to B, that is solving $Ax = tBx$, x a nonzero vector, t a scalar. Matlab will also list the eigenvectors.

We should remark here how critical round-off error is in some of these computations. There is a constant in Matlab called "eps," which is the smallest positive number distinguishable from 0. Eps can be set by the user. A too small or too large value of eps may lead to a spurious result for the rank or nullspace of a matrix. Similarly, Matlab apparently believes all matrices are semisimple. For instance, when we ask it to find the eigenvectors of the unipotent matrix

$$U = \begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix},$$

it returns two linearly independent eigenvectors, $(1,0)$ and $(1, -0.0000000000000000003)$! This result persisted even when I set eps to 10^{-33}. The Matlab manual also seems to assume every matrix is diagonalizable, which I suppose is true up to experimental error.

Matlab includes a few operations on general polynomials, which are represented as the vector of their coefficients. Matlab can evaluate a polynomial, convolve two polynomials, and find all the roots of a polynomial, real and complex.

Certain useful matrices can be created in one command, such as diagonal, constant, and random matrices. The random elements can be generated from either a uniform or a normal distribution.

Now we come to the rich list of algorithms for various matrix factorizations. This is the core of Matlab. With single commands, we can factor a matrix into 1) lower-triangular $*$ permutation $*$ upper-triangular (LU decomposition); 2) unitary $*$ triangular (QR decomposition); 3) unitary $*$ diagonal $*$ unitary (singular value decomposition). Similarly we can find the Hessenberg and Schur forms of a matrix, which are upper-triangular or almost upper-triangular matrices similar to the given one. The unitary similarity transformation will be given at the same time if requested. The Cholesky factorization of a positive-definite matrix is also available.

Let's look at a sample algorithm. All of the major algorithms used by Matlab are taken from two collections of linear algebraic routines, called LINPACK and EISPACK [**1, 2, 3**]. These collections were written in FORTRAN, but PC-Matlab has them rewritten in the C language, with slight modifications.

Suppose we want to find the eigenvalues of the n-by-n matrix X. Matlab does not compute the characteristic polynomial of X and find its roots. Instead, it puts X into Hessenberg form, and then applies the QR method. Here is a sketch of the method (see for example [**4**], p. 294 for more details). Using the Gram-Schmidt algorithm, it writes $X = QR$, with Q unitary and R upper triangular. Then RQ is similar to X, so it

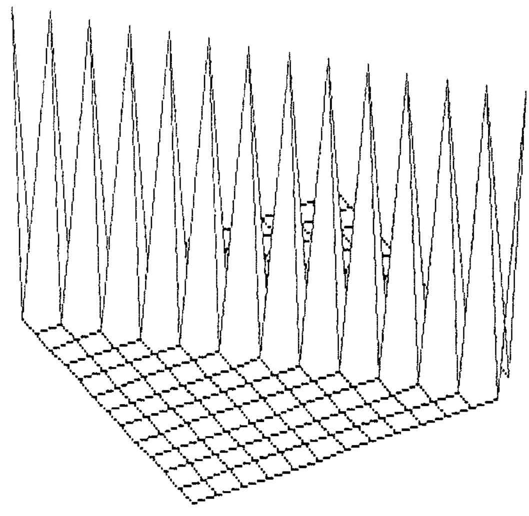


FIGURE 1

has the same eigenvalues. Replace X by RQ, and repeat again and again. X will converge to triangular form and then we can read off its eigenvalues from the diagonal. (A few extra tricks help speed up the method.) Matlab does have a warning message if no eigenvalue is found after $30n$ iterations of the method: "Solution will not converge."

Now suppose we want to find the roots of a polynomial P. Then Matlab constructs a companion matrix, whose characteristic polynomial equals P, and applies the method above to find its eigenvalues.

Matlab has three special abilities besides the matrix manipulation outlined above. One is data analysis. There are functions to sort a vector and to find simple statistical measures of its dispersion. However, Matlab is no substitute for a statistics package. A second specialty is signal processing. Here we have fast Fourier transforms and their inverses, in one and two dimensions, and some elementary filter designs. Most users will probably enjoy the third specialty: graphics. Matlab very speedily plots one variable against another, once it is given a pair of vectors of the same length. Give it a matrix Z of values and it will draw a three-dimensional mesh diagram (in perspective from above and to the side) representing the graph of the function $z(x, y)$ = the xyth entry in Z. The ordinary two-dimensional graphs can be superimposed on each other with various line styles, and the axes can be scaled and labeled by the user. Polar and logarithmic coordinates can be invoked by single commands. The sample plot shown in Figure 1 took ten seconds to appear fully on the screen. It is a plot of the 14-by-14 identity matrix. A monkey saddle with one hundred and twenty-one mesh points takes under five seconds to appear. (See Figure 2.)

Matlab provides us with three kinds of looping: "if", "for", and "while". All data consists of complex matrices of floating-point numbers, so there is no need for data types or dimensioning statements. This language suffices to write short procedures which set up matrices and then act on them with Matlab's powerful commands.

2. Matlab in the concrete. PC-Matlab runs on an IBM PC or compatible computer, with at least one disc drive, and MS-DOS version 2.0 or higher. It requires at least 320K of random access memory (RAM) and an 8087 coprocessor chip. Under MS-DOS 2.1 or higher, it will utilize all RAM up to 640K. To take advantage of the graphics capability, some kind of graphics display is necessary.

A single copy of PC-Matlab, which is copy-protected, costs \$695. There are discounts for multiple and academic purchases. For instance, one copy ordered by a university staff member goes for \$395, while a classroom kit, which allows only matrices of size 10 by 10 or less, costs \$500 for ten copies.

Along with two discs that contain the basic programs and some auxiliary files, PC-Matlab includes a manual, on-line help, and some demonstrations. The manual includes a tutorial, which is good, and a reference section, which is well organized but not complete, as I will illustrate below.

How does PC-Matlab interact with the outside world? It possesses its own style for data files, but it comes with a translation program which helps to transfer data between Matlab and other sources or targets. PC-Matlab can read in data from disc files or the keyboard. It can write out data to disc files or the printer or the CRT terminal. However, it allows the user very little choice in formatting the report. Some of the formatting commands require knowledge of the relevant portions of the C language.

There are two ways of ordering PC-Matlab around. In interactive mode, it responds immediately to one logical line of instructions. For more extensive work, Matlab can compile a sequence of commands stored in a special file. A "command file", when invoked, will execute the sequence as if it had been entered in interactive mode, so that all variables can acquire new values. A "function file" will return an answer, which can contain more than one matrix. In this case, all variables used in the file are dummy variables, and any namesakes outside the function file remain unaffected. There is a provision for declaring global variables, but the authors of Matlab do not recommend using it. Both command and function files can accept sequences of parameters.

By convention, the names of command and function files end in .m, so they are called ".m files." Many of the built-in single commands of Matlab, described in section 1, are actually .m files, which are read and compiled at the time of use. These .m files can only be read from disc, so the user cannot create them interactively and try them out while stored in memory, as one can with Turbo Pascal, for example. Instead, one must cycle between Matlab and an editor of one's choice. No editor is supplied with PC-Matlab. This cycle is facilitated by the ability to call external programs, outlined below.

The possibility of writing personal .m files turns PC-Matlab into a programming language, or as the authors like to say, it makes PC-Matlab extensible. Our .m files behave just like theirs, so we ourselves can add to the package. We can even add to the on-line help facility to explain our .m files.

PC-Matlab allows the user to invoke any DOS-executable file from the disc without exiting Matlab. Since it takes about forty-eight seconds to load Matlab from a floppy disk, this is a great boon. Of course, there must be sufficient internal memory beyond the required 320K to hold and execute the external file.

3. Evaluation. I have already mentioned some negative features of PC-Matlab. Most of these can be summarized by saying that Matlab is too rigid. For instance, three-dimensional plots cannot be scaled or rotated at will without some tricky preliminary transformation of the data. It is awkward to do computations in integer arithmetic. It is impossible to send the result of a computation directly to the printer without some acquaintance with the C language.

The documentation is clear and readable, but not complete. For example, the reference section explains that [] represents the empty matrix, but does not say what will happen when you try to append new rows to it. Normally, the new rows must be the same length as the rows of the old matrix. How long are the rows of the empty matrix?

Nowhere does the manual state any limits on how large a matrix can be. An attempt to create too large a matrix will elicit a message that matrices of more than 8188 entries are not allowed. This could be bad news to a new purchaser of Matlab whose heart was set on some calculations involving 100-by-100 arrays.

There is much to say on the positive side and I hope that my description will convince the reader that, on the whole, PC-Matlab is excellently thought out, and gives access to powerful algorithms in linear algebra. It is efficient and easy to use. It seems to be very accurate, although I have not tested that carefully. Of course, round-off error and instability are inherent in computations with matrices. The authors of Matlab have tried to select the most stable algorithms for each task. And PC-Matlab executes very quickly. For instance, it multiplied two random real 50-by-50 matrices in ten seconds, found the inverse of a random real 50-by-50 matrix in twenty-three seconds, and found the eigenvalues of a random 25-by-25 real matrix in twenty-six seconds. Loops slow it up. It performed the loop "for i from 1 to 1000, set $a = 1$" in eighteen seconds.

The language APL also deals exclusively in arrays, and a few comparisons might be helpful. Matlab is not a full-scale programming language. It does not possess the formatting resources of APL, nor the wide range of elementary functions that act on arrays, nor the capacity to deal with arrays of more than two dimensions. Any large program would be inordinately cumbersome in Matlab. On the other hand, APL has none of the high-level matrix algorithms built in, and it uses many special and confusing symbols in a special syntax. Matlab has few special symbols and its syntax is immediately comprehensible to a mathematician.

4. Matlab in action. I have used PC-Matlab for some computations of the homology of subgroups of finite index in $SL(3,\mathbf{Z})$. There is a close relationship between such homology with coefficients in a finite dimensional rational complex representation and the theory of automorphic forms for the group $GL(3)$. In particular, let $S(g)$ denote the $SL(3,\mathbf{C})$-module of homogeneous polynomials in three variables of degree g, let $S(g)^*$ be its dual, and let $W(g)$ be the largest irreducible constituent of $S(g) \otimes S(g)^*$. Let G be the group $SL(3,\mathbf{Z})$. If g is even, it is easy to produce a nontrivial class in $H_3(G,W(g))$, which corresponds to an "eisenstein series" in the theory of automorphic forms. Any additional classes, or any classes at all for g odd, would correspond to "cusp forms" for $GL(3)$ [**5**]. Cusp forms, in this context, are the interesting ones because, aside from certain predictable ones which are "lifted" from $GL(2)$, their existence is obscure. The first "lift" occurs when $g = 10$ [**6**].

I wrote a program in Matlab to compute $H_3(G,W(g))$ for $g < 10$. It just so happened that $g = 9$ was the limit attainable by any simple approach on account of the memory and variable size limitations of PC-Matlab. To run $g = 9$ required solving approximately three hundred and sixty equations in sixty-six variables. To fit this into Matlab, I had to divide the equations into batches and keep track of an ever shrinking null space. It ran overnight, and made 3,888,343 floating point operations. The final result was that there are no cusp forms for $g < 10$.

I cannot say that I have proved this, nor that I believe it without a remnant of doubt. Round-off becomes very prominent in a calculation of this length on PC-Matlab. If I set the tolerance around 0 ("eps") too small, I could not even find the eisenstein series. If I set it too large, spurious solutions crept in. I based my conclusion on a purely empirical setting of eps. A "proof" would require a careful analysis of the errors and even then I suppose there are people who might withhold assent. To continue this series of calculations will require a mainframe computer, but the experience gained in the unpressured environment of my own PC will be very helpful.

I am also computing the homology of subgroups of finite index in G with trivial coefficients. As a preliminary I must compute the first homology group of $\Gamma_1(p)$ with trivial coefficients, where $\Gamma_1(p)$ is Hecke's group of 2-by-2 integral matrices of determinant 1 where the second row is congruent to $(0,1)$ modulo p. By the theorem of Eichler and Shimura, this homology group is naturally isomorphic to the vector space of holomorphic and antiholomorphic elliptic modular forms of weight 2 and level p [**7**].

As explained for instance in [**8**], the homology calculation comes down to finding the space of all functions $f(x,y)$ of two variables x and y (not both 0) in $\mathbf{Z}/p$ such that

(i) $f(x,y) = -f(-y,x)$;

(ii) $f(x,y) + f(-y,x-y) + f(y-x,-x) = 0$.

Technical considerations allow the inclusion of a third condition,

(iii) $f(-x,y) = f(x,y)$,

which essentially eliminates the classes corresponding to antiholomorphic forms. Similarly, half the eisenstein series can be eliminated by imposing

(iv) $f(x,0) = 0$.

Now $(\mathbf{Z}/p)^*$ acts on the solutions f by $(a \cdot f)(x,y) = f(ax,ay)$, so we can diagonalize with respect to this action. That is, fixing a character t of $(\mathbf{Z}/p)^*$, we impose

(v) $f(ax,ay) = t(a)f(x,y)$.

I have computed only when p is prime, which is much simpler to program than the general case. A few instructions in PC-Matlab find the smallest primitive root, say r, modulo p. Then it is easy to write down the character t, namely for some n, $t(r^{\,k}) = e^{2\pi\sqrt{-1}nk/(p-1)}$. (Because of condition (i), we need only consider even n.) In doing this, the automatic capability of PC-Matlab to work in the complex numbers is very useful.

Another small program prepares a list of powers of r, a logarithm function with respect to r, and a choice of a set of representatives for the projective line over $\mathbf{Z}/p$ with respect to the equivalence relation induced by (i) and (iii). These two .m files together take up about two-thirds of a page.

Another two-thirds of a page goes for the program to prepare the equations to be solved. I view conditions (i), (iii), (iv), and (v) as defining a set of variables, by choosing a set of pairs (x,y) such that knowing f on those pairs determines f completely. Then (ii) defines a set of equations on the values of f on those basic pairs. Now $(\mathbf{Z}/p)^*$ and a group of order six both act on the set of pairs (x,y), leaving (ii) stable, so there are about $p/6$ equations in about $p/8$ unknowns. Because of fixed points, there are actually a few more equations and unknowns than that.

My final .m file to compute the homology of $\Gamma_1(p)$ for all even characters t, for prime p, took only fourteen lines, exclusive of comments. I used the singular value decomposition for finding null spaces. PC-Matlab found all thirty-five solutions for $p = 29$ in one hundred and forty-one seconds.

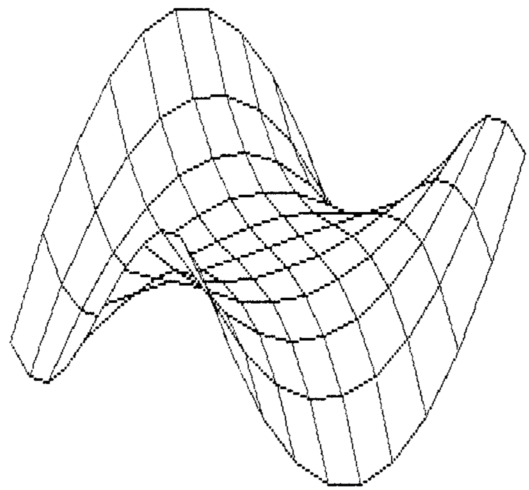


FIGURE 2

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8. A. Ash, *Cohomology of congruence subgroups of $SL(n,\mathbf{Z})$*, Math. Ann. **249** (1980), 55–73.

Washington Outlook

Kenneth M. Hoffman

Increasing Awareness

A long-term effort to increase awareness of the importance of mathematics and the needs of our community began with the activities surrounding preparation of the David Report, 1981–1984. Subsequently, two important mechanisms for providing national leadership were put in place by the National Research Council at the instigation of our community: the Board on Mathematical Sciences and the Mathematical Sciences Education Board. These boards are already developing and amplifying priorities and directions in mathematics research and education.

Since last fall, our ability to increase awareness in Washington and around the country has been further enhanced by the decisions of the Joint Policy Board for Mathematics (JPBM) to retain the services of Kathleen Holmay as a public information consultant and Jennifer Vance as a general counsel specializing in congressional matters. The addition of these two professionals to our team has given us both a stronger presence in Washington and a national capability which we have never had.

This was vividly demonstrated in the planning and development of National Mathematics Awareness Week, held April 14–21. In a few short weeks, our new consultant-representatives devised and implemented strategies for producing a spectrum of events, centered about the two main thrusts of the week: congressional sponsorship and participation, and public observation of the fractal-space public service announcement which appeared on about two hundred television stations around the country. These thrusts brought us the highest degree of congressional and public visibility our field has yet attained.

These are accomplishments of which our community can be proud, especially because of the participation of many mathematicians who wrote their representatives in Congress and planned supportive local events on very short notice. It is important, however, not to view these as isolated events. They are initial steps in long-term strategies planned to heighten awareness on Capitol Hill and throughout the country. If the efforts continue to get the kind of support from the mathematical community that they received in March and April, we will be able to carry out our long-range plans and make a significant difference in how our field and its needs are perceived.

With Mathematics Awareness Week behind us, it seems like a good time to review how we are doing elsewhere on our awareness scorecard.

Executive Branch. Awareness of the need to rebuild our research funding was exhibited in February by Erich Bloch, Director of the National Science Foundation (NSF). Bloch went to Congress for authorization to reprogram so that NSF's Mathematical Sciences Division would be exempt from the FY 1986 cuts made under the Gramm-Rudman-Hollings Budget Reduction Act.

The picture was not so rosy at the Department of Defense (DOD), where mathematical sciences funding took a pretty good pounding because of Gramm-Rudman. Building effective working relationships between our community and the powers-that-be at DOD remains demanding.

Congress. On February 26, Dr. Edward E. David, Jr., testified before the Science, Research and Technology Subcommittee of the House Committee on Science and Technology and presented an update of the David Report as part of the NSF budget authorization hearings. He placed particular emphasis on the need to move mathematics more to the center of science policy considerations in Congress. He also noted that, as the field faces an escalating shortage of talent, the manpower situation in the mathematical sciences is worse now than it was two years ago. In the question and answer period, he expressed grave concern that big science and big projects may push out support for the individual researcher, on whose creativity the future of science depends. Dr. David's was the first testimony before Congress on the overall needs of mathematics since the time of the American Revolution. It will be followed by several more appearances which Jennifer Vance is arranging for this spring.

The Public. A major symposium on "Mathematics in Modern Science" will be held at the National Academy of Sciences in Washington on May 12, the first day of National Science Week. Organized and sponsored by the Board on Mathematical Sciences, the symposium will feature three Nobel Laureates in science: Allan Cormack (medicine), Steven Weinberg (physics), and Herbert Hauptman (chemistry), who will talk about the significance of mathematics for their sciences. The moderator will be I. M. Singer. You will see publicity for this event, as well as for other events and accomplishments of our community, amplified through the work of Kathleen Holmay.

The Mathematical Community. As we venture further into the worlds of congressional and public affairs with the aim of increasing awareness, we need to be aware that we will be the group most enlightened in the process. That is as it should be. We must change because our field and its place in the scheme of things are changing. We have entered an era in which the power of mathematics will surpass anything in history thus far, principally because of the coming together of pure and applied mathematics, indeed, of all the major branches of the discipline, developed at such a mind-boggling pace over the last thirty-five years. Our field is forming into a giant mathematical laser, to be trained on the basic problems of mathematics and engineering science. It is a time for reaching out, for letting our various publics know that massive changes, especially in education, will be required if the emerging power of our discipline is to be properly utilized.

INTERNATIONAL CONGRESS OF MATHEMATICIANS

Berkeley, California, U.S.A.
August 3–11, 1986

The Public Information Committee for the 1986 International Congress of Mathematicians (ICM-86) has solicited the views of a number of distinguished mathematicians on the significance of the Congress for the furtherance of mathematics and mathematical activity. The following are extracts from some of the responses we received.

"Mathematics underpins both the natural and social sciences and is an essential part of our scientific culture. Research in mathematics is conducted on a very wide front both in terms of its content and in its geographical distribution. Moreover new ideas of great depth and with long-term implications are being developed at the present time.

"All this makes international meetings important occasions for mathematicians from all over the world to find out what is happening in their subject, to derive stimulus from the latest ideas and to benefit from new developments. The 1986 International Congress in Berkeley will be a major event for the mathematical community, with several thousand mathematicians from all over the world expected to attend. While small specialist meetings play an important role, the grander occasions provided by the 4-yearly International Congresses are vital in helping to emphasize and maintain the overall unity of the subject and to provide overall guidance for the world's mathematicians on the direction of current research."

Michael Atiyah

"I have met many interesting foreign mathematicians at past ICMs. One meeting in particular that stands out in my memory is the meeting of the International Congress in Edinburgh in the summer of 1958. There I saw the Russian mathematician Yu. M. Smirnov. As was pointed out in the comments under the photo in the April 1982 issue of the American Mathematical Monthly, Smirnov and I, along with J. Nagata, had gotten independent solutions of the metrization problem. When Smirnov and I met in Edinburgh, we wanted to arrange a meeting to discuss mathematics. This was difficult since Smirnov had a busy agenda. Rather than seeing sites and taking excursions he had arranged his schedule to include mathematical discussions with other visiting mathematicians. I was impressed with the extent to which he used his visit outside Russia to learn of the work of outside researchers. Finally we found a time late at night after most activities had slowed when we could meet. What we discussed I do not remember. It was not a private meeting; many other Russians were present, not all of whom seemed to be mathematicians. There Smirnov showed me a copy of the booklet Summary of Lectures and Seminars, Summer Institute on Set Theoretic Topology, Madison, 1955. The Chinese had printed the booklet and sent some of the copies to Russia. Rather than resent the pirating of our booklet by the Chinese I was flattered by it. Since that time Smirnov and I have met many times. I admire his mathematical talent. I have had dinner at his home in Moscow along with his mentor Paul Alexandrov. We exchange cards at the Christmas season. He and I remain friends.

"It is my feeling that individual friendships between people enhance our chances for peace and good will between nations."

R H Bing

"'Mathematics is basic to other sciences, yet has a strong independent existence', 'Mathematics is truly international', 'Mathematics is a single subject'. I read these three statements to which every mathematician will agree recently in an important committee report. The International Congress of Mathematicians is the place where these statements come to life. The 16 invited one-hour expository lectures and the approximately 130 invited 45-minute lectures in the 19 sections are supposed to be understandable to nonspecialists and to show the links between different fields. Some talks will stress the applications outside of mathematics. A survey of the most important results of the last years will be given. Every participant will have the chance to get new insights for his own research work. Many mathematicians travel to many smaller meetings in many countries every year, but at the ICM and—perhaps—only at the ICM every member will have the opportunity to meet mathematicians outside of his normal circles and to get a really broad view of mathematics and the whole international family of mathematicians."

F. Hirzebruch

"As a former invited speaker, and as a participant, I have attended some of the International Congresses of Mathematicians (ICM) since the 1950 Harvard one. These meetings are of the highest level from the standpoint of current research in mathematical sciences and its applications. Each such congress offers a wealth of excellent lectures by top experts in a great variety of fields, by far more than a single person can digest. As a Brazilian mathematician, I am convinced that the ICM has a series of unique events to stimulate furthering research and university teaching in mathematics in developing countries. They are by far the most important meetings offered to the mathematical community of all parts of our world. Young and relatively young research mathematicians should particularly be encouraged and supported to attend, to have personal contact with speakers and leaders in their fields present there, getting acquainted with the frontier boundaries of our mathematical accomplishments. It is not at all possible to do that otherwise through journals, preprints and less comprehensive gatherings. In view of the wide use of mathematics in concrete applications that benefit our modern society, on the one hand, and its lasting value as an intellectual activity, on the other hand, the high standard and the large size of the ICM make them a major attraction to mathematicians."

Leopoldo Nachbin

"Mathematics is the work of mathematicians, and most mathematicians work best in contact with other mathematicians. Thus it is important that mathematicians meet, to discuss their mathematics, to exchange ideas, to learn of new progress, or just to get to know one another.

"The ICM is, true to its name, truly international: you meet mathematicians there from all over the globe. Some, from countries that could not afford to send them, come with travel grants from the International Mathematical Union. Thus the ICM gives its participants a unique opportunity to meet mathematicians whom they would not otherwise be able to meet.

"Do I attend the ICM? You bet I do: I went to my first one, in Zurich, Switzerland, in 1932: and since then I have missed only one, in 1950—and I still kick myself for not having had the courage to borrow the money to go. So do come and let us meet at the ICM in Berkeley, California, in August 1986."

Bernhard H. Neumann

"Some benefits of ICM are The Proceedings Books, which give us, every four years, a well balanced view of what mathematicians are working on at the moment. The list of speakers, which is obtained after a long selection process (Committees, Panels, etc.) involving many different countries. The fact that it gives to the press an opportunity to speak about mathematics. This shows to the general public that mathematics is not a dead subject (as many wrongly believe), and that there is a lot of work to be done there—just as in physics and biology; this is important for high school students, for instance."

Jean-Pierre Serre

We believe that the views we have quoted make it plain that the Congress is an important event for us, enabling us to learn more about the developments in our subject and bringing us into contact with some of those who are doing very exciting work today. We hope that you will be convinced that you should attend ICM-86. Information about the Congress and registration may be obtained by writing to ICM-86, Post Office Box 6887, Providence, Rhode Island, U.S.A. 02940.

Members of the Public Information Committee for ICM-86

Yousef Alavi, *Chair*
Western Michigan University

Donald J. Albers
Menlo College

William G. Chinn
City College of San Francisco

Jane M. Day
San Jose State University

Peter J. Hilton
State University of New York, Binghamton

Lester H. Lange
San Jose State University

Jean J. Pedersen
Santa Clara University

TENTATIVE SCHEDULE

The information on the ICM-86 program provided below is tentative, and subject to change. A copy of the final version of this timetable will be included in the Congress program. The number in parentheses following the name of the 45-minute speaker represents the section number.

Saturday, August 2

12:00 – 20:00 **Registration**

Sunday, August 3

08:00 – 17:00 **Registration**

09:00 – 10:30 **Opening Ceremonies**
Greek Theater

11:00 – 12:30 **Addresses On Works Of Fields Medalists And Nevanlinna Prize Winner**

14:00 – 14:45 **45-Minute Lectures In Sections**

Speaker and title to be announced (1)
Immersed tori of constant mean curvature in R^3 (A counterexample to a conjecture of H. Hopf)
Henry C. Wente (4)
A survey of recent developments in three-dimensional topology
Andrew J. Casson (5)
Fixed points of symplectic mappings and periodic solutions of Hamiltonian systems
Eduard J. Zehnder (12)
Renormalization: from magic to mathematics
Krzysztof Gawedzki (13)
Some questions related to numerical methods for stiff nonlinear ordinary differential equations
Germund G. Dahlquist (14)

14:00 – 18:00 **Sessions for Short Communications**

15:00 – 15:45 **45-Minute Lectures In Sections**

Modern developments in invariant theory
Vladimir L. Popov (2)
Sullivan's fixed point conjecture and homotopical representation theory
Haynes R. Miller (5)
Inner functions: results, methods, problems
A. B. Alexandroff (7)
Speaker and title to be announced (9)
Vortex methods in the analysis of turbulent flow
Alexandre J. Chorin (14)

16:00 – 16:45 **45-Minute Lectures In Sections**

Periods of abelian integrals, theta-functions, and differential equations of KdV type
Enrico Arbarello (6)
Boundary distortion under conformal mapping
N. G. Makarov (7)
Speaker and title to be announced (11)
Dynamics of area preserving mappings
John Norman Mather (12)
Polyhedral combinatorics – Recent developments
Alexander Schrijver (15)

17:00 – 17:45 **45-Minute Lectures In Sections**

Milnor k-theory and Galois cohomology
A. Merkurjev (2)
L'approche geometrique du probleme de Schottky
The geometric approach of the Schottky problem
Arnaud Beauville (6)
A self-focusing solution to the Navier-Stokes equations with a speed-reducing external force
Vladimir Scheffer (11)
Pseudo-random sequences that pass all polynomial time statistical tests... and other tales of randomness
Manuel Blum (16)
Verbal problems in arithmetic teaching
Zbigniew Semadeni (19)

17:00 – 18:00 **International Commission on Mathematical Instruction Session**

18:30 – 20:00 **Chancellor's Reception**
Faculty Glade

Monday, August 4

08:00 – 17:00 **Registration**

09:30 – 10:30 **Plenary Address**
Complexity aspects of numerical analysis
Stephen Smale

10:00 – 18:00 **Exhibits**
Pauley Ballroom, Student Union

11:00 – 12:00 **Plenary Address**
Quasiconformal mappings
Frederick W. Gehring

14:00 – 14:45 **45-Minute Lectures in Sections**

Spectral theory of automorphic functions and recent developments in analytic number theory
Henryk Iwaniec (3)
Complex geometry in convex domains
László Lempert (7)
Speaker and title to be announced (9)
The problem of the regularity of minimizers
Mariano Giaquinta (11)
Multi-level approaches to large scale problems
Achi E. Brandt (14)

14:00 – 18:00 **Sessions for Short Communications**

15:00 – 15:45 **45-Minute Lectures in Sections**

Homogeneous structures
Alistair Lachlan (1)
Kloosterman zeta functions for GL(n)
Dorian Goldfeld (3)
The Weil-Petersson geometry of the space of Riemann surfaces
Scott A. Wolpert (7)
Speaker and title to be announced (9)
Estimates for number of negative eigenvalues of Schrödinger operators with singular potentials
Victor Ivriĭ (11)
Computational complexity in polynomial algebra
D. Yu. Grigorev (16)

16:00 – 16:45 **45-Minute Lectures in Sections**

Definability problems in analysis
Alexander S. Kechris (1)
Quantum groups (Hopf algebras, deformation of universal enveloping algebras and integrable quantum systems)
V. G. Drinfeld (8)
Homoclinic bifurcations
Floris Takens (12)
Intersection theorems for finite sets
Peter Frankl (15)
Equilibrium analysis of large economies
Werner Hildenbrand (17)

17:00 – 17:45 **45-Minute Lectures in Sections**

Some remarks on Peano arithmetic and its subtheories
A. J. Wilkie (1)
Manifolds of nonpositive sectional curvature and manifolds without conjugate points
Werner Ballmann (4)
Speaker and title to be announced (9)
The problem of guaranteed accuracy in numerical methods of linear algebra
Sergei Konstantinovic Godunov (14)
Speaker and title to be announced (15)
The origins of the representation theory of semisimple Lie algebras
Thomas Hawkins (18)

17:00 – 18:00 **International Commission on Mathematical Instruction Session**

19:00 – 21:00 **Videotapes of Plenary Addresses**

Tuesday, August 5

08:00 – 17:00 **Registration**

09:30 – 10:30 **Plenary Address**
Geometry of four dimensional manifolds
Simon K. Donaldson

10:00 – 18:00 **Exhibits**
Pauley Ballroom, Student Union

11:00 – 12:00 **Plenary Address**
Underlying concepts in the proof of the Bieberbach conjecture
Louis de Branges

14:00 – 14:45

45-Minute Lectures in Sections

Large cardinals and small sets (a survey)
Menachem Magidor (1)
Segal's Burnside ring conjecture and the homotopy limit problem
Gunnar E. Carlsson (5)
Quantum strings and algebraic curves
Yuri I. Manin (13)
Mathematical, physical, and computational aspects of turbulence
Steven A. Orszag (14)
Speaker and title to be announced (15)
Mathematical teaching, computers, and calculators
Jean-Pierre Kahane (19)

14:00 – 18:00

Sessions for Short Communications

15:00 – 15:45

45-Minute Lectures in Sections

The two faces of infinity
W. Hugh Woodin (1)
Algebraic groups, Hodge theory and transcendence
G. Wüstholz (3)
Index theorem and the heat equation
Jean-Michel Bismut (4)
Actions of semisimple groups and discrete subgroups
Robert J. Zimmer (12)
Free boundary problems and problems in noncompact domains for the Navier-Stokes equations
Vsevolod A. Solonnikov (11)
The centrality of mathematics in the history of Western thought
Judith V. Grabiner (19)

16:00 – 16:45

45-Minute Lectures in Sections

Speaker and title to be announced (3)
Curves on higher dimensional complex projective manifolds
Charles H. Clemens (6)
Generalized Hamiltonian systems and optimal control theory
Ivan A. K. Kupka (12)
Computer-assisted proofs in analysis
Oscar E. Lanford III (14)
Speaker and title to be announced (19)

17:00 – 17:45

45-Minute Lectures in Sections

Speaker and title to be announced (6)
Chirurgie sur les fonctions holomorphes? Surgery on holomorphic mappings?
Adrien Douady (7)
Optimization of the ensured result for the dynamical systems
Arkadii V. Kryazhimskiǐ (12)
Speaker and title to be announced (15)
Geometric problems of robot motion planning
Jacob T. Schwartz (17)

17:00 – 18:00

International Commission on Mathematical Instruction Session

19:00 – 21:00

Videotapes of Plenary Addresses

Wednesday, August 6

08:00 – 17:00

Registration

09:30 – 10:30

Plenary Address
Efficient algorithms in number theory
Hendrik W. Lenstra, Jr.

10:00 – 18:00

Exhibits
Pauley Ballroom, Student Union

11:00 – 12:00

Plenary Address
New developments in the theory of geometric partial differential equations
Richard M. Schoen

14:00 – 14:45

45-Minute Lectures in Sections

Description of the local automorphisms groups of real hypersurfaces
N. G. Kruzhilin (7)
The supercuspidal representations of GL_n and other p-adic groups
Philip C. Kutzko (8)
Gauge theories and nonlinear partial differential equations
Clifford H. Taubes (11)
Speaker and title to be announced (14)
Markov random field image models and their applications to computer vision
Stuart A. Geman (17)

14:00 – 18:00

Sessions for Short Communications

15:00 – 15:45 **45-Minute Lectures in Sections**

L-series and the Green's functions of modular curves
Don B. Zagier (6)
Rational approximation of analytic functions
A. A. Gonchar (7)
Beyond the affine Lie algebras
Igor B. Frenkel (8)
Oscillations and concentrations in solutions to nonlinear partial differential equations
Ronald J. DiPerna (11)
Renormalization group in statistical mechanics and field theory
G. Gallavotti (13)
Speaker and title to be announced (14)

16:00 – 16:45 **45-Minute Lectures in Sections**

Heights and L-series
Benedict H. Gross (3)
Almost Lie groups
Ernst A. Ruh (4)
Recent results in potential theory
Thomas Wolff (9)
Spatial stochastic growth models – survival and critical behavior
Thomas M. Liggett (10)
Speaker and title to be announced (16)

17:00 – 17:45 **45-Minute Lectures in Sections**

On p-adic Hecke algebras for GL(2)
Haruzo Hida (3)
Singularities in some geometric variational problems
Robert M. Hardt (4)
Geometrical aspects of representation theory
V. A. Ginzburg (8)
Stochastic flows and stochastic partial differential equations
Hiroshi Kunita (10)
Phenomena of nonintegrability in Hamiltonian systems
V. V. Kozlov (12)
Reliable computation in the presence of noise
Nicholas Pippenger (16)

17:00 – 18:00 **International Commission on Mathematical Instruction Session**

19:00 – 21:00 **Videotapes of Plenary Addresses**

Thursday, August 7

08:00 – 13:00 **Registration**

09:30 – 10:30 **Plenary Address**
String theory and geometry
Edward Witten

10:00 – 13:00 **Exhibits**
Pauley Ballroom, Student Union

11:00 – 12:00 **Plenary Address**
Recent progress in arithmetic algebraic geometry
Gerd Faltings

15:15 – 22:00 **Barbecue and Rodeo**
Cow Palace

Friday, August 8

09:00 – 16:00 **Registration**

09:30 – 10:30 **Plenary Address**
Soft and hard symplectic geometry
Mikhael Gromov

10:00 – 18:00 **Exhibits**
Pauley Ballroom, Student Union

11:00 – 12:00 **Plenary Address**
Representations of reductive Lie groups
David A. Vogan, Jr.

14:00 – 14:45 **45-Minute Lectures in Sections**

Some aspects of spectral geometry
Jeff Cheeger (4)
Concentration phenomena and linear structure of finite dimensional normed spaces
Vitali D. Milman (9)
Conditionally positive definite functions in quantum probability
A. S. Holevo (10)
Ultraviolet stability problems in quantum field theory
Tadeusz Balaban (13)
Zeros of Epstein zeta functions and the CRAY-1 supercomputer
Dennis A. Hejhal (14)

14:00 – 18:00 **Sessions for Short Communications**

15:00 – 15:45 **45-Minute Lectures in Sections**

Fast algorithms for evaluating the Riemann zeta function and other number theoretic functions
Andrew Odlyzko (3)
Geometric representation theory of compact Lie groups
Tammo tom Dieck (5)
Regularity of the $\bar{\partial}$-Neumann problem
David W. Catlin (7)
Modifications of functions, homeomorphisms of the circle and Fourier series
A. M. Olevskii (9)
A nonparametric framework for statistical modelling
Charles J. Stone (10)
Parabolic equations in differential geometry
Richard Hamilton (11)

16:00 – 16:45 **45-Minute Lectures in Sections**

The what, where and why of almost split sequences
Maurice Auslander (2)
Spectre de varietes riemanniennes et spectre de graphes
Spectra of Riemanian manifolds and spectra of graphs
Yves Colin de Verdiere (4)
Applications of topology with control
Frank S. Quinn, III (5)
Vanishing theorems and positivity in algebraic fibre spaces
Eckart E. Viehweg (6)
Base change for automorphic forms on general linear groups
Laurent Clozel (8)

17:00 – 17:45 **45-Minute Lectures in Sections**

Representations of finite-dimensional algebras
Peter Gabriel (2)
A survey of Riemannian metrics with special holonomy groups
Robert L. Bryant (4)
Speaker and title to be announced (8)
Diffusion and waves in random media
George C. Papanicolaou (10)
Theory permanents and proof of van der Waerden conjecture
Georgii Petrovich Egorychev (15)
Recent studies on the history of Chinese mathematics
W.-T. Wu (18)

17:00 – 18:00 **International Commission on Mathematical Instruction Session**

19:00 – 21:00 **Videotapes of Plenary Addresses**

Saturday, August 9

09:00 – 16:00 **Registration**

09:30 – 10:30 **Plenary Address**
Problems in harmonic analysis related to oscillatory integrals and curvature
Elias M. Stein

10:00 – 15:00 **Exhibits**
Pauley Ballroom, Student Union

11:00 – 12:00 **Plenary Address**
Random processes in infinite dimensional spaces
A. V. Skorokhod

14:00 – 14:45 **45-Minute Lectures in Sections**

Simple Lie algebras over fields of prime characteristic
Robert Lee Wilson (2)
Trees and hyperbolic geometry
John W. Morgan (5)
Corona problems, interpolation problems and inhomogeneous Cauchy-Riemann equations
John B. Garnett (9)
Axiomatising the observable behaviour of automata
Robin Milner (16)

14:00 – 18:00 **Sessions for Short Communications**

15:00 – 15:45 **45-Minute Lectures in Sections**

Reflection groups in Lobachevsky spaces and algebraic surfaces
Viachevslav V. Nikulin (6)
Integrable systems and infinite dimensional algebras
Tetsuji Miwa (8)
Cyclic cohomology and noncommutative differential geometry
Alain Connes (9)
Speaker and title to be announced (11)
Qualitative analysis of bursting oscillations in biological systems
John Rinzel (17)

16:00 – 16:45

45-Minute Lectures in Sections

Combinatorial methods in symplectic geometry
Ya. M. Éliashberg (4)
Representations of 3-manifold groups and applications in topology
Peter B. Shalen (5)
Harmonic analysis and partial differential equations
Carlos E. Kenig (9)
Schrödinger operators with random or quasi periodic potentials
Thomas Spencer (13)
The search for provably secure cryptosystems
Adi Shamir (16)

17:00 – 17:45

45-Minute Lectures in Sections

Local representation theory of finite groups
Theorie locale des representations d'un groupe fini
Michel Broué (2)
Recent progress on the geometry of surfaces in R^3 and using computer graphics as a research tool
William H. Meeks III (4)
Numerical geometry of algebraic 3-folds
V. V. Shokurov (6)
Some new results in the theory of nonlinear elliptic and parabolic equations
N. V. Krylov (11)
The concept of construction and the representation of curves in seventeenth-century mathematics
Henk J. M. Bos (18)

17:00 – 18:00 **International Commission on Mathematical Instruction Session**

19:00 – 21:00 **Videotapes of Plenary Addresses**

20:00 – 22:00 **Jazz Concert**

Sunday, August 10

09:00 – 16:00 **Registration**

09:30 – 10:30

Plenary Address
Algebraic K-theory of fields
Andrei Aleksandrovich Suslin

11:00 – 12:00

Plenary Address
Equation solving in terms of computational complexity
Arnold Schönhage

14:00 – 14:45

45-Minute Lectures in Sections

Nilpotent orbits, primitive ideals, and characteristic classes
Walter Borho (2)
Nonlinear estimation and stochastic flows
Mark H. A. Davis (10)
Justification of Feigenbaum's quantitative discovery in one-dimensional dynamical systems
Dennis P. Sullivan (12)
The mechanism of Feigenbaum universality
Jean-Pierre Eckmann (13)
Lower bounds for the monotone complexity of Boolean functions
A. A. Razborov (16)

14:00 – 18:00 **Sessions for Short Communications**

15:00 – 15:45

45-Minute Lectures in Sections

Equivariant embeddings of homogeneous spaces
Corrado de Concini (2)
A class of Markov random fields with finite range
T. Arak (10)
Quasiconvexity and partial regularity in the calculus of variations
Lawrence C. Evans (11)
Speaker and title to be announced (13)
Speaker and title to be announced (16)

16:00 – 16:45

45-Minute Lectures in Sections

On the commutant of absolute Galois group
G. V. Belyĭ (2)
Speaker and title to be announced (8)
Subfactors of type II_1 factors and related topics
Vaughn F. R. Jones (9)
Uniformity and irregularity
Jószef Beck (15)

17:00 – 17:45 **45-Minute Lectures in Sections**

The classification of hyperfinite von Neumann algebras
Uffe Haagerup (9)

The classical problem of plateau and the geometry of the space of Riemann surfaces
Anthony J. Tromba (11)

Spectral properties of metrically transitive operators
Leonid A. Pastur (13)

Face numbers of complexes
Anders Björner (15)

Equations diophantiennes et l'evolution de l'algebra
Diophantine equations and the evolution of algebra
I. Bashmakova (18)

17:00 – 18:00 **International Commission on Mathematical Instruction Session**

19:00 – 21:00 **Videotapes of Plenary Addresses**

20:00 –22:00 **Classical Concert**

Monday, August 11

09:00 – 14:30 **Registration**

09:30 – 10:30 **Plenary Address**
Classifying general classes
Saharon Shelah

11:00 – 12:00 **Plenary Address**
Analytical approaches to quantum field theory and statistical mechanics
Jürg M. Fröhlich

12:15 – 13:30 **Closing Ceremonies**

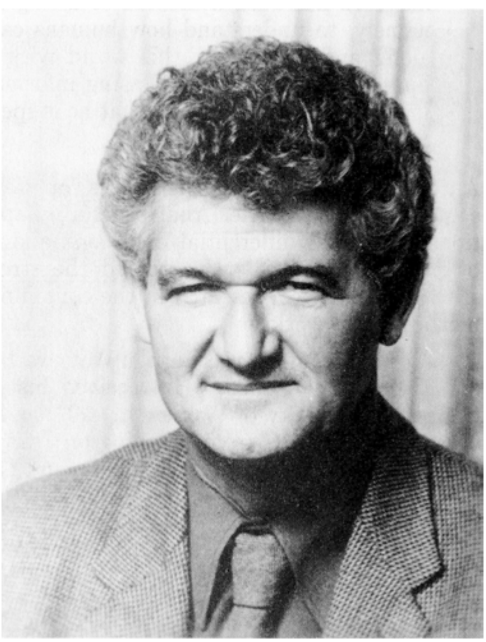
National Medals of Science Awarded

On March 12, 1986, President Reagan awarded the National Medal of Science to twenty individuals in recognition of their achievements in science, mathematics, and engineering. Included in this group were three mathematical scientists: Peter D. Lax, Herbert A. Simon, and Antoni Zygmund.

The National Medal of Science was established by Congress in 1959 to provide special recognition to individuals for their outstanding contributions to knowledge in the physical, biological, mathematical, engineering, behavioral, or social sciences. Selection is based on the total impact and importance of an individual's work on the present state of his or her chosen field. In addition, achievements of an unusually significant nature are considered and judged in relation to their potential effects on the development of scientific thought.

Peter D. Lax was honored for his "outstanding, innovative, and profound contributions to the theory of partial differential equations, applied mathematics, numerical analysis, and scientific computations. He has formed many of the underlying principles in the field of nonlinear hyperbolic equations; his approach to scattering theory has yielded applications to the propagation of sound and light."

Peter D. Lax was born on May 1, 1926, in Budapest, Hungary. He received his Ph.D. in 1949 from New York University, where he became Assistant Professor in 1949. Between 1949 and 1958, he advanced from Assistant Professor to full Professor. In 1963, he became the Director of the AEC Computing and Applied Mathematics Center of the Courant Institute of Mathematical Sciences. He was Director of the Courant Institute from 1972–1980. Professor Lax was a staff member of the Los Alamos Science Laboratory in 1945.



Peter D. Lax

Professor Lax was a Fulbright Lecturer in 1958 and a Sloan Fellow from 1959–1963. He was awarded the Chauvenet Prize of the Mathematical Association of America in 1974 and the Norbert Wiener Prize in Applied Mathematics in 1975. Also, he is a member of the National Academy of Sciences, the National Science Board (1980–1986), and the Academie des Sciences. Professor Lax has served on many AMS committees and as Member-at-Large of the Council (1962–1964), Vice President (1970-1971), and President (1979-1980).

Cathleen S. Morawetz, of the Courant Institute of Mathematical Sciences, was asked by the Editors of *Notices* to comment on Lax's contributions. She responded:

> Peter Lax has made deep contributions to both pure and applied mathematics. He has brought to bear, on several difficult and unwieldy problems arising in applications, the elegance and structure of mathematics and bent the results into useful answers. He has influenced a whole generation of young mathematicians, arousing their interest in mathematics and its application to practical problems. He has also made exceptional contributions to public service. As a member of the National Science Board, he chaired the "Lax Panel" which conducted a careful scrutiny of the computer power available to American scientists and called the country's attention to its extremely serious inadequacy.
>
> Three major areas of research work have been nonlinear hyperbolic equations, scattering theory and nonlinear dispersive equations. Many of the underlying principles for nonlinear hyperbolic equations, including the role of conservation laws and many stability issues in numerical models, are due to Lax. In scattering theory, Lax and Phillips' approach yielded a deeper understanding of the propagation of sound and light and ultimately to new methods in hyperbolic geometry. In nonlinear dispersive equations, Lax discerned the intrinsic mathematical structure of the KdV-Schrödinger relationship and led researchers to new insight in dispersive problems.

Herbert A. Simon was honored for his "fundamental contributions to our understanding of human problem-solving behavior and decision-making within economic organizations. His work includes philosophy and methodology of science, economics, political science, applied mathematics, computer science, and cognitive psychology. The sheer breadth of his record, spanning so many areas and disciplines, would be pretentious were it not so innovative and scientifically distinguished."

Herbert A. Simon was born on June 15, 1916, in Milwaukee, Wisconsin. In 1943, he received a Ph.D. in political science from the University of Chicago. He has held research and faculty positions at the University of California, Berkeley, and at the Illinois Institute of Technology. He has been a member of the faculty of Carnegie-Mellon University since 1949, where he is currently the Richard King Mellon University Professor of Computer Science and Psychology.

Professor Simon's work was recognized by his election to the National Academy of Sciences in 1967. He has received the Distinguished Scientific Contribution Award of the American Psychological Association and the A. M. Turing Award of the Association for Computing Machinery and was elected Distinguished Fellow of the American Economic Association. In 1978, he received the Alfred B. Nobel Memorial Prize in Economics "for his pioneering work on decision-making processes within economic organizations." Professor Simon was also the Gibbs Lecturer in 1984.

Herbert A. Simon

Allen Newell of Carnegie-Mellon University was asked by the Editors of *Notices* to comment on Simon's contributions. He responded:

> Herbert A. Simon received the National Medal of Science for his work in understanding the nature of information processing in humans. This has been a central concern of his for thirty years and one that led to his co-founding the field of artificial intelligence in the mid-fifties. For the methods whereby humans solve novel problems is very much of a piece with how computers solve novel problems. But this is only one of the fields in which Simon has worked, as attested by his Nobel Prize in economics. In fact, a quick enumeration reveals that Simon has made contributions to at least a dozen fields–administrative science, artificial intelligence, computer science, economics and econometrics, history and philosophy of science, management science and operations research, philosophy, political science, psychology (both individual and social), sociology, and statistics. In all of these the contributions were technical and often extensive. In many, they made major impacts on the conduct of the field. In the social sciences his work has uniformly moved the fields towards greater use of quantification and mathematics. However, he has also been deeply involved in the substantive content of each discipline. For instance, he co-authored a leading textbook in public administration. Simon is indeed a scientist and intellectual for all seasons. But he will tell you that all of his work has been dedicated to a single aim, namely, to understand how humans can get along and prosper in this world with their limited resources for processing information. It would appear, however, that he is speaking mostly about the rest of us.

Antoni Zygmund was honored for his "outstanding contributions to Fourier Analysis and its applications to partial differential equations and other branches of analysis. He created the strongest school of analytical research in the contemporary mathematical world."

Antoni Zygmund was born in Warsaw, Poland on December 26, 1900. He received his Ph.D. from the University of Warsaw in 1923, and honorary D.Sc. degrees from Washington University (1972), the University of Torun in Poland (1973), the University of Paris (1974), and the University of Uppsala in Sweden (1976). From 1922 to 1930 he was Instructor of Mathematics at Warsaw Polytechnical School, from 1926 to 1930 Privat Docent of the University of Warsaw, and during 1930–1939 Professor at Wilno University. He spent 1939-1940 as Visiting Lecturer at the Massachusetts Institute of Technology, then became

Assistant Professor at Mt. Holyoke College, where he advanced to Associate Professor by 1945. He was Professor at the University of Pennsylvania from 1945–1947, then became Professor at the University of Chicago, where he has been Swift Distinguished Service Professor of Mathematics since 1967.

Professor Zygmund served as Member-at-Large of the Council of the American Mathematical Society from 1954–1956, as Vice President from 1954 to 1955, and on many AMS committees. He gave an invited address at the 1943 Summer Meeting in New Brunswick, New Jersey. He delivered the Colloquium Lectures at the 1953 Summer Meeting in Kingston, Ontario, gave a thirty minute address at the 1954 International Congress of Mathematicians in Amsterdam, and spoke at the Symposium on Singular Integrals in Chicago in April 1966. He was also an organizer of the Special Session on Differentiation Theory in Evanston, Illinois in November 1968.

Professor Zygmund held a Rockefeller Foundation Fellowship at Oxford and Cambridge Universities in 1929–1930 and a Guggenheim Foundation Fellowship in 1953-1954. He received the prize of the Polish Academy of Sciences in 1939. In 1979 he was awarded the AMS Steele Prize. He is a member of the National Academy of Sciences, the American Association for the Advancement of Science, the Polish Academy of Sciences, the Argentinian National Academy, the Spanish National Academy in Madrid, and the National Academy of Sciences in Palermo, Italy.

Antoni Zygmund

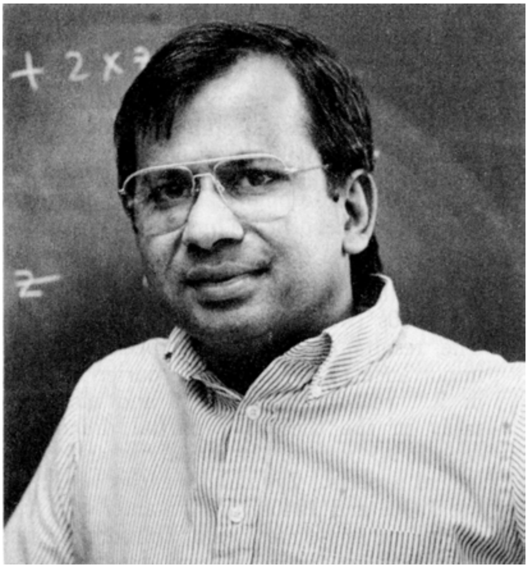
Elias M. Stein of Princeton University was asked by the Editors of *Notices* to comment on Zygmund's contributions. He responded:

> Antoni Zygmund is one of the great analysts of our time, whose deep and many-faceted work and broad influence continue to have highly significant impact on many areas of mathematics.
>
> Perhaps his most famous work is the theory of singular integrals which he began in the 1950s (working jointly with Calderón). The results obtained have been of great importance in questions of Fourier analysis in $\mathbf{R}^n$, real-variable theory, and most notably in the theory of partial differential equations, both in their analytic and topological aspects. Zygmund's earlier work (in the 1930s and 1940s) dealt mainly with the theory of one-dimensional Fourier theories (the Riemann theory of trigonometric series, and Littlewood-Paley theory), but even then his interests in analysis in $\mathbf{R}^n$ had already developed in work with Marcinkiewicz (his student). Among their results were the theory of the strong maximal function, with applications to multiple harmonic functions, and boundary behavior of functions of several complex variables.
>
> No description of the importance of A. Zygmund to modern mathematics would be complete without mention of the strong school of mathematicians whose development he guided, and the major accounts he gave of Fourier analysis in his *Trigonometric Series* (1959), a greatly expanded version of the first edition *Trigonometrical Series* (1935). This work will surely be considered one of the classics of twentieth century mathematics.

AMS Postdoctoral Research Fellowship

The Society has awarded one Postdoctoral Research Fellowship for 1986-1987. The recipient is Dinakar Ramakrishnan, who received his Ph.D. from Columbia University in August 1980. Ramakrishnan was an instructor at the University of Chicago (1980–1982), an assistant professor at the Johns Hopkins University (1982–1985), and a member of the Institute of Advanced Study (1982-1983). He is currently an assistant professor at Cornell University.

Professor Ramakrishnan received a Columbia University Faculty Fellowship (1975–1977), and a Graduate Research Fellowship (1977–1979). He was awarded an Alfred P. Sloan Fellowship in February 1986. Professor Ramakrishnan plans to spend his AMS Fellowship year at the Institute for Advanced Study and the Mathematical Sciences Research Institute.



Dinakar Ramakrishnan

The AMS Research Fellowship fund was established in 1973 in response to the need for funds for postdoctoral research. The fellowships are awarded on the basis of mathematical merit to persons who are five to ten years past the Ph.D., but below the academic rank of professor (regardless of their age). Fellows must be citizens or permanent residents of a country in North America. The awards are intended to support research fellows for a period of one year and, at present, carry a stipend of $30,000 each with an expense allowance of $1,000. The competition was held under the supervision of the Society's Committee on Postdoctoral Fellowships, consisting of J. William Helton, Peter J. Kahn, Neil I. Koblitz, Stephen Lichtenbaum, Kenneth C. Millett, and Ivar Stakgold (chairman).

There were many strong candidates among the forty-three applicants. The fellowship is financed by the generous contributions of supporters of mathematical research, supplemented with Society funds appropriated according to a matching formula. The continuation of the AMS Research Fellowship program depends on contributions the Society receives. Every member of the Society is urged to contribute to the Fund. Contributions are, of course, tax deductible. Checks should be made payable to the American Mathematical Society, clearly marked "AMS Research Fellowship Fund," and sent to the American Mathematical Society, P.O. Box 1571, Annex Station, Providence, RI 02901.

USCMI Pre-Congress Session

As announced in the March 1986 *Notices*, the United States Commission on Mathematical Instruction (USCMI) will sponsor a series of invited survey talks on August 2, 1986. The series is meant to enhance the understanding and appreciation of some of the major research-related work to be discussed at ICM-86. There is no registration fee for this USCMI Pre-Congress Session. It will take place from 2–6 p.m. at the Wheeler Auditorium on the University of California at Berkeley campus.

The presentation times, the speakers, and the titles of their talks are: 2 p.m., Robert Edwards, *Highlights of low dimensional topology*; 3 p.m., Richard Karp, *The polynomial-time frontier: Recent developments in computational complexity theory*; 4 p.m., Clifford Taubes, *The physics and geometry of estimates in nonlinear partial differential equations*; and 5 p.m., Andrew Ogg, *Modular functions and number theory.*

For further information, contact the session organizer, Warren Page, New York City Technical College, 300 Jay Street, Brooklyn, New York 11201. Telephone: (718) 643-3637, or (718) 643-2470.

AMS Membership Category Changes

There have been two changes in AMS membership categories which the Society would like to bring to the attention of its members. At the urging of the AMS President, Irving Kaplansky, the Council has approved life memberships. In response to suggestions from the AMS membership, the Trustees Committee on Membership has formulated a scheme for multi-year memberships which was recently approved by the Council. (See the **AMS Reports and Communications** sections in the October 1985 and March 1986 issues of *Notices.*)

Effective with the 1987 membership year, AMS members who are at least sixty-two years of age and who have been members of the Society for at least twenty years may elect to become life members. The dues for this class of membership have been set as a one-time payment equal to five times the higher ordinary member dues for the membership year in which the life membership becomes effective. This does not effect those persons who became life members before October 25, 1941, when another version of life membership, with no age restriction, was discontinued.

Also effective with the 1987 membership year, individual AMS members may elect to prepay their dues for up to five years. The details for this option had not yet been set by the Executive Committee and Board of Trustees at the time this issue of *Notices* went to the printer. The option will not apply to journal subscriptions.

The request for early payment of your 1987 dues, which you will be receiving shortly, will contain details about these new options. If you wish to take advantage of one of these new categories of membership, please be sure to make the appropriate change in your dues category when making your payment. If you have any questions about either of these dues categories, please do not hesitate to call the Society's membership department at 800-556-7774, or write: American Mathematical Society, Attn: Membership Secretary, P.O. Box 6248, Providence, RI 02940.

Guggenheim Fellowships

The John Simon Guggenheim Memorial Foundation has announced the award of 272 fellowships in its sixty-second annual competition. This year's list of awards includes eight in the mathematical sciences and related disciplines.

Names of these recipients, their positions, institutional affiliations, and their proposed studies are: Solomon Feferman, Professor of Mathematics and Philosophy, Stanford University, (Proof theory of formal systems for mathematics, and editorial work on Kurt Gödel's *Nachlass*); Harvey M. Friedman, Professor of Mathematics and Philosophy, Ohio State University (Studies in the foundations of mathematics); Mark H. Holmes, Associate Professor of Mathematics, Rensselaer Polytechnic Institute (Mathematical modeling of mechanoreceptors); Vaughan F.R. Jones, Professor of Mathematics, University of California, Berkeley (Studies in algebra, analysis, and topology); Victor Kac, Professor of Mathematics, Massachusetts Institute of Technology (Studies in representation theory); Carlos E. Kenig, Professor of Mathematics, University of Chicago (Studies in harmonic analysis and partial differential equations); Charles D. Parsons, Professor of Philosophy, Columbia University (Studies in the philosophy of mathematics); and Jeffrey Scott Vitter, Associate Professor of Computer Science, Brown University, on leave at the Mathematical Sciences Research Institute (Mathematical analysis of algorithms and computational complexity).

Sloan Research Fellowships Awarded

Ninety young scientists of extraordinary promise have been selected under a program known as Sloan Research Fellowships to receive awards of $25,000 each, the Alfred P. Sloan Foundation announced. The fellows are working at forty-nine colleges and universities on problems at the frontiers of physics, chemistry, neuroscience, economics, and pure and applied mathematics.

The Sloan Research Fellowships Program is by far the oldest of the Sloan Foundation and one of the oldest fellowship programs in the country. It began in 1955 as a means of encouraging basic research by young scholars at a time in their careers when teaching duties can be most pressing and when other support can be difficult to obtain. Many fellows have gone on to distinguished careers both in their disciplines and in public life. Ten Sloan Fellows have won Nobel prizes later in their careers and hundreds have received other honors.

This year's winners were selected from 450 nominees by a committee of recognized scientists and economists. The mathematicians on the committee this year were Peter D. Lax, Courant Institute of Mathematical Sciences, New York University; Barry Mazur, Harvard University; and John Milnor, The Institute for Advanced Study.

Twenty awards for mathematicians were made to: GREG W. ANDERSON, University of Minnesota; MICHAEL F. CHRIST, Princeton University; LAURENT CLOZEL, University of Michigan; J. BRIAN CONREY, Oklahoma State University; PETRE S. CONSTANTIN, University of Chicago; MARC CULLER, Rutgers University; LAWRENCE EIN, University of Illinois, Chicago; NICHOLAS M. ERCOLANI, Ohio State University; ROBERT FRIEDMAN, Columbia University; DAVID GABAI, California Institute of Technology; HENRI A. GILLET, University of Illinois, Chicago; JONATHAN B. GOODMAN, New York University; GLEN R. HALL, Boston University; PHILIP J. HANLON, University of Michigan; JOHN L. HARER, University of Michigan; HIDEKI KOSAKI, Tulane University; GREGORY

Combined Membership List Shipping and Handling Charge

As a privilege of membership, individual members of the Society are entitled to receive a free copy of the *Combined Membership List* (*CML*) in even numbered years. While the *CML* is free, the Society can no longer absorb the cost of shipping it to members. If you wish to receive the 1986-1987 *CML* when it is published, kindly remit $2 when you return your membership listing update, or include it with your membership dues. If you choose to add this remittance to your dues, please indicate this clearly when paying your bill.

News from the Mathematical Sciences Institute

Cornell University

The Mathematical Sciences Institute, sponsored by the U.S. Army, announces a Workshop on Fracture in Polymers and Metals to be held August 4–8, 1986. Topics include: modeling of time dependent crack growth; micromechanics of local failure; constitutive models for material breakdown; analytical and numerical methods; and interdisciplinary tutorials. The workshop organizers are C. Y. Hui, Theoretical and Applied Mechanics, Cornell University, Ithaca, NY 14853 and S. L. Phoenix, Mechanical and Aerospace Engineering, Cornell University, Ithaca, NY 14853.

F. LAWLER, Duke University; DINAKAR RAMAKRISHNAN, Cornell University; JAMES A. SETHIAN, University of California, Berkeley; and STANISLAW J. SZAREK, Case Western Reserve University. –Alfred P. Sloan Foundation News

Fulbright and Other Grants for Graduate Study Abroad

The United States Information Agency (USIA) and the Institute of International Education (IIE) announced recently that the official opening of the 1987-1988 competition for grants for graduate study or research abroad in academic fields and for professional training in the creative and performing arts is scheduled for May 1, 1986. It is expected that approximately 700 awards to over 70 countries will be available for the 1987-1988 academic year.

The purpose of these grants is to increase mutual understanding between the people of the United States and other countries through the exchange of persons, knowledge, and skills. The grants are provided under the terms of the Mutual Educational and Cultural Exchange Act of 1961 (Fulbright-Hays Act) and by foreign governments, universities, corporations, and private donors.

Applicants must be U.S. citizens at the time of application, will generally hold a bachelor's degree or its equivalent before the beginning date of the grant and, in most cases, will be proficient in the language of the host country. Except for certain specific awards, candidates may not hold the Ph.D. at the time of application. Candidates for 1987-1988 are ineligible for a grant to a country if they have been doing graduate work or conducting research in that country for six months or more during the 1986-1987 academic year.

Creative and performing artists are not required to have a bachelor's degree, but they must have four years of professional study or equivalent experience. Candidates in medicine must have an M.D. or equivalent degree (e.g. D.D.S., O.D.) at the time of application.

Selection is based on the academic, professional, and/or artistic excellence of the applicant, the validity and feasibility of the proposed study plan, the applicant's language preparation, and personal qualifications. Preference is given to candidates who have not had prior opportunity for extended study or residence abroad.

Application forms and further information may be obtained from the Institute of International Education, 809 United Nations Plaza, New York, NY 10017, or from one of IIE's regional offices in Atlanta, Chicago, Denver, Houston, or San Francisco. The deadline date for receipt of completed applications is October 31, 1986. Requests for application materials postmarked after October 15, 1986, will not be honored.

–IIE News Release

Fulbright Collaborative Research Grants

The United States Information Agency (USIA) and the Institute of International Education (IIE) announce the May 1, 1986, opening of the competition for collaborative research grants abroad for teams of two or three U.S. graduate students or recent postdoctoral researchers under the Fulbright Program.

The Fulbright Collaborative Research Grants will be available for study in all countries in the world, except most East European countries, the U.S.S.R., and Indochina, for the academic year 1987-1988. There are no restrictions on fields of study. Prospective applicants should check with the IIE regarding country availability prior to applying.

Applicants must be U.S. citizens at the time of application, must have received the majority of their high school and undergraduate education at educational institutions in the U.S., and must hold a B.A. degree or equivalent before the beginning date of the grant. Applicants with a Ph.D. at the time of application may have obtained the degree no earlier than June 1984. Applicants in medicine must have an M.D. degree or the equivalent (e.g., O.D., D.D.S.) at the time of application. Applicants in the creative and performing arts need not have a degree, but must have four years of relevant training and/or experience. All applicants must have sufficient proficiency in both the written and spoken language of the host country to carry out research.

The statements of proposed research submitted by team members may be identical, complementary, or present different dimensions of the team's research. It is preferable that applications be submitted through a U.S. academic institution or professional organization. In addition, evidence of affiliation abroad with a host country institution or with an ongoing project that will oversee the research must be presented with the application.

Grants will normally be for six to ten months and will provide monthly fixed sum awards to each member of the team. Grantees will also receive basic health and accident insurance coverage as part of the award. It is expected that each member of the team will carry out their research in one foreign country for a minimum of six months during the same academic year, although all members of the team do not necessarily have to concurrently conduct research in the host country.

Additional information and application forms may be obtained from the U.S. Student Programs Division, Institute of International Education, 809 United Nations Plaza, New York, NY 10017, or from one of IIE's regional offices in Atlanta, Chicago, Denver, Houston, or San Francisco. Completed applications from all team members must be submitted to IIE's New York headquarters by January 16, 1987. —IIE News Release

Fulbright Teacher Exchange Program

The United States Information Agency is pleased to announce the 1987-1988 Fulbright Teacher Exchange Program.

The Teacher Exchange Program involves a one-on-one exchange for teachers at the elementary, secondary, and postsecondary levels with suitable teachers overseas. The 1987-1988 overseas exchange programs will involve Canada, the United Kingdom, France, the Federal Republic of Germany, Belgium/Luxembourg, Denmark, Norway, Switzerland, Colombia, and Argentina. The number of exchanges available and the eligibility requirements vary by country.

The program also provides opportunities for teachers to participate in summer seminars from three to eight weeks in length. During the summer of 1987, seminars will be held in Italy and in the Netherlands.

Applications will be available in the summer. The deadline for receipt of completed applications is October 15, 1986. For further information, write Fulbright Teacher Exchange Program, E/ASX, United States Information Agency, 301 Fourth Street, S.W., Washington, D.C. 20547. Telephone: (202) 485-2555.

Rollo Davidson Trust

Rollo Davidson Prizes have been awarded to Peter Hall of the Australian National University, Canberra, and to Jean-François Le Gall of the Université Pierre et Marie Curie, Paris. Peter Hall is being honored for his work on continuum percolation. Jean-François Le Gall received the award for his use of local-time arguments to obtain uniqueness theorems for stochastic differential equations and for his work on the multiple points of brownian motion.

The first Rollo Davidson Prize was awarded in 1976. Sixteen prizes have been awarded in all. The work of the Trust is supported by individual donations and by royalties associated with the books *Stochastic Analysis* and *Stochastic Geometry*, published in 1973 and 1974 as memorial tributes to Rollo Davidson. Communications relating to the work of the Trust should be addressed to its Secretary, The Bursar, Churchill College, Cambridge CB3 ODS, England.

L. V. Kantorovich
1912–1986

Leonid Vital'evich Kantorovich, of the Academy of Sciences of the U.S.S.R. in Moscow, died April 7, 1986, at the age of 74.

Kantorovich was born January 19, 1912, in St. Petersburg (now Leningrad). At the age of 14, he enrolled at Leningrad University, graduating in 1930. By the age of 15, Kantorovich had already begun active research, obtaining important results in the descriptive theory of functions in 1927-1928. Since that time, Kantorovich published more than 260 articles and books on set theory, descriptive and constructive theory of functions, functional analysis, numerical mathematics, the theory of extremal problems, mathematical economics, and computer science.

Kantorovich was appointed Professor of Mathematics at Leningrad University in 1932, where he worked until 1960. In 1935, he was awarded the degree of Doctor of Physico-Mathematical Sciences for the totality of his scientific work. From 1930–1939, Kantorovich also taught at the Leningrad Institute of Civil Engineers. It was there that he encountered a practical problem of optimal cutting of timber and plywood that prompted his fundamental work in linear programming. Kantorovich's first publications on this subject appeared in 1939. From 1940–1960, Kantorovich also worked at the Leningrad Branch of the Steklov Institute of Mathematics (LOMI).

The Laboratory for the Application of Statistical and Mathematical Methods in Economics was established in the framework of the newly created Siberian Division of the U.S.S.R. Academy of Sciences in 1958. The joint heads of the laboratory were V. S. Nelmchinov and Kantorovich.

In 1960, Kantorovich moved with the Leningrad group of the laboratory to Novosibirsk where the group was incorporated into the Institute of Mathematics as the Department of Mathematical Economics. Kantorovich was appointed Deputy Director and head of the Department of Mathematical Economics at the Institute. At the same time, he became the head of the Department of Computational Mathematics at Novosibirsk University. He occupied these positions until he moved to Moscow in 1971.

From 1971–1976, Kantorovich worked at the Institute for the Management of the National

Economy and, from 1976 until his death, at the Institute of System Research. He was also a member of the State Committee for Science and Technology and chairman, vice-chairman, and member of numerous scientific committees of various Ministries and State Committees. He was awarded the Stalin Prize, now called the State Prize, in 1949. In 1965 he shared the Lenin Prize, and in 1975 he shared the Nobel Prize in Economics.

Kantorovich's scientific achievements were widely recognized throughout the world. Many universities awarded him honorary doctoral degrees and numerous scientific societies and academies elected him to membership.

Directory of Women in the Mathematical Sciences

In 1981 the AMS-MAA-SIAM Committee on Women in Mathematics published a *Directory of Women in the Mathematical Sciences* with financial support from the AMS, the MAA, SIAM, and several publishers. It superseded the original *Directory of Women Mathematicians* which was published by the AMS in 1973-1974 and which was followed by several supplements. The Association for Women in Mathematics (AWM) has now assumed the responsibility for publication of an updated edition of the *Directory of Women in the Mathematical Sciences.*

The questionnaire which appears in the back of this issue will form the basis for the new directory. Women who have earned a Ph.D. degree, or its equivalent, and candidates expecting to receive a Ph.D. at a later date will be kept on file.

The purpose of the directory is to make it possible for employers, individuals arranging colloquia, conferences or mathematics meetings, and officers of professional organizations seeking nominees for committees to find, in summary form, the curricula vitae of women in the mathematical sciences.

The AWM has designed a questionnaire for the directory so that entries in subsequent issues will require little updating. Each listing will include the woman mathematical scientist's name, address, and employer or institution; position; one or two fields of mathematical interest; and titles of her two most important publications.

Women who wish to be listed in the new directory should complete the questionnaire and send it immediately to the *Directory of Women in the Mathematical Sciences*, c/o R. Struik, Mathematics Dept., Campus Box 426, University of Colorado, Boulder, CO 80309.

Mathematics into Type

It is anticipated that *Mathematics into Type* by Ellen E. Swanson will be revised and updated in the near future. Since the book's last revision in 1979, mathematical typesetting has undergone numerous changes, due mostly to the availability of computers to authors as well as typesetters. The author is interested in comments from mathematicians or their representatives who have used her book in the preparation of mathematical manuscripts. She would like feedback as to what sections of the book are most valuable, what areas need to be expanded, what areas, if any, are not useful, etc. Please send your comments to Ms. Ellen Swanson, c/o Editorial Department, American Mathematical Society, P.O. Box 6248, Providence, RI 02940.

Erratum

In "A New Knot Polynomial and von Neumann Algebras," by V.F.R. Jones, *Notices*, March 1986, Volume 33, Number 2, page 223, please note the following correction. The example $P_{\text{trefoil}} = 2l^2 - l^4 + m^2l^2$ should read $P_{\text{trefoil}} = -2l^2 - l^4 + m^2l^2$.

R H Bing 1914-1986

R H Bing, Professor of Mathematics, University of Texas at Austin, died on April 27, 1986, at the age of 71. He was President of the Society in 1977-1978. The news of his death reached the officers of the Society on the date that this issue of *Notices* was being sent to the printer. An article will appear in the August issue.

Reprogramming NSF FY 1986 Funding

It was reported in the March issue of *Notices* that the anticipated impact of the Gramm-Rudman-Hollings legislation on the Division of Mathematical Sciences would be a funding reduction of approximately $2.2 million. This resulted from a 4.3% reduction in the overall National Science Foundation (NSF) budget and would have been implemented through a variety of measures, including a 10% reduction in continuing and new grant awards. Director Erich Bloch viewed this funding decrease as particularly damaging to mathematics research and chose to request the reprogramming of the NSF budget to exclude the allocation to the Division of Mathematical Sciences from the reduction. This request was approved by a congressional committee and the $2.2 million slated to be cut was restored. A few other programs also received favorable treatment, and as a result the remaining programs in the Foundation will sustain a 4.8% cut. One should remember that the constitutionality of the Gramm-Rudman-Hollings Act is still in question and that the whole budget cutting process may be a mental exercise. However, it appears that mathematics does not need to worry about the legality of the legislation as it affects FY 1986. This preferential treatment may not be repeated next year.

It should be pointed out that the $4 million increase (8.4%) over last year's budget in the Division of Mathematical Sciences does not move rapidly toward solving the funding problems highlighted in the David Report. Statistics from the AAUP indicate a 6.7% increase in salaries at Ph.D. granting institutions. As a result, salary support may exhaust the budget increase to the Division of Mathematical Sciences, with little left for additional grants.

Computer-Related Activities to be Coordinated

Erich Bloch, director of the NSF, plans to establish a new organizational unit, consolidating several computer-related activities into a Directorate for Computer and Information Science and Engineering (CISE).

In another organizational change, Mr. Bloch said the NSF's Division of Astronomy will be moved to the Directorate for Mathematical and Physical Sciences (MPS) from the Directorate for Astronomical, Atmospheric, Earth, and Ocean Sciences (AAEO). The latter unit's name will be changed to the Directorate of Geosciences (DOG).

The new directorate would include the Division of Computer Research, now in the Directorate for Mathematical and Physical Sciences; the Division of Information Science and Technology, now in the Directorate for Biological, Behavioral, and Social Sciences; the Office of Advanced Scientific Computing, now in the Office of the Director; and some programs from the Directorate for Engineering.

The new directorate is being established to create closer ties among such activities as computer science, information science, computer engineering, supercomputers, and networking.

C. Gordon Bell, a widely known computer architect, will head CISE when it is officially established on July 1. Mr. Bell was chief technical officer of Encore Computer Corporation, a computer manufacturer in Marlboro, Massachusetts, from July 1983 to January 1986. He helped develop the highly successful minicomputers of the Digital Equipment Corporation (DEC), including the PDP-4, PDP-5, and PDP-8 as well as larger computers such as the PDP-6 and the DEC system 10. These computers established DEC as a leading manufacturer of minicomputers and of computers used in scientific research throughout the world.

As vice president of engineering at Digital Equipment Corporation, Mr. Bell led the design work for the VAX-11 which set the world standard in research laboratories and departments for scientific and engineering calculations. From 1966 to 1972, he was a member of the faculty of Carnegie-Mellon University where he conducted the first experiments on multiple processor architecture and cooperated on fundamental work related to the classification of computational systems and their design.

Minority Graduate Fellowships Awarded

The NSF recently announced the award of fifty-five fellowships to minority students of outstanding ability for graduate studies in the sciences, mathematics, and engineering.

More than 670 American Indian, Black, Pacific Islander, and Hispanic students submitted applications in a nationwide competition for these fellowships, which are awarded on the basis of merit.

Panels of scientists, assembled by the National Research Council of the National Academy of Sciences, reviewed and evaluated the applications, with final selections made by the NSF. In addition to the fellowships awarded, NSF accorded Honorable Mention to 192 applicants.

Each fellowship provides a stipend of $11,100 per year for full-time graduate study. An annual cost-of-education allowance of $5,250 is also provided to the U.S. institution by NSF in lieu of all tuition fees. The cost-of-education allowance for U.S. institutions was reduced from the previously announced level of $6,000 to accommodate the deficit reduction provisions of the Gramm-Rudman-Hollings Act.

NSF Minority Graduate Fellows may attend any appropriate nonprofit U.S. or foreign institution of higher education. Three years of graduate study are supported by each fellowship. The fellowships may be used over a five year period, so students can incorporate teaching or research assistantships into their education during periods in which they are not receiving their fellowship support.

The new Minority Fellows come from 25 states and the District of Columbia. Of the 55 awards, 23 were made to women. The distribution among ethnic groups was as follows: American Indians, 4; Blacks, 17; Hispanics and Pacific Islanders, 34. There were 19 awards in the behavioral and social sciences, 11 in engineering, 10 in the life and medical sciences, 15 in mathematics and physical sciences, including chemistry, physics, and earth sciences.

The 1987-1988 recipients in the mathematical and computer sciences are listed below (institutions listed in parentheses are those awarding bachelor's degrees, those listed outside the parentheses are those at which graduate study will be pursued): RITA TERESE DURAN (Trinity University), Northwestern University; SELMA MARIA GOMEZ (Harvard University), Harvard University; JACQUELINE M. HUGHES (University of Cincinnati), University of California, Berkeley; RICARDO A. PINCHEIRA (Vanderbilt University), University of California, Berkeley.

–NSF News Release

Graduate Fellowship Awards Announced

Five hundred and five outstanding college students are being offered fellowships for graduate study in the natural and social sciences, mathematics, and engineering, the NSF recently announced.

Nearly 4,900 students submitted applications in the nationwide competition for the NSF Graduate Fellowships, which are awarded on the basis of merit.

Panels of scientists, assembled by the National Research Council of the National Academy of Sciences, evaluated the applications; final selections were made by NSF. In addition to the fellowship awards offered, NSF awarded Honorable Mention to 1,417 applicants in recognition of their potential for scientific and engineering careers.

The fellowships provide a stipend of $11,100 per year for full-time graduate study. An annual cost-of-education allowance of $5,250 is also provided by NSF in lieu of all tuition fees to the U.S. institution selected by each fellow. The cost-of-education allowance for U.S. institutions was reduced from the previously announced level of $6,000 to accommodate the deficit reduction provisions of the Gramm-Rudman-Hollings Act.

NSF Graduate Fellows may attend any appropriate nonprofit U.S. or foreign institution of higher education. Each fellowship is awarded for three years of graduate study. The fellowships may be used over a five year period to permit students to incorporate teaching or research assistantships into their education during periods in which they are not receiving their fellowship stipends.

The new fellows come from 45 states and the District of Columbia. Of the 505 award offers, 173 were made to women. By scientific discipline, the distribution of awards was as follows: 107 in engineering; 18 in mathematics; 9 in applications of mathematics; 33 in computer science; 40 in physics and astronomy; 41 in chemistry; 26 in earth sciences; 134 in biological sciences, including biochemistry; and 97 in the social sciences and psychology.

The recipients in the mathematical and computer sciences are listed below (institutions listed in parentheses are those awarding bachelor's degrees, those listed outside the parentheses are those at which graduate study will be pursued): GREGORY DOMINIC ABOWD (University of Notre Dame), University of Illinois, Urbana-Champaign; ROBERT NEIL ASHCROFT (Cornell University), Massachusetts Institute of Technology; SCOTT ELLIOT AXELROD (Rutgers University), Princeton University; BRENT ARNOLD BANISTER (Washington State University), Washington State University; WALTER BRIAN BARNAS (Dartmouth College), Princeton University; CHARLES ANTHONY BIER (Rice University), Princeton University; CHRISTINA LOUISE BLACK (Cornell University), Stanford University; PABLO ALBERTO CALDERON (University of Buenos Aires), New York University; JOHN BRUCE CARTER (Rice University), Rice University; MARA CHIBNIK (Brown University), Harvard University; ROBERT EDWARD CYPHER (Stanford University), University of Washington; ART DUVAL (California Institute of Technology), University of Wisconsin, Madison; MARK ALAN EPSTEIN (University of Chicago), University of Chicago; STEPHEN JEFFRAY FROMM (Princeton University), Massachusetts Institute of Technology; DOUGLAS AZIZ GALBI (Princeton University), University of California, Berkeley; ERANN GAT (Virginia Polytechnic Institute and State University), Stanford University; RICHARD GRANT GIBSON (Central Missouri State University), University of California, Berkeley; ADAM MICHAEL GOTTLIEB (Harvard University), Massachusetts Institute of Technology; MICHELANGELO GRIGNI (Duke University), Massachusetts Institute of Technology; EDWARD FRANKLIN GROVE (Brown University), University of California, Berkeley; KARL ROBERT GUTSCHERA (Harvard University), Princeton University; MAX HAILPERIN (Massachusetts Institute of Technology), Stanford University; MARK DAVID HANSEN (Cornell University), Harvard University; MICHAEL JOHN HANSON (University of Washington), Stanford University; MARTHA JEAN HILLER (Massachusetts Institute of Technology), Massachusetts Institute of Technology; EVERETT WILLIAM HOWE (California Institute of Technology), University of Illinois, Urbana-Champaign; JOSEPH DAVID JACOBS (Northwest Missouri State University), Stanford University; DANIEL ELLIOTT LOEB (California Institute of Technology), Massachusetts Institute of Technology; HAW-MINN LU (Massachusetts Institute of Technology), Massachusetts Institute of Technology; PETER MATTHEW MAGYAR (Princeton University), Harvard University; CHRISTOPHER M. MALONE (Harvard University), Stanford University; RICHARD STUART MARGOLIN (Yale University), Princeton University; NICHOLAS FREITAG MCPHEE (Reed College), Stanford University; DEBORAH F. MINEHART (Harvard University), University of California, Berkeley; ROBERT DEVORE MITCHELL (Case Western Reserve University), University of Wisconsin, Madison; CHETAN RAM MURTHY (Rice University), Cornell University; LEE AARON NEWBERG (Massachusetts Institute of Technology), Princeton University; MICHAEL DOWNES PETERSON (Princeton University), Massachusetts Institute of Technology; KAREN LEE PIEPER (Rice University), Stanford University; KEITH ANDREW RAMSAY (University of Chicago), Princeton University; PAUL JONATHAN RESNICK (University of Michigan), Carnegie-Mellon University; RONALD ROSENFELD (Tel Aviv University), Massachusetts Institute of Technology; EDWARD ERIC ROTHBERG (Stanford University), Stanford University; JAMES ROBERT RUSSELL (Massachusetts Institute of Technology), Stanford University; ERIC JOHN SCHWABE (Carnegie-Mellon University), Massachusetts Institute of Technology; DAVID SHAO (Michigan State University), Cornell University; STEPHANIE FRANK SINGER (Yale University), Stanford University; MICHAEL JUDE SLIFKER (University of Pennsylvania), Cornell University; ROBERT HAL SLOAN (Yale University), Massachusetts Institute of Technology; LINCOLN TODD SMITH (University of Illinois, Urbana-Champaign), University of Michigan; EDITH NELSON STARR (Harvard University), Massachusetts Institute of Technology; IAN LANCE TAYLOR (Yale University), Massachusetts Institute of Technology; CYNTHIA PAIGE THARPE (James Madison University), Duke University; RICHARD ALARIC VAUGHAN (University of Virginia), Stanford University; BYRON LEE WALDEN (Vanderbilt University), University of California, Berkeley; FRANK YU-HENG WANG (Princeton University), Harvard University; JACOB ANDREAS WEGELIN (University of Washington), University of Chicago; ELIZABETH SUSAN WOLF (University of California, Berkeley), Stanford University; DAVID S. WOLFE (Cornell University), University of California, Berkeley; NEAL ERIC YOUNG (Cornell University), University of California, Berkeley.

–NSF News Release

Small Business Innovation Research Awards

The NSF has made 124 initial phase awards of up to $40,000 each under its Small Business Innovation Research (SBIR) program. The awards, which total approximately $4.8 million, are for advanced research in essentially all NSF science and engineering areas.

One hundred and seven firms in 27 states received the awards which were selected from 938 proposals received under the 1985 SBIR solicitation.

SBIR grants support high risk, potentially high payoff research in science-based or technology firms with 500 or fewer employees. A second objective is to accelerate the conversion of federally supported research into commercial applications with private investment.

SBIR is a unique approach to federal R&D designed at NSF in 1977. The program is intended to increase opportunities for small business to participate in NSF research as well as to use small high-technology companies to convert research into technology. This three-phase program became the model for the Small Business Innovation Development Act (P.L. 97-219) which was signed into law by President Reagan on July 22, 1982. The act requires all federal agencies with $100 million or more in external R&D budgets to conduct a similar SBIR program on their own R&D needs. During the first three years under the act, twelve participating agencies received more than 35,000 proposals and have made approximately 3,500 awards.

The 124 new NSF awards are for Phase I of the three-phased SBIR program. These awards provide up to $40,000 and 6 months to determine, as much as possible within these limitations, whether the research idea is technically feasible and whether the small firm can perform high quality research before further government support takes place.

Phase II is the principal research effort for those projects that are most promising after the first phase. These awards at NSF have averaged $200,000 for 1-2 years. Phase III involves the follow-on private funding from venture capital or large industrial firms for product development and commercialization. No SBIR funds are provided in Phase III.

Of the 124 awards ranging over 21 disciplines, the following 9 awards were made in the mathematical and computer sciences. The winning firms, their locations, and project titles are:

Weidlinger Associates, Palo Alto, California, *Numerical Methods for Inverse Problems in Three-Dimensional Geophysical Modeling*; XOX Corporation, Minneapolis, Minnesota, *Intersection of Higher Dimensional Shapes for Geometric Modeling*; Computer Technology Associates, Inc., Englewood, Colorado, *A New Approach in Automated Theorem Proving*; Daniel H. Wagner, Associates, Sunnyvale, California, *Dealing With Uncertainty in Expert Systems*; Datawise, Inc., Orlando, Florida, *An Algorithm for Supporting Views in the Microcomputer Environment*; Incremental Systems Corporation, Pittsburgh, Pennsylvania, *Incremental Semantic Analysis and Overload Resolution for Ada*; Machine Vision International, Ann Arbor, Michigan, *Integrated Computer Vision Research for Manufacturing*; Scientific Computing Associates, Inc., New Haven, Connecticut, *Building an Interactive Software System for Scientific Computation on Supercomputers*; and Scientific Computing Associates, Inc., New Haven, Connecticut, *Building a Linda Compiler and Communication Kernel for Parallel Programming on Hypercube-Connected Multicompilers.* - NSF News Release

U.S.-China Cooperative Science Program

The purpose of the U.S.-China Cooperative Science Program is to promote opportunities for cooperation in basic science between scientists of the United States and of the People's Republic of China on projects of mutual interest and benefit. The underlying rationale of the program is that scientific cooperation on the basis of equality, reciprocity, and mutual benefit can strengthen the scientific capabilities of both countries, advance world scientific knowledge, promote understanding between the United States and China, establish enduring relationships between American and Chinese scientists and institutions, and, in general, contribute to broad national goals on both sides.

The program supports joint research projects of up to two years' duration in all fields of science (including social sciences) and engineering normally supported by NSF. Proposals should follow format and budgetary guidelines provided in the program announcement (NSF 82-50: U.S.-China Cooperative Science Program) which may be obtained by calling (202) 357-7393 or writing to U.S.-China Cooperative Science Program, Division of International Programs, National Science Foundation, 1800 G Street, N.W., Room 1214, Washington, DC 20550.

It is the policy of the NSF to encourage minorities and women to compete in this program.

NSB Cites Serious Flaws in Undergraduate Science, Math, and Engineering Education

Undergraduate education in science, mathematics, and engineering contains "serious deficiencies" that are harming this country's economy and security, according to a recent report of the National Science Board (NSB), the NSF's policymaking body.

The report cited three areas that require immediate attention "of the highest priority" by the NSF and other federal agencies, by the states, and by the private sector. The areas of gravest concern, according to the report, are laboratory instruction, faculty preparation, and courses and curricula.

The report was prepared by the NSB's Committee on Undergraduate Science and Engineering Education, chaired by Dr. Homer A. Neal, provost at the State University of New York at Stony Brook. The Committee held four public hearings at which industry, government, and academic leaders presented their views on undergraduate education.

The Committee recommended that the NSF's annual expenditures at the undergraduate level in science, mathematics, and engineering education reach a "total of $100 million in new funds by FY 1989" with appropriate distribution among the following areas of highest priority: laboratory development, instructional instrumentation and equipment, faculty professional enhancement, course and curriculum development, comprehensive improvement projects, undergraduate research participation, minority institutions program, and information for long-range planning.

"The Committee has concluded that the Foundation's role must be strong leadership of a nation-wide effort, an effort that will require participation by public and private bodies at all levels," the report says.

According to the NSB report, responsibility for the academic health of undergraduate education lies primarily with the nation's colleges and universities and their governing bodies. Responsibility for the financial health of the educational institutions lies primarily with states, municipalities, and the many supporters of private higher education.

Single copies of the NSB Committee's report may be obtained from the Office of Legislative and Public Affairs, Room 527, National Science Foundation, 1800 G Street, N.W., Washington, D.C. 20550. Telephone: (202) 357-9498.

- NSF News Release

National Mathematics Awareness Week

During March, mathematicians across the country received a mailing asking for their assistance in the passage of legislation that would establish April 14–20, 1986, as National Mathematics Awareness Week. This plea was answered by an overwhelming response by the mathematical community and resulted in the April 10th passage of House Joint Resolution 519. This resolution was introduced to the House by Representatives Don Fuqua (D-Fla.), Manuel Lujan, Jr. (R-N.Mex.), Doug Walgren (D-Pa.), and Sherwood Boehlert (R-N.Y.). An identical bill, Senate Joint Resolution 261, was introduced to the Senate by Senator Pete Domenici (R-N.Mex.) on January 29, 1986, and passage was subsequently secured in February.

The method by which such recognized days, weeks, and months become official is a significant process. Before legislation can be sent to the floor of the House, a majority of members must sign on as cosponsors. Passage is usually obtained only a few days before the official starting date of the event. As a result, only a fraction of the bills requesting the recognition of special events ever receive congressional approval. It was interesting that, even with a spring recess for Congress in early April, the required number of 218 cosponsors was obtained on April 8 and, by the time of passage on April 10, 242 members of the House signed on to the bill. The bill was brought to the floor by Representative Robert Garcia (D-N.Y.), whose involvement was largely prompted by the letters and phone calls he received from his constituency. Also instrumental in bringing this effort to completion was Representative William Ford (D-Mich.).

The passage of this bill is a prime example that the mathematical community can, by working together, make its voice heard in the chambers of Washington, and positively effect the future well-being of mathematics.

Activities during Mathematics Awareness Week included the distribution of a public service announcement to over 200 television stations across the country. This unusual and colorful announcement opened and closed with fractal representations created by H. O. Peitgen. Other highlights of the week were the Natural History Museum's exhibit on the *History of Mathematics Teaching in the U.S.* at the Smithsonian Institution and the presentation of the Franklin Medal to Benoit Mandelbrot for "his development of fractal geometry."

The week concluded with a congressional reception on Capitol Hill at which Senator Domenici was presented with a framed fractal in recognition of his efforts on behalf of Mathematics Awareness Week. Domenici responded with a few comments on the problems facing mathematics due to budget restraints in Congress and expressed his desire to do more to stimulate mathematics and to improve young minds. Recognizing that the budget crisis is constraining new program development, he went on to say that, with the return of financial stability, it will be possible to act more vigorously and with less worry as to cost.

Mathematics Awareness Week served as a focal point, highlighting the accomplishments of mathematics and American mathematicians. At this time of crisis for the mathematical profession, public awareness is essential for regaining adequate funding for mathematics research and for increasing the attractiveness of mathematics as a professional career.

Congressional Strategy for the Mathematical Community

Jennifer W lsong Vance, Esquire

The Congress has shown a growing interest over the past few years in many areas of science and mathematics: recruitment of students, supply of college teachers, public understanding of science and mathematics, collegiate curriculum, and continued support for mathematics research.

Congressional interest in these issues is important not only because it suggests future possible roles for the mathematics community in congressional relations, but also because it may signal the beginning of a shift in the way science and mathematics policy is developed in this country.

Goals of the Mathematical Community

It is easy to identify specific goals of the mathematical community that directly support major policy priorities of Congress—scientific advancement, increased economic productivity, and a secure national defense. The impact of mathematical research on society, the significance of mathematics education at all levels of training, and the general education of the citizenry bear directly on these congressional goals.

Jennifer Vance is an attorney specializing in federal practice in education and science who has been retained by the Joint Policy Board for Mathematics for assistance in dealing with congressional issues. From 1975 to 1982 she was a Senior Legislative Associate for the House Committee on Education and Labor, and from 1982 to 1985 she worked on science education policy and congressional liaison for the National Science Foundation.

To support these goals, the mathematical community needs to document for Congress the consequences of the present crisis in training new mathematicians, the importance of recent developments in mathematics—especially those that bear on scientific computation—and the risks associated with continued under-funding of mathematics research and mathematics education.

Goals of the Congress

Whereas in the past the Executive Branch (e.g., primarily the National Science Foundation) has been responsible for establishing priorities within the general science budget, recent changes in the congressional process may alter the tradition whereby Congress has deferred in budget allocations to the scientific community. Serious budget deficits, which resulted in the passage of the Gramm-Rudman-Hollings amendment, may have a dramatic impact both on total funding for science and mathematics and on the way the budget decisions are made.

Members of Congress are growing more interested in the technical aspects of science policy as they seek new ways to lower unemployment, restore the balance of international trade, improve the education of students, and revitalize the industrial work force. At the same time there has been a breakdown in the peer review system, with repeated direct appeals to Congress by individual universities for support of specific scientific projects.

The mathematical community may be surprised to learn of the very strong interest within the Congress in mathematics and science education. Close to $150 million has been appropriated to the Department of Education for a mathematics and science education program directed across the spectrum from the elementary to the postsecondary level. Needs in mathematics are specifically cited in the fiscal year 1986 Department of Defense appropriations reports where it concerns the University Research Initiative—a new $100 million program to create science and technology centers. And, more generally, there is increasing interest in collegiate mathematics and science education both within Congress and at the National Science Foundation.

Dealing with Congress

Strong relationships with key congressional staff, both in committees and in members' personal offices, are very important for building a base of informed understanding necessary for effective action. Unfortunately, the tenure of congressional staff is often short, so constant renewal of contact is required to maintain continuity.

The congressional process itself is also very important. One must know the rules that govern the operation of the House and the Senate, the authorization, appropriation and budget processes, and the ad hoc political nuances that affect legislative issues. Misunderstanding the congressional process can create significant obstacles to achieving one's goals.

Another very important factor is the role and cohesiveness of the mathematical community. Recent examples, particularly in the area of astronomy, have shown that the Congress responds well to field-initiated consensus and ordering of priorities. A few years ago the astronomers provided the Congress with a report in which they documented policy and project priorities, thus enabling the Congress to understand better the importance of various projects and the relationship among them.

Congress is able to devote only a small amount of time to understanding any particular issue. The clearer the mathematical community can paint the global picture, the better Congress will understand the consensus of mathematicians. These understandings will help enable Congress to resist pork barrel requests that distort the balance of funding and undermine sound national policy.

The David Report, *Renewing U.S. Mathematics: Critical Resource for the Future*, is an excellent document that continues to be effectively used with Congress to expand their understanding of the history of mathematics research funding. Other shorter and more specific reports need to be written to clarify funding needs and priorities within and among various branches of mathematics and mathematics education.

The Legislative Process

If one seeks to exert influence within the legislative process, it is important to understand some of the general patterns of activity on Capitol Hill. At the risk of being over-simplistic, the following observations provide a framework for understanding specific strategies.

First, Washington is a town driven by information and misinformation. Those able to carefully articulate their case in precise and easily understandable terms are most likely to be understood—an important contribution to success in reaching their objectives.

Second, the federal budget deficit is the single most important issue affecting the way Congress views policy. Congress is no longer thinking about the New Deal or the Great Society. Now it is primarily concerned with the ordering of priorities against a background of fiscal restraint.

Third, although political "deals" continue to be part of the Congressional process, legislative decisions will increasingly come under sharper fiscal and intellectual scrutiny.

Last, and most important, the legislative agenda is often crisis driven. What may be subject to careful deliberation over several months in the private sector is often condensed on Capitol Hill to short one-page summaries prepared overnight. It is very important for the mathematical community to develop the contact that will enable it to respond in timely fashion when these crises occur.

Recommendations to the Mathematical Community

The ability of the mathematical community to reach its important long-term goals will require consistent effort directed primarily at creating an awareness among policy makers—virtually all of whom are nonmathematicians—of the importance of mathematics to the well-being of the intellectual, scientific, and technological infrastructure of the nation. The community must:

- increase its understanding of the congressional authorization, appropriation, and budget process and the impact these have on mathematics budget and funding;
- help members of Congress and their staffs understand the importance of mathematics to the well-being of the nation;
- identify several key members of Congress who have shown particular interest in mathematics and cultivate their support by increasing their understanding of mathematics.

The problems of communicating the role of mathematics to the Congress are formidable. But mathematics itself can carry the day: it is recognized as useful, it is widely supported by everyone interested in educational reform, and it isn't burdened with controversial baggage that would make politicians avoid it. What is needed is for the mathematical community to develop a consensus on a legislative program and then present it to Congress.

Graduate S/E Enrollment Shows Smallest Increase Since 1977

This report presents data collected in the National Science Foundation's (NSF's) Survey of Graduate Science and Engineering Students and Postdoctorates, Fall 1984. Estimates are based on responses from all 325 doctorate-granting institutions in the United States and a stratified random sample of the 293 U.S. institutions with one or more master's-level programs in science and engineering (S/E) fields. Data are believed to be accurate within ± 3 percent at the 95-percent confidence level. Responses were received from 93 percent of the departments surveyed, and estimates for nonresponse made up less than 6 percent of the graduate S/E total shown in this report. Unless otherwise specified, "graduate S/E enrollment" includes all students enrolled either full- or part-time in programs leading to graduate S/E degrees.

Highlights

All Graduate Institutions. The estimated 415,000 S/E graduate students enrolled in all institutions of higher education in fall 1984 represented almost no change from the prior year. Various factors which have contributed to the slowdown in enrollment growth are expected to continue, and an increase of less than 1 percent is estimated for fall 1985 graduate S/E enrollment. By contrast, the 1977–1983 yearly increase averaged 2 percent. The current leveling off follows the general slowdown in the rate of expansion of academic enrollment at all levels.

The leveling off in overall graduate S/E enrollment occurred primarily as a result of smaller enrollment among nondoctorate institutions coupled with a slight drop in the enrollment growth rate in doctorate-granting institutions.

Graduate engineering enrollment rose by 2 percent to about 95,000 in 1984, compared to a 5-percent average annual growth rate between 1977 and 1983. Graduate science enrollment was virtually unchanged from 1983, after an average increase of 2 percent per year during 1977–1983.

Doctorate-Granting Institutions. Graduate S/E enrollment in doctorate-granting institutions reached 363,000 in 1984, up 2 percent from 1983. This compares to a 3-percent average annual growth rate over the previous six years. This growth reflects a 1-percent rise in the number of students enrolled full-time and a 2-percent increase in part-timers since 1983, compared to average annual rates of increase of 2 percent and 4 percent respectively, during 1977–1983.

Among individual S/E fields, full-time graduate enrollment in computer science continued to increase at the fastest rate. The 9-percent increase from 1983 to 1984 represented a sharp reduction from the 14-percent average annual increase reported in the 1977-83 period. In view of the slackening of the growth rate in total S/E enrollment, however, the 1983-1984 increase indicates that the market for computer scientists is still relatively strong. Graduate engineering enrollment growth also slowed, from a 7-percent average annual rise between 1977 and 1983 to 2 percent in 1984.

The number of women enrolled full time grew by 2 percent in 1984, a rate of growth that was about one-half the 4-percent average of the 1977–1983 period. The number of men rose by 1 percent, equalling the rate of the previous six years.

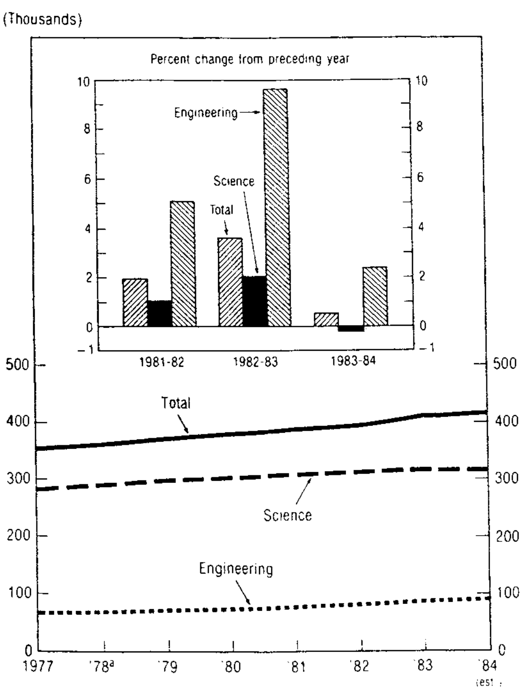
Full-time S/E graduate students receiving their primary support from the Federal Government increased by 1 percent, repeating the growth rate of the previous year. The 48,000 total reported for 1984 is 10 percent below the 1980 peak of nearly 53,000. NSF and the National Institutes of Health (NIH) were primarily responsible for the 1983-1984 growth, up 4 percent and 3 percent, respectively. Full-time S/E graduate students receiving their main support from their institutions rose by 4 percent, and from other U.S. sources, by 6 percent. Decreases were reported in self and family support (1 percent) and foreign support categories (8 percent).

All support categories (research assistants, teaching assistants, etc.) except "other types of support" showed slight increases in 1984. The 1-percent increase in the number of fellowships and traineeships awarded was the first growth since 1977.

The 61,000 foreign students enrolled full time in graduate S/E programs in doctorate-granting institutions in 1984 represented a 2-percent increase, down considerably from their 8-percent annual rise during the 1977-1983 period. The number of U. S. citizens rose by 1 percent.

Total Graduate S/E Enrollment. Total graduate enrollment in S/E programs in all institutions in the United States in fall 1984 is estimated at 415,000, virtually the same as in 1983 (Chart 1).[1] A slowdown in the rate of graduate enrollment growth was also reported by the Council of Graduate Schools, which showed a slight decline in 1984 in graduate enrollment in all fields at master's-granting institutions and an increase of less than 1 percent in doctorate-granting institutions, for an overall level of enrollment almost unchanged from 1983.[2] Data from the Department of Education's Center for Statistics (CS) also show an increase of less than 1 percent in total graduate enrollment.

Chart 1. Graduate enrollment in the sciences and engineering in all institutions



aIncludes interpolated data for master's-granting institutions
SOURCE: National Science Foundation

Full-time Graduate Students in Doctorate Institutions. The remainder of this report concentrates on full-time graduate S/E enrollment in doctorate-granting institutions, which comprises 59 percent of total graduate S/E enrollment in all institutions.

The 247,000 graduate students enrolled full time in programs leading to a master's or doctorate S/E degree represented an increase of 1 percent over the 1983 total, compared to nearly 2 percent in the number of part-timers. Both groups showed substantial declines from their 1977-1983 average annual growth rates of 2 percent and 4 percent, respectively.

S/E Fields

Although full-time enrollment in most S/E fields was up slightly from the 1983 levels, the rates of increase were significantly lower than those of the 1977-1983 period. Engineering enrollment, which showed an average annual growth of 7 percent over the previous three years, rose by only 2 percent in 1984. In the computer sciences, the 1983-1984 growth was 9 percent, compared to 14 percent per year from 1977 through 1983. Only in the social sciences was an actual decline recorded—2 percent—continuing a drop which began in 1981 (table 1).

The slowdown in graduate engineering enrollment growth may be partly attributable to the declining rates of growth in the number of foreigners enrolled. From 1983 to 1984, the number of foreign graduate engineering students increased at only about one-half the 3-percent growth rate of U.S. citizens. As indicated below, about two out of every five graduate students in engineering in recent years have been non-U.S. citizens; however, the proportion has declined slightly since 1981. According to the American Society for Engineering Education, undergraduate enrollment fell by nearly 3 percent in 1984, primarily in the freshman and sophomore classes.[3] Graduate engineering enrollment may therefore level off or decline in the next few years.

The patterns of growth by field differ significantly for men and women. For men, computer science was still the fastest growing field, up 10 percent since 1983; for women, however, engineering showed the highest 1983-1984 increase, up 7 percent. Both of these rates represent sharp declines from the 1977-1983 period, when the number of men enrolled in graduate computer science programs grew at an average annual rate of 12 percent and the number of women in engineering rose by 16 percent per year.

Sources and Types of Support

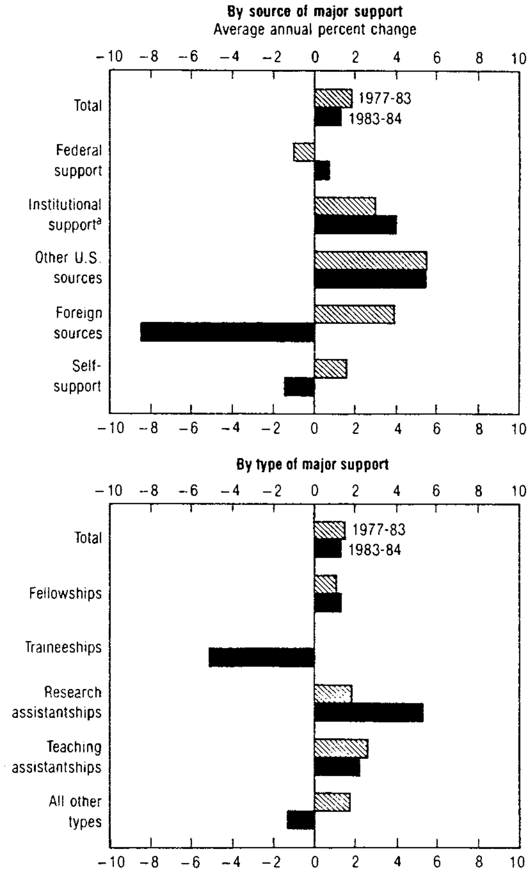
The number of full-time graduate students receiving their primary support from the Federal Government increased by 1 percent from 1983 to 1984, the same rate as the previous year, an average annual decline of 4 percent from the 52,900 in 1980. Growth in graduate students supported by

Table 1. Full-time graduate science/engineering enrollment in doctorate-granting institutions by field: 1984

Field	1984	Percent change, 1983-84
Total, all S/E fields	246,800	1
Engineering	54,800	2
Sciences	192,000	1
Physical sciences	25,100	3
Environmental sciences	11,300	-2
Mathematical sciences	10,600	3
Computer sciences	10,100	9
Life sciences	66,200	2
Agricultural sciences	9,300	-1
Biological sciences	36,000	2
Health sciences	20,900	2
Psychology	21,600	1
Social sciences	47,100	-2

SOURCE National Science Foundation

Chart 2. Full-time graduate science/engineering enrollment in doctorate-granting institutions by source and type of major support



[a]Includes support from State and local governments
SOURCE: National Science Foundation

NSF (4 percent) and NIH (3 percent) accounted for most of the rise in the federally supported graduate student total. The largest relative growth, 6 percent, was reported in students supported by "other U. S. sources," including industry and nonprofit institutions. These sources, however, still accounted for only about 7 percent of all full-timers. As in earlier years, institutional funds supported the largest number of S/E graduate students–two out of every five. The number relying primarily on self and family support declined 1 percent, the first drop since 1979, while those receiving their primary support from foreign sources showed an 8-percent decrease in 1983-1984.

The number of graduate students relying on fellowships increased for the second consecutive year, with institutional fellowships and those from other U.S. sources accounting for most of the increase. Students holding federally funded fellowships declined slightly, with increases in the number of NSF and NIH fellowships offset by decreases in those supported by other agencies. The latest data on federal support for fellowships and traineeships indicate a 6-percent rise in the dollar amount obligated for fellowships and traineeships from 1983 to 1984.[4] The growth in NSF-supported fellows reflects a 36-percent rise in the amount budgeted for fellowships.[5]

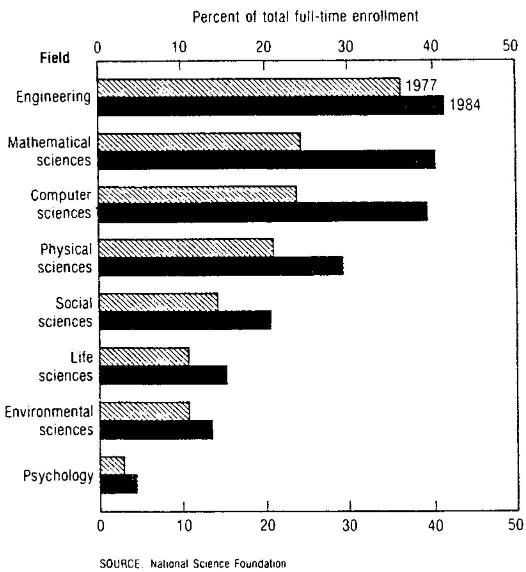
Research assistants showed the largest relative increase, 5 percent over the 1983 figure. This increase is consistent with a 5-percent constant-dollar rise in academic R&D expenditures from FY 1983 to FY 1984.[6] Major growth came from non-federal sources, with smaller growth in federally supported research assistantships. On the basis of data presented in the FY 1985 and 1986 budget documents, the number of NSF-supported research assistants is expected to level off after steady growth since 1981.[7] As in previous years, almost all teaching assistants–99 percent of the total reported–depended primarily on institutional funding (chart 2).

Citizenship

Although the total number of foreign students continued to rise, the 1983-1984 increase of 2 percent was well below the 8-percent average annual growth rate over the 1977–1983 period. By comparison, the 1983-1984 rise in foreign enrollment at all levels of higher education in all fields was less than 1 percent. Factors contributing to the 1983-1984 reduction in the rate of growth include the strength of the U.S. dollar, which has made it more costly for foreigners to come to the United States to study, and the decline in oil prices, which has reduced the foreign exchange available to the OPEC countries. These nations accounted for 21 percent of the foreign students enrolled in American institutions of higher education in

1984.[8] Foreigners were more heavily concentrated in graduate engineering programs than were U.S. students but were underrepresented in psychology and the life and social sciences in comparison to their proportion of total graduate enrollment (Chart 3).

Chart 3. Foreign full-time graduate science/engineering enrollment in doctorate-granting institutions as a percent of total by field



Detailed Statistical Tables for *Academic Science/Engineering: Graduate Enrollment and Support, Fall 1984* will be available early in 1986. For further information on the tables, contact the Editorial and Inquiries Unit, Division of Science Resources Studies, Telephone: (202) 634-4622.

[1] Because the sampling error at the total level is significantly larger than the apparent growth rate in total graduate S/E enrollment from 1983 to 1984, universe data presented in this report should be used with caution.

[2] *CGS Communicator*, Special Report, Vol. XVIII, No. 2, February 1985, p. 6.

[3] "Engineering Enrollments, Fall 1984," in *Engineering Education*, Vol. 76, No. 2, November 1985, p. 104.

[4] National Science Foundation, *Federal Support to Universities, Colleges, and Selected Nonprofit Institutions, Fiscal Year 1984* (Washington, D.C., 1985), unpublished data.

[5] National Science Foundation, *Justification of Estimates of Appropriations to the Congress, Fiscal Year 1985* (Washington, D.C., 1985), p. 43.

[6] National Science Foundation, *Academic Science/Engineering: R&D Funds, Fiscal Year 1984* (Detailed Statistical Tables) (in press) (Washington, D.C., 1986), table B-6.

[7] National Science Foundation, *Justification of Appropriations to the Congress, Fiscal Year 1985*, p. 17, and *Fiscal Year 1986*, p. 20, op. cit.

[8] This proportion represents a sharp decline from the 24 percent in 1983/84 and 26 percent in 1982/83. See Institute of International Education, *Open Doors: 1983/84* (New York: Institute of International Education, 1984), p. 23. *Open Doors: 1984/85* is currently in press.

Mathematical Text Processing

Richard S. Palais

Technical Word Processing

Originally I had planned to review Macintosh technical word processing software this month. However, several important software packages are "about to be released" and, since I would like to try out the released versions before writing my review, I have decided to postpone this review column until at least the August issue of *Notices*. Also planned for the August issue is an article by Larry Siebenmann on TEX preprocessors including, in particular, his own "Sweet-TEX".

I would like to thank all those who have written or telephoned to me with comments, criticisms, questions, and information. I will try to respond to your comments in later columns, but now I would like to mention some comments that took me entirely by surprise.

I have always taken it as axiomatic that one should have in hand a reasonable first draft of a mathematical paper *before* sitting down with a word processor. But two readers maintain that they work best by creating their papers from scratch on a word processor. Moreover they claim that by my unstated assumptions I had omitted from discussion what they felt was a potentially large class of TWP users and that I had failed to give due consideration to software that was best adapted to their use. They also felt that this latter software was often simpler, less expensive, and easier to use than the more sophisticated software I concentrated on in my article; namely software that was meant to produce publication quality copy.

I still feel that all but a few mathematicians would be ill advised to choose this mode of creating their papers, but I would like to hear from others who find that the method works for them, and perhaps someone who does will write a short article on this approach. Please address correspondence to Richard S. Palais, Department of Mathematics, Brandeis University, Waltham, MA 02154.

Effective Text Editors

The two articles about mathematical and technical word processing which appeared in the January 1986 *Notices* were quite interesting. As Richard Palais said in the second paragraph of his article, he was writing from "the viewpoint of the working mathematician who would like to convert handwritten mathematics into a computer file, and then use that file to produce printed copy." The report of the Boston Computer Society compared technical word processors from pretty much the same viewpoint. Unfortunately the **authoring and editing** side of technical word processing is receiving no consideration. This failure is partly responsible for a counterproductive trend which is occurring with the spread of word processors into mathematics departments. Many departments are choosing word processors solely on the basis of ease of use by secretaries and the quality of the technical output produced. More and more mathematicians in these departments are using the same word processors to prepare their papers from scratch as opposed to first creating handwritten (or typewritten) documents. They are using word processors which are not particularly well suited to the tasks of writing and editing. Ironically, the secretaries for whom the word processors were chosen are being eliminated from the document preparation process.

Readers may wonder about the different word processor needs for authoring and editing as opposed to converting existing copy into printed output. Here are examples related to the **search** capability of word processors. **Search** is extremely important for authoring and editing. For example **search** is used:

for checking if a word or string occurs in a manuscript,

for moving to a particular location in a manuscript by **searching** for a string which is more or less unique to the location,

as part of **search-replace** to change occurrences of one string to another. This is called **global search-replace** when the word processor automates the process of changing repeated occurrences.

While comparing IBM PC based technical word processors last spring I noticed that a word processor tended to have good authoring and editing facilities throughout its design or lack them throughout. One technical word processor, which a number of departments have adopted for use by their secretaries, **searched** many times more slowly than some others. It also lacked **global search-replace**. When facing the situation of inserting a numbered theorem early in a long paper and renumbering all the subsequent theorems, formulas and internal references, a fast word processor with a few other good authoring and editing features could do in five minutes what this slow one took hours to do. Another example is **back search**, meaning **search** done from the current editing location in a manuscript back toward the beginning. The slow word processor lacked **back search**. When creating a first draft of a paper the current editing location is generally at or near the **end-so-far**. If a word processor lacks **back search** the writer must frequently move back toward the top of the manuscript before **searching**. **Back search** is not so important for preparing finished output from existing copy. These are just two examples; there are many others.

Word processors are seeing increasing use for authoring, because once learned, they are excellent writing tools. For example, even using the slow word processor mentioned above, electronic cut and paste is many times more convenient than cut and paste by hand. Having to move toward the top of a document before **searching** is still a lot more convenient than not having **search** at all. Especially when working on a long paper. But the extra step of moving toward the top is annoying if you are used to a word processor with **back search**. Good authoring and editing features contribute enormously to the pleasure and productivity obtained from a word processor.

Moss Sweedler
IBM, Thomas J. Watson
Research Center
(Received January 27, 1986)

Policy on Letters to the Editor

Letters submitted for publication in *Notices* are reviewed by the Editorial Committee, whose task is to determine which ones are suitable for publication. The publication schedule requires from two to four months between receipt of the letter in Providence and publication of the earliest issue of *Notices* in which it could appear.

Publication decisions are ultimately made by majority vote of the Editorial Committee, with ample provision for prior discussion by committee members, by mail or at meetings. Because of this discussion period, some letters may require as much as seven months before a final decision is made.

The committee reserves the right to edit letters.

Notices does not ordinarily publish complaints about reviews of books or articles, although rebuttals and correspondence concerning reviews in *Bulletin of the American Mathematical Society* will be considered for publication.

Letters should be mailed to the Editor of *Notices*, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940, and will be acknowledged on receipt.

Presidential Young Investigators

I served on the screening panel in mathematical sciences this fall for the Presidential Young Investigators (PYI) awards. I was surprised by the low number of applicants in pure mathematics. The PYI is a very important NSF award and it is important that outstanding junior mathematicians apply. I think there are some obstructions that need to be removed.

(a) Under the present rules, the PYI is only for applicants who have been out for a short number of years and involves a commitment by the sponsoring institution. These rules remove from consideration new Ph.D.'s holding 3 year terminal positions at leading institutions. This should be addressed by the NSF as it impacts unfairly on mathematics in contrast to some of the physical sciences.

(b) The PYI awards are not sufficiently publicized in the mathematical community. Some potential applicants are discouraged by the (theoretical) requirement of obtaining matching industrial support although in practice this requirement can be waived. I would urge all departments to consider nominations for the PYI.

Peter B. Gilkey
University of Oregon
(Received January 28, 1986)

Ph.D. Thesis Style

Upon encountering once again a very lengthy Ph.D. thesis that contained some excellent material, some, but not **that** much, I felt some public discussion of thesis style was merited. I would like to address the advisors who believe that long-winded theses are a mandatory tradition, a tradition that I feel is wasteful of time and people. The degree recipient is at a difficult and crucial point in her or his career. Typically the recipient will almost immediately be holding down a full time job such as teaching a couple of courses that he or she has not previously taught. Still that thesis must be turned into publishable papers. For most mathematicians, especially those with no experience in writing papers for publication, the task of converting the thesis into one or more papers will often take months. One of the most important skills a budding research mathematician must learn is how to write papers, and I feel the time to begin that education is as a student, when one's writings are being supervised. I ask my students to write papers and to staple them together and call it a thesis. Of course pages must be renumbered and maybe the references will be collected together before binding. A common reason given for padding of a thesis with unpublishable material is that one must be sure that the writer understands the details of what has been written, but that is as true of papers as it is of theses. For those who feel additional elementary material must be included, please let it be a separate section so that it is readily discarded. If material then winds up being repeated in different sections, so what? That is allowed in theses.

We like to imagine that the young mathematician has years to prove herself or himself. Six years to develop credentials to get tenure is the standard, but it only applies to those who have gotten the job. Careers can be and are permanently sidelined much earlier even when the student does everything right, but does not find three faculty members who are willing to understand the thesis work and write letters of recommendation about the research accomplishments. I often see people being selected for–or rejected from–assistant professorships or instructorships before the thesis is finished. Many of these positions come with heavy teaching loads, perhaps little hope for summer support, and perhaps no experienced researchers in the field of specialization to talk to. Any upgrading of that job must be done quickly if at all. We all recognize that good second jobs go preferentially to people at the best universities. Publications and research quality preprints can be the critical asset. Time can be wasted with impunity only in fields such as physics where people average perhaps 3 years with postdoctoral fellowships. Let us teach our students how to write what it is necessary to write and not worry that a thin thesis will reflect poorly on us as advisors.

James A. Yorke
The University of Maryland
(Received January 20, 1986)

Funding for Computational Mathematics

The mathematical community is singularly unwilling to apply its analytical skills to itself. We have unconsciously made lack of funding an axiom. Our financial expectations are, on the whole, out of touch with the rest of science and engineering (salaries, grants, equipment, travel). Particularly pernicious is the claim that the mathematical community has no large-scale funding needs such as the big dollar projects in physics, astronomy, etc. We greatly need to create a computational infrastructure to support applied and computational mathematics.

The recent article in *Notices*, "Future Directions" reveals the same assumed limits. All of our top schools should now have *in place* programs in Numerical Analysis, Parallel Computation and Discrete Mathematics, with supporting computational facilities. Getting *one* small group at each of ten or twenty schools over the next few years is a very limited goal! We need Numerical Analysts now, not in ten years.

The *Notices* survey claims average spending of $50,000 per Mathematics department per year. What is the corresponding figure for physics, chemistry, engineering? In industry, the typical workstation (for someone with less training than a

Ph.D. mathematician) goes for \$50,000 plus (per person–well, maybe two or three).

To take advantage of the NSF's supercomputing efforts, departments need a VAX-class minicomputer as local link to the high speed network accessing the supercomputers. Most Computer Science, Physics, Chemistry, and Engineering departments have several such VAX-equivalents. Most Mathematics departments have *none*. Electronic mail networks are becoming an important means of communication (and publication). We've just excluded ourselves from the realm of modern scientific discourse!

How do faculty become aware of computational methods? How do computers make their way into the curriculum? In physics and other fields, lab computers train the faculty in computer use, keeping them abreast of the state-of-the-art. This eventually leads to classroom applications. Mathematics departments are not acquiring comparable computer expertise. What expertise we have tends to be on out-of-date, cheap microcomputers. We are not accumulating distilled knowledge in the form of software, nor making use of computers in the classroom. This further turns off gifted students, who perhaps are reacting to a perceived bias towards "pure" math.

This dearth of equipment is related to our historic lack of funding: we never asked for it. People rave about Mu-Math, which is expensive and inadequate compared to MACSYMA or SMP. The same is true of technical word processing software, where even the official formatting system is arguably user-unfriendly. Much of the discussion reveals an acceptance of the status quo, mathematicians adjusting their expectations to what they have (Apple II computers). This is a shame, because computers finally have the power to do things of interest to mathematicians, if we could only obtain them.

Within the year we'll see a lap-top portable IBM PC/AT compatible with internal hard disk. Within at most two years, the price will be in the \$1500 range a student (or prof) can afford. Research-class machines will also be less expensive. Yet the mathematical community is relatively ignorant of this, because we lack a "critical mass" of 10% or more who are regular, knowledgeable, computer users. Many mathematicians purposely ignore anything related to computers.

The *Notices* survey indicated relative satisfaction with computer resources. Naive! No graduate student is going to try to do research on a non-existent or hard-to-access computer, without NSF and faculty support. Thus I am not surprised that the supply of computers seems to roughly match demand. Not asked: would you use a computer if one were available? Note that it is very hard to switch fields. Even in the presence of an abundance of computational resources, one might take several years to begin doing research using a computer.

Conclusions:

(1) The David report understated our computer equipment needs by a considerable factor. Funding is needed to build a computational infrastructure in mathematics, but we lack a consensus that this is, in fact, necessary.

(2) A mechanism is needed to get faculty at undergraduate institutions involved in research and instructional development. Researchers not using computers must have a way to gain computer expertise without compromising their research productivity or grants.

A tangential question: why do we have two Institutes for Retraining in Computer Science, and none for, say, Retraining in Numerical Analysis, Scientific Computation, Statistical Computation, Computational Combinatorics and Graph Theory, or Mathematics and Computer Graphics? Does Numerical Analysis lack the hype or glamour of Computer Science?

Thank you for the opportunity to raise these issues in public. I'm quite aware that much of the above may be contentious and controversial. My purpose is to initiate discussion.

Peter J. Welcher
U. S. Naval Academy
(received February 7, 1986)

Queries

Edited by Hans Samelson and Stuart Antman

QUESTIONS ARE WELCOMED from AMS members regarding mathematical matters such as details of, or references to, vaguely remembered theorems, sources of exposition of folk theorems, or the state of current knowledge concerning published or unpublished conjectures. This is not intended as a problem corner, except for occasional lists of problems collected at mathematical meetings.

REPLIES from readers will, when appropriate, be edited into a composite answer and published in a subsequent column. All answers received will be forwarded to the questioner.

QUERIES and RESPONSES should be typewritten if at all possible and sent to Queries Column, American Mathematical Society, P. O. Box 6248, Providence, Rhode Island 02940.

Queries

351. David Halprin (P. O. Box 186, North Carlton, Victoria 3054, Australia). Has any reader seen reference to, or use of, the "Condition for Immobility of a Point," and also the "Condition for Immobility of a Straight Line" (as derived and used by Ernesto Cesaro), appearing anywhere other than in Cesaro's own book, *Lectures in intrinsic (natural) geometry*, and in some of his papers? Especially does any reader know of a better (more rigorous, yet simpler in derivation) proof? It appears to be a very useful mathematical tool, no longer in use, but with much untapped potential in geometry, differential geometry and calculus of variations.

352. Ashot E. Djrbashian (Inst. of Math. of Armenian Acad. Sci., Marshal Baghramian st. 24b, Erevan 19, Armenian SSR, USSR, 375019). Consider a vector-valued function $F = (f_1, \dots, f_n)$, defined in a region $G \subset \mathbf{R}^n$, for which the equations

$$\sum_{j=1}^{n} \frac{\partial f_j}{\partial x_j} = 0, \quad \frac{\partial f_k}{\partial x_j} = \frac{\partial f_j}{\partial x_k}, \qquad 1 \le j, k \le n$$

are satisfied.

This is one of the possible generalizations of the notion of analytic function in $\mathbf{R}^n$ and it is natural to call the components of F conjugate harmonic functions (see, e.g., E. M. Stein and G. Weiss, *Introduction to Fourier analysis on Euclidean spaces*, Princeton, New Jersey, 1971).

Is anything known about conjugate kernels of the Poisson kernel in the unit ball of $\mathbf{R}^n$, $n \ge 3$?

353. Aldo P. Peretti (Murillo 1121-9° D, (1414) Buenos Aires, Argentina). (a) What is the expression for

$$\prod_{i=1}^{n} \prod_{j=1}^{n} (1 + x_i + y_j)$$

as a polynomial in the elementary symmetric functions of the x_i and of the y_j?

(b) Is the infinite product expansion

$$1 - \frac{1}{e} = \left(1 - \frac{1}{2}\right) \cdot \left(1 + \frac{1}{3 \cdot 2 - 3}\right) \cdot \left(1 - \frac{1}{4 \cdot 3 \cdot 2 - 4 \cdot 3 + 4}\right) \cdot \left(1 + \frac{1}{5 \cdot 4 \cdot 3 \cdot 2 - 5 \cdot 4 \cdot 3 + 5 \cdot 4 - 5}\right) \cdots$$

correct?

354. R. N. Gupta (Centre for Advanced Study in Mathematics, Panjab University, Chandigarh-160014, India). Let V_F be a vector space with an infinite countable basis $v_1, v_2, \dots, v_n, \dots$. Let $E = \mathrm{Hom}^l_F(V, V)$ acting on the left of V. It is easily seen that, up to isomorphism, V is the only simple left E module such that $\mathrm{ann}(V) = 0$. Let $I = \{\sigma \in E \ni (\sigma V{:}F) < \infty\}$. Does there exist a unique simple left E module S such that $\mathrm{ann}(S) = I$?

355. David Shelupsky (Department of Physics, City College, CUNY, New York, NY 10031). A number of films recently shown on educational television refer to the results of using numerical models for the distribution of wind and temperature in the Earth's atmosphere. Are there such readily available models compact enough for classroom presentation? Are there idealizations (e.g., using an Earth whose surface is entirely covered with dry land or with water) that can be treated analytically or, at least, with a small computer?

Responses

The editors would like to thank all those who sent in replies.

280. (vol. 30, p. 491, August 1983, Howard Kleiman) Polynomial-time mapping of the traveling salesman problem onto the hamiltonian circuit problem. **Reply:** If the directed (i.e., asymmetric) traveling salesman problem can be solved in polynomial time, then so can its subproblem consisting of the undirected (i.e., symmetric) traveling salesman problem with distances restricted to $\{1, 2\}$. For an equivalence between this subproblem and that of obtaining a hamilton circuit in an undirected graph, see pp. 35, 36 in M. R. Garey and D. S. Johnson, *Computers and intractability: A guide to the theory of NP-completeness*, W. H. Freeman & Co., New York, 1979. Note that the technique in the reference is also valid for an equivalence between the directed traveling salesman problem with distances restricted to $\{1, 2\}$ and that of obtaining a hamilton circuit in a directed graph. Further insight is provided in E. L. Lawler et al. (editors), *The traveling salesman problem*, John Wiley & Sons, New York, 1985. (Contributed by R. H. Warren)

325. (vol. 32, p. 379, June 1985, Bertram Ross) Do difference operators of fractional order exist? (See first reply in these *Notices*, vol. 33, p. 53.) **Reply:** See the report, *Discretized operational calculus, I: Theory*, by C. L. Lubich (Inst. F. Math. and Geom., Univ. Innsbruck, A-6020 Innsbruck, Austria) and his paper *Discretized fractional calculus* (to appear in SIAM J. Math. Anal.). (Contributed by H. J. J. te Riele)

335. (vol. 32, p. 608, October 1985, Sherwood Washburn) The diophantine equation $6y^2 = x(x+1)(2x+1)$. (See earlier response, vol. 33, p. 336, March 1986.) **Correction:** The announced elementary solution by M. W. Bunder has a serious gap in it. It is in fact unlikely that an elementary solution is possible. (Contributed by J. J. Schäffer and J. C. Owings, Jr.)

Acknowledgement of Contributions

The officers and the staff of the Society acknowledge with gratitude gifts and contributions received during the past year. The inside cover of each issue of *Mathematical Reviews* carries the names of the sponsoring societies which support that publication. Contributing members of the Society paid dues of $117 or more. In addition to contributions to the AMS Research Fellowship Fund, there were a number of unrestricted general contributions. Also listed this year are AMS members who have contributed to ICM-86. Some of the contributors have asked to remain anonymous. All of these gifts provide important support for the Society's programs. The names listed below include those whose contributions were received during the year ending March 31, 1986.

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  Wolmer V
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Wright, David J
Wu, T C
Wyman, Bostwick F

Yachter, Morris
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Anonymous (55)

A'Campo, Norbert
Abadie, Jean M
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Abbott, James C
Abbott, James H
Abdel-Megied, Mohamed
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Abdelkader, Mostafa A
Abdullah, Masood B
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Acker, Andrew F III
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Adachi, Steven H
Adams, David D
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Benke, George
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Beretta, E F
Beretta, Giordano B
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Berg, Gene A
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Bergman, George M
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Susan Grooms
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Berthiaume, Pierre
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Bessenrodt, Christine
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Betounes, David E
Betsch, Gerhard
Betz, Ebon E
Beukers, F
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Beyer, William A
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Bhaskaran, M
Bhattacharya, Prabir
Bhattacharya, Rabi N
Bhattacharya,
Ramendra K
Bialostocki, Arie
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Bickel, Marilyn S
Bickel, Thomas F
Bidwell, Leonard N
Bielawski, Jan
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Bilaniuk, Stefan
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Billik, Martin
Bilodeau, Gerald G
Binding, Paul A
Bindschadler, David E
Bing, R H
Bingen, Franz
Bini, Dario
Binkley, Dean H
Biot, Maurice A
Bircher, John J
Biriuk, George
Birman, Graciela S
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Birnbaum, Eric S
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Birnbaum, Z William
Birnir, Bjorn
Birtel, Frank T
Bishop, Alan A
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Bisson, Terrence Paul
Bisztriczky, Tibor
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Bix, Michael C
Bjorklund, Peter B
Björner, Anders
Black, Richard H
Blackall, Clair J
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Blank, Brian Evan
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Blanton, John D
Blasius, Don M
Blaskie, Marc
Blatter, Christian
Blatter, Jorg
Blattner, Robert J
Blaufox, Norman H
Bledsoe,
Kathryn Phillips
Bleicher, Michael N
Bleiler, Steven A
Blij, Frederik Van Der
Blitch, Patricia M
Bloch, Ethan D
Bloch, Spencer J
Blockus, Marilyn J
Bloom, David S
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Bloom, Stephen L
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Steven Herman
Bloom, Thomas
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Blowers, James V
Blows, T R
Blum, Dorothee Jane
Blum, Howard S
Blum, Ilya Eugene
Blum, Joseph
Blum, Lenore
Blumenthal, Robert A
Blyth Rentzsch,
Barbara J
Blyukher, Grigory
Boardman, John M
Boas, Harold P
Bobisud, Larry E
Bobonis, Augusto
Bochnak, Jacek
Bodfish, Scott E
Bodnar, Andrea C
Bodnar, Istvan
Boduch, David J
Bodvarsson, Gunnar
Boe, Brian D
Boehme, Thomas K
Boehmer, Klaus W A
Boenecke, Ernst
Boffi, Giandomenico
Bogar, Gary A
Bogart, Kenneth P
Bogdan,
Victor Michael
Boghossian, Artin
Bogus, Rolf
Bohannon, Barbara
Bohn, S Elwood
Bohnke, G C
Boivin, André
Bojanic, Ranko
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Bolker, Ethan D
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Boman, Jan
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Bona, Jerry L
Bond, Robert Joseph
Bonet, Jose
Bonnice, William E
Bonsall, Frank F
Boo, Per-Anders
Book, Ronald V
de Boor, Carl
Boos, William
Booth, George W
Boothby, William M
Borchers, Hans-Jurgen
Borel, Armand
Borelli, Mario
Borgman,
William M Jr
Borisewich, John
Borkowski, Mark S
Borrego, Joseph T
Borrelli, Robert L
Borwein, David
Bosch, Carlos Giral
Bosch, William W
Boschan, Paul
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Boswell, Rupert D Jr
Bouchard, Pierre
Bouchet, Andre
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Bourgeat, Alain P
Bourgeois, Brian A
Bourgin, Richard D
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Bousfield, Aldridge K
Boutang, Charles
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Boutot, Jean Francois
Bouwsma, Ward D
Bove, Antonio
Bower, Julia W
Bower, Oliver K
Bowers, Julie M
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Boyce, Elsa K
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Boyer, Steven Patrick
Boyle, Jeffrey
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Bozeman, Sylvia T
Bozonis, Petros
Braaksma, B L J
Brace, John W
Brachman, Malcolm K
Brackx, Freddy F
Braden, Eddie Jr
Braden, Lucian J
Bradford,
Giles Edward III
Bradley, John S
Bradley, Richard C
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Bradlow, Steven B
Brady, Walter F
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Braga-Filho,
Luiz Juliao
Bragg, Arthur E
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Brahana, Thomas R
Brahm, Matthew V
Brakke, Kenneth A
Bralver, Peter Jeffrey
Bramble, Charles C
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Branch, Steve A
Brand, Neal E
Brandal, Willy
Brandenburg, Harald
Brandon, Robert L
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Hugo F K
Brandt, Dennis E
de Branges, Louis
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Thomas Patrick
Brant, Larry J
Branton, Richard G
Brattström, Gudrun B
Braude, Eric J
Brauer, Fred
Brauer, George U
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Brawley, Joel V Jr
Brawley, Lori J
Breaux, Gary R
Brechner, Beverly L
Breckenridge, John C
Breen, Marilyn
Breen, Stephen
Breidbart, Seth I
Bremermann, Hans J
Brender, Melvin
Brennan, Joseph P
Brenneman,
Franklin S
Brenner, Susanne C
Brent, Richard P
Brenti, Francesco
Bressler, David W
Bressoud, David M
Bressoud, Thomas C
Breuer, Shlomo
Brewer, James W
Brewster,
Stephen Thomas
Brickman, Louis
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Bridges, Douglas S
Bridgland, Michael F
Brierly,
Joseph Edward
Brieske, Thomas J

Brigham, Robert C
Brin, Matthew G
Brink, Daryl M
Brinkmann, H W
Brinkmann, Hans-Berndt
Brisson, Erik
Britton, John L
Broadwin, Judith E
Brobeck, Barbara Caldwell
Brode, John
Brodie, Robert Bruce
Brodskii, M S
Broline, Duane M
Bromberg, Eleazer
Bromley, Darwin P
Brons, Hans
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Brooks, Peter S
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Brosamler, Gunnar A
Brosowski, Bruno H
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Broué, Michel
Broughan, Kevin A
Broughton, S A
Browder, Felix E
Browder, William
Brown, Anne E
Brown, Arthur A
Brown, Beverley M
Brown, C Sue
Brown, Dean R
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Brown, Edgar H Jr
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Brown, Kenneth S
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Brown, Richard H
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Brown, Robert Bruce
Brown, Robert Dillon
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Brown, Scott W
Brown, Sharan Inez
Brown, Thomas C
Brown, William G
Brownawell, W Dale
Browne R F, Henrique
Browne, H Nelson Jr
Browne, Patrick J
Brownell, Frank H III
Browning, William J
Brownstein, Beth
Brualdi, Richard A
Bruck, Ronald E Jr
Bruckner, Andrew M
Bruen, Aiden A
Bruggeman, Roelof W
Brumer, Armand
Brumfiel, Gregory W
Bruna, Joequim
Bruner, Robert R
Bruni, Anthony J
Brüning, Jochen
Brunk, Hugh D
Bruno, Vincent J
Bruns, Winfried
Brunschwig, Mildred C
Brunson, Barry W
Brunswick, Natascha A
Bryan, Charles A
Bryant, Billy F
Bryant, John G
Bryant, John L
Bryant, Robert L
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Brydges, David C
Brylinski, Jean-Luc
Bryn, Milo F
Brzezinski, Juliusz
Bube, Kenneth P
Buccino, Alphonse
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Buck, Marshall W
Buck, Robert E
Bucki, Andrzej J
Buckley, Joseph T
Buckley, Stephen M
Bucy, Richard S
Buddrus, Lee Edward
Budnik, Paul Jr
Buechler, Steven Allen
Bueckner, Hans F
Buehler, Royce E
Buekenhout, F
Buell, Duncan A
Buhler, Joe P
Buianouckas, Francis R
Buis, Paul E
Bulena, Richard
Bulirsch, Roland Zdenek
Bull, Everett L Jr
Bullen, Peter
Bulman-Fleming, Sydney D
Bumby, Richard T
Bunce, Gary R
Bunce, John W
Bunge, Marta C
Buntinas, Martin G
Buoni, John J
Burchard, Hermann G
Burchard, Paul
Burckel, Robert B
Burdick, G R
Burgess, C Edmund
Burgess, Richard Dennis
Burgess, Walter D
Burke, James E
Burkhart, Richard H
Burkholder, Donald L
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Burkill, John C
Burns, Anne M
Burns, Daniel M Jr
Burris, Stanley N
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Burt, Philip B
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Burton, Theodore A
Busemann, Herbert
Busenberg, Stavros N
Buser, Peter J
Bush, George C
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Buss, Samuel R
Butchart, John H
Butcher, John C
Butcher, Ralph Stevens
Butler, A Fred
Butler, James William
Butler, John B Jr
Butson, Alton T
Butts, Thomas R
Buys, Mutiara
Buzano, Ernesto
Byerly, Robert E
Bykat, Alexander
Byleen, Karl E
Byrd, Kenneth A
Byrne, Catriona M
Byrne, Charles L
Byrnes, James S
Byrnes, Raymond Albert Jr
Byun, Hyeja

Cable, Charles A
Cadogan, Charles C
de Caen, D
Caffarelli, Luis A
Caflisch, Russel
Cagnac, Francis
Cahill, Pamela M
Cahill, Rotraut G
Cahlon, Baruch
Cai, Haiyan
Cain, Bryan E
Cain, George L Jr
Caine, Bruce R
Caines, Peter E
Cairoli, R
Calcaterra, Robert
Calderer, M Carme
Caldwell, Roderick P C
Caldwell, Thomas E
Caldwell, William V
Calica, Arnold B
Calkin, Neil J
Callahan, James J
Calloway, Jean M
Calvert, James E
Camacho, James Jr
Camarena, Vicente
Cameron, Douglas E
Camillo, Victor P
Camina, A R
Campanino, Massimo
Campbell, Daniel D
Campbell, Dave A
Campbell, Harold E A
Campbell, Hugh G
Campbell, James T
Campbell, Jean McCroskey
Campbell, L Andrew
Campbell, L Lorne
Campbell, Robert Ives
Campillo, Antonio
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Canary, Richard D
Canavan, Robert I
Canfield, E Rodney
Canjar, Mike
Cannon, James W
Cannon, John R
Cannonito, Frank B
Cantor, David G
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Cantwell, John C
Cap, Clemens Heinrich
Capasso, Vincenzo
Capozzi, Alberto
Capozzoli, Anthony B
Caranti, A E
Cardenas, Juan Donoso
Carey, Michael C
Cargal, James M
Cargo, Gerald T
Carlącci, Franco
Carleson, Lennart A E
Carlip, Walter
Carlisle, Ronald L
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Carlson, Dean A
Carlson, James A
Carlson, John W
Carlson, Jon F
Carlson, Kermit H
Carlson, Robert C
Carlson, Timothy J
Carlsson, Renate
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Carmichael, Richard D
do Carmo, Manfredo P
Carone, Patricia L
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Carpenter, Gail Alexandra
Carr, Ralph W
Carroll, Edward M
Carroll, Jeffrey S
Carroll, Joel
Carroll, Michael P
Carroll, Robert W
Carroll, Timothy B
Carson, John M Sr
Cartan, Henri
Carter, David W
Carter, Karen
Carter, Patricia Hawks
Carter, Thomas J
Cartlidge, James M
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Casal, Alfonso
Casanova, Toussaint
Casazza, Peter G
Case, Bettye Anne
Case, James H
Case, James R
Casey, Robert Francis
Casey, Stephen D
Casler, Burtis G
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Castagnoli, Erio A
Castellet, Manuel
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del Castillo, Beatriz M
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Castro, Peter E
Catanese, Fabrizio M E
Cateforis, Vasily C
Cathey, Frederick W
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Cavanaugh, Joseph M
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Cavender, James A
Caveny, Deanna Marie
Cavior, Stephen R
Cawley, Robert
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Cegrell, Urban
Çelik, Hasan A
Cenkl, Bohumil
Cerda, Joan
Cerlin, Zvonko
Cernuschi-Frias, Bruno
Cerruti, Umberto
deCesare, Kenneth M
Cesari, Lamberto
Cha, Hyung Koo
Chabert, J L
Chachere, Gerald R
Chaffee, James W
Chaiken, Seth D
Chakerian, Gulbank D
Chakravarti, R S
Chakravarty, Subinoy
Chalk, John H
Chalkley, Roger
Chalmers, Bruce L
Chalmers, Graham D
Chamberlain, Robert Mathieu Jr
Chamberlin, Richard E
Chambers, Daniel Warren
Chambers, Florence D Rozniak
Chambers, Graham A Jr
Champagne, Carol Z
Chan, Chiu Yeung
Chan, Jack-Kang
Chan, Tony F
Chan, Y H
Chandarana, Sharad
Chandler, Richard G
Chandra, Jagdish
Chaney, Robin W
Chang, Bomshik
Chang, Derek Kong
Chang, Gerard J
Chang, I-Lok
Chang, Joo Sup
Chang, Kun Soo
Chang, Li-Fung
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Chang, Ping-Tung
Chang, Shao-Chien
Chang, Shih-Hung
Chang, Shu-Jung
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Chaperon, Marc
Chapin, Edward W
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Chapman, Robert M
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Charles, Josette
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Chen, Dayue
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Chen, Jau-Die W
Chen, Kuang-Ho
Chen, Kuo-Tsai
Chen, Kwan-Wei
Chen, Louis H Y
Chen, M
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Chen, Wen
Chen, Y W
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Chen, Yongzhuo
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Cheng, Jih-Hsin
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Cheng, Kuo-Shung
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Chi, Dong Pyo
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Chiang, Peter H S
Chiarenza, Filippo
Chidambaraswamy, Jayanthi
Chihara, Theodore S
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Chillag, David
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Chinburg, Ted C
Ching, Wai-Sin
Chinn, William G

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Chivukula, R Rao
Cho, Choong Yun
Cho, Dall-Hoon
Cho, Sung Je
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Choi, Man-Duen
Choi, Un Haing
Choksi, Jal R
Chollet, John
Chong, Chi Tat
Chong, Tjee Hung
Choo, Koo-Guan
Choquet, Gustave
Chou,
Wei-Chung Arthur
Chouteau, Charles C
Chover, Joshua
Chow, Pao-Liu
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Chow, Yuan S
Choy, Stephen T L
Chrestenson, Hubert E
Christensen, Chris
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Christy, Joe
Chu, Chinku
Chuang, Pi-Chun
Chuaqui, Rolando B
Chung, Fan R K
Chung, Kai Lai
Chung, Lung Ock
Church, Alonzo
Church, Philip T
Churchill, Edmund
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Chute, Cheryl Ann
Chyung, Dong Hak
Ciarlet, Philippe G
Cifuentes, Patricio
Cima, Joseph A
Ciment, Melvyn
Cincotta,
Dominick Anthony
Cipra, Barry A
Cirina, Marco
Claasen, H L
Clapp, Michael H
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Clare, Loren Paul
Clark, Cathy Ann
Clark, David M
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Clark, Robert A
Clarke, A Bruce
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Graham Thomas
Clary, Stuart
Claus, Elly
Cleaver, Charles E
Clement, Mary Dean
Clench, Ralfe J Jr
Cleveland, Richard A
Clifford, Alfred H
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Clifton, Joseph M
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Cobb, John
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Cobham, Ian P
Cochran, James A
Cockcroft, Wilfred H
Coddington, Earl A
Cody, William F Jr
Coen, Salvatore
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Cogdell, James Wesley
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Cohen, Moses E
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Cohn, Harry
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Cohn, Paul M
Cohn,
Stephen Edward
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Colbourn,
Charles Joseph
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Cole, Brian J
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Cole, Nancy
Cole, Paul Dana
Coleman, A John
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Collier, Jarrell D
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Colwell, Peter
Comenetz, Daniel
Comer, Stephen D
Comfort, Steven H
Comfort, W Wistar
Compton, Esther A
Compton, Kevin J
Comstock, Dale R
Conlon, Joseph G
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Conn, Jack Frederick
Connelly, Robert Jr
Conner, Luther T Jr
Conner, Pierre E Jr
Connolly, Mary V
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Conrad, Bruce P
Constantinescu,
Corneliu
Contessa, Maria
Conti, Roberto
Conway, John B
Cook, Clarence H
Cook, David Edwin
Cook, Joseph M
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Cook, Roger J
Cooke, Kenneth L
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Cooley, Clifford R
Coombes, Kevin R
Coonen, Jerome T
Cooney,
Sister Miriam P
Cooper, E D
Cooper, Hilda L
Cooper, J B
Cooper, Jeffery M
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Cootz, Thomas A
Cope, Davis K
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Coppel,
William Andrew
Coppersmith, Don
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Coram, Donald S
Coray, Daniel
Corbacho, Eusebio T
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Cordova, Jeffrey Q
Cordovil, Raul
Corduneanu,
Constantin
Corliss, George F
Cornelius, E Frank
Cornet, H
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Corrigan,
Thomas Carney
Corsi Tani, Gabriella
Cortzen, Barbara
Cosner, George C
Costa, David G
Cote, Louis J
Cotlar, Mischa
Cotsaftis, Michel
Cottle, Richard W
Cotton, Robert M
Couch, Alva L
Coulter, Malcolm A
Countryman,
William Mark
Courter, Richard C
Coury, Nicholas J
Covey, David N
Cowan, Jack D
Cowen, Carl C Jr
Cowens, J Wayne
Cowles, John R
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Cox, David A
Cox, Dennis D
Cox, Gregory V
Cox, Milton D
Cox, Raymond H
Cox, S H Jr
Coxeter,
H S MacDonald
Coxson, Pamela G
Coyne, Steven Thomas
Cozzens,
Margaret Barry
Crabtree, J B
Craggs, Robert F
Craig, Cecil Jr
Craig,
Jessica Marguerite
Craig, Walter L
Craig, William
Crandall, Michael G
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Crane, George E
Crane, Jane P
Crapo, Henry H
Crauder, Bruce C
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Cravetz, Allan E
Crawford, John David
Crawford, Pamela
Creekmore, Joseph W
Creese, Franklyn G
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Criscenti,
Jacqueline P
Criss, Steven P
Critchlow, Florence G
Crittenden, Richard J
Crockett, Diane W
Cronheim, Arno
Croom, Frederick H
Cross, James J
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Crossman, Howard L
Crothers, Derrick S F
Crow, Edwin L
Crumb, Cyndi A
Cruse, Allan B
Cruthirds, John E
Csorgo, Miklos
Cuculiere, Roger
Cude, Joe E
Cudia, Dennis F
Cullinane, Steven
Cummings, Jeffrey T
Cunningham, A B
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Frederic Jr
Cunningham,
Richard J
Cuntz, Joachim
Cuoco, Albert A
Cupillari, Antonella
Curjel, Caspar R
Curlovic, Donald L
Curran, Peter M
Curraś-Bosch, Carlos
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Curtis, Charles W
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Curto, Raul E
Cushing, Jim M
Cusick, David A
Cusick, Larry William
Cusick, Thomas W
Cuthill, Elizabeth H
Cutler, Doyle O
Cutrer, M Wayne
Cygan, Jacek

D'Agostino, Santo
D'Alotto, Louis A
D'Ambrosio, Ubiratan
D'Angelo, John P
D'Aprile, Margherita
D'Aristotle,
Anthony J
D'Atri, Joseph E
D'Attorre, Leonardo
D'Entremont,
Edward Joseph
D'Orazio, Silvano
Da Costa,
Newton C A
Daboussi, Hedi
Dabrowski, André
Dabrowski, Romuald
Dade, Everett C
Dadok, Jiri
Daepp, Ulrich
Dafermos,
Constantine M
Dahari, A Sh
Dahlin, Rolf B
Dai, Taen-Yu
Daigneault, Aubert
Dajczer, Marcos
Dale, Knut T
Dale, Richard H
Dales, H Garth
Daly, John F
Daly, John T
Damiano, David B
Damkohler, Wilhelm L
Damon,
James Norman
Dana, Martin P
Daney, Charles G
Danforth, Katrine
Dang, X-Hong
Dangello, Frank Ralph
Daniel, Timothy
Daniels, M Peg M
Dannan, Fozi Mustafa
Dantzig, George B
Dar, Karamat Hussain
Darafsheh,
Mohammad-Reza
Dare, Adrienne M
Dark, R S
Darken, Joanne S
Darling, R W R
Darmody, Laurie M
Darnel, Michael R
Darst, Richard B
Das, Anadijiban
Das, Lovejoy S
Dashiell, Fred K Jr
Dassios, George
Datskovsky, Boris A
Datskovsky, Joseph A
Datta, Dilip K
Dautray, Robert I
Davey, Brian A
David, Daniel
David, Florin R
David, Karl
David, Nancy A
Davidoff, Giuliana P
Davidoff, Kathleen S
Davidson, James R
Davidson, Kenneth R
Davidson,
William Robert
Davies, Morton J
Davis, Burgess J
Davis, Chandler
Davis, James F
Davis, Lincoln Ross
Davis, Paul L
Davis, Paul W
Davis, Reid R
Davis, Richard L
Davis, Ruth M
Davis, William E
Davis, William J
Davison, J Leslie
Davison, Walter F
Davitt, Harold H
Dawes, A M
Dawson, Donald A
Dawson, John W Jr
Day, B J
Day, George W
Day, Jane M
Day, K Michael
Day, Mahlon M
Day, Peter W
Daybell, Dorothy A
Daykin, Donald R
Dayton, Barry H
De Angelis, Valerio
De Bouvére, Karel L
De Bruin, Marcel G
De Cecco, Giuseppe
De Iongh, Johan J
De Koning, Jan
De La Rica,
Mariano Hermida
De Land, Paul N
De Lorenzo, Helene
De Los Reyes,
Josefina P
De Marr, Ralph E
De Meersman, Roger
De Pascale, Espedito
De Rezende, Ketty
De Souza, Vera H G
De Villiers, Raoul A
De Vries, Hendrik
DeBlassie,
Richard Dante
DeFacio, Brian
DeKoninck,
Jean Marie
DeLong, R Peter
DeShalit, Ehud
DeTurck, Dennis
DeVore, Ronald A
Deal, Albert L III
Dealba-Guerra,
Luz Maria
Deanin, Alice
Deblasi, Francesco S
Debnath, Lokenath
Debrunner, Hans E
Dechéne, Lucy I
Deckert, Kenneth L
Dediu, Mihai Michael
Deeb, Waleed M
Deeter, Charles R
Defrancesco, Henry F
Dehesa, Jesus Sanchez
Deheuvels, Rene
Deiermann, Paul J
Deift, Percy Alec
Dejter, Italo J
Dekker, Jacob C E
Dekleine, Herbert A
Dekster, B V
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Castillo, L
Delahunty, Michael D
Delange, Hubert
Delchamps, David F
Deleanu, Aristide
Delges, H Wolfgang

Dell'Antonio, Gianfausto
Della Riccia, Giacomo
Dellwo, David R
Delmer, Thomas N
Delporte, Jean
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Delver, Robert
Demana, Franklin D
Demetrius, Lloyd A
Demeyer, Frank R
Deming, Robert W
Denbow, Carl H
Deneen, Linda L
Denig, William A
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Denman, Richard Thomas
Dennis, Roger Keith
Dennis, William A
Denny, William F II
Dent, Elliod
Denzel, Gene
Deodhar, Vinay Vithal
Deprima, Charles R
Depue, Bill Earl
Deretsky, Tatiana
Deriggi, Dennis F
Derr, Leroy J
Deruaz, Marcel A F
Derwent, John E
Désarménien, Jacques
Deskins, W E
Desmond, James Eddy
Desoer, Charles A
Desolneux-Moulis, Nicole
Dethlefsen, Douglas G
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Dettman, John W
Deumens, Erik
Deutsch, Daniel H
Devaney, Robert L
Deveaux, Raymond C
Deveney, James K
Dewallens, Jean H
Dezern, David H
Dhaliwal, Ranjit S
Di Cenzo, Alan
Di Franco, Roland B
Di Maio, Giuseppe
Di Martino, Lino
Di Paola, Jane W
Di Stefano, Charles J
DiGiallonardo, Joseph A
DiPietro, Alpbonso J
Diamond, Jack
Dias Da Silva, J A
Diaz, Gregorio
Diaz-Miranda, Antonio
Dibner, Steve
Dickerson, Charles E
Dickson, Robert J
Diederich, Klas
Diehlmann, Richard K
Diener, Karl-Heinz
Dietz, David
Dietz, Klaus
Dieudonné, Jean A
Digernes, Trond
Dijksma, Aalt
Dikshit, G D
Dilão, Rui
Dilcher, Karl H
Dilley, Gary Alan
Dillon, Richard T
Dilts, Gary A
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Diminnie, Charles R
Dimitracopoulos, Constantinos
Dimsdale, Bernard
Dineen, Sean
Dinitz, Jeffrey Howard
Dinneen, Gerald P
Dion, Gloria S
Dionne, Benoit
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Diperna, Ronald J
Disney, Ralph L
Diute, Patricia J
Divis-Poracka, Zita M
Dixon, John D
Dixon, Martyn Russell
Dixon, Michael J
Dixon, Peter Grant
Dixon, William O
Djamboulian, Ara M
Djoković, Dragomir Ž
Djomehri, M Jahed
Dlab, Vlastimil
Dobbins, Robert R
Dobbs, David E
Dodds, Peter G
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Dodson, B
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Dodziuk, Jozef
Doerfler, Willibald
Doering, Boro
Dolan, James M
Dolbeault, Pierre E
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Dolgachev, Igor
Doll, Nelly E
Dollard, John D
Dolph, Charles L
Dolzycki, Stanislaw J
Dombroski, Michael
Dombrowski, Joanne M
Dominguez, J M
Dominijanni, Roberto
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Domokos, Gabor
Donahue, Sister Gabriel Mary
Donaly, James P
Donoho, David Leigh
Donovan, Peter
Doob, Joseph L
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Doplicher, Sergio
Doran, Robert S
Dordal, Peter L
Doree, Suzanne
Dorfmeister, Josef F
Dorner, Bryan C
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Dos Santos, Antonio F
Dotzel, Ronald M
Dougherty, Robert P
Douglas, Craig C
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Douglas, Lloyd E
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Dovidio, Catherine Slanta
Dow, Alan
Dow, Stephen J
Dowd, Robert E
Dowers, J F
Dowlen, Mary M
Dowling, Thomas A
Downey, Rodney G
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Dragan, Irinel
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Draper, Patricia J
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Dressel, Francis G
Drew, Gerald C
Driscoll, Mark J
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Drobot, Vladimir
Drucker, Daniel S
Drucker, Thomas L
Drzyzgula, Robert P
Dshalalov, Jewgine
Du, Ding-Zhu
Du, S W
Dubins, Lester E
Dubinsky, Ed
Dubisch, Roy
Dubreil, Paul J
Dubson, Alberto S
Duchamp, Thomas E
Dudek, Zbigniew C
Dudley, Richard M
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Dudziak, James J
Duffin, Richard J
Duffus, Dwight A
Duffy, Michael A Jr
Duggal, Krishan Lal
Duhamel, Tammy Lee
Duke, Richard A
Dukelow, James S Jr
Dumas, H Scott
Duncan, Cecil E
Duncan, Hilda
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Dunn, D W
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Dupont, Johan L
Dupre, Maurice J
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Durand, Loyal
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Durfee, Alan H
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Durgun, Kanat
Durkin, Marilyn B
Durnota, Bohdan P
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Duskin, John W Jr
Duszynski, Martin Jr
Dutt, J E
Dutta, Sankar Prasad
Dutton, Charles Everett
Dwork, Bernard M
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Dydak, Jerzy
Dye, Henry A
Dym, Harry
Dymacek, Wayne Marshall
Dynin, Alexander
Dynkin, Eugene B
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Eachus, J J
Ealy, Clifton E Jr
Eames, William P
Earle, Clifford J Jr
Earle, Frederick O
Earles, Robert W
Earnest, Andrew G
Ebanks, Bruce R
Eberlein, Patricia J
Eberlein, Patrick Barry
Eberly, David H
Ebey, Sherwood F
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Egle, David L
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Ehrlich, Karel
Ehrlich, Louis W
Ehrlich, Paul Ewing
Eid, Yousef R
Eifrig, Bernd
Eigel, Edwin G Jr
Eigen, Stanley J
Eilenberg, Samuel
Ein, Lawrence Man Hon
Einstein-Matthews, Stanley M
Einthoven, Isabella H
Eisele, Carolyn
Eisenberger, Isidore
Eisenbud, David
Eisenstadt, B J
Eisman, Sylvan H
Eisner, Elmer
Eiss, Joseph J
Ekeland, Ivar
Eklof, Paul C
Eklund, Anthony D
Ekman, Kenneth E
Ekong, Samuel
El Kacimi Alaoui, Aziz
El Kohen, Abdelouahab
El-Helaly, Sherif Taha
El-Shobaky, Entisarat
Eldridge, Klaus E
Elhadad, Jimmy H
Elhay, Sylvan
Elia, Michele
Eliason, Stanley B
Elich, Joe
Elkins, Bryce L
Elko, Constance B
Ellers, Erich W
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Elliott, David L
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Elliott, Herbert E Jr
Elliott, P D T A
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Ellis, James W
Ellis, Kathryn P
Ellis, Robert
Ellis, Sharon Theleman
Ellner, Stephen P
Elman, Richard S
Eloe, Paul W
Elson, Constance McMillan
Elton, John H
Elzanowski, Marek
Emamzadeh, Abolqasem
Embry-Wardrop, Mary R
Emch, Gerard G
Emerson, Marion P
Emery, Carol J Reinhard
Emmer, Michele
Enderton, Herbert B
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Endsley, Neil H
Engber, Michael
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Engl, Heinz W
England, James W
Engle, Jessie Ann
Engler, Hans P
Engquist, Bjorn
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Enns, Theodore C
Enochs, Edgar E
Enomoto, Kazuyuki
Ensey, Ronald J
Entringer, Roger C
Epp, Helmut P
Epp, Susanna S
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Epstein, Benjamin
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Epstein, D I
Epstein, Richard L
Erban, Daniel
Erbe, Lynn H
Erber, Friedrich M
Erbland, John P
Ercolano, Joseph L
Erdelyi, Ivan N
Erdman, John M
Erdmann, Michael A
Erdos, Paul
Erickson, Roger P
Erkiletian, Dickran H Jr
Erlandsson, Thomas
Erle, Dieter H
Errico, Thomas G
Ervynck, Gontran J O H
Eschenbach, Dieter
Escobales, Richard H Jr
Eskin, Gregory
Eslinger, Robert C
Espina, Carlos L
Essawy, Abdelrahman Hussein
Essén, Matts R
Esser, Anne-Marie Simon
Estrada, Luis
Etheridge, William L
Etter, Daniel O Jr
Evans, Michael Jon
Evans, Trevor
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Evyatar, Asriel
Ewen, Ira
Ewing, George M
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Ewy, Daniel J
Ezeilo, James O C

Fabec, Raymond C
Fabes, Eugene B
Fabrykowski, Jacek W
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Fagg, Charles Rocke
Faierman, Melvin
Fair, Wyman G
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Fairgrieve, Thomas F
Faith, Carl
Falbo, Clement E
Falconer, Etta Z
Falkner, Neil F
Fall, Thomas C
Faltings, Kai
Famoye, Kiya Felix
Farahat, H K
Faran, James J
Faris, William G
Farley, Belmont G
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Farmer, Thomas A
Farmer, William Michael
Farnsteiner, Rolf
Farran, Hani Reda
Farrand, Scott M
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Farrell, Paul A
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Farrer, Brian H
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Farris, Mark K

Fass, Arnold L
Fathi, Albert
Faudree, Ralph J Jr
Faulkner, Frank D
Faulkner, Gary Doyle
Fauntleroy, Amassa C
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Feder, Moshe
Feeman, George F
Feeman, Timothy G
Feferman, Solomon
Fegan, H D
Fegreus, John F
Fehlmann, Richard
Feibel, Werner M
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Feichtinger, Hans Georg
Fein, Burton I
Feinberg, Robert Benjamin
Feinerman, Robert P
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Feit, Walter
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Feldman, Arnold D
Feldman, Edgar A
Feldman, Jacob
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Feldman, Norman
Fell, James M G
Fellers, Norman V Jr
Fellman, Johan
Fellows, Michael Ralph
Fenchel, Werner
Fendel, Daniel M
Fendrich, John W
Feng, Qi
Fenley, John C
Fenley, Sergio Roberto
Fennell, James G
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Fennig, Joseph N
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Fenstad, Jens E
Fenton, William E
Ferguson, Helaman
Ferguson, Pamela A
Ferguson, Thomas S
Fernandez, Roberto
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Ferrari, Carlo
Ferreira, Fernando J
Ferri, Massimo
Ferris, Ian M
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Feuer, Albert
Feuerbacher, Gary A
Fickett, James W
Fidler, K Steven
Fieldhouse, D
Fields, David E
Fields, Jerry L
Fields, K L
Figá-Talamanca, Alessandro
Filgo, Holland C Jr
Filippenko, Vladimir I
Finch, David V
Finch, John V
Finch, Steven Richard
Fingerman, Joel
Finkel, Allan J
Finkel, David
Finkelstein, Leib
Finkelstein, Louis D
Finlayson, Henry C
Finol, Carlos E
Finston, David R
Fintushel, Ronald A
Firey, William
Fischer, David R
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Fischer, H
Fischer, Hans R
Fishback, William T
Fishburn, Peter Clingerman
Fisher, Edward R
Fisher, Joe W
Fisher, Stephen D
Fishman, Louis
Fisk, Steve
Fitch, Frederic B
Fitz-Gerald, Gary F
Fitzgerald, Eugenia E
Fitzpatrick, Ben Jr
Fitzpatrick, Patrick M
Fitzsimmons, Patrick J
Fixman, Uri
Flahive, Mary Elizabeth
Flanders, Harley
Flanigan, Francis J
Flapan, Erica L
Flaspohler, John C
Flath, Dan
Fleckner, Oscar L Jr
Fleming, Charles G
Fleming, Daniel J
Fleming, M Brendan
Fleming, Richard J
Fleming, Wendell H
Fletcher, Evan Martin
Fletcher, G Yates
Fliess, Michel
Florence, John B
Flores, Jorge Gilberto
Floret, Klaus
Flosser, H O
Floyd, Edwin E
Flynn, David E
Flynn, Lawrence E
Flynn, Robert
Flytzanis, E
Foata, Dominique
Foehl, Henry Clay
Foglio Susana, F L de
Foias, Ciprian Ilie
Foley, Amby M
Foley, Daniel M Jr
Folk, Thomas F
Folland, Gerald B
Fong, Che-Kao
Fong, Kirby W
Fong, Pamela Yuk-Ching
Fong, Paul
Fonseca, Irene
Fontaine, Jean-Marc
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Fontana, Marco
Fontenot, Robert A
Foote, Robert L
Foran, James
Forbes, Donald
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Ford, David A
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Forkeotes, Ann A
Forman, John W
Formanek, Edward W
Forster, Otto F
Forte, Bruno
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Foster, Andrew
Foulis, David J
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Fournelle, Thomas A
Fournier, John J F
Fowler, Robert S
Fox, John Michael
Fox, Ralph
Fraga, Robert J
Frame, J Sutherland
Frame, Michael Lee
Francaviglia, Mauro
Francel, Margaret Ann
Francis, Bruce A
Francis, Eugene A
Francsics, Gabor
Frandsen, Henry
Frangos, Nicholas Efstr
Frank, George N
Franke, John E
Frankel, Theodore T
Franklin, Joel N
Frantz, Deborah A
Frantz, Henry W III
Franzblau, Deborah S
Franzen, Alan
Frappier, Clement
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Frayne, Thomas E
Frazier, Michael W
Frech, Bruce
Frederickson, Elvy L
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Fredricksen, Harold M
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Freedman, Allen R
Freedman, Michael H
Freeland, Mark S
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Freeman, Michael B
Frei, Armin
Freier, Jerome B
Freire Nistal, J L
Freitag, Herta T
Freskos, Mark Allen
Frey, Regina F
Freyd, Peter J
Fricker, Francois
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Fridy, John A
Fried, David
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Friedlander, Eric M
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Friedman, Joyce B
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Friesen, Donald K
Frink, Orrin
Frisch, Norman J
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Froese, Richard G
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Frohlich, Jurg M
Frohliger, John A
Frucht, Robert W
Fry, Cleota G
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Fry, Thornton C
Fryer, S Harvey
Fu, Joseph H G
Fuchs, Laszlo
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Fuchssteiner, Benno
Fuglede, Bent
Fuglister, Frederick J
Fuhrken, E Gebhard
Fuji-Hara, Ryoh
Fujimagari, Tetsuo
Fujisaki, Rieko
Fujiwara, Daisuke
Fujiwara, Masahiko
Fukuda, Komei
Fukui, Seiichi
Fukushima, Masatoshi
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Fuller, Kent R
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Fulton, Curtis M
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Fulton, William
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Furuta, Takayuki
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Fusaro, B A
Fusco, Giorgio
Futaki, Akito
Futia, Carl A
Fwu, Chihchy

Gaal, Lisl Novak
Gabai, David
Gabay, Jacques
Gabber, Ofer
Gabriel, Richard F
Gackstatter, Fritz
Gadbois, Steven Charles
Gadia, Shashi Kumar
Gage, Michael E
Gaglione, Anthony M
Gagola, Gloria Potter
Gagrat, Mani S
Gaier, Dieter
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Gainer, Dianne M
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Galbraith, A S
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Gallier, Jean H
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Games, Richard A
Gamst, Andreas
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Ganesan, Subramanian
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Gani, Joseph M
Ganser, Carl C
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Gao, L Zhiyong
Gapaillard, Jacques
Gaposchkin, Peter J A
Garb, Regina H
Garcia, Mariano Jr
Garcia-Lafuente, Jose M
Garcia-Loygorri, Cristobal
Garcia-Planas, Isabel
Garcia-Rodeja F, Eduardo
Gard, Thomas C
Gardiner, Christopher J
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Garg, Krishna M
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Garnett, John B
Garraway, Annie Marie
Garrett, John W
Garrison, Betty B
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Garsia, Adriano M
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Gartland, Eugene C Jr
Garver, Michael
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Garza, Gene G
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Gasca, Mariano
Gaschütz, Wolfgang
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Gaskill, Jerry W
Gasqui, Jacques H
Gass, Michael D
Gass, Noreen Herefeld
Gastl, George C
Gatterdam, Ronald W
Gatteschi, Luigi
Gauchman, Hillel
Gaudefroy, Alain
Gaudry, Garth I
Gauthier, Paul M
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Gazik, Ray J
Gechter, Jerry
Gehring, Frederick W
Geissinger, Ladnor D
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Gelbart, Abe
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Geluk, Jaap L
Geman, Stuart Alan
Gemeda, Demissu
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Gentili, Graziano
Geoghegan, Ross
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George, John Clay
Georgiou, D A
Geramita, Anthony V
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Geremia, Raymond S Jr
Gerhard, J Arthur
Gerhardt, C
Gerig, Stephen R
Gerisch, Wolfgang
Gerlach, Eberhard G P
Gerlach, Jacob H
Gerlach, Jürgen
Germain, Paul
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Gershenson, Hillel H
Gerstein, Larry J
Gerstenhaber, Murray
Gerszonowicz, Jorge A
Gerth, Frank E III
Gervais, Jean Jacques
Gerver, Joseph L
Gessaman, Margaret P
Gessel, Ira M
Getu, Seyoum
Geue, Andrew S
Gewand, Marlene E
Gewirtz, Stephen J
Ghatage, Pratibha
Ghent, K S
Ghisa, D
Ghosh, Bhaskar K
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Giannini, Paola
Gibson, Peter M
Gieseker, David
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Giga, Yoshikazu
Gilbarg, David
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Gillman, David S
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Gilsdorf, Thomas E
Gine-Masdeu, Evarist
Gingell, Robert A Jr
Gingrich, Ross B
Gioia, Anthony A
Giovannitti, Anthony J
Giraud, Daniel
Girolo, Jack E
Gittings, Raymond F
Givant, Steven R
Gladue, Earl C
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Glassey, Robert T
Glauberman, George
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Glaz, Sarah
Glazebrook, James F
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Glimm, James G
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Goad, Robert E
Goblirsch, Richard P
Godbole, Anant P
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Goebel, K
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Goetz, Abraham
Golan, Jonathan S
Golber, David L
Gold, Karen F
Gold, Steven
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Goldbeck, Ben T Jr
Goldberg, David M
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Goldblatt, Robert I
Golden, Kenneth M
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Goldman, Jay R
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Goldner, Siegfried R
Goldstein, Gerald
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Goldstein, Larry J
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Goldstein, Sheldon
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Goldstone, Richard J
Golightly, George
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Golubitsky, Martin
Gomes, Gracinda
Gomez Pardo, Jose Luis
Gomez, Gerard
Gomez, Jose A
Gomez-Ruiz, Francisco
Gomi, Kunio
Gomory, Ralph E
Gompf, Robert E
Gondard-Cozette, Daniell J
Gonshor, Harry
Gonzalez-Guzman, Jorge
Gonzalo, Jesus
Gooch, B Dean
Good, Anton
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Goodearl, Kenneth R
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Goodman, Roe W
Goodner, D B
Goodson, Geoffrey Ross
Goolsby, Ronnie C
Goon, Jonathan L
Gootman, Elliot C
Gopal, Mangalam R
Gordh, George R Jr
Gordon, B Brent
Gordon, Carolyn S
Gordon, Derek
Gordon, Hugh
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Gordon, S Robert
Gordon, Yehoram
Gorenflo, Rudolf
Gorenstein, Daniel
Goresky, R Mark
Gori, Franco
Gorkin, Pamela B
Görlich, Ernest
Gorman, William J III
Gormley, Michael J
Goroff, Daniel L
Gorostiza, Luis G
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Gosselin, John A
Gosselin, Richard P
Gossett, Eric James
Goth, John A
Goto, Hideo
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Gottlieb, Allan J
Gottlieb, Daniel H
Gould, Henry W
Gould, Lawrence D
Gould, Lillian V
Gould, Sydney H
Goutziers, Constant J
Gouvêa, Fernando Quadros
Govaerts, Willy J F
Gover, Eugene H
Gowda, Muddappa Seetharama
Goze, Michel
Graber, James S
Grabiel, Federico
Grabiner, Sandy
Grabner, Gary Clem
Grace, Dennis R
Grace, Edward E
Grad, Harold
Graef, John R
Graf, Siegfried
Grafakos, Loukas
Gragg, Karen E
Graham, Aly
Graham, C Robin
Graham, Colin C
Graham, George
Graham, George P
Graham, Ronald L
Graham, Sidney W
Graham, Victor W
Grainger, Arthur D
Gramsch, Bernhard
Grannell, Michael John
Grant, Caroline Galt
Grasman, William B
Grasser, Horst-Siegfried
Grassi, Peter Matthew
Gratiaa, Marceline C
Gratzer, George A
Gravel, Pierre
Graver, Jack E
Graves, Alan S
Graves, Glenn W
Graves, Larry K
Graves, Robert L
Gravesen, Jens
Gray, Denise
Gray, Jack D
Gray, James M
Gray, Jeremy John
Gray, John W
Gray, Robert E
Gray, Samuel Hutchison
Grayson, Daniel Richard
Greaves, G
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Greechie, Richard J
Greek, John W
Green, David Jr
Green, John W
Green, Leon W
Green, William L
Green, Willie H
Greenberg, Peter A
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Greenberg, Ralph
Greene, John Robert
Greene, Peter H
Greenfield, Gary R
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Greenleaf, Allan T
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Greenspan, Bernard
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Greenspan, Donald
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Greever, John
Gregorac, Robert J
Gregory, David A
Gregory, John
Gregory, Thomas Bradford
Greif, Anthony David
Greif, Stanley J
Greim, P
Greiner, Peter C
Gresser, John T
Greville, Thomas N E
Griego, Richard J
Griffin, E L Jr
Griffin, Philip Stanley
Griffin, William Gerald
Griffing, Gary R
Griffiths, Phillip A
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Grigis, Alain A
Grillakis, Manoussos
Grimmer, Ronald C
Grimson, W Eric L
Grinberg, Vladimir
Groemer, Helmut
Grogan, Eleanor M
Grognard, Rene J M
Gromov, Mikhael
Grone, Bob
Gropp, William D
Gross, Benedict H
Gross, Kenneth I
Gross, Leonard
Gross, Louis J
Gross, Mark Thomas
Grossman, Edward H
Grossman, Robert
Grosswald, Emil
Grove, Edward A
Grove, K
Grove, Larry C
Grover, Carole L
Groves, J R J
Grubb, Daniel J
Grudin, Arnold
von Grudzinski, Olaf
Gruenberg, Karl W
Gruenhage, Gary F
Grundlnd, Alfred Michel
Gruter, Michael
Gryllakis, Constantinos
Guacaneme, Julio Enrique
Gualtierotti, A F
Guaraldo, Rosalind J
Guay, Merle D
Gudder, Stanley P
Gudimetla, V S Rao
Guenard, Francois
Guerin, Esther E
Guest, Martin A
Guetti, Joan F
Güichal, Edgardo N
Guillemin, Victor W
Guillot, J C
Gulbenkian, Garabed
Gulden, S L
Gulick, Denny
Gulliver, Robert D II
Gundersen, Gary G
Gundy, Richard F
Gunn, Charles G
Gunn, Michael E
Gupta, Hansraj
Gupta, Rajiv
Gupta, Ram Niwas
Gupta, Shiv Kumar
Guralnick, Robert M
Gurel, Okan
Gurganus, Kenneth R
Gurney, Margaret
Gurtin, Morton E
Gustafson, Richard F
Gustafson, Robert A
Gustafson, Sven-Ake
Gustafson, William H
Gutek, Andrzej S
Guterman, Martin M
Guthery, Scott B
Gutierrez, Cristian E
Gutknecht, Martin H
Gutowitz, Howard Andrew
Guttalu, Ramesh S
Gutzman, Wayne W
Guy, Richard K
Guy, Wynne Alexander
Guyker, James

Ha, Kwang Chul
Ha, Young-Hwa
Haagensen, Kenneth E
Haario, Heikki
Haarsma, Loren D
Haas, Felix
Habegger, Nathan B
Haber, Seymour
Habetha, Klaus
Habibullah, G M
Hackborn, William W
Hackenbroch, Wolfgang
Hackler, Donald B
Haddad, George F B
Haddad, Hadi M
Haddad, Labib S
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Haebich, William
Haefliger, Andre
Haemmerlin, Guenther
Hafner, James L
Hag, Per
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Hager, Anthony W
Hager, Harold W
Hagis, Peter Jr
Hagler, James N
Hagood, John W
Hahn, Geña
Hahn, Kyong T
Hahn, Neale M
Hahne, Gerhard E
Hailat, Mohammad Q
Haile, Darrell E
Haiman, Mark
Haimo, Deborah T
Hain, Richard Martin
Haji-Ghassem, Kamran
Hajian, Gerald
Hajja, Mowaffaq Abdulla
Halberstam, Heini
Halchin, Judy D
Hale, David R
Hale, Jack K
Hale, Margie A
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Hales, R Stanton Jr
Halkin, Hubert
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Halverson, Kimberly J
Hamadani-Zadeh, Javad
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Hamill, William A
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Hamm, Rose C
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Hammer, Peter L
Hammond, William F
Hampton, Charles R
Hamrick, Gary C
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Han, Jin Kyu
Handel, David
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Hanes, Kit
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Hanna, Charles C
Hanna, Peter
Hannan, James F
Hano, Jun-Ichi
Hansell, Roger W
Hansen, Idar
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Hansen, Vagn Lundsgaard
Hanson, Stanley C
Harada, Koichiro
Harary, Frank
Harbater, David
Harborth, Heiko
Harbourne, Brian
Hardie, Keith A
Hardin, R I
Hardt, Robert M
Hardy, Darel W
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Hare, Gordon B
Hare, William R
Hargrove, E E
Harinath, K S
Harine, Katherine Jane
Haring-Smith, Robert H
Harker, Patrick
Harkleroad, Edie
Harkleroad, Leon
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Harmand, Peter
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Harrison, Monica L
Harrold, Orville G Jr
Harrop, Fred F
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Hart, Garry D
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Hartl, Johann
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Hartshorne, Robin
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Harvey, Charles A
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Harzheim, Egbert
Hasegawa, Minoru
Hashimi, Jamil R
Hashimoto, Ki-ichiro
Haskell, Peter E
Haslach, Henry W Jr
Hasselbach, Eric R
Hassinger, Bill Jr
Hasumi, Morisuke
Hatada, Kazuyuki
Hathaway, Dale K
Hattori, Akio
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Hauptman, Herbert Aaron
Hausmann, Jean-Claude
Hausner, Melvin
Havens, Jim
Haver, William E
Hawkins, William Grant
Hay, George E
Hay, Louise
Hayashi, Elmer K
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Hayden, John L
Hayes, David F
Hayne, Roger M
Haynes, Robert C
Hayslip, Iris C
Hazlewood, Carol
Hazlewood, Donald G
Head, Richard R
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Headley, Velmer B
Healey, Timothy J
Heard, Melvin L
Heath, Lenwood S
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Heatherly, Henry E
Hebert, Michel
Hecht, Henryk
Hecht, James E
Hecht-Nielsen, Robert
Hecker, David A
Hedberg, Lars I
Hedlund, Gustav A
Hedlund, James H
Hedstrom, Gerald W
Hefez, Abramo
Heifetz, Daniel B
Heiman, Barbara
Heineken, Hermann
Heinicke, Allan G
Heinig, Hans P
Heinold, Robert D
Heinrich, Katherine
Heins, Albert E
Heins, Maurice H
Heinze, Joachim
Heinzer, Martin N
Heitsch, James L
Hejtmanek, Johann Hans
Heldermann, Norbert
Helgason, Sigurdur
Hellberg, H Stefan
Heller, Alex
Heller, Barbara Ruth
Heller, Dorothy M
Heller, Robert
Hellerman, Leo
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Helson, Henry
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Helton, Frances J
Helton, J William
Helton, Jon C
Helton, Robert Arthur
Helwig, Karl-Heinz
Helzer, Garry A
Hemker, Pieter W
Hemmeter, Joseph S
Hemminger, Robert L
Hemmingsen, Erik
Hempel, John P
Hemstead, Robert J
Henderson, Francis McVey
Henderson, James P
Hendricks, Walter J
Henkin, Leon A
Henn, Hans-Werner
Hennequin, Paul-Louis
Hennessy, Patricia A
Henniart, Guy M
Henniger, J P
Henrich, Christopher J
Henrici, Peter
Henriksen, Melvin
Henry, Myron S
Hensel, Robin Ann Morgan
Hensley, Douglas A
Hensley, Elmer L
Henstock, Ralph
Herbst, Albert F
Herda, Hans-Heinrich W
Herfort, Wolfgang Norbert
Hergenrother, Steven L
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Hermann, Robert
Hernandez, Diego B
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Herod, James V
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Herron, David A
Herron, Wm Kent
Herschorn, Michael
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Herstein, Israel N
Herve, Michel
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Herz, Carl S
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Herzog, John O
Hesla, Todd
Hess, Jacob J
Hess, Peter
Hesselink, Wim H
Hestenes, Marshall D
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Heuer, Gerald A
Heumos, Michael J
Heuser, Harro G
Heuvers, Konrad John
Hewitt, Gloria C
Hewitt, P R
Heyneman, Robert G
Hiai, Fumio
Hickernell, Fred J
Hicks, Darrell Lee
Hida, Takeyuki
Higdon, Robert L
Higgins, John A
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Higgins, Philip J
Higgins, William J
Hight, Orian L
Hightower, James K
Hightower, William L
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Higuchi, Yasunari
Hijab, Omar B
Hilbert, Stephen R
Hildebrand, Adolf
Hildebrandt, Theodore W
Hildebrant, John A
Hilden, Hugh M
Hilditch, A Stephen
Hilgers, John W
Hill, David G B
Hill, E Stamford II
Hill, James
Hill, Ned W Jr
Hill, Robert N
Hill, Sarah Lynn
Hill, Shirley A
Hillman, Jonathan Arthur
Hilton, Peter J
Himmelberg, Charles J III
Hindley, James Roger
Hindman, Neil B
Hinman, Peter G
Hinojosa-Berrones, J A
Hinrichsen, D
Hinson, Edward K
Hintz, Elizabeth Mansfield
Hintzman, William R
Hirano, Tetsutaro
Hironaka, Eriko
Hironaka, Heisuke
Hirsch, Morris W
Hirschfelder, Elizabeth S
Hirschfelder, John J
Hirschfelder, Rosemary
Hirzebruch, F E P
Hitchin, Nigel J
Hitotsuyanagi, Nobuo
Hively, Gregory A
Hjorth, Poul G
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Ho, Grace P
Hobbs, Arthur M
Hobby, Charles R
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Hochstadt, Harry
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Hockett, Kevin G
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Hodel, Richard E
Hodges, Lucille M
Hodges, Wilfrid A
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Hofer, Robert D
Hoffman, Jerome William
Hoffman, Kenneth M
Hoffman, Kenneth R
Hoffman, Michael E
Hoffman, Michael J
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Hoffmann, Banesh
Hoffmann-Jorgensen, Jorgen
Hofmann, Charles E III
Hofmann, Karl H
Hofmann, Steve C
Höft, Hartmut
Hoft, Margret H
Hogan, Daniel A
Hogan, Guy T
Hogbe-Nlend, Henri
Hogesteeger, F W
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Holberton, John V
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Holenweg, Werner
Holladay, Kenneth W
Holland, Daniel L
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Holland, W Charles
Holley, Frieda K
Holley, Richard Andrew
Hollingsworth, B J
Hollins, Clinton G
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Holman, Wayne James III
Holmann, Harald R A
Holmberg, Bengt R
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Holtom, Carl
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Holzer, Joseph C
Holzman, Robert E
Homer, Roger H
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Homsy, Elham
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Honda, Koji
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Hook, Julian L
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Horn, Jean Macgregor
Horne, J G Jr
Horner, T S
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Horrocks, Geoffrey
Horsfield, Christopher H
Horvath, Charles Daniel
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Hosack, John M
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Hotta, Ryoshi
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Houston, Evan G
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Hoye, Laurence G
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Hoyt, Kenneth
Hratz, Joseph A
Hrbacek, Karel
Hsia, J S
Hsiang, Wu-Chung
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Hsieh, Po-Fang
Hsieh, Simon C
Hsu, Nai-Chao
Hsu, Pao-Sheng
Hu, Chih-Chen
Hu, S T
Hu, Shou-Jen
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Huang, Abigail S
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Huber, Alfred O
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Huch, Donna L
Huckaba, James A
Huckemann, Friedrich C
Hudson, Charles C Jr
Hudson, D L
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Huerta, Carlos Cuevas
Huet, Denise
Huff, Gerald B
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Huilgol, Raja R
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Hummel, James A
Hummel, Kenneth E
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Huneke, Craig L
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Hung, David C
Hung, Henry Hin-Lai
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Hunkins, Dalton R
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Hunt, Walker E
Hunte, Beryl E
Hunter, Colin B
Hunter, Norma Gerkens
Hunter, Roger H
Huotari, Robert Heikki
Huq, Syed A
Hurd, Spencer Peyton
Hurder, Steven E
Hurley, Donal J
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Hurley, Michael G
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Hurst, C A
Hurvich, Clifford M
Hurwitz, R Daniel
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Husain, Taqdir
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Hutchinson, George A
Hutchinson, Joan P
Hutchinson, John J
Hutson, Holmes L
Hutton, Edward L
Huynh, Quyen Q
Hveberg, Steinar Magne
Hvidsten, Michael D
Hwang, Jang C
Hwang, John Jew-Chen
Hyers, Donald H
Hyllengren, Anders R
Hyvonen, Jaakko P

Iarrobino, Anthony A Jr
Ibele, Charles E
Ibrahim, A Shawky
Iei, Yutaka
Igarashi, Akira
Igarashi, Masao
Igusa, Jun-Ichi
Iha, Franklin T
Ihringer, Thomas
Iino, Riichi
Iio, Tutomu
Ijjasz Vasquez, Ede J
Ikebe, Teruo
Ikeda, Kazumasa
Ikenaga, Bruce M
Illman, Sören A
Im Hof, Hans Christoph
Im, Chang Ku
Imai, Hideo
Imam, Ibrahim N
Imrich, Wilfried
Inaba, Hiroshi
Indlekofer, K H
Infante, Ettore
Infante, Ronald P
Ingraham, Edward C
Ingram, John Michael
Ingram, Nancy Jane
Ingram, Steven K
Innami, Nobuhiro
Insel, Arnold J
Ioakimidis, N I
Iorio, Rafael J Jr
Ipina, Lynne Kamstra
Irving, Ronald S
Irwin, Robert C
Isaac, Richard E
Isaacs, Godfrey L
Isaacs, I Martin
Isaacson, Eli
Isaacson, Eugene
Isard, Stephen D
Isbell, John R
Ishibashi, Makoto
Ishihara, Tadashige
Ishii, Jyun
Ishikawa, Hirofumi
Ishimoto, Hiroyasu
Iskander, Awad A
Ismail, Mourad El-Houssieny
Ito, Noboru
Itô, Seizô
Itzkowitz, Gerald L
Iverson, I B
Iwanaga, Yasuo
Iwasawa, Kenkichi
Iwata, Koichi
Ize, Jorge A
Izuchi, Keiji
Izumi, Shin-Ichi

Jablow, Eric Robert
Jabon, David C
Jackins, Harvey
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Jaco, William H
Jacob, Henry G Jr
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Jaffe, Arthur M
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Jain, M K
Jain, Naresh C
Jakobsen, Hans Plesner
Jambois, Thomas F
James, David M
James, Donald G
James, Ralph L
James, Robert C
Janik, Jacqueline C
Jankins, Mark
Jans, James P
Jansen, Willem G
Janson, Barbara J
Janssen, Robert D
Jantosciak, James S
Janusz, Gerald J
Janwa, Heera Lal
Jara Martinez, Pascual
Jarchow, Hans
Jarden, Moshe
Jardine, John Frederick
Jarvi, Pentti K
Järvinen, Richard D
Jarvis, Trevor M
Jategaonkar, Arun V
Javor, James A
Jayne, John W
Jea, Hae-Pyng
Jea, Kang C
Jean, Michel
Jeanquartier, Pierre
Jech, Thomas J
Jeffrey, Alan
Jeggle, Hansgeorg
Jeltsch, Rolf
Jenkins, Joe Wiley
Jenkins, Theodore Allen
Jenness, Jeffrey W
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Jensen, Arne
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Jenson, Richard Alan
Jepsen, Charles H
Jerison, David
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Jerome, Carlos
Jerome, Joseph W
Jeroslow, R G
Jerrard, Richard P
Jerri, Abdul Jabbar
Jessen, Borge
Jha, V
Jiang, Boju
Jimenez, Jose Alfredo
Jockusch, Carl G Jr
Jodeit, Max A Jr
Johanson, Arnold A
Johansson, Bo Ingvar
John, David J
John, Fritz

Johnsen, Eugene C
Johnsen, Ronald L
Johnson, Charles N
Johnson, D Randolph Jr
Johnson, Dale Martin
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Johnson, David Copeland
Johnson, David H
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Johnson, Diane Louise
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Johnson, Donald G
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Johnson, P B
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Johnson, R Warren
Johnson, Robert Shepard
Johnson, Roberta F
Johnson, Roy A
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Joichi, James T
Jonah, David W
Jones, Alfredo R
Jones, Carl Hilton
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Jones, F Burton
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Jones, John Jr
Jones, Peter R
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Jones, Theodore W
Jones, Vaughan F R
Jones, William A Jr
Jones, William R
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Jongen, Hubertus Th
Jongmans, Francois
Jonker, Leo B
Jonsdottir, Kristin Halla
Jonsson, Bjarni
Jonsson, Thordur
Jordan, G Samuel
Jordan, Kirk E
Jordan, Sister Mary
Jorgensen, Murray A
Jorgensen, P E T
Jorgensen, Roy A Jr
Joris, Henri E
Joseph, James E
Josephson, William Allen
Josephy, R Michael
Joshi, Padmini T
Jou, S S
Joyal, Andre
Joyner, David W
Juberg, Richard K
Jumper, Gregory S
Jun, Byung Moon
Jun, Kil Woung
Jungck, Gerald F
Junghenn, Hugo D
Jungnickel, Dieter

Jungreis, Irwin L
Jurca, Dan
Jurzysta, Sonja H
Justice, James H
Justus, Charles H

Kaashoek, Marinus A
Kabak, Bertram S
Kádas, Zsuzsanna Margit
Kadlecek, David
Kahan, William M
Kahane, Jean-Pierre
Kahaner, David Kenneth
Kahn, Daniel S
Kahn, Jeff N
Kahn, Peter J
Kahn, Steven M
Kailath, Thomas
Kajiwara, Joji
Kakihara, Yuichiro
Kakiichi, Yoshiaki
Kalai, Ehud
Kalantari, Iraj
Kalia, R N
Kalisch, Gerhard K
Kall, Peter
Kalliongis, John E
Kallman, Ralph A
Kallstrom, Anders
Kalton, N J
Kaman, Charles H
Kamejima, Kohji
Kamel, Hyman
Kamishima, Yoshinobou
Kamiya, Shigeyasu
Kammler, David W
Kamowitz, Herbert M
Kamp, William P
Kamran, Niky
Kan, Charn-Huen
Kanamori, Akihiro
Kanda, Mamoru
Kaneda, Masaharu
Kaneko, Akira
Kaneko, Hideaki
Kanemitsu, Shigeru
Kanenobu, Taizo
Kaneyuki, Soji
Kang, Ming-Chang
Kani, Ernst J
Kaniuth, Eberhard
Kann, Edgar D
Kannan, Ravindran
Kanner, Richard A
Kanno, Tsuneo
Kano, Takeshi
Kanold, Hans-Joachim
Kantorovitz, Shmuel
Kao, Calvin C
Kaper, Hans G
Kaplan, Alan
Kaplan, Harold M
Kaplan, Stanley
Kaplan, Wilfred
Kaplansky, Irving
Kappe, Luise-Charlotte
Kappe, Wolfgang P
Karal, Frank C Jr
Karamatsu, Yoshikazu
Karamzadeh, O A S
Karch, Paul T
Karel, Martin Lewis
Karle, Jerome
Karlof, John K
Karlovitz, Les A
Karnik, Subhash Moreshwar
Karoubi, Max
Karpilovsky, G
Karpinski, Marek
Karr, Alan F
Karras, Ulrich
Karreman, Herman F
Karrenberg, Frederick G
Karrer, Guido

Kartsatos, Athanassios G
Karube, Takashi
Karush, William
Kascic, Michael J Jr
Kasriel, Robert H
Kato, Goro C
Kato, Masakimi
Kato, Shin-ichi
Kato, Takao
Kato, Tosio
Katok, Anatole
Katok, Svetlana R
Katz, Andrew
Katz, Victor J
Katzen, Dahn
Katznelson, Y
Kauffman, Louis H
Kauffman, Robert M
Kaufman, Allan N
Kaufman, Arthur
Kaufman, Edwin H Jr
Kaufman, William E
Kaufmann-Buhler, Walter
Kaup, Burchard
Kaup, Wilhelm
Kawai, Takahiro
Kawamata, Yujiro
Kay, David C
Kay, Leslie D
Kazamaki, Norihiko
Kazdan, Jerry L
Kearfott, R Baker
Kearn, Vickie H
Kearney, Robert D
Kearton, Cherry
Keating, Kevin P
Keating, M E
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Keaty, John Michael
Keeler, Stephen P
Keenan, Daniel Macrae
Keeping, Anthony J
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Kehayopulu, Niovi
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Keisler, James E
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Keldys, Ljudmila
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Keller, Arthur M
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Keller, Herbert B
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Kelley, Al
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Kelly, G Maxwell
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Kelly, John Clive
Kemeny, John G
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Kemp, Marilyn J
Kempachiro, Ohashi
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Kempf, George R
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Kent, George A
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Kerckhove, Michael George

Kerman, R A
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Kervaire, Michel A
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Kettner, James E
Key, Eric Stephen
Keyfitz, Barbara L
Keys, Charles David
Keys, Robert Gene
Khadr, Amr S
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Khalimsky, Efim Davidovich
Khan, Donald W
Khan, Liaqat Ali
Khan, Mizan R
Khan, Mohammad Ahmad
Kharaghani, Hadi
Khavinson, Dima
Khazal, Reyadh Rashed
Khor, Hoe Peng
Khosraviyani, Firooz
Kibbey, D E
Kichenassamy, Satyanad
Kidwaii, Hariss
Kidwell, Mark E
Kiefer, James E
Kielczewski, Zbigniew
Kiernan, Bryce M
Kieval, Harry S
Kifer, Yuri
Kilgour, D Marc
Kilhefner, Dale Z
Killeen, John
Killgrove, Raymond B
Kilpi, Yrjo O
Kiltinen, John O
Kim, Chong-Rae
Kim, Choo W
Kim, Hayon
Kim, Hong Jong
Kim, Hyuk
Kim, In Su
Kim, Jin Bai
Kim, Jong-Chul
Kim, Jongsik
Kim, Joong Ho
Kim, Kyongsoo
Kim, Kyung Hwa
Kim, Sang Og
Kim, Soon-Kyu
Kim, Sung-Ock
Kim, Wan Se
Kim, Woo Jong
Kim, Young Joon
Kim, Young-Kook
Kimber, John E Jr
Kime, Katherine A
Kimme, Ernest G
Kimmel, John Edward
Kimura, Kyoko
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Kincaid, Wilfred M
Kinderlehrer, David S
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Kiraly, Emery
Kirby, A R
Kirby, Mary D
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Kirch, Allan M
Kirchbraber, Urs
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Kirk, David B
Kirk, Joe E Jr
Kirk, William A
Kirmayer, Greg A
Kirmser, P G
Kirsch, Werner
Kirwan, Frances C
Kirwan, William E II
Kiselman, Christer O
Kiser, Terry Lee
Kishi, Masanori
Kishore, Masao
Kister, James
Kister, Jane
Kita, Hiroo
Kitada, Hitoshi
Kitano, Koh-Ichi
Kitchen, Joseph W Jr
Kittaneh, Fuad A
Kittappa, R Kit
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Kiyek, K
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Klaasen, Gene A
Klainerman, Sergiu
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Klass, Michael J
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Klatman, David S
Klawe, Maria Margaret
Klee, Victor L Jr
Kleiman, Steven L
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Kleiner, Mark
Kleinerman, Samuel
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Kleisli, H
Kleitman, Daniel J
Kleppner, Adam
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Klingen, Helmut
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Knaust, Helmut
Kneece, Roland R Jr
Knight, Frank B
Knight, Julia
Knight, Lyman C Jr
Knill, Ronald J
Knoebel, Arthur
Knoerr, Alan P
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Knorr, K R K
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Knuth, Donald E
Knutson, Donald I
Ko, Hai-Ping
Ko, Ki Hyoung
Ko, Ohseun Park
Ko, Tsz Mei
Kobayashi, Shoshichi
Kobayashi, Yuji
Kober, Wolfgang
Kocan, Daniel
Koch, Charles F
Koch, Richard M
Kochendorfer, Anne
Kochman, Stanley Oscar
Kodama, Tetsuo
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Koditschek, Daniel Eliezar
Koehler, Anne B
Koehler, T L
Koellner, William G
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Koh, Jee Heub
Koh, Kwangil
Kohler, Peter
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Kohn, Joseph J
Kohn, Robert V
Köhnen, Walter
Koizumi, Shoji
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Kokoska, Stephen M
Kolaitis, Phocion G
Kölbig, Kurt Siegfried
Kolchin, E R
Kolesar, R J
Kolesnik, Grigori
Kolk, Johan A C
Kollar, Janos
Koller, Herbert
Kolman, Bernard
Kolmus, Peter A
Kolodner, Ignace I
Koltracht, I
Komanska, Henryka Krystyna
Komatsu, Hikosaburo
Komatu, Yusaku
Komiya, Yurin
Komm, Horace
Komornicki, Wojciech
Kōmura, Takako
Kon, Mark Andrew
Kong, Man Cheong
Konhauser, Joseph D E
Konig, Heinz J
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Koornwinder, Tom H
Kopacek, Hal W
Kopell, Nancy J
Kopperman, Ralph D
Korányi, Adam
Korenblum, Boris
Korevaar, Jacob
Korevaar, Nicholas Jacob
Koriyama, Akira
Korsmo, Eric Paul
Kortanek, Kenneth O
Korzeniowski, Andrzej
Kosarew, Siegmund
Kosinski, Antoni A
Kosler, Karl Andrew
Koslowski, Juergen
Koss, Walter E
Kossack, C R
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Kostenbauder, Adnah G
Kotiuga, P Robert
Kottman, Clifford A
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Kountz, Linnea M
Kourouniotis, Christos
Kovacs, Anton Amos
Kovářík, Zdislav V
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Kozin, Frank
Kra, Irwin
Krabbe, Gregers L
Kracht, Manfred
Krafft, Olaf W
Kraft, Hanspeter
Kraines, David P
Krakowski, Fred
Krall, Harry L
Kramer, Earl S
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Kramer, Robert J
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Kranjc, Marko
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Kranzer, Herbert C
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Kraut, Gertrud L
Kravvaritis, D
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Kreider, Donald L
Krein, Mark G
Krein, Selim Grigorjevitch
Kreith, Kurt
Krener, Arthur J
Krengel, Ulrich
Kress, Michael E
Kreyszig, Erwin O
Krieger, Henry A
Kriegman, David A
Kriegsman, Helen F
Krinik, Alan Cary
Krishnamoorthy, Mukkai S
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Kristensen, Leif
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Krogstad, Harald E
Kronheimer, Erwin H
Kronstein, Karl M
Kropp, Karl V
Krumpholz, Gary R
Kruskal, Martin D
Krystock, Robert Lawrence
Ku, Hsu-Tung
Kubelka, Richard P
Kubert, Daniel S
Kubo, Fumio
Kubo, Tadao
Kubota, Yoto
Kuczumow, Tadeusz
Kudla, Stephen S
Kudo, Tatsuji
Kuebler, Roy R Jr
Kueker, David W
Kuelbs, James D
Kuga, Michio
Kugler, Lawrence D
Kuhlmann, Norbert
Kuhn, Nicholas J
Kuhn, Robert M
Kuiken, Kathryn
Kuiper, Hendrik J
Kuiper, Nicolaas H
Kuku, A O
Kulp, Daniel Teibi
Kumagai, Donna J
Kumahara, Keisaku
Kumar, A Anil
Kumasawa, Nin
Kumm, Elizabeth A
Kummer, Dawn M
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Kunen, Kenneth
Kunle, Heinz
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Künzle, Hans Peter
Kuo, Tzee Char
Kupferwasser, Marcelo
Kupka, Ivan
Kuranishi, Masatake
Kurata, Yoshiki
Kurowski, Gary J
Kurshan, Robert P
Kurss, Herbert
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Kurtzke, John F Jr
Kurtzman, Stephen Joseph
Kushner, Harvey
Kustin, Andrew Richard
Kusunoki, Yukio
Kuttler, Kenneth Latimer
Kutzko, Philip C
Kuusalo, Tapani J
Kuyk, Willem
Kwak, Edward K
Kwak, Hyo Chul
Kwak, Nosup
Kwon, Do-Ha
Kwun, Kyung W
Kydoniefs, Anastasios
Kye, Seung-Hyeok
Kyner, Walter T
Kyrouz, Thomas J
Kythe, Prem K
Kyuno, Shoji

LaBorde, Hasell T
LaBudde, Christian D
LaSalle, Margaret M
Labbe, Marcel Adrien
Labelle, Jacques
Labrousse, Jean-Philippe
Laca, Marcelo E
Lacampagne, Carole B
Lachance, Michael Anthony
Lacher, R C
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Lacomba, Ernesto A
Lada, Thomas J
Ladde, Gangaram S
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Laduke, Jeanne
Ladwig, John A
Laffey, Thomas J
Lafontane, Jacques
Lagarias, Jeffrey C
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Lahr, Charles Dwight
Laidacker, Michael A
Laird, Cameron B
Lakshmanan, Neela
Lakshmikantham, V
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Lam, Tsit-Yuen
Lamb, Charles W
Lambarth, David A
Lambek, Joachim
Lambert, Harvey W
Lambert, Joseph M
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Landrock, Peter
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Lane, Richard N
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Lang, George E Jr
Lang, Patrick M
Lang, Serge
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Langebartel, Ray G
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Langer, Robert W
Langsam, Joseph A
Langstaff, John E
Langston, Michael David
Laning, J H
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Lanteri, Antonio
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Lantz, Vicky L

Lanza de Cristoforis, M
Lanzano, Paolo
Lapidot, Eitan
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Lardy, Lawrence J
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Larsen, Soren
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Larson, Jean
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Larson, Suzanne Lynne
Larue, David M
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Laska, Michael
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Lászlö, Gãbor
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Lattin, Christopher
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Lau, Chi-Ping
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Laudenbach, Francois
Lauer, Robert M
Laufer, Henry B
Lauria, Francesco E
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Lausch, Hans
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Lawson, Walter R
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Laywine, Charles F
Lazar, Aldo J
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Lazarus, Andrew J
Lazerson, Earl E
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Lê, Düng Tráng
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LeMesurier, Brenton John
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Lee, Kyung Bai
Lee, Myrna Pike
Lee, Peng-Yee
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Lee, Ronnie
Lee, Sa-Ge
Lee, Shyling
Lee, Tack-Wang
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Lee, Yuh-Jia
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Lehr, Marguerite
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Leibowitz, Rochelle
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Leipholz, Horst Hermann Eduard
Leipnik, Roy B
Leith, Cecil E Jr
Leitzel, James R C
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Leja, Stanislaw
Lelek, Andrzej
Lelong, P J
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Lemei, Han
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Lenihan, Stanley R
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Leon, Steven J
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Leonardi, Sharon Ann
Leong, Yu Kiang
Lepisto, Timo Valter
Lepowsky, James I
Lerat, Alain
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Leslie, Arthur S
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Leu, Hsiao-Tung
Leung, Anthony W
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Leung, Kar-Koi
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Levenberg, Norman
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Levy, Azriel
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Lewis, John Howard
Lewis, L Gaunce Jr
Lewis, Robert H
Lewis, William James
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Lhee, Byung Su
Li, Bingxi
Li, Li-Ge
Li, Luen-Chau
Li, Peter W K
Li, Tien-Yien
Li, Wen-Ching Winnie
Liang, David Shien
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Liao, Luby
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Libby, Richard Allan
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Lichnerowicz, Andre
Lichtenbaum, Stephen
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Lick, Dale W
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Lieberman, David I
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Lien, Magnhild
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Light, F W Jr
Lighterman, Mark S
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Lim, Chong-Keang
Lima, Asvald
Lin, Charlotte
Lin, Jindro
Lin, Pei-Kee
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Lindberg, John A Jr
Lindemann, Willi
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Lindquist, W Brent
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Ling, William Halstead
Linnell, P A
Linsenmeyer, Edward C
Lions, J L
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Lipman, Joseph
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Lipp, D W
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Lister, William G
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Liu, Zhong-Dong
Liulevicius, Arunas L
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Livingston, Charles
Livingston, Ellen Schmitz
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Livsic, Moshe S
Llave, Rafael de La
Llewellyn, Mark A
Llibre Salo, Jaume
Llovet, Juan
Lloyd, Noel G
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Lo, Chi Yeung
Lo, Libo
Lo, Tzee-Nan Kuo
Loane, Edward P
Loatman, R Bruce
Lochs, Gustav E
Lockhart, Deborah Frank
Lockhart, Jody Meyer
Loday, Jean-Louis
Lodha, Suresh K
Loeb, Henry L
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Lohuis, David J
Lok, Walter L
Lombardo, Charles J
Lominac, Thomas C
Lomont, John S
Londen, Stig Olof
London, David
Lonergan, Francis D
Long, David Darren
Long, Ding-Gwo
Long, John J Jr
Long, John M
Long, Robert L
Longo, Roberto
Longobardi, Patrizia
Longstaff, W E
Longyear, Judith Q
Loomis, Irene H
Lopez, Amparo
Lopez-Carmona, Antonio
López-Escobar, Edgar G K
Lopp, Kenneth W
Lord, James M
Lord, Nicholas J
Lorell, Jack
Lorenz, Dan H
Lorimer, Joseph Wilson
Lott, Fred W Jr
Lou, Shih-Pe
Loud, Warren S
Louhivaara, Ilppo S
Lounesto, Pertti
Loustau, John A
Louton, Tom
Love, Sister M Genevieve
Love, Thomas Robert
Loveland, L Duane
Lovell, John R
Lovett, Jane T
Lovric, Miroslav
Lowe, Peter G
Lowengrub, Morton
Loxton, John Harold
Lu, Chin-Pi
Lu, Kau-Un
Lu, Yung Chen
Lubin, Clarence I
Lucas, Billy J
Lucas, Thomas R
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Luce, R Duncan
Luchins, Edith H
Lucht, Lutz Gerhard
Lucier, Bradley J
Ludden, Gerald D
Ludington, Anne L
Ludwig, Donald A
Ludwig, Garry
Lue, Huei-Shyong
Luecking, Daniel H
Luehr, Charles P
Lueneburg, E
Luersen, Barbara
Luft, Erhard
Luh, Jiang
Luk, Hing-Sun
Luke, Jonathan Hwa Chung
Lumer, Gunter
Luna, Eduardo A
Lundell, Albert T
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Luo, Feng
Luskin, Mitchell B
Lustman, Liviu R
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Luther, C F
Luther, Norman Y
Lutoborski, Adam
Lutterodt, Clement Henry
Lutzer, David J
Luvisetto, Maria Luisa
Luxemburg, Wilhelmus A J
Lyche, Tom J
Lynch, Robert E
Lynch, William C
Lyndon, Roger C
Lyon, Herbert Chancellor
Lyons, Carter G
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Lysko, Janusz M
Lytle, Raymond A
Lyubeznik, Gennady M

Ma, Tsoy-Wo
Ma, Xiaoyun
Mac Lane, Saunders
MacCaull, Wendy A
MacCluer, Barbara D
MacDonald, James Hugh
MacDonnell, John J
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MacGillivray, Archibald D
MacGregor, Thomas H
MacKenzie, Robert E
MacLaren, M Donald
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MacNeil, Robert L
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Macbeath, A M
Macdonald, Ian D
Macfarlane, Andrew Ian
Macgibbon, Brenda
Mach, Lenka
Machado, Armando
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Macías, Roberto A
Mack, John E
Mack, John Michael

Mackenzie, Kirill
Mackey, Michael C
Maclachlan, Colin
Macphail, Moray S
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Madan, Manohar L
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Maddux, Roger D
Mader, Adolf
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Madsen, Gregory W
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Maecher, John H P
Maeda, Fumi-Yuki
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Magee, Gordon R
Magenes, Enrico
Magid, Martin A
Magill, Kenneth D Jr
Magnanini, Rolando
Magnus, Arne
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Magnuson, Alan William
Mah, Peter F
Mahdavianary, Seyed Kazem
Maher, Mary Anne
Mahler, Kurt
Mahoney, Anne
Mahowald, Mark
Maiellaro, Michele
Maier, Robert S
Mair, Bernard A
Mairhuber, John C
Maj, Mercede
Majda, George J
Majeed, Abdul
Majumdar, Samir R
Makar, Boshra H
Makar-Limanov, L G
Makepeace, Coline M
Maki, Daniel P
Makowsky, Johann Andreas
Malafronte, Thomas A
Malcolmson, Peter
Maleki, Amir
Malitz, Jerome I
Malkevitch, Joseph
Mallach, Lawrence E
Mallet-Paret, John J
Malliaris, Tassos G
Malon, David M
Malone, J J
Maloof, Giles W
Maltese, George J
Malvern, Lawrence E
Mamelak, Joseph S
Man, Chi-Sing
Mand, Lawrence R
Mandelbrot, Benoit B
Manfredi, Juan J
Manis, Merle E
Manjarrez, Victor M
Mann, Benjamin M
Mann, Henry B
Mann, W Robert
Mann-Nachbar, Pauline
Manogue, Joseph F
Manougian, Edward
Mansfield, Maynard J
Manske, Brian K
Mantel, Francis
Mantel, Harold John
Mantel, Jeffrey Hunt
Mantini, Lisa
Mapa, Felina G
Marathe, Kishore B
Marble, Robert P
Marchand, Margaret O
Marchetti, Federico
Marchiafava, Stefano
Marcou, R J
Marcum, Howard J
Marcus, David J
Marcus, Leo G
Marcus, Morel M
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Marcus, Steven I
Mardešić, Sibe
Margolis, Stuart W
Margosian, Zaven
Margulies, William
Maria, May H
Marin, Francisco L
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Marion, Jean Albert
Markanda, Raj K
Marker, David E
Markert, Matthew J
Markin, Jack T
Markoff, Nicholas G
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Markowsky, George
Markus, Lawrence
Marle, Charles Michael
Marley, Anthony A J
Marley, Gerald C
Marley, Thomas J
Marlowe, Thomas J Jr
Marotto, Frederick R
Marques, Carlos A
Marr, Robert B
Marrone, Lydia B
Marrone, Pedro A
Marsden, Jerrold E
Marsh, Marcus M
Marshall, Bernard P
Marshall, David Imler
Marshall, Murray Angus
Marstrand, John M
Martelli, Mario Umberto
Martens, Henrik H
Marti, Jurg T
Martin, E Dale
Martin, George E
Martin, Hayden Garth
Martin, James E
Martin, John R
Martin, Joseph E
Martin, Margaret A
Martin, Nathaniel F G
Martin, Nigel
Martin, Norman M
Martin, Peter E
Martin, Robert H Jr
Martin, William T
Martindale, Wallace S III
Martinez, Jorge
Martinez, Rafael A
Martins, Joyce A
Martonak, Stephen H
Marty, Roger H
Marumoto, Yoshihiko
Maruyama, Toru
Marvin, John W
Marzuq, Maher M H
Masani, Pesi R
Mascioni, Vania D
Masha, Edward V
Mashburn, Joe D
Maskit, Bernard
Maslanka, David Joseph
Maslennikov, M V
Mason, Ian
Massa, Silvio
Massam, Helene
Massell, Paul B
Masser, D W
Massey, Fred A
Masten, Jeffrey Paul
Masters, Harold U
Masur, Howard A
Matchett, Andrew J
Mate, Attila
Mather, John Norman
Matheson, John D
Mathis, Darrell L
Mathison, Neil T
Mathsen, Ronald M
Matijevic, Jacob R
Matsuda, Shigeo
Matsui, Kiyoshi
Matsumoto, Yukio
Matsumura, Hideyuki
Matsunaga, Teru
Matthews, Jane
Matthies, Karl H
Matti, Joseph T
Mattingly, Robert Bruce
Mattson, Leroy T
Mattuck, Arthur P
Mau, Mary Sue
Maurer, Donald E
Maurer, Peter M
Maurer, Stephen B
Mawhin, Jean L
Mawyer, Farley
Maxfield, John E
Maxson, Carlton J
Maxwell, James W
May, Coy L
May, E Lee Jr
May, J Peter
May, Michael K
May, Warren L
Mayans, Robert A
Mayberry, John P
Mayer, Dieter H
Mayer, John Clyde
Mayer, Karl Heinz
Mayer, Meinhard E
Mayer, Raymond A Jr
Mayor, John R
Mazhar, Syed M
Maziarz, E A
Mazumdär, Täpas
Mazur, Barry
Mazzeo, Rafe R
Mazziotto, Gerald
McAdam, Stephen J
McArthur, C W
McAuley, Louis F
McBrien, Vincent O
McBroome, Greg
McCall, James D Jr
McCallum, William G
McCarthy, Charles A
McCarthy, Donald J
McCarthy, Edward D
McCarthy, John
McCarthy, John David
McCarthy, Paul J
McCarty, Carl P
McCarty, George S
McCarty, Kevin P
McCasland, Roy Lynn
McCaughan, Dennis J
McCleary, John H
McClenahan, Maurice D
McClish, Wayne E
McConnell, John C
McConnell, Tanya D
McConnell, Terry R
McConnell, Thomas
McCormick, Ferris E
McCoy, Daisy C
McCoy, Robert A
McCoy, Thomas L
McCray, Patrick D
McCready, Robert R
McCrory, Clint G
McCulloh, Leon R
McCullough, Darryl
McCurley, Kevin Snow
McDaniel, Andrew
McDivett, Robert D
McDonald, Bernard R
McDonald, Gerard
McDonald, John N
McDonald, Katherine J
McDonough, J M
McDowell, Kenneth P
McDuff, Dusa
McEliece, Robert J
McElroy, Betty K
McFaden, Harold H
McFarland, Thomas L
McGaffey, Thomas N
McGarry, Dorothy
McGavran, Dennis R
McGee, Robert I
McGehee, O Carruth
McGehee, Richard P
McGibbon, Charles A
McGovern, Richard J
McGovern, William M
McGuigan, Robert A
McGuinness, Francis Oisin
McIntosh, Harold V
McIntosh, William D
McKay, James H
McKay, Thomas G
McKean, Henry P Jr
McKee, Timothy W
McKelvey, Robert W
McKenzie, Lionel W
McKenzie, Ralph N
McKeon, James P
McKibben, William P
McKinney, Richard L
McKinney, Wilbur T
McLaughlin, Donald E
McLaughlin, Harry W
McLaughlin, Jack E
McLaughlin, Renate
McLaughlin, T G
McLeod, Edward B Jr
McLeod, Robert M
McMahon, Douglas C
McMahon, Edith Mary
McMillan, Audrey W
McMillan, Brockway
McMillan, Daniel R Jr
McMillan, Evelyn R
McMillen, William Robert
McMinn, Trevor J
McMullen, P
McMurtrie, Kenneth A
McNab, Robert
McNeill, Robert B
McNulty, George F
McNulty, Nieves Austria
McNulty, Sallie Keller
McOwen, Robert C
McRae, D George
McShane, Edward J
McWilliams, Ralph D
Meacham, Robert C
Mead, David G
Meadows, Douglas Shelby
Meadows, Lawrence F
Meagher, Jack R
Meakin, John C
Mears, Florence M
Meder, Albert E Jr
Medhin, Negash G
Meeker, Loren David
Megginson, Robert Eugene
Mehlman, Marc H
Mehrmann, Volker
Meilan, Gerard
Meisner, Morris J
Meister, Erhard V
Meixner, Th
Mejia, Raymond
Mejlbo, Lars C
Melin, Anders E
Mellender, James W
Melrose, Richard B
Melzi, Giovanni
Memory, Margaret C
Menconi, Mario
Mendelson, Elliott
Mendelssohn, Roy
Mendoza, Charles Gerard
Mercier, Armel N
Meredith, David B
Merkel, Rudolph B
Merriell, David M
Merrien, Jean
Merrill, Kathy Donovan
Merryfield, Kent G
Mertens, John R Jr
Meserve, Bruce E
Mesirov, Jill P
Messer, Karen
Metakides, George
Metas, Nick
Metzler, Richard C
Metzner, Ellen L
Meuser, Diane Mae
Mewing, Robert
Meyer, Burnett C
Meyer, Donald V
Meyer, Gerard G L
Meyer, Herman
Meyer, Jean-Pierre G
Meyer, Kenneth R
Meyer, Norman C Jr
Meyer, Paul R
Meyer, Victor Arthur
Meyer, W Weston
Meyer, Wolfgang T
Meyerhoff, Robert
Meyerowitz, Aaron D
Meyers, Charles Frank
Mez, Hans-Christian
Mezzino, Michael J Jr
Miao, Lung-Chi
Michael, Ernest A
Michael, Mark
Michael, William A
Michaels, Brenda
Michel, Rene
Michel, Russell J
de-Michele, Leonede
Michiaki, Watanabe
Michler, G
Michon, Gérard Ph
Mickens, Ronald E
Middleton, David
Middleton, Jeffrey Blake
Miel, George
Mielke, Marvin V
Mielke, Paul T
Mientka, Walter E
Miesner, Walter
Mignot, Fulbert
Mihalik, Michael L
Miklos, Dezso
Mikolič-Torreira, Igor
Mikusinski, P
Milcetich, John G
Miles, E P Jr
Miles, Joseph B
Miles, Philip E
Miles, Thomas J
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Miličić, Dragan
Millar, Robert F
Millar, T S
Miller, Dale A
Miller, Douglas E
Miller, Forrest R
Miller, Haynes R
Miller, Hugh D B
Miller, Jack M
Miller, James Curtis
Miller, John C
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Miller, Matthew
Miller, Richard Alan
Miller, Richard K
Miller, Richard R
Miller, Stephen S
Miller, Victor S
Miller, W F
Miller, Willard Jr
Miller, William David
Miller, William V
Miller, Zevi
Millett, Kenneth C
Millman, Richard S
Mills, Harlan D
Mills, Janet E
Mills, Stuart E
Mills, William H
Milman, Mario
Milman, V D
Milne, Stephen C
Milner, Eric C
Milner, Fabio A
Miloslavsky, G C
Milutinović, Uroš

Mimura, Mamoru
Min, Kang-Joo
Min-oo, Maung
Minagawa, Takizo
Minc, Henryk
Minda, C David
Minehart,
Deborah Fairley
Minemura, Katsuhiro
Mines, Ray
Miniowitz, Ruth
Minkus, Jerome B
Minsker, Steven
Mintel, Ernest J
Minton, Roland B
Miranda, Rick
Mirchandaney,
Arjan Sobhraj
Mirsky, Norman D
Mishoe, Luna I
Mishra, Sudhakara
Mislin, Guido
Misra, A K
Misra, Prabudh Ram
Mital, J N
Mitchell, Alan R
Mitchell, Emerson C
Mitchell, George E
Mitchell, James C
Mitchell, John W
Mitchell, Josephine M
Mitchell, Roger W
Mitchell,
Stephen Ames
Mitchell, Stephen G
Mitchem, John A
Mitrovic, Dragisa
Mittal, D M
Mittenthal, Lothrop
Mityagin, Boris
Miura, Robert M
Miyadera, Isao
Miyahara, Yoshio
Miyazaki, Ken-Ichi
Miyoshi, Takeo
Mizel, Victor J
Mizumoto, Hisao
Mizuno, Hirobumi
Mlitz, Rainer
Moak, Daniel Stuart
Mochizuki, Horace Y
Mochizuki, Leslie Y
Modica, Luciano
Moeller, Helmut Karl
Moen, Courtney H
Moet, H J K
Mohamed, I J
Mohamed, Saad
Mohapeloa,
Khomo T S
Moise, Edwin E
Moite, Sally M
Molino, Pierre
Moller, Raymond W
Molloy, C T
Molnar, Joseph R
Molnar, Richard K
Molnar,
Suzanne Miller
Monahan, Maurice L
Mond, Bertram
Mong, Kai Cheong
Mongelli, Dominic
Monheit, Lilly A
Monk, J Donald
Monleon-Pradas,
Manuel
Monma, Clyde L
Monna, Antonie F
Monrad, Ditlev
Monro, Gordon P
Monsky, Paul H
Monson, Stephen R
Montague,
Patricia Tucker
Montaldi, James A
Montesinos, José M
Montgomery, Deane
Montgomery, Hugh L
Montgomery, M Susan
Montgomery, Peter L
Montgomery, Philip R
Montgomery,
W Duane
Month, Leslie A
Monticone, Leone C
Moody, Robert V
Moon, Kyung-Ho
Mooney, Charles D
Mooney, John J
Moons, Theodoor M
Moore, Alan L
Moore, Hal G
Moore, John D
Moore, John G
Moore,
Judy Hennessey
Moore, Lawrence C Jr
Moore, Marion E
Moore, Marvin G
Moore, Polly
Moore, Richard A
Moore, Robert H
Moore, Robert T
Moore, W Keith
Moore, William E
Moori, Jamshid
Mora, Xavier
Morales, Pedro A
Moran, Charles W
Moran, William
Morawetz, Cathleen S
Mordeson, John N
Moreau, Jean Jacques
Moreland, Robert A
Moretz, Marjorie A
Morey, Philip S Jr
Morgan, Christopher L
Morgan, Frank
Morgan, Raymond Jr
Morgantini, Edmondo
Morimoto, Akihiko
Morley, Larry J
Morrel, Bernard B
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Morrill, John E
Morris, Alun O
Morris, Chester R
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Morris, L E
Morris, Peter C
Morris, Robert A
Morrisette, Thomas M
Morrison, David R
Morrison, John A
Morrison, John F
Morrison, Kent E
Morrison, Michael A
Morrison, Sally D
Morrison, Tim H
Morrow, James R
Morse, Burt J
Morse, Jack Neil
Morton, Lynda S
Moschovakis,
Joan Rand
Moschovakis,
Yiannis N
Moscovici, Henri
Moser, Joseph G
Moser, Jürgen K
Moser, Lucy I
Moser, William O J
Mosher, James R
Mosier, Ronald G
Moskowitz,
Daniel Nathan
Moskowitz, Martin A
Moss, Kenneth N
Moss, Lawrence Stuart
Moss, William F III
Mostow, George D
Motamedi, Mansoor
Motte, David L
Motto, Michael H
de Mottoni, Piero L
Moulden, Trevor H
Mourant, Wanda J
Movahedi-Lankarani,
Hossein
Moy, Allen
Moyls, Benjamin N
Mozzochi, C J
Mrowka, Stanislaw G
Mrowka, Tomasz S
Muckenhoupt,
Benjamin
Muder, Douglas J
Mueller, Bruno J W
Mueller, Carl Douglas
Mueller, James R
Mueller, Julia
Mugele, Raymond A
Muhly, Paul S
Mulase, Motohico
Mulay, Shashikant B
Muldoon, Mark
Mulflur, James H
Muller, George M
Muller, Gert H
Mullikin, Thomas W
Mullin, Albert A
Mullins, Sarah E
Mullis, James W Jr
Mullis,
Robert Harvey Jr
Mulrow, Edward J
Mulry-Liggan, Mary H
Mumford, David
Munoz, Edgar
Munoz, Miguel-C
Murakami, Shingo
Murali, V
Murasugi, Kunio
Murata, Hiroshi
Murayama, John T
Murphy, Brian B
Murphy, Catherine M
Murphy, Donald P
Murphy, Grattan P
Murphy,
Katherine Adele
Murphy, Paul F
Murphy, R B
Murphy, Thomas N
Murray, Alan G
Murray, G Graham
Murray,
Margaret A M
Mur-e, Jacob P
Muse, Archie Henry
Muto, Hideo
Myers, Dale W
Myers, Earle F
Myers, John R
Myers, Russell W
Myerson, Gerald
Myszewski, Mathew
Myung, Hyo Chul

Naatanen, Marjatta
Nachbin, Leopoldo
Nachman, Louis J
Nadel, Mark E
Nadell, Paul T
Nadler, Edmond J
Naeem, Rana Khalid
Nagahara, Takasi
Nagai, Osamu
Nagami, Keio
Nagarkatte, Umesh P
Nagasaka, Kenji
Nagata, K Wayne
Nagel, Alexander J
Nagel, Bengt C H
Nagisetty, Rao V
Nagle, R Kent
N.impally,
Somashekhar A
Nairn, Dean C
Najar, Rudolph M
Najarian, John P
Nakagawa, Kiyokazu
Nakagawa, Yoko
Nakamura, Masahiro
Nakamura, Riichiro
Nakanishi, Yasutaka
Nakano, Kazumi
Nakashima, Martin M
Nakata, Mie
Namba, Kanji
Nambooripad, S K S
Namioka, Isaac
Nance, Dana W
Nandakumar, N R
Nanzetta, Philip
Napolitano,
Margaret M
Narasimhan, Revathi
Narayanaswami, P P
Nariboli, Gundo A
Narushima, Hiroshi
Nash, David
Nash, Stephen G
Nash-Williams,
Crispin St J A
Nastold,
Hans-Joachim
Nath, Radha G
Nathanson, Melvyn B
Nation, James B
Naugle,
Norman Wakefield
Navarro, Francisco J
Nayak, M K
Nayar, Brij M
Naylor, Lawrence W
Nduka, A
Nebres, Bienvenido F
Needham, C Sam
Neff, John D
Neff, Mary M
Neggers, Jospeh
Negro, Angelo L
Negron, Pablo Victor
Neher, Erhard
Nehs, Robert M
Neidhardt, Arnold L
Neidhardt, Wayne L
Nel, Louis D
Nelimarkka, Esa
Nelligan, John D
Nelms, Dorothy
Nelson, Edward
Nelson, Edward O
Nelson, George C
Nelson, James Jr
Nelson, Larry D
Nelson, Roger B
Nelson, Stuart A
Nelson, William
Nemethi, Csaba
Nesbitt, Cecil J
Nesin, Ali H
Neubauer, Gerhard J
Neuberger, John W
Neugebauer,
Christoph J
Neumann, Bernhard H
Neumann,
Walter David
Neustadter,
Siegfried F
Neuwirth, Jerome H
Neuwirth, Lee P
Nevai, Paul G
Neveu, Jacques
Newberger, Stuart M
Newcomb, Lynn T
Newell, David C
Newhouse, Sheldon E
Newlander, August Jr
Newman, Morris
Newton, Mervin E
Ney, Peter E
Ng Wong Hing,
John Dilwyn
Ng, Che Tat
Ng,
Eugene Kwan Sang
Ng, Ho Kuen
Ng, Kok Lip
Ng, Kung-Fu
Ng, Sze-Kui
Ng, Tze-Beng
Nguiffo, B Michel
Nguyen, Hung Thac
Nguyen, Thanh Van
Nguyen, Truc T
Nguyen, Van Hien
Nguyen-Huu-Bong
Nicholls, Peter J
Nichols, Edward
Nichols, Eugene D
Nichols, John C
Nicholson, Victor A
Nicholson, W Keith
Nickel, James A
Nickerson, Helen K
Nico, William R
Nicol, Sherrie Jean
Nicolas, Jean-Louis
Nicolas-Carrizosa,
Alfredo
Niederhausen,
Heinrich
Niedzwecki, G P
Nielsen, Peter A
Nievergelt, Yves
Niino, Kiyoshi
Nijenhuis, Albert
Nirenberg, Louis
Nishida, Takaaki
Nishiura, Eizo
Nishiura, Togo
Nissim, Leonard J
Nitecki, Zbigniew H
Niven, B S
Niven, Ivan
Njastad, Olav
Nöbauer, Wilfried H
Noble, Andrewa R
Noble, William
Nobusawa, Nobuo
Noel, Guy G J
Noguchi, Hiroshi
Noguchi, Junjiro
Nohel, John A
Nolan, John P
Nold, Annett
Noll, Landon Curt
Nomizu, Katsumi
Noonburg, Virginia A
Noor, Khalida Inayat
Nordgren, Eric A
Norfleet, Jesse Peter
Norman,
Francis Alexander
Norman, Peter
N rman, R Daniel
Normand, Gerard L
Norris, Douglas A
Northcutt, Robert A
Norton, V Alan
Nottrot, Roel
Novacky, George A
Nowlin, Benjamin
Nowosad, Pedro
Nulton, James D
Nummela, Eric C
Nunez,
Pascual Ballesta
Nunke, Ronald J
Nussbaum, A Edward
Nussbaum, Roger D
Nusse, Helena E
Nutt, Michael D
Nyman, Philip D
Nymann, Dewayne S

O'Callaghan, Liam J
O'Connell, James R Jr
O'Connor, Anthony J
O'Donnell, Daniel F
O'Farrell,
John Michael
O'Halloran, Joyce
O'Keefe, David F
O'Leary, Daniel J
O'Meara, O Timothy
O'Neil, Kevin A
O'Neil, Philip J
O'Neill, Anne F
O'Neill, Bernard V Jr
O'Neill, Edward J
O'Neill, Ronald C
O'Rourke, Joseph
O'Shea, Donal B
O'Sullivan, John J
Oates-Williams, Sheila
Obaid, Samih A
Obata, Morio
Obeid, Mustafa A
Oberg, Edwin N

Oberguggenberger, Michael B
Oberlin, Daniel M
Oberschelp, Walter
Obi, Wilson C
de las Obras, Carmen
Obrock, Arthur E
Ochoa, Juan C
Ochoa-Lions, Jorge Daniel
Ocneanu, Adrian
Ocone, Daniel L
Oda, Tadao
Odlyzko, Andrew M
Oehmke, Robert H
Oertel, Ulrich
Oertly, Alda F
Oertly, Frederick Jay
Ogawa, Hajimu
Ogden, Nancy C
Ogg, Andrew P
Ogg, Frank C Jr
Oguchi, Kunio
Oh, Yong-Geun
Ohkuma, Tadashi
Ohm, Jack E
Ohme, Paul A
Ohta, Haruto
Ohtsuka, Makoto
Ohwaki, Shin-Ichi
Oikawa, Kôtaro
Okada, Masami
Okada, Satio
Okada, Susumu
Okamoto, Kiyosato
Okamoto, Sigeru
Okayasu, Takateru
Okoronkwo, Emmanuel O
Oksendal, Bernt K
Okuyama, Akihiro
Oldham, Frank Ernest
Oldroyd, L Andrew
Oler, Norman
Olesen, Dorte Marianne
Oliger, Joseph E
Oliker, Vladimir I
Olin, Robert F
Oliveira, Joseph Stephen
Oliver, Fatma
Olivier, Reinhard M
Olmstead, P S
Olsen, Martin
Olshen, A C
Olson, Dwight M
Olson, Loren D
Olson, Pearl
Olum, Paul
Olver, Frank W J
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Oman, John Arthur
Omar, A A H
Ombe, Hitoshi
Omori, Hideki
Onat, Emin T
Ong, Sing-Cheong
Onishi, Hironori
Onneweer, Cornelis W
Ono, Takashi
Onose, Hiroshi
Oodaira, Hiroshi
Ooms, Alfons I
Opfer, Gerhard H
Opolka, Hans
Oppenheim, Joseph H
Oprea, John F
Ordman, Edward T
Orellana, Chacin Mauricio
Orihuela, Jose
Orland, George H
Orlik, Peter P
Orloff, Daniel
Orloff, Leo N
Ornstein, Avraham J
Ornstein, Donald S
Ornstein, Wilhelm
Orsted, Bent
Ortiz-Franco, Luis
Ortmeyer, William Albright
Ortner, Gene M
Osborn, Howard A
Osborn, J Marshall
Osborn, John E
Osborn, T A
Osborne, Mason S
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Osborne, Richard P
Oslon, Steve G
Osner, H J
Osofsky, Barbara L
Osondu, Kevin E
Ossa, Erich
Osserman, Robert
Ostaszewski, Krzysztof M
Osteen, Robert Ernest
Osterburg, James
Osterby, Ole
Osterwalder, Konrad
Ostrogorski, Tatjana
Ota, Clem Z
Ôta, Schôichi
Otermat, Scott C
Otter, Richard R
Ottmann, Thomas A
Oursler, C C
Ouyang, Chung-Hsing
Overdeck, John M
Owa, Shigeyoshi
Owen, David R
Owens, Owen G
Owings, James C Jr
Oxley, Theron D Jr
Oxtoby, John C
Oyabu, Takashi
Ozols, Vilnis
Ozsvath, Istvan

Pacella, Filomena
Paciorek, Joseph W
Packer, Judith A
Pade, Offer
Padma, Narasimhachari
Pagano, Miriam E
Page, David A
Pai, Chikaung
Paige, Eugene C Jr
Paige, Lowell J
Painter, George W
Paisner, Helen L
Pak, Jingyal
Palais, Eleanor G
Palais, Richard S
Palenz, Diana G P
Paley, Hiram
Palka, Bruce P
Palled, Shivappa V
Palm, Andrew C
Palmer, Edgar M
Palmer, John N
Palmer, Kenneth J
Palmer, Theodore W
Pan, Ting K
Panchal, Champak D
Panchapagesan, T V
Pandian, Ramaiah Devadoss
Pandit, Onkar Nath
Pantoja-Macari, Jose Eduardo
Panzone, Rafael
Papangelou, Fredos
Papantonopoulou, Aigli Helen
Pappas, Peter C
Pappas, Richard C
Paradise, Michael E
Parchment, Osborne C
Pardee, Otway O'M
Pareek, Chandra Mohan
Pareja-Heredia, Diego
Parikh, Rohit J
Paris, Alan Terry
Park, Chull
Park, Jae Keol
Park, Jong Geun
Park, Samuel
Park, Sehie
Park, Young Soo
Parker, Elwood G
Parker, Francis D
Parker, George D
Parker, Phillip E
Parker, Thomas H
Parker, Willard A
Parks, Harold R
Parlett, Beresford N
Parr, James T
Parrish, Daniel M
Parrish, Herbert C
Parrott, David
Parrott, Mary E
Parry, R Bryce
Parry, Walter R
Parry, William
Parsons, Lee
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Parter, Seymour V
Parzen, Emanuel
Pas, Michael Francis
Paschke, William L
Pasini, Antonio
Pass, Ralph P III
Passell, Nicholas
Passerini, Henry J
Passman, Donald S
Passty, Gregory B
Pastor, David E
Pastro, Pier-Ivan
Pasztor, Ana
Patera, J
Patnaik, Surendra-Nath
Patrick, E Vincent
Patrizio, Giorgio
Patten, Donald L
Patten, Paul R
Patton, Charles M
Patton, L Raphael
Patty, C Wayne
Patula, William T
Paul, DeDe
Paul, Jerome L
Paulling, John M B
Paulowich, David G
Paulsen, Vern I
Paur, Sandra O
Pavel, Monique L
Pavlakos, Panaiotis
Pavlicek, Glenn H
Pawelke, Siegfried H R
Payne, Fred R
Payne, Lawrence E
Payne, Stanley E
Pazy, Amnon J
Pearce, Kent
Pearcy, Carl M
Pears, Alan R
Pearson, Bennie J
Pearson, Kenneth R
Pearson, Robert W
Peccati, Lorenzo
Peck, Emily Mann
Peck, N Tenney
Peck, Paul S
Peck, Vincent Christopher
Pedersen, Edward A
Pedersen, Flemming P
Pedersen, Franklin D
Pedersen, Henrik
Pedersen, Jean J
Pedersen, John F
Pedersen, Katherine L
Pedersen, Niels Vigand
Pedersen, Stig Andur
Peek, James M
Peetre, Jaak
Pefkaros, Kenneth
Peglar, George W
Pego, Robert L
Peitgen, Heinz O
Peixoto, Mauricio M
Peleg, Bezalel
Peletier, Lambertus A
Peligrad, Magda
Pelikan, Stephan
Pelin, Alex
Pell, William H
Pelletier, Donald H
Peltier, Charles F
Pence, Dennis D
Pence, Sallie E
Penenberg, Darryl Neil
Pengelley, David John
Penn, Howard Lewis
Pennell, Stephen A
Penner, Robert Clark
Penney, Carol W
Penney, David E
Pennisten, John W
Pepper, Paul M
Percus, Jerome K
Pereira da Silva, C
Perel, William M
Pérez-González, Fernando
Perez de Vargas, Alberto
Perkel, Manley
Perkins, Peter
Perko, Lawrence M
Perlis, Robert V
Perlman, Sanford
Perry, William J
Perry, William L
Persek, Stephen C
Persens, Jan
Persson, Ulf
Pertica, Horacio N
Pervin, William J
Pesotan, Hoshang
Pestana, Dinis Duarte
Petermann, G E
Peters, James Vincent
Peters, Klaus
Peters, Meinhard H
Peters, Thomas Joseph
Petersen, Bent E
Petersen, Gordon M
Petersen, Karl E
Petersen, Peter
Petersen, Troels
Petersen, Wesley P
Peterson, Chariya P
Peterson, Charles L
Peterson, Franklin P
Peterson, Ronald J
Pethe, S
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Petro, John
Petro, John W
Petroni, Ann T
Petryshyn, W V
Pettitt, Richard Bruce
Petty, Clinton M
Pew, Thomas Vincent
Pfeffer, Washek F
Pfeiffer, Paul E
Pflaum, C W
Pflug, Peter
Phadke, Bhalchandra Balvant
Pham, Tuan Dinh
Phanord, Dieudonne D
Pheidas, Athanasios C
Phelps, Robert R
Phili, Christine Melle
Philipp, Walter V
Phillips, Anthony V
Phillips, Christopher K
Phillips, Daniel
Phillips, John Gilbert
Phillips, Keith L
Phillips, Ralph S
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Phillips, William J
Piacentini, Giulia Maria
Piacenza, Robert John
Piatetski-Shapiro, I
Picard, Rainer H
Piccinini, Renzo A
Piccinni, Paolo
Pickel, Paul Frederick
Pickrell, Douglas M
Piech, M Ann
Piegl, Leslie
Piene, Ragni
Pier, Jean-Paul
Pierce, John Festus
Pierce, Rebecca L
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Piger, Jean
Pignedoli, A
Pigno, Louis
Pigozzi, Don L
Pilgrim, Donald H
Pillay, Anand
Pilz, Gunter
Pinch, Richard Gilmour Eric
Pinchon, Didier
Pinkham, Henry C
Pinkus, Allan M
Pinney, Karen R
Pinsky, Mark A
Pinsky, Ross George
Pinter, Joseph Kalman
Piotrowski, Zbigniew
Pippert, Raymond E
Piranian, George
Pitcairn, Joel
Pitcher, Everett
Pitt, Loren D
Pittenger, A O
Pitteri, Mario G
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Pitts, Andrew M
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Plaut, Conrad P
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Pless, Vera S
Plotkin, Neal J
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Plummer, Michael D
Plymen, Roger J
Podio-Guidugli, Paolo
Poenaru, Valentin A
Pohl, William F
Pohle, Frederick Valentine
Pokrass, David J
Polachek, Harry
Polemarchakis, H
Polking, John C
Pollack, Richard
Pollak, Barth
Pollatsek, Harriet S
Pollingher, Adolf
Polly, Mary R
Polombo, Albert
Polonsky, Ivan P
Pomerance, Carl
Ponce, Gustavo Alberto
Pons, Montserrat
Pool, James C T
Poon, Yat Sun
Poor, Walter A
Pop-Stojanovic, Zoran R
Poritz, Alan B
Port, Sidney C
Porta, Harry J
Porte, Jean
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Porter, James F
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Posey, Eldon E
Poss, Richard L
Post, Karel A
Postema, Dale

Pothoven, Kenneth L
Potts, Donald H
Poulin, J
Poulsen, Ebbe T
Pour-El, Marian B
Pourahmadi, Mohsen
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Bruce Hunter
Pouzet, Maurice
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Powers, Morris Walton
Powers, Robert T
Powls, Keith W
Prabhu,
Narahari Umanath
Pradines, Jean
Prakash, Jagdish
Prakash, Nirmala
Prange, John D
Pranger, Walter A
Preissendoerfer,
Manfred W
Prest, Michael Y
Preston, Gordon B
Price, David T
Price, G Baley
Price, John F
Price, Justin J
Price, Ray H
Price, Roderick A
Price, Thomas E Jr
Priddy, Stewart B
Priest, Cynthia J
Priestley, William M
Prill, David D
Primc, Mirko
Prisco, Mary K
Pritchard, Frank Leon
Proctor, C Wayne
Proctor, Robert A
Promel, Hans Jurgen
Propes, J C
Protas, David S
Protter, Philip E
Proulx,
Viera Krňanová
Provencher, Normand
Pruitt, William E
Prussner, Laird Drew
Przebinda, Tomasz
Przybylski, Thomas L
Pu, Hwang-Wen
Pucci, Carlo
Pucci, Patrizia
Puckette, Stephen E
Pudaite, Paul R
Puel, Jean Pierre
Puerta, Fernando S
Puig, Lluis
Puigbo, Jaume Vila
Pukanszky, Lajos
Pumplun, Dieter
Pun, Ping-Sham
Puppe, Dieter
Puri, Pratap
Purisch, Steven D
Pursell, Lyle E
Putcha, Mohan Sastri
Putnam, Alfred L
Putnam, Calvin R
Pyle, Ernest
Pyle, H Randolph
Pym, John S

Quackenbush,
Robert Willis
Quade, Edward S
Quartararo, Philip Jr
Quigg, John C
Quigley, Frank D
Quine, J R
Quinn, Frank S III
Quint, Richard A
Quint, Simon R
Quintas, Louis V
Quinto, Eric Todd
Quiring, Donald K
Quirk, Paul B
Quiroga, Rafael P

Rabinowitz, Paul H
Rabinowitz, Stanley
Rabung, John R
Racine, Michel L
Radin, Lon Berk
Radjavi, Heydar
Radzikowski, Pawel
Raggio, Guido A
Rahe, Maurice H
Rahman, Mizanur
Raimi, Ralph A
Rains, M A
Rainville, Russell
Rajca, John F
Rajnak, Stanley L
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Ralevic, Nebojsa V
Rall, Louis B
Ralston, Elizabeth W
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Ramachandran,
Doraiswamy
Ramakrishnan,
Dinakar
Ramalho, Margarita
Ramanujan,
Melapalayam S
Rambavilas, C D
Ramey, Wade C
Ramírez de A, Enrique
Ramirez,
Arturo Flores
Ramsay, Arlan B
Ran, Abselom
Ran, Andre C M
Randall, A Duane
Randall, John D
Randol, Burton S
Randolph, John F
Rangaswamy, K M
Range, R Michael
Rankin, R A
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Samuel Murray
Ransom, Adelbert W
Rao,
Vidhyanath Kajana
Rapp, P E
Rascle, Michel
Raskind, Wayne Mark
Rasoulian, Amid
Rassias, George M
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Michael
Ratcliff, Gail D L
Ratiu, Tudor Stefan
Ratliff, Louis J Jr
Ratschek, Helmut
Rätz, Jürg J
Raugh, Michael R
Rausen, John
Rawsthorne, Daniel A
Ray, Nigel
Rayburn, Marlon C Jr
Raymond, Frank A
Rayna, Gerhard
Read, Dwight
Read, Thomas T
Reade, Maxwell O
Reardon, Philip C
Reber, Douglas C
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Recillas, Felix J
Rector, David L
Reddy, William L
Redfield, Robert H
Redheffer,
Raymond M
Redlin, Lothar H
Redmond, Don
Redner, Richard A
Reed, Bruce E
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Reed, Irving S
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Reed, Myra Jean
Reed, Robert E
Reedy, Christopher L
Rees, Charles S
Rees, Mina S
Rees, P K

Reese, Matthias F
Reese, Richard H
Reese, Sylvester
Reeves, Roy F
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Ernestine
Regan, Francis
Rehder, Wulf
Rehm, Allan S
Rehmann, Ulf
Reichard, Rosalind
Reichaw, Meir
Reid,
Christopher Ervin
Reid, James D
Reid, Kenneth B
Reid, R Clay
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Reid, William H
Reilly,
Norman Raymond
Reineck, James F
Reiner, Irma M
Reiner, Irving
Reinhardt, Elsi A
Reinhart, Bruce L
Reinoehl, John H
Reissner, Eric
Reiter, Edna E
Reiter, Stanley
Reitwiesner, George W
Rejali, Ali
Rejto, Peter A
Rem, Martin
Rempel, Richard S
Remus, Dieter
Renardy, Michael
Renault, Jean N
Renegar, James M
Reneke, James A
Renner, Lex E
Renno, James G Jr
Renz, Peter L
Resch, Richard I
Restrepo, Guillermo
Retzloff, David G
Reuterdahl, J Thomas
Reyna, Luis Guillermo
Maria
Reynolds, David W
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Reynolds, Jim D
Reynolds, Robert R
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Reza, Fazlollah
Reznick, Bruce A
Rhai, Tong-Shieng
Rheinboldt, Werner C
Rhemtulla,
Akbar Hussein
Rhie, Young H
Rhoades, Clark P
Rhodes, Burgess H
Rhodes, Frank
Riaza, Roman
Ribeiro, Hugo B
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Ribes, Luis
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Ricci, Fulvio
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Ricci, Stephen J
Rice, Barbara Slyder
Rice, Henry G
Rice, John R
Rice, John William
Rice, Richard E
Richard, B K
Richards, Donald St P
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Richardson, Henry R
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Raymond E
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Roger W Jr
Richert, Arthur
Richert, Hans-Egon
Richert, Norman J
Richman, Daniel J

Richmond, Glayvera
Richmond, Jean B
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Lawrence B
Richter, Gary Hardin
Richter, Guenther E
Richter, Michael M
Richtmyer, Robert D
Rickart, Charles E
Rickert, Neil W
Rickey, V Frederick
Rickman, B
Riddle, Lawrence H
Riddle, Malcolm Lee
Ridenhour, Jerry R
Rider, Daniel G
Ridolfo, Anthony S
Riedel, Herbert H J
Rieffel, Marc A
Rieger, Georg J
Riehemann, Robert M
Riehm, Carl R
Riemen, William P
Riemenschneider,
Oswald
Ries, John F X III
Riesel, Hans I
Riess, Karlem
Riffelmacher, David A
Rigdon, Robert D
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Leo Juhani
Rijnks, H
Riley, Bruce V
Riley, Robert F
Riney, John S
Ringel, Gerhard
Ringrose, John R
Rio, Sheldon T
Rippon, Philip J
Ripy, Sara L
Rishel, Thomas W
Risnes, Martin
Ritt, Robert K
Ritter, David L
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Rival, Ivan
Rivet, Roger
Rno, Jung-Sik
Roach, G F
Roach, Michael D
Robacker, John T
Robbie, Desmond A
Robbins, Steven
Robbins, Wade B
Robbins, Walter M
Robel, Gregory F
Robert, Alain
Roberts, Dorothy K
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Florence Ellen
Roberts, George A
Roberts, Howard M
Roberts, Jean E
Roberts, Joel L
Roberts, Joseph B
Roberts, Leslie G
Roberts, Richard C
Roberts, Stephen G
Robertson,
Alexander P
Robertson, Malcolm S
Robertson, Neil
Robinson, Clark
Robinson, Daniel A
Robinson, Derek J S
Robinson, G de B
Robinson,
Helen Drummond
Robinson, Ivor
Robinson,
Joanna Ryten
Robinson, Karl H
Robinson, Michael L
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Robinson, Thomas J
Robkin, Eugene E
Robson, Robert O
Rocha, Alvany
Rocha, Carlos V
Rocha, Luiz F C

Rochberg, Richard H
Roche, Claude
Rockland, Charles
Rockwell, Richard D
Rod, David L
Rodin, Burton
Rodino, Luigi
Rodman, Leiba
Rodrigue, Garry H
Rodrigues Filho, Joao
Rodriguez, Gilmar
Roeder, David W
Roels, Jacques Albert
Roessler, E B
Roettinger-Kaplan,
Ida
Rogawski,
Jonathan David
Roger, Claude
Rogers, Edwin
Rogers, Leland E
Rogers, Thomas D
Roggenkamp, Klaus W
Rohatgi, Vijay K
Rohl, Frank D
Rohrbach, Hans
Rohrl, Helmut
Rohrlich, David E
Roitman, Judith
Rojo, Oscar
Rokni, Kamran A
Romanelli, S
Ronga, Felice L L
Rood, John J
Rooker, John C II
Rooney,
Elaine Kasimatis
Rooney, Gerald E Jr
Rooney, Paul G
Roonguthai, Warut
Roos, Cornelis
Roos, Guy
Roos, Jan-Erik I
Roos, Paul
Roosenraad, Cris T
Root, William L
Roozemond, Leen
Rosa, Alexander
Rosales, Rodolfo
Rosales, Silvia Huerta
Rosalsky, Andrew
Rosati, Mario
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Frances M
Rose, Donald J
Rose, N J
Roselle, David P
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Dennis Martin
Roseman, Joseph J
Rosen, Julie A
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Rosenbaum, Robert A
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Jonathan M
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Rosenberger, Gerhard
Rosenblatt, David
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Joseph Max
Rosenblum, Marvin
Rosenfeld, Gerald
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Rosenlicht, Maxwell A
Rosenstein,
George M Jr
Rosenthal, Arthur J
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Rothman, Neal J
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Linda Preiss
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Rovnyak, James L
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Rowan, William H
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Roxin, Emilio O
Royden, Halsey L
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Royster, Wimberly C
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Flores Espinoza
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Rubinstein, Joachim H
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Jose L
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Rudnick, Karl
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Ruess, W
Ruh, Ernst A
Ruijsenaars,
Simon Norbert
Ruiz Morillo,
Alejandro J
Ruiz, Ceferino
Rumely, Robert S
Rumford, Fred K
Rumsey, Howard C Jr
Runck, Paul Otto
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Rund, Hanno
Rung, Donald C
Ruoff, Dieter
Rush, David Eugene
Rusinak, William A
Ruskai, M Beth
Russell, David Martin
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Ralph Gordon
Rutland, Leon W Jr
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Ryan, Donald E
Ryan, Francis D
Ryan, Patrick J
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Rydeen, Clarence F
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Rzedowski, Martha

Saaty, Thomas L
Saccoman, John J
Sachs, David
Sacks, Paul E
Sacksteder, Richard C
Sadosky, Cora S
Saeki, Sadahiro
Saff, Edward B
Sagan, Bruce E
Sah, Chih-Han
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Saibel, Edward A
Saint Mary, Donald F
Saito, Akira
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Salane, Douglas E
Salas, Saturnino L
Saleem, Mohammad
Salehi, Ebrahim
Salinas, Luis C
Salinas, Norberto
Salisbury, Thomas S
Sallee, G Thomas
Sallman, Jeffrey E
Sally, Judith D
Sally, Paul J Jr
Salmon, Jessie Blake
Saltiel, Leon
Saltz, Daniel
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Jeffrey Stewart
Salvadori, Anna
Salwach, Chester J
Salzberg, Betty
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Samayoa, Rodolfo
Samelson,
Christopher L
Samelson, Hans
Samolis,
Ruth Anastasia
Sampson, Gary
Samuel, Pierre
Sanchez, Antonio
Sanchez, David A
Sanchez, Juan Miguel
Sanchez-Diaz, Rafael
Sanchez-Pedreno,
Salvador
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Sancho San Roman,
Juan
Sanders, Georgia E
Sanders, Jan A
Sanders, Robert W
Sandomierski, Frank L
Sands, Bill
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Jonathan Winslow
Sands, Suzanne E
Sangren, Ward C
Sangwine-Yager,
Jane Rosamund
Santa Pietro, John J
Santalo, L A
Santos Filho,
Jose Ruidival S
Santos, Rafael
Sanz-Serna, J M
Saphar, Pierre David
Sapozhnikova, Vera D
Saracino, Daniel H
Sarafyan, Diran
Sarason, Donald E
Sarason, Leonard
Sarhan, Mahmoud
Sarian, Edward
Sario, Leo
Sarrat, Charles F
Sastri, Chelluri C A
Satake, Ichiro
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Sato, Ken-iti

Sattinger, David H
Sauer, Timothy D
Saul, Alan Bruce
Saunders, Frank W
Saunders, William G
Saut, Jean Claude
Savage, James R
Savage, Richard P Jr
Savariraj, G A
Sawka, John M
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Parfeny P
Sawtell, Roy G Jr
Sawyer, Emerson L
Sawyer, Eric T
Saxton, Ralph Arthur
Sayasov, Yuri S
Sayeki, Hidemitsu
Sayre, John E
Sbordone, Carlo
Scalzo, Richard C
Scanlon, Jane Cronin
Scaramuzzi, Roberto
Scariano, Stephen
Scarpi, Giambattista
Scarsini, Marco
Scavo, Thomas R
Šcedrov, Andre
Schaal, Werner G H
Schacher, Murray M
Schaefer, Donald J
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Schaeffer, David G
Schaer, Jonathan
Schafer, Alice T
Schafer, Richard D
Schäffer, Juan Jorge
Schaffer, Matthew J
Schaller, Kay-Uwe
Schaps,
Malka Elisheva
Scharlau, Rudolf M E
Scharlemann,
Martin G
Schattschneider,
Doris W
Schatz, James R
Schatz, Joseph A
Schatzman,
James Carl
Schauer, Richard L
Schaumberger,
Norman
Schay, Geza
Schechter, Samuel
Schecter, Stephen
Scheffer, Carel L
Scheffer, Vladimir
Scheier, M A
Scheim, David E
Scheinberg, Stephen
Schellhorn,
Jean-Pierre
Scherkoske,
Kenneth D
Schibell, Stephen T
Schiffer, Max M
Schiller, Ilya
Schindler, Guenter M
Schirmer, Helga H
Schlagbauer, Hartmut
Schlesinger, Ernest C
Schlichenmaier,
Martin
Schmeelk, John F
Schmerl, James H
Schmetterer,
Leopold K
Schmid, Josef
Schmid, Jurg
Schmid,
Norma Pauline
Schmid, Peter P
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Schmid, Wilfried
Schmidlin, Dean J
Schmidt, Darrell
Schmidt, Dieter S
Schmidt, Harvey J Jr
Schmidt, Henry J Jr
Schmidt, Kenneth C

Schmidt, Roland
Schmidt, Wolfgang M
Schneebeli, H R
Schneider, David I
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Schneider, Manfred F
Schneider, Victor P
Schnitzer, Franz J
Schober, Anton G
Schochet, Claude L
Schochet, Steven H
Schoen, Richard M
Schoenberg, Isaac J
Schoenenberger-Deuel,
Johanna
Schoenfeld, Lowell
Schoenwaelder,
Ulrich F
Scholz, E
Schon, Rolf
Schonbek, Maria Elena
Schoneborn, Heinz
Schoonover, Melvin R
Schori, Richard M
Schot, Steven H
Schottenloher,
R Martin
Schramm, Ruben
Schrauf, Geza H
Schraut, K C
Schreiber, Bert M
Schreiber, Morris
Schreiner, Erik A
Schrijver, Alexander
Schroder, M
Schroeck,
Franklin E Jr
Schroeder, Johann
Schruben, Johanna
Schryer, Norman L
Schubert, Cedric F
Schulman,
Michael David
Schulte, Felix
Schulte, Thomas R
Schultz, Phillip
Schultz, Reinhard E
Schumacher, Carol S
Schumacher, Georg B
Schumacher, Scott
Schumaker, John A
Schumer, Peter David
Schumitzky, Alan
Schurle, Arlo W
Schuster, Seymour
Schutz, John W
Schuur, Susan E
Schwabauer, Robert J
Schwandt, Ernst
Schwanz, Cheryl L
Schwartz, Ira B
Schwartz, Jacob T
Schwartz, Laurent
Schwartz, Randy Ken
Schwartz, William
Schwarz, Binyamin
Schwarz, Friedhelm
Schwarz, Gerald W
Schwarz, Thomas
Schweiger, Fritz
Schweitzer, Eric
Schwerdtfeger,
Hans W E
Schwermer, Joachim
Schwietzer, Michael J
Scissors, Richard H
Scoppola, Carlo M
Scott, Dana S
Scott, Frederick J
Scott, Leonard L Jr
Scott, Peter
Scott, Ridgway
Scott, Warner Henry
Harvey III
Scott, William R
Scott-Thomas, John F
Scourfield, Eira J
Scowcroft, Philip H
Scriba, Christoph J
Seal, Charles Edwin
Sealy, Robert P

Seaman, Douglas D
Searcy, Charles J
Searl, James E
Sedgewick,
Charles H W
Sedory, Stephen A
Seebach, J Arthur
Seebach, Linda
Seebeck, Charles L III
Seeley, Robert T
Seenithamby,
Sivasundaram
Segal, David M
Segal, Irving E
Segers, Richard G
Sehgal, Surinder
Sehnert, James Ellis
Seibert, Peter
Seidel, Johan J
Seiden, Esther
Seidenberg, Abraham
Seidman, Thomas I
Seifert, George
Seifert, Ralph L
Seifter, Norbert
Seitelman, Leon H
Sejeeni, Fowzi A
Sekimoto, Toshihiko
Sekino, Kaoru
Selby, Alan M
Selden,
Annie Alexander
Selden, John Jr
Seldin, Jonathan P
Selgrade, James F
Seligman, George B
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Seligson, Stuart A
Sell, George R
Sellers, Peter H
Selmer, Ernst S
Seltzer, Stanley E
Semmes,
Stephen William
Sempi, Carlo E
Sen, Dipak K
Senderovizh, Rivka
Senechal, Lester J
Senge, George
Senger, Steven O
Seppala,
Mika Kristian
Serapioni, Raul
Serbyn, William D
Serfling, Robert J
Serfozo, Richard F
Serizawa, Shozo
Serre, Jean-Pierre
Serrell, Robert
Servedio, Frank J
Sesay, Mohamed W I
Seshu, Lily H
Sethuraman, Bharath
Sethuraman, J
Seubert, Steven M
Sever, Michael
Sevilla, Alicia N
Sevrain, Christophe
Jean-Paul
Sexauer, Norman E
Seydel, Robert E Jr
Sgro, Joseph A
Shabazz, Abdul Alim
Shabell, Barbara J
Shader, Bryan L
Shadwick,
William Francis
Shafer, Douglas S
Shaffer, Dorothy B
Shahabi, M A
Shahidi, Freydoon
Shahin,
Mazen Mohammed
Shahshahani,
Mehrdad M
Shakil, Mohammed
Shallit, Jeffrey Outlaw
Shand, Sherman M
Shannon, Christine A
Shannon, David L
Shannon, Susan

Shapiro, Daniel B
Shapiro, George S
Shapiro, Harold N
Shapiro, Helene
Shapiro, Jack S
Shapiro, Jay
Shapiro, Joel H
Shapiro, Louis W
Shapiro, Michael
Shapiro, Victor L
Shar, Albert O
Sharkey, Michael
Sharma, P L
Sharp, Henry Jr
Sharp, Jack Carroll Jr
Sharp, Rodney Y
Sharpe, Michael J
Sharpe, Richard W
Shaughnessy, J Michael
Shaw, Guy B
Shaw, Mei-Chi
Shaw, Sen-Yen
Shayib, Mohammed A
Shearer, James William
Shearer, Michael
Sheffer, Isador M
Sheil-Small, Terence Brian
Shekoury, Raymond
Shell, Niel
Shelly, Maynard W
Shelton, Chrispian E
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Shelupsky, David I
Shemanske, Thomas R
Shen, C Y
Shen, John
Shen, Mei-Chang
Shen, Nien-Tsu
Shen, Yuan-Yuan
Shepherd, Raymond T
Shepherdson, John C
Sher, D
Sherk, F A
Sherling, Dorothy Davis
Sherlock, Philip Thomas
Sherman, Clayton C
Sherman, Gary J
Sherman, Malcolm J
Sherr, Joseph S
Sherrill, M David
Sherwood, Howard
Shestakov, Aleksei Ilyich
Sheu, Albert Jeu-Liang
Shiba, Masakazu
Shibata, Masanori K
Shibata, Yukio
Shibuya, Yhuji
Shick, Paul L
Shiffman, Bernard
Shiffman, Max
Shifrin, Theodore
Shiga, Koji
Shih, Kung-Sing
Shih, Weishu
Shilepsky, Arnold C
Shim, Jae Ung
Shimada, Nobuo
Shimamoto, Don H
Shimizuike, Yuzi
Shin, Kyo Il
Shin, Yong-Tae
Shiohama, Katsuhiro
Shiohara, Hiroshi
Shipp, R Dale
Shiraiwa, Kenichi
Shiratani, Katsumi
Shiu, Elias S
Shivaji, Ratnasingham
Shively, Barbara S
Shoaff, William D
Sholander, Marlow C
Shor, S W Williston
Shore, Richard A
Shore, Terence R
Short, Donald R Jr
Shorter, William Ivan
Shortt, Rae Michael
Shreve, Darrell R
Shreve, David C
Shreve, Warren E
Shrikhande, Mohan Sharad
Shu, Wun-Item
Shube, Beatrice
Shucker, David S
Shulberg, Gary W
Shultz, Harris S
Shutt, Elsie G
Sibille, E
Sibley, Thomas Q
Sibner, Lesley M
Sibner, Robert J
Sibuya, Yasutaka
Sichler, J
Siddiqi, Rafat N
Sidney, Stuart J
Siebenmann, Laurence C
Sieg, Wilfried
Siegel, Alan
Siegel, Eli A
Siegel, Jerrold N
Siegel, Paul H
Siegrist, Kyle T
Siersma, Dirk
Sigrist, Francois
Sigurdsson, Gunnar
Silberger, Allan J
Silberstein, Esther
Silbert, Gary Allen
Siler, Jack G
Silva, Alessandro
Silva, Maria Welleda
Silvennoinen, Risto Pekka
Silverman, Herb
Silverman, Joseph H
Silverman, Richard Allan
Silverman, Robert David
Silvia, Evelyn Marie
Sim, Soon Kiong
Simen, David C
Simmons, Harold
Simmons, John Wiseman II
Simms, David J
Simó, Carles
Simões-Pereira, J M S
Simon, Imre
Simon, Jonathan K
Simon, Robert
Simons, Gordon Edward
Simons, Roger A
Simons, Stephen
Simpson, James E
Sims, Benjamin T
Sims, Charles C
Sinclair, Allan M
Sinclair, George Edward
Singer, David Allen
Singer, Michael
Singer, Phyllis E
Singer, Seymour
Singer, William M
Singerman, David
Singh, Bhagat
Singh, Kanhaya L
Singh, Sankatha P
Singh, Surjeet
Singman, David H
Sinkiewicz, Gerald P
Sinkov, Abraham
Sinnott, Warren Mann
Sistar, Carolyn Denise
Sitia, Candido
Siu, Man-Keung
Siu, Yum Tong
Sivera, Rafael
Siwiec, Frank E
Sizer, Walter S
Skaff, Michael S
Skau, Christian F
Skeath, James E
Sklar, Abe
Sklar, David
Skora, Richard Kevin
Skoug, David L
Skowronski, Janislaw M
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Slade, Gordon D
Slaminka, Edward E
Slater, John B
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Sleeman, Brian D
Slifker, James F
Sloane, Neil J A
Slodowy, Peter J
Slook, Thomas H
Sloss, James M
Slowikowski, Wojciech
Sluchin, Benny
Slud, Eric V
Slye, John M
Smale, Stephen
Small, Charles
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Small, Lance W
Small, Lynne Barnes
Smart, John R
Smiley, Leonard
Smillie, John
Smith, Bryan A
Smith, Constance Flahive
Smith, David A
Smith, Donald R
Smith, Edgar C Jr
Smith, F R
Smith, Frank A
Smith, Frank D Jr
Smith, Fredrick L
Smith, Gene Ward
Smith, Harold Robert Jr
Smith, Harvey A
Smith, Herman J Jr
Smith, James Lester
Smith, John Howard
Smith, John Huntington
Smith, John M
Smith, Kenneth Woodward
Smith, Kirby C
Smith, Lois E B
Smith, Marianne Freundlich
Smith, Mark A
Smith, Matthew D
Smith, Mi-Soo Bae
Smith, Michael Ainsworth
Smith, Michael G
Smith, Perry B
Smith, Raymond F
Smith, Robert Colman
Smith, Roland F
Smith, Ronald K
Smith, Scott
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Smith, Stephen D
Smith, Tom C
Smith, Truett Lee
Smith, Wayne Stewart
Smith, Wilbur L
Smith, William K
Smithson, Raymond E
Smoke, William H
Smolarski, Dennis C
Smoller, Joel A
Smyth, William F
Snaith, Victor P
Snell, J Laurie
Snover, James E
Snow, Dennis M
Snow, Joanne R
Snyder, David F
Snyder, Richard D
Snyder, William Merritt Jr
Soardi, Paolo Maurizio
Soare, Robert I
Sobel, Bernard A
Sobolev, Serguei L
Socolovsky, Eduardo Adolfo
Sohmer, Bernard
Sohrab, Houshang H
Soldate, Albert M Jr
Solheid, Ernie S
Solian, Alexandru
Solin, Robert N
Solmon, Donald C
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Somer, Lawrence E
Somes, John D
Sommer, Richard D
Somolinos, Alfredo S
Soni, Kusum K
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Sonn, Jack
Sonneborn, Lee M
Sonner, Johann
Sonnesso, Geraldine
Sons, Linda R
Sontag, Alexia Henderson
Sontag, Eduardo Daniel
Sontz, Stephen Bruce
Soong, Roland
Sorensen, Niels T
Sorenson, John R
Sormani, Michael J
Sorvali, Tuomas
Souganidis, Panagiotis E
Sourour, Ahmed Ramzi
Southgate, Theodore J
Southworth, Raymond W
Spanier, Jerome
Spatz, Ian N
Spears, Otis S
Specht, Edward J
Spector, Rene
Speed, Terence Paul
Speh, Birgit
Spellman, Dennis
Spence, Lawrence E
Spencer, Domina E
Spencer, Guilford L II
Spencer, Joel H
Spencer, Thomas Crawford
Spencer, W Dean
Sperry, Marvin G
Spiegel, W
Spielberg, Jack
Spielberg, Stephen E
Spieler, Barry S
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Spitzer, Frank L
Sprecher, David A
Spring, David H
Springer, Tonny A
Spruck, Joel
Spurr, Michael J
Squires, William A
Srebro, Uri
Sribney, William M
Srinivasan, Bhama
Srinivasan, V K
Sritharan, Sivaguru
Srivastav, Anupam
Srivastav, Ram P
Srivastava, Krishna J
St Vincent, Michael
Stacey, Peter John
Stackelberg, Olaf P
Staffeldt, Ross E
Stafford, Jonathan
Stafney, James D
Stagnaro, Ezio
Stahl, Saul
Stair, Lynda F
Stakgold, Ivar
Staley, Walter L
Stallings, John R
Stallmann, Friedemann W
Stamey, William L
Stamm, Emil
Stammbach, Urs
Stampfli, Joseph G
Stanaitis, Otonas E
Stancl, Donald L
Stancl, Mildred L
Stanczak, Romuald
Stanley, Lee James
Stanley, Richard P
Stanley, Walter L
Stanojević, Časlav V
Stanton, Charles M
Stanton, Charles S
Stanton, Nancy K
Staples, Edmund Beauclerc III
Staples, John C
Starbird, Thomas W
Stark, Christopher W
Stark, Eberhard L
Stark, Harold M
Stark, Sheldon H Jr
Starr, Edith N
Stasheff, James D
State, Emile Y
Staton, William A III
Stavroudis, Orestes N
Stavru, Hristos
Stecher, Michael J
Steel, Thomas B Jr
Steele, Alfred T
Steele, Charles A Jr
Steelman, John Henry
Steen, F H
Steen, Lynn A
Stefani, Stefano T
Stefánsson, Jón R
Steflik, Theresa M
Stegeman, Jan D
Stegenga, David A
Steger, Arthur
Steger, Tim Joshua
Steggles, Irving
Stegun, Irene A
Stein, Alan H
Stein, Elias M
Stein, Howard
Stein, Ivie Jr
Stein, Marjorie L
Stein, Michael
Stein, Sherman K
Steinberg, Arthur
Steinberg, Leon
Steinberg, Maria W
Steinberg, Paraskevi
Steinberg, Robert
Steinberg, Stanley Lee
Steinberger, Mark
Steinberger, Meir
Steiner, Anne K
Steiner, Donald D
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Steinhardt, Fritz
Steinhorn, Charles I
Steketee, Jakob A
Stell, George R
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Stemmer, Gaspar H
Stenger, Frank
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Stepp, James Wilson
Sterba-Boatwright, Blair D
Sterling, Theodor D
Stern, Alan Spector
Stern, Mark A
Stern, Ronald J
Sternberg, David
Sterrett, Andrew Jr

Stetkaer, Henrik
Steuerwalt, Michael H
Stevens,
Glenn Howard
Stevens, John G
Stevens, Randy S
Stevens, Richard S
Stevens, T Christine
Stewart, Cameron L
Stewart, G W
Stewart, Robert C
Stiel, Edsel F
Stiles, Joseph L
Still, Charles Herbert
Stinson, Kevin
Stob, Michael
Stock, John R
Stocker,
Harold Edward
Stockmeyer, Paul K
Stocks, Douglas R Jr
Stoddard, James H
Stokes, H Christine B
Stokes, Marion Jeffries
Stokes, Russell A
Stokes, William G
Stolarsky, Kenneth B
Stolberg, Harold J
Stoll, Wilhelm F
Stoller, Gerald S
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Viggo
Stoltzfus, Neal W
Stone, Alexander P
Stone, Arthur H
Stone, Arthur L
Stone, Charles J
Stone, David A
Stone, Eugene A
Stone, Lawrence D
Stone, Michael G
Stong, Robert E
Storc, Lise
Storey, Albert J
Stormes, James M
Storrer, Hans H
Stortz, Clarence B
Story, Donald D
Story, Helen F
Stout, Edgar Lee
Stout, Lawrence Neff
Stout, Quentin F
Stowe, Dennis C
Straffin, Philip D Jr
Stralka, Albert R
Strang, W Gilbert
Strassberg, Helen A
Strassen, Volker
Straube, Emil J
Straubing, Howard
Straughan, Brian
Straume, Eldar J
Strauss, Leon
Strauss, Monty J
Strauss, Walter A
Streater, David Neil
Strebel, Kurt
Strebel, Ralph
Stredulinsky,
Edward W
Street, Ross H
Streit, Franz
Streitman, Max
Strikwerda, John C
Stroeker, R J
Stroessner, Heinz
Strohl, G Ralph Jr
Strom, Arne
Strom, Bernee D
Stromberg, J O
Stromberg, Karl
Stromquist, Walter R
Stroock, Daniel W
Stroth, Gernot H W
Stroud, Eric G
Strout, John E
Stroyan, K D
Struik, Dirk J
Struik, Ruth Rebekka
Struppa, Daniele C
Strzelecki, Emmanuel

Stuart, H W Jr
Stuckwisch, Stephen E
Stummel, Friedrich
Sturgeon, Michael L
Sturley, Eric A
Sturnfield, James F
Styer, Robert A
Stynes, Martin
Su, Yuh-Ling
Suarez, Pedro A
Suchanek, Ana M
Sucheston, Louis
Sudderth, William D
Sueiro-Bal, Juan
Sueyoshi, Yutaka
Sugarman, Paul J
Sugawara, Masahiro
Sugden, Dorothy A
Sugiyama, Linda E
Suita, Nobuyuki
Sulanke, Robert A
Suleman, Hermono
Sullins, Kenneth W
Sullivan, Dennis P
Sullivan, Joseph A
Sullivan, Richard W
Sullivan, Wayne G
Sulski, Leonard C
Summerhill,
R Richard
Summers, John W
Summers, Stephen J
Summers, Timothy W
Summerville,
Richard M
Sun, Hugo Sui-Hwan
Sun, Twan
Sun, Tze-Chien
Sundararaman, D
Sundberg, Carl
Sunderland,
Benjamin B Jr
Sung, Cheng Chih
Sunley, Judith S
Sunouchi, Gen-ichiro
Sunouchi, Haruo
Sunseri, Mary V
Suri, Manil
Suryanarayan, E R
Sussman, Myron M
Sussmann, Hector J
Suter, Bruce
Sutherland, Scott
Sutner, Klaus
Sutton, Charles S
Suttorp, L G
Suziedelis, Eligijus S
Suzuki, Haruo
Suzuki, Michio
Suzuki, Yoshiya
Svendsen,
Edward Charles
Svensson, Erik J
Sverdlove, Ronald
Swaminathan,
Srinivasa
Swamy, Srikanta M N
Swan, Richard G
Swann, Howard S G
Swanson, David L
Swanson, Ellen E
Sward, Gilbert L
Sward, Marcia P
Swardson, Mary Anne
Swartwout, Donald E
Swartz, Blair K
Swartz, Charles W
Swartz, Edward B
Swartz, Joseph H
Swearingen, Daniel B
Sweeney, Edward T
Sweeney, Orval L
Sweeney, William J
Sweet, Melvin M
Swick, Kenneth E
Swift, Clare
Swokowski, Earl W
Swong, Khyson
Synowiec, John A
Sysikaski, Pirjo
Szabo, Manfred Egon

Szalajka, Walter S
Szambien, Horst H
Szankowski, Andrzej
Szarek, Stanislaw J
Szczarba, Robert H
Szczepanski, Susan
Szeto, Mabel
Sznitman, Alain-Sol
Szucs, Joseph M
Szulkin, Andrzej
Szwec, R J
Szyld,
Daniel Benjamín

Tabak, Barbara L
Tadic, Marko
Tadmor, Eitan
Taft, Earl J
Taft, Margaret W
Tagawa, Masa-Yoshi
Taggart, Marcia D
Tahani, Hossein
Taiani, Geraldine
Taibleson, Mitchell H
Taira, Kazuaki
Tait, Robert James
Tait, William W
Takacs, Lajos F
Takahashi, Reiji
Takahashi, Shuichi
Takeda, Ziro
Takemoto, Hideo
Takenaka, Shigeo
Takesaki, Masamichi
Takeuchi, Masaru
Takeuti, Gaisi
Takizawa, Kiyoshi
Takizawa, Seizi
Talaga, Paul C
Talenti, Giorgio G
Talge, Gordon J III
Taliaferro, Steven D
Talmadge, Richard B
Tam, Bit-Shun
Tam, Kwok-Wai
Tamari, Dov
Tan, Henry K
Tan, Sin-Leng
Tanabe, Hiroki
Tanaka, Hisao
Tanaka, Jun-Ichi
Tanaka, Toshie
Tancredi, Alessandro
Tang, Alfred S
Tang, Betty M
Tang, Chi-Ming
Tang, Francis Chi-Yu
Tang, Hwa Tsang
Tang, Wai-Shing
Tangeman, Richard L
Tangora, Martin C
Tanimoto, Taffee T
Tanis, Elliot A
Tannenbaum, Peter
Tanny, David
Tao, Yoko
Taqqu, Murad S
Targonski, Gyorgy I
Targonski, Jolan M
Tarski, Jan
Tartakoff, David S
Tashiro, Yoshihiro
Tashjian, Gloria J
Tatevossian, Leon H
Taussky, Olga
Tavantzis, John
Taylor, Angus E
Taylor, B A
Taylor, Donald E
Taylor,
Gladys Gillman
Taylor, Howard M
Taylor, Jean E
Taylor, Laurence R
Taylor, Michael D
Taylor, Samuel J
Taylor, Thomas J
Taylor, William W
Tee, Garry J
Teitelbaum, Jeremy T
Teitelbaum, Pinchas

Teleman, Nicolae
Telgársky, Rastislav
Temam, Roger
Temes, Lorne
Temple, John Blake
Temte, Mark C
Tena, Juan
Tench, Douglas
Tenenblat, Keti
Teply, Mark L
Terao, Hiroaki
Terkelsen, Frode
Terng, Chuu-Lian
Terras, Riho
Terrell, Steven W
Terwilliger, Paul M
Terzuoli, Andrew J
Tesei, Alberto
Tews, Melvin C
Textorius, Bjorn O B
Thakur,
Umesh Sarwottam
Thaler, Alvin I
Thedy, Armin
Thelen, Brian J
Theodorescu, Radu
Theohari-Apostolidi,
Theodora
Theusch, Colleen J
Thickstun, Thomas L
Thiele, Ernst-Jochen
Thieler, Peter
Thierrin, Gabriel
Thoele, Edward C
Tholen, Walter P
Thom, Rene
Thoma, Elmar H
Thomas, Alan T
Thomas, Clayton J
Thomas, Erik G F
Thomas, Garth H M
Thomas, Janet D
Thomas, Jay F
Thomas, Lawrence E
Thomas, Marc Phillip
Thomas, Mark A
Thomas, P Emery
Thomas,
Richard Kenneth
Thomason, Steven K
Thomee, Vidar C
Thomeier, Siegfried
Thompson, Harold B
Thompson, Jon H
Thompson, Lee D
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Robert James
Thompson, Russell C
Thomson, Brian S
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Thorbergsson,
Gudlaugur
Thorne,
John Farley III
Thornton, Melvin C
Thorpe, James C
Thorpe, John A
Thrall, Robert M
Throop, T
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Edward Gerrish
Tiberio, Ronald S
Tichy, Robert F
Tierney, Ann R
Tierney, John A
Tietz, Horst
Tijdeman, Robert
Tijs, Stef H
Tilidetzke,
Robert James
Tillmann, Heinz G
Timmer, Kathleen M
Timmerscheidt, Klaus
Timoney, Richard M
Timourian, James G
Tin, Saw
Tinberg, Nalsey B
Tindle, Graham L
Tinkelman, Robert P

Tinsley, Frederick C
Tippett, James M
Tischler, David C
Titani, Satoko
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Toby, Ellen H
Toczycki, Wladyslawa
Toda, Nobushige
Todd, Aaron R
Todd, John
Todd, Peter M
Todor, Fabian
Todorov,
Pavel Georgiev
Togo, Shigeaki
Toledo, Domingo
Toll, Charles H
Toll, Kathryn B
Tolle, Louis F
Tolosa, Juan
Tolsted, Elmer
Tolstoy, Alexandra I
Tomasovic, Joseph
Tomber, Marvin L
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N
Tomei, Carlos
Tomer, Eugene R
Tominaga, Hisao
Tomiuk, Daniel B J
Tomiyama, Jun
Tompson, R N
Tomsky, Jack
Tomter, Per
Tong, Mary Powderly
Tonne, Philip C
Topsoe, Flemming
Toptsis, Anestis A
Torelli, Paul A
Torrejon, Ricardo M
Torres, Euclides
Torres, Waldo A
Torrico, James O
Toshi, Iida
Tosques, Mario
Totaro, Burt J
Toth, Michael Richard
Tousley, Horace W
Town, George G
Townsend,
Douglas Wayne
Townsend, James T
Traina, Charles R
Tran, Lanh Tat
Tranah, David A
Transue, William R
Transue, William R R
Trapp, G E Jr
Trautman, David A
Trautmann, G
Traynor, Tim E
Trebels, Walter
Treibergs, Andrejs E
Treiman, Jay S
Trench, William F
Trenholme, Alice Ruth
Tretkoff, Carol
Treves, Francois
Triantafillou, Georgia
Trias Pairó, Joan
Tribbey, William P
Tricerri, Franco
Trigiante, Donato
Trimble, Selden Y
Trinh, Sinh Han
Trione, Susana Elena
Tripp, John C
Troger, Hans
Tromba, A J
Trombi, Peter C
Tronel, Gerard
Tross, Ralph G
Trotter, Hale F
Trotter, P G
Troue, Jacques
Trout, John D
Troutman, John L
Troyanov, Marc
Troyer, Stephanie F
Trudinger, Neil S
Trueman, D C

Truglio, Marilyn Ann
Trytten, Deborah A
Trytten, George N
Tsai, Chester E
Tsai, Long-Item
Tsai, Yen-Shung
Tsai, Yuh-Dong
Tsangaris, Panayiotis
Tsao, Anna
Tsao, Chia K
Tsao, Liang-Chi
Tschantz, Steven T
Tseng, Shiojenn
Tsuchikura, Tamotsu
Tsui, Sze-Kai Jack
Tsui, Waikin
Tsuji, Kazô
Tsuji, Mikio
Tsukada, Makoto
Tsukiyama, Kouzou
Tsukui, Yasuyuki
Tsutsumi, Massayoshi
Tu, Yih-O
Tubaro, Luciano
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Tucker, Alan C
Tucker, Don H
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Tucker, Susan L
Tugue, Tosiyuki
Tuler, Randy
Tulipani, Sauro
Tull, Jack P
Tung, Shih-Hsiung
Turett, J Barry
Turiel, F J
Turisco, Joann Stephanie
Turkington, Bruce E
Turner, Edward C
Turquette, Atwell R
Turull, Alexandre
Turyn, Lawrence
Turyn, Richard J
Tuttle, Keith Allan
Tuvell, Walter E
Tuzar, Jaroslav
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Twersky, Victor
Tyrl, Paul
Tysk, Johan
Tzafriri, Lior
Tzavaras, Athanassios E
Tzeng, Chun-Hung

Ucci, Jack
Uchiyama, Akihito
Uchiyama, Saburo
Uebelacker, James W
Uesugi, Toshitane
Uhlenbeck, Karen
Uhlmann, Gunther A
Uhlmann, Werner
Ullery, William D
Ullian, Joseph S
Ullman, Joseph L
Ulmer, Douglas L
Ulmer, F
Ulrich, Bernd
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Umble, Ronald N
Umeda, Takato
Umoh, Hanson M
Unai, Yasushi Unai
Unal, Aynur
Underwood, Douglas H
Ungar, Abraham
Ungar, Peter
Unger, Ernst R
Upatisringa, Visutdhi
Updike, John Bernard
Upham, Mary H
Upmeier, Harald
Upton, John A W
Urda, Michael
Uribe Espinosa, Guillermo
Usmani, Riaz A
van der Vaart, H Robert
Vachuska, Colleen A
Vainio, Reino Johan
Vajravelu, Kuppalapalle
Valdivia-Gutierrez, Oscar
Valk, Henry S
Valle, Antonio
Vamanamurthy, Mavina K
Van Bendegem, Jean Paul
Van Casteren, Johannes A
Van De Water, Arthur M Jr
Van Den Ban, Erik P
Van Der Hoek, John
Van Der Kallen, Wilberd
Van Der Maas, Gerard J
Van Der Poorten, Alfred J
Van Engelen, F
Van Horne, John W
Van Lint, Jacobus H
Van Mulbregt, Paul A
Van Rootselaar, Bob
Van Rossum, Marijke
Van Strien, Sebastian J
Van Tuyl, A H
Van Vleck, Fred S
Van Wesenbeeck, Walter F
Van Winter, Clasine
Van de Wetering, R Lee
Vance, Elbridge P
Vance, James T Jr
Vanden Boss, Eugene L
Vanderbauwhede, A L
Vandevelde, J Richard
Vanhecke, L
Vanstone, James R
Varadarajan, Kalathoor
Varadarajan, V S
Varadhan, Srinivasa S R
Varberg, Dale E
Varga, Richard S
Vargas, John David
Vasak, Janet Trzcinski
Vasconcelos, Wolmer V
Vaserstein, L N
Vasquez, Alphonse T
Vassiliou, Efstathios
Vatsala, A S
Vaughan, Herbert E
Vaughan, Jerry E
Vaughan, Theresa Phillips
Vaughn, James M Jr
Vayl, Vladimir
Vazquez, Juan L
Vega de Prada, Jose Manuel
Vein, Howard B
Veldman, Willem H
Velleman, Daniel
Veneri, James M
Ventre, Aldo Giuseppe
Ventura, Belisario Augusto
Venugopalan, P
Venzi, P
Venzke, Paul B
Vepsalainen, Seppo Juhani
Verde Star, Luis
Verdera, Joan
Vergne, Michele
Verma, Ghasi R
Vermeer, Johannes
Vermes, Robert
Vernon, Michael
Veron, Laurent
Verona, Andrei
Verrios, Katherine G D
Verstraelen, Leopold
Vervaat, Wim
Vesentini, Edoardo
Vesley, Richard E
Vetter, Udo
Vietsch, W Karel
Vigneras, Marie France
Vila-Freyer, Ricardo Francisco
Villa-Salvador, Gabriel D
Villamil, Hilda P
Vilms, Jaak
Vinacua, Alvaro
Vincent, Alan W
Vinograd, Robert E
Vinti, Calogero
Viola, Carlo
Virsik, George
Viterbo, Claude
Vitter, Albert L III
Vitulli, Marie A
Vives, Luis A
Viviente, Jose L
Voehl, Deanna Lynn
Voelker, Dietrich H
Vogan, David A Jr
Vogel, Kurt
Vogel, Thomas I
Vogelius, Michael Steenstrup
Vogt, Andrew
Vogt, E
Vogtmann, Karen
Vohra, Rakesh V
Voichick, Michael
Voigt, Paul S
Voigt, Robert G
Vojta, Paul A
Volkmann, Bodo
Voreadou, Rodiani
Vougiouklis, Thomas N
Voytuk, James A
Vrbik, Jan
Vrscay, Edward R
Vuilleumier, Monique
Vuorinen, Matti
Vyas, U D
Vyborny, Rudolf

Wada, Hidekazu
Wada, Junzo
Wade, William R
Wadhwa, Bhushan Lal
Waelbroeck, Lucien
Wage, Michael L
Wagener, Raymond
Wagner, Daniel H
Wagner, David H
Wagner, Diane M
Wagner, Eric G
Wagner, Gretchen B
Wagner, Neal R
Wagon, Stan
Wagoner, John B
Wagreich, Philip D
Wagstaff, Samuel S Jr
Wahba, Grace G
Wahl, John J
Wahl, Jonathan M
Wahlbin, Lars B
Waid, C Carter
Wainwright, Eric
Wainwright, John
Wajnryb, Bronislaw
Wakana, Kaoru
Wake, Bob Alan
Walczak, Hubert R
Walde, Ralph E
Wales, David B
Walker, Carol L
Walker, Elbert A
Walker, Homer F
Walker, James Edward
Walker, James S
Walker, James W
Walker, Julia A
Walker, Larry R
Walker, LeRoy H
Walker, Marshall
Walker, Michael F
Walker, Philip W
Walker, Russell Bruce
Wall, Charles T C
Wall, Curtiss E
Wall, G E
Wallace, David A R
Wallace, David Robert
Wallen, C J
Wallen, Lawrence J
Wallis, Walter D
Walsh, Dennis Patrick
Walsh, John J
Walsh, Mary L
Walster, G William
Waltcher, Azelle B
Walter, Gilbert G
Walter, John H
Walter, Martin E
Walter, Norman R
Walter, Rolf W
Walter, Wolfgang L
Walters, Eleanor B
Walters, Peter
Walters, Randall K
Walters, Robert F C
Waltman, Paul E
Walton, Jay R
Walton, Lewis F
Wanby, Goran
Wang, Ai-Nung
Wang, Cecilia Y
Wang, Derming
Wang, Edward T H
Wang, Hwai-Chiuan
Wang, Kwang-Shang
Wang, McKenzie Y
Wang, Ming-Chang
Wang, Paul K C
Wang, Shicheng
Wang, Stuart Sui-Sheng
Wang, Tseng-Chan
Wang, Ying Hsiung
Wantland, Evelyn K
Wanzong, Robert C
Ward, Harold N
Ward, James E III
Ward, James Norman
Ward, John T
Ward, Joseph D
Ward, Josephine A
Ware, Buck
Ware, Roger P
Warfield, Robert B Jr
Warga, Jack
Warne, Ronson J
Warnecke, Gerald
Warner, Frank W III
Warnock, Robert L
Warren, Bette L
Warren, William E
Warrinnier, Alfred E
Warshauer, Max Leon
Warsi, Shaukat Ali
Washburn, Robert B Jr
Washburn, Sherwood
Washington, Lawrence C
Wasow, Wolfgang R
Wasserman, Arthur G
Wasserman, Richard S
Watanabe, Hisao
Watanabe, Shôji
Watatani, Yasuo
Waterhouse, William C
Waterman, Daniel
Waterman, Michael S
Wathen, Judy A
Watkins, David S
Watkins, Joseph C
Watkins, Murray S
Watkins, Robert James
Watkinson, Anthony
Watnick, Richard M
Watro, Ronald J
Watson, James D
Watson, Martha F
Watson, Saleem
Watson, Stephen
Watt, Jeffrey Xavier
Watt, Stephen B
Wavrik, John J
Wayland, Keith
Wayman, Arthur K
Waymire, Edward C
Wayne, Alan
Weaver, George E
Weaver, James R
Weaver, John C
Weaver, Robert Wooddell
Webb, Cary H
Webb, William A
Webber, Robert P
Weber, Claude A
Weber, Waldemar C
Webster, Sidney M
Wechsler, Martin T
Wedel, Arnold M
Wefelscheid, Heinrich
Wehausen, John V
Wehlau, David L
Wehlen, Joseph A Jr
Wei, S Walter
Weibel, Charles A
Weibel, John L
Weil, Clifford E
Weiler, Fred W
Weiler, Jerome T
Weill, Lawrence R
Weinberg, David A
Weinberg, Elliot C
Weinberger, Hans F
Weiner, Jerome H
Weinert, Hanns Joachim
Weinfeld, Joel M
Weinitschke, Hubertus J
Weinkam, James J
Weinstein, Alan D
Weinstein, Jack
Weinstein, Michael I
Weinstein, Stephen T
Weintraub, Elaine Y
Weintraub, Steven H
Weis, Lutz
Weiser, Alan
Weisner, Louis
Weiss, Asia Ivić
Weiss, David M
Weiss, John
Weiss, Norman J
Weiss, Richard M
Weissler, Frederic B
Weitkamp, Galen L
Welch, Lawrence V
Welch, Lloyd R
Welland, Grant V
Wellner, Jon A
Wells, Charles F
Wells, David M
Wells, Jane F
Wells, R O Jr
Welters, G E
Wen, Shih-Liang
Wendel, James G
Wendland, Wolfgang L
Wendroff, Burton
Wendt, Dieter W F
Wene, Gregory P
Wenger, Ronald H
Wente, Henry C
Wenzel, John A
Wermer, John
Werner, Willes L
Werschulz, Arthur G
Wessel, W Roy
West, Dennis E
West, Donald C
West, James E

Westbrook, Edwin P
Western, D W
Westman, Joel J
Weston, Jeffrey D
Weston, Kenneth W
Westphal-Schmidt, U
Westwood, Derek J
Wetzel, John E
Wexler, D
Wheeler, Charles H III
Wheeler, John A
Wheeler, Robert F
White, Alvin M
White, Arthur Thomas II
White, Benjamin S
White, Charles Scott
White, Denis A
White, Dennis E
White, Donald B
White, George N Jr
White, Janis E
White, John T
White, Neil L
White, Stevan Russell
White, Steven J
White, Wm A
Whitehart, F E
Whitehead, George W
Whitehead, Kathleen B
Whiteman, Albert L
Whitfield, John H M
Whitley, W Thurmon
Whitman, Andrew P
Whitman, Philip M
Whitmore, William F
Whitney, D Ransom
Whitney, Hassler
Whitney, James N
Whitney, Ronald F
Whitney, Stephen
Whitson, Kim J
Whitt, Lee B
Whittaker, James V
Whitten, Wilbur
Whittlesey, Emmet F
Wick, Brian D
Wicke, Howard H
Wickelgren, Wayne A
Wickerhauser, Mladen Victor
Widger, Charles F
Widlund, Olof B
Widman, Kjell-Ove H
Wiedemann, Alfred
Wiedemann, Douglas H
Wiegand, Roger A
Wiegand, Sylvia Margaret
Wiegmann, Klaus Werner
Wielenberg, Norbert J
Wiener, Don
Wiener, Howard W
Wiener, Matthew
Wightman, Arthur S
Wihstutz, Volker
Wilcox, Theodore W
Wildman, Louis R
Wiles, Andrew J
Wilke, Frederick W
Wilken, Donald R
Wilker, John B
Wilker, Peter
Wilkerson, Clarence W
Wilkins, J Ernest Jr
Wilkinson, Steven V
Willard, Stephen
Willey, Richard N Jr
Williams, Bennie B
Williams, Dana P
Williams, David A
Williams, Dorothy J
Williams, E Bruce
Williams, Frederick C
Williams, Gareth
Williams, George K
Williams, Gerald W
Williams, Gregory P
Williams, Hugh C
Williams, Hugh M
Williams, James G
Williams, Joyce W
Williams, Lawrence R
Williams, Lynn R
Williams, Mark
Williams, Neil H
Williams, Peter David
Williams, Richard R Jr
Williams, Robert F
Williams, Ronald O
Williams, Ruth J
Williams, Stephen A
Williams, Susan Gayle
Williams, Vincent C
Williams, William O
Williamson, Charles K
Williamson, Clifton J
Williamson, Francis U
Williamson, Frank Jr
Williamson, Jack
Williamson, Richard E
Williamson, Robert E
Willis, Paul A
Wills, Jorg M
Wilson, Edward N
Wilson, James B
Wilson, John H
Wilson, Leslie C
Wilson, Raymond B
Wilson, Robert L
Wilson, Robert Lee
Wilson, Robert R
Wilson, Ted C
Wilson, Terence E
Wilson, W Stephen
Winarsky, Norman D
Windham, Michael Parks
Wine, James D
Winfrey, W R
Wing, G Milton
Wingler, Eric J
Winograd, Shmuel
Winslow, Dennis N
Winston, Clement
Winston, Kenneth
Winter, Eva P
Winters, Robert
Winther, Ragnar
Wintrobe, F
Wirszup, Izaak
Wirth, Andrew
Wise, Gary Lamar
Wisniewski, Helena S
Withers, Wm Douglas
Witt, Donald M
Witte, David S
Witte, Franklin P
Woan, Wen-Jin
Woeppel, James J
Woess, Wolfgang
Wofsy, Carla
Woldar, Andrew J
Wolfe, Carvel S
Wolfe, Dorothy W
Wolfe, Harold E
Wolfe, John E
Wolfe, Michael David
Wolff, Manfred P H
Wolfson, Paul R
Wolk, Elliot S
Wolkowicz, Gail S K
Wolpert, Scott A
Wolsson, Kenneth
Wong, Edward T
Wong, James S W
Wong, Kwok Chi
Wong, Philip Pit-Wang
Wong, Pit-Mann
Wong, Raymond Y
Wong, Roman Woon-Ching
Wong, Sherman K
Wong, Warren J
Wong, Yim-Ming
Wong, Yuen-Fat
Wong, Yung-Chow
Woo, K Y
Wood, Geoffrey V
Wood, John C
Wood, John W
Woodroofe, Michael B
Woodrow, Robert Edward
Woodruff, Edythe P
Woodruff, William M
Woods, Alan C
Woods, Dale
Woods, Jerry D
Woods, R Grant
Woodward, Gordon S
Woolf, William B
Wooster, Kenneth
Wooton, William
Worley, Patrick H
Worsham, Robert D
Wortman, Dennis H
Wouk, Arthur
Woyczyński, Wojbor A
Woythaler, Joseph William
Wrench, John W Jr
Wrentmore, Anita K
Wright, David G
Wright, David J
Wright, Jeffrey Allen
Wright, Randy
Wright, Ron
Wright, Steve J
Wright, Thomas Perrin Jr
Wrona, Wlodzimierz
Wu, Hung-Hsi
Wu, Ling-Erl Eileen T
Wu, T C
Wulf, Leo M
Wunderlich, Marvin C
Wurfel, Tilmann
Wurster, Marie A
Wyler, Oswald
Wylie, Clarence R Jr
Wyman, Bostwick F
Wyneken, Matthew Fair
Wyss, Walter

Xia, Daoxing
Xia, Jingbo

Yablon, Marvin
Yachter, Morris
Yackel, James W
Yadin, Micha
Yahya, S M
Yajima, Yukinobu
Yaku, Takeo
Yale, I Keith
Yale, Paul B
Yamada, Miyuki
Yamada, Shinichi
Yamada, Toshihiko
Yamaguchi, Itaru
Yamaguchi, Jinsei
Yamaguchi, Keizo
Yamaguchi, Ryuji
Yamaguti, Kiyosi
Yamaki, Hiroyoshi
Yamamoto, Koichi
Yamanoshita, Tsuneyo
Yamaoka, Kenya
Yamasaki, Masayuki
Yanagawa, Minoru
Yang, Chao-Hui
Yang, Chung-Tao
Yang, Deane
Yang, Jeong Sheng
Yang, Kung-Wei
Yang, Paul C
Yang, Shaochen
Yang, Wei-Shih
Yanik, Joe
Yano, Kentaro
Yanowitch, Michael
Yao, Andrew Chi-Chih
Yap, Leonard Y H
Yaqub, Adil M
Yaqub, Fawzi M
Yaqub, Jill S
Yasue, Kunio
Yasugi, Mariko
Yasuhara, Ann
Yasuhara, Mitsuru
Yau, Stephen S-T
Yeager, Dorian P
Yebra, Jose Luis Andres
Yee, George S
Yeh, James J
Yeh, Roger C
Yen, David H Y
Yerion, Katherine Ann
Yetter, David N
Yhap, Ernesto Franklin
Yntema, Mary K
Yocom, Kenneth L
Yohe, James M
Yokoi, Hideo
Yoneda, Kaoru
Yoneguchi, Hajimu
Yood, Bertram
Yorke, James A
Yoshino, Genji
Yoshino, Takashi
Yoshizawa, Taro
Yosida, Kosaku
Young, Barry H
Young, David M Jr
Young, Donald F
Young, Elmer Lorne
Young, Eutiquio C
Young, Gail S
Young, Lael M
Young, Laurence C
Young, Paul M
Young, Sam Wayne
Young, Wo-Sang
Younger, Daniel H
Yovanovich, M Michael
Yu, Chien-Chih
Yu, Lucille Chieh
Yui, Noriko
Yun, Dall-Sun
Yung, Tin-Gun
Yus, Nicolas
Zaanen, Adriaan
Zabrodsky, Alexander
Zacharia, Dan
Zacharias, Gail
Zacks, Shelemyahu
Zadeh, Lotfi A
Zafrany, Samy
Zagier, Don Bernard
Zahid, Muhammad Ishaq
Zajac, Edward E
Zaks, Abraham
Zalik, R A
Zama, Nobuo
Zambrini, Jeau-Claude
Zanco, Clemente A
Zandi, Ahmad
Zanolin, Fabio
Zapf, Hermann
Zaretzki, Philip M
Zaring, Wilson M
Zaslavsky, Thomas
Zdinak, Edward G
Zedek, Mishael
Zehnder, Eduard J
Zeigler, Fredrick J
Zeleznikow, John
Zelinsky, Daniel
Zelinsky, David S
Zelle, Joseph
Zeller, Karl
Zemaitis, Vincent R
Zemmer, Joseph L Jr
Zerzan, Terrance P
Zhu, Jianchao
Ziebur, Allen D
Ziege, Roland W
Ziegler, Zvi
Ziemer, William P
Zierler, Neal
Ziller, Wolfgang
Zilmer, Delbert E
Zimering, Shimshon
Zimmer, J W
Zimmerman, Grenith J
Zimmerman, Jay J
Zink, Robert E
Zinn, J
Zipfel, Christian
Zippo, Siro
Zipse, Philip W
Zirilli, Francesco
Zitarelli, David E
Zitron, Norman R
Zitzler, Siham Braidi
Zizi, Khelifa
Zizler, Vaclav
Zlatev, Zahari
Zo, Felipe J
Zoch, Richmond T
Zoercher, C Z
Zomorrodian, Reza
Zondek, Bernd
Zorn, M A
Zorn, Paul
Zoroa, P
Zorzitto, Frank A
Zsidó, László
Zucker, Steven M
Zuckerberg, Hyam L
Zuckerman, Gregg J
Zuckerman, Paul R
Zweifel, Paul F
Zwick, D
Zwier, Paul J
Zygmund, Antoni

Anonymous (130)

The Nominating Committee and the Preferential Ballot

The method of counting the ballots for places on the Nominating Committee (but *not* for the election of officers) is the one known as the "single transferable vote." As this was codified in British law, there were certain ambiguities and elements of chance. These have been removed in a subsidiary document, also followed, known as the "senatorial rules." The reader who wishes general background on preferential ballots and on the single transferable vote may read *Voting in Democracies* by Enid Lakeman and James D. Lambert (Faber and Faber, 1955). The reader who wishes to go further and to become familiar with the case advanced against preferential ballots may read books by F. A. Hermens, such as *Europe between Democracy and Anarchy* (University of Notre Dame, 1951). There is a criticism of the preferential ballot by Steven J. Brams in *Notices*, vol. 29, pages 136–138 (February 1982).

In a preferential ballot, the voter ranks his choices and indicates the ranks with consecutive integers, beginning with one for the candidate of his first choice. The voter may order any desired number of candidates. However, the voter may reach a point where ignorance or indifference makes further ordering impossible. A ballot becomes not transferable and thus of no further use (see the next paragraph) when an integer is used twice or is skipped in indicating the order of choice, so that the tellers are not effectively informed.

The precise rules by which the votes are counted are stated in Appendices IV and V of the cited text of Lakeman and Lambert. This is a passage of thirty-three pages of definitions, rules, interpretations, and examples. It is too much to attempt a complete summary here. The spirit is that every ballot shall count somewhere if possible; if it is not needed (as when the candidate is either elected without it or defeated with it), it shall be transferred to the next choice. There is a "quota", the number of votes required to elect a candidate. With N ballots and m places to be filled, the quota Q is the smallest integer J such that at most m candidates can receive at least J votes, that is $Q = [1 + N/(m+1)]$. Ballots are distributed according to first choice votes, any candidate receiving the quota being declared elected. Then votes are transferred, repeatedly if necessary, first using up excesses over the quota, the largest excess first, and then eliminating candidates with insufficient votes, the smallest first. In transferring either an excess number of votes or an insufficient number of votes, numbers of votes with total equal to the number to be transferred are assigned to the remaining candidates, the assigned number for a candidate being proportional to the number of next choice votes for that candidate. Transfers follow the order of preference of the voters. The process is determinate, but it is too long to explain completely here.

Please do *not* correspond with the writer or the editors about the ambiguities that are unresolved in the above abbreviated description. Instead, read Appendices IV and V already referred to, where eleven pages of rules, essentially a teller's flow chart, appear to leave no ambiguities.

Everett Pitcher, Secretary

1986 Election Information

The names of candidates for the election of 1986 would appear in this issue of Notices if it were possible to follow the plan of past years. However, the spring meeting of the Council, at which nominations are made, was unusually late this year and occurred after this issue of Notices went to press. Thus names of candidates will not appear until the August issue.

Everett Pitcher, Secretary
Bethlehem, Pennsylvania

Logan, October 10–11, Utah State University

First Announcement of the 828th Meeting

The eight hundred and twenty-eighth meeting of the American Mathematical Society will be held at Utah State University in Logan, Utah, on Friday and Saturday, October 10–11, 1986.

Invited Addresses

By invitation of the Committee to Select Hour Speakers for Far Western Sectional Meetings, there will be two invited one-hour addresses. The speakers and the titles of their talks are:

PETER LI, University of Utah, *Harmonic functions on complete manifolds.*

KENNETH C. MILLETT, University of California, Santa Barbara, *New combinatorial methods in three dimensional topology.*

Special Sessions

By invitation of the same committee, there will be five special sessions of selected papers. The topics of these sessions, the names and affiliations of the organizers, and partial lists of the speakers, are as follows:

Applications and computational aspects of numerical continuation methods, EUGENE ALLGOWER, Colorado State University. The tentative speakers are Eusebius Doedel, Kurt Georg, Herbert Keller, Hans Mittelmann, T.-Y. Li, Alexander Morgan, Aubrey Poore, Chris Tiahrt, and Layne Watson.

Analysis on manifolds, S. Y. CHENG, University of California, Los Angeles. Some of the speakers are Michael Anderson, Robert Brooks, Hui-Dong Cao, Robert Greene, Douglas Moore, V. Oliker, Luen-Fai Tam, Andrejs Treibergs, and Johan Tysk.

Representations of reductive groups, DAVID H. COLLINGWOOD, University of Oregon. Some of the speakers are Brian Boe, J. Chang, Tom Enright, Devra Garfinkle, Henryk Hecht, R. Irving, J. Johnson, Dragan Miličić, Ivan Mirkovic, Hugo Rossi, R. Scaramuzzi, Brad Shelton, Peter Trombi, and Joseph Wolf.

Random fields, random measures and applications, ED WAYMIRE, Oregon State University. The speakers are Kenneth S. Alexander, Florin Avram, Rabi Bhattacharya, Michael D. Brennan, Peter Brockwell, Robert M. Burton, Colleen Cutler, Richard Darling, Stuart Ethier, Peter Gaenssler, Evarist Gine, Thomas G. Kurtz, Charles M. Newman, Mina Ossiander, Richard F. Serfozo, Winfried Stute, Murad Taqqu, and Stanley C. Williams.

Geometric topology, DAVID WRIGHT and J. W. CANNON, Brigham Young University. The speakers are Colin Adams, Ric Ancel, Mladen Bestvina, Steven Bleiler, John Bryant, Ed Burgess, J. W. Cannon, Bill Eaton, Bill Floyd, David Gabai, Dennis Garity, Matt Grayson, Jim Henderson, Jim Hoste, Stephen Humphries, Louis Kaufman, Chris Lacher, Duane Loveland, Jerr Levine, Vo Thanh Liem, John Luecke, Dale Rolfson, T. Benny Rushing, Martin Scharlemann, Jon Simon, Mike Starbird, Abigail Thompson, Keith Wolcott, and David Wright.

Most of the papers to be presented at these special sessions will be by invitation. However, anyone submitting an abstract for the meeting who feels that his or her paper would be particularly appropriate for one of these special sessions should indicate this clearly on the abstract form and submit it by **July 28, 1986**, three weeks before the deadline for contributed papers, in order that it may be considered for inclusion. Participants are reminded that a charge of $16 is imposed for retyping abstracts that are not in camera-ready form.

Contributed Papers

There will also be sessions for contributed ten-minute papers. Abstracts should be prepared on the standard AMS form available from the AMS office in Providence or in Departments of Mathematics. Abstracts should be sent to the Editorial Department, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940, so as to arrive before the **August 18, 1986**, abstract deadline. Participants are reminded that a charge of $16 is imposed for retyping abstracts that are not in camera-ready form. Late papers will not be accommodated.

Registration

The meeting registration desk will be located on the main floor of the Eccles Conference Center. The desk will be open from 10:00 a.m. to 4:30 p.m. on Friday, and from 8:00 a.m. until noon on Saturday. The registration fees are $10 for members of the AMS, $16 for nonmembers, and $5 for students or unemployed mathematicians.

Petition Table

A petition table will be set up in the registration area. Additional information can be found in a box in the New Orleans meeting announcement on page 72 of the January 1986 issue of *Notices*.

Accommodations

A block of rooms is being held for conference participants at the University Inn. This is a full-service hotel complex located on campus. Other motels are located within 1.5 to 3 miles of campus in downtown Logan. Participants should make their own reservations directly with the University Inn or other motel of their choice.

Rates are subject to possible change and do not include local taxes.

University Inn
Utah State University, Logan, UT 84322
Telephone: 801-750-1153
Single $28 Double $32

Baugh Motel
153 South Main Street, Logan, UT 84321
Telephone: 801-752-5220
Single $26 and up Double $30 and up

Best Western Weston's Lamplighter
250 North Main Street, Logan, UT 84321
Telephone: 801-752-5700
Single $28 Double $32

Holiday House
447 North Main Street, Logan, UT 84321
Telephone: 801-752-9141
Single $26 and $28 Double $31 and $33

Food Services

The cafeteria in the Taggart Student Center will be open during both days of the meeting. In addition, there are numerous restaurants along Main Street, and a restaurant list will be available at the registration desk.

Travel and Local Information

Logan is located approximately 90 miles north of Salt Lake City. Salt Lake City is served by Amtrak, Greyhound and major airlines. Most car rental agencies have counters at the airport terminal.

Persons driving from Salt Lake City to Logan should take I-15 north to Brigham City, exit at 363 and take US highway 89-91 to Logan. In Logan, turn east off Main Street to 400 North and then turn left off 400 North to 700 East to the University Campus.

Parking is available in the visitor parking terrace on 700 North, adjacent to the University Inn, and to the east of campus at 1200 East. Terrace parking will be validated for conference participants and the University Inn guests. Parking is permitted virtually anywhere on weekends.

Regularly scheduled limousine service between Salt Lake City and Logan is available through Key North Limousine. Current one-way prices are $36.40 for one person and $25 each for two or more persons. Up to six departure times per day are offered weekdays, and four times per day on weekends, with additional limousines added as needed. Reservations must be made no later than 24 hours in advance by calling Key North Limousine, 801-394-7743.

Logan is at an elevation of 4000 feet. Autumn days are cool and frost is likely at night. Rain or snow is possible, but unlikely.

Salt Lake City, Utah

Hugo Rossi
Associate Secretary

Charlotte, October 17–18, Adam's Mark Hotel

First Announcement of the 829th Meeting

The eight hundred and twenty-ninth meeting of the American Mathematical Society will be held at the Adam's Mark Hotel in downtown Charlotte, North Carolina, on Friday and Saturday, October 17–18, 1986. This meeting will be hosted by the University of North Carolina at Charlotte.

Invited Addresses

By invitation of the Committee to Select Hour Speakers for Southeastern Sectional Meetings, there will be three invited one-hour addresses. The speakers are as follows:

PATRICK EBERLEIN, University of North Carolina, Chapel Hill, *Structure of manifolds of non-positive curvature.*

STEVEN C. FERRY, University of Kentucky, title to be announced.

FRANK RAYMOND, University of Michigan, Ann Arbor, title to be announced.

Special Sessions

By invitation of the same committee, there will be four special sessions of selected twenty-minute papers. The topics of these sessions and the names and affiliations of the organizers, are as follows:

Singularities and algebraic geometry, GARY KENNEDY, Duke University.

Geometric topology, JOHN MAYER, University of Alabama, Birmingham.

Group actions on manifolds, DAVID ROYSTER, University of North Carolina, Charlotte.

Twistor theory and four-dimensional geometry, ALBERT L. VITTER III, Tulane University.

Most of the papers to be presented at these special sessions will be by invitation. However, anyone submitting an abstract for the meeting who feels that his or her paper would be particularly appropriate for one of these special sessions should indicate this clearly on the abstract form and submit it by **July 30, 1986**, three weeks before the deadline for contributed papers, in order that it may be considered for inclusion. Participants are reminded that a charge of $16 is imposed for retyping abstracts that are not in camera-ready form.

Contributed Papers

There will also be sessions for contributed ten-minute papers. Abstracts should be prepared on the standard AMS form available from the AMS office in Providence or in Departments of Mathematics. Abstracts should be sent to the Editorial Department, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940, so as to arrive before the **August 20, 1986**, abstract deadline. Participants are reminded that a charge of $16 is imposed for retyping abstracts that are not in camera-ready form.

Information concerning registration, accommodations, food service, etc., will be available in the August issue of *Notices*.

Frank T. Birtel
New Orleans, Louisiana — Associate Secretary

Denton, October 31–November 1, North Texas State University

First Announcement of the 830th Meeting

The eight hundred and thirtieth meeting of the American Mathematical Society will be held at North Texas State University in Denton, Texas, on Friday, October 31 and Saturday, November 1, 1986.

Invited Addresses

By invitation of the Committee to Select Hour Speakers for Central Sectional Meetings, there will be four invited one-hour addresses. The speakers are as follows:

PAUL FONG, University of Illinois at Chicago, *Modular representations of finite groups.*

RAVI S. KULKARNI, Indiana University, Bloomington, title to be announced.

ALEXANDER NAGEL, University of Wisconsin, Madison, title to be announced.

MARY WHEELER, Rice University, title to be announced.

Special Sessions

By invitation of the same committee, there will be several special sessions of selected twenty-minute papers. The topics of the sessions, and the names and affiliations of the organizers, are as follows:

Banach spaces and related topics, ELIZABETH BATOR, RUSSELL BILYEU and PAUL LEWIS, North Texas State University.

Connections between combinatorics, algebra and geometry, NEAL BRAND and JOSEPH KUNG, North Texas State University.

Differential equations, ALFONSO CASTRO, Southwest Texas State University, and JOHN NEUBERGER, North Texas State University.

Mathematics for large scale computing, J. C. DIAZ, University of Oklahoma.

Computational mathematics, WARREN FERGUSON, JR., Southern Methodist University.

Geometric structures on manifolds and Kleinian groups, RAVI S. KULKARNI.

Invariant theory, V. LAKSHMIBAI, Texas A & M University.

Most of the papers to be presented at these special sessions will be by invitation. However, anyone submitting an abstract for the meeting who feels that his or her paper would be particularly appropriate for one of these special sessions should indicate this clearly on the abstract form and submit it by **August 4, 1986**, three weeks before the deadline for contributed papers, in order that it may be considered for inclusion. Participants are reminded that a charge of $16 is imposed for retyping abstracts that are not in camera-ready form.

Contributed Papers

There will also be sessions for contributed ten-minute papers. Abstracts should be prepared on the standard AMS form available from the AMS office in Providence or in Departments of Mathematics. Abstracts should be sent to the Editorial Department, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940, so as to arrive before the **August 25, 1986**, abstract deadline. Participants are reminded that a charge of $16 is imposed for retyping abstracts that are not in camera-ready form. It appears unlikely that late papers can be accommodated.

Information concerning registration, accommodations, food service, etc. will be published in the August issue of *Notices.*

Robert M. Fossum
Urbana, Illinois — Associate Secretary

Invited Speakers and Special Sessions

Invited Speakers at AMS Meetings

The individuals listed below have accepted invitations to address the Society at the times and places indicated. For some meetings, the list of speakers is incomplete.

Logan, October 1986

Peter Li
Kenneth C. Millett

Charlotte, October 1986

Patrick Eberlein
Steven C. Ferry
Frank Raymond

Denton, October 1986

Paul Fong
Ravi S. Kulkarni
Alexander Nagel
Mary Wheeler

San Antonio, January 1987

Marc Culler
Peter D. Lax (Colloquium Lecturer)
Robert J. McEliece
David J. Saltman
Lesley M. Sibner
Thomas Spencer (Gibbs Lecturer)

Newark, April 1987

Robert V. Kohn
Rodolfo Rosales
Birgit Speh
Lars S. Wahlbin

Organizers and Topics of Special Sessions

The list below contains all the information about Special Sessions at meetings of the Society available at the time this issue of the *Notices* went to the printer. The section below entitled **Information for Organizers** describes the timetable for announcing the existence of Special Sessions.

October 1986 Meeting in Logan

Far Western Section
Deadline for organizers: Expired
Deadline for consideration: July 28, 1986

Eugene L. Allgower, *Applications and computational aspects of numerical continuation methods*
S. Y. Cheng, *Analysis on manifolds*
David Collingwood, *Representations of reductive groups*
Ed Waymire, *Random fields, random measures and applications*
David Wright and J. W. Cannon, *Geometric topology*

October 1986 Meeting in Charlotte

Southeastern Section
Deadline for organizers: Expired
Deadline for consideration: July 30, 1986

Gary Kennedy, *Singularities and algebraic geometry*
John Mayer, *Geometric topology*
David Royster, *Group actions on manifolds*
Albert L. Vitter, III, *Twistor theory and four-dimensional geometry*

October 1986 Meeting in Denton

Central Section
Deadline for organizers: Expired
Deadline for consideration: August 4, 1986

Elizabeth Bator, Russell Bilyeu, and Paul Lewis, *Banach spaces and related topics*
Neal Brand and Joseph Kung, *Connections between combinatorics, algebra and geometry*
Alfonso Castro and John W. Neuberger, *Differential equations*
J. C. Diaz, *Mathematics for large scale computing*
Warren Ferguson, Jr., *Computational mathematics*
Ravi S. Kulkarni, *Geometric structures on manifolds and Kleinian groups*
V. Lakshmibai, *Invariant theory*

Fall 1986 Meeting

Eastern Section
No meeting will be held

January 1987 Meeting in San Antonio

Associate Secretary: Robert M. Fossum
Deadline for organizers: Expired
Deadline for consideration: September 24, 1986

Ronald J. DiPerna, *Nonlinear partial differential equations*
Burton Fein, David J. Saltman, and Murray Schacher, *Brauer groups and Galois theory*
Michael Gage and Edwin Lutwek, *Geometric inequalities*
Philip J. Hanlon, *Combinatorics and group representations*
Paul D. Humke, *Complex analysis*
Lesley M. Sibner, *Gauge theory*
Lynn McLinden and Jay S. Treiman, *Theoretical optimization*
Gregory P. Wene, *Mathematical physics*

Spring 1987 Meeting

Eastern Section
Deadline for organizers: October 15, 1986
Deadline for consideration: To be announced

Spring 1987 Meeting

Central Section
Deadline for organizers: October 15, 1986
Deadline for consideration: To be announced

Spring 1987 Meeting

Far Western Section

Deadline for organizers: October 15, 1986
Deadline for consideration: To be announced

Spring 1987 Meeting

Southeastern Section

Deadline for organizers: October 15, 1986
Deadline for consideration: To be announced

Information for Organizers

Special Sessions at Annual and Summer meetings are held under the general supervision of the Program Committee. They are administered by the Associate Secretary in charge of the meeting with staff assistance from the Society office in Providence.

Some Special Sessions arise from an invitation to a proposed organizer issued through the Associate Secretary. Others are spontaneously proposed by interested organizers or participants. Such proposals are welcomed by the Associate Secretaries.

The number of Special Sessions at a Summer or Annual Meeting is limited to twelve. Proposals, invited or offered, which are received at least nine months prior to the meeting, are screened for suitability of the topic and of the proposed list of speakers, and for possible overlap or conflict with other proposals (specific deadlines for requesting approval for Special Sessions at national meetings are given above). If necessary, the numerical limitation is enforced.

Proposals for Special Sessions should be submitted directly to the Associate Secretary in charge of the meeting (at the address given in the accompanying box). If such proposals are sent to the Providence office, addressed to *Notices*, or directed to anyone other than the Associate Secretary, they will have to be forwarded and may not be received before the quota is filled.

In accordance with an action of the Executive Committee of the Council, no Special Session may be arranged so late that it may not be announced in *Notices* early enough to allow any member of the Society, who wishes to do so, to submit an abstract for consideration for presentation in the Special Session before the deadline for such consideration.

Special Sessions are effective at Sectional Meetings and can usually be accommodated. They are arranged by the Associate Secretary under the supervision of the Committee to Select Hour Speakers for the section. The limitation on the number of sessions depends on the space and time available. The same restriction as for national meetings applies to the deadline for announcing Special Sessions at sectional meetings: no Special Session may be approved too late for its announcement to appear in time to allow a reasonable interval for members to prepare and submit their abstracts prior to the special early deadline set for consideration of papers for Special Sessions.

The Society reserves the right of first refusal for the publication of proceedings of any special session. These proceedings appear in the book series *Contemporary Mathematics*.

Information for Speakers

A great many of the papers presented in Special Sessions at meetings of the Society are invited papers, but any member of the Society who wishes to do so may submit an abstract for consideration for presentation in a Special Session, provided it is received in Providence prior to the special early deadline announced above and in the announcements of the meeting at which the Special Session has been scheduled. Contributors should know that there is a limitation in size of a single special session, so that it is sometimes true that all places are filled by invitation. Papers not accepted for a Special Session are considered as ten-minute contributed papers.

Abstracts of papers submitted for consideration for presentation at a Special Session must be received by the Providence office (Editorial Department, American Mathematical Society, Post Office Box 6248, Providence, RI 02940) by the special deadline for Special Sessions, which is usually three weeks earlier than the deadline for contributed papers for the same meeting. The Council has decreed that no paper, whether invited or contributed, may be listed in the program of a meeting of the Society unless an abstract of the paper has been received in Providence prior to the deadline.

Send Proposals for Special Sessions to the Associate Secretaries

The programs of sectional meetings are arranged by the Associate Secretary for the section in question:

Far Western Section (Pacific and Mountain)

Hugo Rossi, Associate Secretary
Department of Mathematics
University of Utah
Salt Lake City, UT 84112
(Telephone 801-581-8159)

Central Section

Robert M. Fossum, Associate Secretary
Department of Mathematics
University of Illinois
1409 West Green Street
Urbana, IL 61801
(Telephone 217-333-3975)

Eastern Section

W. Wistar Comfort, Associate Secretary
Department of Mathematics
Wesleyan University
Middletown, CT 06457
(Telephone 203-347-9411)

Southeastern Section

Frank T. Birtel, Associate Secretary
Department of Mathematics
Tulane University
New Orleans, LA 70118
(Telephone 504-865-5646)

As a general rule, members who anticipate organizing Special Sessions at AMS meetings are advised to seek approval at least nine months prior to the scheduled date of the meeting. No Special Sessions can be approved too late to provide adequate advance notice to members who wish to participate.

Call For Topics For 1988 Conferences

Suggestions are invited from mathematicians, either singly or in groups, for topics of the various conferences that will be organized by the Society in 1988. The deadlines for receipt of these suggestions, as well as some relevant information about each of the conferences, are outlined below. An application form to be used when submitting suggested topic(s) for any of these conferences (except the Short Course Series) may be obtained by writing to the Meetings Department, American Mathematical Society, P.O. Box 6248, Providence, Rhode Island 02940, or telephoning 401-272-9500, extension 296.

Individuals willing to serve as organizers should be aware that the professional meeting staff in the Society's Providence office will provide full support and assistance before, during, and after each of these conferences. Organizers should also note that for all conferences, except Summer Research Conferences, it is required that the proceedings be published by the Society, and that proceedings of Summer Research Conferences are frequently published. A member of the Organizing Committee must be willing to serve as editor of the proceedings.

All suggestions must include (1) the names and affiliations of proposed members and chairman of the Organizing Committee; (2) a two- or three-page detailed outline of the subject(s) to be covered, including the importance, timeliness of the topic, and estimated attendance; (3) a list of the recent conferences in the same or closely related areas; (4) a tentative list of names and affiliations of the proposed principal speakers; (5) a list of likely candidates who would be invited to participate and their current affiliations; and (6) any other observations which may affect the size of the conference and the amount of support required. Any suggestions as to sites and dates should be made as early as possible in order to allow adequate time for planning. By action of the AMS Board of Trustees, the Meetings Department of the Society is responsible for the final selection of the site for each conference and for all negotiations with the host institution. Individuals submitting suggestions for the conferences listed below are requested to recommend sites or geographic areas which would assist the Meetings Department in their search for an appropriate site. In the case of Joint Summer Research Conferences in the Mathematical Sciences, a one-, two-, or three-week conference may be proposed.

Refer to the accompanying box titled **Topics of Current and Recent Conferences** for lists of topics.

Topics of Current and Recent Conferences

AMS-SIAM Symposium in Applied Mathematics

1980 - *Mathematical psychology and psychophysiology,* organized by STEPHEN GROSSBERG of Boston University.

1983 - *Inverse problems,* organized by D. W. MCLAUGHLIN of the University of Arizona.

AMS Summer Institute

1983 - *Nonlinear functional analysis and applications,* organized by FELIX BROWDER of the University of Chicago.

1984 - *Geometric measure theory and the calculus of variations,* organized by WILLIAM K. ALLARD of Duke University and FREDERICK J. ALMGREN, JR. of Princeton University.

1985 - *Algebraic geometry,* organized by DAVID EISENBUD of Brandeis University.

1986 - *Representations of finite groups and related topics,* organized by JONATHAN L. ALPERIN of the University of Chicago.

AMS-SIAM Symposium on Some Mathematical Questions in Biology

1983 - *Muscle physiology,* organized by ROBERT M. MIURA of the University of British Columbia.

1984 - *DNA sequence analysis,* organized by ROBERT M. MIURA of the University of British Columbia.

1985 - *Plant biology,* organized by ROBERT M. MIURA of the University of British Columbia.

1986 - *Modeling circadian rhythms,* organized by GAIL A. CARPENTER of Northeastern University.

1987 - *Models in population biology,* organized by ALAN HASTINGS of the University of California, Davis.

AMS-SIAM Summer Seminar

1983 - *Large scale computations in fluid mechanics,* organized by RICHARD C. J. SOMERVILLE, Scripps Institution of Oceanography.

1984 - *Nonlinear systems of PDE in applied mathematics,* organized by BASIL NICOLAENKO of Los Alamos National Laboratories.

1985 - *Reacting flows: Combustion and chemical reactors,* organized by G.S.S. LUDFORD of Cornell University.

1988 Symposium In Pure Mathematics

This four-day symposium in pure mathematics usually takes place in even-numbered years, sometimes in conjunction with a spring sectional meeting. Since none is scheduled in 1986, however, the next such symposium is due to be held in the spring of 1987 at a location to be announced. Subject to final approval by the AMS Board of Trustees, the topic selected by the Committee on Summer Institutes and Special Symposia is *The mathematical heritage of Herman Weyl.* Other topics in recent years have been *Relations between combinatorics and other parts of mathematics* (1978); *The mathematical heritage of Henri Poincaré* (1980); *Several complex variables* (1982); and *Pseudodifferential operators and Fourier integral operators with applications to partial differential equations* (1984). Proceedings are published by the Society as volumes in the series *Proceedings of Symposia in Pure Mathematics.*

Deadline For Suggestions: August 15, 1986

1988 AMS Summer Institute

Summer institutes are intended to provide an understandable presentation of the state of the art in an active field of research in pure mathematics, and usually extend over a three-week period. Dates for a summer institute must not overlap those of the Society's summer meeting, which in 1988 is the AMS Centennial Celebration from August 8 - 12, and there should be a period of at least one week between them. Proceedings are published by the Society as volumes in the series *Proceedings of Symposia in Pure Mathematics.*

Deadline For Suggestions: August 15, 1986

1988 AMS-SIAM Summer Seminar

The goal of the summer seminar is to provide an environment and program in applied mathematics in which experts can exchange the latest ideas and newcomers can learn about the field. Proceedings are published by the Society as volumes in the series *Lectures in Applied Mathematics.*

Deadline For Suggestions: August 15, 1986

1988 Joint AMS-IMS-SIAM Summer Research Conferences in the Mathematical Sciences

These conferences are similar in structure to those held at Oberwolfach, and represent diverse areas of mathematical activity, with emphasis on areas currently especially active. Careful attention is paid to subjects in which there is important interdisciplinary activity at present. Topics for the fifth series of one-week conferences, being held in 1986, are *Mathematics in general relativity*, *Large scale data analysis via computer graphics*, *Time reversal of Markov processes and potential theory*, *Artin's braid group*, *Discrete and computational geometry*, and *Representation theory of Lie groups.* If proceedings are published by the Society, they will appear as volumes in the series *Contemporary Mathematics.*

Deadline For Suggestions: February 1, 1987

Call for Topics for 1988 AMS Short Course Series

The AMS Short Courses consist of a series of introductory survey lectures and discussions ordinarily extending over a period of one and one-half days immediately prior to the Joint Mathematics Meetings held in January and August each year. Each of the courses is devoted to a specific area of applied mathematics or to areas of mathematics used in the study of a specific subject or collection of problems in one of the physical, biological, or social sciences. Topics in recent years have been *Approximation Theory* (January 1986), *Actuarial Mathematics* (August 1985), *Fair Allocation* (January 1985), *Environmental and Natural Resource Mathematics* (August 1984), *Mathematics of Information Processing* (January 1984). Proceedings are published by the Society as volumes in the series *Proceedings of Symposia in Applied Mathematics*, with the approval of the Editorial Committee.

Deadline for Suggestions: July 1, 1986 for January 1988 course, and December 1, 1986 for August 1988 course.

Submit suggestions to: Professor Stefan A. Burr, Chairman, AMS Short Course Subcommittee, Department of Computer Sciences, CUNY, City College, New York, New York 10031.

Special Meetings

THIS SECTION contains announcements of meetings of interest to some segment of the mathematical public, including *ad hoc*, local, or regional meetings, and meetings or symposia devoted to specialized topics, as well as announcements of regularly scheduled meetings of national or international mathematical organizations. (Information on meetings of the Society, and on meetings sponsored by the Society, will be found inside the front cover.)

AN ANNOUNCEMENT will be published in *Notices* if it contains a call for papers, and specifies the place, date, subject (when applicable), and the speakers; a second full announcement will be published only if there are changes or necessary additional information. Once an announcement has appeared, the event will be briefly noted in each issue until it has been held and a reference will be given in parentheses to the month, year, and page of the issue in which the complete information appeared.

IN GENERAL, announcements of meetings held in North America carry only date, title of meeting, place of meeting, names of speakers (or sometimes a general statement on the program), deadlines for abstracts or contributed papers, and source of further information. Meetings held outside the North American area may carry more detailed information. In any case, if there is any application deadline with respect to participation in the meeting, this fact should be noted. All communications on special meetings should be sent to the Editor of *Notices*, care of the American Mathematical Society in Providence.

DEADLINES for entries in this section are listed on the inside front cover of each issue. In order to allow participants to arrange their travel plans, organizers of meetings are urged to submit information for these listings early enough to allow them to appear in more than one issue of *Notices* prior to the meeting in question. To achieve this, listings should be received in Providence SIX MONTHS prior to the scheduled date of the meeting.

1985–1986. **Academic Year Devoted to Nonlinear Differential Equations**, Mittag-Leffler Institute, Djursholm, Sweden. (January 1985, p. 89)

1985–1986. **Special Year in Complex Analysis**, University of Maryland, College Park, Maryland. (August 1985, p. 522)

1985–1986. **Special Year in Differential Geometry**, University of Illinois, Urbana-Champaign, Illinois. (October 1985, p. 674)

1985–1986. **Special Year in Operator Theory**, Indiana University, Bloomington, Indiana. (August 1985, p. 522)

1985–1986. **Special Year in Singularities and Algebraic Geometry**, University of North Carolina, Chapel Hill, North Carolina. (June 1985, p. 397, note change in years since previous listings.)

1985–1986. **Year in Mathematical Logic**, University of Notre Dame, Notre Dame, Indiana. (October 1985, p. 674)

August 19, 1985–July 31, 1986. **Program on Stochastic Differential Equations and Their Applications**, University of Minnesota, Minneapolis, Minnesota. (Note date change from June 1985, p. 397)

October 1985–October 1986. **Material Instabilities in Continuum Mechanics**, Heriot-Watt University, Edinburgh, Scotland. (June 1985, p. 397)

1986–1987. **Academic Year Devoted to Algebraic Geometry**, Mittag-Leffler Institute, Djursholm, Sweden. (January 1986, p. 130)

JUNE 1986

1–5. **First Japan Conference on Graph Theory and its Applications**, Tokai University, Hiratsuka, Japan. (October 1985, p. 677)

1–8. **Ninth International Conference on Analytic Functions**, Maria Curie-Skłodowska University, Lublin, Poland. (January 1986, p. 132)

2–4. **The Second Symposium on Computational Geometry**, IBM T. J. Watson Research Center, Yorktown Heights, New York. (October 1985, p. 677)

2–4. **Workshop on Differentiability Properties of Real-Valued Functions**, Université de Montréal, Québec, Canada. (March 1986, p. 366)

2–6. **Greco Calcul Formel**, Marseille, France.

Information: A. Zeller-Meirer, CIRM, Luminy Case 916, Route Léon-Lachamp 70, F-13288 Marseille Cedex 9, France.

2–6. **Mathematical Modeling**, Salisbury State College, Salisbury, Maryland. (January 1986, p. 132)

2–6. **NSF-CBMS Regional Conference on Hierarchical and Empirical Bayes**, Bowling Green State University, Bowling Green, Ohio.

Information: J. H. Albert, Department of Mathematics, Bowling Green State University, Bowling Green, Ohio 43403. (Note change from March 1986, p. 366)

2–6. **NSF-CBMS Regional Conference on Mathematical Modelling in the Energy and Environmental Sciences**, West Virginia University, Morgantown, West Virginia.

Information: C. L. Irwin or I. Christie, Department of Mathematics, West Virginia University, Morgantown, West Virginia 26506. (Note change from March 1986, p. 366)

2–6. **Seventeenth Yugoslav Congress of Theoretical and Applied Mechanics**, Zadar, Yugoslavia. (January 1986, p. 132)

2–11. **Twenty-third Symposium on Functional Equations**, Gargnano, Italy.

Information: C. Pagani, Dipartimento Matematica, Politecnico, 9 via Bonardi, I-20133 Milano, Italy.

2–12. **Eleventh Annual International Conference on Operator Theory**, Bucharest, Romania. (March 1986, p. 366)

3–6. **IMACS International Symposium on Modeling and Simulation of Lumped and Distributed Control**, Lille, France. (January 1986, p. 132)

4–6. **Japan-United States Joint Seminar on Discrete Algorithms and Complexity Theory**, Kyoto, Japan. (March 1986, p. 366)

4–6. **1986 National Educational Computing Conference**, Town and Country Hotel, San Diego, California. (October 1985, p. 677)

5–12. **International Conference on Mathematical Problems from the Physics of Fluids**, Roma, Italy.

Information: G. Benfatto, Dipartimento Matematica, Universita di Tor Vergata, Via O. Raimondo, I-00173 Roma, Italy.

8–12. **Internationaler Workshop: Geometrische und Quantitative Komplexe Analysis**, Wuppertal, Federal Republic of Germany.
Information: Workshop Komplexe Analysis, D. Lindner, FB Mathematik, Univ.-GHS Wuppertal, Gaußstr. 20, D-5600 Wuppertal 1, Federal Republic of Germany.

8–13. **Alpine–United States Seminar on Inverse and Ill-posed Problems**, Saint Wolfgang, Austria. (March 1986, p. 366)

8–14. **International Symposium on Topological and Geometric Methods in Field Theory**, Espoo, Finland.
Information: J. Mickelsson, Res. Inst. theor. Phys., 20-C Siltavuorenpenger, SF-00170 Helsinki, Finland.

9–13. **Discrete Mathematics**, Salisbury State College, Salisbury, Maryland. (January 1986, p. 132)

9–13. **1986 Gordon Research Conference on Theoretical Biology and Biomathematics**, Tilton School, Tilton, New Hampshire. (March 1986, p. 366)

9–14. **Applications Harmoniques**, Marseille, France.
Information: A. Zeller-Meier, CIRM, Luminy Case 916, Route Léon-Lachamp 70, F-13288 Marseille Cedex 9, France.

9–14. **Symposium on Ill-Posed and Inverse Problems**, Lake St. Wolfgang, Austria.
Information: H. Engl, Kepler-Univ., A-4040 Linz, Austria.

9–14. **Workshop on Universal Algebra and Lattice Theory**, Berkeley, California. (March 1986, p. 366)

9–19. **Stochastic Differential Systems with Applications to Control Theory, Electrical/Computer Engineering, and Operations Research**, University of Minnesota, Minneapolis, Minnesota. (June 1985, p. 402)

9–20. **First China-U.S.A. International Conference on Graph Theory and its Applications**, Jinan, Shandong Province, China. (March 1986, p. 366)

9–August 22. **Gordon Research Conferences**, New Hampshire.
Program: Meetings on a variety of topics at various locations in New Hampshire will extend the Frontiers of Science by fostering a free and informal exchange of ideas among persons actively interested in the subject under discussion. For a description of the conferences and for applications to the conferences, see below.
Information: Before June 8: A. Cruickshank, University of Rhode Island, Kingston, Rhode Island 02881-0801, 401-783-4011 or 401-783-3372. After June 8: A. Cruickshank, Director, Gordon Research Conferences, Colby-Sawyer College, New London, New Hampshire 03257, 603-526-2870.

12–14. **Institute of Mathematical Statistics Central Regional Meeting**, Purdue University, West Lafayette, Indiana. (March 1986, p. 366)

12–14. **1986 Annual Summer Meeting of the Canadian Mathematical Society**, Memorial University, Saint John's, Newfoundland. (March 1986, p. 366)

12–16. **Workshop on Analysis**, National University of Singapore, Singapore, Republic of Singapore.
Program: Lectures will be given on Interpolation of Linear Operators on Product Measure Spaces, Singular Integral Operators and Pseudo-Differential Operators, and Probabilistic and Volume Methods in the Geometry of Banach Spaces by S. Igari, A. Miyachi, and G. Pisier respectively.
Information: Organizing Committee, Analysis Workshop, Department of Mathematics, National University of Singapore, Singapore 0511, Republic of Singapore.

15–20. **Fourth International Symposium on Statistical Decision Theory and Related Topics**, Purdue University, West Lafayette, Indiana. (January 1986, p. 133)

15–21. **Function Spaces and Applications**, Lund, Sweden. (March 1986, p. 366)

16–18. **Forefronts '86**, Rensselaer Polytechnic Institute, Troy, New York.
Program: Invited speakers will explore the common infrastructure of computing technology upon which applications of large-scale computation are based.
Information: H. Raveché, Dean of the School of Science, Rensselaer Polytechnic Institute, Troy, New York 12180-3590, 518-266-6305.

16–19. **1986 National Computer Conference**, Las Vegas, Nevada. (March 1986, p. 366)

16–20. **Colloque International du CNRS en L'Honneur de A. Lichnerowicz "Géometrie et Physique"**, Paris, France.
Information: M. Stefan, IRMA, 7 rue René Descartes, F-67084 Strasbourg Cedex, France.

16–20. **Fifteenth International Symposium on Rarefied Gas Dynamics**, Grado, Gorizia, Italy. (October 1985, p. 677)

16–20. **Septième Colloque International "Simulation d'Ecoulements par Elements Finis"**, Antibes, France.
Information: INRIA, Serv. des Relations extérieures, Rocquencourt, B.P. 105, F-78153 Le Chesnay Cedex, France.

16–20. **Tenth United States National Congress of Applied Mathematics**, University of Texas at Austin, Texas. (March 1986, p. 366)

16–20. **The 1986 Johns Hopkins Mathematical Sciences Lecture Series**, The Johns Hopkins University, Baltimore, Maryland. (March 1986, p. 366)

16–21. **Théorie des Nombres**, Marseille, France.
Information: A. Zeller-Meier, CIRM, Luminy Case 916, Route Léon-Lachamp 70, F-13288 Marseille Cedex 9, France.

16–4 July. **Dynamique des Structures**, Centre d'Etudes du Bréau-Sans-Nappe, Ablis, France.
Information: Secretariat des Ecoles d'Eté, Electricité de France, 1, Avenue du Général de Gaulle, 92140 Clamart, France. Telephone: (1) 47 65 36 44.

17–21. **Analysis Conference**, National University of Singapore, Republic of Singapore. (October 1985, p. 677)

18–20. **Colloque sur les Proprietés Structurelles des Systèmes Lineaires Multivariables**, Paris, France.
Information: M. Malabre, LAN ENSM, 1 rue de la Noe, F-44072 Nantes Cedex, France.

19–21. **Second Meeting on the Mathematics of Fuzzy Systems**, Napoli, Italy.
Information: A. Di Nola, Institute Matématiques, Faculté d'Architecture, 3 Via Monteoliveto, I-80134 Napoli, Italy.

20–July 5. **Third Workshop on Nonlinear Evolution Equations and Dynamical Systems**, Baia Verde, Gallipoli, Italy.
Information: M. Boiti, Dip. Fis., Università, via Arnesano, I-73100 Lecce, Italy.

22–29. **Society of Women Engineers 1986 National Convention**, Sheraton Hartford and Parkview Hilton, Hartford, Connecticut. (October 1985, p. 678)

23–27. **NSF-CBMS Regional Conference on Stochastic Processes in the Neuro Sciences**, North Carolina State University, Raleigh, North Carolina.
Information: C. E. Smith, Department of Statistics, North Carolina State University, Raleigh, North Carolina 27695. (Note change from March 1986, p. 367)

23–28. **Colloque International de Théorie des Graphes et Combinatoire**, Luminy, France.
Information: Colloque Théorie des Graphes, ER 175, c/o M. Ulrich, C.A.M.S.-M.S.H., 54 boul. Raspail, F-75270 Paris Cedex 06, France.

23–28. **La Combinatoire**, Marseille, France. (January 1986, p. 133)

24–27. **Seventh International Conference on Analysis and Optimization of Systems**, Antibes, France. (October 1985, p. 678)

25–July 3. **Secondo Corso del CIME: Mathematical Economics**, La Querceta, Montecatini Terme, Italy.
Information: CIME, c/o Ist. Mat. U. Dini, 67-A viale Morgagni, I-50134 Firenze, Italy.

29–July 4. **Ninth Dundee Conference on the Theory of Ordinary Partial Differential Equations**, Dundee, Scotland. (March 1986, p. 367)

30–July 2. **Seventh European Workshop on Applications and Theory of Petri Nets**, Oxford, Great Britain.
Information: G. Cutts, Dept. Comp. Studies, Sheffield City Polyt., Pond Str., GB-Sheffield S1 1WB, England.

30–July 4. **NSF-CBMS Regional Conference on The Formation Space of Algebraic and Geometric Structures**, University of California, Los Angeles, California.
Information: J. J. Millson, Department of Mathematics, University of California, Los Angeles, California 90024. (Note change from March 1986, p. 367)

30–July 4. **Tenth Prague Conference on Information Theory, Statistical Decision Functions and Random Processes**, Institute of Information Theory and Automation of the Czechoslovak Academy of Sciences, Prague, Czechoslovakia. (October 1985, p. 678)

30–July 6. **The First KIT Mathematics Workshop**, Korea Institute of Technology (KIT), Taejon, Korea.
Program: The workshop will consist of series of lectures by invited speakers and one hour special sessions by some of the participants.
Invited Speakers: W. Baily, D. Buchsbaum, T. Ono, K. H. Dovermann, T. Petrie, C. N. Lee, and R. Lashof.
Information: J. K. Koo, Mathematics Workshop, Korea Institute of Technology, 400 Kusong-dong, Chung-gu, Taejon, Korea 300-31.

30–July 12. **Quatrième Ecole d'Eté de Didactique des Mathématiques**, Orléans, France.
Information: R. Douady, IREM Univ. Paris -7, 2 place Jussieu, F-75251 Paris Cedex 05, France.

30–July 26. **Ecole d'Eté du CIMPA: Les Mathématiques Appliquées a la Méchanique**, Monastir, France.
Information: Centre intern. Math. Pures et Appl., 1 av. Edith Cavell, F-06000 Nice, France.

JULY 1986

1–2. **Mathematics in Major Accident Risk Assessment**, Oxford, England. (January 1986, p. 133)

1–3. **Sixteenth Symposium on Fault-Tolerant Computing**, Wien, Austria.
Information: H. Kopetz, Interkonvention Hofburg, P.O. Box 80, A-1107 Wien, Austria.

1–3. **Structural Failure, Product Liability and Technical Insurance**, Vienna, Austria. (January 1986, p. 133)

1–4. **A European Turbulence Conference**, Lyon, France. (January 1986, p. 133)

1–4. **Euromech 212: Nonlinear Waves in Solids**, Toledo, Spain.
Information: E. Alarcon, Univ. Politecn., E.T.S. Ingen. industr., 2 J. Gutierrez Abascal, E-28006 Madrid, Spain.

2–4. **Conference on Differential Equations in Banach Spaces**, Bologna, Italy.
Information: G. Dore, Université de Bologna, 5 Piazza Porta S. Donato, I-40127 Bologna, Italy.

2–12. **LMS Symposium on Non-classical Continuum Mechanics: Abstract Techniques and Applications**, University of Durham, Durham, England. (November 1985, p. 812)

3–5. **Fourth Geometry Symposium at Siegen on Discrete and Combinatorial Geometry**, Universität Siegen, Siegen, Federal Republic of Germany. (March 1986, p. 367)

5–6. **Incontro di Analisi Funzionale**, Firenze, Italy.
Information: C. Franchetti, Ist. Mat. appl., 3 via S. Marta, I-50139 Firenze, Italy.

6–13. **Deuxième Université d'Eté sur l'Histoire des Mathématiques**, Toulouse, France.
Information: M. Guillemot, IREM de Toulouse, Univ. P. Sabatier, 118 route de Narbonne, F-31062 Toulouse Cedex, France.

7–9. **The Fourth IMA Conference on the Mathematical Theory of the Dynamics of Biological Systems**, University of Oxford, Oxford, England. (October 1985, p. 678)

7–9. **The Mathematical Theory of the Dynamics of Biological Systems**, Oxford, England.
Information: The Deputy Secretary, The Institute of Mathematics and its Applications, Maitland House, Warrior Square, Southend-on-Sea, Essex SS1 2JY, England.

7–11. **Nonstandard Analysis and its Applications**, University of Hull, England. (January 1986, p. 133)

7–11. **The Fourth International Conference on Boundary and Interior Layers–Computational and Asymptotic Methods**, Institute of Mathematics, Siberian Branch of the U.S.S.R. Academy of Sciences, Novosibirsk, U.S.S.R. (October 1985, p. 678)

7–12. **Fifth Brazilian Conference on Topology**, Universidade de São Paulo, São Carlos, Brasil.
Information: P.F.S. Porto, Universidade de São Paulo, Caixa Postal 668, 13560 São Carlos, SP-Brasil. Telephone: (0162)71-2238.

7–19. **Abidjan Symposium of Mathematics**, University of Abidjan, Abidjan, Ivory Coast.
Theme: Methods of Group Theory and their Applications.
Program: The morning sessions will be devoted to lecture courses and the afternoon sessions to discussions and presentation of contributed scientific papers by participants.
Information: S. Toure, Institute de Recherches Mathématiques, 08 Post Office Box 2030 Abidjan 08, Ivory Coast.

7–25. **Séminaire de Mathématiques Supérieures-NATO Advanced Study Institute–Variational Methods in Nonlinear Problems**, Université de Montréal, Montréal, Canada. (January 1986, p. 133)

7–25. **Tendances dans les Architectures Normalisées de Réseaux**, Centre d'Etudes du Bréau-Sans-Nappe, Ablis, France.
Information: Secretariat des Ecoles d'Eté, Electricité de France, 1, Avenue du Général de Gaulle, 92140 Clamart, France. Telephone: (1) 47 65 36 44.

8–11. **Practical Bayesian Statistics**, Cambridge, United Kingdom. (March 1986, p. 367)

9–19. **A Workshop on Stochastic Analysis**, Silivri Center, Silivri, Turkey.
Program: First week will be devoted to lectures on Stochastic Partial Differential Equations, Stochastic Calculus of Variations (Malliavin Calculus) and an introductory lecture on Brownian Motion and Diffusions. The second week will be devoted to presentation of contributed papers on topics related to the above subjects and their applications.
Information: H. Korezlioglu, Ecole Normale Supérieure des Télécommunications, 46 rue Barrault, 75634 Paris Cedex 13, France.

14–17. **First International Conference on Numerical Grid Generation in Computational Fluid Dynamics**, Landshut, Federal Republic of Germany.
Information: J. Häuser, Dept. mech. and electr. Eng., College, 32-34 Stetheimerstr., D-8300 Landshut, Federal Republic of Germany.

14–18. **Chaotic Motion in Nonlinear Dynamic Systems**, Udine, Italy.
Information: Segr. CISM, Palazzo del Torso, 18 Piazza Garibaldi, I-33100 Udine, Italy.

14–18. **Introduction to Working Statistics**, Ohio State University, Columbus, Ohio.
Program: This short course presents the basic concepts underlying statistical data analysis including necessary

probability concepts, effective methods of collecting data, and simple descriptive techniques for initial interpretation of data.

Information: L. B. Larew, Ohio State University, Department of Conferences and Institutes, Office of Continuing Education, Fawcett Center for Tomorrow, 2400 Olentangy River Road, Columbus, Ohio 43210, 614-422-8571.

14–18. **NSF-CBMS Regional Conference on Harmonic Analysis and Probability**, Depaul University, Chicago, Illinois.

Information: R. L. Jones, Department of Mathematics, De Paul University, Chicago, Illinois 60614. (Note change from March 1986, p. 367)

14–19. **Logic Colloquium 1986**, University of Hull, Hull, England. (March 1986, p. 367)

14–25. **Partial Differential Equations**, Eighth Latin American School of Mathematics, Instituto de Matemática Pura e Aplicada, Rio de Janeiro, Brazil. (October 1985, p. 678)

14–26. **Oscillation, Bifurcation and Chaos: An International Conference in Differential Equations**, The University of Toronto, Toronto, Canada. (November 1985, p. 812)

15–17. **Symposium on Recent Advances in Simulation of Complex Systems**, Tokyo, Japan. (January 1986, p. 133)

15–19. **Treizième Colloque Automates, Langages et Programmation**, Rennes, France.

Information: E. Lebret, IRISA-INRIA, Campus de Beaulieu, F-35042 Rennes Cedex, France.

16–25. **Eighth International Congress on Mathematical Physics**, Marseille, France. (March 1986, p. 367)

21–25. **Introductory Biostatistics**, Ohio State University, Columbus, Ohio.

Program: This short course provides an introduction to basic concepts and techniques in statistics applied to life sciences.

Information: L. B. Larew, Ohio State University, Department of Conferences and Institutes, Office of Continuing Education, Fawcett Center for Tomorrow, 2400 Olentangy River Road, Columbus, Ohio 43210, 614-422-8571.

21–25. **Ninth Escola de Algebra**, University of Brasilia, Brasilia, Brasil. (March 1986, p. 367)

21–25. **Third International Conference on Logic Programming**, London, England.

Information: K. Clark, Imp. Coll. of Sc. and Techn., London, England.

21–26. **International Congress on Computational and Applied Mathematics**, University of Leuven, Belgium. (October 1985, p. 678)

21–31. **Workshop on Functional Integration with Emphasis on the Feynman Integral**, Université de Sherbrooke, Sherbrooke, Québec, Canada.

Program: Two expository lectures of six hours each, ten lectures of one hour, and contributed papers of thirty minutes. The proceedings should appear in a special issue of the Rendiconti del Circola Matematico di Palermo.

Information: P. Morales and J. Dubois, Département de Mathématiques et d'Informatique, Université de Sherbrooke, Sherbrooke, Québec, Canada J1K 2R1. Telephone: 819-821-7035 and 819-821-7032 respectively.

22–26. **Conference on Constructive Function Theory**, University of Alberta, Edmonton, Alberta, Canada. (August 1985, p. 525)

23–31. **1986 Corvallis Conference: Quadratic Forms and Real Algebraic Geometry**, LeSell Stuart Center, Oregon State University, Corvallis, Oregon. (November 1985, p. 812)

26–31. **Fourteenth Canadian Symposium on Operators and Operator Algebras**, University of Victoria, Victoria, British Columbia. (March 1986, p. 367)

27–30. **Tenth Summer Symposium on Real Analysis**, University of British Columbia, Vancouver, British Columbia, Canada. (November 1985, p. 812)

27–August 1. **International Conference on Algebraic Topology**, Humboldt State University, Arcata, California. (March 1986, p. 367)

27–August 1. **Thirteenth International Biometric Conference**, Seattle, Washington. (June 1985, p. 402)

27–August 2. **Eugene Strens Memorial Conference on Intuitive and Recreational Mathematics and its History**, The University of Calgary, Calgary, Alberta, Canada. (March 1986, p. 367)

28–August 1. **Applied Discrete Data Analysis**, Ohio State University, Columbus, Ohio.

Program: This short course introduces various statistical methods for analyzing data organized in tables of count.

Information: L. B. Larew, Ohio State University, Department of Conferences and Institutes, Office of Continuing Education, Fawcett Center for Tomorrow, 2400 Olentangy River Road, Columbus, Ohio 43210, 614-422-8571.

28–August 1. **NSF-CBMS Regional Conference on Probabilistic Methods in Combinatorics**, Fort Lewis College, Durango, Colorado.

Information: R. A. Gibbs, Department of Mathematics, Fort Lewis College, Durango, Colorado 81301. (Note change from March 1986, p. 368)

28–August 1. **Conference on Singularities**, University of Iowa, Iowa City, Iowa. (January 1986, p. 133)

28–August 1. **International Conference on Harmonic Measure and Potential Theory in Euclidean Spaces**, University of Toledo, Toledo, Ohio. (March 1986, p. 368)

28–August 1. **Operator Algebras Conference**, University of California at Santa Barbara, Santa Barbara, California. (March 1986, p. 368)

28–August 1. **The Seventh International Conference on Nonlinear Analysis and Applications**, The University of Texas, Arlington, Texas. (October 1985, p. 678)

28–August 2. **Extremal Families of Sets, Designs and Finite Geometries**, Université de Montréal, Québec, Canada. (March 1986, p. 368)

29–August 1. **Conference on Continuous Time, Fractional and Multiobjective Programming**, St. Lawrence University, Canton, New York. (November 1985, p. 813)

30–August 1. **Computers and Mathematics**, Stanford University, Stanford, California. (March 1986, p. 368)

30–August 1. **Conference on Universal Algebra and Lattice Theory**, National Institutes of Health, Bethesda, Maryland. (October 1985, p. 678)

30–August 2. **Computers in Mathematics**, Stanford University, Palo Alto, California. (November 1985, p. 813)

AUGUST 1986

2. **United States Commission on Mathematical Instruction Pre-Congress Series of Invited Survey Talks**, New York City Technical College, Brooklyn, New York. (March 1986, p. 368)

3–11. **International Congress of Mathematicians**, Berkeley, California. (February 1984, p. 159)

4–8. **Workshop on Micromechanical Aspects of Creep Fracture in Metals and Polymers**, Mathematical Sciences Institute, Cornell University, Ithaca, New York.

Information: Program Coordinator (Hui or Phoenix), Mathematical Sciences Institute, Cornell University, Caldwell Hall, Ithaca, New York 14853.

6–9. **First IMACS Symposium on Computational Acoustics**, Yale University, New Haven, Connecticut. (January 1986, p. 134)

11–16. **Second International Conference on Teaching Statistics**, University of Victoria, Victoria, British Columbia, Canada. (January 1985, p. 93)

12–14. **SIAM Conference on Linear Algebra in Signals, Systems and Control**, Park Plaza Hotel, Boston, Massachusetts. (March 1986, p. 368)

12–16. **Structure, Coherence and Chaos in Dynamical Systems**, The Technical University of Denmark, Lyngby, Denmark. (March 1986, p. 368)

13–16. **Second International Conference on Fibonacci Numbers and their Applications**, San Jose State University, San Jose, California.

Program: Talks on branches of mathematics and science related to the Fibonacci numbers and their generalizations will be given.

Information: C. Long, Department of Mathematics, Washington State University, Pullman, Washington 99163 or G. Bergum, The Fibonacci Quarterly, Department of Mathematics, South Dakota State University, Post Office Box 2220, Brookings, South Dakota 57007-1297.

13–29. **Workshop on Jordan Structures**, University of Ottawa, Ottawa, Ontario, Canada.

Program: Informal lectures and discussion sessions.

Information: E. Neher or M. Racine, Department of Mathematics, University of Ottawa, Ottawa, Ontario K1N 9B4, Canada.

18–22. **Bifurcation, Analysis Algorithms Applications**, Universität Dortmund, Dortmund, Federal Republic of Germany. (October 1985, p. 679)

18–29. **Opening Workshop on Basic Methods of Numerical Analysis and Introduction to State of the Art Research**, University of Minnesota, Minneapolis, Minnesota. (March 1986, p. 368)

19–24. **Third International Conference on Applied Systems Research, Information, and Cybernetics and International Symposium on Mathematics and Logic**, Baden-Baden, Federal Republic of Germany. (March 1986, p. 369)

20–September 6. **Seizième Ecole d'Eté de Calcul des Probabilités**, Saint-Flour, France.

Information: P. L. Henniquin, B.P. 45, F-63170 Aubière, France.

23–25. **Optimisation and Simulation of Large Scale Systems**, Reading, United Kingdom. (January 1986, p. 134)

23–26. **International Symposium on Probability and Bayesian Statistics**, Innsbruck, Austria. (January 1986, p. 134)

25–29. **Congrès Franco Chilien de Mathématiques Appliquées**, Santiago, Chile.

Information: C. Carasso, Faculty of Sciences, 23 rue du Docteur Paul Michelon, 42023 Saint-Etienne cedex 2, France or R. Correa, Universidad de Chile, Departamento Matématicàs, Casilla 170 Correo 3, Santiago, Chile.

25–29. **Sixth Prague Topological Symposium**, Prague, Czechoslovakia. (June 1985, p. 402)

25–30. **Analyse Harmonique**, Marseille, France. (March 1986, p. 369)

25–September 13. **Microprogram on Nonlinear Diffusion Equations and their Equilibrium States**, Mathematical Sciences Research Institute, Berkeley, California. (October 1985, p. 679)

25–September 20. **Ecole d'Automne 1986 du CIMPA: "L'Analyse Fonctionelle et Applications"**, Nice, France.

Information: CIMPA, 1 av. Edith Cavell, F-06000 Nice, France.

31–September 6. **International Meeting on Ring Theory**, Grenada, Spain.

Information: B. Torrecillas, dept. de Algebra y Fundamentos, Fac. de Ciencias, Univ. de Grenada, E-18071 Grenada, Spain.

SEPTEMBER 1986

1–3. **Elft Symposium über Operations Research**, Darmstadt, Federal Republic of Germany.

Information: Elft SOR, FB Mathematik, TH Darmstadt, Schloßgartenstr. 7, D-6100 Darmstadt, Federal Republic of Germany.

1–5. **Analyse Harmonique**, Marseille, France.

Information: A. Zeller-Meier, CIRM, Luminy Case 916, Route Léon-Lachamp 70, F-13288 Marseille Cedex 9, France.

1–5. **COMPSTAT 1986 Seventh Symposium on Computational Statistics**, Universita "La Sapienza," Rome, Italy. (March 1986, p. 369)

1–5. **Représentations des Groupes et Analyse Complexe (Journées S.M.F.)**, Marseille, France.

Information: P. Torasso et M. Rais, Dept. de Mathématiques, Univ. de Poitiers, 40 av. du Recteur Pineau, F-86022 Poitiers Cedex, France.

1–5. **Tenth World Computer Congress**, Trinity College, Dublin, Ireland. (March 1986, p. 369)

1–5. **Theorie des Nombres**, Marseille, France. (March 1986, p. 369)

2–3. **Mathematical Modelling of Non-Destructive Evaluation**, Cambridge, Great Britain.

Information: The Secretary and Registrar, IMA, Maitland House, Warrior Square, Southend-on-Sea, GB- Essex SS1 2JY, England.

3–5. **Symposium on Control Theory**, Somerville College, University of Oxford, Oxford, England. (March 1986, p. 369)

3–6. **Workshop on Sign-Pattern Analysis of Linear and Nonlinear Systems**, Université de Montréal, Québec, Canada. (March 1986, p. 369)

4–7. **Polish Symposium on Interval and Fuzzy Mathematics**, Technical University of Poznań, Poznań, Poland. (October 1985, p. 679)

7–9. **The Mathematics of Surfaces**, University College, Cardiff, United Kingdom. (January 1986, p. 134)

8–13. **Algebra-Tagung Halle 1986**, Martin Luther Universität, German Democratic Republic. (October 1985, p. 679)

8–14. **First World Congress of the Bernoulli Society for Mathematical Statistics and Probability**, Tashkent, U.S.S.R. (October 1985, p. 679)

11–13. **Spinors in Physics and Geometry**, International Centre for Theoretical Physics, Trieste, Italy.

Information: J. Eells, International Centre for Theoretical Physics, Post Office Box 586, Miramare, Strada Costiera 11, 34100 Trieste, Italy. Telephone: 2240-1.

12–17. **International Conference on Graphs, Steiner Systems and their Applications**, Santa Tecla, Catania, Italy.

Program: The program will consist of invited lectures and contributed papers (talks). Topics include graph theory, block-designs theory, their applications.

Information: Professor M. Gionfriddo, Dipartimento di Matematica, Università, viale A. Doria numero 6, 95125 Catania, Italy.

14–20. **Nonlinear Random Vibration**, Oberwolfach, Federal Republic of Germany.

Information: M. Barner, Institutsdirektor, Geschaftsstelle, Alberstrasse 24, D-7800 Freiburg, Federal Republic of Germany.

14–20. **Sechst Pannonisches Symposium über Mathematische Statistik**, Bad Tatzmannsdorf, Austria.

Information: W. Wertz, Inst. für Statistik u. Wahrscheinlichkeitsth., TU Wien, Wiedner Hauptstr. 8–10, A-1040 Wien, Austria.

15–19. **International Conference on Stochastic Programming**, Charles University, Prague, Czechoslovakia.
Topics: Stochastic programming including related parts of mathematical statistics, probability theory and mathematical programming; applications of stochastic programs and experience with their numerical solution.
Information: T. Cipra, Department of Statistics, Charles University, Sokolovská 83, 186 00 Prague, Czechoslovakia.

15–19. **Workshop on Global Differential Geometry**, International Centre for Theoretical Physics, Trieste, Italy.
Information: J. Eells, International Centre for Theoretical Physics, Post Office Box 586, Miramare, Strada Costiera 11, 34100 Trieste, Italy. Telephone: 2240-1.

15–20. **Journées de Probability**, Marseille, France.
Information: A. Zeller Meier, CIRM, Luminy Case 916, Route Léon-Lachamp 70, F-13288 Marseille Cedex 9, France.

15–26. **Workshop on Computational Fluid Dynamics and Reacting Gas Flows**, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, Minnesota. (March 1986, p. 369)

17–19. **The Impact of Mathematical Analysis on the Solution of Engineering Problems**, University of Maryland, College Park, Maryland. (March 1986, p. 369)

18–19. **Second Catalan International Symposium on Statistics**, Barcelona, Spain.
Information: Secr. Symp. Cons. Inform., 1 Doc. de Catalunya, 187 Urgell, E-08036 Barcelona, Spain.

21–October 4. **Mathematics and Computer Science in Medical Imaging**, Il Ciocco, Italy.
Information: M. A. Viergever, Delft Univ. of Techn., Dept. of Mathematics & Informatics, P.O. Box 356, NL-2600 AJ Delft, Netherlands.

22-26. **Euromech 216: Integrable Systems in Nonlinear Analytical Mechanics**, Leeds, England.
Information: A. P. Fordy, Centre for nonlinear studies, Univ. of Leeds, GB- Leeds L52 9JT, England.

22–26. **IFAC-IMACS Symposium on Simulation of Control Systems**, Vienna, Austria. (January 1986, p. 134)

22–26. **Théorie Analytique des Nombres**, Luminy, France.
Information: A. Zeller-Meier, CIRM, Luminy Case 916, Route Léon-Lachamp 70, F-13288 Marseille Cedex 9, France.

22–27. **Orthogonal Polynomials and Their Applications**, Segovia, Spain. (November 1985, p. 813)

23–25. **Optimisation and Simulation of Large Scale Systems**, University of Reading, Reading, Berkshire, United Kingdom. (January 1986, p. 134)

23–26. **International Symposium on Probability and Bayesian Statistics**, Innsbruck, Austria.
Information: Prof. R. Viertl, Inst. für Statistik und Wahrscheinlichkeitsth., TU Wien, A-1040 Wien, Austria.

26–28. **Congress on Variational Methods in Differential Problems**, Trieste, Italy.
Information: E. Mitidieri, Ist. Mat., Univ., 1 piazzale Europa, I-34127 Trieste, Italy.

29–30. **Computers in Mathematical Research**, University College, Cardiff, United Kingdom. (January 1986, p. 134)

29–October 1. **Fifth Meeting on Mathematical Physics**, University of Coimbra, Coimbra, Portugal.
Topics: Differential geometry, variational methods, differential equations in mathematical physics, analytic mechanics, and field theories.
Call for Summaries: Those interested in contributing a short talk should submit a summary to the Organizing Committee by June 30, 1986. Send summary to the address below.
Information: Grupo de Física-Matemática, Departamento de Matemática, Apartado 3008, 3000 Coimbra, Portugal.

29–October 2. **Wirtschaftsmathematik in Beruf und Ausbildung**, Klagenfurt, Austria.
Information: Fünft Kärtner Symposium für Didaktik der Mathematik, Inst. für Mathematik, Univ. für Bildungswiss., Universitätsstr. 65–67, A-9022 Klagenfurt, Austria.

OCTOBER 1986

1–4. **Concurrence Imparfaite et Modeles de Marche**, Luminy, France.
Information: A. Zeller-Meier, CIRM, Luminy Case 916, Route Léon-Lachamp 70, F-13288 Marseille Cedex 9, France.

3–4. **The Fourteenth Annual Mathematics and Statistics Conference**, Miami University, Oxford, Ohio.
Theme: Discrete Mathematics.
Speakers: R. Graham, A. Tucker, and H. Wilf.
Information: G. Gilbert, Department of Mathematics and Statistics, Miami University, Oxford, Ohio 45056, 513-529-5818.

5–9. **International Symposium on Information Theory**, University of Michigan, Ann Arbor, Michigan. (March 1986, p. 363)

9–11. **Interdisciplinary Conference on Inference**, Ohio University, Athens, Ohio.
Program: The program will include tutorials and contributed papers. The topics should deal with inference, as it applies to computer science, linguistics, mathematics, philosophy, and psychology.
Information: M. Swardson, Department of Mathematics, Ohio University, Athens, Ohio 45701, 614-594-6603.

13–November 29. **Topology and Number Theory**, Université de Montréal, Québec, Canada. (March 1986, p. 369)

15–18. **Convegno su Ipergruppi, Altre Strutture Multivoche e Applicazioni**, Udine, Italy.
Information: P. L. Corsini, Ist. Mat., 3 via Mantrice, I-33100 Udine, Italy.

17–18. **Fifteenth Annual Midwest Diffferential Equations Conference**, Marquette University, Milwaukee, Wisconsin. (March 1986, p. 369)

20–24. **Les Sondages**, Marseille, France.
Information: A. Zeller Meier, CIRM, Luminy Case 916, Route Léon-Lachamp 70, F-13288 Marseille Cedex 9, France.

24–25. **Second Eastern Small College Computing Conference**, University of Scranton and the Hilton at Lackawanna Station, Scranton, Pennsylvania. (March 1986, p. 369)

24–25. **The Sixth Southeastern-Atlantic Regional Conference on Differential Equations**, Clemson University, Clemson, South Carolina.
Program: Lectures will be given by J. Burns, G. Fix, and J. Herod. In addition, there will be sessions for twenty minute contributed talks.
Information: T. Proctor, Mathematical Sciences Department, Clemson University, Clemson, South Carolina 29634-1907, 803-656-3434.

NOVEMBER 1986

2–6. **Fall Joint Computer Conference**, Dallas, Texas. (March 1986, p. 370)

3–7. **Workshop on Numerical Algorithms for Modern Parallel Computer Architectures**, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, Minnesota. (March 1986, p. 370)

9–15. **Austrian Symposium on History of Mathematics**, Neuhofen an der Ybbs, Austria.
Topics: "Mathematics–stimulated or stimulating? and "On the interaction between 'pure' and 'applied' mathematics through the ages."
Information: Ch. Binder, Inst. für techn. Mathematik, Technische Universität Wien, Wiedner Hauptstrasse 6-10, A-1040 Wien, Austria.

10–15. **Workshop on Artin L-functions and Related Topics**, Université de Montréal, Québec, Canada. (March 1986, p. 370)

10–28. **Workshop on Representation Theory of Lie Groups**, International Centre for Theoretical Physics, Trieste, Italy.
Information: J. Eells, International Centre for Theoretical Physics, Post Office Box 586, Miramare, Strada Costiera 11, 34100 Trieste, Italy. Telephone: 2240-1.

18–22. **Didactique des Mathématiques**, Marseille, France.
Information: A. Zeller Meier, CIRM, Luminy Case 916, Route Léon-Lachamp 70, F-13288 Marseille Cedex 9, France.

24–28. **Géométrie Symplectique**, Marseille, France.
Information: A. Zeller Meier, CIRM, Luminy Case 916, Route Léon-Lachamp 70, F-13288 Marseille Cedex 9, France.

DECEMBER 1986

3–5. **Forty Second Annual Conference on Applied Statistics**, Atlantic City, New Jersey. (March 1986, p. 370)

3–6. **Theory of Robots Symposium**, Vienna, Austria. (January 1986, p. 134)

15–17. **Cryptography and Coding**, Cirencester, Glos., England.
Information: The Secretary and Registrar, IMA, Maitland House, Warrior Square, Southend-on-Sea, GB- Essex SS1 2JY, England.

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JANUARY 1987

January–May. **Nonlinear PDE's**, Brigham Young University, Provo, Utah.
Program: During the winter semester N. Alikakos, G. Caginalp, and P. Fife will lead seminars in topics related to continuum models of phase transistion, singular perturbations and reaction–diffusion equations.
Information: P. Bates, Department of Mathematics, Brigham Young University, Provo, Utah 84602.

FEBRUARY 1987

13–18. **Annual Meeting, American Association for the Advancement of Science**, Chicago, Illinois. (March 1986, p. 370)

MARCH 1987

22–25. **Institute of Mathematical Statistics Central Regional Meeting**, Dallas, Texas. (March 1986, p. 370)

23–30. **NSF-CBMS Conference on Mathematical Statistics**, Ohio State University.
Information: S. Leurgans, Department of Mathematics, Ohio State University, Columbus, Ohio 43210.

MAY 1987

25–29. **The Ninth International Symposium on Noise in Physical Systems**, Université de Montréal, Québec, Canadà. (March 1986, p. 370)

JUNE 1987

8–19. **Singapore Group Conference Theory**, National University of Singapore, Republic of Singapore. (March 1986, p. 370)

15–July 3. **Microprogram on Commutative Algebra**, Mathematical Sciences Research Institute, Berkeley, California. (October 1985, p. 679)

23–26. **Sixth IMACS International Symposium on Computer Methods for PDE's**, Lehigh University, Bethlehem, Pennsylvania. (January 1986, p. 134)

23–27. **International Conference on Generalized Functions, Convergence Structures and Their Applications**, Dubrovnik, Yugoslavia.
Information: Inst. of Math., GFCA-87, Dr Ilije Djuričića 4, YU-21000 Novi Sad, Yugoslavia.

29–July 4. **Joint IMA-GAMM-SIAM-SMAI Conference on First Joint International Conference on Industrial and Applied Mathematics**, Paris, France. (January 1986, p. 134)

JULY 1987

13–17. **Fourteenth International Colloquium on Automata, Languages, and Programming**, University of Karlsruhe, Federal Republic of Germany. (March 1986, p. 370)

19–24. **Conference on Potential Theory**, Charles University, Prague, Czechoslovakia.
Program: One-half and one hour lectures will be given on various aspects of potential theory including the applications of potential theory in other areas.
Information: Potential Theory, Faculty of Mathematics and Physics, Charles University, Sokolovská 83, 186 00 Praha 8, Czechoslovakia.

AUGUST 1987

9–15. **International Conference on Abelian Groups**, Perth, Western Australia.
Information: P. Schultz, Department of Mathematics, University of Western Australia, Nedlands, Western Australia 6009, Australia. Telephone: 380 3838.

17–20. **International Conference on Rings, Modules, and Radicals**, Hobart, Tasmania.
Information: B. Gardner, Mathematics Department, University of Tasmania, General Post Office Box 252C, Hobart, Tasmania 7001, Australia.

24–28. **Conference on Differential Equations "Equadiff '87"**, Democritus University of Thrace, Greece. (January 1986, p. 134)

24–28. **International Conference on Web Geometry and Related Fields**, Szeged University, Szeged, Hungary.
Organizing Committee: S. S. Chern (Honorary Chairman), M. A. Akivis, V. V. Goldberg, P. Nagy, K. Strambach.
Information: P. Nagy, Bolyai Institute, Szeged University, Aradi Vértanúk tere 1, H-6720 Szeged, Hungary.

24–28. **Second International Conference on Combinatorial Mathematics and Computing**, Canberra, Australia. (March 1986, p. 370)

24–28. **Sixth National Conference on Artificial Intelligence**, Seattle, Washington. (March 1986, p. 370)

SEPTEMBER 1987

9–12. **Internationale Konferenz über Anwendungen und Modellbildung im Mathematikunterricht**, Kassel, Federal Republic of Germany.
Information: W. Blum, Univ. GHS Kassel, FB Mathematik, Heinrich-Plett-Str. 40, D-3500 Kassel, Federal Republic of Germany.

13–19. **Journées Arithmétiques 1987**, Ulm, Federal Republic of Germany.
Information: E. Wirsing, Univ. Ulm, Abt. Mathematik II, Postfach 4066, D-7900 Ulm, Federal Republic of Germany.

20–26. **DMV-Jahrestagung 1987**, Berlin, Federal Republic of Germany.
Information: D. Sauer, DMV, Albertstr. 24, D-7800 Freiburg, Federal Republic of Germany.

NEW AMS PUBLICATIONS

PARTIALLY ORDERED ABELIAN GROUPS WITH INTERPOLATION

K. R. Goodearl

(Mathematical Surveys and Monographs, Volume 20)

In the past decade a new branch of ordered algebraic structures has grown, motivated by K-theoretic applications and mainly concerned with partially ordered abelian groups satisfying the Riesz interpolation property. This monograph is the first source in which the algebraic and analytic aspects of these interpolation groups have been integrated into a coherent framework for general reference. The author provides a solid foundation in the structure theory of interpolation groups and dimension groups (directed unperforated interpolation groups), with applications to ordered K-theory particularly in mind.

Although interpolation groups are defined as purely algebraic structures, their development has been strongly influenced by functional analysis. This cross-cultural development has left interpolation groups somewhat estranged from both the algebraists, who may feel intimidated by compact convex sets, and the functional analysts, who may feel handicapped by the lack of scalars. This book, requiring only standard first-year graduate courses in algebra and functional analysis, aims to make the subject accessible to readers from both disciplines.

High points of the development include the following: characterization of dimension groups as direct limits of finite products of copies of the integers; the double-dual representation of an interpolation group with order-unit via affine continuous real-valued functions on its state space; the structure of dimension groups complete with respect to the order-unit norm, as well as monotone sigma-complete dimension groups and dimension groups with countably infinite interpolation; and an introduction to the problem of classifying extensions of one dimension group by another. The book also includes a development of portions of the theory of compact convex sets and Choquet simplices, and an expository discussion of various applications of interpolation group theory to rings and C^*-algebras via ordered K_0. A discussion of some open problems in interpolation groups and dimension groups concludes the book.

Of interest, of course, to researchers in ordered algebraic structures, the book will also be a valuable source for researchers seeking a background in interpolation groups and dimension groups for applications to such subjects as rings, operator algebras, topological Markov chains, positive polynomials, compact group actions, or other areas where ordered Grothendieck groups might be useful.

1980 *Mathematics Subject Classifications*: 06F20, 46A55, 19K14, 19A49, 16A30 16A54, 46L05, 46L80
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To order, please specify SURV/20N

GROUP RINGS, CROSSED PRODUCTS AND GALOIS THEORY

Donald S. Passman

(CBMS Regional Conference Series, Number 64 Supported by the National Science Foundation)

For readers with a basic graduate level background in algebra, these ten articles provide a readable introduction to three major interrelated subjects of noncommutative algebra. The theme is the interplay between group theory and ring theory, dealing specifically with group rings, crossed products, and the Galois theory of rings. The author has carefully included most definitions, to keep the required background minimal. Furthermore, each article contains a selection of results on the given topic, a limited number of proofs or sketches, and at least a few open problems.

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(continued)

1980 *Mathematics Subject Classifications*:
16A27, 16A74
ISBN 0-8218-0714-5, LC 86-1177
ISSN 0160-7642
80 pages (softcover), due May 1986
All individuals $7, List price $12
To order, please specify CBMS/64N

NEW CONSTRUCTIONS OF FUNCTIONS HOLOMORPHIC IN THE UNIT BALL OF C^n

Walter Rudin

(CBMS Regional Conference Series, Number 63 Supported by the National Science Foundation)

The starting point for the research presented in this book is A. B. Aleksandrov's proof that nonconstant inner functions exist in the unit ball B of C^n. The construction of such functions has been simplified by using certain homogeneous polynomials discovered by Ryll and Wojtaszczyk; this yields solutions to a large number of problems.

The author has organized the lectures, presented at a CBMS Regional Conference held at Michigan State University in June 1985, into a body of results discovered in the preceding four years in this field, simplifying some of the proofs and generalizing some results. The book also contains results that were obtained by Monique Hakina, Nessim Sibony, Erik Løw and Paula Russo. Some of these, surprisingly, are new even in one variable.

An appreciation of techniques not previously used in the context of several complex variables will reward the reader who is reasonably familiar with holomorphic functions of one complex variable and with some functional analysis.

Contents

1980 *Mathematics Subject Classifications*:
32A07, 32A35, 32A40, 32H99
ISBN 0-8218-0713-7, LC 86-1205
ISSN 0160-7642
96 pages (softcover), due May 1986
All individuals $8, List price $13
To order, please specify CBMS/63N

EXTREMAL GRAPH THEORY WITH EMPHASIS ON PROBABILISTIC METHODS

Béla Bollobás

(CBMS Regional Conference Series, Number 62 Supported by the National Science Foundation)

Problems in extremal graph theory have traditionally been tackled by ingenious methods which made use of the structure of extremal graphs. In this book, an update of his 1978 book *Extremal Graph Theory*, the author focuses on the more recent trend towards probabilistic methods. He demonstrates both the direct use of probability theory and, more importantly, the fruitful adoption of a probabilistic frame of mind when tackling main line extremal problems.

Essentially self-contained, the book does not merely catalog results, but rather includes considerable discussion on a few of the deeper results. The author addresses pure mathematicians, especially combinatorialists and graduate students taking graph theory, as well as theoretical computer scientists. He assumes a mature familiarity with combinatorial methods and an acquaintance with basic graph theory. The book is based on the NSF-CBMS Regional Conference on Graph Theory held at Emory University in June, 1984.

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The size Ramsey number of a path
Weakly saturated graphs
List colourings

1980 *Mathematics Subject Classifications*:
05C35, 05C25, 05C10, 05C40, 05C65, 60C05
ISBN 0-8218-0712-9, LC 85-30670
ISSN 0160-7642
72 pages (softcover), due May 1986
All individuals $7, List price $12
To order, please specify CBMS/62N

DIFFERENTIAL ANALYSIS IN INFINITE DIMENSIONAL SPACES

Kondagunta Sundaresan and Srinivasa Swaminathan, Editors
(Contemporary Mathematics, Volume 54)

This volume focuses on developments made in the past two decades in the field of differential analysis in infinite dimensional spaces. New techniques such as ultraproducts and ultrapowers have illuminated the relationship between the geometric properties of Banach spaces and the existence of differentiable functions on the spaces. The wide range of topics covered also includes gauge theories, polar subsets, approximation theory, group analysis of partial differential equations, inequalities, and actions on infinite groups.

Addressed to both the expert and the advanced graduate student, the book requires a basic knowledge of functional analysis and differential topology.

Contents

1980 *Mathematics Subject Classifications*:
58B10, 58C25, 46E15, 41A65
ISBN 0-8218-5059-8, LC 86-3510
ISSN 0271-4132
136 pages (softcover), due June 1986
Individual member $11, List price $18,
Institutional member $14
To order, please specify CONM/54N

THE SELBERG TRACE FORMULA AND RELATED TOPICS

Dennis A. Hejhal, Peter Sarnak, and Audrey Anne Terras, Editors
(Contemporary Mathematics, Volume 53)

This volume provides both a good introduction to current work and a collection of survey articles on the Selberg trace formula and its applications. As the proceedings of a joint AMS-IMS-SIAM Summer Research Conference, these twenty papers represent a diverse set of attitudes toward the trace formula, including those from mathematical physics, classical analytic and modern adelic number theory, modern geometric representations, and classical harmonic analysis.

The background required varies considerably from introductory papers to those requiring familiarity with representation theory, the theory of automorphic forms, and number theory.

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(continued)

David Fried, *Fuschian groups and Reidemeister torsion*
Paul B. Garrett, *Theta-correspondences on unitary groups*
Paul Gérardin and Wen-Ch' ing Winnie Li, *Establishing correspondences without the trace formula*
George T. Gilbert, *Multiplicity theorems for* GL(2) *and* GL(3)
A. Good, *The convolution method for Dirichlet series*
Martin C. Gutzwiller, *Physics and Selberg's trace formula*
Ki-ichiro Hashimoto, *Representations of the finite symplectic group* $SP(4, F_p)$ *in the spaces of Siegel modular forms*
Dennis A. Hejhal, *Roots of quadratic congruences and eigenvalues of the non-Euclidean Laplacian*
M. N. Huxley, *Exceptional eigenvalues and congruence subgroups*
Hervé Jacquet, *An introduction to the trace formula from the adelic point of view*
N. Mandouvalos, *The theory of Eisenstein series for Kleinian groups*
M. Scott Osborne, *The continuous spectrum: some explicit formulas*
M. Scott Osborne, *Selberg's trace formula and a character identity for generalized Heinsenberg groups*
J. D. Rogawski, *Some remarks on Shalika germs*
Peter Sarnak, *On cusp forms*
Audrey A. Terras, *Some simple aspects of the theory of automorphic forms for* $GL(n, \mathbb{Z})$
V. S. Varadarajan, *The eigenvalue problem on negatively curved compact locally symmetric manifolds*
Marie-France Vignéras, *Correspondances entre representations automorphes de* GL(2) *sur une extension quadratique de* GSp(4) *sur D, conjecture locale de Langlands pour* GSp(4)
Garth Warner, *Traceability on the discrete spectrum*
Rainer Weissauer, *Stable modular forms*
Floyd L. Williams, *Finite spaces of non-classical Poincaré theta series*

1980 *Mathematics Subject Classifications*: 10D20, 10D24, 10D40, 12A85, 22E40, 22E45, 22E50, 22E55, 30F35, 30M10, 30N10
ISBN 0-8218-5058-x, LC 86-3512
ISSN 0271-4132
568 pages (softcover), due June 1986
Individual member $25, List price $42, Institutional member $34
To order, please specify CONM/53N

THE B-CONJECTURE: CHARACTERIZATION OF CHEVALLEY GROUPS

John H. Walter
(Memoirs of the AMS, Number 345)

This memoir provides a well-organized and efficient approach to proving the B-conjecture, a theorem which is an essential step in the classification of finite simple groups. This conjecture asserts that the 2-components of the centralizer of an involution in a finite simple group are quasisimple, and is proven using the signalizer functor method.

The first part of this publication contains many interesting theorems on the characterization of group, which are needed for the proof of the principal result in Part II.

The memoir is aimed at specialists in the theory of finite simple groups. It presumes a thorough knowledge in the arguments and principal results of classification theory.

Contents

1980 *Mathematics Subject Classification*: 20D05
ISBN 0-8218-2345-0, LC 86-3388
ISSN 0065-9266
204 pages (softcover), 1986
Individual member $11, List price $19, Institutional member $15
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Use the order form in the back of this issue or call 800-556-7774 to use VISA or MasterCard.
Shipping and handling charges will be added.

HOMEOMORPHISMS OF 3-MANIFOLDS WITH COMPRESSIBLE BOUNDARY

Darryl McCullough and Andy Miller

(Memoirs of the AMS, Number 344)

This memoir studies the group $G(M)$ of isotopy classes of self-homeomorphisms for a $\mathbb{P}^2$-irreducible 3-manifold M with compressible boundary. When M is orientable, $G(M)$ is proved to be finitely generated, and the subgroup $J(M)$ generated by Dehn twists about discs, annuli, and tori is shown to have finite index. Moreover, any orientation-preserving self-homeomorphism inducing the identity on $\pi_1(M)$ is proved to be isotopic to a product of Dehn twists about properly imbedded 2-discs. When M is nonorientable, the authors develop a different set of techniques to obtain appropriate extensions of these results.

Aimed at mathematicians and graduate students with an interest in geometric topology, especially the topology of 3-manifolds, this memoir requires a knowledge of the basic "classical" techniques of 3-manifold topology.

Contents

1980 *Mathematics Subject Classifications*: 57M99, 57R50, 55P10, 55S37
ISBN 0-8218-2346-9, LC 86-3387
ISSN 0065-9266
116 pages (softcover), April 1986
Individual member $8, List price $14, Institutional member $11
To order, please specify MEMO/344N

OVERGROUPS OF SYLOW SUBGROUPS IN SPORADIC GROUPS

Michael Aschbacher

(Memoirs of the AMS, Number 343)

This memoir systematically describes the maximal overgroups of noncyclic Sylow subgroups of the sporadic finite simple groups. The author associates with this collection of overgroups a geometric structure which can be used to study the group and its permutation representations. He includes reasonably self-contained proofs of the existence and uniqueness of the relevant subgroups. Though the text is aimed primarily at simple group theorists, the tables which describe the maximal subgroups will be useful to any mathematician seeking information about the subgroups, permutation representations, or the geometry of the sporadic groups.

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(continued)

1980 *Mathematics Subject Classifications*: 20B25, 20D08, 20D05
ISBN 0-8218-2344-2, LC 86-1040
ISSN 0065-9266
240 pages (softcover), March 1986
Individual member $13, List price $21, Institutional member $17
To order, please specify MEMO/343N

EXPLICIT DETERMINATION OF AREA MINIMIZING HYPERSURFACES, II

Harold R. Parks
(Memoirs of the AMS, Number 342)

The author presents a method for explicitly determining an oriented area minimizing hypersurface with a given boundary. The method, which uses the least gradient approach, is presented as quickly as possible after the introduction of the necessary notation. As an essential hypothesis, the author assumes that the given boundary lies on the surface of a bounded convex subset of $\mathbb{R}^n$. This strengthens an earlier result of the author, where the uniqueness of the area minimizing hypersurface is no longer required, and the given boundary is replaced by an appropriate approximation. The goal of the remainder of the book is to determine how accurate an approximation ensures that all the topological complexity of the minimizing surface has been expressed in the approximating set.

Aimed at the research mathematician interested in the calculus of variations in general and area minimizing problems in particular, the text requires a working knowledge of basic geometric measure theory.

Contents

1980 *Mathematics Subject Classification*: 49F22
ISBN 0-8218-2339-6, LC 86-1039
ISSN 0065-9266
96 pages (softcover), March 1986
Individual member $7, List price $12, Institutional member $10
To order, please specify MEMO/342N

ILL-POSED PROBLEMS OF MATHEMATICAL PHYSICS AND ANALYSIS

M. M. Lavrent′ev, V. G. Romanov, and S. P. Shishat·skiĭ
(Translations of Mathematical Monographs, Volume 64)

Aimed at specialists in applied mathematics, physics, and geophysics, this volume fills some of the gaps in the monographic literature on the theory of ill-posed problems. The theory has developed intensively in the past two decades, aided by the advent of modern computing technology. It is connected with a wide variety of applied problems, including interpretation of readings of many physical instruments and of geophysical and astronomical observations, optimization of control, management, and planning, and the synthesis of automatic systems.

The authors begin by presenting a number of examples which lead to ill-posed problems arising with the processing and interpretation of data of physical measurements. Basic postulates and some results in the general theory of ill-posed problems follow. The exposition also includes problems of analytic continuation from continua and discrete sets, analogous problems of continuation of solutions of elliptic and parabolic equations, the main ill-posed boundary value problem for partial differential equations, and results on the theory of Volterra equations of the first kind. A very broad presentation is given of modern results on the problem of uniqueness in integral geometry and on inverse problems for partial differential equations.

(continued)

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1980 *Mathematics Subject Classifications*: 35R30, 45D05
ISBN 0-8218-4517-9, LC 86-3642
ISSN 0065-9282
296 pages (hardcover), May 1986
Individual member $59, List price $98, Institutional member $78
To order, please specify MMONO/64N

ONE-DIMENSIONAL INVERSE PROBLEMS OF MATHEMATICAL PHYSICS

(American Mathematical Society Translations, Series 2, Volume 130)

This monograph deals with the inverse problems of determining a variable coefficient and right side for hyperbolic and parabolic equations on the basis of known solutions at fixed points of space for all times. The problems are one-dimensional in nature since the desired coefficient of the equation is a function of only one coordinate, while the desired right side is a function only of time. The authors use methods based on the spectral theory of ordinary differential operators of second order and also methods which make it possible to reduce the investigation of the inverse problems to the investigation of nonlinear operator equations. The problems studied have applied importance, since they are models for interpreting data of geophysical prospecting by seismic and electric means.

In the first chapter the authors prove the one-to-one correspondence between solutions of direct Cauchy problems for equations of different types, and they present the solution of an inverse problem of heat conduction. In the second chapter they consider a second-order hyperbolic equation describing a wave process in three-dimensional half-space. The third chapter investigates formulations of one-dimensional inverse problems for the wave equation in multidimensional space.

Contents

1980 *Mathematics Subject Classifications*: 35K05, 35L05, 35R30
ISBN 0-8218-3099-6, LC 86-7917
ISSN 0065-9290
80 pages (hardcover), due July 1986
Individual member $22, List price $37, Institutional member $30
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Personal Items

James Eells of the University of Warwick, Coventry, England, has been appointed head of mathematics at the International Centre for Theoretical Physics in Trieste, Italy. He will share his time between the University and the Centre.

B. K. Ghosh, Professor and former Chairman of the Department of Mathematics at Lehigh University, has been selected by the Alexander von Humboldt Foundation to receive a Senior U.S. Scientist Award. He will visit the Institute of Mathematical Statistics at the University of Münster during the academic year 1986-1987.

Paul R. Halmos of Santa Clara University was awarded the honorary degree of Doctor of Humane Letters by Kalamazoo College, at a Scholars' Day Convocation held on March 14, 1986.

Robert H. Lewis of Fordham University has been promoted to Associate Professor at that institution.

Julius M. Zelmanowitz, Professor of Mathematics at the University of California, Santa Barbara, assumed the post of Associate Vice Chancellor for Academic Affairs in September, 1985.

Deaths

Daniel T. Finkbeiner II, Professor Emeritus of Kenyon College, Gambier, Ohio, died on March 28, 1986, at the age of 66. He was a member of the Society for 38 years.

Henri G. Garnir of Angleur, Belgium, died on November 18, 1985, at the age of 58. He was a member of the Society for 24 years.

Emmert A. Gassman of Mount Carmel, Illinois, died on January 13, 1986, at the age of 80. He was a member of the Society for 20 years.

Tadeusz Maćkowiak of Wrocław University, Poland, died on February 4, 1986, at the age of 37. He was a member of the Society for 6 years.

A. A. H. Omar of Cairo, Egypt, died on December 11, 1985, at the age of 37. He was a member of the Society for 9 years.

Wolfram Schwabhäuser of the University of Stuttgart, Federal Republic of Germany, died on December 27, 1985, at the age of 54. He was a member of the Society for 17 years.

Kurt Vogel, Professor Emeritus of the University of Munich, Federal Republic of Germany, died on October 27, 1985, at the age of 97. He was a member of the Society for 22 years.

Visiting Mathematicians

The list of visiting mathematicians includes both foreign mathematicians visiting in the United States and Canada, and Americans visiting abroad. Note that there are two separate lists.

American Mathematicians Visiting Abroad

Name and Home Country	Host Institution	Field of Special Interest	Period of Visit
Babbitt, Donald G. (U.S.A.)	Université de Dijon, France	Mathematical Structures Arising in Quantum Theory	11/86 - 6/87
Blackwell, John H. (Canada)	Oxford, United Kingdom	Heat Conduction in Media with Change of Phase	10/86
Buckley, B. (Canada)	Institute National de Recherche en Informatique et Automatique, France	Optimization	1/87 - 7/87
Dennis, S.C.R. (Canada)	University of Poitiers, France; University College, England	Fluid Mechanics	7/86; 1/87 - 9/87 8/86; 10/87 - 12/87
Gamelin, Theodore W. (U.S.A.)	University of Saarbrucken, West Germany	Function Algebras, Analytic Functions	7/86 - 6/87
Ghosh, B. K. (U.S.A.)	University of Münster, West Germany	Mathematical Statistics	9/86 - 6/87
Groetsch, C. W. (U.S.A.)	Australian National University	Integral Equations	7/86 - 8/86
Hamacher, Horst W. (U.S.A.)	Technical University Graz, Austria	Combinatorial Optimization	10/86 - 7/87
Michelson, Daniel (U.S.A.)	Hebrew University, Israel	Partial Differential Equations, Numerical Analysis	7/86 - 6/87
Nagano, Tadashi (U.S.A.)	Sophia University, Japan	Differential Geometry	6/86 - 7/87
Naylor, Derek (Canada)	King's College, England	Integral Transforms and Eigenfunction Expansions	1/87 - 12/87
Rasmussen, Henning (Canada)	University of Edinburgh, Scotland	Fluid Mechanics	5/86 - 9/86
Smith, Penny (U.S.A.)	Max Plank Institute, West Germany	Nonlinear Analysis/Geometry	9/86 - 6/87
Stakgold, Ivar (U.S.A.)	Ecole Polytechnique Fédérale de Lausanne, Switzerland	Nonlinear Analysis	2/87 - 5/87
Talman, James D. (Canada)	University of Oslo, Norway	Theoretical Atomic Physics	9/86 - 6/87

Visiting Foreign Mathematicians

Andreatta, Marco (Italy)	University of Notre Dame	Algebraic Geometry	8/86 - 1/87
Andréka, Hajnal (Hungary)	Iowa State University	Universal Algebra, Logic	8/86 - 5/87
Avellaneda, Marco M. (Argentina)	Courant Institute, New York University	Partial Differential Equations, Probability	9/86 - 5/87
Beauville, Arnaud (France)	Columbia University	Algebraic Geometry	9/86 - 12/86
Ben-David, Shai (Israel)	University of Toronto	Set Theory	7/86 - 6/87
Berman, Abraham (Israel)	University of California, Santa Barbara	Linear Algebra	1/87 - 6/87
Brenier, Yann (France)	University of California, Los Angeles	Applied Mathematics	1/87 - 3/87
Canuto, Giuseppe (Italy)	Princeton University	Algebraic Geometry	9/86 - 6/87
Cao, Z. (China)	Florida State University	Fuzzy Sets Theory	8/86 - 8/87
Catanese, Fabrizio (Italy)	Columbia University	Algebraic Geometry	1/87 - 5/87
Ciecielski, Krzysztof (Poland)	Auburn University	Set Theory	9/86 - 6/87
Coen, Salvatore (Italy)	Johns Hopkins University	Several Complex Variables	7/86 - 6/87
Constanda, Christian (Scotland)	Iowa State University	Analysis	8/86 - 5/87
Conway, John H. (England)	Princeton University	Finite Mathematics	9/86 - 6/87
DeConcini, Corrado (Italy)	Brandeis University; Harvard University	Algebraic Geometry	9/86 - 12/86 1/87 - 6/87
Eastham, Michael S. P. (England)	University of Western Ontario	Differential Equations	9/86
Epstein, David (England)	University of Minnesota	Geometry	9/86 - 12/86

Name and Home Country	Host Institution	Field of Special Interest	Period of Visit
Escobar, Jose (Colombia)	Courant Institute, New York University	Differential Geometry and Partial Differential Equations	9/86 - 6/87
Floer, Andreas (West Germany)	Courant Institute, New York University	Differential Equations	9/86 - 5/88
Foata, Dominique (France)	University of Pennsylvania	Combinatorics	7/86 - 12/86
Fraenkel, Edward (England)	University of Minnesota	Analysis	7/86 - 12/86
Friedman, Menachem (Israel)	Florida State University	Computational Mathematics	8/86 - 8/87
Fröhlich, A. (United Kingdom)	University of Western Ontario	Algebraic Number Theory	8/86 - 10/86
Graham-Eagle, James (New Zealand)	University of Delaware	Functional Analysis, Partial Differential Equations	9/86 - 5/88
Grillakis, Manoussos (Greece)	Courant Institute, New York University	Partial Differential Equations	9/86 - 5/88
Györi, Ervin (Hungary)	Vanderbilt University	Combinatorics	9/86 - 5/87
Gardner, B. J. (Australia)	Dalhousie University	Ring Theory	8/86 - 1/87
Han, Yong Shen (People's Republic of China)	Washington University	Analysis	9/86 - 5/87
Hills, Roger N. (Scotland)	University of California, Los Angeles	Applied Mathematics	9/86 - 6/87
Hilton, Anthony J. W. (England)	Auburn University	Graph Theory and Combinatorics	9/86 - 6/87
Hirano, Yasuyuki (Japan)	University of Cincinnati	Ring Theory	4/86 - 3/87
Hsu, Pei (People's Republic of China)	Courant Institute, New York University	Probability	9/86 - 6/87
Iacob, Andrei (Israel)	Brandeis University	Symplistic Geometry and Mechanics	9/86 - 5/87
Jarosz, Krystof (Poland)	University of California, Santa Barbara	Banach Space Theory, Banach Algebras	9/86 - 6/87
Journé, Jean-Lin (France)	Princeton University	Analysis	2/87 - 6/87
Kasch, Friedrich (West Germany)	University of California, Santa Barbara	Ring Theory	10/86 - 12/86
Kato, Akio (Japan)	University of Toronto	Set Theoretic Topology	8/86 - 7/87
Koslowski, Jürgen (West Germany)	Vanderbilt University	Category Theory	9/86 - 5/87
Lascar, Bernard (France)	University of California, Los Angeles	Analysis, Partial Differential Equations	9/86 - 6/87
Lin, Fang-Hua (People's Republic of China)	Courant Institute, New York University	Partial Differential Equations	9/86 - 5/87
Little, C.H.C. (New Zealand)	University of Waterloo	Graph Theory	9/86 - 8/87
Liu, Guizhen (People's Republic of China)	Simon Fraser University	Combinatorics	7/86 - 6/87
Looijenga, Eduard (Netherlands)	Columbia University	Algebraic Geometry	1/87 - 5/87
Ma, Daowei (People's Republic of China)	Washington University	Analysis	9/86 - 5/87
Magidor, Menachem (Israel)	University of California, Los Angeles	Logic	9/86 - 6/87
Martin, Paul A. (England)	University of Delaware	Scattering Theory	9/86 - 5/87
Mawhin, Jean (Belgium)	University of Colorado, Boulder	Differential Equations	9/86 - 12/86
Mohar, Bojan (Yugoslavia)	Simon Fraser University	Combinatorics	9/86 - 8/87
Moszkowski, Paul (France)	University of Pennsylvania	Combinatorics	7/86 - 6/87
Motohashi, Yoichi (Japan)	University of Colorado, Boulder	Number Theory	1/87 - 5/87
Németi, István (Hungary)	Iowa State University	Universal Algebra, Logic	8/86 - 5/87
Nochetto, Ricardo (Italy)	University of Minnesota	Numerical Analysis	8/86 - 6/87
Ozluk, Ali E. (Turkey)	Simon Fraser University	Discrete Mathematics	9/86 - 8/87
Paivarinta, Lassi J. (Finland)	University of Delaware	Scattering Theory	2/87 - 5/87
Pakes, Anthony G. (Australia)	Colorado State University	Probability	1/86 - 12/86
Papageorgiou, Demetrius (England)	Courant Institute, New York University	Fluid Dynamics	9/86 - 5/87
Paulraja, P. (India)	University of Waterloo	Cycles in Graphs and Digraphs	9/86 - 8/87

Name and Home Country	Host Institution	Field of Special Interest	Period of Visit
Peikert, Ronald (Switzerland)	University of Minnesota	Computer Algebra	7/86 - 1/87
Pisanski, Tomaz (Yugoslavia)	Simon Fraser University	Combinatorics	5/87 - 8/87
Power, Steve (United Kingdom)	University of Alabama	Operator Algebras, Operator Theory and Function Theory	1/87 - 5/87
Przytycki, Jozef (Poland)	University of Toronto	Algebraic Topology	9/86 - 8/87
Rademacher, Hans-Bert (West Germany)	University of Pennsylvania	Differential Geometry	7/86 - 6/87
Ramanan, S. (India)	Harvard University	Algebraic Geometry	9/86 - 1/87
Rendl, F. (Austria)	University of Waterloo	Combinatorial Optimization	9/86 - 8/87
Roan, Shi-Shyr (Taiwan)	Brandeis University	Complex Algebraic Geometry and Complex Manifolds	9/86 - 12/86
Romanowska, Anna (Poland)	Iowa State University	Lattice Theory	8/86 - 5/87
Sakai, Katsuro (Japan)	University of California, Santa Barbara	Geometric Topology	6/86 - 12/86
Scott, Alastair J. (New Zealand)	University of Wisconsin, Madison	Statistics	8/86 - 1/87
Shinkai, Kenzo (Japan)	University of Minnesota	Partial Differential Equations	8/86 - 2/87
Sibony, Nessim (France)	University of California, Los Angeles	Analysis	1/87 - 6/87
Smedsaas, Tom (Sweden)	University of California, Los Angeles	Numerical Analysis	9/86 - 12/86
Stock, Josef (West Germany)	University of California, Santa Barbara	Ring Theory	9/86 - 6/87
Sudo, Masaki (Japan)	Johns Hopkins University	Number Theory	8/86 - 12/86
Szpiro, Lucien (France)	Columbia University	Number Theory	9/86 - 12/86
Tangerman, Folkert M. (Holland)	Courant Institute, New York University	Dynamical Systems	9/86 - 5/88
Teicher, Mina (Israel)	Columbia University	Algebraic Geometry	1/87 - 5/87
Thomann, Enrique (Argentina)	Courant Institute, New York University	Partial Differential Equations	9/86 - 6/87
van der Geer, Gerard (Netherlands)	Harvard University	Algebraic Geometry	1/87 - 5/87
Viterbo, Claude M. (France)	Courant Institute, New York University	Symplectic Geometry	9/86 - 1/87
Wajnryb, Bronislaw (Israel)	University of Toronto; Columbia University	Algebraic Topology	9/86 - 12/86
Wilson, John (Great Britain)	University of California, Santa Barbara	Group Theory	1/87 - 3/87
Yu, Chen (China)	University of Notre Dame	Algebra	8/86 - 5/87
Zhu, Kehe (People's Republic of China)	Washington University	Analysis	9/86 - 5/87

Recent Appointments

> Committee members' terms of office on standing committees expire on December 31 of the year given in parentheses following their names, unless otherwise specified.

Joel M. Cohen has been appointed to the *Committee to Select Hour Speakers for the Eastern Sectional Meetings* by President Irving Kaplansky. Continuing members of the committee are W. Wistar Comfort (ex officio), Roger Keith Dennis (1987), Clifford J. Earle, Jr., (1986), and Srinivasa S. R. Varadhan, chairman (1986).

A joint AMS-MAA *Committee on Arrangements for the San Antonio Meeting* (January 22–25, 1987) has been appointed by Presidents Lynn A. Steen (MAA) and Irving Kaplanksy (AMS). Committee members are Donald F. Bailey, Robert M. Fossum (ex officio), William J. LeVeque (ex officio), Kenneth A. Ross (ex officio), Gregory Wene, chairman, Lawrence R. Williams, and Bennir A. Zinn.

Kenneth M. Hoffman, Thomas R. Kramer, Louise A. Raphael, T. Christine Stevens, and Marcia P. Sward have been appointed by President Irving Kaplansky to be the selection panel for the *Congressional Fellow for 1986-1987.* Professor Kramer is chairman.

Statistics on Women Mathematicians Compiled by the AMS

At its August 1985 meeting, the Council of the AMS approved a motion to regularly assemble and report in *Notices* information on the relative numbers of men versus women in at least the following categories: membership in the AMS; invited hour addresses at AMS meetings; speakers at special sessions at AMS meetings; and members of editorial boards of AMS journals.

It was subsequently decided that this information would be gathered by determining the sex of the individuals in the above categories based on name identification and that additional information on the number of Ph.D.'s granted to women would also be collected using the AMS Annual Survey. Since name identification was used, the information for some categories necessitated the use of four classifications:

- Male - names that were obviously male;
- Female - names that were obviously female;
- Unknown - names that could not be identified as clearly male or female (i.e., only initials given); and
- Foreign - foreign names that could not be identified as clearly male or female.

The following is the first reporting of this information. Updated reports will appear annually in *Notices.*

Members of the AMS Residing in the U.S.

Male:	12,527	72%
Female:	2,200	13%
Unknown:	2,157	12%
Foreign:	497	3%
Total checked:	17,381	

Invited Hour Address Speakers at AMS Meetings (1975–1985)

Male:	372	85%
Female:	10	2%
Unknown:	19	4%
Foreign:	36	8%
Total checked:	437	

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Male:	2,545	77%
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Total checked:	3,287	

Trustees and Council Members

	1985		1984		1983		1982	
Total:	71		70		63		64	
Male:	61	86%	62	89%	55	87%	58	91%
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Total:	102		93		90		83		85		82		82		67		59		58	
Male:	94	92%	85	91%	84	93%	77	93%	79	93%	77	94%	78	95%	64	96%	56	95%	55	95%
Female:	8	8%	8	9%	6	7%	6	7%	6	7%	5	6%	4	5%	3	4%	3	5%	3	5%

Ph.D.'s Granted to U.S. Citizens

	1985		1984		1983		1982		1981		1980		1979		1978		1977		1976	
Total:	396		433		455		519		567		578		596		634		689		722	
Male:	315	80%	346	80%	366	80%	431	83%	465	82%	491	85%	503	84%	545	86%	602	87%	636	88%
Female:	81	20%	87	20%	89	20%	88	17%	102	18%	87	15%	93	16%	89	14%	87	13%	86	12%

Classified Advertisements

SUGGESTED USES for classified advertising are books or lecture notes for sale, books being sought, positions available, exchange or rental of houses, and typing services.

THE RATE IS $.65 per word with a minimum of $30.00. The same ad in 6 consecutive issues is $3.50 per word. Type will be set solid unless centering and spacing are requested. A centered line of any length or the equivalent in white space is $6.00. A word is defined as a group of characters with space at each end. Prepayment is required of individuals but not of institutions. For an additional $10.00 charge, announcements can be placed anonymously. Correspondence will be forwarded.

DEADLINES are listed on the inside front cover.

U. S. LAWS PROHIBIT discrimination in employment on the basis of color, age, sex, race, religion or national origin. "Positions Available" advertisements from institutions outside the U. S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U. S. laws. Details and specific wording may be found following the Classified Advertisements in the January and August issues of the *Notices*.

SITUATIONS WANTED ADVERTISEMENTS from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-556-7774 and speak to Wahlene Siconio for further information.

SEND AD AND CHECK TO: Advertising Department, AMS, P. O. Box 6248, Providence, Rhode Island 02940. Individuals are requested to pay in advance, institutions are not required to do so.

POSITIONS AVAILABLE

Northern Michigan University invites applicants for a temporary position in the Department of Mathematics & Computer Science. The person filling this position is expected to teach undergraduate mathematics or statistics or computer science, depending on preparation, and must have at least a Master's degree in one of these areas.

Applicants should send a resume, transcripts and three letters of recommendation to:

Dr. Terrance L. Seethoff, Head
Department of Mathematics & Computer Science
Northern Michigan University
Marquette, MI 49855-5340
(906)227-2020

Applicant screening will begin June 1, 1986.

It is expected that this position will be filled by June 30, 1986. An affirmative action/equal opportunity employer.

THE UNIVERSITY OF PITTSBURGH

Applications invited for tenure-track or visiting faculty positions anticipated in 1986. Preferred area: PDE's, analysis, applied mathematics, statistics. Present teaching load: 2 classes per term, 2-term 8-month academic year. Ph.D., publications and active research program, effective teaching ability required. C.V., 4 letters of recommendation, reprints, preprints should be sent to W. E. Deskins, Chairman, Department of Mathematics and Statistics, University of Pittsburgh, Pittsburgh, Pennsylvania 15260.

U. P. is an Equal Opportunity/Affirmative Action Employer.

STANFORD UNIVERSITY

Department of Computer Science

Applications are invited for a tenure-track professor with interest in any area of theoretical computer science. Applicants must have a record of strong research and an interest and competence in teaching. Candidates should send curriculum vitae with suggested references to Professor Andrew C. Yao, Computer Science Department, Stanford University, Stanford, CA 94305. Further inquiries can be made to the above address or to ARPAnet address: Yao@SU-SCORE.

Stanford is an Equal Opportunity/Affirmative Action employer and welcomes applications from women and minorities.

STANFORD UNIVERSITY

Departments of
Computer Science and Mathematics

Applications are invited for a joint tenure-track professor with interest in numerical analysis and scientific computing for a newly proposed Applied Mathematics/Scientific Computing program. Applicants must have a record of strong research and an interest and competence in teaching. Candidates should send curriculum vitae with suggested references to Professor Gene H. Golub, Computer Science Department, Stanford University, Stanford, CA 94305. Further inquiries can be made to the above address or to ARPAnet address: Golub@SU-SCORE.

Stanford is an Equal Opportunity/Affirmative Action Employer and welcomes applications from women and minorities.

Several tenure track positions at all levels anticipated for academic year 1986-1987. All areas considered, applied mathematics preferred. Requirements are Ph.D., strong research credentials, evidence of active interest in quality teaching, and U.S. citizenship or permanent resident status. Rank and salary commensurate with experience. Applicants should send vita, statement of current research activities and three letters of recommendation to Professor Alan Doerr, Personnel Committee, UNIVERSITY OF LOWELL, Mathematics Department, 1 University Avenue, Lowell, MA 01854. Positions contingent upon funding. The University of Lowell is an Equal Opportunity/Affirmative Action, Title IX, 504 Employer.

FLORIDA INTERNATIONAL UNIVERSITY DEPARTMENT OF MATHEMATICAL SCIENCES, Miami, FL 33199

The Department of Mathematical Sciences announces tenure-track positions at all levels beginning August, 1986. Candidates must have a Ph.D. in Mathematics, research potential and demonstrated teaching ability. Teaching load is 15 semester hours per academic year; summer teaching available. Preferred areas of specialization include harmonic analysis, algebra, and mathematical logic; qualified candidates in other areas considered. Send resumes and 3 letters of reference to Recruitment Committee, Dept of Math Sciences, Florida International University, Miami, FL 33199. FIU is a member of the State University of Florida and an equal opportunity/affirmative action employer.

POSITIONS AVAILABLE

FACULTY POSITIONS IN MATHEMATICS FLORIDA INTERNATIONAL UNIVERSITY

The Department of Mathematical Sciences at Florida International University announces several tenure-track assistant professorships, and one opening at the associate or full professor level beginning August 1986. Requirements: Ph.D. in Mathematics, research potential, demonstrated teaching ability. Senior position requires demonstrated research record. Teaching load: 15 semester hours per academic year; summer teaching available. Preferred specialties: harmonic analysis, several complex variables, mathematical logic, algebra, combinatorics; other areas considered. Send resume by January 30, 1986 to: Recruitment Committee, Dept of Mathematical Sciences, Florida International University, Miami, FL 33199. FIU is a member of the State University System of Florida and an Equal Opportunity/Affirmative Action Employer.

THE AUSTRALIAN NATIONAL UNIVERSITY invites applications from suitably qualified women and men for appointment to the following position: POSTDOCTORAL FELLOW/RESEARCH FELLOW, DEPARTMENT OF MATHEMATICS, RESEARCH SCHOOL OF PHYSICAL SCIENCES. The Department of Mathematics (Head: Professor D. W. Robinson, FAA) carries out research in several areas, namely Operator Algebras; Semigroups and Mathematical Physics; Partial Differential Equations and Geometry; Foundations; Lie Groups and Algebraic Groups; Ordinary Differential Equations and Control Theory; Global Analysis; Group Theory. Closing date: 31 July 1986. Ref: PS. 25.3.3. Salary will be in accordance with qualifications and experience within the range: Postdoctoral Fellow Grade 1 (at a fixed point) $23,473-$26,889 p.a.; Research Fellow $27,233-$35,777 p.a. Appointment, unless otherwise stated, will be: Research Fellow normally up to three years with the possibility of extension to maximum of five years; Postdoctoral Fellow normally two years, with the possibility of extension to maximum of three years. Grants towards travel, assistance with housing, superannuation. Maternity leave is available. The University reserves the right not to make an appointment or to make an appointment by invitation at any time. Applicants should quote the reference number when submitting applications to R. V. Dubs Registrar, GPO Box 4, Canberra, ACT, 2601 Australia. THE UNIVERSITY IS AN EQUAL OPPORTUNITY EMPLOYER.

OTTO SZASZ VISITING PROFESSORSHIP

The Department of Mathematical Sciences of the University of Cincinnati expects to establish, pending final budgetary approval, a visiting professorship named in honor of the late Otto Szasz. The professorship will be tenable for a period of one year. Applicants with strong research accomplishments in an area compatible with one of the existing research groups of the Department may address inquiries to C. W. Groetsch, Head, Department of Mathematical Sciences, Mail Location 25, University of Cincinnati, Cincinnati, Ohio 45221.

The University of Cincinnati is an AA/EOE.

UNIVERSITY OF CRETE, GREECE
Department of Mathematics

Applications are invited from Greek-speaking mathematicians, holding the Ph.D. degree, for visiting positions at all ranks for both semesters of the whole Academic Year 1986-7. Send expression of interest, vita and representative research work to Professor Susanna Papadopoulou, Chairperson, Mathematics Department, University of Crete, Iraklion, Greece.

UNIVERSITY OF CINCINNATI, DEPT. OF MATH. SCIENCES MAIL LOCATION #25, CINCINNATI, OH 45221

The University of Cincinnati expects to make several tenure-track appointments at the assistant professor level. Preference will be given to candidates with potential to strengthen the existing research areas in the Department. All candidates must have outstanding potential for research, scholarship, and teaching. Send vita and direct 3 letters of reference to C. W. Groetsch, Head, Department of Mathematical Sciences, M.L. #25, University of Cincinnati, Cincinnati, OH 45221. U.C. is an AA/EOE.

Tenure-track and visiting positions in mathematics, applied mathematics and statistics are available beginning September 1986. Excellent teaching and a commitment to research are required. Some 3-year instructorships may also be open. The department offers B.S. and M.S. degrees. MTU is a state supported university emphasizing science and engineering. To apply, write: Dr. Martyn R. Smith, Head, Mathematical and Computer Sciences, Michigan Technological University, Houghton, MI 49931.

Michigan Technological University is an equal opportunity educational institution/equal opportunity employer.

TEXAS A&M UNIVERSITY

Applications are invited for tenure-track positions in Mathematics starting September 1, 1986. Candidates must have a Ph.D. in Mathematics and salaries are competitive. We are especially interested in applicants in algebra, applied mathematics, and non-linear analysis. There is a possibility of appointments at Professor, Associate Professor, and Assistant Professor ranks. Visiting positions are also expected. Send vita and arrange for three reference letters to be sent to

Dr. H. E. Lacey, Head
Department of Mathematics
Texas A&M University
College Station, TX 77843-3368

Texas A&M is an equal opportunity employer.

The University of Wyoming
Head—Department of Mathematics

The Department of Mathematics at the University of Wyoming invites applications for the position of Department Head. The University is the sole four-year institution of higher education in the state of Wyoming with an enrollment of 10,000 students. The mathematics program offers degrees in mathematics, applied mathematics, and several joint-degree options at the bachelor, master and doctoral levels. The department has a growing major research component in applied mathematics including a petroleum research institute with funding from major industrial supporters. Other active research areas in the department include numerical analysis, partial differential equations, functional analysis, optimization theory, dynamical systems, rigidity theory, and combinatorics.

Candidates should have a strong research record compatible with department interests and a commitment to excellence in instruction. Applicants should submit a current curriculum vita and the names of at least three suitable references to

W. G. Bridges, Chair
Search Committee
Mathematics Department
University of Wyoming
Laramie, WY 82070

Applications will be considered through January 31, 1986. The University of Wyoming is an equal opportunity employer.

POSITIONS AVAILABLE

MERRIMACK COLLEGE

Department of Math/CS

Chairperson and two other positions (one in mathematics and one in Computer Science or a combination) available Fall 1986. For chairperson, a PhD in CS is preferred but a Masters accompanied by appropriate experience will be considered. Rank and salary commensurate with qualifications. For the other positions, a PhD in Math and/or a Masters in CS with demonstrated teaching experience preferred. Tenure slots available. Send resume, salary requirement and references to: R. E. Ozimkoski, Dept. of Math/CS, Merrimack College, North Andover, MA 01845. An Equal Opportunity Employer.

MATHEMATICS EDITOR

Cambridge-based international scientific publisher has an opening for Mathematics Editor. This job entails the development and expansion of an already existing strong graduate-level program in pure and applied mathematics. Applicants are expected to be able to assume responsibility for the development of such a program, to work, under initial guidance, independently and to maintain good personal and professional ties with members of the mathematical community. Prior publishing experience is desirable but not essential; substantial exposure to graduate-level mathematics is required. Salary commensurate with educational background/experience. Excellent benefit package. Send resume and salary history to: AMS, #1 June Classifieds, P. O. Box 6248, Providence, RI 02940.

The University of B. C.–Department of Mathematics: Applications are invited for a tenure track position to fill a vacancy in Geometry/Topology for the academic year commencing 1 July, 1986. This position is subject to final budgetary approval. Candidates must have a Ph.D. and demonstrated excellence in research and ability to teach undergraduate and graduate courses in the Department. Salary commensurate with experience and research record. Applicants must include a complete C.V. and arrange for at least three letters of reference to be mailed directly to:

Head, Department of Mathematics
The University of British Columbia
Vancouver, Canada V6T IY4

Applications received after May 31, 1986 will be considered only if a position remains unfilled.

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

AUSTIN PEAY STATE UNIVERSITY, DEPT. OF MATHEMATICS AND COMPUTER SCIENCE, CLARKSVILLE, TN 37044

A tenure-track position in computer science will be available September 1986. A doctorate in computer science or a doctorate in a related field with substantial experience in computer science is required. All areas of specialization will be considered. The department offers a curriculum structured according to ACM guidelines. Computing equipment includes a DEC VAX 11/780 dedicated to academic use, a DEC PDP 11, a microcomputer laboratory, and a hardware laboratory. The successful applicant will be expected to participate in curriculum development and academic advisement in addition to teaching responsibilities. Send letter of application, resume, transcripts, and three letters of recommendation to Dr. William Stokes, Chairman. APSU is an Equal Opportunity, Affirmative Action Employer.

UNIVERSITY OF BRITISH COLUMBIA-DEPARTMENT OF MATHEMATICS. Applications are invited for a tenure track position for the academic year commencing 1 July, 1986. This position is subject to final budgetary approval. Candidates must have a Ph.D. and demonstrated excellent research potential in an area of interdisciplinary applied analysis, preferably related to one or more of the following fields: geophysical fluid dynamics, non-linear waves, nonlinear diffusion, continuum mechanics, applied differential equations, applied optimization, biomathematics, or resource modelling. In addition to carrying out undergraduate and graduate instruction, the successful applicant will become an active member of the Institute of Applied Mathematics, which offers interdisciplinary M. Sc. and Ph.D. degrees. Salary commensurate with experience and research record. Applicants must include a complete C.V. and arrange for at least three letters of reference to be mailed directly to:

Head, Mathematics Department
The University of British Columbia
Vancouver, Canada V6T 1Y4

Applications received after May 31, 1986 will be considered only if a position remains unfilled. In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

THE UNIVERSITY OF ALABAMA DEPARTMENT OF MATHEMATICS

As part of ongoing development in applied mathematics, we have received funding for a new position in applied mathematics. Salary will be negotiable, up to a maximum of $35,000 and rank will depend upon qualifications. We invite applications from experienced mathematicians in applied mathematics with excellent records in research and teaching. We are looking for someone who will help us develop our research group and our graduate programs in applied mathematics. Applications or inquiries should be sent to: Alan Hopenwasser, Chairman, Department of Mathematics, P. O. Box 1416, University, AL 35486. THE UNIVERSITY IS AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER.

UNIVERSITY OF TORONTO
Department of Mathematics
Toronto, Ontario M5S LA1
Canada

The Department of Mathematics, University of Toronto is looking for strong applicants in pure or applied mathematics to nominate as candidates for NSERC Research Fellowships beginning July 1, 1987. These are five year research positions (subject to a review in the third year) with teaching load of at most one course per year. One of the five years may usually be taken as a sabbatical. Successful candidates may in special circumstances be considered directly for a tenure-stream position.

Applicants should be mathematicians with a relatively recent doctorate and who have demonstrated their ability with some substantive post-thesis research accomplishment. They must be Canadian citizens or landed immigrants by November 1, 1986. University of Toronto encourages both men and women to apply for these fellowships.

Applicants should send an up to date curriculum vitae and a short description of their research program to Professor T. Bloom, Chairman, and arrange to have sent three letters of reference. This material should arrive before Monday, September 15, 1986. The Department's choice of candidates will be made in late September, and the final decision by NSERC is announced (by NSERC) in the spring.

POSITIONS AVAILABLE

THE UNIVERSITY OF TEXAS OF THE PERMIAN BASIN
Department of Mathematics and Computer Science
Odessa, TX 79762-8301

Opening for Assistant or Associate Professor, starting in the fall of 1986. The candidate must hold a Ph.D., in Mathematics or Computer Science. U.T. Permian Basin is an upper level institution with no Freshmen or Sophomore students. The total enrollment is about 2000 with approximately 130 of these majoring in Computer Science or Mathematics. Contact: Dr. James A. Nickel, Chairman. The University of Texas of the Permian Basin is an AA/EOE.

THE AUSTRALIAN NATIONAL UNIVERSITY

invites applications from suitably qualified men and women for appointment to the position of POSTDOCTORAL FELLOW/RESEARCH FELLOW in the DEPARTMENT OF MATHEMATICS, RESEARCH SCHOOL OF PHYSICAL SCIENCES. The Department of Mathematics (Head: Professor D. W. Robinson, FAA) carries out research in several areas, namely Operator Algebras; Semigroups and Mathematical Physics; Partial Differential Equations and Geometry; Foundations; Lie Groups and Algebra Groups; Ordinary Differential Equations and Control Theory; Global Analysis; Group Theory. Two positions are available for one year from dates between 1 September 1986 and 28 February 1987 and preference will be given to applicants working in Partial Differential Equations, Geometric Measure Theory or related fields of research in mathematical analysis. Enquiries may be made to Professor Leon Simon, Department of Mathematics. Closing date: 31 July 1986. Ref: PS. 2.4.1. Salary will be in accordance with qualifications and experience within the range: Postdoctoral Fellow Grade 1 (at a fixed point) $23,473-$26,889 p.a.; Research Fellow $27,233-$35,777 p.a. Grants towards travel, assistance with housing, superannuation. Maternity leave is available. The University reserves the right not to make an appointment or to make an appointment by invitation at any time. Applicants should quote the reference number when submitting applications to R.V. Dubs Registrar, GPO Box 4, Canberra, ACT, 2601 Australia. THE UNIVERSITY IS AN EQUAL OPPORTUNITY EMPLOYER.

SHEPHERD COLLEGE
Shepherdstown, West Virginia 25443

MATHEMATICS: FALL, 1986. For tenure-track appointment, PhD required, or date commitment for degree completion; one-year temporary appointment possible for other candidates. Commitment to quality teaching at a growing, undergraduate, state-supported liberal arts college with over 3700 enrollment, located on the banks of the Potomac River, 90 minutes drive from Washington, DC. Applications reviewed beginning June 2 and received until position filled. Send vita and three letters of recommendation, at least one referring to teaching abilities, to Dr. Peter Morris, Shepherd College, Shepherdstown, WV 25443. AA/EOE

FOR SALE

Math/Stats Library: List from R. Chesters, Suite 1900, 2 First Canadian Place, Toronto, Canada M5X 1E3.

MATH SCI PRESS, 53 Jordan Rd, Brookline MA, 02146, 617-738-0307. Just published: Proceedings of the Berkeley-Ames Conference on Nonlinear Problems in Control and Fluid Dynamics, L. R. Hunt and C. F. Martin, (eds), 450 pages, $50. (Lie Groups Series B: Systems Information and Control, vol. II). Topics in the Geometric Theory of Linear Systems, by Robert Hermann, $50. (Interdisciplinary Mathematics, v. 22). The Geometric theory of ordinary Differential Equations and Algebraic Functions, by G. Valiron, $75. (Lie Groups, v. 14). Topics in the Geometry Theory of Integrable Systems, $65, by Robert Hermann (Interdisciplinary Mathematics, v. 23.). Write or call for special prices on back list.

Foundations of Semiological Theory of Numbers
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Volume 2 (1985), Semio. Functions, 695 pp., $34.95
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UMO Press, Univ. of Maine, Orono, ME 04469
(Post free within US if check included)

Mathematics library. Request list. Bert Ross, University of New Haven, West Haven, CT 06516.

HELDERMANN VERLAG, Nassauische Str. 26, D-1000 Berlin-West 31. Just published: M. Jünger, *Polyhedral combinatorics and the acyclic subdigraph problem*, $15. G. Reinelt, *The linear ordering problem - algorithms and applications*, $15. A. B. Romanowska and J. D. H. Smith, *Modal theory - an algebraic approach to order, geometry, and convexity*, $16. G. Mazzola, *Gruppen und Kategorien in der Musik*, $20. R. Lowen, *On the existence of natural nontopological, fuzzy topological spaces*, $14. Ask for full catalogue!

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Proceedings of the Nineteenth Nordic Congress of Mathematicians, University of Iceland, August 13-17,1984

Detailed advertisement with list of contents in the January 1986 Notices, p. 181. Send order and payment ($20) to: Icelandic Mathematical Society, Science Institute, Dunhaga 3, IS-107 Reykjavik, Iceland.

BOOKS WANTED

Required back volumes of journals in mathematics. Contact Librarian with the list of journals and terms of offer. Institute of Mathematical Sciences, Taramani S.O., Madras-600 113, India. Telegram: Matscience, Madras.

WANTED

English language/mathematical symbols typewriter old inexpensive ok. Send sample script. Peter Bralver,13110 Bloomfield Street, Sherman Oaks, CA 91423.

THE LONDON MATHEMATICAL SOCIETY

Burlington House, Piccadilly, London W1V 0NL

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The Society was established in 1865 for the promotion and extension of mathematical knowledge. Members of the American Mathematical Society are very welcome to join the London Mathematical Society under the Reciprocity Agreement, which enables certain formalities to be dispensed with and a reduced subscription to be applied. For the year 1985/86 the reduced subscription is £3.00 (US$5.00).

Members of the American Mathematical Society may commence or continue their reciprocity membership of the London Mathematical Society during periods of temporary residence in the United Kingdom. They may then take advantage of all the facilities offered to London Mathematical Society members, such as use of the Society's extensive Mathematical Library at University College, London. They are also welcome to attend Society meetings, which take place about seven times a year.

Members of the American Mathematical Society resident outside the United Kingdom may be chiefly interested in subscribing to the periodicals of the L.M.S. These are the Bulletin, the Journal and the Proceedings of the London Mathematical Society. One volume of the Bulletin is published per year, and two volumes each of the Journal and Proceedings. Members of the American Mathematical Society may purchase periodicals at special rates on condition that they are for personal use of members and not for the supply of libraries or similar institutions.

The London Mathematical Society also publishes a series of Monographs, Lecture Notes, Students Texts and the proceedings of its Instructional Conferences. Members may purchase these books at a discount of 25%.

Full particulars of the activities of the L.M.S. and application forms for reciprocity membership may be obtained from the Administrative Assistant of the L.M.S. at the above address.

MATHEMATICAL SCIENCES RESEARCH INSTITUTE
BERKELEY, CALIFORNIA

The Institute solicits applications for memberships in the Institute for the 1987-88 year, which begins in September 1987.

In 1987-88 two programs will be featured.

Classical analysis. The following areas will receive particular attention: singular integrals and pseudo-differential operators, Fourier analysis in Euclidean space, Hardy space theory, applications of probability theory to Fourier analysis, and applications of harmonic analysis to partial differential equations and several complex variables. The program committee consists of C. Fefferman, E. Stein (chairman), and G. Weiss.

Representations of Lie groups. The program will focus on the representations of semisimple Lie groups. Among topics to be emphasized are:

(1) The systematic use of asymptotics and homological methods,

(2) The development of new geometric methods,

(3) Recent advances in the understanding of the structure of Harish-Chandra modules,

(4) The structure of the unitary dual.

The program committee consists of W. Schmid, D. Vogan, and J. Wolf (chairman).

Although these two areas will be emphasized, applications from candidates in all fields will be welcome.

The academic year 1987-88 will conclude with a "microprogram" on the Structure of Banach Spaces, running from June 27 to July 15, 1988. The program committee consists of J. Bourgain, W. Johnson, Y. Lindenstrauss, G. Pisier, and H. Rosenthal (chairman). The mathematical public is cordially invited to participate. At a later time there will be a separate poster giving details.

The Institute does not use formal application forms. However, an information sheet for prospective applicants is available on request. Write to the Mathematical Sciences Research Institute, 1000 Centennial Drive, Berkeley, CA 94720. Applicants' files should be completed by December 15, 1986. Please note that this is a half month earlier than the deadline of previous years.

For 1988-89 the Institute plans yearlong programs on Combinatorial Group Theory and Geometry and on Symplectic Geometry and Mechanics. Suggestions for programs for future years are welcome.

The Institute is committed to the principles of Equal Opportunity and Affirmative Action.

Directory of Women in the Mathematical Sciences

Questionnaire for Women who Hold the Ph.D.
or Have Equivalent Training, and Ph.D. Candidates

(PLEASE TYPE. Handwritten forms may not be used.)

1. A. Name (last name first) ______________________________

   B. Cross listing of name (if desired) ______________________________

2. Mailing Address (Preferred) ______________________________

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*Current Status ☐ (Employed) ☐ (Retired) ☐ (Graduate Student) ☐ (Unemployed)
(*This information is for record keeping and will not be printed in the Directory.)

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   (If retired, give last institution where employed.)

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4. Highest academic degree conferred ______________________________

   Year degree conferred ______________ Institution ______________________________

5. Fields of mathematical interest (Write 1 for primary field, 2 for other. Only two will be printed.)

   A. _____ Algebra
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   E. _____ Computer science
   F. _____ Functional analysis
   G. _____ Geometry
   H. _____ Logic and foundations
   I. _____ Number theory
   J. _____ Operations research
   K. _____ Statistics and Probability
   L. _____ Topology
   M. _____ Other

6. Publications: Bibliographic information for two most important publications. In addition to the title, give MR number and date only, if available; otherwise for an article, use MR abbreviation for journal, give volume number and date.

   i. ______________________________

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   ii. ______________________________

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Return this form as soon as possible to Directory of Women in the Mathematical Sciences, c/o R. Struik, Math. Dept., Campus Box 426, University of Colorado, Boulder, CO 80309.

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Journal back numbers, *Mathematical Reviews* indexes and review volumes are sent via surface mail to any destination unless air delivery is requested. Postage for surface mail is paid by the AMS. Air delivery rates, which will be quoted upon request, must be paid by the purchaser.

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By O.P. MISRA and J.L. LAVOINE

NORTH-HOLLAND MATHEMATICS STUDIES, 119

Notas de Matemática (106) Editor: Leopoldo Nachbin

Transform Analysis of Generalized Functions concentrates on finite parts of integrals, generalized functions and distributions. It gives a unified treatment of the distributional setting with transform analysis, i.e. Fourier, Laplace, Stieltjes, Mellin, Hankel and Bessel Series.

Included are accounts of applications of the theory of integral transforms in a distributional setting to the solution of problems arising in mathematical physics. Information on distributional solutions of differential, partial differential equations and integral equations is conveniently collected here.

The volume will serve as introductory and reference material for those interested in analysis, applications, physics and engineering.

1986 xiv + 332 pages. Price: US $48.25/Dfl. 140.00
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Harvey Friedman's Research on the Foundations of Mathematics

Edited by L.A. HARRINGTON, M.D. MORLEY, A. ŠČEDROV and S.G. SIMPSON

STUDIES IN LOGIC AND THE FOUNDATIONS OF MATHEMATICS, 117

This volume discusses various aspects of Harvey Friedman's research on the foundations of mathematics over the past fifteen years. It should appeal to a wide audience of mathematicians, computer scientists, and mathematically oriented philosophers.

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