The Flight from the Arts and Sciences: Trends in Degrees Conferred

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After rising steadily between 1954 and 1968, the percentage of all bachelor's degrees awarded in the arts and sciences declined dramatically. These swings cannot be explained by demographic variables; however, they have been affected by changes in the academic profiles of educational institutions that were in turn related to trends in enrollment. Even more important have been the changing choices of fields of study made by men and women (particularly in the case of the humanities), in part as a consequence of widening opportunities for women. The flight from the arts and sciences now appears to be over, and in the future gender-related variables can be expected to have less impact on the distribution of degrees conferred.

IN THIS COUNTRY, UNDERGRADUATES ARE UNUSUALLY FREE to elect (and change) the fields of study in which they major. Their choices directly affect the demand for teaching hours in the academic disciplines and the preparation that graduating classes take with them as they enter job markets, pursue further education, and participate in civic activities. The shifting popularity of fields of study tells a great deal about a society's evolving philosophy of education—and its values.

The distribution of degrees conferred has changed greatly in recent years, and there is evidence of a dramatic flight from the arts and sciences (*1*). Between 1968 and 1986, the number of BA degrees awarded to students who concentrated in one of the fields within the arts and sciences (humanities, social sciences, mathematics, physical sciences, biological sciences, and psychology) plummeted from 47% of all BA degrees to about 26%. This rapid decline followed a steady increase in the arts and sciences share (AS share) during the earlier post–World War II (hereafter postwar) years (*2*). The increase in the AS share occurred simultaneously with the most rapid expansion of higher education in the nation's history (Fig. 1).

Some students elect fields of study for reasons that are strictly intellectual; others may be influenced by job prospects, broad social and political trends, family background and parental pressures, and the curricular options made available by colleges and universities. An exhaustive analysis would require examination of all variables influencing the perceived returns (noneconomic as well as economic) related to investments by students and educational institutions of time and other resources in various fields of study.

The analytical framework used here is less comprehensive. We first consider the implications of broad developments in higher education, both demographic and curricular. Then we concentrate on an explanatory key of considerable power: the role of gender and the factors associated with the changing curricular choices made by men and women.

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Demographic Changes

During the 1960s, the traditional college-age population increased by slightly more than 50% as a result of the baby boom. The sectors of higher education that grew most rapidly (state colleges and large comprehensive institutions) were not the sectors that traditionally emphasized the arts and sciences (such as liberal arts colleges). Thus, these population-driven increases in enrollment should have reduced the AS share at the very time that it increased significantly.

A second demographic factor also raised enrollments during the 1960s: sharply higher age-specific enrollment rates. The percentage of the 18 to 24 age group enrolled in college increased from 15.9% in 1960 to 23.9% in 1970 (*3*). Normally, a rapid increase in enrollment rates would be expected to lead to a decline in the AS share of degrees conferred because new college entrants, representing a wider socioeconomic spectrum and a broader range of aptitudes, are likely to come disproportionately from families inclined to emphasize training for the job market rather than the more general values associated with an arts and sciences curriculum. Nonetheless, the AS share rose significantly between 1952 and 1969; it was only during the last years of the expansion (1969 to 1974) that it started to decline (Fig. 2A). Moreover, the most pronounced decline in the AS share occurred in those years (1974 to 1984) when enrollment rates and degrees conferred were roughly constant.

In short, the principal demographic variables (excluding gender) not only fail to explain the observed changes in AS shares, but they push in the wrong direction, putting more burden on other variables (*4*).

Institutional and Curricular Changes

Colleges are much more than passive actors in determining AS shares. They establish the curricular options open to students, based on institutional aspirations and other considerations such as the costs of entering (and leaving) various disciplines.

Hefferlin's examination of curricular change between 1962 and 1966 is helpful in explaining why the AS share rose so rapidly during the 1960s, a time of widespread reform and curricular expansion in higher education (*5*). Within vocational fields, depart-

ments dropped service offerings and adopted a more academic focus; at the same time, the arts and sciences became more inclusive. Some of the increase in the AS share may have reflected developments of this kind. There was also a movement away from preprofessional programs and toward greater emphasis on basic disciplines.

When the supply of students was increasing rapidly, "many formerly struggling institutions . . . [had] the opportunity . . . to move toward academic respectability. . . . Former vocational colleges . . . at last embraced general education" [(*5*), p. 67]. Favorable labor market conditions and the general mood of optimism that characterized much of the 1960s facilitated these curricular changes by encouraging students to assume that they could study whatever they liked, without having to worry about whether they would be able to get a job after graduation.

A reverse process took place in the 1970s. When the supply of students stopped rising, colleges had to compete vigorously to fill their classes and dormitories, and they were much less able to insist on their own academic priorities. The advent of more difficult economic conditions caused students to worry about their vocational prospects, and institutions that had moved aggressively to bolster their offerings in the arts and sciences now became more inclined to emphasize preprofessional and job-related offerings. Whereas educational institutions have considerable leeway to shape academic programs when the demand for education is rising (the 1960s), student preferences can be expected to have more impact on college curricula when demand is weaker and there is strong pressure on institutions to maintain enrollment (the 1970s).

The experiences of particular colleges and universities illustrate these propositions and remind us of the variety of forms of curricular adaptation. We take as examples the distribution of degrees conferred at six quite different institutions—Ball State, Muncie, Indiana; Cornell University, Ithaca, New York; Fairleigh Dickinson, Teaneck, New Jersey; the University of Michigan, Ann Arbor, Michigan; San Jose State, San Jose, California; and Swarthmore College, Swarthmore, Pennsylvania (Table 1).

Cornell and Swarthmore define one end of the spectrum: the number of degrees granted increased only modestly during the great expansion in higher education of the 1960s; and the AS share remained relatively high throughout the postwar years. At the University of Michigan, undergraduate programs expanded more rapidly, but at nothing like the rate of the comprehensive institutions discussed below; nor did the AS share decline significantly after 1970.

A sharp contrast is provided by Ball State, Fairleigh Dickinson, and San Jose State. All three institutions experienced tremendous growth during the 1950s and 1960s (with degrees granted increasing tenfold at Fairleigh Dickinson and three- to fourfold at Ball State and San Jose State). They also exemplify the trend toward more broadly based curricula. In 1954, Ball State was primarily a teacher's college that awarded almost no degrees in the arts and sciences; Fairleigh Dickinson and San Jose State awarded most of their BA degrees in business and other professional fields. During the 1960s, the AS share rose dramatically at all three institutions, reaching 30 to 40%. Between 1970 and 1986, the number of degrees conferred fell significantly at Fairleigh Dickinson and San Jose State and remained roughly stable at Ball State. During these years of contraction, the AS share also declined rapidly, presumably because these institutions had to accommodate the stronger vocational interests of their students.

Table 1. Arts and sciences share of degrees conferred at six institutions.

Institution	Degrees awarded in					
	1954		1970		1986	
	BAs (no.)	AS share (%)	BAs (no.)	AS share (%)	BAs (no.)	AS share (%)
Cornell	1234	49.3	1390	46.8	1693	47.1
Swarthmore	197	76.1	225	90.2	341	82.1
University of Michigan	2600	27.9	4444	57.4	5025	45.0
Ball State	596	2.5	2225	29.9	2568	13.3
Fairleigh Dickinson	245	29.0	2276	41.1	1602	19.6
San Jose State	864	25.1	4136	43.5	3458	26.2

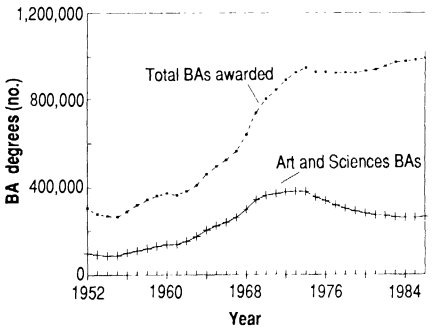

Fig. 1. Bachelor degrees conferred (1952 to 1986).

Thus, the overall increase in the AS share during the 1960s was associated with a fundamental change in the character of many state colleges and comprehensive institutions. It was at these rapidly growing schools, which had been heavily oriented toward professional and preprofessional programs in the immediate postwar years, that the sharpest increases in AS shares occurred. Subsequently, the flight from the arts and sciences was most pronounced at these same institutions, even though it also occurred at many research universities (*6*).

Choices of Majors by Men and Women

For the arts and sciences as a whole, the pattern of year to year changes in shares is remarkably similar for men and women: each time that the AS share for men rose (or fell), so too did the share for women (Fig. 2A) (*7*). Between 1954 and the mid-1980s, the AS share for men was consistently higher than the AS share for women; but this gender gap finally closed, and in 1986 the shares were precisely the same.

Taken field by field, however, male and female choices have diverged significantly. In the case of the humanities (Fig. 2), the differences by gender are especially striking: for men, the humanities share declined steadily from 1954 to 1986; but for women, the humanities share increased sharply only between 1954 and 1966, before falling to about 5%.

The social sciences enjoyed the greatest surge in popularity during the 1960s, when fields such as sociology were perceived by many as the source of answers to the societal problems that were so high on the national agenda. But this boom was short-lived, and the appeal of these subjects soon declined along with interest in the humanities (Fig. 2).

The launching of Sputnik in 1957 evoked a wave of concern about the nation's standing in mathematics and the related sciences, which was followed by a substantial rise in the proportion of undergraduates majoring in mathematics, especially among men (Fig. 2). Degrees conferred in the physical sciences also responded to the events of the mid-1950s, but in less dramatic fashion (Fig. 2). We suspect that increased numbers of students majored in mathematics because it was perceived as a pathway into many applied fields, including engineering and computer science. Interest in both

Table 2. Changes in shares of degrees conferred (percentage point allocations). M, male; F, female.

Field	1954 to 1970				1970 to 1986			
	Total change	Change due to			Total change	Change due to		
		M/F ratio	Choices			M/F ratio	Choices	
			M	F			M	F
Humanities	1.93	0.39	−0.80	2.34	−6.47	0.20	−1.64	−5.03
Social sciences	5.58	−0.26	3.87	1.96	−8.45	−0.20	−4.94	−3.31
Mathematics	1.91	−0.03	1.22	0.73	−1.76	−0.02	−0.99	−0.75
Physical sciences	−0.95	−0.14	−0.66	−0.15	−0.41	−0.16	−0.42	0.17
Biology	1.17	−0.12	1.06	0.24	−0.63	−0.03	−0.92	0.33
Psychology	2.07	0.00	1.32	0.74	0.08	0.23	−0.80	0.65
Total arts/sciences	11.70	−0.17	6.01	5.85	−17.65	0.01	−9.71	−7.95
Education	−0.39	1.14	−0.65	−0.89	−13.41	0.68	−2.39	−11.71
Business	−2.07	−0.79	−0.12	−1.16	11.84	−0.38	2.59	9.62

fields peaked between 1962 and 1964, and then declined steadily until new plateaus were reached—with, however, very different ratios of male to female students majoring in these subjects (about 1 to 1 in mathematics versus 2.5 to 1 in the physical sciences, respectively).

Historically, men have been more heavily represented than women in the biological sciences; however, this differential has narrowed markedly, perhaps partly as a consequence of increased participation by women in the field of medicine, and hardly any difference by gender remains (Fig. 2). Psychology is the only field in which differences by gender have widened. Between 1954 and 1970, the psychology shares for men and women were nearly the same; by 1986, women were more than twice as likely as men to major in this field (Fig. 2).

Gender-Related Components of Changes in Shares

Because men and women choose fields in different proportions, any change in the relative number of men or women in the student population will itself affect overall shares, even in the absence of changes by males and females in their choices of majors. In the postwar period there has been a marked increase in the relative number of BA degrees awarded to women. In 1954, women earned 39% of all BA degrees; by 1986, they earned 51%. For this reason, the male-female ratio must be considered along with male and female choices of majors in seeking to explain overall changes in shares of degrees conferred.

To isolate the part of the total change attributable to each of these three gender-related variables between discrete points in time (such as 1954 and 1970), we determined what the total AS share would have been in 1970 if the fields of study chosen by men had remained just as they were in 1954 while both the fields chosen by women and the male-female ratio were permitted to take on their actual 1970 values. The hypothetical AS share for 1970 calculated in this way is then subtracted from the actual AS share in 1970: the difference is the amount of the observed change in the AS share that can be attributed to the change in majors chosen by men (male choice) between these 2 years. Precisely analogous procedures were used to calculate the parts of the change in the total AS share associated with female choice and with changes in the male-female ratio (*8*).

Contrary to what one might have expected to find, changes in the male/female ratio never accounted for a significant part of the total change in the AS share; the changing choices of fields by both men and women were far more important (Table 2).

Extending this analysis to individual fields of study leads to an important finding: male choices have been more important than female choices in determining movements in shares in five of the six fields of study within the arts and sciences—in every field but the humanities. In the social sciences, for example, changes in male choices accounted for two times as much of the increase in share (measured in percentage points) between 1954 and 1970 as did changes in female choices (+3.87 versus +1.96 in Table 2); and 1.5 times as much of the decrease in share between 1970 and 1986 (−4.94 versus −3.31).

Why should male choices so consistently explain more of the

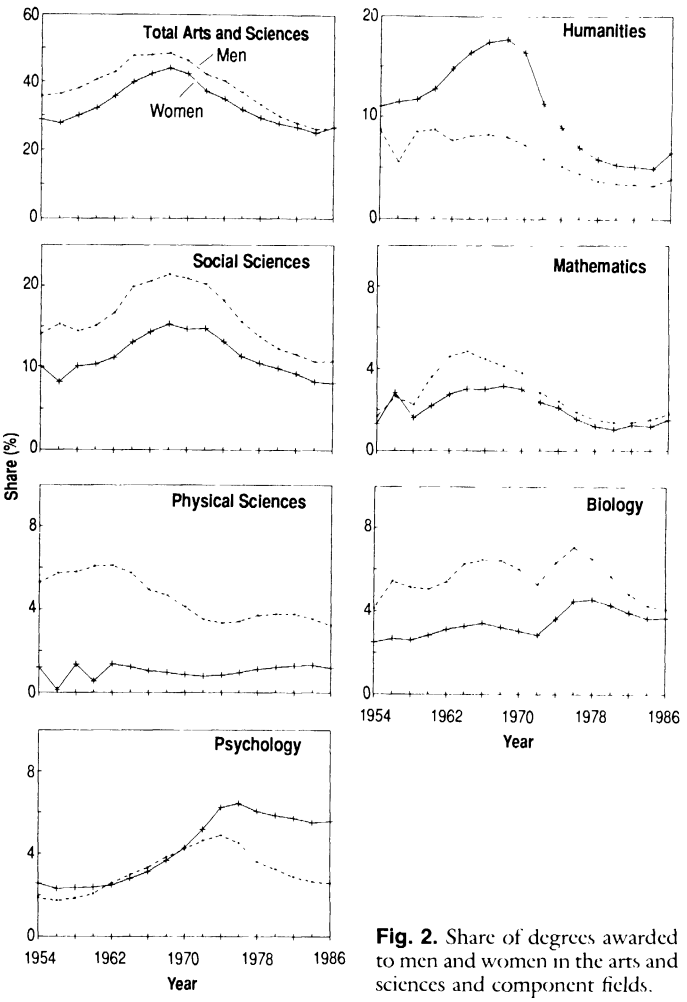

Fig. 2. Share of degrees awarded to men and women in the arts and sciences and component fields.

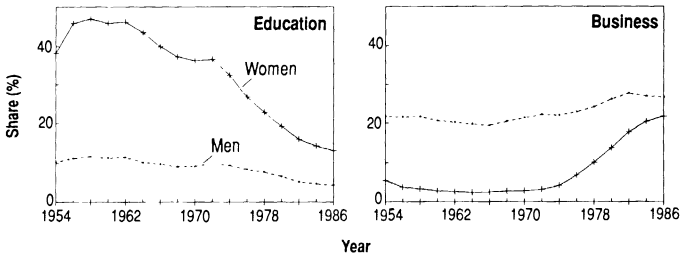

Fig. 3. Degrees awarded outside the arts and sciences.

change in shares than female choices, both when shares were rising and when they were falling? We have a simple hypothesis: as a rule, men have had more occupational options than women. Thus, when general economic conditions have changed, or when job opportunities have become more attractive in one sector and less attractive in another, men have had an easier time adapting.

In the humanities alone, the changing curricular choices of women have dominated the other determinants of changes in shares. As we saw earlier, men began moving away from the humanities as early as 1962, and continued to do so (more or less regularly) since then. Women, on the other hand, increasingly chose to major in the humanities between 1954 and 1970, and these changes were so powerful that they caused the overall humanities share to rise between these years in spite of the declining interest of men in these fields. Then, between 1970 and 1986, the declining participation of women accounted for more than three times the loss in share attributable to reduced interest in the humanities among men (Table 2). This pattern can be understood only by examining developments outside the arts and sciences.

Education and Business

Education and business are the largest fields of study outside the arts and sciences, and the changing appeal of these fields has also had the greatest impact on other curricular choices made by women (*9*). The increasing demand for teachers caused by the baby boom resulted in more women entering the field of education in the early and mid-1950s. By 1958, nearly half of all BA degrees awarded to women were conferred in education. Ever since, however, there has been an unrelenting decline, and by 1986, only 13% of all BA degrees earned by women were in education (Fig. 3A). Revolutionary changes occurred at institutions such as Ball State, which once were primarily teachers colleges and have since diversified their offerings. In 1954, over 90% of all degrees awarded to women at Ball State were in education; that figure fell to 64% in 1970 and to 18% in 1986.

Between 1958 and 1966, a large share of the women who might have gone into education migrated to the humanities. Other women, in relatively smaller numbers, elected to study the social sciences. These shifts are consistent with the educational backgrounds of most women at this time. It was easier for many of them—who, in earlier times, might have chosen to major in education—to choose these subjects than it would have been for them to major in fields that required radically different kinds of preparation, especially in mathematics.

The years from 1966 to 1974 can be thought of as a period of transition: women in increasing numbers decided not to major in education and determined that the humanities were not the best alternative. Some of them turned to fields such as biology and psychology. There was also a modest increase in interest in mathematics and the physical sciences, but the absolute numbers of women in these fields continued to be small.

By far the most significant developments took place in the field of business. Beginning in the early 1970s, there was an extraordinary increase in the relative number of women majoring in business (Fig. 3B) as a direct consequence, presumably, of the marked improvement in professional employment opportunities for women in related occupations. The business share of all degrees earned by women rose from 2.8% in 1970 to 21.7% in 1986. Whereas the business share of degrees earned by men also rose during these years, the rate of change was much more modest. In both business and education, then, the shifting patterns of degrees conferred have been dominated by the movements of women into and out of these fields (bottom rows of Table 2), with pronounced effects on interest in the humanities.

Implications

Fields of concentration chosen by men and women have converged substantially, and gender-related variables may have less influence on the pattern of degrees conferred in the future. It is unlikely, in our view, that men's choices of majors will dominate changes in shares within the arts and sciences, as they have over the past three decades.

The overall AS share of degrees conferred is likely to be more stable over the next few decades than it has been during 1954 to 1986. Some of the main factors responsible (in at least a proximate sense) for recent trends have run their course. In particular, greatly increased opportunities for women in fields outside the arts and sciences, such as business, have removed certain culturally imposed constraints that in the past induced comparatively large numbers of women to major in areas such as the humanities. We do not expect the flight from the arts and sciences to continue, and one implication is that the demand for faculty in these fields may be greater in the years ahead than recent projections suggest.

Perhaps the most significant developments will occur within the arts and sciences, since there is certainly no current equilibrium between men and women in their choices of majors such as physics. If more progress can be made in removing cultural barriers and in improving teaching and learning at the primary and secondary levels of schooling, women may participate much more fully in the math-intensive subjects. Marked changes have occurred in other fields, and these changes should encourage efforts designed to address what seems to us to be the most serious anomaly in the present pattern of degrees conferred (*10*).

REFERENCES AND NOTES

1. W. G. Bowen and J. A. Sosa, *Prospects for Faculty in the Arts and Sciences* (Princeton Univ. Press, Princeton, NJ, 1989), pp. 47–65.
2. BA degrees include both bachelor of science and bachelor of arts degrees. AS share is defined as the number of BA degrees awarded in the arts and science fields divided by the total number of BA degrees awarded in all fields. These data have been compiled from the *Earned Degrees Conferred Survey* (Department of Education, Washington, DC), for the years in question. Data from 1978 on are from the *Digest of Educational Statistics* (Department of Education, Washington, DC), which contains summary tables that were used to make the calculations reported here (for example, table 172, pp. 194–201, for 1986). For 1954 through 1976, the raw data were obtained from the annual volumes of the *Earned Degrees Conferred Survey* (for example, table 5, pp. 11–15, for 1968). Of the broad fields that are included in the arts and sciences, humanities and social sciences are the most difficult to define. For our purposes, the humanities include foreign languages, letters, philosophy, and religion (including theology in the early years). The social sciences include anthropology, archeology, criminology, demography, economics, geography, history, international relations, political science, sociology, urban studies, and other social sciences. Fields of study are never static, and changes over time in the boundaries between fields are inevitable. The most serious discontinuity occurred between 1955 and 1956, when the number of subfields in the *Earned Degrees Conferred Survey* increased from 69 to 160. In general, the new set of fields was structured so as to maintain a high degree of comparability with earlier data; however, this goal was not achieved fully (especially for the biological sciences),

and one result is the statistical "blip" in 1956 (Fig. 2). Between 1952 and 1962, first professional degrees were subtracted from all BA degrees to achieve maximum comparability with later years.

3. P. M. Seigal and R. Bruno, *School Enrollment—Social and Economic Characteristics of Students October 1982* (U.S. Bureau of the Census, *Curr Popul. Rep. Ser. P-20, No. 408*, Government Printing Office, Washington, DC, 1986), table A-4.
4. Other demographic variables were also considered. Specifically, neither the age profile of the student population nor its racial or ethnic composition correlate closely with the AS share [*Curr Popul. Rep Ser P-20*, October 1982, tables A-3 and A-4; National Center for Education Statistics, *The Condition of Education*, 1989, vol. 2, tables 2.5–3 and 2:6–1)].
5. J. B. Lon Hefferlin, *Dynamics of Academic Reform* (Jossey-Bass, San Francisco, 1971), especially chapter 3.
6. More complete data for the major sectors of higher education document this proposition [table 4.3 in (*1*), p. 56].
7. We define AS share for men as the percentage of all BA degrees earned by men that were awarded in the arts and sciences; we do not mean the percentage of all degrees in the arts and sciences that were earned by men rather than by women. Similarly, the humanities share for men is the percentage of all BA degrees earned by men that were awarded in the humanities.
8. The total AS share is related to the gender-specific shares as follows.

$$AS_T = AS_M R_M + AS_W(1 - R_M)$$

where AS_T is the total AS share; AS_M is the share for men; R_M is the percentage of all degrees awarded to men; and AS_W is the AS share for women.

9. Engineering is the other large field outside the arts and sciences, but it has been important quantitatively only for men; in 1986, the engineering share for women was still only 2.5%. Nursing is another field in which woman have sought degrees, and the nursing share of all BA degrees for women rose from about 3% in 1970 to a peak of 6.7% in 1980—largely as a result of the increasing technical sophistication of the field and the associated tendency for BA programs to replace certificate programs
10. We thank L. Cremin and L. Stone, as well as N. Rudenstine, H. Zuckerman, and other colleagues at the Foundation too numerous to mention individually, for helpful comments on drafts of this paper. Also, we thank K. Motihar and P. McNeil for assistance in assembling data for the six case-study institutions.

Scattering and Recoiling Spectrometry: An Ion's Eye View of Surface Structure

J. Wayne Rabalais

Recent developments in ion-scattering spectrometry have led to a surface crystallography that is sensitive to all elements, including hydrogen. Time-of-flight techniques for the detection of atoms scattered and recoiled from surfaces in simple collision sequences, together with calculations of shadowing and blocking cones, can be used to make direct measurements of interatomic spacings and adsorption sites within an accuracy of ≤0.1 angstrom. Time-of-flight detection of both neutrals and ions provides the high sensitivity necessary for nondestructive analysis. Structures are determined by monitoring the angular anisotropies in the scattered primary and recoiled target atom flux. Such surface and adsorption site determinations find application in such fields as catalysis, thin film growth, and interfaces.

Scattering experiments had their origins in the development of modern atomic theory at the beginning of this century. As a result of both the Rutherford experiment on the scattering of alpha particles (He nuclei) by thin metallic foils and the Bohr theory of atomic structure, a consistent model of the atom as a small massive nucleus surrounded by a large swarm of light electrons was confirmed. It was quickly realized that the inverse process, namely, analysis of the scattering pattern of ions from crystals, could provide information on composition and structure. This analysis is straightforward because the kinematics of energetic atomic collisions is accurately described by classical mechanics. Such scattering occurs as a result of the mutual Coulomb repulsion between the colliding atomic cores, that is, the nucleus plus core electrons. The scattered primary atom loses some of its energy to the target atom. The latter, in turn, recoils into a forward direction. The final energies of the scattered and recoiled atoms and the directions of their trajectories are determined by the masses of the pair of atoms involved and the closeness of the collision. By analysis of these final energies and the angular distributions of the scattered and recoiled atoms, the elemental composition and structure of the surface can be deciphered.

Ion-scattering spectrometry (ISS) with ion energies in the low kiloelectron volt range is the surface-sensitive analog of Rutherford backscattering spectrometry (RBS) (*1*). RBS is sensitive to long-range bulk structure through the use of ions in the million electron volt range. ISS as a surface analysis technique developed rapidly after the 1967 work of Smith (*2*), which demonstrated surface elemental analysis. Interest in ISS as a technique for investigating surface structure grew quickly after the 1982 work of Aono *et al.* (*3*), which showed that the use of backscattering angles near 180° greatly simplified the scattering geometry and interpretation. In 1984, Buck and his associates (*4*) demonstrated the high sensitivity of time-of-flight (TOF) detection of scattered particles for structural analysis. The recent coupling (*5*) of TOF methods with detection of both scattered and recoiled particles has led to the development of time-of-flight scattering and recoiling spectrometry (TOF-SARS) as a tool for structural analysis. Several research groups (*6–16*) throughout the world are now engaged in surface structure determinations using some form of kiloelectron volt ISS.

Basic Physics Underlying TOF-SARS

Two basic physical phenomena govern atomic collisions in the kiloelectron volt range. First, repulsive interatomic interactions, described by the laws of classical mechanics, control the scattering

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