of virus penetration, packaging, and exit, areas that are quite relevant to those of cancer.

2) Study of infection by influenza A virus, which highlights RNA replication, as well as budding processes. A considerable knowledge of this disease, including that of some virus-induced proteins, should facilitate this work.

3) Study of a protozoan infection such as trypanosomiasis or malaria which demands new and modern approaches. Infectious disease is responsible for 44 and 11 percent of the mortality rate in developing and developed countries, respectively (*7*). Although many of the parasitic diseases common in the developing countries are essentially confined to those countries, the effects of those diseases in causing world poverty, and ultimately in provoking world tensions, cannot be overestimated.

The theses presented in this proposal are a challenge to almost every biomedical discipline. The routes to the stepwise solution of the various scientific problems cannot be expected to involve mere repetitions of earlier successful investigations. Each biological system, etiological agent, enzyme, synthesis, and so forth, will provide its own new and special problems and difficulties; nevertheless, the existing and rapidly evolving capabilities of modern science and technology are clearly up to the tasks outlined above. The development of pharmacological science and skills is greatly needed in the development of therapy. There should be a positive gain to science in this area during the evolution of the project. Integrated efforts within the project should be most helpful in this aspect of the work, as well as in strengthening the chemical efforts. The studies should also contribute to cancer-related problems, and indeed such work will prepare for the possibility that many cancers may arise following the vertical transmission of certain viral genomes (*8*).

It has been suggested that the worldwide cure of infectious disease would exacerbate the problem of growing world population. However, as stated recently by McNamara for the World Bank (*9*), a decrease of infant mortality has been and will be a condition for a decrease in population growth rate in all developing countries.

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Prices of Physics and Chemistry Journals

New survey reports high prices that reduce access to needed publications for academic scientists.

F. F. Clasquin and Jackson B. Cohen

Scientific journals can be quite expensive. The 1976 subscription price for the *Journal of Organometallic Chemistry*, for example, was $961.50 and for *Nuclear Physics, A and B* was $1540. While these prices are extreme cases, the average subscription cost of journals for some scientific subjects is $100 or more (*1*), excluding abstracting and indexing journals (which are omitted here).

The high cost of journals has forced some scientific libraries to reduce drastically or eliminate entirely the purchase of books in order to maintain journal and other serial subscriptions (*2*). The scientific community is not unaware of the high cost of scientific journals or of the difficulties that this entails for libraries, as is clear from comments by Walsh and others (*3*). The scientific community in the United States, however, does not have satisfactory information on this subject because the two major American periodical price surveys have significant limitations insofar as scientific journals are concerned (*4*).

A New Survey

The annual American Library Association (ALA) survey (*5*) covers only U.S. periodicals and uses some price categories, such as chemistry and physics, which cover more than one subject. Clasquin's survey (*1*) shows prices for journals on lists selected from indexing or abstracting services such as *Physics Abstracts*, which are called authority groups. Since some authority groups include journals on more than one subject, the Clasquin survey does not necessarily provide price data by subject (*6*). Our new survey reported here is based on these earlier American surveys, but avoids their limitations in regard to scientific journals. Our survey uses specific—but separate—subject categories, and price averages and indexes, as in the ALA survey. It is also international in scope, is based on an authority group, and makes use of weighted averages, as in the Clasquin survey. The weighted average is a popularity factor; this factor gives the average cost of all subscriptions to each title on a given list which are sold through the F. W. Faxon Company periodical subscription agency to any of approximately 18,000 libraries. The weighted average may thus give a more accurate idea of average prices paid by libraries for titles on a given list than does the unweighted average. Since this weighted average is obtained from the sales records of one agency, it is not

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definitive, although it may be indicative because of the size of the agency. This new survey is limited to physics and chemistry journals since they are the most expensive scientific journals, according to the earlier surveys.

We used the 1975 *Science Citation Index* (*SCI*) subject list of "Source Journals Arranged by Category" as a starting point for the lists of physics and chemistry journals priced for this survey. This is an international list which covers the most important scientific journals (*7*) and thus provides a valid basis for determining journal price data. Moore (*8*) has pointed out, however, that this subject listing of *SCI* journals is not, nor was it intended to be, an instance of thorough indexing. There are some multiple subject categories, moreover, which cover both science and engineering. The journals listed in each of the *SCI* physical science categories (except mineralogy) and in multiple subject categories which include physical sciences, were, therefore, checked in other sources (*9*) to determine which covered physics and chemistry and were thus to be used in our survey.

In some instances, we followed Garfield's practice (*7*, p. 473) in dealing with certain bibliographic complications: we counted journals published in parts as one journal; if journals changed titles, we considered the former titles as the same journals; and if journals merged with other journals, we considered the earlier journals as though they were the journals resulting from the mergers. We also excluded multidisciplinary journals in parts that cover not only physics and chemistry but other sciences as well. Journals that cover both physics and chemistry were counted in both subject categories. To conform to an American National Standard definition of a periodical (*5*, p. 1604), titles published irregularly or less than three times a year were excluded. We priced 294 journals for this survey. Of these, 123 cover physics, 149 cover chemistry, and 22 cover both physics and chemistry. We excluded 16 journals for which we did not have prices (*10*). Prices from 1972 to 1976 were obtained from records stored in an IBM 370 data processing system used by the F. W. Faxon Company. Most 1967 prices were obtained from the 1967 *Faxon Librarians' Guide* and some from other sources. Since we had to use some 1968 and 1969 prices for 1967 averages, these averages, as well as the price changes shown between 1967 and 1976 are slightly in error. We have used institutional subscription rates where applicable.

Survey Results

Figures 1 and 2 are lists of the physics and chemistry journals priced for this survey. Tables 1 and 2 show physics and chemistry journal prices from 1967 to 1976. The 1975 *SCI* list of source journals contains many titles which began publication after 1967, the base year of our survey. It is largely for this reason that the number of titles is not the same each year (also, we did not have prices for some journals for some years). Because we were measuring average price changes of *SCI* source journals, we did not eliminate from our survey those source journals that began publication after 1967. Since we are interested in costs to libraries, we believe that price data which do not take important new

ACT MECHAN	COMM MATH P	J MACR S	NUCL ENG IN	REV G THERM
ACT PHYS AU	COMPUTER PH	J MAGN RES	NUCL FUSION	REV M PHYS
ACUSTICA	CONT PHYS	J MATH PHYS	NUCL INSTR	REV RO PHYS
ADV MOL REL	CZEC J PHYS	J MECH PHYS	NUCL PHYS	SOLAR PHYS
ADV PHYSICS	ELECTRO CO J	J MOL SPECT	NUCL SAFETY	SOL ST COMM
AM J PHYS	ENERGA ATOM	J MOL STRUC	NUCL SCI EN	SOL ST TECH
ANN PHYSICS	ENERGA NU M	J NON CRYST	NUCL TECH	SOV AT EN R
ANN PHYSIK	ENERGA NUCL	J NUC SCI T	NUOV CIM	SOV J NUC R
ANN PHYSIQ	ENERGY CONV	J NUCL MAT	OPT COMMUN	SOV PH AC R
APPL OPTICS	FOUND PHYS	J OPT SOC	OPT ENG	SOV PH SE R
APPL PHYS	HELV PHYS A	J PHYS	OPT QUANT E	*SOV PHYS
APPL PHYS L	HIGH TEMP R	J PHYS JAP	*OPT SPECTROS	SOLID
APPL SPECTR	I J PA PHYS	J PHYS CH S	(USSR)	STATE
ARCH R MECH	I J PHYSICS	J PHYS CHEM	OPTICA ACTA	*SOV PHYS
ASTROPHYS J	I J THEOR P	J PHYSIQUE	ORG MASS SP	CRYSTALLOGR
ATOM ENER A	IEEE NUCL S	J PLASMA PH	PHILOS MAG	*SOV PHYS
ATOM ENER R	IEEE SON UL	J POL SCI	PHYS FLUIDS	JETP
ATOM STROM	INFRAR PHYS	J QUAN SPEC	PHYS LETT	*SOV PHYS
ATOMKERNENE	INT J A RAD	J SOL ST CH	PHYS MED BI	TECH PHYS
ATOMWIRTSCH	INT J HEAT	J SOUND VIB	PHYS REV	*SOV PHYS USP
ATT ANL R F	INT J RAD P	J STAT PHYS	PHYS REV L	SPECT ACT
AUST J PHYS	INT J THEOR	J VAC SCI T	PHYS SCR	SPECT LETT
B AM PHYS S	J ACOUST SO	JAP J A PHYS	PHYS ST S	SURF SCI
*BULL ACAD	J APPL PHYS	JETP LETTER	PHYS TODAY	THIN SOL FI
SCI USSR,	J BR NUCL E	KERNENERGIE	PHYSICA	TRANSP THEO
PHYS SER	J CHEM PHYS	KERNTECHNIK	PLASMA PHYS	ULTRASONICS
CAN J PHYS	J COMPUT PHYS	LETT NUOV C	PROG T PHYS	VACUUM
CAN J SPECT	J FLUID MEC	MOL PHOTOCH	*RADIO ENG	VAKUUM-TECH
CHEM PHYS	J GEOMAGN G	MOLEC PHYS	ELECTRON	VISION RES
COLLOID J	J HEAT TRAN	NOUV R OPT	PHYS (USSR)	Z ANG MA ME
COM PA MATH	J L TEMP PH	NUCL ENG DE	REP PR PHYS	Z PHYS

Fig. 1. The 145 physics journals priced for the survey. Abbreviations without asterisks are from the *Science Citation Index (SCI)*. Abbreviations with asterisks are from the *Bibliographic Guide for Editors and Authors* and are for the English translations of the Russian journals listed in the *SCI* with Russian titles. The list covers journals which cover both physics and chemistry.

ACC CHEM RE	CHEM SCR	J AM OIL CH	J ORG CHEM	*POLYMER SCI
ACT CHEM	CHEM SOC RE	J ANAL CHEM	*J ORG CHEM	USSR
ACT CRYST	CHEM TECH	J AOAC	USSR	PRZEMY CHEM
ADV MOL REL	CHEM ZEITUN	J APPL CH B	J ORGMET CH	PUR A CHEM
ANAL LETTER	CHEM ZVESTI	J APPL CHEM	J PHYS CH S	RADIAT RES
ANALYST	CHEMTECH US	J APPL CRYS	J PHYS CHEM	RADIOCHEM ACT
ANALYT CHEM	CHIM IND M	J APPL ELEC	J POL SCI	REC TR CHIM
ANALYT CHIM	CHIMIA	J APPL PHYS	J PRAK CHEM	REV CHIM MI
ANGEW CHEM	CLIN CHEM	J CATALYSIS	J RAD CHEM	REV I F PET
ANGEW MAKRO	CLIN CHIM A	J CHEM EDUC	J SA CHEM I	REV RO
ANN CHEM	COLL CZECH	J CHEM EN D	J SOL ST CH	CHIM
ANN CHIM	COLLOID J	J CHEM INF	J STEROID B	ROCZN CHEM
ANN CHIM FR	COLLOID P S	J CHEM PHYS	J STRUCT CHEM	*RUSS CHEM
ARM KHIM ZH	COORD CH RE	J CHEM S	J THERM ANA	REV
AUST J CHEM	CROAT CHEM	J CHEM THER	JAP ANALYST	*RUSS J INORG
B ACAD SCI	DENKI KAG	J CHIM PHYS	KEM TIDSKR	CHEM
B CHEM S J	ELECTR ACT	J CHIN CHEM	KOBUNSH RON	*RUSS J PHYS
B POL CHIM	ERD KOH EPB	J CHROM SCI	MACROMOLEC	CHEM
B S CH FR	EUR POLYM J	J CHROMAT	MAGY KEM FO	SOL ST COMM
B S CHIM BE	FET SEI ANS	J COLL I SCI	MAGY KEM LA	*SOV PHYS
BER BUN GES	FINN CHEM L	J CRYST GR	MAKROM CHEM	CRYSTALLOGR
BIOORG CHEM	GAZ CHIM IT	J ELCHEM SO	MATER RES B	STEROIDS
BIOPOLYMERS	HELV CHIM A	J ELEC CHEM	MICROCHEM J	SURF SCI
CAN J CHEM	HIGH TEMP S	J ELEC SPEC	MIKROCH ACT	SYN REAC IN
CAN J SPECT	I J CHEM	J FLOURINE	MOL PHOTOCH	SYNTHESIS
CARBOHY RES	INORG CHEM	*J GEN CHEM	MOLEC PHYS	TALANTA
CARBON	INORG CHIM	USSR	MONATS CHEM	TETRAHEDR L
CATAL REV	INORG NUCL	J HETERO CH	*MOSCOW UNIV	TETRAHEDRON
CHEM BER	INT J A RAD	J IND CH S	CHEM BULL	THEOR CHIM
CHEM INSTR	INT J CH K	J INORG NUC	NIP KAG KAI	THIN SOL FI
CHEM LETT	INT J PEPT	J LABEL COM	OMR ORG MAG	UAR J CHEM
CHEM LISTY	INT J QUANT	J LESSC MET	ORG MASS SP	X-RAY SPECT
CHEM P LETT	INT J RAD P	J MACR S	PHOTOCHEM P	Z ANAL CHEM
CHEM PHYS	ISR J CHEM	J MED CHEM	POLYM J	Z ANORG A C
CHEM PHYS L	J AM CHEM S	J MOL STRUC	POLYMER	Z CHEM
CHEM REV	J AM LEATH	J NON CRYST	POLYMER ENG S	Z PHYS CH L

Fig. 2. The 171 chemistry journals priced for the survey. The list includes journals which cover both physics and chemistry. The legend for Fig. 1 explains the abbreviations used.

scientific journals into account will be less reliable than our data which do (*11*). A comparison of 1976 data in Tables 1 and 2 shows that physics journals are not only significantly more expensive than chemistry journals but also that prices of physics journals have been increasing at a faster rate than prices of chemistry journals. The average 1976 price for physics journals was $165.71. The index figure was 341.32, or more than double the U.S. Consumer Price Index of 170.5 for all items for 1976. (The year 1967 is the base period for the U.S. Consumer Price Index as well as for the price indexes in our survey.) The average 1976 price for chemistry journals, on the other hand, was $148.81 and the index figure was 296.26, or nearly 75 percent greater than the Consumer Price Index for 1976. The tables show that at least since 1972 there has been double-digit inflation in the cost of both physics and chemistry journals.

It is instructive to compare 1976 data from our survey with 1976 data for other subjects from earlier surveys. We chose ALA data because of its index numbers and Clasquin data for subjects for which the ALA survey does not have appropriate subject categories. ALA 1976 data (*5*) for selected subjects are shown in Table 3. Clasquin's (*1*) 1976 average price for journals selected from *Biological Abstracts* was $48.23 and for journals from *Mathematical Reviews* it was $81.23. Even if we allow for differences between surveys, it is clear that basic science journals, especially for physics and chemistry, are considerably more expensive than journals for other disciplines. While other surveys show this, the present survey makes the point even more cogently.

Factors in Price Increases and Differences

According to Walsh (*3*, p. 1275), scientific journals have increased in price only in part because periodicals in general have become more expensive as costs of editorial work, postage, paper, and printing have been increasing. The growth of scientific specialization, which has created a profusion of specialized journals, has also been a major factor. This is because the narrower the subject scope of specialized journals, the fewer subscribers they have, and the greater their cost per subscription. Another important factor in the increased cost of scientific journals is growth in the volume of scientific literature. Matarazzo (*12*) found that at the same time the subscription cost of 20 physics journals increased 202 percent between 1959 and 1969, the number of pages published by these journals increased 147 percent. Garside (*13*) showed that the average cost per page of the physics journals studied by Matarazzo increased only 16.4 percent. Increased subscription costs for these physics journals are thus seen to be due more to increases in the number of pages published rather than to increases in cost per page.

Data from a study by Fry and White (*14*) show that, of American journals they surveyed in 1973, those in the pure sciences had about two and a half times the median number of pages as did journals in the social sciences and humanities. The mean cost per page of pure science journals (*14*, pp. 246–250) was higher by 17.9 percent for journals with one subscription rate and higher by 36.36 percent at the institutional rate for journals which also have an individual rate than it was for social science journals, which had the lowest cost per page of any discipline. The 1973 ALA average price (*5*, pp. 1601–1603) for chemistry and physics journals was almost six times that for political science journals, almost five times that for business and economic journals, and five times that for sociology and anthropology journals.

From these data, it seems clear that the greater subscription cost of American journals in the physical sciences as compared with American social science journals is due far more to their larger number of pages than it is to their higher cost per page. Fry and White (*14*, p. 24) also suggest that the subscription rate increases for foreign journals purchased by American libraries may be due not only to "normal" increases but also to U.S. dollar devaluations in recent years, and they note that this factor requires further study.

Table 1. Physics journal prices. The number of titles is not the same for each year because prices were not available for some titles for some years. A total of 44 titles in both Tables 1 and 2 did not begin publication until after 1967. Also, prices were not given for some titles for some years in the sources used. The percent change of the average price (column 5) is the change from the preceding year listed. In column 6 the price index for the average price with 1967 as the base year is listed. In column 7 the U.S. Consumer Price Index (CPI) for all items for each year was obtained from (*29*).

Year (1)	Titles priced (2)	Price		Percent change (5)	Index (6)	CPI (7)	Weighted average (8)	Price range (9)
		Median (3)	Average (4)					
1967	122	$ 35.62	$ 48.55		100.00	100.00	$ 43.66	$3.00–306.00
1972	139	62.09	88.01	81.28	181.28	125.3	82.29	2.40–734.75
1973	144	70.53	103.85	18.00	213.90	133.1	94.50	2.40–964.90
1974	145	86.80	127.46	22.73	262.53	147.7	118.74	3.05–1123.20
1975	145	103.85	148.85	16.78	306.59	161.2	127.94	2.60–1368.80
1976	145	118.48	165.71	11.33	341.32	170.5	142.29	7.74–1540.80

Table 2. Chemistry journal prices. Column headings are explained in the legend of Table 1.

Year (1)	Titles priced (2)	Price		Percent change (5)	Index (6)	CPI (7)	Weighted average (8)	Price range (9)
		Median (3)	Average (4)					
1967	135	$37.82	$50.23		100.00	100.00	$ 45.37	$2.60–250.00
1972	156	58.33	83.71	66.65	166.65	125.3	85.88	6.00–455.00
1973	161	64.58	96.06	14.75	191.24	133.1	95.65	6.00–562.60
1974	167	77.21	111.97	16.56	222.91	147.1	104.92	6.00–734.40
1975	169	91.07	131.43	17.38	261.66	161.2	122.81	7.00–1000.00
1976	171	99.30	148.81	11.23	296.26	170.5	139.08	7.50–961.50

Implications of Journal Prices

There has been a significant decrease in the growth rate of expenditures by American academic libraries in recent years (*15*). While the average annual rate of increase of all academic library expenditures ranged from 12 to 15 percent from 1967–1968 to 1970–1971, it declined to 5 percent from 1972–1973 to 1974–1975. Expenditures for books and microforms grew at an annual average rate of 8 to 13 percent from 1967–1968 to 1970–1971, but declined to 1.4 percent from 1972–1973 to 1974–1975, while during the latter period book prices increased 4 percent per year. Expenditures for periodical subscriptions from 1972–1973 to 1974–1975 increased at an annual average rate of 18 percent as periodical subscription costs reportedly increased by 17 percent.

When this decline in the growth of academic library expenditures is combined with both the high dollar cost of physics and chemistry journals, as compared to the cost of journals for other subjects—especially journals for nonscientific subjects—and the high rate of increase in subscription costs for the higher-priced scientific journals, the implications are clear, and they are serious.

In libraries in academic institutions where graduate studies and research in the sciences are important, scientific journals tend to consume the lion's share of library funds available for books and journals. The Queens College Library, for example, spent 70 percent of its periodicals budget to subscribe to 1147 scientific journals in 1976. Yet this 70 percent of the periodicals budget purchased only 26.84 percent of the library's 4274 periodical titles (*16*). The ratio of percent of scientific journal titles to percent of total journal expenditures used for scientific journals was 1 to 2.61; that is, each 1 percent of the number of scientific journal title subscriptions required 2.61 percent of the total library expenditures for journals for all subjects (*17*).

Using F. W. Faxon Company computer records, we made similar calculations for two other academic libraries with serial collections comparable in size to that of the Queens College Library. Both of these libraries use the F. W. Faxon Company as agent for the purchase of virtually all of their periodical and other serial subscriptions (*18*). In 1976, Library A spent 39.86 percent of its serials budget to subscribe to 947 scientific serials. Yet this 39.86 percent of serials expenditures purchased only 18.05 percent of the library's 4980 serial titles. The ratio of percent of scientific serial titles to percent of total serials expenditures used for science was 1 to 2.21. Library B spent 38.49 percent of its serials budget to subscribe to 596 scientific serials in 1976. This 38.49 percent of serials expenditures purchased only 14.42 percent of the library's 3893 serial titles. The ratio of percent of scientific titles to percent of total serials expenditures used for science was 1 to 2.67. It is significant that in all three instances each 1 percent of scientific titles absorbed more than 2 percent of each library's total journal or serials expenditures. This was true whether the percent of the number of scientific titles was 26.84 or 18.05 or 14.42, and whether this percent of scientific titles consumed 70, 39.86, or 38.49 percent of the total periodicals or serials budget.

Table 3. ALA 1976 data for selected subjects [adapted from (*5*)].

Subject	Average price	Index
Business and economics	$16.98	225.2
Chemistry and physics	86.72	354.2
Engineering	31.87	317.7
Fine and applied arts	12.42	185.1
History	11.94	197.7
Literature and language	11.60	215.6
Medicine	47.47	244.9
Political science	13.09	211.8

Fry and White (*14*, pp. 13 and 38) have found that, because of budgets which are growing slowly or even declining and because of rapidly increasing journal prices, libraries of nearly every type and size have been cutting down on book expenditures in order to meet increased periodical costs. We believe our data show that the reductions in book purchases by libraries to pay for periodical subscriptions, reported by Fry and White, is due in many instances chiefly to the high cost of scientific journals, which absorb a disproportionately large share of many academic library book and journal budgets. It is our further belief, although we lack conclusive data, that for all but the richest academic libraries there probably have been and will continue to be decreases in the number of any or all of the following: (i) physics and chemistry journal subscriptions; (ii) journal subscriptions for all sciences; and (iii) purchases of scientific books. De Gennaro (*2*) has noted that some scientific and technical libraries are already spending 80 to 100 percent of their book budgets on journals and other serials.

In the face of high subscription costs, furthermore, departmental and personal subscriptions to scientific journals are likely to decrease, with a consequent growing reliance on the library as a journal source. Resource sharing arrangements between libraries—either for photocopies or interlibrary loan—are assuming increasing prominence in order to meet reader needs for books and journals that cannot be purchased due to lack of funds (*19*). For publishers, the decrease in library journal subscriptions and book purchases will reduce publisher income and create additional pressure for price increases, further reducing library ability to purchase scientific journals and books.

The acquisitions crisis in academic science libraries is not due to the indiscriminate, wholesale purchase of all available journals, as some scientists believe (*20*). It is due rather to the growing inability of these libraries to purchase essential standard journals and new books. The small- and medium-sized scientific collections used by most researchers and students—as distinct from the large research collections of several hundred thousand volumes or more—will come nowhere near exhaustiveness in number of journal subscriptions and will of necessity be highly selective collections. Rather than spending their limited acquisitions budgets on thousands of obscure journals and other serials of limited interest, hard-pressed academic libraries more likely are spending the preponderance of their funds for scientific publications on many of the same essential, but expensive, journals.

A preliminary analysis of the extent of duplication of scientific journal subscriptions in libraries of 18 units of the City University of New York (CUNY) tends to support this assumption. This analysis was based on titles listed in the *CUNY Checklist of Scientific, Technical and Medical Periodicals* (*21*), which contains an estimated 3275 titles. Nearly 25 percent (796 journals) appear on a list of the 1000 most cited journals in science and technology (*22*). This means that they are common, widely held titles. The number of CUNY subscriptions to the first 25 of the 1000 most cited journals totaled 224, or an average of 8.96 subscriptions per title. Any library which purchased all 25 titles would have paid $6794.05 for them at an average cost of $271.76 per title. The total 1976 cost of these 224 subscriptions to the 25 journals for these 18 libraries was $48,258.10. These data suggest that essential, standard scientific journals are consuming library acquisitions budgets at a prodigious rate, leaving little money for purchase of other publications.

In the price data we have produced,

there are also implications connected with the new copyright law, effective 1 January 1978, which contains a prohibition against systematic copying (*23*). "Systematic copying" is defined as copying from a journal done by a library which subscribes to the journal for another library which is using the copy as a substitute for a subscription to that journal. Because of the prohibition against systematic copying, we believe that regional resource sharing between libraries in the form of photocopies from journals will become virtually impossible. Since both money and space are finite, libraries have in the past been forced to engage in systematic copying agreements in order to make a greater number of different periodical titles available within a region than would be otherwise possible. The diversity of needed scientific journal titles held within a region depends on the ability of libraries to obtain photocopies of papers in journals that they cannot afford to buy from neighboring libraries on a reciprocal basis. If the prohibition against systematic copying remains the law, scientific libraries will be forced to spend their limited budgets almost exclusively on journals of the widest circulation—which would suffer least from systematic copying—and forego subscriptions to specialized journals of limited circulation, which would benefit most from the practice of systematic copying. Given the present difficult financial straits of academic libraries, we believe that scientists and student scientists will find themselves increasingly unable to obtain quickly the texts of papers that appear in journals which their own libraries can neither afford to buy nor are legally able to obtain in copy form for them. This, of course, will eventually severely hamper the progress of scientific and technical research in this country (*24*)

Reports of research do not have to be published in journals. They could be published in less expensive forms; for example, digests, separates, or microforms. Fry and White (*14*, p. 19) report that the use of journal substitutes such as these are being thoroughly studied, but they have so far had little impact on journal publication. This is largely because researchers have not usually been willing to accept publication in journal substitutes as equal to publication in journals. Until such time as acceptable alternatives to journals are found, therefore, scientific libraries and the scientific community must deal with the current problems which ensue from their high cost (*25*).

Financial Aid for Science Libraries

The high cost of scientific journals, as we have indicated, absorbs a disproportionately large share of many academic library acquisitions budgets and has, in such instances, impeded the acquisition of scientific books and of books and journals for all other subjects. When scientists become aware of this, it is hoped that they will be willing to view current journal lists at their institutions as critically as possible and to agree to cancellations of subscriptions to all infrequently used journals. They may also be—indeed must be—more selective in their requests for new journals. If our assumptions regarding the implications of the high cost of commonly used scientific journals are correct, however, this will not be sufficient to deal with these problems. It is equally important for scientists, administrators of academic institutions, and grant and contract administrators to be aware of these problems in order to help science librarians to obtain supplementary budgetary assistance to purchase the journals needed for education and research by the scientists and student scientists whom they serve. This supplementary budgetary assistance should come in the form of increased support from their own institutions where possible. Given the present depressed financial state of academic institutions, this is unlikely to occur except in unusual instances. Supplementary budgetary assistance, if it comes at all, therefore, is more likely to come from federal grant and contract support specifically earmarked for library acquisition of scientific journals and books (*26*).

Under the existing system, academic science libraries often receive little or no benefit from overhead funds that are part of federal research grants and contracts. Instead of including library costs of research grants and contracts with overhead or indirect costs, as is now done, we propose that a separate scientific library grant should be created, one which is not tied to research grants and contracts. Any academic institution that conferred advanced degrees in accredited programs in the natural sciences would be eligible to apply for this new grant. Initial grants would be limited to a maximum of $50,000 per year, but this would be increased each year to take increasing publication costs into account. For each $2 spent on journals and books in the natural sciences in a given year, a library would receive $1 in grant funds, which could only be used for purchase of journals and books in the natural sciences (*27*). If such a grant is not created, federal grant and contract funds might be prohibited from being used for the purchase of books and journals by individual researchers and channeled to support library collections. A library component appropriate to each grant or contract should mandate the library acquisition of publications in order to make them available to all library users and not just to the particular researchers who may have a personal need for them at the moment. These are stopgap measures, however, and would leave the underlying problem unresolved.

In our proposal for federal aid for science libraries, we are open to criticism as being unfair to other disciplines. Our case for such federal aid, however, rests squarely on two basic facts. Journals in the sciences, as we have emphasized, are, on the average, many times more expensive than are journals for other disciplines. This means, as our data show, that it can cost much more to maintain journal collections in the sciences than it does for other disciplines. Our plea for federal aid to science libraries, furthermore, is based not only on their clear need, but also on the need to make more library funds available to meet the needs of other disciplines. We believe, as we have indicated, that our data show that the cost of science journals is consuming a disproportionately large share of the limited funds available for books and journals in many academic libraries, and therefore less money is available not only for science books, but for books and journals for other subjects as well. The high cost of science journals is thus making academic library acquisitions difficult for all subjects, and not just in the sciences, at least in libraries where graduate studies and research in the sciences are important. This will continue to be the case unless federal aid such as we have proposed is forthcoming.

Scientific progress, as is generally acknowledged, is expensive. Scientific education and research frequently require well-equipped laboratories with sophisticated, expensive scientific instruments. It is not uncommon for scientific instruments to cost upward of $100,000. Expenditures of this magnitude are usually not made from regular funds, but from grant funds. A ^{13}C nuclear magnetic resonance spectrometer obtained with the aid of federal grant funds for one unit of the CUNY, for example, cost about $175,000. The high cost of scientific equipment such as this is a recognized cost of scientific research and education. The high cost of scientific publications—especially journals—also needs to be acknowledged as a basic component of the expense of scientific research and education.

Scientists who have been frustrated in attempts to obtain needed journal articles or books which libraries at their institutions ought to have bought but could not afford to buy know how much of their limited time is wasted in efforts to use inadequate library resources. American society has been willing, though of late somewhat grudgingly, to support basic scientific research. That support must include the libraries which acquire, organize, and make available for use the reports of research published in the journals which are an essential component of the scientific enterprise (*28*).

Summary

We have presented price data for the decade 1967–1976 for physics and chemistry journals, which two earlier price surveys show are the most expensive scientific journals. Whereas this survey is based on earlier ones, nevertheless, it avoids their limitations in regard to scientific journals. Journals selected for pricing are those used as source publications for the *SCI*. The *SCI* list of source publications provides a valid basis for determining scientific periodical price data since it covers the world's most important scientific journals. Survey results show that the average prices of physics journals have been increasing at a faster rate than prices of chemistry journals, that the 1976 index figure for physics journals is more than twice that of the U.S. Consumer Price Index for June 1976, and that the index figure for chemistry journals is nearly 75 percent greater than that for the Consumer Price Index. When compared with prices of journals for other subjects, prices of scientific journals are usually many times higher. Prices of scientific journals are also increasing at a faster rate than prices of journals for other subjects. The implications of these facts are serious.

There is evidence of an acquisitions crisis in academic science libraries. This crisis is due largely to the high cost of essential, standard scientific journals as well as to a sharp decline in the growth rate of academic library expenditures since 1972–1973. Scientific journals are so much more expensive than journals for other subjects that purchasing them is costing many academic libraries a disproportionately large share of their acquisition funds. The Queens College Library, for example, spent 70 percent of its 1976 periodical subscription funds for the purchase of scientific journals which numbered only 26.84 percent of its total periodical subscriptions. Data from three academic libraries show that each 1 percent of the number of scientific journal or serial subscriptions absorbed more than 2 percent of the total library journal or serial expenditures for all subjects. For chemistry, we must also note the high cost of two publications which are not primary journals. *Chemical Abstracts* cost colleges and universities $3000 in 1976. Its *10th Collective Index* for 1977–1981, due in 1982, costs $7750 under one of several payment plans. Ten volumes of Beilstein's *Handbuch der Organischen Chemie* cost the Queens College Library $4971 in the 1975–1976 academic year. Both publications are indispensable for many academic chemistry collections. When combined with the costs of scientific journals, however, they add greatly to the burden of the abnormal acquisition costs which academic library science collections must bear. This budgetary distortion threatens the continued ability of many academic libraries to purchase not only scientific journals, but scientific abstracting services, treatises, and books also, as well as books and journals for all nonscientific subjects. What is needed is recognition by the scientific community of the fact that scientific publications, especially journals, are abnormally expensive, and that academic libraries need supplementary budgetary assistance in the form of federal grant support to purchase scientific journals and books just as such assistance is given to purchase expensive scientific equipment.

References and Notes

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4. Periodical prices are also published annually in England. See *Libr. Assoc. Rec.* **78**, 244 (1976). Data from this survey, presented in British currency units, cannot be readily used in the United States. We are not told the titles of journals priced, only that they are the "more important" ones to which scholarly and special libraries subscribe.
5. N. B. Brown, *Libr. J.* **101**, 1600 (1976).
6. Clasquin introduced price data by subject in his 1976 survey (*1*, pp. 2017–2019). This data is of two types. One type gives 3-year price averages for journals in nine subject categories, which include physics and chemistry, but the lists of journals used for pricing are not identified. The other type gives the same 3-year price averages for journals to which five university libraries subscribe in the same nine subject categories. There were significant differences in these averages for specific subject categories because of differences in subscription lists of the five institutions as well as because of differences in 1- or 3-year ordering plans used by them.
7. E. Garfield, *Science* **178**, 471 (1972).
8. J. R. Moore, *J. Am. Soc. Inf. Sci.* **24**, 360 (1973).
9. *Ulrich's International Periodicals Directory, 1973–1974* (Bowker, New York, ed. 15, 1973), and earlier editions, was the source chiefly used. We also used *New Serial Titles* when we could not locate a title in *Ulrich's*. The subject content of each journal was determined from *Ulrich's* by using its index to locate journals listed under more than one subject heading in its main classified subject section, and by using Dewey Decimal classification numbers in journal listings that had them. Journals covering physics and chemistry were used in our survey even if they were also assigned to other subjects, as long as they were not published in parts.
10. Prices for these journals were not given in the sources used. We would have had to write to publishers for the information. Many of the journals are foreign. Because of the fluctuating currency exchange rates, prices for foreign journals must be calculated at the exchange rate prevailing for each year needed. Rather than write, wait for replies, and make the calculations, we excluded these journals from the survey.
11. If we deleted titles that began after 1967, we would have had to eliminate many essential journals that libraries are obliged to buy, such as *Accounts of Chemical Research*, which began publication in 1968. Compilers of other periodical price data (*5*, p. 1604) have not been able to use the same titles year after year because of the incessant change and complication that is characteristic of journal publishing and of which Garfield (*7*, p. 473) has given a good description.
12. J. M. Matarazzo, *Spec. Libr.* 63 58 (1972).
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14. B. M. Fry and H. S. White, *Economics and Interaction of the Publisher-Library Relationship in the Production and Use of Scholarly Journals*, PB-249108 (National Science Foundation, Office of Science Information Service, Washington, D.C., 1975), pp. 181–182 (available from National Technical Information Service, Springfield, Va.)
15. T. Samore, in *Bowker Annual of Library and Book Trade Information* (Bowker, New York, ed. 21, 1976), p. 238.
16. Fry and White (*14*, p. 49) divided academic library periodical collections into six strata based on the number of periodical titles held. In stratum 5, the number of periodical titles ranges from 2000 to 4999. In stratum 6, the number of periodical titles is 5000 or more. The number of periodical titles in the Queens College Library is thus near the upper end of the stratum that is next to the stratum with the largest number of periodical titles.
17. O. H. Mosely, Jr., *Science Library Annual Report, July 1975 to June 1976* (Queens College, Paul Klapper Library, Flushing, N.Y., 1976), p. 2). The linking of the percentage of the total periodicals budget required by scientific periodicals with the percentage of all library periodical subscriptions that have scientific titles appears to have been originated by O. H. Mosely, Jr., former head of the Queens College Science Library. We derived the ratio described in the text from his figures.
18. The Faxon figures for libraries A and B are not exactly comparable to the Queens College figures, although we believe that they are nonetheless indicative of the pattern of academic library expenditures for scientific journals. The Faxon figures include all serials, not just journals. They do not include a substantial number of "bill later" titles—765, or 12.73 percent, of the total number of titles for library A and 402, or 8.87 percent, of the total number of titles for library B. "Bill later" titles are those for which subscription rates are not available until after the subscription year has begun. The majority of such titles are annuals or other serials that do not meet the definition of a periodical used in our survey and therefore would have been excluded. For library A, the percent of scientific titles of the total number of serials, both billed and bill later, was 17.15, as compared to 18.05 when "bill later" titles were excluded. For library B, the percent was 14.14 for scientific titles, both billed and bill later, compared to 14.42 percent when bill later titles were excluded.
19. Fry and White (*14*, p. 86) predicted that by 1975 (their report covered the years 1969 to 1973) academic library journal cancellations might exceed new subscriptions. They reported that there has been a decline in individual subscriptions to scholarly journals (*14*, p. 17). They also reported increasing resource-sharing activity among libraries (*14*, p. 12).
20. A group of chemists claim that there are too many chemical journals, that the money that libraries spend on unnecessary chemical journals

would be better spent on research, and that libraries feel constrained to "buy every journal published irrespective of its overall quality" [see C. J. Ballhausen *et. al.*, *Chem. Eng. News* **51** (No. 50), 44 (1973)].
21. J. B. Cohen, Ed. *CUNY Checklist of Scientific, Technical and Medical Periodicals* (Hunter College Library, New York, 1975).
22. *Journal Citation Reports, Journal Ranking Package* (Institute for Scientific Information, Philadelphia, 1973).
23. *Am. Libr.* 7, 609 (1976).
24. It [*Coll. Res. Libr. News* **68** (No. 3), 72 (1977)] is reported that the National Commission on Library and Information Science (NCLIS) is at work on a plan for a national periodicals system, which would operate within the copyright law. A feature of this system would be one or more national periodical centers with a comprehensive collection, which would lend periodicals or supply photocopies of articles. A final report of the task force at work on this plan is due early in 1977. A national periodicals system may help to alleviate problems posed by the new copyright law as well as by the high cost of scientific journals. But we will not know until such a plan is put into operation. In the meantime, we must deal with the problems described in this article.
25. We have no assurance that alternative forms of publications will be inexpensive. The *Journal of Chemical Research*, which began in 1977, and which is a joint publication of the British, German, and French chemical societies, for example, publishes synopses of papers in full-size copy, with complete texts of the summarized papers available in miniprint or microfiche. The 1977 subscription price of $140 per year for this journal is not much lower than the 1976 average subscription price of $148.81 for the chemistry journals shown in Table 2.
26. Fry and White (*14*, p. 9) also maintain that subsidies are needed for scholarly journals and that the most likely source of such subsidies is the federal government. They suggest that subsidies could be made either to libraries, to publishers of journals, or to authors of scholarly papers. Their proposal, however, applies to all scholarly journals, not just to those in the sciences. R. De Gennaro [*Am. Libr.* **8**, 71 (1977)], objects strongly to the now common practice of charging libraries significantly higher rates for journal subscription—which are called institutional rates—as compared with rates charged to individuals. He views this as a form of subsidy by libraries to the scholarly publishing enterprise. He points out that research libraries no longer have the funds to subsidize scholarly publication.
27. H. S. White [*Libr. Q.* **46**, 377 (1976)], convinced of the need for subsidy of scholarly publication, probably by the federal governmment, calls for a thorough study of the problem to determine how much subsidy is required and to whom it should be given. We believe that our proposal merits the most serious consideration in any such study.
28. The fact that information is an inherent part of research and the conviction that more of the resources of science, both financial and human, must be used to make scientific and technical information more readily available to those who need it is one of the themes of the Weinberg report [A. M. Weinberg, *Science Government and Information*, a report of the President's Science Advisory Committee (U.S. Government Printing Office, Washington, D.C., 1963), p. 14]. White observes that "To provide financial incentive for the completion of research, but to stop short of enabling the researcher adequately to report and disseminate his findings, appears to be inconsistent and even foolish" (*27*).
29. *Mon. Labor Rev.* **100** (No. 2), 117 (1977).

NEWS AND COMMENT

Computer Encryption and the National Security Agency Connection

Theft of sensitive or private computer data has become a serious threat to many federal agencies and private corporations. This threat is magnified by the increasing use of computers to do such things as transfer large sums of money between banks. In order to foil the would-be computer-tappers, many federal agencies as well as bankers and corporations are now buying computer equipment that converts their private data to a secret code. All government users of such secret codes and a large proportion of private users as well plan to employ a new coding system put forth by the National Bureau of Standards (NBS) and designed by IBM. But some critics suspect that this coding system was carefully designed to be just secure enough so that corporate spies outside the government could not break a user's code and just vulnerable enough so that the National Security Agency (NSA) could break it. Presumably, foreign governments could too.

The NBS encryption equipment, known as the Data Encryption Standard (DES), has just come onto the market. Federal agencies that want to encrypt nonclassified computer data are required by law to use it. Manufacturers of the equipment also see a burgeoning market in banks, insurance companies, oil firms, and other commercial concerns.

Each user of the DES—a device that can be attached to a computer—will have its own key. The key (which is a string of 56 "bits" or 0's and 1's) is used to inform the computer how to encode data with this system and how to decode it as well. Each user of the DES generates its own key, preferably by choosing the 56 digits randomly. Once a user's key is known, all of its encrypted data can be decoded. A contingent of computer scientists, led by Martin Hellman and Whitfield Diffie of Stanford University, warn that a machine could be built to determine any user's key. The catch is that the machine would be expensive to build and operate. Private corporations, presumably, would not find it economically feasible to buy such a machine. But a government agency such as NSA might find it very worthwhile to build one.

Such a code-breaking machine might not even be necessary, some critics charge. The NSA was involved in the development of the DES and it classified some critical features of the encryption scheme. The critics cannot shake the feeling that these features were classified because to reveal them would be to reveal far simpler ways to break the code.

Critics of the DES say they can well understand why NSA would find it useful to break the code. Computer equipment incorporating the DES hardware will be sold abroad as well as in the United States. The NSA would not want to encourage the sale to foreign countries of an unbreakable encryption scheme. Of course, NSA would then also have the capacity to decode domestic computer data encrypted by the DES.

The most alarming possibility, according to Jeremy Stone of the Federation of American Scientists, is that foreign governments might decode U.S. computer data. For if NSA can build a machine to break the DES code, so can the Soviet Union and others. Stone is concerned that other countries would use information from the computer data to wage economic warfare. The Soviet Union manipulated the grain market during the wheat deal, he says, and it spends large sums of money to intercept telephone messages transmitted by microwaves. The capability and motivation exist for it to build a machine to break the DES code.

Although many private companies are convinced that the DES is sufficiently secure for their purposes, some have decided not to use this scheme. For example, Robert Morris of Bell Laboratories in Murray Hill, New Jersey, says that officials of the Bell Telephone Company have decided that the DES is too insecure to be used in the Bell System. Andrew Del Preore of Banker's Trust Company in New York says that his company will not use the DES because it "did not meet all the bank's requirements."

The purported problems with the DES were first pointed out 2 years ago by Hellman and Diffie. The NBS published a description of its proposed encryption scheme in the *Federal Register* and solicited comments. Hellman and Diffie sent in several comments, among them that the key size, which determines how easy it is to break the code, seemed too small. At little extra expense, these investigators pointed out, the key size could be increased and the standard