response-to-injury hypothesis by saying that lesions of injured animal arteries are not necessarily comparable to human atherosclerotic plaques. There is disagreement about the validity of this objection among investigators. Proponents of the hypothesis that plaques are benign tumors—the monoclonal hypothesis—avoid this criticism since evidence supporting this hypothesis comes from studies of human plaques.

Earl Benditt and John Benditt of the University of Washington School of Medicine advanced the monoclonal hypothesis on the basis of an analysis of human plaques obtained at autopsies. Their analysis relies on a method that had been used previously to support the contention that benign uterine tumors made up of smooth muscle cells are derived from single cells. This method is based on the generally accepted beliefs that only one of the two X chromosomes in a given cell of a female expresses its genes and that which X chromosome in a cell is active is decided at random during embryo development. All progeny of a particular cell express genes from the same X chromosome as their parent, but neighboring cells are often derived from different parent cells and thus often express genes from different X chromosomes.

One particular gene carried on X chromosomes codes for the enzyme glucose-6-phosphate dehydrogenase (G6PD). This enzyme can occur in two distinguishable forms, and black females tend to be heterozygous for the gene. Thus cells from black females who are heterozygotes will synthesize, at random, one or the other form of G6PD.

The Benditts examined atherosclerotic plaques from four black females and found that most cells collected from a single plaque expressed one or the other form of G6PD, but not both. They interpret this to mean that each plaque was generated by progeny of a single cell. In contrast, they found that cells from samples of artery walls adjacent to the plaques tended to produce both forms of G6PD.

In the 3 years since the Benditts advanced the monoclonal hypothesis, their results have been confirmed by other groups of researchers. Various investigators have published speculations as to how this hypothesis could be further tested and how previous results could be interpreted in light of it. Wissler, for example, believes that investigators should address the question of whether the arterial cells that seem to proliferate so readily when exposed to plasma lipoproteins are transformed cells. Ross points out that transformed arterial smooth muscle cells may not be affected by the same growth stimulants, such as factors released from platelets, as are normal arterial smooth muscle cells grown in tissue culture. Thus, in vitro studies of growth stimulants of smooth muscle cells may have to be reexamined.

Earl Benditt suggests that the meaning of proposed risk factors for atherosclerosis should be assessed in light of the monoclonal hypothesis. For example, cigarette smoking may be associated with this disease because cigarette smoke contains mutagens. And plasma lipoproteins may carry fat-soluble mutagens to arteries where these mutagens may pass through the arterial endothelium and contact smooth muscle cells. Benditt points out that diets high in fat have been associated with the development of various cancers, such as breast cancer, as well as atherosclerosis. He proposes that such diets may cause both cancers and plaques by similar mechanisms.

Although other investigators have confirmed the Benditts' results, several groups have recently raised objections to their interpretation. Philip Fialkow of the University of Washington, for example, points out that there is some evidence that plaques develop in layers. A group of cells may proliferate, then most die, and a few remaining cells proliferate again. If this is the case, a plaque could end up with cells of a single enzyme phenotype even though the plaque originated from many cells. Similarly, George Martin and his associates at the University of Washington School of Medicine argue that the Benditts' data do not necessarily indicate that plaques are formed by mutated or transformed cells. After studying a variety of cell lines, they discovered that cells that divide rapidly enjoy a selective advantage. Thus progeny of a single cell might take over a plaque that had a multicellular origin.

Somewhat different evidence against the monoclonal hypothesis is reported by Wilbur Thomas and his associates at Albany Medical College. These investigators found that plaques in swine are not monoclonal. They radioactively labelled the normal arterial tissue and induced lesions by feeding the animals diets high in cholesterol. If each lesion were formed from a single cell, the radioactivity of each lesion should be substantially less than the radioactivity of the surrounding cells of the artery. This did not occur. Instead the radioactivity of each lesion was not sufficiently diluted for it to be derived from one rather than many cells.

Thomas admits that the lesion in swine may not be analogous to those of humans, but still maintains that the evidence advanced by the Benditts is not sufficient to support the monoclonal hypothesis. Despite these arguments against the monoclonal hypothesis, no one has yet succeeded in ruling it out. It, like the response-to-injury hypothesis, continues to have both supporters and detractors. Both hypotheses continue to suggest new experiments whose results, many believe, are narrowing the range of possible causes of and ways to prevent atherosclerosis.—GINA BARI KOLATA

The 1976 Nobel Prize in Economics

The Nobel Prize in Economics for 1976 has been awarded to Milton Friedman of the University of Chicago. The weight and range of his scholarly contributions fully justifies this honor, which has long been overdue. Friedman has advanced many original and fruitful ideas bearing on a wide range of problems and phenomena. His ideas influenced many questions asked, the nature, of the theoretical analysis developed, and the empirical examinations applied by the profession.

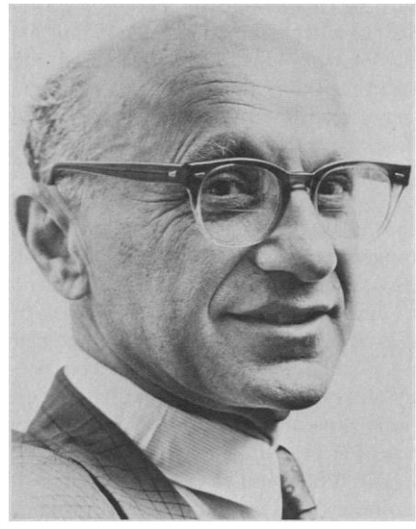
The recipient's scholarly interests have dealt with price theory (analysis of demand and household behavior) and utility theory (behavior under risk), and have covered important problems in macrotheory (the consumption function). Moreover, Friedman's work has reshaped monetary theory and influenced monetary policy, has produced critiques of the profession's standard arguments on evaluation of hypotheses, and has pioneered important ideas in statistical analysis and the application of capital theory to human knowledge and skills. Perhaps most importantly, Friedman pointed the way to imaginative extensions and applications of economic

analysis to subjects beyond the traditional range of conventional work. The statement issued in Stockholm barely did justice to the power of Friedman's protean mind.

The Nobel Prize winner began his academic studies in the early 1930's as a student at Rutgers University and then the University of Chicago. He was a lecturer at Columbia University from 1937 to 1940 and received his Ph.D. there in 1946. Arthur Burns, Frank Knight, Harold Hotelling, and Jacob Viner were probably the most influential teachers shaping Friedman's intellectual attitude. He published his first paper in 1935 on a topic in utility theory and helped with a theoretical study on demand behavior for a book prepared by Henry Schultz. Subsequently, Friedman joined the National Resources Planning Board and worked on consumer income and expenditures, developing for this purpose a nonparametric procedure for analysis of variance. A study for the National Bureau of Economic Research on income data from professional activities, probably prepared in the early 1940's, already contained the seminal idea of "permanent" income in contrast to measured income. It also suggested a human capital approach to labor market phenomena. A short interlude at the University of Wisconsin and the U.S. Treasury was followed by a return to statistical work with a statistical research group at Columbia University. This period witnessed the germination (jointly with Allen Wallis) of sequential analysis, an idea later submitted to Abraham Wald for mathematical exploration. These expressions of Friedman's originality in statistical analysis were also revealed by important contributions to the analysis of sampling inspection, and three other major papers on sampling techniques. In 1946 he went to the University of Chicago. His name has been inseparably connected with that institution ever since.

Friedman's most pervasive contribution to economics is, in my judgment, his remarkable sense of empirical science. In the early postwar period, mathematics and econometric methods were well on the way to being integrated with economists' research practices. But unfortunately, their spreading use did not guarantee a useful understanding of economics as an empirical science. Friedman's example influenced the profession's sense and appreciation in this respect.

Friedman's early work in statistics and the analysis and interpretation of data may have sharpened his understanding.



Milton Friedman

He developed a superb skill in exploiting "simple ideas" without undue analytic complications and in formulating effective and manageable hypotheses. His work also expresses a subtle sense of proportion. He understands that an assault on all the detail and minor variations of a problem is an investment with dubious or poor returns. An ability to slash away trivia is a necessary condition for understanding economics, and Milton Friedman exhibited this ability to a rare degree. But this is not all. The standard education at graduate schools usually involves some training in price theory, the central core of economic analysis. But this training also fostered a general attitude that price theory is an intellectual exercise to be enjoyed for its "esthetic pleasures," but does not or cannot offer any relevant explanation of the world around us. A peculiar schizophrenia dominated the profession: price theory was all right for the classroom but not for the "real world."

This attitude was effectively challenged by Friedman, not only by his published scholarly work, but also by his teaching and public discussions. He belonged at an early time to a small group of economists who understood the wide range of opportunities available to economic analysis and fully appreciated that economic analysis can be seriously and effectively applied to noncontrived problems actually encountered in our social environment. It is increasingly recognized today that economic analysis is the only systematic and coherent instrument really available in the social sciences and that it can be usefully applied to a wide range of social phenomena beyond the traditional marketplace.

Friedman's work on the consumption function exemplifies the general assessment made in the previous paragraph. Among the analytic and empirical building blocks developed over the first 10 to 15 years after the publication of Keynes' major work were money demand and household behavior. Household behavior was codified at the time in the form of the Keynesian consumption function, which related the level of household expenditures on consumer goods to the level of disposable income. The early phases of the postwar period produced events and independent sets of observations difficult to reconcile with the initial hypotheses. The apparent contradiction in the behavior of the savings ratio derived from budget data and long-term time series data was particularly glaring. This failure induced many discussions and a persistent search for a useful reformulation of the consumption function.

The extensive work on household behavior, income data, and demand analysis in earlier phases had prepared Friedman for the task and sharpened his awareness of the puzzling observations to be explained. For this purpose, he developed more fully the original idea of permanent income perceived when working on income data. The remarkable result was the book *A Theory of the Consumption Function*, published in 1957. The statistical idea introduced was interpreted in the context of the appropriate price-theoretical framework developed by Irving Fisher. Thus, the approach exposed the inadequacy of the income measure used in the Keynesian formulation. A new hypothesis emerged emphasizing the role of long-run measures of income or "consumption power," and the permanent income hypothesis was born. This hypothesis related household behavior to permanent income as an index of the households' wealth position. Permanent income and measured current income differ by transitory income subject to a variety of random influences. The dependence of consumption on permanent income implies that substantial variations in measured current income cause at most small adjustments in household consumption.

The discussion of the hypothesis in the opening chapters of Friedman's book was followed by a rich and subtle application to diffuse phenomena ranging far afield. These chapters show at its very best Friedman's mastery of subtle analysis developed with elementary means. The basic idea was also applied to the reformulation of money demand. Others found applications in diverse fields and contexts. The literature of the consumption function has not settled at the point where Friedman left it—empirical sci-

ence does not work that way. But our current state of knowledge on this subject and many other unrelated problems was crucially shaped by Friedman's imaginative and productive work. The exploration of the relation between consumption and consumers' expenditures, and of the effects of transitory income (particularly windfalls) on consumers' expenditures in contrast to real consumption, were stimulated by Friedman's ideas.

Monetary theory offered another range of interests attracting the Nobel Prize winner's efforts over many years. The field has a long history of outstanding contributions since David Hume. It includes Irving Fisher's classic piece published just before World War I. Progress seemed to stall in the late 1920's, and with the "Keynesian revolution" of the 1930's professional interest in the field was suspended. The macroanalysis emerging after World War II essentially denied the relevance of monetary processes and assigned no real significance to monetary policy beyond the task of holding interest rates low (or lowering them). Stabilization policies were only concerned with the proper manipulation of government expenditures, tax programs, and credit guarantees. The Keynesian establishment dominated academia and the professional literature. This sweeping acceptance was particularly remarkable in view of the almost total absence of any relevant evidence supporting the Keynesian monetary position. And few economists questioned this position in the early postwar period.

But Friedman's workshop developed during the 1950's into a major center of research on the role of money and monetary processes. The questions and issues investigated by Irving Fisher and discarded by the profession for decades emerged with a new vigor and in a new form. The workshop produced, under Friedman's guidance, some of the best studies on inflation and the role of money in inflation. A substantial dispute was generated by his studies (jointly with David Meiselmann) on the comparative role of fiscal and monetary variables in income determination. There were also important investigations of the relation between money and the business cycle, or unemployment and inflation. And most of all, we need to mention that monumental study published in 1963 (jointly authored with Anna Schwartz) titled *A Monetary History of the United States*.

Friedman's work gradually changed professional thinking on matters pertaining to the role of money. The old Keynesian position decayed. Money and monetary processes were generally recognized as an important element in adequate macrotheories. Moreover, in scholarly research and discussions increasing attention was directed to monetary policy. Much of Friedman's work dealt with the consequences of institutional arrangements and demonstrated a skillful use of economic analysis in assessments of different arrangements. The broad research he stimulated gradually but definitely changed important aspects of policy-making and helped modify conceptions governing our policy procedures over the past 10 years.

The issues confronting researchers in monetary theory can be usefully grouped into four topics: the impulse problem, the nature of the transmission mechanism, the relative dynamic stability of the economy's private sector, and the relevance of allocative detail for the analysis of aggregative behavior. Important and often leading contributions can be attributed to Friedman under all four topics. A condensed selection is offered here.

Analyzing Broad Patterns

His analysis of the dominant impulse problem demonstrated his ability to concentrate on broad patterns of regularity and develop a useful analysis of these patterns. We learned in this way to distinguish between monetary growth and monetary accelerations. The evolving analysis implies that monetary growth exerts little effect on employment and output, but dominates the average inflation rate. Employment and output, on the other hand, are strongly influenced by monetary accelerations and decelerations. These propositions were not a part of the old quantity theory. Neither this theory nor the Keynesian theory could explain the simultaneous occurrences of inflation and declining output observed on occasion for many years in Latin American countries and introduced in the past 6 years in Western countries under a new label.

Friedman's extensive work on monetary history was also related to the impulse problem. The reliable and substantial correlation between income or prices and monetary evolution could barely be denied by the end of the 1950's. Its interpretation was, however, seriously disputed. Three hypotheses were in contest: that money drives income and prices, that income or prices determine the behavior of money, or lastly, that money and income mutually interact. Friedman's pioneering study of money supply processes under different institutional arrangements, with careful attention to the import of specific extraneous events or "unplanned" experiments by government, exploited discriminating evidence from a mass of carefully collected data. He concluded that there is indeed some interaction, but with money definitely the "senior partner in longer-run movements and major cyclical movements." In milder and shorter-run movements money and income seem to operate more as "equal partners." The study also yielded an excellent account of the major forces at work in determination of monetary growth and accelerations.

The central contribution on the second topic (transmission mechanism) pertained to the nature of the Phillip's curve—that is, the relation between unemployment and inflation. From the beginning, Friedman expressed serious reservations about the interpretation and usefulness of this relation. His ideas were eventually presented in a presidential address to the American Economic Association in the late 1960's. Friedman argued that a larger inflation could not permanently lower the level of unemployment. The institutions and practices established in any given economy determine a natural rate of unemployment. Attempts to lower unemployment below this level with the aid of monetary and fiscal policy produce an increasing inflation without any lasting effect on the average rate of unemployment. This seminal idea stimulated much theoretical and empirical work. The work has been substantially "helped" by the "unplanned" (and unfortunate) worldwide inflationary policies pursued since the early 1970's.

Two additional major topics should be mentioned. Detailed study of a massive volume of historical data led Friedman to a thorough reassessment of the great depression of the 1930's. This contribution was particularly significant, as it substantially reshaped the profession's thinking. The study also exposed some unwarranted legends which had been conveyed through one generation of textbooks to the next. We note also the careful investigations of New Deal policies and the claims made on their behalf. Our profession gained new and important knowledge from them.

Most important, probably, is the inversion of a central Keynesian idea emanating from this work. Keynesians emphasize the basic instability of the private sector and the stabilizing function of a stable government sector. The profession's most thorough study of the great

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primarily from different assumptions about the appropriate population base to be considered in estimating probabilities. This is a problem that traditionally frustrates cluster analysis. Does one ask how likely it is that three deaths would occur normally on a given day among the relative handful of people who were vaccinated during the critical hour at that one clinic, or among the 1200 who were vaccinated at the clinic that day, or among the 8000 or so elderly who were immunized in Allegheny County that day, or among even larger groups of elderly immunized in the state or nation?

Using one set of assumptions, the Center for Disease Control, which is promoting the immunization campaign, has managed to calculate the odds as low as 1 in 50 that the deaths would occur normally. Using another set, the county coroner's office, acting as devil's advocate, puts the odds as high as 1 in a million. One neutral expert—Robert J. Armstrong, chief of mortality statistics at the National Center for Health Statistics—has a gut feeling that the deaths were "an extremely rare event—a tremendous long shot." But he notes that highly improbable events do in fact occur.

Federal officials also stress that, on a nationwide basis, the death rate following vaccination is far less than the normal death rate for the elderly population, a statistic which tends to exonerate the vaccination campaign as a cause of mortality. But skeptics put little stock in such figures. They doubt that the reporting of deaths after vaccination is complete. They also suspect that most of those who are about to die on any given day are too sick to venture out for a flu shot. Thus the population that visits clinics might be expected to show fewer deaths.

One federal investigator who is skeptical that the three deaths were coincidental is Philip Graitcer, one of two specialists from the Center for Disease Control who masterminded the investigation here. Graitcer speculates that some of the deceased might have been killed by hysteria or stress at the shock of seeing others collapse, receive oxygen treatment, and then get carted away on a stretcher, amidst a wailing of sirens. He hopes to return to Pittsburgh soon to investigate this hypothesis more thoroughly. If his theory proves plausible, it might explain how the million-to-one shot occurred. It might also suggest the need for new procedures aimed at minimizing the hubbub caused by medical emergencies.—PHILIP M. BOFFEY

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depression led Friedman to invert the proposition—an essentially stable private sector operates as a shock absorber to the shocks imposed by an erratic and "unstable" government sector. This inversion created much intellectual heat. It is noteworthy, however, that Friedman provided us with the only piece of evidence we have on an issue of fundamental importance. The issue is anything but settled. But again, Friedman raised a radically unfashionable question and we should hope that scholarship will attend to its serious examination.

My presentation of Friedman's work to a wider group in the scientific establishment has concentrated on his extensive scholarly work. But the new Nobel Prize winner is far removed from "academia's ivory towers." He has been embroiled for many years in important issues of public policy. This aspect of Friedman's life deserves some clarification. He is frequently presented as an ideologue, as a man who lets his politics dominate his economics. He is also refered to patronizingly as a "controversial figure."

The accusation that politics plays an important role in Friedman's work thoroughly distorts the actual situation. The remarkable fact is that many of Friedman's "political or policy views" were guided by a strong commitment to a relevant empirical use of economic analysis. His "politics" emerges to a major extent as an assessable consequence of his economic analysis. Analysis led him to a series of quite radical questions bearing on many of our social institutions, or more specifically, on the prevalent views of stabilization policies. The proposal for a monetary rule was not motivated by any "laissez-faire preconception" but evolved from his appreciation of the unpredictable variability of monetary lags.

And, lastly, there is indeed a commitment. It involves the value and freedom of an individual human being, and a commitment to rational discourse and the cognitive adventure called science. But views about social institutions, their mode of working, and their consequences remain a matter subject to the procedures of empirical science. Perhaps we may hope that Friedman's lifelong struggle to insert such scientific commitment into economics may yield a broader application of relevant analysis over the full range of social institutions and political processes.

KARL BRUNNER
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less homogeneous and their teaching load very heavy. In contrast, others viewed a mix of both 2-year and 4-year college teachers in the same course as mutually beneficial.

There was some sentiment for courses specifically designed for academic deans and faculty development officers. One participant felt that several of the short courses would also benefit nonscience faculty, and another thought that the current program seems more profitable for nonscientists than scientists.

A potpourri of suggestions for the content of the short courses emerged:

- more emphasis on lab-centered and hardware-type courses, perhaps 1 or 2 weeks in duration;
- the latest laboratory techniques—what's going on at the leading laboratories in the country;
- courses on the current year's happenings in biology, chemistry, or physics; and
- more on improved methods of teaching the sciences, such as how to develop teaching materials; how to reach nonmajors; how to apply the techniques of modular instruction to the all-important introductory course.

A suggestion that the AAAS consider arranging some sort of credit for short courses highlights a basic question which was asked and discussed, but not resolved: How do you motivate faculty who are comfortably uninterested in self-improvement?

JOSEPH M. DASBACH
Office of Science Education

Nuclear Power Seminar Scheduled

A regional seminar on nuclear power, cosponsored by the AAAS Division of Public Sector Programs and Knox College, will be held on 1 December on the Knox College campus in Galesburg, Illinois. The program will include a discussion of the Illinois energy picture, the nuclear fuel cycle, and a number of concerns associated with the safety and waste management of nuclear power.

AAAS members in the Galesburg area are invited to attend. For further information, contact Dr. Herbert Priestley, Knox College, Department of Physics, Galesburg, Illinois 61401. Telephone: (309) 343-0112, Ext. 248/485.