5-Å resolution, are being studied by x-rays in order to visualize the substructure of the nucleosome.

The initial low-resolution studies have already revealed the outline of the first level of folding of DNA in the nucleosome. Two superhelical turns of the DNA double helix are wound around a shallow ramp made up of the four inner histones. This DNA supercoil is sealed off by the fifth histone, H1, which also stabilizes the next level of coiling of the chromatin filaments, the solenoid.

Klug's work on the solenoidal aggregates found in intact chromatin relates the cellular and molecular levels of organization. These studies exemplify his approach of chemically dissecting out parts of complex structures for detailed analysis by x-ray diffraction, the results of which are correlated with information about macromolecular organization of the intact assembly from electron microscopy.

Colleagues

Klug's interest in the structure of matter was first stimulated while he was a student in South Africa by R. W. James, who had worked with W. L. Bragg in building the foundations of x-ray crystallography. After Klug obtained his Ph.D. at the University of Cambridge, he turned to work on the structure of living matter, joining Rosalind Franklin in J. D. Bernal's department at Birkbeck College in 1954. Franklin had just then switched from studying DNA to studying TMV; Bernal, who had started protein crystallography 20 years earlier in Cambridge, had also begun x-ray diffraction studies of TMV and crystalline viruses. After Franklin's death, in 1958, Klug continued structural studies on viruses with John Finch and Kenneth Holmes and started a collaboration with one of us (D.L.D.C.) on the principles of virus construction. In 1962 he moved to Cambridge, where the scope of his investigations and number of collaborators expanded: in the study of virus chemistry and assembly he worked with Reuben Leberman, Tony Durham, Jo Butler, and David Zimmern; in virus crystallography, with William Longley, Peter Gilbert, John Champness, Gerard Bricogne, and Anne Bloomer; in electron microscopy and image reconstruction, with one of us (D.J.D.), Harold Erickson, Tony Crowther, Linda Amos, Jan Mellema, Nigel Unwin, and, throughout, John Finch; in the structural studies on transfer RNA, with Brian Clark, Jon Robertus, Jane Ladner, and Tony Jack; in chromatin, with Roger Kornberg, Markus Noll, Len Lutter, Daniela Rhodes, Ray Brown, and Tim Richmond. This list is incomplete and it is still growing.

Many of the notable achievements in structural biology have been made at the MRC Laboratory of Molecular Biology in Cambridge. This laboratory has provided an environment enabling long-term structural studies, which may lack the immediate excitement of some other areas of biology, but the knowledge painstakingly gained from these investigations is essential for understanding how living machinery works. Since 1978, Klug has been codirector with Hugh Huxley of the structural division, and together they have kept this laboratory at the forefront of structural biology. In 1962, when Klug joined the MRC Laboratory in Cambridge, Nobel prizes were awarded to Francis Crick, John Kendrew, and Max Perutz, fellow members of the laboratory, for their work on the structure of nucleic acids and proteins. It is fitting on this 20th anniversary of his arrival and of the earlier prizes, that Klug's work on the interaction of protein and nucleic acids has been so appropriately recognized.

Both of us wish to express our appreciation for the knowledge and understanding we have gained from Aaron Klug, and we congratulate him both for his award and for realizing spectacular potentials in the structural biology of macromolecular assemblies.

—D. L. D. CASPAR and D. J. DEROSIER

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The 1982 Nobel Prize in Economics

We get about what we pay for in this world. George J. Stigler has been a walking exception to this popular economic maxim, for the world has long received more from Stigler than it has paid to him. The Nobel Prize Committee's 1982 award helps reduce the imbalance. This is especially gratifying in the case of Stigler because of his insistence on empirical verification of economic maxims. Even a true believer in the importance of evidence can have his belief strengthened by 157,000 tax free data points.

Academic Affiliations and Early Work

Stigler's formal education in economics took place at the University of Chicago during the depths of the 1930 depression. Chicago's economics faculty included some of the leading economists of the time—Frank Knight, Henry Schultz, Henry Simons, and Jacob Viner. Some of the students they lectured also proved to be outstanding—Allen Wallis (President and Chancellor of the University of Rochester and now a senior member of the Department of State), Milton Friedman (1976 Nobel Prize winner) and George Stigler. This rare mixture of talents must have educated and excited students and teachers alike.

With Ph.D. in hand (1939), Stigler began his professional chores at Iowa State College but soon moved on to the University of Minnesota (traditionally possessing an above average economics department). From there he moved to Brown, but his first professional appointment of real duration was at Columbia. There he wrote and taught from 1947 to 1958, concluding the maturing part of his career. This was marked by the publication of his dissertation materials, a successful price theory text that was later to become *The Theory of Price* (*1*), several monographs for the National Bureau of Economic Research, and about 30 articles on a variety of topics. One of these, *Roofs or Ceilings, Foundation for Economic Education* (1946), which was coauthored with Milton Friedman,

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achieved a degree of notoriety by demonstrating the free market's ability to allocate and augment housing in the aftermath of the great San Francisco earthquake, and by arguing that the use of rent control in such a situation could only exacerbate the shortage problem.

Stigler's scholarly reputation grew during this period, but his most important work waited upon his return to Chicago, in 1958, as the Charles R. Walgreen distinguished Professor of American Institutions. Rarely has there been a more productive combination of man, chair, and place of employment. Stigler was and remains interested in understanding the causes and consequences of economic and political institutions. The chair's donors sought such interests, and the chair's stature and funds gave him the means for pursuing them; there was no better environment for this pursuit than the University of Chicago. One important use to which he put Walgreen funds was the creation of a workshop in industrial organization. The workshop gained a national reputation for its quality and toughness. Scholars have found new ideas in their work and no ideas in their work at Stigler's workshop. Stigler also used Walgreen funds to finance the research of others where their work seemed germane to the study of American institutions.

His Major Work

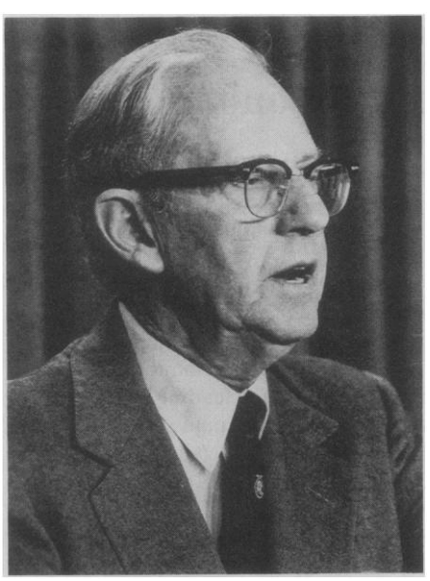
Only a small fraction of Stigler's output during his Chicago years can be discussed in this short appreciation. His work may be divided into three categories, of which the first two may be passed over quickly for they are not the basis of the Nobel Prize award. First is his work on the history of economic thought, which has earned him an unofficial title as perhaps the world's leading scholar of the lives and works of the early masters of economics. Second are his essays, contained mainly in two existing volumes, *The Intellectual and the Market Place* (*2*) and *The Citizen and the State* (*3*), and in one forthcoming volume, *The Economist as Preacher* (*4*). This subject matter is easily accessed by the intelligent layman. There he will find a potpourri of wit and seriousness blended with high writing style. A light sample may be selected from "Stigler's First Law of Sympathy":

> My sympathy for myself, I carelessly calculated, was at the rate of 127 units per minute, and the vagrant thought flitted through my mind: how sorry was I for other people? I was about to dismiss the query with an off-hand "enough," when it occurred to me that my sympathy for a person fell off, the more distant he was. And he could be far away not only in a geographical sense, but also socially. Would it not be possible to construct a vast social law corresponding to Newton's law for physical bodies, but naturally superior because distance was a more complex concept in social relations?

As in most Stigler essays, the humor makes a point.

It is in the third category of Stigler's work, his scientific study of economic and political institutions, that we find his most important contributions to economics. He devoted first efforts to the study of economic institutions and behavior. Included here is his empirical study of the relation between the profit rate of an industry and the degree to which that industry's output is concentrated in a few large firms [*Capital and Rates of Return in Manufacturing Industries* (*5*)]. This work confirmed earlier studies that had found a modest but statistically significant correlation between profit rates and industrial concentration. It led Stigler to accept the then prevalent explanation of the correlation—the more concentrated an industry's output, the easier the firms in the industry can avoid profit-lowering competition. He later changed his belief about the source of this correlation because a different interpretation of available evidence offered a more robust explanation.

A second important empirical study, coauthored with J. K. Kindahl [*The Behavior of Industrial Prices* (*6*)], examined the question of price stability. Many economists believed that an important sector of the economy set prices by management decision, the "administered price sector," in situations that insulated these prices from normal competitive pressures. This belief was nurtured by the seemingly greater stability of prices in this sector compared to the nonadministered price sector. The evidence for stability of prices came primarily from governmental sources that relied mainly on the list prices of large industrial firms. Stigler believed this source of prices imparted an upward bias to measured price stability. What seller lists the lowest price he is willing to accept? So he and Kindahl painstakingly collected and examined actual transaction prices as revealed on purchase invoices of buyers of industrial products. Their new price series show considerably more price flexibility, and they seriously undermine the supposed evidence for the existence of an important administered price sector.



George J. Stigler

Stigler also examined puzzling pricing and marketing practices of certain industries, especially basing-point pricing and block booking. Under the former, buyers pay prices according to their distance from a basing point (usually an important center of production) rather than according to the distance the purchased good is actually shipped (the producer might be located in the same town as the buyer although the basing point is some distance away). In block booking, sellers insist that buyers purchase related goods in a "block," as when a block of movies is sold to television stations, rather than allowing them to purchase separately the individual components of the block. Since some buyers attach different relative values to the constituent components of the block than do other buyers, the seller's insistence is puzzling. Ingenious explanations for these practices, together with supporting evidence, were offered by Stigler. These subjects continue to attract attention and competing explanations from young scholars.

Stigler's major theoretical work on the functioning of the economic sector is his analysis of the economics of information. Price theory implies that competition among sellers, combined with the self-interest of buyers, will not tolerate different prices for the same good sold in the same market. Yet we seem to observe differences in prices under conditions that seem competitive. This incongruence between theory and observation is due in large part to the fact that traditional price theory ignores the cost of acquiring information about prices. By combining insightful economic reasoning and simple probability theory, Stigler sets forth a powerful model of rational search based on the cost of searching for price information. The

model allows Stigler to specify the economic conditions that will give rise to greater and smaller differences in the prices at which the same good will sell and to reconcile these differences with competitive activity. To take a simple case, the more expensive is the item to be purchased, the greater is the search cost that buyers are willing to bear in seeking a lower price; then ceteris paribus, the percentage variation in prices of the same good should be a declining function of the value of what is being purchased, for more intensive search implies a smaller tolerance of high prices. As usual, Stigler calls attention to data that shed light on the validity of the model.

This theoretical work gave birth to a considerable literature in economics, including some additional research by Stigler. On the basis of his search model, for example, Stigler analyzes how the conditions surrounding an industry will influence its ability to collude successfully. Successful collusion calls for the detection of those rivals who "cheat" on the collusive agreement, and this in turn requires a search for evidence that their gains in market share are attributable to cheating and not to various other factors that might also shift market share. By deploying his model of economic search, Stigler is able to demonstrate how factors such as the size distribution of rival firms, and buying firms, and the natural rate of entry of new buyers into the market affect the ease with which cheating can be detected, and, therefore, the ease with which a collusive agreement can be policed by its participants. Stigler's analysis of economic search has opened a large new territory for fruitful research.

Stigler always has had an interest in the economics of regulation. Two early studies examined the impact of two types of regulation. In a paper coauthored with Claire Friedland, Stigler found that electricity prices did not differ significantly, after standardizing on the cost of production, between states that regulated these prices and states that did not. Another paper examined how well investors in newly issued securities would have done, relative to purchasing seasoned stock, before and after the creation of the Securities and Exchange Commission. As in the case of electric utility prices, he found no significant difference, even though the Commission was created in large part to protect investors in new issues by requiring issuers to supply detailed information. These two findings led Stigler to conclude that economic regulation is likely to have no effect on the industries being regulated, so that the cost of regulation is difficult to justify.

The study of the regulation of economic activity became a passion of Stigler's. His later studies led him to change his opinion of the impact of regulation. Increasingly, these showed not that the effect of regulation was nil, but that it was perverse. Where commissions were created to protect consumers, they functioned by protecting the industries they regulated from competition—to the disadvantage of consumers.

This work helped give birth to an economic analysis of political processes based on the pursuit of self-interest by both elected officials and politically potent economic constituencies. The powerful reasoning and mounting evidence yielded by this view of the functioning of democracy has completely undermined naïve political theories based on the presumption that democratically elected governments seek primarily the interests of the broadly based electorate. This new application of economic models of self-interested behavior has increased substantially our ability to understand political behavior. The acquisition of import restrictions on imported steel clearly reduces U.S. per capita income, but the losers from this policy, primarily users of steel, are unorganized and diffusely located geographically and economically. The cost to them of becoming informed and of effectively acting politically is so great that the political process, in general, is more likely to serve the narrower but easier to organize interests of the steel industry. Not to do so may quickly deprive an elected official of the economic and political support required to remain in office. Stigler's work, along with that of J. M. Buchanan and G. Tullock, has given rise to a fascinating and burgeoning economic theory and accompanying empirical study of democracy.

Other Matters

Attention should be called to Stigler's value as a colleague. Stigler is exceedingly generous of his time in evaluating, critiquing, and improving the work of his colleagues. No other person I know is as likely to provide the author of a study or a manuscript with such detailed and insightful comments as is Stigler. A concomitant of this is his low tolerance for foolishness. Many a friend, colleague, and stranger has been put quickly in his place by a pointed remark of Stigler's. A student once complained of the injustice in a grade he had received, whereupon Stigler confessed his disappointment that the grade was not more appropriate and pointed out a University prohibition on any lower grade.

Finally, in acknowledging the contribution Stigler has made to economics at the University of Chicago, it is also necessary to recognize the institutional contribution of the University to economic inquiry. At Chicago, economics is taken seriously, not only by members of its economics department, but also by the faculties of its Graduate School of Business and its Law School. Critical mass is important not only in atomic fission, but also in intellectual endeavor. Chicago has long invested in the necessary scale, the requisite energy of interaction, and the required devotion to excellence. This is partly attributable to Chicago's disproportionate interest in graduate and professional education (about 6000 out of 8000 students). It is also due to a long list of able administrators and chairmen who have had the courage and foresight to keep their sights on the proper objectives of a great University. Stigler would have become a great economist anywhere, but he is a greater economist for having been at Chicago. It is no accident that four of the twelve American winners of the Nobel Prize for economics (Hayek, Schultz, Friedman, and Stigler) have done much of their best work at Chicago.

—HAROLD DEMSETZ

References and Notes

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