Summary

A large ape existed in India at the close of the Miocene or the beginning of the Pliocene epochs; this ape shows a complex of anatomical structures at the opposite pole from its contemporary, *Ramapithecus*. Although found in the same beds, the two seldom occur at the same exact sites and levels. Considering the thickness of these beds, recovery close to Haritalyangar does not, of itself, prove sympatry of these two different kinds of Hominoidea. However, both are definitely present at one recently located site representing, most probably, a death assemblage.

Observations by the authors on scores of chimpanzees suggest that, at least in this ape, wear gradients on molar crowns exist, but that the wear differential between adjacent molars is almost never raised to the degree seen in most *Ramapithecus*. *Dryopithecus indicus* and *D. fontani* (from southern France), in contrast, show almost no wear gradient at all; that is, whether an individual is dentally young or old, wear on all three molars and the two premolars has proceeded to about the same degree. It is of considerable importance in understanding hominid phylogeny to be able to stress that an ape known to be contemporary with *Ramapithecus* shows far less differential wear than does the hominid. This, in turn, strongly suggests that the molar eruption sequence of *D. indicus* was rapid, while that of the hominid was delayed. The implication is that, as far back as the late Miocene, the hominid maturation period was lengthened, relative to that of apes. A further fact which emerges is that the rate of interstitial wear was faster in the Haritalyangar ape than in the hominid contemporary with it. This, together with its large size, flatness of unworn tooth crowns, and other associated characters, suggests that *D. indicus* is in, or close to, the ancestry of *Gigantopithecus*. From this emerges yet another object lesson, emphasizing the caution one has to observe in the manner and method by which ancient and modern apes are compared and contrasted. None of the species of Hominoidea dealt with here, whether pongid (*D. indicus* and *Pan troglodytes*) or hominid (*R. punjabicus*), accumulates either interstitial or crown wear at the same rate or in the same manner.

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Reflections on the Decline of Science in America and on Some of Its Causes

The evolution of scientific societies illuminates present problems of the scientific community.

Arnold Thackray

Consider the following quotation, about the failure of scientific societies to meet the needs of the times: "Many attacks have lately been made on the conduct of various scientific bodies, and of their officers, and severe criticism has been lavished on some of their productions. Newspapers, magazines, reviews and pamphlets have all been put in requisition for the purpose." The words have a familiar ring. They sound like a fragment from a very contemporary debate. Yet their author was Charles Babbage, the year 1830, and their source a book entitled *Reflections on the Decline of Science in England and on Some of Its Causes*, from which I appropriate my title (*1*, *2*).

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In order to set the stage more fully, consider two further quotations. The first concerns not the shortcomings of scientific societies in general, but the problems of that one-time favored and now beleaguered discipline of physics: "Physics has enjoyed a place in the sun which it cannot expect to hold permanently. . . . Physicists would be more than human if they were not somewhat spoiled by the popularity they have enjoyed. . . . Physics in [the United States] has simply growed like Topsy and, unless some thought is given to these matters, we may have an autopsy on our hands" (*3*). Those words were delivered with urgency and conviction, not in 1971, but in the mid-1930's. Finally, reflect on this news item from *Science*. It concerns not scientific societies in general, nor one discipline in particular, but the broader social functions and social implications of science (*4*):

The resolution of the American Association for the Advancement of Science . . . and recent actions of the British Association bear witness to a widespread interest . . . in the increasingly critical development of social problems. Members of the staff of Harvard University, the Massachusetts In-

stitute of Technology, and other institutions in Boston and Cambridge, Mass., have formed . . . [a society] to promote an understanding of the relationship between science and social problems . . . [and] to promote . . . action on the conclusions reached.

The contribution of scientific workers to world progress is to-day larger than ever before. Nevertheless, they are faced with economic and international developments which continually become more critical. As a group they have virtually no control over the applications of science. . . . The only expressions of opinion which reach the public are those of a few individuals whose views are not necessarily representative and in some instances misleading.

This news item was of course reporting not on the 4 March movement of 1969, but on the Association of Scientific Workers of 1938. With a judicious choice of periods and problems, many similar expressions of unrest may be unearthed from the literature of science.

As might be feared of a historian, my first point is thus simply that present debate and questioning over the structure and functions of scientific societies, the health of particular scientific disciplines, and the proper social responsibility of the man of science should not be viewed as sudden novelties. Rather, the reappearance of these symptoms should cause us to ask whether something has once again become disfunctional in the always precarious homeostasis between science as an institutionalized and public enterprise and the wider society that at once sustains and is sustained by it.

In order to provide a framework in which answers to that question may be developed, I would like to dwell on particular aspects of the history of scientific societies, within an Anglo-American context. Scientific societies have of course been undergoing a continuing evolution, ever since their first appearance. In a crude, first-order fashion one can usefully distinguish three successive stages in that evolutionary process, at least in the English-speaking world. They might be named the stages of elegant amateurs, of poor professionals, and of dominant dukes. Examination of each in turn will illuminate certain facets of present anxiety and debate.

The Age of the Elegant Amateur

Consider first the period of elegant amateurs—of virtuosi, if you will. When that synthesis of craft technique, rational scholarly inquiry, and secular determination to examine the secrets of a demythologized nature finally occurred in late Renaissance Italy, its leading spirits adapted to their purposes the cosmopolitan camaraderie of the princely academies so common in the towns and courts of the period. In Italy, France, and then England, natural knowledge, like law and medicine before it, found its true home neither in the church nor in the university. Instead the scientific enterprise was quickly centered in chartered guilds, replete with royal sanction, suitable mechanisms of social reward and social control, and considerable metropolitan and national pride (*5*). The definitive Anglo-Saxon institution was of course the Royal Society of London for Promoting Natural Knowledge, chartered in 1662.

In keeping with the new idea of natural knowledge as a suitable, but never overriding, concern for gentlemen, the Royal Society elected noblemen on demand, and bishops, foreign ambassadors, and other assorted worthies with remarkable frequency. Indeed the proportion of "scientific fellows" never reached even a third, from the 1660's to the 1830's. Science in the Thirteen Colonies was commanded and coordinated from London in corresponding style, and colonial Fellows of the Royal Society (F.R.S.'s) were no different from the rest in being sometimes men of science, but always gentlemen. The intimacy of the relations between London and the Colonies may be seen in Cromwell Mortimer's 1741 declaration that "had not the civil wars ended as they did, Mr. Boyle and Dr. Wilkins, with several other learned men, would have left England . . . [for John Winthrop's] new-born colony, and there have established that society for Promoting Natural Knowledge . . . which afterwards [became the Royal Society]" (*6*, *7*).

To all intents and purposes, the Royal Society did come to America, with the eventual secure establishment of the American Philosophical Society (held at Philadelphia) for Promoting Useful Knowledge. The most significant difference from the English model, and one that continues to inform the American scene, was that of state and regional rivalry. By the 1820's there had been not one but four such quasi-national societies formed in the United States. Their locations ranged from Richmond, Virginia, to Boston, Massachusetts, but they had in common their more than local ambition (*8*).

Generalist societies, run by elegant amateurs, were particularly well suited to the demands of the 17th and 18th centuries. That their members found them peculiarly congenial is evident by the failure to adapt to a changing world. In the early 19th century both the American Philosophical Society and the Royal Society of London presented classic examples of institutional inertia, bureaucratic rigidity, and reluctance to innovate or accommodate. As illustration one might cite Sir Joseph Banks's hostile statement concerning the new specialist societies then appearing, that "all these newfangled associations will finally dismantle the Royal Society and not leave the old lady a rag to cover her" (*9*). Only after much bitterness and pamphleteering (of which Babbage's *Reflections on the Decline of Science in England* is the most well known but by no means the solitary example) was the necessary organizational reform of British science accomplished. In the case of the American Philosophical Society a satisfactory adaptation was never made. The Society's gentle but continuous decline in national importance dates from this period (*10*).

I have dwelt on the age of elegant amateurs because the social organization adopted by natural knowledge at that time bequeathed two attitudes which endure in the scientific enterprise long after the particular circumstances that gave rise to them have vanished. One is the conscious segregation of science from politics. The other is the oligarchic and informal nature of the relations between science and government.

As Robert Hooke expressed it in 1663, "The business and design of the Royal Society is to improve the knowledge of natural things, and all useful arts, manufactures, mechanic practices, engines and inventions, by experiments (not meddling with divinity, metaphysics, morals, politics, grammar, rhetoric or logic)" (*6*, p. 41). That initial prohibition on political discussion in the Royal Society was highly functional, given the intense antagonisms resulting from the English civil war, the considerable political interests and influence of many F.R.S.'s, the very limited impingement of scientific inventions on affairs of state, and the existence of alternative groups and mechanisms through which the

virtuosi could readily pursue their political concerns and ambitions. Isaac Newton's easy movement from Cambridge professor through Member of Parliament to minor state functionary, and simultaneously to president of the Royal Society, is one example. (Recall that his knighthood, when president, was for political not scientific services.) Benjamin Franklin's multiple political, philosophical, and social roles provide another illustration.

If the gentlemen who pursued science could also engage in politics, the limited but necessary relations between science and government could themselves be developed without formality and excessive codification. The Royal Society's involvement with the Board of Longitude, Thomas Jefferson's simultaneous presidencies of the United States and the American Philosophical Society, and the arrangements for the Lewis and Clark Expedition, all testify how early and how intimately a tradition of oligarchic decision-making came to characterize the activities by which science served government in Britain and America (*11–13*). This tradition was established as a functional matter of simple convenience in an autocratic age, not from any pressures of military secrecy and national policy. Nonetheless, the tradition proved pervasive and influential.

Poor Professionals and Specialist Societies

Though the generalist scientific societies were slow to perceive and respond to the change, the nature of the scientific enterprise was rapidly altering by the early 19th century, first in Europe, then in the United States. The forces of population growth, economic expansion, urbanization, and industrialization were transforming the whole nature of Western society. Their immediate manifestation in the world of science was in the allied growths of professionalism and specialism. Multiplication in the number of men of science and the formation of specialist societies to serve their ever more narrowly differentiated interests were the outstanding features of the period (*14*). A new accommodation between science and the universities was a further crucial characteristic. Specialist scientific disciplines proved peculiarly well suited to the new professionalism and departmentalism of the university.

The British Isles in 1760 had only 12 societies that were in any way concerned with natural knowledge, and only one—the amateur and generalist Royal Society—had such knowledge as its ostensible focus. The idea of a specialist scientific society was still to be born, as was the very word scientist. By 1870 the 12 societies in the British Isles had grown to 125. And while the Royal Society had been joined by 14 other societies that may be classed as "generalist," no less than 59 specialist societies had been created (*15*). Similar American growth may be seen at a later time by focusing on the AAAS. From a membership of 400 just after the Civil War, the figures climbed remorselessly to 4,000 in 1903 and 11,000 in 1920 (*16*). The growth in specialist societies paralleled the growth in personnel. Before 1860 some 15 generalist scientific societies had been founded in the United States, but only 12 specialist societies. The years from the Civil War to World War I saw not only rapid growth, but a decisive reversal of emphasis. By 1900, a further 81 specialist societies had been founded, but only 48 new generalist groups (*8*, p. 121).

Specialism and professionalism meant that not just more people, but also very different people, were attracted to the scientific enterprise. Elegant amateurs were replaced by poor professionals, virtuosi by scientists, the confident gentry by the aspiring lower orders. John Dalton, Michael Faraday, and Joseph Henry provide familiar examples of the new breed of scientist. To them a "career open to the talents" provided both intellectual challenge and social reward. In the century after 1840, American men of science were to be disproportionately recruited from the rural, lower-middle-class Protestants of the mid- and far West (*17*).

In fact the social rewards of science were no longer such as to appeal greatly to those more comfortably placed. To quote Charles Babbage once again: "The estimate which is formed of the social position of any class of society, depends mainly on the answer to these two questions: What are the salaries of the highest offices to which the most successful may aspire? What are the honorary distinctions which the most eminent can attain?" On both counts Babbage easily demonstrated "the inferior position occupied by science," compared with careers in law, divinity, or the armed forces. The validity of Babbage's contention may be seen, in reverse, in the way Sir Roderick Murchison, already a retired army officer of secure income, discovered with considerable surprise that a gentleman might still engage in science: "In the summer following the hunting season of 1822–3, when revisiting my old friend Morritt of Rokeby, I fell in with Sir Humphry Davy, and experienced much gratification in his lively illustrations of great physical truths. As we shot partridges together in the morning, I perceived that a man might pursue philosophy without abandoning field sports; and Davy . . . encouraged me to come to London and *set to* at science" (*18*).

Such men as Murchison who "pursued philosophy without abandoning field sports" were the exceptions whose existence serves to highlight the reality of 19th-century science as the pursuit of poor professionals, in both Britain and America. "The inferior position occupied by science" extended even to its new setting in the university. To see this plainly revealed, one need only compare the incomes of the Cavendish Professor of Physics and the Lady Margaret Professor of Divinity at Cambridge, or reflect on Willard Gibbs's salary-less status at Yale (*13*, p. 316; *19*).

The specialist societies founded to serve the poor professionals took on and reinforced many aspects of their generalist predecessors. Their greater utility lay in their better adaptation to twin roles as accumulators of scientific capital and dispensers of scientific prestige. They provided social means of meeting new costs far beyond the reach of rich, let alone more restricted, individuals. As science advanced, specialized, and professionalized, so larger libraries, more exhaustive collections of minerals, better botanical specimens, and rarer fossils were demanded, along with new telescopes, more powerful microscopes, more sophisticated chemical apparatus, and ever more and better equipped lecture and laboratory space. Specialist societies were one highly effective means of answering these demands, while also offering informed audiences, publication outlets, critical evaluation and peer group encouragement, and mechanisms of social advancement and personal reward, all safely remote from the larger philistine world. What specialist societies supplied, universities also offered. Hence the growing alliance between the scientific discipline

and the university department, also characteristic of the period.

The specialism of the new societies undoubtedly served the scientist well. In turn, these societies became major centers of the physical and intellectual capital of science and arbiters of scientific taste and excellence. The continuing disavowment of general politics, inherited from the virtuosi, was only natural in groups manifestly lacking powerful connections and politically appealing projects. Even the much more limited matter of *internal* scientific politics (that is, partisan activity within a science and between different sciences) was perceived only as an unavoidable evil, better left undiscussed than recognized and acknowledged. The poor professionals also found it difficult to maintain and continue, let alone extend, the earlier informal relations between government and science. They were not men of influence, born to rule and command, but weakly organized professionals with arcane and expensive demands difficult to explain, let alone justify. Few links existed to provide access to government for scientists, as scientists. And those few remained in the hands of oligarchic groups.

In both Britain and America philosophies of laissez-faire and localism served to reinforce the isolation and atomization of the scientific enterprise in the 19th century. The strength of these philosophies, and the aversion to direct political activity embedded in the traditions of Anglo-American science, may be seen in the fates of the two Associations for the Advancement of Science. Each began at least in part as a deliberate pressure group seeking government aid and recognition for the new professional science—"increased facilities and wider usefulness . . . for the labours of scientific men," to quote from the original "Objects and Rules" of the AAAS (*1*; *8*, p. 75). In each case these ambitious aims proved illusory, given the social philosophies and political realities of the day. Instead the Associations had to settle for a quieter and more modest role, stimulating and directing private and local enterprise.

In somewhat similar fashion a U.S. national academy of science was only created in 1863, when, in a fit of absence of mind, Congress finally responded to a highly secretive and arbitrary scientific lobby. The National Academy of Sciences, left to survive or perish on its own, in accord with laissez-faire doctrine, was quickly beset by the localism inherent in American life. It was in no facetious spirit that Asa Gray wrote to Joseph Henry, in 1874, suggesting that the National Academy "merely . . . add the word Washington to its title, which gives a local habitation. . . . While [I myself remain] President of the [American Academy of Arts and Sciences] I [can] not for a moment entertain the idea of any prerogative of the Washington Society such as its original organization seemed to claim" (*12*, p. 135; *13*, p. 223).

Specialism and professionalism were characteristics of late 19th century science throughout the Western world. But individualism, pluralism, localism, and laissez-faire were most apparent in the Anglo-American tradition. The state centralism of French science and government promotion and control of higher learning on the German model serve to remind us that nothing in successful scientific specialism required the private and impoverished anarchy so familiar in Britain and America. Vannevar Bush was confusing matters of social philosophy with those of the nature of science when, in 1943, he nostalgically wrote how "after many years I have come to the realization that science flourishes to the greatest degree when it is most free, [hence] I feel strongly that . . . [we should] return the maximum of independence to our scientific institutions and our scientific men, wherever they may be located." George Biddell Airy, Astronomer Royal, more accurately represented the situation in both countries when he said, a century before Bush: "In science, as well as in almost everything else, our national genius inclines us to prefer voluntary associations of private persons to organizations of any kind dependent on the State" (*20*).

Such deliberate avoidance of government intervention, always at least as welcome to the government as to the scientific community, placed a correspondingly heavy burden on private and local initiative, disinterested philanthropists, enlightened autocrats, college administrators, and industrial innovators. Of course, neither the British nor the American governments could wholely avoid the need for some science, whether in the Coast and Geodetic Survey, the Royal Observatory, or the Agricultural Experiment Stations. But the career structures and funding patterns of professional science in its formative period were at the mercy of the marketplace.

Scientists were in an unenviable position—offering ever more expensive services to a largely uncaring world. The stress on discipline organization, specialism, and professionalism in 19th-century pure science may perhaps be seen in part as an escape response from the unpleasant realities of the outer world. Be that as it may, the era of poor professionals added the idea of "freedom" in research (meaning the absence of organized and responsible government support) to the legacy that Anglo-American science inherited from the elegant amateur.

"Freedom" in research, the avoidance of general and scientific politics, and a penchant for oligarchic decision-making—all three were to cause problems when the dominant dukes arrived. In fact all three were beginning to trouble American science in the late 1930's, although unavoidably urgent business and increasing flows of money were able to postpone serious discussion to this present time.

Dominant Dukes and Present Problems

In 1962 W. H. Auden could say, "When I find myself in the company of scientists, I feel like a shabby curate who has strayed by mistake into a drawing room full of dukes" (*21*). Clearly something has changed from the days of the poor professionals. The implications of that change for the recruitment of scientists, and the organizations and functions of science, are as little examined as they are enormous.

This is not the place to consider the line of development that led from the deliberate use of scientific expertise in the German dyestuffs industry of the 1870's, through World Wars I and II, the Cold War, and the space race, to the all-too-familiar mushrooming of the health-education and military-industrial complexes, and their manifold links with the scientific enterprise. Rather I want briefly to point to the corresponding decline of specialist scientific societies as centers of the physical and intellectual capital of science and of scientific decision-making. These final remarks will of necessity focus only on the United States.

No formal reorganization of American science has paralleled that science's more than tenfold growth since

1920. Instead ever more narrowly defined specialist societies have spawned and multiplied, feeding off the growing personnel of science. Ad hoc mechanisms of considerable sophistication and complexity have of course evolved to serve the elaborate scientific needs of government, in the National Institutes of Health as well as the National Aeronautics and Space Administration, the Food and Drug Administration as well as the Pentagon. The demand for apparatus beyond the purse of any one society or institution and the continually increasing need for federal support have also contributed to changes in the social system of pure science. Perhaps the most obvious of those changes is the emergence of the new breed of dominant dukes. Unlike either the elegant amateurs or poor professionals, these men draw their fame, their monetary, intellectual, and social rewards, and their power in society directly from their enormous scientific ability. These "new mandarins" of science have been more often caricatured than studied. Their dominant role in shaping the directions, assumptions, and priorities of recent American science is both obvious and unexplored. As yet we know little of the reasons for their great functional efficiency in promoting and directing the growth of the scientific enterprise in the past half century, although the history I have sought to sketch may help explain their emergence.

When the science-government relation was entirely marginal both to the scientific enterprise and to general politics, it was of no consequence that the mechanisms of advice were oligarchically administered and centrally focused on finding scientific answers to the client's problems. The near absence of explicit concern for the broader health of, support for, and social implications of science was in no way critical. But ideas of "freedom" from government control, of avoiding overt politics, of allowing vital decisions to be made by closed groups, all continue to exercise considerable influence in a scientific world radically different from the ones that gave them birth. The older social organisms of science—and in particular the by now traditional specialist societies—have not as yet made extensive functional adaptations to the new world. The notable exception of the fresh paths that the National Academy of Sciences–National Research Council has itself been so determinedly pioneering over the last several years merely serves to highlight the extent to which the specialist societies have continued to be content with traditional definitions of their functions. A certain autumnal chill in the air may remind us that decay is the evolutionary alternative to adaptation.

Questions regarding science and politics, science and government policy, science and the environment, science and its social support and social implications are difficult and obscure, even when tackled with the scientist's traditional determination and honesty. That some new social accommodation and organization of the scientific enterprise is in process of formation is, I think, evident from the present restlessness in the larger scientific and political community. This restlessness is reflected in a host of articles, meetings, discussions, and resolutions. From a historian's perspective the central question would seem to be whether specialist societies will reorganize in ways that help accommodate broader social concerns, or whether such societies will undergo a relative decline in importance. It could well be that generalist societies, like the AAAS and the National Academy of Sciences, are better adapted to pioneer these new roles, which also cut across traditional disciplinary boundaries and concerns. If so, we may be on the edge of a new era in the life of scientific societies as social organisms, an era in which both general and scientific politics feature unashamedly in the *raisons d'etre* of reinvigorated and reorganized generalist scientific societies.

The present unease and debate concerning the structure and functions of science is reminiscent of that attending previous periods of transition in the social organization of natural knowledge. It seems clear that the broadening social cost and social implications of science raise the demand for new organizational forms, just as earlier social changes led science from generalist to specialist societies. It was the failure of a venerable and distinguished society to face fresh problems and responsibilities at that time, which led Charles Babbage to his impatient *Reflections on the Decline of Science in England.* My hope is that a sense of perspective, and calm and informed discussion, will aid the continuing responsive evolution of scientific societies in this country. Such evolution would forestall any need for the serious use of the title I chose, more for its historic associations than its present accuracy.

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22. Supported by the National Science Foundation. Many colleagues have been generous with arguments and conversation on the social relations of science, but I must especially acknowledge the stimulus of particular discussions with I. Bernard Cohen, Thomas S. Kuhn, Robert K. Merton, and Everett Mendelsohn.