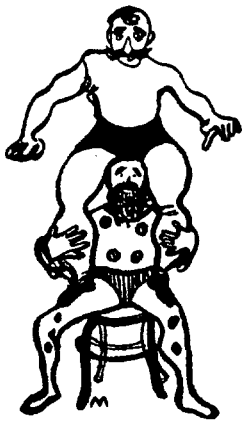
THE ORIGINS OF THE SCIENTIFIC SPECIES



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Professor Richard Meier of the Program of Education and Research in Planning at the University of Chicago and executive secretary in 1947 of the Federation of American Scientists attempts a sociological interpretation of the typical political, social, and cultural orientations of chemists, physicists, biologists, and engineers.

HAVE you ever had a conversation with a scientist and then started to wonder why and how he became what he was? Did you ever feel instinctively that one investigator was typical of his profession and that another in many ways was exceptional? Impressions like this imply that there must be some regularities in the social origins and personalities of scientists. Not only do they seem to come in distinct species, but in recognizable varieties within the larger subdivision.[1]

Most scientists in America today made the critical decision during the '20's and '30's which led eventually to the laboratory or the designing room. Somewhere between the ages of ten and eighteen the issue was settled for each of them and after that, education, work, and even many pleasures were closely conditioned by the choice. The most remarkable feature one encounters over and over again is the large proportion of scientists who chose their careers on the basis of virtually no information or experience relating to what was really involved in the scientific professions. Very few are able to isolate and identify the underlying motivation. Thus the original choice was usually subjective in nature, and therefore highly unscientific—according to standards later acquired.

The essential clues to a generalized picture lie in the social milieu of the '20's and '30's. This was the era of *Main Street, Dodsworth, Arrowsmith,* and *The Big Money.* There was a rapid, chaotic urbanization and a decline of the rural community. It became generally recognized that henceforth the pathway to higher social status and economic security led through the colleges and universities to the professions and managerial posts. Thus the land grant universities doubled and redoubled their registration, and the enterprising country colleges did almost as well. Any institution with tuition low enough to permit a fellow with grit and determination to work his way through obtained a fair cross-section of the bright youngsters of the period. Student bodies ranging west from Penn State and North Carolina developed remarkably similar social environments whereas the Ivy League schools, due to tradition and high tuition, remained individual and atypical; and New York City, because of the press of recent immigrants, developed into a special case.

THE CHEMISTS

Chemists are the most abundant of the scientific species. Their origins have on the whole been neither humble nor magnificent, but mainly lower middle class. They are sons of schoolteachers, small businessmen, successful farm owners, and lesser folk who had strong ambitions toward joining these ranks but, for one reason or another, failed. As youngsters they were encouraged to read widely, but the channels available were limited because more than three-quarters grew up in a Main Street atmosphere. They became both curious and romantic. Therefore it was quite natural that, when the subject of career came up, a profession was seized upon which was novel, romantic, and offered release from the tedium of the small town. The books available in small Carnegie libraries or high school collections had much to do with this decision, since all had such titles as *The Romance of Modern Chemistry* and *Science Remaking the World.* The fact that chemists were getting jobs when other graduates were unsuccessful was also a powerful argument, but this was known only to a minority at the time of decision.

During most of the inter-war period more than half of all entering science students were chemistry majors. They were pressed into laboratories well beyond their rated capacities. Many were ruthlessly flunked out, but those who remained were of the same background as those who failed. No real selection occurred until the junior year when those who could not comprehend thermodynamics drifted into biochemistry, bacteriology, ceramics, and related fields. Those who mastered this subject went on to become chemical engineers or chemists, either organic or physical. Thus chemistry tended to retain most of its best minds; graduate schools in the 30's were blessed with far more than their share of higher competences and rare intellects—a fact which reflects today in the thickness and quality of the research journals and the vigor of chemical technology.

[1] This analysis has been based upon discussions I have had with more than a thousand scientists scattered over the country. Such a survey is not strictly scientific because the sample could easily be skewed, but since a rigorous study is not justified (the present crops of scientists are evolving in quite a different fashion), this presentation is at least enlightening as to the kinds of interactions which occur between a society and its science.

The definition of the species used here has already been set down by the scientific and technical societies. Thus if a man identifies himself as a professional chemist and has the qualifications for being accepted as a member of the American Chemical Society he is *ipso facto* a chemist. Thus these generalizations cannot be applied to faculty members because they obviously are not a suitable cross-section of the profession. Representatives in industry and government must be included.

Chemists are seldom rebels or radicals. In an organization they grumble extensively but still are responsible, patient, and cooperative. They constitute at present the largest single reservoir of managerial talent in the technical area, and these capacities will be exploited even more in the years to come. The chemists' politics are usually a non-violent conservatism or liberalism (this depends upon your own vantage point) which is compatible with service both in corporations and in government agencies.

THE ENGINEERS

Whenever I talk to engineers about the current state of engineering they invariably make an exception of chemical engineers and their achievements. Why is this so? One man explained that chemical engineers have only a top dressing of engineering. Scratch a chemical engineer, he said, and you will find underneath nothing but a chemist who is used to dealing in tons rather than grams. Engineers are different.

He is right—everyone seems to agree that engineers *are* different. The bulk of today's engineers are more absorbed in their professional duties and less involved in either management or community activities. They are mostly apolitical, but when they do have views, these are of a stereotyped conservative nature. They find it difficult and exhausting to express themselves in writing or formal speech.

The reasons are not hard to find, since the engineer has had a harder struggle rising into the professional classes. Most engineers were sons of skilled workers, mechanized farmers, service workers, and the least literate of the lower middle classes. There was little encouragement to read at home but multifarious sports events to participate in, jalopies to fix, and miscellaneous contrivances to fiddle with. For these youngsters engineering was a subject where you learned "what made things tick." Thus it was natural to decide at ages 16–18, when the question of career came to a head, that one owed it to himself to go to college and become an engineer.[2]

Engineers had to contribute more to their own support while in college, and had a more demanding study program. There was no time to get a broad education when problem sets were demanding solutions. Thus it was natural that, on campus at least, engineering students became a race apart from the others, developing their own humor and informal associations. They failed gloriously in economics and English composition, but gained respect for their facility with the slipstick which dangled from their belts in a brown leather holster. Their bull-sessions were uninspiring because only two topics seemed to engross their attention besides course work, namely sports and sex.

Yet it would be unfair to draw these lines too sharply. At every engineering school there was an elite, much of it the sons or close relatives of contemporary engineers, but some from every section of society, who embraced a much broader conception of the world. They were as brilliant outside of the engineering school as they were within it. The real reputation of a school depended upon the size and capacities of this 5–20 per cent segment because today they constitute the cream of the profession—the consulting engineers and the top executives.

THE PHYSICISTS

The trials of the physicists came later in life. Most physicists (this category includes most astronomers, applied mathematicians, and some advanced electrical and electronics engineers) came from the upper middle class and the intelligentsia in general. Great numbers of them were sons of ministers, rabbis, deacons, cantors, and other church stalwarts. They were exposed from infancy to a wide variety of ideas, lived in homes with considerable libraries, and were nurtured on idealism, ethical behavior, and a rationalized morality. The ease with which they handled mathematical abstraction as youths made the unfolding physical world highly attractive. Here was something truly fundamental; here lay the secrets of the universe.

There were not more than a dozen significant physics departments in the United States before the mid-'30's, but Hitler's persecutions resulted in the great enrichment of American research starting at that time so that the production of finished physicists of all kinds reached a peak by 1941–42. Thus the bulk of the physicists were still absurdly young when the war directed their activity into two large-scale efforts—electronic devices, including radar, and the atomic bomb.

The physicist by nature is politically radical. His mind is schooled in the proposition that progress is made by discarding various assumptions and premises and thereby making it possible to create a more powerful theory upon a simpler underpinning. The physicist, more than any scientist, deals with abstractions which make nonsense out of observations based upon the commonplace; he is educated in doubt and can disregard evidence which to the ordinary observer is both convincing and conclusive. Thus many physicists chose a vague leftist political philosophy, partly as the only relatively rational set of value premises which was offered at the time ('36 to '40) in the world of ideas. The idea of an international community of science has from the beginning been very real to the physicists, while for the chemist it has been but dimly comprehended, and the engineer is almost completely oblivious.

The developments of the last decade have brought on many value conflicts within the minds of physicists which have often resulted in an apparent change of personality. No one hates secrecy with as much emotional vigor as a physicist, yet hardly any are more thoroughly afflicted with it. Everyone knows the disillusionment that accompanied the lack of international agreement on atomic energy but few can imagine the confusion of thought, the loss of goals, and even faith, that followed it. For many the fun has gone out of physics, they feel stale and unproductive.

THE VARIOUS BIOLOGISTS

The biologists are a complex assemblage. The profession can only be successfully described as the conjunction of several quite different streams of talent.

One important group has already been mentioned. These are the chemistry majors who bowed to thermodynamics and therefore moved into areas where their laboratory techniques were welcomed and the theory was less abstract. These were almost uniformly from the lower middle and professional classes and brought with them the same reasonable conservatism described earlier.

There is another group which is

[2] Margaret Mead suggested that these boys were canny enough to deduce "that it was really the engineer in the front office, and not the foreman, who was responsible for telling his old man what to do." This possibility of unconscious quest for power introduces a whole series of subconscious factors which might have been profession-determining during the '20's and '30's but are not reviewed here. I don't know how they could be adequately explored at this late date.

made up of exceptional minds which developed under agricultural surroundings. There was no material to experiment with in their early environment except the plants and animals which are the central theme of farm life. When these men got to college they enrolled in agriculture, botany, zoology, and related areas. The numbers of these scientists dwindled rapidly during the inter-war period because of the intrusion of urban values into the countryside. By 1940 it was mainly the South that was contributing any substantial number to this stream. A large share of the senior biologists in this country have such origins.

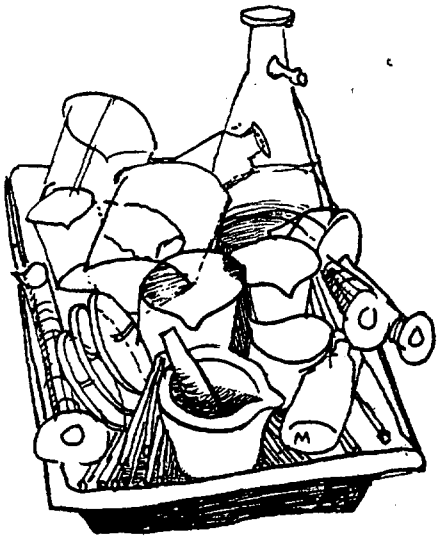
One doesn't think of this group as having any political orientation, yet I have often been surprised to detect attitudes voiced which hark back to LaFollette progressivism and quite radical-sounding ideas which were discussed widely in the farm areas in the days of William Jennings Bryan. Other than these few minor deviations, they seem to conform quite closely to the Protestant ethic.

Perhaps the largest portion of today's biologists aspired to become medics but were disappointed. One segment of these are the intensely ambitious and capable boys from poorer families who worked their way through college but were unable to finance medical school, and therefore turned their efforts to research in the biological sciences. The other segment came from middle class students who didn't make sufficiently high marks to gain entry to the medical schools and were therefore faced with loss in social status. Many drifted into pharmacy and dentistry but others became very high-grade technicians, often in applied research directions. A large number developed into ultra-specialists and so are able to maintain their self-respect as well as adequate incomes. In spite of the difference in social origins the political and social views of these men are remarkably similar to those exhibited by engineers.

ESTHETICS

Appreciation of music and the visual arts offers a striking demarcation of sensibilities between the scientific professions. The physicists, for instance, will show a strong preference for Bach. (I'm told that some *experimental* physicists will go so "modern" as to embrace Beethoven as a favorite.) Probably 95 per cent of all physicists are addicted to classical music and many are musicians themselves. Art criticism among circles of physicists and their wives is perhaps as sophisticated as one finds anywhere in the United States.

The chemists are also inclined to the classics, at least one might say that the majority express these preferences, but chemists want more melody and color and less counterpoint. When chemists congregate one is more likely to hear Brahms, Tchaikowsky (when Tchaikowsky is in vogue), Enescu, or Ferde Grafe. In their music, their artistic sensibilities, and their tastes in home decoration they are definitely "middle-brow," but this range is broad and inclusive since it brings together everyone from *Collier's* readers to *New Yorker* enthusiasts (where a merging occurs with the "high-brows").



The engineers can hardly be classified in this manner because engineers try to accommodate themselves to their surroundings. If they live and work with fundamental scientists they will gradually come to like Gershwin and Offenbach and not be completely bored by Beethoven. In the metropolitan areas, where engineers associate more with their own kind, they take to stage musicals and may also specialize in classics of jazz, swing, or bop. In heavily industrial areas you will find their enthusiasm in sports undimmed and over-riding—but, strangely, the best minds among them reserve an hour a week or so for some private effort, such as modern poetry, ancient history, or the anthropology of exotic places, a diversion which seems to release some of the pressures under which they work professionally.

It is interesting to note how exceptional the New York City environment has been in the differentiation of esthetic preferences. Those scientists and engineers who grew up in New York had little more chance of finding a high level of esthetic appreciation at home than those in the rest of the United States, but since New York was *the* cultural center, culture was always close to home and provided an early challenge to the intellect and imagination. In New York, most bright youngsters developed preferences for symphonies and opera, irrespective of profession. One notes this same equalization of tastes regardless of class origin in the San Francisco area, but to a lesser extent.

For the vast majority of scientists, the esthetic sensibilities were already molded by the time they entered college, and since then there has been only minor adaptation, just as the foundations for their political orientations had also already been laid.

THE DRIFTERS AND HYBRIDS

Generalizations about human society can never be perfect, so one is continually running into instances of careers which fall athwart the neatly defined categories. The supreme accomplishment then is to find new generalizations which apply to virtually all exceptions.

The scientists who changed their minds are a most fascinating study. The "drifter" may be defined as a person who came to realize that he had chosen an unsuitable profession while still obtaining his training. These men found, to their inner consternation, that there were fields more intellectually exciting than their own. America's cafeteria-style education system made it quite possible to salvage most of the effort already invested, so the change of direction was not a formidable undertaking. By this process the armchair sciences, such as theoretical chemistry, physics, and mathematics were greatly enriched from the ranks of the engineers and the applied science areas. There were much larger numbers of incompetents and dilettantes also drifting at the time, but very few of them are identified as scientists today; therefore they can be excluded from this discussion.

The drifters were outstanding among youngsters who were all exceptionally able. They found it easy to discover the standards of behavior in the new profession and adjusted without great difficulty; however, one could always note a more practical bent in

their line of theorizing than was common among their colleagues.

The hybrid scientist is a somewhat rarer phenomenon; he is the full-fledged professional who decided that the problems were more vital in some area for which he had no training whatsoever. Crossing over at this late stage takes fortitude because the more solid members of the profession he has been in and those in the new area will mutually cluck their tongues at his brashness. Yet there have now been so many instances in which crossing over has been accomplished successfully that the research councils and foundations have been setting up funds and programs to encourage still more of this sort of thing. Thus physicists may move into metallurgy or meteorology, engineers into psychology, and biology is fair game for everyone. Even the social sciences are receiving a few. The contributions of the hybrids are very rapidly bringing about a unification of the conceptual framework of the various scientific disciplines.

There is one highly successful generalization that can be made about the hybrid scientist. Almost without exception he crosses over from a more precise subject matter to a new area which is less precise in its data-gathering and experimental techniques. The hybrid is usually impelled to do this because his curiosity is stronger than the set of behavior patterns communicated to him as characteristic of his specialty. He is problem-oriented and, when the solution to the problem takes him to the boundary of his established competence, he refuses to be intimidated. Armed with the concepts and techniques he has learned and the special insights he has personally deduced, he will vault the barrier—if the new subject matter is more diffuse and qualitative.

Here is encountered a phenomenon among scientists which is often subconscious, occasionally recognized in part, but seldom understood for what it is—a consistent deference to theorists and the wielders of abstraction. The men who fit symbols to the data, or vice versa, generally have the last word. Thus an informal hierarchy of intellect has been created in the scientific community which finds the theoretical physicists, the geneticists, and the mathematical statisticians at the top of the peck order and the ordinary engineers and medicos at the bottom. Therefore a feeling of intellectual superiority reinforces one's confidence in himself if he crosses over into a less organized field of endeavor, but this is missing if the problem were pursued into a more theoretical discipline. In the latter instance the curious scientist will try to establish a cooperative arrangement with some sympathetic specialist rather than educate himself to meet those higher standards of criticism and manipulation of symbols.

THEIR MORAL CODES

The personal ethos for every person is a product of his social origins as modified by his adult experience. Problems of ethics are much more severe if the individual no longer circulates in the kind of society to which he became accustomed as a child.

Most chemists, engineers, and many biologists have ascended in social status and so have had to learn, in later life, how to behave in new and relatively strange surroundings. As one would expect, the adaptation was usually not complete, a high degree of sophistication in the new role was seldom achieved, and elaborate "holeproof" analyses of right versus wrong were rare. The engineers, because in general they have moved farther up the social scale and have had the least booklearning in cultural subjects, tend to exhibit responsibility only toward their families, their employers, and a close circle of suburban or metropolitan friends. The chemists will go farther and usually become responsible participants in the community, while a large proportion of the physicists struggle to define their responsibilities in terms of ultimates such as Truth, the liberal viewpoint, or the democratic concept. The attitudes of biologists are so diverse it is best not to generalize.

Scientists are bedeviled because two codes of behavior are demanded of them, and society requires that these be kept separate. In the laboratory and design office an attempt is made to exclude emotional bias and moral standards (mainly because experience tells us they lead to errors in logic and fact-finding), while in the remainder of daily life a rigorous scientific outlook is quite reprehensible. The mark of the successful scientist is that he has disciplined himself to compartmentalize his life so that neither side will seriously influence the other. It is not surprising then that many have developed schizoid personalities and that they suffer from the mental strain that is thereby induced.

The scientist's ethical troubles come to a head when his work takes on a recognizable social purpose. The results and consequences of one's own scientific work are obscured as long as the individual's effort is a highly specialized contribution to knowledge or technological advance. When the consequences of the search for truth are essentially unpredictable, the ethics of the investigators are limited mainly to their dealings with each other. In recent years, however, large and effective research organizations have been put together whose primary purpose (such as, for instance, weapons development) may conflict with the ideals maintained in the "social compartment" of the scientist's life. The most sensitive, of course, do not take risks with their consciences and refuse to join up, but the letting of research and design contracts to existing industrial organizations and academic research institutes means that the issue can be brought right to the scientist in his own laboratory. He must either accede or move out. Knowledge of this destructive aim seldom perturbs the engineer, since cause-and-effect relationships in society and international relations are extremely vague to him. Most of the chemists can effect the compromise without visible qualms, but the physicists are made very uneasy. The later build up highly elaborated rationalizations to justify what they do but are obviously not confident of the logical validity of their alibi.

The dilemma of what to do about the uses to which their findings are put confronts all the scientific species today, but each approaches the issue in a different manner. The engineer does not take the trouble to comprehend it, the chemist is more likely to be the "realist," explaining he couldn't do much about it unless chemists were the rulers, while the physicist sulks and worries, occasionally bursting into a protest. Few biologists have been personally affected as yet (the fraction

involved in biological warfare was very small) because their efforts are directed to the betterment of health and the improvement of agriculture—goals which can still be both practical and idealistic. The fact that only biology offers the same ideals that all science did in H. G. Wells' time is another important reason (operating at the sub-conscious level) for the current drift of the best scientific minds into biological subjects.

The differences in background among the scientific species leads to conflicting viewpoints in their national societies and even greater ones in their regional organizations. Scientific groups drawn upon professional lines cannot agree upon what a scientist's duty should be. The coming generation, however, will start from quite different social premises and may actually be able to effect a compromise between these two disparate worlds.

THE FORTHCOMING GENERATION

The present students view a scientific career as the path to prestige and security, rather than the road to romance and the power to control the environment. The new generation doesn't care to "set the world on fire." Like fire, they see science and engineering as double-edged occupations which may result in either good or evil. They hope to earn a decent income with intellectual effort and to live out a normal existence; they expect trouble but do not intend to be responsible for stirring it up.

Many students have grasped from their teachers, after spending some time in the departments, that the fun has gone out of physics, and that chemistry has lost its romance. This is reflected in the reduced numbers of students intending to continue in chemistry, since the proportion is much smaller now than before the war. The number of good minds enrolling is even more reduced, and this is just now showing up in the new crop being brought into the graduate schools—the chemistry professors are going to have a hard time getting adjusted to the level of mediocrity which other departments have always had to put up with. There was a post-war expansion in the physics schools, but the attractive power of nuclear studies has already diminished and, in spite of the abnormally high salaries beckoning in the AEC, appears to be declining.

Biology has glamor for the youngsters too, and the amount of drifting in that direction is considerable. Those with chemical training are intrigued by problems in the prevention of disease and the even more complex processes of aging, while those with background in physics are interested in reproduction or in the nervous system.

Up till now the social studies have remained virtually unaffected by the flux in the scientific professions, but their isolation is likely to come to an end in the near future. Already there are isolated examples of invasion from the physical sciences, and an interesting post-war phenomenon in many American graduate schools was the application of a few physicists and chemists to study for degrees in international relations, economics, social psychology, etc.

Today's novices are somewhat less ignorant of science and engineering than their predecessors at the time of decision, since they are often influenced by relatives or family friends who have had scientific experience. However the most important rationalizing element in their choice of profession is the counselling service. Veterans, in particular, were handed free, and supposedly expert, advice on virtually every campus. These choices were affected much less by adolescent dreams and relatively little by experiences while in the service (except for engineering, which attracted many young men who would not have gotten to college at all if it were not for the provisions of the G.I. Bill) but based mainly upon their individual capacities as demonstrated by scores on aptitude tests.[3]

There is another major step that needs to be taken before the selection of students for scientific training becomes fully "scientific." It is a procedure for adjusting the supply of each species to fit the predicted demand. In Great Britain, for instance, there is a consistent tendency to select and train at least three times too many geologists and architects and far too few chemical engineers.[4] Both Tories and Fabians are inclined to favor the intervention of the state so that the supply more nearly conforms to the demand. Presumably this would mean creating greater inducements for the study of such subjects as chemical engineering, or it could mean that the crossing over from such subjects as physical chemistry, metallurgy, and mathematics would be encouraged. Because of unanticipated changes in society's need for the respective scientific species, it seems best to overload the curriculum with the more theoretical subjects because the "law" formulated earlier regarding the creation of hybrids holds almost as universally in Europe as in the United States. Thus, by utilizing the crossing-over phenomenon, it is possible to provide for a considerable safety factor, which would be valuable for the survival of a society if it were to face an emergency of five to ten years duration or more.

The use of psychological tests to sort out scientific talent means that the class bias distinguishing the species will gradually disappear. The social outlook will also change, but in directions which are still indeterminate. Perhaps fully rationalized behavior may obtain a release from its imprisonment in the laboratory, infiltrate the character-building going on in the schools and some of the homes, and a variety of scientific humanism may be the keynote of the subsequent generations. On the other hand, the requirements of a strict ultra-loyalty, demands for conforming in both thought and deed, and the continuous intrusion of the political sphere will make of all the science a routine performance of superior skills. Theoretically, either of these alternatives would alleviate the discomfort of the schizoid pattern of behavior which is now required for scientific success.

[3] In many ways these developments parallel recent trends in British and some Continental university systems. There a predominant proportion (70–90 per cent) of the students have middle class origins so that fear or failure, and therefore loss of social status drive almost all of them to choose the safest areas for specialization, i.e., the ones in which their entrance exams were rated the highest. In these countries all the scientific professions are so thoroughly middle class in outlook that the minority which filters up from the lower strata have to assume quite completely the customs and idiosyncrasies of the middle classes. Differences in attitudes among the scientific species are largely limited to the intellectual hierarchy described earlier, but modified locally by long-standing traditions.

[4] The underlying causes and possible cures for this situation are discussed in my paper "Research as a Social Process," *British Journal of Sociology*, 1951 (in press).