Chapter 5: Scientism 1966-1968*

HANDLER READ MANY BOOKS when he was a child and found solace in them during the social isolation he experienced in his youth, which at the end of his career he described as "destructive in my case and led to social paralysis that I did not overcome until I got out of graduate school." He studied biochemistry intensively in college and graduate school, graduated in half the normal time, and joined the Duke faculty at twenty-one, an unnuanced, inexperienced, fervent biochemist. During the next quarter-century he developed his philosophy of "physical science," his term for chemistry and physics. He never studied physics and couldn't understand it because he never learned mathematics, but he deeply respected the logical structure of physics and the prominent physicists of his time. In speeches and congressional testimonies, Handler often described his concept of physical science metaphorically as a Gothic edifice. He was particularly effusive when he presided over the opening of a new physics laboratory his Foundation had funded (1967 May):

> We all rejoice in the Gothic concept of the House of God, a noble physical structure which conveys in stone and glass the majesty and grandeur of men's theological beliefs, edifices within which all of us experience awe and elation. Science, too, should have its cathedrals, cathedral-laboratories which convey the grandeur of its concepts, and the bold imagination which has gained insight into the essential aspects of man as a living creature and into the nature of matter, while gathering understanding of the universe in which we find ourselves. Such cathedrals should express also the essentially aesthetic nature of the scientific experience. And accordingly, it is but fitting that science, too, should be conducted in a structure which elicits awe and elation, a structure in which one can, in dignity, pay occasional homage to the pantheon of the gods of science: Newton, Maxwell, Gibbs, Einstein, Darwin, and all their company. As medieval man looked exclusively to religion for salvation in another world, modern man also looks to science, the understanding it affords, and the technology it breeds, to alleviate the condition of man on this planet. So worthy an enterprise should be housed in an equivalently noble structure, and I am most pleased that the National Science Foundation made possible this symbolic structure for exploring the physics of the atmosphere.

Handler often analogized science to cathedrals on the basis of majesty, but he never mentioned the huge toll they took on the societies that built and were supposedly elevated by them.

According to Handler, the edifice was composed of "facts" and grew as new facts were added; otherwise it never changed because facts were permanent, value-free, objective truths. He believed that only chemistry and physics could enable discovery of facts, each by means of its own version of the reductive method. In chemistry, facts were the result of observations in pointillist studies; there couldn't be a chemical fact that wasn't an observation. In physics, facts were observations predicted by laws; there couldn't be a fact in physics that wasn't predictable. All other human activities were subjective because they had no method for discovering objective facts. At best nonscientific activities produced only what he called "subjective facts," by which he meant

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inextricable mixtures of values and observations that didn't generalize to reliable knowledge. Nonscientific activities included the "life sciences," a term he used to describe a diverse group of subspecialties in biology and medicine other than biochemistry, and the "social sciences," a group of specialties he disdained and, at least early in his career, called "voodoo science."

Those who disagreed with Handler's edifice model of science as it applied to biomedical research viewed the results of the pointillist studies not as objective facts found by biochemists but rather as subjective claims — interpretations constructed on the basis of biases, values, opinions, particular laboratory methods used, specific kind of data chosen for collection, and the details of the assumed mechanical models of nature used in the studies. Handler's own publications in the 1940s were fine examples of what the constructionists regarded as subjective claims — assertions that could become temporally unstable facts if accepted by enough of an investigator's colleagues but certainly not girders supporting an edifice. Constructionists saw all forms of research, especially biomedical research, as profane and fluid — a perpetual quest for knowledge governed by rational methods as well as values, the results of which were always challengeable based on new observations and ideas. Handler scrupulously avoided debating constructionists, who may have had the better view but were far weaker than him politically and financially, and lacked a forum in which they could confront him.

Handler's commitment to the edifice concept of physical science and to the notion that chemists and physicists were essentially the only true scientists was the defining feature of his professional personality. He recognized that the opinions of scientists had to be perceived as validated to gain acceptance by the public, like the preaching of clergy was validated by the Bible. But chemists and physicists had no holy book so he located validation in the nature of the specialties themselves, their "epistemological specialness," his term for the idea that chemistry and physics were the only human activities dedicated to the search for universal objective truth. What chemistry and physics achieved, Handler said, "was one of the few aspects of modernity in which the human race could justifiably feel unalloyed joy."

The early physicists had recognized living and non-living objects were fundamentally different and, therefore, that there had to be some factor which accounted for the rigid dichotomy. For practical purposes, however, they concentrated their basic research on the behavior of non-living objects, which they conceived of as composed of rigidly distinct parts, and they employed that reductive model in their efforts to understand the behavior of the whole. When Handler was only eighteen years old, he accepted the proposition that the model also applied to living objects; their parts, called biochemicals, made life when stirred together. He was taught that different combinations of the biochemicals made different kinds of life, and that subtle concentration variations of particular biochemicals accounted for the differences among individuals of the same species. According to Handler, the fundamental reason chemists and physicists in his time could discover scientific facts was that their thinking and experiments were based on the model of an object of study as composed of parts that could be studied independently to understand the behavior of the whole.

The methodological strategy of reducing the behavior of an object to that of its parts contributed to technological development. However, the strategy failed to explain life or the overwhelming majority of phenomena manifested only in living objects. Let me say that again. Use of the reductive model developed by physicists did not result in the explanation of life or most biophenomena. The model explained some phenomena that occurred in living objects but only if they also occurred in non-living objects — the explanations for why a microwave beam generated heat in a live rat or a dead rat or a pot of water were identical. But the model couldn't explain why the microwave beam in Moscow caused changes in the bodies of American diplomats that it didn't cause in dead people.

Handler knew the limitation of the reductive model — its inherent inability to explain most biophenomena — threatened his goal of establishing biochemistry as the exclusive science of clinical medicine. He could hardly expect to succeed if biochemistry couldn't explain biophenomena. Even worse in Handler's eyes was the possibility that a perceived failure would resurrect the idea of a soul or spirit sent by God as an explanation for life. Handler dealt with the issue of what life was early in his career, and concluded it was the result of the operation of the chemical principle of mass action. He believed that, someday, life would be created by biochemists who mixed off-the-shelf chemicals in a test-tube, and he had no intention whatever of revisiting the issue. His response to the threat was to characterize the limitation as only apparent, not real. He did not challenge the reality of the binary classification of matter — that every object in world was either alive or not alive, but he denied the inference pregnant in the distinction, that there had to be something which accounted for the dichotomy — some, law, factor, interaction, process, or principle that was present only in living objects. No such inference was necessary, he argued; if it were necessary then physicists would have discovered it. He concluded that that anyone who accepted the inference was denying the laws of physics.

His opinion — that physics was already complete and no further development was needed — was a rank form of misleading demagoguery because physics is never complete but rather continually changing, as evidenced by the twentieth-century developments of relativity, conversion of matter into energy, and quantum mechanics. The path remained open for physicists to explore new models of nature; the reductive model was far from being the only model for studying biophenomena. The plain facts were that a new model was indispensable for understanding biophenomena, and that physics was the only scientific specialty that had the inherent capacity to discover it. Chemistry had no such capacity because it was only a subspeciality of physics with no independent existence apart from the laws of physics. Nevertheless, by means of arguments that echoed those of Euthydemus and Dionysodorus, Handler persuaded America's political leaders who controlled the funding for scientific research that the reductive model could and would explain life and particular biophenomena — notwithstanding abiding evidence that it couldn't and wouldn't — and he was given the bureaucratic power to achieve his goal.

Handler had the requisite economic influence over basic research funding by the Institutes and the Foundation to successfully discourage experimental attempts to directly study life, and to block attempts to explain the underlying reason for the universal recognition and acceptance of the binary classification of matter. Consequently, his naked assertion — that the existence of a life principle defied the laws of physics — was accepted by federal funding agencies as an operating principle for choosing research proposals that merited financial support, and the members of their advisory panels were chosen accordingly. The overall result was a blockade of all biological, physical, and mathematical research aimed at developing non-machine models of humans that had the potential to deepen scientific understanding of life, health, and disease.

In Handler's view, scientists were personally free and solely responsible for all decisions regarding what research they performed. Individually and collectively, they chose what research should be done, identified what was good or bad research, and evaluated its societal implications. All the important decisions regarding both who received the money required for research and the nature of that research were made by scientists who served on advisory panels of the Institutes and Foundation, committees appointed by the National Academy of Sciences, boards of directors of professional societies, journal editorial boards, or university faculties. According to Handler, their decisions were objective because they were made by scientific rather than democratic processes, and were untainted by the participation of laymen or consideration of lay values. The epistemological specialness of science, Handler believed, entitled scientists to freedom from direct political control or oversight by the government and to protection from federal bureaucracies. He saw self-regulation and self-direction as the keystones of basic research, and any attempts by the government to exert political control over the activity as an impediment to the discovery and elaboration of true facts. The government's sole responsibility, Handler said, was to provide the money for the basic research that contributed to the Gothic edifice.

Handler's expansive views of the freedom of scientists applied to the right he imagined they had to be paid by the government for basic research motivated by intellectual edification but not to the right of free speech. A mathematician used travel money in his Foundation grant to go to Moscow to attend a scientific society, and while there he criticized American involvement in the Vietnam War. Handler, the Foundation's highest official, cancelled the grant and refused to publicly disclose the basis or scope of his decision, effectively saying the reasons for his action were none of the public's business. If Handler had the power to punish a grantee who had the poor judgement to criticize the nation's war policy while abroad, which was his constitutional right, the question arose whether Handler might go further and cancel a grant to any critic of any national policy voiced anywhere. The potential scope of such a power was chilling because the Foundation funded essentially all academic basic research conducted in the nation's universities.

In return for the freedom to perform research funded by the government, Handler believed scientists were bound by a social contract to employ their epistemological exceptionalism in the service of society. In his conception of the contract, the government had a responsibility to consult scientists regarding issues involving science. He thought the responsibility of scientists could be discharged only if they were given a more prominent role in resolving public policy issues. Because science was too complex to be comprehended by laymen, the issues could not be resolved adequately by the political processes employed to develop policy for ordinary societal issues. Handler assumed that the science and non-science aspects of policy were separable and separably resolvable, and that a bifurcated evaluation process was necessary to avoid contamination of science by lay participation. In cases of mixed science and values, Handler expected the authority to distinguish between them to be granted to scientists because, he believed, they had the wisdom to confine their opining to the scientific aspects.

HANDLER'S EPISTEMOLOGY OF SCIENCE had pervasive consequences on the kind of basic research in biology and physics that was conducted at American universities. He established a reductive funding policy for biomedical research at the Institutes and managed its application at the Foundation, where its use pre-dated his appointment to its board of directors. Handler's popularization of the exclusive use of reductionism in federally-supported research in biomedicine and biology — essentially nonexistent before his time — led to greatly increased federal spending but, ironically, to artificially limited meaningful growth in both areas.

Historically, biologists developed methods for discovering knowledge of living systems that were uniquely appropriate for living systems and were primarily guided by a complexity model. The model was based on an integrative view of living nature that sharply contrasted with the meat-chopper reductive view Handler imported from physics. Because the objects biologists studied were immensely more complex than those studied by physicists and chemists, biological research was mostly empirical in the sense it was aimed at establishing reliable facts and causal relations as opposed to developing grand theories of everything, as in physics. In Handler's time, biology had established only one grand theory, evolution, which today is still its only grand theory. And as appropriate for a specialty based on empiricism, the theory of evolution was formulated and transmitted to posterity in prose, not mathematics.

The methods used to study the complexity model were logical, observational, organizational, experimental, and only occasionally reductive. The model of living organisms as complex entities composed of multiple levels of interacting levels of structural organization required nimble, sensitive, and logical experimental designs. There were no over-arching physics-type mathematical laws that governed the behavior of living matter; consequently biologists developed a variety of experimental designs for discovering knowledge. They employed the designs to discover the contributing causes of biophenomena, and in the process built a growing tree of knowledge that continuously gained and lost branches , as opposed to a monotonically evolving edifice consisting of permanent levels.

However, biologists lacked a proselytizer like Handler, and there was no federal funding agency that supported the discovering of knowledge using experimentation based on the complexity model. Consequently, in contrast to biochemistry which grew like cancer, progress in biology during Handler's time was comparatively minimal. Handler actively opposed attempts to directly study biophenomena, favoring instead the exclusive use of test-tube biochemistry for the determination of biochemical mechanisms. He employed his rhetorical gifts to teach that efforts of biologists to understand biophenomena by studding contributory causes were unscientific. According to him, it was ultimately futile to study life directly because "it's not possible to do an experiment to find life." By exercising his power over grant funding at the Institutes and the Foundation, Handler had outsized responsibility for the seemingly irreversible diminution in the perceived importance of traditional biology, which declined in inverse proportion to the increased role of the federal government in funding biochemical research. The perspective of biologists became a foreign element in the pro-reductive mechanism-seeking federal funding environment Handler principally authored and instantiated by testifying before numerous congressional budget committees.

Handler shaped the then-burgeoning federal biomedical research enterprise into a purely biochemical activity. Biochemistry became the black-letter law and official science of medicine — not on merit but because the federal government patronized Handler's egregiously incorrect model of living organisms. Essentially all available federal money for biomedical research at universities became dedicated to research whose objective was to understand test-tube-type chemical reactions. Other federal agencies also supported research at the universities, but the Institutes and the Foundation were the agencies that defined the norms for basic research and to which the other agencies conformed. Hidden in plain sight was the reality that the contributory causes and likely cures of diseases — the ostensible purpose for which the nation's biomedical research establishment was created — could never be discovered solely by test-tube research on human tissue extracts because the contributory causes and likely cures of diseases didn't exist at that level of anatomical organization. Handler played a significant role in the descent of clinical medicine that occurred — from an art and skill based on experience to applied biochemistry, which Handler began calling "molecular biology," an oxymoronic term he used after deciding "biochemistry" no longer had public appeal. Handler was acutely aware and exceedingly proud of his impact on clinical medicine. From his earliest days to his death, Handler's attitude toward physicians varied only narrowly between the limits of disdain and outright contempt. Despite his multitude of symptoms and signs, he consulted a physician only in desperate situations because he strongly believed their methods were unscientific. He believed his efforts to advance biochemistry would improve clinical medicine and rescue it from woeful anecdotalism.

Handler had been an authoritative voice at the upper levels of governance within the National Institutes of Health, and a major designer of its system for choosing which research proposals would be funded. When he controlled the biochemical advisory panel, he established reductionism as the quintessential experimental design for biomedical research; while on the board of directors of the Institutes, he founded a new Institute devoted to the idea that biochemistry should be supported and encouraged because of its ethereal beauty, as if it were a Platonic Form. But soon after the new Institute was created, the Congress, apparently recognizing it had gone too far down the road toward insulating scientists from democratic control, stipulated that public money must be spent for a public purpose and that pursuit of subjective concepts of scientific beauty was not such purpose. Congressional insistence that federal funds be used only for research primarily intended to yield tangible results rather than intellectual satisfaction was a setback to Handler's vision of the elevation of biochemistry in society. In a speech at the Institutes, Handler explained how he thought the setback could be overcome.

He recommended that the Institutes develop "planning opportunities" to attract biochemists to research areas that were popular with the public, and he singled out genetic defects as one such area. He said interference by congressmen who favored other areas of research should be treated with "a wise and salutary neglect," the same way their demands that planned research be performed at non-elite universities in their districts were managed. Handler emphasized the necessity of avoiding long-range planning for the enterprise of basic research, such as the Administration's so-called "war on cancer," by asking rhetorically, "How many instances of governmental planning of successful major advances in the elucidation of human biology or in the understanding, prevention, or treatment of disease have there ever been?" and answering "none." He said there was no viable alternative to his plan because the pursuit of basic research could be organized only by granting complete independence to biochemists; the Institutes' responsibility was to obtain and provide the necessary financial resources.

Handler urged the Institutes to strive to advantage grant applications primarily intended to advance biochemistry itself, and to not adopt a policy of limiting grants to the pursuit of objectives chosen by politicians or bureaucrats because they were unqualified to make such decisions. The research objectives of the biochemical researchers were sufficient justification for the support they needed. Giving them free rein would insure they attacked the important problems in biochemistry and, Handler asserted:

> Armed with the information and understanding thus to be acquired, it is almost certain that one day we shall understand and hence, hopefully, learn to control the major killers of mankind — cardiovascular disease, cancer, and dozens of other disorders. There is now reason to hope that when there has been gathered sufficient understanding of the brain's chemistry, the products of our pharmaceutical houses or the skill of our neurosurgeons will successfully displace the practice of psychiatry.

He conceded that most biochemists who were free to choose "would shun the immediate problems of disease and seek to enjoy the esthetics of basic research, perhaps genetics, or perhaps some wisp of the Zeitgeist might lead many to examine the mechanisms of carcinogenesis." But he predicted that the fruit of their work be discrete jumps in basic understanding of the biochemical bases of disease, contributions to the Gothic edifice of knowledge that would allow biochemists interested in applied research to find cures for specific diseases, and would serve as a catalyst to open the public purse thereby increasing the budget of the Institutes. In language that was tortuous even for Handler, he summarized the idea behind his proposal; "A rational problem-solver wants what he can get and does not try to get what he wants except after identifying what he wants by examination of what he can get."

While Handler was in authority at the Institutes, the number of biochemists in the U.S. increased by more than a factor of a thousand, and its budget grew prodigiously, enabling it to make hundreds of thousands of grants. But they did not lead to any great advances in science or winners of a Nobel Prize, only to a wide river of pointillist publications and a good living for mediocre biochemists. In an unguarded but revelatory moment Handler conceded that the research was characteristically pedestrian but said it was the price society had to pay to produce the once-in-a-lifetime advance that adds a new wing to the edifice of knowledge.

In his capacity as chairman of the board of directors of the National Science Foundation, Handler set its policy and controlled its spending. It was a ponderous federal agency, constantly enmeshed in political disputes with the Administration and the Congress and geologically slow in developing and effectuating its policies, a condition Handler illustrated using one of his favorite stories: “Running something as large as the Foundation is like making love to an elephant. You probably wouldn't enjoy it and you would have to wait two years to see the results.” Although he was appointed by the President and the Foundation was in the executive department, Handler regarded the Foundation principally as a representative of the scientific community rather than an instrument for Administration policy. He used his office to proselytize his ideas about basic research and elevate the status of the physical sciences in society. He said:

> I think that society has the right to have four-lane, limited-access highways. But it also has the right to have scientists who only ask questions of nature, questions of their choosing, just for the sake of asking, to satisfy their own curiosity. I don’t mean this to sound like the arrogance of a scientist who claims that because we’re such bright and extra-special people you should leave us alone, support us, but leave us alone. I mean that, in the long run, society is the beneficiary of the self-interest of the pure scientist.

According to Handler, it was difficult for congressmen and scientists to agree because most congressmen were lawyers and the intellectual gulf separating them from scientists was hard to bridge.

Handler viewed his position at the Foundation with a swagger that was unprecedented for a public science official. In a speech to heads of the nation’s largest scientific society, Handler asserted that the National Science Foundation had sole federal jurisdiction over “the progress of science, science education, and development of the universities in which the activities are conducted.” Because he was the head of the Foundation, he said, according to the law, he was the official primarily responsible for determining federal science policy related to universities. He said he communicated its policies to the President by memoranda and by the content of the programs it supported. Thus, according to Handler, if the President wanted to know the Foundation’s policies, he had the options of reading what Handler wrote or watching what he did.

Handler’s attitude was that the government had a duty to pay for basic research because it was a triumph of human reason that affected the whole intellectual life of the nation; he said basic research was the best single element humanity had ever contributed to its culture. He earnestly believed that adequate governmental support for research would improve the nation’s spiritual climate and favorably influence all other human activities. Failure to do so, in Handler’ view, was an assault on physical science, but he seemed never to have considered whether spending the money for some other purpose might create a better climate. In congressional testimony, he repeated the argument first made by Frederick Seitz soon after he became president of the National Academy of Sciences, that spending for research should increase annually so that by the end of the century it would amount to half of the national income. Handler’s efforts to support the physical sciences produced some societal benefits, but his descriptions of them were obscured by a cloud of rhetoric and self-interest, and the funding levels he demanded lacked even rudimentary economic justification.

Handler developed a grossly inflated view of the importance of biochemistry in American society. He had gotten his major start-up money for biochemistry research with the help of influential friends in the Biochemical Society, and his research grants reached unprecedented financial heights with the help of his friends at the Institutes. Other biochemists followed more or less the same trajectory and, human nature being what it is, friend helping friend, particularly through the Institutes' advisory-panel funding process, became the norm in biochemical research. The process grew the numbers and political power of biochemists and facilitated their exclusion of the other specialties involved in biomedicine from drinking at the Institutes trough. The exclusion further strengthened the political power of biochemists, which developed to the point where Handler felt emboldened to demand, on their behalf, privileges and prerogatives not enjoyed by any other professional group in the country. On the basis that biochemists were the creators and guardians of knowledge related to biology and medicine, Handler pressed for more money and more freedom for them, asserting that they were deserving because they had the requisite training and character. Because Handler misinterpreted the cronyism he fostered as if it were scientific competence, he saw a level of importance for biochemistry that didn't exist.

Handler didn't understand physics at any level deeper than that of a well-read science journalist, but he admired the explanatory power of physics and the preeminent role it played in the construction of the edifice of science. His respect for physics was enhanced as a result of his interactions with the prominent physicists, which occurred routinely because of Handler's various science, managerial, policy, and advisory positions. He would surely have been stunned to learn that his science policies contributed materially to the arrest in the growth and development of physics that occurred, but that was exactly what happened. Handler sought to deny that there was a fundamental difference between a living organism and a rock, a position he believed necessary to defend the importance of biochemistry. His defense of the position failed, as it had to because it was foolish. But worse, in attempting to mount the defense, Handler effectively injected physics with a strong sedative that put it to sleep for at least the next century.

By the end of the nineteenth century there was general agreement among physicists that life was entirely a physical process, but there was no understanding regarding what physically distinguished the living from the lifeless, or regarding how that difference could be derived from the laws of physics as they were then understood. Soon after Handler became a biochemist, then a new specialty, great progress occurred in biochemistry; the structures of myoglobin and hemoglobin and DNA were discovered, the basic biochemical units of proteins were synthesized in test tubes, a DNA enzyme and the genetic code were identified, and both messenger RNA and transfer RNA were discovered. They were halcyon days for Handler. He expressed intense pride in being a biochemist, and interpreted the discoveries as conclusive evidence that the human body was a chemical machine. And just like any other machine, according to Handler, living machines were governed by known physical laws capable of deductively explaining life. He said:

> Life can be understood in terms of the laws that govern and the phenomena that characterize the inanimate, physical universe and, indeed, that at its essence life can be understood only in the language of chemistry.

But his biochemically reductionist model did not actually address the question of what physically distinguished the living from the lifeless. He simply begged the question.

Although the federally-funded biochemical enterprise was synchronized to Handler's reductionist view of life, there were more skeptical and holistically minded thinkers who believed there existed ways to understand or extend the laws of physics so as to provide a proper, logically consistent answer to the question of how life and lifeless differed. Experimental attempts to explain life and the behavior of living organisms using the language of physics occurred relatively frequently, both historically and during the time Handler was in power. But he was in authority at the Foundation — the only source of federal funding for university-based basic research in physics in the U.S. — and did his best to deny funding proposals for non-reductive experimental approaches to the study of life, viewing them with the same contempt he would view an application for support of research into the physics of love or hate or belief in God. He never made his decisions about physics proposals on the basis of knowledge or understanding of physics and mathematics — he had none. Rather he blocked new initiatives because they were invariably based on complexity models of living systems, which were personally abhorrent to him, and because politically prominent physicists like Seitz wanted basic physics research funds used for big-science projects like astronomical telescopes, atom-smashers, and floating platforms to drill holes in the earth's mantle.

The thermodynamic research of Prigogine was one example of a novel research project Handler refused to fund; the discovery by Edward Lorenz of the limits of physics to explain complex systems was another. Lorenz applied the laws of physics to the study of weather, a natural, complex, chemical system, and proved that weather was highly sensitive to even the smallest possible changes in climatic conditions, a sensitivity he described metaphorically as "like the ability of a flap of a butterfly's wings in Brazil to set off a tornado in Texas." His results showed that, in a complex system, infinitesimally small changes due to interacting elements could have consequences observable on a macroscopic scale. Such behavior was absolutely certain to occur in humans — the most complex objects in the universe and vastly more complex than weather systems. Lorenz's discovery revealed the limitation of reductionism to explain complex systems. If properly recognized, Lorenz's work would have been seen as conclusive evidence that Handler's dream — that life could be predicted based on the biochemical principle of mass action — was just that, a chimera in his brain. Although Lorenz provided a meaningful insight into how physics might explain life, it was not funded by the Foundation, and was carried out only because it was supported by the military. The more important consideration from Handler's point of view was maintaining the appearance of viability of the cognitive structure of biochemistry he had built. He did not understand that one of the consequences of his bias was blindness to developments in physics that were then occurring around him.

The cost of basic research in physics became enormous because big machines were required — particle accelerators, telescopes, and huge electromagnets needed to explore controlled nuclear fusion. Physicists working in big physics banded together in large groups and sought funding from the defense, space, energy, and nuclear federal agencies. The Foundation became relatively insignificant — its entire research budget couldn't support even one big-science project. Handler contributed to a general downslide in physics research by blocking funds for university-based research in small laboratories to study the physical principle of life, a domain he reserved for biochemists who, by training, temperament, and learned bias, had no knowledge of physics and no interest in physical principles.

Big-physics became politically untenable because of its costs and lack of support by the public, which saw the projects as efforts that benefited only physicists. Little-physics experimentation was tenable, popular, and potentially beneficial to society, but it was an existential threat to the cognitive construct Handler had built. Consequently there was no meaningful direction for physics to grow that was both fundable and foreseeably beneficial to society. The number of new physics students dropped steeply, as if physics had fulfilled its historic mission of birthing technology and was exiting the stage of science. New PhDs left physics in search of opportunities to do research that was based on thinking like a physicist but that sought knowledge that was foreseeably beneficial to society — I was one.

The depression in physics undercut Handler's ability to use the Foundation to fund university-based research as a stepping-stone toward national scientism, but that was only part of the problem Handler faced, as head of the Foundation, in his attempts to use it to elevate basic science. Against his advice, the Administration and the Congress made fundamental changes in the Foundation's mission, requiring it to support applied research, research in the social sciences, and engineering applications of science. Faced with those changes, Handler made a desperate proposal, that the government fund block grants to universities for any academic purpose they deemed appropriate, including basic research. Publicly, he argued that block grants were needed to prevent universities from being taken over by the government; privately, he conceded that his goal was to secure a stable funding source for the continuation of university biochemistry. The Administration rejected the plan.

Handler's model of biology drew heavily on the biochemical-machine model of life, despite the increasing evidence that it was inadequate for a mature science of life. The model depended solely on the chemical energy extracted by the body from food and incorporated no meaningful role for electromagnetic energy. When scientific developments occurred in Russia that were inconsistent with the machine model and exclusion of electromagnetic energy, Handler broadly attacked the quality of Russian research. In speeches and congressional testimonies, he frequently claimed — always without supporting evidence — that Russian biological and medical research was vastly inferior to that of the U.S. But during the years he was alleging Russian biomedical inferiority, U.S. government agencies began systematically providing American scientists with translations of Russian scientific journals. One result of the government's interest in Russian science was a dawning awareness in the U.S. that Russia was far ahead in some areas of biomedical research — Russian agricultural science had suffered from a Lysenko but its biomedical science did not suffer from a Handler. Results of numerous animal and human studies whose designs were not intellectually confined to a strict biochemical model of biology appeared in the Russian literature. Among the newly disclosed studies were those involving the biological effects of electromagnetic energy obtained from animals and humans — research that had no parallel in the U. S. Russian authorities, relying on information in the publications, set safe exposure level for the general population to microwave electromagnetic energy ten thousand times lower than the safe level set by American authorities, which was based entirely on mathematical calculations by Herman Schwan. The huge difference in safety levels was exploited politically by Russia when it directed a continual beam of microwave electromagnetic energy in a weapon-like fashion against the U.S. Embassy building in Moscow, using an energy level slightly above the Russian safety level but far below the U.S. level. After embassy personal developed a range of medical signs and symptoms, Handler advised the government that the Russian research was inferior and did not support the Russian safety level. Relying on Schwan's calculations, and on what Handler said was a general biological principle that a very small amount of anything is presumed safe unless proven otherwise, he dismissed the possibility that the reported health problems were related to exposure to the electromagnetic energy, and speculated that they were due to an unrecognized virus.

In what was perhaps the earliest coherent marshaling of experimental evidence that Handler had taken U.S. biomedical research down the wrong road, Aleksandr Presman, from Moscow University, published a book on the relation between electromagnetic energy and life. An experienced scientist in bioelectromagnetism, he comprehensively reviewed and analyzed the relevant Russian research, and the related work of American and European investigators and reached decidedly un-Handler conclusions. Presman recognized that electric shock and microwave heating were trivial electrobiophenomena in the sense that they were easily explained by the laws of physics when using a reductive model of living systems. However, Presman described numerous other electrobiophenomena reported in the literature that were a result of the interaction of the energy with complex processes in the living body and therefore could not be explained on the basis of the simplistic reductive model of biology advocated by Handler and his followers. Presman recognized the importance of further research aimed at understanding the electrobiophenomena rather the option of continuing to deny their existence, as favored by Handler, who ardently pursued a policy of promoting scientism, but not anybody's scientism, only his version.

The view that Handler's machine model was inadequate and took biological research up a blind alley prompted some investigators to pursue other paths. Only a few were sufficiently well-known that they could do so while receiving funding for their research from the Institutes despite Handler's opposition. Frank Brown, who studied circadian rhythms in animals, was one such investigator. He showed that animals had inborn clocks, inborn rhythms, and inborn sensory systems in addition to the visual system for detecting electromagnetic energy signals in the environment that synchronized the clocks and the rhythms — three related but different things. Handler objected to the non-visual sensory-system aspect of Brown's work for reasons Handler never explained but that, according to what Brown told me, probably stemmed from a visceral antagonism toward bioelectromagnetism. Handler acted against Brown by funding research grants to Brown's severest critic, a biochemist named Woodland Hastings. He performed test-tube biochemical studies and claimed they refuted the essential message in Brown's work — that circadian rhythms were a result of complex interactions among multiple levels of organization in animals and humans. According to Brown, the rhythms were inherently unexplainable using only a machine model of life because they did not exist in the gears of a living system but rather were one of its emergent properties.

Like Handler, Hastings regarded the clock and the rhythm as the same thing, and argued that the clock was a completely self-contained timer, independent of environmental signals except light; otherwise, he asserted, rhythms were a self-regulating property of the biochemical activity inside living systems. Hastings repeatedly claimed Brown's work on energy biosensitivity and its role in synching biorhythms to environmental rhythms was unsound. He said, "The property of being sensitive to a hypothesized exogenous electromagnetic cue whose putative effect is that of providing time information of some sort is not supported by evidence." Hastings faulted Brown for failing to explain the biophysical nature of the biochemical clock mechanism that was sensitive to electromagnetic factors, and urged that "the hypothesis should be viewed with the greatest skepticism." Hastings made no attempt to repeat Brown's experiments; he believed they must be wrong because he somehow knew that electromagnetic energy was biologically insignificant. Handler opposed Brown and favored Hastings for the same reason — not because of any identified or even suspected inconspicuous experimental defect, but because Handler somehow knew that nothing worthwhile could come from any non-mechanistic biological study, particularly one involving electromagnetic energy, like an umpire calling a batter out before he enters the batter's box.

Brown was the first investigator to establish that animals had a sensory system in addition to the eye for detecting natural electromagnetic energy and transferring information in the detected signal to the brain, permitting it to orchestrate appropriate behavioral responses, in particular, changes in the timing of inborn behavioral rhythms. He found that animals could differentiate the natural periods of change of electromagnetic energy in the atmosphere from the small fluctuations that occurred in association with changes in in longitude and latitude, an ability that could enable organisms to use the earth's field as a compass. His discovery of an animal electromagnetic sense had a significant effect on natural biologists, resulting in field and laboratory studies by many investigators that showed birds, insects, fish, bacteria, and even the platypus, a mammal, were sensitive to environmental electromagnetic energy, and employed the information in the detected signal for purposes of migration, orientation, and prey-location. However, from among the multiplicity of questions that Brown's novel research raised, the only issue that earned Handler's attention was the biochemical nature of the innate clock. When the responsible biochemical oscillators in the brain were discovered, which was inevitable because the clock existed, Handler was satisfied that the important questions regarding circadian rhythms had been solved.

Rutger Wever extended Brown's observations to humans by showing experimentally that natural electromagnetic energy affected circadian rhythms in volunteers. He further showed that the effect on the rhythms could be replicated by first blocking the natural energy and then applying man-made electromagnetic energy. Because of its practical implications for space travel, Wever's research was supported by the U.S. space agency, but neither the Institutes nor the Foundation provided any support because his objective was to verify and characterize a phenomenon as opposed to testing a mechanistic hypothesis. Verifying a phenomenon is logically prior to understanding the mechanistic details because nonexistent phenomena have no mechanisms. Nevertheless, largely as a consequence of Handler's influence, the biomedical research sponsored by the Institutes and the Foundation was restricted to the study of known phenomena; only studies of their mechanisms were allowed. The egregious bias inherent in his notion of biological research was that something unknowable for almost all important human biophenomena — its so-called mechanism — had to be known before the biophenomena were accepted as valid. The research of Brown and Wever inextricably linked animals and humans with natural electromagnetic energy in the environment, and obviated the possibility of rigidly distinguishing environmental electromagnetic energy from metabolically maintained internal electromagnetic energy, a connection undreamed of by Handler. Their work also raised the possibility of side-effects from the addition of man-made electromagnetic energy to the environment due to atmospheric testing of atomic bombs.

HANDLER CONCEPTUALIZED SCIENTISTS and engineers as a distinct and independent class in society, a kind of fifth estate that had jurisdiction over matters of science and science policy. He styled the issue of side-effects from man-made agents in the environment as a scientific problem in biochemical toxicity that could and should be solved by biochemists. According to his understanding of the way science ought to function in society, engineers would use information provided by biochemists to design and build the technology needed to eliminate side-effects and pollution. Handler thought the government agencies responsible for setting emission, exposure, and tissue-residual levels of chemical agents linked to side-effects should do so in accordance with advice provided by committees of scientists and engineers.

The main influences on Handler's attitude about side-effects were the scientism he embraced beginning when he was a seventeen-year-old student studying biochemistry in college and the politics he experienced where he lived and worked beginning when he was a twenty-one-year-old biochemistry teacher at Duke. Handler first manifested his attitude when the side-effects of smoking became a national concern. His home state grew as much tobacco as all the other states combined and he was on the faculty of a university built by the founder of the cigarette industry; he felt he had no choice except to support the interests of the tobacco industry. Additionally, Handler was a heavy smoker and genuinely disbelieved the scientific evidence of harm, all of which was non-biochemical. He earned industry kudos for successfully blocking the Institutes from studying the causal relationship between smoking and cancer. His defense of the safety of DDT, a pesticide widely used by tobacco farmers, further elevated his stature in the tobacco industry. Despite his inability to prevent the Administration from issuing public warnings that smoking cased cancer, Handler's stature within the industry remained high because he helped persuade the Administration to not go further and ban smoking.

Handler advised the Administration that any dangers associated with DDT were issues of biochemical toxicity that could and should be resolved by university-based biochemical research, not by federal agencies conducting gold-standard studies. He believed the mere *possibility* of health impairment was a scientifically invalid concept because possibilities were not numerically measurable and had no physical mechanism, a view that placed him at variance with all the other presidential advisors who spoke on that issue. Discussion or disclosure of the possibility of harm was undesirable, he said, because it would create fears in the public and disrupt normal economic activities. But administration policy developed oppositely, resulting first in restrictions and then in a ban on the use of DDT, which triggered a near apoplectic reaction from Handler. He called supporters of the ban "dishonest ideologues," and accused them of "the intentional promotion of disease which DDT prevented." It would be "disgraceful and dishonest to deal with DDT that way," he said, and he accused them of having a "manifest desire to find society guilty, and particularly to find industry guilty, essentially from ideological convictions." He said the supporters of the ban had "a blatant unwillingness to stand up and just be plain honest" and claimed, "There are no charges leveled against DDT which stand up scientifically. None."

Despite Handler's advice, the government developed safety rules for other pesticides and for food additives based on value judgements using data from gold-standard studies. Again Handler objected because he felt biochemists were not consulted and their concern regarding the centrality of mechanistic knowledge was unappreciated. Handler opposed restrictions on the use of artificial sweeteners that were based on evidence based on gold-standard studies, arguing that evidence of actual harm in humans was needed to warrant the regulations. He escaped accusations of bias even though he was on the board of directors of a company that manufactured sweeteners because, at that time, the public generally assumed scientists were trustworthy and morally upright — the same public attitude that allowed Handler to escape charges of incestual financial relations with the Institutes and to avoid criticism for conflict-of-interest when he received research funds from the tobacco industry. The prevailing assumption that scientists had more integrity than laymen obscured all Handler's ethical lapses.

Similarly unappreciated was his tactic of burden-shifting, which he more or less invented for application to side-effects and pollution. Handler shrewdly recognized that the federal regulatory system, in most cases, was not purposed to protect against the threat of danger and that doing so was not a matter of congressional interest. He took the position that a company which manufactured a product had no duty to show that it was safe and should not be required by the government to do so. Instead, according to Handler, the company was entitled to a presumption of safety and the burden of proving the product was not safe rested with whoever believed it produced side-effects. Rhetorically, Handler moved away from naked reliance on biochemical research as the optimal strategy for resolving environmental problems because it was perceived as lacking credibility. He moved toward development of what he called a science of social policy, a key element of which was the tactic of burden-shifting. The stunning unfairness of burden-shifting was largely unappreciated by the public, whose attention was transfixed on assimilating reports of new side-effects, which occurred with distracting regularity.

The threat of danger from side-effects was a principal obstacle to the instantiation of scientism in society because evaluating threats was obviously a subjective process that, in a democracy, was properly the responsibility of the elected representatives of the people. But subjectivity and democracy had no place in Handler's edifice of science, so he had no choice but to oppose, any way he could, official recognition of the concept of a threat of danger — it was a hill he was prepared to die on.

Early in his career, Handler was a consultant to the government's atomic energy agency and helped it commercially exploit man-made biochemicals containing radioactive atoms that spontaneously emitted a form of electromagnetic energy called X-rays. Handler taught biochemists how to use the energy-emitting biochemicals in pointillist laboratory studies of animal metabolism and showed physicians how the biochemicals could be used to diagnose cancer. He told the physicians "toxicity is dose" was a general biochemical principle and that the minuscule number of radioactive atoms typically injected into patients was far too low to cause chemically-induced toxic side-effects. Nevertheless, gold-standard studies in animals injected with the radioactive atoms showed the emitted electromagnetic energy caused cancer in animals and birth defects in their progeny — clear evidence that the energy altered genes. Handler accepted the results, the implications of which brought him both hope and angst. On one hand, the studies accented the need for government funding of basic biochemical research into the interaction of electromagnetic energy and DNA. But on the other hand, they highlighted the inherent ability of electromagnetic energy to cause biological effects — a reality that contradicted Handler's foundational fiction that chemical energy was the sole energy responsible for life. The fiction was especially fatuous because electromagnetic energy from the sun in the form of light and heat was the driving force of evolution; nevertheless the fiction was critical to Handler's biochemical model of life. His textbook on biochemistry was based exclusively on principles of chemical energy; he never mentioned electromagnetic energy or the reality of biological effects it caused.

Handler was disturbed by the publicity that developed regarding potential side-effects of electromagnetic energy in the environment from numerous other man-made sources including but not limited to radioactive atoms. Testing of atomic bombs released X-ray-producing radioactive chemicals into the environment, raising public concern about side-effects from the electromagnetic energy, and the concern was further heightened after new atomic power plants released similar radioactive chemicals. Myriad devices that emitted electromagnetic energy, not caused by radioactive atoms but rather by the engineering design of their electrical circuitry, were manufactured and entered the steam of commerce. Some devices were purposefully designed to produce electromagnetic energy including clinical X-ray machines, lasers, microwave ovens, radars, and broadcast antenna; other devices produced the energy as an inherent consequence of their design including televisions, radios, and myriad other objects that functioned by means of electrical power. A massive grid of high-voltage powerlines was constructed to transport the electromagnetic energy that was manufactured in power plants to every home , business, and factory in the country. A popular belief developed that the energy was carried inside the wires, but that is a physical impossibility; the energy was actually carried outside the wires, extending laterally several hundred feet and moving along the wires, like water flowing in a riverbed. Because of the powerlines grid, for the first time in the history of mankind, humans lived and worked in a permanent man-made environment of electromagnetic energy, the consequences of which were unevaluated, consistent with the principle of burden-shifting. Handler adopted Schwan's argument that humans had evolved in a sea of electromagnetic energy from the sun, and there was no theoretical reason to suspect that adding additional electromagnetic energy to the environment was a threat of danger to health or caused adverse effects in exposed subjects.

The rapid expansion of man-made sources of electromagnetic energy in the environment led Handler to fear that that the Administration and the Congress would overreact to the public's concern about potential harm. There were some known toxic hazards that were caused by electromagnetic energy but nil knowledge of its side-effects, long-range effects, health consequences, or interactions with known health threats because the requisite research had not been done. Handler opposed empirical studies aimed at determining biological consequences or defining safety levels, and advised the Administration to limit government regulations to setting emission limits of electromagnetic energy to protect against known hazards. Recent federal drug laws, prompted by an unvetted drug that caused deformed babies after it was sold to pregnant woman, required drug companies to prove the safety of their drugs prior to selling them. Handler opposed application of the pre-market approval principle to the problem of side-effects from electromagnetic energy, preferring instead that the question of latent hazards be decided in the marketplace. The Administration supported Handler's position and drafted a bill it called "the hazardous radiation act," which meant energy levels that were obviously harmful. because they produced shock or heating. One of the bill's congressional sponsors who was seeking support from scientists for inclusion of a requirement for pre-market approval asked Robert Becker for his opinion on the issue. The request resulted in the first direct conflict of opinion between Handler, who was a consultant to the Veterans Administration and follower of Schwan, and Becker, who was an employee of the Veterans Administration and profoundly disagreed with Schwan. Becker replied to the congressman:

> It is my opinion that we should establish standards and control procedures while we are still in the early stages of the electronic age. I feel that if we begin studying the problem now before there is evidence of possible biological damage to large portions of the general population, we will be able to set standards — not through pressures of panic but rather through the fruits of diligent and expanded research projects. We know that there are very definite biological effects with surprisingly small amounts of exposure. For example, in my own most recent work we have observed marked alteration in structure and function in certain cells with exposure of these cells to electromagnetic energy so small as to be at the limit of modern day measurement. It is quite possible that exposure to such small levels may arise inadvertently in the human population. I feel quite strongly that a start should be made in the direction of the finding of the areas of potential danger and instituting appropriate controls.

He conceded that his viewpoint was a departure from classical biochemistry, but said his recommendations could lead to answers to problems that biochemistry had failed to solve. Becker told the congressman he published evidence that showed cells exposed to exceedingly small levels of electromagnetic energy underwent changes similar to those seen when a cell becomes cancerous, and on that basis he warned about the possibility electromagnetic energy could cause cancer. In the end, Handler was pleased and Becker was disappointed; the bill became law without any provision for premarket validation of safety.

When the novel environmental consequences of post-war industrialization — side-effects of products, energy pollution, chemical contamination of food, and pollution of air and water — were first studied epidemiologically, the results were pregnant with the threat of danger to public health. Laws and ethics prevented direct human experimentation regarding the danger but a strong scientific basis for the threat was subsequently provided by gold-standard studies in which animals were used as surrogates for humans as experimental subjects. The studies consistently showed man-made agents in the environment, when simulated and applied in the laboratory under controlled conditions, produced biological effects in animals. The plain meaning of the results was that the environmental consequences of post-war industrialization were not biologically neutral like the color of one's clothes, as had been supposed, but rather impacted the body's physiology. The inference of the results supported the inference of the epidemiological studies, that the environmental consequences posed possibilities of danger to human health — what became called "health risks." Their existence raised a babel of complex interrelated questions: What environmental agents posed health risks? What was the relationship between exposure level and degree of risk? What harm was threatened? What government regulations should be adopted? Should pre-market testing for safety be required? When the relationship between exposure and harm was uncertain, should the benefit of the doubt be given to the industry or the public? What scientific procedures should be used to produce the requisite information for assessing safety and harm? Who should make the judgements?

The industrial-scale creation of environmental problems complicated Handler's goal to elevate the status of science and scientists in society because much of the public blamed science for causing the problems. Handler's strategy for addressing the questions about health risks was essentially to recommend increased basic and applied research in biochemical toxicology, a muted federal regulatory response, and an educational effort to teach the public that time would be needed to solve the problems; he warned that stopping side-effects and pollution too rapidly would cause worse problems. According to Handler, there were good and bad people on both sides of the problems. Side-effects and pollution were wrong but so was what he called "exaggeration," by which he meant public warnings by bona fide scientists about the possibility of side-effects with which Handler strongly disagreed. In such cases, for Handler, exaggeration was no vice; referring to biologists who spoke publicly regarding contaminated fish he said, "Finding lead or mercury in food is trouble enough without hysteria." All the while, Handler maneuvered politically in search of a more stable and effective platform in Washington from which he could pursue his goal.

Handler contended that water pollution problems were "less acute than they frequently were made out to be," and that "there was a danger of emotional overreaction." He conceded "Lake Erie is surely filthy around its periphery," but argued that it was an exaggeration to say it was a "dying body of water" because it was still possible to catch edible fish in the center of the lake, and that "a lake which produced protein couldn't be called dead." Handler believed that the daily news had too much of an emphasis on bad news and too little on good news. "Although Lake Washington was a dying body of water a few years ago," he noted, "the situation was turned around when the amount of untreated sewage going into the lake was markedly reduced." Rivers were also improving; "The Mississippi still is bearing fish throughout most of its length and the Hudson is not hopeless."

Handler urged that ecology, "the kind of biology at the other extreme of the biochemistry type that I represent," be studied biochemically: "Narragansett Bay used to be an important source of oysters but now there are no oysters and nobody knows why. It is easy to say pollution, but pollution with what, and from whence, one really doesn't know. Biochemical research will tell us what we need to know so we can repopulate the oyster beds." In an evocative story about swordfish, Handler emphasized that research could help the economy as well as the environment:

> Catching swordfish off the coast became a new industry but it's not clear where they come from or know how many there are, and we don't know where they breed. There is a great danger of building up an industry — a freezing plant and packing plants — and suddenly discovering that the swordfish have vanished because you have overfished. Now, the biologists are looking for their breeding grounds, are beginning to provide some notion as to the quantity of swordfish there are and how many swordfish may be taken to keep the population reasonably constant so you have a continuing sword-fishing industry.

Hander emphasized that the benefits of research would only be achieved over the long range: "I join my nature-loving friends in their concern for the handful of bird species that seem to be endangered. But the alternatives, at the moment, are even worse. With the proper research we will learn how to capture undesirable insects and then destroy them or render them infertile." He said appropriate research would enable enacting reasonable antipollution laws to protect the environment without unnecessarily endangering the economy. But presently, according to Handler, scientists lacked the knowledge necessary to show the government how to set antipollution standards and regulate the quality of the environment. Consequently there was not enough understanding for new regulations. The way to a better tomorrow, he advised, was more research, technology, and patience to allow scientists to understand the mechanisms and effects of many types of pollution. "We need time to acquire the understanding upon which to base such regulations and to develop new technology that could allow their implementation."

Handler's credibility suffered during the period he advocated for his policies, mostly because they were only rhetorical rather than based on evidence or other objective support, like a father telling a young child a bedtime story. Nevertheless he continued for a while, spending his reputation and the credit he earned from prior managerial successes. Handler's stature in Washington was still such that he could expect many would believe what he said rather than what they saw.

Handler's views about pollution and health risks were strongly supported by the manufacturing, chemical and energy-producing industries, which opposed the federal regulatory agencies' process of elaborating a scientific basis for risk assessment to protect the public by relying on gold-standard studies. The industries, which were subject to potentially costly regulations, attacked the federal agencies and university scientists whom Handler considered to be acting unethically by exaggerating the peril of side-effects and pollution. The industries also hired biochemical researchers and commenced sponsoring their own contrary science to contradict the results of the gold-standard studies that formed the basis of proposed agency actions. The scientists working for industry manufactured doubt and criticism. They produced results they interpreted to mean that the gold-standard studies which supported inferences of health risks contained conspicuous and inconspicuous experimental errors, thereby vitiating the health-risk inferences. The pattern — attacking federal regulators and scientists whose work posed a challenge to industry interests while drumming up contrary science — spread to include essentially every instance of side-effects and environmental pollution. Handler enjoyed the support of industry but was completely blind to the price he was paying, loss of the possibility of achieving his goal. The consequence of the developing dynamic of industry control of science, particularly when seen in conjunction with the already established government control of science, brought to light the fact that science wasn't and never could be the independent force in society he sought to establish. Instead, it was only a tool that could be wielded for any purpose its possessor desired — to build a bomb, win a war, discover DNA, generate wealth or defend it — and, like any other tool, it could be bought and sold. The scientists themselves were like birds following a trail of breadcrumbs. Handler spent his energy trying to establish science as a center of culture and never recognized the danger that science could become subordinated to social forces —corporations, the Institutes, government agencies, and the military.

As if the revelations that science was descending from, not ascending to, high stature in society and that scientists could never be a coherent authoritative class in a democratic society were not enough, Handler blundered into one of the major historical errors of the last century — the establishment of a health risk as an economic rather than biological concept. He adopted the then novel position that the management of the problems of side-effects and pollution problems always came down to a question of weighing risk against benefits. He said that society either accepts some side-effects and pollution or it will not be possible to maintain the present standard of living. "The world has to be viewed through realistic glasses. In managing the environment, we must learn to make judgments by weighing risks versus benefits."

During the decade in which Handler interacted with congressional committees and presidential administrations, the reductive biochemistry that was installed at the Institutes largely because of his efforts became the established norm for biomedical research in the U.S., and the research budgets of the Institutes and the Foundation more than quadrupled. They were halcyon days for Handler — what he thought were scientists funded by the agencies "engaged in widening frontiers and attaining ever more penetrating insight into the nature of man and the universe." But then the prosperity disappeared with a rapidity that stunned Handler. The agencies produced no penetrating insights and the Congress severely cut back their budgets, and the universities became hot-beds of opposition to the war and the campus-based research that supported it. Social problems developed involving civil rights, health care ,and the environment, particularly side-effects and pollution; science progressively became seen as irrelevant to the problems of society or even responsible for then. Handler, who pictured himself as an emergent scientist-statesman with the wisdom to visualize a national policy for science, strained to resist the developing arc of public disinterest and opposition to science. But he failed to articulate a federal policy that rationalized the importance of basic research in biochemistry and physics and the necessity of constantly providing increased financial support, seeming instead to believe that not offering a coherent supporting rationale was a virtue. His stratagem of conveying notions of basic science and its importance by telling historical stories of heroic scientific achievements no longer succeeded. The situation worsened. The Congress changed the mission of the Foundation from exclusively supporting basic research to also supporting applied research in essentially any area of knowledge, including the social sciences, which Handler detested, calling them "voodoo science." As he feared, applied research supported by federal agencies chased basic research out of the Edifice. The inclination of the public, congress, and the administration to confound basic science — biochemistry and physics —with engineering, medicine, and especially social science exasperated Handler. He was forced by the administration to publicly moderate his dislike of the social sciences, the increasing influence of physicians, who sought to establish a National Academy of Medicine, and of engineers, who also sought their own Institute.

Handler had become a polarizing figure. He was perceived more or less as a hero by professional scientists, but the administration's advisors came to dislike and distrust him because of his disloyalty to administration policies and propensity for self-elevation. The chairmen of the congressional committees that had once warmly welcomed him retired and were replaced by more conservative politicians who were not nearly so receptive to Handler's constant demands for more money and not nearly as enthralled by his rhetorical style of argument. Prompted by his mostly unsuccessful attempts to establish his science policies, Handler looked for some kind of a career change.

Handler's Duke salary was trivial compared with that of other men who had risen to positions of power and responsibility — so low that his family had to live in Durham for almost a decade while he lived in a Washington apartment. But he was a unique figure in twentieth-century science. There were nil appropriate opportunities for someone with his beliefs, ambitions, accomplishments, resolute confidence in the righteousness of his beliefs, and personality — he was not a warm human being. Handler received no compensation for his services to the federal government even though he was a presidential science advisor, travelled and spoke extensively on behalf of the administration, and worked almost full-time as the head of the Foundation, which was responsible for implementing the administration's policies regarding basic science. Having never actually been hired by the government, he was essentially free to say and do as he pleased and was not directly answerable to anyone. His personal views often conflicted with the administration's policies. Among the indications that he was slipping into disfavor was the progressive decrease in invitations from officials and politicians to dine at the Cosmos Club — a gauge of political status in Washington. Handler's salary from Duke —small by the standards of his Washington social strata but his principal income — was paid by funds from Institutes' grants from research which he was not performing. The situation was not far from fraudulent because Handler got the grants based on his connections rather than the merits of the proposed work. He hired biochemists to do the research he had contracted to perform, few of whom could have qualified for the grants in an influence-free meritocracy.

Even though the situation was not a problem in public perception of probity, Handler recognized he was potentially vulnerable as well as relatively poor. The threat involved the stability of the arrangement under which he was paid as the titular head of the biochemistry department at Duke. But his academic connections with Duke shriveled significantly after he joined the Foundation. During his testimonies, he frequently said he taught at Duke, but he actually gave only a handful of canned lectures because the medical students had fixed topic schedules whereas Handler appeared in Durham only sporadically, depending on his Foundation and administration responsibilities. Handler's direct influence at the Institutes waned with the passage of time, jeopardizing his annual research grants, the source of the money for his salary. His financial difficulties were partially compensated by his income for service on the board of directors of a drug company, but not enough to create financial stability for himself and his family.

Handler met Frederick Seitz, the president of the National Academy of Sciences, in 1964 when Handler joined Seitz as a science advisor to the Administration. Handler wrote a chapter about science policy for Seitz's book on science, and soon after Handler became second-in-command at the National Science Foundation, Seitz arranged for Handler to become a member of the National Academy of Sciences. Their relationship was stiff but mutually beneficial; Handler supported Seitz when a congressional committee criticized the Academy's mismanagement of a multi-million dollar geophysical research project, and Seitz guided Handler's introduction to the culture and intricacies of the Academy, like Higgins and Doolittle. Handler began to understand how the Academy operated. He wanted a job where he could pursue his own science policy goals, advocate for his opinions, and be paid a good salary for doing only what he wanted to do, all while being answerable to no one. Handler realized the presidency of the Academy could be the apex position of his career. When he joined the Academy, presidency was only a part-time position with a salary insufficient to support a family. However, soon thereafter, Seitz's campaign to elevate the presidency to a full-time position succeeded, and he was elected to a six-year term as the Academy's first full-time president. Handler later reminisced that he set his sight on being the second.

Seitz was a wunderkind. He became a world-class expert in the physics of solids and wrote the definitive textbook in the field; his research led to the invention of semiconductors and transistors. During the Second World War, he worked on weapons development, including the atomic bomb and radar, and in the post-war years was a physics professor and government consultant on matters of science policy. He became perhaps the nation's most politically astute and powerful true scientist at the time, far above Handler's level of scientific accomplishment, although far below his rhetorical abilities and ability to turn a phrase. Both men were intensely dedicated to implementation of their respective concepts of science policy, but their scientific specialties were moving in opposite directions with regard to societal importance. Biochemistry was increasing and physics was decreasing, leaving only technology as evidence that it actually existed.

When Seitz became the head of the National Academy of Sciences, it was composed almost entirely of physicists and chemists. The Academy had been created during the Civil War to provide the government with free scientific advice, but during the next half-century the government scarcely ever requested the Academy's advice; its only activities were to meet annually and elect new members. Shortly before the First World War, the Academy was authorized to establish a Business Arm that could contract with government agencies and collect a fee to support machinery for providing advice regarding "the applications of science as will promote the national security and welfare." The fees had to be paid to the Academy, not to individual advisors, because the Academy charter required all advisors chosen by the Academy to serve the government pro bono. The Academy's activities were also negligible during the inter-war period; when physicists saw that the Nazis might build an atomic bomb they went to Einstein, not the Academy, for help in warning President Roosevelt about the danger. After the Second World War, Seitz's immediate predecessor formalized procedures for contracting with the government, and Seitz greatly expanded the Business Arm's capacity and operated it to provide advice in the manner of any other profitable modern business. He increased the number of employees, secured congressional committees as clients in addition to executive-department agencies, and restructured the composition and administration of the contract committees — ad hoc groups of experts that generated the advice specified in the contracts between the Academy and its clients.

The clients posed questions to Seitz that involved science-related economic and political issues, and he appointed ad hoc committees of experts approved by the clients to provide the advice. The experts were rarely members of the Academy. Preponderantly, they were academicians or scientists working in industry who were willing to work without remuneration for the benefit of the Academy in return for the prestige of a tangential association with it. To avoid a contention that the advice of a committee was only the opinion of the particular experts he appointed, Seitz invented the cachet "issued under the aegis of the National Academy of Sciences," and attached it to the final report of every contract committee. He apparently intended the cachet to suggest that the advice came from or at least was supported or somehow validated by the Academy membership, which was untrue and misleading, and also fatuous because the members weren't experts about everything. Nevertheless the trope effectively conveyed a sense of authority in the public mind for all the Business Arm's reports.

Seitz used the profits generated by contract committees to fund another innovation — a standing Policy Committee composed of politically connected Academy members, commonly first-rank physicists, whose advice was self-generated rather than responsive to a question posed by a government agency or congressional committee. The Policy Committee commenced writing reports that advanced policy positions favored by Seitz and those whom he appointed to the committee, each with the cachet attached. The first Policy Committee reports advised the government to do something about the problems of birth control and overpopulation. Its next report recommended to the government how much money was needed for basic research in physics so that technology could advance to the extent the committee believed the nation required, and also recommended how the money should be divided among the various subspecialties in physics. In its third and fourth third reports, which dealt with chemistry and computers, the committee offered comparable advice. Seitz wanted the Academy to issue a similar report about biology, but was unable to do so because there were no credible experts in biology on the Policy Committee.

Handler was stirred by the idea of expressing his opinions by means of a committee that spoke to the nation with the aegis of the Academy on matters of science policy. He had echoed the Policy Committee's recommendations regarding birth control in his speeches and congressional testimony, citing the recommendations as a reason for funding basic research into the biochemistry of birth control and eugenics. And at a deeper level, Seitz's invention of the Policy Committee opened Handler's eyes to the potential effectiveness of the Academy as a platform for any matter related to science, especially the matters that interested him. Seitz had recently completed *The Scientific Endeavor,* a massive project in honor of the Academy's centennial, that contained contributions from all the major living physicists. Handler proposed to Seitz that the Policy Committee undertake a similar project on biology, arguing that, given the development of biochemistry, biology had come of age as did physics in the first half of the century. The scope of the project Handler suggested far exceeded any previous Policy Committee report, but Seitz agreed provided Handler raised the money needed to fund the undertaking. After Handler provided tangible evidence that he had the necessary financial backing from several governmental agencies, Seitz appointed Handler to the Policy Committee with authority to create a subcommittee and execute the task as he saw fit. Seitz's actions sent a clear signal that Handler was a made man in science policy — still just an underboss but destined to be a capo.

Handler envisioned a project involving hundreds of scientists, a large editorial staff and a budget significantly larger than any previous committee in the history of the Academy, whether an ad hoc contract committee or the Policy Committee. Handler believed his abortive attempt to secure funding for the massive program of basic biomedical research he had proposed when he worked on the Debakey Commission had resulted from a general lack of understanding of the scientific complexity and societal importance of biology. He decided that he failed because he was constrained by the President to focus the role of biochemical research too narrowly on biomedicine, and therefore was unable to convey the importance of biochemistry for understanding the larger area of biology. Consequently, Handler believed, the government never recognized the true importance of biochemical research, which he saw as the scientific heart and conceptual soul of biology. Handler designed the biology project of the Policy Committee to remedy the problem. His goal was to enlighten the government regarding the critical importance to the nation of biochemically based biology. After that happened, he believed, a national science policy regarding biology that was appropriate for the nation's actual needs would be formulated and implemented.

Handler's policy priorities shaped how he divided biology into parts amenable to inquiry by the Policy Committee. He viewed population growth as the nation's most pressing problem. From overpopulation, according to Handler, sprung the ills of society including pollution, environmental degradation, overcrowding in the cities, crime, and aggressive behaviors at the personal and national level. With an eye toward the research he believed was needed to address the various ills, Handler divided biology into twenty-one areas and appointed panels of experts to analyze and comment on progress and potential in the areas. He split his specialty into two divisions, each with a panel; biochemistry, the traditional name, and molecular biology, a name he believed was a more modern and appealing. Three additional divisions corresponded to the standard subjects traditionally taught in the first two years of medical school; anatomy, physiology, and the nervous system. He included seven divisions he thought would be interesting to the public and readily regarded as important: cells, education, medicine, agriculture, growth, behavior, and environmental health. He chose seven additional divisions that matched topics popular in the press: ecology, overpopulation, aging, drug development, evolution, computers, and biological warfare. He also created two purely speculative divisions: what will happen in the future, and how life began.

Handler was the head of the National Science Foundation, and consequently had no difficulty obtaining almost several hundred thousand dollars from the Foundation for his project. He raised an even greater sum from the National Institutes of Health, for whom he had done yeoman service testifying before the Congress for many years. Seitz, who signed the contracts for the biology project with both agencies, was pleased he would not be required to utilize profits from the Business Arm of the Academy to support the Policy Committee's work, which he had been required to do for the other similar projects conducted by the Committee.

Handler described, in grandiose terms, thirteen aims of his project to characterize the status of biology in the U.S.:

- To present a rationally structured view of the intellectual content of modern biology;
- To appraise the nature and level of understanding that has been attained thus far;
- To demarcate the present limits of understanding of the nature of life;
- To describe the manner in which the physiological problems of organisms are solved in nature and to delineate the interrelationships within biological communities;

- To estimate the significant features and magnitude of the total current effort in biological research;
- To learn where such research is in progress;
- To determine the numbers of scientists so engaged and their level of training, and the number of students now in training for careers as professional biologists;
- To determine the magnitude of private and federal support for the classical sub-disciplines of biology and for the segments of biology as it will be classified in the report;
- To develop suitable projections for the magnitude of the total biological research enterprise in the future, the requirements for its support, and the number of individuals and institutions that will be so engaged;
- To identify and assess those factors that appear currently to limit the rate of progress in the furthering of understanding of biological processes;
- To develop recommendations for appropriate courses of action to reduce such limitations;
- To appraise the nature and magnitude of the contribution of increasing biological understanding to the betterment of human life, specifically, the potential contribution of enhanced biological understanding to medical practice, agricultural productivity, national defense, and the civilian economy.

He sent thousands of questionnaires to people he deemed knowledgeable about biology, and recruited hundreds of scientists to serve on the panels for his divisions of biology. The panels were tasked to analyze their assigned topics in the light of the information received in the questionnaires and then predict what would happen during the next decade. Handler asked each panel to look into a crystal ball and address a series of open-ended questions that were more rhetorical than scientific:

- What are the central problems and questions in the area?
- How close are we to the answers?
- What lines of investigation are likely to succeed, and which to fail?
- What lines of investigation can be visualized for tomorrow?
- Are the questions themselves likely to change?

Handler appointed a staff within the Academy to collect and analyze the results from the questionnaires and provide the appropriate information to the panels, and he made provisions for the members of the respective panels to meet several times to facilitate drafting a report of their opinions. He planned to complete data collection in 1967, receive the panel reports by mid-1968 and, by the end of the year, integrate them into a final report that he believed would be nothing less than a basis for completely reshaping government thinking about biology. However, he encountered many problems and did not meet his target dates.

Despite Handler's chronic efforts to establish the principle that basic scientific research deserved financial support because it was a core value of society, the Congress repeatedly told Handler public money could be spent only for a public purpose and that pursuit of knowledge for knowledge's sake did not satisfy the public-purpose requirement. The major exception had been the National Science Foundation, which was originally tasked, in part, to support basic research. But despite Handler's bitter opposition, the Congress required it to support applied research and research in the social sciences, and as expected and probably as intended, budgeted funds for basic research in physics and biochemistry dropped to near zero. The change in the Foundation's mission essentially guaranteed Handler's dream of a permanently funded class of biochemists who performed only basic research would not be realized, at least in his lifetime. He accepted reappointment as the head of the Foundation, and thus for the next six years had the joyless responsibility of managing the distribution of funds for applied research, which gave him no pleasure or satisfaction, especially considering that he worked for free, without any remuneration except for costs when he traveled for Academy business — and he didn't even get that if he failed to fill out the requisite forms in a timely fashion.

Not only did Handler fail to establish science as a central societal value, he quite unintentionally helped the opposite to happen. Widespread demonstrations occurred in the nation's universities by students who saw the technology spawned by science as the problem not the solution for society's problems, and progressively fewer students pursued a career in science. The problem became so acute, at least in Handler's eyes, he warned that America was in danger of losing its preeminence in science unless more students studied it.

Adding to Handler's aggravation was the rapid national rise in concern for the environment, and the rejection by the Administration and the Congress of his strategy of allowing the pollution to continue while simultaneously performing the research needed to develop the technology for removing it from the environment. His views and those of the Administration concerning the problems of side-effects and pollution, which never match well, became incommensurate. With the advent of nuclear power, he said, unlimited pollution-free energy would soon be available, and the energy abundance would permit conversion of polluted water to clean water, and technology would allow restoration of the environment "to that which our ancestors found when they arrived on here." The real problem, according to Handler wasn't side-effects and pollution but rather overpopulation:

> Hunger, pollution, crime, despoliation of the natural beauty of the planet, extermination of countless species of plants and animals, dirty, over-crowded cities, continual erosion of limited natural resources, and the unrest which creates the political instability that leads to international conflict and war all derive from the unbridled growth of human populations.

His proposed short-term solutions were abortion, contraception and artificial insemination using sperm from distinguished men. Long-term, he proposed basic biochemical research to learn how to modify the gene pool to eliminate cases of genetic disease, and brain research to understand the biochemical basis of abnormal behavior, which he said "will generate the capacity to design chemical or physical processes to alter behavior."