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The Anatomy of Collaboration

Edwin F. Taylor

NIELS BOHR—COLLABORATION BACK ONE STEP

In a commanding position in the Wheeler home hangs a picture of Niels Bohr. It is not possible to write in any detail about John Wheeler without mentioning the central place Niels Bohr held in his esteem and how Bohr's influence shaped him. Others have told me that this influence extended to facial expressions and mannerisms. I never met Niels Bohr, and yet feel I have watched him through John's hesitant, careful, serious speech, his invariant politeness (invariant as observed in every frame of reference!), and his ability to mold a critique from positive comments—traits so charming and insidious that I find myself adopting them, at least in caricature. How similar were their habits of mind I cannot say, yet John's admiration for Bohr was intense and unembarrassed. When John, as a young man, applied to visit Copenhagen, he did so because of his conviction that Niels Bohr had the ability to see farthest into the way physics must develop.

John told me that Bohr's office had one wall filled with narrow drawers. In each drawer resided a manuscript in some stage of preparation. As Bohr's musings, conversations, and collaborations revealed a subject to him in a new light, he would retrieve the relevant manuscript, work it over awhile, and return it to the drawer until finally, fully ripe after many reworkings over months or years of time, the completed manuscript would be posted to a journal—"Too great for haste, too high for rivalry."

John told me also of Bohr's tactic for generating and criticizing new ideas. On alternate days of the week—say Monday, Wednesday, and Friday—he would think of a flood of new ideas on whatever topic was absorbing his attention, prodigiously, prodigally, without a trace of restraint or thought of counterargument. Then on the remaining alternate days—Tuesday, Thursday, and Saturday—he subjected these raw thoughts to the most careful scrutiny under the blackest presumption of error. By this means the exuberance of creativity and the inhibitions of logic and experimental verification could live side by side.

During the academic year 1962—63, Edwin F. Taylor spent a sabbatical year at Princeton University where he began a collaboration with John Wheeler on an introductory text in special relativity, published in 1966 by W. H. Freeman and Company of San Francisco [now New York] under the title *Spacetime Physics*. This article is his account of that collaboration.

The ability always to make polite, positive comments has a practical basis. Great men, by definition if not consistently in fact, produce great work. Anyone who collaborates with them or is vulnerable to their comments fears to compare his work with theirs. To be demolished by the eminent man—particularly in public—can be a devastating experience. It was John's talent, and presumably Bohr's also, to transform an occasion for judgment into an occasion for encouragement. This strategy ("positive reinforcements only") seems to be psychologically sound as well, though I find it fiendishly hard to apply in some situations.

Bohr's unfailingly positive reaction to public seminar speakers in Copenhagen had an amusing side-effect. The students prepared a translation list to assist in gauging the real quality of a talk. Bohr's comment, "Very, very interesting" meant "terrible"; "A very significant contribution" meant "not bad," and so forth. John reports that Bohr was dismayed when shown the list. "What can I possibly say at the end of a talk now!" he exclaimed.

Niels Bohr died in 1962 while I was at Princeton with John. I vividly recall John's discussion that day with his honors introductory physics class about his collaboration with Bohr, first at Copenhagen, then later when Bohr arrived by ship in New York City just before World War II. John related how Bohr had taken him aside at the dock and informed him privately of the recognition of nuclear fission by Meitner and Frisch. There followed the intense day-and-night collaboration between Bohr and Wheeler that led to the famous paper on nuclear fission, published in the *Physical Review* the day the war began. This paper played its part in developing both our knowledge of the nucleus and also nuclear weapons—consequences that inform our days and haunt our nights. John began to read to the class a release about Bohr that he had prepared for the press, but was overcome with emotion and, after a moment, resumed his lecture on physics. In the front hall of Palmer Laboratory I recognized the picture of Niels Bohr from John's study at home, under which was written in John's handwriting: "Niels Bohr, October 7, 1885—November 18, 1962."

Thus, in a multiplicity of ways: in print, in characteristic gesture, in mode of thought, in politeness and openness of mind—at first and second and third hand—do the lives of great men reverberate in our own.

THE SETTING FOR COLLABORATION

My wife Helen and I and our first two children arrived in Princeton in the fall of 1962 on sabbatical leave from Wesleyan University in Connecticut. At the Palmer Laboratory I shared the office of Eric Rogers (then on leave) with Hendrik Van Dam and Stanley Engelsberg.

John Wheeler and I got to talking one day in the empty office. When he heard that I was completing a textbook on mechanics, he immediately intimated that we might work together on the substance of his honors introductory physics course to be given that year. I was much surprised but not much honored because presumably he knew nothing about me (though now I wonder). The truth of the matter is that I knew, if anything, less about John than he knew about me—certainly nothing professional beyond a certain glow of eminence. I recall making no inquiries about him before beginning the collaboration. The closest allegiances of one's life begin in the most casual ways. Of course, neither

John nor I had anything much to lose if the relationship were to end with the transcription of a set of class notes.

Any nonchalance I felt about our collaboration vanished when John began lecturing on relativity to the 34 freshmen in his honors physics class. Transfixed by the power of his presentation and brought close to tears by its beauty and simplicity, I threw myself wholeheartedly into its transcription, which soon became a full-time occupation. The first draft was typed and handed out to the students for their review of the material. A copy went for comment to John, who penciled on the title page, "An enormous job, of tremendous value to any student." In Bohr-talk that meant "not bad."

Then came *The Crisis*: would we turn this material into a book? Now John was not so casual. No doubt he sensed, as I did, that the stakes of time and commitment were rising. In spite of many articles published, he had written only one book before—*Geometrodynamics*, published that year—and knew something of the enormous price exacted for a tedious job that brings little professional credit. Moreover, there was the touchy problem of a publisher. John had signed a contract two years earlier with one publisher for an introductory text, while my first book was with another, to whom I felt an allegiance. I recall pacing with John up and down the long hallway of Palmer Laboratory discussing the various questions. The hallway stroll provided protection against interruption by the phone, some privacy (another collaborator was working in John's office under the terribly tight space limitations in Palmer), and, I suspect, satisfaction to John in the *Virtue of Exercise*. Finally we decided to go ahead with the first publisher. John, as I recall, reserved the right to withdraw his name and let me finish the book alone if time limitations prevented him from collaborating fully. I assured him that, at most, a few days of his time would be required to check my revisions. Hah!

The physics class continued with material other than relativity after the first six weeks or so. In a parallel laboratory, run principally by Robert Pollock, the students were given the assignment "by means of separate but cooperative experiments [to] try to learn as much as you can in one semester about the nature of the electron: its properties and behavior." The grader was Richard Roth. In the lectures I was impressed by the intense seriousness with which John treated questions from the students. He even asked their advice. He was on some sort of military scientific review panel, a fact which passed without comment in those days (and which John might well undertake in spite of comment today). One time he presented for the students' consideration the question of the advisability of producing a 100 megaton bomb, explaining that such a bomb could do great damage from such a height that differential deceleration by the atmosphere lower down could not be used by the defenders to distinguish warheads from decoys.

It was audacious of John to *begin* an introductory course with the study of relativity. Something of his reasoning on the subject comes through in his telegraphic response to a publicity questionnaire the publisher sent him much later, when the book was in press. He wrote:

Belief strongly upheld at Princeton that teaching and research are mutual sustaining parts of one and the same activity. Graduate course gives way to work out and simplify materials to point where they can be taught to freshmen—and freshmen trained in the broader and deeper and better ways of understanding science, as they come

along to advanced work, force the professor to still further advances in the subject, to the benefit of all and the gain of society.

Erasmus tells somewhere [we never could track down the reference] of a colleague having to go to University of Krakow in Poland to learn long division—and why not?—because in those medieval days Roman numerals were used! Today we're still in some ways using "Roman numerals" in our physics. Content of the good texts so vast that one is going to have to try a different approach where the really big principles come in much earlier than they do now. Those big principles—relativity and the quantum principle. Without them one is doing physics in "Roman numerals." My conviction that this move is the wave of the future led me to ask to teach a 30 man experimental freshman course (after I had taught 250 man freshman course standard way 5 years). So present book grew out of that 3 year experiment.

The exercises of *Spacetime Physics* were designed to be as comprehensive as possible and to present the properties of spacetime over and over again in many contexts: paradoxes, puzzles, derivations, technological applications, estimates, precise calculations, and philosophical difficulties. The qualifying examinations for the Princeton doctorate were culled through, along with the journal literature. This activity and writing the second draft of the text completed the year at Princeton.

My family and I returned to Wesleyan and the collaboration became a more episodic one. My original idea of leaving John out of most of the creative work had long since gone by the board; his inventiveness made each draft virgin territory. John almost never worked on the manuscript in my absence; he was too accommodating to others who demanded his attention. It was necessary for me to be physically present, so the mails were useless as a mode of collaboration, and the phone was effective only in making appointments to meet. As a result, many weekends were spent in John's study on Maxwell Lane in Princeton or, in the summer, on High Island in Maine where his study commanded a magnificent view of John's Bay (no relation). Janette Wheeler once told me that she bought their summer home in John's absence and was apprehensive about his reaction to it until, on his first day there, he placed a chair on the front lawn and sat looking at the view for the entire afternoon.

It was clear that I was only one of a continuous stream of professional collaborators working with John. Many independent interests occupied Janette during the long hours that John spent with these visitors. Sometimes I felt a bit apologetic for monopolizing his attention during my visits, but no shadow of resentment fell on Janette's unfailing hospitality.

After a further year at Wesleyan I moved to the Education Research Center (then the Science Teaching Center) at the Massachusetts Institute of Technology in Boston, and long car trips to Princeton were replaced by air shuttle flights by way of Newark airport. John came to Boston too, being careful to share the travel inconvenience of collaboration. This jet-set life was new to me. The finale was the most remarkable of all. John called one day to say that during a trip away from Princeton he would have three hours free at the Philadelphia airport; could I join him there? So I flew down from Boston for three hours. And it was there, in the Golden Falcon Lounge of Eastern Airlines, that the manuscript was finally completed. Many further trips remained during the production process—

John believed that many authors reduce the impact of their work by becoming negligent when the manuscript is finished—but the Golden Falcon Lounge seems a fitting stage on which to conclude the narrative of what was for me an altogether unique experience.

THE NATURE OF COLLABORATION

He who collaborates with a famous man soon discovers how harassed such a man is by those with competing demands on his time. The classic modes of interruption, mail and an occasional genteel visit, are now augmented a hundredfold ("I'll drop in on John," says the bookman, "on my way down to Washington"), to which is added the tyranny of the telephone, whose call is insistent and immediate. No small test of genius is the ability to operate creatively under the hammer blows of eminence, and many fail the test. We readily understand and forgive those who turn a crusty exterior to the world and retreat to conserve energy for their top-priority preoccupations.

John Wheeler operates in an entirely different manner, with a kind of prodigal receptiveness that puts him in the main stream of many simultaneous enterprises large and small. A publisher's representative told me that he was once seriously embarrassed by the length of time John took to talk with him, a complete stranger, about the characteristics of a good textbook. On the larger level John's technique is to commit himself firmly to enterprises most nearly in line with his own current aspirations and then to surfboard energetically down the near side of the day-to-day urgencies created by the commitments he has selected. Deadlines play an important part in this style, the resultant emergencies creating sufficient turbulent motive power to test the most sure-footed surfer. This mode of work apparently evolved, rather than being planned, and is somewhat ragged in execution. John obviously feels some guilt about the personal disappointments caused to others when an occasional deadline is not met, as well as about the results of outside pressures on his academic commitments. He admitted to me once with chagrin that he is often forced to compose a lecture in his head while walking down the hall to the classroom. One time I saw this happen—the resulting lecture was brilliant!

Eminent people have long faced the problem of working with collaborators in the face of the harassments of eminence and have reached some ingenious solutions. Quite often the first step is to seize a related project to which the senior collaborator is already committed or can arrange to commit himself and to make it walk on two or more legs. John's first book, *Geometrodynamics*, was a reprint volume that grew out of a series of lectures delivered in Italy summarizing and extending his collaborations with colleagues and graduate students (which collaborations produced their own separate theses and journal articles). In the case of the relativity text, John was scheduled to teach the honors introductory physics course at his own request. Our first encounter leads me to believe that he was consciously or unconsciously searching for a way to capitalize on the course in order to fulfill his contract for an introductory text in physics.

Given the setting for collaboration, an indispensable talent for the senior collaborator is the ability to switch his attention from one enterprise to another. Quite often our work together was interrupted by an important phone call. John's mind would instantaneously engage the problem posed by the caller, concentrating on a clean resolution, if possible, at that moment. After hanging up, he would immediately pick up where we

left off. John's ability to shift mental gears rapidly affects his private as well as his professional life. Another of his collaborators, Kip Thorne, has commented,

It is this trait as much as any other, I think, that makes his life with Janette a happy one. When she needs him or calls him to dinner, his pen drops in the middle of a sentence and his undivided attention goes to her. No "Just a minute dear" for him (which in such cases can stretch into hours). When it is time for him to return to his writing, his mind flips back and he picks up his sentence where he left off. What his relationship with Janette lacks in time spent together it makes up in the quality of his undivided attention.

One might suppose that a first-rate collaborator can bring an initial presentation of a subject by his senior colleague to polished form with only an occasional word of direction and correction. This misconception is strengthened by the observation that the recorded thoughts of even (especially?) the greatest men have a coherence and fidelity to a few fundamental themes that sometimes smacks of repetitiousness. I fell easily into this self-deception, thunderstruck as I was by the beauty and coherence of John's initial presentation of relativity to his freshman class. How could such flawless symmetry require more than a coat of varnish to be ready for the public?

The delusion is quickly dispelled when work begins on a specific project. For, in genius, fidelity to a few central themes is coupled with creativity in interpreting, teaching, and extending them, a creativity not exhausted by the initial presentation but which flows again when the new work—book, article, or experiment—develops sufficiently to have a demanding integrity of its own. Then creativity is measured not by dependability but almost by unpredictability. For the genius confined by his own fidelities is expendable; we can predict what he will say and so do without him. In contrast, I could never tell in advance how John would modify or reinterpret his lectures when they took on manuscript form. The warm-blooded generalization uttered in person became, in cold print, an embarrassment requiring careful thought, precise restatement, and arduous polishing to reveal its gem-like lustre. In this process John's detailed participation continued to be indispensable.

So "picking the brain" is entirely the wrong image for what goes on in collaboration. Truth is refined and adapted—one is tempted to say "comes into existence"—in the laborious creative process of being expressed or revealed in specific form.

An almost classic example of how collaboration with John can be misunderstood is provided by Seymour Tilson, who was an associate editor of *International Science and Technology* magazine. After talking with John informally and reading carefully the publications available on geometrodynamics, Mr. Tilson prepared the first draft of a popularized review article for his magazine (finally published in December, 1963). He arrived at the Wheeler residence with his wife on a Monday morning expecting, one supposes, either blanket approval of his draft or a few general pointers from John as to how it could be improved. After touching base in this way, the Tilsons planned a brief vacation by themselves. Thursday morning they finally left, having eaten and slept there, with Seymour working intensively with John since Monday. Mrs. Tilson became so integrated into the household that part of her "vacation" was spent doing dishes.

The intensive collaborative labor of creation is exemplified for me in the derivation of the relativistic expression for momentum. One Saturday John came up to a motel in Cambridge, north of Harvard University. There we wrestled all day with the derivation of the relativistic expression for momentum. At the day's end we had forty handwritten pages full of diagrams, arrows, symmetry arguments—the heavy equipment of pedagogy. The next morning we decided to try summarizing the argument in a figure. As we worked, the structure erected the preceding day collapsed into a few simple statements. The upshot is the only derivation I know for the relativistic expression for momentum contained in a single figure and its caption (Figure 85 of *Spacetime Physics*, first edition). John told me with amusement how he and Richard Feynman once constructed a diagram so complicated that they were tempted to label it: "For figure caption, see text," thus making the entire article a caption for one figure!

"I am against logic," said John very early in our collaboration. This was a statement about pedagogy—about how students learn—and also about research and the progress of organized knowledge. "I am in favor of the clash of ideas." He went on to compare the method of Euclid—axioms and postulates leading to proofs of theorems leading to conclusions in particular cases—with the method of Hegel—the unavoidable contrast between starkly stated and apparently irreconcilable points of view (thesis and antithesis), leading to the synthesis that evidences a new formulation and becomes a new thesis armed for combat. John felt—I think this is a fair construction of his view—that in most textbooks the author uses logic as an essentially dishonest tool to drag the student by the hair to a predetermined conclusion. The sensitive student sees this instinctively, one reason that textbooks are so unpopular. Much better policy is to enlist the student's participation in controversy, with alternatives personified by their originators acting as adversaries in a sort of cross-centuries trial-by-combat. Then the derivations, when they come, are the almost off-handed elaboration or justification that clinches an already accepted point of view. This way of presenting material is equally likely to outrage the professional purist, the experimentalist, and the historian.

Nowhere is the anti-logic policy better carried out, if I may say so, than in the third and final chapter of *Spacetime Physics*, [the ninth chapter of the second edition] where Newton and Einstein, flanked by Galileo, each stand astride the solar system, as it were, issuing conflicting commands to the planets about how to respond to the demands of gravitation. The resulting mock-serious confrontation that explodes into analogies, parables, portraits, quotes, outrageous figures, and concludes with a monster dialog-table [in the first edition] is almost pure Wheeler, and I am proud to have been present at its birth.

One result of John's simultaneous involvement with many projects was that by the time I presented him with a typed revision he had forgotten all about the previous versions. This made each draft a brand new existential encounter. He had an almost frightening intensity in confronting each new draft. Writing a text, along with every other creative activity, presents a series of interconnected problems or blocks—technical, professional, stylistic, philosophical—that must be overcome one at a time or simultaneously. Most of these blocks went down effortlessly, outflanked, undermined, or overflowed more often than frontally assaulted. But several times in a day of work John and I would pitch up against a problem that stumped us. Then the fire would come into John's eye. He had a characteristic clenched-fist gesture toward but not touching the table. He never let up attacking the problem; one radically different proposal would fol-

low another, many of them patently useless but keeping up the drum-fire assault. Out would come the bound notebook: "July 18, with Ed Taylor, looking for a phrase for . . ." followed by a wide-ranging list. Or a diagram or figure would spring into being. I believe that the figures and tables for which John is well known come from sheer exuberant inventiveness in the face of pedagogic snags.

John quoted his (from Bohr?) definition of genius as the ability to make all possible mistakes in the shortest possible time. *That* was the way he attacked a problem.

John told of an occasion during the war when those working on the nuclear bomb relaxed by swimming in a swift-flowing concrete-sided irrigation channel. A rope was stretched across the channel downstream to catch the swimmers, and a controversy arose whether or not one could save himself if the rope broke or was not there. Stripping down, Enrico Fermi jumped in to test the issue. Repeatedly he tried to clamber up the rough, steep sides, falling back again and again. Finally he scrambled out before reaching the rope, bleeding and triumphant. *That* was the way John attacked problems.

At his High Island summer home I watched John in the woods with a power hand saw. The cutting had a double purpose: to provide firewood and to throw the tangled dry dead brush and limbs to earth where the dampness would rot them. The same light of determination shown in John's eye; the unremitting attack on the trees and brush clearly revealed a symbolic struggle, an attitude toward life's difficulties. *That* was the way John attacked a problem.

The hand power saw was symbolic in another way. The individual must be master and not slave of the engines of solution to any problem. John liked to talk of the "world's biggest computer." This device consisted of a large cardboard picture of a computer pasted all around the four walls of one's office. Faced with any problem requiring a large computer, one prepared carefully for computation: looking at the problem from this way and that, extracting the physical meaning, milking out rough approximations and refining them. Finally one saw the solution so clearly and thoroughly that he no longer required the world's biggest computer—which therefore never needed to be anything but cardboard! *That* was the way John attacked problems.

I cannot resist mentioning two delightful idiosyncrasies that further lightened our effort. The first is the Duco Cement Distemper. John never learned to type, so there was no question of running off a clean copy of the current draft on the typewriter. Instead he cut and pasted the typescript to handwritten inserts and corrections (frightening me terribly, for once it was scrambled there was no reassembling the original manuscript in that era before the general availability of Xerox copiers). Duco cement was used—for permanence, John told me—rubber cement let go in a year or two! (Some uncharitable collaborators detect a loyalty motive—John consulted for the duPont company at one time.) Sometimes uniformity of page length was sacrificed in the intensity of effort, resulting in the most disreputable parcel of manuscript imaginable. Once an entire massive dialog (Table 14: Uses and Abuses of the Concept of Mass) was cemented together in a single long sheet; our secretary was amused when handed the Torah-like roll for transcription. The Duco Cement Distemper is characteristic of those who have collaborated with John, I am told, and I succumb to it yet with glee, the pervasive fragrance of organic solvents serving as incense for a secular sacrament.

The liberal use of exclamation points is as characteristic of John's style as elaborate tables and diagrams, and flies in the face of the convention that texts are to be sober and

understated. Those exclamation points are genuine: genuine astonishment at the simplicity of nature properly seen; genuine exuberance in the power this vision gives us ("he rejoiceth as a strong man to run a race," says the psalmist).

The football-chant use of exclamation points, together with the cardboard-computer philosophy of problem solving and John's own rapid-fire attack on difficulties comes through clearly in Wheeler's First Moral Principle that I salvaged from one of our conversations and installed at the introduction to the exercises of *Spacetime Physics*:

WHEELER'S FIRST MORAL PRINCIPLE. *Never make a calculation until you know the answer.* Make an estimate before every calculation, try a simple physical argument (symmetry! invariance! conservation!) before every derivation, guess the answer to every puzzle. Courage: no one else needs to know what the guess is. Therefore make it quickly, by instinct. A right guess reinforces this instinct. A wrong guess brings the refreshment of surprise. In either case life as a spacetime expert, however long, is more fun!

RIPPLES OF PERSONAL INFLUENCE

No one who has opened this book or looked at its index is likely to be in doubt about the influence John Wheeler has had on the subject of physics and on the nation, influence large in scale like the gigantic breaking ocean combers so beloved by John in explaining the curvature of spacetime. My testimony is less objective and more personal, the small-scale ripples of influence that change individual lives.

One purpose of my sabbatical year in Princeton was the development of a professional research interest of the kind so central to academic promotion. Authoring a textbook or two ordinarily carries insufficient weight for this purpose, particularly at a small ivy league school such as Wesleyan, self-conscious of its standing in the various research disciplines. Thus, in retrospect, the decision to work with John on a relativity text was a fateful one, and fateful in a meaningful sense because it was so natural an enterprise for me that it required no conscious decision at all.

Harry Truman had a rule for guiding the young: Find out what it is they want to do and then advise them to do it. That rule is almost as irresponsible as the contrasting attempt to make of the young what you think they should be. The true rule lies elsewhere: Create or help them to find circumstances in which their own aptitudes and skills are developed to the point that anyone who cares to look can see what they are. Is there any better definition of education?

Circumstances for testing and developing oneself can lead to negative as well as positive conclusions. John told me about a summer he spent as a youth rewinding burned-out electric motors at his uncle's silver mine. It dawned on him then that after another nine years or so the same job would have to be done all over again—and that he wanted no part in such a cyclic enterprise. He preferred to participate in a discipline that was cumulative, where one could hope to make a contribution based on the work of others, which would, in turn, become the floor on which later workers might stand—hence theoretical physics! In my own case, repeated involvements in experimental physics led to repeated ciphers.

Writing *Spacetime Physics* involved me in what was recognizably a first-rate enterprise and totally absorbed my energy and enthusiasms. In such circumstances the word "decision" is revealed as the pale ghost it is. I recall pacing up and down alone on the empty Sagamore Beach near Cape Cod mulling over the decision between "professional" research in physics and a full-time commitment to physics education. That decision, when it came, was no decision at all, since reality had outrun it. When "two roads diverged in a yellow wood" for Robert Frost, it is silly to say that it was his decision to take "the one less traveled by" that "has made all the difference." He was the one less traveled by; to have taken the more-traveled road would have been to fail to recognize himself, in which case you and I would never have heard of him. In such a way collaboration with John Wheeler helped me to recognize myself.

All this is not to say that John's influence in this case was what he planned or expected, or that he approved of my becoming a research worker in education. Indeed, there is evidence that John is hard-nosed about physics professionalism, seeing teaching and research as indissoluble (recall the quote about the process of educational change in the second section of this paper) and feeling that an educational innovator must have won his spurs in research so that he will merit the respect of those he seeks to influence. But this divergence of opinion between us, if it exists, is just the point: John provided the occasion for me to discover my vocation, not his. I graduated from him to myself. How can ripples of personal influence be more beneficial than that?

For the truth is that after a long history in the shadow, education research is now taking on the classic aspects of experimental and theoretical research in science: the cumulative assault on ignorance and error; the discipline of being hard up against the data; the recognizability of failure; a community of workers among whom one can have a more or less objective professional reputation. Whether or not John would acknowledge this I do not know; it is a measure of his success with me that I look forward to his opinion with interest but not apprehension. Meanwhile, ironically, the Massachusetts Institute of Technology—the citadel of professionalism—has the size, self-confidence, and versatility to provide anchorage for education research. Of course this versatility is the hard-won prize of local leaders—but that is another story for another day.

About the time *Spacetime Physics* was to be published, John made the only comment I can remember on the work as a whole. "The more I think about this book the more excited I am," he said over the phone. "Sometimes when I am low I think it is special [that is, special pleading—the presentation of a limited point of view]. Other times I think it will clean up the world." How well these overstatements reflect the emotional state of an author-to-be! "Other times I think it will clean up the world," summarizes by hyperbole the attitude of one who has found his place in harness and produced a work true to his inner vision. Far from being boastful, it expresses satisfaction in creating one instrument through which the fundamental simplicity of nature can be seen by those who choose to look. Only through such self-fulfilling selflessness, surely, can genius be harnessed to devotion so that, bit by bit, we can "clean up the world."