It has been fifteen years since I entered college as a freshman. I remember vividly the complex of emotions I felt at the time. There was relief at having escaped my parents and younger sister; there was exhilaration over the prospect of a sinful college life; there was apprehension over the possibility of not having a sinful college life; and, as I look back on it, there was a perfectly reasonable fear or ptomaine poisoning in the dining commons. I became a biology major because science came relatively easy to me, but I did not last in biology past my sophomore year. Labs and problem sets cut into my social life (it wasn’t too sinful, but it was social, and the final straw was a human anatomy course in which I found that the parts of the cadaver, whom we irreverently referred to as Carl, bore no resemblance whatsoever to the clearly drawn illustrations in the text. I defected to the humanities and social sciences, which were then becoming fashionable, and eventually I got interested in Chinese history. Along the way I took a B.A. in Political Science with a minor in art. Then it was on to graduate school in Chinese history as a more attractive prospect than army, which was involved at the time in a lengthy overseas venture of dubious wisdom. I am still not sure, however, whether it is better to take courses in intensive Chinese or to be shot at.

The point of all this is that I think I did the right thing with my undergraduate education but in the wrong way and for the wrong reasons. Exposure to a wide variety of courses in the sciences, humanities and social sciences was personally satisfying and intellectually rewarding; but it was not as rewarding as it could have been for two reasons. The first is that, to be honest, I was not very highly motivated. The second is that I gave so little thought to what I was learning, why I was learning it, and perhaps most important, how it related to what I already knew. I do not propose to speak to you today about motivation; but I would like to say a few words about the purpose and value of education in a science-oriented liberal arts university.
First, an explanation of the rather obscure title of this address, “The Tao of Physics.” It is the title of a recent book by a physicist named Fritjof Capra. One of my students, a physics major, suggested to me last spring that I read it. Eventually I did. Capra’s major theme is that the various models of subatomic physics express, in different ways, the fundamental insight of what he refers to broadly as Eastern Mysticism: “That the constituents of matter and the basic phenomena involving them are all interconnected, interrelated and interdependent; that they cannot be understood as isolated entities, but only as integrated parts of the whole.” Integration is the key concept, and the tao is an apt metaphor. In classical Chinese, the term tao has a variety of meanings. The character itself depicts a head in movement, on the road, so to speak. It is usually translated “the way.” As a philosophical concept tao implies unity, harmony and universality. But there are several different taos. One is the Confucian tao, representing the wisdom of the ancients distilled and interpreted by Confucius. Another is the Buddhist tao, which refers to the borrowed teachings of the historic Buddha. Yet another is the Taoist tao, which is simply the undefinable unifying principle behind all things in nature. This last tao is the one Capra has in mind, although he uses examples from Buddhism and Hinduism to illustrate his theme.

Capra’s book is the kind specialists love to tear apart. Both the philosophy and the physics are rather superficial. The prose is breezy and the comparisons are stretched. In the hands of Capra, a true believer, Lao-tzu, the legendary Chinese mystic becomes a relativistic physicist. One is tempted to think: If only he could have gotten external funding and travel money to work at the Fermi Lab he might even have gotten tenure.

It is easy to take shots at Capra, but I believe he deserves to be taken seriously. Whatever the flaws of his book, I am impressed by his effort to step outside his field of specialization and look at things in a fresh and stimulating way. The Tao of Physics is valuable not for its hard information but for its suggestiveness, for its bold and provocative attempt to establish a link between ancient Far Eastern wisdom and modern Western science. No one can remain unmoved after reading the book. My own response was to explore in a systematic way that part of Capra’s world I knew least about—the world of modern science—and my remarks today are inspired at least in part by my investigations of the subject this summer. In all, it was an exciting, somewhat dizzying
voyage of discovery, and my hope this afternoon is to communicate to you as much of
the excitement, and as little of the dizziness, as possible.

Back to the title. “The Tao or Physics” suggests to me a triple metaphor. The first
centers on the idea of tao as an all-pervading unity, one that establishes an integral
relationship not only between things in Capra’s sense, but also between ideas and forms
of knowledge. The second metaphor is based on the notion of tao as inspiration, the
source of the imaginative, creative search for understanding that characterized the Taoist
point of view. The third metaphor involves the idea of yin-yang balance embodied in the
 tao, the harmony of non-antagonistic interaction. These three related themes—unity or
integration, imagination, and balance in the pursuit of knowledge—seem appropriate to
thinking about education in any university, and education at Rice in particular. As a
China specialist, it is difficult to avoid patronizing local industries, talking about what I
know best. At times I will succumb to the urge, as you have already seen. But essentially
my message is this: The kind of knowledge we should all be seeking, especially in the
university environment, transcends areas specialties, disciplines, departments, and
divisions. No single branch of knowledge has a monopoly on truth, and each can benefit
from exposure to the others. This is my first theme.

There are, however, barriers to effective communication. The most basic of these
is what C.P. Snow refers to as the “two cultures” problem. Snow’s view, first articulated
in a famous lecture at Cambridge University in 1959 and still a source of lively debate, is
that a split has occurred in the intellectual and practical life of Western society between
the culture of the so-called literary intellectuals and that of the scientists. Separating the
two, Snow maintains, is “a gulf of mutual incomprehension—sometimes (particularly
among the young) hostility and dislike, but most of all lack of understanding.” Scientists
cannot read Dickens critically and humanists do not know the Second Law of
Thermodynamics. As a novelist, Snow castigates scientists for considering “the whole
literature of the traditional [literary] culture irrelevant to their interests,” but as a physicist
he reserves his strongest criticisms for the humanists, who like, he says, ”to pretend as
though the natural order didn’t exist.”

Like all such juxtapositions, Snow’s contrast is too stark; it lacks subtlety and is
terribly overdrawn. Yet there is point to it, and we can see the evidence at Rice. Consider
the vocabulary of student discourse. One regularly hears references to the two “sides” of
the campus—designations that imply more than simply physical separation. Academs
generally consider S.E.s to be uncultured, narrow, compulsive and uninteresting. They
are blamed by the particularly unenlightened for every technological problem known to
humanity, from aerosol sprays to neutron bombs. I am told there is even a physical
stereotype: Glasses, seventeen different pens, calculator on the belt, white socks, and
high-water pants. S.E.’s, for their part, see Academs as hopelessly naive, mechanically
inept, intellectually inferior, and possessed of no redeeming social value, like
pornography. These are destructive myths that should have been abandoned at Rice long
ago. Why do they persist? Why is there so much misunderstanding?

The answer is simple: The irrational failure of rational minds to communicate.
Unfortunately, this intellectual problem has social implications. Often S.E.’s and
Academs at Rice do not even try to exchange ideas, satisfied that cross-cultural dialogue
is in fact impossible. In contemplating this absurd, self-fulfilling prophecy, I am
reminded of a story once told by Dr. Edward Hume, a famous Western physician who
practiced and taught in China for many years. Hume spoke Chinese like a native, and was
especially adept at the Hunan dialect. One day, he became lost in the Hunan countryside,
and asked two peasants the way to the city of Ch’angsha. The two men looked blank, and
after repeating the question several times, Hume gave up. As he was leaving to find his
own way, he overheard one peasant say to the other, “You know, I could have sworn that
foreigner was asking us in Chinese how to get to Ch’ang-sha!”

It is easy enough to look at the subject matter, research techniques, and
specialized vocabulary of various fields of knowledge and despair of effective
communication. But the problem lies with those who assume they cannot understand or
appreciate new concepts, and those who assume that their ideas will not be understood.
Space physics seems to be an awesome and impenetrable subject. Yet in reading Rice
professor Don Clayton’s book on cosmology this summer, I was amazed to see how
clearly he was able to communicate the essence of his highly specialized field to me. I
was also surprised to find how similar his basic intellectual concerns were to
mine, despite radical differences in the subjects we study, and the way we go about our
work.
It is common, I think, to view science as objective, concrete and rational, and to see the humanities as subjective, abstract and intuitive. The social sciences, as their name implies, lie somewhere in between taking humanity as their object of study, and scientific techniques as their tools. But on closer examination, some of the deceptive clarity of such distinctions—particularly those between the sciences and the humanities begins to disappear. The sciences certainly have not cornered the market on objective inquiry, nor are they immune to subjectivity. Anyone who doubts this would be well-advised to read James Watson’s *The Double Helix*, which vividly chronicles the all-too-human quality of the search for the structure of DNA. Both the sciences and the humanities grapple with “facts” in some form, and both find it necessary on occasion to go beyond them. Newton once wrote that “No great discovery is ever made without a bold guess.” T.H.Huxley stated: “It is a popular delusion that the scientific enquirer is under an obligation not to go beyond generalization of observed facts.” And Pasteur replied unashamedly to his critics: “It is true that I have freely put myself among ideas which cannot be vigorously proved. That is my way of looking at things.”

All branches of knowledge seek “truth,” or, to put it another way, a better understanding of “reality.” They all accumulate and integrate data, and employ models, symbols and metaphors to describe and explain their ideas and findings. All are involved in continual reinterpretation. They search for principles, patterns, unities and uniformities, and at the same time, try to account for significant differences. And virtually all forms of knowledge have an aesthetic as well as an intellectual dimension. G.H. Hardy, for example, saw mathematics as pure poetry, and Bertrand Russell described it as cold but magnificent sculpture. Paul Dirac, a Nobel prize-winning physicist went so far as to say (in the *Scientific American*) that it was more important “to have beauty in one’s equations than to have them fit the experiment.” But perhaps the most significant similarity of all is that in every branch of learning, theories and models developed by human beings serve only as approximations of the true nature of things. To put it in Taoist terms, the only reality is that there is no single reality, no one true perspective.

We are accustomed to the view that artists—painters in particular—express in their individual work different realities, different interpretations of their sensory perceptions. But even science, with the precision of its measurements and the elegance of
its mathematical formulations, must confront several different “realities.” In everyday experience, things are seen to operate in space and time. These things consist of matter, and matter can produce and be acted upon by forces. Events follow from the interplay between matter and forces, and every event is the result and the cause of other events. This is the “real” world of classical physics. But it is not the “real” world of either quantum mechanics or relativity theory. In the subatomic realm, matter does not exist with certainty at definite places, but only has “tendencies to exist.” In the stellar realm, one cannot consider space without considering time. Scientists are forced to speak in terms of probabilities and paradoxes. Theoretical physicists developed elaborate “quark” models (the term is derived from Joyce’s *Finnegan’s Wake!* ) without any evidence of “quarks.” Even in the most precise part of science, mathematics, it is impossible to avoid concepts that involve con- tradictions, such as infinity. What more glaring illustration of the problem of confronting reality could there be than Heisenberg’s famous “uncertainty principle,” which demonstrates that precise measurement in one area of investigation necessarily involves greater uncertainty in another?

Let’s face it, then: We are all in the same intellectual boat—humanists, social scientists, and scientists alike. Although each of us goes about trying to understand a given reality in his or her own way, we are all involved in a single creative act, the act of reconstruction. In Bronowski’s words, ”We remake nature by the act of discovery.” The common denominator in this process is creative imagination, which brings me to my second theme.

We are all Taoists, in our way, stepping boldly out into the void. Or at least that is what we should be doing. Knowledge without inspired exploration, without creative imagination, is sterile. The accumulation of mere “facts” reduces the mind, with all its vast potential, to a simple storehouse of information. By imagination, I mean not only the synthesizing power of the mind and its ability to form new symbols and images, but also the ability to escape from convention, adopt fresh perspectives, even take flights of Taoist fancy. Once again we are inclined to accord this freedom to artists and writers, and to deny it to others. But throughout history imagination has played a highly significant role in virtually every area of human affairs, not least in the realm of scientific discovery. When Copernicus developed the revolutionary idea that the earth moved around the sun,
one of his first steps was a giant leap of imagination: He lifted himself up from the earth and “put himself wildly, speculatively into the sun.” Einstein sowed the seeds of his relativity theory by imagining what a light wave would look like to someone moving along with it. Rutherford and Bohr found a model for the atom in, of all places, the planetary system.

Imagination also allows the mind to discover hidden relationships. Michael Faraday established a link between electricity and magnetism; Clerk Maxwell linked both with light; Einstein linked time with space and mass with energy. Scientific investigation, although essential, could only take these individuals so far. Max Planck, a pioneer in quantum theory, summed up the importance of creativity this way in his autobiography: “pioneer scientists must have a vivid intuitive imagination for new ideas, ideas not generated by deduction, but [by] artistically creative imagination.” Along the same lines, Max Born, one of the great mathematical physicists of the twentieth century, wrote: “Faith, imagination and intuition are decisive factors in the progress of science . . . [just as they are] in any other human activity.” Faraday advised: “Let the imagination go, guarding it by judgment and principle . . . [and] holding it in and directing it by experiment.”

It is commonly believed that premodern China had no science. This misconception continues to be a source of great dismay to Professor Joseph Needham of Cambridge University, who has devoted some thirty years of his productive life to studying the subject. Chinese science, inspired primarily by Taoist naturalism, has, over more than two thousand years, produced a steady flow of ideas, many of which anticipated, paralleled, or directly influenced, important scientific discoveries in the West. These contributions include the earliest known use of decimal place value, all basic knowledge of magntetical phenomena, early triumphs in the theory of optics and acoustics, highly sophisticated algebraic techniques, the most accurate astronomy anywhere before the Renaissance, and a tremendous array of practical inventions from the seismograph to the compass. Yet China never experienced the kind of scientific revolution that helped transform the West in the seventeenth century and thereafter. At least one important reason was the eclipse of Taoism as a creative force in Chinese life, and the establishment of a rigid neo-Confucian orthodoxy, which valued only moral
knowledge. Orthodox neo-Confucianism, in turn, was maintained by the well-known Chinese examination system, which by the fourteenth century had reached full form. Thereafter, China produced no scientific accomplishments of any significance until the twentieth century.

My intent here is not to argue against the importance of either moral knowledge or examinations (for the record, I shall continue to be woefully deficient in the former and to place limited and reluctant reliance on the latter. What I am suggesting is simply that rigid orthodoxy eventually produced in China intellectual stagnation. The problem with the Chinese examination system was not that it tested knowledge, but that it tested only one kind of knowledge, and placed no premium on any other. We are better served by higher education in contemporary America, especially at Rice, but there are still barriers to creative thought, obstacles to overcome.

It is impossible to avoid burdening you at this point with my conception of what a university should be. Undoubtedly the dim outlines of this vision have already emerged. In my view, the major function of undergraduate education should be to encourage the exploration of new ideas, to promote an active sense of intellectual discovery, and to foster creativity. I am in total agreement with the philosopher Alfred North Whitehead, who once wrote that the purpose of the university was to preserve the connection between “Knowledge and the zest for life by uniting the young and old in the imaginative consideration of learning.” “The university imparts information,” says Whitehead, “but it imparts it imaginatively.” William G. Bowen, president of Princeton University, recently put the matter this way: Liberal education should be directed toward helping us “to develop those habits of thought which always ask why, which believe in evidence, which welcome new ideas, which seek to understand the perspectives of others, which accept complexity and grapple with it, which admit error and which pursue truth.” Again, it is worth emphasizing that such habits of thought are not the exclusive preserve of any single discipline, department or division.

So much for the theory of liberal education. What about the practice here at Rice? We all know Rice is a fine school. Even the Yale Daily Press says so. But judging from the last two university-wide Convocations held in 1976 and 1977, there are several major criticisms of the undergraduate educational experience here. One is that too often
teachers in both the sciences too and the humanities encourage too much specialization too soon. Another is that the departmental system discourages faculty members from dealing with questions outside their disciplines and hinders the development of courses that encompass several areas of knowledge. A third criticism is that the course load, grade pressures, and intense competition encourage students to become conservative in their choice of courses, causing them to “answer to the instinct or self-preservation rather than to the impulses of curiosity or adventurousness.” These are serious criticisms, and it would be irresponsible of me not address them.

Aside from leaving, there are the usual two options. One is to work at changing the system. As a child of the sixties I am sympathetic. But I feel obliged to warn you against a Chinese-style Cultural Revolution. It is not, you understand, that I mind hordes of Red Guards swarming around my classroom chanting slogans and putting up posters. Nor do I mind being paraded around the campus in a dunce cap; we all need to be humbled on occasion. It would at even be all right to close down the school or at least the food service. But think of the damage that would be done to the agricultural sector if all the faculty were sent to the countryside to work in the fields. At best nothing would get done because the professors would spend all their time in committee meetings.

We are left, then, with the second option—to work within the system. This is not as bad as it may sound. Although the course load at Rice probably should be reduced, and there should definitely be greater communication and cooperation between individual faculty members and between departments, there is still a great deal of room on this campus for what Whitehead calls “the imaginative consideration of learning,” for the exploration of new ideas and relationships. Competition should not in any way discourage this process; in fact, imagination can often be used to competitive advantage.

One obvious but often neglected way to enhance the value of undergraduate education here is to take a variety of courses in different departments and see how the knowledge gained in one class relates to the subject matter of another. The possibilities are almost inexhaustible. Invariably this approach to learning is personally satisfying, and often it is academically rewarding. It cannot help but be stimulating, and serves to free us from parochialism and intellectual rigidity. Philosophy majors may be reminded of the relationship of their own field to the biological sciences by Darwin’s disconcerting
remark that “Whoever achieves understanding of the baboon will do more for metaphysics than Locke.” On the other hand, biology majors may be stimulated to investigate philosophy after reading recent research that indicates a neurological basis in the human mind for separate image-making capabilities corresponding to the traditional epistemological categories of empiricism, existentialism and pragmatism. Physicists, whose recent findings touch on some of the most profound philosophical questions of any age, might well ponder, in turn, how Leibniz came to the conclusion over two hundred years before Einstein that time and space were not things but relations.

In the humanities and social sciences, cross-cultural comparisons of various sorts are vital to the testing of theories, models and basic generalizations. Historians can ill-afford to ignore developments in virtually every other branch of knowledge, including the sciences, but by the same token, as William James has noted, the other branches stand to gain from an appreciation of the historical approach to problem solving. C.P. Snow asserts that since science is cumulative and incorporative, “no student of science need ever read an original work of the past,” but I doubt that anyone can fail to benefit from an understanding of the way Copernicus, Newton, Einstein and others did their thinking.

For the less adventuresome, there are other ways to go about exploring the relationship between seemingly discrete bodies of knowledge. Take a good look at the current university catalogue. One thing you will find is a surprising number of courses that, although offered by a single department, touch on one or more other areas of knowledge. Let me mention just a few: Medical Anthropology, Computer Applications in Architectural Programming, Bioengineering, Mathematical Structure of Economic Theory, Digital Computing for Humanities and Social Sciences, History of Science, the Role of Mathematics in Civilization; Philosophical Perspectives on Science, and so forth.

Several departments offer separate courses covering what appears to be the same basic subject material. For example, there are courses on medicine and given in Anthropology and History, and on language in Philosophy and Anthropology. There are also a few innovative team-taught courses, such as The New Shape of Work, offered jointly by professors in History and Sociology. This teaching concept should be especially inviting to open minds: One broad and significant topic, two disciplinary perspectives, and undoubtedly three individual points of view.
Many new fields of knowledge that cut across traditional disciplinary boundaries in a highly creative fashion are not taught formally at Rice. Sociobiology, cliometrics, psychohistory and exobiology are a few of the more interesting and controversial of the headlinemakers. But I am sure that there are any number of courses here that deal with these subjects in one way or another. And even if there are not, you can find out what you want to know. The point to remember is that whatever the other failings of professors, they always know more about, and are interested in, much more than they ever teach. Do not assume that professors will be uninterested in the things that interest you, or that knowledge can be gained only by taking classes. One important conclusion reached by the 1976 Convocation Committee was that Rice students too often mistakenly think of their education as something that goes on “exclusively within the structured boundaries of classrooms and laboratories.” More attention needs to be given to education as a process of “exchange and interchange between faculty and students outside the classroom; in office conferences, over meals, in the colleges, and in other places where people congregate.” I am particularly fond of the pub.

Students are not the only beneficiaries of such interaction. Professors learn much more from inquisitive students than is generally recognized. I can think of numerous examples from my own experience, but I will spare you the details because time is short and we are all tired. Only one point deserves emphasizing. Whether inside the classroom or outside, if your education is to have any value, you must take charge. Be assertive and inquisitive. Challenge your professors and yourself. Make full use of your human potential and we will all benefit.

This brings me to my last theme, and I will make it brief. It is that ultimately formal education is a matter of balance, a question of yin and yang interaction. In traditional Chinese thought, the terms yin and yang refer to a wide range of polarities: passive/active, dark/light, cold/hot, wet/dry, soft/hard, and so on. The important point about these two concepts is that they are complementary and non-antagonistic. The two interact, but they do not contend. In traditional China there was never a struggle between absolute good and absolute evil in the Western sense—only the interplay between balance and imbalance. Good expressed itself in the idea or balance and harmony, evil in imbalance, which created chaos and confusion.
When used in the vocabulary of social philosophy, *yang* signified outward-oriented activity, social service, structure, order and self-sacrifice. These were the central concerns of Confucianism. By contrast, *yin* denoted inward-oriented behavior, withdrawal from social concerns, freedom, spontaneity, and self-indulgence. These were the essential features of Taoism. In Chinese society, Confucian scholarship brought material rewards and prestige; Taoist scholarship brought personal satisfaction and a sense of ease. Both were necessary for a balanced, meaningful life, and each enriched the other. Confucians needed intellectual refreshment and a kind of spiritual release; Taoists needed something to escape from. As Joseph Levenson has remarked “The pleasure of a flight from civilization is open only to [the] civilized man.”

In all, a healthy balance in Chinese intellectual life had to be maintained between what one had to do, and what one’s natural impulse was to do. So it will be with your education here. In one sense you will be operating within a structure of Confucian-style ritual in the form of major requirements, examinations, problem sets, labs, and papers. If you survive the experience, the rewards are substantial: A degree, social approval, perhaps even a job. Parents are pleased, and we all feel socially productive. But Taoist balance is necessary. In the world of undergraduate education there must be a place for the free exploration of ideas that have no market value, ideas that are their own rich reward. Each of you must strike a balance between career goals and personal needs in order to find the *tao* of Rice. It is an intensely personal quest, and an elusive *tao*, but well worth pursuing.

In closing I would like to read two Chinese poems. Unfortunately they lose a great deal in translations, but the sentiments are clear enough. The first, written by Po Chü-i, celebrates the social rewards of Confucian scholarship. It is called: “After Passing the Examinations.”

For ten years I never left my books; I went up and won unmerited praise.
I do not prize much my high position; It is the joy of my parents that will make me most proud.
Six or seven fellow students see me off as I leave the city gate.
My covered carriage is ready to go; flutes and strings play their parting tune.  
Fulfilled hopes dull the pain of leaving; and the fragrance or wine shortens the long road.  
My horse has wings as it takes me home this delightful spring day.

These are fine feelings, and you will know them soon enough. But listen also to the words of Yüan Chieh, in his poem entitled “Civilization.”

To the southeast, many miles away, the Yüan and Hsiang Rivers form into a mighty lake.  
Above the lake are deep mountain valleys, where men dwell whose hearts are pure and innocent.  
With the happiness of children they climb to the top of trees, and run to the water to catch bream and trout.  
Their pleasures are the same as those of wild animals and birds  
They put no restraint on body or mind.  
I have wandered far throughout the Nine Lands, and wherever I have gone, such habits have disappeared.  
I find myself standing here wondering, perplexed, whether Saints and Sages have really done us any good.

My earnest hope is that the few saints and many sages at Rice will do you some good; but while you are here, do not forget the pleasures of free flight. Good luck.