THE GAME OF SCIENCE

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PREFACE

The following is an attempt to create the conditions for the development of an aesthetic for science. The heavy weight of morality threatens to make the scientist over-weary and to take the savor from his work. There is no great gain in this constant, almost neurotic insistence that the scientist accept responsibility for the moral shambles which is our modern world. Besides, it may well be that what the scientist needs most to make him more moral (if indeed he should be) is a more interesting and more vital aesthetic. Philosophy has long abandoned the scientist to his own devices, except in certain severely specialist areas such as logic and quantum mechanics. On the other hand, the philosophers have retained for themselves the existentialist aesthetics, never caring whether any such things as existentialist science ever will or can come into being.

I have not tried to lay the foundation for an existentialist aesthetic for science in these notes. Rather, I have simply set forth the skeleton of a generalized aesthetic, hoping that cultural conditions may now be ripe for covering the skeleton with flesh and bones. I put forth the following ideas in the expectation not that they will guide but that they will at least stimulate the thought of others and that so stimulated something like the game of science as here outlined will get underway. I welcome comments on this somewhat quixotic, intellectual adventure.

INTRODUCTION

Readers of Hermann Hesse's Magister Ludi, the Master of the Game, are easily led to reflect on the mysterious way in which the poets anticipate practical life. For if science is at least practical, and if system science including game theory is not the least practical aspect of science, then what shall we say of the poet and novelist who attempts to show how to play the game of science so that it should be not only a moral exercise but also an aesthetic way of life? We should have to call him the most practical of all scientists, I suppose.

The poet takes science for a whole way of life and no matter how far from this ideal one feels his own life course to be diverging, he must admit that the existence of the ideal is a matter of the most pressing practical consequence. Like the existence of the pole star on one level of reality or of the principle of the conservation of energy on another.

Hesse's "game" is a spiritual exercise. It is an attempt to bring all aspects of one's life, the scientific, the economic, the social, the political and the recreational, the wildly fantastic, and the severely practical, together. Of course, it is therefore pre-eminently religious; so much so that (as with all true religions) it is scarcely necessary to characterize it as such. The hope is that one can simply live it. But how?

Our trouble begins with words. The poet speaks of a "game": Latin, ludus; German, spiel; French, jeu. Is this what life is, especially the life of science? What serious object can one have who speaks of the game of science? It will not help us to try to trace the battered history of words. The Latin ludus is so far from us that one suspects that the first free association of a modern American would be the word ludicrous. German spiel is just as little aid. We need not trace the continuum of the word "game" from the most utterly random semi-conscious twitchings of a child at play to the heavily tragic seriousness of the agony of a crucified Savior in the "Passion Play." Indeed, we need no foreign term at all to do justice to the infinity of nuance that we are here considering. The English word "play"

presents us with all the difficulties we might need in order to get our theory born. For the word "play" is by no means only playful. One plays music, all kinds of music. We see Shakespeare's tragedies and call them plays. We play sniff, old maid, chess, poker, go. If the German word spiel cannot be translated into English, the English word "play" cannot either.

Nietzsche described the pre-Socratic nature-philosophers' work on the fundamental nature of the physical universe as "play," the notion of a god at play creating a random beautiful world. Before him, Schiller thought of play as the saving grace that rescues us from the cold rigors of rationalism on the one hand and the absurd emotional excesses of romanticism on the other. He speaks of serious play. He means the effort to see beneath the myriad facets of creativity to its structure. Not alone to be spontaneous, but also to seek the structure of the spontaneous is to play.

What name should we moderns give to the serious business of seeking the structure of spontaneous creativity? Could we call it a game?

I am aware that much of what I have said sounds like the philosophy of science. But it is also more. If the net outcome of the game, saved up in the most frugal if not parsimonious way, is philosophy of science, nevertheless the effect of the game on players, their entourage and finally the public, is not only philosophy and not only science. Indeed, the object of the game of science is not science at all. It is not even morality, though one could hardly see how its practice could fail to clarify moral aims. The main object of the game is aesthetic. It seeks to justify a way of life. A less self-conscious age than our own would frankly call it religious.

Can we now risk an attempt at a description of the game of science? Are we sufficiently aware of the danger of destroying what we would preserve when we attempt to describe the structure of spontaneous scientific creativity? Of course, we know the danger. In fact, so fully aware of it are we, that prudence advises us to give up the attempt. The spontaneous, it will say, can never yield to analysis. Alas, we know that, but even if we ourselves do not kill the spontaneous by dissecting it, it will die a natural death anyway. Besides, are we

sure that the spontaneous does not want to be analyzed? Why else does it present itself to us analyzers?

So we shall imagine that spontaneous creativity wants to be analyzed. But should it? Is not analysis under the obligation to refrain from destroying the spontaneity of the creative by refusing to dissect it? This is a matter of scientific morality, a self-conscious exercise of restraint to avoid doing evil. Not the spontaneously creative, which after all is an aspect of nature, but the scientist himself is under a moral obligation not to misuse his tools.

This is a serious matter, to be sure. The first objection, namely, the charge that analysis kills spontaneity is after all only a spur to us to perfect our methods. Maybe with increased awareness of its delicate nature, we may learn to handle spontaneity without killing it, is the thought. But the second charge is more serious. It asserts that the better the scientist becomes at handling spontaneity, the worse for spontaneous creativity, so that the perfection of scientific technique would imply the total destruction of spontaneous creativity. This touches a very delicate nerve in the body of science. True, the situation looks like another instance of scientific indeterminacy. Yet, science has learned much recently in the way of living with its various indeterminacies, such for example as those in logic, mathematics, and physics, and even in the behavioral sciences where the investigator's manipulations produce artifacts rather than "natural" behavioral patterns. But the scientific effort to study spontaneous creativity brings up a fundamental challenge to scientific method. For the scientist's method demands control of his subject matter, and control of spontaneity is an arrant contradiction in terms. Hence, to live with this paradox takes much more doing than to live with the indeterminacies of physics or the paradoxes of logic. It really means adding to the ideal of scientific investigation, that is, the unbounded pursuit of ever-expanding truth, a new ideal in which truth-seeking is by no means the most important part. This suggests that the likeliest way the structure of spontaneous creativity can be handled is in a game, the game of science.

The game of science should exist only for itself. It should set

its own aims and aspirations. It should not be played for the sake of the advancement of truth, or indeed for any other goal than the pure fun of the game. So conceived, spontaneity can be seen as structured, for if the object of the game is spontaneity itself, then the paradox that arises when spontaneity is subject to control disappears. Spontaneity structures itself.

I hope it will be apparent that if what I have said about the game of science is accepted, the older paradox that attends the separation of pure from applied research will have been superseded. For the game of science is pure research in its most nearly ideal form. Seen from its vantage point, the distinction between pure and applied research has only historical significance.

THE SUBJECT MATTER OF THE GAME

For a long time while struggling to uncover the elements of the Game of Science, I regarded it as imperative to formulate as many sample games as my limited store of ingenuity could suggest. I invariably discovered that all I could come up with were instances of unresolved problems of my own, largely those that occupy me at present. These turned out to be enigmas, paradoxes and unresolved problems in decision theory. Strive as I might, I could not get beyond the area of my own immediate perplexities. It took quite a while for the reason for this difficulty to become apparent. When it did, it seemed absurdly simple. The Game of Science is nothing if not a collective effort. One person may or may not be able to devise an apt instance of the Game by himself. The essence of the Game would surely be to transform it immediately. Hence, the start need not be auspicious, nor the proposed game be instantly perceived as apt, still less as typically likely to be interesting or to succeed. This reflection relaxed my anxiety about apt examples and allowed me to proceed with the following brief consideration of game areas. I append my own haphazard list of game examples at the end.

MUSIC AND MATHEMATICS

Did this classically famous amalgam really disappear with the

Pythagoreans? European scholarship has never let the subject die. It is a loss too poignant for the mathematician to accept without lament. Hence, the historiographers and indeed the classical historians of philosophy never fail to call attention to the natural affinities between mathematics and music. Since the final aim of the game of science is aesthetic, it is hard to imagine a more appropriate exercise than to reconstitute an intimate relationship between music and mathematics. Those with competence in either subject would be the best judges of how to start the game and what steps to take to do justice to the transcendent importance of the subject matter.

PHYSICS AND PHILOSOPHY

Physics came of age when it accepted the fact that the paradoxes at the heart of the universe are real and not merely verbal; that paradox is material, not subjective only; that the twin endeavor to probe ever more deeply into the nature of Nature and to express the findings of such effort in ever more refined language both lead inevitably to the paradoxes of logical form and of material substance.

This revelation set the stage for the physicist as the modern cosmogonic mythmaker. How worlds come into being used to be the monopoly of religion, until, first in the history of Western culture, the pre-Socratic nature-philosophers attempted to claim this function for philosophy. This gallant attempt lasted, as Nietzsche has pointed out, until Plato and Aristotle buried the scientific cosmogonies of their predecessors under their towering edifices of ethics and morality, of common sense empiricism in the case of Aristotelian science, and of rational moral behavior in the case of Plato. The Platonic cosmogony is frankly conscious and heavily ethical. There is no place in it for the simple non-moral, aesthetic cosmogonic myths of the early scientists.

The age needed a practical ethics. Plato and Aristotle swamped out the nature-philosophers in supplying this need. That their learning in turn became buried under the religious avalanches of the time seems like poetic justice. For ethics is only a half-way house on the road to religion. And the simple-minded, non-scientific, religiously oriented cosmogonies of unsophisticated Judaeo-Christian tribesmen fashioning

a monotheistic anthropomophic god lasted nearly two millennia. World building became once more the monopoly of religion.

I should say that when at the Renaissance, physical scientists once more turned to the problem of world building and Galileo in the name of science accepted the modern compromise--the world as non-moral machine for science and the world as myth for religion--it was subconsciously apparent to all that in the course of time science would have to violate that uneasy truce. And it was precisely the paradoxes disclosed by and to the scientist in the very nature of the world order, I think, that forced on him the contemporary ethical dilemma represented by knowledge of how to destroy the world and responsibility for preventing that catastrophe.

I like to think that the moral paradox resulted from the physical paradoxes and not the other way around. I realize that this "materialistic" interpretation has its own difficulties. Still, whenever the matter is one of the inevitable dilemmas which face a profession (in this case, physicists), it seems to me that a good place to look for causation is in the day-to-day practice of the profession.

Does the contemporary physicist realize that his efforts at world-building must necessarily end in cosmogony--unless, that is, he has a failure of nerve? That too is being tested to the bitter end as Dürrenmatt's The Physicists plainly tells us. Assuming that physics will weather the political and moral storm, then its cosmogonic efforts must lead it to myth-building as the aesthetic motifs of the effort come to predominate over the moral and the truth-seeking. And this is surely the artist's realm of the creative plan.

The general form of the game could be expressed as a vast question: Is it possible to create myth consciously? World myth? Cosmogonic myth as truth? Science fiction presents the challenge in its starkest form. In science fiction, the scientific elements are fantastically creative, that is, projections of the science of the future. The morality of science fiction on the other hand is Renaissance individualism, its aesthetics is archaic and barbarian. The over-all objective of the game of science on the contrary would be to create a morality and an aesthetic in keeping with the advanced state of modern science.

The speculations of modern cosmologists might be a natural starting-point for the games. Now that paradox has invaded the fundamental assumption of the cosmologists that time is reversibly invariant, an opportunity exists for the creative imagination to conjure with the mechanical orientation of cosmological speculation in the interest of myth creation. The origin of the proto-universe need no longer be conceived as occurring only in the eternal present. The imagination is free to create alternative world origins and developments. It goes without saying that the "causes" of such transformations need not be primitive demiurges or world-shapers.

CHEMISTRY AND ALCHEMY

It is no longer necessary to refer to the two-thousand-year-old effort of the alchemists to penetrate the heart of matter as nothing but a long episode in the history of superstition. It is still very difficult, however, for modern scientists to see that sustained effort as anything but very primitive attempts on the part of proto-scientists to create an experimental science of chemistry. Modern science is so unsure of itself that its ancestors are often thought of as fumbling amateurs. Certain towering historical figures are exempt from this denigration, but the past rank and file of the profession are thought to fit the description.

It is still hard for the modern scientist to imagine what the practice of science would be like for a scientific community wholely embedded in a unitary religious culture such as that which enfolded science from Greek Alexandrian times until the Renaissance. That the scientific community, no less than all other elements of the culture, should work solely for the honor and glory of God seems to be an ideal which modern science with great reluctance, but nevertheless quite definitely, surrendered at the Renaissance. The results of the modern revolution of science against established religion, that is to say, an immense proliferation of power over inanimate nature with a consequent impoverishment of spiritual life, seems not only inevitable but good. Conversely, the contemporary mood of calling into question the

desirability of indiscriminate proliferation of material power devices should, it is hoped, open the way to science to approach once more the question of the consonance of the scientific and the religious way of life. This is a truly revolutionary outlook.

It might lead to a re-evaluation of the alchemist's central objective. Alchemists were practitioners of a subversive religious way of life. They practiced science in an aura of revolt directed against all elements of the culture, including, in particular, religious orthodoxy. The heavy weight of the authority of the universal church was never great enough to suppress them entirely. They persisted right down to the beginning and indeed for some perceptible time after the beginning of modern science. Not religion but science itself dealt alchemy the death blow. The paradoxical figure of Newton, whose peripheral and prosaic efforts alone are preserved in the history of science, marks the effective end of the alchemical effort to link true science with true religion. What Newton thought to have been his life work is discarded today as the understandable aberration of genius.

What were the alchemists up to? C. G. Jung's vast erudition has uncovered a sustained and extraordinarily sophisticated body of alchemical practices devoted to the study of the depth psychology of the human being. The alchemists' ritual projected unconscious contents onto the base matter in their crucibles in order to receive back these unconscious contents in the form of heightened knowledge of the nature of the human soul. In brief, they were adept at the practice of depth psychology. Compared with this body of learning, their chemical discoveries were, in his view, relatively inconsequential. They were forerunners of modern psychoanalysis, done in by the preoccupation of science with the nature of matter to the exclusion of mind. Modern psychology in this view simply continued the predominant scientific materialistic bias.

This view of the alchemists' work, if accepted, would explain why so many of the most powerful minds of the medieval world and of antiquity were so heavily engaged in alchemical practice. But it does tend to depreciate the importance of alchemy as a forerunner of modern physical science, and specifically of chemistry. Is it possible to reconstruct that link?

If, as Jung so firmly believed, the alchemists were predominantly and pre-eminently psychologists, it would seem necessary to show in what way psychology is linked to chemistry in order to re-constitute the link between alchemy and modern chemistry. Can this possibly be done? Or is it still so that the chemist purports to be investigating only the interrelations of matter and energy and not at all the inter-relation of the human mind with both of these? This is a touchy question. Can the alchemist, so far ahead in psychology and so far behind in chemistry, be fruitfully linked with the modern chemist, so far ahead in chemistry and so far behind in psychology?

Would the resolution of this difficulty require an exercise in the philosophy of science to show how the psychology of the observer enters intimately into the scientific process of observation regardless of the nature of the subject-matter being observed? Granting that this inquiry is in its own right a pressing necessity in current scientific methodology, is there any reason to suppose that the inquiry could soon come upon the relation of unconscious mind to scientific method? And if this vast effort should somehow be miraculously accomplished, is there any reason to suppose that it will disclose any link between the unconscious mind and chemistry as a special science?

It would be indeed mysterious if what had always been taken to be (proto) chemistry should turn out to be a vast exercise in the mysteries of the unconscious mind. How did the link originate in the first place? Why did the early "psychoanalysts" become chemists; why did they turn to base matter in search of the philosopher's stone, the mercury of the soul, the real and especially the metaphorical turning of lead (the symbol of despair, anguish, depression) to gold (the symbol of bright, shining hope and deliverance)? This is to displace one mystery by another.

The appeal for help must be to the historian of science. It is perhaps now possible to re-examine the life of Newton as an integrated human being and scientist and to find out why he felt his work in

physics and mathematics to be specific exercises in religion.* The way back, surely including Roger Bacon as a central figure, would be long and arduous. But it looks as though the former must be undertaken.

Meanwhile, a limit might be in order. One is tempted to point out that particle physicists are only a hair's-breadth from recognizing how much of the nature of the human mind is read into current models of the behavior of particles. Indeterminacy, complementarity, symmetry, are analogues of the mental processes of human beings. Are physicists projecting certain typical contents of the structure of the human mind upon "matter" and "energy"? As they stare deeper and deeper into the interior of the nucleus do they find mirrored there the human mind? In a word, are they becoming the modern alchemists? Enough of this. Such suggestions can easily become irresponsible. Besides, a chemist is not a physicist in practice but only in theory. And it was chemists we were talking about. Therefore, a reasoned estimate of the situation calls for one conversant with modern chemical practice.

BIOLOGY AND LIFE

Strangely enough, the explosion of molecular biology and the rapid introduction of cybernetics into genetics have actually sharpened the question of what biology has to do with life. This results from the fact that as biologists get a firmer hold on their materials, the question of what to do with the new techniques opens upon the broad stage of general human purposes. The imminence of genetic control puts this type of problem on the order of the day. Current reaction among biologists seems to be taking the form of a deep discontent with the traditional structure of agreed-upon objectives of the science. Perceptive leaders of opinion raise the question of whether biologists in fact, are dealing with vital problems. This kind of discontent and the raising of value questions often heralds a radical shift in the philosophical outlook of a particular science.

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*"John Maynard Keynes, who studied Newton's writings on esoteric and theological matters, concluded that Newton was 'a Judaic monotheist of the school of Maimonides.'...Ultimately, the amount of time and energy that he devoted to alchemy probably rivaled that given to physics or to mathematics," Encyclopedia Britannica, Vol. 16, 1965, p. 419.

There is no evidence that existentialism has directly contributed to the biologist's present discontent. But biologists are raising existentialist questions, covered largely to be sure by the more pervasive and now generally recognized intrusion of value theory upon the biological scene. The old mechanist-vitalist controversy in biology gave way to a mechanist-teleology frame of discussion. The problem of value now separates the more philosophical members of the profession from their more matter-of-fact brethren. As has been noted, this division becomes more than merely theoretical with the issue of genetic control on the horizon. But beneath value theory lies existentialism whose challenge is issued not to the scientist to incorporate value theory in his discipline but to the very worth of what he is doing.

Modern science tends to look the other way when existentialism is mentioned. At best, it is dismissed as a philosophical or, worse still, an aesthetic issue. But precisely for this reason, existentialism must be a vital problem for the Game of Science. The challenge could hardly be more nearly total. Most elements of modern culture, that is to say, philosophy, religion, psychoanalysis, politics, and even law, effect an uneasy truce with existentialism. In the arts, it is in more or less complete philosophical control. But science is the great holdout. For existentialism is, or purports to be, militantly subjectivist, individualistic, anti-materialistic, anti-rational, and, in brief, anti-scientific. It ranges itself against the whole system of values that modern science has cultivated since its origin in the Renaissance. It is of immense and immediate consequence to all interested in an aesthetic foundation for modern science.

I am not sure that biology is an apt field in which to confront this contemporary challenge. That question will have to be decided by specialists. But I feel that it is about time to start the inquiry about what place "life," the stuff of the existentialist, has in biology, the science of life. We could begin with the following question: Is there any scientific meaning to the term "the biology of the individual?"

Appendix

THE GAME OF SCIENCE: BRIEF DESCRIPTION

I. The object of the Game is play. It bears the same relation to the professional activity of the scientist, namely, organized thought, that physical exercise bears to everyone.

II. The course of scientific play leads to the full exercise of intuition within a prescribed framework of rules, the rules of scientific method.

III. The rules of scientific method for purpose of game play are not the same as those for scientific work. The rules of sport are not those of warfare.

IV. Two practical outcomes of the Game of Science are the training of the youth and the constant conditioning of the experienced.

V. The ordering conception of the game is the idea of System. Each game must conform to this notion, however simple it may be at the outset or however sophisticated it may become.

VI. The system of the game must conform to the requirements of an Equilibrium System. An equilibrium system exists primarily for itself. All outputs or pay-offs are ephemeral.

VII. The spirit of the game is serious; its intent is worthy of prolonged intellectual effort and the expenditure of considerable time and material, for the subject matter of the game is nothing other than scientific method itself.

VIII. A most strenuous effort should be made to develop the aesthetics of the game to a high order. For Americans, this cannot mean the imposition of an artificial ritual or of constrained formalities. But it does begin in a serious personal respect for the other players and for the game itself. Delicacy of feelings and the nuances of individual sensibility should be particularly respected. This constitutes a corrective to the impersonal crushing of individual differences which often seems to accompany science at work.

THE STRUCTURE OF THE GAME

The most elementary game starts with the conception of sides; it may be two persons in direct opposition to each other. As the game progresses and more players become engaged, coalitions form: The game becomes many-sided. Increased complexity brings the perception that the opponent is Nature, that is, the impersonal subject-matter of the human learning process. Finally, it is perceived that there is no opponent, human or natural. All of the elements of the game are contained within the intent of the players themselves. The players not only set the rules that direct the play and supply the subject matter of a particular game, they also define the meaning of "victory." The game is seen to be an example of an equilibrium system. It is "auto-telic."

THE RULES

The Paramount Rule

All subsidiary rules may be changed or set aside by agreement among the players.

Subsidiary General Rules

1. All disagreements about rules stop the game *pro tempore*; that is, the provenance of rules is outside the game itself. If this rule is set aside, the game becomes a rules or procedure game.

2. Upon request, rules pertaining to an anticipated game must be stated explicitly. If necessary, the game is stopped for this purpose. Where required, the set of rules of a specific game may be formulated as a game itself.

3. Upon request, a *model* of the game may be built. Considerations relevant to Rule 2 apply.

4. Before play begins, a decision on whether the objective of the game is to be specified or is to remain open must be made. If the objective is to be specified, the game is stopped for this purpose.

5. Where conflicts arise that are to be resolved by appeals *ad auctoritatem*, the game is stopped and the authority is specified. Examples: What logic; what mathematics, physics, psychological or sociological, mythological or religious body of authoritative opinions is to govern; and what specialists in these fields are to be taken as authority? If agreement is not readily reached, a sub-game may be formulated.

6. All *subsidiary* general rules prevail over the *specific* rules of a game unless expressly changed *pro tempore*.

7. All games formally initiated and played to some definitive conclusions must be reported to a Games Archivist. It is the duty of the Games Archivist to formulate rules covering such reports.

8. It is a matter for the conscience of the Games Archivist to determine whether a game submitted for inclusion in the Archives is a

game of science or not. In case of doubt, particularly where the game deviates markedly from the authoritative canons of scientific method, the Archivist is advised to accept the game.

9. When the course of the game or its outcome is seen to give rise to a practical application, the game is stopped and the practical application stated for report to the Archivist. The game may then continue if the emergence of the practical application has not adversely affects its game-like character. If this happens, the game ends.

GAME POSTULATES

I. Every move is a decision.

The rules applicable to any particular game may specify as much or as little Decision Theory as the players desire. However, even the most strictly deterministic games, such as proof of theorems in a logical calculus, must be framed as decision games.

II. Every decision implies that at least one alternative decision exists.

If no alternative exists, the game ends.

III. Each game must follow the demands of an Equilibrium System.

(See, "On the Very General Character of Equilibrium Systems," General Systems, University of Michigan, December 1963.)

IV. All data used in games are assumed to be true.

The basis of such assumptions may be challenged and must be set forth upon demand. If the integrity of the game does not rest upon an actual knowledge of fact, facts may nevertheless be assumed or hypothecated.

V. Players accept a moral responsibility to report the formulation and (where interesting) the results of every formal game to a Games Archivist.

This moral obligation yields to aesthetic considerations, as where the game is seen to eventuate in a breach of good taste.

VI. The primary consideration permeating all games is aesthetic.

This yields to no other consideration, even though the aesthetics of the game may cause much perplexity or even anguish. Moral considerations are secondary. Therefore, if the motives of a player are challenged, the game ends immediately. It would be impossible in such a setting to do justice to the aesthetics of the game. Lastly, in this

order of importance, is the truth or science of the game. Since the subject matter of science is the universe, the mark of science is scientific method. If the game disregards the canons of scientific method it is simply not a game of science. No harm is done unless one claims that it is.

SIMPLE GAMES

1. Bavelas' random clouds (see Ackoff, "Toward a Science of Philosophy," Working Paper).

2. Fabian's game: Reconstruct a computer program from inputs and outputs alone.

3. Man simulates computer in varying degrees of complexity.

4. Alternative axiom sets for tic-tac-toe.

5. Find instances of order in a set of randomized numbers and eliminate each such ordering principle when found.

6. Write a computer program for a series of abstract paintings.

7. Devise a set of principles for the most inefficient queue under conditions of increasing generality.

8. Show how a given firm can be driven into bankruptcy by
   a. maximizing profits.
   b. minimizing costs.
   c. adopting a rational inventory policy.
   d. hiring experienced personnel.
   e. increasing sales.
   f. cutting production costs.
   g. reducing competition.
   h. the combination of all of these.

9. Any number of OR games.

10. Devise a series of correlations whose mathematical relation constantly rises and whose real relation constantly diminishes until the mathematical relation is perfect and the real relation is perfectly random.

11. Simulate a simple real process; now, simulate the simulation, continue until exhausted. What philosophical, scientific principles emerge?

12. Under what circumstances is a digital computer an analogue computer and vice versa? Suggestion: Try to construct a digital computer that has no "analogue" features, and vice versa.

13. Describe a truly finite sample of a truly finite population.

14. Characterize completely a truly unique situation or object.

15. Construct a small real sound language whose coefficient of communication is virtually zero by actual test. Now break the code.

16. A perfectly randomized process is a perfectly ordered one. Try to show that the "converse," the contradictory, and any number of contraries of this proposition are also true.

COMPLEX GAMES

1. Design an Earth-based support system for a team of scientists on Mars making critical astronomical and/or biological and/or geological observations.

2. Design a utopia to replace the City of Los Angeles.

3. Design a computer with an Unconscious Mind.

4. Develop a Logic of the Unique.

5. Try the inventor of an "annihilation bomb" before a World Court specially constituted for this purpose.

6. Design a fully automated Operations Research Laboratory.

7. Axiomatize scientific method.

8. Revise the Constitution of the United States as system specifications for the governance of the country.

9. Develop a Logic of Command.

10. Create the domain of empirical mathematics using integers as the stuff of nature that must be processed stochastically in accordance with the ordinary procedures of experimental science. The generation of prime numbers is a stochastic process governed by probability methods. Such methods could be perfected by using advanced probability techniques. The classical number problems which rest primarily on the stochastic nature of the prime numbers should be restated as problems in probability theory.

    Example: Are the Mersenne primes governed by the basic probability function that characterizes the occurrence of primes? The perfect numbers? Is Goldbach's conjecture governed by similar considerations? Fermat's last theorem? etc.

    At another level, number theory could be taught in a neater and more elementary fashion as an exercise in probability theory.