

From Myth to Math: Chaos and Consciousness.

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with
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Introduction

My work in math since 1970 has focused on the application of the dynamical systems theories of chaos and vibration to problems of the social sciences, the history of world problems, and the enigma of consciousness. In this chapter I trace my 60-year evolution along this discontinuous background of change in the ambient culture.

My career path to mathematics

I didn't get interested in dynamics and decide that's what I was going to study. It happened like this.

I was an engineer and worked in a physics project. One day a physics professor said in class that if you want to understand physics you have to study mathematics. So I changed to mathematics and found a mentor, somebody who took care of me and helped me out, a wonderful man, Professor Nathaniel Coburn. I responded to his program which had to do with general relativity. My father respected Einstein very much; a household word when I was growing up. It was said that only eight people in the world could understand Einstein. My teacher apparently could and was writing in that field.

I had taken very few math courses during that period. I remember two or three very influential courses. One was differential geometry taught by Raoul Bott who became a famous mathematician. I later found some concepts included in that course useful in dynamics. So I had some math

background, but not the kind of background I would have had if I'd done a Ph.D. under a famous mathematician.

Then I was looking for a job. I had one offer for some place where I didn't want to go and at the last minute, before the school year began, I got a letter from Berkeley offering me a job. In 1960 there wasn't any big mathematical center there, but of course I took it. I was engaged in rewriting my thesis for publication. One day I discovered that they were

having tea in a little room in the back of the building, and I had already been at UC Berkeley for two or three months and hadn't met anyone. So I went to the tearoom to meet some people and to find out what was going on. And in this way I discovered a couple of people who later became my best friends in mathematics.

Everybody had just arrived. Overnight, Berkeley had become one of the most important mathematical centers in the world and I just happened to be there, apparently because of a clerical error. One of the people I met that day at tea was Steve Smale. I was done rewriting and was looking for something new to do. So I said, "What do you do?" and he said, "Well, stop by the office and I'll show you." The next day I stopped by his office and we started working together. Later I found out that he was a really famous mathematician. He won the Fields Medal which is the mathematical equivalent of the Nobel Prize for doing the very work that he was showing me.

So I found myself on the research frontier in mathematics, working with some really wonderful people who all thought I was fine, because in this group there was no

insecurity. It was just, “This is what we do and if you fit in, fine.” So we worked together and had great fun. We had fantastic parties where we played music and danced and got drunk and we did a lot of creative work in what became a new branch of mathematics called *global analysis*. And all this happened in just one or two years.

The trouble with mathematics education

There are serious problems with the present state of American mathematical education. The whole thing is in a really dangerous plight. I’ve been saying this for years and so

have other people, but only recently the problem has risen to a scale of national prominence where even the president and the governor and everybody's saying our kids are no good at mathematics.

So we have a serious situation. First of all, mathematics is sort of akin to walking as a human experience . It's just really easy. It shouldn't be easy; how can you tell somebody how to walk? Yet people do find it easy and naturally learn how to do it. They just watch, and by imitation they can do it. It's the same with mathematics!

It's part of our heritage, all of us, to be genius at mathematics. It is a completely human activity. It involves the resonance between prototypical objects in the morphogenetic field and specific examples of similar forms in the field of nature, as they're experienced by human beings through the doors of perception. And as life forms a resonant channel between these two fields, it's just as natural as understanding anything, including walking, playing

tennis, and so on. Mathematical knowledge is part of our human heritage.

Furthermore it's essential to evolution. Where there's no mathematical knowledge there can be no evolution, because evolution to a stable life-form requires a kind of mathematical, sacred guidance. Linguistically, this can be understood in many different images, the least controversial metaphors conjuring a harmonious resonance between metonymic components, parts, and sub-systems involved in purposeful life, products and processes.

Where there is an inharmonious resonance, or dissonance, there would be some kind of illness whether the organism is a snail, a human, a society, or the all and everything that we know by the name history. So the harmonious resonance maintained during the process of our own growth, or social evolution, requires mathematical understanding. You may see the dissonance of the lack of mathematical understanding

through the gross national product, or the number of wars, or the spread of AIDS, for example.

Another importance of chaos theory is in correcting a problem in mathematical education that has consisted, in part, of denial. People have been taught the non-existence of some of the essential mathematical forms, namely, chaotic forms. This kind of denial produces an educated adult somewhat less capable than an uneducated adult. So that education which functions in this way is not the same as no education. It's worse, because it destroys intelligence, it destroys functionality, it destroys harmony with the resonance of the all and everything which is necessary for health.

Our educational system, in short, is producing sickness and contributing to the global ecological problems on the planet by destroying the native intelligence that children have, the capability they have to understand the world around them in its complexity, in its chaos, in its resonance and harmony and love, destroying it through the inculcation of false

concepts and through the production of avoidance mechanisms connected with certain mathematical ideas.

It's a very serious problem. One possible response would be to revise mathematical education so that, within the same system, to provide more highly-trained teachers. That could only make matters worse, since mathematics teachers are already highly mis-trained. Many have already been taught to hate mathematics, so they can only teach hatred for mathematics. They don't really have any idea what mathematics is. For them, it's a knee-jerk response of this dark emotion, so more retraining wouldn't help.

Rather than revision of the schools — which are full of false ideas and bad habits built into the field on a deep level — the most efficacious, practical solution would be the construction of a new educational system outside the usual channels of

the school system. This is not too radical, as we have all been brought up to think of our real education as going on outside the school system. Parents wanting their children to really know music, provide a separate teacher outside the school. Similarly with religious and dance instruction - anything that you really want to learn is studied outside of the school. And so it may be with mathematics.

One practical solution to this challenge would be a new breed of learning machines based on computers, educational software, and digital video. Even programs like Hypercard on the Macintosh, for example, could provide alternative education that could be approached by individuals without teachers. So far, however, the creation of educational software has proved to be a very unrewarding activity for authors. And in spite of all different kinds of alternative funding agencies, nobody has seen this as a very important problem, although the National Science Foundation, the American Mathematical Society and similar organizations have convened conferences to discuss possible solutions of the crisis in mathematical education.

Visual Math, refers to the coordination of multiple modes of intelligence and representation, cognitive styles, for the purpose of communication of mathematics; for example, the dynamic technique coordinates visual, verbal, and symbolic modes. From 1975 to 1982, research grants enabled Visual Math Institute (VMI) research and education, including computation math, computer graphics, and interactive environments.

The most promising alternative solution at this time has not been funded. And so there are very few existing alternatives for children now. Maybe after another generation or two there will be.

3. *Chaos theory*

The repression of chaos began with the patriarchal takeover six thousand years ago. To look at an example of a high culture accepting chaos as part of their mythological pantheon and in their arts and behavior, one has to go back before that takeover. The most common example of such a culture is

Minoan Crete. This culture was excavated by Sir Arthur Evans whose controversial reconstruction of the temples and religion have since been seriously questioned by archaeologists.

Extensive mythology is traced back to Crete; one thing that's known from paintings is the dance with bulls, Bacchic mysteries derived from the Orphic, Dionysian and so on. Following this backwards, like tracing roots or Ariadne's thread, you come to a certain mythic kernel which would be associated with Minoan Crete. I wouldn't say these are expressions of chaos; they might be, despite so many differences between Western and Cretan culture. We know something about Dionysian ritual: importance of music in ritual, dichotomy of religious ritual into two types, outdoors on the open plain and indoors in a cave. Mystic revelation that came with Gaia sees the planet as an organism, and the plain as its surface. Gaia is very chaotic, so if you reject chaos, you reject Gaia. The Orphic trinity of Chaos, Gaia, and Eros go together.

Gaia as the Earth, love of the planet, integrity of life-forms; Chaos as essence of life: more chaos as healthier; Eros as human behavior in resonance with Chaos and Gaia. It's rumored that the Minoans had a very high degree of bisexual activity, licentious behavior and wild parties, possibly characteristic of the genders in a partnership society as described by Riane Eisler.

Later Western Culture tended to view chaos as an undesirable quality in nature. I think that this has to do primarily with the patriarchal takeover. The repression of Chaos, Gaia and Eros is characteristic of the patriarchal paradigm, which turned out to

be the dominant one in our recent history. And it could be that sexual repression is somehow its key.

Human society is an evolving system — including psyche, mythology, and cultural metaphoric structures. This evolution is punctuated by bifurcations, mutations caused by the planetary equivalent of lightning: comets. Comets were probably very important in the history of consciousness; they still are. There are some mutations where changes are made in the memes, the cultural genetic structure. Then there's a kind of natural selection which goes on when two societies are in conflict over a common goal, due to seasonal inundations and so on, and in this conflict one would be selected not just by military strength, but perhaps through the stability of its social structure.

And in the long run, in evolutionary history, there are dead ends. A lot of species become extinct without the necessity of a comet or of global catastrophe, but just because they're the wrong ideology to begin with. It seems likely that the human species represents inappropriate 'wrong' values to begin with and may not succeed in having a stable long-

lived civilization on this planet. We know that Egyptian society lasted for three thousand years and that's a fine record for a society. Since the Renaissance we're not up to one thousand years now, and we'll see how long this goes on. I'm not placing any bets. It may turn out that there are some structural flaws that are endangering the future of human habitation on this planet. The planet is in symbiosis with the human infection. This could be a very good symbiosis; it could mediate some sort of divine plan on a cosmic scale with the actual material of planet Earth, and that includes the consciousness of the human species. There is a certain promise there, I don't deny it.

However, archaeologists coming from another star system in the

future may say that a structural flaw in our society resulted in the advantage of patriarchy over the partnership model. It could be that the basis for the stability of our violent society is the nuclear family, so that the repression of Eros, Gaia and Chaos — the Bacchic, Orphic, Dionysian — by the patriarchy was chosen by people who had grown up in a nuclear family. And when two civilizations came into contact, the one that had the nuclear family won. This is just one possibility among many, in answer to the question: why was chaos rejected?

Chaos societies had moon festivals such as we had in the Sixties. This is no coincidence, because the Sixties, the Italian Renaissance, the Renaissance of the troubadours in the twelfth century, early Christianity, the Pythagorean Academy in Croton — all these have the common aspect of temporary resurgence of Orphic ideals, followed by massive and violent repression by the conservative society. All these have been foci in history for burning people at the stake. Of all the forms of terrorism, burning people at the stake seemed to be the most appropriate for

the patriarchal society, in repressing revivals of the preceding form involving the goddess. In the Sixties, which was one of these Orphic revivals, we got to experience what life was like in Minoan Crete, in the Garden of Eden. We had moon festivals, and people abandoned themselves to their feelings, to Chaos, to Gaia, to Eros. Many of these groups, which experienced the Garden of Eden, eventually broke up. The Sixties came to an end. A number of break-ups were caused by patriarchal, sexual jealousy.

This is exactly the reason why I said that chaos theory isn't very important, except as a kind of double negative while on the other hand, dynamical systems theory does offer something very important. We need to understand whole systems, and whole systems cannot be understood

by reduction. The terrific gains in understanding made by the reductionist scientist will, I'm sure, be used in the future to understand whole systems by means of some process of synthesis. The reduced understanding of the biochemistry of the adrenal cortex, for example will be synthesized into models of whole systems, such as the stress response and the immune system. The technology for modeling whole systems is on the frontier of science at the moment; it is the crucial frontier for the solution of our global, planetary problems.

Dynamical systems theory, specifically the branch called complex dynamics, offers a strategy for the re-synthesis of fractionalized scientific knowledge, and an understanding of complex whole systems. Complex systems theory has replaced chaos theory on the fashion pages of the science newspapers of our day. And I think the fascination of intellectuals with complex systems theory is not going to be a short-lived flash-in-the pan. This is somehow the real thing. Our challenge now is the reintegration of the sciences after their dissolution in the Renaissance into an understanding of whole systems,

particularly planetary systems, that is to say the hydrosphere, the hydrosphere, the atmosphere, the biosphere and the noosphere.

Within the lower spheres, a new direction called global modeling is already under way. Global modeling tries to put together reductionist models people have made for the oceans, for atmospheric phenomena, and for solar radiation. Individual models made by reductionist scientists of these different areas — the oceanographers, the atmospheric chemists, the solar physicists — are being synthesized into one global model. This global synthesis requires two things. First of all it needs models for the separate components or organs of the planetary system to be made in a common strategy so that they can relate to each other. Secondly, it requires a wiring diagram to put them together. In the field of global modeling

a tremendous synthesis is now taking place, including conferences on the wiring diagram, which will provide a global model of the geosphere.

For the sociosphere, we must start from scratch. We don't yet have many specialists producing mathematical models for society, although there are a few outstanding pioneer first steps. There are for example the archaeologists and anthropologists worrying about the demise of the Mayan civilization in Central America in the Fifteenth and Sixteenth Centuries, because it was so complex and there are so many hypotheses, and it was such a controversial question, they tried to resolve it by building mathematical models. There are now a number of competing complex dynamical models for the Mayan society, taking into account the food chain, the weather, the population, and the distance between ceremonial centers.

All these factors are built into different competing models. Then they run them and try to see which one

wins the best relationship to the archaeological data. And thus a model system can be created, because Mayan civilization was relatively small. This pioneering first step might lead to similar models for larger societies; for ancient Greece, for example, or for the downfall of Rome, where many more factors and more people were involved. Navigation, naval trade, the effect of inventions like better clocks for navigating: all these things might be included in the model.

So in the future then, as global planet models become more successful, global social modeling will begin. Then individual components have to be modeled, such as the political and economic systems of individual nations, their interactions, and so on. They have to be made in a common strategy, so they can be connected together. And then one has to extrapolate from the Mayan models and gain wiring diagrams for these different component parts, including psychological

and medical factors. In the reductionist physical sciences, we will only have to connect existing components together, following a diagram, to get global models. For the social sciences we'll have to start from scratch. We're going to have to make models for the organs, do experiments in simulation with various wiring diagrams, compare with data, improve the component models, the global models, the data, and so on. After many circuits of this hermeneutical circle we might create a global social model. Then the global planet model and the global social model have to be connected together.

There's also the mythological and the spiritual dimension and the understanding of the world of the unconscious. To achieve a transformation, Dynamical Epoch, Golden Age or Conscious Era, we must learn to see the good side of chaos, to understand the shadow side of order, and to recognize how we participate in the repression of Chaos and creativity by Cosmos (order) in our daily lives. In other words, the whole thing has to take place once again in the noosphere, and then that has to be connected up. Eventually, we hope to get some kind of model for

understanding what — if any — are the effects of choices we could make — if there are any — upon our long-range future. This may never happen, but if it did, mathematics would be of use to Gaia in creating the future, through the direct, conscious interaction with the evolutionary process. This seems to be our challenge.

Psychedelics and math

My experiences with psychedelics had a tremendous influence on my mathematical perspective and research. There was a period of five years or so which included psychedelics, traveling in Europe and India, and so on. These were all part of the walkabout between my first mathematical period and all that has followed. This was my hippie period, the spectacular wave of Gylanic Revival of the Sixties. I think my emphasis on vibrations and resonance is one thing that changed after my walkabout. Another thing that changed, which had more to do with psychedelics than with

India, was that I became more concerned with the application of mathematics to the important problems of the human world. I felt, and continue to feel, that this planet is really sick; there are serious problems that need to be faced, and if mathematics doesn't have anything to do with these problems then perhaps it isn't worth doing. One should do something else. So I thought vigorously after that period about something I had not even thought about before: the relationship of the research to the problems of the world. That became an obsession, I would say.

Consciousness

Since the early 1970s, I have been trying to formulate mathematical models of consciousness, and the mind/body problem. There are specific models for different perceptual functions of human physiology which represent the frontier of neurobiology. One example is Walter Freeman's model of the olfactory bulb. These models are mathematical objects known as cellular dynamical systems, which include neural-nets and excitable media as special cases. These mathematical models for perception

pertain to the question of how consciousness interacts with the natural world. And they comprise a conceptual frontier today.

In that context, what would an idea be? In the context of the olfactory bulb, what is a smell? So it turns out that from the perspective of reductionist science, along with its mathematical models, a smell is a certain space-time pattern on the olfactory cortex, a pattern of excitation. The cortex consists of a sheet of oscillators side by side vibrating. A certain pattern in their frequency, phase relationship, and amplitude, is a smell. There is a certain picture, where inside a region there is a larger oscillation, and outside, a smaller one. This picture is recognized as a smell.

This kind of modeling does provide the possibility of making a simple model for the natural world, a simple model for consciousness, and a simple model for the interaction between the two. The interaction model, in this cellular dynamics context, is based on resonance. A lot of my work has to do with vibration and resonance phenomena in this context and has provided a specific mechanism for the transfer of a space-time pattern from one such medium to another.

However, these mechanical models may be too simple to provide intuition as to such things as how your mythology, your perceptual filter, function so as to limit your perception of the natural world to a certain paradigm in your consciousness. Such models, would have to do with a more linguistic or symbolic approach rather than at the mechanical model level.

Chaos and the future

The fantasy of the importance of mathematics has to do with the idea that we might have a future, that we might have something to do with it, and that conscious

interaction with our evolutionary process is possible and desirable. And in this case, things will go better if we understand our process better.

The importance of chaos theory to our future is that it provides us with a better understanding of such processes, the behavior of complex systems such as the one we live in. This is due to the fact that chaotic behavior is characteristic of complex metaphors. The more complex the system, the more chaotic its behavior. And if we don't understand chaotic behavior, then we can't understand complex metaphoric systems we live by well enough to give it guidance, make informed decisions, and participate in the creation of our future.

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