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ALEXANDRIA

COSMOLOGY • PHILOSOPHY • MYTH • AND CULTURE



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EDITED BY DAVID FIDELER

Chaos and the Millennium

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1. Introduction

In this short lecture I want to discuss three things: The first is *Chaos*, secondly, the *Millennium*, and finally and most importantly, *Chaos and the Millennium*, and how they go together in an essential way.

2. The Mathematics of Chaos and Bifurcations

Chaos means the chaos of everyday life, but also, it means *chaos theory*, a new branch of mathematics also known as *dynamical systems theory*. The question naturally arises as to whether there is a connection between the mathematical model of chaos and the chaos of everyday life. For a long time I rejected this connection, but now I feel it is justified.

Mathematics has the branches which are standard in history books: arithmetic, geometry, dynamics, and so on. These branches are more or less old. Algebra and geometry are very old subjects, coming to us from ancient city-states like Sumer, Babylon, Indus, and Egypt. Dynamics is newer, only three or four hundred years old. A new branch of mathematics would be a tremendous novelty, and pose a challenge to the orthodoxy of mathematics at universities, because for a long time there has not been a new branch of mathematics. But now there are new branches. Chaos theory is a new branch of mathematics, one which has evolved into a mass movement and major social transformation called the *chaos revolution*.

Now I would like to introduce briefly the five most essential concepts from chaos theory: *states*, *trajectories*, *attractors*, *basins*, and *bifurcations*.

This talk was given for the National Collegiate Honors Council, San Francisco, October 31, 1996.

2.1. *States*

The most fundamental and important of the basic notions of chaos theory is the *state space*. This is at the basis of everything and goes back to geometry. It is an imaginary geometrical model for a system. Let's say you have a restaurant. The groceries come in the back door, and the satisfied customers go out the front door leaving money behind. Now you count up the supplies and the money left behind; these counts represent the state of the restaurant (as an economic system) at a given instant. But they may also be regarded as the coordinates of a point in a geometric space, a model for the system. This geometrical model is the state space of this example.

2.2. *Trajectories*

Now here enter the *dynamics* of the dynamical system: the system changes. Every minute it has a slightly different state. So its representative in the model is a point wandering around in the state space. It is a moving point which draws a curve called a *trajectory*. And this is where mathematicians put a simple restriction. It is imagined that at every point (state) in this state space there is a single *vector*, which gives the direction and speed of any trajectory which will ever pass through that state.

2.3. *Attractors*

Suppose we have such a model and we are interested in the long-term behavior of the system. This means that we only want to know, twenty years from now, for example, if there will be a fortune to pass down to the next generation or not. In other words: what is the long-term expectation of a trajectory in the model? We have to start from one point and follow the instructions, drawing the trajectory of the system for a long time. And when we do that, we come to what is called an *attractor*. There are three kinds of attractors:

- A point attractor, otherwise known as a static attractor, a good model for death,
- A periodic attractor, or oscillation, a model for simple life, and
- A chaotic attractor, a model for more complex life.

The third sort, amazingly, was discovered only recently and unexpectedly, thanks to computer graphics.

Attractors are models for the long-term behavior of an idealized mathematical model for practically any kind of a dynamical system subject to this very rigid restriction that the rules of evolution don't change in time, a so-called *autonomous dynamical system*.

2.4. Basins

It is important to know that a typical dynamical system has more than one attractor. Suppose, for example, that there were two. Then some trajectories would evolve toward one, while other trajectories would wind toward the other attractor. And if one attractor models death and the other life, it may be very important to know which final state is in your future! The *basin* of an attractor is the piece of the state space filled by trajectories tending to that attractor. If there are two attractors, then the state space falls naturally into two pieces: the basin of death and the basin of life. Each attractor has a basin, and each basin contains a single attractor.

2.5. Bifurcations

Now suppose the rules *do* change in time. Then the attractors and their basins might change. One kind of attractor can change into another kind. An attractor (along with its entire basin) might disappear into the blue, or a new one appear out of the blue. A basin might suddenly explode or implode, radically changing in size. These significant changes in the picture of the state space determined by the attractors and basins are called *bifurcations*. There are three kinds of bifurcations:

- Subtle bifurcations, in which an attractor changes type,
- Catastrophic bifurcations, attractors appear out of (or disappear into) the blue, and
- Explosive bifurcations, in which attractors drastically change size.

It is this aspect of chaos theory which has been of the utmost importance in the applications to the sciences, and to history.

3. The Mathematics of History

So now let us look at history from the perspective of chaos theory.

3.1. *Interesting Times*

In the preface of *The Age of Bifurcation*, subtitled "Interesting Times," futurist and systems philosopher Ervin Laszlo writes:

There is an old Chinese curse that says "May you live in interesting times." I don't believe anyone would dispute that we do indeed live in interesting times. Most interesting. But whether these times are accursed or blessed is probably less clear to many people. My own orientation is that neither is the case. We are under no dark cloud. Nor do the heavens smile upon us. What the world will be like for us and our progeny is very much up to us. This belief constitutes the basic underlying premise upon which our work is predicated. This century has seen the advent of an era in which the range of possibilities for life, for the quality of life, and perhaps even for the persistence of life on our planet, is very much if not entirely to be determined by what we, the human inhabitants of the planet, do. And what we do, we assert, will be a direct consequence of what we believe and know—of how we approach problems and situations.

Some people are pessimistic and others optimistic, but Laszlo says that he is neither. According to studies made by the World Future Society, and published in its monthly magazine, *The Future*, the predictions of futurists are right about two times out of three. So we must take Laszlo seriously. The World Future Society also surveys to see what other people think about the future. They surveyed thousands of people, and found that two-thirds were more optimistic than pessimistic.

Sociologist Paul Ray has studied three subcultures in the United States. These he calls:

- The *Heartlanders* (*Traditional Stream*, dating from about 1870)
- The *Modernists* (*Modern Stream*, from 1920), and
- The *Cultural Creatives* (*Transmodern Stream*, 1970)

He defines these groups according to three different world views. Heartlanders favor a return to the past. Modernists champion the secular, economic, and scientific paradigm of the twentieth century. Cultural Creatives are bearers of a new world view, currently evolving in reaction to the shadow side of the Modern Stream. In a social research survey in 1994, Ray sampled about two thousand people in the United States. He found the proportions of these three subcultures to be:

- Traditional, 29%, equivalent to 56 million adults of today's United States population
- Modern, 47%, or 88 million adults, and
- Transmodern, 24%, or 44 million adults

He concludes that we are now at a Great Divide between the Modern Stream and its Transmodern sequel, the latter yet to be determined.

In this talk we are going to take sides with Ervin Laszlo, the World Future Society, Paul Ray, and the 44 million Transmoderns. And we are going to bring the Chaos Revolution into the picture.

3.2. *Bifurcations in History*

At one time people thought that history was continuous and gradually changing, that nothing ever happened suddenly. This was the opinion of Leibniz, who contributed ideas of evolution and linear progression to history. Leibniz is the coinventor with Newton of the calculus, and was also a futurist and historian. Applying the new mathematical ideas of his time to history, he came up with his *principle of continuity*. He was a *gradualist*.

The idea of *bifurcation* (or *catastrophe*) is a different idea—an idea of discontinuity, of punctuated or saltatory change, sudden or miraculous transformation.

Laszlo concludes his preface:

The issues are burning, the stakes enormous, the options impressive.

These truly are interesting times. This stands to reason. We stand in humankind's greatest age of bifurcation.

For him, bifurcation is an important new word and mathematical concept. He uses it in place of the equivalent general terms, *major social transformation*, or *Great Divide*. He sees history as consisting of flat spots punctuated by major social transformations or bifurcations. This is like the evolution of species in the Darwinian sense where long flat spots are followed by the sudden emergence of new species, which may be triggered by collisions with comets. Laszlo is a *bifurcationist*. Even more: he says that this current transformation, our own bifurcation, is the biggest one in human history. Quite an idea!

3.3. *Histomaps*

Historiography is the study of structure in history. And now that mathematics has been redefined as the study of space-time patterns, we could say that historiography is the mathematics of history.

Jacob Burckhardt of Switzerland was an early bifurcationist. He analyzed the Italian Renaissance as a catastrophic bifurcation, and made his reputation with this theory. It was the first of the saltatory or discontinuous theories of history, coming shortly after Leibniz and his principle of historical continuity.

A controversy developed over this interpretation: was the Renaissance a sudden, catastrophic bifurcation, or just a gradual change? The conservatives in this controversy believed in the continuity of history. They noted that, a century earlier, Petrarch, Boccaccio, and others had introduced new ideas in literature which were more or less characteristic of what was later called Renaissance Humanist thought. They said that history was continuous, while Burckhardt and his followers said that it was discontinuous. This controversy, still ongoing today, led to a whole school of the philosophy of history, which came to be known as historiography.

My idea of historiography consists of the space-time pattern of world cultural history, the history movie, superimposed over the

space-time pattern of our biosphere, the biogeographical movie. But the simplest representation of this combined space-time pattern is a *histomap*. In a histomap, geography, which really lives on the two-dimensional sphere of the earth, is reduced to one dimension for convenience, so that geographical space plus time comprise a two-dimensional display in which to locate space-time events.

A histomap by Edward Hull, from around 1900, may be the best histomap ever made. In it, the map of the world is a one-dimensional, vertical interval about eighteen inches high. The time span is a horizontal line several feet long. It starts in 2,500 B.C.E. and ends more or less now, with approximately two inches corresponding to a century. A later histomap, published by John Sparks in 1931, was the first to actually use the word *histomap*.¹

A small piece of Hull's histomap is shown in figure 1. The colored streams denote cultures. They suddenly get wider when there are more people or more territory. There are thin ones and thick ones and they change in their relative sizes as we go down the river of time. Between and around them are icons from archaeological and historical records.

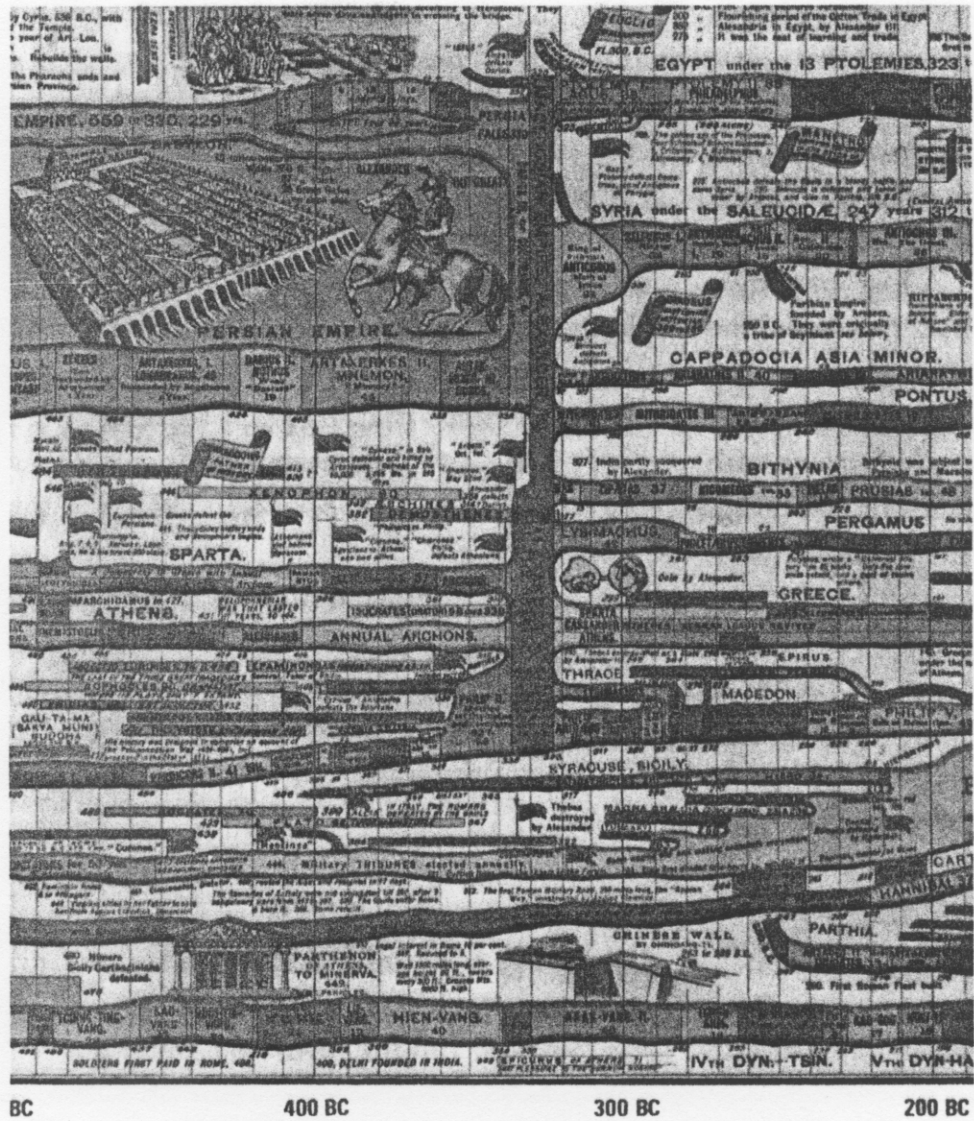


Figure 1. A Section of Hull's Histomap.

3.4. *Bifurcations in a Histomap*

A bifurcation is a special feature of chaos theory. Applied to historiography, the study of the space-time patterns in history, a bifurcation would be a significant historical event. When you look at a histomap, a bifurcation should just jump out at you.

For example, let's look at Hull's histomap, in figure 1. The vertical bar in the center is an exemplary bifurcation, the conquest of Alexander the Great. In a decade he conquered most of the known world. All of the separate strands of different cultures were united by him personally, so all the horizontal rivers of culture join that vertical bar. Upon Alexander's death his empire disintegrated, so the vertical bar breaks up into more rivers. This was a double bifurcation.

4. Millennia as the Epochs of History between Bifurcations

If world cultural history is punctuated by quantum leaps, then there must be periods of gradual change in between the major bifurcations. These we call *epochs*. The division of the whole of history and prehistory into epochs is a subjective process, and many such divisions, or *schemes*, have been proposed. We will now review several of them.

4.1. *An Archeoastronomical Scheme*

Ancient skywatchers followed the histomap of the zodiac. The major bifurcations were marked by the passage of the vernal equinox from one zodiacal constellation to another. These events occur roughly every 2,200 years, and were very important in early cultures.² Within the recent millennia of the Holocene Interglacial, here are the dates:

- 10,500 B.C.E., Leo; 7,900 B.C.E., Cancer; 6,500 B.C.E., Gemini
- 4,500 B.C.E., Taurus; 1,900 B.C.E., Aries; 100 B.C.E., Pisces
- 2,500 C.E., Aquarius

4.2. *My Scheme of Three Epochs*

In my book *Chaos, Gaia, Eros*, a scheme of three epochs is proposed, with major bifurcations:

- 10,000 B.C.E., the agricultural revolution
- 4,000 B.C.E., the discovery of the wheel
- 1972 C.E., the chaos revolution

4.3. *William Irwin Thompson's Scheme of Four Epochs*

William Irwin Thompson is one of the leading cultural historians of our time. His approach to world cultural history, which is both cultural and mathematical, has a division into four periods which he calls *cultural ecologies*. Associated with each is a characteristic mathematical style, or *mentality*. These, with beginning dates, are:

- 4,000 B.C.E., the riverine cultural ecology, with the arithmetic mentality
- 500 B.C.E., transcontinental, geometric
- 700 C.E., oceanic, dynamic
- 1972 C.E., biospheric, chaotic

A comparison of these three schemes is shown in figure 2.

4.4. *What is a Millennium?*

Originally, the millennium meant a particular period of one thousand years, which was to follow a great bifurcation, according to an apocalyptic doctrine of the ancient Hebrews.³ When the coming of Christ was thought to signal that event around the year 1 B.C.E., the end of the millennium (that is, the apocalypse) was to fall around the year 1000 C.E. It did not, but the concept persisted in groups known as revolutionary millenarians.

The millenarians believe that the end of this world, and of historical time, is at hand. A new world, and a new time, will be inaugurated, usually

	Vernal Equinox	Abraham <i>Chaos, Gaia, Eros</i>	Thompson
12,000 B.C.E.			
10,000 B.C.E.	Leo		
8,000 B.C.E.	Cancer		
6,000 B.C.E.	Gemini	Static	Arithmetic
4,000 B.C.E.	Taurus		
2,000 B.C.E.	Aries	Periodic	
- X -	Pisces		Geometric
2,000 C.E.			Dynamic
	Aquarius	Chaotic	Chaotic

Figure 2.
Comparison of Schemes for the Holocene Interglacial.

through the agency of a messiah: a saviour or deliverer. There will be many tribulations and mighty conflicts. The forces of evil will gather themselves up in a last bid for victory. But the good will triumph. The new era—the millennium—will be a time of peace, plenty and righteousness.⁴

For the purposes of this talk, I am pirating the word *millennium*, and appropriating it as a synonym for *epoch*. It has no longer any implication of a period of one thousand years.

Thus, we now have a catastrophic bifurcation from the Periodic millennium to the Chaotic millennium, according to me; from the Oceanic millennium to the Biospheric millennium according to Thompson; or from the Modern to the Transmodern, according to Ray. Whatever you call the epochs, all agree that we are now in a bifurcation—one which is the largest so far, according to Laszlo. As William Irwin Thompson writes,

In our global development, we have moved from the ancient arithmetic mentality to the classical geometrical mentality to the modernist dynamical mentality and now finally to the new chaos dynamical mentality, a mentality that is based on the new sciences of complexity, on the new art forms that cross one genre with another, and on the new multidisciplinary sciences such as Lovelock's geophysiology that give us a biospheric vision of our new planetary cultural ecology.⁵

But in addition to characterizing the dominant mathematical style of the coming millennium, *the chaos mentality is able to model the great transformation itself*. This is my main message here: Chaos theory can help us to understand our unique experience in this special moment of history, at the dawn of a new millennium. *Chaos and the millennium!*

5. Education for the Chaos Millennium

Chaos and the millennium is a very important subject. It is very appropriate for this time, and it has crucial implications for education

in general and for honors programs in particular. The school system is where the future is actually created, and honors programs provide a special opportunity to teach new paradigms. So here is something for us to do: the reformation of education on all its levels, to address the future, and to create a society which has a sustainable future.

New programs are badly needed which integrate world cultural history, the new branches of mathematics, and the willful creation of the future. Chaos theory must be rescued from the fringes of academia and brought into the center of our schools and universities. Curricular reform in our schools, and integrative programs such as honors programs in our universities, provide opportunities for the renewal of our outworn educational system, and the creation of a viable future.

Notes

1. See John Sparks, *Histomap of World History*.
2. See Giorgio de Santillana and Hertha von Dechend, *Hamlet's Mill*.
3. See Cohn, *The Pursuit of the Millennium*.
4. Krishnan Kumar, *Utopianism*, 7.
5. William Irwin Thompson, *Coming into Being*, 241.

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Acknowledgements

I am grateful to my colleagues of the General Evolution Research Group and the Lindisfarne Association for the collegial sharing of ideas over the years, to Courtney Sale Ross for awakening me to the possibilities of elementary education, and to Russell Spring for bringing Paul Ray to my attention.