Schismogenesis

Dynamical systems theory is a branch of mathematics about a century old.[1] Catastrophe theory is a derivative of dynamical systems theory, since 1966. And chaos theory is a popular name for the applied and computational aspects of dynamical systems theory, since 1974.

The basic ideas of these theories — attractors, basins, and bifurcations — have been extensively applied in the sciences, history, and philosophy. The underlying mathematical idea of my writings on consciousness is the bifurcation concept. This idea is also known as saltatory leap, major transformation, schismogenesis, and other. Here I will lay out its origins.

The genesis of the bifurcation concept

A concise account of the history of saltatory historigraphy, including 38 pioneers, is given in 20 pages in my book, *Chaos, Gaia, Eros*, written in 1988.[2]

There is an ancient background, including the four yugas of Ancient India, and the four ages of Ancient Egypt and Classical Greece. Starting with 1000 CE, these are among the leading pioneers of this chronicle of major transformations in world cultural history:

1000, Albiruni
1197, Joachin de Fiora

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1 For a mathematical summary, see my *Foundations of Mechanics*, of 1967, Ch. 9.

2 This book, published in 1994, influenced the development of the revolutionary curriculum of the Ross School, in East Hampton, NY.

1377, Ibn Khaldun
1697, Gottfried Leibniz
1725, Giambattista Vico
1855, Herbert Spenser
1860, Jacob Burckhardt
1911, William Flinders Petrie
1917, Oswald Spengler

The expansion of this idea from historiography to larger spheres and the whole of epistemology was made by Ludwick Fleck. I will begin our chronology with him and tell five crucial stories:

1933, Ludwik Fleck (1896-1961)
1934, Arnold Toynbee (1989-1975)
1935, Gregory Bateson (1904-1980)
1962, Thomas Kuhn (1922–1996)
1966, Rene Thom (1923-2002)

1933, Ludwik Fleck (1896-1961)[3]

Life. Fleck, a Polish Jew, was born in Lvov, Poland. He received his M.D. there in 1922, and began a lifetime of medical research. Initially he studied typhus and virology in Lvov, then microbacteriology in Lvov and Vienna. He became an erudite humanist, and wrote his first philosophical paper in 1927. He developed his original theory of thought styles and thought collectives in 1933, which was published in German in 1935. In that year he was dismissed from his position as head of a bacteriogical laboratory in Lvov under the anti-Jewish measures of the time, and continued in Lvov in private

3 An excellent biography may be found in (Fleck, 1935/1979).

practice. He discovered important seriological methods, especially regarding the Wasserman antibody test for syphillis. Lvov was captured by the Germans in 1941, and Fleck was resettled to the Lvov ghetto, then deported to Auschwitz, and then to Buchenwald, which was liberated in 1945. Fleck then resettled in Lublin, Poland. In 1957, he emigrated to Isreal, where he died.

Ideas. Fleck's book on his original theory was written in 1933. The English translation of 1979 by Fred Bailey and Thaddeus J. Trent, was entitled, *Genesis and Development of a Scientific Fact.* This was a founding contribution to the sociology of science. The Prologue, written in 1934, begins with the question, *What is a fact?*

His answer is: A fact is a consensus, the result of a social process among a thought collective, that is, a community of minds with a common thought style. The collective is more-or-less defined by the shared thought style. He is interested in the interaction of distinct thought styles, and the develoment of a thought style A historical line of develoment may have discontinuties, which are sometimes accompanied by the genesis of a new fact.

His main example is the Wasserman test for syphilis:

> Once a structurally complete and closed system of opinions consisting of many details and relations has been formed, it offers enduring resistance to anything that contradicts it.
>
> A striking example of this tendency is given by our history of the concept of "carnal scourge" in its prolonged endurance against every new notion. What we are faced with here is not so much simple passivity or mistrust of new ideas

as an active approach which can be divided into several stages.

(1) A contradiction to the system appears unthinkable.

(2) What does not fit into the system remains unseen;

(3) alternatively, if it is noticed, either it is kept secret, or

(4) laborious efforts are made to explain an exception in terms that do not contradict the system.

(5)Despite the legitimate claims of contradictory views, one tends to see, describe, or even illustrate those circumstances which corroborate current views and thereby give them substance.[4]

And later he wrote:

All empirical discovery can therefore be construed as supplement, development, or transformation of the thought style.[5]

Fleck distinguished between gradual and sudden trransformations, anticipating the mathematical theories of bifurcation of the 1960s. Although described in the context of microbiology and medical science, he foresaw the application of his ideas throughout epistemology:

We see professional and semiprofessional thought communities in commerce, the military, sports, art, politics, fashion, science, and religion.[6]

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4 See (Fleck, 1935; p. 27).

5 See (Fleck, 1979; p. 92). Original is italicized.

6 See (Fleck, 1979; p. 107).

1934, Arnold Toynbee (1989-1975)

Life. Toynbee was born in London and educated at Oxford, where he taught ancient history from 1912 to 1915. After a stint in the British Foreigh Office, he taught modern Greek and Byzantine studies at University London until 1921. He resumed academic work at the London School of Economics in 1925.

Toynbee was among the most read scholars of his time. *A Study of History*, published 1934-1961 in 12 volumes by Oxford University Press, was his best-known work.

Ideas. A quick look into his thought is provided by the chapter titles of his main work:

Vol I: Introduction; The Geneses of Civilizations

Vol II: The Geneses of Civilizations

Vol III: The Growths of Civilizations

Vol IV: The Breakdowns of Civilizations

Vol V: The Disintegrations of Civilizations

Vol VI: The Disintegrations of Civilizations

Vol VII: Universal States; Universal Churches

Vol VIII: Heroic Ages; Contacts between Civilizations in Space

Vol IX: Contacts between Civilizations in Time; Law and Freedom in History; The Prospects of the Western Civilization

Vol X: The Inspirations of Historians; A Note on Chronology

Vol XI: Historical Atlas and Gazetteer (with Edward D. Myers)

Vol XII: Reconsiderations

> In summary, Toynbee ...
> ...examined the rise and fall of 26 civilisations in the course of human history, and he concluded that they rose by responding successfully to challenges under the leadership of creative minorities composed of elite leaders.[7]

Toynbee's suggestion for the trigger of historical transformations —minority leaders — became controversial, and his influence on later historians declined. Today, in light of the Me Too and Black Lives Matters movements of today, he seems to be spot on.

1935, Gregory Bateson (1904-1980)

Life. Bateson, born in Cambridgeshire, was the son of the geneticist, William Bateson. He earned a PhD in anthropology from Cambridge University in 1929, and did field work in New Guinea and Bali before World War II. He was a founding member of the Macy Conferences, 1941-60, from which the field of cybernetics evolved. He came to the United States in the 1950s, and taught at UC Santa Cruz from 1972 until retirement. I met him there in 1973.

Ideas. Following his field work with the Iatmul tribe in New Guinea, he wrote a field report of sorts as his first book, *Naven* of 1936. This Iatmul word refers to a tribal ritual which is the main topic of the report. In this book, an entire chapter of 26 pages is devoted to the introduction of his novel concept of schismogenesis, which derived from his analysis of the Naven ceremony. In a prior article, Culture Contact and Schismogenesis, originally published in the journal *Man* in 1935 (and reprinted in his book *Steps to an Ecology of*

7 From the *Encyclopedia Britannica*.

Mind of 1972) he introduced *schismogenesis* as a synonym for *progressive differentiation*.[8] In 1936, he wrote:

> I would define schismogenesis *as a process of differentiation in the norms of individual behavior resulting from cumulative interaction between individuals*.[9]

This is specifically anthropological. But following his participation in the Macy conferences and cybernetics, he broadened his scope. By 1958, in the second edition of *Naven*, he wrote:

> It seems to me, today, that there is a partial answer to these problems [of epistomology] in the processes of schismogenesis which are analyzed in this book [Naven], but this partial answer could hardly be extracted from that analysis when the book was written. These further steps had to wait upon other advances, such as the expansion of learning theory, the development of cybernetics, the application of Russell's Theory of Logical Types to communication theory, and Ashby's formal analysis of those orders of events which must lead to parametric change in preciously steady-state systems.
>
> A discussion of the relationship between schismogenesis and these more modern developments of theory is therefore a first step toward a new synthesis.[10]

We may see that by 1958, Bateson had advanced from

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8 See (Bateson, 1972; p. 68).

9 See (Bateson, 1936; p. 175).

10 See (Bateson, 1958; p. 52) or equally (Bateson, 1991; p. 284).

Toynbee's limited proposal for the development of a schism, of 1934, to a more detailed transactional process invoving two parties.

1962, Thomas Kuhn (1922–1996)

Life. Born in Cincinnati, Ohio, Kuhn obtained his PhD in physics from Harvard in 1949, and became a very influential philosopher of science. He joined the faculty of UC Berkeley in 1956, as I did in 1960, but we did not meet there. Then he moved to the faculty of Princeton University in 1964, as I did also, from Columbia University. We occasionally had lunch together in the student cafeteria.

Ideas. In 1957 he published his first book, *The Copernican Revolution*. Here he dissected in detail the major transformation in astronomical world-view occasioned by Copernicus, and evolved his notion of paradigm shift. This was followed in 1962 by his best known work, *The Structure of Scientific Revolutions*.

He developed a theory of paradigm shift, in which epochs of constant paradigm were punctuated by shifts caused by the accumulation of anomalies, in which observations conflict with the current paradigm. These anomolous results accumulate into a crisis, and if a rival paradigm comes into view, the shift is triggered.

This idea is similar to that of Ludwick Fleck. In fact, Kuhn read Fleck's book in 1949 or 1950, while still at Harvard. And in his Foreword to the second edition of Fleck's book, Kuhn wrote:

> I have more than once been asked what I took from Fleck and can only respond that I am almost totally uncertain. Surely I was reasssured by the

> existence of his book, a nontrivial contribution because in 1950 and for some years thereafter I knew of no one else who saw in the history of science what I myself was finding there.[11]

So Kuhn was to some extent inspired by his reading of Fleck, but he goes further in analyzing the shift process.

1966, Rene Thom (1923-2002)

Life. Thom was born in Montbéliard, in the Northeast of France, near the Swiss Border. He received the PhD in 1951 from the University of Paris. When we met at UC Berkeley in 1960, he was a professor at the University of Strasbourg. In 1964 he joined the Institut des hautes études scientifiques (IHES) outside Paris as a founding professor.

Ideas. Following the development of cobordism theory (a new branch of differential topology) begun in his PhD thesis, for which he received the Fields Medal in 1958, Thom went on in 1960 to develop the theory of stratified sets, another new branch of differential topology. In 1966, I began to receive letters from Thom on his emerging ideas of catastrophe theory, with proposed applications to linguistics and to quantum theory. This project eventually became a book, *Stablite structurelle et morphogenese*, in 1972. An excellent English translation by David Fowler was brought out by William Benjamin in 1975.

The English translation by Fowler, also published by Benjamin, was more than a translation. It greatly clarified the difficult ideas of Thom and launched the subject into a trajectory which lasted for several years, and affected the history of several sciences and philosphies. This trarjectory

11 See (Fleck 1979; p. xiii).

was further boosted by the splendid writings of E. C. Zeeman, developing applications of the theory to various fields, first in an article in 1976, and then a thick and readable book in 1977.

This book includes a model for the nerve impulse, which was a great stimulus for my own attempts to model consciousness. I noted this connection in my journal on July 31, 1969, while I was a visiting fellow at the University of Warwick.

Early Catastrophe Theory

I learned of catastrophe theory from Thom in 1966, He had then a great interest in algebraic geometry, and had made a theory of straified sets which generalize algebraic varieties. He had an acute visual ability, and it occured to him that these figures might be the basis for a universal theory of forms. He began looking for applications of some of these sets which appear in three-dimensional space.

Meanwhile, Conrad Waddington (1905-1975), a developmental biologist at the University of Edinburgh, became interested in organicism, an idea for overcoming the dichotomy between materialism and vitalism in theoretical biology.[12] A great organizer, he managed to get funding from the Rockefeller Foundation for a series of four conferences at the Foundation's property, the Villa Serbelloni, on Lake Como.

At the first of these conferences, in August 1966, Thom was present. He and Waddington had inspirational talks. In a report of the first two meetings, Waddington wrote:

> The facts that in normal development only a limited number of different cell types put in an appearance, and that each of them shows some power

12 See (Peterson, 2016; Introduction).

of "regulation" or resistance to disturbing effects of the environment, indicate that we are dealing with a number of domains of phase space, each containing a vector field dominated by a particular attractor. In the context of development we have to think of these attractors as extended in the time dimension. The fact that the vector fields converge on to the attractors gives rise to a process of "homeorhesis", which can be contrasted with the more conventional idea of homeostasis in which the vector fields converge on to a static point which is not time-extended. I have proposed the name "chreod" for such a multidimensional domain which contains a vector field converging on to a time-extended attractor.

This notion was developed in a way which was both more generalized and more precisely formulated by the French topologist, Rene Thom. He pointed out that the concept can be used over a much wider field than that of embryonic development; for example, the field of the shades of meaning of a word can be regarded as a chreod dominated by the attractor which is its "concise dictionary" meaning. Again, at the second meeting Richard Gregory discussed a theory of perception under the provocative title "How so little information controls so much behaviour". His answer was, roughly, that a small amount of information arriving through the sense organs activates "pre-existing" models in the brain—which can be otherwise expressed by saying that the incoming information falls within the domain of a certain chreod and thus converges on to its attractor.

The main feature of the discussions in this area,

> however, was an analysis by Thom of the "catastrophes" at which the organization controlling one domain breaks down and the system becomes switched into one or more alternatives. Physical examples are a shock wave, a liquid jet breaking up into drops, a wave breaking. He claims to have shown that in real four-dimensional space there are only seven possible types of elementary catastrophe.[13]

Here we find the origin of Thom's applications of catatrophe theory to biology, and also, Waddington's identification of the *chreod* with Thom's model.

The demise of catastrophe theory

The theory of Thom included simple catastrophes, which were much studied and applied, especially by Zeeman, due to their relative simplicity. But these had a serious limitation, in that they applied only to static attractors. Thus, systems with periodic or chaotic attractors (discovered in 1961) could not be accomodated. As chaos theory rose, catastrophe theory declined.

A further burden on the theory was the opposition of some very influential mathematicians, such as Steve Smale, who wrote a devastating review of Zeeman's 1977 book in 1978.

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13 See (Waddington, 1968; p. 526).

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