

Beautiful Networks TDS

Class notes week 3

***Technical terms of Prigogine, Maturana and Varela with Capra and Kauffman**

READ KAUFFMAN PAGES 18-22

Autopoiesis (“Self-making” or “Self-creation” and “Organization of the living”)

Self-organization and “dissipative structures” describe how living systems exist in conditions of “nonequilibrium” (Capra, p. 86)

Conditions of “far from equilibrium” or “nonlinearity” are expressed mathematically in “nonlinear equations”

“Under what conditions nonequilibrium situations may be stable” (Capra, p. 86)

Prigogine turned away from explaining living systems and instead focused on thermodynamics or “heat convection”

This phenomenon is known as “Benard instability” (Capra, p. 86)

Benard discovered that “the heating of a thin layer of liquid may result in strangely ordered structures.” (Capra, p. 86)

The Benard cell is created when heat applied at the bottom moves to the top through the liquid

The liquid itself is at rest while the heat moves through it by way of conduction

The temperature difference between the top and bottom will reach a critical point

At this point the conduction is replaced by convection thus the creation of the Benard cells form

In each of these cells hot liquid rises in the middle while the cooler liquid descends to the bottom along the cell walls (Capra, p. 87)

Prigogine’s analysis is to say that as the system moves away from equilibrium or uniformity and closer to instability or nonequilibrium the “hexagonal pattern emerges” suggesting that order emerges from instability as “spontaneous organization”

In a “low-energy equilibrium” system we see entropy take hold as the energy in that system has a tendency to reach stasis or uniformity

Examples: Either the ball in the bowl rolls until it reaches the point of stasis or like dye in water the molecules evenly disperse so as to create a perfectly uniform mixture of water and dye

This model of entropy is represented in “phase space” by a spiral where the single point attractor grips the direction of the system. Where that point rests is equilibrium.

Here is how a constant supply of matter-energy creates ordered structure but out of instability!

Thus such “nonequilibrium dissipative structures” use the constant flow of matter-energy coming in and leaving as what sustains the order produced

The nonequilibrium is maintained by the flow of energy thus producing the complex patterns and order expressed as a coherent structure like the hexagonals take place

Practical example: “the flow of warm air from the surface of the earth toward outer space may generate hexagonal circulation vortices that leave their imprints on sand dunes in the desert and on arctic snow fields.” (Capra, p. 88)

Chemical clocks are one further example of spontaneous self-organization

Far from chemical equilibrium where periodic oscillations are produced

For example, if there are “blue” molecules in the system as well as “red” molecules” the system will change from being all BLUE to all RED

This coherence to shift from one to the other requires the molecules to act as a whole

At critical points of instability “far from equilibrium” the coherent behavior emerges spontaneously (Capra, p. 88)

Prigogine’s nonlinear thermodynamics described self-organization in open systems far from equilibrium (Capra, p. 88)

Classical thermodynamics leads to “equilibrium structures” like the ball coming to rest or the dye dissolving uniformly until all activity ceases and entropy sets in (uniformity; stability; stasis). *Like in crystals where the order created is unchanging*

Thus “dissipative structures” embody a complex relationship between structure and order on the one hand and dissipation or change on the other hand

In classical thermodynamics heat transfer and friction were associated with waste or lost to entropy in the system

In Prigogine’s view Open Systems are a source of order (Capra, p, 89)

Thus dissipative structures not only maintain themselves in a stable ordered state “far from equilibrium” but they may also evolve (Capra, p. 89)

When energy increases and flows through the system a “bifurcation point” or “phase transition” occurs: this is where higher order structures emerge like “emergent properties” in self-organization

A complimentary view but still different comes from Maturana and Varela called **Autopoiesis** or “Self-Making systems”

There is according to Kauffman and others an “autocatalytic metabolism” or “metabolic network” where life must have emerged from nonliving matter whole and complex (Kauffman, p. 47-48)

In other words, life has *emergence* built into it and is deeper than DNA. It is in chemistry itself

The idea is “metabolic networks” are formed because once there are enough molecules in a self-generating relationship then a metabolism is created

Such a metabolic network emerges whole and not in stages or parts!

“It’s order for free” as Kauffman says (Kauffman, p. 45)

Autopoiesis is similar to Prigogine’s dissipative structures in that a self-sustaining process is created like the Great Red Spot of Jupiter or cells in our bodies

Autopoiesis describes a living process as not only maintaining its order but generating new elements inside it

Thus the order has to be maintained in a fluid environment, the stability has to be allowed to change and new molecules must be produced in order to regenerate the whole over again

In other words, not only are there new elements created in the system but the parts that do the regeneration must be regenerated as well

Unicyclist on a tightrope juggling as autonomous action embodied in a whole!

READ CAPRA PAGE 96

Thus the behavior of Prigogine's dissipative structures and Maturana and Varela's Autopoietic systems are similar but different still

One difference is Autopoiesis is describing a "system" more than a "structure"

They argue that Autopoiesis is more the system of "organization" so that we can tell the class of each system like cat, sunflower or human. This pattern they see is more an abstract description and does not point to the actual physical components of the structure. Autopoiesis is a general pattern of organization no matter which components are used. Each of the examples would have different components.

The real zinger is that they argue the "organizational pattern" of Autopoiesis is independent of the properties of its components. So that a given organization can be embodied in many different components or physical structures.

This explains why we can consider an Autopoietic system like the Great Red Spot and the cells in our bodies as structurally different but organizationally similar.

But to know if a system is living we must be able to say it is Autopoietic or self-making! We also must be able to say that such a living system does not simply rely on physical parts alone. Rather "relationships of processes" help define living biological systems from nonliving ones.

READ CAPRA PAGE 96-98 (CONCERNING COGNITION)

Thus it's the "pattern" and "structure" that they each explain above

The pattern of organization in a system are those relationships and interactions between the component parts or nodes

The structure of a system is the physical embodiment of its pattern of organization

Both embody each other!

So the pattern of organization of living systems is affirmed by Autopoiesis while the structure of such a system is dissipative

The synthesis of pattern (form, order, quality) and structure (substance, matter, quantity) help explain how living systems evolve

Thirdly, cognition may be the process of life in those systems themselves. In this view cognition does not require a nervous system but is the process of life itself!

READ CAPRA PAGES 160-162

Pattern of organization: relationships in the system that help determine its characteristics

Structure: physical embodiment of the system's pattern of organization

Life Process: continual embodiment of the system's pattern of organization

Autopoiesis and cognition are two different aspects of the same phenomenon of life

An Autopoietic network not only is self-organizing but is self-generating and regenerating so as to create new elements inside itself. **It is also autonomous in the sense that stability and order are created while still connected to the environment in which matter-energy flows in and out.** Such order and stability can come from an unstable or chaotic flow of energy.

All living systems are dissipative but not all dissipative structures are living!

As an organic-living-biological organism I am also dissipative while my computer too is dissipative but it is not composed of biological cells. I am

carbon based and the computer is silicon based and so far the latter does not share the emergent properties of life!

Thus a dissipative structure can be living or nonliving. In the case of cells it is living in the case of chemical clocks it is not

A vortex in flowing water is a nonliving example just as the Great Red Spot is as well. Even though we might argue, because of its life span, the Great Red Spot might be alive. This makes an interesting point how both the pattern and structure embody one another and are experienced together!

For something to be alive doesn't mean it has to have a nervous system or brain

The crystal is self-organizing but not Autopoietic since it cannot regenerate itself over and over again. The crystal relies on external forces to create it whereas in Autopoietic systems that force is generated by the system itself. The crystal forms into one stable order among static components and that's it! Whereas the famous slime mold is Autopoietic as it regenerates all those elements it needs to keep changing form and reorganizing itself. It remakes those elements used for regeneration.

In other words, the parts that do the regeneration have to also be regenerated.

READ CAPRA PAGES 167-168

Finally, Autopoiesis is the pattern of life among process of *production* while dissipative structures are *metabolic* and *developmental* processes.

They embody each other but can still be distinguished from one another. Cognition is what embodies both as the process of life. Thus the mind may be a process of life more than a thing. All living organisms would share in cognition as they interact and communicate in their environment: Semiosis or biosemiosis. For communication to occur one doesn't need a central nervous system. Plants, cells, animals and humans all take part in semiosis!

Autopoiesis is open and closed: structurally open to the environment while organizationally closed or autonomous!

READ CAPRA PAGE 172