

..... 6. Autopoiesis is living

CONFRONTATION WITH DEATH

POERKSEN: In the year 1944 the physicist Erwin Schrödinger published a small book that has since become a classic in the history of science. It is entitled: *What is Life?* Your own thinking has been intensely concerned with this question. You have developed a description of the living – as a biologist –, the theory of autopoiesis, which is still causing excitement in the scientific world. However, let us start at the beginning. Why have you been so deeply fascinated and obsessed by the question of what it is to be living? Was there a particular incident, some key intellectual experience?

MATURANA: In fact, there have been various incidents and different key experiences that have inspired me. You must realise that I was often very ill as a child; death was a constant companion in the days of my childhood. I fell ill with tuberculosis several times, and the threat of this disease made me think about the relation between life and death quite early. I remember writing a poem at the age of 14 years, which deals with the difference between a corpse and a rock, the corpse being different from the rock because it had been alive. The fact of being alive was, therefore, not a property of matter – but what was it then, I asked, if one can lose it?

POERKSEN: You are describing a dialectical pattern: In the encounter with our own death, we become aware of our craving for life.

MATURANA: You could say so. In the year 1949 I was in a sanatorium in the mountains, being ill with tuberculosis again, and I had strict orders not to exert myself in any way; the prescribed therapy was, in

fact, not to do anything at all. In secret, however, I read two books. In Nietzsche's *Thus Spake Zarathustra* I discovered that wonderful story of the metamorphosis of the spirit, the spirit being transformed first into a camel, then into a lion, and finally into a child. The child is described as the first movement: If I ever got out of the sanatorium alive, I thought, I would be like a child, starting from scratch, at the beginning again. Towards the end of Julian Huxley's book *Evolution: The Modern Synthesis*, I came upon a chapter in which I read that evolutionary progress meant increasing independence of a living being from its environment. Human beings, therefore, appear to be the most independent and most advanced living beings. So there I was lying in my bed, completely dependent on my medium, unable to leave the sanatorium, ill, close to death, and knew clearly that Julian Huxley could not have been right.

POERKSEN: If I understand correctly, the confrontation with death led you to ask the question of the nature of life. Moreover, Nietzsche and Huxley offered answers, which you could relate to your own situation.

MATURANA: Indeed. Life, I said to myself, has no meaning, no sense, and does not follow any programme of evolutionary progress. My conclusion had a tautological ring: the sense and the purpose of a living being is just to be what it is. The purpose of a dog is being a dog, the purpose of a human being to be a human being. Anything affecting a living being and happening to it, it became clear to me, had to do only with itself. When a dog bites me because I have stepped on its tail, then it bites me because it wants to avoid pain. This means that living beings are autonomous, that they have defined limits, that there is a boundary marking what belongs to them and what does not.

POERKSEN: It has become customary in biology to answer the question of what being alive means by drawing up a list of necessary properties. To be alive means, it is said for example, to be capable of reproducing and to be able to move around. Why did you not find any such list satisfactory?

MATURANA: Because such a procedure does not tell when the list of features or criteria that are necessary to claim that a system is a living

system is complete. We cannot know when such a list has been completed unless we already know beforehand the list of features that characterise a system as a living system. In the year 1960 a student asked me during a lecture what actually began four thousand million years ago so that we can claim now that living systems began then. The question embarrassed me considerably because I could not answer it. Therefore, I asked the student to come back a year later; I would then be in a position to answer his question. I kept asking myself, though, as I continued to ponder the question, how I might be able to decide to have actually found the proper answer. How could I be sure to have defined life appropriately by listing features like reproduction or locomotion, special chemical composition, or a combination of such features?

POERKSEN: The problem is how we might be able to prove that we have found all the central features.

MATURANA: Drawing up a list of features presupposes, strictly speaking, knowledge of all the potential features. Only those who believe that they already have the answer, although they are still looking for it, could possibly know when their list is complete. I was, however, searching for an understanding of living systems which did not require the enumeration and classification of all the components and processes involved. I was looking for a form of organisation common to all living systems, which had to be independent from their particular components and their particular structures.

POERKSEN: How did you come to develop the theory which has become widely known under the catchword *autopoiesis*?

MATURANA: My own thinking went through various stages. At first I spoke about systems without an external purpose, whose activities make sense only within their own being. These *self-referential systems* were distinguished from *allo-referential systems*, whose essential feature was that they served a purpose external to them. (A car, for example, is an allo-referential system: its sense and purpose is to serve as a vehicle of locomotion from one place to another.) The concept of reference did not really appeal to me, though, because it always involves a relation between different elements – and I did not

want to describe a pattern of relations; I wanted to understand the processes of a system through the system itself. Therefore, I looked for a concept that would highlight the processes that ultimately resulted in the phenomenon of self-reference.

POERKSEN: You wanted your theory of the living to be alive itself.

MATURANA: I was both obsessed and fascinated by a characterisation of the living that could not be separated from the actual realisation of the living. Although I had read Erwin Schrödinger's book, my question was not what life *was*, but what essentially constituted a living system. I wanted to discover the configuration of processes, the specific molecular dynamics, which produced, as a result, a living system, a cell, for instance. What must happen for such a system to arise? Conceptually, at least, I wanted to create a living system; that was my goal.

POERKSEN: You wanted to play God.

MATURANA (laughing): I did not want to *play* God, I wanted to *be* God.

A FACTORY THAT PRODUCES ITSELF

POERKSEN: What happened next in the step-by-step development of your new theory of the living?

MATURANA: In 1963, in the laboratory of a microbiologist friend with whom I regularly discussed the developments in molecular biology, I had the decisive inspiration. The dogma in molecular biology was, at the time, that information travels from the cell nucleus to the cell cytoplasm. We asked ourselves whether it might not also travel the other way, from the cytoplasm to the nucleus; nobody had yet heard of retroviruses, so our question was quite justified. We designed experiments that were never implemented, but one of those days I drew a diagram on the blackboard and said to my friend: "The DNA participates in the synthesis of the proteins, and the proteins participate as enzymes in the synthesis of the DNA." My diagram had the form of a circle. When I looked at what I had just drawn on the

blackboard I exclaimed: "My goodness, Guillermo, that is it! This circularity of the processes reveals the dynamics that makes living systems autonomous, bounded, and independent entities." I had found the conceptual basis of the phenomenon that was later termed *autopoiesis*. From then on, I described living systems as circular systems.

POERKSEN: We have now reached the last phase of this short scientific and historical prelude. How did the concept of autopoiesis finally come to be invented?

MATURANA: It must have been in the year 1970; I had met with my friend José María Bulnes who had written a doctoral thesis on *Don Quixote*. In this thesis he dealt with the dilemma confronting Don Quixote: to choose the path of poiesis (production, creation), or to involve himself in praxis (actual work), without paying much attention to the consequences of his actions. He finally goes for praxis and decides to become a wandering knight, and therefore decides against poiesis and writing novels about wandering knights. During that conversation it hit me: "That is the word I have been looking for: *autopoiesis*." It means *self-creation* and consists of the Greek words *autos* (self) and *poiëin* (produce, create). I had successfully condensed into a concept my idea of what essentially characterises a living system. There was the additional advantage that the term was completely unknown – in contradistinction to the somewhat cumbersome expression *circular systems* –, and that it focussed the attention on the result of the constitutive processes of systems that produce themselves as unities through their own operations. The product of the autopoietic organisation of a system is that very system itself.

POERKSEN: Can the concept of autopoiesis be specified in greater detail?

MATURANA: Living systems produce themselves within their closed dynamics. They share the autopoietic organisation in the molecular domain. When we examine a living system, we find a network producing molecules that interact with each other in such a way as to produce molecules that, in turn, produce the network producing

molecules, and determine its boundary. Such a network I call autopoietic. If we, therefore, encounter such a network in the molecular domain, whose operations effect its own production, then we are dealing with an autopoietic network and, consequently, with a living system. It produces itself. This system is open to the input of matter but closed with regard to the dynamics of the relations that generate it.

POERKSEN: Perhaps an example demonstrating the autopoiesis of the living would be helpful at this stage. You have often referred to the cell as an autopoietic system. Would that be a compelling model?

MATURANA: In my terminology the cell is described as a molecular autopoietic system of the first order; consequently, a multicellular entity is an autopoietic system of the second order. The special thing about cellular metabolism is that it produces components, which are in their entirety integrated into the network of transformations that produced them. The production of components is, therefore, the condition of the possibility of a boundary, of the membrane of a cell. This membrane, in turn, participates in the ongoing processes of transformation, it participates in the autopoietic dynamics of the cell: it is the condition of the possibility of the operation of a network of transformations that produces the network as an integral whole. Without the boundary of the cell membrane everything would dissolve into some sort of molecular slime, and the molecules would diffuse in all directions. There would no longer be an independent entity.

POERKSEN: This means that the cell produces the membrane and the membrane the cell. The producer, the act of production, and the product, have become indistinguishable.

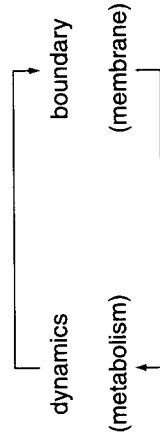


Fig. 9: The cell – an autopoietic system of the first order – is a factory that is its own product.

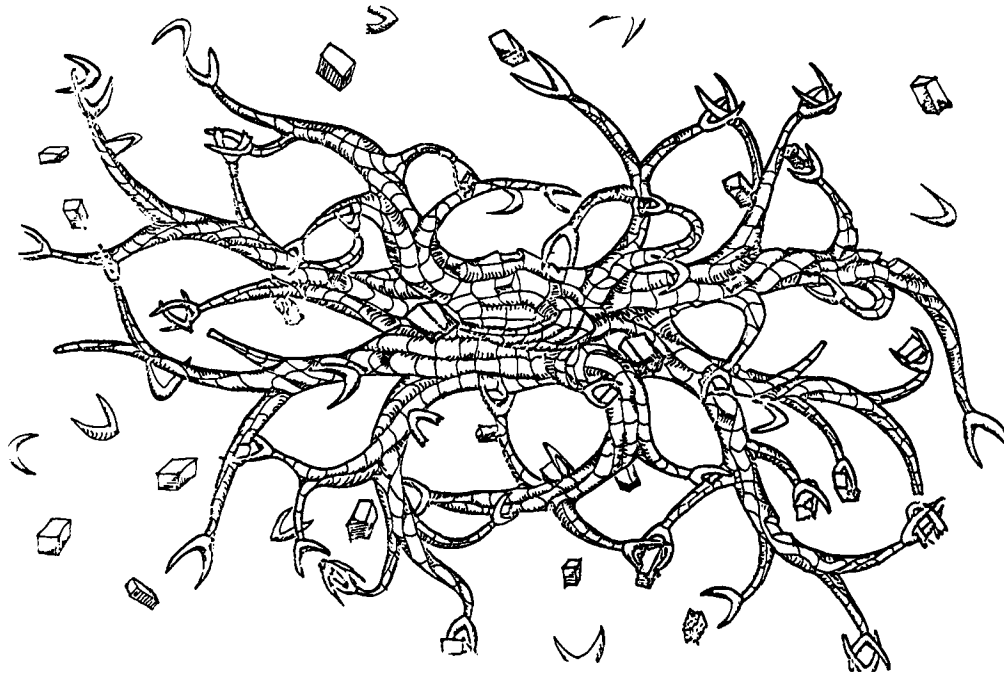


Fig. 10: An autopoietic system uses its components as elements of self-creation. (Drawn by Alejandro M. Maturana.)

MATURANA: I would say, a little more rigorously: The molecules of the cell membrane participate in the realisation of the autopoietic processes of the cell and in the production of other molecules within the autopoietic network of the cell; and autopoiesis generates the molecules of the membrane. They produce each other, and they participate in the constitution of the whole.