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GROUND RULES FOR THE 21ST CENTURY
Chapter 4

THE EMERGENCE OF WEALTH

Self-organization or emergence may sound arcane, but in fact the phenomenon is so common and familiar that we hardly notice it. Take the taste of sugar molecules, which are composed of carbon, hydrogen and oxygen, each of which have no particularly sweet taste. In combination - and interacting with our taste buds – they acquire a new and different quality: a taste of sweetness. The same goes for music: Something completely new emerges when several instruments interact and the individual tones and melodies color and compliment each other.

Self-organization is the emergence of something new and different in the interaction between elements that are connected in a system. The result of the process becomes more than the simple sum of its parts.
Self-organization is a general mechanism that unfolds in all kinds of complex systems, and we can it in many, very different contexts all around us.

This book will primarily look at self-organization as it occurs among humans or in the large technical systems we have created. For instance, self-organization is a good way of describing how thoughts arise: Our brains work by billions of neurons transmitting electrical and chemical impulses among each other - but each of the neurons do not contain anything that remotely resembles a thought or a memory. The thought emerges only in the interaction among the many neurons. Thinking has been compared to paintings by the French pointillist Seurat, who painted pictures composed of tiny dots. Seen from up close, you will get no sense of the overall picture by looking at the individual dots. But at a distance, the dots form a clear picture when they are seen together.
At the social level, a group of people can get together and brainstorm, and with a little luck the result will be some ideas and thoughts that none of participants would have come up with on their own.
It is one of the most promising features of the ongoing wiring together of all of us in digital networks that it can lead to self-organization; that the community can develop or achieve something new that was not possible before we started interacting with each other.

The self-organized qualities are the extra advantage we can gain by engaging in successful cooperation with others. This extra that can emerge in an interaction - the new features, greater understanding or greater benefit - is what brings us forward in development.
In this sense, self-organization is the origin of our prosperity and development. In contrast, if we stick to ourselves, we miss that extra dimension, and run the risk of being relatively worse off compared to others who manage to combine their resources.

Organization without an organizer
An anthill is an excellent example of how interaction between the participants in a

system can lead to entirely new properties. Anthills are complex structures with amazingly advanced features that enable the colony to survive and thrive under very different circumstances. But if you want to understand how anthill works, it is not enough to look at the individual ant. An ant on its own is not burdened by great intelligence, and its behavior follows some very simple rules - but the collective behavior of ants can be amazingly smart.

It’s evident in the way the ants help each other to find food. Ants communicate through scents, called pheromones. An ant foraging or looking for building materials starts by randomly scanning the area, and when it finds food, it leaves a trail of pheromones on its way back to the colony. In this way, the other ants in the anthill can follow the trail to the food and as more ants return with food, the scent on the trail becomes stronger. When the food runs out, the ants will stop leaving pheromones; the smell evaporates and stops attracting more ants to the spot. It’s as simple as that.
The ants follow a procedure which is quite simple at the level of the individual ant, but which proves to be an extremely efficient way to organize thousands of ants to find food. And the procedure doesn’t require an über-ant directing the others. The organization and functionality of the system emerges from the bottom up.

This kind of fundamental mechanisms guiding a system is called "algorithms". An algorithm describes how interactions between different elements function - in the example of the anthill, the behavior of the ants is determined by the algorithm that you must leave a trail of scents when you find food.
Algorithms are different from formulas. With a formula you can calculate the precise outcome in a particular situation. An algorithm, however, is a kind of program that determines the general rules for interactions in the system. When you study the individual parts of a complex system, it often turns out to be surprisingly simple algorithms that underlie extremely sophisticated and varied phenomena.

There are plenty of self-organized phenomena in human interaction and organization. In the previous chapter, we mentioned that fashion trends or changes in public opinion can occur because of a simple feedback algorithm – not because any one person decides so. Another example of self-organization is the concept of "wisdom of the crowds" which is used to describe how new ideas can emerge, spread and developed, when many people combine their skills and resources by using networks and social software.

<u>The shortcomings of reductionism</u>
The traditional way of studying a phenomenon was to take it apart and study its components - what we call the reductionist method. The problem of reductionism, however, is that it doesn’t allow you to observe the self-organizing properties of the system as a whole.
In medicine you could perform an autopsy of the deceased Mr. Smith and you can achieve an understanding of how he functioned mechanically and biologically. But looking at the parts will not tell you what personality or which views and feelings Mr. Smith had when he was alive. The system needs to be running before these qualities emerge. The dynamic interaction is crucial, for it only when the algorithms run, that the self-organized properties emerge. If you only study a system when it is stationary, you lose a substantial part of the qualities that make it what it is.

Studying complex systems, the focus is as much on the relationships and interactions between the components of the system, as on the characteristics of the parts themselves.
That is a very different perspective from the approach which most of science has had so far. Traditional reductionist science does not look at the whole system at once, and it does not study the system while it is moving.

There are good reasons why science has been reductionist - and still largely is. First and foremost, you simply did not have the tools to study entire complex systems in motion until a few years ago. Only in recent decades, has there been enough computing power available to work with the enormous volumes of data that simulations of entire systems typically require.
So ironically, digital technology and networking are both a major reason why our circumstances have become so complex - and they are the main tools to understand the complexity.

It's important to know about complexity and the mechanisms of systems theory because so many of the systems, we depend upon and must interact with today are of a nature where an reductionist approach is inadequate if you want to grasp what's going on.
One cannot understand how traffic jams in cities evolve, if you only study the individual motorist. Similarly with stock markets, the climate, ecology, our health, development of the Internet or international politics. They are complex systems with large numbers of very diverse elements. Often you will need to compute the interactions of several million factors. It requires enormous computing power - but it's the only way to understand complex systems behavior: by simulating the whole system in motion.

The new reality is characterized by the integration into increasingly comprehensive processes. Whether it is politics, commerce, science or culture, there is generally a greater number of people involved, there are far more factors interacting, and solutions and products integrate more supplier through longer supply chains
You will understand less and less of an issue - whether it is yourself, society, a product, or a company - if you can not take the larger context into consideration. When everyone and everything is integrated into one system, it is necessary to understand developments at the system level.

<u>Meteorology; from simple measurements to complex simulations</u>
Meteorologists' work with the weather forecasts is very much about understanding self-organized phenomena in complex systems.
Until the 1850ies meteorologists concerned themselves with describing and explaining incidents like tornadoes, thunderstorms, rainbows, etc. The early meteorology was linked to the emerging understanding of thermodynamics, basic principles of freezing points, evaporation, the relationship between pressure and temperature and the like.
It wasn't till the advent of the telegraph, that it became possible to rapidly collect and compare measurements of the weather from many different places in order to understand the patterns in how weather systems develop and spread.
By the 1920ies there was sufficient insight into the many factors that affect the

weather that meteorologists could develop computational models, but at that time, the calculations were simply too extensive to use for practical weather forecasting. Moreover, there wasn't enough data to achieve a very high precision.
In 1960, the first weather satellites were launched, and today we both have an ongoing comprehensive detailed collection of data and computers able to calculate the consequences for a week or 10 days ahead.
When we are watching the animations of weather systems moving across the continent on TV, it is an example of how we can now assess the patterns of weather much more accurately because we can actually see the entire system with it millions of data points in motion.

Bigotry and pitfalls of simplification
The world is complicated and confusing and in order to make sense of it in our daily life, we need to simplify and choose what we take into consideration. But by simplifying we run the risk of focusing on the wrong factors or completely misunderstanding the nature of the problem we are working with. In complex contexts, one cannot isolate and solve one part of a problem without taking into account the effects and influences from the rest of the system.
Unfortunately, a great deal of very important decisions rely on a too simple perspective.

In 2007, approximately one third of the U.S. corn crop was used as feedstock for producing bioethanol. The Bush administration wanted to reduce the American dependence on imported oil, and therefore introduced schemes that made it attractive for farmers to sell their maize to bio-refineries. The following year, the World Bank in their annual report on global food production could conclude that the extensive use of corn for ethanol production in the U.S. was a major contributing factor to the dramatic increases in food prices, which hit the world's consumers in 2008.
Meanwhile, a number of studies showed that the actual savings of bioethanol, measured in CO_2 as well as in barrels of oil, were extremely limited. Growing corn requires large amounts of fertilizer (produced from natural gas); it requires irrigation and pesticides, and heavy use of oil and gasoline to run farm machinery.
The story is not much better in Europe, where we – to protect the climate - have agreed that 10% of fuel for transportation in 2020 must come from biofuels. One of the consequences has been a large increase in the ethanol production in Malaysia, where enterprising planters resolutely clear large swaths of rainforest to plant palm trees for oil production.
The story of bioethanol illustrates that if you choose to focus on a single or very few parameters of a much larger problem, you may end up with a result that is almost the opposite of what you wanted.

There are many other examples of this. The debate on biotechnology is often characterized by a misleading focus on individual factors. There are often reports of scientists finding the gene for improved memory, longer life, Parkinson's disease, etc. In reality, however it's very few properties that can be attributed to a single gene. One of the big surprises when the human genome was decoded, was that humans have far fewer genes than had been assumed - probably only between 20,000 and 25,000. When a system with a relatively small number of genes is able to code for a much larger number of different properties, it shows that it's generally misleading to talk of isolating a single gene responsible for very complex properties such as aging, obesity

or intelligence.
It also points to the fact that the functions of genes are so closely tangled together that a tiny change in a plant or an animal's genes can have major unforeseen consequences, when it turns out that small gene sequence that was changed, is part of many different interactions with other genes.

Summary

Let’s briefly go over the main points of complexity theory again:
Complexity is a characteristic of systems in which many factors interact closely. We are surrounded by complex systems - our bodies, the weather, markets and politics are examples of very different complex systems.
There are some mechanisms and patterns, which can be observed in all complex systems. One of the great benefits of systems thinking is precisely that you can use observations of how one complex system evolves to better understand the driving forces behind the evolution of another complex system in a completely different area.
Some of the specific properties of complex systems are that they are non-linear, i.e. that they may evolve in spurts. This is partly because of the feedback mechanism, which can be self-reinforcing, so a system suddenly goes into overdrive. This is called positive feedback.
There is also negative feedback. This is a mechanism that opposes change, and it can have the effect that a system remains unchanged for a long time despite that the circumstances surrounding it have changed dramatically. Eventually such a system may reach the limit of its ability to resist change, and in a sudden shift the system switches to an entirely new condition - like water that freezes into ice. When a system is close to a phase shift, a very small stimulus can trigger a major shift. And this is yet another way, in which complex systems are non-linear: There is not necessarily a proportional relationship between the size of an event and the scope of its consequences.
When the many elements of a complex system interact, patterns or properties that were not found among the individual elements can emerge: Something completely new and qualitatively different. This phenomenon is called self-organization or emergence.
If you want to observe these complex mechanisms and emergent properties, it is no use to stop the system and study its parts. One has to look at the system as a whole, while it is running. It is in the dynamic interaction that the special qualities of complex systems arise.
And why is this important? Because our economy, the technology we use and the relationships we enter are just a few examples of the innumerous, increasingly complex systems in which everything is connected and interact. Therefore, the fundamental mechanisms that complexity theory describes are crucial to understand if you want to thrive in the networked era, where everything and everyone are connected ever closer together.