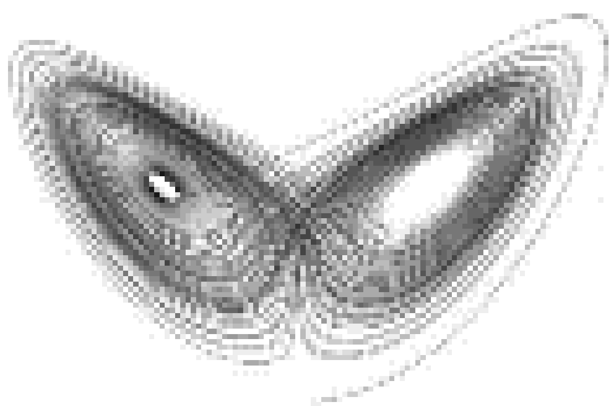
On Complexity

By Blas Moros



Intro

The hope is that this "teacher's reference guide" helps highlight and clarify the key concepts and terms of complexity and its wide ranging applicability. Complexity is fascinating in that it is fundamental to so many vastly different fields – physics, chemistry, economics, biology, psychology, sociology and more. A true, deep fluency may lead to better thinking, decision making and outcomes in nearly every area of life. Principles which seem universal and have survived the test of time are surely worth further study!

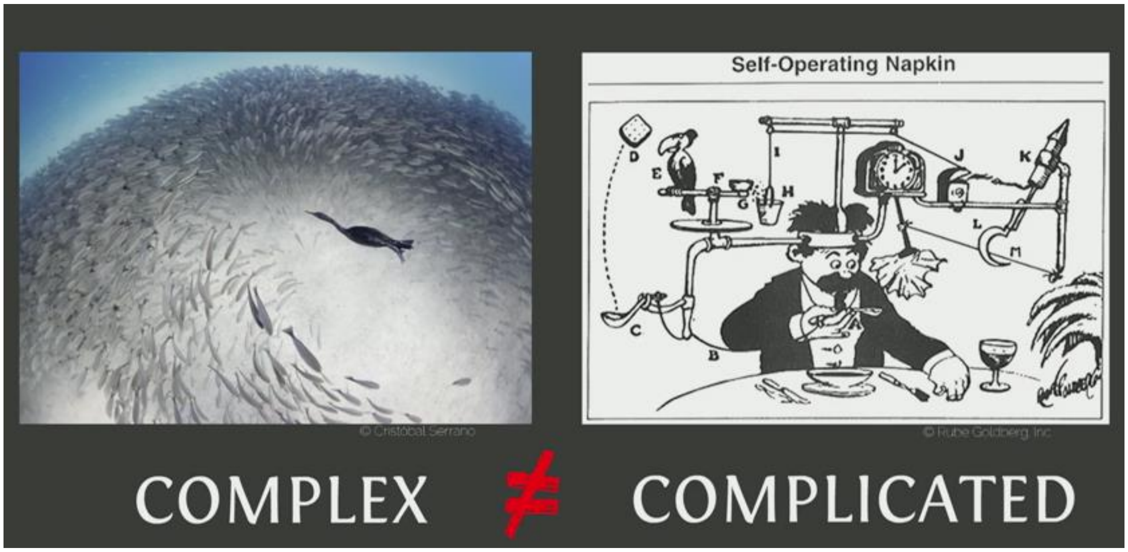
I recently came across an excellent website called BetterExplained.com which attempts to simply describe topics in order to understand them in a more intuitive fashion. Although the site focuses on math, one of the more impactful posts for me described his teaching process – one he terms ADEPT. Analogy, Diagram, Example, Plain English and Technical Description. If you can teach a concept while keeping this framework in mind, you most likely have a good grasp of the topic yourself and will be able to teach it more effectively as well. This is the model I have chosen to follow in attempting to describe the following key terms and concepts.

Please note that this guide is something I plan to update, iterate, improve and expand upon over time. There are surely flaws throughout and parts which true experts would disagree with. I welcome any questions, comments and corrections in this quest to better understand complexity and its many offshoots!

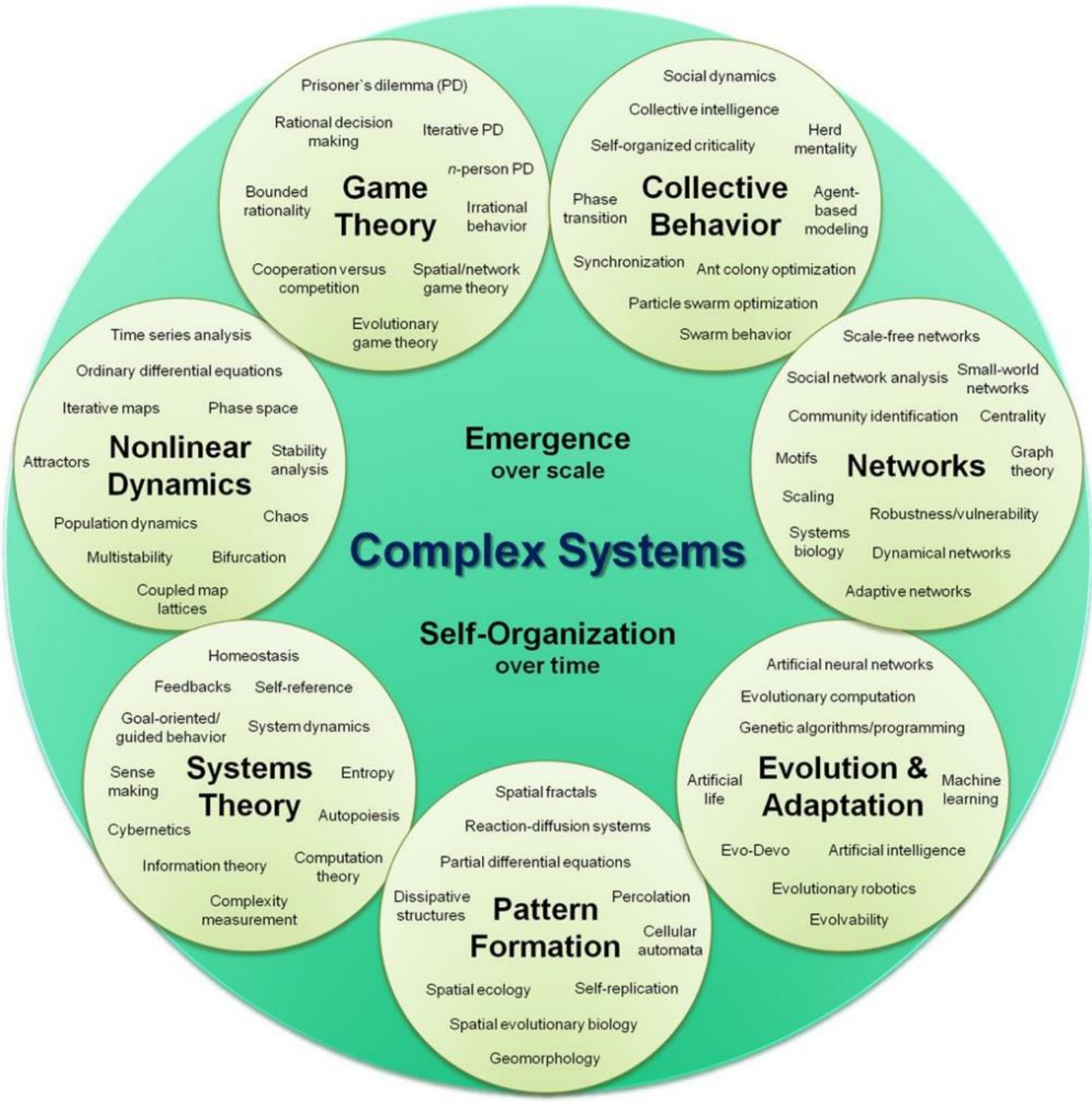
Key Terms & Concepts

Complex Systems

- Analogy – A complex system is like an ant colony which collectively seems intelligent even though the individual ants are not. By interacting and following simple rules, emergent behavior can arise even from organisms as simple as ants.
- Diagram –

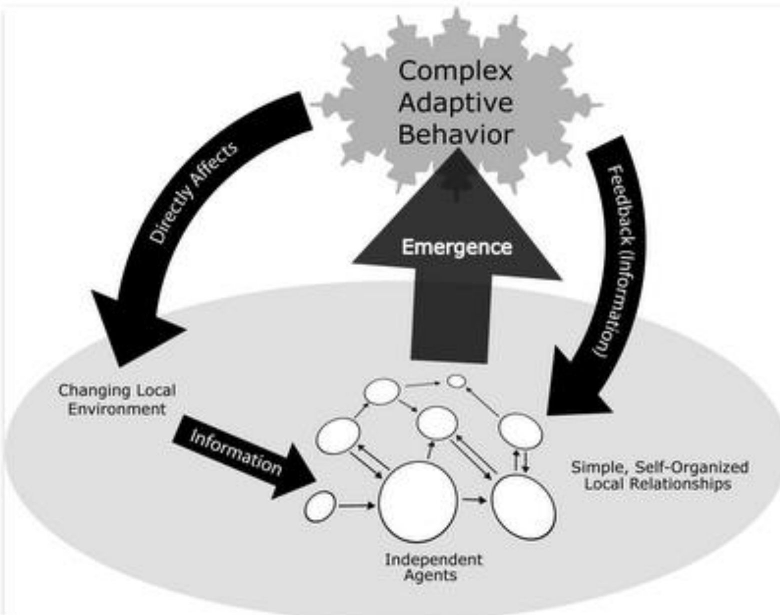


- Example – Ant colonies, world wide web, economy, brain's neural network, immune system, flock of birds or a school of fish avoiding predators.
- Plain English – A complex system exhibits emergent behavior due to the interactions of agents which follow simple rules. Emergence is a process where larger entities arise through interactions among smaller or simpler entities such that the larger entities exhibit properties the smaller / simpler entities do not exhibit.
- Technical Description – A system in which many individual agents *interact* leading to rich, complex and hard to predict behavior although the interactions are based on simple rules and there is no central controller. Complex systems tend to exhibit: non-trivial, emergent, self-organizing behavior; signaling and information processing; adaptation via learning or evolution; large variability.


Complex Systems
Emergence over scale
Self-Organization over time
Game Theory
Prisoner's dilemma (PD)
Rational decision making
Iterative PD
n-person PD
Bounded rationality
Irrational behavior
Cooperation versus competition
Spatial/network game theory
Evolutionary game theory
Collective Behavior
Social dynamics
Collective intelligence
Self-organized criticality
Herd mentality
Phase transition
Agent-based modeling
Synchronization
Ant colony optimization
Particle swarm optimization
Swarm behavior
Networks
Scale-free networks
Social network analysis
Small-world networks
Community identification
Centrality
Motifs
Graph theory
Scaling
Robustness/vulnerability
Systems biology
Dynamical networks
Adaptive networks
Evolution & Adaptation
Artificial neural networks
Evolutionary computation
Genetic algorithms/programming
Artificial life
Machine learning
Evo-Devo
Artificial intelligence
Evolutionary robotics
Evolvability
Pattern Formation
Spatial fractals
Reaction-diffusion systems
Partial differential equations
Dissipative structures
Percolation
Cellular automata
Spatial ecology
Self-replication
Spatial evolutionary biology
Geomorphology
Systems Theory
Homeostasis
Feedbacks
Self-reference
Goal-oriented/guided behavior
System dynamics
Sense making
Entropy
Cybernetics
Autopoiesis
Information theory
Computation theory
Complexity measurement
Nonlinear Dynamics
Time series analysis
Ordinary differential equations
Iterative maps
Phase space
Attractors
Stability analysis
Population dynamics
Chaos
Multistability
Bifurcation
Coupled map lattices

Complex Adaptive Systems (CAS)

- Analogy – CAS is like competition for survival between predator and prey. As one adapts, evolves, improves or changes strategy, so must the other in order to simply survive. Fitness requires both feedback and prediction.
- Diagram –

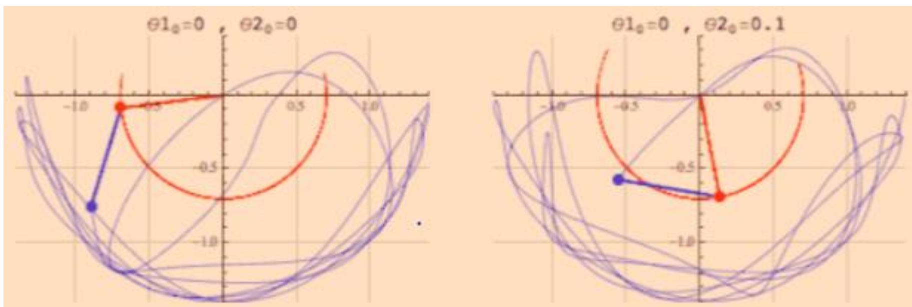


- Example – Stock market, an animal's niche within a food web or ecosystem, sports.
- Plain English – CAS have agents which are connected to other components in a system, who evolve based on other components and interactions, follow simple rules, exhibit emergence, and are self-organizing. Most human interactions and systems are CAS as one can't understand the parts simply by observing the whole and behavior constantly changes as agents and therefore the system adapts.
- Technical Description – CAS are a subset of complex systems which have the ability to adapt to their environment, competition, limiting factors, etc. The critical variable that makes a system both complex and adaptive is the idea that agents in the system accumulate experience by interacting with other agents and then change themselves to adapt to a changing environment (coevolution, Red Queen Effect). CAS tend to exhibit: perpetual novelty, dispersed networks, hierarchies, ability to learn / adapt / evolve / anticipate the future, non-linearity (whole > than sum of the parts), diversity, internal models, building

blocks (deconstruct complex problem into simpler parts which can be used and reused in different circumstances).

Chaos

- Analogy – A gas chamber is chaotic in the sense that you can never predict where the individual gas molecules will be but they will also never exhibit emergent behavior.
- Diagram – The image of the double pendulum helped me solidify what a chaotic system entails – in this case, one agent, the pendulum, follows simple rules leading to seemingly unpredictable behavior (link has video to double pendulum)



- Example – Weather and climate, traffic, cryptography, population models
- Plain English – A system exhibits seemingly random, unpredictable behavior although it truly follows simple, determinate rules. Difference between chaos and complexity – chaotic systems can have very few interacting subunits but they interact in such a way as to produce very intricate dynamics whereas complex systems always have a large number of units interacting. Chaos leads to complicated, non-periodic behavior from *iteration* of a simple rule(s), complexity leads to rich, collective behavior from simple *interactions* between large numbers of subunits. Chaos and complexity based on two simple ideas – sensitivity of a system to its given starting condition and feedback (butterfly or Lorenz Effect where prediction of complex systems is impossible as can never know starting conditions precisely and small changes lead to huge differences in outcomes).
- Technical Description – Chaos theory stipulates that the generation of complicated, non-periodic, seemingly random, unpredictable behavior can result from simple, non-random, determinate rules. Predictable in the short run but unpredictable in the long run. The complexity lies in the dynamical evolution – the way the system changes over time driven by numerous iterations of some very simple rules, rather than the system itself. Life exists

at the edge of chaos (also known as complexity) as too much equilibrium does not provide the energy or impetus to evolve and too much chaos does not give anything a chance to adapt to survive. Equilibrium = death

Self-Organization

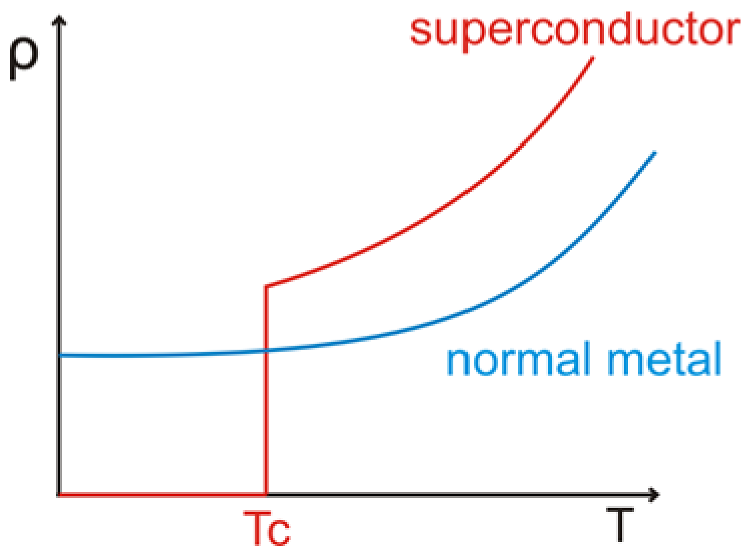
- Analogy – Self-organization is like a flock of birds which is able to form complex shapes, avoid predators and move as if one unit although the individual agents are not aware of the overall shape, design or consequences of their actions.
- Diagram –

- Example – Earthquakes, landslides, epidemics, financial markets, solar flares, biological evolution
- Plain English – Order arises spontaneously and naturally from interactions of smaller components and leads to self-organized systems and emergent properties ("order for free")
- Technical Description – The thermodynamically counterintuitive observation that systems tend to self-organize with no central "conductor" in a generally more stable or optimal way than would be predicted. Self-organization does not occur in chaotic systems and is often known as anti-chaos. Common properties of self-organization: positive feedback, increasing returns, lock-in (more niches dependent on a technology, the harder it is to

change that technology until something vastly better comes along), unpredictability, tiny events that have immense consequences.

Criticality

- Analogy – Criticality is like a game of Jenga where the whole tower is hardly balancing and one minor effort to remove another block leads to an avalanche of blocks.
- Diagram – The description of superconductors was fascinating to me. Often huge amounts of energy can be applied to either cool down or heat up molecules but until the critical point is breached, it appears as if very little is happening. However, once the critical point is breached, the molecules align and you start seeing unexpected, emergent behavior and



vast improvements in efficiency, conductivity and more!

- Example – Sand pile, earthquakes, landslides, superconductivity, superfluidity
- Plain English – A system is critical if its state changes dramatically given some small input – this phase is said to be on the "edge of chaos", at a tipping point or at a phase transition where fractions of a degree (whether it be temperature, effort, energy, etc.) can make all the difference. Same can be said about learning, mastery, habit formation and more – you may not see results for some time but once you cross the threshold of the "phase transition", you might see tremendous results quickly! Hard wood grows slowly and it takes bamboo

years to set up its underground, unseen root structure before it can grow as quickly as it does.

- Technical Description – A system at a critical point has a high degree of connectivity between its subunits – everything depends on everything else. Critical phenomena include scaling relations among different quantities, power-law divergences of some quantities, universality, fractal behavior, ergodicity breaking. Critical phenomena take place in second order phase transition, although not exclusively (like superconductivity).

Self-Organized Criticality (SOC)

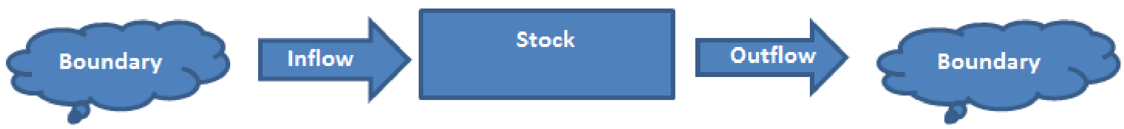
- Analogy – SOC is like a sandpile where grains of sand are slowly added until occasional, unpredictable avalanches occur once the point of criticality is breached.
- Diagram –

- Example – Regularity of catastrophic events (such as earthquakes), fractals (scale invariant properties), 1/f noise, Zipf's Law
- Plain English – Smaller events (such as minor earthquakes) occur predictably more than larger events (disastrous earthquakes) but both at random intervals. This is known as nature's power law and it is a deep, universal truth affecting people, weather, earthquakes, the economy, etc. Same size triggers don't cause same size events (see punctuated equilibrium in Appendix for further detail)
- Technical Description – Systems tend to naturally evolve to a complex, critical state without interference from any external, organizing force. Criticality, and therefore complexity, can and will emerge "for free" without any watchmaker tuning the world. These fluctuations are unavoidable and cannot be repressed over the long-term and the

most efficient systems show (and embrace) fluctuations of all sizes. An over-engineered system may be more efficient for some time but catastrophically unstable. Critical state is the most efficient state that can happen dynamically. Why does it occur all over nature? Because it is robust and efficient!

Systems

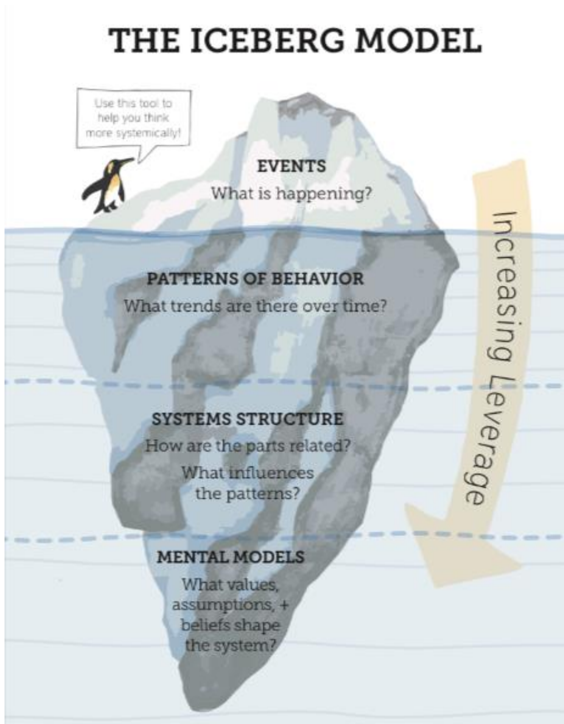
- Analogy – A system is like a feedback loop that can either be very simple or extremely complex and sometimes can change, adapt and evolve based on the feedback received.
- Diagram –



- Example – Economy, ecosystems, food webs, supply and demand – you can think of nearly any ecosystem, relationship or company as a system where feedback is created and either incorporated or ignored, leading to adaptation (or not).
- Plain English – A set of interacting, independent factors forming a complex or intricate whole. Systems cannot be controlled but they can be designed and redesigned – structure always effects function! The best way to deduce a system's purpose is to first watch it for some time to see how it behaves.
- Technical Description – A system is an interconnected set of elements that are coherently organized in a way that delivers something (elements, interconnections, function/purpose). Systems can be self-organizing, self-repairing (up to a point), resilient and many are evolutionary (adaptive). Three typical delays which can cause massive oscillations include perception, response and delivery. Systems work so well due to resilience, self-organization and use of hierarchies (see Appendix for further detail, especially about the importance of hierarchies). Systems fool us by presenting themselves (or we fool ourselves by seeing the world) as a series of events. Like the tip of the iceberg above the water, events are the most visible aspect of a larger complex but not always the most important. We are less likely to be surprised if we can see how events accumulate into dynamic patterns of behavior.

Systems Thinking

- Analogy – Systems thinking is like making a financial model for a company and truly understanding the levers for that particular company and how growth, decline, supply, demand, competition, regulations, innovation, culture, etc. will affect the company's profitability, moat, market share and so on.
- Diagram –

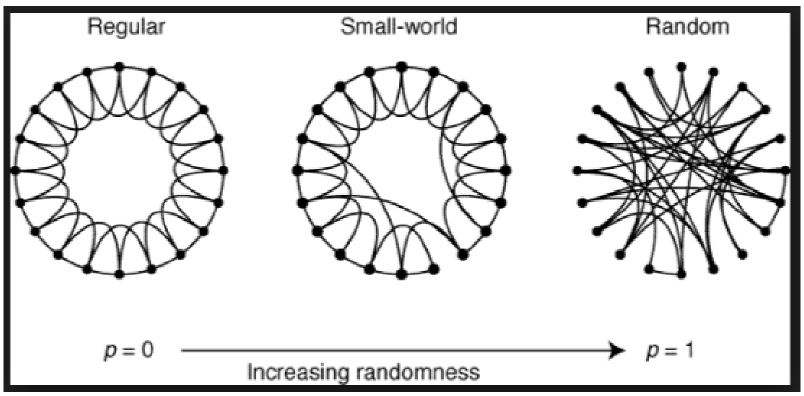


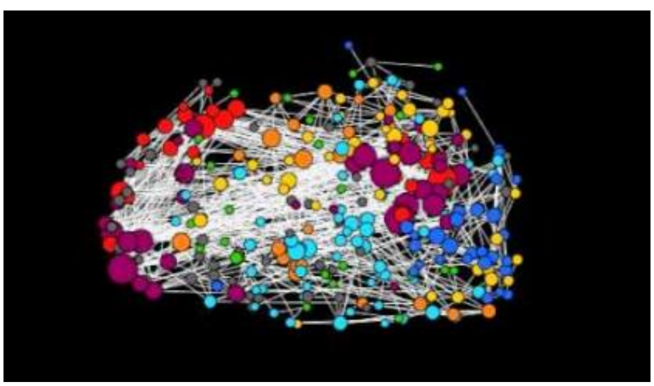
- Example – Holacracy, urban planning, competitive strategy, prisoner's dilemma
- Plain English – Involves truly understanding a system by understanding the linkages and interactions between components that comprise the entirety of that system. It encourages businesses to look at the bigger picture and long-term, sustainable solutions as you must truly understand the root of the problem, the cause, rather than simply the effect.
- Technical Description – Systems thinking involves the use of various techniques to study systems of many kinds. In nature, examples of the objects of systems thinking include living systems in which various levels interact (cell, organ, individual, group, organization, community, earth). In organizations, systems consist of inputs, transformations, outputs, feedback loops, goals, stakeholders, and external influences that operate together to make an organization healthy or unhealthy. Systems engineering is a

discipline that applies systems thinking to design, build, operate, and maintain complex engineered systems. (please see Donella Meadow's *Thinking in Systems* summary in the Appendix for additional detail – especially around leverage points and some guidelines for living in a world of systems.)

Small-World Networks

- Analogy – A small world network is like a social network in that there are few very social people with thousands of connections and many more people with fewer connections.
- Diagram –





- Example – Brain, six degrees of separation, power grid, food chains, underlying architecture of the internet, Wikipedia, Facebook, Google, Amazon, Zillow, LinkedIn, GrubHub

- Plain English – The concept that networks and ecosystems tend to self-organize in such a way that some major players (hubs) connect to many smaller players (nodes) and make transmission of information or any other source of value more efficient.
- Technical Description – A small-world network is a type of mathematical graph in which most nodes are not neighbors of one another, but the neighbors of any given node are likely to be neighbors of each other and most nodes can be reached from every other node by a small number of hops or steps. In the context of a social network, this results in the small world phenomenon of strangers being linked by a short chain of acquaintances. Small-world networks exhibit three central tendencies: short chains, high clustering and scale-free link distributions. This seems to be a universal pattern of complexity as they are resilient, robust, reliable, efficient, effective, cheap. Nature has selected for them for this reason and this type of architecture should be exploited and applied when possible.

Parallel Traced Scan

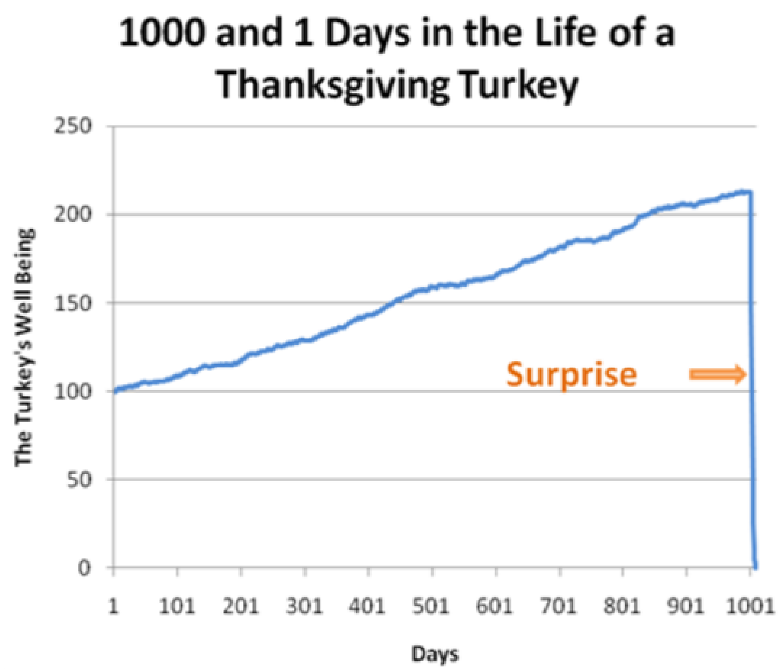
- Analogy – A parallel traced scan is like an ant colony searching for and finding food. The greater the food source, the more ants that will be attracted to it, the more pheromones are left and therefore the more ants will be attracted to the path and a virtuous feedback cycle begins until a new, more lucrative food source is found.
- Diagram –

- Example – Ant colonies, the immune system
- Plain English – Random, unfocused exploration based on little information but as information is obtained and acted on, exploration gradually becomes more deterministic and focused in response to what has been perceived by the system.
- Technical Description – Many, if not all, complex systems in biology have a fine grained architecture, in that they consist of large numbers of relatively simple elements that work together in a highly parallel fashion. Several possible advantages arise out of this type of architecture including robustness, efficiency and evolvability. One additional major advantage is that a fine-grained parallel system is able to carry out a parallel traced scan which is a simultaneous exploration of many possibilities or pathways in which the resources given to each exploration at a given time depend on the perceived success of that exploration at that time. The search is parallel in that many different possibilities are explored simultaneously, but is "terraced" in that not all possibilities are explored at the same speeds or to the same depth. Information is used as it is gained to continually reassess what is important to explore. This balancing act between unfocused exploration and focused exploitation has been hypothesized to be a general property of adaptive and intelligent systems.

Black Swans

- Analogy – A Black Swan is like the Great Financial Crisis in that most people didn't see it coming, it had a large impact and people could only rationalize it and understand it in hindsight.

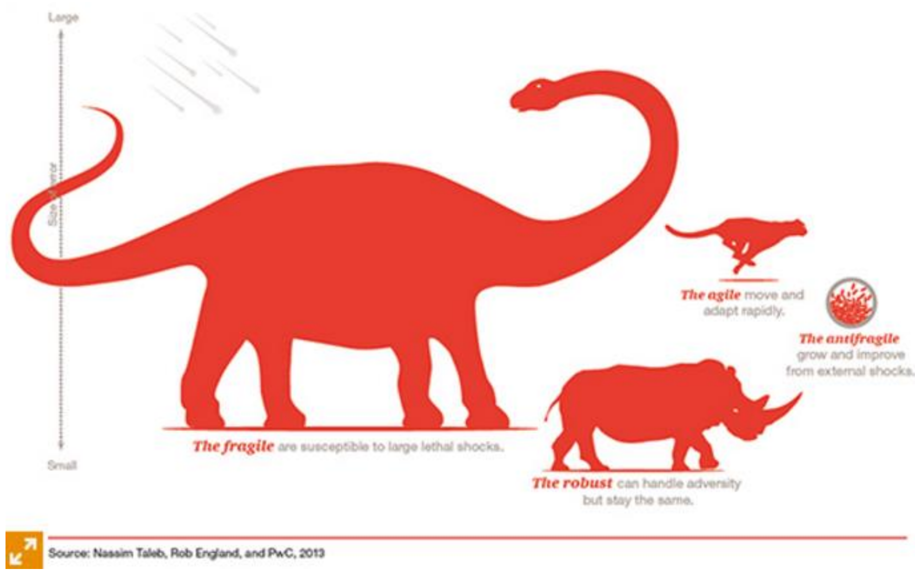
- Diagram –



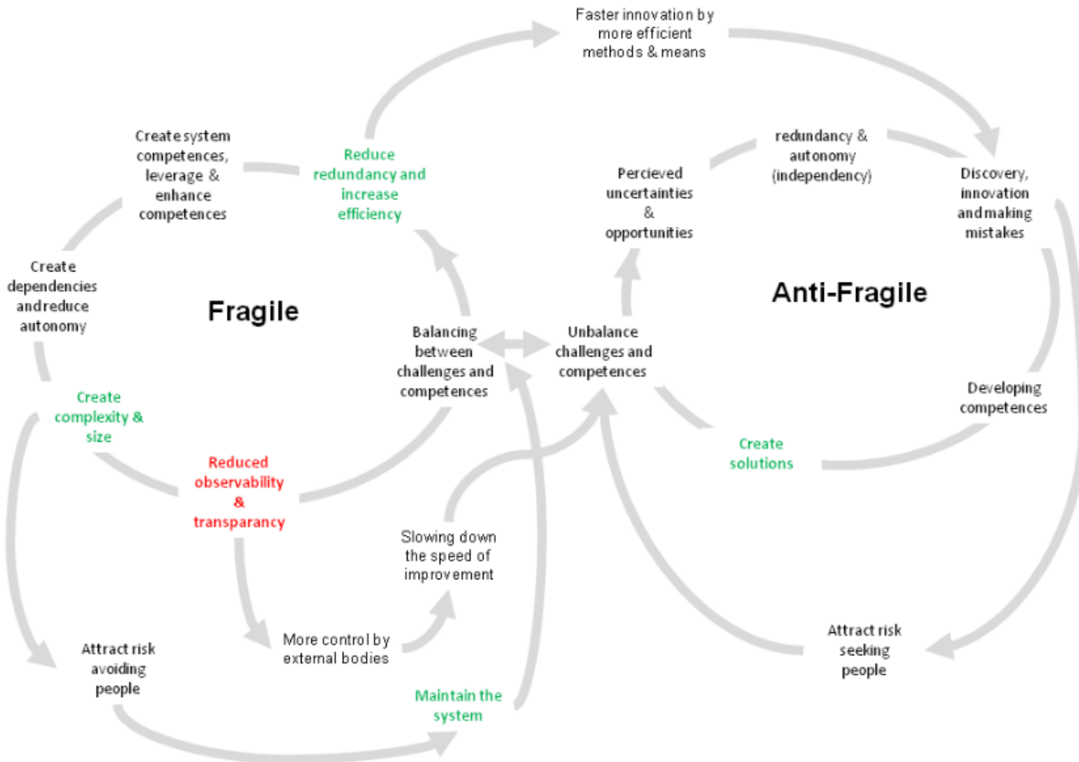
- Example – Assassination of Archduke Ferdinand, death of Alexander the Great and Attila the Hun, Global Financial Crisis
- Plain English – Black Swans are events which almost nobody saw coming, have massive consequences and in hindsight are rationalized and thought to be understood. Trying to exert control over systems can sometimes lead to short-term predictability but will inevitably lead to large corrections.
- Technical Description – Black Swans stem from the use of degenerate metaprobability – mistaking the interpretation of probability for knowledge rather than simply the frequency by which something will occur (please see Appendix for further information as well as how to limit exposure to Black Swans, turn Black Swans into Gray Swans, and how to build robust societies).

Antifragility

- Analogy – Antifragile systems are like vaccinations or working out in that temporary exposure to stressors first breaks us down but once rebuilt, we are stronger than before.
- Diagram –



The Antifragility of Bitcoin



Source: http://www.innoguru.nl/fragile-and-anti-fragile-two-sides-of-the-innovation-coin/

- Example – Evolution is the premier example of antifragility as it thrives with randomness and volatility. Natural things love randomness – up to a point (please see Appendix for more examples of how complexity and antifragility play a role and shape natural systems and biology).
- Plain English – Antifragile systems get better with chaos and disorder and improves with time whereas anything fragile hates volatility.
- Technical Description – Antifragility is a nonlinear, convex response to a stressor or source of harm (for some range of variation), leading to a positive sensitivity to increase in volatility (or variability, stress, dispersion of outcomes, or uncertainty, what is grouped under the designation "disorder cluster"). Likewise, fragility is defined as a concave sensitivity to stressors, leading a negative sensitivity to increase in volatility. The relation between fragility, convexity and sensitivity to disorder is mathematical, obtained by theorem, not derived from empirical data mining or some historical narrative. It is a priori.

Teacher's Reference Guides

My "teacher's reference guides" are deep dives into a subject, theme, person, or idea which are then distilled into (hopefully) clear, concise, and helpful resources. My goal is to effectively share what I think are the most actionable, impactful, and noteworthy takeaways of the topic at hand.

There isn't much rhyme or reason to how I choose these teacher's reference guides. Sometimes I want to dive deep on a specific concept such as complexity and spend months reading about that and sometimes I simply stumble across a person or topic randomly which captures my attention – trying to balance serendipity and chaos with routine and order.

You can find a full sampling of my teacher's reference guides (blas.com/teachers-reference-guides/) on my blog, blas.com.

If any of this is of interest, you can subscribe to the monthly newsletter (http://blas.com/newsletter/) and you can always reach out to me directly at rabbithole@blas.us

Amor Fati.

Blas

Appendix

1. *Thinking in Systems* by Donella Meadows
2. *Sync: How Order Emerges from Chaos in the Universe, Nature and Daily Life* by Stephen Strogatz
3. *Deep Simplicity* by John Gribbin
4. *Hidden Order* by John Holland
5. *The Black Swan* by Nassim Taleb
6. *Antifragile* by Nassim Taleb
7. *Complexity: The Emerging Science at the Edge of Order and Chaos* by Mitchell Waldrop
8. *How Nature Works* by Per Bak
9. *Complexity: A Guided Tour* by Melanie Mitchell
10. *At Home in the Universe* by Stuart Kauffman
11. *Investing: The Last Liberal Art* by Robert Hagstrom
12. *The Fifth Discipline* by Peter Senge
13. *A Simple Guide to Chaos and Complexity*

Hidden Order: How Adaptation Builds Complexity by John Holland

Summary

1. Holland walks us through how coherence emerges from unstructured agents in environments of continuous flux; coherence under change and complex adaptive systems (CAS)

Key Takeaways

1. Behavior depends much more upon interactions of agents than their actions
2. Catalog of all activities does not equal understanding the effect of changes in the ecosystem
3. Many complex systems show coherence in face of change through extensive interactions, aggregation of diverse elements and learning/adaptation
    1. **Must understand the interactions and dynamics of the system before can hope to make any significant, lasting changes**
4. Theory can help detect lever points where small changes lead to big outcomes - Amplifier Effect
    1. **Cross-disciplinary comparisons are vital as subtle characteristics in one context can be easily drawn out in others**
5. CAS systems made up of a large number of active elements diverse in form and capability
    1. Makes system stronger and more robust. Weeding out weak actors so that only the strong remain counter-intuitively leads to worse performance
6. Rules are used to describe agent's strategies - few, simple rules can lead to complex behavior
    1. A major part of the modeling effort for any CAS, then, goes into selecting and representing stimuli and responses, because the behaviors and strategies of the component agents are determined thereby. Once we specify the range of possible stimuli and the set of allowed responses for a given agent, we have determined the kinds of rules that agent can have
7. Adaptation - process by which an organism best fits itself to its environment
    1. Time scale of adaptation varies drastically and they are very important to take into account in any system (humans vs. trees)
        1. The fast dynamics will shape the slow

2. Overall, we will view CAS as systems composed of interacting agents described in terms of rules. These agents adapt by changing their rules as experience accumulates. In CAS, a major part of the environment of any given adaptive agent consists of other adaptive agents, so that a portion of any agent's efforts at adaptation is spent adapting to other adaptive agents, co-evolution (Red Queen). This one feature is a major source of the complex temporal patterns that CAS generate

8. The 7 Basics
    1. Aggregation
        1. Simplifies complex systems by grouping similar things which leads to constructing models as these are prime building blocks
        2. Emergence of complex, large-scale behavior from aggregate of small, simpler behaviors (ants and "intelligent" ant colony)
    2. Tagging
        1. Facilitates the formation of aggregates as tags manipulate symmetries (flag as a rallying cry which helps group people together)
        2. Tags enable us to observe and act on properties previously unobservable due to symmetries (spinning white cue ball harder to spot but when a stripe is added you can easily tell in which direction it is rotating)
        3. Facilitates selective interaction - filtering, specialization, cooperation leads to emergence of meta-agents and organizations through individual agents are always changing
        4. Tags are the mechanism behind hierarchies
    3. Non-linearity
        1. whole is greater than the sum of the parts
        2. Behavior in aggregate more complex than the parts would indicate
    4. Flows
        1. Nodes (processors, agents), connectors (designate possible interactions), Resource
        2. Adapt as time elapses and experience accumulates
        3. Tags almost always define the network by delimiting the critical interactions, the major connections. Tags acquire this role because the adaptive processes that modify CAS select *for* tags that mediate useful interactions and *against* tags that cause malfunctions
        4. Multiplier Effect - resource injected in one node spreads over network which leads to chain of changes (big in network/flows modeling)

        5. Recycling Effect - the effect of cycles in the network can drastically increase output of the system over time as the system retains resources and these resources can be further exploited as they offer new niches to be exploited by new kinds of agents. This process leads to increasing diversity through increasing recycling (virtuous cycle)
5. Diversity
    1. Each agent fills a niche which is determined based on interactions centering on that agent
    2. Nature abhors vacuums and will fill empty niche with new agent - typically similar in form and habit (the convergence effect, mimicry)
    3. CAS systems get diverse via adaptation which leads to further interactions and new niches - symbiosis, parasitism, mimicry, biological arms races
    4. **Perpetual novelty is a hallmark of CAS**
6. Internal models
    1. Mechanisms CAS used to anticipate - eliminate details so that selected patterns are emphasized. Agent must select patterns in the torrent of input it receives and then must convert those patterns into changes in its internal structure
        1. A model allows us to infer something about the thing modeled
    2. Tacit and overt models
        1. Tacit simply prescribes a current action, under an implicit prediction of some desired future state
        2. Overt model is used as a basis for explicit, but internal, explorations of alternations, a process often called *lookahead*
    3. Natural selection selects for better internal models
7. Building blocks
    1. Deconstruct complex problem into simpler parts which can be used and reused in different circumstances
    2. **The search for powerful building blocks is the most effective way to make the best internal models**
        1. **We can a significant advantage when we can reduce the building blocks at one level to interactions and combinations of building blocks at a lower level: the laws at the higher level derive from the laws at the lower level building blocks. This does not mean that the higher level laws are easy to discover but it does add a tremendous interlocking strength to understanding systems and hierarchies**

9. CAS exhibit coherence under change via conditional action and anticipation and do so with no central controller.
10. Can discover lever points if can uncover general principles which govern CAS dynamics
11. Agents must act somewhat similarly if a uniform approach to CAS is feasible
12. Adaption - a rule's ability to win based on its usefulness in the past - older rules are likely best as they've been tested by time
    1. Credit Assignment to best rules easiest when have immediate feedback - tests the rule's utility
        1. Bucket Brigade - the credit assignment procedure which strengthens rules that belong to chains of action terminating in rewards
    2. Agent should prefer rules which use more information about a situation
        1. Higher specificity leads to stronger rules (higher in the hierarchy)
    3. Default hierarchy - early on, agents will depend on overly general default rules that serve better than random actions. As experience accumulates, these internal models will be modified by adding competing, more specific exception rules. These will interact symbiotically with the default rules and the resulting model is called a default hierarchy. Default hierarchies expand over time from general default to specific exceptions (the young man knows the rules, the old man the exceptions)
    4. Adaptation by rule discovery - trial and error may work but doesn't leverage system experience
        1. Plausibility - take strong rules and apply to new areas which seem promising
            1. Innovation / creativity - simply combining tested building blocks in new ways
    5. Recombination of rules leads to discovery and occasionally mutation which can produce a more fit offspring
        1. More fit building blocks are used more frequently which are then passed on more often to succeeding generations
        2. More complicated building blocks usually formed by combining simpler blocks
            1. The higher levels are typically composed of well-tested, above-average simpler blocks. Over time, the hierarchy becomes more elaborate, providing for the persistence of still more complex behavior. A
        3. **Reproduction, recombination and replacement (genetic algorithm) found in nearly every CAS system**

4. Implicit parallelism - individuals (no matter how great) don't recur but their building blocks do
    1. Evolution "remembers" combinations of building blocks which increase fitness
5. Discovery of new building blocks leads to a slew of new innovations (punctuated equilibrium)

13. With any model, must know what has been emphasized (exaggerated) to make a point and what has been left out to keep focused on that point
14. **Hierarchy -** the appearance of new levels of an organization in this evolution depends on one critical ability: each new level must collect and protect resources in a way that outweighs the increased cost of a more complex structure. If the seeded aggregate collects resources rapidly enough to "pay" for the structured complexity, the seed will spread.
15. Successful approach to any theory - interdisciplinary; computer-based thought experiments, a correspondence principle (models should encompass standard models from prior studies in relevant disciplines); a mathematics of competitive processes based on recombination

What I got out of it

1. Fascinating book on how the universe seems to produce order for free via coherence, spontaneous self-organization and complex adaptive systems.

Investing: The Last Liberal Art by Robert Hagstrom

Summary

1. Hagstrom walks the reader through why and how to incorporate fundamental principles from multiple fields to become a better thinker, decision maker, investor, etc.

Key Takeaways

1. Worldly Wisdom
    1. Combine key ideas from all disciplines and then develop a latticework in head to 'hang' all mental models on
    2. Chances of good decisions improve when many, disparate models yield the same conclusion
    3. Educate self and then train to see problems by seeing/thinking differently
        1. Learn big ideas so well that they are always with you
    4. Key is finding linkages and connecting one idea to another
        1. Connectionism - we learn by analogy, more connections leads to more intelligence
        2. Massive number of connections more efficient than raw speed (small world networks are everywhere)
    5. Two keys to innovative thinking - understand basic disciplines we draw knowledge from and be aware of the benefits and uses of metaphors
        1. Concise, memorable, colorful way to depict thought, action, ideas and more importantly translate ideas into models - stimulating understanding and new ideas
2. Physics
    1. The bridge between equilibrium in physics, economics and the stock market
    2. Equilibrium - state of balance between two opposing forces, powers or influences
        1. Static vs. dynamic
        2. Rational actions lead to stock market equilibrium - where the shadow price (intrinsic value) = stock price
            1. Now argue market is complex adaptive system - a network of many individual agents all acting in parallel and interacting with one another. The critical variable that makes a system both complex and adaptive is the idea that agents in the system accumulate experience

by interacting with other agents and then change themselves to adapt to a changing environment

1. Irrational, organic, not efficient

3. Biology
    1. Evolution and natural selection to law of economic selection
    2. After crashes, market and economy best understood from a biological perspective as equilibrium could not account for them
    3. Struggle between species and individuals of same species leads to natural selection and evolution
    4. Schumpter - economics essentially an evolutionary process of continuous and creative destruction
        1. Innovation, a visionary and action-oriented entrepreneur and access to credit are all necessary
        2. Innovation leads to periods of punctuated equilibria - creative destruction
    5. 4 distinct features of economy
        1. Dispersed interaction - what happens in the economy is determined by the interactions of a great number of individual agents all acting in parallel
        2. No global controller
        3. Continual adaptation (co-evolution)
        4. Out of equilibrium dynamics - constant change leads to a system constantly out of equilibrium
    6. Evolution takes place sin stock market via economic selection and capital allocation
    7. Living systems make themselves up as they go along
    8. Efficiency and evolutionary / behavioral not necessarily exclusive - times of less emotions leads to more efficient market
4. Sociology
    1. Study of how individuals function in society and ultimate goal is predicting group behavior
    2. Relationship between individual investor and stock market a profound puzzle
    3. All human interactions and systems are complex adaptive - can't separate part from the whole and behavior constantly changes as agents and therefore system adapts
    4. Self-organization and self-reinforcement found in physics, biology, economics, etc.
    5. Emergence - larger entities arise out of interactions of simpler, smaller entities and have characteristics that the smaller entities do not exhibit

        1. Crowds can be collectively intelligent IF diverse and independent
        2. Smart and dumb agents lead to better outcomes than a group of just smart people
        3. Information cascades, which lead to diversity breakdowns happen when people make decisions based on others rather than private information and leads to inefficient system
            1. Can even happen with small groups if have a very dominant leader
        4. Self-organized criticality - market one example where instability is inherent, unpredictable and small fluctuations lead to big changes
            1. Different meta-models of reality (quant vs. fundamentally oriented...) leads to instability
        5. Complex adaptive, self-organization leads to emergence which leads to instability, unpredictability, criticality
5. Psychology
    1. Anchoring, framing, overreaction, overconfidence, mental accounting, loss aversion key biases
    2. Equity risk premium is puzzling - people hold bonds because of loss aversion and mental accounting
    3. Loss aversion makes people short-term focused
    4. Longer investor holds an asset, the more attractive it becomes IF not evaluated frequently - advises checking prices only once per year!
    5. Information overload can lead to illusion of knowledge
    6. Don't be Walter Mitty investor - feed during difficult times!
    7. Decisions we make based on skill lead to higher risk taking and luck to lower
    8. Mental models are imprecise ways of modeling reality but very helpful and simplify life
        1. Mistakes - believe models equiprobable, focus on few or one, ignore what is not easily seen
    9. Innate pattern seeking leads to magical thinking and superstitions by people trying to explain the unexplainable
        1. In this case, beliefs precede reasoning, beliefs dictate what you see
            1. Why people listen to forecasters - quells anxiety we hate to live with even if we rationally know how stupid it is
    10. Reduce noise via accurate communication of information makes for better rational decisions

        1. Correction device - get information from first-hand sources and then do your best to remove prejudices and biases
6. Philosophy
    1. Forces us to think and can't be transferred intact from one mind to another
    2. Metaphysics - ideas independent of space and time (God, afterlife)
    3. Aesthetics / ethics / politics three main branches
    4. Epistemology - study of the nature/limits of knowledge; thinking about thinking
        1. Develop rigorous, cohesive epistemological routines
    5. **Failure to explain caused by failure to describe - Mandelbrot**
    6. Disorder simply order misunderstood
    7. **Wittgenstein - world we see is defined and given meaning by the words we choose**
        1. Reality is shaped by the words we select
        2. Stories very powerful description tools - beware of the overconfidence they can deliver
    8. Pragmatism - true belief defined by actions and habits it produces (William James)
        1. Idea or action is real, good, true if it makes a meaningful difference
            1. Our understanding of truth evolves as it is based on results
            2. No absolutes
7. Literature
    1. Read selectively but analytically
    2. Always evaluate its worth in the larger picture and then either reject or incorporate what you learn into your mental models - the importance of reflection!
    3. Improves understanding (over fact collecting) and critical thinking
    4. Critical mindsets evaluate the facts and separate facts from opinion
    5. Fiction important because it helps us learn from others' experiences
    6. Detectives best practices
        1. Develop a skeptic's mindset; don't automatically accept conventional wisdom
        2. Conduct a thorough investigation
        3. Begin an investigation with an objective and unemotional viewpoint
        4. Pay attention to the tiniest details
        5. Remain open-minded to new, even contrary, information
        6. Apply a process of logical reasoning to all you learn
        7. Become a student of psychology
        8. Have faith in your intuition
        9. Seek alternative explanations and redescriptions

8. Mathematics
    1. Bayes' Theorem - updating initial beliefs with new information leads to new and improved belief
        1. AKA Decision Tree Theory
    2. Probability theory - analysis of random phenomena
    3. Kelly Criterion - how to size bets
        1. 2p - 1 = x (p = probability of winning)
        2. To compensate people not having an infinite bankroll or time horizon, halve (or take some fraction) of the Kelly Criterion
    4. Never fail to take variation into account - trends of system vs. trends in system (individual winners even during sideways overall market)
    5. Never fail to take into account regression to the mean
9. Decision Making
    1. Intuition helpful when situation is reliable enough to be predictable and when can learn regularities through prolonged practice (mostly linear systems)
        1. Intuition nothing more than recognition - increase store of knowledge and connections leads to improved intuition
    2. How you think more important than what you think
    3. Humans cognitive misers and stop thinking the minute they're satisfied with an answer
    4. Building blocks from many disciplines used to form mental models must be dynamic and updated with new information

What I got out of it

1. A fascinating read which was helpful to get a good, broad understanding of what it means to be a multi-disciplinary learner

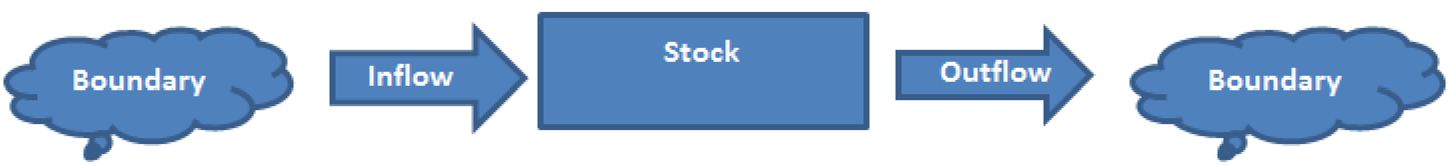
Thinking in Systems by Donella Meadows

Summary

1. A primer on problem solving on scales from local to global, how systems exist and react in the real world while acknowledging that all models are false although they help us simplify and at times make better predictions

Key Takeaways

1. **System** - interconnected set of elements that is coherently organized in a way that delivers something (elements, interconnections, function/purpose)
    1. Systems can be self-organizing, self-repairing (up to a point), resilient and many are evolutionary (adaptive)
    2. Intangibles (such as school pride) are also part of systems
    3. Best way to deduce a system's purpose is to watch it for some time to see how it behaves (avoid rhetoric and stated goals)
    4. Important function of nearly every system is its own perpetuation



1. Systems thinking transcends disciplines and cultures and when it is done right, it over arches history as well
2. **Systems work so well due to:**
    1. **Resilience** - ability to survive and persist in a variable environment
        1. Resilience in a system is restored through balancing feedback loops through different mechanisms, at different time scales and with redundancy
        2. A set of feedback loops that can restore or rebuild feedback loops is resilience at a still higher level - meta-resilience
        3. Even higher meta-meta-resilience comes from feedback loops that can learn, create, design and evolve ever more complex restorative structures. Systems that can do this are self-organizing

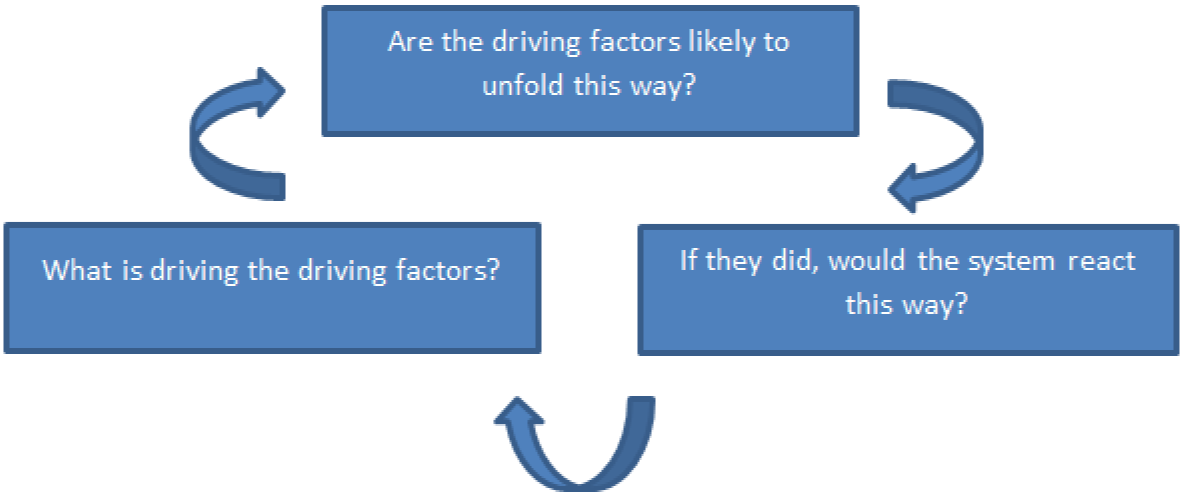
4. A resilient system has a big plateau, a lot of space over which it can wander, with gentle, elastic walls that will bounce it back, if it comes near a dangerous edge. As a system loses resilience, this plateau shrinks
5. Resilience often coupled with dynamism as static systems tend to become fragile

2. **Self-organization** - leads to complexity, heterogeneity and unpredictability
    1. Like resilience, often sacrificed for productivity/short-term gain but drastically increases fragility of the system overall
    2. Few, simple organizing principles can lead to wildly different self-organizing outcomes
3. **Hierarchy** - arrangement of systems and subsystems
    1. Complex systems can evolve from simple systems only if there are stable intermediate forms. The resulting complex forms will naturally be hierarchical. That may explain why hierarchies are so common in the systems nature presents to us. Among all possible complex forms, hierarchies are the only ones that have had the time to evolve
    2. Hierarchies are brilliant systems inventions, not only because they give a system stability and resilience, but also because they reduce the amount of information that any part of the system has to keep track of. In hierarchical systems relationships within each subsystem are denser and stronger than relationships between subsystems. Everything is still connected to everything else, but not equally strongly. If these differential information links within and between each level of the hierarchy are designed right, feedback delays are minimized. No level is overwhelmed with information. The system works with efficiency and resilience
    3. Hierarchies are partially decomposable and much can be learned by taking apart systems at different hierarchical levels and studying them separately
    4. Hierarchies evolve from the lowest level up. The original purpose of a hierarchy is always to help its originating subsystems do their jobs better. This is something which is easily forgotten and leads to malfunctioning hierarchies (suboptimal systems)

3. **External solutions help solve many problems (such as vaccines) but those deeply embedded in the internal structure of systems won't go away unless we see the problem holistically, see the system as the cause of the problem and restructure it**

4. **Individual rationalism can lead to collective insanity** - why things happen much faster or slower than people expect and why systems can unexpectedly jump into a behavior you've never seen before (leaping emergent effects)
5. **Archetypes** - common structures which produce characteristic behaviors
6. **The behavior of a system cannot be known just by knowing the elements of which the system is made**
7. **Stock** - accumulation of material over time, a memory of the history of changing flows in the system
8. **Dynamics** - behavior over time
    1. Dynamic equilibrium stays the same though it is always changing (inflows exactly equal outflows)
9. **People tend to focus more on stock than flows** (> inflow = < outflow)
    1. Stocks take time to change because flows take time to flow
    2. Changes in stocks set the pace of the dynamics in the system
    3. Stocks allow inflows and outflows to be decouple, independent and temporarily out of balance
        1. World is a collection of feedback processes
    4. **The gap, discrepancy, between current and ideal state drives feedback loops and the bigger the gap the stronger the feedback loop**
10. **1 stock system** - system with two competing, balancing loops (thermostat)
    1. The bigger the gap (between hot and cold in this case) the bigger the outflow
11. **Shifting dominance** - one loop dominates and therefore drives behavior, oscillations and complex behavior
12. **Systems with similar feedback structures produce similar dynamic behavior**
13. 3 typical delays - perception, response, delivery
    1. These delays cause small changes to turn into massive oscillations
14. 2 stock systems
    1. Renewable stock constrained by a non-renewable one (oil)
        1. Look for loops driving system and the loop that will ultimately constrain it (can be temporary, permanent and/or more than one)
    2. Renewable constrained by renewable (fishing)
15. 3 important questions to ask to test the value of any model
    1. Are the driving factors likely to unfold this way?
    2. If they did, would the system react this way?
    3. What is driving the driving factors?

4. Model utility depends not on whether its driving scenarios are realistic (since no one can know for sure), but on whether it responds with a realistic pattern of behavior



1. **Why hierarchies surprise us**
    1. **Everything we think we know about the world is a model (language, maps, books, databases, equations, computer programs, mental models) - nothing will ever be the real world**
    2. Our models usually have a strong congruence with the real world
        1. Systems fool us by presenting themselves (or we fool ourselves by seeing the world) as a series of events. Like the tip of the iceberg above the water, events are the most visible aspect of a larger complex but not always the most important. We are less likely to be surprised if we can see how events accumulate into dynamic patterns of behavior
        2. The behavior of a system is its performance over time - growth stagnation, decline, oscillation, randomness, evolution
        3. **When a systems thinker encounters a problem, the first thing he does is look for data, item graphs, the history of the system. That's because long-term behavior provides clues to the underlying system structure. And structure is the key to understanding not just what is happening but why**

        1. Systems thinkers try to understand the connections between events and the resulting behavior and the mechanical characteristics of the structure
        2. Behavior based models are more useful than event based models but still flawed as they over focus on flows and under emphasize stocks. There is also no reason to expect any flow to bear a stable relationship to any other flow
    4. We are in sufficiently skilled at seeing in systems' history the clues to the structures from which behavior and events flow
2. Non-linear relationships do not change in proportion and changes the relative strength of the feedback loops (shifting dominance)
3. **Greatest complexities occur exactly at the boundaries - sources of diversity and creativity**
    1. Boundaries are false, man-made but necessary to simplify and comprehend systems
4. **Most important input in a system is the one that is most limiting**
5. Growth itself depletes or enhances limits and therefore changes the limits themselves
6. **Bounded rationality** - people make reasonable decisions based on information they have but since it is imperfect it leads to bad outcomes
    1. Change comes first from stepping outside the limited information that can be seen from any single place in the system and getting an overview. From a wider perspective, information flows, goals, incentives and disincentives can be restructured so that separate, bounded rational actions do add up to results that everyone desires. It's amazing how quickly and easily behavior changes can come, with even the slightest enlargement of bounded rationality, by providing better, more complete, timelier information
    2. What makes a difference is redesigning the system to improve the information, incentives, disincentives, goals, stresses, and constraints that have an effect on specific actors. Must change the structure to change the behaviors
    3. However, and conversely, our models fall far short of representing the world fully
7. **You can't navigate well in an interconnected, feedback-dominated world unless you take your eyes off short-term events and look for long-term behavior and structure; unless you are aware of false boundaries and bounded rationality; unless you take into account limiting factors, nonlinearities and delays. You are likely to mistreat, mis-design, or misread systems if you don't respect their properties of resilience, self-organization and hierarchy**
8. 3 ways to deal with policy resistance - overpower it, totally let go or find ways to align the goals of all the subsystems involved

1. **Tragedy of the commons** - invisible or too long delayed feedback (educate / exhort, privatize or regulate the commons)
2. **Drift to low performance**
    1. The trap is allowing performance standards to be influenced by past performance, especially if there is a negative bias in perceiving past performance. It sets up a reinforcing feedback loop of eroding goals that sets a system drifting to low performance
    2. Solution - Keep performance standards absolute and let standards be enhanced by the best actual performances instead of being discourage by the worst. Use the same structure to set up a drift of high performance
3. **Escalation** - avoiding falling into it in the first place but if you are, refuse to compete or negotiate a new system with balancing loops to control the escalation
4. **Success to the successful** - winners keep winning and enhance prospects of future prosperity. Diversification, strict limitation on the fraction of the pie any one winner may win (antitrust laws), policies leveling the playing field, policies that devise rewards for success that do not bias the next round of competition all good solutions
5. **Addiction** - beware of symptom relieving or signal denying policies or practices that don't really address the problem. Take the focus off short-term relief and put it on long-term restructuring
6. **Rule beating** - design, or redesign, rules to release creativity you not in the direction of beating the rules, but in the direction of achieving the purpose of the rules
7. **Seeking the wrong goals** - specify indicators and goals that reflect the real welfare of the system. Be especially careful not to confuse effort with result or you will end up with a. System that is producing effort, not results.

9. **Leverage point** - point in system where a small change can lead to big shift in behavior
    1. The leverage point is often hidden and counterintuitive
    2. 12 examples of leverage points (from least to most effective)
        1. **Numbers** - constants and parameters such as subsidies, taxes and standards
            1. Least effective as changing these variables rarely changes the behavior of the system
        2. **Buffers** - the sizes of stabilizing stocks relative to their flows
            1. Big stocks relative to their flows are more stable than small ones
            2. Often stabilize a system by increasing the capacity of the buffer but if the buffer gets too big, the system gets inflexible
        3. **Stock and flow structures** - physical systems and their nodes of intersection

   1. The stocks and flows and their physical arrangement can have a tremendous effect on how the system operates
   2. The only way to fix a system that is laid out poorly is to rebuild it, if you can
4. **Delays** - the lengths of time relative to the rates of system changes
   1. A delay in the feedback process is critical relative to rates of change in the stocks that the feedback loop is trying to control
   2. High leverage point except that delays are not often easily changeable
   3. Usually easier to slow down the change rate so that inevitable feedback delays won't cause much trouble or oscillations
5. **Balancing feedback loops** - the strength of the feedback is important relative to the impacts they are trying to correct
   1. **One of the big mistakes is removing these "emergency" response mechanisms because they aren't often used and they appear to be costly. May be no effect in the short-term but in the long-term you drastically reduce the range of conditions over which the system can survive**
   2. For people, this means reducing personal rest, recreation, socialization, meditation, etc. for short-term productivity over long-term health
6. **Reinforcing feedback loops** - the strength of the gain of driving loops
   1. Reinforcing loops are sources of growth, explosion, erosion and collapse in systems
   2. Slowing the growth is usually a more powerful leverage point in systems than strengthening balancing loops and far more preferable than letting the reinforcing loop run
7. **Information flows** - the structure of who does and does not have access to information
   1. A new feedback loop to a place it wasn't going before
8. **Rules** - incentives, punishments, constraints
   1. **Rules are high leverage points. Power over rules is real power**
   2. **If you want to understand the deepest malfunctions of systems, pay attention to the rules and who has power over them**
9. **Self-organization** - the power to add, change or evolve system structure

        1. The ability to self-organize is the strongest form of system resilience as it can evolve and survive almost any change, by changing itself
    10. **Goals** - the purpose or function of the system
        1. **Everything further down the list from physical stocks and flows, feedback loops, information flows, even self-organizing behavior will be twisted to conform to the goal**
        2. **Single players who can change the system goal can affect the whole system**
    11. **Paradigms** - the mind-set out of which the system (it's goals, structure, rules, delays, parameters) arises
        1. Paradigms are the source of systems and harder to change than anything else about the system
        2. Best chance to change paradigms is to keep pointing at the anomalies and failures in the old paradigm
        3. **Must get outside the system and force you to see the system as a whole (Galilean Relativity)**
    12. **Transcending paradigms**
        1. Keeping oneself unattached in the arena of paradigms, to stay flexible, to realize that no paradigm is "true" gives a tremendous source of perspective when dealing with systems
10. **Systems can't be controlled but they can be designed and redesigned**
11. **Guidelines for living in a world of systems**
    1. **Get the beat of the system** - observe how it behaves before disturbing it. Forces you to focus on facts and long-term behavior rather than rhetoric and theories
    2. **Expose your mental models to the light of day** - judicious testing of theories allows you to faster admit uncertainties and correct mistakes leading to more flexibility. Mental flexibility, the willingness to redraw boundaries, to notice that a system has shifted into a new mode, to see how to redesign structure, is a necessity when you live in a world of flexible systems
    3. **Honor, respect and distribute information**
    4. **Use language with care and enrich it with systems concepts** - keep it concrete, meaningful and truthful
    5. **Pay attention to what is important, not just what is quantifiable** - quality over quantity and never ignore a part of a system just because it can't be counted
    6. **Make feedback policies for feedback systems**

7. **Go for the good of the whole** - don't optimize something which shouldn't be done at all
8. **Listen to the wisdom of the system**
9. **Locate responsibility within the system** - design systems which are accountable for its own actions
10. **Stay humble, stay a learner** - acknowledging uncertainty leads to more credibility
11. **Celebrate complexity**
12. **Expand time horizons**
13. **Defy the disciplines** - be a multidisciplinary learner and thinker
14. **Expand the boundary of caring**
15. **Don't erode the goal of goodness**

What I got out of it

1. Systems consist of boundaries, inflows, stocks, and outflows. Must understand the structure and goals of the system as this affects its behavior and function. Systems work well due to resilience, self-organization and hierarchies. Delays (perception, response, delivery) cause oscillations and often people take the wrong course of action and cause higher oscillation. 3 important questions to test the value of any model. Focus on leverage points. Must take a long-term view and focus on the history of behavior to understand how and why systems function the way they do

Complexity: The Emerging Science at the Edge of Order and Chaos by Mitchell Waldrop

Summary

1. Explanations of complexity, self-organization, emergence, order and chaos and some of the pioneers behind this work. It also details the history of the Santa Fe Institute

Key Takeaways

1. Complex systems - many individual agents interacting and outcomes difficult to predict
    1. Complexity is the science of emergence
2. Spontaneous self-organization (organization with no central conductor) found all over nature
    1. Complex systems all over nature have somehow acquired ability to bring order and chaos into a special kind of balance - the edge of chaos. The components of the system never lock into place yet never dissolve into turbulence either. the edge of chaos is where life has enough stability to sustain itself and enough creativity to deserve the name of life. The edge of chaos is where new ideas and innovative genotypes are forever nibbling away at the edges of the status quo and where even the most entrenched old guard will eventually be overthrown; where eons of evolutionary stability suddenly give way to wholesale species transformation. the edge of chaos is the constantly shifting battle zone between stagnation and anarchy, the one place where a complex system can be spontaneous, adaptive and alive.
    2. Self-organization is the most powerful force in biology and living systems operate at the edge of chaos
        1. Evolution always seems to lead to the edge of chaos
3. Them that has, gets - domino effect once tipping point hits leads to cascades and often winner-take-all systems
4. The crucial skill is insight. The ability to see connections
5. At some fundamental level that Brian Arthur didn't yet understand, the phenomena of physics and biology are the same
    1. Self-organization found everywhere! - positive feedback, increasing returns, lock-in (more niches dependent on a technology, the harder it is to change that

technology until something vastly better comes along), unpredictability, tiny events that have immense consequences all seem to be a re-requisite for life itself

6. Must look at world how it is, not as some elegant theory says it ought to be
7. Essence of science lies in explanation more than prediction
8. Increasing returns prominent when marginal cost is minimal (software for example)
9. Nearly everything and everybody caught up in non-linear web of incentives, constraints and connections
10. Innovations never happen in a vacuum and often come from someone who is outside the field
11. Catalysis everywhere and life wouldn't be possible without it - molecules could have catalyzed the formation of other molecules so that those in the web would have taken over. The web would keep growing and would have catalyzed its own formation, it would become an autocatalytic set - order for free
    1. Autocatalytic set can bootstrap its own creation and evolution by growing more and more complex over time and will also experience booms and busts from small changes
12. Complex adaptive systems - characterized by perpetual novelty; dispersed, hierarchical, learn / adapt / evolve, anticipate the future
    1. Can never get to equilibrium as new opportunities are always being created by the system - always unfolding, always in transition
13. Emergence is hierarchical - building blocks at one level combining into new blocks at a higher level. Hierarchies are one of the fundamental organizing principles of the world. Found everywhere because a well-designed hierarchy is an excellent way of getting some work done without any one person being overwhelmed or having to know everything. Also, utterly transforms a system's ability to learn, evolve and adapt - can reshuffle building blocks and take giant leaps. Can describe a great many complicated things from relatively few building blocks
14. Adaptive agents always playing game with environment for fitness requires feedback and prediction
    1. In order to learn, must be able to take advantage of what the world is trying to tell it
15. Implicit expertise - a huge, interlocking set of standard operating procedures that have been inscribed on the nervous system and refined by years of experience
    1. Competition much more essential than consistency

    2. Competition and cooperation may seem antithetical but at some very deep level, they are two sides of the same coin (leading to symbiosis across nature, tit for tat strategy)
16. Self-reproduction requires medium to be both data and instructions (DNA)
    1. von Neumann and cellular automata
17. Spectrums:
    1. Dynamical systems: Order - Complexity - Chaos
        1. Complexity is emergent, dynamical, characterized by phase transitions
        2. Interesting things always happen at the edge of chaos
    2. Matter: Solid - Phase Transition - Liquid
        1. First and second order phase transitions - sharp and precise phase transitions (molecules forced to make either or choice between order and chaos) compared to second order which is much less common in nature - much less abrupt because molecules don't need to make an either-or choice, they combine order and chaos (fluid with pockets of solid or vice versa)
    3. Computation: Halting - "Undecidable" - Nonhalting
    4. Life: too static - "life / intelligence" - too noisy
18. Life is based to a great degree on its ability to process and store information and then mapping it out to determine proper action
19. Always ask, "**optimal relative to what?**"
20. Artificial life - effort to understand life by synthesis, putting together simple pieces to generate lifelike behavior in man-made systems. Its credo is that life is not a property of matter per se, but the organization of that matter
    1. **'Aliveness' lies in the organization of the molecules and not the molecules themselves**
    2. Fact that simple rules leads to unpredictability is reason trial and error (Darwinian natural selection), although somewhat crude and 'wasteful' is the best strategy in nature and evolution
    3. If organization determines life, it shouldn't matter what it is made of if properly organized
    4. Complex, life-like behavior is the result of simple rules unfolding from the bottom up
21. Emergence - somehow, by groups of agents cooperating and seeking self-accommodation, they manage to transcend themselves and become something more where the whole is greater than the sum of the parts

22. Power truly lies in connections - exploitation (improving what you already have) vs. exploration (taking big risk for big reward)
23. Edge of chaos - found right in between order and chaos, aka complexity
    1. Stable enough to store information but evanescent enough to transmit it
    2. Observe systems in terms of how they behave instead of how they are made
    3. Systems which are too controlled, too stagnant, too locked in will perish
    4. Healthy economies and societies must balance order and chaos via feedback and regulation while leaving room for creativity, change and response to new conditions - "evolution thrives in systems with a bottom-up organization which gives rise to flexibility"
    5. Information has to flow from the bottom-up and from the top-down
    6. Learning and evolution move agents along the edge of chaos towards ever greater complexity, sophistication and functionality
        1. One of the greatest questions and mysteries is why life gains 'quality' and becomes more complex over time. It is also one of the most fascinating and profound clues as to what life is all about
24. Complex phenomena of life only associated with molecular scale due to variety and reactivity
25. Tao of complexity - there is no duality between man and nature, we are all part of this interlocking network
    1. Once this is realized, conversation changes from optimality to co-adaptation and accommodation - what would be good for the system as a whole
    2. You keep as many options open as possible and go for what's workable, rather than what's 'optimal'
    3. Optimization isn't well defined anymore. Rather, what you're trying to do is maximize robustness, or survivability, in the face of an ill-defined future

What I got out of it

1. Ties together a lot of fascinating concepts and drew some more light on phase transitions and complexity for me

The Fifth Discipline by Peter Senge

Summary

1. The Fifth Discipline describes what a learning organization is and why it is vital in today's world. It combines 5 core disciplines to help any organization gain a competitive advantage

Key Takeaways

1. Communities survive and prosper because people work together
2. A learning organization creates a community where the team learns together and shares the same vision. It creates interconnected thinking so everyone is on the same wavelength - ingenuity, flexibility, ability to think forward and innovate and adapt to new systems
3. Team learning creates greater and more productive combined knowledge than individual, disparate insight
4. Nature of constant change in business and in life makes constant learning imperative. Those who emphasize this get ahead and succeed in their fields
5. Knowledge and experience is the foundation of intuition and the more you gain the stronger your intuition will be
6. **The 5 Core Disciplines**
    1. **Personal mastery** - mastering one's focus, energy and patience can go some way to creating a well-rounded individual of great worth to any organization
        1. Promotes intellectual and problem-solving growth
        2. Promotes new skills
        3. Drives the individual to better themselves and those around them
        4. Form a clearer vision
        5. As we accumulate knowledge, we can form better intuitions - the more we learn the better our intuition becomes
    2. **Mental models** - understanding the role our ingrained mentality and prejudiced perceptions play in our decision making
        1. Altering mindsets has to come before altering reality
        2. Mental models exist solely in the mind, are never perfect, are resistant to change and affect actions

    3. To alter mental models must create alternatives, encourage new ways of thinking, become more self-aware of biases inherent in all mental models, get people to ask questions
3. **Building shared visions** - a team-shared vision for the future is more beneficial to a company than a few disparate visions promoted by self-obsessed employees
    1. Many people have vision but pooling that passion into a shared vision can bring outstanding results
    2. Build shared vision by: suppressing egos, encourage people to share in the vision, allow the vision to grow over time but don't avoid directing it when needed
    3. The shared vision is the centerpiece, the final expression of each individual
    4. "When you are immersed in a vision, you know what needs to be done. But you often don't know how to do it."
4. **Team learning** - team work that brings together combined knowledge and expertise creates a fulfilling, powerful collective
    1. Team learning is all about collaborating and combining in order to point the organization, with all its acquired and assembled skills, in one clear direction, reaching all goals
    2. Foster team learning by: creating platform for open debates, encourage conflict, create learning platforms (come together in a fun, stimulating environment outside the office)
5. **Systems thinking** - encourages businesses to look at the bigger picture, thereby providing sustainable long-term, rather than short-term, solutions to problem
    1. Systems thinking is the fulcrum, it is the driving force upon which the performance of the other disciplines hinge
    2. Encourages us to spot patterns that are affecting our performance and subsequently analyze them for any possible improvement. It does not simply look at the consequences of an event and seek to eradicate the problem 'for now'
    3. All about preventing long-term problems
    4. The system is often the problem with a company's poor performance so you should carefully examine the underlying issues plaguing poor business performance
    5. Systems thinking discourages quick fixes and says no to short-cut solutions
    6. Must focus on cause and effect - solve the root of the problem rather than always fighting fires

7. Can often find small changes that lead to huge improvements in results - leverage points are key to find
    1. Leverage becomes possible when you consider the structure behind the results

7. **Crucial to overcome common problems** - internal politics, exclusive power, lack of time for learning, difficulty in maintaining a good work / life balance, repeated mistakes, difficulty in leading a learning organization
    1. Learning organizations encourages its people to admit these problems exist so that solutions can be found
    2. Failure to acknowledge own mistakes leads to bad habits
    3. Businesses tend to react to the consequence of an event, rather than root out the cause of it
    4. Non-learning organizations are reactive rather than proactive and therefore repeat mistakes
    5. If everyone is given responsibilities and the chance to make decisions, your organization will reap the rewards as everyone will be inspired and motivated to come up with solutions and work harder
    6. It is imperative that businesses create time for learning - more effective in every sense in the long run than working in ignorance and creating bad habits
    7. Fostering a healthy work / life balance is paramount as it will lead to huge benefits in the long run for both individuals and the organization
    8. Leaders tend to be hard working and very ambitious but must blend in softer traits such as openness, foresight, open communication, creativity and patience
8. Learning organizations are
    1. Active
    2. Forward thinking - continual learning irons out mistakes
    3. Dynamic - emphasis placed on team-work and shared learning
    4. Productive - because the whole team is learning, each member can feed off another's strengths, leading to greater production
    5. Communal - shared knowledge and production is the key. Constant communication and sharing talents takes teams forward
    6. Innovative - they lead the way in genuinely effective improvements
9. "Building learning organizations involves developing people who learn to see as systems thinkers see, who develop their personal mastery and who learn how to surface and restructure mental models collaboratively. Given the influence of organizations in today's world, this may be one of the most powerful steps towards helping us 'rewrite the code',

altering not just what we think, but our predominant ways of thinking. In this sense, organizations may be a tool not just for the evolution of organizations, but for the evolution of intelligence."

10. Learning organizations are a trial and error base in the sense that problems are confronted and attempts made to resolve them. They act almost as solutions providers

What I got out of it

1. Continuously learning on an individual and organizational level is key to adapting to change and staying ahead of competitors. Important to schedule time to think deeply, learn, understand your mental models and its biases and prejudices and constantly think in systems

How Nature Works by Per Bak

Summary

1. Self-organized criticality (SOC) is a new way of viewing nature - perpetually out of balance but in a poised state, a critical state, where anything can happen within well-defined statistical laws. The aim of the science of SOC is to yield insight into the fundamental question of why nature is complex, not simple, as the laws of physics imply

Key Takeaways

1. **Manifestations of SOC** - regularity of catastrophic events, fractals, 1/f noise, Zipf's laws
    1. So similar that they can be expressed as straight lines on a double logarithmic plot - are they all manifestations of a single principle? Can there be a Newton's law of complex behavior? Maybe SOC is that single underlying principle.
    2. Catastrophism - majority of changes take place mostly from catastrophic events, also known as punctuated equilibrium
    3. Fractal - nature is generally fractal, scale free
    4. 1/f noise - features at all time scales, found all over nature
    5. Zipf's Law - straight line plot between rank and frequency
2. **Complex systems** - systems with large variability
    1. Brain may be the most complex system of all as it is able to model the complex outer world
    2. Biggest puzzle of all may be how does complexity arise out of simple laws
    3. Because of the large sensitivity of the critical state, small perturbations will eventually affect the behavior everywhere (butterfly/Lorenz effect)
    4. **Complexity is a consequence of criticality**
    5. Complexity deals with common phenomena in different sciences so the study of complexity benefits from an interdisciplinary approach
3. **Chaos theory -** shows that simple, mechanical systems show unpredictable behavior
    1. Chaos is not complexity - gas in a chamber is chaotic but not complex (no emergent properties where non-obvious consequences occur based on underlying dynamical rules. Small changes in initial value does not cause huge differences in the end)
4. **SOC systems evolve to the complex critical state without interference from any outside agent, an external organizing force. Criticality, and therefore complexity, can and will emerge "for free" without any watchmaker tuning the world**

5. The process of self-organization takes place over a very long transient period. Complex behavior, whether in geophysics or biology, is always created by a long process of evolution. It cannot be understood by studying the systems within a time frame that is short compared with this evolutionary process
6. Once the poised state, the critical state, is reached, it is similar to that of a nuclear chain reaction
7. Catastrophes can occur for no reason whatsoever
8. Nature is SOC, the only known mechanism to generate complexity (sand pile metaphor and "avalanches" - punctuated equilibria)
    1. **Punctuated equilibrium** - rate of evolution occurs periodically in spurts. This idea is at the heart of the dynamics of complex systems (expect Black Swans!)
        1. This idea is contrary to Darwin's original theory which proposed that evolution happens gradually, uniformly and steadily
        2. **These fluctuations are unavoidable and cannot be repressed over the long-term and the most efficient systems show fluctuations of all sizes!**
9. **Perhaps our ultimate understanding of scientific topics is measured in terms of our ability to generate metaphoric pictures of what is going on. Maybe understanding is coming up with metaphoric pictures**
    1. All thinking is a type of analogy
10. Laws of physics are simple but nature is complex - the philosophy of physics has always been reductionist
11. Quality, in same way, emerges from quantity. But how? Maybe through the ever pressing laws of nature and scarcity. The fittest (most able to rapidly adapt) will survive and this becomes deemed as "quality"
12. An unlikely event is likely to happen because there are so many unlikely events
13. Must learn to free ourselves from biases and herd mentality in order to see things as they truly are
14. The problem with understanding our world is that we have nothing to compare it with (Galilean relativity!)
15. Systems in balance are not complex and generally have no emergent properties
16. Earthquakes may be the cleanest and most direct examples of SOC in nature
    1. Faults form fractals; earthquakes follow power laws
    2. Crust of earth has self-organized to the critical state, as evidenced by the Gutenberg-Richter law (simple power law)

        1. **The importance of this law cannot be exaggerated. It is precisely the observation of such simple empirical laws in nature that motivates us to search for a theory of complexity**
    3. Pulsar glitches, black holes and solar flares also exhibit elements of SOC

17. Real life operates at the point between order and chaos, the critical state. **Punctuations, avalanches, are the hallmarks of SOC**
    1. May be living in a highly nonlinear world where emergent events are very difficult, if not impossible, to predict.
18. **Nothing prevents further progress more than the belief that everything is already understood**
19. Science is often driven by sheer inertia. Science progresses "death by death"
20. Adaptation at individual or species-level is the source of complexity in biology
21. Fitness - we are "fit" only as long as the network/ecosystem exists in its current form. Fitness is not absolute and evolution cannot be seen as a drive towards a more fit species
22. Life only in cold places with little chemical activity, not a hot sizzling primordial soup with a lot of activity since this does not allow for large periods of stasis for complexity to emerge
23. Gaia hypothesis - all Earth should be viewed as a single system as all organisms interact and co-evolve
    1. Red Queen effect - if all other species adapt and become more fit, you have to become more fit just to stay in the same place
24. Regularity does not mean periodic. Just because a massive earthquake hasn't happened in 5,000 years, does not mean we should expect one soon
25. **Acquiring insight is itself a worthwhile effort**
26. **Insight seldom arises from complicated messy modeling, but more often from gross oversimplification.** Once the essential mechanism has been identified, it is easy to check for robustness by tagging on more and more details
27. Complex behavior can arise from a simple model through the SOC process
28. Thought can be viewed as a punctuated equilibrium event as it occurs only once enough signal hits the brain
    1. Seek out challenges and important questions to focus on!
29. Brain operates at the critical state where ideas are just barely able to propagate. Too little and nothing happens, too much and the brain would overload
    1. It appears that the human brain has not developed a language to deal with complex phenomena. We see patterns where there are none, like the man in the moon and the inkblots in a Rorschach test. We tend to experience phenomena as periodic even if they are not, gambling casinos and earthquakes. When there is an obvious

deviation from the periodicity, like the absence of an event for a long time, we say that the volcano has become dormant. We try to compensate for our lack of ability to perceive the pattern properly by using words, but we use them poorly

30. Economics shows many signs of being critical but has made the mistake of trying to be "scientific" where everything needs to be predictable - it cannot be predicted
    1. Shows periods of avalanches (financial crashes)
31. Traffic jams also at critical state
    1. No cataclysm necessary to cause a jam
    2. Perfect 1/f noise - stop and go behavior
32. **SOC is a law of nature for which there is no dispensation - cannot suppress the fluctuations forever**
    1. **Critical state is the most efficient state that can happen dynamically**
        1. **Why does it occur all over nature? Because it is robust and efficient!!**
        2. **Fluctuations are not perfect but they are healthy for dynamic systems. An over-engineered system may be more efficient for some time but catastrophically unstable**

What I got out of it

1. Self-organized criticality stems from simple rules with no "blind watchmaker" and can lead to very complex outcomes. Exhibits criticality through occasional punctuated equilibria and emergent, non-linear properties (such as earthquakes). Fluctuations should be expected and are healthy! They are the most efficient way to run a dynamic system. Complexity can arise out of simple laws with no outside help and is seen all over nature. Chaos is not complexity.

Complexity: A Guided Tour by Melanie Mitchell

Summary

1. Seeks to explain how large scale, complex, organized and adaptive behavior can follow from simple rules among many individuals

Key Takeaways

1. **Complex systems** - a system in which large networks of components with no central control and simple rules of operation give rise to complex collective behavior, sophisticated information processing and adaptation via learning or evolution
    1. How large numbers of relatively simple entities organize themselves, without benefit of any central controller, into a collective whole that creates patterns, uses information, and, in some cases, evolves and learns.
    2. Many simple parts are irreducibly entwined, and the field of complexity is itself an entwining of many different fields
    3. Systems in which organized behavior arises without an internal or external controller or leader are sometimes called self-organizing. Simple rules produce complex behavior in hard-to-predict ways, the macroscopic behavior of such systems is sometimes called emergent
    4. Another definition of complex systems - a system that exhibits nontrivial emergent and self-organizing behaviors
    5. Order is created out of disorder, upending the usual turn of events in which order decays and disorder (or entropy) wins out. A complete account of how such entropy-defying self-organization takes place is the holy grail of complex systems science
    6. Brain network, ants, immune system, world wide web, economy are all excellent examples of complex systems
        1. Ants are one of the simplest organisms but when millions of them are working together they can achieve "collective intelligence"
        2. Brains, like ant colonies, have billions of neurons (ants) working in parallel without central control
        3. Information processing has taken an ontological meaning similar to mass/energy, namely as a third primitive component of reality. In biology

in particular, the description of living systems as information processing networks has become commonplace.

1. Information processing seems to play a leading role in natural systems - immune system, ant colonies, cellular metabolism

7. Prediction of complex systems impossible as can never know starting conditions precisely and small changes lead to huge differences in outcomes
    1. However, there are universal traits to chaotic systems: period doubling route to chaos (bifurcation) and Feigenbaum's constant

2. Revolutionary ideas from chaos
    1. Seemingly random behavior can emerge from deterministic systems, with no external source of randomness
    2. The behavior of some simple, deterministic systems can be impossible, even in principle, to predict in the long term due to sensitive dependence on initial conditions
    3. There is some "order in chaos" seen in universal properties common to large sets of chaotic systems
3. **Dynamical systems** - description and prediction of systems that exhibit complex, changing behavior emerging from interaction of many components
4. **Nonlinear syste**m - whole is different from the sum of the parts
    1. Attractors - fixed point, periodic, chaotic (logistic map)
5. **Entropy** - energy which can't be converted to work and turns to heat
    1. The second law of dynamics is said to define the "arrow of time" in that it proves there are processes that cannot be revised in time (heat spontaneously returning after work is done). The "future" is defined as the direction of time in which entropy increases. Why the second law of thermodynamics is different from all other physical laws in that it should distinguish between the past and future while all other laws of nature do not is perhaps the greatest mystery in physics
6. Thermodynamics describes energy's interaction with matter
7. Reductionism great but it fails (so far) to explain chaos theory. Anti-reductionism systems are situations where the whole is more than the sum of its parts. Chaos theory, systems biology, evolutionary economics and network theory move beyond reductionism to explain how complex behavior can arise from large collections of simpler components. These disciplines require multi-disciplinary thinking from fields such as cybernetics, synergetics, systems science and complex systems
8. How does intelligence and consciousness arise from nonmaterial and nonconscious substrates?

9. **Statistical mechanics** - proposes that large-scale properties (heat) emerge from microscopic properties (motion of trillions of molecules)
10. Information is processed via computation
11. Turing's accomplishments - defined notion of "definite procedure"; definition, in the form of Turing machines, laid the groundwork for the invention of electronic programmable computers; showed what few ever expected in that there are limits to what can be computed
12. Darwin had single best idea ever - "in a single stroke, the idea of evolution by natural selection unifies the realm of life, meaning and purpose with the realm of space and time, cause and effect, mechanism and physical law."
    1. Evolution gives appearance of design with no "designer"
13. **Self-reference in DNA** - complex cellular machinery - mRNA, tRNA, ribosomes, polymerases and so forth - that effect the transcription, translation, and replication of DNA are themselves encoded into that very DNA
    1. **It is both information and input!**
14. **Shannon entropy** - one simple measure of complexity is size so Shanon entropy is the average information content or "amount of surprise" a message source has for a receiver
    1. The most complex entities don't have the most order or randomness but fall somewhere in between
15. Fractals have non-integer dimensions. Koch curve has 1.26 dimension and this is what makes them so strange
16. Simon contends that evolution can design complex systems in nature only if they can be put together like building blocks - have hierarchy and are non-decomposable. Cell can evolve to become a building block for a higher level organ, which itself can become a building block for an even higher-level organ and so forth
17. Most agree life includes autonomy, metabolism, self-reproduction, survival instinct and evolution and adaptation
    1. Dual use of information (as instructions AND data) avoids self-referential loop (how DNA replicates)
    2. Van Neumann proved in principle that computers can self-replicate
    3. Holland studied if programs could breed, adapt and evolve (professor at UMich)
18. Genetic algorithm - output is solution to a problem
    1. Job of genetic algorithm is to find (evolve) to good strategy once encoded
    2. Many real world applications and solves problem often hard for people to see why it works
19. **Parallel traced scan** - many, if not all, complex systems in biology have a fine grained architecture, in that they consist of large numbers of relatively simple elements that work

together in a highly parallel fashion. Several possible advantages arise out of this type of architecture including robustness, efficiency and evolvability. One additional major advantage is that a fine-grained parallel system is able to carry out a parallel traced scan which is a simultaneous exploration of many possibilities or pathways in which the resources given to each exploration at a given time depend on the perceived success of that exploration at that time. The search is parallel in that many different possibilities are explored simultaneously, but is "terraced" in that not all possibilities are explored at the same speeds or to the same depth. Information is used as it is gained to continually reassess what is important to explore

1. Allows many different paths to be explored and allows the system to continually change its exploration paths since only relatively simple micro-actions are taken at any time
2. The redundancy inherent in fine-grained systems allows the system to work well even when the individual components are not perfectly reliable and the information available is only statistical in nature. Redundancy allows many independent samples of information to be made and allows fine-grained actions to be consequential only when taken by a large number of components
3. Continuous interplay of unfocused, random explorations and focused actions driven by the system's perceived needs. Early explorations, based on little or no information are largely random and unfocused. As information is obtained and acted on, exploration gradually becomes more deterministic and focused in response to what has been perceived by the system.
4. **This balancing act between unfocused exploration and focused exploitation has been hypothesized to be a general property of adaptive and intelligent systems**

20. **Meaning** - the meaning of an event is what tells one how to respond to it
21. Computers, unlike humans, lack sensitivity to context, a lack of ability to use analogies
    1. Humans are very good at perceiving abstract similarities
22. **Idea Models** - relatively simple models meant to gain insights into a general concept without the necessity of making detailed predictions about any specific system
    1. Maxwell's demon - exploring the concept of entropy
    2. Turing machine - defining "definite procedure" and exploring computation
    3. Logistic model and logistic map - minimal models for predicting population growth, dynamics and chaos in general
    4. Von Neumann's self-reproducing automaton - exploring the "logic" of self-reproduction

    5. Genetic algorithm - exploring the concept of adaptation. Sometimes used as a minimal model of Darwinian evolution
    6. Cellular automaton - complex systems in general
    7. Koch curve - exploring fractal-like structures such as coastlines and snowflakes
    8. Copycat - human analogy making
23. **Prisoner's dilemma** - pursuit of self-interest for each leads to poor outcome for all
    1. **Tit for Tat is the best strategy with the first being cooperation**
    2. Predictability is important for cooperation
    3. Close proximity aids cooperation
24. **People have poor intuitive understanding of coincidence**
25. **Network thinking will permeate through all human activity and inquiry**
    1. Scale-free degree distributions, clustering and the existence of hubs are the common themes. These features give rise to networks with small-world communication capabilities and resilience to deletion of random nodes. Each of these properties is significant for understanding complex systems, both in science, technology and business
    2. Means focusing on relationships between entities rather than entities themselves
    3. A major discovery to date of network science is that high-clustering, skewed degree distributions and hub structure seem to be characteristic of the vast majority of all the natural, social and technological networks that network scientists have studied
        1. Hubs - high-degree nodes and are major conduits for the flow of activity or information in networks (Google)
        2. Small-world property - a network with relatively few long distance connections but has a small average path-length relative to the total number of nodes
            1. A network with 1,000 nodes, slightly rewired with random links brings down the average path length from 250 to 20...
            2. Evolved because information needs to travel quickly within the system and creating and maintaining reliable long-distance connections is very energy expensive. Nature has selected for it - robust, resilient, effective, efficient, energy-cheap...
            3. Web is scale-free, small world network (fractal) - relatively small number of very high-degree hubs (Google), nodes with degrees over a very large range of different values (heterogeneity of degree value), self-similarity
            4. Scale-free network = power-law degree distribution

    4. What seems to generate the complexity of humans as compared to plants is not how many genes we have but how those genes are organized into networks
    5. Focus on the hubs as that is where the power, influence, network, etc. falls to and relies on (Google, Facebook, GrubHub, LinkedIn, Zillow, Amazon, etc.) Winner take all systems!!
    6. Dangers of networks is that a small problem can quickly balloon into a major one if it is allowed to reach its tipping point
26. **Scaling** - how one property of a system will change if a related property changes. The scaling mystery in biology concerns the question of how the average energy used by an organism while resting - the basal metabolic rate - scales with the organism's body mass
    1. Metabolic rate proportional to body mass ^3/4
        1. Larger animals are more efficient than smaller ones and this leads to heart having to work less hard and the larger animal, on average, to live longer
    2. Circulatory system is fractal
    3. Metabolism is universal to all life so this touches every aspect of biology
27. Evo-Devo (evolutionary development) - genetic switches main cause for large differences between species with very similar DNA. "Junk DNA" and allows for punctuated equilibrium in evolution
28. **Life exists at the edge of chaos**
29. Natural selection is in principle not necessary to create a complex creature. Once a network becomes sufficiently complex, that is, it has a large number of nodes controlling other nodes, complex and self-organized behavior will emerge
30. Life has an innate tendency to become more complex which is independent of any tendency of natural selection

What I got out of it

1. Awesome book on chaos and complexity, how it arises, what its real-world implications are, how they might shape our world moving forward, the importance of networks and hubs, scaling, parallel traced scan, some idea models

Sync: How Order Emerges from Chaos in the Universe, Nature and Daily Life by Stephen Strogatz

Summary

1. Strogatz describes the universality of sync in nature, human biology, social networks, etc. and how it might come to be. "For reasons I wish I understood, the spectacle of sync strikes a chord in us, somewhere deep in our souls. It's a wonderful and terrifying thing. Unlike many other phenomena, the witnessing of it touches people at a primal level. Maybe we instinctively realize that if we ever find the source of spontaneous order, we will have discovered the secret of the universe."

Key Takeaways

1. At the heart of the universe is a steady, insistent beat - the sound of cycles in sync. It pervades nature at every scale and spontaneously, almost as if nature has an eerie yearning for order
2. **Spontaneous order baffles scientists as thermodynamics seems to predict the opposite - greater disorder and entropy rather than order**
3. **Synchrony** - explaining order in time. We interpret persistent sync as a sign of intelligence, planning and choreography and it gives humans intrinsic happiness to witness and be a part of something in sync
4. **Chaos** - seemingly random, unpredictable behavior governed by non-random, determinate laws. Occupies an unfamiliar middle ground between order and disorder. Looks erratic superficially, yet it contains cryptic patterns and is governed by rigid rules. It's predictable in the short run but unpredictable in the long run. And it never repeats itself: it's behavior is non-periodic
    1. Linear = whole is equal to sum of the parts
    2. Non-linear = whole is greater than the sum of the parts
    3. Chaotic systems can sync! No rhythmic it's (periodic cycles) and scrambling communication lines is one example
    4. Tends to exhibit self-organized criticality which leads to cascade effects as increasing pressure builds up and overcomes a threshold (earthquakes)

5. **Small world networks** - most networks resemble each other in design with most everyone connected by a short chain of intermediaries with hubs having the most connections
    1. **Small world networks are ubiquitous in nature, technology, social interactions, etc. They are resilient, robust, reliable, efficient, effective, cheap. Nature has selected for it**
    2. **At an anatomical level - the level of pure, abstract connectivity - we seem to have stumbled upon a universal pattern of complexity. Disparate networks show the same three tendencies: short chains, high clustering, and scale-free link distributions. The coincidences are eerie, and baffling to interpret**
6. **Structure always affects function**. The structure of social networks affects the spread of information and disease; the structure of power grids affects the stability of power transmission. The same must be true for species in an ecosystem. The layout of the web must profoundly shape its dynamics
    1. Average path length (degree of separation) and clustering (how big, how incestuous) are two important factors
    2. Small-world networks are small networks and highly clustered, scale-free link distributions (brain, power grid, social networks)
7. **Phase transitions (tipping points)** - "If the network is too sparsely connected, it fragments into tiny islands and cascades can't spread beyond any of them. At a higher, critical level of connectivity - the first tipping point - the islands abruptly link together into a giant mesh and global cascades become possible. An initial seed can now trigger an epidemic of change that ultimately infects much of the population. With further connectivity, the cascades at first become even larger and more likely, as one might expect, but then - paradoxically - they become larger yet rarer, suddenly vanishing when the network exceeds a critical density of connections. This second tipping point arises because of a dilution effect: when a node has too many neighbors, each of them has too little influence to trigger a toppling of its own. The more neighbors there are, the less impact any one of them has in a fractional sense. Just before this second tipping point, the outcome is extremely unpredictable in much the same way real fads are. Seems highly stable and resistant to outside disturbances but then another fad comes along, seemingly indistinguishable from the first, yet this one triggers a massive cascade. In other words, near this second tipping point, fads are rare but gigantic when they do occur. A subset of connected nodes in the network, called the vulnerable cluster, shapes how fads percolate through the rest of the structure. The vulnerable cluster in humans are "early adopters." Most people really in the "early and late majority" and not the vulnerable cluster but because the network is so densely connected near the second tipping point, a spark that

happens to ignite the vulnerable cluster is able to create enough momentum to detonate nearly everyone else."

8. Nature uses every means to allow oscillators to communicate which leads to sync. Oscillators when they freeze into sync, line up in time, not space
9. Fireflies self-organize with no conductor or intelligence - internal metronome and then adjust based on other firefly's oscillators
10. **Even lifeless things can synchronize pulses and communicate**. Pendulums sync through minute vibrations of the medium
    1. Inanimate sync stems from deepest laws of math and physics
    2. Lasers, power grids, pendulums, moon/earth, asteroids/planets, electrons all examples
11. Poincare is considered the father of chaos theory
12. Sync almost always occurs regardless of the number of oscillators or how it started
13. In any population, oscillators must be somewhat similar or no sync occurs
14. Great geniuses often have a vision for how the world should work, strip it to its essence and then search until they find it
15. **Human biological clock is like an enormous orchestra with the circadian pacemaker acting as the conductor. Sync at cellular level, sync between various organs and sync between our bodies and the world around us (entrainment)**
16. Without external cues, circadian rhythm a little longer than 24 hours and body temperature varies accordingly
    1. Nearly everyone desires a nap after being awake between 9-10 hours
    2. High alertness correlated with high body temperature
    3. 3-5am trough of circadian rhythm and body temperature
    4. REM tied to body temperature and not sleep (early morning has most REM)
    5. Many disparate rhythms controlled by same biological clock, the circadian pacemaker
    6. People are the least alert around 5am and between 1-4pm
17. Serendipitous discoveries are always made by people who are focused and alert yet calm and relaxed. They're searching for something but just happen to find something else
18. **Downside of sync is the domino effect of failure - becomes a vicious cycle which reinforces itself**
19. Accurate time allows for precise positioning (GPS relies on atomic clocks)
20. **Super conductivity is a type of perpetual motion machine which doesn't defy thermodynamics due to electrons ability to pair up and sync**

21. **Bose-Einstein condensate** - near absolute zero, bosons will intermingle and act as one (quantum sympathy) and merge into one "super atom" and "sing in unison"
    1. Lasers are an example of technology relying on this principle
    2. Electrons are fermions (recluse) but once they pair, they become bosonic (gregarious)
22. **Fractions of a degree make all the difference in phase transitions (water freezing, electrons lining up for super conductivity)**
23. **There is beauty and wonder in recognizing hidden unity**
24. **A dumb rule in a smart architecture can achieve world-class results**
    1. Importance of structuring properly aligned habits, incentives, environment, thoughts, actions, etc.
25. Power laws naturally arise from network growth (Geiger Scale)
26. **People are terrible at estimating probabilities of rare events**
27. Evidence that insights occur when different parts of the brain sync. Some guess that thinking and consciousness is a byproduct of sync

What I got out of it

1. Synchrony can be found universally from lasers to electrons to human biological clocks to pendulums. The sync of inanimate objects is an appearance of some of the deepest laws of math and physics at work. Small world networks, phase transitions, superconductivity. Structure always affects function - before trying to change behavior, look at the environment in which people are in and try to change that first

At Home in the Universe by Stuart Kauffman

Summary

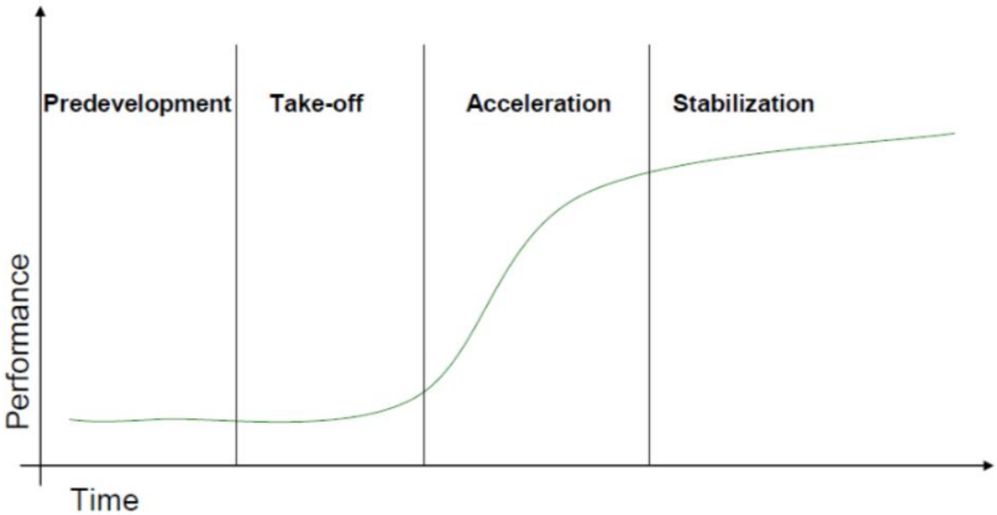
1. Natural selection is important, but it has not labored alone to craft the fine architectures of the biosphere. Self-organization is the root source of order and is not merely tinkered, but arises naturally and spontaneously because of the principles of self-organization. Self-organization works together with natural selection to help shape and drive evolution in species

Key Takeaways

1. Science has taken away our paradise - purpose and values are ours alone to make - job today is to reinvent the sacred and Kauffman believes that complexity may contain the answer
2. Complexity suggests that not all order is accidental and is responsible for much of the spontaneous order seen throughout the world
    1. May lie at the heart of the origin of life and leads to order found in organisms today
    2. Life, therefore, is to be expected and is not an accident if it arises out of fundamental self-organizing principles
    3. **Spontaneous order and natural selection have always worked together**
3. Second law of thermodynamics - order tends to disappear in equilibrium systems
4. Best models explain *and* predict but failure to predict does not equal failure to understand or explain, especially with chaotic systems. Can find deep theories without knowing every detail (don't have to know every detail of ontogeny (development of an adult organism) but we can understand it - spontaneous order which then natural selection goes on to mold)
5. **For most systems, equilibrium = death**
6. **Order for free -** order arises spontaneously and naturally and leads to self-organized systems and emergent properties
    1. Life would then be able to emerge full-grown from a primordial soup and would not need to be built one component at a time - life emerges whole and not piece meal
    2. **Life is a natural property of complex chemical systems and that when the number of different kinds of molecules in a chemical soup pass a certain threshold, a self-sustaining network of reactions - an autocatalytic metabolism - will suddenly appear**
        1. Life did come from non-life - reduces biology to physics and chemistry

        2. Must pass the subcritical / supracritical threshold
    3. Life exists in between order and chaos - in a kind of phase transition where it is best able to coordinate complex activities and evolve
    4. The very nature of coevolution is to attain this edge of chaos, a self-organized criticality, a web of compromises where each species prospers as well as possible but where none can be sure if its best next step will set off a trickle or a landslide
        1. This world does not lend itself to long-term prediction, we cannot know the true consequences of our own best actions. **All we players can do is be locally wise, not globally wise**
7. All living things seem to have a minimal complexity, below which it is impossible to go
    1. Matter must reach a threshold of complexity in order to spring to life - this is inherent to the very nature of life
8. **Living organisms are autocatalytic systems - living organisms began as a system of chemicals that had the capacity to catalyze its own self-maintaining and self-reproducing metabolism once a sufficiently diverse mix of molecules accumulates. Once this threshold is reached, a vast web of catalyzed reactions will crystallize. Such a web, it turns out, is almost certainly autocatalytic - almost certainly self-sustaining, alive. Life emerges as a phase transition once the subcritical threshold of reactions to chemicals is breached**
    1. The spontaneous emergence of self-sustaining webs is so natural and robust that it is even deeper than the specific chemistry that happens to exist on earth; it is rooted in mathematics itself
    2. There is an inevitable relationship among spontaneous order, robustness, redundancy, gradualism, and correlated landscapes. Systems with redundancy have the property that many mutations cause no or only slight modifications in behavior. Redundancy yields gradualism. But another name for redundancy is robustness. Robust properties are ones that are insensitive to many detailed alterations. Robustness is precisely what allows such systems to be molded by gradual accumulation of variations - the stable structures and behaviors are ones that can be molded
9. **Homeostasis, the ability to survive small perturbations, required for life to survive**
10. Small-world, sparsely connected networks are extremely efficient at connecting agents and trend toward internal order
11. Complexity - orderly enough to ensure stability but flexible enough to adapt and exhibit surprises - evolution takes life to the edge of chaos
    1. Organisms evolve to the subcritical-supracritical boundary which exhibit a power law distribution of events

12. Be smart by being dumb - have a huge sample set and choose what serves your purpose (don't be ideological, go with promising evidence over beautiful theory)
13. Immune system is a universal tool box - ability to produce 100m + antibodies allows you to recognize and respond to any threat
14. **Cambrian pattern of evolution - It is a general principle that innovations are followed by rapid, dramatic improvements in a variety of very different directions followed by successive improvements that are less and less dramatic**.
    1. **Learning curve** - After each improvement, the number of directions for further improvement falls by a constant fraction - an exponential slowing of improvement (applies to technology, evolution, business, mastering skills, any improvement!)
        1. The more complex the system, the more difficult it is to make and accumulate useful drastic changes through natural selection
        2. Correlation length - taking massive jumps can lead to fitter mutations if land at a fitter peak - explore and try vastly different areas to possibly get outsized rewards (deep fluency in many fields and iterate constantly with small bets and pursue promising areas - parallel traced scan)
            - When fitness is average, the fittest variants will be found far away but as fitness improves, the fittest variants will be found closer and closer to the current position. Expect to find dramatically different variants emerging during early stages of an adaptive process but later the fitter variants that emerge should be ever less different
            - When fitness is low, there are may directions uphill. As fitness improves, the number of directions uphill dwindles. Thus we expect the branching process to be bushy initially, branching widely at its base, and then branching less and less profusely as fitness increases



1. Optimal solutions to one part of the overall design problem conflict with optimal solutions to other parts of the overall design. Then we must find compromise solutions to the joint problem that meet the conflicting restraints of the different subproblems
2. Coevolution itself evolves over time as fitness landscape changes - maybe towards Red Queen or Evolutionary Stable Strategy
    1. Evolution pushes towards edge of chaos, towards phase transitions
    2. Highest fitness occurs right between chaos and order
3. **Mill-mistake - mistaking the familiar for the optimal**
4. **A central directing agent is not necessary to life, life results as an emergent property**

5. **The tools we make help us make tools that in turn afford us new ways to make tools we began with**
6. Technological revolution is coevolution - niche creation and combinatorial organization
    1. **Diversity begets diversity and growth but must first cross the supracritical threshold to hit the autocatalytic phase transition**
        1. Diversity (resources, goods, trade, skills, etc.) great predictor of economic growth
7. **Patch Procedure**
    1. Take a hard, conflict-laden task in which many parts interact and divide it into a quilt of nonoverlapping patches. Try to optimize within each patch. As this occurs, the couplings between part in two patches across patch boundaries will mean that finding a "good" solution in on patch will change the problem to be solved by the parts in adjacent patches... - models coevolving ecosystems
        1. If a problem is complex and full of conflicting constraints, break it into patches and let each patch try to optimize such that all patches coevolve with one another
    2. May not give us the solution to the real problem but may teach us how to learn about the real problem, how to break it into quilt patches that coevolve to find excellent solutions
    3. Ignoring certain subsets of restraints may be helpful at times - should not please all of the people all of the time but you should pay attention to everyone some of the time

What I got out of it

1. Spontaneous self-organization is a deep, fundamental principles of math, physics, life. Order for free, patch procedure, learning curves and the Cambrian diversity principle, subcritical and supracritical threshold breach is the same thing as phase transition, all we can do is be locally wise and not globally wise since our system is too complex to predict

Deep Simplicity by John Gribbin

Summary

1. Gribbin explores our biological history to show how complexity can arise out of simplicity. **Chaos leads to complexity which leads to life. The interesting things happen at the edge of complexity; in chaotic systems, minute differences in the initial conditions lead to huge differences in outcome**

What I got out of it

1. **Common theme - explains complex/complicated objects by breaking down to its simplest parts and begin by explaining these**
2. **Common theme - emergence, the whole is greater than the sum of its parts**
3. Gribbin describes many of the shared, common components of life and different systems
4. **Chaos begets complexity, complexity begets life**
    1. **World starts with the simple and eventually leads to the complex**
5. **Chaos and complexity based on two simple ideas - sensitivity of a system to its given starting condition and feedback**
    1. There are simple, orderly laws underpinning the confusion of the world
6. Galileo, Newton, Faraday, Maxwell (electromagnets), Einstein (general/specific relativity), Fourier (Law of transfer of heat), Rumford (heat is work), Joule / Helmholtz (conservation of energy), Clausius (entropy), Boltzman (over time, gas averages out in a container), Poincare (solar system orbits are stable, periodic; foundations of chaos), Lorenz (butterfly effect), Turing (cryptography, AI, embryonic development)
7. Near fractal self-symmetry is pervasive in living organisms
8. **DNA is more of a recipe than a blueprint** - much simpler, more elegant as it doesn't have to have everything planned out, simply the base of what is needed
9. Turing mechanism - embryo experiences chemical reaction from actuators and inhibitors which leads to whatever the recipe calls for (stripes, spots, hands, hair, etc.)
10. **Nature's power law** - smaller events (minor earthquakes) occur predictably more than larger events (disastrous earthquakes) but both at random
    1. **Power law a deep universal truth affecting people, weather, earthquakes, economy, etc. (1/f noise)**
11. Fractals are scale invariant (look the same no matter if microscopic or macroscopic view)

12. **No large triggers are needed for earthquakes or other power laws. Happen randomly but larger ones with much less frequency (black swans)**
    1. Same size triggers don't cause same size events
13. **All life built on networks** - interconnections between simple parts that make up the complex system (emergence of life from non life)
    1. Kaufman's theory about emergence due to network effects
    2. Also, genes control machinery of cell and genes can turn on/off other genes. That is why it is so difficult to cure anything because one gene is interconnected to everything else
    3. **Humans are the most complicated things and even we run on very simple rules (trust, all-in, win/win, love, self-preservation, rituals, hierarchy, territoriality)**
14. Darwinian evolution - genes get passed down, some mutations, more species with each generation
15. **The most interesting things happen on the edges of chaos**
    1. Natural for simple systems to organize at the edge of chaos
16. **Evolution has no aim**, it simply helps species fit the niches they're in. Species do not get better or worse at surviving, simply are better/worse at surviving particular niche in a particular time
17. Living systems reduce entropy - how we are looking for life in other planets
18. Gaia Hypothesis - Earth is a self-regulating system
19. Clouds are extremely important for Earth's thermal regulation
20. If we find life abroad, very likely it is made of simple building blocks working together in one connected, self-regulated network
21. Carbon plays such a key role in life because it can combine chemically with as many as four other atoms at once (CHON)
22. **Boundary between life and non-life is very blurry**
23. Humans are the most complicated things in the world but still made of the most common materials

Key Takeaways

1. Interesting read and I'll remember that interesting things happen at the edge of chaos as chaos leads to complexity which leads to life

The Black Swan by Nassim Taleb

Summary

1. Black Swan is an event which is an a rarity, has an extreme impact and is retrospectively (though not prospectively) predictable. This book concerns itself with our blindness with respect to randomness, particularly the large deviations. Must use the extreme event as the starting point and not treat it as an exception to be pushed under the rug. The future will be increasingly less predictable the more we try to control it and "know" it through vast amounts of data

Key Takeaways

1. Human nature makes us concoct explanations for black swans *after* the fact, making it explainable and predictable
2. Literally, just about everything of significance might qualify as a black swan
3. Black Swan logic makes what you don't know far more relevant than what you do know
4. It is much easier to deal with the Black Swan problem if we focus on robustness to errors rather than improving predictions
5. What is surprising is not the magnitude of our forecast errors, but our absence of awareness of it
6. Certain professionals, while believing they are experts, are in fact not
7. You can set yourself up to collect serendipitous Black Swans (of the positive kind) by maximizing your exposure to them. Tinker as much as you possibly can to collect as many Black Swan opportunities as possible
8. **People often get into trouble as they tend to learn the precise, not the general. Also, people tend to only learn facts and not rules**
9. To the author, the rare event = uncertainty
10. **Platonicity - mistaking the map for the territory, forcing categorizations and forms when it is inappropriate (almost always)**
11. Read books are far less valuable than unread ones (antilibrary)
12. History is opaque. You see what comes out, not the script that produces events, the generator of history

13. **Triplet of opacity - the illusion of understanding (world is more complicated than we realize); retrospective distortion (can only assess matters after the fact); overvaluation of "factual" information**
14. Our minds are incredible explanation machines - often creating stories to fit the facts
15. History and society does not crawl. It jumps
16. Categories are necessary to survive but people get in trouble when they don't realize the fuzziness of boundaries
17. The problem lies not in the nature of the events, but in the way we perceive them
18. Extremistan (real world) where Black Swans exist and have a huge impact (notion of Bill Gates distorting average wealth in a group) vs. Mediocristan (average) where there is no person tall/heavy enough to distort group averages
19. **Be suspicious of knowledge you derive from data**
20. **Don't simplify anything beyond what is necessary**
21. Black Swans differ per person - it occurs relative to the person's expectations and they don't have to be instantaneous surprises
22. Positive Black Swans tend to take time to show their effects whereas negative ones happen very quickly
23. **Blindness to black swans can come from: error of confirmation, narrative fallacy, human nature is not programmed for Black Swans, distortion of silent evidence and we "tunnel" (focus on a few well-defined sources of uncertainty)**
24. Domain specificity - our reactions, mode of thinking, intuitions, depend on the context
25. **Naive empiricism - finding evidence of what suits your beliefs (NED - no evidence of disease vs. END - evidence of no disease)**
26. **People build stories in order to help tie events, facts together but can hurt us when it increases our *impression* of understanding**
27. It takes considerable effort to see facts while withholding judgment and resisting explanations
28. The Black Swans we imagine, discuss and worry about do not resemble those likely to be Black Swans. We worry about the wrong "improbable" events
29. **Favor experimentation over storytelling, experience over history and clinical knowledge over theories. Another approach is to predict and keep a tally of the predictions (decision / prediction journal)**
30. The relevant is often boring, nonsensational and we tend to favor the sensational and the extremely visible
31. **Your happiness depends far more on the number of instances of positive feelings than on their intensity when they hit**

32. Silent evidence - you only see survivors and hear their stories, you don't hear of the "drowned sailors who also prayed to God"
    1. **The gravest of all manifestations of silent evidence is the illusion of stability**
33. Has been shown that people often take risks not because of bravado but because of ignorance and blindness to probability
34. Reference point argument - don't compute odds from the vantage point of the winning gambler but from all those who started in the group
35. Be very careful of the "because," especially in situations where you suspect silent evidence. People harbor a natural scorn for the abstract
36. Ludic fallacy - the attributes of the uncertainty we face in real life have little connection to the sterilized ones we encounter in exams and games
37. Knightian risks you can compute whereas Knightian uncertainty is incomputable
38. **Prediction, not narration, is the real test of our understanding of the world**
39. **The larger the role of the Black Swan the harder it will be for us to predict**
40. People are arrogant about what we think we know. Increasing knowledge helps but it can hurt as even more by increasing our confidence, ignorance and conceit
41. **Ideas are sticky - once we produce a theory, we are not likely to change our minds - those who delay forming theories are better off**
42. Certain fields like astronomers and physicists tend to have experts whereas stockbrokers, court judges, etc. tend not to be experts
43. **You cannot ignore self-delusion**
44. **What matters is not how often you are right, but how large your cumulative errors are**
45. We cannot truly plan because we do not understand the future but we can plan while bearing in mind such limitations
46. People cannot work without a point of reference (anchoring)
47. **The policies we need to make decisions on should depend far more on the range of possible outcomes than on the expected final number**
48. When new technology emerges, we either grossly underestimate or severely overestimate its importance
49. Choose to follow evidence over theory as we cannot explain everything and often underestimate the complexity of nature and biology
50. We fail to learn about the difference between our past predictions and the subsequent outcomes (when we think of tomorrow we just project it as another yesterday)
51. **We don't learn much from our past experiences and we also don't know what to expect from the future**
52. Randomness is incomplete information (opacity)

53. Doesn't advise always withholding judgment, opinions, predicting, being a fool - but be a fool in the right places. Avoid unnecessary dependence on large-scale harmful predictions. Avoid the big subjects that may hurt you in the future. Do not listen to economic forecasters or to predictors in social science but do make your own forecasts. **Know how to rank beliefs not according to their plausibility but by the harm they may cause**
54. **Make many small bets with asymmetric payoffs and where the harm is minimal**
55. Maximize the serendipity around you
56. Trial and error means trying a lot
57. **You need to love to lose - series of small failures are necessary in life**
58. Barbell strategy - be hyperconservative and hyperaggressive instead of being mildly aggressive or conservative (90% in extremely safe instruments and 10% in extremely speculative bets)
59. **Do not try to predict precise black swans. Invest in preparedness, not in prediction**
60. Seize anything that looks like opportunity - free options
61. Beware of precise plans by governments
62. Nobody in particular is a good predictor of anything
63. **Pascal's wager - eliminates the need for us to understand the probabilities of a rare event and focus on the payoff and benefits of an event if it takes place**
64. Gray Swan - reducing Black Swan's surprise effect by getting a general idea about the possibility of their outcomes
65. **An early, initial advantage tends to follow people through life**
66. For something to become "contagious" it must agree with human nature
67. Luck is the grand equalizer
68. Moving forward we will have fewer but more severe crises
69. **80/20 rules can become the 50/01 rule - 50% of work done by 1% of workers (80/20 might even be more extreme in Extremistan, like 97/20)**
70. Study the intense, uncharted, humbling uncertainty in the markets as a means to get insights about the nature of randomness that is applicable to psychology, probability, mathematics, decision theory and even statistical physics . You will see the sneaky manifestations of the narrative fallacy, the ludic fallacy and the great errors of Platonicity (going from representation to reality)
71. Fractal randomness is a way to reduce these surprises, to make some of the swans appear possible, so to speak, to make us aware of their consequences, to make them gray. Fractal randomness does not yield precise answers

72. Worries less about small failures than large, catastrophic ones ("safe" blue chips vs. venture capital)
73. "Missing a train is only painful if you run after it." - it is more difficult to lose in a game that you set up yourself
74. **Redundancy equals insurance**
75. Mother Nature does not like overspecialization, anything too big, too much connectivity and globalization, will eventually fail
76. **The organism which has the highest number of secondary uses is the one that will gain the most from environmental randomness and opacity**
77. Certain fields make distinctions which make sense in their narrow world but have no effect in the real world
78. Let human mistakes and miscalculations remain confined - artificially reducing volatility and ordinary randomness increases exposure to Black Swans as it creates an artificial quiet
79. **Living organisms need variability and randomness in order to avoid become fragile - diet, workouts, tabata, slow meditative walks, thermal variability, sleep deprivation, fasting - trade duration for intensity**
    1. **A little bit of extreme stress is vastly better than a little bit of stress all the time**
80. Volatility does not equal risk
81. **Do not bet on Black Swans taking place - he is advocating acts of omission and not commission**
82. **Evolution does not work by teaching but by destroying**
83. The Black Swan corresponds mainly to an incomplete map of the world
84. **Focus more on the consequences of decisions than on their probabilities**
85. People are suckers and will gravitate to those variables which are unstable but appear stable
86. There is no reliable way to compute small probabilities
87. **It is much more sound to take risks you can measure than to measure the risks you are taking**
88. Recommendations of the style "do not do" are more robust empirically. **Success consists mainly in avoiding losses, not in trying to derive profits**
89. Acting, doing something, often more harmful than doing nothing
90. **How to move from the Third to Fourth Quadrant (Black Swan)**
    1. Have respect for time and nondemonstrative knowledge
    2. Avoid optimization; learn to love redundancy (do not overspecialize)

3. Avoid prediction of small-probability payoffs - though not necessarily of ordinary ones
4. Beware the "atypically" remote events
5. Beware moral hazard with bonus payments
6. Avoid some risk metrics
7. Positive or negative Black Swan?
8. Do not confuse absence of volatility with absence of risk
9. Beware presentations of risk numbers

91. **10 Principles for Black Swan Robust Societies**
    1. What is fragile should break early, while it's still small
    2. No socialization of losses and privatization of gains
    3. People who were driving a school bus blindfolded (and crashed it) should never be given a new bus
    4. Don't let someone making an "incentive" bonus manage a nuclear plant - or your financial risks
    5. Compensate complexity with simplicity
    6. Do not give children dynamite sticks, even if they come with warning labels
    7. Only Ponzi schemes should depend on confidence. Governments should never need to "restore confidence"
    8. Do not give an addict more drugs if he has withdrawal pains (no leverage)
    9. Citizens should not depend on financial assets as a repository of value and should not rely on fallible "expert" advice for their retirement (investments should be for entertainment)
    10. Make an omelet with broken eggs (have the right people like entrepreneurs take the risks, not bankers; smaller firms with less effects if they fail)

What I got out of it

1. Awesome book. I think Antifragile ties in all his books into one but still makes a lot of great points and might be worth re reading at some point

Antifragile: Things that Gain from Disorder by Nassim Taleb

Summary

1. Taleb describes that anything is antifragile as it gets better with chaos and disorder and improves with time whereas anything fragile hates volatility. He lays out extremely convincing arguments for doing away with most predictions and trying to forecast into the future as this in reality handicaps us and doesn't allow us to react to what is truly happening. His arguments can and should be molded into every facet of your life and your decisions

Key Takeaways

1. **Anything that has more upside than downside during random events has antifragility**
2. Suppressing randomness from antifragile things (ourselves are one of the most antifragile things) actually harms them and makes them weaker. The diet, our economy are antifragile but we have been making them weaker by trying to exert too much control over them
3. Fragility and antifragility can be measured but rare events cannot be predicted accurately
4. Should focus on the fragility of things instead of the probability of something happening. Things lie on a scale of fragility (the triad - antifragile, robust and fragile)
5. **Moving towards simplicity and removing things makes things more antifragile than adding anything**
6. Absence of challenge degrades the best people and firms. Mental and physical effort forces people into a higher gear
7. **Evolution one of the best examples of antifragility** as it loves randomness and volatility and gets stronger from it. Natural things love randomness up to a point - if all life on earth wiped out the fittest will not survive to reproduce
8. Central illusion in life - **randomness is risky. Man made smoothing of randomness makes things more fragile. Daily variability helps strengthen a person or system**
9. Extremely important to try to differentiate between true and manufactured stability
10. Much more difficult to examine people who have been successful by procrastinating or non acting as it is not obvious or apparent as that is what caused their success

11. **Believes that in eliminating projections** which are almost never right will make us and our economy more robust. What is not measurable and non predictable will remain that way. Let's not kid ourselves and make us more exposed than we already are
12. **Turkey problem** - mistaking what we don't see for the nonexistent
13. Exposure more important than knowledge. Do, rather than just learn
14. **Time is the world's best debunker of fragility. Time reveals truth**
15. Small occurrences and events affect us much less than a large event does. For example, a 10 lb stone thrown at your head would do more than 5x the damage of a 2 lb stone thrown at your head. That which is fragile is hurt much more by extreme events than by a succession of small ones
16. Barbell - medium risks are still exposed to massive volatility. Better to be at either end (completely anti black swan or pro black swan) than stuck in the middle. Don't do things in the middle - pure action or pure reflection. Barbell method is the domestication, not the elimination, of risk
17. **You are antifragile when you have more to gain than lose from volatility** - more upside than downside. First decrease your exposure to downside
18. When have optionality, do not need to understand something perfectly and can make good decisions with less information. Can still limit downside and have upside. Having options helps us understand ourselves as we are forced to decide
19. **Tinkering and iterations are much more antifragile than blueprints and hard plans**. This allows for more optionality and better decisions since will have better information
20. **When you find antifragile options, there are hidden benefits** and therefore need to be right less often compared to linear payoffs to still wind up on top
21. **Avoiding mistakes and being a sucker is quickest way to become antifragile**. We know much more of what is wrong than what is right (negative knowledge). Disconfirmation much more rigid than confirmation
22. **Robust decisions rarely require more than one good reason**. The man with the most alibis is usually guilty. In addition, a man should be known for one great idea
23. The longest surviving works are the most robust as time devours everything, the fragile first
24. Longer term forecast are most prone to error and exponentially so compared to short term. Any reliance on predictions is fragile. Respect and consume the wisdom of our ancestors - philosophy, food, tools, etc.
25. Perishable v nonperishable - for perishable, younger expected to live longer but for non the older can be expected to lived longer. Established tech more likely to outlive new tech

26. **There is logic in nature much deeper than we can often understand**
27. Even if there is solid evidence (lose fat if limit carbs), People often don't act until there are theories they believe. Should be the opposite, **if solid evidence, should act regardless of theory as they change all the time**
28. Via negativa - Subtracting things not seasoned by nature reduces the chances of black swans while leaving one open to improvements. For example, eating less extends lives and avoiding new foods and sugars
29. He argues against buying things with huge marketing budgets as most high quality things do not require it (eggs, meat, art, museums, etc .)
30. Antifragility helps understand fragility better
31. Absence of skin in the game is truly hurting the antifragile systems since people can get the upside without any of the downside and exposing others
32. Black swans are huge and unpredictable events which we can only explain in hindsight which makes us underestimate randomness
33. Neomania - our current state where we are making everything more vulnerable to black swan events
34. Complex systems are often more fragile but regardless simplicity is key
35. Taleb wants to modify our systems (from banking to health care) to make simpler and more antifragile
36. Antifragility is relative and not always worth it as it can be very costly
37. One or a thing cannot be antifragile against everything
38. Domain dependence - can make contradictory claims or thoughts depending on the context
39. Overcompensation and "noise" are necessary for people to grow and learn
40. Redundancy is often a great investment and can often be very efficient (2 kidneys)
41. Always allow for extra wiggle room - worst drop in market was worse than anyone could've been predicted based on past models of market drops
42. Often stronger once have made a mistake than if never have made one
43. Don't know what type of person someone is until they're given the option to do something immoral
44. Switzerland is the most antifragile place in the world and benefits tremendously when others are hurt or in a panic. It is stable because of the mix of people but mainly because of its lack of a large central government - very few citizens could name its president. Experiences daily fluctuations which make it stronger overall
45. When randomness concentrates is when big shocks and volatility can be expected (financial crisis of 2009 a prime example) (what Taleb calls extremistan)

46. The world has never been closer to catastrophic wars - man has attempted to smooth out and get rid of randomness but this only will build up until some massive event occurs which will be much more difficult if not impossible to recover from
47. In anything and with anyone - light control works but tight control leads to more crashes
48. Injecting randomness strengthens systems
49. Iatrogenics - when the people who are supposed to help (doctors for instance) actually do more harm than good. Any type of intervention has iatrogenics
50. Intervening to limit size and speed can be beneficial. Taleb especially worried about non intervention with anything modern
51. The more often you tune into news the more noise you'll have to sift through in order to get to the signal (finance or whatever). Only pay attention to very large changes in data
52. Excess wealth if you don't need it is a burden
53. When possible, try to bet against those who rely on predictions
54. Wisdom in making decisions is vastly more important than knowledge. Seneca is a prime example of this
55. Stoicism is extremely robust. Possessions make us worry about downside and make us fragile. Mentally adjust for the worst before it happens and everything positive from then on will seem like a bonus. Stoicism about the domestication and not the elimination of emotions. Invest in good deeds as things can be taken away
56. Never ask people what they want as people's preferences can change instantly. Like Jobs, show them what they want
57. Freedom, independence and options is the ultimate trifecta
58. Your work and ideas are more antifragile when have a small but loyal following and a lot of dissenters than if everyone mildly liked it
59. Options are the weapon against fragility. Believes that most of what we think comes from skill in fact comes from optionality - well used optionality
60. Humans lack imagination and don't even know what tomorrow will look like
61. Randomness plays two roles - innovation and implementation. The implementation of a tool or medicine does not always immediately succeed its invention (the period between is the translational gap)
62. Every trial and every failure provides more information into the right direction to go. Up to you to act rationally and to recognize the options
63. Recognize epiphenomenon - wrong cause and effect. Fooled by randomness - mistaking the purely random for causal

64. Green lumber - very successful people who do, do not need extensive knowledge in a lot of areas. Example - very successful Swiss franc trader in US didn't even know where Switzerland is on a map
65. Do not get too technical and smart for your own good - keep the elementary in mind
66. Tinkering and trial and error is robust and antifragile to the unknown
67. The experts and anybody else who thinks they know more than they do are fragile
68. Argues against planning or at least over planning as it can make you option blind
69. Look and rank things according to optionality, options with open ended and not closed ended payoffs, do not invest in business plans but in people, make sure you are "barbelled"
70. Argues for more experiential and unstructured learning
71. Aims to read between 30-60 hours a week! Did this while at Wharton even. Read nothing but books about probabilities for years!
72. What you choose to read and experience you remember much better and it's ingrained much deeper
73. A squeeze is when you have to act and have no other choice. As you grow larger, squeezes become more common and more devastating and expensive. Small is antifragile
74. Spread the consumption - whether of fish or pollution, consuming or using too much of one will have much more disastrous effects than spreading it out over different sources
75. Beware of asymmetry the wrong way - volatility has a higher negative effect and grows with more volatility whereas the positive effects are small and decrease with more volatility (Fannie Mae)
76. Planning fallacy - it will always take longer and cost more than you think
77. Bears model error and small probabilities as they are often very antifragile
78. Can classify things into 3 groups - those which like volatility in the long run, are neutral or don't like them
79. In many areas a disproportionately small number of people or things cause the majority of the problems
80. Future lies in the past - technology replacing itself and getting us back to the way we used to do things. For example, iPad allows us to write longhand on a tablet like we used to. Best running shoes going for barefoot feel
81. People notice change much more than what is static and do not easily take into account the failed endeavors - making success seem easier than it actually is since losing examples are gone and hard to come by
82. Treadmill effect - with goods and tech we get an initial boost when we buy the latest model but quickly revert to our baseline

83. Lindy effect- books that have been around the longest will survive the longest
84. With health conditions, ignore small symptoms and don't treat as their use is marginal but with severe symptoms, diagnose and treat. Excessive hygiene, antibiotics, surgery, metric lowering medicines all fall into this category
85. We only understand risks after they happen but continually make the mistake of thinking we can risk manage. The risks come from what we cannot see
86. Does not drink anything that hasn't been around for 1,000 years (water, coffee and wine) and eats only what our ancestors ate and is even cautious to only eat fruits from his ancestor's region
87. Should randomize our diet - do not need a balanced meal at every meal. Should randomize and deprive at times to reap biological benefits
88. Every risk taker needs to have some skin in the game - Hammurabi's code. No opinion without risk. This is becoming rare in today's world where bankers and politicians can make decisions which affect millions but they themselves don't pay if they're wrong
89. A margin of safety should be built into every decision
90. Beware those who explain anything after the fact
91. Those with no skin in the game can cherry pick and convince themselves and others they had predicted it while taking no action
92. Don't ask people their opinions or theories, ask them what they own in their portfolio
93. Cowards today are prevalent but Romans removed this incentive to run away by killing 10% of the legion of cowardice was suspected. Similar situation - Welch firing bottom 10% of employees
94. Beware those who do not live or act as they preach
95. A truly free man can voice his own opinions

What I got out of it

1. An amazingly thought provoking book which makes you very aware of how fragile many things we assume are stable really are. The most powerful part of this book is understanding that this mental model can be integrated into every single part of your life - from diet to work to investing to relationships, etc. An absolute must read