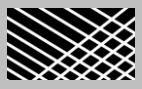
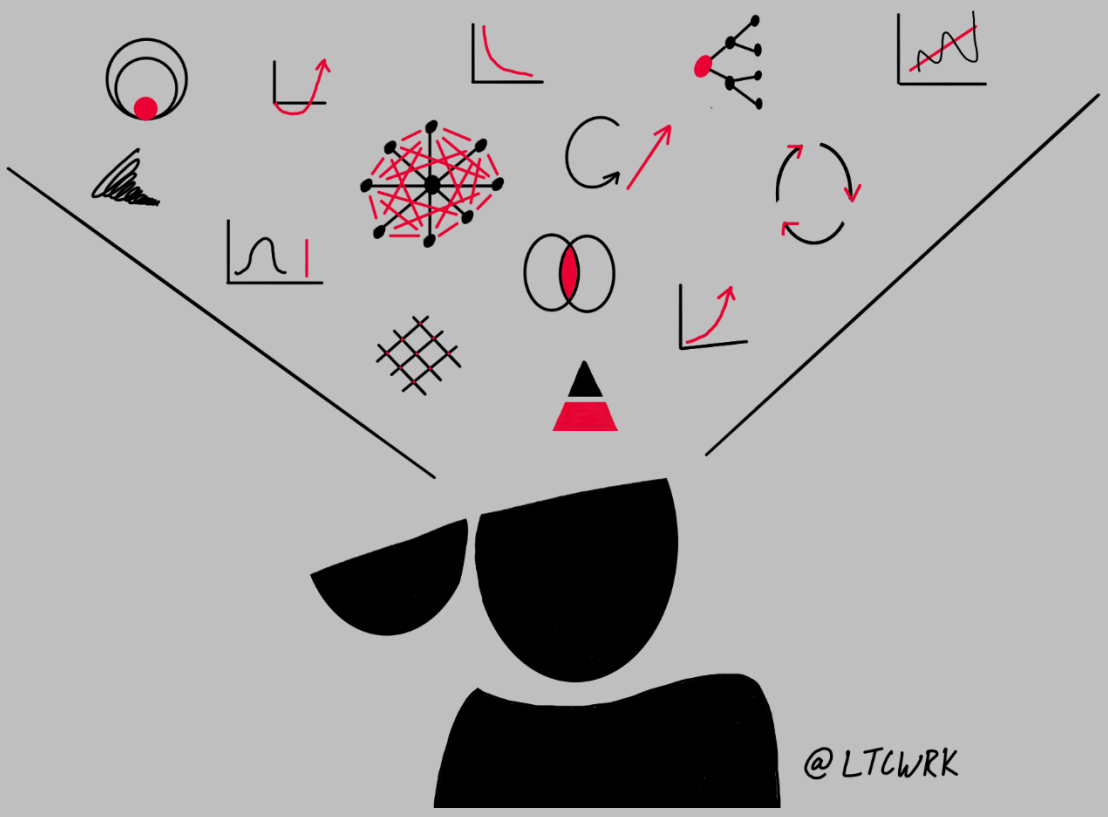


The Latticework:

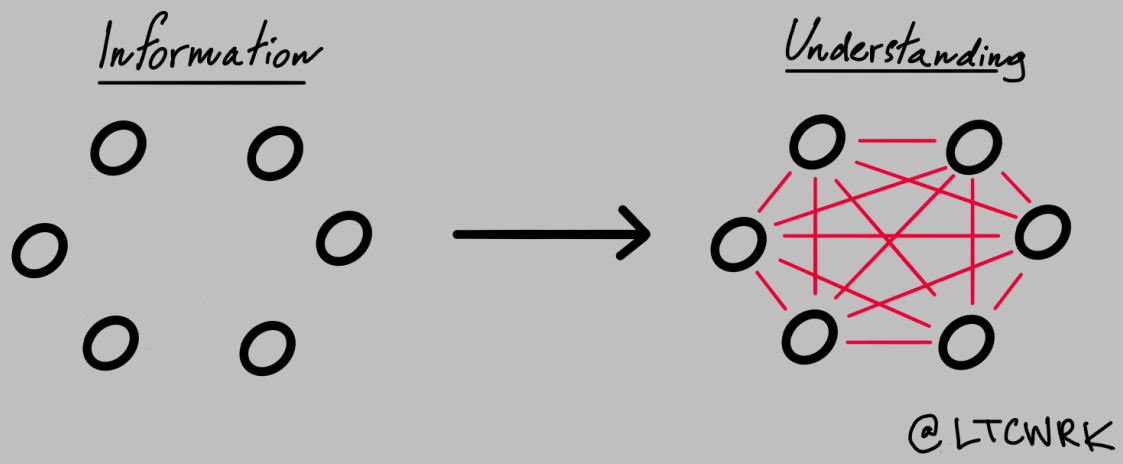
1-Pager Compilation


@LTCWRK

Introduction to The Latticework

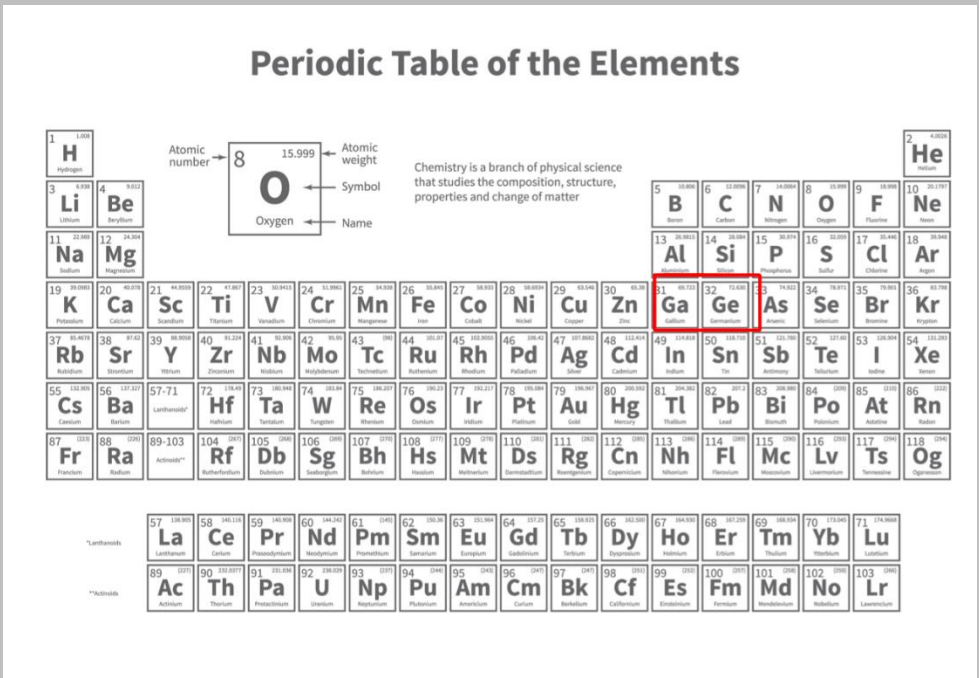
The power of a proper mental framework is that it is descriptive, predictive, and helps expose blind spots – and all mistakes come from blind spots.

In order to build this proper mental framework or "latticework," it must be composed of time-tested and robust principles – what we call "the big ideas from the big disciplines."1A latticework is traditionally used in home improvement projects to create shade, decorate fences, support plants, and more. It creates a stable structure as each point connects and reinforces every other point. Using this metaphor for our own purposes, we can use a latticework structure to organize and reinforce ideas and mental models. If successful in forming this mental structure, you'll be able to attach new knowledge to previous knowledge, allowing you to more easily learn new concepts. Forming this latticework is important no matter your stage of life, context, or future goals as it helps sharpen your thinking, judgment, and decision-making. Rather than having ideas floating around aimlessly in our heads, our mental latticework will allow us to organize and categorize information so that it becomes interconnected and robust understanding.



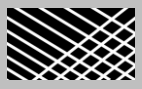
The value of this type of structure and organization is beautifully exemplified by Dmitri Mendeleev and his Periodic Table of Elements. Mendeleev was a Russian chemist who discovered that elements could be organized by their atomic mass and valence, revealing that their chemical properties are derived from these two characteristics. This discovery went on to become the Periodic Law, an early version of the periodic table of elements. Amazingly, his new framework for organizing the elements allowed him to correct the properties of some already known elements and predict the properties of eight, which were yet to be discovered! People mocked him at first and called him crazy, but he was so confident in his structure that he even left missing spaces in

his table for some yet to be discovered elements. He was vindicated when gallium (Ga) and germanium (Ge) were discovered in 1875 and 1886, respectively, and fit perfectly into the two empty slots he left for them.



Mendeleev's insights created a structure that helped organize the elements, deepening our understanding of the world, and making our collective future efforts more effective. This is precisely what we are aiming to achieve with The Latticework. If we can create our own "periodic table of elements" or "latticework" in which to organize, categorize, and interconnect information, we too can deepen our understanding of the world. This will make us more effective thinkers, improve our decision-making, and reduce our blind spots, resulting in more complete and fulfilling.

While the resource is tremendously valuable on its own, the contributions made by our all-in community will allow what Charlie Munger calls "Lollapalooza Effects" to emerge, resulting in outcomes far more powerful than anyone could imagine. By hosting this resource online and allowing for our partners to add highlights, ideas, comments, and feedback, we will transform what is typically a passive and single-player learning process into an active and multi-player one. Together, we can learn more than we otherwise could. Together, we can help each other widen



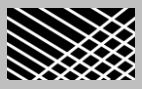
our perspectives. Together, we can build a beautiful resource and community that is continuously learning, iterating, and improving.

We hope this multidisciplinary resource and community helps structure and inform your latticework, widening your perspective, and positively impacting how you live and interact with the world around you. We also hope you disagree with parts of it (we're just students, not experts) and can explain things more clearly and completely than they currently are. That way, we can simultaneously improve the resource and ourselves. This process truly is an infinite game – a journey worth starting and never finish.

If the facts don't hang together on a latticework of theory, you don't have them in a usable form. You've got to have models in your head. And you've got to array your experience both vicarious and direct on this latticework of models.

– Charlie Munger

If you want to join a global community of ~300 partners and want access to more than just these 1-pagers, consider becoming a Day 1 Partner. For $250 per year, you'll get access to our content and our community. To start, please simply fill out this quick survey.



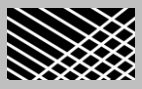
1-Pagers Compilation

In this document, we've compiled all the "1-pagers" of the disciplines we've covered so far. We strive to make these vital ideas as accessible as possible, bringing them down to their essence to the best of our abilities. If you want more depth beyond just these high-level summaries, consider joining to unlock the content and community.

So far, we've covered:

- Worldly Wisdom
- Physics
- Chemistry
- Mathematics
- Statistics & Probabilities
- Engineering
- Science & Experimenting
- Technology & Computer Science
- Biology & Nature
- Health & Nutrition
- Psychology
- Philosophy
- Spirituality & Religion
- Family & Relationships
- History
- Learning & Mastery
- Productivity & Habits
- Competing
- Decision-Making
- Leadership
- Business & Investing
- Economics
- Military & War
- Communication & Persuasion
- Creativity & Design

Those that are not linked above are yet to be covered and will soon be shared. In the meantime, we hope you enjoy and find value in our 1-pagers.

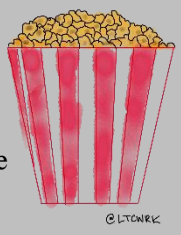


The Latticework:

Worldly Wisdom

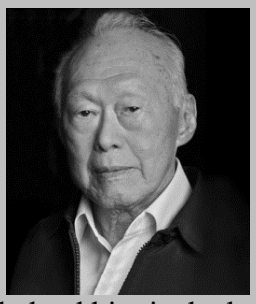
Worldly Wisdom

> The kernel is a computer program that is the core of a computer's operating system, with complete control over everything in the system…It handles the rest of start-up as well as input/output requests from software, translating them into data-processing instructions for the central processing unit.
>
> – Wikipedia



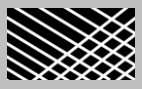
Worldly Wisdom can be thought of as meta-learning or meta-ideas – essentially instruction manuals for life. These concepts are universally valuable and applicable, being time-tested and proven robust. We begin with these ideas because, if properly applied, they can form the "kernel" to your "operating system" – governing how you think and learn, paving the way for deeper understanding later on.

Worldly Wisdom is, by definition, multidisciplinary. It would be an oxymoron to say worldly wisdom comes from a particular field, time, or country. It requires deep fluency in a range of disciplines, which, when combined, adds a tremendous interlocking strength to our understanding of how the world works. The world is not siloed, and our thinking must not be either.



Rather than discounting ideas simply because they come from a different field, we should embrace them! In this sense, we should emulate Lee Kuan Yew. He was Singapore's first Prime Minister and managed to pull Singapore from third world to first within a generation. He was one of the great leaders and nation-builders of our time and his maxim was "do what works," regardless of who discovered it, when, where, why, or how. If it helped him inch closer to his goals, he adopted the practice. This sounds so simple, but how often have we neglected or been blind to a solution simply because it hails from a foreign field? We should follow suit and not worry whether the solution to our problem comes from physics, chemistry, biology, psychology, history, sports, or any other domain.

This is the benefit of acquiring worldly wisdom – it allows us to better understand and, as Ludwig Wittgenstein tells us, "To understand is to know what to do." If we know what to do, we not only become more effective, but we also avoid time-sucking mistakes and the stresses that accompany them. This type of mastery requires automatic associative understanding (coming from taking the time to truly grasp general principles), and the formula lies in synthesizing big ideas – combining art and science into a whole that is greater than the sum of its parts.



> To understand is to know what to do.
>
> – Ludwig Wittgenstein

Some of the most condensed sources of Worldly Wisdom we've come across include the following:

Charlie Munger

- The 1986 Harvard School Commencement Speech
- A Lesson on Elementary, Worldly Wisdom
- The USC Gould School of Law Commencement Address
- The Psychology of Human Misjudgment

Richard Hamming

- *The Art of Doing Science and Engineering: Learning to Learn*
- Experts
- Systems Engineering
- You and Your Research

Naval Ravikant

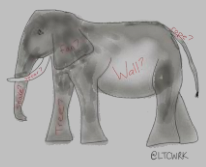
- *How to Get Rich*

> Having spent a lifetime analyzing the game of chess and comparing the capacity of computers to the capacity of the human brain, I've often wondered, where does our success come from? The answer is synthesis, the ability to combine creativity and calculation, art and science, into a whole that is much greater than the sum of its parts. Chess is a unique cognitive nexus, a place where art and science come together in the human mind and are then refined and improved by experience.
>
> – Gary Kasparov, *How Life Imitates Chess*

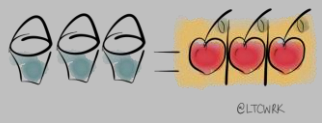
The Big Ideas of Worldly Wisdom:

1. The Latticework

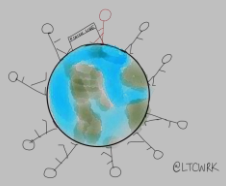
2. Mental Models



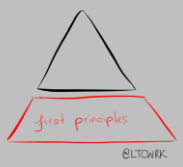
3. The Three Buckets



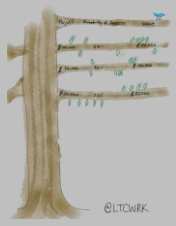
4. Advantageous Divergence



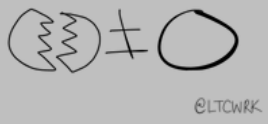
5. First Principles Thinking



6. Second-Order Thinking

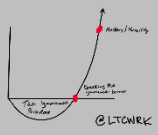


7. Systems Thinking

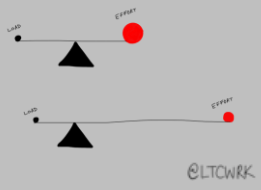


8. The Map is Not the Terrain

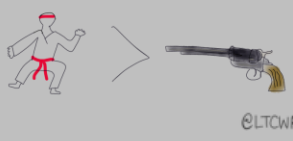
9. The Ignorance Paradox



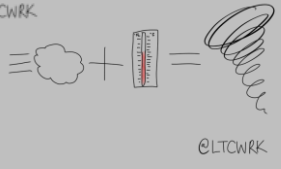
10. Choosing Important Problems



11. On Having Opinions



12. Lollapalooza Effects



The Latticework

A latticework is traditionally used in home improvement projects to create shade, decorate fences, support plants, and more. Using this metaphor for our own purposes, we can use a latticework structure to organize and support ideas and mental models.

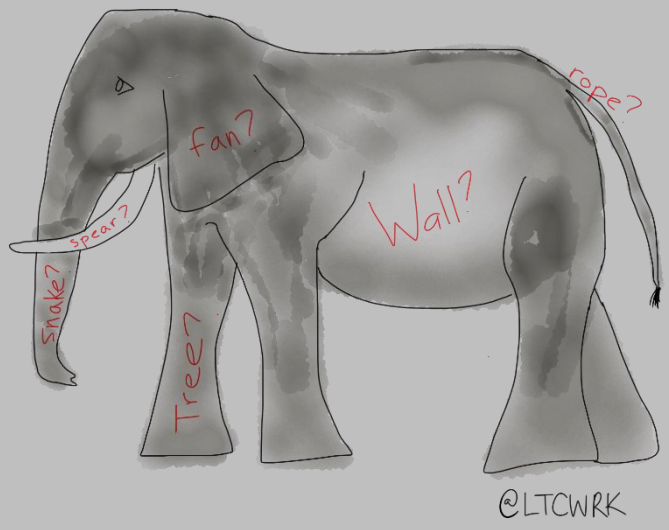
If successful in forming this mental structure, you'll be able to attach new knowledge to previous knowledge, allowing you to learn more efficiently and effectively.

> *Another idea that was hugely useful to me was one I obtained when I listened in law school when some waggish professor said, "A legal mind is a mind that considers it feasible and useful, when two things are all twisted up together and interacting, to try to think about one thing without considering the other." Well, I could see from that indirectly pejorative sentence that any such "legal" approach was ridiculous. And this pushed me further along in my natural drift, which was toward learning all the big ideas in all the big disciplines, so I wouldn't be the perfect damn fool the professor described. And because the really big ideas carry about 95% of the freight, it wasn't at all hard for me to pick up about 95% of what I needed from all the disciplines and to include use of this knowledge as a standard part of my mental routines. Once you have the ideas, of course, you must continuously practice their use. Like a concert pianist, if you don't practice, you can't perform well. So, I went through life constantly practicing a multidisciplinary approach.*
>
> *– Charlie Munger,* 2007 USC Gould School of Law Commencement Speech

Mental Models

A mental model is a representation of how the world works. Proper mental models help us more accurately explain and navigate the world.

Mental models can be made up of one idea, whereas others are based on several. While we may never be able to reach fundamental truth, the best mental models are invariant, universal, descriptive, and predictive.



I've long believed that a certain system which almost any intelligent person can learn – works way better than the systems that most people use. What you need is a latticework of mental models in your head. And, with that system, things gradually get to fit together in a way that enhances cognition. However, my particular approach seldom seems to get through, even to people of immense ability. Things usually die after going to the 'Too-Hard' pile.

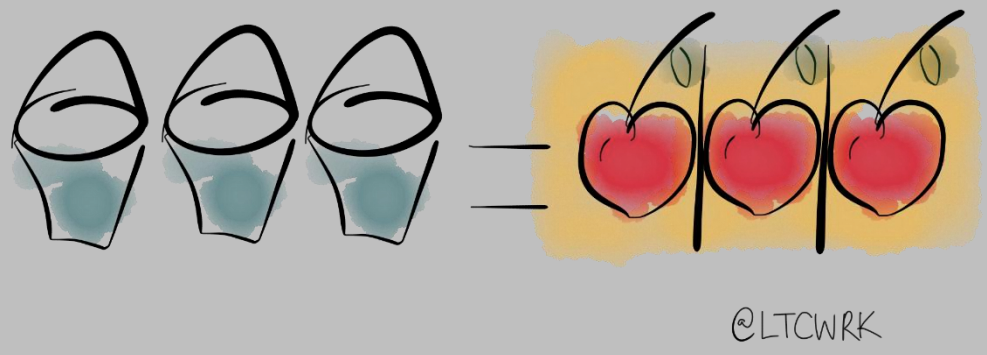
– Charlie Munger, Poor Charlie's Almanack

The Three Buckets

The Three Buckets is like a slot machine.

> The first bucket ("slot") is composed of inorganic systems – physics, chemistry, science, geology, etc. It is the oldest at 13.7 billion years and has the largest relevant data set.
>
> The second bucket is 3.5 billion years old and is composed of the biological universe – evolution, natural selection, etc.
>
> The third bucket, while having the smallest sample size, is also the most relevant to us. It is composed of 20,000 years of recorded human history.

Because of the large sample size and relevance of these three buckets, when they all yield the same answer, it is the functional equivalent of getting cherries straight across on a slot machine – you've got a winner! The Three Buckets approach provides a framework for arriving at universal, invariant principles that have stood the test of time. As time discovers truth, when an idea aligns with the three buckets, the joint probability of error drops towards zero.



Nothing can be more incorrect than the assumption that one sometimes meets with, that physics has one method, chemistry another, and biology a third.

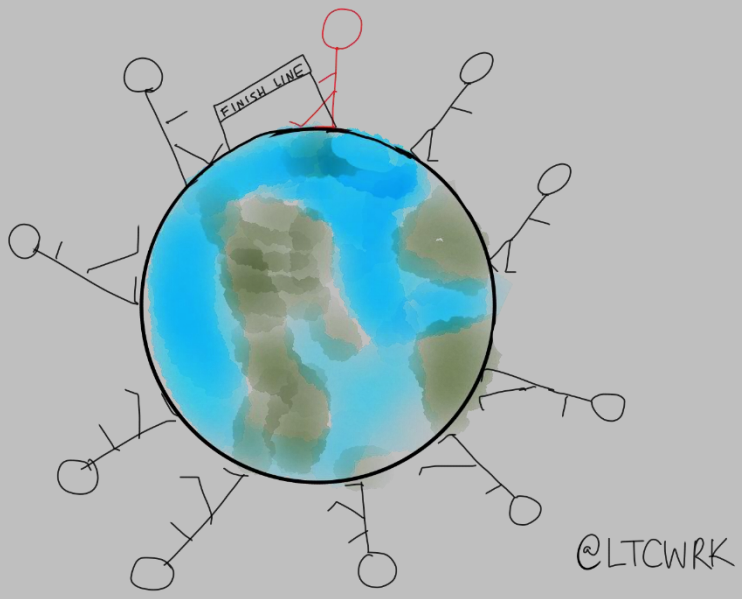
– Thomas Huxley

Advantageous Divergence

This is the utopia we are after – finding ways to do things differently, yet correctly. This, in its purest form, is working smarter, not harder.

These mental models are all about gaining Advantageous Divergence – by having a different (and correct!) set of tools than everyone else, you can succeed and prosper when others can't.

It is important to understand and honor the fact that reality doesn't reward effort. It rewards utility and effectiveness.



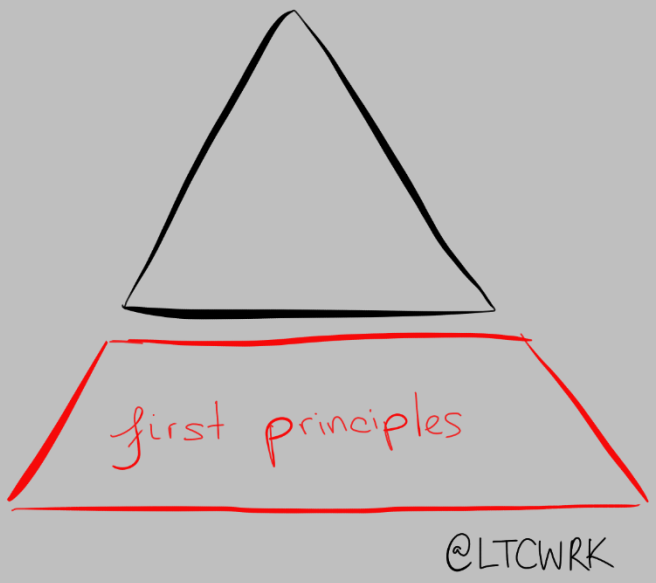
You can't be normal and expect abnormal results.

– *Jeffrey Pfeffer*

First Principles Thinking

By deeply understanding general principles, we gain the ability to deconstruct, combine, and recombine ideas into a more useful whole. If we understand the fundamental truths, we are no longer limited to the way things are today.

This clarifies what is feasible and what is not, avoiding the need for brute force or blind trust. This provides tremendous freedom and energy to tackle big projects!

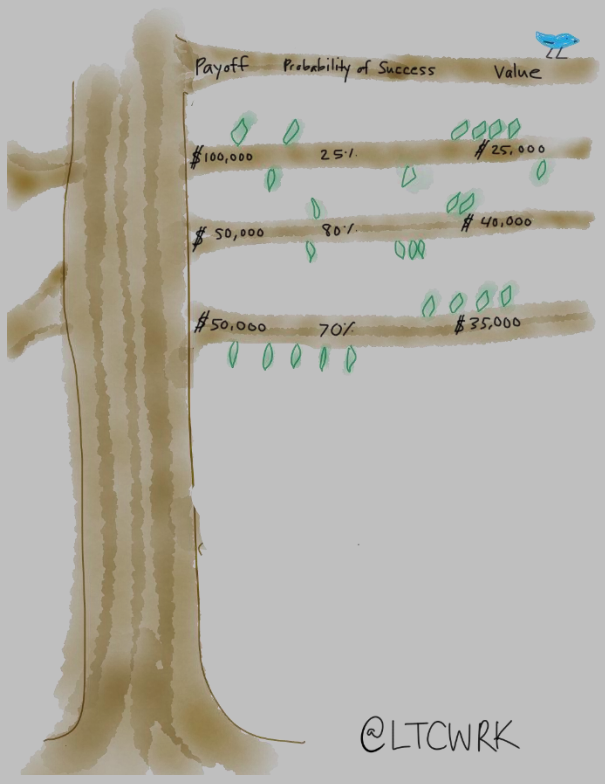


I think it's important to reason from first principles rather than by analogy. So, the normal way we conduct our lives is, we reason by analogy. We are doing this because it's like something else that was done, or it is like what other people are doing…with slight iterations on a theme. And it's… mentally easier to reason by analogy rather than from first principles. First principles are kind of a physics way of looking at the world, and what that really means is, you…boil things down to the most fundamental truths and say, "okay, what are we sure is true?" … and then reason up from there. That takes a lot more mental energy. – Elon Musk

Second-Order Thinking

First-order thinking is the fast and simple understanding of the basic implications of a decision. This mode of thinking only solves the immediate problem without considering the consequences.

Second-order thinking is the process of coming to understand, as best as you can, the implications of those first-order impacts – the effects of effects.



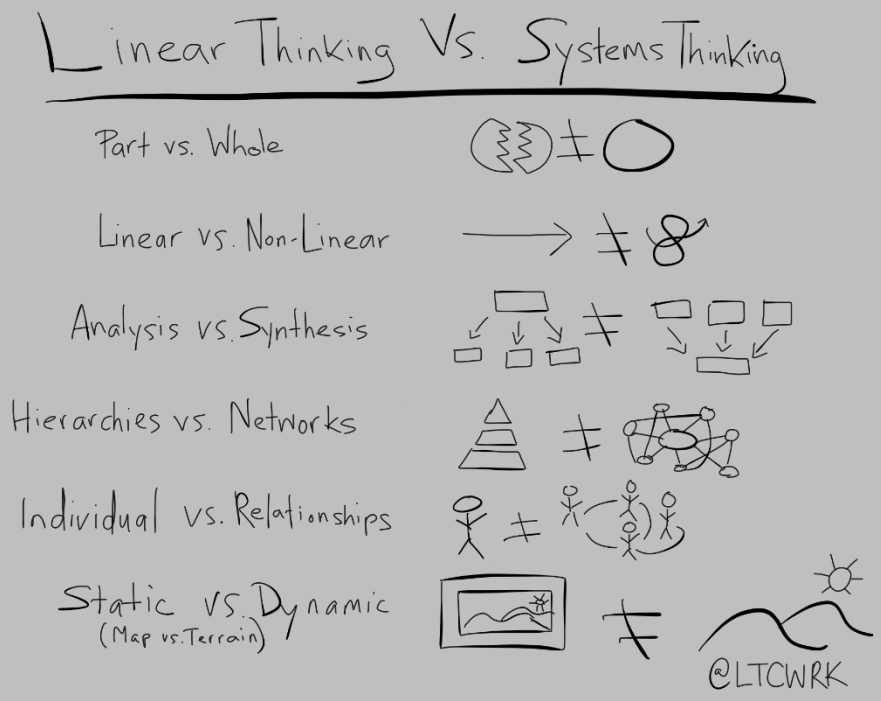
First-order thinking is any type of thinking that is about something other than thinking itself. Second-order thinking is thinking about thinking.

– *Kevin Maurice*

Systems Thinking

Systems thinking into account the structure of the system, the agents and their interactions/incentives, and the dynamics of the system (a system's behavior over time). This is necessary to understand the connections between events and the behavior of the structure.

This mindset helps get to the root of the problem, thereby increasing the chance of implementing a sustainable long-term solution, rather than simply fighting fires. You must change the structure to change the behaviors

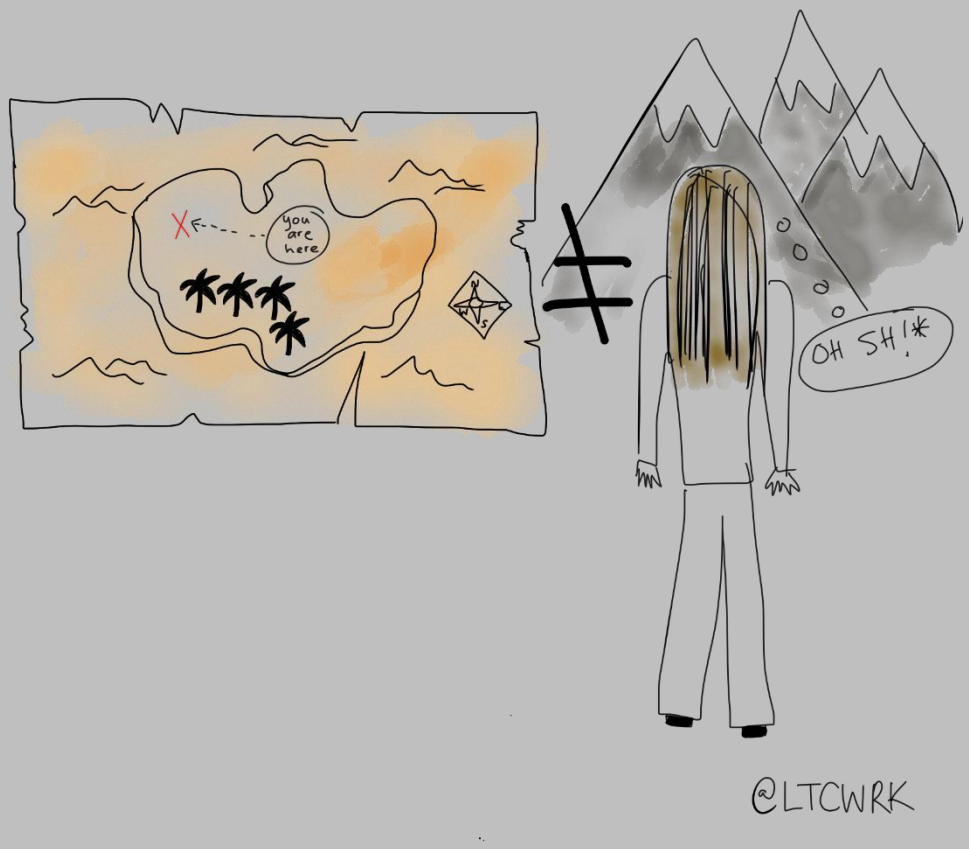


From the process of working back and forth between assumptions about the parts and the observed behavior of the whole, we improve our understanding of the structure and dynamics of the system.

– Richard Hamming, *The Art of Doing Science and Engineering*

The Map is Not the Terrain

The map is not the terrain, and the name is not the nature. This mental model is so important because it reminds us to see reality for what it is, and not how we wish it to be.

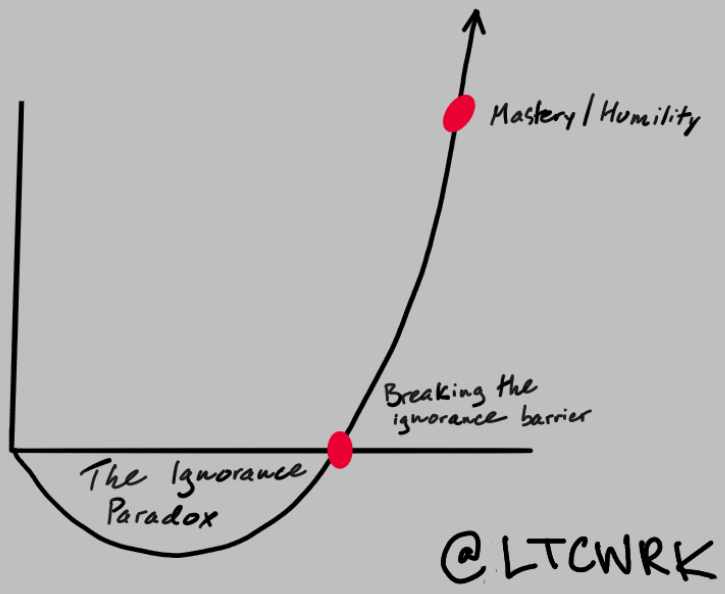


Knowing the name of something means nothing, we must know its essence. See that bird? It's a brown-throated thrush, but in Germany it's called a halzenfugel, and in Chinese they call it a chung ling and even if you know all those names for it, you still know nothing about the bird. You only know something about people; what they call the bird. Now that thrush sings, and teaches its young to fly, and flies so many miles away during the summer across the country, and nobody knows how it finds its way.

– *Richard Feynman*

The Ignorance Paradox

Counterintuitively, a small quantity of knowledge is initially destructive to the utility of knowledge because it can lead to overconfidence.



Be on the lookout for chauffeur knowledge. Do not confuse the company spokesperson, the ringmaster, the newscaster, the schmoozer, the verbiage vendor, or the cliché generator with those who possess true knowledge. How do you recognize the difference? There is a clear indicator: True experts recognize the limits of what they know and what they do not know. If they find themselves outside their circle of competence, they keep quiet or simply say, "I don't know." This they utter unapologetically, even with a certain pride. From chauffeurs, we hear every line except this.

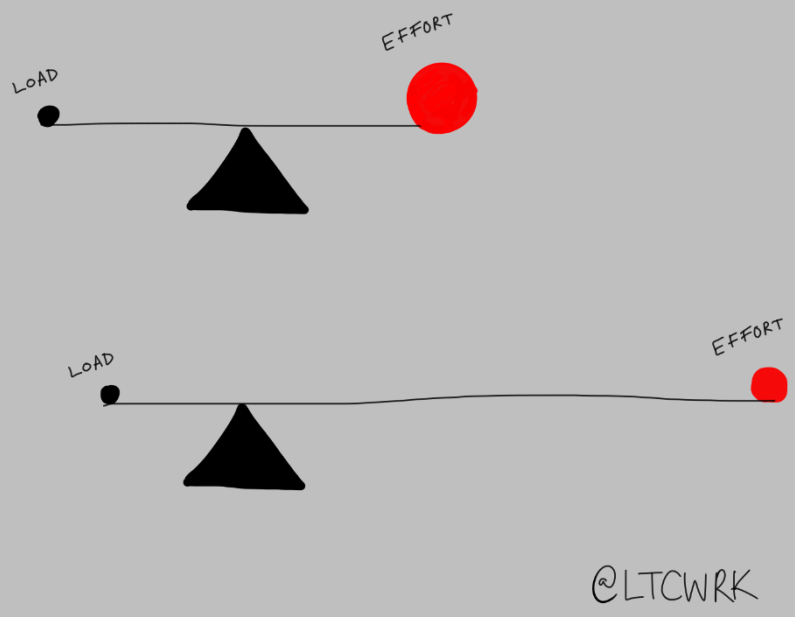
– Rolf Dobelli, The Art of Thinking Clearly

Choosing Important Problems

All decisions must be made taking opportunity costs into account because we only have one life, and we naturally want to make the most of it.

If we aren't working on the most important problems in our field, that can make a significant difference in people's lives, that we are jumping out of bed in the morning to work on, we are disrespecting opportunity costs.

Not only is there the beneficial first-order effects of working on and trying to solve hard problems, but the second-order effects are noteworthy as well – it drastically influences how and what you think about.



In many fields, the hard problem is not solving problems, but deciding what problems to solve…Interesting projects have a few big, clear problems rather than a lot of little nasty ones. Working on nasty little problems makes you stupid and great hackers avoid them at all costs.

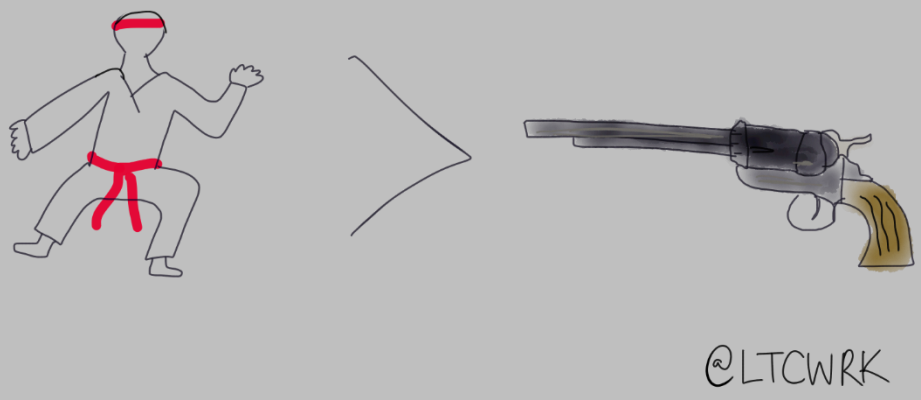
– Paul Graham, Great Hackers

On Having Opinions

Munger has an appropriately high bar for what it takes to hold an opinion:

> *"I'm not entitled to have an opinion on this subject unless I can state the arguments against my position better than the people do who are supporting it…I think that only when I reach that stage am I qualified to speak." Now you can say that's too much of an iron discipline. It's not too much of an iron discipline. It's not even that hard to do."*

A massively important positive unintended consequence of this mindset is that it makes it easier to think independently and destroy your own ideas.



When the facts change, I change my mind. What do you do, sir?

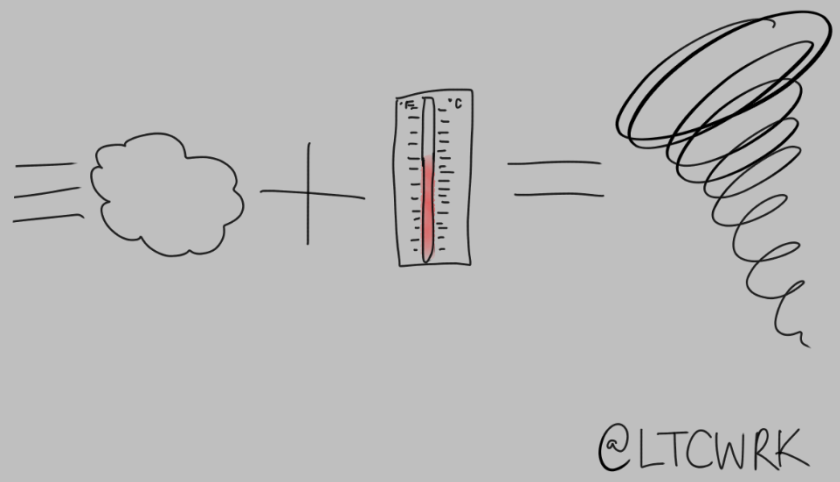
– John Maynard Keynes

Lollapalooza Effects

Lollapalooza Effects occur when many different factors come together, leading to multiplicative, rather than additive results.

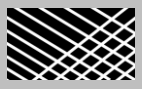
A common mistake is to look at a situation linearly or in isolation. You must take all factors into account and, as best as you can, understand how they fit together and might impact each other.

This is such a vital idea because it can occur in all complex systems – everything from sports, investing, relationships, business, nature, and more.



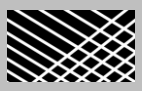
The most important thing to keep in mind is the idea that especially big forces often come out of these one hundred models. When several models combine, you get lollapalooza effects; this is when two, three, or four forces are all operating in the same direction. And, frequently, you don't get simple addition. It often like a critical mass in physics where you get a nuclear explosion if you get to a certain point of mass-and you don't get anything much worth seeing if you don't reach the mass…You have to recognize how these things combine. And you have to realize the truth of biologist Julian Huxley's idea that "Life is just one damn relatedness after another." So, you must have the models, and you must see the relatedness and the effects from the relatedness.

– Charlie Munger, Outstanding Investor Digest, December 29, 1997



The Latticework:

Physics

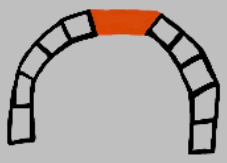


Physics

After the meta-learning principles we discussed in Worldly Wisdom, we will be diving into physics.

Physics investigates how matter and energy interact which helps us understand how the universe around us works. These core principles dictate how everything from subatomic particles to planets move, react, and interact with the matter and energy around it.

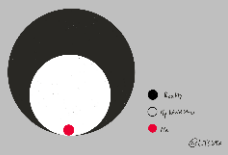
> Physics is the most fundamental and all-inclusive of the sciences and has had a profound effect on all scientific development. In fact, physics is the present-day equivalent of what used to be called natural philosophy, from which most of our modern sciences arose. Students of many fields find themselves studying physics because of the basic role it plays in all phenomena.
>
> – Richard Feynman, *Six Easy Pieces*



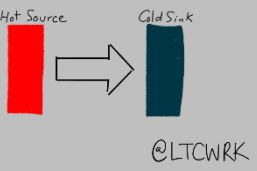
Physics is the keystone of our first bucket, serving as a primary filter in which to view the world. As we understand the facts today, these big ideas from physics have held true for 13.7 billion years and contain the largest relevant data set. These fundamental concepts are time-invariant and permeate every facet of scientific development and of our lives. This is why coming to understand the ideas, language, and sound theory of physics can help add context, color, and depth to the rest of our journey. If properly approached, it can train us to be thorough thinkers who deeply understand the laws which underpin our physical world, giving us a robust foundation to build our latticework upon.

The Big Ideas of Physics:

1. Galilean Relativity



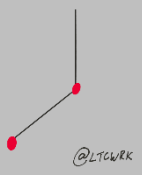
2. The Laws of Thermodynamics



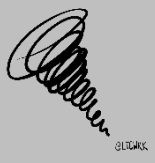
3. Newton's Laws of Motion

4. Complexity

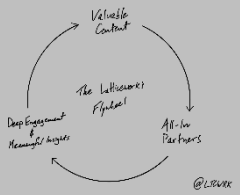
5. Chaos Theory



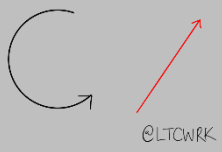
6. Emergence



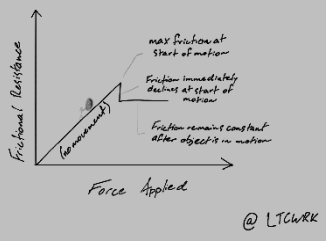
7. Momentum



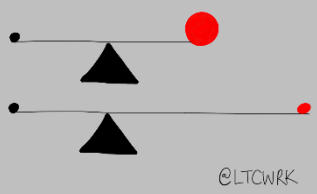
8. Velocity



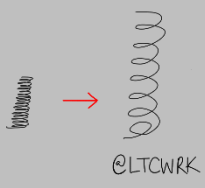
9. Friction



10. Equilibrium



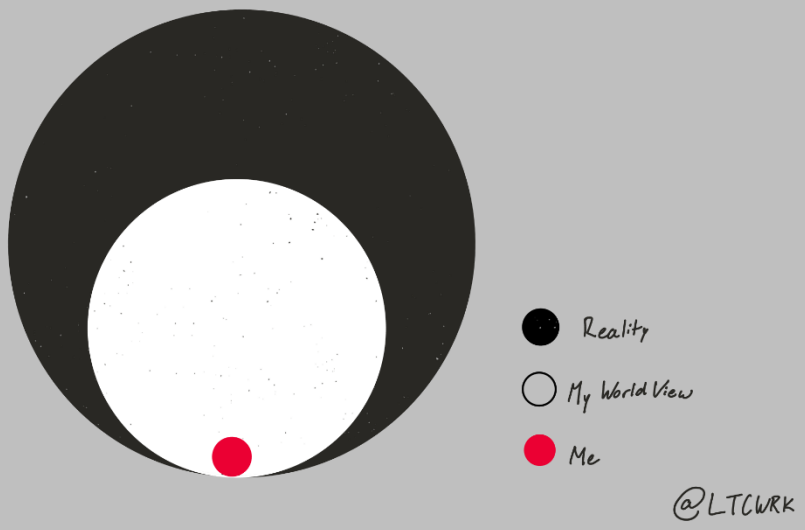
11. Hysteresis



Galilean Relativity

Galilean Relativity states that we can never fully grasp, define, or understand a system we are part of. This is to say, "distance provides perspective" and wisdom in life is often about perspective.

We can escape Galilean Relativity by stepping out of our system. This "fresh set of eyes" allows us to gain perspective and to see problems for what they are. Theoretically, if we can overcome Galilean Relativity, eliminating our blindspots, we'll also eliminate our mistakes – as all mistakes come from blindspots.



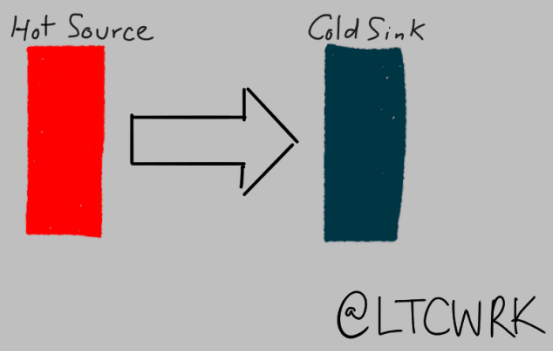
There is more than one way to look at any situation, namely one where we are NOT the center of the universe – I'm operating on the automatic, unconscious belief that I am the center of the world, and that my immediate needs and feelings are what should determine the world's priorities. The thing is that, of course, there are totally different ways to think about these kinds of situations. In this traffic, all these vehicles stopped and idling in my way, it's not impossible that some of these people in SUV's have been in horrible auto accidents in the past, and now find driving so terrifying that their therapist has all but ordered them to get a huge, heavy SUV so they can feel safe enough to drive. Or that the Hummer that just cut me off is maybe being driven by a father whose little child is hurt or sick in the seat next to him, and he's trying to get this kid to the hospital, and he's in a bigger, more legitimate hurry than I am: it is actually I who am in HIS way.

– David Foster Wallace, This is Water

The Laws of Thermodynamics

Thermodynamics is the study of the large-scale behavior of systems exchanging work and heat with connected systems or their environment. There are *four* key laws in thermodynamics:

0. Zeroth Law – The Transitive Law (If two systems are in thermodynamic equilibrium with a third system, the two original systems are in thermal equilibrium with each other.)
1. First Law – The Law of Conservation or the "No Free Lunch" Law (energy can be transformed from one form to another, but can neither be created nor destroyed)
2. Second Law – The "Contrast Advantage" Law (While there will always be "leakage" in a system, the most efficient systems have the hottest possible source and the coldest possible sink. This is what we mean by "contrast." Finding contrast in your field allows you to differentiate yourself in a "thermodynamically efficient" manner.)
3. Third Law – The "Absolute Zero" Law (The entropy of a system approaches a constant value as the temperature reaches absolute zero.)



In every engine, there has to be a cold sink, and that at some stage of the cycle energy must be discarded into it. That little mouse of experience is nothing other than the second law of thermodynamics. All the law seems to be saying is that heat cannot be completely converted into work in a cyclic engine: some has to be discarded into a cold sink. That is, we appear to have identified a fundamental tax: Nature accepts the equivalence of heat and work, but demands a contribution whenever heat is converted into work. Note the dissymmetry. Nature does not tax the conversion of work into heat: we may fritter away our hard-won work by friction, and do so completely. It is only heat that cannot be so converted. Heat is taxed; work is not.

– PW Atkins, The Second Law

Newton's Laws of Motion

Newton's Laws of Motion are three fundamental, general laws which help describe how objects in the world move and react to forces.

1. First Law – The Inertia Law (an object at rest, stays at rest)
2. Second Law: Force = Mass * Acceleration (F = ma).
3. Third Law – The Law of Reciprocity (for every action there is an equal and opposite reaction)

My most surprising discovery: the overwhelming importance in business of an unseen force that we might call "the institutional imperative." In business school, I was given no hint of the imperative's existence and I did not intuitively understand it when I entered the business world. I thought then that decent, intelligent, and experienced managers would automatically make rational business decisions. But I learned over time that isn't' so. Instead, rationality frequently wilts when the institutional imperative comes into play. For example: (1) As if governed by Newton's first law of motion, an institution will resist any change in its current direction; (2) Just as work expands to fill available time, corporate projects or acquisitions will materialize to soak up available funds; (3) Any business craving of the leader, however, will be quickly supported by detailed rate-of-return and strategic studies prepared by his troops; and (4) The behavior of peer companies, whether they are expanding, acquiring, setting compensation, or whatever, will be mindlessly imitated.

– Warren Buffett, Berkshire Hathaway 1989 Chairman's Letter

Complexity

A complex system exhibits emergent behavior due to the collective interaction of many individual agents according to simple rules. Some common properties of complex systems include: emergent collective behavior; signaling and information processing; adaptation via learning or evolution; exhibiting non-trivial emergent and self-organizing behaviors; large variability; dynamic interactions; phase transitions.

For example, you would not be able to predict the sophisticated anthill or behavior that arise out of the collective interaction of simple, individual ants. Same can be said of schools of fish or flocks of birds.

Complex systems are sensitive to original conditions, influenced by feedback loops, and buffeted by random outside variables.

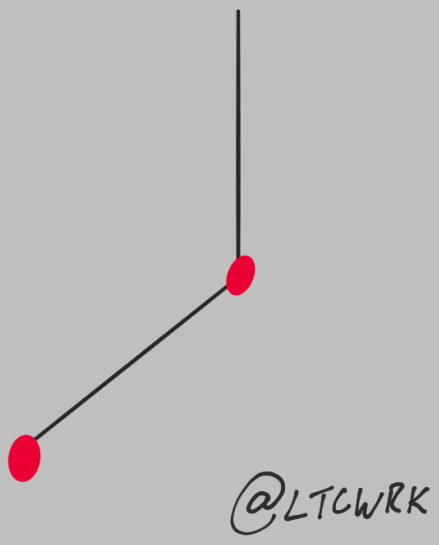
Complex systems must be studied as a whole, not in individual parts, because the behavior of the system is greater than the sum of the parts. The old science was concerned with understanding the laws of being. The new science is concerned with the laws of becoming.

– Robert Hagstrom, Latticework

Chaos Theory

The difference between chaos and complexity is subtle and important. Chaos leads to complicated, non-periodic behavior from *iteration* of a simple rule(s), whereas complexity leads to rich, collective behavior from simple *interactions* between large numbers of subunits. A double pendulum easily exemplifies the difference. Although the path is difficult to predict, it will never display emergent behavior.

Another way to think about complexity compared to chaos is along a spectrum: order – complexity – chaos. Complexity lies in between order (equilibrium, stasis) and chaos (anarchy). That is why life can be thought of as occurring at the "edge" of chaos.



Some systems are very sensitive to their starting conditions, so that the tiny difference in the initial push you give them causes a big difference in where they end up. And there is feedback, so that what a system does affects its own behavior.

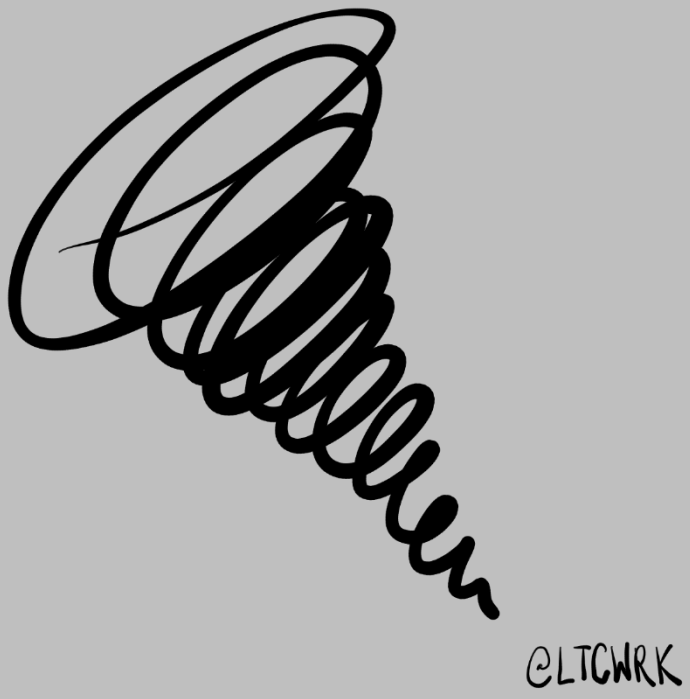
– John Gribbin, Deep Simplicity

Emergence

Emergence is a process where higher-order behavior emerges from the interaction of lower-order components.

These smaller or simpler entities do not exhibit the properties that the higher-order entity ends up exhibiting. The result is frequently not a matter of simple addition – but rather non-linear, multiplicative, or even exponential.

An important resulting property of emergent behavior is that it cannot be predicted from simply studying the component parts – the whole is greater than the sum of its parts.



It is not the amount of knowledge that makes a brain. It is not even the distribution of knowledge. It is the interconnectedness.

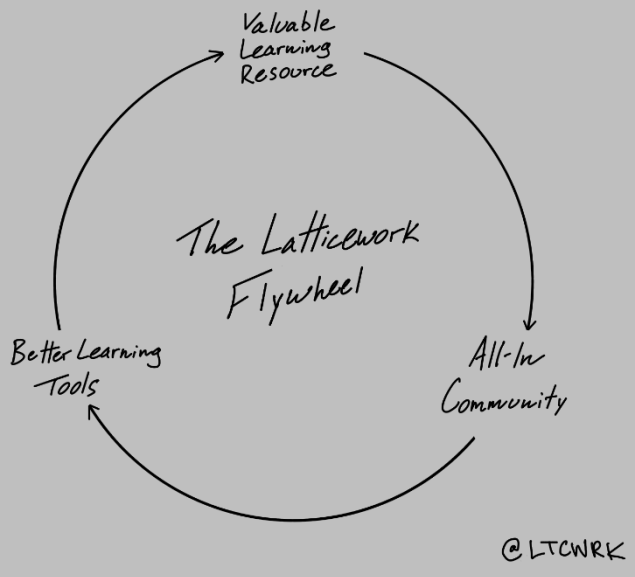
– Howard Bloom, The Lucifer Principle

Momentum

Momentum is the quantity of motion of a moving body, measured as a product of its mass and velocity: Momentum = Mass * Velocity

Momentum is broadly applicable outside of physics as it can help you understand how things change and how difficult or easy it is to change them.

The metaphor made famous by Jim Collins in *Good to Great* is that of a flywheel. A flywheel is a bit of an outdated metaphor, but the idea is time-invariant. A flywheel is a heavy revolving wheel in a machine that is used to increase the machine's momentum, giving it greater stability or a reserve of available power during interruptions in the delivery of power to the machine. Flywheels are heavy and therefore have a lot of inertia but, once they get started, quickly gain and can sustain momentum.



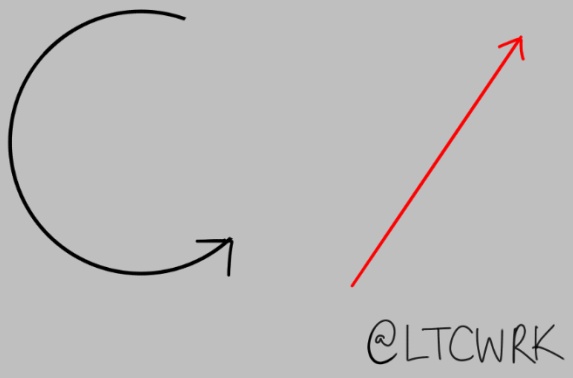
Positive feedback loops that build momentum, increasing the payoff of incremental effort. When good things you do lead to more good things "just happening."

– Eric Jorgenson

Velocity

There are 3 key things to deeply understand regarding velocity:

1. The difference between velocity and speed – the difference is vector. Velocity has magnitude *and* direction whereas speed does not. If you're sprinting in circles, you're clearly not going to go anywhere.
2. While nobody knows why nature favors velocity over mass, she does, and we should harness it. How do we know this? Kinetic Energy = $\frac{1}{2}mv^2$
3. The stark difference between potential energy and kinetic energy. P_e is the energy an object possesses due to its position relative to others. You can be totally still yet have potential energy (think of a car on top of a hill). K_e is energy is energy which a body possesses by virtue of being in motion. We should seek K_e



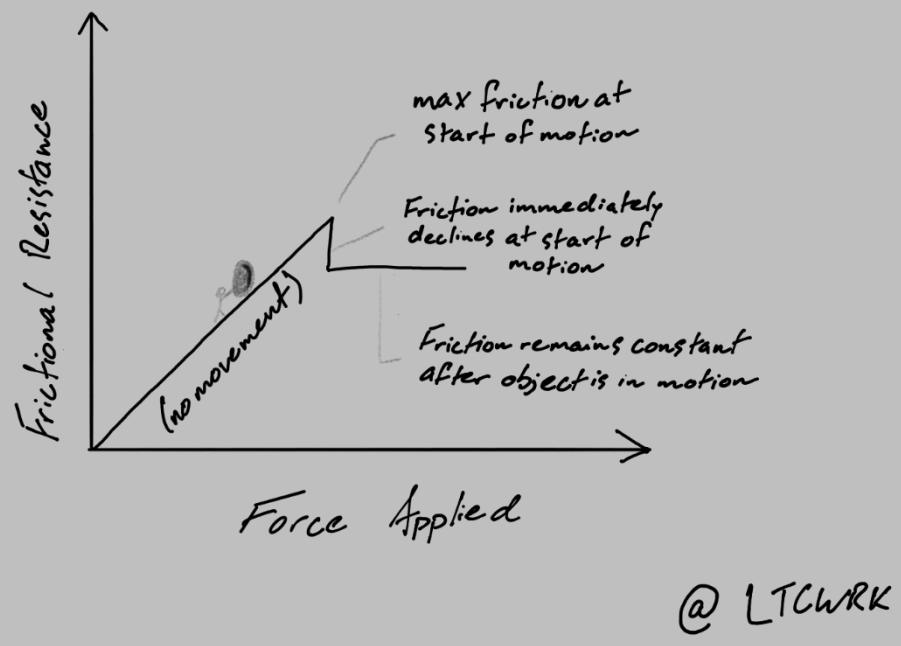
Google famously prioritized speed as a feature. They realized that if search is fast, you're more likely to search. The reason is that it encourages you to try stuff, get feedback, and try again. When a thought occurs to you, you know Google is already there. There is no delay between thought and action, no opportunity to lose the impulse to find something out. The projected cost of googling is nil. It comes to feel like an extension of your own mind…The general rule seems to be: systems which eat items quickly are fed more items. Slow systems starve.

– James Somers, Speed Matters

Friction

Friction is the force that causes the resistance felt when two objects are moving against one another.

Inertia is a prime example of friction. Take the boulder in the diagram below. It has significant inertia as it takes a lot of energy to get it moving but, once you do, its inertia will work in your favor. Although this can be daunting to overcome, be encouraged that there is typically a tipping point which, when crossed, makes change seem relatively easy.



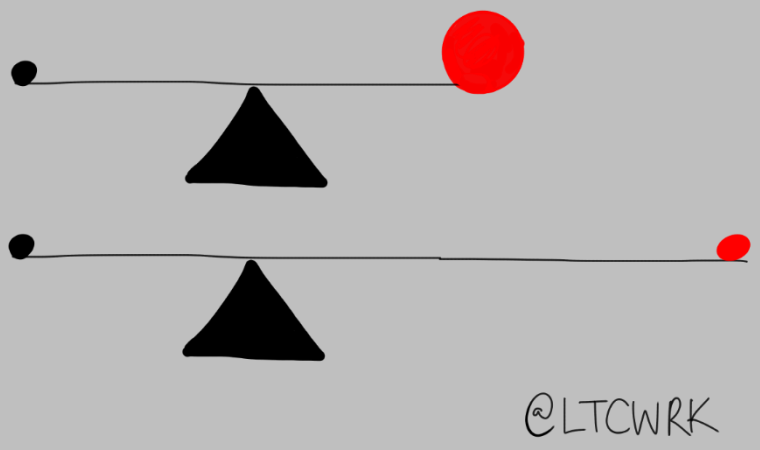
Most people, most of the time, will take whatever choice requires least work – death before inconvenience. When you understand this, you can take advantage of it – whether you're a programmer or the operator of a business. Often competitors will not be willing to put in the work required and although it is by definition difficult, it will be successful. Successful design sees through the customer's eyes and makes whatever choice they are being asked to make as simple as possible. Little nudges go a long way…

– Paul Graham, The Other Road Ahead

Equilibrium

Equilibrium is a state of balance between opposing forces, powers, or influences.

Although the idea of equilibrium might evoke an image of a static or unchanging system, that isn't always necessarily the case. In dynamic equilibrium, you have a system that stays the same though it is always changing (inflows exactly equal outflows). Imagine a whirlpool in a bathtub that can go on forever as long as the water is running, and the drain is open.



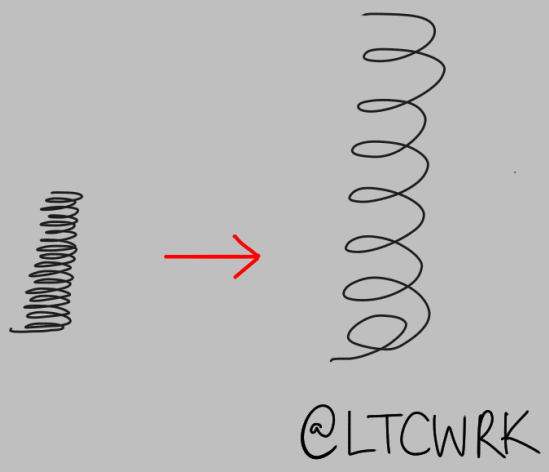
Swing is extreme coordination. It's a maintaining balance, equilibrium. It's about executing very difficult rhythms with a panache and a feeling in the context of very strict time. So, everything about the swing is about some guideline and some grid and the elegant way that you negotiate your way through that grid.

– *Wynton Marsalis*

Hysteresis

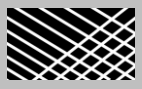
Hysteresis is when the state of a system is dependent on its history – what happened previously influences what happens next.

It can also be thought of as delayed feedback, where a result lags behind that which causes it. Another word for this is springloading, and every human system is either positively or negatively springloaded. Understanding this may help clarify why certain situations unfold the way they do, such as the "powder keg" that was Europe before WWI.



One basic principle found throughout nature is this: tension seeks resolution. From the spider web to the human body, from the formation of galaxies to the shifts of continents, from the swing of pendulums to the movement of wind-up toys, tension resolution systems are in play. We can observe in nature and in our lives both simple and complex tension-resolution systems that influence not only the changes that occur but how those changes will occur. The simplest tension-resolution system is a structure that contains a single tension. The tendency of the structure is to resolve the tension. If you stretch a rubber band, the tendency of the rubber band is to pull back to resolve the tension in the structure. A compressed coiled spring has a tendency to release the tension by springing back toward its original state.

– Robert Fritz, The Path of Least Resistance



The Latticework:

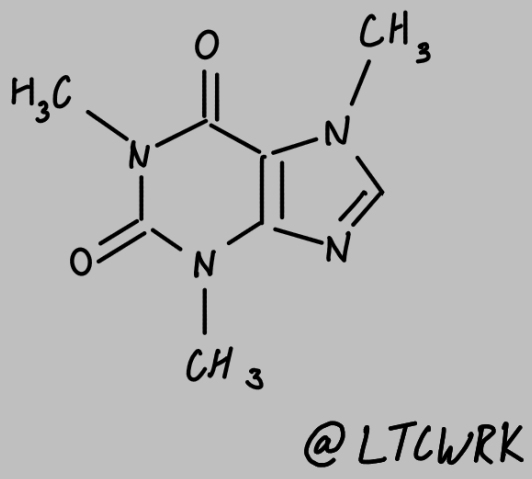
Chemistry

Chemistry

The big ideas from chemistry also fall into the first bucket of our Three Bucket framework and are broadly applicable and helpful in understanding the world around us.

For example, the language from chemistry is particularly beautiful and useful when describing how ideas spread, how teams communicate and work together, how to approach mastery, how to think about self-improvement, and much more. As Spanish essayist Miguel de Unamuno said, "Chemistry ought to be not for chemists alone."

Given chemistry's long and robust history, these ideas can and should serve as a fundamental "hanger" in our mental latticework.

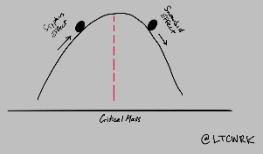


> Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less.
>
> – Marie Curie

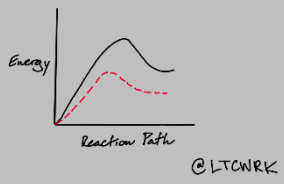
The Big Ideas of Chemistry:

12. Chemical Reactions

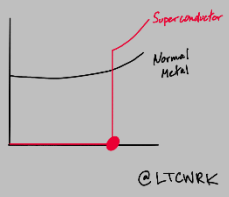
13. Critical Mass



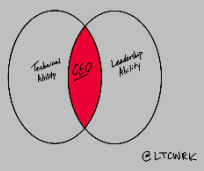
14. Catalysts



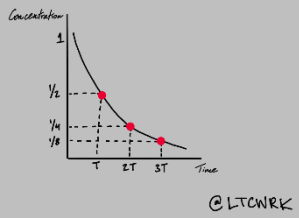
15. Phase Transitions



16. Alloying



17. Half-Life

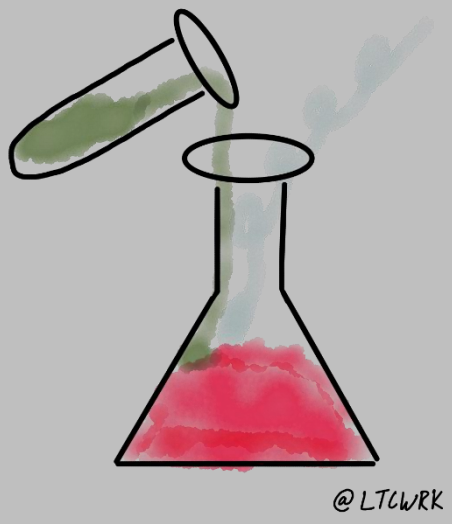


Chemical Reactions

Chemical reactions involve processes in which reactants (match head, oxygen) produce products (heat, light) known as new compounds. Most elements exist as chemical compounds which are collections of two or more elements held together by relatively strong attractive forces. These forces (chemical bonds) greatly influence the properties of compounds. Weak bonds between particles of an element/compound can also contribute to the properties of the material.

In organic and inorganic chemistry, weak food, water, or other bonds can be rearranged through chemical processes and reactions so that enormous energy is released.

Similarly, in team chemistry, the "bonds" we have with our teammates or counterparties are weak or strong based upon win/win, all-in relationships. When weak human bonds based on win/lose, lose/win, or lose/lose are rearranged into stronger "win/win" bonds, enormous energy is released.



The purpose of Navy Seal Hell Week is to weed out recruits who can't or won't make a total commitment to the group.

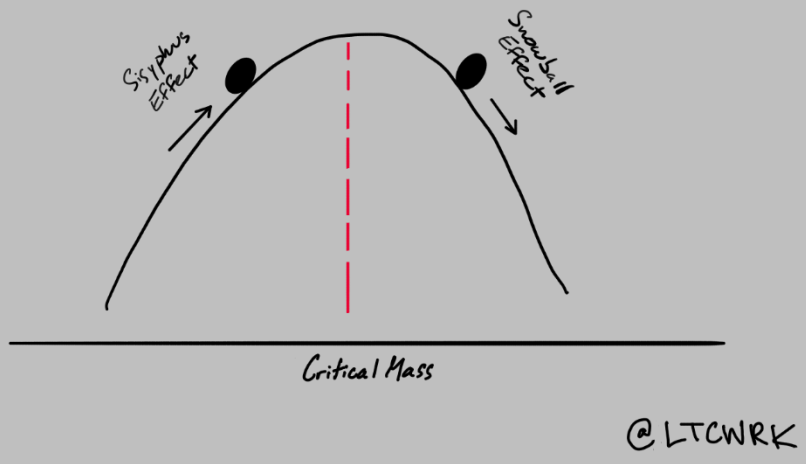
– Elite Teams Get the Job Done, Fortune Magazine

Critical Mass

Critical mass is like an avalanche.

Snow slowly builds up on the mountainside, eventually leading to an unstable condition where the wrong minor movement, sound, or disturbance can cause a destructive force to be unleashed.

This is a universal principle with wide-ranging applications, including learning, mastery, habit formation, sand piles, earthquakes, landslides, superfluidity, and more – you may not see results for some time but once you reach critical mass, you will 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.



At a certain scale, a system reaches a critical mass or a limit where the behavior of the system may change dramatically. It may work better, worse, cease to work or change properties. Small interactions over time slowly accumulate into a critical state – where the degree of instability increases. A small event may then trigger a dramatic change like an earthquake. A small change may have no effect on a system until a critical threshold is reached. For example, a drug may be ineffective up until a certain threshold and then become effective, or it may become more and more effective, but then become harmful.

– Peter Bevelin, Seeking Wisdom

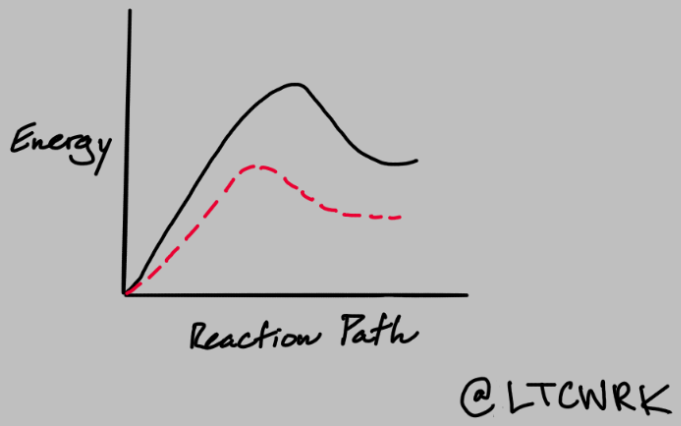
Catalysts

A catalyst is a substance which increases the rate of a chemical reaction, decreasing the activation energy needed to start the chemical reaction.

When trying to make something happen, be aware that activation energy is always required (even if minimal) and to be on the lookout for catalysts which decrease the energy needed to do so.

For example, if trying to establish a new habit, find ways to alter your environment to make it easier. If trying to be healthier, avoid having junk food in the house. If you're looking to read more, unplug your tv.

People, technology, culture, leadership, innovation, and more can all be considered catalysts. They can reduce the "activation energy" – the energy required to reach escape velocity – and decrease the effort necessary to change. Keep a close eye out for these catalysts as they can leverage your efforts.



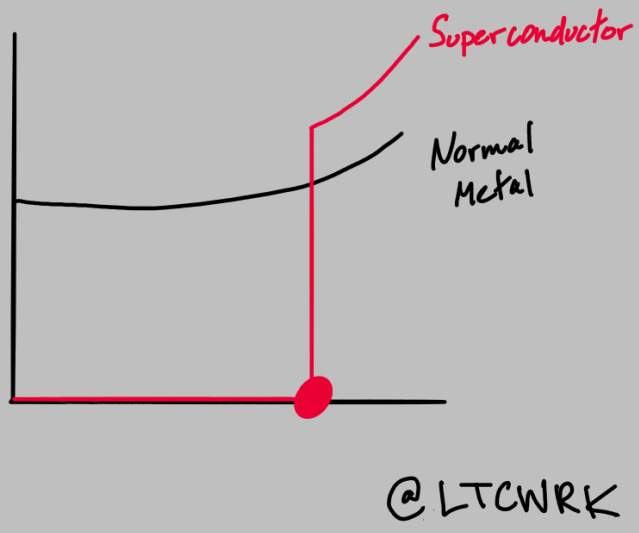
Part of the activation energy required to start any task comes from the picture you get in your head when you imagine doing it. It may not be that going for a run is actually costly; but if it feels costly, if the picture in your head looks like a slog, then you will need a bigger expenditure of will to lace up. Slowness seems to make a special contribution to this picture in our heads. Time is especially valuable. So, as we learn that a task is slow, an especial cost accrues to it. Whenever we think of doing the task again, we see how expensive it is, and bail.

– *James Somers, Speed Matters*

Phase Transitions

Phase transitions are the point at which elements transition from one phase to another. In this unique phase, fractions of a degree make all the difference in this state and can lead to Lollapalooza Effects (water freezing, electrons lining up to become superconductive, tornadoes emerging, etc.)

When pursuing anything challenging and feeling the wall of resistance, we must believe that we are perpetually on the cusp of hitting exponential growth. This will help drive motivation, deliberate practice, innovation, so that we can breach the critical threshold and reach the next phase transition.



Although all people are different, and all teams are different, what makes emergent properties and the phase transitions between them so interesting is that they are so predictable. We will see why organizations will always transform above a certain size, just like water will always freeze below a certain temperature, traffic will always jam above a critical density of cars, and one burning tree in a forest will always explode into a wildfire in high winds. These are all examples of phase transitions. Each person and team may be a puzzle. But in the aggregate, as Sherlock Holmes might say, the likelihood that any group will experience a phase transition becomes a mathematical certainty.

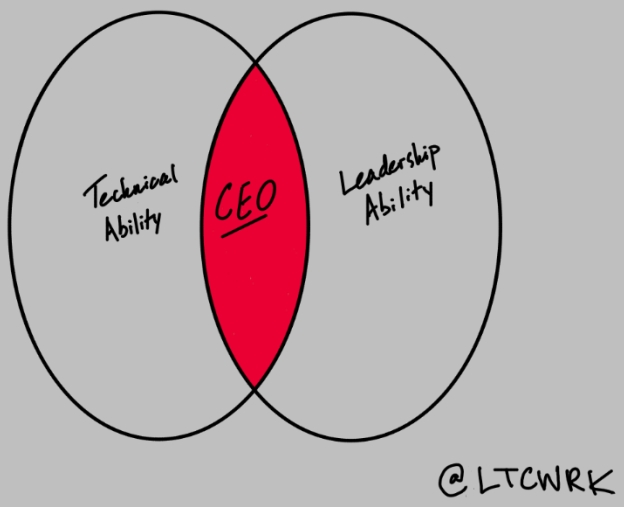
– Safi Bahcall, Loonshots

Alloying

A powerful example first heard from Paul Graham and later refined by Peter Kaufman is the concept of alloying as it relates to the combination of tin and copper, creating bronze.

In chemistry, the Mohs scale of hardness classifies how hard various minerals are. Talc is a 1 and diamond is a 10. In our example, tin is a 1.5 and copper a 3. These metals are not in close geographic proximity but, one day, thousands of years ago, somebody had the brilliant idea to combine these metals, creating a new alloy – bronze. You would think that when you combine these metals that the resulting alloy would be a 2.25 ((1.5+3)/2 = 2.25). However, we obviously don't get that or else this example would be a waste of time! What we get is 6! 1 + 3 = 6!

Similarly, people can use this same example and "blend in" characteristics which are typically not "in close geographic proximity" – characteristics which are not normally found together in people with their background, personality, disposition, status, etc. Instead of becoming a "purer" version of yourself, this new "alloy" is surprisingly strong.



Learn to sell, learn to build. If you can do both, you will be unstoppable.

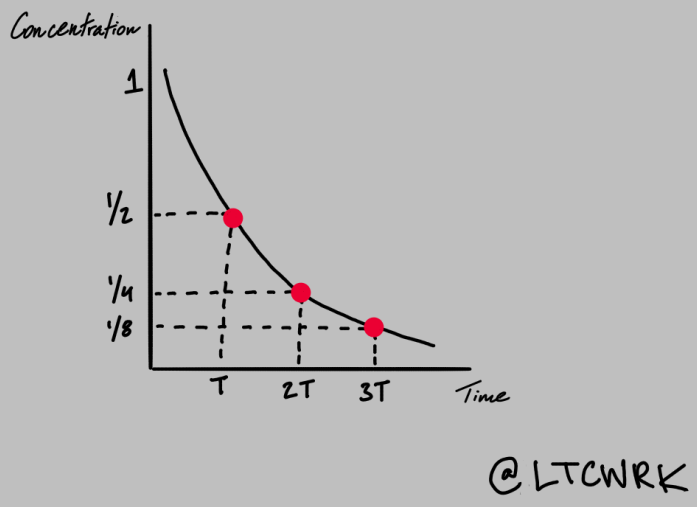
– Naval Ravikant, The Almanack of Naval Ravikant

Half-Life

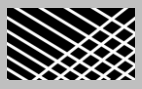
Half-life is the time it takes for something to halve.

While half-life is typically associated with radioactive decay, for most people the more applicable aspect of half-life relates to knowledge and information. Although often not appreciated, knowledge and information decay over time, yet most people don't often question what they "know for sure."

Understanding half-life helps to determine drug dosages and the progression of decay in radioactive materials, but for more laymen's purposes, half-life can help us understand why it is important to focus on invariant principles. These principles have stood the test of time, proven robust, and therefore worthy of our time and attention.



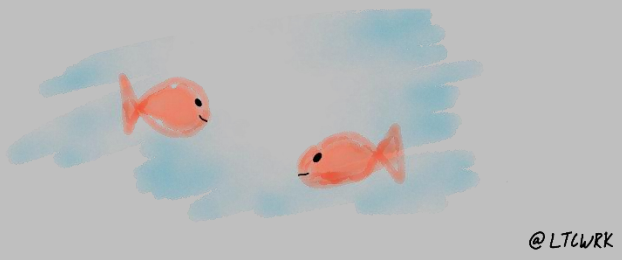
We can see how information changes in the figures for how long it takes for a body of knowledge to double in size. The figures quoted by Arbesman (drawn from Little Science, Big Science … and Beyond by Derek J. de Solla Price) are compelling, including: Time for the number of entries in a dictionary of national biographies to double: 100 years; Time for the number of universities to double: 50 years; Time for the number of known chemical compounds to double: 15 years; Time for the number of known asteroids to double: 10 years… The doubling of knowledge increases the learning load over time. As a body of knowledge doubles so does the cost of wrapping your head around what we already know. This cost is the burden of knowledge. To be the best in a general field today requires that you know more than the person who was the best only 20 years ago. Not only do you have to be better to be the best, but you also have to be better just to stay in the game.
– Farnam Street, Half Life



The Latticework:

Mathematics

Mathematics



Mathematics is central to our lives and our world, but few people truly take the time to grasp it at a fundamental level. It is like DFW says in This is Water, we are fish unknowingly swimming in water. Similarly, math is all around us, impacting everything and, while we might not understand why math functions so beautifully to describe and navigate the world, it does, and is why it is crucial to have a basic familiarity with these big ideas. As Eugene Wigner said, math is unreasonably effective in describing the natural sciences, making it an effective way to spend our time so that we can come to better understand the universe around us.

Those without a firm grasp of these big ideas may find themselves constantly disadvantaged and easily influenced. The hope is that if the ideas addressed in this discipline are thoroughly understood, that this disadvantage may turn into an advantage.

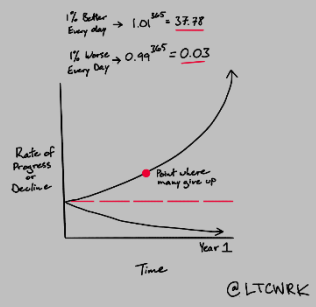
While you may still be skeptical of the impact math can have on your daily life, like the other hard sciences, it is worth studying as it can provide useful metaphors and perspectives to help sharpen your thinking and decision-making. With that, let's dig in…After the meta-learning principles we discussed in Worldly Wisdom, we will be diving into physics.

We have been using Mathematics without ever discussing what it is – most of you have never really thought about it, you just did the Mathematics – but Mathematics plays a central role in science and engineering. Perhaps the favorite definition of Mathematics given by Mathematicians is: "Mathematics is what is done by Mathematicians, and Mathematicians are those who do Mathematics." Coming from a Mathematician its circularity is a source of humor, but it is also a clear admission they do not think Mathematics can be defined adequately. There is a famous book, "What is Mathematics," and in it the authors exhibit Mathematics but do not attempt to define it. Once at a cocktail party a Bell Telephone Laboratories Mathematics department head said three times to a young lady, Mathematics is nothing but clear thinking. I doubt she agreed, but she finally changed the subject; it made an impression on me. You might also say Mathematics is the language of clear thinking.

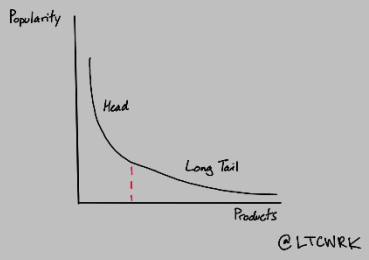
– Richard Hamming, Mathematics

The Big Ideas of Mathematics:

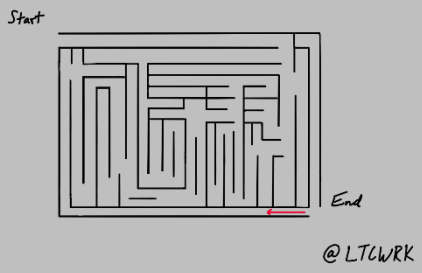
1. Compounding



2. Power Laws



3. Inversion

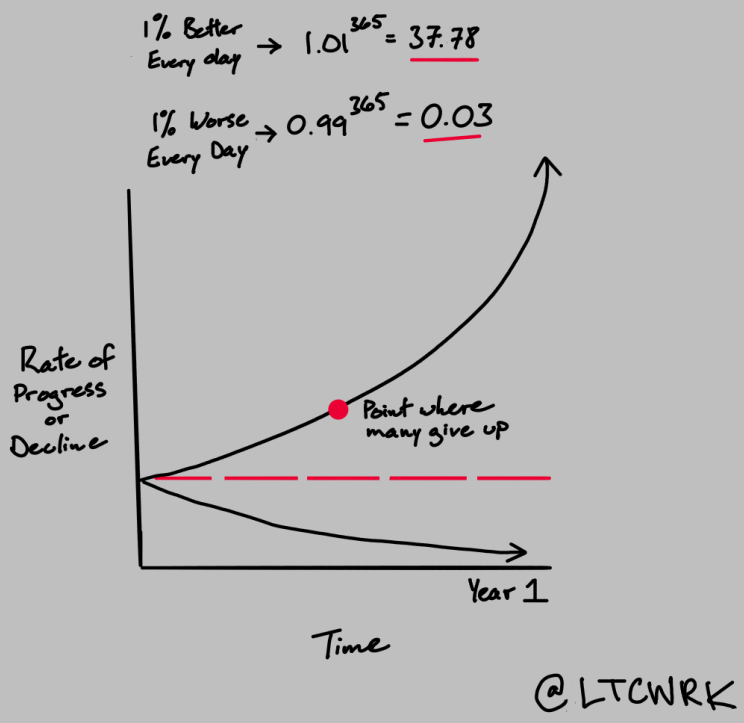


4. Algorithm

Compounding

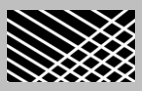
Compounding occurs when something begins to grow at a faster rate as it gets bigger and has more time. This progression may start deceptively small (and is why many people give up and fall off the exponential curve), but quickly becomes non-linear, improving faster the more time goes on.

While compounding is traditionally thought of as a scientific, mathematical, or financial concept, it is just as important in considering intangibles such as ideas, trust, knowledge, mastery, relationships, and more.



What's the most powerful force in the universe? Compound interest. It builds on itself. Over time, a small amount of money becomes a large amount of money. Persistence is similar. A little bit improves performance, which encourages greater persistence, which improves persistence even more. And on and on it goes.

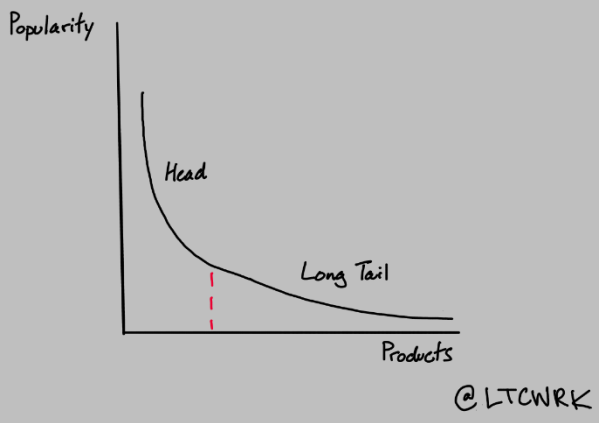
– *Daniel Pink, The Adventures of Johnny Bunko*



Power Laws

Power laws are mathematical relationships where the frequency of an event varies as a power (exponent) of some trait of that event. For example, the Richter scale describes the power of earthquakes on a power-law distribution scale: an 8 is 10x more destructive than a 7, and a 9 is 10x more destructive than an 8, etc. The larger are inversely proportional to some power of their size. In this case, the central limit theorem does not apply and therefore there is no "average" earthquake. This is true of all power-law distributions.

A key insight that understanding power laws unlocks is that these "black swans" are far more likely to occur than what "normal" bell curves would suggest. This is why we can live through several three standard deviation events in our lifetimes. We've been trying to fit a complex system into a static and "normal" paradigm, leaving us vulnerable and unprepared. However, by replacing these normal models with power law models, we can be better prepared for these likely black swan events.



Most people struggle to understand that we don't live in a normal world, we live under a power law…The biggest secret in venture capital is that the best investment in a successful fund equals or outperforms the entire rest of the fund combined. This implies two very strange rules for VCs. First, only invest in companies that have the potential to return the value of the entire fund. This is a scary rule, because it eliminates the vast majority of possible investments. Even quite successful companies usually succeed on a more humble scale. This leads to rule number two: because rule number one is so restrictive, there can't be any other rules…The power law means that differences between companies will dwarf differences in roles inside companies.

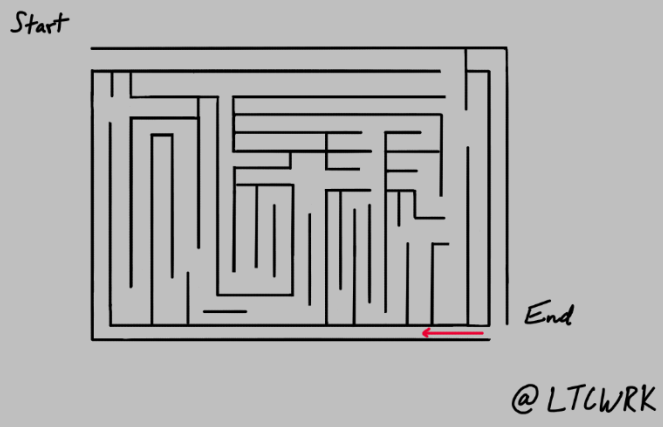
– Peter Thiel, Zero to One

Inversion

Inversion rests on analyzing and solving problems in reverse.

It's almost impossible to know what works a priori, because every situation is unique. It's far easier to understand what causes failure and simply seek to avoid those things.

This can be likened to the Hippocratic Oath. Attributed to Hippocrates, the oath had the doctors of the time vow to "first, do no harm." Much malpractice and heartache would be avoided if this millennia old inversion could be adhered to in various life domains. When trying to improve your diet, your decision making, your relationships, and more, it can be beneficial to first understand how you can harm yourself or those around you, and then do everything possible to avoid doing that. This is a great way to "invert" the problem. Rather than trying to help as much as possible, first understand how you can cause harm.



If you had to compress the top 5 mistakes Bronnie Ware compiled from the dying into a single piece of advice, it might be: don't be a cog. The 5 regrets paint a portrait of post-industrial man, who shrinks himself into a shape that fits his circumstances, then turns dutifully till he stops. The alarming thing is, the mistakes that produce these regrets are all errors of omission. You forget your dreams, ignore your family, suppress your feelings, neglect your friends, and forget to be happy. Errors of omission are a particularly dangerous type of mistake, because you make them by default…I inverted these regrets, yielding a list of 5 commands: don't ignore your dreams, don't work too much, say what you think, cultivate friendships, be happy.

– Paul Graham, The Top of My To-Do List

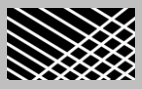
Algorithms

As Pedro Domingos says in *The Master Algorithm*, "An algorithm is a series of instructions telling a computer what to do. No matter how complex, there are 3 options – and, or, not." It can also be thought of as an automated set of rules or a "blueprint" which kickstart a series of steps or actions resulting in a desired outcome, and is often stated in the form of a series of "If ⟶ Then" statements.

You can set up algorithms in your life to help you eliminate the need to make too many decisions. Decision fatigue is real and willpower is more fragile than we like to believe, and that's ok! By developing a series of rules and routines to apply consistently, we can improve our decisions since we have a better structural framework to work with, helping mitigate emotion from our decisions. For example, if you choose that health and exercise are key pillars in your life, it may be worth doing them first thing in the morning. Working out is never fun if you're hung over, so the "algorithm" you can set up is that you will not have more than two alcoholic drinks at night and that you'll be asleep by 11pm. This will give you the rest necessary for a great workout the following morning. This process reduces decision fatigue and helps you be aligned with your priorities, funneling as much of your time and energy into living your ideal life.

The greater the uncertainty, the bigger the gap between what you can measure and what matters, the more you should watch out for overfitting - that is, the more you should prefer simplicity.

– *Tom Griffiths, Algorithms to Live By*



The Latticework:

Statistics & Probabilities

Statistics & Probabilities

Statistics and probabilities are an offshoot of mathematics. These ideas are incredibly important to understand to effectively operate in the world and make better decisions. Thinking in this manner is quite difficult and often counterintuitive, but a basic understanding of statistics and probabilities, coupled with concepts we'll tackle later on like compound interest, the time value of money, and opportunity costs, provide the foundation for making effective decisions. This process will help us see reality for what it is, rather than how we wish it to be.

Many of these ideas aren't complex, but a number of biases make it hard for us to adhere to statistical and probabilistic thinking. People can be overconfident, misunderstand the role of luck and skill, overweight losses compared to gains, overvalue the things they currently own, and much more. However, by keeping some of these big ideas in mind, we can mitigate these biases and make more effective decisions that align with the probabilities we face.

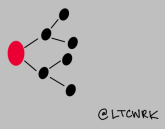
These ideas in isolation, if not understood to the point that they're applicable in your life, are not fulfilling their purpose. The point is to enhance the way you think and live in the real world and while it can be intellectually stimulating when these concepts sound beautiful on paper, it misses the point. We are seeking ideas that concretely improve our lives and the process of becoming a more thorough statistical and probabilistic thinker is an uncomfortable, yet lucrative journey that accomplishes this.

The most important questions of life are indeed, for the most part, really only problems of probability.

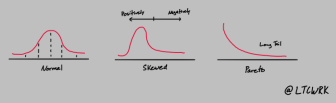
– Pierre Simon Laplace

The Big Ideas of Statistics & Probabilities:

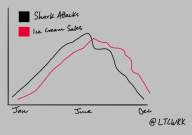
18. Bayes' Theorem



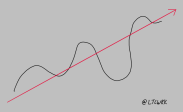
19. Probability Distributions



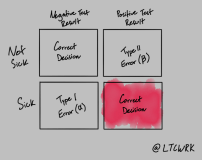
20. Correlation vs. Causation



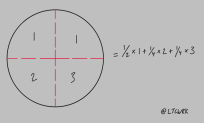
21. Regression to the Mean



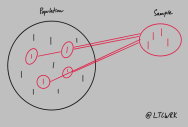
22. Hypothesis Testing



23. Expected Value

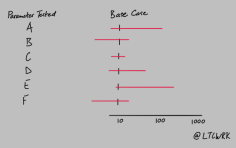


24. Sample Size

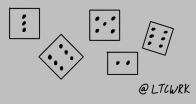


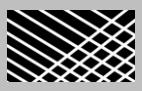
25. Permutations & Combinations

26. Sensitivity Analysis



27. Randomness



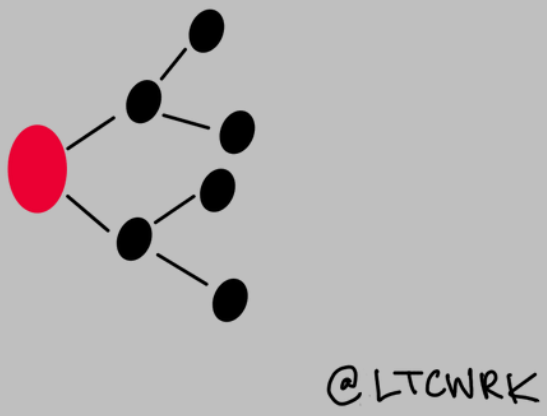


Bayes' Theorem

The Bayesian method is an approach to thinking where you first consider all known information and then actively update your forecast as newer information becomes available.

This method is especially productive given the fundamentally probabilistic and non-deterministic world we live in. We must use prior odds and new information in combination to arrive at our best decisions.

This is not necessarily our intuitive decision-making engine and this process helps us manage some natural human biases by encouraging us to recalculate the odds of success after a subsequent event has occurred. Past performance tells you something (but not everything!) about future results. We must be willing to make the effort to understand the probabilities we face and act accordingly.



The theorem itself isn't so hard: the probability that a proposition is true, given some new data, is proportional to the probability it was true before that data came in, times the likelihood of the new data if the proposition were true.

– Sean Carroll, Bayes' Theorem

Probability Distributions

A probability distribution provides the chance of occurrence of different possible outcomes in a given context. It is concerned with the analysis and approximate estimation of any specific or random phenomena occurring.

Because we live in an unknowable, complex world that is dominated by probabilistic outcomes, this is important to understand. Although we cannot predict the future with great certainty, we are wise to ascribe odds to more and less probable events. We do this every day unconsciously – from driving our cars to choosing where to travel – but the trick is to make it a conscious habit and to track your guesses and their outcomes (this is where Journaling could be game-changing).

Understanding the probability of success, or failure, in any given situation is crucial to making good decisions and improving our decision-making process over time. Thinking probabilistically is about managing risk and understanding potential rewards.

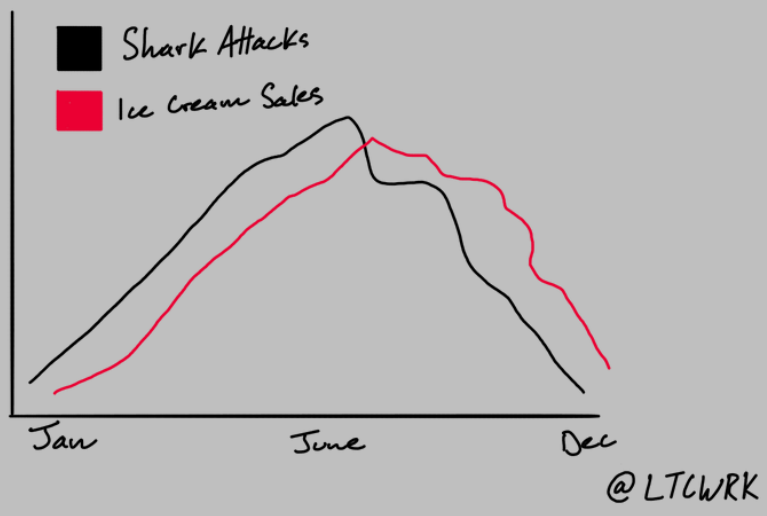
How can investors deal with the limitations on their ability to know the future? The answer lies in the fact that not being able to know the future doesn't mean we can't deal with it. It's one thing to know what's going to happen and something every different to have a feeling for the range of possible outcomes and the likelihood of each one happening. Saying we can't do the former doesn't mean we can't do the latter. The information we're able to estimate – the list of events that might happen and how likely each one is – can be used to construct a probability distribution. Key point number one in this memo is that the future should be viewed not as a fixed outcome that's destined to happen and capable of being predicted, but as a range of possibilities and, hopefully on the basis of insight into their respective likelihoods, as a probability distribution….Bruce Newberg says, "There's a big difference between probability and outcome." Unlikely things happen – and likely things fail to happen – all the time. Probabilities are likelihoods and very far from certainties.

– Howard Marks, Dare to Be Great II

Correlation vs. Causation

When two things seem linked, it is easy and tempting to assume that one causes another. It may be true, but make it a conscious decision rather than simply assuming it is so.

As we discussed in mental models, our models about the world will never perfectly represent reality, but, if at least grounded in reality, they can be good enough. However, we get into trouble when we fool ourselves into thinking that the world is a linear or predictable 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. This is difficult work, but necessary (Systems Thinking)



Cars with flames painted on the hood might get more speeding tickets. Are the flames making the car go fast? No. Certain things just go together. And when they do, they are correlated. It is the darling of all human errors to assume, without proper testing, that one is the cause of the other.

– Barbara Kingsolver, Flight Behavior

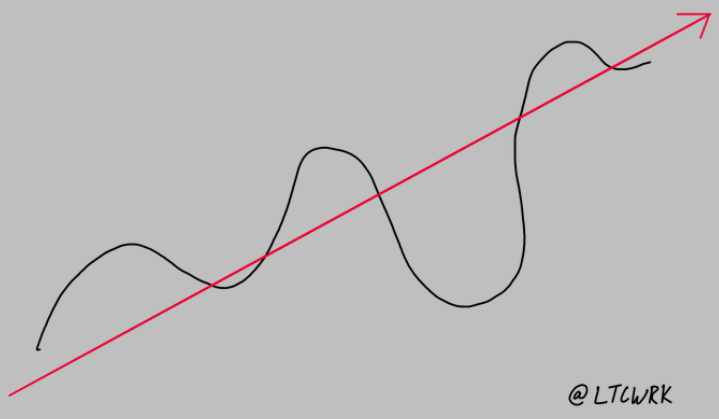
Regression to the Mean

Regression to the Mean is the phenomenon that if a variable is extreme on its first measurement, it will tend to be closer to the average in future measurement.

For example, did the remedy cure the sick patient or was it simply the body regressing to the mean? Could very well be the remedy, but we should at least consider regression to the mean.

This fools people all the time. The addicted gambler who thinks things are bound to turn his way. They might, eventually. But, as Warren Buffett said, the market can stay irrational longer than you can stay solvent. We might not know when or how quickly things will regress back to the mean, simply that they eventually should.

This is the danger with averages. They often mask the underlying distribution. Howard Marks is a big fan of the line: "You must never forget the six-foot-tall man who drowned crossing the river that was five feet deep on average."



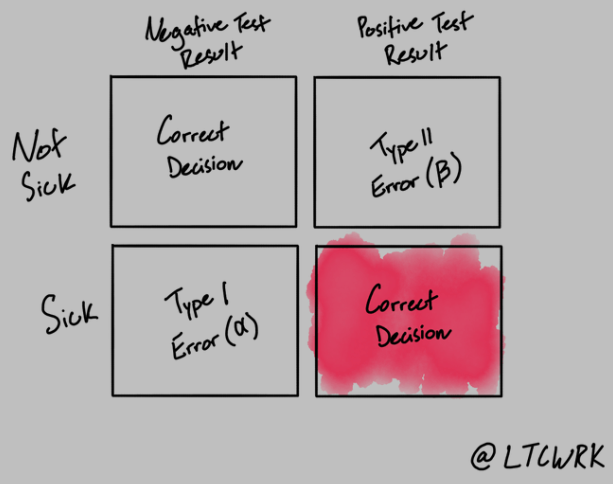
Regression to the mean is the most powerful law in financial physics: Periods of above average performance are inevitably followed by below-average returns, and bad times inevitably set the stage for surprisingly good performance.

– Jason Zweig

Hypothesis Testing

Hypothesis testing uses statistics to determine the probability that a given hypothesis is true. The usual process of hypothesis testing consists of four steps.

1. Formulate the null hypothesis H0 (commonly, that the observations are the result of pure chance) and the alternative hypothesis Ha (commonly, that the observations show a real effect combined with a component of chance variation).
2. Identify a test statistic that can be used to assess the truth of the null hypothesis.
3. Compute the P-value, which is the probability that a test statistic is at least as significant as the one observed would be obtained assuming that the null hypothesis were true. The smaller the P-value, the stronger the evidence against the null hypothesis.
4. Compare the P-value to an acceptable significance value alpha (sometimes called an alpha value). If p <= alpha, that the observed effect is statistically significant, the null hypothesis is ruled out, and the alternative hypothesis is valid.



The idea is if you put ill-determined numbers and equations (garbage) in then you can only get ill-determined results (garbage) out. By implication the converse is tacitly assumed, if what goes in is accurate then what comes out must be accurate. I shall show both of these assumptions can be false.

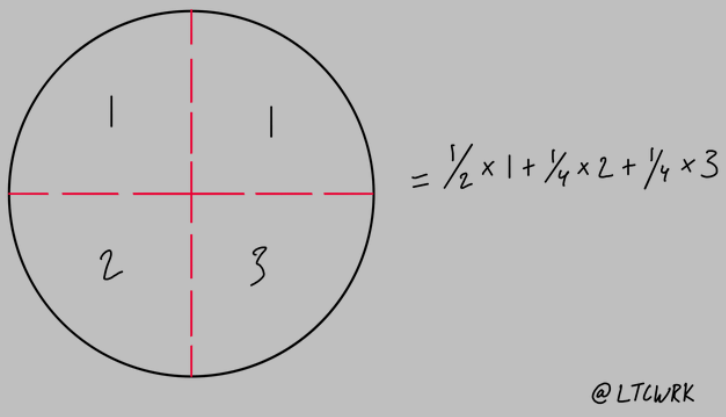
– Richard Hamming, Simulation

Expected Value

Expected value is the long run average value of an experiment or series of events.

The value is determined by multiplying each possible outcome by its probability of occurring and summing the results.

The expected value (and the variance) is important to know when making a decision. It can inform how confident you should be in your assessment and how big of a bet to place.



Often the best way to choose between alternative courses of action is by figuring out which has the highest "expected value": the total value arrived at by multiplying each possible outcome by its probability of occurring and summing the results. As I learned from my first textbook at Wharton fifty years ago (Decisions Under Uncertainty by C. Jackson Grayson, Jr.), if one act has a higher expected value than another and "…if the decision maker is willing to regard the consequences of each act-event in purely monetary terms, then this would be the logical act to choose. Keeping in mind, however, that only one event and its consequences will occur (not the weighted average consequence)," agents may not be able to choose on the basis of expected value or the weighted average of all possible outcomes. If a given action has potential bad consequences that are absolutely unacceptable, the expected value of all its consequences – both good and bad – can be irrelevant.

– Howard Marks, Dare to Be Great II

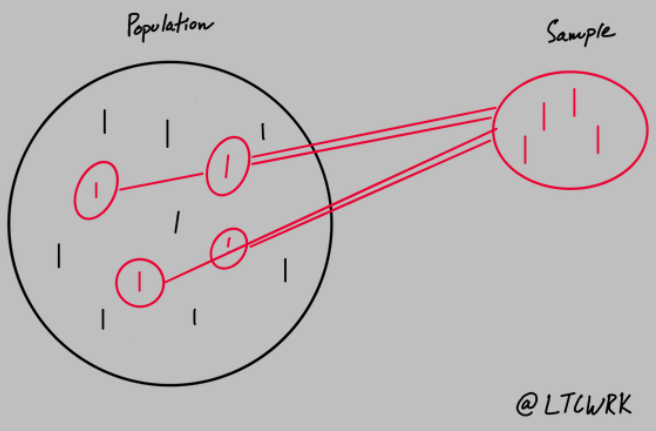
Sample Size

Sample Size is the number of observations to include in a statistical sample. This is an important consideration as too few or irrelevant samples would lead to incorrect conclusions. That is why we said earlier that a large, relevant sample size is a statistician's best friend. The bigger the sample size, the more reliable the conclusions (remember The Three Buckets?)

One of the fundamental underlying assumptions of probability theory is that as more instances of an event occur, the actual results will converge on the expected value and trend closer as more trials are performed. This is known as the law of large numbers.

For example, if I know that the average man is 5 feet 10 inches tall, I am far more likely to get an average of 5' 10" by selecting 500 men at random than 5 men at random.

The opposite of this model is the law of small numbers, which states that small samples can and should be looked at with great skepticism as much larger fluctuations, randomness, and noise should be expected. Anecdotes and broad generalizations are common examples of the law of small numbers coming into play and influencing our perspective.



A few billion years is vastly more proof than a thousand days of survival, and the oldest system around is clearly Mother Nature.

– Nassim Taleb, The Black Swan

Permutations & Combinations

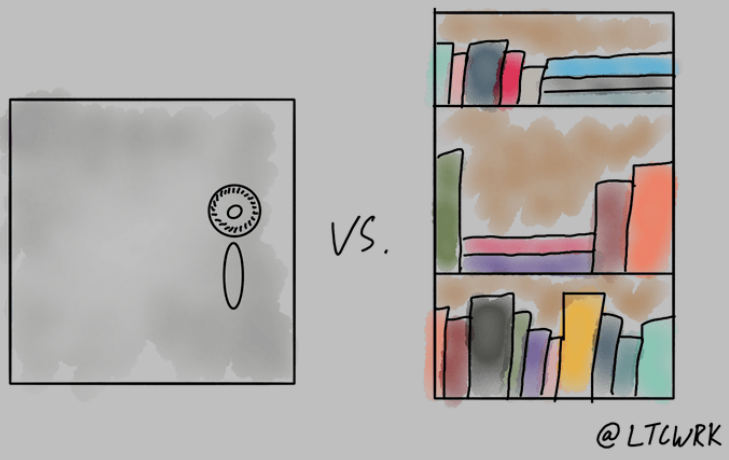
In everyday English, we use the word "combination" without thinking if the order of things is important. However, in mathematics, there are distinct words for groupings in which the order does and does not matter.

When the order does matter it is a Permutation.

When the order doesn't matter, it is a Combination.

In other words, a permutation is an ordered combination.

The mathematics of permutations and combinations leads us to understand the practical probabilities of the world around us, how things can be ordered, how we should think about things, and help us improve our intuition around probabilities and make good decisions based on expected value.



No one in the world is going to beat you at being you. You're never going to be as good at being me as I am. I'm never going to be as good at being you as you are. Certainly, listen and absorb, but don't try to emulate. It's a fool's errand. Instead, each person is uniquely qualified at something. They have some specific knowledge, capability, and desire nobody else in the world does, purely from the combinatorics of human DNA and development. The combinatorics of human DNA and experience are staggering. You will never meet any two humans who are substitutable for each other.

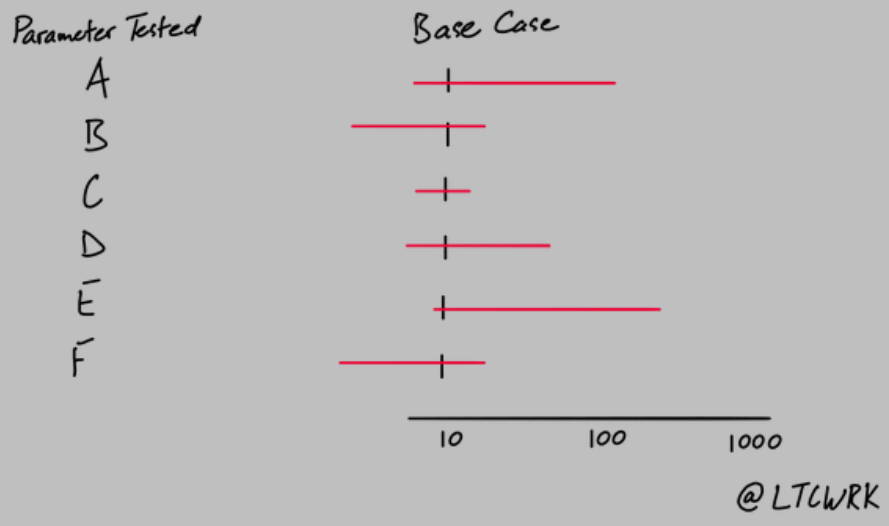
– Naval Ravikant, The Almanack of Naval Ravikant

Sensitivity Analysis

Sensitivity Analysis is the process of analyzing how sensitive a model is to its various inputs, helping determine the impact of these inputs.

This process helps you quickly uncover the key inputs which impact the results, showing you where you should focus your time and efforts.

For example, to better understand the reliability of systems such as bridges, tunnels, railways, and more, Monte Carlo simulations can be run an infinite number of times to better understand how the failure of the various components would impact the reliability of the overall system. The simulations tests how sensitive each component is under a wide variety of circumstances.



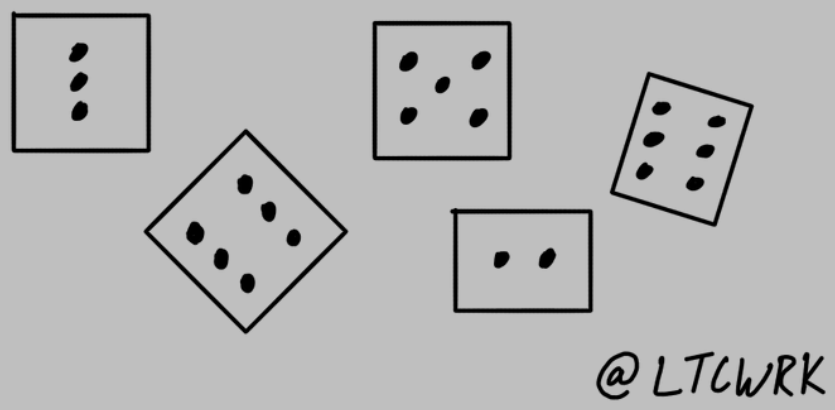
Limit risk with: Deep analysis, bargain purchase, sensitivity analysis.

– Seth Klarman

Randomness

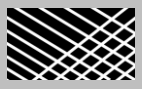
Randomness is a measure of uncertainty of an outcome and, although the human brain has trouble comprehending it, much of the world is composed of random, non-sequential, non-ordered events.

As Taleb says, we are "fooled by randomness" when we attribute causality to things that are actually outside of our control (Correlation vs. Causation). If we don't course-correct for this fooled by randomness effect – our faulty sense of pattern-seeking and our love of narrative – we will tend to see things as being more predictable than they are and act accordingly, making ourselves vulnerable to randomness and black swans. This should humble us and make clear why considering redundancy and a margin of safety into thinking and decision-making is so valuable.



A large group of physicists, certainly, created a healthy flow of ideas. But Kelly believed the most valuable ideas arose when the large group of physicists bumped against other departments and disciplines, too. "It's the interaction between fundamental science and applied science, and the interface between many disciplines, that creates new ideas," explains Herwig Kogelnik, the laser scientist. This may indeed have been Kelly's greatest insight.

– Jon Gertner, The Idea Factory



The Latticework:

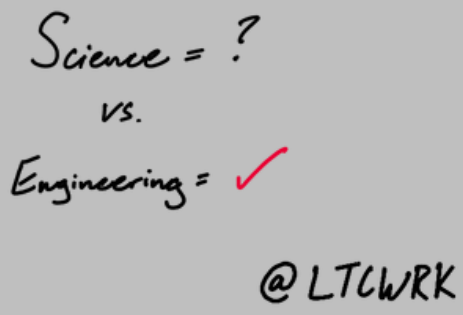
Engineering

Engineering

Engineering is a wonderful combination of physics, mathematics, statistics, probabilities, incentives, and more. Many of the terms, such as margin of safety, have been adopted far beyond engineering and serve as the bedrock for entire industries.

These ideas are important on their own, but as important is coming to think like an engineer – someone who thinks in systems, who understands how things are tied together, how trade-offs, redundancy, scaling effects, and more might impact the overall design and outcome (Systems Thinking).

Whether you're literally dealing with the design and build of a technical system or trying to build out a team, these core concepts and language can serve as useful guideposts in your journey

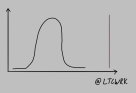


I need to discuss science vs. engineering. Put glibly: in science if you know what you are doing you should not be doing it. In engineering if you do not know what you are doing, you should not be doing it.

– Richard Hamming, Orientation

The Big Ideas of Engineering:

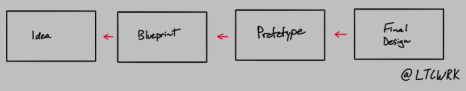
29. Margin of Safety



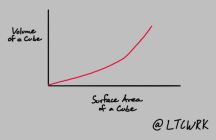
30. Leverage

31. Redundancy

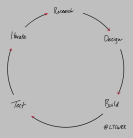
32. Reverse Engineering



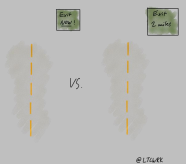
33. Scale Effects



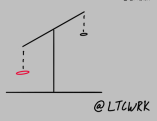
34. Feedback Loops



35. Designing for the Bottom



36. Trade-Offs

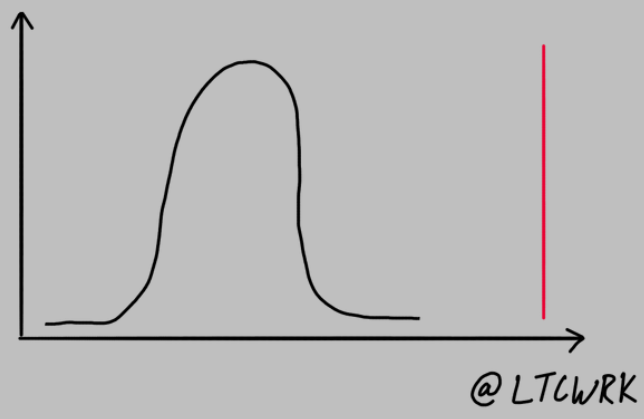


37. Structure & Function

Margin of Safety

As we'll learn in our Biology & Nature discipline, nothing is more important than sustainability.

So, taking their cue from nature, engineers developed the habit of adding a margin for error into all calculations. This became known as a margin of safety and it is a system's ability to withstand more weight, pressure, higher/lower temperatures, friction, etc. than can be reasonably expected in most situations. Let's repeat – withstand more than can be *reasonably* expected in *most* situations.



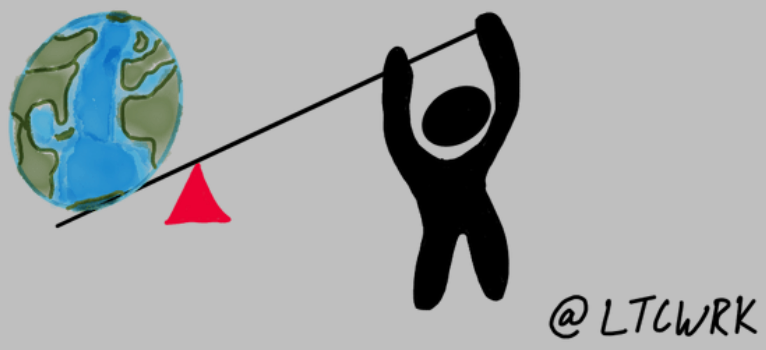
Room for error is underappreciated and misunderstood. It's usually viewed as a conservative hedge, used by those who don't want to take much risk. But when used appropriately it's the opposite. Room for error lets you stick around long enough to let the odds of benefiting from a low-probability outcome fall in your favor. Since the biggest gains occur the most infrequently – either because they don't happen often or because they take time to compound – the person with enough room for error in part of their strategy to let them endure hardship in the other part of their strategy has an edge over the person who gets wiped out, game over, insert more tokens, at the first hiccup.

– Morgan Housel, Ideas That Changed My Life

Leverage

Leverage is the idea that at select points in a system, inputs lead to disproportionately greater output – "force multipliers" achieved by working smarter, not harder.

These select points may be hidden and counterintuitive but finding these leverage points will help turn small changes into non-linear outcomes. Understanding where we can apply this model to the human world can be a source of great success and having leverage as the central, guiding metric might be helpful in determining where to focus your time, energy, and effort.



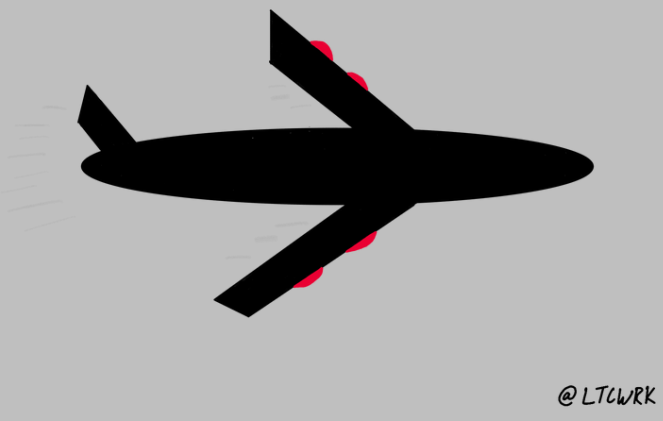
So, you want to look for professions and careers where the inputs and outputs are highly disconnected. This is another way of saying that you want to look for things that are leveraged. And by leveraged I don't mean financial leveraged alone, like Wall Street uses, and that has a bad name. I'm just talking about tools. We're using tools. A computer is a tool that software engineers use. If I'm a lumberjack with bulldozers, and automatic robot axes, and saws, I'm gonna be using tools, and have more leverage than someone who is just using his bare hands, and trying to rip the trees out by the roots. Tools and leverage are what create this disconnection between inputs and outputs. Creativity, so the higher the creativity component of a profession, the more likely it is to have disconnected inputs and outputs.

– Naval Ravikant, How to Get Rich Without Getting Lucky

Redundancy

Shit happens. It's part of life. We must account for it and be antifragile against it (remember, the spectrum is: fragile – robust – antifragile).

A critical model of the engineering profession is that of backup systems, of redundancy. A good engineer never assumes the perfect reliability of the components of the system. She builds in redundancy to protect the integrity of the total system, to make sure there is a duplication of critical components so that the system can function and not fail through multiple means. Redundancy is in-built insurance, a margin of safety that allows for you and your system to survive the vast majority of scenarios.. Without the application of this robustness principle, tangible and intangible systems tend to fail over time. Redundancy is an aggressive, not a defensive approach to life. This is widely misunderstood and avoided because it is generally more expensive in the short-term and takes longer to implement. But, what is the alternative? Short-term gain followed by calamity and potential extinction? The former seems like a better option. But, there is a balance. The optimal path is a balancing act between underappreciation of risk and over planning. Either extreme can be harmful.



Nature is the master statistician and probabilist. It follows a certain logic based on layers of redundancies, as a central risk-management approach. Nature builds with extra spare parts (two kidneys), and extra capacity in many, many things – lungs, central nervous system, arterial apparatus, etc. Design by humans tends to be spare, over optimized, and have the opposite attribute of redundancy, that is, leverage.

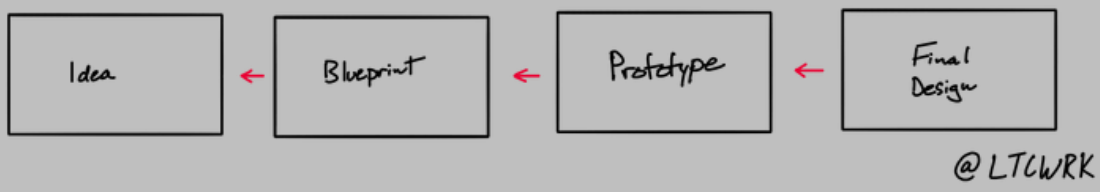
– Nassim Taleb

Reverse Engineering

Reverse engineering is simply the process of extracting knowledge by working backwards, disassembling and analyzing the components.

In business, it is common to try to reverse engineer the products, services, culture, circumstances that have lead to a successful company. This type of blatant copying hardly ever works, especially when there is a lack of understanding. For example, in 2019 Huawei came under scrutiny by the US government for plagiarism. It was claimed that they copied so thoroughly that they also copied bugs in the software and typos in the manual! Beware the pitfalls of blind copying. If you don't have deep fluency, you will reverse engineer the strengths as well as the weaknesses.

While many designs, technologies, and systems can be reverse engineered, some truly important aspects (such as culture and innovation) cannot be reverse engineered. They have to be understood and applied consistently. This is why culture and innovation are considerable moats to overcome.



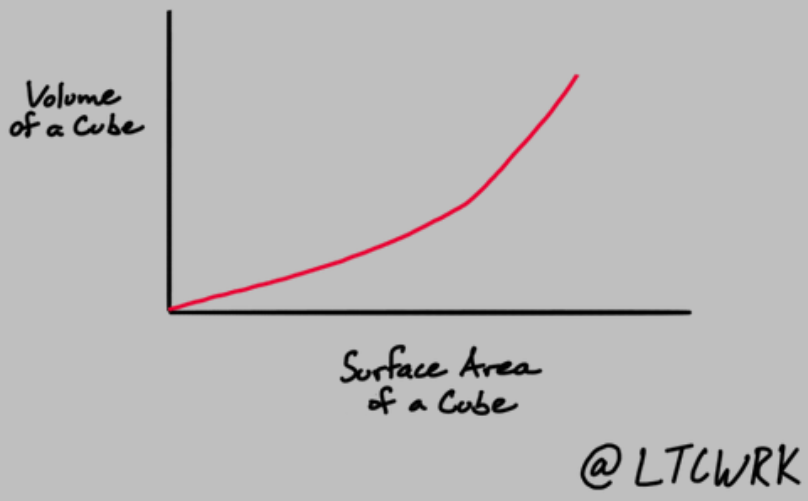
Roman military engineers pored over the battered vessel, examining every detail. They took it apart and noted each trick of the boat's construction, then built a copy of their own. When the Roman technicians tested their warship, it worked as well as the original. So, the Romans rapidly hammered together an entire fleet, turning out 220 ships in only three months. These traditional landlubbers were now the proud possessors of a navy.

– Howard Bloom, The Lucifer Principle

Scale Effects

One of the most important principles of systems is that they are sensitive to scale. Counterintuitively, things sometimes fundamentally change as their scale changes. Just as we can't look at an individual ant and predict the outcomes that occur when you have an entire anthill, we can't look at a simple system and simply extrapolate the current behavior we are seeing and understand how that system will behave at different scales (Complexity).

In studying complex systems, we must always be roughly quantifying – in orders of magnitude, at least – the scale at which we are observing, analyzing, or predicting the system.



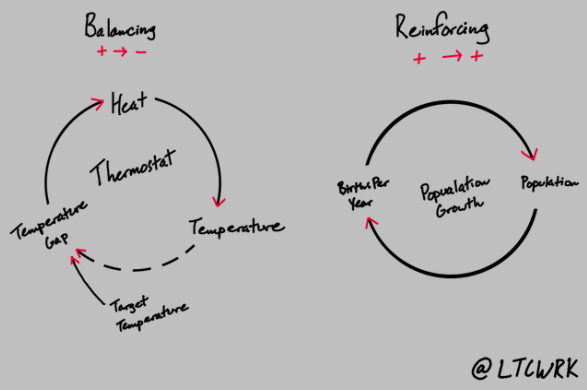
When you scale animals you can't just keep everything in proportion. For example, volume grows as the cube of linear dimension but surface area only as the square. So as they get bigger, they have trouble radiating heat. That's why mice and rabbits are furry and elephants and hippos aren't. You can't get a mouse by scaling down an elephant. YC represents a new, smaller kind of animal – so much smaller that all the rules are different. All good investors supply a combination of money and help. But these scale differently, just as volume and scale do. Late stage investors supply huge amounts of capital and comparatively little help.

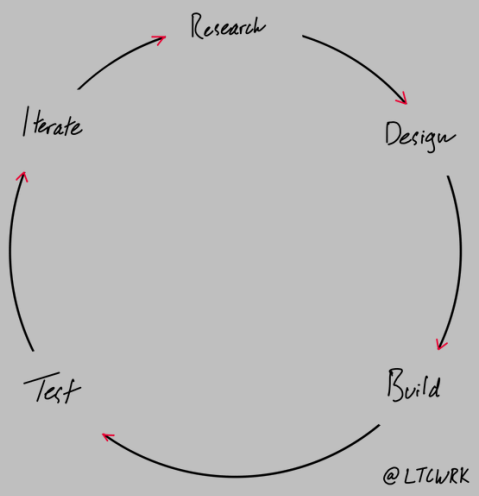
– Paul Graham, A New Venture Animal

Feedback Loops

We're all familiar with the term "feedback." It's a reaction, a source of information, a coach's suggestion, a boss's review that helps us calibrate our behaviors and decisions. When our outputs become the inputs back into the system and affect themselves, we've created a feedback loop.

It's important to understand the two types of feedback loops, positive (reinforcing) and negative (balancing), and the consequences of each. Sometimes an action causes an even greater reaction in the same direction (positive feedback), while other times it results in a dampening reaction (negative feedback). This makes system designs crucial to getting the desired outcome.





I think it's very important to have a feedback loop, where you're constantly thinking about what you've done and how you could be doing it better.

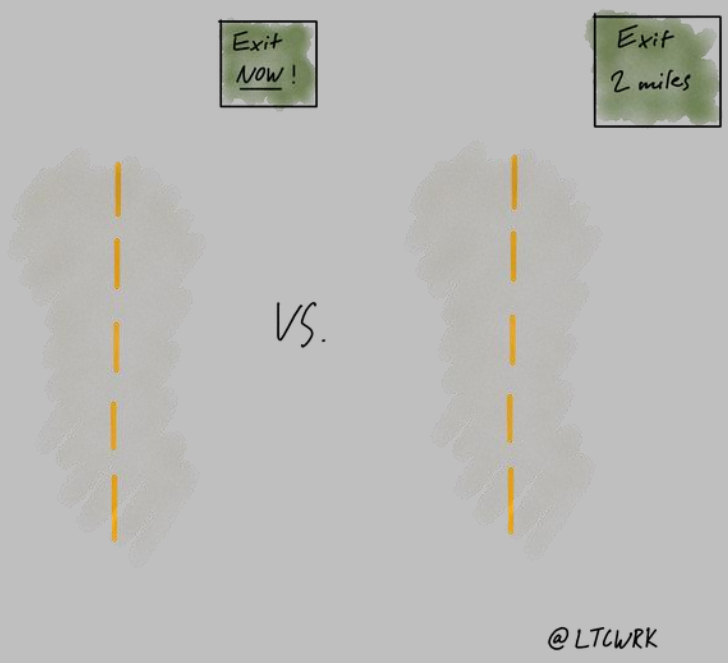
– Elon Musk

Designing for the Bottom

Who is the least sophisticated or informed user of your product or service? Can you design it so that even they could intuitively understand how to use it and make the most out of it?

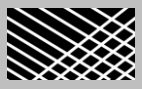
People have limits and many of our mistakes are predictable effects of those limits. Rather than trying to be perfect or rely on willpower (which eventually fails), it is better to design systems that minimize or mitigate inevitable human mistakes.

Just as a highway should be designed for the 15-year-old who just got their permit rather than just "expert drivers," so too should the systems we design take into account less experienced users. Get the most from the least and the best from the best.



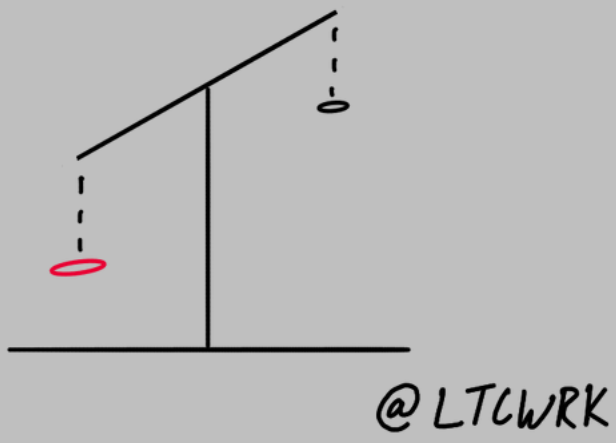
I don't know that anyone pays as much attention to the back half of his roster than Bill Belichick. In August, when you're in training camp, it takes some real vision to look out and see, well this guy's going to contribute to me in December, in this role. He's got a vision for how they're going to fit in.

– Dan Dierdorf



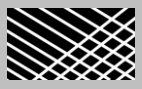
Trade-Offs

Engineering is all about trade-offs. There are always limits and constraints (physical, logical, semantic, cultural, financial, psychological, time, skill, temperament, etc.), and effective design is about figuring out which aspects to maximize, which to minimize, and where you are willing to compromise. Remember that the best choices are the ones with more pros than cons, not those that don't have any cons. Deeply intertwined is the idea of opportunity costs.



There is a trade-off between exploration and exploitation. In order to explore a new niche, a system must use new and untried action sequences that take it into new parts (state sets) of the environment. This can occur only at the cost of departing from action sequences that have well-established payoff rates. The ratio of exploration to exploitation in relation to the opportunities (niches) offered by the environment has much to do with the life history of a system.

– David Krakauer, Worlds Hidden in Plain Sight



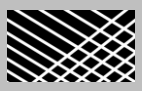
Structure & Function

The structure of a system always impacts its function which impacts its behavior. As Marshall McLuhan said, “The medium is the message.” The structure of social networks affects how viruses spread. The structure of an organizational hierarchy affects how people interact with each other. The structure of an ecosystem shapes its dynamics.

Another way of saying this is that structure is upstream, at the “river head.” So, because a system’s function and behavior is downstream, a dumb rule in a smart architecture can achieve world-class results and what you study is more important than how you study (material > method) whereas a genius-level rule in a poor structure will fail miserably. This is also helps clarify and highlight the importance of structuring properly aligned habits, incentives, environment, thoughts, actions, and more. *Change in Structure* ⟶ *Change in Function* ⟶ *Change in Behavior*

One of the most important insights of this book is in this principle: structure determines behavior! The way anything is structured determines the behavior within that structure. There are fundamental structures in your life which determine the path of least resistance. The structures that have the most influence on your life are composed of your desires, beliefs, assumptions, aspirations, and objective reality itself. Humans act in accordance with the underlying structures in their lives. Because humanity is part of nature, it should be no surprise that people act consistently with natural law. But for most of us, this is a new idea. In our culture we have been taught to ignore our relationship to nature, to treat nature simply as the stage or background that we use, adopt, tolerate, or oppose, as the case may be.

– Robert Fritz, The Path of Least Resistance



The Latticework:

Science & Experimenting

Science & Experimenting

The scientific method, coupled with the mindset and proper thinking habits that come with it, may be responsible for the biggest inflection point in human history.

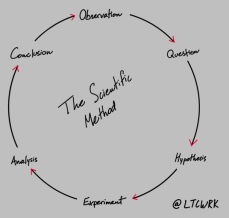
Rather than blindly trusting and accepting, people started to experiment, tinker, and think for themselves. People sought patterns, trying to understand not only what is happening but why, developing along the way more effective habits and procedures for answering questions and solving problems. This was a huge step forward in the evolution of human thinking and has become such an ingrained part of the modern life that it largely goes unnoticed, but keeping the big ideas found within Science & Experimenting top of mind can help you more effectively navigate in the world – whether as a scientist, entrepreneur, or a parent who is trying to help explain and explore the world with their little ones.

Science has continuously increased the efficiency with which inquiry can be conducted. The products of scientific inquiry then are 1) a body of information and knowledge which enables us better to control the environment in which we live, and 2) a body of procedures which enables us better to add to this body of information and knowledge. Science both informs and instructs.

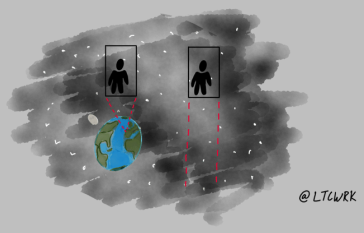
– Russell Ackoff, Ackoff's Best

The Big Ideas of Science & Experimenting:

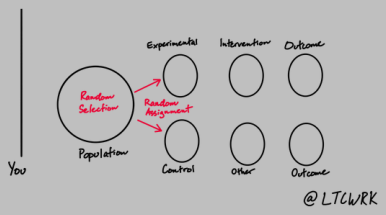
1. The Scientific Method



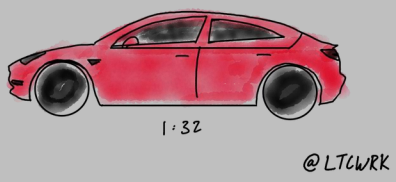
2. Thought Experiments



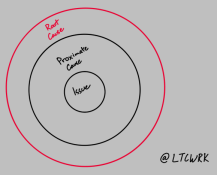
3. Randomized Controlled Experiment



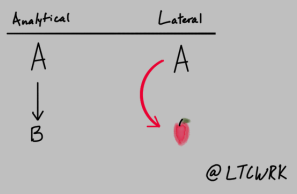
4. Simulation & Modeling



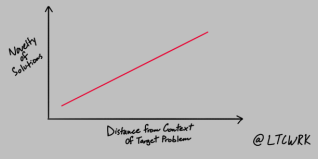
5. Proximate vs. Root Cause



6. Lateral Thinking



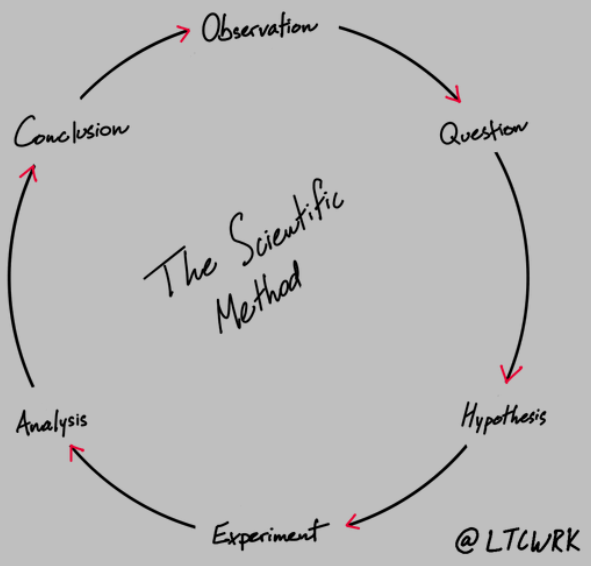
7. Fresh Eyes



The Scientific Method

We have learned much of what we know about the universe around us due to the scientific method – that is, from observation, then explanation, then prediction, and finally verification. This process, of learning how to most effectively learn, is at least partially responsible for the major leaps society has made these past 500 or so years.

Questions extend previous knowledge into the unknown. Form a hypothesis, including your assumptions. The point is to take an educated guess at how you think change would play out over time, including what results would either validate, or invalidate the assumption. As Richard Feynman said, "It is not unscientific to take a guess, although many people who are not in science believe that it is." Now you're ready to test. Depending on circumstances, you could start with a survey, a focus group, or observe customer behavior. The idea is to benchmark results against assumptions and get good, actionable data. Lastly, you must review the data and form a conclusion, with two possible outcomes: 1) It validated your hypothesis and you should move forward with implementation or further testing; 2) It invalidated your hypothesis, in which case you either scrap the idea, or change your hypothesis and test again.



Observation, reason, and experiment make up what we call the scientific method.

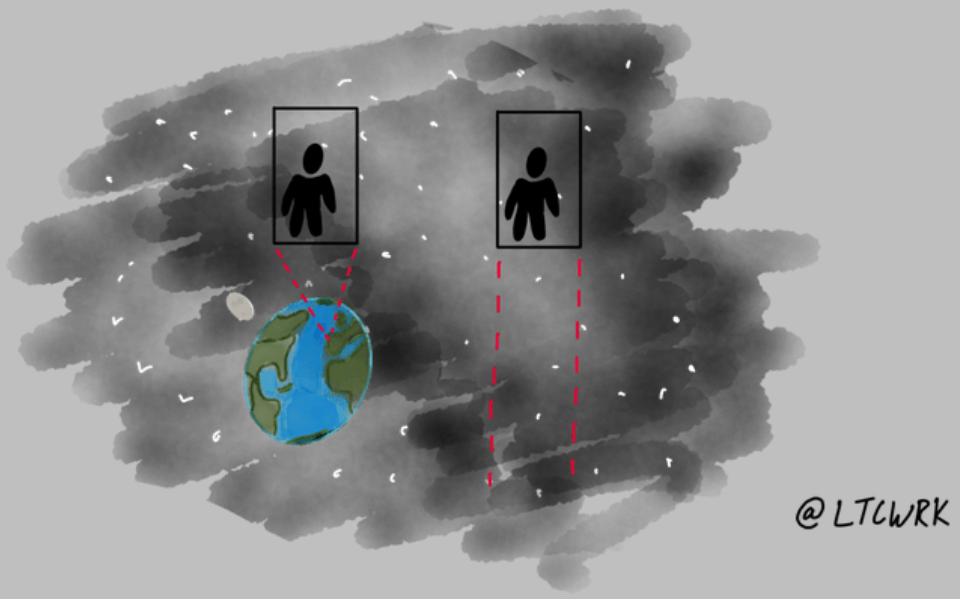
– Richard Feynman, Six Easy Pieces

Thought Experiments

Thought experiments are imaginary scenarios conducted to study the nature of things. They are used for diverse reasons in a variety of areas, including economics, history, mathematics, philosophy, and the sciences, especially physics.

A thought experiment generally entails diligent research, a hypothesis, testing the thought experiment, analyzing the results, drawing conclusions, compare to what you expected in your hypothesis and update as appropriate.

Thought experiments can help with counterfactual thinking – asking "what-if" questions about the past, trying to imagine and better understand how the past could be different than what actually occurred. This can help you better understand the system, probabilities, and improve your creativity – also known as lateral thinking. This is partially why being multidisciplinary is so powerful. You can pull ideas, solutions, examples from "lateral" fields that help you solve whatever problem you're dealing with in your current field.

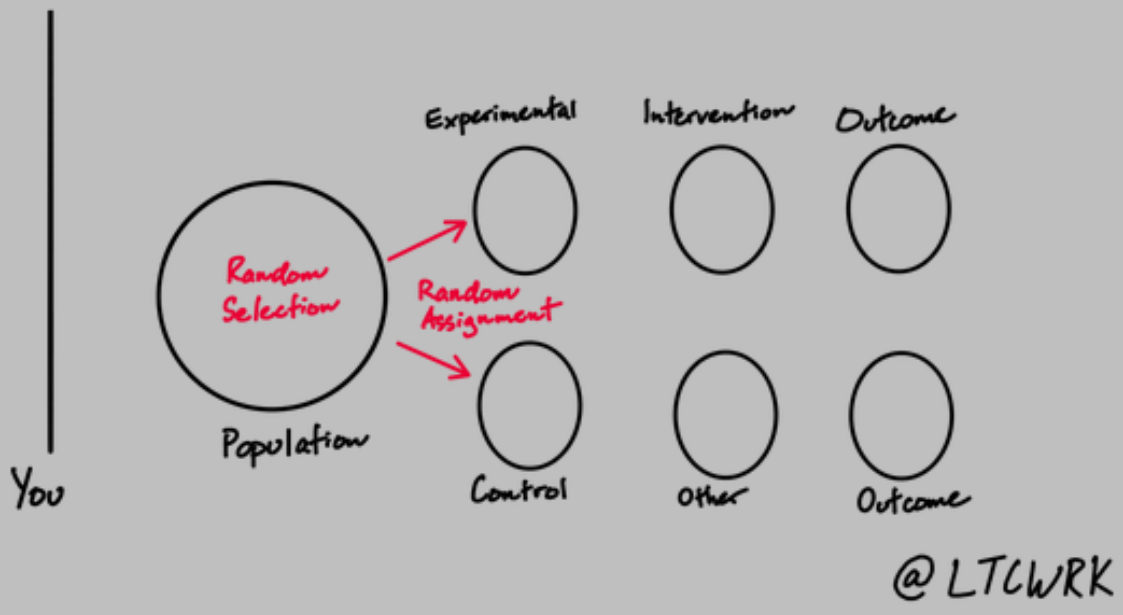


Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world.

– Albert Einstein

Randomized Controlled Experiment

Randomized Controlled Experiments are considered the gold standard in research – especially when double blind (meaning neither the subjects nor the researchers know who the control group or the experimental group is). Participants are randomly selected for the to one of two groups and then the results from the experimental group (who receive something) are compared with the results from the control group (who don't). These procedures are followed mainly to reduce the bias. For the most important and highest quality experiments in pharma, psychology, and other research, randomized controlled experiments are used. How can we use "blind studies" in our day to day lives to reduce our bias and increase objectivity?



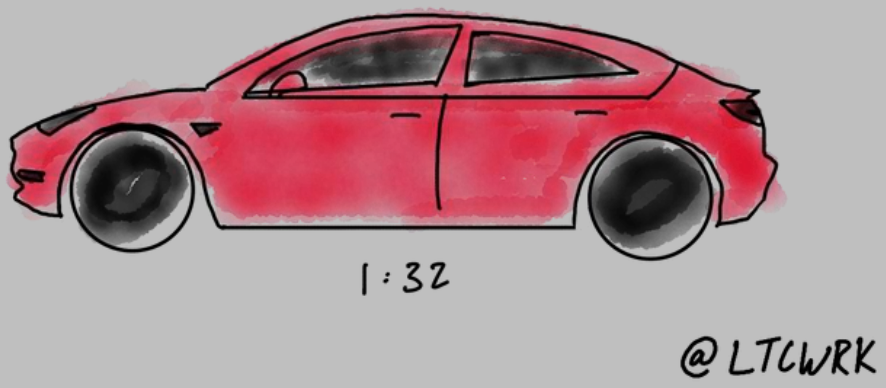
It is particularly important for managers to understand that correlation and regression analyses cannot establish causal relationships – only experiments can do that.

– Russell Ackoff, Ackoff's Best

Simulation & Modeling

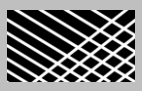
Simulation & Modeling helps you understand how a person, process, system, design, product, or technique might function in the real world without having to build a perfect, full-scale version. Consider what the easiest, simplest version of what you want to accomplish would look like. Simply take baby steps towards that direction and iterate like crazy based on your vision and the feedback you get. Adaptability > Planning.

In startup land, a minimum viable product (MVP), is the functional equivalent of minimum effective dose (which we'll cover more in Health & Nutrition) – the lightest, fastest, cheapest example of what you're trying to build in order to gage demand and viability. This can also be thought of as a prototype – a first, incomplete version (whether software, a sketch, CAD, a physical model, etc. that helps you get valuable feedback.



Even the most ambitious people shrink from big undertakings. It's easier to start something if one can convince oneself (however speciously) that it won't be too much work. That's why so many big things have begun as small things. Rapid prototyping lets us start small.

– Frederick P. Brooks, The Mythical Man-Month

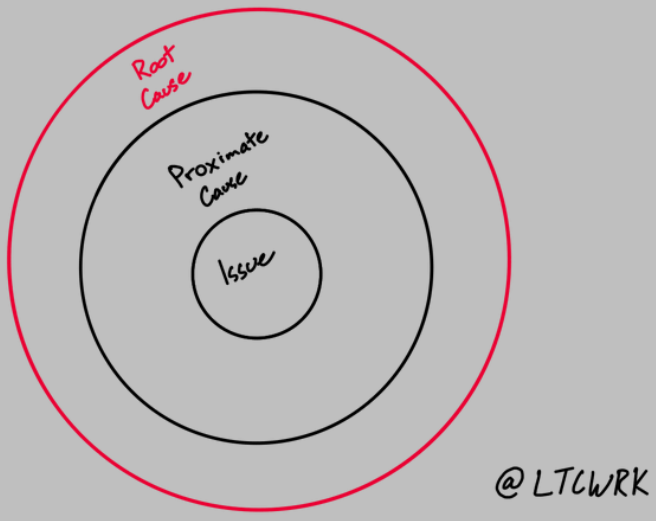


Proximate vs. Root Cause

A proximate cause is immediately responsible for the problem whereas the root cause is the underlying reason.

If we spend all our time fighting the fires that proximate causes start, we will never get anywhere. We must get to the root of the problem, understanding the structural and systemic effects that led to the problem in the first place. This is where systems thinking, second-order thinking, first principles thinking, Galilean Relativity, and more come into play as it will help solve the root of the problem, leading to better long-term outcomes rather than short-term band aids.

However, be careful of complex systems where it may be impossible to pin down a single root cause. It may often be better to not try to isolate any one thing because it may make you blind to seeing the bigger picture.



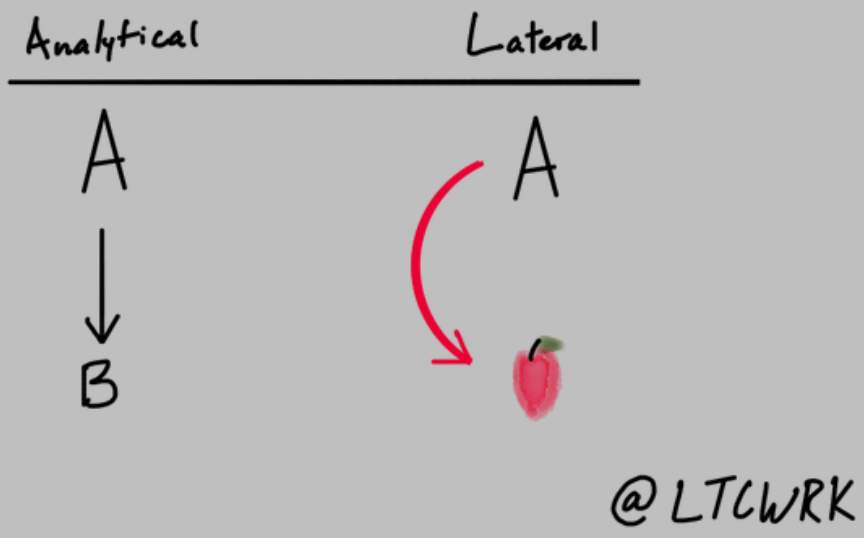
When you are solving a problem, you are taking action to have something go away: the problem. When you are creating you are taking action to have something come into being: the creation. Notice that the intentions of these actions are opposite. When you think structurally, you ask better and more useful questions. Rather than asking, "How do I get this unwanted situation to go away?" you might ask, "what structures should I adopt to create the results I want to create?"

– Robert Fritz, The Path of Least Resistance

Lateral Thinking

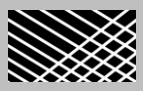
Solving problems through an indirect and creative approach, using reasoning that is not immediately obvious and involving ideas that may not be obtainable by using only traditional step-by-step logic. This is where being multidisciplinary is so helpful – this is like that, that is like this.

By making connections across fields, we can make intellectual and intuitive leaps that otherwise would be hard to make. The fascinating and powerful part of this type of thinking is that the analogy doesn't have to be all that close, it can be weak and loose and still get the job done. This is why thinking through analogies, metaphors, stories, similes can spark thoughts and ideas that otherwise may never have occurred.



Most fairly good ideas are adjacent to even better ones.

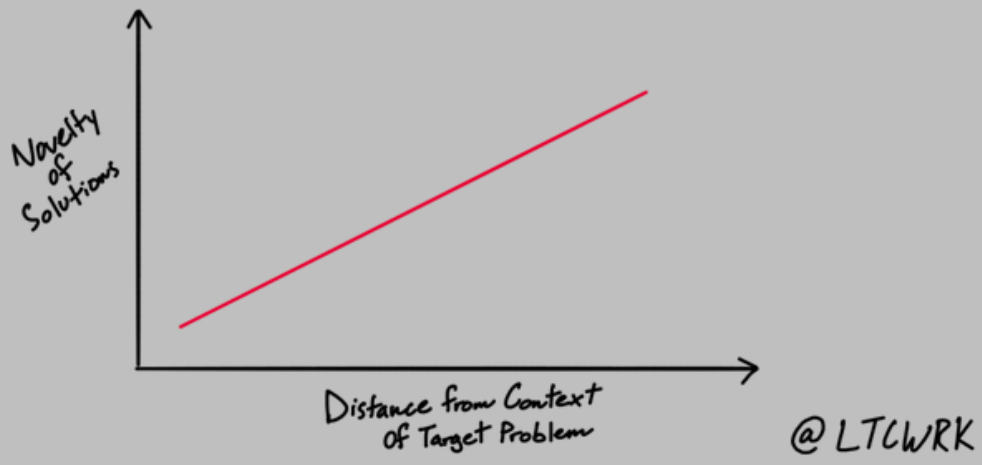
– Paul Graham, Startup = Growth



Fresh Eyes

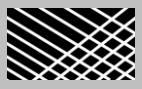
Fresh eyes gives you a different perspective than someone who has been immersed in the details, allowing you to partially escape Galilean Relativity. What seems obvious to you may have been totally overlooked by the "experts." This is the downside of being an expert, an insider – fear of taking risks, weight of expectations, power of vested interests, inability to change perspective, etc.

Having Fresh Eyes is like gaining a super power. Many of the world-changing inventions came from people who came from outside the given field. They were able to question basic assumptions and see a problem differently than insiders did. Everything from MRIs to X-rays were discovered by "outsiders."



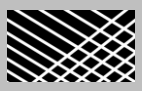
To see the obvious, it often takes an outsider, or else someone like me who is thoughtful and wonders what he is doing and why it is all necessary. Even when told, the old timers will persist in the ways they learned, probably out of pride for their past and an unwillingness to admit there are better ways than those they were using for so long.

– Richard Hamming, History of Computers – Software



The Latticework:

Technology & Computer Science

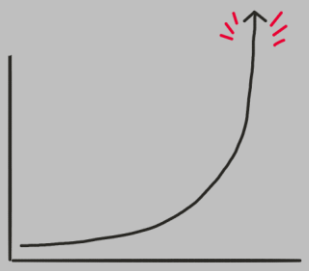


Technology & Computer Science

Technology has been the overriding tidal wave in the last several centuries (maybe millennia, if tools like plows and horse bridles are considered) and understanding the fundamentals in this field can be helpful in seeing the patterns behind these innovations, how they were arrived at, and their potential impacts. The ideas discussed in this section have far reaching implications which tie together several other key disciplines already discussed and yet to be discussed.

These driving forces influence so much of our world today, to the point that Marc Andreessen's quip that "software is eating the world" is now seen as axiomatic. Every company will soon be a technology company, or whither.

One of the most exciting aspects of the rise of ubiquitous technology is the frictions which it helps reduce. Companies such as Microsoft, Google, Facebook, Shopify, Amazon, and others have ridden the ever-decreasing cost of hardware and increasing power of software to become some of the most valuable and fastest growing companies in history. Moore's Law coupled with leverage, lock-in, increasing returns, network effects, and near-zero marginal costs combine to form something extremely powerful.



As the ideas, concepts, language of technology become more influential and prominent, mastering these ideas and the jargon that comes with it may be more important than ever. This is one of the key second-order benefits of becoming multidisciplinary – you gain the "jargon" of an insider, allowing you to better understand and communicate with people in that field.

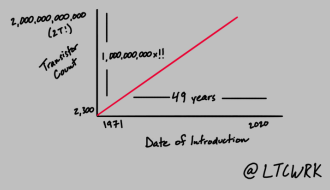
Technology is no panacea, no silver bullet for humanity's ails, but if we can learn to work in tandem with technology while applying human empathy, wisdom, and perspective, we will likely reach better outcomes than we otherwise would.

The purpose of computing is insight, not numbers.

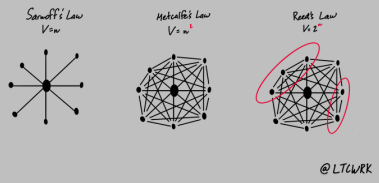
– Richard Hamming, History of Computers

The Big Ideas of Technology & Computer Science:

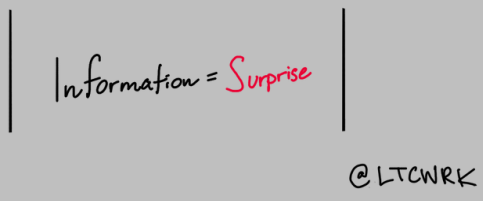
39. Moore's Law



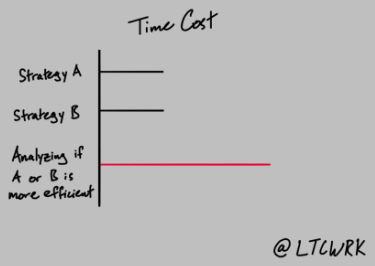
40. Metcalfe's Law



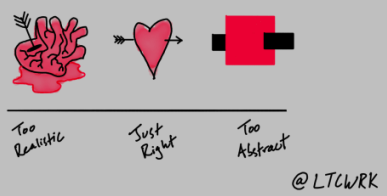
41. Information Theory



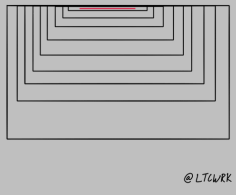
42. Premature Optimization



43. Abstraction



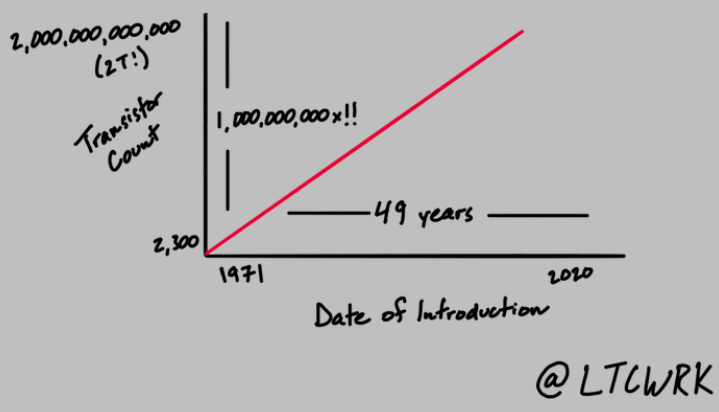
44. Recursion



Moore's Law

Moore's Law is the observation that the number of transistors in a dense integrated circuit doubles every 18-24 months. This advancement is important as other aspects of technological progress – such as processing speed or the price of electronic products – are linked to Moore's Law. It is the fountainhead to so much of the innovation and technological progress that has happened over the last 50-60 years. It truly is a miracle – the smaller the transistor becomes, the better it actually performs!

In Acquired's podcast on Electronic Arts, founder Trip Hawkins talks about how he thought about the early days of EA and when to found it. He calculated how long it would take to get computing power where it needed to be in order to build games. He concluded that it would take about 7-8 more years. He worked at Apple and learned all he could until those 7-8 years were up. He then started EA because, sure enough, computing power got there just when he thought!



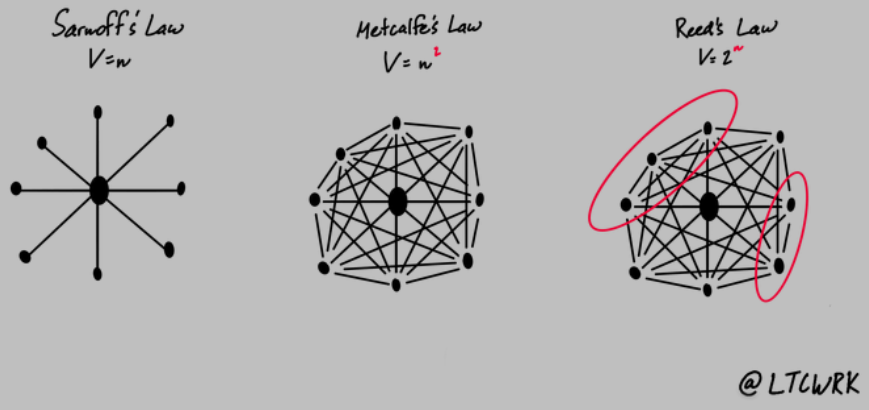
West didn't seem to like many of the fruits of the age of the transistor. Of machines he had helped to build, he said, "If you start getting interested in the last one, then you're dead." But there was more to it. "The old things, I can't bear to look at them. They're clumsy. I can't believe we were that dumb." He spoke about the rapidity with which computers became obsolete. "You spend all this time designing one machine and it's only a hot box for two years, and it has all the useful life of a washing machine." He said, "I've seen too many machines." One winter night, at his home, while he was stirring up the logs in his fireplace, he muttered, "Computers are irrelevant."

– Tracy Kidder, The Soul of a New Machine

Metcalfe's Law

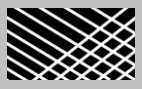
Metcalfe's Law is commonly referred to as network effects. As distilled as possible, network effects occur when the product or services improves and becomes more valuable with each additional user.

Network effects occur when the value of participating in a network goes up for the participants as more nodes come on to the network (Metcalfe's Law), or as engagement increases between existing nodes (Reed's Law). Historically, things like the telephone and supply-side economies of scale for industrial companies (where widget 500 is much cheaper to produce than widget 5) dominated, but in today's world, demand-side economies of scale (network effects) are taking center stage.



Network effects are tricky and hard to describe but fundamentally turn on the following question: Can the marketplace provide a better experience to customer "n+1000" than it did to customer "n" directly as a function of adding 1000 more participants to the market? You can pose this question to either side of the network – demand or supply. If you have something like this in place it is magic, as you will get stronger over time not weaker.

– *Bill Gurley, All Markets are Not Created Equal*



Information Theory

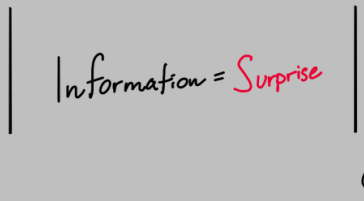
Information Theory sets the foundation for all our communications networks. It is the simple idea which says that information is correlated with *surprise*.

Claude Shannon is the godfather of Information Theory and is credited with spurring the boom in communication technology that came from his simple and deep insights. There are 3 core pieces he laid out regarding information:

- All communications could be thought of in terms of information
- All information could be measured in bits
- All the measurable bits of information could be thought of, and indeed should be thought of, digitally. This could mean dots or dashes, heads or tails, or the on/off pulses that comprised PCM.

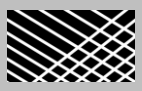
Importantly, a communication system consists of 5 parts and, crucially, information can only be lost, never gained, information is not conserved, and there is no upper limit:

- An information source – produces a message or a sequence of messages
- Transmitter – operates on the message to produce a signal that can be transmitted over a channel
- Channel – the medium used to transmit the signal from the transmitter to the receiver
- Receiver – reconstructs the message
- Destination – person for whom the message is intended
- Noise – anything that obscures or disrupts the message



What information consumes is rather obvious. It consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention.

– Herbert A. Simon

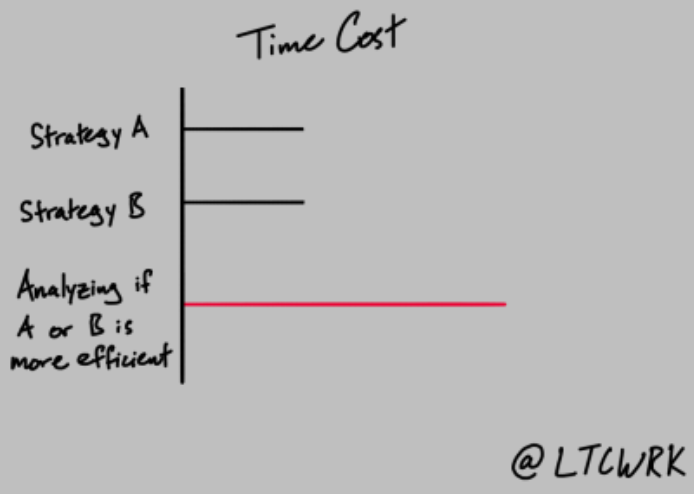


Premature Optimization

Peter Drucker had a great line: “There is surely nothing quite so useless as doing with great efficiency what should not be done at all.”

Similarly, premature optimization entails optimizing for something before it is appropriate to do so. It might feel good to make a beautiful logo and print it on a t-shirt, but is that really your best use of time in the early days of starting your company? Probably not. The most insidious distractions seem productive but truly aren’t.

How often do we waste time doing things that shouldn’t yet be done or be done at all? They serve to distract us from the hard work that is truly productive, that truly moves the needle forward. Next time you are debating between two options, choose the more difficult one. You likely already know this is the right answer, you’re just trying to convince yourself otherwise.



Premature optimization is the root of all evil.

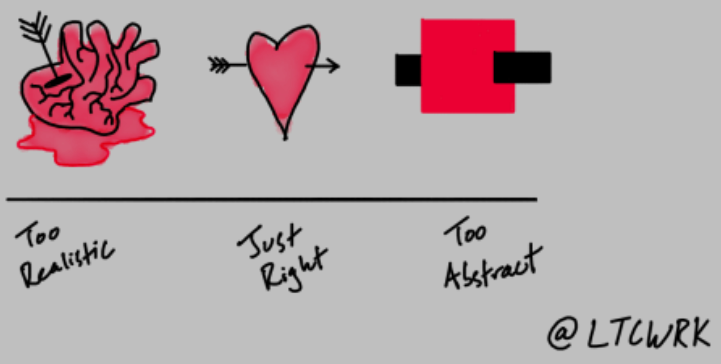
– Donald Knuth

Abstractions

In software engineering and computer science, abstraction is a technique for arranging complexity of computer systems. It works by establishing a level of complexity on which a person interacts with the system, suppressing the more complex details below the current level. We need to simplify complex systems so people can understand them and effectively utilize them without becoming overwhelmed. The balance lies in making it simple, but not simplistic.

Anytime you see a simple interface covering a more complex system, you should think "abstraction."

- A car is a very complex machine, but the interface is simple (a steering wheel, a gas pedal and a gear shift)
- A video game controller only has a few buttons, but underneath the controller is complex control mechanisms
- A programming language can be fairly simple, but it translates the instructions you write into machine code, which is impossibly complex



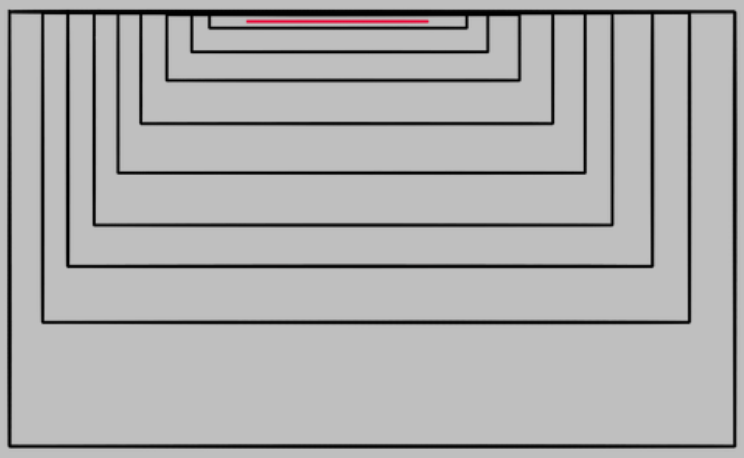
In The Medium Is the Message, Marshall McLuhan expanded this argument to electronic media. Media representations, especially on screens, are abstractions, or virtual "extensions" of what our sensory channels, bodies, thinking and feeling do for us in real life.

– Wikipedia

Recursion

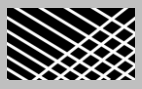
Something is recursive when it references itself. A dictionary definition that uses the word its is defining to define itself is recursive – i.e., someone is witty when they have wit.

Understanding the nature of recursion can clarify how systems are structured, why they work, and how you might be able to tweak them. It also helps you acknowledge the importance of first principles and of structuring things well from the on start. If the foundation is shaky – whether your knowledge foundation or the foundation of your house – everything built on top of it will reflect the same.



Self-reference lies at the core of how human minds work.

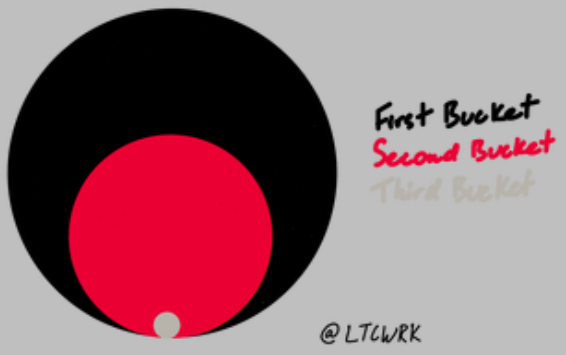
– Douglas Hofstadter, GEB



The Latticework:

Biology & Nature

Biology & Nature



Biology & Nature falls into the second bucket of our three bucket framework. But, why study it? Why is it important and how on earth could biological principles improve my day-to-day life?

Well, biologically inspired ideas are not just stab-in-the-dark guesses that happened to work out well, but time-tested, billion-year-old solutions that have worked out in the coldest, highest, darkest, hottest, most predator-full, and water-starved places on Earth. Nature's culling is severe, but it results in hardy stock! Biological systems have evolved over 3.5 billion years and enormous power lies in applying their time-tested, successful models to human systems. By combining our first bucket – physics, chemistry, mathematics, etc. – with our second bucket – biology – we gain increasing conviction in our ideas. The joint probability of these ideas being incorrect if they've held true across 13.7 billion years and multiple domains starts becoming de minimis.

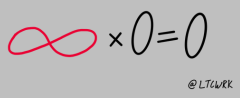
Importantly, Biology & Nature knows not good / bad, moral / immoral – simply adaptability, utility, and survival. If we can align ourselves with these biological principles which have been honed and tested for billions of years, we will have reliable models to work and this provides confidence and Advantageous Divergence – ideas which are contrarian and correct – resulting in profitable endeavors.

For ages, wise men such as Arthur Schopenhauer have recommended making use of the "book of the world" – studying nature and learning from her. However, people tend to ignore biology's time-tested principles because people don't like being displaced from the center of the universe and compared to the creatures of nature. Our one big difference – gigantic brainpower – fools us into thinking we're completely different, rather than somewhat different, from the rest of nature's creatures. We can either make our peace with our place within the patterned world of biology, or like many people, ignore these patterns and suffer the consequences. Fight this urge and understand how much we can learn and benefit from studying Biology & Nature.

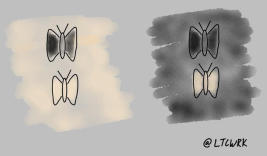
Never does nature say one thing and wisdom another.– Juvenal

The Big Ideas of Biology & Nature:

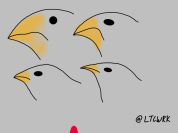
46. Sustainability



47. Natural Selection

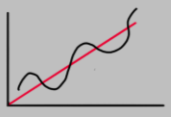


48. Evolution

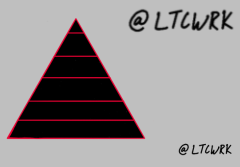


49. The Red Queen Effect

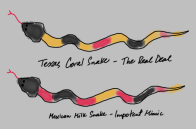
50. Dialectical Materialism



51. Hierarchies

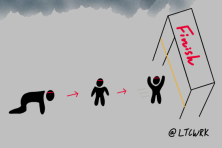


52. Signaling



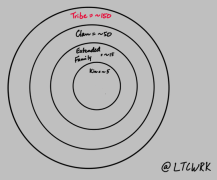
53. Symbiosis

54. The Goal Gradient Hypothesis



55. Niche

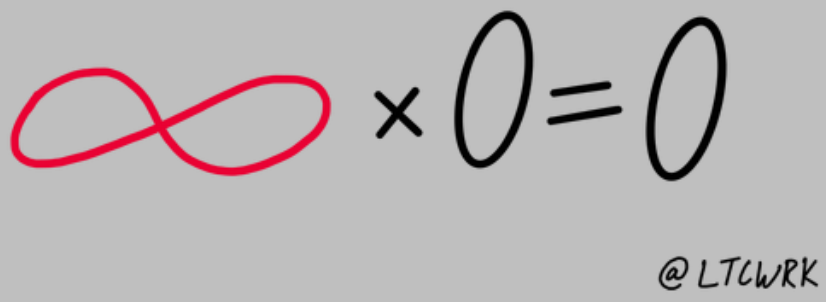
56. Dunbar's Number



Sustainability

The first law of biology is sustainability, the ability to survive and avoid extinction events. If you can't sustain, all else becomes irrelevant. You can be the fastest, most impressive species in the jungle, but if you can't sustain the marathon of life before leaving offspring, your blood line will quickly die out. In fact, the first mammals were scraggly little creatures that weren't too imposing or impressive. However, they were able to survive in a period when a significant portion of the world's animals perished, giving them the space to fill new niches, and the resources to do so.

Nature does not agree with man's definition of good and bad. For nature, that which is good is what has survived and that which is bad goes under. In the human realm, this principle is often forgotten or simply neglected for lack of patience, the desire for immediate gratification, the need to keep up with the Joneses. People too often tend to risk it all for the lottery "ticket," the once-in-a-lifetime pay-off. However, these rarely pan out and typically increase risk. And, remember, any time you risk a "zero" in any aspect of your life, you risk sustainability as anything multiplied by zero is zero. First position yourself to survive, then to thrive. Growth is important (see The Red Queen Effect), but durability even more so. The power of compounding is greatest in its latter years, outweighing early years of rapid growth, no matter how great if unsustainable. Of course, the holy grail is healthy organic growth coupled with extremely long periods of compounding – this is true whether we are discussing biology, relationships, or finance. Time is an incredibly important, yet often overlooked element in value and isn't often considered by people outside of finance, but it should be! It is the articulation and measure of opportunity cost!



Survival comes first, truth, understanding, and science later.

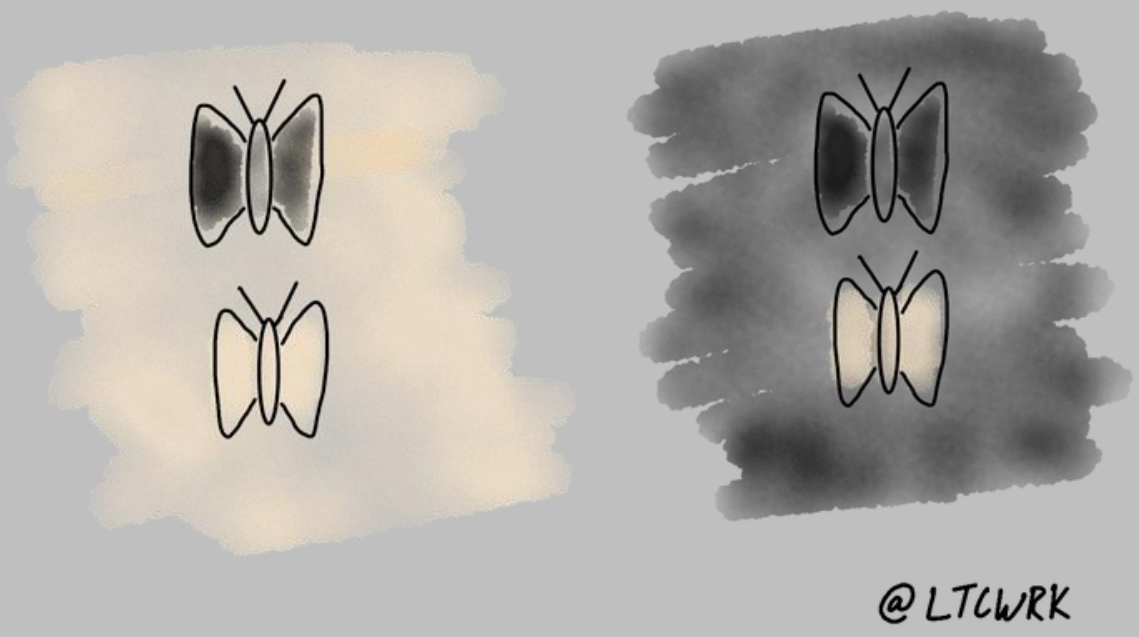
– Nassim Taleb, Skin in the Game

Natural Selection

Natural selection and evolution are often equated as the same. Although they are related, they are separate.

Natural selection is a key mechanism of evolution – it is the change in heritable traits of a population over time as these traits become more or less useful depending on competition, their environment, the resources at hand, and other challenges they face. Again, nature does not consider any trait good nor bad, she only considers its usefulness.

It is also important to understand and differentiate between natural selection and sexual selection. Natural selection helps us understand features common to a species, whereas sexual selection can help us understand differences between the sexes of the same species.



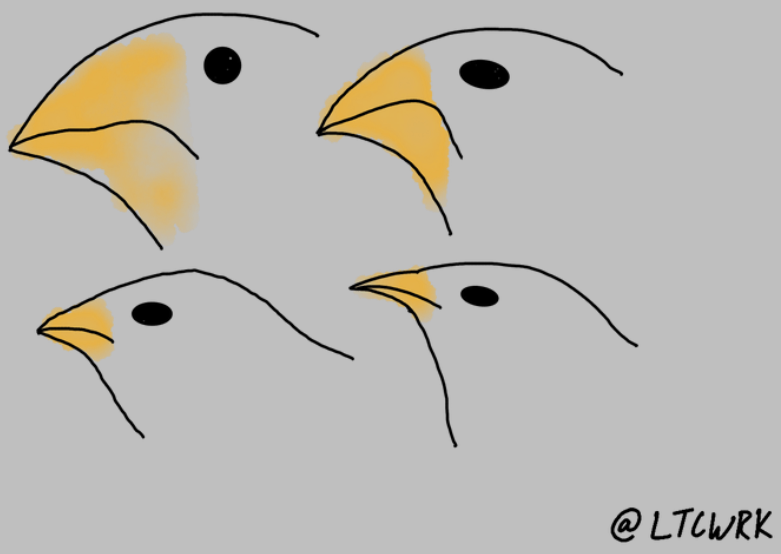
Natural selection…is an incredibly simple process requiring just three simple elements – variation between individuals, environmental conditions that favor or select certain variants over others, and a means to reproduce those variants that are better suited to the environment.

– Rafe Sagarin, Learning From the Octopus

Evolution

Evolution is the general process of adaptation in organisms. It is not survival of the fittest but survival of those who can quickest and best adapt to its environment and competition, passing on their genetics to the next generation.

Species tend to adapt to their surroundings in order to survive, given the combination of their genetics and their environment – an always-unavoidable combination. Populations of species adapt through the process of evolution by natural selection, as the most-fit examples of the species replicate at an above-average rate. Importantly, evolution has no final destination and its only definition of "good" and "bad" is that which is good helps one survive where something bad does not. Species do not get better or worse at surviving, simply are better/worse at surviving particular niches in a particular time.



Change breaks the brittle.

– Jan Houtema

The Red Queen Effect

The Red Queen Effect describes the biological law that in order to survive, one must continually keep adapting and evolving as everyone around you is also evolving, adapting and getting more fit. It is a perpetual arms race and the process of standing still leads to falling behind relative to everyone else. This dynamic is apparent in nearly every system which is finite, scarce, competitive, and high stakes.

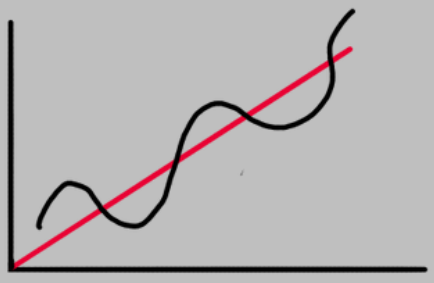
In times of change learners inherit the earth; while the learned find themselves beautifully equipped to deal with a world that no longer exists.

– Eric Hoffer

Dialectical Materialism

Materialism is the eternal order into chaos, chaos into order cycle that abound in any system, including biology. The eternal cycle of decay and rebirth.

The inescapable irony and paradox of life is that as any complex system grows and maximizes towards its peak, it inherently builds in the very structures and contradictions which will become its downfall. This is absolutely fascinating, exciting, maybe disturbing. Is this rise and fall inescapable? Can we learn how to mitigate against it? To this we say, "hell yes!" That's what makes becoming multidisciplinary so exciting and rewarding. We may not be able to put this rise and fall off forever, but we can certainly delay it by studying history and gaining deep fluency in a variety of disciplines.



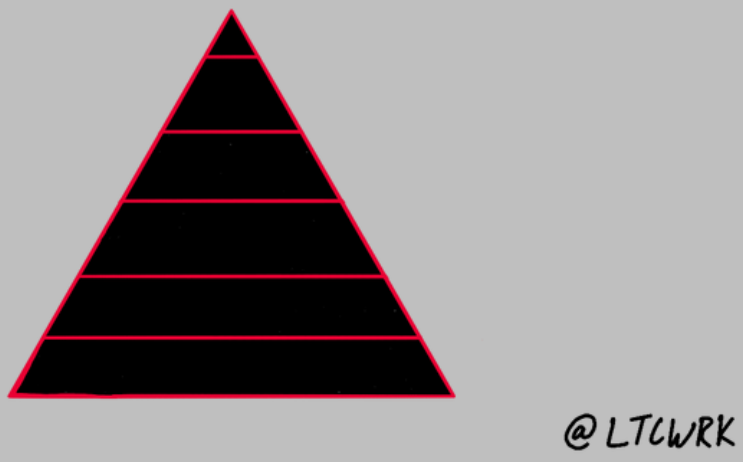
Every great victory carries the seed of ultimate defeat.

– Rich Cohen, The Fish That Ate The Whale

Hierarchies

A hierarchy is a representation showing how one group, person, species, department, corporation, country, skill, etc. is above or below another, indicating power, responsibility, wealth, or other forms of status. It is an arrangement of systems and subsystems.

Hierarchies are one of the fundamental organizing principles of the world. Why? Because, among all possible complex forms, hierarchies are the only ones that have survived the test of time It may be obvious, but complex systems can evolve from simple systems only if there are stable intermediate forms. There must be a solid foundation which has been able to survive before the next layer on top of it can be built. The resulting complex forms will naturally be hierarchical (how could it be otherwise?). Perhaps it is obvious, but hierarchies must necessarily evolve from the lowest level up. The original purpose of a hierarchy is always to help its originating subsystems (the bottom of the hierarchy) do their jobs better. This is something which is easily forgotten in large corporations and leads to malfunctioning hierarchies that value, incentivize, and reward power over competence.

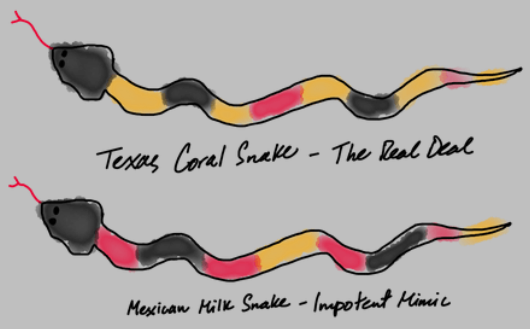


If you start to straighten up, people might just start looking at you and treating you differently. Your nervous system responds totally differently when you take on a challenge directly as opposed to being forced into it. Being higher up in the food chain, in the social hierarchy, has obvious social, physical, psychological, physiological effects which ripple into everything we do or undertake.

– Jordan Peterson, 12 Rules for Life

Signaling

Signaling is the verbal or non-verbal cues an animal (or person) gives to convey a message. It could be a pleasing scent to lure others in (like flowers do with bees) or it can be brightly colored patterns which signals that it is a potentially dangerous animal (like venomous snakes, spiders, frogs, and other creatures do). The more "expensive" a signal is, the more trustworthy it seems to be. Take, for example, Batesian mimicry. This occurs when one non-venomous animal nearly exactly copies the color and patterns of a venomous species (see our diagram above). It is "expensive" in the sense that if other animals are able to easily pick out the difference, the copycat will quickly be eaten. However, predators and other animals are wary of brightly colored prey in general because if they choose incorrectly and attack a venomous species, they can potentially end up with a fatal injury. There are dozens of fascinating examples of signaling – in the human realm as much as in the biological realm. Watches, sports cars, expensive packaging, essentially all advertising is meant to signal something – whether it be scarcity, wealth, status, or sexual fitness.

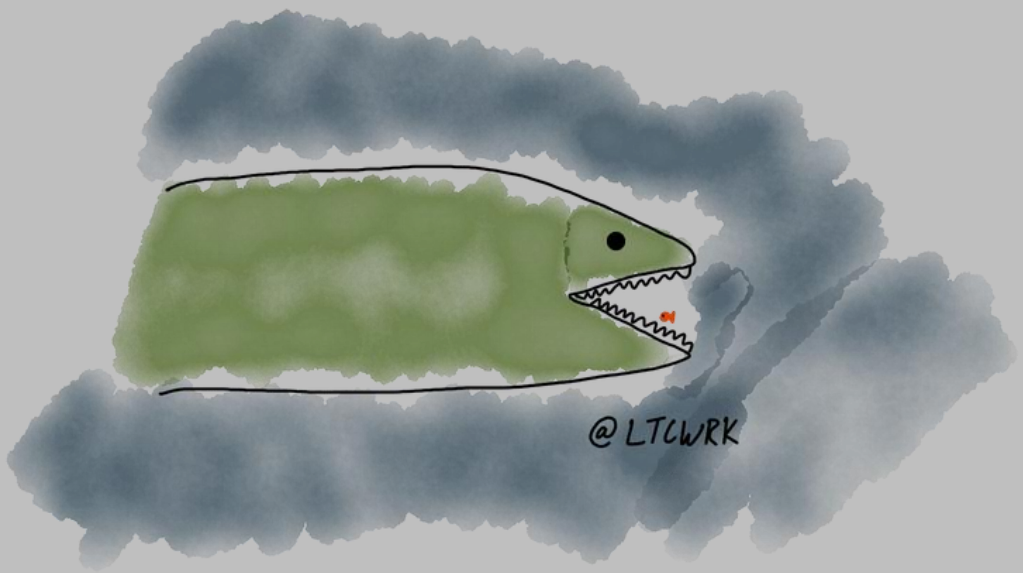


We should remember that non-aposematic species can also use aposematic warning signals for their defense. For example, when a hunter is entering a grassy patch where a wounded lion is prepared to defend its life, if a lion growls menacingly, this is an aposematic warning signal to the hunter, signal declaring that a lion wants to be left alone, but it will attack if hunter goes closer. If a lion definitely wants to attack someone, or if it is actually hunting a prey, it will be waiting without making any sounds. Let us remember: a growling predator wants to be left alone. A silent predator is more dangerous.

– Alexander Jikuridze and Alexander Jordania, Why Do People Sing?

Symbiosis

Symbiosis is when two different organisms pair together for mutual benefit. Although competition tends to describe most biological systems, but cooperation at various levels is just as important a dynamic. In fact, the cooperation of a bacterium and a simple cell probably created the first complex cell and all of the life we see around us. Without cooperation, no group survives, and the cooperation of groups gives rise to even more complex versions of organization. Cooperation and competition tend to coexist at multiple levels – both inter and intraspecies. However, the line between symbiosis and parasitism is unclear. Are you "infected" by your mitochondria? Regardless, parasitism is often thought of as the inverse of symbiosis. While some parasitism is ok, and maybe even healthy at low levels, if its exaggerated, the host will eventually die alongside the parasites. It is all about equilibrium.



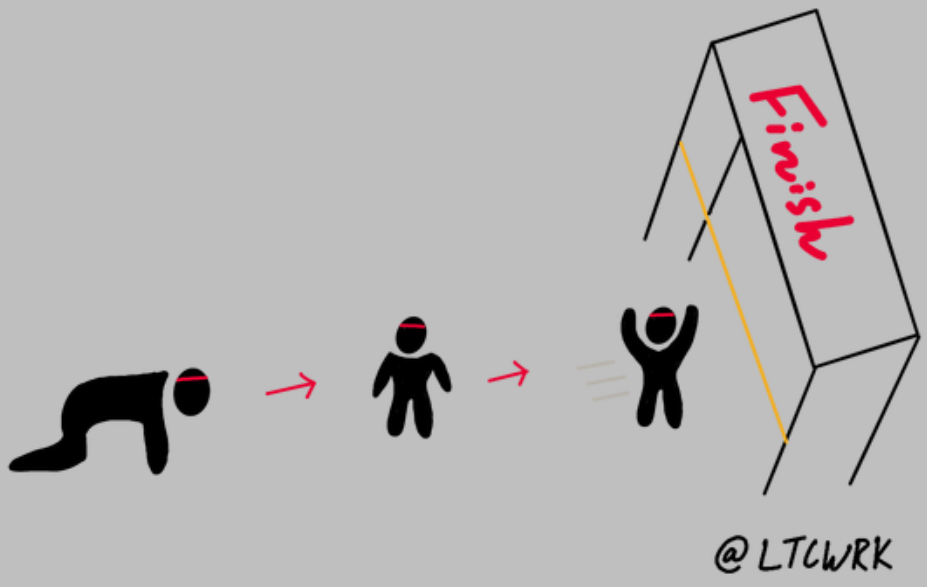
Cooperation is real, and increases with social development, mostly because it is a tool and form of competition.

– Will Durant

The Goal Gradient Hypothesis

People will find extraordinary strength if they see a finish line in sight. It is common to see marathoners struggle until the last 100 yards once the finish line is in sight, at which point they begin sprinting. Talk about a psychological change leading to a physiological one!

Play tricks on yourself if necessary by giving yourself some interim finish lines to help you stay motivated and on track. Staying on the log curve of learning is crucial for preserving precious time.



The most important role of a finish line is to get you over the start line.

– Stevie Smith

Niche

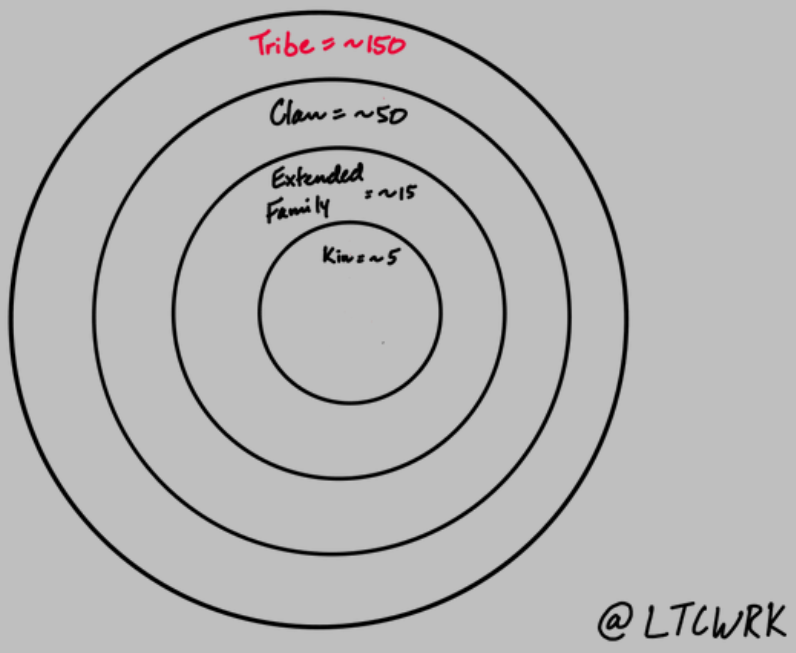
A niche is the space an organism occupies within a given habitat or ecosystem. It usually encompasses its relation to the other species it is connected to (whether predator, prey, or peer) and how the dynamics with the environment and the other species play out.

The forest ecosystem is held in a delicate balance. Every being has its niche and its function, which contribute to the well-being of all. Nature is often described like that, or something along those lines; however, that is, unfortunately, false. For out there under the trees, the law of the jungle rules. Every species wants to survive, and each takes from the others what it needs. All are basically ruthless, and the only reason everything doesn't collapse is because there are safeguards against those who demand more than their due. And one final limitation is an organism's own genetics: an organism that is too greedy and takes too much without giving anything in return destroys what it needs for life and dies out. Most species, therefore, have developed innate behaviors that protect the forest from overexploitation. We are already familiar with a good example, and that is the jay that eats acorns and beechnuts but buries a multitude of them as it does so, ensuring that the trees can multiply more efficiently with it than without it.

– Peter Wohlleben, The Hidden Life of Trees

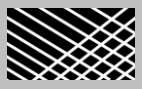
Dunbar's Number

Dunbar's Number represents the theoretical number of relationships a species can maintain stable social interactions at any given time, estimated at ~150 for humans. This number is important because group dynamics, trust, and cooperation change with scale, whether you like it or not. As human group sizes increase, the communication, cohesion, and intimacy breakdown and the amount of structure, laws, and rules must be increased. This careful growth and scaling requires you to be thoughtful and proactive in order to make these transitions as smooth as possible. Otherwise, it can lead to social loafing, politicking, and a number of other suboptimal group dynamics as individual effort and accountability decrease as we become one with the crowd. Smaller teams tend to be more effective (see Skunk Works)



Triangular awareness in chimpanzees (the ability of individual A to calculate the interdependence of the three separate relationships composed by his relationships with individuals B and C and the relationship between B and C themselves) suggests that the same ability in us has phylogenetically deep roots and is therefore innate.

– Donald Brown, Human Universals



The Latticework:

Health & Nutrition

Health & Nutrition

Health is life's fountainhead. Nothing else matters if you don't get this right, so don't let others' short-term sacrifices deter you from making your health a high priority (if not your highest priority). Understand that the body isn't magic – that if you have the right inputs, you'll get the right outputs. Find a way to balance diet, nutrition, aerobic/anaerobic exercise, strength, mobility, flexibility, sleep, meditation & mindfulness, and whatever else you enjoy that gets you moving, in flow, and out in nature. If we first and foremost take care of our health, it will allow us to pursue and deepen life's other dimensions.

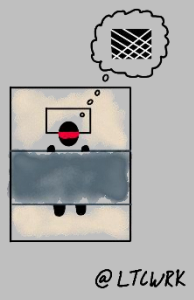
A helpful place to start is figuring out what your main Health & Nutrition priorities are and then work your schedule around that. What would you have to do to get to sleep at the time you want so you can get enough sleep? What time do you need to wind down at the end of the day? Can you do things the night before, so you don't have to worry about them in the morning? What time are you at your best? How can you maximize the amount of time and energy you have during this window? What time and how often do you want to work out? Similar to the apocryphal story about first getting the big stones, then pebbles, then sand, and then water into a container, you must first fit the big things into your life or else the small things will crowd them out. This is Gresham's Law at play, where the bad drives out the good.

When it comes to your health, take this simple idea seriously: 50% of the results do *not* come from 50% of the effort. Power laws are at play in Health & Nutrition and it is up to you to figure out your own "minimum effective dose" that helps you optimize for your own health, happiness, and longevity. We hope these 1-page summaries help you better know where to start and how to spend your precious time and energy to achieve the results you want.

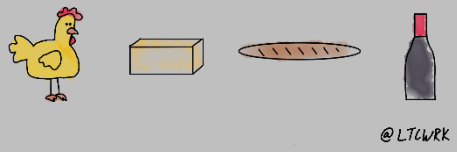
To keep the body in good health is a duty…Otherwise, we shall not be able to keep our mind strong and clear. – Buddha

The Big Ideas of Health & Nutrition:

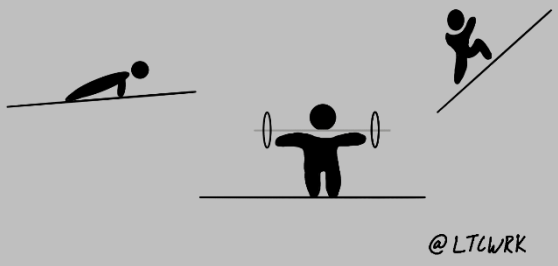
57. Sleep



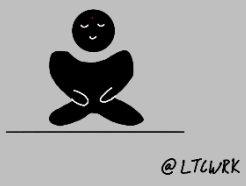
58. Diet



59. Exercise



60. Meditation & Mindfulness

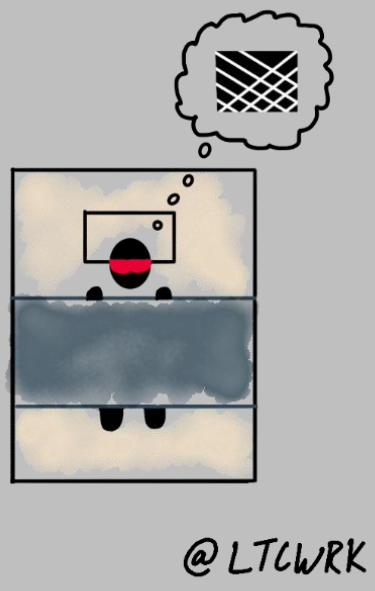


Sleep

Evolution is a natural culling machine. What puts organisms in danger and killed doesn't get furthered. And, after 3.7 billion years, we still have sleep – spending nearly one third of our lives in this state. This may not technically be scientifically sound reasoning, but if all animals we know of sleep and nature hasn't done away with it, that is enough evidence for me that this is an important process that we should take very seriously. We are playing with fire when we reduce the amount we sleep by 20% like we have done these past couple of decades.

If you buy into the above, getting high quality sleep is one of the most important variables in improving your brain function, longevity, and performance in all aspects of life. There seems to be no viable replacement for proper sleep – not caffeine, not willpower, not brief naps.

So, what can we do to better understand sleep and how to improve it? Check out Matthew Walker's *Why We Sleep* as well as our full write-up on this important topic, but some key habits include keeping a consistent schedule, exercising, avoiding big dinners and alcohol, keeping a dark and cold bedroom, and limiting caffeine. Easy to say, hard in practice.



Sleep is the interest we have to pay on the capital which is called in at death; and the higher the rate of interest and the more regularly it is paid, the further the date of redemption is postponed.

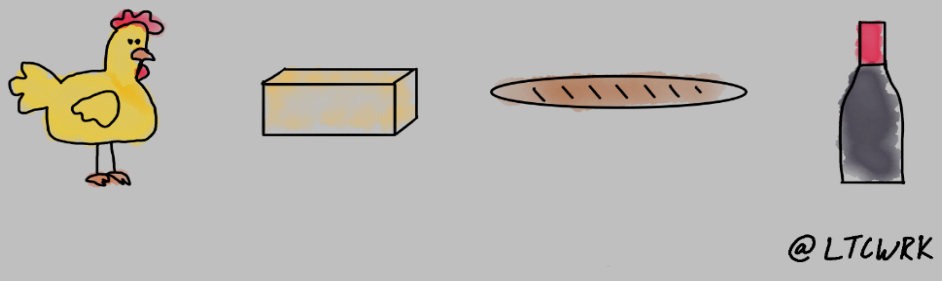
– Arthur Schopenhauer

Diet

A diet is simply the sum of food an organism eats, but it has become used in relation to the type of diet you follow (anything goes, vegan, vegetarian, pescatarian, keto, paleo, intermittent fasting, etc…)

Peter Attia has become a trusted source for many when it comes to health, diet, nutrition, and longevity. Much of what he discusses on his podcast gets quite technical, but he does an enviable job of doing the work so that he can understand and explain the details. His nutritional framework is an excellent high-level overview of how to think about diet:

Nutrition is such a loaded topic – almost a religious or political one – so I'm always looking for ways to explain it that are as free from that baggage as possible. So far (and this is constantly evolving, so look for this to get better over time) the framework I use to explain eating is based on modifying three parameters or "pulling 3 levers" in various combinations. A few months ago I posted a short video explaining this way to think about nutrition. It comes down to three forms of restriction. Whether it's what you eat or don't eat (i.e., dietary restriction or DR), how much you eat (i.e., caloric restriction or CR), or when you eat and don't eat (i.e., time restriction or TR), virtually all of the dietary schemes you can think of can be distilled into these three elements in some combination. One thing is for certain: if you want to be sick, don't do any of these things. Eat as much as you want (no CR), of anything you want (no DR), whenever you want (no TR). This is called the "standard American diet." The further you can get away from this pattern of eating, the better. As I say in the video, always pull one of the levers; often pull two; sometimes pull all three.



Any malady that can be treated by a change in diet should be treated in no other way.

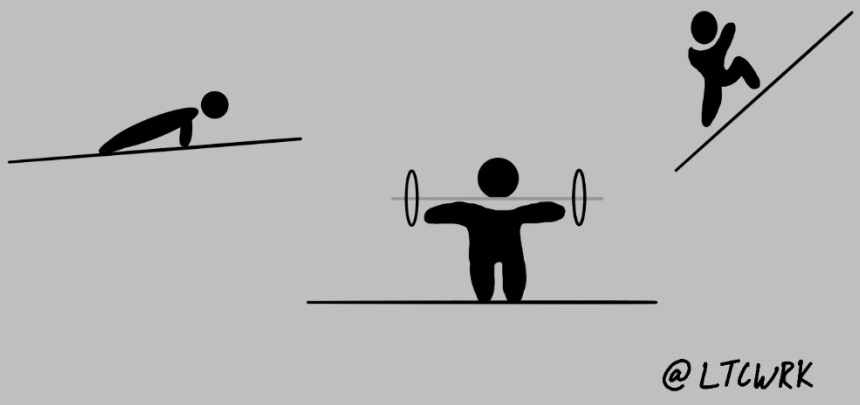
– Moses Maimonides

Exercise

Exercise is any movement that maintains physical and mental wellness, flexibility, robustness, and longevity. If we look at that list and what many people consider exercise, they don't resonate. So, if we were to start with first principles of exercise, what would be some of the goals?

- Goal #1 – avoid injury
- Goal #2 – build muscle mass (especially as you age)
- Goal #3 – be able to do the activities you enjoy doing whenever you want and at any age
- Goal #4 – Feel and look good, having consistent energy and stable moods

Following a "minimum effective dose" program can help us achieve the above without needing to spend hours in the gym. HIIT has become more mainstream these last several years, but the idea is to do short bursts of high intensity activity for relatively short periods of time. For example, run as fast as you can for 15-60 seconds, rest for 45-120 seconds. Do this for a total of 8-20 reps, a total of only 15-25 minutes, 1-2x per week. The point is to get your muscles close to failure, with >90% HR max achieved. *Body by Science* also outlines a beautifully simple lifting protocol that might be helpful in this quest for lifelong health.



Body and mind are not two separate entities. What happens in the body will have an effect on the mind and vice versa. Mind relies on the body to manifest, and body relies on mind in order to be alive, in order to be possible.

– Thich Nhat Hanh

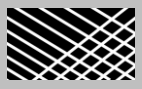
Meditation & Mindfulness

One of the better definitions of mindfulness I heard is from Jon Kabat-Zinn: "paying attention in a particular way: on purpose, in the present moment, and non-judgmentally." This, at the end of the day, is what meditation helps foster – mindfulness, awareness, detachment, focus, calm, patience, perspective, and so much more. However, mindfulness and attention are not the end goals of most meditation traditions. Rather, the true end goal is *insight*. The greatest benefit of cultivating this power of sustained attention is to be able to develop insights into our mind, feelings, emotions, desires. The idea is to train attention to create a quality of mind that is calm and clear at the same time. That quality of mind forms the foundation for emotional intelligence.

There are so many varying beliefs and dogmas around meditation – how to best practice it, when, mantra/no mantra, it is the solution to everything, it is a total waste of time, etc…. However, if we try to take it down to the foundation, to first principles, meditation is all about increasing our awareness and decreasing the amount of control our conscious, thinking mind has over our lives. As the axiom goes, the mind is a great servant but a terrible master. Meditation helps ensure the mind serves your purpose and not the other way around. Importantly, acceptance and awareness is not passivity and meditation is not about feeling a certain way, it's about being mindful of what you are feeling. The basic building block for most forms of meditation is to simply focus on your breathing. It is amazing how difficult this is at the start. Simply trying to still your mind and focus on one thing is frustratingly difficult, but that's the point of the whole practice. It's like doing a rep in the gym. You don't get frustrated when you can't do another rep, you simply keep training and, over time, you improve. The whole practice is about catching yourself when your mind wanders and lovingly bringing your attention back to your breath. It is much deeper than that, of course, but that is a pretty good place to start.

Forces beyond your control can take away everything you possess except one thing, your freedom to choose how you will respond to the situation.

– Viktor Frankl



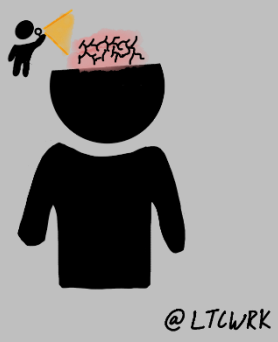
The Latticework:

Psychology

Psychology

Psychology is the study of people's behavior and mental processes. It impacts every human system and, since we're part of that system, prioritizing these fundamental principles can be supremely beneficial.

Unfortunately, even though these are some of the most practical and important tools you can have in your toolbox, many of these ideas aren't taught or emphasized in school. And, while there is more to study in this field than we could ever cover here, we will attempt to focus on the most influential and pragmatic ideas, those which, as Charlie Munger says, "carry 95% of the freight." Academics and professors can make this so complex you just tune out. Our goal is to make it so simple it just sinks in.



The insidious and dangerous aspect of these mental biases and cognitive illusions is that, unlike optical illusions, they cannot be seen. They're like carbon monoxide – if ignored, odorless and invisible but, nonetheless, potentially fatal. If we don't know what to look for or don't understand the basic biases most people have, we can live our whole lives fighting the current, rather than understanding the flow and finding the path of least resistance. This is working smarter, not harder. These ideas, if used properly and with the right intent, can be considered master keys which "unlock" human beings. Knowing what they are and how to operate them are useful skills.

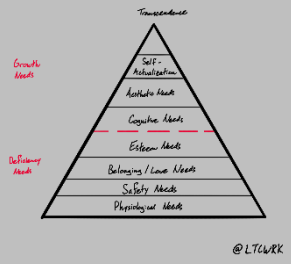
Interestingly, and importantly, one of these master keys may be an idea we've already encountered, an idea from Physics – Galilean Relativity. If we could step out of our system and see the world through others' eyes, we'd be less likely to fall victim to these psychological pitfalls. These mental models are all about gaining perspective to mitigate blind spots and psychology is one of the key disciplines in progress of this pursuit.

If you could see the world the way I see it, you'd understand why I behave the way I do. – Axiom of Clinical Psychology

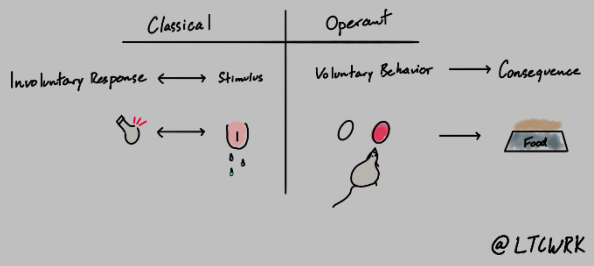
The Big Ideas of Psychology:

61. Munger's Psychology of Human Misjudgment

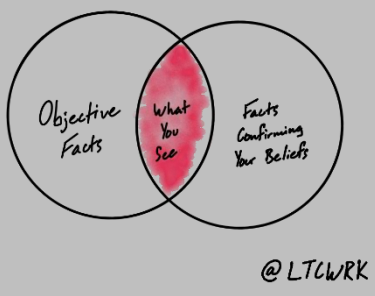
62. Maslow's Hierarchy



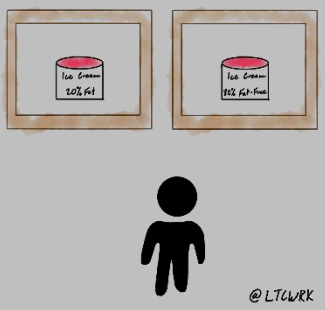
63. Conditioning



64. Biases



65. Framing

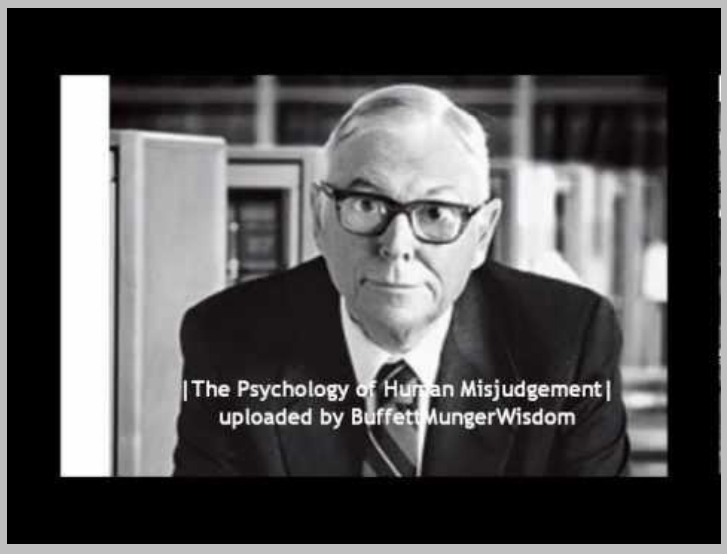


Munger's Psychology of Human Misjudgment

One of Charlie's more famous speeches is his "Psychology of Human Misjudgment."

In this goldmine of wisdom, Munger synthesizes and outlines some of the key psychological ideas we should know, how these biases and missteps affect us in our daily lives, and how we might be able to mitigate them. We can and likely should read this every year and let these ideas slowly sink in. This is a cheat sheet for understanding some of the inanities and Lollapalooza Effects that tend to happen and how we might side step them.

When someone so brilliant has done the hard work for you, why duplicate the effort? Below is a video of the speech, here is the transcript, and below are some of our key takeaways.

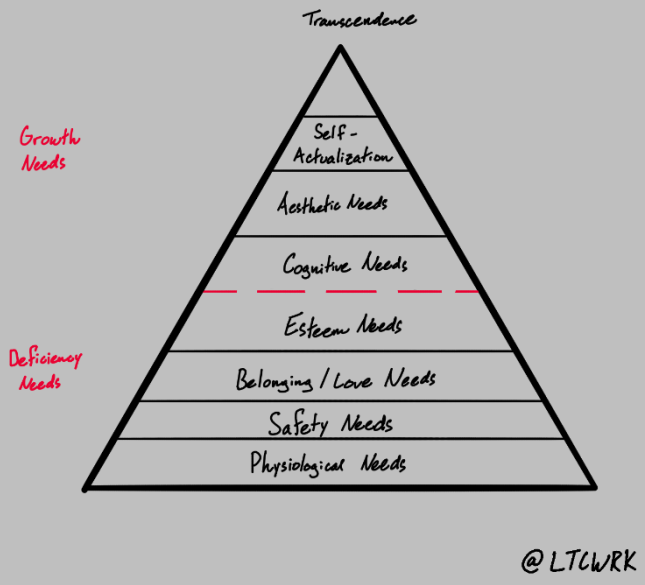


I have fallen in love with my way of living out psychology because it has been so useful for me…I have long been interested in standard thinking errors. However, I was educated in an era wherein the contributions of non-patient-treating psychology to an understanding of misjudgment met little approval from members of the mainstream elite. Instead, interest in psychology was pretty well confined to a group of professors who talked and published mostly for themselves, with much natural detriment from isolation and groupthink. And so, right after my time at Caltech and Harvard Law School, I possessed a vast ignorance of psychology…Soon after leaving Harvard, I began a long struggle to get rid of the most dysfunctional part of my psychological ignorance. Today, I will describe my long struggle for elementary wisdom and a brief summary of my ending notions…

– Charlie Munger, The Psychology of Human Misjudgment

Maslow's Hierarchy

Abraham Maslow, the father of positive psychology, revolutionized how we thought about people and our possibilities. Rather than focusing on disease, on the negatives, on the biases, he focused on the factors that could untap our full potential. Although there seems to be little evidence that Maslow ever described the pyramid he is now mostly closely associated with, it can serve as a useful framework to understand how most people move through a psychological evolution.



Seeing one's hierarchy of needs in this way can be helpful to prioritize what you want out of your career, your relationships, your life. You must know the priority or else you won't be able to reach the pinnacle. How can you get to your destination if you don't know where you're going?

A fascinating term we came across while learning about Maslow and this hierarchy is "Maslow's Synergy." It resonates very much with another idea we'll cover, Enlightened Self-Interest, but it states that there is a point where what is selfish and unselfish eventually merge. If you are working your ass off to become a better version of you (whether through sport, dance, drawing, business, therapy, etc.), this can be as a selfish decision because you're not directly helping others. But, this is short-term, first-order thinking. If you get your own house in order, if you feel good about yourself and can maximize your own potential, that can't help but aid others in the process. At some point, this dichotomy melts away and what ends up being good for you is also good for the world.

What a man can be, he must be. This need we call self-actualization.

– Abraham Maslow

Conditioning

There are several schools of thought and variations but, broadly, conditioning can be thought of as "You get what you reward."

Classical Conditioning (Pavlovian Mere Association)

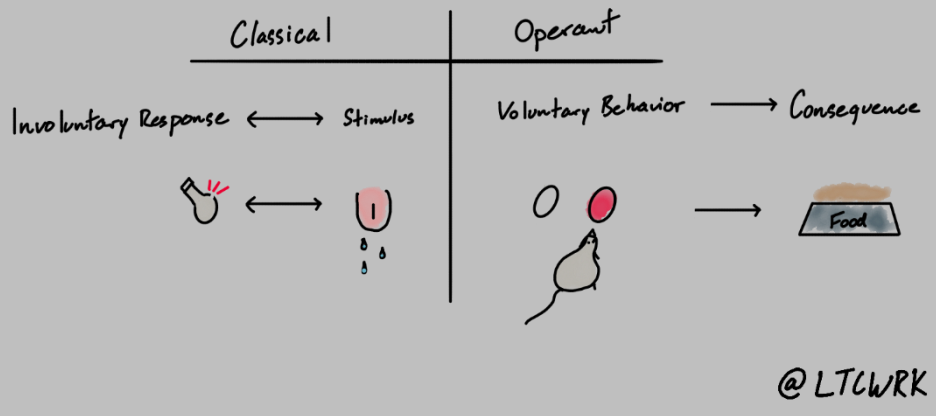
Pavlov very effectively demonstrated that animals can respond not just to direct incentives but also to associated objects. He was able to produce an unrelated response as the result of pairing a neutral stimulus with a more potent one.

Operant Conditioning

This type of conditioning presents a positive or negative feedback loop in order to encourage/disincentivize good/bad behavior. In short, reinforcing or punishing in order to learn behaviors. Important to operant conditioning is the type of reward or punishment, when it is doled out, the frequency, how large or small it is, and more.

Intermittent Reinforcement / Variable Schedule of Reinforcement

We crave the unpredictable. It's an innate curiosity that creates a compulsion to explore, to find the new and interesting. The technical term is "intermittent reinforcement," or when rules, rewards, or behaviors are inconsistently and occasionally doled out.



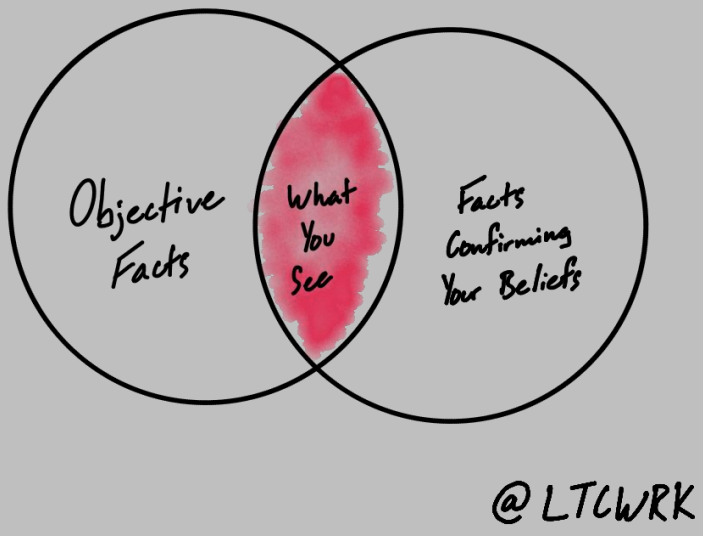
Students do not have to be made to study. Reinforcement is enough, and good programming provides it.

– BF Skinner

Biases

Biases are the tendencies to think in certain ways that can lead to blind spots, poor judgments, or suboptimal outcomes.

Some of the key biases to keep top of mind include confirmation bias, loss-aversion, hindsight bias, availability bias, zero-risk bias, inattentional bias, absence blindness, paradox of choice, the do something tendency, the omission bias, reason respecting tendency, narrative instinct, Halon's razor, and the mere exposure effect. Read more about each one here.



My own personal opinion is that more damage to the world comes from the cognitive glitches than does from malevolence.

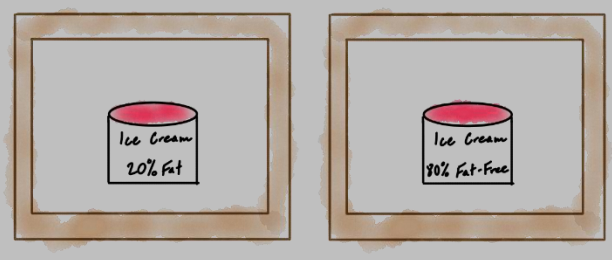
– Charlie Munger, Unplugged

Framing

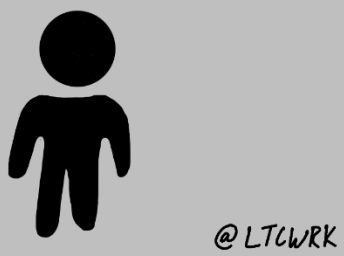
Framing refers to how something is explained or put into context. This includes everything from how the question is posed, to the environment you're in, to the person who says it.

The less knowledgeable we are about an issue, the more influenced we are by how it is framed. If we don't hold ourselves to a high standard and practice First Principles Thinking, we can easily get manipulated through the framing of a situation.

Framing is fascinating because the same information, with a different 'frame' surrounding it, can change the person's perception without having to alter the actual facts .

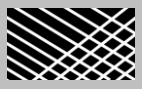


The same can be said with art and a literal frame. Much thought is put into picking a frame which will properly accentuate the painting – not distracting nor detracting.



Similarly, we should be thoughtful about the frame in which we view decisions, circumstances, others, and even ourselves. Somebody can be giving us constructive feedback but if we're insecure about it and adopt a "shame frame" rather than a "feedback frame", we will shutdown and get mad rather than understanding how we can use this information to improve.

The idiographic and nomothetic approaches have different focusses. The idiographic emphasizes the subjective and unique experience of an individual, whereas the nomothetic approach studies the numerical and statistical side to draw universal conclusions.
– Owlcation



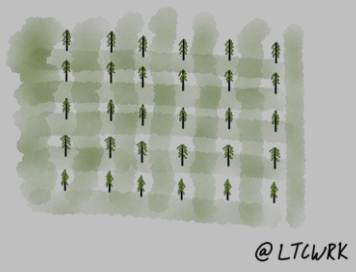
The Latticework:

Business & Investing

Business & Investing

There really is no such thing as "business" – it's simply an amalgamation of different disciplines – and this is what makes Business & Investing so fascinating!

To achieve deep fluency and sustainable long-term success, operators, investors, and managers must be adept psychologists, understand complexity adaptive systems, emergence, incentives, agency costs, Galilean Relativity, second-order thinking, increasing returns, comparative advantage, redundancy, margin of safety, game theory, and so much more. In a complex world where things are always changing, where money and leverage are on the line like in few other arenas, the practical application of these big ideas and big disciplines is front and center.



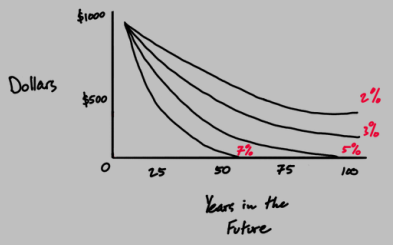
Like any art, mastery of these disciplines requires a paradoxical set of qualities which must be honed over a lifetime, and the dynamic nature of people and markets makes it a moving target. This challenge makes Business & Investing an intellectually stimulating calling for many people. If we can deeply understand the concepts covered in this discipline, paired with disciplines like worldly wisdom, psychology, competing, economics, and more, we can make even more effective decisions across multiple life domains. As Buffett said, "I am a better investor because I am a businessman, and a better businessman because I am an investor." For our purposes, we can become better multidisciplinary thinkers by better understanding these core concepts from Business & Investing.

Complicating matters further, a successful investor must possess a number of seemingly contradictory qualities. These include the arrogance to act, and act decisively, and the humility to know that you could be wrong. The acuity, flexibility, and willingness to change your mind when you realize you are wrong, and the stubbornness to refuse to do so when you remain justifiably confident in your thesis. The conviction to concentrate your portfolio in your very best ideas, and the common sense to nevertheless diversify your holdings. A healthy skepticism, but not blind contrarianism. A deep respect for the lessons of history balanced by the knowledge that things regularly happen that have never before occurred. And, finally, the integrity to admit mistakes, the fortitude to risk making more of them, and the intellectual honesty not to confuse luck with skill.

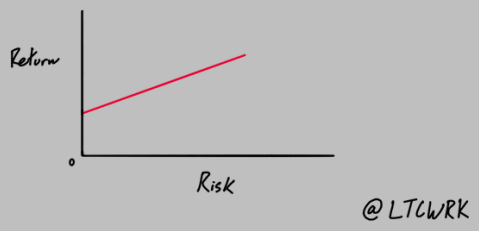
– Seth Klarman

The Big Ideas of Business & Investing:

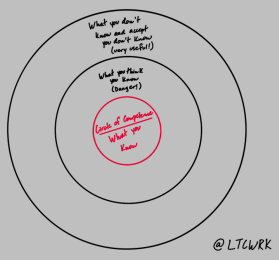
1. Time Value of Money



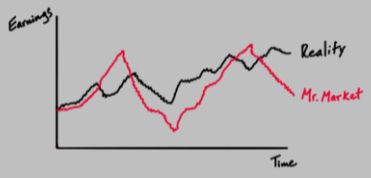
2. Risk & Return



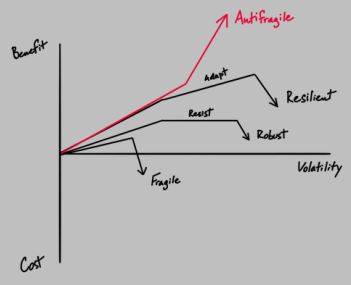
3. Circle of Competence



4. Mr. Market



5. On Antifragility

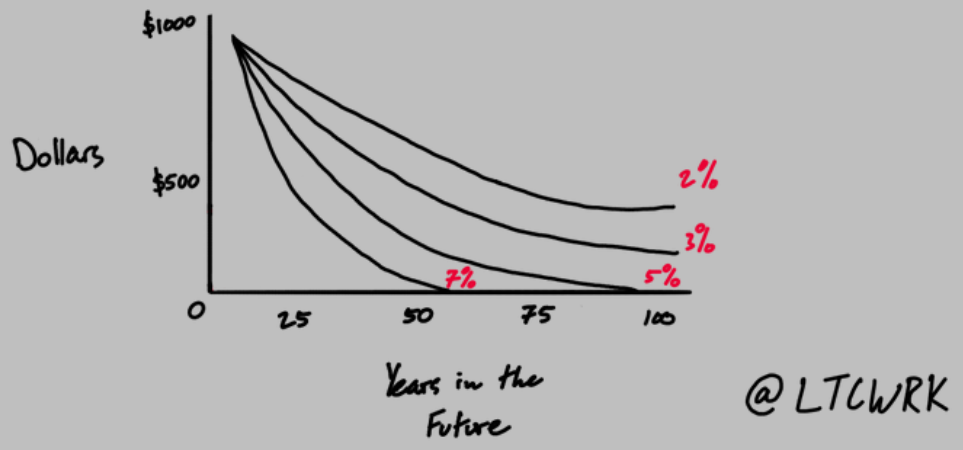


Time Value of Money

Time Value of Money describes the fact that money available in the present is worth more than the same amount in the future because we have the ability to invest it and earn a return in the meantime.

Time is an incredibly important, yet often overlooked element in value and isn't often considered by people outside of finance, but it should be! It is the articulation and measure of opportunity cost!

So, for example, when taking out a loan, getting paid, or making an investment, understanding and taking the time value of money into account is paramount. Are you getting appropriately compensated given the risks and time that your money will be invested?



All intelligent investing is value investing – you are acquiring more than you are paying for. You must value the business in order to value the stock.

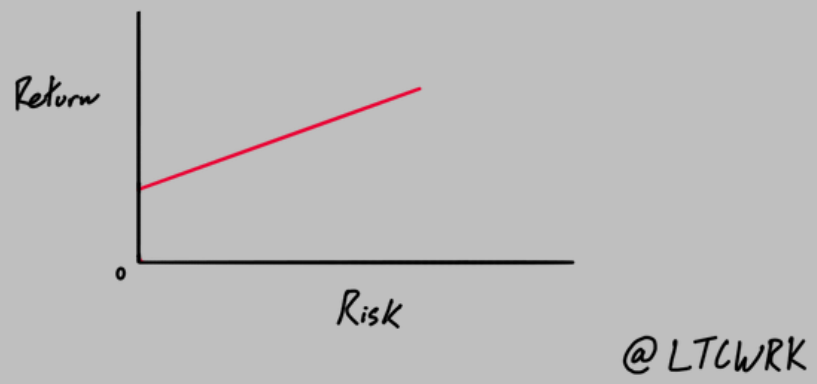
– Warren Buffett

Risk & Return

The definition and underpinnings of risk are not widely agreed upon, but the most elegant definition of risk we've yet come across is "permanent loss of capital." Volatility must be expected and planned for, so short-term fluctuations should not be considered risk nor define our willingness to invest. It must be the probability of permanent loss that drives how we think about the riskiness of an investment.

Return is generally easier to define, although there are countless ways people measure it (oftentimes to hide or obscure reality). However, return is simply the profit made on an investment. There is ROI, IRR, various time periods, taxation, and many more factors that add complexity to this measurement, but at its heart it is a simple concept.

Risk & Return are intimately intertwined, as the desired rate of return increases, so should the risk, creating the upward slowing line below that represents the "capital market line." There is some riskless asset that earns some nominal rate of return and everything that generates a return greater than that should theoretically have greater risk as well. What we'll find is that perceived risk and actual risk is quite different and the best investors spend a disproportionate amount of their time on identifying and understanding risks rather than returns.



Investors must be willing to forego some near-term return, if necessary, as an insurance premium against unexpected and unpredictable adversity…Rather than targeting a desired rate of return, even an eminently reasonable one, investors should target risk.

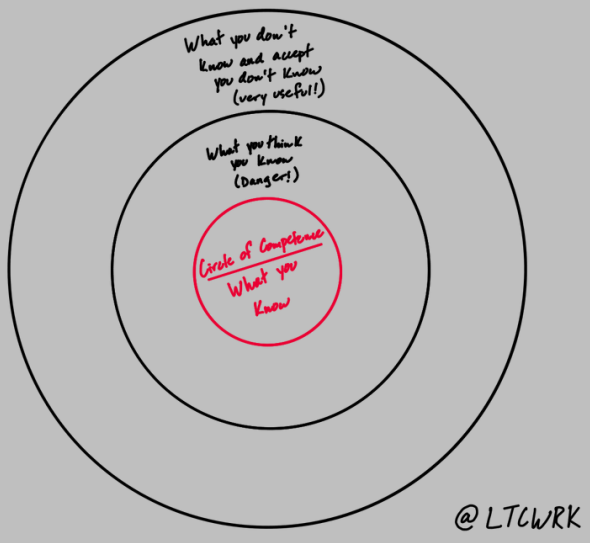
– Seth Klarman, Margin of Safety

Circle of Competence

Your Circle of Competence is your area of expertise – the topic, skill, or industry where you have some deep fluency that gives you an edge. It is a very valuable skill to know what you know, know what you don't know, and be humble enough to admit that there will always be things that you don't know you don't know. Double down on what you know, but always keep expanding the circle!

Buffett made the analogy that investing should be approached as Ted Williams approached hitting. Williams was scientific in how he practiced and decided which pitches to swing at. He knew where he had the greatest probability of a good hit – his "circle of competence" – and was incredibly disciplined at swinging only at pitches that were in his strike zone. This is how he managed to be the last hitter to average a .400 batting average.

We, too, should find our "circle of competence" within which we have the greatest probability of success and swing big when opportunities fall into that strike zone. Crucial to successfully executing this is knowing what our circle of competence even is and what falls outside of that circle. Simple, but not easy!



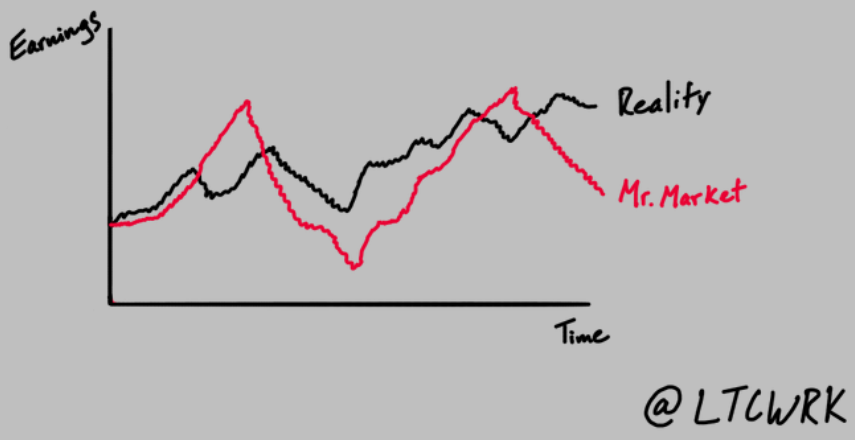
The size of that circle is not very important; knowing its boundaries, however, is vital.

– Warren Buffett

Mr. Market

Ben Graham, widely considered to be the father of value investing, created the idea of Mr. Market in Chapter 8 of his seminal book, *The Intelligent Investor*. He anthropomorphized the economy into "Mr. Market" in order to represent the emotional and often irrational fluctuations of the financial markets.

While there may be legitimate concerns and reasons to be afraid and to sell, the pendulum often swings too far – whether towards overly greedy or fearful. The key is to remain calm and rational, striking while others are fearful and being weary while others are greedy.



But note this important fact: The true investor scarcely ever is forced to sell his shares, and at all other times he is free to disregard the current price quotation. He need pay attention to it and act upon it only to the extent that it suits his book, and no more. Thus the investor who permits himself to be stampeded or unduly worried by unjustified market declines in his holdings is perversely transforming his basic advantage into a basic disadvantage. That man would be better off if his stocks had no market quotation at all, for he would then be spared the mental anguish caused him by other persons' mistakes of judgment.

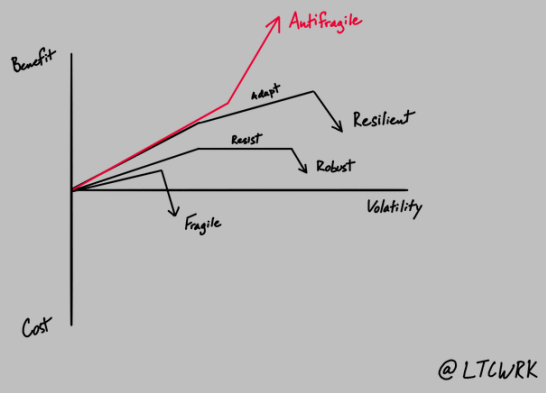
– Benjamin Graham, The Intelligent Investor

On Antifragility

Popularized by Nassim Taleb, the sliding scale of fragility, robustness, resilience, and antifragility refers to the responsiveness of a system to increasing negative volatility. Does something get stronger or weaker with additional chaos and disorder?

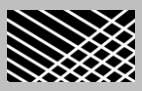
A fragile system or object is one in which additional negative variability has a disproportionately negative impact. For example, if a stone falls on someone from 50 feet, it can kill them whereas this same stone falling from 5 feet won't do much damage (rather than 1/10th the damage).

A robust system or object tends to be neutral to the additional negativity variability (think a well-engineered bridge), resilient systems can adapt to negative volatility up to a point (certain algorithms and ML programs), and, of course, an antifragile system benefits with chaos and disorder (some, but not all, people). Systems, organizations, habits, people, and more can be antifragile. For example, some people respond incredibly well to stress and actually become stronger in difficult times – they retain more upside than downside during volatility.



Spain, like Rome, imposed uniformities on particularities. This could produce impressive results: it's unlikely, otherwise, that either empire would have expanded so far so fast. The price, though, was shallow roots, which allowed adversity to shake authority. The English spread their influence more slowly, but adapted more easily, especially in North America. Where when trouble came, it brought a republican revolutionary transfer of authority, not a collapse, the example of which, over the next two centuries, would undermine empires everywhere.

– John Lewis Gaddis, On Grand Strategy

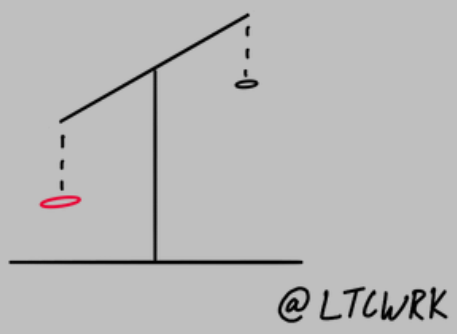


The Latticework:

Economics

Economics

Economics – specifically, microeconomics – is the study of choice and how these choices are made given individuals' and firms' naturally limited resources.



Importantly, economics isn't an exact science. When the human element is forgotten or simply neglected because it makes mathematical theories easier to model and control, we are asking for trouble. Humans are not rational cogs, but emotional and often irrational beings. This is not something to be ashamed of, but it must be taken into account when making economic decisions. For example, what people do is much more telling than what they say. People are rationalizing animals and can rationalize just about anything they do post-hoc. This is actually pretty incredible and is why changing someone's actions can cause them to change their beliefs, but doing the opposite is exceedingly hard. This is the idea of "revealed preferences." What and how people truly think can be difficult to pin down, but what they do is measurable, actionable, and more telling.

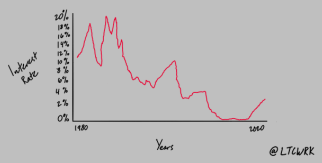
Economics is fascinating and valuable to study because it intertwines and informs several other ideas from various disciplines such as first principles thinking, second-order thinking, systems thinking, complexity, chaos, emergence, equilibrium, critical mass, psychology, game theory, compounding, and more.

One of the most important things to bear in mind today is that economics isn't an exact science. It may not even be much of a science at all, in the sense that in science, controlled experiments can be conducted, past results can be replicated with confidence, and cause-and-effect relationships can be depended on to hold. It's not for nothing that economics is called "the dismal science…" The main ingredient in economics is psychology, and the workings of psychology clearly can't be fully known, controlled, or fixed.

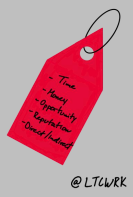
– Howard Marks, The Most Important Thing

The Big Ideas of Economics:

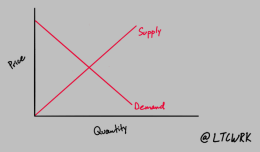
66. Interest Rates



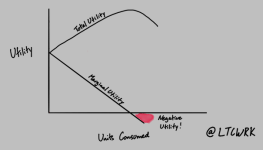
67. Costs



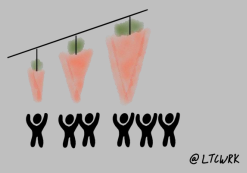
68. Supply & Demand



69. Utility



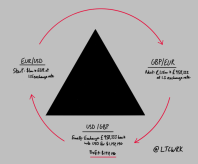
70. Incentives



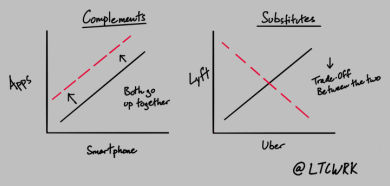
71. Comparative Advantage

Opportunity Costs (for 1 Unit)	Cars	Bikes
Country A	2 Bikes	½ Car
Country B	4 Bikes	¼ Cars

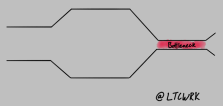
72. Arbitrage



73. Complements & Substitutes

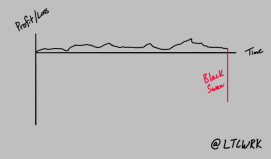


74. Bottlenecks

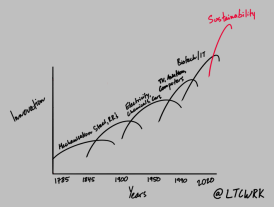


75. Externalities

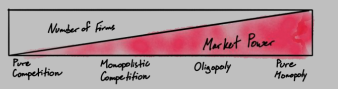
76. Black Swans



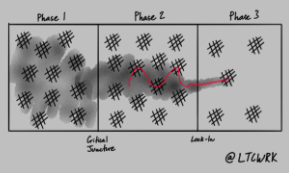
77. Creative Destruction



78. Market Power



79. Path Dependence

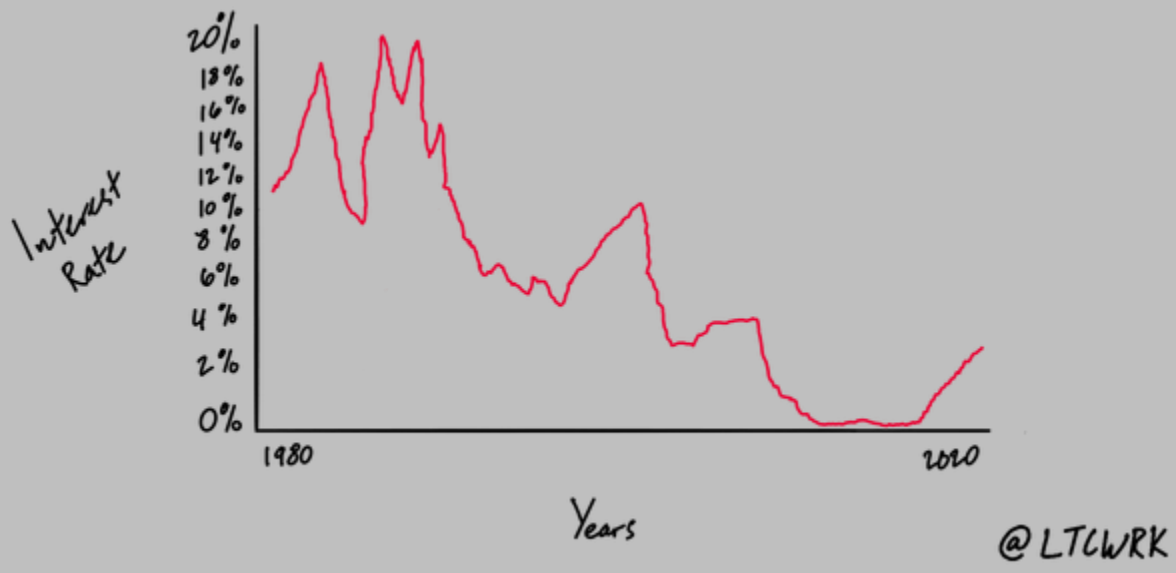


Interest Rates

Interest is the cost of borrowing money and the Interest Rate tells you how quickly those costs accumulate over time. Interest Rates are so important because they impact the value of everything.

As we discuss in Time Value of Money, investing consists of investing money today in order to get more in the future. The "discounted present value" of the projected future returns varies inversely interest rates. In more simple words, when interest rates rise, the present value of a future dollar falls.

So, this can help shed light on why the Federal Reserve has kept low interest rates since 2008. By reducing short-term interest rates (in this case to near-zero), the government makes it more attractive to spend and invest, stimulating the economy. Lower rates also provide a direct subsidy to financial institutions, which can borrow cheaply and lend at higher rates – reducing risk aversion and allowing people to take out loans when needed.



Only now do we see articles pointing out (after the fact) that if a hedge fund borrows short to buy long Treasury bonds with 6% "down," a 1% rise in the bonds' yield will wipe out 100% of the equity in the position.

– Howard Marks, Risk in Today's Markets, Revisited

Costs

A cost is an expense incurred for creating or doing something. There are, of course, monetary costs that we are all intimately familiar with, but there are also psychological costs, strategic costs, short-term vs. long-term costs, and so many more. There are an innumerable variety of costs we could dig into, but we'll focus on what we currently consider some of the key varieties: Opportunity Cost, Sunk Cost, Marginal Cost, Fixed vs. Variable Cost, Direct vs. Indirect Cost, Switching Cost, Bribery, Transaction Cost, Search Cost, and Accounting to help keep track of it all.

Investment is the discipline of relative selection.

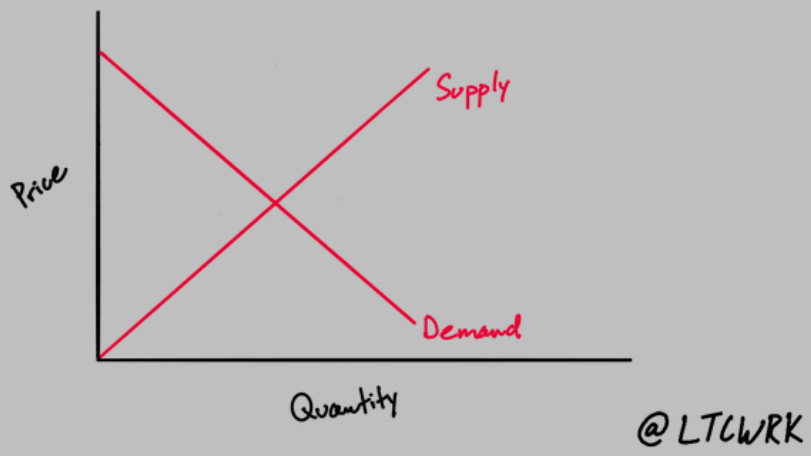
– Sid Cottle

Supply & Demand

Demand is a consumer's desire to buy and supply is a producer's desire to sell.

Demand is influenced by quality, quantity, price, and the availability of substitutes, as well as psychological factors like social proof, framing, commitment bias, need for consistency, or authoritative endorsements.

Supply steps in to fill demand; it's a solution to the consumer's problem. Supply is influenced by barriers to entry (a cost that must be incurred by a new entrant into a market that incumbents don't or haven't had to incur), the severity of the problem being solved, the cost of inputs, government interventions and regulations, the state of applicable technology, transportation conditions, and the price of related goods.



The concept of equilibrium is so deeply embedded in our theory of economics and the stock market, it is difficult to imagine any other idea of how these systems could possible work…One place where the question is being raised is the Santa Fe Institute, where scientists from several disciplines are studying complex adaptive systems – those systems with many interacting parts that are continually changing their behavior in response to changes in the environment…If a CAS is, by definition, continuously adapting, it is impossible for any such system, including the stock market, ever to reach a state of perfect equilibrium. What does that mean for the stock market? It throws the classic theories of economic equilibrium into serious question.

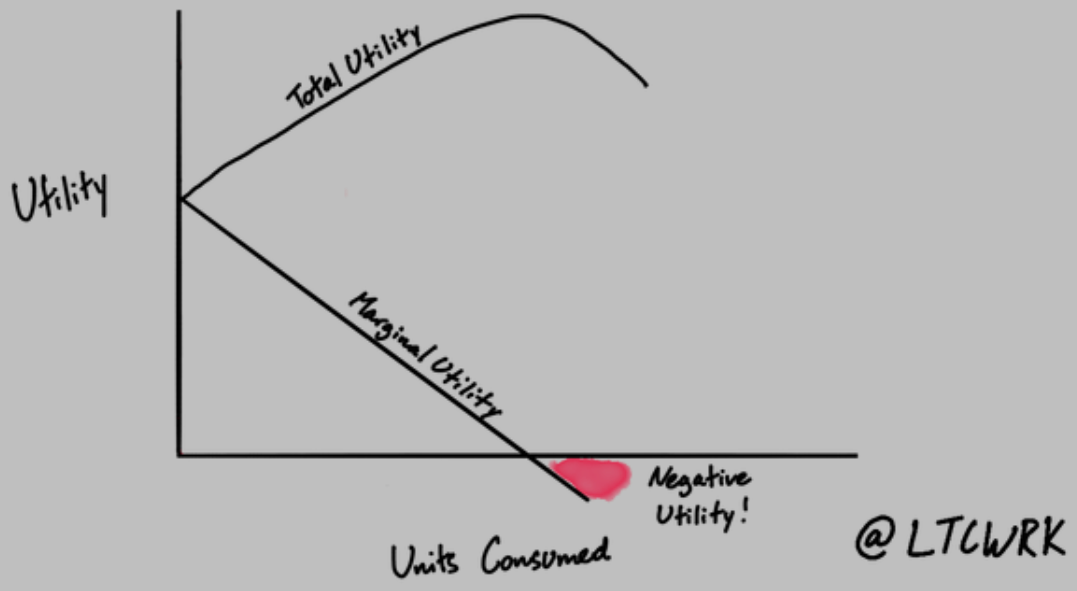
– Robert Hagstrom, Latticework

Utility

Utility is a valuable concept to keep in mind. It is a measure of the usefulness (utility) of a good or service, acknowledging that additional units tend to vary with scale.

Total Utility – the total satisfaction received from consuming a good or service.

Marginal Utility – this concept allows us to understand the value of one additional unit, and in most practical areas of life, that utility diminishes at some point. This is the point at which you hit diminishing returns and, in some cases, may even hit negative marginal utility.



I trust in nature for the stable laws of beauty and utility. Spring shall plant and autumn garner to the end of time.

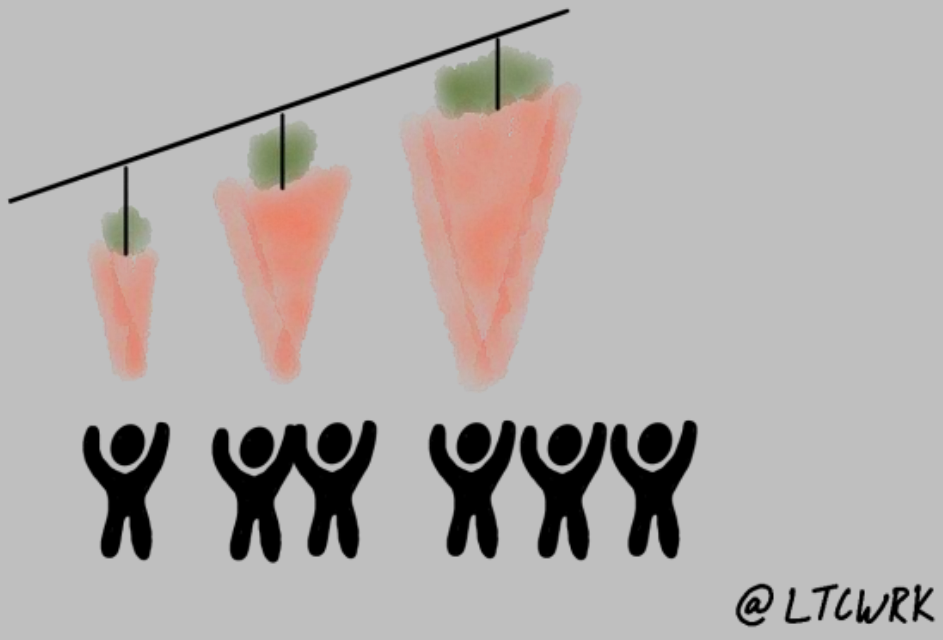
– Robert Browning

Incentives

An incentive is a reward or punishment that motivates or suppresses behavior.

All creatures respond to incentives to keep themselves alive. This is the basic insight of biology. Constant incentives will tend to cause a biological entity to have constant behavior, to an extent.

Humans are included and are particularly great examples of the incentive-driven nature of biology; however, humans are complicated in that their incentives can be hidden or intangible. The rule of life is to repeat what works and has been rewarded.



Understanding human behavior is not difficult: people move towards what they find agreeable, and away from what they find disagreeable.

– Moses Maimonides

Comparative Advantage

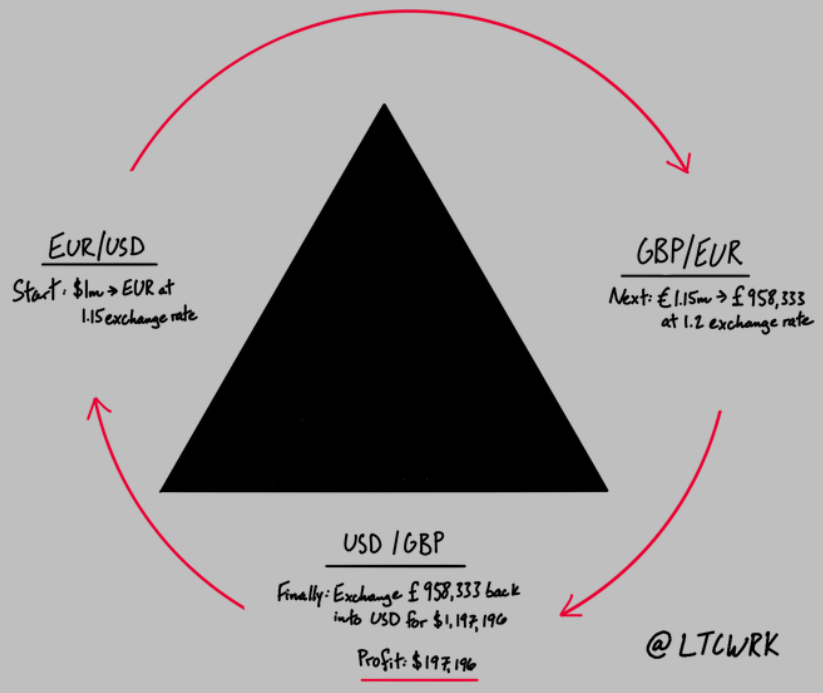
First considered by famous Scottish economist David Ricardo, Comparative Advantage states that two people, organizations, or even entire nations could be better off by trading with each other, even if one of them was superior at everything they traded. How could this be? If we only look at absolute advantages, we are neglecting all important opportunity costs! By not having to manufacture a certain good, that nation could pour additional money and time into perfecting another good that may be even more profitable and valuable. So, the person, organization, or nation that faces lower opportunity costs to produce one unit has a comparative advantage.

Small merchants need to avoid coming at us head-on and do their own thing better than we do ours. It doesn't make sense to try to underprice Walmart on something like toothpaste. That's not what the customer is looking to a small store for anyway. Most independents are best off, I think, doing what I prided myself on doing for so many years as a storekeeper: getting out on the floor and meeting every one of the customers. Let them know how much you appreciate them, and ring that cash register yourself. That little personal touch is so important for an independent merchant because no matter how hard Walmart tries to duplicate it – and we try awfully hard – we can't really do it.

– Sam Walton, Made in America

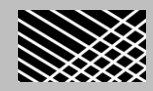
Arbitrage

Arbitrage is the practice of taking advantage of a price difference between two or more markets. Given two markets selling an identical good, an arbitrage exists if the good can profitably be bought in one market and sold at a profit in the other. This model is simple on its face but can present itself in disguised forms: The only gas station in a 50-mile radius is also an arbitrage as it can buy gasoline and sell it at the desired profit (temporarily) without interference. Nearly all arbitrage situations eventually disappear as they are discovered and exploited. This is where learning to learn and think effectively become such valuable tools.



In a sense, value investing is a large-scale arbitrage between security prices and underlying business value. Arbitrage is a means of exploiting price differentials between markets.

– Seth Klarman, Margin of Safety

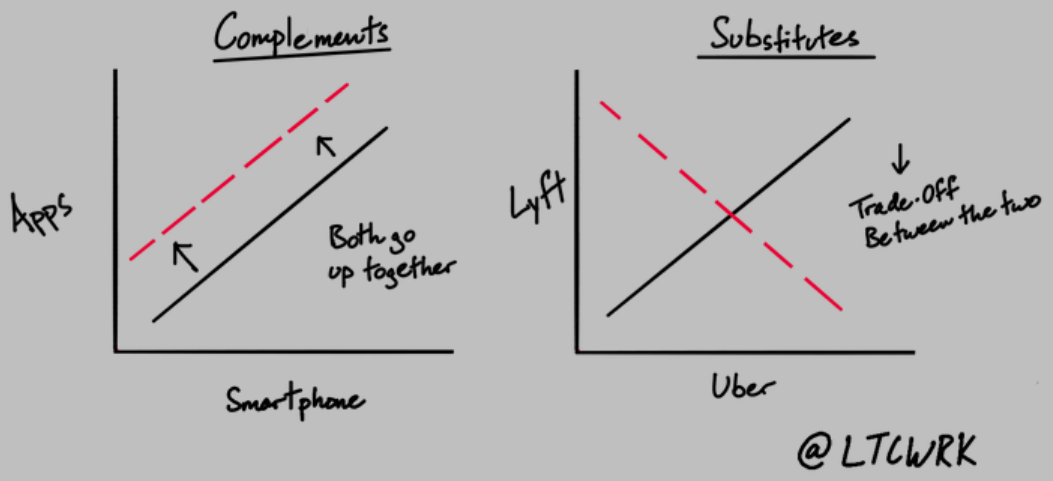


Complements & Substitutes

Complements are consumed together whereas substitutes are goods where you can consume one in place of the other.

When the price of a good that complements a good decreases, then the quantity demanded of one increases and the demand for the other increases.

You may have heard a famous phrase – "commoditize your complements" – and by better understanding what a complement is, hopefully this makes more sense. The cheaper and more ubiquitous your complements are, the higher the usage of your product or service.



All else being equal, demand for a product increases when the prices of its complements decrease…Smart companies try to commoditize their products' complements.

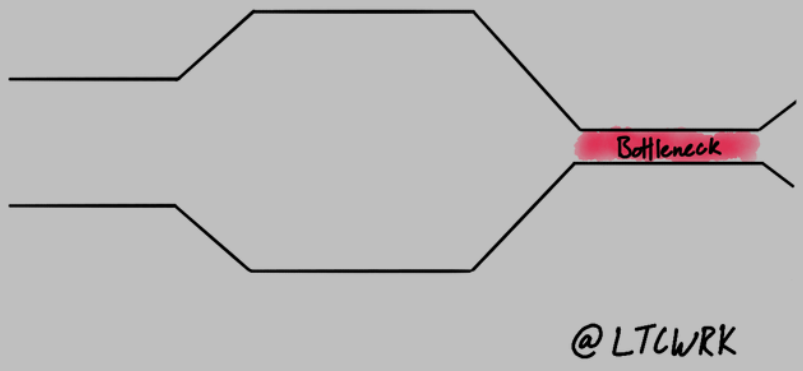
– Joel Spolsky, Strategy Letter V

Bottlenecks

A bottleneck describes the place at which a flow (of a tangible or intangible) is stopped, thus holding it back from continuous movement. As with a clogged artery or a blocked drain, a bottleneck in production of any good or service can be small but have a disproportionate impact if it is in the critical path.

The opportunity for improvement comes from identifying and unclogging bottlenecks, which come in a variety of forms. Some bottlenecks are physical like machine capacity, scheduling inefficiencies, or a supply of materials. Others are caused by policies, rules, attitudes, miscommunications, cultural inertia, or even integrity issues. A great place to start is always to invert and ask, "What does success look like and what are the biggest obstacles to us achieving it?" Those answers are the bottlenecks and opportunities for improvement. In most organizations, these constraints are buried so as not to expose, or embarrass, those involved. To the contrary, constraints should be readily identified, elevated, and resourced to the fullest extent.

How do you go about identifying these bottlenecks? Sometimes it'll be obvious and sometimes it'll be a bit more buried. However, a lens that might be helpful is one from physics. By stealing some jargon from physics, like "heat, noise, friction, volatility, turbulence, drag, load, etc.", you'll be able to easily identify bottlenecks. Whenever you find these symptoms, you'll find a bottleneck. Then apply common sense measures until you fix the most restrictive bottleneck, then rinse and repeat. This simple formula will work in any human system. What could be easier?



The most restrictive bottleneck within any system, no matter where it is, regulates the output of the entire system.

– Eli Goldratt, The Goal

Externalities

An externality is the cost or benefit that affects a party who did not choose to incur that cost or benefit. It is increasingly important today when we are more interconnected than ever before.

Tragedy of the Commons – A situation within a shared-resource system where individual users acting independently according to their own self-interest behave contrary to the common good of all users by depleting that resource through their collective action.

Free-Rider Problem – When those who benefit from resources, goods, or services do not pay for them, which results in an under-provision of those goods or services.

Principal-Agent Problem – These are some of the most important and influential ideas you can master. This dilemma exists in circumstances where agents are motivated to act in their own best interests, which are contrary to those of their principals, and is an example of moral hazard.

Moral Hazard – Moral hazard is when the risks and rewards of a behavior are separated, causing the risk taker to be unaffected by poor outcomes. The antidote is skin in the game.

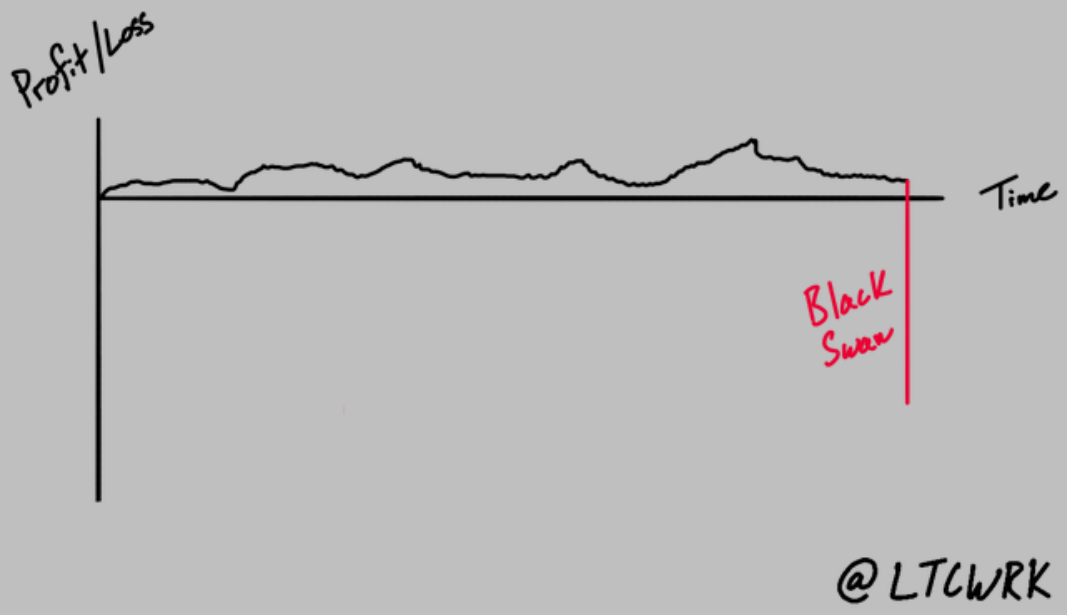
Parents tend to be more conservative for their kids than they would for themselves, simply because, as parents, they share risks more than rewards. If your eight year old son decides to climb a tree, or your teenage daughter decides to date the local bad boy, you won't get a share in the excitement, but if your son falls, or your daughter gets pregnant, you'll have to deal with the consequences.

– Paul Graham, How to Do What You Love

Black Swans

Black Swans are events which almost nobody saw coming, have massive consequences, and in hindsight are rationalized and thought to be understood.

To better understand the term, imagine you've only seen white swans. It is improper to say that there are no black swans, but the opposite isn't true – seeing just one black swan allows you to say that they do exist. This is a key idea Taleb hits on over and over again – we should not go about the world seeking evidence of what suits our beliefs, instead we should understand when we've only seen white swans and act appropriately.



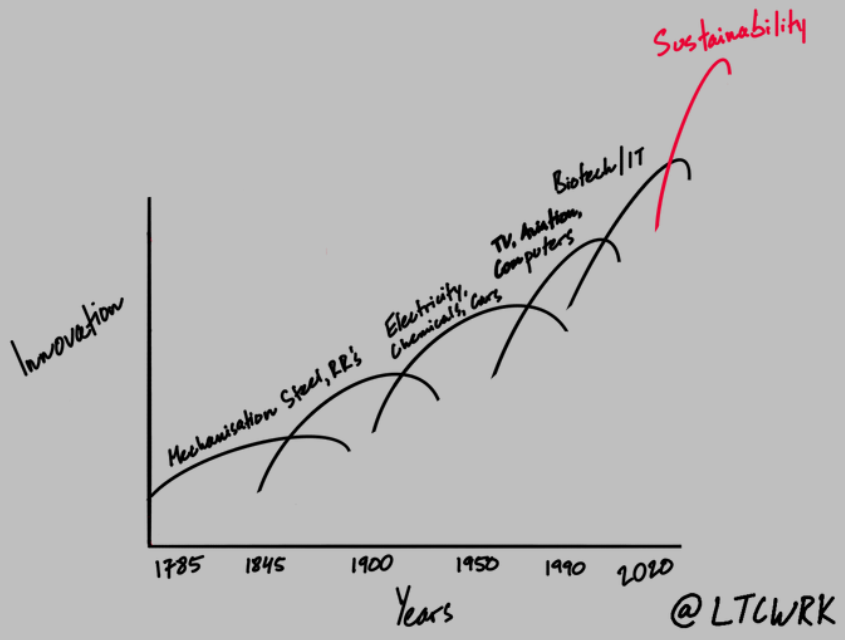
Long tails drive everything. They dominate business, investing, sports, politics, products, careers, everything. Rule of thumb: Anything that is huge, profitable, famous, or influential is the result of a tail event. Another rule of thumb: Most of our attention goes to things that are huge, profitable, famous, or influential. And when most of what you pay attention to is the result of a tail, you underestimate how rare and powerful they really are.

– Morgan Housel, Tails, You Win

Creative Destruction

Creative Destruction is the relatively quick and intense process by which companies, industries, and even entire economies progress. The companies based on the older technology or way of doing things is destroyed as the new one has structural advantages that are difficult, if not impossible, to compete with.

This creative destruction comes about because of new innovations. Most innovations tend to be evolutionary, rather than revolutionary, but every once in a while there is something that goes from "zero to one" or a critical mass is reached with small baby steps that all of a sudden what was never possible or thought of before all of a sudden becomes probable.



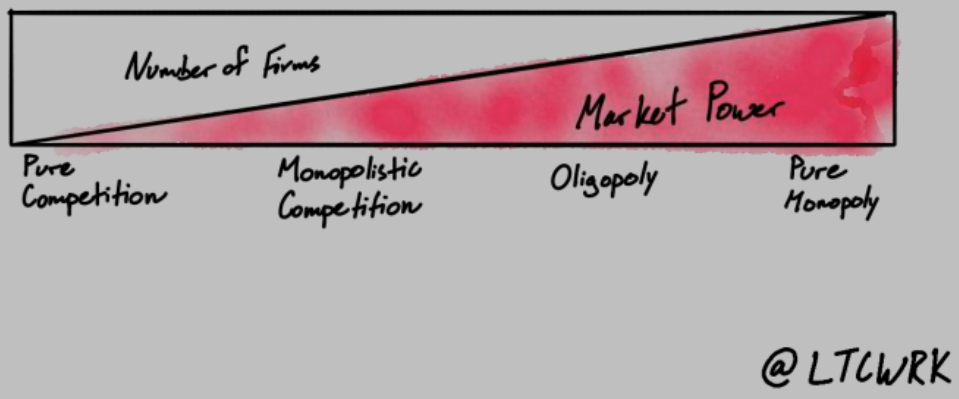
Achilles heel of successful companies is their inability to cannibalize themselves. Many innovations consist of replacing something with a cheaper alternative, and companies just don't want to see a path whose immediate effect is to cut an existing source of revenue. So if you're an outsider you should actively seek out contrarian projects. Instead of working on things the eminent have made prestigious, work on things that could steal that prestige. The really juicy new approaches are not the ones insiders reject as impossible, but those they ignore as undignified.

– Paul Graham, The Power of the Marginal

Market Power

Market Power is the ability of a firm to raise prices of their good or service over their marginal cost. In a perfectly competitive and efficient market, no firm would have market power since another firm would see this, step in, and charge lower prices. This is why we could say that pricing power is the ultimate moat. There is some structural advantage that allows the firm with market power to charge prices above what is expected without attracting too much competition or it has the ability to effectively repel competition.

Market power lies on a spectrum and we'll discuss some of the key ways Market Power takes shape, including monopolies, monopsonies, oligopolies, duopolies, commodities and related ideas such as lock-in, increasing returns, Ben Thompson's aggregation theory, and more.

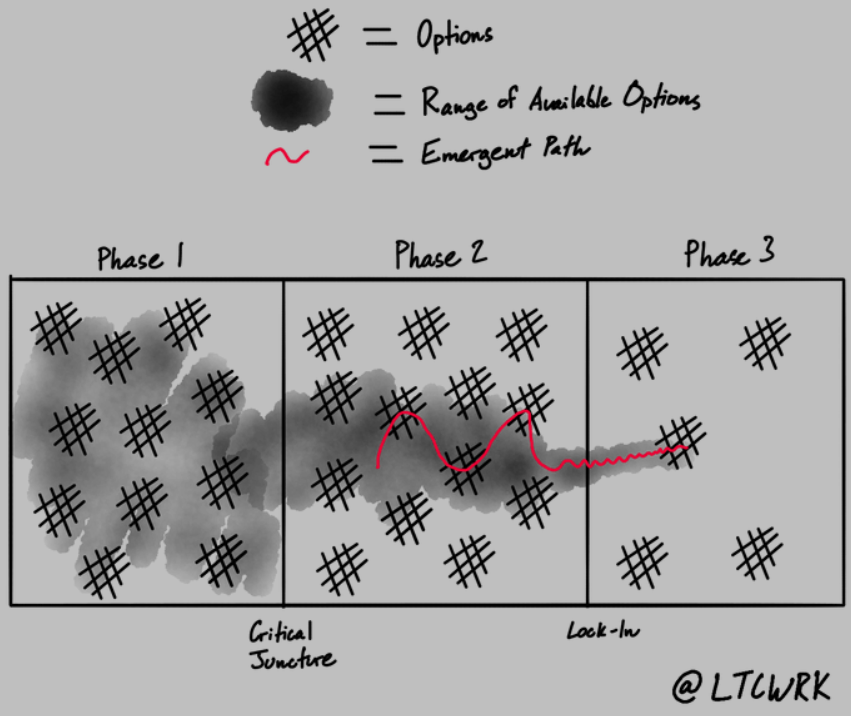


To an economist, every monopoly looks the same, whether it deviously eliminates rivals, secures a license from the state or innovates its way to the top. I'm not interested in illegal bullies or government favorites: By "monopoly," I [Peter Thiel] mean the kind of company that is so good at what it does that no other firm can offer a close substitute. Google is a good example of a company that went from 0 to 1: It hasn't competed in search since the early 2000s, when it definitively distanced itself from Microsoft and Yahoo!"

– Peter Thiel, Zero to One

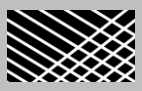
Path Dependence

Path Dependence shows that history matters. The options, decisions, circumstances you face are dependent and have been limited by what you did in the past, even though these past circumstances may no longer be relevant. This is why being intentional, knowing what you want, and doing things that have extremely high optionality and relatively little downside is so important. How can you preserve optionality so that you open more doors as you progress? You want to choose the opportunities that preserve or, even better, increase, future opportunities and options. Preserving Optionality is a strategy of keeping options open and fluid, fighting the urge to make choices before you have to.



Very often individual technologies show increasing returns to adoption – the more they are adopted the more is learned about them; in then the more they are improved, and the more attractive they become. Very often, too, there are several technologies that compete for shares of a "market" of potential adopters.

– Brian Arthur, Increasing Returns



As the African proverb goes, “If you want to go fast, go alone. If you want to go far, go together.”

Thank you for choosing to go together.