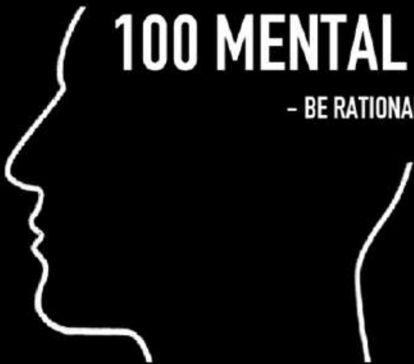
100 MENTAL MODELS

- BE RATIONAL -



BOOK · CARDS · MAPS · QUOTES

@wisdom_theory

To Charles T. Munger

> You have to learn all the big ideas in the key disciplines in a way that they're in a mental latticework in your head and you automatically use them for the rest of your life. If you do that, I solemnly promise you that one day you'll be walking down the street and you'll look to your right and left and you'll think "my heavenly days, I'm now one of the few competent people in my whole age cohort." If you don't do it, many of the brightest of you will live in the middle ranks or in the shallows.
>
> —Charlie Munger

INDEX

INTRODUCTION

> If all you have is a hammer, everything looks like a nail.
>
> —Abraham Maslow

Evolution has rewarded the curiosity of human beings, compelling us into a relentless search for progress through the acquisition of knowledge. In order to organize the knowledge that we learn along the path of our exploration, we ceaselessly divide it into more or less tightly related compartments.

The increase of knowledge made specialization necessary, and through it, knowledge started to become more and more specific, divided into different sub-branches and sub-sub-branches … It would be difficult to think we could have progressed so much without these classifications and subcategories. Specialization paved the way for progress by enabling the classification and labeling of every aspect of knowledge. But this wonderful tool of specialization is a double-edged sword, because it carries the risk of making us observe the world through an incomplete prism, appearing thus as full of divisions.

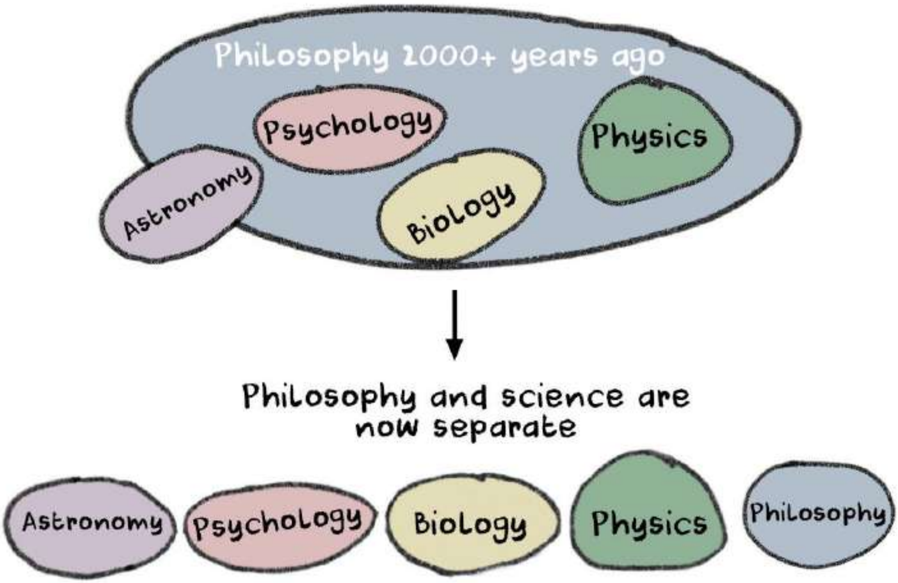
These divisions we make of the world, and everything that comprises them, exist only in our minds and in our universities.

> If our small minds, for some convenience, divide this universe, into parts—physics, biology, geology, astronomy, psychology, and so on—remember that nature does not know it!
>
> —Richard Feynman

The world is holistic; hence it has to be appreciated as a whole, that is, from various points of view; otherwise the labels that help us discern and understand every aspect of it can take us away from reality. Today more than ever, the growth of specialization makes it necessary to have an integral vision of the world in which we live. We need a global approach to be able to observe it as it is; bringing us closer to reality and, therefore, helping us make better decisions.

Due to the tremendous amount of knowledge accumulated over the centuries, the educational system has forced us to specialize in a specific branch of knowledge. But the belief that the only way to add value to society is to have an ultra-specific knowledge of a subject, disregards the notion of having a global vision.

The idea of focusing our knowledge in a specific field, although today seems common due to its popularity, only began a couple of centuries ago. It was during the Industrial Revolution when work was split into separate tasks and divided among society. In the times of the classics, 2,000 years ago, the approach was certainly the opposite: The wise men sought a plural knowledge in search of an accurate vision of nature— this idea prevailed for many centuries, from Aristotle to Johann Wolfgang von Goethe.



While it is true that a deep dive in a given area enables us to advance, it is no less true that having a greater global vision will improve us in our areas of specialization too. It is essential that we are able to apply and relate concepts and ideas from other fields in order to help us better understand the world in which we live.

Therefore, in any situation or event, we will not only have a tunnel vision of what we know, but also the ability to see events through different lenses, and hopefully with the knowledge from the great ideas of each science.

These great ideas are known as *mental models*, an expression popularized by Charlie Munger, who recommends having a network of mental models to help us make better decisions, and "developing the habit of mastering the multiple models, is the best thing you can do." Practice that he has carried out and perfected for decades, and that has led him to be one of the most brilliant minds of the last century.

Munger is so adept at this idea; he suggested that if he were younger, he would create a course to teach it.

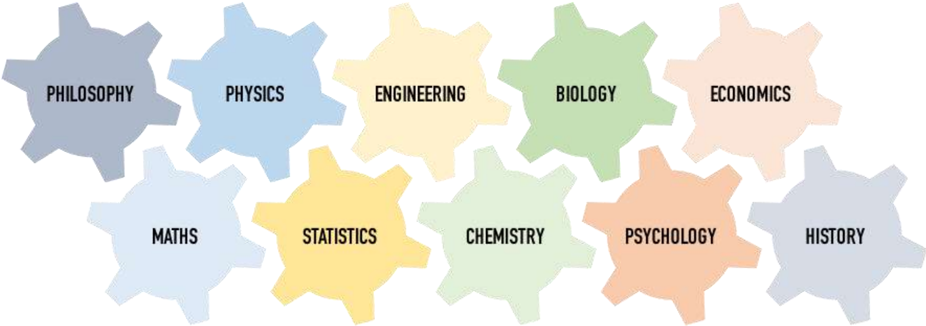
This book comes from this old idea from Charlie Munger.

MENTAL MAP

> You've got to have models in your head and you've got to array your experience—both vicarious and direct—onto this latticework of mental models.
>
> —Charlie Munger

We will see the most important ideas of each science. This classification will serve as a tool to order them, and although it is not closed, some will inevitably affect several fields of knowledge. The fact that an idea can be related to several sciences is another sign that knowledge, on its own, is not compartmentalized and we should relearn to appreciate it like that.

That said, it is important to have a *mental map* of the sciences, from the purest to the humanities. When we use mental models routinely, we must do so starting with the purest sciences—starting from left to right on the below diagram with philosophy, mathematics and physics, as these form the basis of our known world. Thus, this map is not only of classification but of order.



BRANCHES OF KNOWLEDGE

- Philosophy
- Mathematics
- Physics
- Statistics
- Engineering
- Chemistry
- Biology
- Psychology
- Economics
- History

The deepest questions belong to philosophy, which, as we will see, delves into the unknown. Mathematics is the basis of the known world, the language of nature. From it arise physics, chemistry, statistics, and engineering. From physics and chemistry, biology emerges, which shapes psychology, which in turn explains economic decisions.

Finally, we will see history as the collection of facts about the human being throughout their existence.

From the fields of study and their order, we will see the most important ideas. The number of mental models will be 100, as Munger indicated. With them, we can solve and explain 95% of the situations. The important thing is not to know only the names of all mental models, but to actually put them to use. Therefore, the first task is to find a balanced number that allows us to remember them and, at the same time that helps us to have a real vision of the world, helping us make better decisions.

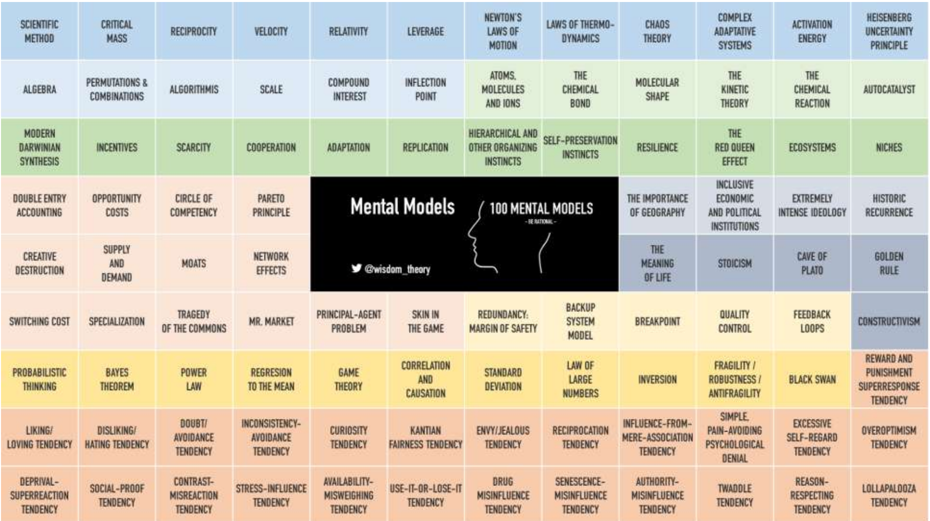
> Any fool can know. The point is to understand.
>
> —Albert Einstein

When measuring knowledge, we frequently use data that is not optimal—for example, listing a large number of mental models or books one has read. As Naval Ravikant reminds us: "I don't want to read everything. I just want to read the 100 great books over and over."

> You can know the name of that bird in all the languages of the world, but when you're finished, you'll know absolutely nothing whatever about the bird. You'll only know about humans in different places, and what they call the bird. So, let's look at the bird and see what it's doing — that's what counts. I learned very early the difference between knowing the name of something and knowing something.

> —Richard Feynman

It is better to only know 5 or 10 models and use them repeatedly than to know the name of 300 and never use them. Quoting Bruce Lee, "I fear not the man who has practiced 10,000 kicks once, but I fear the man who has practiced one kick 10,000 times."



However, these ideas should only be taken as a base which is flexible and not set in stone. Even though the models seen here are distilled from important ideas of each science, one may still find some of them not useful—and thus discard or replace them with different ones in order to complete our own set of mental models.

Additionally, a recommended list of books is included, which will serve as an amplification of each of the ideas, as well as a source of many others.

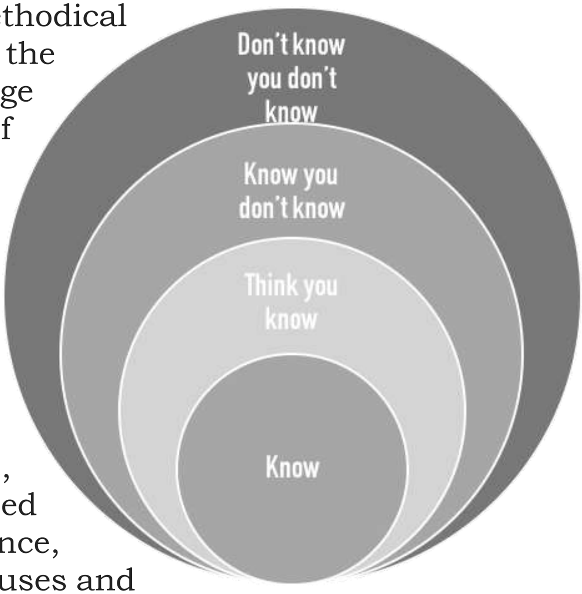
PHILOSOPHY

> Science is what you know. Philosophy is what you don't know.
>
> —Bertrand Russell

It is intrinsic to the human condition to seek knowledge and to explore its limits. In the following chapters, we will focus on what human beings know, on what they take for granted, but more importantly, on what they don't know. This ignorance is greater than our knowledge, it takes the form of great questions that cannot find an answer in science. These are the questions of philosophy.

Philosophy comes from the Greek word *φιλοσοφία* and the Latin word *Philosophia* coined by Pythagoras in Ancient Greece, a term composed of two words: *Philos* (love) and *Sophia* (thought, wisdom, knowledge). Therefore, philosophy is the *love of wisdom*.

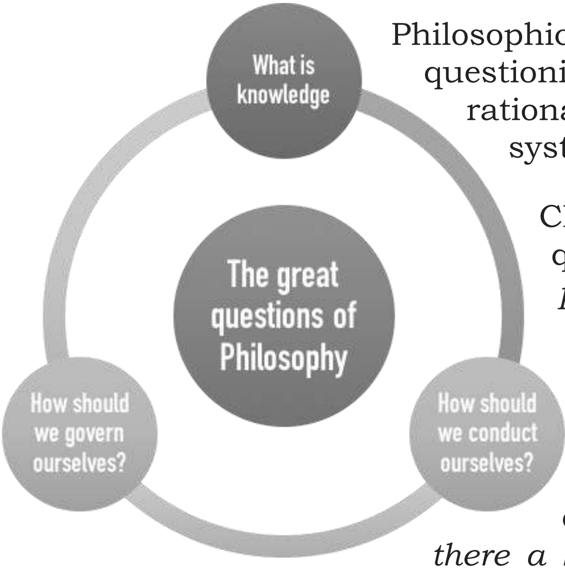
In a broad sense, philosophy seeks to understand fundamental truths about ourselves and the world in which we live.



Thereby, it is the methodical thinking that reflects the articulation of knowledge and the limits of existence and ways of being is called philosophy. This is a doctrine that uses a set of logical and methodical reasoning about abstract concepts such as existence, truth, and ethics based on the essence, characteristics, and causes and effects of natural things such as human beings and the universe.

The philosopher, on the other hand, is an individual who seeks knowledge for its own sake, without a pragmatic end. Their motivation is curiosity and inquiries about the ultimate foundations of reality. Beyond the development of philosophy as a discipline, the act of philosophizing is intrinsic to the human condition. It is not a concrete knowledge, but man's natural attitude towards the universe and his own being.

> I see I have made myself a slave to Philosophy.
>
> —Isaac Newton



Philosophical methods include questioning, critical discussion, rational argument, and systematic presentation.

Classic philosophical questions include: *Is it possible to know anything and to prove it? What is most real?* Philosophers also pose more practical and concrete questions such as: *Is there a best way to live? Is it better to be just or unjust (if one can get away with it)? Do humans have free will?*

PHILOSOPHY MODELS

In this first section we will see five models which will provide with a broad framework: from looking for a meaning to our lives, to having an appropriate stoic mindset or how to treat other people; aspects that have proven useful throughout history.

Additionally, we will examine a metaphor from Plato—more relevant today than ever before—and we will end by analyzing how we build knowledge and therefore our reality.

- The meaning of life
- Stoicism
- Cave of Plato
- Golden Rule
- Constructivism

THE MEANING OF LIFE

> There is nothing in the world that empowers a human being to overcome external difficulties or internal hardships so much as the awareness that one has a task in life.
>
> —Viktor E. Frankl

One of the most basic and primitive questions of the human being is to understand the meaning of life. In this regard, there have been several schools of thought that have tried to answer this question.

Like any philosophical question, it does not have a unique answer; we must each find it within oneself. In this sense, one of the most appropriate answers arises from logotherapy.

Logotherapy proposes that the will to meaning is the primary motivation of the human being. It was founded in 1925 and developed by Viennese psychiatrist Viktor Frankl.

> He who has a why to live can bear almost any how.
>
> —Friedrich Nietzsche

Source: Anna Vital

Logotherapy is a psychotherapy that proposes that the will to meaning is the primary motivation of the human being, a psychological dimension unexplored by previous psychotherapeutic paradigms, and that clinical attention to it is essential for the integral recovery of the patient.

After Freud's psychoanalysis and Alfred Adler's individual psychology, logotherapy is the *third Viennese school of psychotherapy* developed by the neurologist and psychiatrist Viktor Frankl. It is a type of psychotherapy that relies on existential analysis and focuses on a *will to* *meaning* as opposed to Adler's doctrine of *will to power* or Freud's *will to pleasure*.

To understand the origin of logotherapy, it is important to know that Frankl was a prisoner in a concentration camp. There, he considered that he was able to survive more than anyone else because he knew how to give *logos* (meaning) to his existence. He tells of his experience in his book *The Man in Search of Meaning*.

Logotherapy is based around the meaning of life, which it considers an unconditional factor that is not lost under any circumstance but can escape human understanding. Logotherapy is a positive perception of the world (reductionism).

> What man actually needs is not a tensionless state but rather the striving and struggling for a worthwhile goal, a freely chosen task. What he needs is not the discharge of tension at any cost but the call of a potential meaning waiting to be fulfilled by him.
>
> —Viktor Frankl

Logotherapy postulates that the human being is not motivated by the search for pleasure or power, but is oriented towards the meaning of life. The human being is a being in search of meaning. Logotherapy seeks self-determination of the person based on their responsibility in the context of their world of values and meaning. According to logotherapy, the human being represents a point of interaction between three levels, as part of a single unit:

- Physical
- Psychic
- Noetic (spiritual)

Frankl explains:

> The unity of man is a unity despite the multiplicity of body and psyche, and unity cannot be found in the biological or psychological dimension but must be sought in the noetic dimension, that is, the dimension of meaning, the spiritual dimension.
>
> …
>
> It can be seen that health is based on a certain degree of tension, the tension between what has already been achieved and what has not yet been achieved, or the gap between what is and what should be. This tension is inherent in human beings and, therefore, is indispensable to mental well-being. We must not, therefore, hesitate to challenge the man to fulfill his potential sense. Only in this way do we awaken from the state of latency his will of significance. I consider it a false and dangerous concept for mental hygiene to assume that what man needs above all is a balance or, as it is called *homeostasis* in biology, that is, a state without tensions. What man really needs is not to live without tensions, but to strive and fight for a worthwhile goal. What he needs is not to eliminate the tension at all costs, but to feel the call of a potential sense that is waiting for him to fulfill it. What man needs is not *homeostasis*, but what I call *noodynamics*, that is, the spiritual dynamics

> within a field of bipolar tension in which a pole is represented by the meaning that must be fulfilled, and another pole for the man who must fulfill it. And it should not be thought that this is true only for normal conditions; its validity is even more evident in the case of neurotic individuals. When the architects want to shore up a sinking arch, they increase the load on top of it, so that their parts join together more firmly. Also, if therapists want to strengthen the mental health of their patients, they should not be afraid to increase this burden and guide them towards the meaning of their lives.

Logotherapy relies heavily on Psychodrama, a dramatization performed by the patient, thinking that their life is ending at that precise moment. Issues arise from this dramatization, usually known as "what would I change if I had a second chance." These changes will be noted and implemented by the patient to find their own *logos* or the meaning of their life.

According to Viktor Frankl, the meaning of life is the most authentic and profound engine of human actions. The quest for meaning is a human one, which does not imply any pathology. Meaning is always associated with a specific and unique situation. The possibility of having meaning is characterized by our uniqueness as unrepeatable and irreplaceable people, by the concrete situation and by the possibility we have of going beyond ourselves towards what the world demands of us (self-transcendence). The meaning of life cannot be given; it is not transferable. There is no sense of *life* as such, but the meaning of each one’s life at any particular moment. It is always centered around a person and a specific situation. Logotherapy helps to discover all the possibilities of meaning that exist before us.

The human being realizes meaning through values. The third level of logotherapy—the *noetic* dimension—is energized by the aspiration to these values. According to logotherapy, values are possibilities of meaning; they are universal concepts, objectives, although we do not aspire to them.

> The search by the man of the meaning of life constitutes a primary force and not a *secondary rationalization* of his instinctive impulses. This sense is unique and specific in that it is oneself and only one who has to find it; Only in this way can man achieve a meaning that satisfies his own sense of meaning. Some authors argue that the senses and principles are nothing more than *defense mechanisms, formations, and sublimations of reactions*. As far as I am concerned, I would not want to live simply because of my *defense mechanisms*, nor would I be willing to die for my *reaction formations*. Man, however, is able to live and even die for his ideals and principles!
>
> …
>
> Whatever they have taken from you when you arrive at the concentration camp until the last breath, no one can take away your freedom to face your destiny in one way or another (like that). And there is always one way or another.

Summed it up in one sentence:

> Mankind was apparently doomed to vacillate between the two extremities of distress and boredom.
>
> —Schopenhauer

Frankl continues:

> Tiredness is today the cause of more problems than stress and, of course, leads more cases to the psychiatrist's office. These problems are becoming increasingly critical, as progressive automation will result in a large increase in the average leisure time for workers. The only bad thing about it is that many may not know what to do with all that newly acquired free time. Consider, for example, the *Sunday neurosis*, that kind of depression that afflicts people aware of the lack of content in their lives when the week's journey ends and their internal emptiness is revealed. Not a few cases of suicide can be traced to that existential void. It is not understandable that the phenomena of alcoholism and juvenile delinquency can extend so much unless we recognize the existence of the existential void that serves as sustenance. And this is equally valid in the case of retirees and the elderly.

STOICISM

> It's not what happens to you, but how you react to it that matters.
>
> —Epictetus

Stoicism proclaims that freedom and tranquility can be achieved only by being oblivious to material comforts, external fortune, and dedicating oneself to a life guided by the principles of reason and virtue (such is the idea of imperturbability or *ataraxia*). Assuming a materialistic conception of nature, the Stoics followed Heraclitus in the belief that the first substance is in the fire and in the veneration of the logos, which they identified with the energy, law, reason, and providence found in nature. The reason for men was also considered an integral part of the divine and immortal logos.

The Stoic doctrine, which considered each person essential as a member of a universal family, helped break regional, social, and racial barriers, and paved the way for the spread of a universal religion. The Stoic doctrine of natural law, which converts human nature into a norm for evaluating social laws and institutions, had a great influence in Rome and the later laws of the West. It also had importance in later currents and philosophers, such as Descartes and Kant.

Ancient Stoics divided philosophy into three parts: *logic* (theory of knowledge and science, which includes rhetoric and dialectic), *physics* (science about the world and things), and *ethics* (behavior science). All of these refer to aspects of the same reality: the universe as a whole and its knowledge. This can be explained and understood globally because it is a rationally organized structure of which man himself is an integral part, *ethics* being the most important facet.

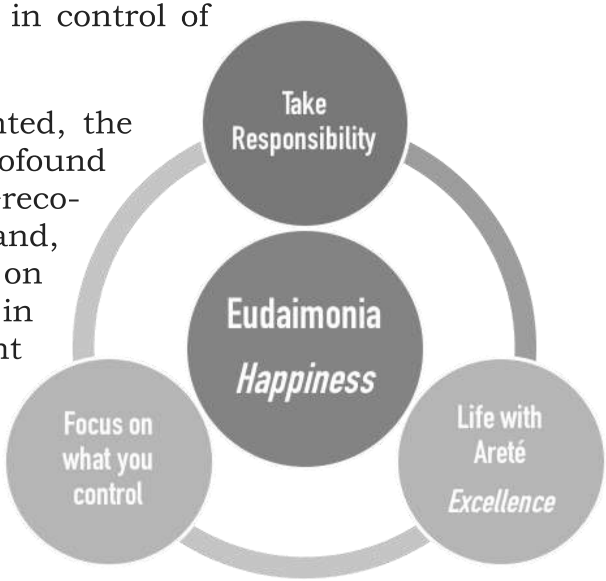
> Desire and happiness cannot live together.
>
> —Epictetus

Since, according to Stoicism, all the events of the world are rigorously determined, and man is part of the universal logos, freedom can only consist of the acceptance of his own destiny, which is a fundamental part of living according to nature. For this, man must know what facts are true and what this truth is based on.

Good and virtue, therefore, consist of living according to reason, avoiding passions (*pathos*), which are nothing more than deviations from our rational nature. Passion is the opposite of reason; it is something that happens and cannot be controlled, and therefore, it should be avoided. Reactions such as pain, pleasure or fear, can and should be mastered through self-control exercised by reason, impassibility (apathy, from which apathy derives), and imperturbability (*ataraxia*). These will arise from the understanding that there is no good or evil in itself since everything that happens is part of a cosmic project. Only the ignorant ignores the universal logos and let themselves be dragged by their passions.

The ideal sage is one who lives according to reason, is free from passions, and considers himself a citizen of the world. Cosmopolitanism, defends the equality and solidarity of men through four virtues:

Stoicism preaches the value of reason, by proposing that destructive emotions are the result of errors in our way of seeing the world, and offers a practical guide to remain resolute, strong and in control of the situation.



As we have commented, the Stoic school had a profound influence on Greco-Roman civilization and, consequently, on Western thought in general. And it went further.

Stoicism is present in Christianity, Buddhism, and the thinking of several modern philosophers, such as the German Immanuel Kant, in addition to having influenced the contemporary technique of psychotherapy called cognitive-behavioral therapy.

Its three top representatives include Marco Aurelio, Seneca, and Epictetus.

- **Marcus Aurelius:** Marcus Aurelius, the emperor philosopher. Marcus Aurelius Antoninus Augustus (nicknamed *the Sage* or *the Philosopher*), born in Rome on April 26, 121, ruled the Roman Empire from 161 until his death in 180. His great legacy, *Meditations* or *Thoughts*, is the result of moral reflections that, at the end of his life, he left in writing, without following a strict or pre-established plan. Divided into twelve books and written in Greek, the work is based on a series of reflections inspired by his daily experience and reveals the Stoic influence, particularly from Epictetus.

- **Epictetus:** Born in Turkey in the year 50 and died in Greece in 135. He was a Roman slave to Epaphrodite and a Stoic philosopher, who devoted himself fully to studying philosophy and how to lead a life based on the moral aspect. The main representative of Stoicism. He lived almost his entire existence as a slave; however, after being released, he became one of the most famous philosophers in the world. Above all, the serenity of spirit. The works that have survived to this day are *The Enchiridion* or *Handbook* and the *Discourses.*

- **Seneca:** Born in Corduba in Hispania c. 4 BC and died in AD 65 in Rome, Italy. He is considered one of the leading figures in Stoic philosophy, whose ideas have served as an example and inspiration for important philosophers, intellectuals, and religious thinkers. He was an important Roman Hispanic philosopher and one of the best orators in the Empire. His *Letters to Lucilius* and his *Dialogues* are two of the top works of Stoicism.

There are three pillars on which this philosophy is built:

MEMENTO MORI

> Memento Mori: Quidquid facies, respide ad mortem.
>
> —Seneca

Whatever you do, contemplate death.

AMOR FATI

> My formula for greatness in a human being is *amor fati*: that one wants nothing to be different, not forward, not backward, not in all eternity. Not merely bear what is necessary, still less conceal it—all idealism is mendacity in the face of what is necessary—but love it.
>
> —Friedrich Nietzsche

CARPE DIEM

> As each day arises, welcome it as the very best day of all, and make it your own possession. We must seize what flees.
>
> —Seneca

In conclusion:

> Philosophy does not promise to ensure anything external to man: in another case, it would mean admitting something beyond its true object of study and matter. For in the same way that the material of the carpenter is wood, and that of the sculptor, bronze, the object of the art of living is one's own life.
>
> —Epictetus

CAVE OF PLATO

> On the walls of the cave, only the shadows are the truth.
>
> —Plato

The myth of Plato's Cave is one of the great allegories of idealistic philosophy that has so far marked the way of thinking of Western cultures.

It is a dialogue written by Plato, in which his teacher Socrates and his brother Glaucon talk about how knowledge and philosophical education affects society and individuals.

In this dialogue, Socrates asks Glaucon to imagine a group of prisoners who have been chained to a wall inside a cave from childhood. Within the cave, a fire burns behind the prisoners, who see shadows casted on the wall they face. These shadows are produced by objects manipulated by people who pass behind the wall the prisoners are chained to.

Socrates tells Glaucon that the prisoners believe what they observe is the real world, without realizing that they are mere appearances of the shadows of those objects.

Later, one of the prisoners manages to free himself from his chains and begins to look around. He observes the light of the fire beyond the wall, whose glow blinds him and almost brings him back to darkness.

After that, the liberated man gets used to the firelight and decides to move forward. Socrates proposes that this is a first step in the acquisition of knowledge. Then, as the man goes outside the cave, he first observes the reflections and shadows of things and people, and eventually sees the things and people themselves.

Finally, the man observes the stars, the moon, and the sun. Socrates suggests that the man here reasons in such a way that he conceives the outside world (world of ideas) as a superior world. The man then returns to share this with the prisoners in the cave, since he feels he must help them ascend to the real world.

When he returns into the cave for the other prisoners, the man is unable to see well, as he has become accustomed to the outside light. The prisoners think that this trip has damaged him, and they do not want to accompany him outside. Plato, through Socrates, states that these prisoners would do their best to avoid such a journey, even killing anyone who dared try to free them.

This is Plato's text:

Socrates is speaking with Glaucon:

> Socrates: And now, I said, let me show in a figure how far our nature is enlightened or unenlightened: --Behold! Human beings are living in an underground den, which has a mouth opened towards the light and reaching all

> along the den. Here, they have been from their childhood, and have their legs and necks chained so that they cannot move, and can only see before them, being prevented by the chains from turning around their heads. Above and behind them, a fire is blazing at a distance, and between the fire and the prisoners, there is a raised way, and you will see if you look, a low wall built along the way, like the screen which marionette players have in front of them, over which they show the puppets.
>
> Glaucon: I see.

> S: And do you see, I said, men passing along the wall carrying all sorts of vessels, and statues and figures of animals made of wood and stone and various materials, which appear over the wall? Some of them are talking, others silent.
>
> G: You have shown me a strange image, and they are strange prisoners.
>
> S: Like ourselves, I replied; and they see only their own shadows, or the shadows of one another, which the fire throws on the opposite wall of the cave?
>
> G: True, he said; how could they see anything but the shadows if they were never allowed to move their heads?
>
> S: And of the objects which are being carried in like manner, they would only see the shadows?
>
> G: Yes, he said.
>
> S: And if they were able to converse with one another, would they not suppose that they were naming what was actually before them?
>
> G: Very true.
>
> S: And suppose further that the prison had an echo which came from the other side, would they not be sure to fancy when one of the passers-by spoke that the voice which they heard came from the passing shadow?

G: No question, he replied.

S: To them, I said, the truth would be literally nothing but the shadows of the images.

G: That is certain.

S: And now look again, and see what will naturally follow if the prisoners are released and disabused of their error. At first, when any of them is liberated and compelled suddenly to stand up and turn his neck round and walk, and look towards the light, he will suffer sharp pains; the glare will distress him, and he will be unable to see the realities of which in his former state he had seen the shadows; and then conceive someone saying to him, that what he saw before was an illusion, but that now, when he is approaching nearer to being and his eye is turned towards more real existence, he has a clearer vision, what will be his reply? And you may further imagine that his instructor is pointing to the objects as they pass and requiring him to name them, will he not be perplexed? Will he not fancy that the shadows which he formerly saw are truer than the objects which are now shown to him?

G: Far truer.

S: And if he is compelled to look straight at the light, will he not have a pain in his eyes which will make him turn away to take and take in the objects of vision which he can see, and which he will conceive to be in reality clearer than the things which are now being shown to him?

G: True, he said.

S: And suppose once more, that he is reluctantly dragged up a steep and rugged ascent, and held fast until he's forced into the presence of the sun himself, is he not likely to be pained and irritated? When he approaches the light, his eyes will be dazzled, and he will not be able to see anything at all of what are now called realities.

G: Not all in a moment, he said.

S: He will require to grow accustomed to the sight of the upper world. And first, he will see the shadows best, next to the reflections of men and other objects in the water, and then the objects themselves; then he will gaze upon the light of the moon and the stars and the spangled heaven, and he will see the sky and the stars by night better than the sun or the light of the sun by day?

G: Certainly.

S: Last of him will be able to see the sun, and not mere reflections of him in the water, but he will see him in his own proper place, and not in another, and he will contemplate him as he is.

G: Certainly.

S: He will then proceed to argue that this is he who gives the season and the years, and is the guardian of all that is in the visible world, and in a certain way the cause of all things which he and his fellows have been accustomed to behold?

G: Clearly, he said, he would first see the sun and then reason about him.

S: And when he remembered his old habitation and the wisdom of the den and his fellow-prisoners, do you not suppose that he would felicitate himself on the change, and pity them?

G: Certainly, he would.

S: And if they were in the habit of conferring honors among themselves on those who were quickest to observe the passing shadows and to remark which of them went before, and which followed after, and which were together; and who were, therefore, best able to draw conclusions as to the future, do you think that he would care for such honors and glories, or envy the possessors of them? Would he not say with Homer?

S: Better to be the poor servant of a poor master, and to endure anything, rather than think as they do and live after their manner?

G: "Yes," he said, I think that he would rather suffer anything than entertain these false notions and live in this miserable manner.

S: Imagine once more, I said, "such anyone coming suddenly out of the sun to be replaced in his old situation; would he not be certain to have his eyes full of darkness?"

G: "To be sure," he said.

S: And if there were a contest, and he had to compete in measuring the shadows with the prisoners who had never moved out of the den, while his sight was still weak, and before his eyes had become steady (and the time which would be needed to acquire this new habit of sight might be very considerable) would he not be ridiculous? Men would say of him that up he went, and down he came without his eyes; and that it was better not even to think of ascending; and if anyone tried to loose another and lead him up to the light, let them only catch the offender, and they would put him to death.

G: "No question," he said.

S: This entire allegory, I said, you may now append, dear Glaucon, to the previous argument; the prison-house is the world of sight, the light of the fire is the sun, and you will not misapprehend me if you interpret the journey upwards to be the ascent of the soul into the intellectual world according to my poor belief, which, at your desire, I have expressed whether rightly or wrongly God knows. But, whether true or false, my opinion is that in the world of knowledge the idea of good appears last of all, and is seen only with an effort; and, when seen, is also inferred to be the universal author of all things beautiful and

> right, parent of light and the lord of light in this visible world, and the immediate source of reason and truth in the intellectual; and that this is the power upon which he who would act rationally, either in public or private life must have his eye fixed.

By understanding this allegory, we can better apprehend the ways of thinking that have been dominant in Europe and America for the past centuries, as well as the foundations of Plato's theories.

> Those who are able to see beyond the shadows and lies of their culture will never be understood, let alone believed, by the masses.
>
> —Plato

Let's interpret this.

Plato argued that as bizarre as the scene may seem, those chained men he described resemble us human beings: neither they nor we see more than those fallacious shadows, which simulate a deceptive and superficial reality. The fiction projected by the firelight distracts the prisoners from the reality of the cavern in which they remain chained.

However, if one of the men broke free of the chains and could look back, reality would confuse and annoy him: the light of the fire would make him look away, and the blurry figures he would see would seem less real than the shadows he had seen all of his life. Similarly, if someone forced this person to walk in the direction of the fire and beyond, until they left the cave, the sunlight would bother him even more, and he would want to return to the dark cave.

To capture reality in all its details, you would have to get used to it, dedicate time and effort to seeing things as they are without giving in to confusion or discomfort. If at some point the freed prisoner returned to the cave and met again with the chained men, he would remain blind because of the lack of sunlight; everything he could say about the real world would be met with ridicule and contempt. We perceive our own knowledge and our world through the shadows that the world transmits to us. In Plato's view, it is necessary to cross the fire at the mouth of the cave in order to find the moral and intellectual liberation from the ties of the sensible world: the ideal is the aphorism of knowing yourself, and ascending to the intelligible world.

Towards the fourth century BC, the Athenian philosopher left us this famous allegory, which remains crucial to the history of Western thought. In a world like the current one, in which the media projects all kinds of illusions and images that are immediately adopted as *realities* and assumed to be *true*, we question our way of being in the world perhaps more than ever. The visionary Plato's cave, more than a metaphor to explain a philosophical theory, is a totally current allegory and whether human beings may or may not know what is really 'true'. The so-called cave myth, which appears in book VII of The Republic, is one of Plato's best-known dialogues, in which he exposed some of his theories through myths and poetic metaphors.

In this story, some of the central themes of Plato's philosophy corresponding to his stage of maturity appear, always with the use of a symbolic language, which ranges from the theory of knowledge to the platonic conception of human beings and reality. The distinction between the deceptive sensorial appearance and the true, absolute, and ideal reality is illustrated with this myth.

Let's summarize the argument of this myth:

Socrates proposes to Glaucon, his interlocutor in the dialogue, to imagine the following situation:

In a dark cavern, which has a long entrance through which sunlight penetrates, men are prisoners from their childhood. They are chained and sitting with their backs to the sunlight that filters through the entrance of the cave. The chains fix the neck and the feet so that they can never turn towards the entrance and directly contemplate the light, but only the shadows that it casts of themselves on the bottom of the cave

Behind these men is a lit fire, burning in the distance and in a plane higher than they are. Between the fire, there is a road built high as if it was a stage. On the road, other men carry diverse objects whose shadows are also projected at the bottom of the cave.

Prisoners can only see their shadows and those of their companions, as well as the shadows casted by the objects passing in front of the firelight. These shadows are for them the only existing reality.

Imagine now that one of the prisoners is released and, with great effort, manages to leave the cave. Upon stepping outside and seeing the sunlight directly, he would immediately be blinded and would instinctively want to return to the gloom of the cave to which he was accustomed. He will then gradually notice that the shadows he saw before are not the true reality, but only shadows of the actual things that cast them. He further realizes he has been misguided his whole life, believing that the only reality was that of the cave. Gradually, after a painful period of adaptation, his eyes get used to the sunlight and he notices that sunlight is what produces the shadows and thus, it is the true reality.

The released prisoner wishes to return to the cave and tell the others what he has seen to free them from their mistake. But no one, in principle, believes him, accustomed as they are to the world of appearance. Although they live a deceptive existence devoid of freedom, many prefer to continue comfortably installed in the world of shadows than to endure the difficult process that leads to the contemplation of the true nature of reality.

In the myth, prisoners symbolize men of all kinds who remain captive and deceived by sensorial appearance. The shadows of things are the appearances that are captured by using the senses exclusively. The difficult and painful ascending process that leads to the exit of the cave symbolizes the educational process. The exterior of the cave is the intelligible world, in which the most important element is the sun, that is, the idea of Good. The released prisoner who returns to rescue the others once he has noticed the deception and contemplated reality, is the philosopher-ruler of the polis.

GOLDEN RULE

> Do not do to others what you do not want done to yourself.
>
> —Confucius

The *Golden Rule of Humanity*, with various formulations, is proclaimed in various civilizations, religions, and cultures. Despite this great relevance, it has not deserved, with exceptions, a special interest for academic reflection.

As Gewirth argues, the *Golden Rule* is the common moral denominator of most religions in the world. In this sense, Küng has compiled formulations of this rule in the Confucian, Jewish, Christian, Islamic, Buddhist, and Hindu religions. In the *Declaration Towards a Global Ethic*, which was approved by the *Parliament of the World's Religions* (in Chicago) in 1993, it states: "There is a principle which is found and has persisted in many religions and ethical traditions of humankind for thousands of years: What you do not wish done to yourself, do not do to others. Or in positive terms: What you wish done to yourself, do to others. This should be the irrevocable, unconditional norm for all areas of life, for families and communities, for races, nations and religions."

This was one of the guiding principles of life that Confucius taught his followers, five centuries before Jesus taught the Golden Rule with similar words.

Related to it, there is a *Silver Rule*: "One should not treat others in ways that one would not like to be treated."

> The golden rule for every businessman is this: 'Put yourself in your customer's place.'
>
> —Orison Swett Marden

Thereby, the Golden Rule is the principle of treating others as you want to be treated.

THE MAIN RELIGIONS CONTEMPLATE THIS RULE

BAHÁ'Í

> Blessed is he who preferreth his brother before himself.
>
> —Tablets of Baha'u'llah 71:26

CONFUCIANISM

> Maximum benevolence is not doing to others what you don't want them to do to you.
>
> —Confucius, The Analects, 15, 23

HINDUISM

> The supreme duty is not to do to others what causes you pain when they hurt you.
>
> —Mahabharata 5, 15, 17

BUDDHISM

> Do not treat others in ways that you would find hurtful.
>
> —The Buddha, Udanavarga 5, 18

CHRISTIANITY

> Everything you want others to do for you, do it for others— this is what the Law and the Prophets consist of.
>
> —Jesus on Mt. 7, 12

JAINISM

> One should treat all the creatures in the world as one would like to be treated.
>
> —Mahavira, Sutrakritanga 1,11,33

SIKHISM

> I am not a stranger to anyone, and nobody is a stranger to me. In fact, I am a friend of everyone.
>
> —The Siri Guru Granth Sahib, p. 1299

ISLAM

> None of you truly believe until you want for others what you want for yourself.
>
> —The Prophet Muhammad, Hadith.

JUDAISM

> What is odious to you, do not do to your neighbor. This is what the whole Law consists of; everything else is a comment.
>
> —Talmud, Shabbat 31 a

TAOISM

> Consider the victory of your neighbor as if it were yours, and the defeat of your neighbor as if it were yours.
>
> —Lao Tzu T'ai Shang Kan Ying Fien 213-218

CONSTRUCTIVISM

> Education is a reconstruction and reorganization of experience.
>
> —John Dewey

In the philosophy of science and epistemology, constructivism or epistemological constructivism emerged in the mid-twentieth century from a handful of researchers across diverse disciplines including philosophers, psychiatrists, sociologists, linguists, etc.

For constructivist thinking, the reality is a construction to some extent *invented* by the observer. We can never get to know reality as it always is by knowing something. We order the data obtained from reality, even basic perceptions, within a theoretical or mental framework. Thus, that object or reality that we understand *as such* is not such. We do not have a *mirror reflection* of what is *out there*, but something that we have built based on our perception and empirical data. Thus, science and knowledge, in general, offer only an approximation to the truth which is beyond our reach.

Constructivism is a philosophy of learning that indicates that we build our understanding of the world we live in based on our experiences. Thus, each of us generates his own wisdom, which we use to make sense of our experiences.

> Every act of perception is in some degree an act of creation and every act of memory is in some way an act of imagination.
>
> —Gerald M. Edelman

> You cannot teach a man anything; you can only help him find it within himself.
>
> —Galileo

Constructivism indicates that we build our own understanding of the world by experiencing and reflecting on those experiences.

When faced with something new we have to reconcile it with our previous ideas and experiences: either we change what we believe or we discard this new information. In any case, we are active creators of our own knowledge.

In this way, to increase our understanding, we must ask questions, explore and evaluate what we know.

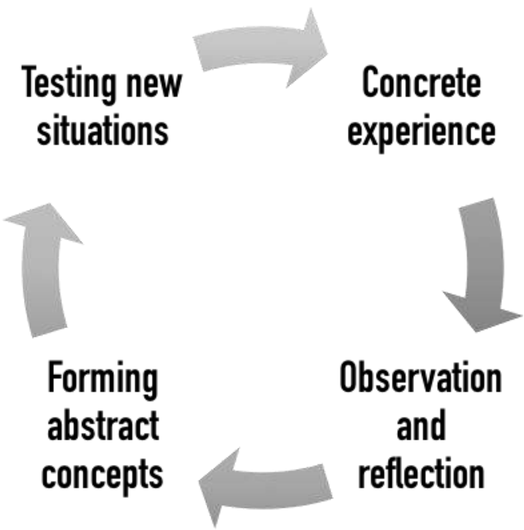
> Knowledge is not a true copy of reality but a construction of human being.
>
> —Jean Piaget

Constructivism is a well-established theory of learning, indicating that people actively construct new knowledge by combining their experiences with what they already know. Knowledge is constructed by the learner, in their head, instead of being delivered.

> The goal of education is to develop the power of thinking and intellectual capacity.
>
> —Socrates

Constructivism has a philosophical origin, from Socrates', John Dewey's, Pestalozzi's, Montessori's, and Frere's ideas.

CONSTRUCTIVE LEARNING MODEL



MATHS

> To not know math is a severe limitation to understand the world.
>
> —Richard Feynman

The word mathematical comes from the Greek *mathema*, which means *science*, *knowledge*, and *learning*. According to its etymology, it is the science that studies the properties of abstract entities (numbers, geometric figures, etc.), as well as the relationships established between them.

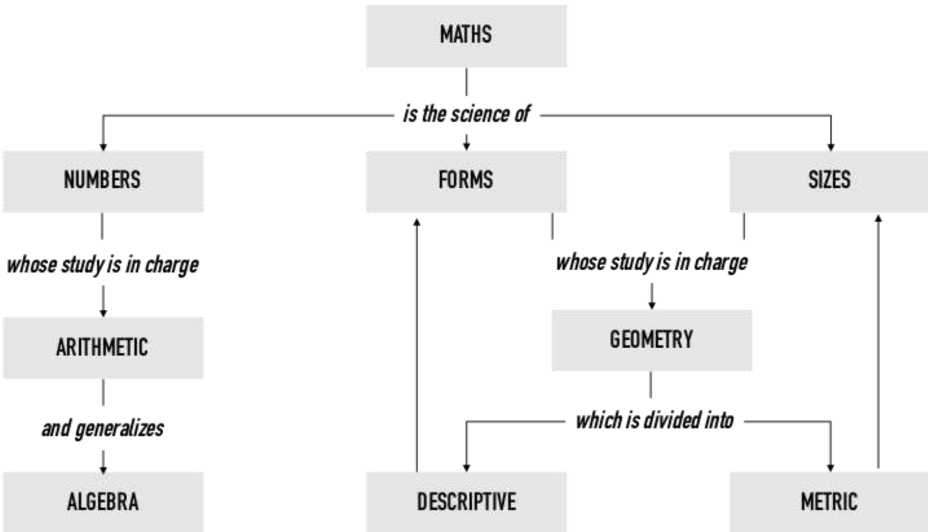
Mathematics is a deductive logical science, which uses symbols to generate an exact theory of deduction and logical inference based on definitions, axioms, postulates and rules that transform primitive elements into more complex relationships and theorems.

It is defined as the exact science that, based on axioms and based on the principles of logic, studies the properties and relationships established between abstract entities and their relationships, understanding abstract entities such as numbers, symbols, and geometric figures, etc.

This analysis allows, once certain patterns have been detected, to formulate conjectures and establish definitions that are reached by deduction.

> In mathematics, you don't understand things. You just get used to them.
>
> —John Von Neumann

> If people do not believe that mathematics is simple, it is only because they do not realize how complicated life is.
>
> —John Von Neumann



Human beings have always had the need to count, measure, and determine the shape of everything around them. The progress of human civilization and the progress of mathematics have gone hand in hand. So, without the Greek, Arab and Hindu discoveries in trigonometry, navigating open oceans would have been an even more risky endeavor. Trade routes from China to Europe or from Indonesia to the Americas, were held together by an invisible mathematical thread.

Until the nineteenth century, mathematics was limited to the study of quantities and spaces. However, as science advanced, this field exceeded those two previously mentioned subjects, requiring a redefinition.

Mathematics is highly related to other sciences. First, it relies mainly on logic and its strategies for demonstration and inference. That is why mathematics is an objective science: it can only advance by demonstrating the presence of mathematical errors. Sometimes the demonstration of these errors causes a change in paradigm.

The method then lies in analyzing those abstract entities to produce hypotheses and conjectures, make deductions, and thus approach mathematical knowledge, which, as has been said, is assumed to be accurate and true. These deductions are made with the support of definitions (limitations of something regarding everything else) and axioms (premises accepted without the need for a demonstration).

Through abstraction and the use of logic in reasoning, mathematics has evolved based on counting, calculation, and measurement, along with the systematic study of the shape and motion of physical objects. Mathematics, from its inception, has had a practical purpose.

Explanations that relied on logic first appeared with Hellenic Mathematics, especially with the Elements of Euclid. Mathematics continued to develop with continuous interruptions until mathematical innovations from the Renaissance interacted with new scientific discoveries. As a consequence, there was an acceleration in the development of mathematics that continues to this day.

Today, mathematics is used around the world as an essential tool in many fields, including natural sciences, engineering, medicine, and social sciences, and even in disciplines that may appear to be totally unrelated, like music. In particular, applied mathematics is a branch of mathematics aimed at applying mathematical knowledge to other areas; it inspires and makes use of new mathematical discoveries and, on occasions, leads to the development of new disciplines. On the other hand, the practical applications of pure mathematics are usually only made apparent with the passage of time.

> To those who do not know mathematics, it is difficult to get across a real feeling as to the beauty, the deepest beauty, of nature … If you want to learn about nature, to appreciate nature, it is necessary to understand the language that she speaks in.
>
> —Richard Feynman

This science is the basis of a great amount of other knowledge. Without mathematics, we would not understand the other sciences, from physics to economics, through chemistry to biology.

Mathematics is closely related to other sciences. It relies primarily on logic and its strategies for proof and inference. This is why mathematics is an objective science: it can only be modified by demonstrating the existence of mathematical errors, for which a large part of the scientific paradigm with which it is working must surely be modified.

The method of mathematics lies in analyzing these abstract entities on which it is based to produce hypotheses and conjectures, make deductions, and thus approach mathematical knowledge, which, as has been said, is assumed to be accurate and true. These deductions are carried out with the support of definitions (limitations of something with respect to everything else) and axioms (premises accepted without the need for a proof). Mathematics is the foundation of technologically advanced society. Mathematicians and well-educated users of mathematics are flexible in applying and inventing tools for work in technological environments which never existed before.

Mathematics was already a key piece for the development of societies thousands of years ago. And today it is more so. In a highly technical society, it is impossible to take a step without running into mathematics. Mobile phones, computers, banks, space missions... all depend on mathematics.

The mental models contained in this subject will be irrefutable by the rest of the sciences. That is why it will be the first place where we start on our mental map.

MATHS MODELS

Next, we will see six important mathematical ideas that apply in many aspects of our lives.

- Algebra
- Permutations and combinations
- Algorithms
- Scale
- Compound interest
- Inflection point

ALGEBRA

> Algebra is the intellectual instrument which has been created for rendering clear the quantitative aspects of the world.
>
> —Alfred North Whitehead

Algebra is a part of mathematics. It uses variables to represent a value that is not yet known. When an equal sign (=) is used, this is called an equation. A very simple equation using a variable is: $2 + 3 = x$, in this example, $x = 5$ (or it could also be said, *x equals five*). This is called solving for *x*.

Besides equations, there are inequalities (*less than* and *greater than*). A special type of equation is called *function*, a relationship or expression involving one or more variables. This is often used in making graphs because it always turns one input into one output.

Algebra can be used to solve real problems because the rules of algebra work in real life, and numbers can be used to represent the values of real things. Physics, engineering and computer programming are areas that use algebra all the time. It is also useful in surveying, construction and business—especially accounting.

People who apply algebra use the rules of numbers and mathematical operations. The simplest ones are adding, subtracting, multiplying, and dividing. More advanced operations involve exponents, starting with squares and square roots.

Algebra was first used to solve equations and inequalities.

Two examples are *linear equations* (the equation of a straight line, $y = mx + b$) and *quadratic equations*, which has variables that are squared (multiplied by itself, for example: $2 * 2$, $3 * 3$, or $x * x$).

$4x - 8x + 2 = - 7 - 6x + 12$

$4x - 8x + 6x = - 7 + 12 - 2$

$2x = 3$

$x = 3/2$

Here is a simple example of an algebra problem:

Sue has 12 candies, and Ann has 24 candies. They decide to combine and share these so that they have the same number of candies each. These are the steps you can use to solve the problem:

1. To have the same number of candies, Ann has to give some to Sue. Let x represent the number of candies Ann gives to Sue.

2. Sue's candies, plus x, must be the same as Ann's candies minus x. This is written as: $12 + x = 24 - x$

3. Subtract 12 from both sides of the equation. This gives: $x = 12 - x$. (What happens on one side of the equals sign must happen on the other side too, for the equation to still be true. So, in this case, when 12 was subtracted from both sides, there was a middle step of $12 + x - 12 = 24 - x - 12$. After a person is comfortable with this, the middle step is not written down.)

4. Add x to both sides of the equation. This gives: $2x = 12$

5. Divide both sides of the equation by 2. This gives $x = 6$. The answer is six. If Ann gives Sue 6 candies, they will have the same number of candies.

6. To check this, put 6 back into the original equation wherever x was: $12 + 6 = 24 – 6$

7. This gives $18 = 18$, which is true. They both now have 18 candies.

With practice, algebra can be used when faced with a problem that is too hard to solve in any other way. Problems such as building a freeway, designing a cell phone or finding the cure for a disease all require algebra.

In algebra, there are a few rules that can be used for further understanding of equations. These are called the rules of algebra.

Before going on to the rules, we reflect on two definitions that will be given.

1. Opposite: the opposite of a is $-a$

2. Reciprocal: the reciprocal of a is $1/a$

COMMUTATIVE PROPERTY OF ADDITION

Commutative means that a function has the same result if the numbers are swapped around. In other words, the order of the terms in an equation does not matter. When the operator of two terms is an addition, the *commutative property of addition* is applicable. In algebraic terms, this gives. $a + b = b + a$

COMMUTATIVE PROPERTY OF MULTIPLICATION

When the operator of two terms is a multiplication, the *commutative property of multiplication* is applicable. In algebraic terms, this gives $a \cdot b = b \cdot a$

ASSOCIATIVE PROPERTY OF ADDITION

Associative refers to the grouping of numbers. The associative property of addition implies that, when adding three or more terms, it does not matter how these terms are grouped. Algebraically, this gives: $a + (b + c) = (a + b) + c$.

ASSOCIATIVE PROPERTY OF MULTIPLICATION

The associative property of multiplication implies that, when multiplying three or more terms, it does not matter how these terms are grouped. Algebraically, this gives: $a \cdot (b \cdot c) = (a \cdot b) \cdot c$

DISTRIBUTIVE PROPERTY

The distributive property states that the multiplication of a number by another term can be distributed: $a \cdot (b + c) = a \cdot b + a \cdot c$

ADDITIVE IDENTITY PROPERTY

Identity refers to the property of a number that is equal to itself. In other words, there exists an operation of two numbers so that it equals the variable of the sum. The additive identity property states that the sum of any number and 0 is that number: $a + 0 = a$. This also holds for subtraction $a - 0 = a$

MULTIPLICATIVE IDENTITY PROPERTY

The multiplicative identity property states that the product of any number and 1 is that number $a \cdot 1 = a$. This also holds for division $a / 1 = a$

ADDITIVE INVERSE PROPERTY

The additive inverse property is somewhat like the opposite of the additive identity property. When an operation is the sum of a number and its opposite, and it equals *0*, that operation is a valid algebraic operation. Algebraically, it states the following $a - a = 0$. *Additive inverse of 1 is (-1)*

MULTIPLICATIVE INVERSE PROPERTY

The multiplicative inverse property entails that when an operation is the product of a number and its reciprocal, and it equals *1*, that operation is a valid algebraic operation. Algebraically, it states the following: $a / a = 1$. *Multiplicative inverse of 2 is 1/2*

PERMUTATIONS AND COMBINATIONS

> Nature, as we know it, consists, in the main of permutations and combinations.
>
> —William Keith Brooks

There are two ways to order or combine dependent event results:

- Permutations are groupings in which the order of objects matters.
- Combinations are groupings where content matters but order does not.

For example:

- "My fruit salad is a combination of apples, grapes and bananas": no matter what order we put the fruits in, it could be "bananas, grapes and apples" or "grapes, apples and bananas", it is the same salad.
- "The combination of the lock is 693": now the order matters. "693" would not work, nor would "936". It has to be exactly 6-9-3

Let's start with Laplace's Rule: in the case where all the results of a random experiment are equally probable, Laplace defines the probability of an event A as the quotient between the number of favorable results for the event A to occur in the experiment and the number of possible results of the experiment.

To apply Laplace's Rule, the calculation of favorable events and possible events sometimes does not pose any problem, since they are a small number and can be easily calculated, for example:

- When calculating the probability of rolling a die and getting a 2, there is only one favorable case while the possible cases are six.

- When we try to guess a person's horoscope on the first try, there is one favorable case and twelve possible cases.

However, calculating the number of favorable cases and possible cases can be difficult sometimes and you have to apply mathematical rules, for example:

Five couples randomly sit down to dinner and we want to calculate the probability that at least the members of one couple sit together. In this case, determining the number of favorable cases and possible cases is complex.

The mathematical rules that can assist us here are the calculation of combinations and the calculation of permutations.

COMBINATIONS

In combinatorics we determine the number of subgroups of 1, 2, 3, etc. elements that can be formed with the *n* elements of one group and where each subgroup differs from the rest in the elements that compose it without taking the order in which they appear into account.

For example, calculate the possible combinations of two elements that can be formed with the numbers 1, 2 and 3.

Three different pairs can be established: (1,2), (1,3) and (2,3). In the calculation of combinations, the pairs (1,2) and (2,1) are considered identical, therefore they are only counted once.

PERMUTATIONS

With permutations we calculate the possible groupings that can be established with all the elements of a group, therefore, what differentiates each subgroup from the rest is the order of its elements.

For example, calculate the possible ways in which the numbers 1, 2, and 3 can be ordered.

A few examples:

Here are a few examples of *combinations* (order doesn't matter) and *permutations* (order matters).

- Combination: Picking a team of 3 people from a group of 10. $C(10,3) = 10!/(7! \cdot 3!) = 10 \cdot 9 \cdot 8 / (3 \cdot 2 \cdot 1) = 120$.
- Permutation: Picking a President, VP and Water boy from a group of 10. $P(10,3) = 10!/7! = 10 \cdot 9 \cdot 8 = 720$.

- Combination: Choosing 3 desserts from a menu of 10. C(10,3) = 120.
- Permutation: Listing your 3 favorite desserts, in order, from a menu of 10. P(10,3) = 720.

BASIS FOR COMPARISON	PERMUTATION	COMBINATION
MEANING	Permutation refers to the different ways of arranging a set of objects in a sequential order.	Combination refers to several ways of choosing items from a large set of objects, such that their order does not matters
ORDER	Relevant	Irrelevant
DENOTES	Arrangement	Selection
WHAT IS IT?	Ordered elements	Unordered sets
ANSWERS	How many different arrangements can be created from a given set of objects?	How many different groups can be chosen from a larger group of objects?
DERIVATION	Multiple permutations from a single combination.	Single combination from a single permutation
EXAMPLES	Assigned seats, race classification, organizational hierarchy, industrial processes	Selecting fruits

ALGORITHMS

> It's all in the algorithms.
>
> —Sebastian Thrun

An algorithm is a finite group of operations organized in a logical and orderly way that allows solving a certain problem. It is a series of instructions or established rules that, through a succession of steps, allows us to arrive at a result or solution.

Algorithms work from a base (or initial) state and by applying the proposed steps, reach a solution.

Algorithms can be expressed using programming languages, pseudocode, natural language or flowcharts.

An instruction manual for the operation of a household appliance or a series of orders from the boss to an employee to perform a certain task may also include algorithms.

This breadth of meaning allows us to appreciate that there is no formal and unique definition of algorithm. The term is usually designated as the fixed number of steps necessary to transform input information (a problem) into an output (its solution).

Some examples of algorithms in everyday life:

How to make coffee:

1. Start
2. Boil water
3. Prepare a mug
4. Put a teaspoon of coffee and sugar
5. Pour hot water
6. Stir
7. End

Brushing Teeth:

1. Wet toothbrush
2. Toothpaste on brush
3. Brush teeth
4. Spit in sink
5. Rinse toothbrush
6. End

SCALE

> Man knows that the world is not made on a human scale; and he wishes that it were.
>
> —Andre Malraux

A scale is the mathematical relationship that exists between reality and the drawing that is made of it on a plane. Scales are written in the form of a ratio where the antecedent indicates the value of the plane and the consequent the value of reality. It is the *ratio* that exists between the measurements of a map or drawing with the original measurements—the proportion of the length in a drawing (or model) of the actual length.

For example, in a drawing, anything of the size of *1* will have a size of 20 in the real world, so a measure of 150mm in the drawing would be 3000mm in reality.

A scale is written in the form where the antecedent indicates the value of the plane and the consequent the value of reality. For example, if we have 1:20 or 1/20 given in meters, it means that every meter on the map is 20 meters in reality. Another example, if we have 1:500000 given in centimeters, each centimeter on the map represents 500000 centimeters in reality, that is, 5 kilometers.

The scale, depending on the relationship between the antecedent and the consequent, can be:

1. Enlargement: if the antecedent is larger than the consequent. Examples: 100:1, 20:1, 5:1, 2:1.

2. Natural: if the antecedent and the consequent coincide fully, that is, 1:1.

3. Reduction: if the antecedent is smaller than the consequent. Examples: 1:2, 1:5, 1:10, 1:20, 1:50, 1:100.

> The essence of life is statistical improbability on a colossal scale.
>
> —Richard Dawkins

Scales can be classified into three types depending on how reality is represented on the map:

1. Numerical scale: the relationship between the antecedent and the consequent has the same units. For example, having 1:6000, if it is in the plane at 1 meter, will actually be at 6000 meters, and so with any unit we take.

2. Textual scale or unit by unit: the relationship of two lengths--that of the map (antecedent) and that of reality (consequent). As an example: 1 cm = 4 km; therefore 2 cm = 500 m.

3. Graphic scale: the representation drawn from the unit by unit scale, where each segment shows the

relationship between the length of the representation and that of reality.

The lower the relationship between the antecedent and the consequent, the more detailed the plan. It depends on what you want to represent: from the plans of a house to a piece of land or the Solar System.

This simple model affects many situations in reality:

Economies of scale are the result of the inverse relationship between the quantity produced and the unit cost. As the quantity produced increases, the unit cost decreases. The total cost of production consists of fixed and variable costs.

The order of magnitude of a number is the decimal power of the relative value of its significant figure. For example, two numbers differ by two orders of magnitude if one is 100 times larger than the other. The most widespread use of describing orders of magnitude is through scientific notation or powers of ten. For example, the order of magnitude of 1500 is 3, since 1500 can be written as 1.5×10^3. Differences in the order of magnitude can be measured on the logarithmic scale in decades (e.g., factors of ten)

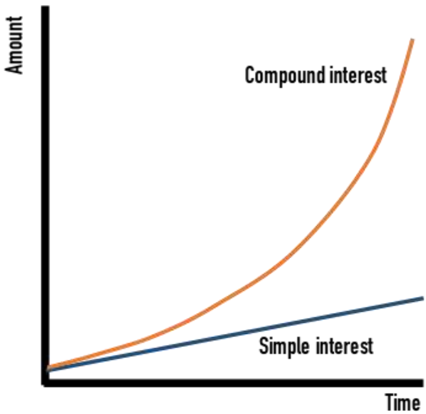
The geological time scale, or international chronostratigraphic table, is the reference frame to represent the events of history of Earth and life in chronological order.

COMPOUND INTEREST

> Compound interest is the eighth wonder of the world. He who understands it, earns it, he who doesn't, pays it.
>
> —Albert Einstein

Compound interest appears when the interest generated is added to the initial capital, which causes the interest generated at first to generate new interest again.

Compound interest has a multiplier effect on investments, since new interest is generated from previously accumulated interest and then added up to it. This makes compound interest a great ally for long-term investment. Albert Einstein humorously said that compound interest is the most powerful force in the universe.



Let's imagine an operation in which we invest 10,000 euros and each year they give us a 5% return on the capital invested. Since compound interest reinvests previously earned interest, unlike simple interest, the future profit is exponentially greater with compound interest. The formula for calculating compound interest is:

Compound Interest = Total amount of Principal and Interest in future (or Future Value) minus Principal amount at present (or Present Value)

$$= [P\,(1 + i)^n] - P$$

$$= P\,[(1 + i)^n - 1]$$

Where: P = Principal, i = nominal annual interest rate in percentage terms, and n = number of compounding periods.

Take a three-year loan of \$10,000 at an interest rate of 5% that compounds annually. What would be the amount of interest? In this case, it would be: *\$10,000* $[(1 + 0.05)^3 - 1]$ = *\$10,000 [1.157625 – 1] = \$1,576.25*.

> All the benefits in life come from compound interest—money, relationships, habits—anything of importance.
>
> —Naval Ravikant

With compound interest, the below aspects of life can offer as other good examples:

- Relationships
- Fitness / Sports
- Learning / Knowledge
- Habits

INFLECTION POINT

> We are at an inflection point in history.
>
> —Joel Garreau

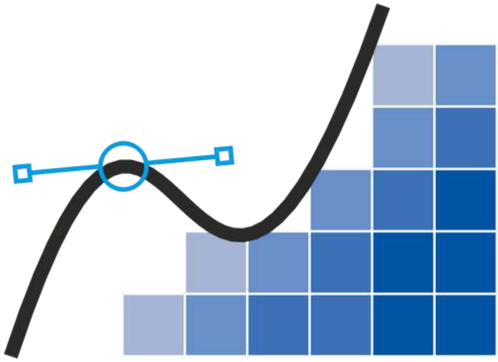
An Inflection Point is the point of a function in which its type of Concavity changes, that is, the function goes from Concave to Convex or from Convex to Concave.

To better understand the concept of inflection point, it is necessary to first understand what concavity and convexity consist of:

- **Concavity**: the function is concave at a point if the second derivative of the function $f''(x)$ at that point is less than zero: $f''(x) < 0$
- **Convexity**: the function is convex at a point if the second derivative of the function $f''(x)$ at that point is greater than zero: $f''(x) > 0$In short, inflection points are the points of the curve where the curvature changes its sign.

A falling point of inflection is an inflection point where the derivative has a local minimum, and a rising point of inflection is a point where the derivative has a local maximum.

For an algebraic curve, a non-singular point is an inflection point when the multiplicity of the intersection of the tangent line and the curve (at the point of tangency) is odd and greater than 2.



For a curve given by parametric equations, a point is an inflection point if its signed curvature changes from plus to minus or from minus to plus, i.e., changes sign.

For a twice differentiable function, an inflection point is a point on the graph at which the second derivative has an isolated zero and changes sign.

One type of inflection point that deserves a special mention is the *tipping point*. A tipping point is one dramatic moment of critical mass when unexpected becomes possible.

> The tipping point is that magic moment when an idea, trend, or social behavior crosses a threshold, tips, and spreads like wildfire.
>
> —Malcolm Gladwell

A tipping point is an example of hysteresis in which the point at which an object is displaced from a state of stable equilibrium into a new equilibrium state that is qualitatively dissimilar from the first.

Tipping points are commonly used in electric switches to assure fast opening and closing of switch contacts, to minimize electric arc formation and prevent burning or welding of the switch contacts.

In the climate system, a tipping point is a threshold that, when exceeded, can lead to large changes in the state of the system. Potential tipping points have been identified in the physical climate system and in impacted ecosystems; and sometimes in both too. For instance, feedback from the global carbon cycle is a driver for the transition between glacial and interglacial periods, with orbital forcing providing the initial trigger. The Earth's geologic temperature record includes many more examples of geologically rapid transitions between different climate states.

As examples:

- Water boils only till 99 degrees. At 100 degrees, it changes its liquid state to vapor.
- Contagiousness, where small things bring big changes.
- Biological adaptation.
- Fishing methods.
- Global warming.
- Technology life cycle.

PHYSICS

> What one man calls God, another calls the laws of physics.
>
> —Nikola Tesla

Physics is a term that comes from the Greek *phisis,* which means *reality* or *nature*. Physics is a science that studies the properties of nature with the support of mathematics. It is responsible for analyzing the characteristics of energy, time, and matter, as well as the links established between them.

This is the science in charge of analyzing physical transformations or phenomena such as the fall of a body or the melting of an ice. After math, physics is the next most fundamental science, being closely related to other natural sciences and in a way, encompasses them all. Chemistry, for example, deals with the interaction of atoms to form molecules. Today, much of modern geology essentially studies Earth's physics, a field known as geophysics; and astronomy is about the physics of stars and outer space.

Physicists orient all their efforts towards the discovery of the laws that govern the behavior of objects in the universe and for this, they use a whole series of symbols, systems of units, equations, principles and definitions. All the means that are used in the process of elaborating a physical law, are always based on the relationship between a certain phenomenon and its cause. These are devised and governed by the so-called field of theoretical physics. Experimental physics, on the other hand, focuses its premises on observation, rational study, and the verification of a series of facts and data referring to a specific phenomenon.

So, physics is the study of nature. It deals with the fundamental particles of which the universe is made, the interactions between those particles, the objects composed of them (nucleus, atoms, molecules, etc.), matter and energy, in space and time. Physicists study a wide range of physical phenomena covering enormous scales: from the subatomic particles to the Universe as a whole. All laws and forces of nature originate from mathematical symmetries of space and time, so modern physics currently focuses on studying these symmetries.

> Physics is like sex: sure, it may give some practical results, but that’s not why we do it.
>
> —Richard P. Feynman

Physics is very dependent on mathematics, and models and theories in physics are expressed using mathematical equations. However, while physics uses mathematics to describe the material world, mathematics may deal with strictly abstract concepts and patterns. There is a large overlap between the two fields and where they converge, is known as mathematical physics.

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Absents : Sir W.H. BRAGG, H. DESLANDRES et E. VAN AUBEL

PHYSICS MODELS

Next, we will see thirteen basic ideas of physics, which will help us better understand the world in which we live. These ideas apply not only to physics but also to other aspects of life as apparently disparate as the business world or human relationships.

- Scientific Method
- Breakpoint
- Critical mass
- Reciprocity
- Velocity
- Relativity
- Leverage

- Newton's Laws of Motion
- Chaos Theory
- Complex Adaptive Systems
- Activation Energy
- Laws of Thermodynamics
- Heisenberg Uncertainty Principle

SCIENTIFIC METHOD

> Observation, reason, and experiment make up what we call the scientific method.
>
> —Richard Feynman

The scientific method is a research method used mainly in the production of knowledge in science.

To be called scientific, a research method must be based on empirical evidence and measurements, and be subject to the specific principles of reasoning tests.

The scientific method has characterized natural science since the seventeenth century, and consists of systematic observation, measurement, experimentation, formulation, analysis, and modification of hypotheses.

The scientific method is supported by two pillars:

The first of these is reproducibility, that is, the ability to repeat a certain experiment, anywhere and by anyone. This pillar is based, essentially, on the communication and publicity of the results obtained.

The second pillar is refutability, that is, that every scientific proposition must be susceptible to being falsified or refuted. This implies that experiments could be designed, which in the case of giving results different from those predicted, would negate the hypothesis being tested.

There really is no single scientific method.

The scientific method uses defining methods, classification methods, statistical methods, hypothetico-deductive methods, measurement procedures, etc.

It is a non-dogmatic method since it is based on laws deduced by humans and not on fixed principles. Its laws are always rejected if the facts contradict what those laws affirm. It's the validity of the scientific method is confirmed by the experience of its day-to-day application.

The scientific method, therefore, refers to the series of stages that must be followed, using reliable instruments, to obtain knowledge that is considered valid from a scientific point of view.

What this method aims to accomplish is minimizing the influence of scientists' subjectivity in their work.

Steps:

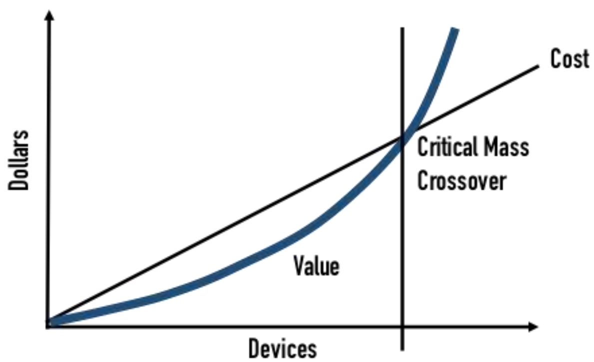
Recommendations:

- Do not take anything for granted, have a beginner's mind.
- Do not rely on popular beliefs or tradition, put everything to test, doubt everything from the basics.
- Have a logical and functional reasoning process.
- Based on the evidence.

CRITICAL MASS

> Silicon Valley has evolved a critical mass of engineers and venture capitalists and all the support structure—the law firms, the real estate, all that—that are all actually geared toward being accepting of startups.
>
> —Elon Musk

In physics, critical mass is the minimum amount of material necessary for a nuclear chain reaction to take place. The critical mass of a fissile substance depends on its physical (in particular its density) and nuclear properties (its enrichment and fission cross section), its geometry (its shape) and its purity, as well as whether or not it is surrounded by a neutron reflector. By surrounding a fissile material by a neutron reflector, the critical mass becomes less. In the case of a sphere surrounded by a neutron reflector, the critical mass is about fifty-two kilograms for uranium 235 and ten kilograms for plutonium 239.



Critical refers to a state of dynamic equilibrium in the fission chain reaction; in it, there is no increase in power, temperature or neutron density over time. *Subcritical* refers to the inability to maintain or sustain a nuclear chain reaction over time. By introducing a certain number of neutrons in a subcritical set, the neutron population will decrease over time (due to absorption phenomena in the material or due to leakage). *Supercritical* refers to a system in which the number of fission processes per unit time increases to the point where some intrinsic feedback mechanism causes the reactor to reach a dynamic equilibrium point (become critical) at a higher temperature or power or is destroyed (in which case the critical assembly is disassembled).

It is possible for a set to reach criticality at powers very close to zero. If it were possible to do an experiment in which an exact amount of fissile material is added to a slightly subcritical mass, a set with an exactly critical mass could be created, and in that case the fission chain reaction would hold exactly one generation of neutrons (since the consumption of the fuel produced by the same fission process would make the whole subcritical again).

If it were possible to carry out an experiment in which an exact amount of fissile material is added to a slightly subcritical mass, a set with a barely supercritical mass would be created, and in that case the temperature of the set would rise to a maximum value after some time to decrease again to the ambient temperature (since the consumption of the fissile material in the chain reaction will cause the whole to become subcritical).This model, originally from nuclear energy, can be observed in many other fields, like compatibly communicating devices:

The systemic value of compatibility communicating devices grows as the square of their number.

This model is related to the tipping point model.

TIPPING POINT

A tipping point is an example of hysteresis in which the point at which an object is displaced from a state of stable equilibrium into a new equilibrium state that is qualitatively dissimilar from the first.

Products such as music or video players, video games, computers, radio, TV broadcasting, or the internet, require a critical mass of complementary products. The immediate and large benefits of this is for users to access an expanded version of complementary goods and services.

As the demand for critical mass increases from users—such as having a wider variety of music, videos, programs and computer software—there is a growing need and importance for firms to find agreements on the standards and methods to capture value and to create alliances that support such agreements.

SWITCHING COST

Critical mass also affects switching costs in network protocols like Bitcoin, Ethernet, Fax, Ethereum, VHS.

When a new technology exceeds a certain *critical mass*, adoption is nearly ubiquitous, making the cost of switching to a different protocol very high.

These protocols are stated standards by which information is transmitted or data is processed. They show a tendency to integrate into all products that use the protocol. Network protocols are some of the most resilient protocol types, they derive most of their value from the network effect.

RECIPROCITY

> There is one word which may serve as a rule of practice for all one's life—reciprocity.
>
> —Confucius

Reciprocity is an idea that is constantly repeated in Nature. The purest science where it occurs is in physics, in electromagnetism.

The reciprocity theorem, which can be proved from Maxwell's equations, indicates that the reaction of fields from sources B with currents A is the same as the reaction of fields from currents A with currents B.

That is, a reciprocity theorem is an explicit mathematical relationship between two different wave fields that can exist within the same space-time configuration.

The result introduced by Maxwell, forms a reciprocity between electric and magnetic fields, a variable magnetic field produces an electric field (Faraday's Law) and a variable electric field produces a magnetic field (Maxwell-Ampère's Law).

Reciprocity is fundamental for the understanding of classical wave field phenomena, as Adrianus T. de Hoop states "field reciprocity theorems can be considered the most basic relationships that exist in classical wave and field theory."

Reciprocity is useful in optics, which (apart from quantum effects) can be expressed in terms of classical electromagnetism, but also in terms of radiometry.

There is also an analogous theorem in electrostatics, known as Green’s reciprocity, relating the interchange of electric potential and electric charge density.

Forms of the reciprocity theorems are used in many electromagnetic applications, such as analyzing electrical networks and antenna systems. For example, reciprocity implies that antennas work equally well as transmitters or receivers, and specifically that an antenna’s radiation and receiving patterns are identical. Reciprocity is also a basic lemma that is used to prove other theorems about electromagnetic systems, such as the symmetry of the impedance matrix and scattering matrix, symmetries of Green’s functions for use in boundary-element and transfer-matrix computational methods, as well as orthogonality properties of harmonic modes in waveguide systems (as an alternative to proving those properties directly from the symmetries of the eigen-operators).

The law of reciprocity is repeated in different areas:

LAW AND TRADE

- Reciprocal trade agreement entered in order to reduce (or eliminate) tariffs, quotas, and other trade restrictions on items traded between the signatories.

- *Quid pro quo*, a legal concept of the exchange of goods or services, each having value.

ENGINEERING

The Maxwell-Betti Theorem describes the relationship that must exist between the work performed by two load states acting on the same structure so that the deformation energy is independent of the order of application of these states.

"In a linear elastic structure, the work done by a first group of forces R1 during the deformation produced by a second group of forces R2 is equal to the work done by the second group of forces through the deformations caused by the first group."

EVOLUTION

Mechanisms for the evolution of cooperation.

SOCIAL NORMS

Social norm of in-kind responses to the behavior of others. A conditioned response where people are compelled to return the kindness of a gift, even if they really don't want to. Related to psychology, where we will see this influence.

ETHICS OF RECIPROCITY

The Golden Rule; one should treat others as one would like others to treat oneself.

VELOCITY

> The velocity with which time flies is infinite, as is most apparent to those who look back.
>
> —Seneca

Velocity is a physical quantity that expresses the relationship between the space traveled by an object, the time used for it and its direction. The word comes from Latin *velocĭtas, velocitātis*.

Since velocity also considers the direction in which an object moves, it is considered a vector quantity.

Therefore, velocity implies the change of position of an object in space within a certain amount of time, that is, speed, plus the direction in which said movement occurs. Hence, velocity and speed are not the same.

Its unit in the International System of Units is the meter per second (m/s), and includes the direction of displacement.

Galileo Galilei was the first to scientifically formulate the concept of velocity by studying the motion of bodies on an inclined plane, dividing the distance traveled by an object in units of time. Thus, he devised the concept of velocity, which is nothing more than a variation of the distance traveled per unit of time.

VELOCITY FORMULA

The most common way to calculate the constant velocity of an object moving in a straight line is with the formula:

$r = d / t$

Where:

r is the rate, or speed (sometimes denoted as v, for velocity)

d is the distance moved

t is the time it takes to complete the movement

WHY VELOCITY MATTERS

Velocity measures motion starting in one place and heading toward another place. In other words, you use measures of velocity to determine how quickly you (or anything in motion) will arrive at a destination from a given location.

> One of my philosophies of building companies is the importance of velocity.
>
> —Andrew Ng

Measures of velocity allow you to (among other things) create timetables for travel. For example, if a train leaves Penn Station in New York at 2 p.m. and you know the velocity at which the train is moving north, you can predict when it will arrive at South Station in Boston.

SPEED, VELOCITY, AND ACCELERATION

SPEED

According to its technical definition, it is a scalar quantity that indicates the rate of motion distance per time. Its units are length and time. Putting this in another way, speed is a measure of distance traveled over a certain amount of time. It is often described simply as the distance traveled per unit of time. It is how fast an object is moving.

VELOCITY

By definition, velocity is a vector quantity that indicates distance per time and direction. Like speed, its units are length and time, but direction is also involved in the equation. Velocity measures displacement over time, as opposed to distance.

> Market leadership can translate directly to higher revenue, higher profitability, greater capital velocity, and correspondingly stronger returns on invested capital.
>
> —Jeff Bezos

ACCELERATION

It is defined in technical terms as a vector quantity that indicates the rate of change of velocity. It has dimensions of length and time. In simpler terms: Acceleration is often called *speeding up*—though it would more accurately be referred to as *velocity up*. The everyday experience of acceleration is in a vehicle. You step on the accelerator, and the car speeds up as increasing force is applied to the drive train by the engine.

RELATIVITY

> Put your hand on a hot stove for a minute, and it seems like an hour. Sit with a pretty girl for an hour, and it seems like a minute. That's relativity.
>
> —Albert Einstein

Relativity generally refers to two theories: Special Relativity and General Relativity. Special Relativity applies to all physical phenomena in the absence of gravity. General Relativity explains the law of gravitation and its relation to other forces of nature. It applies to the cosmological and astrophysical realm, including astronomy.

SPECIAL RELATIVITY

Special Relativity is the theory that no matter what constant speed you're traveling, all the laws of physics are the same.

Special Relativity is *special* because it only deals with simple systems - systems where things are moving in nice straight lines at nice constant velocities. No forces. No acceleration. Einstein developed two postulates of special relativity:

- All physical laws are the same whatever constant velocity you are moving at.

- The speed of light is always the same, independent of the motion of the observer or light source.

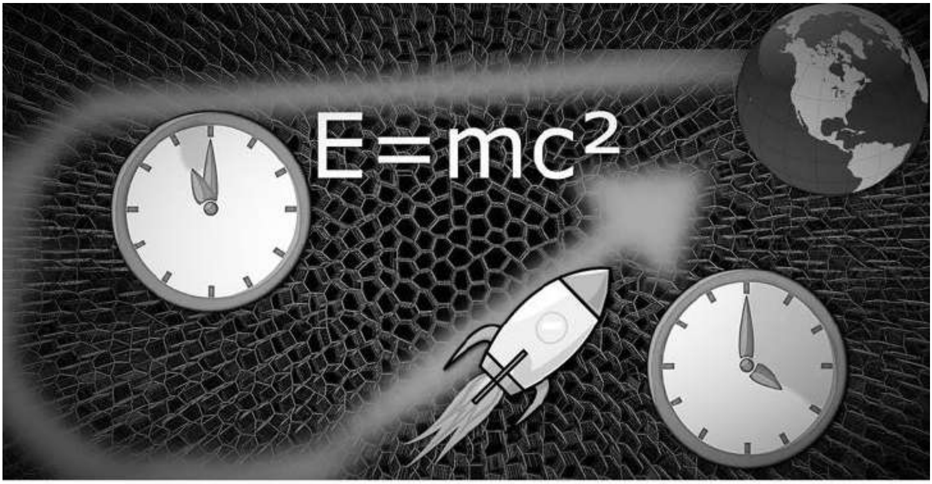
This means that there is no absolute motion. If you're in a car going at 50 mph, there is no way you can prove you are even moving. It could be the earth and everything on it except you and the car, is moving backward at 50 mph. And if you wanted to say that this was happening, you wouldn't be wrong, as the laws of physics would back it up. All you can say is that one thing is moving *relative* to another, which one you pick as a stationary reference frame is up to you.

From the two postulates of Special Relativity come some very important consequences:

- Time Dilation
- Length Contraction
- $E = mc^2$

One of the above implications of Special Relativity is *time dilation*. What this means is that because the speed of light is invariant, and all laws are the same for constant velocities, time can slow down. Time, it turns out, is not a constant throughout the universe but is totally relative.

Special Relativity is a theory of the structure of spacetime. It was introduced in Einstein's 1905 paper, *On the Electrodynamics of Moving Bodies*.



better than classical mechanics. For instance, the second postulate (speed of light being constant) can explain the results of the Michelson–Morley experiment. Moreover, this theory has many surprising and counterintuitive consequences. Some of these include:

- Relativity of simultaneity: Two events, simultaneous according to one observer, may not be simultaneous for another observer if the observers are in relative motion.

- Time dilation: Moving clocks are measured to tick more slowly than an observer's *stationary* clock.

- Length contraction: Lengths of objects are measured shorter when moving in a direction with respect to the observer.

- Maximum speed is finite: No physical object, message, or field line can travel faster than the speed of light in a vacuum.

- The effects of gravity can only travel through space at the speed of light, not faster or instantaneously.

- Mass–energy equivalence: $E = mc^2$, energy and mass are equivalent and transmutable.

- *Relativistic mass*, an idea used by some researchers.

The defining feature of Special Relativity is the replacement of the Galilean transformations of classical mechanics by the Lorentz transformations.

A Galilean transformation is a change of speeds and coordinates, without changing Newton's equations.

Lorentz transformations relate the measurements of a physical quantity obtained by two different observers.

GENERAL RELATIVITY

General Relativity is a theory of gravitation developed by Einstein in the years 1907–1915. The development of General Relativity began with the *equivalence principle*, where the states of accelerated motion and being at rest in a gravitational field (for example, when standing on the surface of the Earth) are physically identical.

The result of this is that free fall is inertial motion: an object in free fall is falling because that is how objects move when there is no force being exerted on them. This differs from an object falling due to the force of gravity as it is the case in classical mechanics.

General Relativity is incompatible with classical mechanics and Special Relativity because in those theories, inertially moving objects cannot accelerate with respect to each other, but objects in free fall do so. To resolve this difficulty, Einstein first proposed that spacetime is curved. In 1915, he devised the Einstein field equations, which relate the curvature of spacetime with mass, energy, and any momentum within it.

From the field equations, the following conclusions emerge:

- Gravitational time dilation: Clocks run slower in deeper gravitational wells.

- Precession: Orbits precess in a way unexpected in Newton's theory of gravity. (This has been observed in the orbit of Mercury and binary pulsars).

- Light deflection: Rays of light bend in the presence of a gravitational field.

- Frame-dragging: Rotating masses *drag along* the spacetime around them.

- Metric expansion of space: the universe is expanding, and the far parts of it are moving away from us faster than the speed of light.

Technically, General Relativity is a theory of gravitation whose defining feature is its use of the Einstein field equations. The solutions of the field equations are metric tensors which define the topology of the spacetime and how objects move inertially.

Together, these two theories show that no matter how you are moving, all the laws of physics work the same, so you can treat yourself as if you were at rest.

LEVERAGE

> Give me a lever long enough and a fulcrum on which to place it, and I shall move the world.
>
> —Archimedes

A lever is a simple machine consisting of a beam or rigid rod pivoted at a fixed hinge or fulcrum.

Simple machine that essentially consists of a bar that rests or can rotate on a point (fulcrum) and is designed to overcome a force (resistance) by applying another force (power).

It is one of the six simple machines identified by Renaissance scientists, along with the wheel and axle, force multipliers, inclined plane, pulley, screw and wedge.

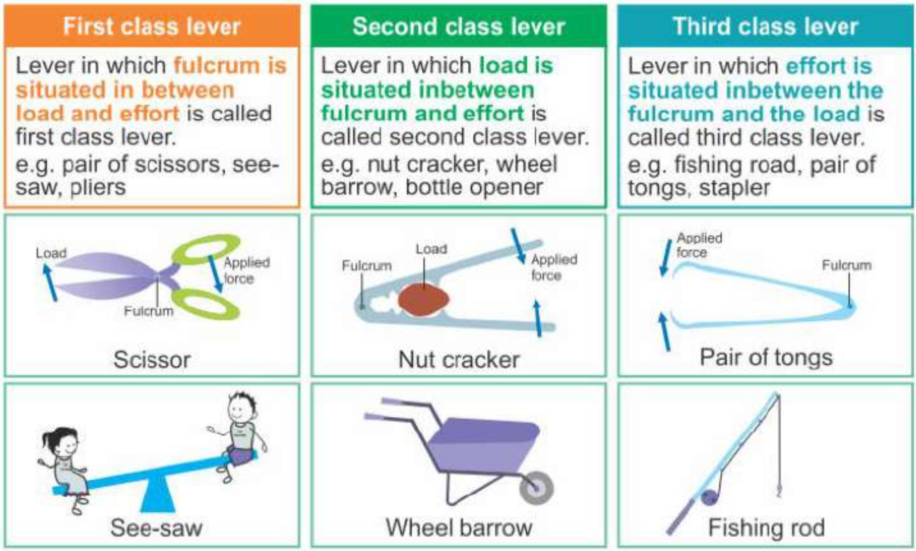
A lever can be used to maximize the mechanical force applied to an object, increase its speed or the distance it travels, through the application of a proportionally smaller amount of force.

Depending on the proximity or distance of the fulcrum from the body to be moved, more or less applied force will be required and a greater or lesser effect will be achieved.

There are three types of lever, depending on the relative position of the resistance point, the power point and the fulcrum. Each one has different characteristics and will have a relatively different effect.

- **First degree lever**: The fulcrum is between power and resistance, achieving that the applied power can be much less than the resistance to overcome, that is, it maximizes power. However, the transmitted speed and the distance traveled by the body are sacrificed.

- **Second degree lever**: The resistance is between the power and the fulcrum, so the power will always be less than the resistance, even if it does not achieve greater displacement or distance traveled (but saving energy is extremely useful).
- **Third degree lever**: The power exerted is between the fulcrum, at one extreme, and the resistance, at the other. The applied force is greater than the resulting one, but it is possible to extend the transmitted speed or the distance traveled by the body.



> When you combine ignorance and leverage, you get some pretty interesting results.
>
> —Warren Buffett

This model applies to virtually all areas of life, such as within the financial field, where debt allows you to leverage to buy an asset. Leverage can apply also to the social field, where you can leverage your friends and the environment, to carry out group activities like sports.

At this point, the Internet should be highlighted, since, among other models such as compound interest and the network effect, it enhances leverage.

The Internet allows easy replication and distribution of work that would just need to be carried out once and then *leveraged* thousands of times. Examples would be music, podcasts, blogs, books, computer programs, applications, etc.

Examples that take advantage of the other commented models are available on the Internet, such as compound interest and the network effect.

NEWTON'S LAWS OF MOTION

> In order to put his system into mathematical form at all, Newton had to devise the concept of differential quotients and propound the laws of motion in the form of total differential equations—perhaps the greatest advance in thought that a single individual was ever privileged to make.
>
> —Albert Einstein

Newton's laws are three principles that serve to describe the motion of bodies, based on an inertial reference system (real forces with constant speed).

These laws about the relationship between force, speed and motion of bodies are the basis of classical mechanics and physics, and were postulated by the English physicist and mathematician Isaac Newton, in 1687.

Newton's work was based on the ideas of Galileo and Descartes and thus, it developed not only the principles of dynamics, but of classical physics in general. Newton did so in 1687 in his book *Philosophiæ naturalis principia mathematica.*

Summarizing, the first law defines the force qualitatively; the second law offers a quantitative measure of the force;

and the third asserts that a single isolated force doesn't exist.

> And thus, nature will be very conformable to herself and very simple, performing all the great motions of the heavenly bodies by the attraction of gravity which intercedes those bodies, and almost all the small ones of their particles by some other attractive and repelling powers which intercede the particles. The vis inertiae is a passive principle by which bodies persist in their motion or rest, receive motion in proportion to the force impressing it, and resist as much as they are resisted. By this principle alone there never could have been any motion in the world. Some other principle was necessary for putting bodies into motion; and now they are in motion, some other principle is necessary for conserving the motion.
>
> —Newton

INERTIA – NEWTON'S FIRST LAW

> An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.
>
> —Newton

Inertia is the property of bodies to oppose a change in their state of rest or movement in which they are. As such, inertia is the resistance offered by a body to altering its state at rest or movement.

> Inertia is the first law of history, as it is of physics.
>
> —Morris Raphael Cohen

Newton's first law, also called the law of inertia or the principle of inertia, states that an object will remain at rest or in uniform motion in a straight line, as long as it does not have its state altered by the action of an external force.

Therefore, the greater the mass of the object, the greater the inertia, that is, the greater the resistance that the body offers to the alteration of its state.

> Nothing happens until something moves.
>
> —Albert Einstein

An object will not change its motion unless acted upon by an unbalanced force.

- If it is at rest, it will stay at rest.
- If it is in motion, it will remain at the same velocity.

Objects with a greater mass have more inertia. It takes more force to change their motion.

FORCE – NEWTON'S SECOND LAW

> The alteration of motion is ever proportional to the motive force impressed; and is made in the direction of the right line in which that force is impressed.
>
> —Newton

Newton's Second Law, also known as the Fundamental Law of Dynamics, is the one that determines a proportional relationship between force and variation of the momentum or linear moment of a body. In other words, force is directly proportional to the mass and acceleration of a body.

Newton's Second Law is responsible for quantifying the concept of force. It tells us that the net force applied to a body is proportional to the acceleration that the body acquires. The constant of proportionality is the mass of the body, so we can express the relationship as follows:

$F = ma$

This law explains what happens if a net force acts on a moving body (whose mass does not have to be constant): the force will modify the state of motion, changing the speed in module or direction. Specifically, the changes experienced in the momentum of a body are proportional to the motive force and develop in the direction of this; that is, forces are causes that produce accelerations in bodies.

ACTION / REACTION – NEWTON'S THIRD LAW

> For every action, there is an equal and opposite reaction.
>
> —Newton

Newton's Third Law, also known as the Principle of action and reaction, tells us that if object *A* exerts an action on object *B*, then object *B* also exerts an equal force on *A* in the opposite direction.

The third law states that for every force acting on a body, the body reacts with a force equal in magnitude but opposite in direction on the body that produced it.

In other words, if object A exerts a force on object B, then object B must exert a force of equal magnitude in the opposite direction on object A.

This law represents a certain symmetry in nature: forces always occur in pairs, and one body cannot exert force on another without experiencing a force itself. Sometimes we colloquially refer to this law as one of action-reaction, where the force exerted is the action and the force experienced as a consequence is the reaction.

When we push a person, a car, etc., we also move in the opposite direction because the other person or the car are pushing back on us, even if they're not actively trying.

> Newton was not the first of the age of reason. He was the last of the magicians, the last of the Babylonians and Sumerians, the last great mind that looked out on the

> visible and intellectual world with the same eyes as those who began to build our intellectual inheritance rather less than 10,000 years ago. He looked on the whole universe and all that is in it as a riddle, as a secret which could be read by applying pure thought to certain evidence, certain mystic clues which God had laid about the world to allow a sort of philosopher's treasure hunt to the esoteric brotherhood. He believed that these clues were to be found partly in the evidence of the heavens and in the constitution of elements [...], but also partly in certain papers and traditions handed down by the brethren in an unbroken chain back to the original cryptic revelation in Babylonia.
>
> —John Maynard Keynes

LAWS OF THERMODYNAMICS

> There is a game, you can't win, you can't break even and you can't even get out of the game.
>
> —Allen Ginsberg

We, like all living beings, are open systems, that is, we exchange matter and energy with our environment. For example, you take in chemical energy in the form of food and do work on your surroundings by moving, talking, walking, and breathing.

All the energy exchanges that occur within us, like your many metabolic reactions, and between us and our environment, can be described by the same laws of physics, as energy exchanges between hot and cold objects or gas molecules or whatever.

> The laws of thermodynamics are a set of laws on which thermodynamics is based. Specifically, these are four laws that are universally valid when applied to systems that fall within the constraints implicit in each. Therefore, the deep impression which classical thermodynamics made on me. It is the only physical theory of universal content, which I am convinced, that within the framework of applicability of its basic concepts will never be overthrown.

> —Albert Einstein

The three laws of thermodynamics are:

FIRST LAW OF THERMODYNAMICS

The First Law of Thermodynamics, also known as *Law of Conservation of Energy*, states that energy cannot be created or destroyed in an isolated system.

When energy passes, as work, as heat, or with matter, into or out from a system, the system's internal energy changes following the law of conservation of energy. Equivalently, perpetual motion machines of the first kind (machines that produce work with no energy input) are impossible.

SECOND LAW OF THERMODYNAMICS

The Second Law of Thermodynamics states that the entropy of any isolated system always increases. Understanding entropy as the thermodynamic magnitude that indicates the degree of molecular disorder of a system.

> Entropy is the price of structure.
>
> —Ilya Prigogine

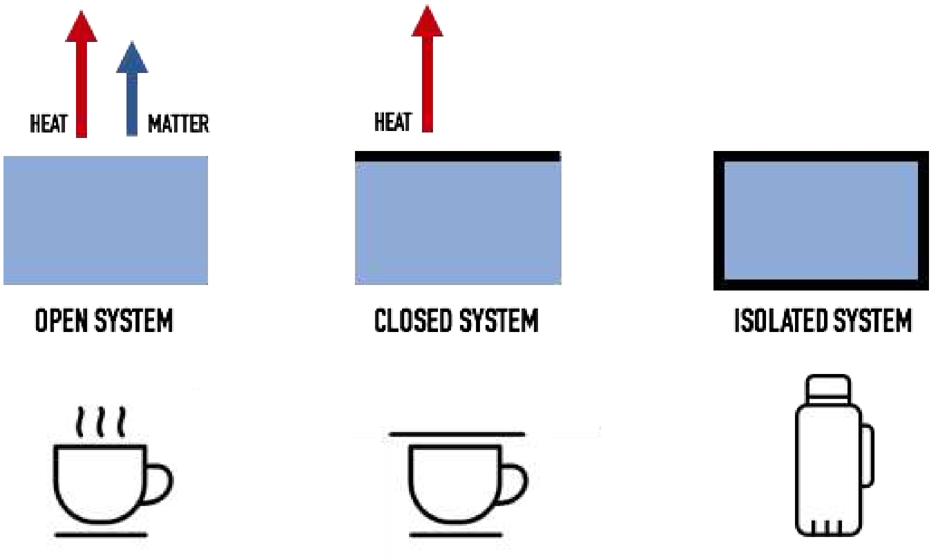
In a natural thermodynamic process, the sum of the entropies of the interacting thermodynamic systems increases. Equivalently, perpetual motion machines of the second kind, machines that spontaneously convert thermal energy into mechanical work, are impossible.

> Nothing in life is certain except death, taxes, and the second law of thermodynamics.
>
> —Seth Lloyd

The second law of thermodynamics is a re-expression of the principle of minimum energy, according to which material systems tend to evolve in the sense in which their potential energy decreases.

> A ball rolls down an inclined plane until it finds the lowest position, which is the one with the lowest energy; A compressed spring expands to achieve a condition of minimum deformation and, therefore, of minimum accumulated energy, and a chemical reaction evolves towards states of lower energy content. If your theory is found to be against the Second Law of Thermodynamics, I give you no hope; there is nothing for it but to collapse in deepest humiliation.
>
> —Arthur Eddington

A closed system is a system which is connected to another, and cannot exchange matter (i.e., particles), but other forms of energy (e.g., heat), with the other system. In contrast, an isolated system is a system that cannot exchange either energy nor matter outside the boundaries of the system. For isolated systems (and fixed external parameters), the second law states that the entropy will increase to a maximum value at equilibrium. If rather than an isolated system we have a closed system, where entropy (rather than the energy) remains constant, it follows from the first and second laws of thermodynamics that energy of this closed system will drop to a minimum value at equilibrium, transferring its energy to the other system.



To restate:

- The maximum entropy principle: For a closed system with fixed internal energy (i.e., an isolated system), the entropy is maximized at equilibrium.
- The minimum energy principle: For a closed system with fixed entropy, the total energy is minimized at equilibrium.

> It is a remarkable fact that the second law of thermodynamics has played in the history of science a

> fundamental role far beyond its original scope. Suffice it to mention Boltzmann's work on kinetic theory, Planck's discovery of quantum theory or Einstein's theory of spontaneous emission, which were all based on the second law of thermodynamics.
>
> —Ilya Prigogine

Second Law of Thermodynamics examples:

- *AWS*: The fastest, easiest, and cheapest to use cloud storage.
- *Amazon Retail*: The fastest, easiest, and cheapest way to buy non-vertically integrated products.
- *Alexa*: The fastest, and easiest way to get information and manage the world around you (Alexa skills).

> The increase of disorder or entropy is what distinguishes the past from the future, giving a direction to time.
>
> —Stephen Hawking

Entropy is a measure of the disorder in a system. All systems gain entropy over time, so the Second Law of Thermodynamics says that the total entropy of both a system and its surroundings will never decrease.

Understanding entropy:

The extent to which physical changes and chemical reactions proceed is controlled by accompanying changes in energy and entropy. A thermodynamic quantity representing the unavailability of a system's thermal energy for conversion into mechanical work is often interpreted as the degree of disorder or randomness in the system.

A lack of order or predictability; gradual decline into disorder.

> I think you should always bear in mind that entropy is not on your side.
>
> —Elon Musk

Reactions occur when the disorder of the universe (or more simply, the reacting system and its surroundings) is increased. This is the case for exothermic reactions: heat transferred to the surroundings increases its entropy or disorder. The majority of reactions that occur under ordinary conditions are exothermic because the heat released to the surroundings causes a large increase in the disorder or entropy of the surroundings; this is usually larger than any entropy decrease that might be occurring in the system. But we can have endothermic reactions if the increase in disorder within the system is greater than the decrease in the disorder of the surroundings owing to heat transferred from the surroundings to the system. This is basically all there is to understanding the role of thermodynamics in reaction chemistry: a reaction will go if the total entropy of the system and its surroundings increases.

Waste energy is associated with all processes. This waste can be reduced, but it can never be eliminated. Anyone who says otherwise is trying to con you.

THIRD LAW OF THERMODYNAMICS

The Third Law of Thermodynamics states that the entropy of a system approaches a constant value as the temperature approaches absolute zero.

Except for non-crystalline solids (glasses), the entropy of a system at absolute zero is typically close to zero.

The third law is rarely applicable to our day-to-day lives and governs the dynamics of objects at the lowest known temperatures. It defines what is called a *perfect crystal*, whose atoms are glued in their positions. The perfect crystal thus possesses absolutely no entropy, which is only achievable at the absolute temperature.

The concept of entropy has also been popular in some theories defining the continuous flow of time objectively, such as the linear increase in the entropy of the Universe.

ZEROTH LAW OF THERMODYNAMICS

Beside the above, there is conventionally added a *Zeroth Law*, which defines thermal equilibrium.

If two systems are each in thermal equilibrium with a third system, they are in thermal equilibrium with each other. This law helps define the concept of temperature.

THEOREM

The *theorem* is given as a restatement of the consequences of the zeroth, first, second, and third laws of thermodynamics, regarding the usable energy of a closed system:

0. There is a game. (consequence of zeroth law of thermodynamics)

1. You can't win. (consequence of first law of thermodynamics)

2. You can't break even. (consequence of second law of thermodynamics)

3. You can't even get out of the game. (consequence of third law of thermodynamics)

It is sometimes stated as a general adage without specific reference to the laws of thermodynamics.

CHAOS THEORY

> Chaos theory simply suggests that what appears to most people as chaos is not really chaotic, but a series of different types of orders with which the human mind has not yet become familiar.
>
> —Frederick Lenz

Chaos Theory is a branch of mathematics, physics and other sciences that deals with certain types of dynamic systems, that is, those systems whose state evolves over time, with the particularity of being very sensitive to variations in initial conditions. Small variations in these initial conditions can imply large differences in future behavior, making long-term prediction difficult.

> Chaos: When the present determines the future, but the approximate present does not approximately determine the future.
>
> —Edward Lorenz

Chaos Theory emerged in the second half of the 20th century and its precursor was the meteorologist and mathematician Edward Lorenz. In 1963 he was working on some equations that he hoped would predict the weather in the atmosphere, and he was trying to graphically see the behavior of his equations using computers. Lorenz was shocked when he observed that small differences in the starting data (apparently as simple as using 3 or 6 decimal places) led to large differences in the model's predictions. In such a way that any small disturbance, or error, in the initial conditions of the system can have a great influence on the final result.

> Without chaos, there would be no creation, no structure, and no existence. After all, order is merely the repetition of patterns; chaos is the process that establishes those patterns. Without this creative self-organizing force, the universe would be devoid of biological life, the birth of stars and galaxies—everything we have come to know.
>
> —L.K. Samuels

This idea is known worldwide as the *Butterfly Effect*, since the proverb "the flapping of a butterfly's wings can cause a Tsunami on the other side of the world" seems to reflect the fact that with small initial variations we can achieve totally unexpected results.

> Small shifts in your thinking, and small changes in your energy, can lead to massive alterations of your end result.
>
> —Kevin Michel

Some examples of Chaos Theory could be:

- The evolution of temperatures.
- The behavior of fluids.
- Population dynamics.

- The structure of social systems.
- Fluctuations in the Stock Market.
- The behavior of the human heart.
- Electrical distribution.

> Order is not universal. In fact, many *chaologists* and physicists posit that universal laws are more flexible than first realized, and less rigid—operating in spurts, jumps, and leaps, instead of like clockwork. Chaos prevails over rules and systems because it has the freedom of infinite complexity over the known, unknown, and the unknowable.
>
> —L.K. Samuels

The three main characteristics that chaotic systems meet are: non-linearity, the extreme sensitivity they have to very small changes in their initial conditions and that the behavior of the system cannot be predicted until the process occurs or is calculated. Despite this unpredictable behavior, the system is deterministic. That is, for given parameters, the system is completely determined for future times, no matter how many times we recalculate or repeat it. Of course, if we slightly change any of the parameters, we may find ourselves with a surprise: a very different end result from the original. As an example, take a pendulum that is attached at a certain point and swings freely. Connecting a second pendulum to the first will completely change the system. It is very difficult to start in the exact same position again, and a change in the starting position so small that it cannot even be seen, can quickly cause the pendulum swing to become different from what it was before.

COMPLEX ADAPTIVE SYSTEMS

> Everything should be as simple as it can be, but not simpler.
>
> —Albert Einstein

A system is a set of elements or parts that interact with each other in order to achieve a specific objective.

Complex adaptative systems (CAS) are characterized mainly because their behavior is unpredictable. However, complexity is not synonymous with complication: the latter refers to something tangled, difficult to understand.

> Overall, then, we will view CAS [complex adaptive systems] as systems composed of interacting agents described in terms of rules. These agents adapt by changing their rules as experience accumulates. In CAS, a major part of the environment of any given adaptive agent consists of other adaptive agents, so that a portion of any agent's efforts at adaptation is spent adapting to other adaptive agents. This one feature is a major source of the complex temporal patterns that CAS generate. To understand CAS we must understand these ever-changing patterns.
>
> —John H. Holland

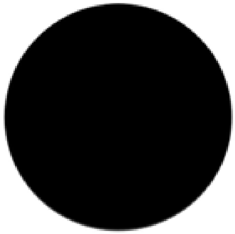
There may be some common peculiarities:

First of all, it is made up of a large number of relatively identical elements. For example, cells in an organism, or people in a society.

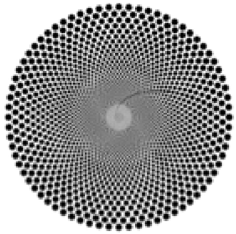
Second, the interaction between its elements is local and originates an emergent behavior that cannot be explained from said elements taken in isolation. A desert can contain trillions of grains of sand, but their interactions are exceedingly simple compared to those of bees in a swarm.

Finally, it is very difficult to predict its future dynamic evolution; In other words, it is practically impossible to predict what will happen beyond a certain time horizon.

> Complex adaptive systems have the property that if you run them—by just letting the mathematical variable of *time* go forward—they'll naturally progress from chaotic, disorganized, undifferentiated, independent states to organized, highly differentiated, and highly interdependent states. Organized structures emerge spontaneously… A weak system gives rise only to simpler forms of self-organization; a strong one gives rise to more complex forms, like life.
>
> —J. Doyne Farmer



SIMPLE



COMPLEX

> The goal of science is to make the wonderful and the complex understandable and simple but not less wonderful.
>
> —Herbert A. Simon

Many examples of complex systems can be found in nature, ranging from physics to neurology, from economics to molecular biology, from sociology to mathematics. For this reason, this class of systems is not a rare or exceptional case, but rather manifests itself in the vast majority of phenomena that are observed on a daily basis.

Most complex systems are unstable, delicately balanced. Any minimal variation between its component elements can modify, in an unpredictable way, the interrelationships and, therefore, the behavior of the entire system. Thus, the evolution of this class of systems is characterized by fluctuation, a situation in which order and disorder constantly alternate.

ACTIVATION ENERGY

> Purpose provides activation energy for living.
>
> —Mihaly Csikszentmihalyi

Activation Energy is the minimum energy required to initiate a chemical reaction.

Substances require a certain activation energy since they must first overcome the forces of repulsion, vibration, translation, etc. that exist between the atoms of the molecules that are going to react.

To understand this, we need to see what actually happens to reactant molecules during a chemical reaction. For the reaction to take place, some or all of the chemical bonds in the reactants must be broken so that new bonds in the products can form. For bonds to reach a state that allows them to break, the molecule must twist (bend or deform) into an unstable state called a transition state. The transition state is a high-energy state and an amount of energy must be added—the activation energy—for the molecule to reach it. Because the transition state is unstable, the reagent molecules do not stay there for long but proceed to the next step in the chemical reaction.

In chemistry and physics, activation energy is the energy that must be provided to a chemical or nuclear system with potential reactants to result in: a chemical reaction, nuclear reaction, or various other physical phenomena.

The activation energy (*Ea*) of a reaction is measured in joules (*J*) and or kilojoules per mole (*kJ/mol*) or kilocalories per mole (*kcal/mol*).

The term *Activation Energy* was introduced in 1889 by the Swedish scientist Svante Arrhenius.

This model is repeated in our day to day, here are some examples:

- Spark, fire, high temperature, and radiation.
- Enzymes function as a catalyst to decrease the energy needed for activation.
- Emotions, from a certain level of energy, the body reaches the limit, which depending on the emotion, can end in tears, screams, etc.
- Habits, we need lower activation energy to start running 3 miles than to run a marathon. Thus, the best way to form habits is to start with small habits that require little energy and to gradually increase them.

> The key to daily practice is to put your desired actions as close to the path of least resistance as humanly possible. Identify the activation energy—the time, the choices, the mental and physical effort they require—and then reduce it. If you can cut the activation energy for those habits that lead to success, even by as little as 20 seconds at a

> time, it won't be long before you start reaping their benefits.
>
> —Shawn Achor

HEISENBERG UNCERTAINTY PRINCIPLE

> The more precisely the position is determined, the less precisely the momentum is known in this instant, and vice versa.
>
> —Werner Heisenberg

In quantum mechanics the Heisenberg indeterminacy principle or Heisenberg uncertainty principle states that certain pairs of physical variables cannot be determined simultaneously and with arbitrary precision, such as, for example, the position and the linear momentum of a given object.

The very concepts of exact position and exact velocity together, in fact, have no meaning in nature.

> This principle can be better understood if we think about what would be the measurement of the position and speed of an electron: to carry out the measurement (to be able to *see* the electron in some way) it is necessary for a photon of light to collide with the electron, by which process it is modifying its position and speed; that is, by the very fact of making the measurement, the experimenter modifies the data in some way, introducing an error that is impossible to reduce to zero, no matter how perfect our instruments are. I think that modern

> physics has definitely decided in favor of Plato. In fact, the smallest units of matter are not physical objects in the ordinary sense; they are forms, ideas which can be expressed unambiguously only in mathematical language.
>
> —Werner Heisenberg

> What we observe is not nature itself, but nature exposed to our method of questioning.
>
> —Werner Heisenberg

> Ultimately… one would hope to find a complete, consistent, unified theory that would include all… partial theories as approximations… *the unification of physics*. Einstein spent most of his later years unsuccessfully searching… Einstein refused to believe in the reality of quantum mechanics, despite the important role he played in its development. Yet it seems that the uncertainty principle is a fundamental feature of the universe… A successful unified theory must… incorporate this principle.
>
> —Stephen Hawking

> If quantum mechanics hasn't profoundly shocked you, you haven't understood it yet.
>
> —Niels Bohr

> Instead of Newtonian certainty and determinism, quantum theory answers our questions with probability and statistics. Classical physics told us precisely where Mars was to be found. Quantum theory sends us to the gambling table to locate an electron in an atom. Then there's Heisenberg's uncertainty principle, which places an ultimate limit on our knowledge of the microworld and tells us that we can make no measurement without affecting the result.
>
> —Roger S. Jones

STATISTICS

> Statistical thinking will one day be as necessary for efficient citizenship as the ability to read or write.
>
> —H. G. Wells

Statistics is a scientific discipline that deals with obtaining, ordering, and analyzing a set of data in order to obtain explanations and predictions about observed phenomena.

Statistics consists of methods, procedures and formulas that allow collecting information and then analyzing it and drawing relevant conclusions from it. It can be said that it is the Science of Data and that its main objective is to improve the understanding of the facts from the available information. Statistics has been the most successful information science.

> Those who ignore Statistics are condemned to reinvent it.
>
> —Bradley Efron

The history of probability began in the seventeenth century when Pierre Fermat and Blaise Pascal were trying to solve some problems related to games of chance. Although some mark its beginnings when Cardano wrote *The Book on Games of Chance: The 16th-Century Treatise on Probability*, it is not until that date that an acceptable theory of games began to be developed.

Christian Huygens learned of the correspondence between Blaise Pascal, Pierre Fermat and the knight De Méré in which the debate on determining the probability of winning a game arose, and in 1657 he published the first book on probability: *De Ratiociniis in Ludo Aleae* (Calculating in Games of Chance), a treatise on games of chance. The concept of equiprobability was accepted as intuitive, the probability of achieving an event was equal to the quotient between the number of favorable and possible cases.

During the 18th century, due particularly to the popularity of games of chance, the calculus of probabilities had a remarkable development on the basis of the previous definition of probability. In 1713 the Bernoulli theorem and the binomial distribution stood out, and in 1738 the first particular case of the Central Limit Theorem (CLT) studied by De Moivre. In 1809 Gauss began the study of the theory of errors and in 1810 Laplace, who had previously considered the subject, completed the development of this theory. In 1812 Pierre Laplace published *Théorie analytique des probabilités* in which he exposes a mathematical analysis on games of chance.

In the middle of the 19th century, Gregor Mendel, an Austrian Augustinian friar, began the study of heredity and genetics with his interesting experiments on the crossing of plants of different characteristics. His work, The Mathematics of Heredity, was one of the first important applications of probability theory to the natural sciences.

From the beginning the main difficulty in considering probability as a branch of mathematics was the elaboration of a sufficiently precise theory to be accepted as a form of mathematics. At the beginning of the 20th century, the Russian mathematician Andrei Kolmogorov defined it axiomatically and established the bases for the modern theory of probability which today is part of a broader theory such as the theory of measurement.

STATISTICS MODELS

The following models will give us a framework to help us think in terms of probability rather than certainties. They will help improve our decision making and give us a more accurate vision of the world.

- Probabilistic thinking
- Bayes Theorem
- Power Law
- Regression to the Mean
- Game Theory
- Correlation and Causation
- Standard Deviation
- Law of large numbers
- Inversion
- Fragility / Robustness / Antifragility
- Black Swan

PROBABILISTIC THINKING

> The theory of probability is the only mathematical tool available to help map the unknown and the uncontrollable. It is fortunate that this tool, while tricky, is extraordinarily powerful and convenient.
>
> —Benoit Mandelbrot

The aim of a probabilistic logic (also probability logic and probabilistic reasoning) is to handle uncertainty through the application of probability theory using the ability of deductive logic to employ the structure of a formal argument which will facilitate its possible applications.

A difficulty with probabilistic logic is that it increases the computational complexity of its probabilistic and logical components. Other difficulties include the possibility of counter-intuitive results. The need to deal with a broad variety of contexts and issues has led to many different proposals.

> If scientific reasoning were limited to the logical processes of arithmetic, we should not get very far in our understanding of the physical world. One might as well attempt to grasp the game of poker entirely by the use of the mathematics of probability.

> —Vannevar Bush

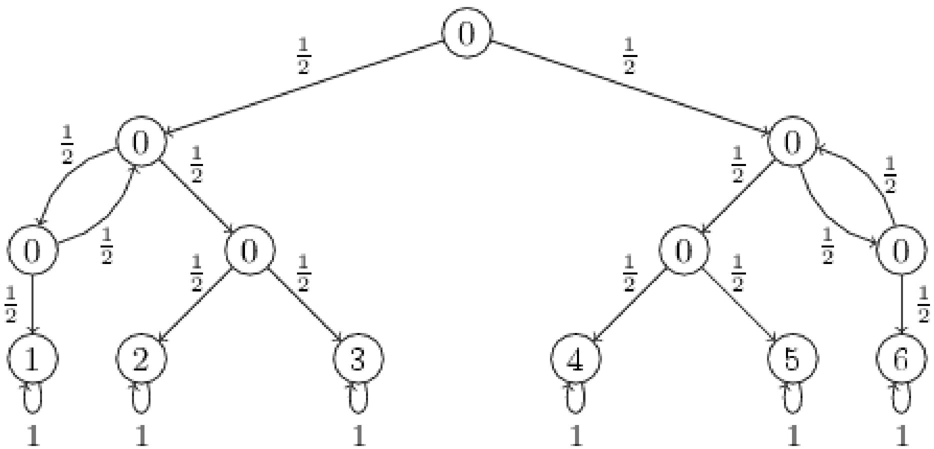
PROBABILISTIC REASONING

The world is not deterministic, because we do not have all the information and we cannot calculate the interaction of all the variables that affect reality.

For this reason, decisions have to be made estimating scenarios and probabilities, defining as well as possible both their possibilities and their consequences.

PROBABILISTIC MODEL

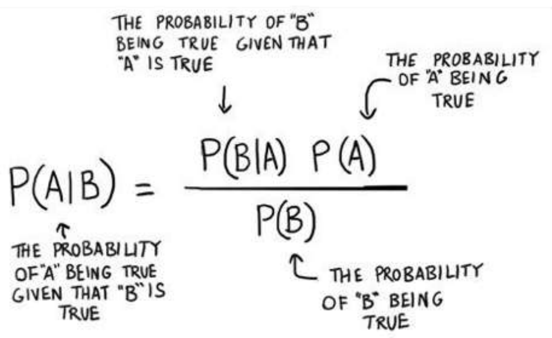
A probabilistic model describes the world in terms of a set *S* of possible states—the sample space. We don't know the true state of the world, so we (somehow) come up with a probability distribution over *S,* which gives the probability of any state being the true one. The world is usually described by a set of variables or attributes.

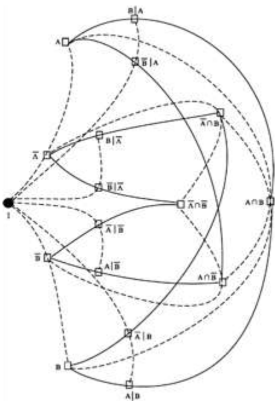


BAYES THEOREM

> Under Bayes' theorem, no theory is perfect. Rather, it is a work in progress, always subject to further refinement and testing.
>
> —Nate Silver

In probability theory and statistics, Bayes' Theorem (alternatively Bayes' Law or Bayes' Rule) describes the probability of an event, based on prior knowledge of conditions that might be related to the event. For example, if *cancer* is related to *age*, then, using Bayes' Theorem, a person's age can be used to more accurately assess the probability that they have cancer, compared to the assessment of the probability of cancer made without knowledge of the person's age.





Bayes' theorem is used to calculate the probability of an event, having information in advance about that event.

We can calculate the probability of an event *A* knowing that it fulfills a certain characteristic that determines its probability. Bayes' theorem understands probability inversely to the total probability theorem. The total probability theorem makes inference about an event *B* from the results of events *A*. For his part, Bayes calculates the probability of an event *A* given an event *B*. Bayes’ theorem is named after Reverend Thomas Bayes (1701–1761), who first used conditional probability to provide an algorithm (his *Proposition 9*) that uses evidence to calculate limits on an unknown parameter, published as *An Essay towards solving a Problem in the Doctrine of Chances* (1763). In what he called a *scholium*, Bayes extended his algorithm to any unknown prior cause.

Independently of Bayes, Pierre-Simon Laplace first in 1774 and later in his 1812 *Théorie analytique des probabilités,* used conditional probability to formulate the relation of an updated posterior probability from a prior probability, given evidence.

> Bayes’ theorem is to the theory of probability what the Pythagorean Theorem is to geometry.
>
> —Sir Harold Jeffreys

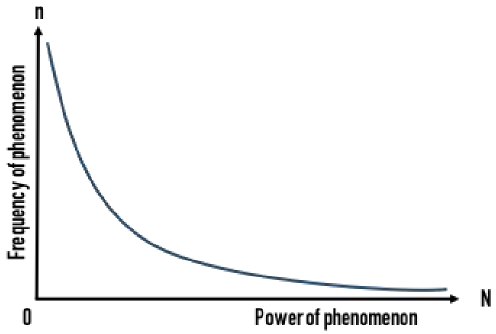
POWER LAW

> The greatest shortcoming of the human race is our inability to understand the exponential function.
>
> —Albert Allen Bartlett

We are surrounded by potential laws. A physical process responds to a potential law when the probability of an event occurring decreases as its magnitude increases.

There are many phenomena that follow these laws: the relationship between the number of cities and inhabitants (few cities with many inhabitants and many with few), the connectivity of nodes on the Internet, the frequency of words in the language, the wealth of people, the size of living beings, internet links, terrorism, etc. It is curious that all these systems respond to potential laws quite accurately since, a priori, we could assume that people's wealth or the connection of nodes to the Internet are quite random phenomena in distribution where we would expect to obtain a bell curve.

Therefore, in a potential law the events occur with variable frequency, where many events are small-scale and a few are large-scale. This relationship between many and few is not arbitrary, but follows precisely a concrete potential law with an exponent (k) characteristic of each physical phenomenon; there is a definite mathematical relationship that indicates how many events of each type occur—it can be calculated. Power Law is one of the most useful concepts for making predictions and decisions in business and management.



The Power Law shows how two variables—one dependent, the other independent—covary. Mathematically, one varies as a function of the other by being raised to a certain power (exponent).

The diagram above shows this type of relationship. Often these are depicted on log or log-log graphs, but I show the *power curve* as an asymptote on both axes of the graph to highlight the non-linearity of the relationship between the two variables. Examples: earthquakes, storms, number of sales by individual sales reps, etc.

A concrete example will help. The great majority of earthquakes are of very low magnitude. High magnitude earthquakes are much rarer than low magnitude earthquakes. In fact, their magnitude varies in inverse exponential proportion to the total number of earthquakes. In practice, this means that there are literally thousands of earthquakes every day around the world, but magnitude 6, 7, and 8 ones are much rarer. The most powerful earthquakes of all over nine on the Richter scale are very rare. They can happen only a few times a century, or even less. This doesn't mean that the magnitude of any particular earthquake can be predicted. It does, however, imply that given a sufficiently large sample, we will eventually see a frequency-magnitude distribution that resembles the graph above.

This type of relationship is ubiquitous in nature, and that includes our human and social natures. There was a whole book written on this topic—*The Long Tail*, by Chris Anderson—with emphasis on the right side of the graph. In his book, Anderson described how the internet has made many businesses or ideas viable, something that would have previously gone unnoticed. He called this the long tail because there are musicians, artists, artisans, crafts workers, professionals, etc. who can provide their productions and services to people around the world, even though they can't compete with the more traditional providers who dominate markets by occupying the left side of the power curve. This makes for much more diversity and many more opportunities to become known and appreciated, and to develop a following because it lowers traditional entry barriers and long-term viability.

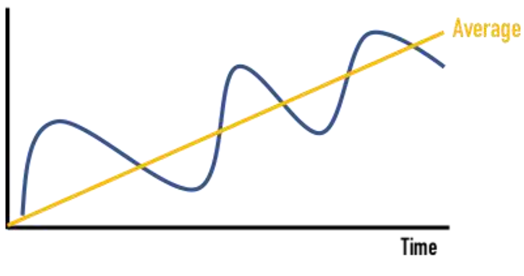
This type of relationship is also depicted in the diagram. Showing the relationship between the number of clients and the number purchases, interactions, or value of each category of client that characterizes the market and product distributions of most, if not all, companies.

REGRESSION TO THE MEAN

> Regression toward the mean. That is, in any series of random events an extraordinary event is most likely to be followed, due purely to chance, by a more ordinary one.
>
> —Leonard Mlodinow

In the phenomenon of regression to the mean, if a variable is extreme in its first measurement, it will tend to be closer to the mean in its second measurement and, paradoxically, if it is extreme in its second measurement, it will tend to have been closer to the average in its first.

The term *regression* was first used by Francis Galton, a cousin of Charles Darwin, in a famous article from the late nineteenth century (Galton, F. 1885. *On the Anthropometric Laboratory at the Late International Health Exhibition*). In this work, Galton had discovered a linear relationship between the height of parents and that of their children, highlighting the fact that children of tall parents are, on average, shorter than their parents and that children of short parents are, on average, taller than their



parents. This phenomenon then received the name of regression towards mediocrity. At present, it is known as regression towards the mean or simply regression to the mean.

As a less restrictive approach, regression towards the mean can be defined for any bivariate distribution with identical marginal distributions. Two such definitions exist.

One definition is closely in accordance with the common usage of the term *regression towards the mean.* Not all such bivariate distributions show regression towards the mean under this definition. However, all such bivariate distributions show regression towards the mean under the other definition.

Jeremy Siegel uses the term *return to the mean* to describe a financial time series in which "returns can be very unstable in the short run but very stable in the long run." More quantitatively, it is one in which the standard deviation of average annual returns declines faster than the inverse of the holding period, implying that the process is not a random walk, but those periods of lower returns are systematically followed by compensating periods of higher returns, as is the case in many seasonal businesses, for example.

GAME THEORY

> Interactive Decision Theory would perhaps be a more descriptive name for the discipline usually called Game Theory.
>
> —Robert Aumann

Game theory studies the choice of the optimal behavior of an individual when the costs and benefits of each option are not fixed in advance, but depend on the choices of other individuals.

In economic life there are countless situations in which two or more people, companies or countries have to choose strategies and make decisions in which they are mutually affected. Game theory attempts to analyze these cases and is used especially in economics to study oligopoly and duopoly markets, in which two or more agents make decisions that jointly affect all participants.

This theory, which conceives individuals as homo economicus (it understands that the player chooses the actions that best satisfy their objectives based on their beliefs), and in turn, shows how cooperation leads to the common good of the agents who perform it, while individual performance does not. One of the games most studied by game theory is the prisoner's dilemma.

Game theory as a field of study came into existence in 1928, when the mathematician John von Neuman published a series of analyses. During this period, game theory studies focused primarily on cooperative game theory.

Game theory was gaining weight throughout the 1950s, when the first discussions of the prisoner's dilemma were established and the Nash equilibrium, the greatest exponent of non-cooperative games, was developed.

Over the last decades, game theory research has intensified, serving as the basis for applications in various areas.

> If you are a leader or someone who works for the interest of a community, first make sure that you understand the interest of the people who make up that community. In this way, you will have a good chance of minimizing, perhaps, avoiding the us versus them mentality.
>
> —Duop Chak Wuol

Game theory has many applications in different fields, especially in economics, political science, evolutionary biology and even in philosophy.

Even though we understand economy as the science that studies how to manage the available resources, this in itself already provides all the ingredients for a game. Researchers in this branch of game theory have focused on studying the duopoly and oligopoly markets.

Game theory has not had the same impact on political science as it has had on economics. Perhaps this is because people behave less rationally when ideas are at stake than when money is at stake. However, it has become an important instrument for clarifying the underlying logic of a number of more paradigmatic problems.

In biology, game theory has been widely used to understand and predict certain outcomes of evolution, such as the concept of stable evolutionary strategy introduced by John Maynard Smith in his essay *Game Theory and The Evolution of Fighting (1972)*, as well as in his book *Evolution and the Theory of Games* (1982).

Regarding philosophy, game theory can show that even the most selfish individuals can discover that cooperating with others can sometimes be in their own best interest.

PRISONER'S DILEMMA

The *Prisoner's Dilemma* is a story usually attributed to A. W. Tucker, which gives its name to the best known of the problems studied in Game Theory. This theory is a flourishing branch of the Theory of Rational Election that has proved to be very useful not only in Economics and Evolutionary Biology but also in Philosophy and Political and Social Theory.

Two prisoners held incommunicado in individual cells have committed two crimes, one minor and one serious. There is sufficient evidence to be condemned for the first, but not for the second unless someone confesses to having committed it. The prosecutor visits one of the prisoners and says: "I have good news and bad news for you. The good news is that if none of you confess your serious crime, we can only sentence you to 2 years for your first crime and if you confess, I will convince the jury that you are a repentant man and that the wicked is your partner so that you would be free in one year and he would remain in prison for eight years. The bad news is that I am going to make the same offer to your partner." "And what would happen if we both confessed?" Asks the prisoner. "Then, I will have no reason to benefit any of you. I will let justice take its course, and, since the crime is serious, I estimate that you will be both sentenced to at least four years." Thus, the prisoners face the following dilemma.

Each one thinks that only two things can happen, that the other confesses or does not confess. If he confesses, it is better that I also do because otherwise, I will stay eight years in jail. If he does not confess and I do, then I can benefit from the prosecutor's offer, and I will be free in a year. The conclusion is that whatever the other does, it is best to confess. Both reason in the same way, with which both confess and stay in jail much longer than they would have been if they had cooperated with each other and neither of them had confessed.

		PRISIONER 2	
		CONFESS	DON'T CONFESS
PRISIONER 1	CONFESS	-4, -4	-1, -8
	DON'T CONFESS	-8, -1	-2, -2

This is a two-person game, but it could happen between *n* people, for example, in the case of a strike, which can be understood as a public good (*tragedy of the commons*).

Each worker may think: *Either there are enough workers who go on strike and achieve the objective of this collective action (for example, a wage increase, a reduction in working hours or an improvement in working conditions), or this does not happen. In the first case, I will still benefit from the success of the strike, and if I stay, I can also continue charging and maybe improve my relationships with my superiors. And if the others do not go on strike, it is best that I do not go either, because I will be paying in vain the costs of my contribution to this collective action that will fail.*

The problem is that the individually rational leads to collective failure. The same can happen in the case of many other collective actions (demonstrations, revolutions, wars, voting, etc.) and in many other contexts, so this game has proven useful in a very wide and varied range of research in social sciences.

CORRELATION AND CAUSATION

> One of the first things taught in introductory statistics textbooks is that correlation is not causation. It is also one of the first things forgotten.
>
> —Thomas Sowell

Correlation does not imply causation - This phrase refers to the inability to legitimately deduce a cause and effect relationship between two variables based solely on an observed association or correlation between them.

The complementary idea that correlation implies causality is a logical fallacy, where two events occurring together are considered to have established a cause and effect relationship.

This idea creates two related fallacies: post hoc ergo propter hoc (one event occurs after another, then it is because of that other) and cum hoc ergo propter hoc (one event occurs at the same time as another, then is caused by that other).

Correlation is a statistical measure between the reciprocal relationship between two or more events; it can be positive if it is observed that all the events occur together or not, or negative if the presence of some is usually accompanied by the absence of the others.

Two uncorrelated events either occur together or do not occur randomly. The correlation does not need simultaneity in time, it can also be calculated in relation to events that occur one after another. As it is a statistical measure, it cannot be applied to specific phenomena or phenomena that only occur once or a few times; statistical measurements are more accurate the more samples are used to calculate them, you never have to accept them if they are calculated with only a few examples; if someone wants to sneak something like that into us, they can only be ignorant, cheeky, or both.

This confusion runs through many studies, especially in the social sciences, so one must be especially careful with interpretations of statistical data so as not to imply causal relationships where it could be nothing more than a spurious correlation or merely casual.

Practically every day we find news in the media whose headline has a structure similar to some of the following:

- A study states that the more *A*, the more *B*.

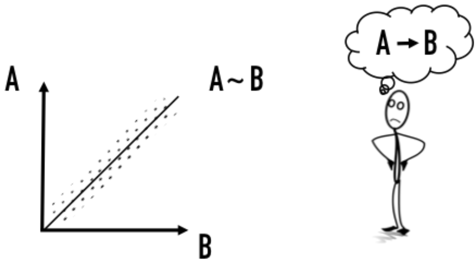
- A study states that those who are *A* have less *B*.

- A study states that since *A* is like this then *B* is this other way.

...

In principle, all those headlines basically indicate that what A says is what causes B to happen, or, what is the same, that B is a consequence of A. Normally, when you read this news, you end up realizing that what is actually happening there is a correlation between A and B (existing a relationship between those two events), but, in principle, without any indication that it is one of them (A in this case) the one that causes the other (B).

For example, a 1999 study published in Nature showed that children under the age of two who slept with night lights were more likely to have myopia. Later, other researchers showed that myopic parents were more likely to keep their lights on at night. It may be that parents are a common cause of the use of night lights, and due to genetic inheritance, myopia was passed on to their children.



There are many obvious examples to which this fallacy can be applied: the crowing of the rooster and the sunrise; the belief that carrying an umbrella when it is doubtful whether it will rain or not prevents it from raining; the ancients' belief that lightning was the result of human actions that angered the gods; or the belief that the actions and measures of a certain government are the cause of all the changes in the economic variables of the legislature, for better or for worse, according to the argument of the executive or the opposition.

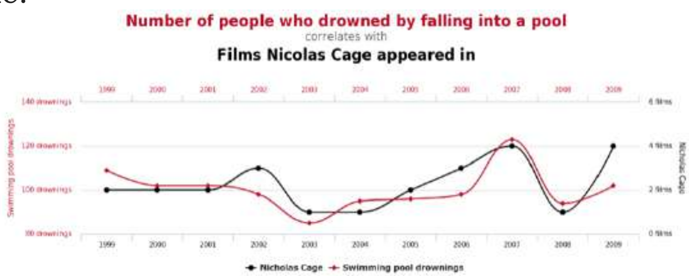
> Don’t confuse correlation and causation. Almost all great records eventually dwindle...
>
> —Charlie Munger

But today we know, thanks to the development of the study of complex systems and mathematical theories such as chaos theory, that most of the important systems that occur in nature, and specifically in our societies, are not governed by linear effects, but by the so-called non-linear. In a non-linear phenomenon, the effect ceases to be proportional and can be calculated using only addition and multiplication, and becomes exponential, oscillating, and, in general, the result of some function that can become tremendously complex and variable in time.

In addition, interactions occur between an infinity of elements, and it is impossible to separate these elements to analyze them because when the interactions between them cease to occur, what are known as emergent properties of the system disappear—these are components that appear as out of nowhere but they also interact with the system itself and produce new effects. An example is our consciousness, which is the reason why we cannot understand the functioning of the brain simply by studying neurons separately.

Thus, this idea is related to the models of Chaos Theory, Power Law and Complex Adaptive Systems.

Example:



STANDARD DEVIATION

> Don't cross a river if it is (on average) four feet deep.
>
> —Nassim Taleb

The standard deviation is a measure that provides information about the mean dispersion of a variable. The standard deviation is always greater than or equal to zero.

To understand this concept, we need to analyze 2 fundamental concepts.

- Mathematical expectation, expected value or mean: It is the mean of our data series.
- Deviation: The deviation is the separation that exists between any value of the series and the mean.
- The standard deviation is the most common measure of dispersion, indicating how spread out the data is from the mean. The greater the standard deviation, the greater the spread of the data.

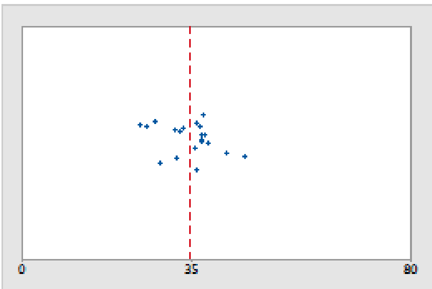
The symbol σ (sigma) is frequently used to represent the standard deviation of a population, while s is used to represent the standard deviation of a sample. Variation that is random or natural in a process is commonly known as noise.

Standard deviation can be used to establish a baseline value for estimating the overall variation of a process.

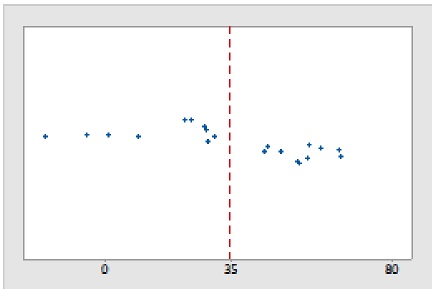
Consider the following example:

The administrators monitor the discharge time of patients treated in the emergency areas of two hospitals. Although the average exit times are approximately the same (35 minutes), the standard deviations are significantly different. The standard deviation for hospital 1 is approximately 6. On average, the time to discharge a patient deviates from the mean (dashed line) by approximately 6 minutes. The standard deviation for hospital 2 is approximately 20. On average, the time to discharge a patient deviates from the mean (dashed line) by approximately 20 minutes.

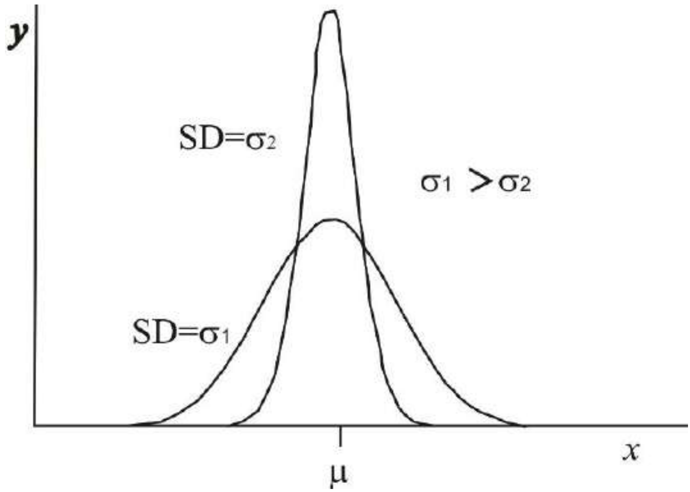
Hospital 1



Hospital 2

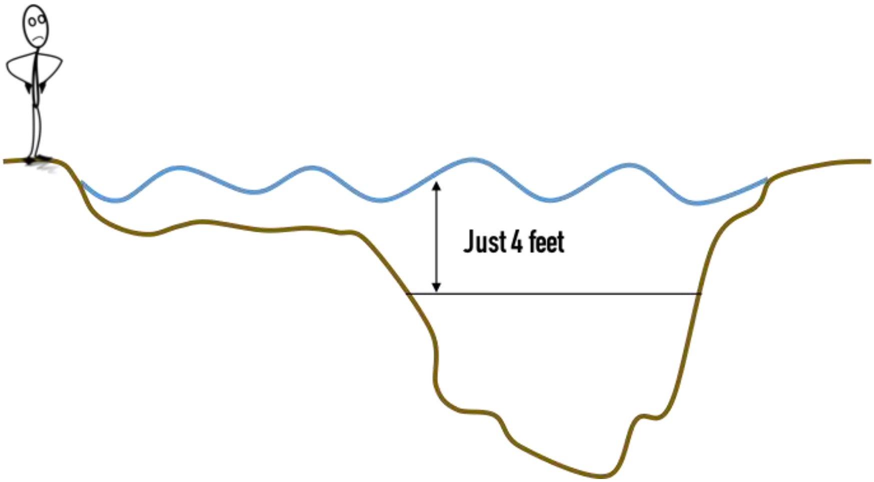


Graphically it would be:



It is very important to note that the standard deviation of a population and the standard error of a statistic derived from that population (such as the mean) are quite different but related (related by the inverse of the square root of the number of observations). The reported margin of error of a poll is computed from the standard error of the mean (or alternatively from the product of the standard deviation of the population and the inverse of the square root of the sample size, which is the same thing) and is typically about twice the standard deviation —*the half-width of a 95 percent confidence interval.*

The standard deviation is also important in finance, where the standard deviation on the rate of return on an investment is a measure of the volatility of the investment.



When only a sample of data from a population is available, the term standard deviation of the sample (or sample standard deviation) can refer to either the above-mentioned quantity as applied to those data or to a modified quantity that is an unbiased estimate of the population standard deviation (the standard deviation of the entire population).

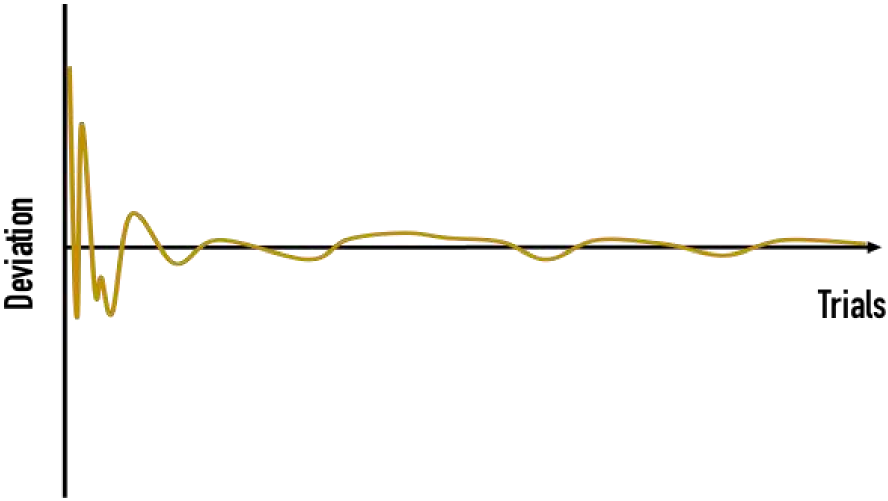
It is common to read and use means to simplify the data without taking into account the standard deviation, which can lead to major errors.

A clear example would be the average return of the stock market. Over the last 200 years, the profitability of the American stock market has been 7% yearly, but in the short term, the variability is large and may yield returns from -40% to +40% yearly.

LAW OF LARGE NUMBERS

> The engine driving the Kelly system is the law of large numbers. In a 1713 treatise on probability, Swiss mathematician Jakob Bernoulli propounded a law that has been misunderstood by gamblers (and investors) ever since.
>
> —William Poundstone

The Law of Large Numbers (LNN) is a fundamental theorem of probability theory that indicates that if we repeat the same experiment many times (tending to infinity), the frequency of a certain event occurring tends to be a constant.



That is to say, the law of large numbers indicates that if the same test is carried out repeatedly (for example, tossing a coin, spinning a roulette wheel, etc.), the frequency with which a certain event will be repeated (that heads or tails comes up, the number 3 comes out black, etc.) will approach a constant. This in turn will be the probability of this event occurring.

The law of large numbers was mentioned for the first time by the mathematician Gerolamo Cardano, although without having any rigorous proof. Later, Jacob Bernoulli managed to make a complete demonstration in his work *Ars Conjectandi* in 1713. In the 1830s the mathematician Siméon Denis Poisson described in detail the law of large numbers, which came to perfect the theory. Other authors would also make later contributions.

Imagine the following experiment: roll a common die. Now let's consider the event that we get the number 1. As we know, the probability that the number 1 is rolled is 1/6 (the die has 6 faces, one of them is one).

What does the law of large numbers tell us? It tells us that as we increase the number of repetitions of our experiment (we make more throws of the die), the frequency with which the event will be repeated (we get 1) will get closer to a constant, which will have an equal value to its probability (1/6 or 16.66%).

Possibly, in the first 10 or 20 throws, the frequency with which we get 1 will not be 16%, but another percentage like 5% or 30%. But as we make more and more throws (say 10,000), the frequency that 1 appears will be very close to 16.66%.

There is no principle that a small number of observations will coincide with the expected value or that a streak of one value will immediately be balanced by the others (see the *gambler's fallacy*).

> It is a common fallacy to believe that the law of large numbers acts as a force endowed with memory seeking to return to the original state, and many wrong conclusions have been drawn from this assumption.
>
> —William Feller

INVERSION

> Invert, always invert.
>
> —Carl Gustav Jacob Jacobi

Carl Gustav Jacob Jacobi (1804 - 1851) was a German mathematician who contributed in various fields of mathematics, mainly in the area of elliptic functions, algebra, and number theory.

When Jacobi had to solve a problem, he would try to invert, since he believed that inverting known results can open up new fields for research, as he did with the inversion of the elliptic integral function.

Thus, when he began to study a problem, he recommended to his students *man muss immer umkehren*, that is, *invert, always invert*. This simple idea is extremely useful in decision making. Sometimes we do not know which option is best, but we know which one is worst, so identifying and avoiding bad decisions, we will make sure we are better decision-makers.

Warren Buffett and Charlie Munger have commented on many occasions that the use of this model has helped them succeed.

> It is remarkable how much long-term advantage people like us have gotten by trying to be consistently not stupid, instead of trying to be very intelligent.
>
> —Charlie Munger

One of Charlie Munger's favorite quotes, which Peter Bebelin used for the title of his book is All I want to know is where I'm going to die so I'll never go there.

> Invert, always invert: Turn a situation or problem upside down. Look at it backward. What happens if all our plans go wrong? Where don't we want to go, and how do you get there? Instead of looking for success, make a list of how to fail instead - through sloth, envy, resentment, self-pity, entitlement, all the mental habits of self-defeat. Avoid these qualities and you will succeed. Tell me where I'm going to die, that is, so I don't go there.
>
> —Charlie Munger

Even more, in 1986, Munger was selected to speak at Harvard-Westlake, a private Los Angeles based secondary school where he has been a longtime trustee.

To determine what he would say in his speech, Munger asked himself which of the previous commencement speeches he wished were longer. Munger settled on a prior speech given by television host Johnny Carson, which specified his *prescriptions* for guaranteed misery in life.

"I, therefore, decided to repeat Carson's speech but in expanded form with some added prescriptions of my own," Munger told the graduating class of 1986.

In this way, in this talk Munger gives us an excellent example. He wants to have a good life, but he is not clear about the points to follow, so he decides to reverse the problem, identifying the points for a miserable life to avoid them at all costs.

The points indicated are:

1. Letting addiction take over
2. Feeling resentful
3. Being unreliable
4. Letting life knock you down
5. Refusing to learn from past mistakes

With what avoiding them we will avoid great possibilities of having a miserable life, which will increase the possibilities of having a happy life.

> Charlie and I have not learned how to solve difficult business problems. What we have learned is to avoid them.
>
> —Warren Buffett

The optimism bias pushes us to overweight the positive outcome of each decision, which makes us irrational and can get us into big trouble. Therefore, as Munger reminds us, related to the ideas of Taleb's Black Swan, we must invert the situations, try to see what we want to avoid, never to go there.

FRAGILITY / ROBUSTNESS / ANTIFRAGILITY

> Antifragility is beyond resilience or robustness. The resilient resists shocks and stays the same; the antifragile gets better.
>
> —Nassim Taleb

Taleb coined the term antifragile after realizing that there are things that benefit from the impacts they receive. They are phenomena that grow or prosper when exposed to volatility, chance, disorder, risk, or uncertainty.

Nassim Nicholas Taleb has expanded and somehow revolutionized the concept of resilience with *Antifragile: Things That Gain from Disorder*, an essay exploring the effects of uncertainty in all areas of life, from science to art, going through economics, education or politics.

And yet, despite its ubiquity, there is no antonym for fragility. Taleb proposes antifragility, a concept that goes beyond resilience or strength. The resilient receives the blow and remains standing. The antifragile, on the other hand, improves with the onslaught of adversity.

Everything that has changed and survived over time has benefited from anti-fragility. We cannot understand bacterial resistance, nor political systems, nor stock market or publishing success, nor even our very existence as a species without the phenomenon of antifragility. Taleb puts it in these terms: "Humans are much more apt to do than to think. I'd rather be stupid but anti-fragile than very smart and fragile".

If antifragility is the property of all surviving natural and complex systems, isolating them and stripping them of unbalancing factors would weaken them and ultimately kill them. Much of our modern world has been structured in an overprotective manner, with policies that have attempted to alter citizens' behaviors from top to bottom.

Just as almost everything that runs from the top down blocks antifragility and tends to stunt growth, everything that grows from the bottom does so under the just pressure of stress and disorder.

Taleb defines it as follows in a letter to Nature responding to an earlier review of his book in that journal:

> Simply, antifragility is defined as a convex response to a stressor or source of harm (for some range of variation), leading to a positive sensitivity to increase in volatility (or variability, stress, dispersion of outcomes, or uncertainty, what is grouped under the designation disorder cluster). Likewise, fragility is defined as a concave sensitivity to stressors, leading to a negative sensitivity to an increase in volatility. The relation between fragility, convexity, and sensitivity to disorder is mathematical, obtained by theorem, not derived from empirical data mining or some historical narrative. It is a priori.
>
> —Nassim Taleb

	FRAGILE	ROBUST	ANTIFRAGILE
MYTHOLOGY – GREEK	Sword of Damocles, Rock of Tantalus	Phoenix	Hydra
MYTHOLOGY – NYC	Dr. John	Nero Tulip	Fat Tony Yevgenia Krasnova
BLACK SWAN	Exposed to negative Black Swan		Exposed to positive Black Swan
BUSINESSES	New York: Banking system		Silicon Valley: *Fail fast*, *Be foolish.*
BIOLOGICAL & ECONOMIC SYSTEMS	Efficiency, optimized	Redundancy	Degeneracy (functional redundancy)
ERRORS	Hates mistakes	Mistakes are just information	Loves mistakes (since they are small)
ERRORS	Irreversible, large (but rare) errors, blowups		Produces reversible, small errors
SCIENCE/ TECHNOLOGY	Directed research	Opportunistic research	Stochastic tinkering (antifragile tinkering or bricolage)
DICHOTOMY EVENT-EXPOSURE	Studying events, measuring their risks, statistical properties of events	Studying exposure to events, statistical properties of exposures	Modifying exposure to events
SCIENCE/ TECHNOLOGY	Theory	Phenomenology	Heuristics, practical tricks
HUMAN BODY	Mollification, atrophy, *aging*, sarcopenia	Materialization, recovery	Hormesis, hypertrophy


FRAGILE
ROBUST
ANTIFRAGILE
Harmed by uncertainly
Dealing with uncertainly
Leveraging uncertainly

BLACK SWAN

> The central idea in the Black Swan is that: rare events cannot be estimated from empirical observation since they are rare.
>
> —Nassim Taleb

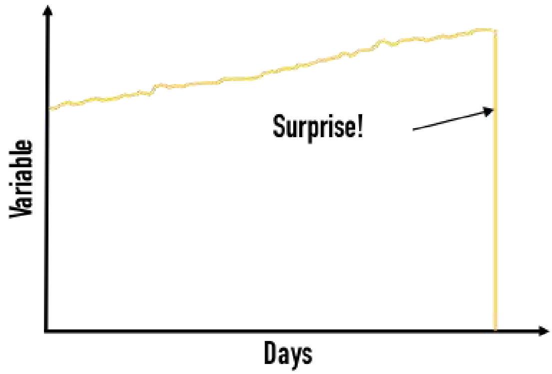
A Black Swan is an unlikely event; its consequences are important, and all the explanations that can be offered afterward do not take into account chance and only seek to fit the unpredictable into a perfect model. The success of Google and YouTube, and even 9/11, are Black Swans.

Black swans are an integral part of our world, from the rise of religions to the events of our personal lives.

Why can't we identify this phenomenon until it has already happened?

Because humans insist on investigating things already known, forgetting what we do not know, this prevents us from recognizing opportunities and makes us too vulnerable to the impulse to simplify, narrate, and categorize, forgetting to reward those who know how to imagine the impossible.

A turkey is fed for a thousand days by a butcher; every day confirms to its staff of analysts that butchers love turkeys *with increased statistical confidence*. The butcher will keep feeding the turkey until a few days before Thanksgiving. Then comes that day when it is really not a very good idea to be a turkey. So, with the butcher surprising it, the turkey will have a revision of belief — right when its confidence in the statement that *the butcher loves turkeys* is maximal and *it is very quiet* and soothingly predictable in the life of the turkey. This example builds on an adaptation of a metaphor by Bertrand Russell. The key here is that such a surprise will be a Black Swan event; but just for the turkey, not for the butcher.



We can also see from the turkey story the mother of all harmful mistakes: mistaking absence of evidence (of harm) for evidence of absence, a mistake that we will see tends to prevail in intellectual circles and one that is grounded in the social sciences.

So, our mission in life becomes simply how not to be a turkey, or, if possible, how to be a turkey in reverse — antifragile, that is. Not being a turkey starts with figuring

> out the difference between true and manufactured stability.
>
> —Nassim Taleb

A turkey before and after Thanksgiving. The history of a process over a thousand days tells you nothing about what is to happen next. This naïve projection of the future from the past can be applied to anything.

This model is the extension of Charlie Munger's idea of always *invert* the problems, to *never go there*. We have to be extraordinarily conservative and cautious, much more than logical reason based on past events indicates, since the events that are unpredictable can happen and we must be prepared for them.

Practical examples would be a conservative management of our assets, diversified in various types of investments, as well as having different sources of income, no matter how stable our job may seem.

ENGINEERING

> Design is not just what it looks like and feels like. Design is how it works.
>
> —Steve Jobs

Engineering is the discipline that deals with the study and application of knowledge from science, so that through designs, models, techniques and solutions the different problems that affect humanity can be solved.

Engineering, basically, will require an accurate knowledge and management of mathematics, on the one hand, and natural sciences, on the other, to develop economic ways that allow the use of certain materials and of the forces of nature in absolute benefit of the environment and of humanity.

The term *engineering* is derived from the Latin *ingenium*, meaning cleverness and *ingeniare*, meaning to contrive, devise.

> There is nothing I believe more strongly than getting young people interested in science and engineering, for a better tomorrow, for all humankind.
>
> —Bill Nye

Engineering goes a little beyond solving problems and satisfying needs and also puts scientific knowledge at the service of invention, improvement and use of any type of technology.

Although engineering is absolutely a human activity and as such it should have been accompanying us from our early origins, in reality, this specific field of knowledge is closely linked to the beginning of the Industrial Revolution.

> A good scientist is a person with original ideas. A good engineer is a person who makes a design that works with as few original ideas as possible. There are no prima donnas in engineering.
>
> —Freeman Dyson

ENGINEERING MODELS

Engineering-related models will serve us specially to analyze and optimize our processes, whether personal or in a professional environment.

- Redundancy: Margin of safety
- Backup system model
- Breakpoint
- Quality control
- Feedback loops

REDUNDANCY: MARGIN OF SAFETY

> Redundancy is ambiguous because it seems like a waste if nothing unusual happens. Except that something unusual happens—usually.
>
> —Nassim Taleb

Redundancy is a term used to describe situations in which the system has duplicate resources for failure prevention, usually in the form of a backup or fail-safe.

Redundancy means that if a party does not act normally, it can do so in a second alternate way or even in a third or fourth one.

For example, having redundancy in our Internet connection means having two connections available so that in case one fails we can still use the other.

Having redundancy or duplication of power supply is common in other areas outside of computing, for example in hospitals. In a hospital, an operating room cannot be without electricity (the life of the patient is at stake) so there are generators in place that run on diesel and start as soon as the electricity goes out.

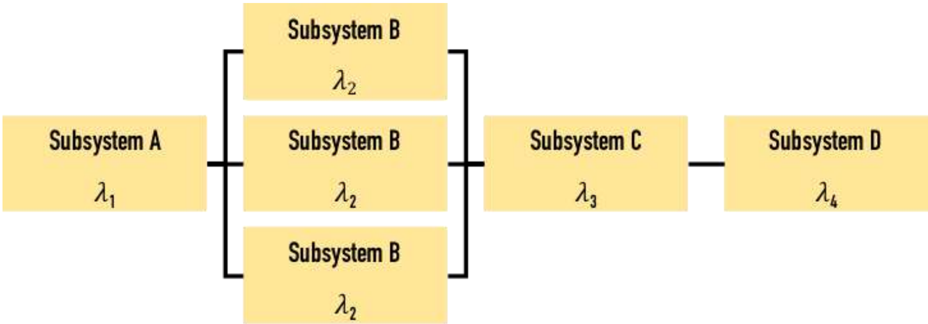
Taking aviation as an example, flight instruments such as speed and altitude indicators, or communications systems, are even tripled in the pilots' cabin. Regarding the structure of airplanes, the materials used must guarantee that they can withstand certain maximum loads. The wings, for example, usually support around three times the weight of the aircraft (3G) and breaking loads of 4.5 G, a limit up to which no structural deformation or breakage is allowed. In computer science, there are four major forms of redundancy, these are:

- **Hardware or physical redundancy**: This type of redundancy consists of incorporating additional hardware, usually in order to detect faults or achieve a high tolerance for them. It is the most frequently used technique.

- **Software redundancy**: This type of redundancy consists in adding additional lines of code to the programs to avoid errors, detecting them or correcting them. This supplementary code can have different functions, such as preventing data from getting out of range, preventing arithmetic errors ...

- **Information redundancy**: This type of redundancy consists of adding additional information to the data to allow the detection or correction of errors. Here we could include methods like parity codes or checksums.

- **Time redundancy**: This technique consists of using a small software that repeats the calculations several times to compare the results and see if there is any difference.


Subsystem B
λ_2
Subsystem A
λ_1
Subsystem B
λ_2
Subsystem C
λ_3
Subsystem D
λ_4
Subsystem B
λ_2

BACKUP SYSTEM MODEL

> Being too busy to worry about backup, is like being too busy driving a car to put on the seatbelt.
>
> —T.E. Ronneberg

In computing, a backup, back-up, or reserve copy is understood to be a copy of the original data of an information system or software (files, documents, etc.) that is stored in a safe place or a secure region of the system memory, in order to have your information available again in case some eventuality, accident or disaster occurs and causes data corruption on the system. In other words, it is a just-in-case copy that is usually updated every so often as a security measure.

Computer systems today can be victim to various types of damage: remote attacks by hackers or computer viruses, physical destruction of storage media, and even accidental deletion by an authorized user. In these cases, backup copies are used to manually or automatically restore lost information, thus minimizing losses in data or information.

These data losses are really common: 66% of Internet users have experienced them, which is why it is very common to have backups in different formats: hard disk sectors, removable storage devices or even in the cloud, that is, on Internet servers. This form of prevention is recommended in all digital security guides and large companies invest part of their budget and their data storage capacity in backing up their most important and confidential information.

> **B**ackup everything
> **A**utomate the process
> **C**onfirm backups work
> **K**eep some old backups
> **U**pdate backups frequently
> **P**rotect your backups
> **S**pread your backups.
>
> —T.E. Ronneberg

BREAKPOINT

> Sometimes success needs interruption to regain focus and shake off complacency.
>
> —Lennox Lewis

In programming, specifically in program debugging, a breakpoint is an intentional and controlled pause during the execution of a program.

The objective will be to check what value the program variables have, what results have been obtained on the screen so far, etc. and in this way check whether the program, up to that moment, is doing what is expected.

A breakpoint is a mark that is set in a line of the source code, in such a way that when the execution reaches that point the application process will stop and its state can be analyzed in the precise moment just before the execution of that line of code

Breakpoints are a way of telling that you want it to stop your program at certain lines of code. You can also have it stop when your program makes specific function calls. Once the program is stopped, you can poke around in memory and see what the values of all your variables are, examine the stack, and step through your program's execution.

In this way, it could be summarized as a point in a program that, when reached, triggers some special behavior useful to the process of debugging; generally, breakpoints are used to either pause program execution and/or dump the values of some or all of the program variables. Breakpoints may be part of the program itself; or the programmer may set them as part of an interactive session with a debugging tool for scrutinizing the program's execution.

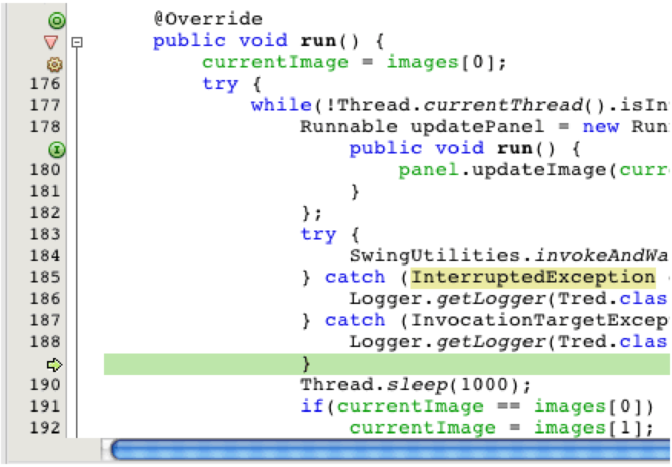
Essentially, in complex engineering systems, an intentional small pause is performed for safety, reflection, and debugging. It is a great idea to have a few breakpoints in your investment checklist, the more decisions you must make, the more room for error you are susceptible to.

When we think of something, divide it into the smallest possible steps and ensure that each step, each stage is correct before moving on to the next.

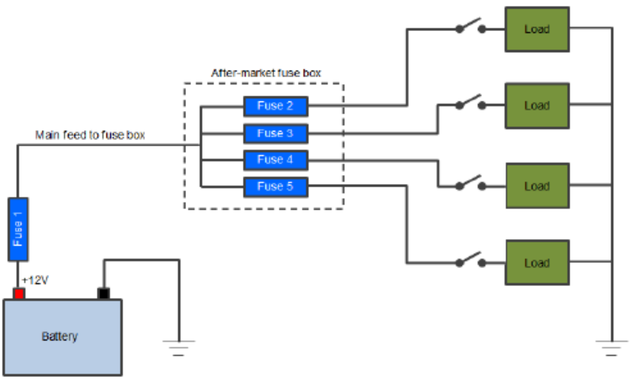
For example, if I think that partying is negative for me, I divide it into steps and conclude that it is alcohol that is negative, that specific step in the party process. Detailing and specifying the problem.

Examples:

- Debug



- Fuse:



QUALITY CONTROL

> Quality control applies to any kind of enterprise. In fact, it must be applied in every enterprise.
>
> —Kaoru Ishikawa

Quality control is the process of ensuring the quality of a product. The least requirements that quality control should meet are the minimum requirements and specifications of a product. However, it is also necessary that the product is satisfactory, dependable, and fiscally sound. To ensure that products meet the standard requirements and are satisfactory, a thorough examination of these products is done. Whenever there are problems identified, the production of such products is temporarily stopped until these problems are rectified.

Quality control (QC) is a process by which entities review the quality of all factors involved in the production. ISO 9000 defines quality control as "A part of quality management focused on fulfilling quality requirements."

This approach emphasizes three aspects (enshrined in standards such as ISO 9001):

- Elements such as controls, job management, defined and well-managed processes, performance and integrity criteria, and identification of records.

- Competence, such as knowledge, skills, experience, and qualifications.
- Soft elements, such as personnel, integrity, confidence, organizational culture, motivation, team spirit, and quality relationships.

Thereby, it is a process through which a business seeks to ensure that product quality is maintained or improved with either reduced or zero errors. Quality control requires the business to create an environment in which both management and employees strive for perfection. This is done by training personnel, creating benchmarks for product quality and testing products to check for statistically significant variations.

A major aspect of quality control is the establishment of well-defined controls. These controls help standardize both production and reactions to quality issues. Limiting room for error by specifying which production activities are to be completed by which personnel reduces the chance that employees will be involved in tasks for which they do not have adequate training.

FEEDBACK LOOPS

> 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

> Feedback occurs when outputs of a system are routed back as inputs as part of a chain of cause-and-effect that forms a circuit or loop. The system can then be said to feed back into itself. The notion of cause-and-effect has to be handled carefully when applied to feedback systems: Simple causal reasoning about a feedback system is difficult because the first system influences the second and second system influences the first, leading to a circular argument. This makes reasoning based upon cause and effect tricky, and it is necessary to analyze the system as a whole.
>
> —Karl Johan Åström And Richard M. Murray


Sales
Satisfied Customers
Positive Word of Mouth

CHEMISTRY

> Be a physical chemist, an analytical chemist, an organic chemist, if you will; but above all, be a chemist.
>
> —Ira Remsen

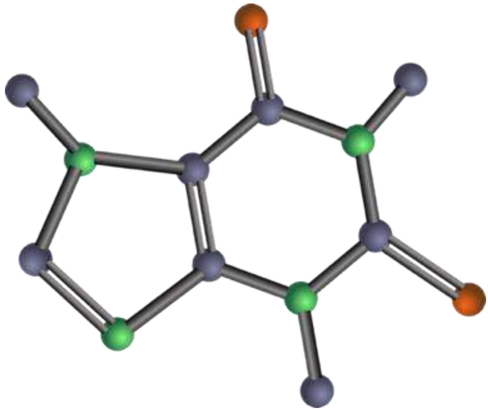
Chemistry is the science of matter at or near the atomic scale. Matter is the substance of which all physical objects are made. Chemistry deals with the properties of matter, and the transformation and interactions of matter and energy. Central to chemistry is the interaction of one substance with another, such as in a chemical reaction, where a substance or substances are transformed into another. Chemistry primarily studies atoms and collections of atoms such as molecules, crystals, or metals that make up ordinary matter. According to modern chemistry, it is the structure of matter at the atomic scale that determines the nature of a material.

Chemistry has many specialized areas that overlap with other sciences, such as physics, biology, or geology. Historically, the science of chemistry is a recent development but has its roots in alchemy, which has been practiced for millennia throughout the world. The word *chemistry* is directly derived from the word *alchemy*.

CHEMISTRY MODELS

Chemistry models will give us an insight into the composition of every body, be it liquid, solid or gas.

- Atoms, Molecules, and Ions
- The Chemical Bond
- Molecular Shape and Geometry
- The Kinetic Theory
- The Chemical Reaction
- Autocatalyst



ATOMS, MOLECULES, AND IONS

> All matter originates and exists only by virtue of a force which brings the particle of an atom to vibration and holds this most minute solar system of the atom together… We must assume behind this force the existence of a conscious and intelligent mind. This mind is the matrix of all matter.
>
> —Max Planck

An atom is a basic unit of matter consisting of a dense, central nucleus surrounded by a cloud of negatively charged electrons. An atom is the smallest unit of an element that can take part in a chemical reaction. An atomic nucleus contains a mix of positively charged protons and electrically neutral neutrons (except in the case of Hydrogen-1, which is the only stable isotope with zero neutrons). The electrons of an atom are bound to the nucleus by an electromagnetic force. Likewise, a group of atoms can remain bound to each other, forming a molecule. An atom containing an equal number of protons and electrons is electrically neutral; otherwise, it has a positive or negative charge associated with it, and it is then an ion. An atom is classified according to the number of protons and neutrons in its nucleus: the number of protons determines the chemical element, and the number of neutrons determines the isotope of the element.

ELECTRONS

Electrons are tiny, subatomic particles that are *negatively* charged. Their mass is insignificant compared to that of protons and neutrons, so, for most purposes, it is ignored.

PROTONS

Protons are small, subatomic particles that are *positively* charged. Their mass is not ignored in calculations of atomic mass (also known as atomic weight) but is given a value of *1 Atomic Mass Unit*, or *amu* (also known as a *dalton*). The atomic number of an element is the number of protons in one atom of an element.

NEUTRONS

A neutron is a particle that has no charge. Their mass is included in calculations of atomic mass, and, like protons, is given a value of *1 Atomic Mass Unit*, or *amu*.

ATOMS, MOLECULES, AND IONS

- Atoms are the smallest unit of matter that can't be broken down chemically.
- Molecules are groups of two or more atoms that are chemically bonded.
- Ions are atoms or molecules that have gained or lost one or more of their valence electrons and therefore have a net positive or negative charge.

MOLECULES

Molecules are groups of two or more atoms that are chemically bonded. Ions are atoms or molecules that have gained or lost one or more of their valence electrons and therefore have a net positive or negative charge.

IONS

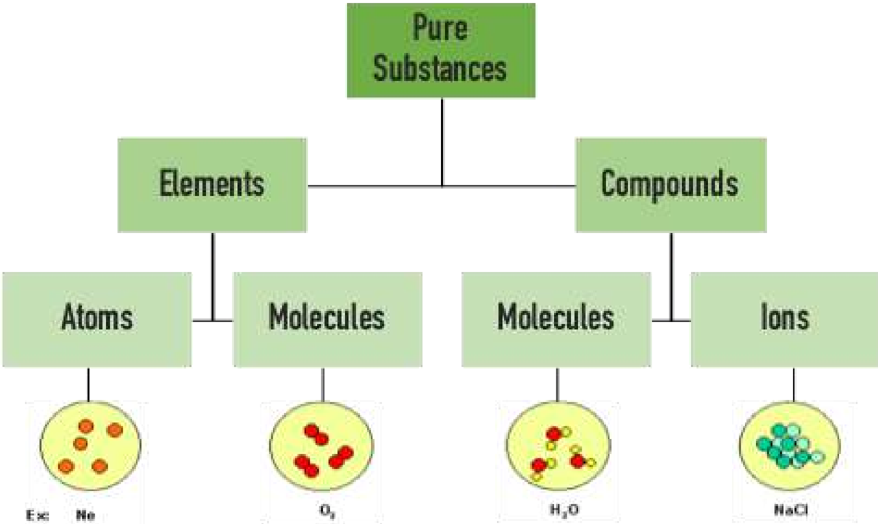
An ion is an atom possessing an electric charge. Atom(s), which contain more electrons than protons, are said to be negatively charged ions or anions, while atoms possessing more protons than electrons are said to be positively charged ions or cations. Sometimes, a group of atoms possessing an electric charge that reacts as a single unit is called a radical.

An atom can be an ion, but not all ions are atoms. There are distinct differences between an atom and an ion

ATOMIC THEORY OF MATTER

This theory of John Dalton, is the earliest version of the atomic theory.

1. Elements are composed of small particles called atoms.
2. Atoms of a given element are identical.
3. Law of Conservation of Matter/ Energy: Matter/ Energy cannot be created or destroyed.
4. Two or more elements that combine chemically form compounds.


Pure Substances
Elements
Compounds
Atoms
Molecules
Molecules
Ions
Ex: Ne
O2
H2O
NaCl

THE CHEMICAL BOND

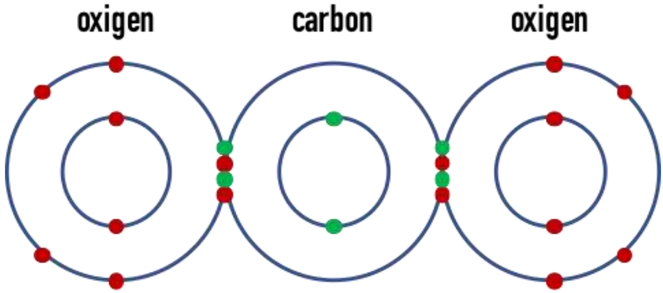
> The nature of the chemical bond is the problem at the heart of all chemistry.
>
> —Bryce Crawford

A chemical bond is an attraction between atoms, ions, or molecules that enables the formation of chemical compounds. The bond may result from the electrostatic force of attraction between oppositely charged ions as in ionic bonds, or through the sharing of electrons as in covalent bonds.

The strength of chemical bonds varies considerably; there are *strong bonds* or *primary bonds* such as covalent, ionic and metallic bonds, and *weak bonds,* or *secondary bonds* such as dipole-dipole interactions, London dispersion force, and hydrogen bonding.

As an example, see the below representation of a carbon dioxide molecule. It is made up of two oxygen atoms and one carbon atom, so its chemical formula is CO2. The carbon dioxide molecule has linear and symmetric geometry, and the Lewis structure that represents it is: O = C = O.

Carbon dioxide is formed from various processes, such as combustion, fermentation, or respiration.



carbon dioxide

MOLECULAR SHAPE AND GEOMETRY

> Life is a relationship among molecules and not a property of any molecule.
>
> —Linus Pauling

Molecular geometry is basically the three-dimensional arrangement, shape and structure of the atoms that make up a molecule. When the molecules are formed by a chemical bond, which means that the atoms join one another, the suborbitals involved in the bond or bonds create different molecular shapes that depend on many factors.

The chemical composition and molecular geometry of a molecule is what mainly determines the properties of the molecule. Like taste, boiling point, magnetism, dynamics, polarity, color, and all other properties.

A bond angle is a geometric angle between two adjacent bonds. Some common shapes of simple molecules include:

- **Linear**: The atoms are linked together to form a straight line. The bonding angles are 180 degrees and, for example, carbon dioxide (CO^2) and nitric oxide (NO).
- **Triangular planar**: Geometry is formed when a compound has one atom in the center attached to three

other atoms in an arrangement that looks like a triangle around the central atom. The four atoms are in the same line and in the same plane.

- **Trigonal pyramidal**: It has the shape of a pyramid with a base that looks like a triangle. The trigonal pyramidal structure resembles tetrahedral molecular geometry, pyramidal structures need three dimensions for them to fully separate electrons. An example is ammonia (NH^3).

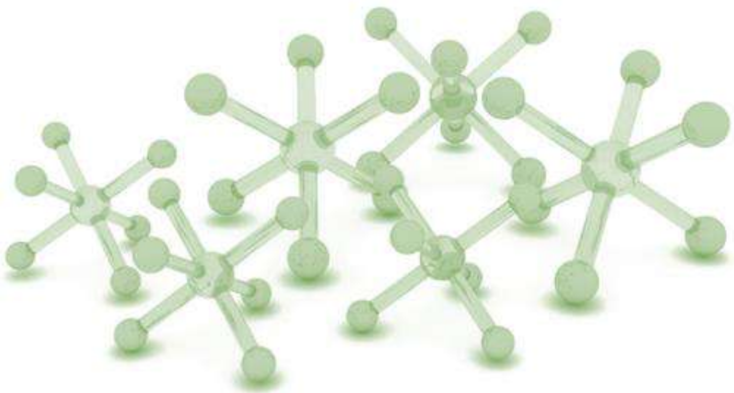
- **Tetrahedral**: Tetra means four and tetrahedral basically means a solid or pyramid that has four sides. Tetrahedral molecular geometry is formed when a central atom has four bonds with four atoms at a time, forming a pyramid shape with four sides. An example is methane (CH^4).

- **Square Plane**: It is formed when a central atom has four bonds and two lone pairs. Xenon tetrafluoride (XeF^4) is an example of the square planar structure; It is formed by six equidistant orbitals arranged at 90 degree angles, which form an octahedral shape.

- **Trigonal bipyramidal**: Occurs when the central atom is connected to five atoms forming five bonds and without lone pairs. Three of the five bonds are created along the equator of the atom at 120 degree angles while the remaining two are formed on the axis of the atom. An example is phosphorous pentachloride (PCl^5).

- **Octahedral**: It is a pyramid or solid that has eight sides or faces. The octahedral structure has six joined atoms that form 90 degree angles to each other. An example is sulfur hexafluoride (SF^6).

- **Trigonal pyramidal**: A trigonal pyramidal molecule has a pyramid-like shape with a triangular base.



THE KINETIC THEORY

> According to the kinetic theory of gases, the mean kinetic energy of a molecule is a measure of absolute temperature.
>
> —Wilhelm Wien

According to this model of matter, everything around us is made up of very small particles, which are called molecules. Molecules are in continuous motion and between them there are attractive forces, called cohesion forces. Molecules, being in motion, are at a certain distance from each other and between the molecules there is empty space. When temperature increases, molecules move faster.

This model was based on the following assumptions:

- Matter is made up of a set of atoms and molecules in continuous motion.
- The size of the particles is negligible compared to the distance that separates them from each other.
- The particles collide with each other, and with other surfaces, elastically.

MATTER CONSISTS OF SMALL PARTICLES

The first assumption in this theory is that matter consists of a large number of very small particles—either as individual atoms or molecules.

All matter (solid, liquid, and gas) is made up of tiny particles called atoms, or atoms that are joined to form molecules.

LARGE SEPARATION BETWEEN PARTICLES

The next assumption concerns the separation of the particles.

In a gas, the separation between particles is very large compared to their size, such that there are no attractive or repulsive forces between the molecules.

In a liquid, the particles are still far apart, but now they are close enough that attractive forces confine the material to the shape of its container.

In a solid, the particles are so close that the forces of attraction confine the material to a specific shape.

PARTICLES ARE IN CONSTANT MOTION

Another assumption is that each particle is in constant motion.

In gases, the movement of the particles is assumed to be random and free.

In liquids, the movement is somewhat constrained by the volume of the liquid.

In solids, the motion of the particles is severely constrained to a small area for the solid to maintain its shape.

The velocity of each particle determines its kinetic energy. There is an exchange or transfer of energy between particles—both atoms and molecules—during a collision between them.

SUMMARY

The Kinetic Theory of Matter states that matter is composed of a large number of small particles that are in constant motion. It also assumes that particles are small and widely separated. They collide and exchange energy.

This theory helps explain the flow or transfer of heat and the relationship between pressure, temperature, and volume properties of gases.

EXPANDING THE IDEA

This model will help us observe other entities as compositions of participants in constant movements, such as society itself, institutions, cities, or ecological ecosystems.

Thus, it will be appreciated that most aspects of life are in continuous movement, being unusual situations in which there is immobility.

THE CHEMICAL REACTION

> Childbirth is a miracle. No, it's not . . . It's a chemical reaction, that's all.
>
> —Bill Hicks

Chemical reactions are thermodynamic processes of transformation of matter. Two or more substances, known as reactants, intervene in these reactions. They change significantly in the process, and are able to consume or release energy.

Thus, chemical reactions happen when chemical bonds are broken or formed between atoms. Reactants are the substances that first participate in a chemical reaction, with the final substances that are produced at the end, which are known as the products.

> Every chemical reaction has a transition state.
>
> —Derek Barton

This means that any chemical reaction involves a profound transformation; altering its structure and molecular composition (unlike physical changes that only affect its form or state of aggregation). Chemical changes generally produce new substances, different from what we had in the beginning.

Chemical reactions are very common and can occur spontaneously, under various conditions in nature, and also in the controlled environment of a laboratory, due to human action.

Many of the materials that we use on a daily basis are obtained industrially, from simpler substances combined through one or more reactions. So, a reaction is a process that leads to the chemical transformation of one set of chemical substances into another. Classically, chemical reactions encompass changes that only involve the positions of electrons in the forming and breaking of chemical bonds between atoms, with no changes made to the nuclei (no change to the elements present); all of which can often be described by a chemical equation. Nuclear chemistry is a sub-discipline of chemistry that involves the chemical reactions of unstable and radioactive elements where both electronic and nuclear changes can occur.

Some examples are iron rusting, burning wood, cooking an egg, etc.

AUTOCATALYST

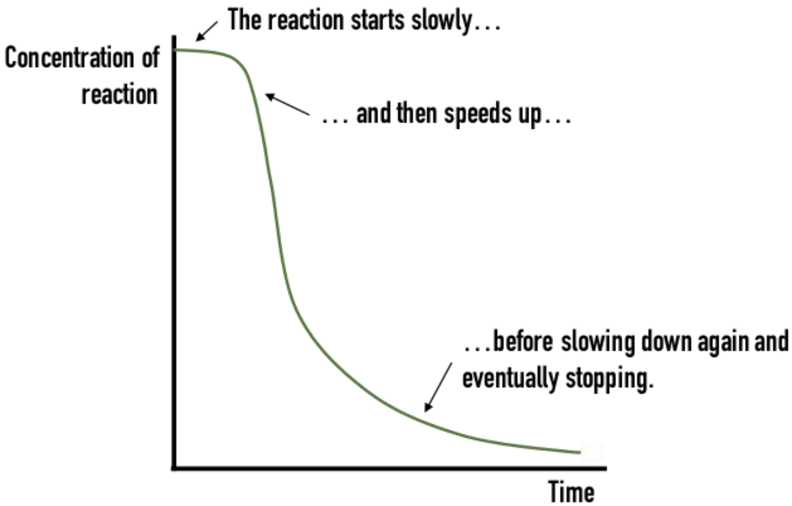
> Chemistry without catalysis would be a sword without a handle, a light without brilliance, a bell without sound.
>
> —Alwin Mittasch

Autocatalysis is the process by which a chemical compound induces and controls a chemical reaction on itself. Autocatalytic compounds are not catalysts in the strict sense since their chemical structure is altered during the process.

A reaction is autocatalytic when one of the products obtained acts as a catalyst for the process. In these cases, the speed law is not linear. At first, when there is little product (catalyst) the speed is slow. However, as it progresses, the speed accelerates reaching a maximum and then decreases as the amount of reagent does. This behavior produces the typical sigmoidal curve of autocatalytic reactions (note: autocatalytic reactions produce sigmoidal curves, but not all sigmoidal curves are produced by autocatalytic reactions).

> The concept of autocatalysis was introduced in 1890 by Ostwald and today it is successfully applied in various fields such as biology or economy to explain phenomena such as the evolution of population or genes (in

> economics one can speak of positive feedback). A catalyst is a substance that alters the velocity of a chemical reaction without appearing in the final products.
>
> —Wolfgang Ostwald



Examples:

- Photographic processing of silver halide film/paper
- DNA replication
- Binding of oxygen by hemoglobin
- The spontaneous degradation of aspirin into salicylic acid and acetic acid, causing very old aspirin in sealed containers to smell mildly of vinegar.

BIOLOGY

> I like to define biology as the history of the earth and all its life —past, present, and future. To understand biology is to understand that all life is linked to the earth from which it came; it is to understand that the stream of life, flowing out of the dim past into the uncertain future, is, in reality, a unified force, though composed of an infinite number and variety of separate lives.
>
> —Rachel Carson

Biology is the branch of science dealing with the study of life. It describes the characteristics, classification, and behaviors of organisms, how species come into existence, and the interactions they have with each other and with the environment.

Biology has many specialized areas, covering a wide range of scales, from biochemistry to ecology.

> Biology is engineering.
>
> —Daniel Dennett

Therefore, it is the natural science that studies life and living organisms, including their physical structure, chemical processes, molecular interactions, physiological mechanisms, development, and evolution.

BIOLOGY MODELS

The models of biology will detail how humans and other animals are wired. What determines our behavior and our relationships.

- Modern Darwinian Synthesis
- Incentives
- Scarcity
- Cooperation
- Adaptation
- Replication
- Hierarchical and Other Organizing Instincts
- Self-Preservation Instincts
- Resilience
- The Red Queen Effect
- Ecosystems
- Niches

MODERN DARWINIAN SYNTHESIS

> I have called this principle, by which each slight variation, if useful, is preserved, by the term of Natural Selection.
>
> —Charles Darwin

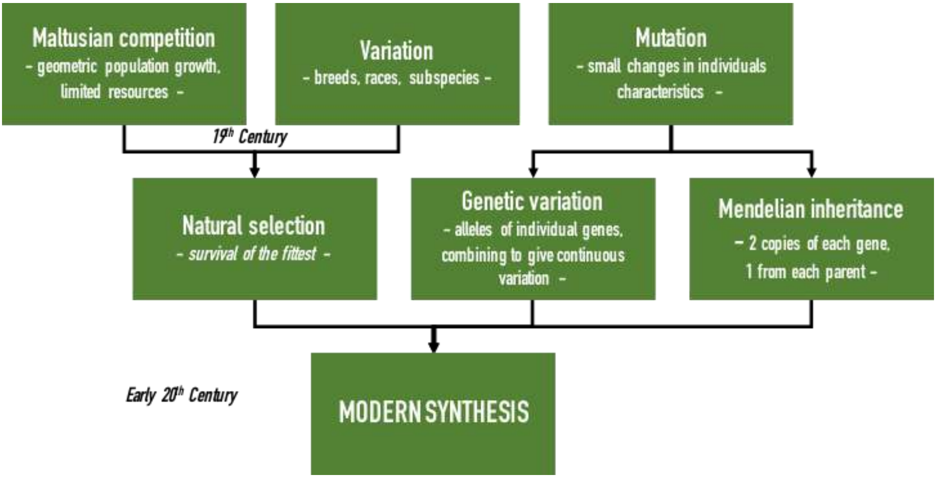
The Modern Synthesis is the integration of Charles Darwin's theory of the evolution of species by natural selection, Gregor Mendel's genetic theory as the basis of genetic inheritance, random mutation as a source of variation, and population genetics. This stream of thought regarding evolution originated between 1937 and 1950, incorporating genetics, systematics, and paleontology as relevant evidence for evolutionary theory.

Modern Synthesis was elaborated by Dobzhansky, Simpson, Mayr, Huxley, etc., based on genetic variability and natural selection, aspects provided by Darwinian theory, but with some modifications mainly due to the novel knowledge about genetics, ecology.

Thus, this theory of evolution refers to Darwinism, especially to natural selection, to discoveries about heredity driven by genetics. Once in Darwin's time the concepts of genetics were not known, which could not explain how the diversity of characteristics occurs within a population.

> Therefore, it was necessary that a new evolutionary theory, reinterpreting Darwinism, was able to answer these questions. The synthetic theory of evolution is based on three aspects of evolution: mutation, recombination, and natural selection. Nothing in biology makes sense except in the light of evolution.
>
> —Theodosius Dobzhansky

According to this theory, the evolutionary process is based on the genetic variability of populations, caused by the appearance of Mutations. Mutation is the main cause of heritable variability. Although most of these are harmful, some are neutral to the individual in the environment in which he lives. These mutations will remain in your DNA and will be passed on to your descendants, leading to differences between individuals. It is likely that under new conditions (e.g. environmental changes) an existing mutation will now be beneficial for individuals who will be more developed compared to the rest of the population. The recombination of genes in sexual reproduction does not originate new alternatives for a gene but, from the alternatives generated in the mutation, they can give rise to new combinations


Maltusian competition
- geometric population growth, limited resources -
Variation
- breeds, races, subspecies -
Mutation
- small changes in individuals characteristics -
19th Century
Natural selection
- survival of the fittest -
Genetic variation
- alleles of individual genes, combining to give continuous variation -
Mendelian inheritance
– 2 copies of each gene, 1 from each parent -
Early 20th Century
MODERN SYNTHESIS

INCENTIVES

> Show me the incentive and I'll show you the outcome.
>
> —Charlie Munger

An incentive is a mechanism that relates a reward or punishment to a certain performance or behavior.

The objective of establishing an incentive is to induce a certain behavior. It is assumed that the subject to which it is applied will act as a rational agent evaluating costs and benefits (homo economicus).

Therefore, the objective subject will consider optimal to develop the behavior that the designer of the incentive seeks, provided that said stimulus is well designed.

Thus, for example, if you want to motivate a worker to try harder, you can design an incentive that rewards their best effort. If it is a salesperson, a common incentive is to share in the highest sales through commissions.

TYPES OF INCENTIVES

There are at least four types of incentives:

- **Monetary or financial incentives**: They are the most widely used and surely one of the most effective. They can include a higher salary, payment of sales commissions, prices in money or stocks, etc.

- **Moral incentives**: They try to push people to do what is supposed to be right or good in a given society. Moral incentives are more complex to apply than monetary ones as values vary between different cultures. Furthermore, it is the person who ultimately decides whether or not she agrees with a certain moral convention.

- **Natural incentives**: They are based on human nature itself. Thus, for example, people in general are naturally curious so they can be motivated to do certain things in order to satisfy these natural needs.

- **Coercive incentives**: They are based on emphasizing the negative consequences or punishments that will not carry out a certain conduct or behavior. These are incentives that are based on the negative and therefore do not usually motivate subjects internally, and they only act out of fear.

Human action is often governed by incentives, many of which exist at the unconscious level. Every time a person performs a certain activity, they do so for a purpose that, in one way or another, will bring satisfaction. This end is the incentive that mobilizes action.

The incentive can be the stimulation that is given to an individual for her good performance in any field (work, affective, etc.) with the intention of making an effort to maintain it. It is, therefore, a reward.

Our daily life usually presents a few incentives, of different magnitudes, that drive us to keep going. When a child strives to achieve good school performance, not only does she seek her own personal and intellectual development, but she is also likely to crave the reaction of her parents or guardians, the satisfaction and pride in their looks. Just as in operant conditioning, where behaviors are performed in order to either gain reinforcement or avoid punishment, incentive theory states that our actions are directed toward gaining rewards. Money is also an excellent example of an external reward that motivates behavior.

SCARCITY

> Economics is the study of how society manages its scarce resources.
>
> —Greg Mankiw

The scarcity law or scarcity principle is a natural law that arises from the insufficiency of various resources (whether material or natural) considered necessary and fundamental for human beings, giving the necessary condition to prioritize needs based on the available budget.

The scarcity principle is one that indicates that since people's needs are unlimited, resources become scarce. In this way, it is not possible to satisfy all the needs and we will always have to choose between several alternatives, in which we want to spend our resources.

In other words, the scarcity principle indicates that resources are insufficient to produce all goods and services to satisfy people's needs.

In order to manage resources, in economics, prices are used as a tool to carry out transactions. In socialist economies prices are set by the state and in capitalist economies prices are determined by the law of supply and demand. The law of scarcity determines which goods are scarce - whose supply is not sufficient to meet their demand - and therefore must be rationed, usually increasing their price. Although there may be another variable that allows adjusting supply and demand.

It is the characteristics of the demand that contribute to define the scarcity of a resource. In other words, its deficiency is not defined by its quantity, but rather responds to a situation in which the expected future demand exceeds the expected supply, resulting in a situation of surplus in the resource in question. The causes are:

- Increase in demand.
- Decrease or depletion of sources and / or resources.

Such a mismatch between supply and demand implies that the prices of the good in question increase until these indicators—the supply and demand already mentioned—reach a new level of equilibrium. Therefore, price fluctuations would be indicators of relative scarcity.

The lack of a resource then occurs in economic terms when the short-term elasticity of demand is close to zero. In fact, a shortage situation arises when a low elasticity of demand is associated with a price elasticity of supply that is also close to zero.

Overcoming this situation will depend on the possibilities of replacing the product or finding alternative sources capable of responding quickly to the increase in demand. In both cases the possibilities rest on the scientific-technological capacities of society and the facilities for their practical application.

COOPERATION

> The theory of evolution is based on the struggle for life and the survival of the fittest. Yet cooperation is common between members of the same species and even between members of different species.
>
> —Robert Axelrod

Cooperation is the set of actions and efforts that, together with another or several other individuals, we carry out with the objective of reaching a common goal. The word, as such, comes from the Latin *cooperatĭo*, *cooperatiōnis*.

> In the ecological field, and in other natural sciences, such as biology, cooperation is known as the collaborative relationship that is established within a population of individuals of the same species in order to achieve common objectives, generally linked to protection against external threats and hunting. What makes the existence and the evolution of society possible is precisely the fact that peaceful cooperation under the social division of labor, in the long run, best serves the selfish concerns of all individuals. The eminence of the market society is that its whole functioning and operation is the consummation of this principle.
>
> —Ludwig Von Mises

Cooperation (sometimes written as co-operation) is the process of groups of organisms working or acting together for common, mutual, or some underlying benefit, as opposed to working in competition for selfish benefit. Many animal and plant species cooperate both with other members of their own species and with members of other species (symbiosis or mutualism).

This process contrasts with an intragroup competition where individuals work against each other for selfish reasons. Cooperation exists not only in humans but in other animals as well. The diversity of taxa that exhibits cooperation is quite large, ranging from zebra herds to pied babblers to African elephants. I speculate that we shall come to accept the more radical idea that each one of our genes is a symbiotic unit.

> We are gigantic colonies of symbiotic genes.
>
> —Richard Dawkins

Symbiosis is a concept of Biology that refers to the type of association established between two individuals, whether animal or vegetable and from which at least one of them benefits. As such, the word is composed of the Greek roots *σύν* (sýn) *with*, and *βίωσις* (biosis), *livelihoods*.

In this sense, symbiosis is a relationship that occurs between two symbionts, denomination that is applied to the organisms involved in this type of link.

Symbiosis can be of several types: mandatory, when it is essential for the survival of one or both species, or optional, when, despite not ceasing to be beneficial, it is not essential for survival. Also, its duration may vary and be both permanent and temporary.

Their classification varies depending on where the symbiosis occurs: *ectosymbiosis*, when one of the individuals lives on another, or *endosymbiosis* when one of the species lives within the other.

A classic example of necessary symbiosis are lichens, formed by the union of a fungus and single-celled algae, and found on rocks or in the bark of trees.

Another example is *mycorrhizas*, which are the symbiosis between the roots of certain plants and certain fungi since the roots benefit from the nutrient absorption capacity of fungi, and fungi obtain from the plant the substances it needs to live.

An interesting type of symbiosis is that between a bull, for example, and the bacteria and protozoa that live in its stomach. The latter provide the bull with the ability to digest the cellulose that the herbs it feeds on, while the bacteria and protozoa feed on them. We humans have in our intestinal flora organisms that do similar work for us, living in symbiosis.

This cooperation model is also related to the Prisoner's Dilemma, seen in the Game Theory model of the Statistics section, it being a specific type of cooperation.

EVOLUTION OF COOPERATION

- Genetic Evolution
    - Lewontin: Cooperation is more adaptive than competition.
    - Lynn Margulis: Evolution was primarily through symbiosis.
    - Tomasello: Children begin cooperative, but adjust socially.

- Strategic Evolution
    - Game theory, win/lose, prisoner's dilemma, etc.
    - Robert Axelrod: *The Evolution of Cooperation.*

- Cultural Evolution
    - Hunter/Gatherer era: The most cooperative and conciliatory people prevailed and prospered.
    - Agricultural era: Boundaries and the private property changed mindset to win-lose (competition).
    - Knowledge era: The more I share with others, the more we all benefit, including myself (*The Third Side* —William Ury).

ADAPTATION

> It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is most adaptable to change.
>
> —Charles Darwin

Within evolutionary theory, evolutionary adaptation is defined as a biological mechanism through which organisms adjust to changes in their environment through morphological, physiological, behavioral and molecular modifications, which make them more suitable for their existence.

In fact, the word indicates this, since the term *adaptation* comes from the Latin *adaptō* which means *I adjust to*. Not all adaptations are completely positive, and for it to be transmitted from generation to generation and persist in the population, reproductive success must be increased.

In addition, there are numerous characteristics of the species that have not been developed to better transmit genetic material and that, therefore, are not adaptations, but are pure coincidences. The following definitions are given by the evolutionary biologist Theodosius Dobzhansky:

1. Adaptation is the evolutionary process whereby an organism becomes better able to live in its habitat or habitats.

2. Adaptedness is the state of being adapted: the degree to which an organism is able to live and reproduce in a given set of habitats.

3. An adaptive trait is an aspect of the developmental pattern of the organism, which enables or enhances the probability of that organism surviving and reproducing.

REPLICATION

> In a universe of blind physical forces and genetic replication, some people are going to get hurt, other people are going to get lucky, and you won't find any rhyme or reason in it, nor any justice.
>
> —Richard Dawkins

The basic unit of information in living beings is the gene, defined in eukaryotic cells as a segment of DNA that carries the information necessary for the synthesis of a protein or of an RNA. The quantity, size and distribution of genes varies according to the species analyzed. In humans, the number of genes that code for proteins is estimated to be only 3% of DNA; the rest being regulatory and structural sequences.

The understanding of the storage mechanisms and the forms of use of the information has served to clarify many of the unknowns raised about the structure and cell function. The cell carries out this activity through the pathways of genetic information; These pathways constitute the fundamental principle of molecular genetics.

There are three processes called:

a) Replication or copying of paternal DNA to form daughter DNA molecules identical to their parent, and identical to each other.

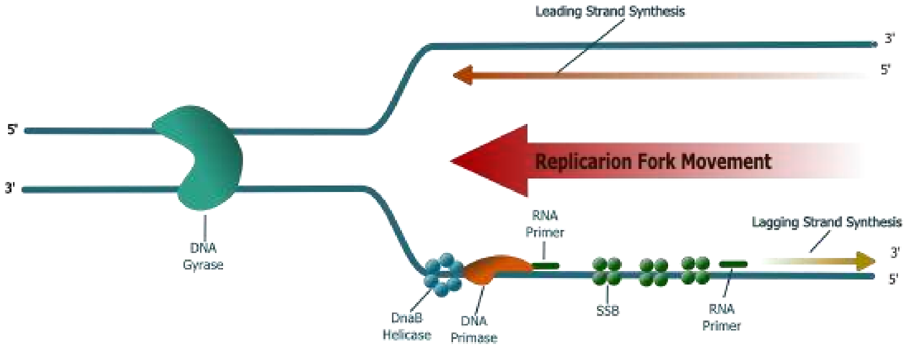
b) Transcription or copying of information from a part of DNA to RNA molecules.

c) Translation or copying of the genetic information of the RNA to the specific amino acid sequence of a protein.

DNA replication is the process by which a DNA molecule is duplicated. When a cell divides, it must first duplicate its genome so that each daughter cell contains a complete set of chromosomes.

One of the most remarkable characteristics of DNA is its ability to replicate; In other words, it has the ability to form copies of itself. Replication takes place in the synthesis (S) phase of the cell cycle. This stage is an obligatory step to carry out cell division. Therefore, it is determined that genetic information is transferred from one cell to another through the process of DNA replication.

The goal of replication is to conserve genetic information. The structural representation of DNA in a double helix allows us to understand how this molecule can give rise to other identical ones, without losing its conformation. In principle, the two strands should be separated and then, by the action of an enzyme, add deoxyribonucleotides and, depending on base complementarity, construct DNA from the two initial template strands.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SSB
RNA
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HIERARCHICAL AND OTHER ORGANIZING INSTINCTS

> Life is not found in atoms or molecules or genes as such, but in organization; not in symbiosis but in synthesis.
>
> —Edwin Grant Conklin

We know that everything begins with the cell and that for some species it ends with a cell, but for others, cells come together to form tissues, tissues that form organs, organs that form organic systems, and organic systems combine to form an organism.

The living world can be organized on different levels. For example, many individual organisms can be organized into the following:

- Cell: Basic unit of structure and function of all living things.
- Tissue: Group of cells of the same type.
- Organs: Structure composed of one or more types of tissue. The tissues of an organ work together to fulfill a specific function.
- Organic System: Group of organs that work together to fulfill a certain function.

- Organism: individual living being that can be composed of one or more organic systems.

> This implies that the laws governing organic cohesion, the organization leading from the part to the whole, represent a biological uncertainty, indeed an uncertainty of the first order.
>
> —Walter Rudolf Hess

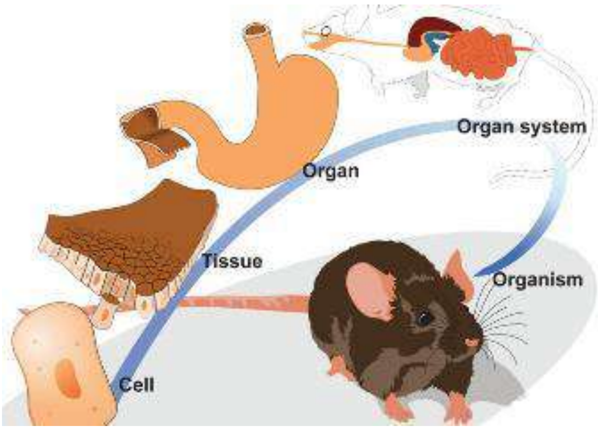
For example, a mouse is only made up of several organ systems. The system shown here is the digestive system, which separates food into a shape that a cell can use. One of the organs of the digestive system is the stomach. The stomach, for its part, is made up of different types of tissue and each type of tissue is made up of cells of the same type.

There are also levels of organization beyond the organism alone.

- Organisms of the same species that live in the same area form a population. For example, all goldfish living in the same area form a goldfish population.

- All populations living in the same area form a community. This includes the population of goldfish, other fish, corals, and other organisms.

- An ecosystem is made up of all living things in a specific area, along with the inert environment. The inert environment includes water, sunlight, and other physical factors.



- A group of similar ecosystems with the same type of physical environment is called a biome.

- The biosphere is the part of the Earth where all life exists, including the land, and the air where living things can be found. The biosphere is made up of many different biomes.

SELF-PRESERVATION INSTINCTS

> Self-preservation is the first law of nature.
>
> —Samuel Butler

Self-preservation is the organism's tendency to stay alive despite other demands that, if unconditionally satisfied, would lead to its destruction.

Thus, the survival instinct is the intrinsic ability that all living beings have to overcome aggressions or changes in the environment, external or internal, in order to remain alive and, therefore, to preserve the species.

Fear and pain are parts of this process. Fear causes the body to seek security and can cause a release of adrenaline that has the effect of increasing strength and enhancing the senses such as hearing, smell and sight. The pain causes discomfort so the body is inclined to stop the pain.

> The strongest human instinct is self-preservation.
>
> —Iris Watts

It is the main instinct of living beings, the process by which an organism protects itself from being damaged or killed.

Self-preservation is related to reproductive aptitude, another of the basic instincts, being more or less present according to the perceived reproductive potential. If the reproductive instinct is low enough, self-destructive behavior is not uncommon in social species.

Self-preservation is also often thought to be the foundation of rational and logical thinking and behavior.

RESILIENCE

> A good half of the art of living is resilience.
>
> —Alain De Botton

Ecological resilience is the ability of an ecological system to recover its properties after being altered by a disturbance.

It is a concept also used in physical sciences that study the behavior of systems, such as the resilience to natural catastrophes of the system that provides energy to society, or even materials, such as subject to deformation.

The term resilience then refers to the capacity of an ecosystem to respond to some type of disturbance, and in turn, a measure of how quickly it recovers.

Ecological systems that are resilient often use a diverse set of strategies and methods to cope with and adapt to change.

Thus, an ecosystem will have more resilience capacity to environmental changes to the same extent that it has two key factors: biodiversity and functional redundancy, the latter concept being understood as the ability of some species within the ecosystem to assume the functions of others.

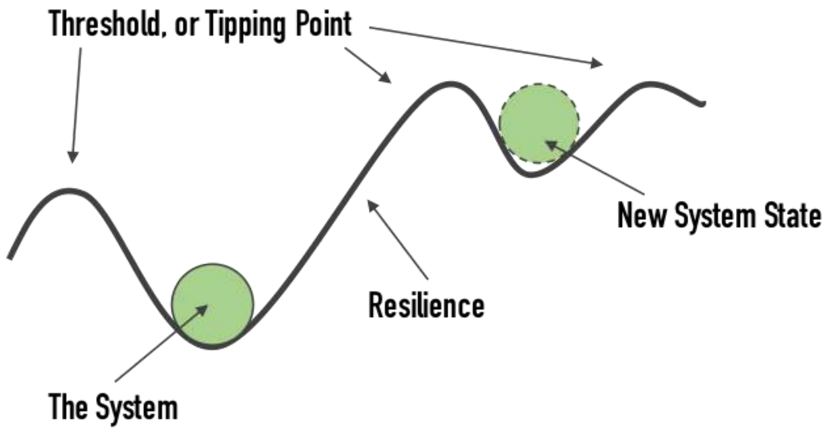
For ecological systems, biodiversity and functional redundancy can help the ecosystem to be more resilient to environmental changes. For example, reef communities with functional redundancy may have a better chance of recovery if a species is lost from a functional group.

Another characteristic of resilience has to do with how to respond to events that occur. There is research that establishes that the system subjected to disturbances can react in two ways:

- Vigorously. That is, the ability to withstand different disturbance factors before radically modifying their structures and operation.

- In a purposeful way. This is understood as an ability to develop new mechanisms that allow it to maintain its characteristics and functions to guarantee continuity in the face of crises that may arise.

Life itself depends on resilience, on adaptation to new scenarios. The processes of change are constant and nothing can remain static and unperturbed. Both the human being and other natural, sociological, cultural and economic systems are constantly subjected to disturbances that put their capacities to the test.


Threshold, or Tipping Point
New System State
Resilience
The System

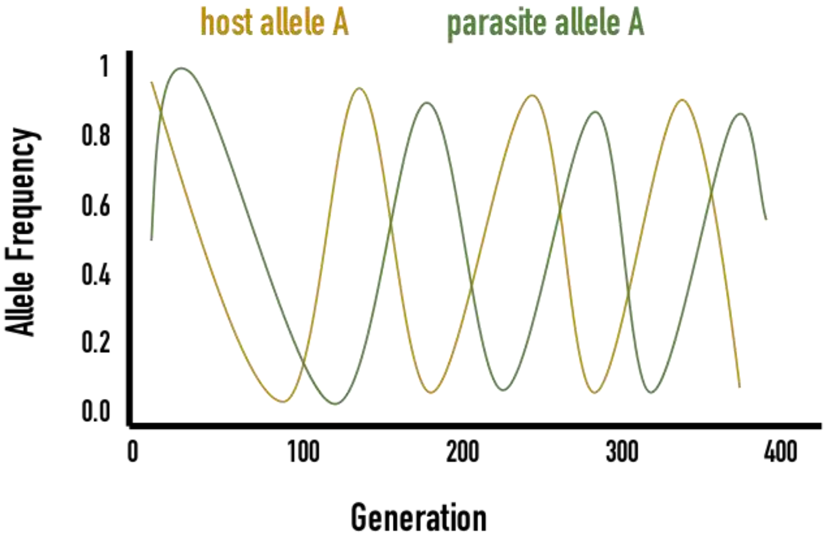
THE RED QUEEN EFFECT

> Now, here, you see, it takes all the running you can do, to keep in the same place. If you want to get somewhere else, you must run at least twice as fast as that!
>
> —Red Queen. Lewis Carroll's Through the Looking-Glass

It is the phrase that begins this chapter that refers to what would later become known as the Red Queen Hypothesis. In 1973, Leigh Van Valen, an American evolutionary biologist, was the first in this evolutionary hypothesis, which describes that a continuous improvement of the species is necessary, only with the objective of maintaining their status quo with the environment, to compensate for the losses of competitive efficiency derived from the evolution of the other species and thus try to avoid becoming extinct.

Every improvement in a competitor for resources, in the attack mechanisms of the predator or in those of defense of a prey has to be immediately compensated for the contrary.

Only by continually evolving can species delay an extinction that, on the other hand, ends up being inevitable. We could generalize this principle in terms of the need for ecosystems and individuals to be continuously offering resistance to the flow of energy in order to maintain their structure and not end up degrading under the effects of the second law of thermodynamics. This effect can occur in several industries, and there are methods to escape from it, as is the network effect, as we will see below.



THE DIGITAL BUSINESS & CLOUD ADVANTAGE: NETWORK EFFECTS VS. RED QUEEN

- **The Red Queen Effect:** Digital ecosystems must constantly adapt, evolve, and proliferate not merely to gain market advantage, but also simply to survive while pitted against ever-evolving opposing competitors in an ever-changing environment.

- **The Network Effect:** The effect that one user of a good or service has on the value of that product to other people. When a network effect is present, the value of a product or service is dependent on the number of others using it. Network effects are a power law, meaning they are highly exponential in terms of value creation and potential to create winner-takes-all outcomes.

ECOSYSTEMS

> Evolution cannot be understood except in the frame of ecosystems.
>
> —Ramon Margalef

In biology, an ecosystem is a system that is made up of a set of organisms, the physical environment in which they live (habitat) and the biotic and abiotic relationships that are established between them. The species of living beings that inhabit a certain ecosystem interact with each other and with the environment, determining the flow of energy and matter that occurs in that environment.

There is a great diversity of ecosystems on the planet. They are all made up of biotic factors (living beings) and abiotic factors (non-living elements, such as soil or air). There are also different types of ecosystems: there are marine, terrestrial, microbial and artificial, among other examples.

An example of the relationships that take place between living things in an ecosystem are food relationships. The trophic or food chains are simple representations of the food relationships that exist between the species that are part of a given ecosystem. In general, in ecosystems, food chains interrelate to form food webs.

Thereby, starting from the basis that an ecosystem is the set of organisms in a community and its environment, we can define various types of living beings that compose them. Looking at the trophic chain, we would first find the primary producers, those that are capable of producing organic matter from inorganic compounds, that is, they are autotrophic organisms. Following the food chain, we find in the second step the consumers, heterotrophic organisms (herbivores, carnivores or omnivores) that feed on matter and energy manufactured by other living beings. In the last link of the trophic chain of organisms that make up an ecosystem we find decomposers, those that feed on dead organic matter.

It is said that there is a trophic relationship between two organisms when one of them is consumed by the other. In turn, the consuming organism can be the food of another that is part of the same ecosystem. Thus, a connection is formed between several links and a food chain is formed. Each of the links in a chain represents an organism that *eats another* or *is eaten by another*.

> I find it quite useful to think of a free-market economy—or partly free market economy—as sort of the equivalent of an ecosystem. Just as animals flourish in niches, people who specialize in some narrow niche can do very well.
>
> —Charlie Munger

The concept of ecosystem should not be confused with that of biome. A biome is an area or geographic region of planet Earth that is characterized by its climate, topography, and biodiversity. Unlike ecosystems, biomes are considered homogeneous geographic units. The same biome can contain several ecosystems.

NICHES

> If everybody is doing it one way, there's a good chance you can find your niche by going exactly in the opposite direction.
>
> —Sam Walton

The ecological niche is the survival strategy used by a species, which includes the way to feed, to compete with others, to hunt, to avoid being eaten. Therefore, it is the function of a species—animal or plant—within the ecosystem.

The ecological niche is a broad concept. It does not refer only to the physical space, but to the functional role of an organism in the community and its position within the environmental variables (temperature, humidity, pH, soils). That is, how a species acts under certain environmental conditions of the habitat and under the influence of other species.

This means that within the same habitat, such as, for example, the trees in a forest, there are various ecological niches. The ecological niche would be the functional or relational position that a species would occupy in a habitat, that is, the ecological niche is how a species acts under certain environmental conditions controlled by the habitat and under the influence of other species. It would be something like the specialized profession that each species performs in an ecosystem: if the plants on which they feed are herbivores, where they live ...

For example, deer occupy the ecological niche to feed on the understory and part of the trees, the birds that inhabit it can inhabit the ecological niche of the tree canopy, and they occupy the same habitat but their ecological niche is different, their ecology is different: they feed on different things, they live in different parts of the tree, ...

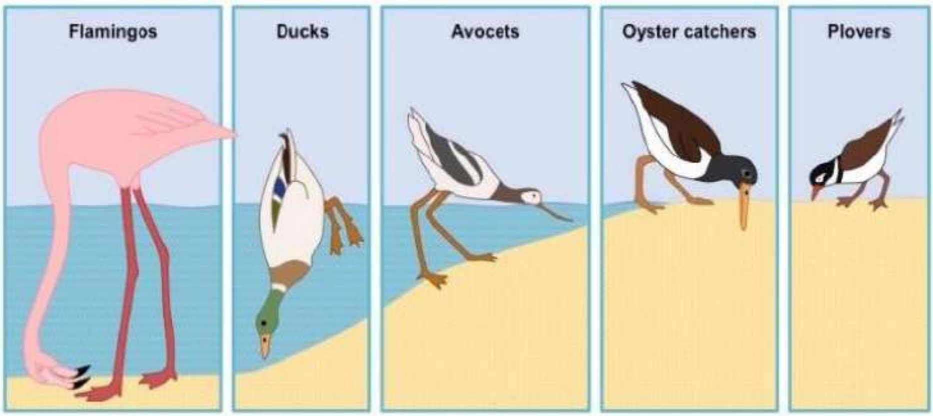
In a pond, there would be the invertebrates that live among the reeds, the invertebrates that live at the bottom of the ponds such as the *trichoptera* or *phygáneas*, or those that inhabit the surface. Inside the pond there would be different ecological niches as can be seen in the examples mentioned: surface water, bottom of the pond, reeds ...

One species can feed on another that occupies a different ecological niche (e.g., lions and zebras). It is also possible that different species occupy the same ecological niche.

The ecological niche is divided into fundamental niche and effective niche.

- The fundamental niche or potential ecological niche depends on the potentialities of the species, that is, it depends on what a species is capable of feeding (for example) without taking into account the interactions with other species.
- The effective niche or real ecological niche is the set of conditions and resources that allows a species to

maintain a viable population even with predators and competitors. The interaction with other species delimits the volume of the niche.



PSYCHOLOGY

> Our comforting conviction that the world makes sense rests on a secure foundation: our almost unlimited ability to ignore our ignorance.
>
> —Daniel Kahneman

Psychology is a discipline that aims to analyze the mental and behavioral processes of human beings and their interactions with the physical and social environment.

The word *psychology* comes from the Greek *psycho* or *psykhé*, which means *soul*, *psyche* or *mental activity*, and from *logy*, which means *study'*or *treatise'*. Therefore, psychology means study or treatise on the psyche.

A cognitive bias is a systematic misinterpretation of available information that influences the way we process thoughts, make judgments, and make decisions. The concept of cognitive bias was introduced by Israeli psychologists Daniel Kahneman and Amos Tversky in 1972.

> The confidence people have in their beliefs is not a measure of the quality of evidence but of the coherence of the story, the mind has managed to construct.
>
> —Daniel Kahneman

The brain represents only 2-3% of our body weight, yet it uses approximately 20% of our energy. It is a rather *expensive* organ that constantly seeks to save energy by avoiding a high cognitive load. It is precisely because of this factor that many neuroscientists say that he is a *cognitive bum*.

This behavior of the brain directly affects our daily decision-making, which is not done in as rational a way as we like to believe, but rather, in many cases, relies on heuristics, procedures that help us when solving a problem. They are mental shortcuts, intuitive judgments that are based on partial knowledge, experience or assumptions that allow us to be more agile and that, therefore, can be useful when making a decision. However, these heuristics can lead us to incorrect judgments. It is then when these biases occur, cognitive errors that can make us act in an irrational way. Psychologists Daniel Kahneman, Paul Slovic, and Amos Tversky introduced the concept of psychological bias in the early 1970s. They published their findings in their 1982 book, *Judgment Under Uncertainty*.

> Nothing in life is as important as you think it is, while you are thinking about it.
>
> —Daniel Kahneman

During the 19th century, human decision-making was held to be essentially rational, with a hyper-maximizing human being making near-perfect cost-benefit assessments for every decision. However, beginning in 1971 Tversky and Kahneman published scientific papers arguing that most important human decisions are based on a limited number of heuristic principles and not on a formal analysis of the problem, thus contradicting the rational model of decision-making in force at that time.

The proposed new approach gave rise to a flood of new research in psychology and also extended to other fields of research such as economics, law, sociology, medicine or political science. All this research was key to the psychologist Daniel Kahneman receiving the Nobel Prize in economics in 2002.The enormous impact on our behavior and the youth of these discoveries that have given rise to the emerging field of knowledge known as *Behavioral Economics*, which is in its infancy, make this section the most important in the book.

It will not help us to know the rest of the models, *how things work* if we fall into biases, and make irrational decisions.

The path started by Kahneman and Tversky towards the search for rationality has just begun, and we don't know where it will take us. At the moment, in the first decades of study, it has meant a revolution, no longer in psychology, but in economics and decision making, recognized worldwide when in 2002, Daniel Kahneman becomes the first non-economist to receive the *Nobel of Economics*. Kahneman is a psychologist.

Knowing that we are not rational, that we are biologically *wired* to not be, changes everything.

From this moment, the economics, unable to explain the real decisions of citizens and economic cycles, is forced to rely on psychology, which in turn relies on evolutionary biology and neuroscience to give birth to an emerging research field that has turned science upside down.

Charlie Munger, as always, already knew the importance of these biases, which he exposes in the magnum opus speech *Psychology of Human Misjudgment* at *Harvard Law School* circa Jun 1995 and expanded in the monumental *Poor Charlie's Almanack*.

We include the full text of the book, since the publisher has kindly given us permission to do so, which we greatly appreciate.

The only inclusion that has been made from the original text is to include a quote from a relevant person in the beginning of each model, that helps and remember the main idea of each model.

Poor Charlie's Almanack is without any doubt one of the most valuable books that exist, and therefore its purchase is practically a must for anyone who wants to improve their life.

THE PSYCHOLOGY OF HUMAN MISJUDGEMENT, BY CHARLES T. MUNGER

PREFACE

When I read transcripts of my psychology talks given about fifteen years ago, I realized that I could now create a more logical but much longer "talk," including most of what I had earlier said. But I immediately saw four big disadvantages.

First, the longer "talk," because it was written out with more logical completeness, would be more boring and confusing to many people than any earlier talk. This would happen because I would use idiosyncratic definitions of psychological tendencies in a manner reminiscent of both psychology textbooks and Euclid. And who reads textbooks for fun or revisits Euclid?

Second, because my formal psychological knowledge came only from skimming three psychology textbooks about fifteen years ago, I know virtually nothing about any academic psychology later developed. Yet, in a longer talk containing guesses, I would be criticizing much academic psychology. This sort of intrusion into a professional territory by an amateur would be sure to be resented by professors who would rejoice in finding my errors and might be prompted to respond to my published criticism by providing theirs. Why should I care about new criticism? Well, who likes new hostility from articulate critics with an information advantage?

Third, a longer version of my ideas would surely draw some disapproval from people formerly disposed to like me. Not only would there be stylistic and substantive objections, but also there would be perceptions of arrogance in an old man who displayed much disregard for conventional wisdom while "popping-off" on a subject in which he had never taken a course. My old Harvard Law classmate, Ed Rothschild, always called such a popping-off "the shoe button complex," named for the condition of a family friend who spoke in oracular style on all subjects after becoming dominant in the shoe button business.

Fourth, I might make a fool of myself. Despite these four very considerable objections, I decided to publish the much-expanded version. Thus, after many decades in which I have succeeded mostly by restricting action to jobs and methods in which I was unlikely to fail, I have now chosen a course of action in which (1) I have no significant personal benefit to gain, (2) I will surely give some pain to family members and friends, and (3) I may make myself ridiculous. Why am I doing this?

One reason may be that my nature makes me incline toward diagnosing and talking about errors in conventional wisdom. And despite years of being smoothed out by the hard knocks that were inevitable for one with my attitude, I don't believe life ever knocked all the boy's brashness out of the man.

A second reason for my decision is my approval of the attitude of Diogenes when he asked: "Of what use is a philosopher who never offends anybody?"

My third and final reason is the strongest. I have fallen in love with my way of living out psychology because it has been so useful for me. And so, before I die, I want to imitate to some extent the bequest practices of three characters: the protagonist in John Bunyan's Pilgrims Progress, Benjamin Franklin, and my first employer, Ernest Buffett. Bunyan's character, the knight wonderfully named "Old Valiant for Truth," makes the only practical bequest available to him when he says at the end of his life: "My sword I leave to him who can wear it." And like this man, I don't mind if I have misappraised my sword, provided I have tried to see it correctly, or that many will not wish to try it, or that some who try to wield it may find it serves them not. Ben Franklin, to my great benefit, left behind his autobiography, his Almanacks, and much else. And Ernest Buffett did the best he could in the same mode when he left behind "How to Run a Grocery Store and a Few Things I Have Learned about Fishing." Whether or not this last contribution to the genre was the best, I will not say. But I will report that I have now known four generations of Ernest Buffett's descendants and that the results have encouraged my imitation of the founder.

I have long been very 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. Those institutions failed to require knowledge of the subject. And, of course, they couldn't integrate psychology with their other subject matter when they didn't know psychology. Also, like the Nietzsche character who was proud of his lame leg, the institutions were proud of their willful avoidance of "fuzzy" psychology and "fuzzy" psychology professors.

I shared this ignorant mindset for a considerable time. And so did a lot of other people. What are we to think, for instance, of the Caltech course catalogue that for years listed just one psychology professor, self-described as a "Professor of Psychoanalytical Studies," who taught both "Abnormal Psychology" and "Psycho-analysis in Literature"?

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. After that, I will give examples, many quite vivid and interesting to me, of both psychology at work and antidotes to psychology-based dysfunction. Then, I will end by asking and answering some general questions raised by what I have said. This will be a long talk.

When I started law practice, I had respect for the power of genetic evolution and appreciation of man's many evolution-based resemblances to less cognitively-gifted animals and insects. I was aware that man was a "social animal," greatly and automatically influenced by behavior he observed in men around him. I also knew that man lived, like barnyard animals and monkeys, in limited size dominance hierarchies, wherein he tended to respect authority and to like and cooperate with his own hierarchy members while displaying considerable distrust and dislike for competing men not in his own hierarchy.

But this generalized, evolution-based theory structure was inadequate to enable me to cope properly with the cognition I encountered. I was soon surrounded by much extreme irrationality, displayed in patterns and subpatterns. So surrounded, I could see that I was not going to cope as well as I wished with life unless I could acquire a better theory-structure on which to hang my observations and experiences. By then, my craving for more theory had a long history. Partly, I had always loved theory as an aid in puzzle solving and as a means of satisfying my monkey-like curiosity. And, partly. I had found that theory structure was a superpower in helping one get what one wanted. As I had early discovered in school wherein I had excelled without labor, guided by theory, while many others, without mastery of theory, failed despite monstrous effort. Better theory, I thought, had always worked for me and, if now available, could make me acquire capital and independence faster and better assist everything I loved. And so I slowly developed my own system of psychology. More or less in the self-help style of Ben Franklin and with the determination displayed in the refrain of the nursery story: "`Then I'll do it myself,' said the little red hen."

I was greatly helped in my quest by two turns of mind. First, I had long looked for insight by inversion in the intense manner counseled by the great algebraist, Jacobi: "Invert, always invert." I sought good judgment mostly by collecting instances of bad judgment, then pondering ways to avoid such outcomes. Second, I became so avid a collector of instances of bad judgment that I paid no attention to boundaries between professional territories. After all, why should I search for some tiny, unimportant, hard-to-find new stupidity in my own field when some large, important, easy-to find stupidity was just over the fence in the other fellow's professional territory? Besides, I could already see that real-world problems didn't neatly lie within territorial boundaries. They jumped right across. And I was as dubious of any approach that, when two things were inextricably intertwined and interconnected, would try and think about one thing but not the other. I was afraid, if I tried any such restricted approach, that I would end up, in the immortal words of John L. Lewis, "with no brain at all, just a neck that had haired over."

Pure curiosity, somewhat later, made me wonder how and why destructive cults were often able, over a single long weekend, to turn many tolerably normal people into brainwashed zombies and thereafter keep them in that state indefinitely. I resolved that I would eventually find a good answer to this cult question if I could do so by general reading and much musing.

I also got curious about social insects. It fascinated me that both the fertile female honeybee and the fertile female harvester ant could multiply their quite different normal life expectancies by exactly twenty by engaging in one gangbang in the sky. The extreme success of the ants also fascinated me-how a few behavioral algorithms caused such extreme evolutionary success grounded in extremes of cooperation within the breeding colony and, almost always, extremes of lethal hostility toward ants outside the breeding colony; even ants of the same species.

Motivated as I was, by midlife I should probably have turned to psychology textbooks, but I didn’t, displaying my share of the outcome predicted by the German folk saying: "We are too soon old and too late smart." However, as I later found out, I may have been lucky to avoid for so long the academic psychology that was then laid out in most textbooks. These would not then have guided me well with respect to cults and were often written as if the authors were collecting psychology experiments as a boy collects butterflies-with a passion for more butterflies and more contact with fellow collectors and little craving for synthesis in what is already possessed. When I finally got to the psychology texts, I was reminded of the observation of Jacob Viner, the great economist, that many an academic is like the truffle hound, an animal so trained and bred for one narrow purpose that it is no good at anything else. I was also appalled by hundreds of pages of extremely nonscientific musing about comparative weights of nature and nurture in human outcomes. And I found that introductory psychology texts, by and large, didn’t deal appropriately with a fundamental issue: Psychological tendencies tend to be both numerous and inseparably intertwined, now and forever, as they interplay in life. Yet the complex parsing out of effects from intertwined tendencies was usually avoided by the writers of the elementary texts. Possibly the authors did not wish, through complexity, to repel entry of new devotees to their discipline. And, possibly, the cause of their inadequacy was the one given by Samuel Johnson in response to a woman who inquired as to what accounted for his dictionary’s misdefinition of the word "pastern." "Pure ignorance," Johnson replied. And, finally, the text writers showed little interest in describing standard antidotes to standard psychology-driven folly, and they thus avoided most discussion of exactly what most interested me.

But academic psychology has some very important merits alongside its defects. I learned this eventually, in the course of general reading, from a book, Influence, aimed at a popular audience, by a distinguished psychology professor, Robert Cialdini, at Arizona State, a very big university. Cialdini had made himself into a super-tenured "Regents’ Professor" at a very young age by devising, describing, and explaining a vast group of clever experiments in which man manipulated man to his detriment, with all of this made possible by man's intrinsic thinking flaws.

I immediately sent copies of Cialdini's book to all my children. I also gave Cialdini a share of Berkshire stock [Class A] to thank him for what he had done for me and the public. Incidentally, the sale by Cialdini of hundreds of thousands of copies of a book about social psychology was a huge feat, considering that Cialdini didn't claim that he was going to improve your sex life or make you any money.

Part of Cialdini's large book-buying audience came because, like me, it wanted to learn how to become less often tricked by salesmen and circumstances. However, as an outcome not sought by Cialdini, who is a profoundly ethical man, a huge number of his books were bought by salesmen who wanted to learn how to become more effective in misleading customers. Please remember this perverse outcome when my discussion comes to incentive-caused bias as a consequence of the superpower of incentives.

With the push given by Cialdini's book, I soon skimmed through three much used textbooks covering introductory psychology. I also pondered considerably while craving synthesis and taking into account all my previous training and experience. The result was Munger's partial summary of the non-patient-treating, non-nature vs. Nurture weighing parts of nondevelopmental psychology. This material was stolen from its various discoverers (most of whose names I did not even try to learn), often with new descriptions and titles selected to fit Munger's notion of what makes recall easy for Munger, then revised to make Munger's use easy as he seeks to avoid errors.

I will start my summary with a general observation that helps explain what follows. This observation is grounded in what we know about social insects. The limitations inherent in evolution's development of the nervous-system cells that control behavior are beautifully demonstrated by these insects, which often have a mere 100,000 or so cells in their entire nervous systems, compared to man's multiple billions of cells in his brain alone.

Each ant, like each human, is composed of a living physical structure plus behavioral algorithms in its nerve cells. In the ant's case, the behavioral algorithms are few in number and almost entirely genetic in origin. The ant learns a little behavior from experiences, but mostly it merely responds to ten or so stimuli with a few simple responses programmed into its nervous system by its genes, sometimes walk round and round until they perish.

It seems obvious, to me at least, that the human brain must often operate counterproductively just like the ant's, from unavoidable oversimplicity in its mental process, albeit usually in trying to solve problems more difficult than those faced by ants that don't have to design airplanes.

Naturally, the simple ant behavior system has extreme limitations because of its limited nerve system repertoire. For instance, one type of ant, when it smells a pheromone given off by a dead ant's body in the hive, immediately responds by cooperating with other ants in carrying the dead body out of the hive. And Harvard's great E.O. Wilson performed one of the best psychology experiments ever done when he painted dead ant pheromone on a live ant. Quite naturally; the other ants dragged this useful live ant out of the hive even though it kicked and otherwise protested throughout the entire process. Such is the brain of the ant. It has a simple program of responses that generally work out all right, but which are imprudently used by rote in many cases.

Another type of ant demonstrates that the limited brain of ants can be misled by circumstances as well as by clever manipulation from other creatures. The brain of this ant contains a simple behavioral program that directs the ant, when walking, to follow the ant ahead, and when these ants stumble into walking in a big circle. The perception system of man clearly demonstrates just such an unfortunate outcome. Man is easily fooled, either by the cleverly thought out manipulation of man, by circumstances occurring by accident, or by very effective manipulation practices that man has stumbled into during "practice evolution" and kept in place because they work so well. One such outcome is caused by a quantum effect in human perception. If stimulus is kept below a certain level, it does not get through. And, for this reason, a magician was able to make the Statue of Liberty disappear after a certain amount of magician lingo expressed in the dark. The audience was not aware that it was sitting on a platform that was rotating so slowly, below man's sensory threshold, that no one could feel the acceleration implicit in the considerable rotation. When a surrounding curtain was then opened in the place on the platform where the Statue had earlier appeared, it seemed to have disappeared.

And even when perception does get through to man's brain, it is often misweighted, because what is registered in perception is in shockingness of apparent contrast, not the standard scientific units that make possible science and good engineering against often-wrong effects from generally useful tendencies in his perception and cognition.

A magician demonstrates this sort of contrast-based error in your nervous system when he removes your wristwatch without your feeling it. As he does this, he applies pressure of touch on your wrist that you would sense if it was the only pressure of touch you were experiencing. But he has concurrently applied other intense pressure of touch on your body, but not on your wrist, "swamping" the wrist pressure by creating a high-contrast touch pressure elsewhere. This high contrast takes the wrist pressure below perception.

Some psychology professors like to demonstrate the inadequacy of contrast-based perception by having students put one hand in a bucket of hot water and one hand in a bucket of cold water. They are then suddenly asked to remove both hands and place them in a single bucket of room temperature water. Now, with both hands in the same water, one hand feels as if it has just been put in cold water and the other hand feels as if it has just been placed in hot water. When one thus sees perception so easily fooled by mere contrast, where a simple temperature gauge would make no error, and realizes that cognition mimics perception in being misled by mere contrast, he is well on the way toward understanding, not only how magicians fool one, but also how life will fool one. This can occur, through deliberate human manipulation or otherwise, if one doesn’t take certain precautions.

Man's often wrong but generally useful psychological tendencies are quite numerous and quite different. The natural consequence of this profusion of tendencies is the grand general principle of social psychology: cognition is ordinarily situation dependent so that different situations often cause different conclusions, even when the same person is thinking in the same general subject area. With this introductory instruction from ants, magicians, and the grand general principle of social psychology; I will next simply number and list psychology-based tendencies that, while generally useful, often mislead. Discussion of errors from each tendency will come later, together with description of some antidotes to errors, followed by some general discussion. Here are the tendencies:

1. Reward and Punishment Superresponse Tendency
2. Liking/Loving Tendency
3. Disliking/Hating Tendency
4. Doubt/Avoidance Tendency
5. Inconsistency-Avoidance Tendency
6. Curiosity Tendency
7. Kantian Fairness Tendency
8. Envy/Jealous tendency
9. Reciprocation Tendency
10. Influence-from-Mere-Association Tendency
11. Simple, Pain-Avoiding Psychological Denial
12. Excessive Self-Regard Tendency
13. Overoptimism Tendency
14. Deprival-Superreaction Tendency
15. Social-Proof Tendency
16. Contrast-Misreaction Tendency

17. Stress-Influence Tendency
18. Availability-Misweighing Tendency
19. Use-It-or-Lose-It Tendency
20. Drug Misinfluence Tendency
21. Senescence-Misinfluence Tendency
22. Authority-Misinfluence Tendency
23. Twaddle Tendency
24. Reason-Respecting Tendency
25. Lollapalooza Tendency

REWARD AND PUNISHMENT SUPERRESPONSE TENDENCY

> If you would persuade, appeal to interest and not to reason.
>
> —Benjamin Franklin

I place this tendency first in my discussion because almost everyone thinks he fully recognizes how important incentives and disincentives are in changing cognition and behavior. But this is not often so. For instance, I think I've been in the top five percent of my age cohort almost all my adult life in understanding the power of incentives, and yet I've always underestimated that power. Never a year passes but I get some surprise that pushes a little further my appreciation of incentive superpower.

One of my favorite cases about the power of incentives is the Federal Express case. The integrity of the Federal Express system requires that all packages be shifted rapidly among airplanes in one central airport each night. And the system has no integrity for the customers if the night work shift can't accomplish its assignment fast. And Federal Express had one hell of a time getting the night shift to do the right thing. They tried moral suasion. They tried everything in the world without luck. And, finally, somebody got the happy thought that it was foolish to pay the night shift by the hour when what the employer wanted was not maximized billable hours of employee service but fault-free, rapid performance of a particular task. Maybe, this person thought, if they paid the employees per shift and let all night shift employees go home when all the planes were loaded, the system would work better. And, lo and behold, that solution worked.

Early in the history of Xerox, Joe Wilson, who was then in the government, had a similar experience. He had to go back to Xerox because he couldn't understand why its new machine was selling so poorly in relation to its older and inferior machine. When he got back to Xerox, he found out that the commission arrangement with the salesmen gave a large and perverse incentive to push the inferior machine on customers, who deserved a better result.

And then there is the case of Mark Twain's cat that, after a bad experience with a hot stove, never again sat on a hot stove, or a cold stove either.

We should also heed the general lesson implicit in the injunction of Ben Franklin in Poor Richard's Almanack: "If you would persuade, appeal to interest and not to reason." This maxim is a wise guide to a great and simple precaution in life: Never, ever, think about something else when you should be thinking about the power of incentives. I once saw a very smart house counsel for a major investment bank lose his job, with no moral fault, because he ignored the lesson in this maxim of Franklin. This counsel failed to persuade his client because he told him his moral duty, as correctly conceived by the counsel, without also telling the client in vivid terms that he was very likely to be clobbered to smithereens if he didn't behave as his counsel recommended. As a result, both client and counsel lost their careers. We should also remember how a foolish and willful ignorance of the superpower of rewards caused Soviet communists to get their final result as described by one employee: "They pretend to pay us and we pretend to work." Perhaps the most important rule in management is "Get the incentives right."

But there is some limit to a desirable emphasis on incentive superpower. One case of excess emphasis happened at Harvard, where B. F. Skinner, a psychology professor, finally made himself ridiculous. At one time, Skinner may have been the best-known psychology professor in the world. He partly deserved his peak reputation because his early experiments using rats and pigeons were ingenious, and his results were both counter-intuitive and important. With incentives, he could cause more behavior change, culminating in conditioned reflexes in his rats and pigeons, than he could in any other way. He made obvious the extreme stupidity, in dealing with children or employees, of rewarding behavior one didn't want more of. Using food rewards, he even caused strong superstitions, predesigned by himself, in his pigeons. He demonstrated again and again a great recurring, generalized behavioral algorithm in nature: "Repeat behavior that works." He also demonstrated that prompt rewards worked much better than delayed rewards in changing and maintaining behavior. And, once his rats and pigeons had conditioned reflexes, caused by food rewards, he found what withdrawal pattern of rewards kept the reflexive behavior longest in place: random distribution. With this result, Skinner thought he had pretty well explained man's misgambling compulsion whereunder he often foolishly proceeds to ruin. But, as we shall later see when we discuss other psychological tendencies that contribute to misgambling compulsion, he was only partly right. Later, Skinner lost most of his personal reputation by overclaiming for incentive superpower to the point of thinking he could create a human utopia with it and by displaying hardly any recognition of the power of the rest of psychology. He thus behaved like one of Jacob Viner's truffle hounds as he tried to explain everything with incentive effects. Nonetheless, Skinner was right in his main idea: Incentives are superpowers. The outcome of his basic experiments will always remain in high repute in the annals of experimental science. And his method of monomaniacal reliance on rewards, for many decades after his death, did more good than anything else in improving autistic children.

When I was at Harvard Law School, the professors sometimes talked about an overfocused, Skinner-like professor at Yale Law School. They used to say: "Poor old Eddie Blanchard, he thinks declaratory judgments will cure cancer." Well, that's the way Skinner got with his very extreme emphasis on incentive superpower. I always call the "Johnny-one-note" turn of mind that eventually diminished Skinner's reputation the man-with-a-hammer tendency, after the folk saying: "To a man with only a hammer every problem looks pretty much like a nail." Man-with-a-hammer tendency does not exempt smart people like Blanchard and Skinner. And it won't exempt you if you don't watch out. I will return to man-with- a-hammer tendency at various times in this talk because, fortunately, there are effective anti-dotes that reduce the ravages of what pretty much ruined the personal reputation of the brilliant Skinner.

One of the most important consequences of incentive superpower is what I call "incentive caused bias." A man has an acculturated nature making him a pretty decent fellow, and yet, driven both consciously and sub-consciously by incentives, he drifts into immoral behavior in order to get what he wants, a result he facilitates by rationalizing his bad behavior, like the salesmen at Xerox who harmed customers in order to maximize their sales commissions.

Here, my early education involved a surgeon who over the years sent bushel baskets full of normal gall bladders down to the pathology lab in the leading hospital in Lincoln, Nebraska, my grandfather's town. And, with that permissive quality control for which community hospitals are famous, many years after this surgeon should've been removed from the medical staff, he was. One of the doctors who participated in the removal was a family friend, and I asked him: "Did this surgeon think, `Here's a way for me to exercise my talents'" – this guy was very skilled technically – "'and make a high living by doing a few maimings and murders every year in the course of routine fraud?'" And my friend answered: "Hell no, Charlie. He thought that the gall bladder was the source of all medical evil, and, if you really loved your patients, you couldn't get that organ out rapidly enough."

Now that's an extreme case, but in lesser strength, the cognitive drift of that surgeon is present in every profession and in every human being. And it causes perfectly terrible behavior. Consider the presentations of brokers selling commercial real estate and businesses. I've never seen one that I thought was even within hailing distance of objective truth. In my long life, I have never seen a management consultant’s report that didn’t end with the same advice: "This problem needs more management consulting services." Widespread incentive-caused bias requires that one should often distrust, or take with a grain of salt, the advice of one’s professional advisor, even if he is an engineer. The general antidotes here are:

1. especially fear professional advice when it is especially good for the advisor;
2. learn and use the basic elements of your advisor’s trade as you deal with your advisor; and
3. double check, disbelieve, or replace much of what you’re told, to the degree that seems appropriate after objective thought.

The power of incentives to cause rationalized, terrible behavior is also demonstrated by Defense Department procurement history. After the Defense Department had much truly awful experience with misbehaving contractors motivated under contracts paying on a cost-plus-a-percentage-of cost basis, the reaction of our republic was to make it a crime for a contracting officer in the Defense Department to sign such a contract, and not only a crime, but a felony.

And, by the way, although the government was right to create this new felony, much of the way the rest of the world is run, including the operation of many law firms and a lot of other firms, is still under what is, in essence, a cost-plus-a-percentage-of-cost reward system. And human nature, bedeviled by incentive-caused bias, causes a lot of ghastly abuse under these standard incentive patterns of the world. And many of the people who are behaving terribly you would be glad to have married into your family, compared to what you’re otherwise likely to get.

Now there are huge implications from the fact that the human mind is put together this way. One implication is that people who create things like cash registers, which make dishonest behavior hard to accomplish, are some of the effective saints of our civilization because, as Skinner so well knew, bad behavior is intensely habit-forming when it is rewarded.

And so the cash register was a great moral instrument when it was created. And, by the way, Patterson, the great evangelist of the cash register, knew that from his own experience. He had a little store, and his employees were stealing him blind, so that he never made any money. Then people sold him a couple of cash registers, and his store went to profit immediately. He promptly closed the store and went into the cash register business, creating what became the mighty National Cash Register Company, one of the glories of its time. "Repeat behavior that works" is a behavioral guide that really succeeded for Patterson, after he applied one added twist. And so did high moral cognition. An eccentric, inveterate do-gooder (except when destroying competitors, all of which he regarded as would-be patent thieves), Patterson, like Carnegie, pretty well gave away all his money to charity before he died, always pointing out that "shrouds have no pockets." So great was the contribution of Patterson’s cash register to civilization, and so effectively did he improve the cash register and spread its use, that in the end, he probably deserved the epitaph chosen for the Roman poet Horace: "I did not completely die."

The strong tendency of employees to rationalize bad conduct in order to get rewards requires many antidotes in addition to the good cash control promoted by Patterson. Perhaps the most important of these antidotes is use of sound accounting theory and practice. This was seldom better demonstrated than at Westinghouse, which had a subsidiary that made loans having no connection to the rest of Westinghouse's businesses. The officers of Westinghouse, perhaps influenced by envy of General Electric, wanted to expand profits from loans to outsiders. Under Westinghouse's accounting practice, provisions for future credit losses on these loans depended largely on the past credit experience of its lending subsidiary, which mainly made loans unlikely to cause massive losses.

Now there are two special classes of loans that naturally cause much trouble for lenders. The first is ninety-five percent-of-value construction loans to any kind of real estate developer, and the second is any kind of construction loan on a hotel. So, naturally, if one were willing to loan approximately ninety-five percent of the real cost to a developer constructing a hotel, the loan would bear a much higher-than-normal interest rate because the credit loss danger would be much higher than normal. So, sound accounting for Westinghouse in making a big, new mass of ninety-five percent-of-value construction loans to hotel developers would have been to report almost no profit, or even a loss, on each loan until, years later, the loan became clearly worth par. But Westinghouse instead plunged into big-time construction lending on hotels, using accounting that made its lending officers look good because it showed extremely high starting income from loans that were very inferior to the loans from which the company had suffered small credit losses in the past. This terrible accounting was allowed by both international and outside accountants for Westinghouse as they displayed the conduct predicted by the refrain: "Whose bread I eat, his song I sing."

The result was billions of dollars of losses. Who was at fault? The guy from the refrigerator division, or some similar division, who as lending officer was suddenly in charge of loans to hotel developers: Or the accountants and other senior people who tolerated a nearly insane incentive structure, almost sure to trigger incentive-caused bias in a lending officer: My answer puts most blame on the accountants and other senior people who created the accounting system. These people became the equivalent of an armored car cash carrying service that suddenly decided to dispense with vehicles and have unarmed midgets handcarry its customers' cash through slums in open bushel baskets.

I wish I could tell you that this sort of thing no longer happens, but this is not so. After Westinghouse blew up, General Electric's Kidder Peabody subsidiary put a silly computer program in place that allowed a bond trader to show immense fictional profits. And after that, much accounting became even worse, perhaps reaching its nadir at Enron.

So incentive-caused bias is a huge, important thing, with highly important antidotes, like the cash register and a sound accounting system. But when I came years ago to the psychology texts, I found that, while they were about one thousand pages long, there was as little therein that dealt with incentive-caused bias and no mention of Patterson or sound accounting systems. Somehow incentive-caused bias and its antidotes pretty well escaped the standard survey courses in psychology, even though incentive-caused bias had long been dis-played prominently in much of the world's great literature, and antidotes to it had long existed in standard business routines. In the end, I concluded that when something was obvious in life but not easily demonstrable in certain kinds of easy, repeatable academic experiments, the truffle hounds of psychology very often missed it.

In some cases, other disciplines showed more interest in psychological tendencies than did psychology, at least as explicated in psychology textbooks. For instance, economists, speaking from the employer's point of view, have long had a name for the natural results of incentive-caused bias: "agency cost." As the name implies, the economists have typically known that, just as grain is always lost to rats, employers always lose to employees who improperly think of themselves first. Employer installed antidotes include:

1. tough internal audit systems,
2. severe public punishment for identified miscreants, as well as
3. misbehavior-preventing routines and such machines as cash registers.

From the employee's point of view, incentive-caused bias quite naturally causes opposing abuse from the employer: the sweatshop, the unsafe work place, etc. And these bad results for employees have antidotes not only in

1. pressure from unions, but also in

2. government action, such as wage and hour laws, workplace safety rules, measures fostering unionization, and workers' compensation systems.

Given the opposing psychology-induced strains that naturally occur in employment because of incentive-caused bias on both sides of the relationship, it is no wonder the Chinese are so much into Yin and Yang.

The inevitable ubiquity of incentive-caused bias has vast, generalized consequences. For instance, a sales force living only on commissions will be much harder to keep moral than one under less pressure from the compensation arrangement. On the other hand, a purely commissioned sales force may well be more efficient per dollar spent. Therefore, difficult decisions involving trade-offs are common in creating compensation arrangements in the sales function.

The extreme success of free-market capitalism as an economic system owes much to its prevention of many of bad effects from incentive-caused bias. Most capitalist owners in a vast web of free market economic activity are selected for ability by surviving in a brutal competition with other owners and have a strong incentive to prevent all waste in operations within their ownership. After all, they live on the difference between their competitive prices and their overall costs and their businesses will perish if costs exceed sales. Replace such owners by salaried employees of the state and you will normally get a substantial reduction in overall efficiency as each employee who replaces an owner is subject to incentive-caused bias as he determines what service he will give in exchange for his salary and how much he will yield to peer pressure from many fellow employees who do not desire his creation of any strong performance model.

Another generalized consequence of incentive caused bias is that man tends to "game" all human systems, often displaying great ingenuity in wrongly serving himself at the expense of others. Antigaming features, therefore, constitute a huge and necessary part of almost all system design. Also needed in system design is an admonition: dread, and avoid as much you can, rewarding people for what can be easily faked. Yet our legislators and judges, usually including many lawyers educated in eminent universities, often ignore this injunction. And society consequently pays a huge price in the deterioration of behavior and efficiency, as well as the incurrence of unfair costs and wealth transfers. If education were improved, with psychological reality becoming better taught and assimilated, better system design might well come out of our legislatures and courts.

Of course, money is now the main reward that drives habits. A monkey can be trained to seek and work for an intrinsically worthless token, as if it were a banana, if the token is routinely exchangeable for a banana. So it is also with humans working for money – only more so, because human money is exchangeable for many desired things in addition to food, and one ordinarily gains status from either holding or spending it. Moreover, a rich person will often, through habit, work or connive energetically for more money long after he has almost no real need for more. Averaged out, money is a mainspring of modern civilization, having little precedent in the behavior of nonhuman animals.

Money rewards are also intertwined with other forms of reward. For instance, some people use money to buy status and others use status to get money, while still others sort of do both things at the same time.

Although money is the main driver among rewards, it is not the only reward that works. People also change their behavior and cognition for sex, friendship, companionship, advancement in status, and other non-monetary items.

"Granny's Rule" provides another example of reward superpower, so extreme in its effects that it must be mentioned here. You can successfully manipulate your own behavior with this rule, even if you are using as rewards items that you already possess! Indeed, consultant Ph.D. psychologists often urge business organizations to improve their reward systems by teaching executives to use "Granny's Rule" to govern their own daily behavior. Granny's Rule, to be specific, is the requirement that children eat their carrots before they get dessert. And the business version requires that executives force themselves daily to first do their unpleasant and necessary tasks before rewarding themselves by proceeding to their pleasant tasks. Given reward super-power, this practice is nice and sound. Moreover, the rule can also be used in the nonbusiness part of life. The emphasis on daily use of this practice is not accidental. The consultants well know, after the teaching of Skinner, that prompt rewards work best.

Punishments, of course, also strongly influence behavior and cognition, although not so flexibly and wonderfully as rewards. For instance, illegal price fixing was fairly common in America when it was customarily punished by modest fines. Then, after a few prominent business executives were removed from their eminent positions and sent to federal prisons, price-fixing behavior was greatly reduced.

Military and naval organizations have very often been extreme in using punishment to change behavior, probably because they needed to cause extreme behavior. Around the time of Caesar, there was a European tribe that, when the assembly horn blew, always killed the last warrior to reach his assigned place, and no one enjoyed fighting this tribe. And George Washington hanged farm-boy deserters forty feet high as an example to others who might contemplate desertion.

LIKING/ LOVING TENDENCY

> Love: I recognize the emotion for what it is, an irrational self-destructive impulse, which is disguised as joy.
>
> —Nikola Tesla

A newly hatched baby goose is programmed, through the economy of its genetic program, to "love" and follow the first creature that is nice to it, which is almost always its mother. But, if the mother goose is not present right after the hatching, and a man is there instead, the gosling will "love" and follow the man, who becomes a sort of substitute mother.

Somewhat similarly, a newly arrived human is "born to like and love" under the normal and abnormal triggering outcomes for its kind. Perhaps the strongest in-born tendency to love – ready to be triggered – is that of the human mother for its child. On the other hand, the similar "child-loving" behavior of a mouse can be eliminated by the deletion of a single gene, which suggests there is some sort of triggering gene in a mother mouse as well as in a gosling.

Each child, like a gosling, will almost surely come to like and love, not only as driven by its sexual nature, but also in social groups not limited to its genetic or adoptive "family." Current extremes of romantic love almost surely did not occur in man's remote past. Our early human ancestors were surely more like apes triggered into mating in a pretty mundane fashion.

And what will a man naturally come to like and love, apart from his parent, spouse and child? Well, he will like and love being liked and loved. And so many a courtship competition will be won by a person displaying exceptional devotion, and man will generally strive, lifelong, for the affection and approval of many people not related to him. One very practical consequence of Liking/Loving Tendency is that it acts as a conditioning device that makes the liker or lover tend:

1. to ignore faults of, and comply with wishes of, the object of his affection,

2. to favor people, products, and actions merely associated with the object of his affection (as we shall see when we get to "Influence-from-Mere-Association Tendency," and

3. to distort other facts to facilitate love.

There are large social policy implications in the amazingly good consequences that ordinarily come from people likely to trigger extremes of love and admiration boosting each other in a feedback mode. For instance, it is obviously desirable to attract a lot of lovable, admirable people into the teaching profession. The phenomenon of liking and loving causing admiration also works in reverse. Admiration also causes or intensifies liking or love. With this "feedback mode" in place, the consequences are often extreme, sometimes even causing deliberate self-destruction to help what is loved.

Liking or loving, intertwined with admiration in a feedback mode, often has vast practical consequences in areas far removed from sexual attachments. For instance, a man who is so constructed that he loves admirable persons and ideas with a special intensity has a huge advantage in life. This blessing came to both Buffett and myself in large measure, sometimes from the same persons and ideas. One common, beneficial example for us both was Warren's uncle, Fred Buffett, who cheerfully did the endless grocery-store work that Warren and I ended up admiring from a safe distance. Even now, after I have known so many other people, I doubt if it is possible to be a nicer man than Fred Buffett was, and he changed me for the better.

DISLIKING/ HATING TENDENCY

> If you hate a person, then you're defeated by them.
>
> —Confucius

In a pattern obverse to Liking/Loving Tendency, the newly arrived human is also "born to dislike and hate" as triggered by normal and abnormal triggering forces in its life. It is the same with most apes and monkeys.

As a result, the long history of man contains almost continuous war. For instance, most American Indian tribes warred incessantly, and some tribes would occasionally bring captives home to women so that all could join in the fun of torturing captives to death. Even with the spread of religion, and the advent of advanced civilization, much modern war remains pretty savage. But we also get what we observe in present-day Switzerland and the United States, wherein the clever political arrangements of man "channel" the hatreds and dislikings of individuals and groups into nonlethal patterns including elections.

But the dislikings and hatreds never go away completely. Born into man, these driving tendencies remain strong. Thus, we get maxims like the one from England: "Politics is the art of marshalling hatreds." And we also get the extreme popularity of very negative political advertising in the United States.

At the family level, we often see one sibling hate his other siblings and litigate with them endlessly if he can afford it. Indeed, Warren Buffett has repeatedly explained to me that "a major difference between rich and poor people is that the rich people can spend their lives suing their relatives." My father's law practice in Omaha was full of such intrafamily hatreds. And when I got to the Harvard Law School and its professors taught me "property law" with no mention of sibling rivalry in the family business, I appraised the School as a pretty unrealistic place that wore "blinders" like the milk-wagon horses of yore. My current guess is that sibling rivalry has not yet made it into property law as taught at Harvard.

Disliking/Hating Tendency also acts as a conditioning device that makes the disliker/hater tend to:

1. ignore virtues in the object of dislike,
2. dislike people, products, and actions merely associated with the object of his dislike, and
3. distort other facts to facilitate hatred.

Distortion of that kind is often so extreme that miscognition is shockingly large. When the world Trade Center was destroyed, many Muslims immediately concluded that the Hindus did it, while many Arabs concluded that the Jews did it. Such factual distortions often make mediation between opponents locked in hatred either difficult or impossible. Mediations between Israelis and Palestinians are difficult because facts in one side's history overlap very little with facts from the other side's.

DOUBT/ AVOIDANCE TENDENCY

> The problem with the world is that the intelligent people are full of doubts while the stupid ones are full of confidence.
>
> —Charles Bukowski

The brain of man is programmed with a tendency to quickly remove doubt by reaching some decision. It is easy to see how evolution would make animals, over the eons, drift toward such quick elimination of doubt. After all, the one thing that is surely counterproductive for a prey animal that is threatened by a predator is to take a long time in deciding what to do. And so man's Doubt Avoidance Tendency is quite consistent with the history of his ancient, nonhuman ancestors.

So pronounced is the tendency in man to quickly remove doubt by reaching some decision that behavior to counter the tendency is required from judges and jurors. Here, delay before decision making is forced. And one is required to so comport himself, prior to conclusion time, so that he is wearing a "mask" of objectivity. And the "mask" works to help real objectivity along, as we shall see when we next consider man's Inconsistency-Avoidance Tendency.

Of course, once one has recognized that man has a strong Doubt-Avoidance Tendency, it is logical to believe that at least some leaps of religious faith are greatly boosted by this tendency. Even if one is satisfied that his own faith comes from revelation, one still must account for the inconsistent faiths of others. And man's Doubt-Avoidance Tendency is almost surely a big part of the answer.

What triggers Doubt-Avoidance Tendency? Well, an unthreatened man, thinking of nothing in particular, is not being prompted to remove doubt through rushing to some decision. As we shall see later when we get to Social-Proof Tendency and Stress-Influence Tendency, what usually triggers Doubt-Avoidance Tendency is some combination of puzzlement and stress. Both of these factors naturally occur in facing religious issues. Thus, the natural state of most men is in some form of doubt-removing religious faith.

INCONSISTENCY-AVOIDANCE TENDENCY

> One cannot live without inconsistency
>
> —Carl Jung

The brain of man conserves programming space by being reluctant to change, which is a form of inconsistency avoidance. We see this in all human habits, constructive and destructive. Few people can list a lot of bad habits that they have eliminated, and some people cannot identify even one of these. Instead, practically everyone has a great many bad habits he has long maintained despite their being known as bad. Given this situation, it is not too much in many cases to appraise early-formed habits as destiny. When Marley's miserable ghost says, "I wear the chains I forged in life," he is talking about chains of habit that were too light to be felt before they became too strong to be broken.

The rare life that is wisely lived has in it many good habits maintained and many bad habits avoided or cured. And the great rule that helps here is again from Franklin's Poor Richard's Almanack: "An ounce of prevention is worth a pound of cure." What Franklin is here indicating, in part, is that Inconsistency-Avoidance Tendency makes it much easier to prevent a habit than to change it.

Also tending to be maintained in place by the anti-change tendency of the brain are one's previous conclusions, human loyalties, reputational identity, commitments, accepted role in a civilization, etc. It is not entirely clear why evolution would program into man's brain an anti-change mode alongside his tendency to quickly remove doubt. My guess is the anti-change mode was significantly caused by a combination of the following factors:

1. It facilitated faster decisions when speed of decision was an important contribution to the survival of nonhuman ancestors that were prey.

2. It facilitated the survival advantage that our ancestors gained by cooperating in groups, which would have been more difficult to do if everyone was always changing responses.

3. It was the best form of solution that evolution could get to in the limited number of generations between the start of literacy and today's complex modern life.

It is easy to see that a quickly reached conclusion, triggered by Doubt-Avoidance Tendency, when combined with a tendency to resist any change in that conclusion, will naturally cause a lot of errors in cognition for modern man. And so it observably works out. We all deal much with others whom we correctly diagnose as imprisoned in poor conclusions that are maintained by mental habits they formed early and will carry to their graves.

So great is the bad-decision problem caused by Inconsistency-Avoidance Tendency that our courts have adopted important strategies against it. For instance, before making decisions, judges and juries are required to hear long and skillful presentations of evidence and argument from the side they will not naturally favor, given their ideas in place. And this helps prevent considerable bad thinking from "first conclusion bias." Similarly, other modern decision makers will often force groups to consider skillful counterarguments before making decisions.

And proper education is one long exercise in augmentation of high cognition so that our wisdom becomes strong enough to destroy wrong thinking, maintained by resistance to change. As Lord Keynes pointed out about his exalted intellectual group at one of the greatest universities in the world, it was not the intrinsic difficulty of new ideas that prevented their acceptance. Instead, the new ideas were not accepted because they were inconsistent with old ideas in place. What Keynes was reporting is that the human mind works a lot like the human egg. When one sperm gets into a human egg, there's an automatic shut-off device that bars any other sperm from getting in. The human mind tends strongly toward the same sort of result.

And so, people tend to accumulate large mental holdings of fixed conclusions and attitudes that are not often reexamined or changed, even though there is plenty of good evidence that they are wrong.

Moreover, this doesn't just happen in social science departments, like the one that once thought Freud should serve as the only choice as a psychology teacher for Caltech. Holding to old errors even happens, although with less frequency and severity, in hard science departments. We have no less an authority for this than Max Planck, Nobel laureate, finder of "Planck's constant." Planck is famous not only for his science but also for saying that even in physics the radically new ideas are seldom really accepted by the old guard. Instead, said Planck, the progress is made by a new generation that comes along, less brain-blocked by its previous conclusions. Indeed, precisely this sort of brain-blocking happened to a degree in Einstein. At his peak, Einstein was a great destroyer of his own ideas, but an older Einstein never accepted the full implications of quantum mechanics.

One of the most successful users of an antidote to first conclusion bias was Charles Darwin. He trained himself, early, to intensively consider any evidence tending to disconfirm any hypothesis of his, more so if he thought his hypothesis was a particularly good one. The opposite of what Darwin did is now called confirmation bias, a term of opprobrium. Darwin's practice came from his acute recognition of man's natural cognitive faults arising from Inconsistency-Avoidance Tendency. He provides a great example of psychological insight correctly used to advance some of the finest mental work ever done.

Inconsistency-Avoidance Tendency has many good effects in civilization. For instance, rather than act inconsistently with public commitments, new or old public identities, etc., most people are more loyal in their roles in life as priests, physicians, citizens, soldiers, spouses, teachers, employees, etc.

One corollary of Inconsistency-Avoidance Tendency is that a person making big sacrifices in the course of assuming a new identity will intensify his devotion to the new identity.

After all, it would be quite inconsistent behavior to make a large sacrifice for something that was no good. And thus civilization has invented many tough and solemn initiation ceremonies, often public in nature, that intensify new commitments made.

Tough initiation ceremonies can intensify bad contact as well as good. The loyalty of the new, "made-man" mafia member, or of the military officer making the required "blood oath" of loyalty to Hitler, was boosted through the triggering of Inconsistency-Avoidance Tendency.

Moreover, the tendency will often make man a "patsy" of manipulative "compliance-practitioners," who gain advantage from triggering his subconscious Inconsistency-Avoidance Tendency. Few people demonstrated this process better than Ben Franklin. As he was rising from obscurity in Philadelphia and wanted the approval of some important man, Franklin would often maneuver that man into doing Franklin some unimportant favor, like lending Franklin a book. Thereafter, the man would admire and trust Franklin more because a nonadmired and nontrusted Franklin would be inconsistent with the appraisal implicit in lending Franklin the book.

During the Korean War, this technique of Franklin's was the most important feature of the Chinese brainwashing system that was used on enemy prisoners. Small step by small step, the technique often worked better than torture in altering prisoner cognition in favor of Chinese captors.

The practice of Franklin, whereunder he got approval from someone by maneuvering him into treating Franklin favorably, works viciously well in reverse. When one is maneuvered into deliberately hurting some other person, one will tend to disapprove or even hate that person. This effect, from Inconsistency-Avoidance Tendency, accounts for the insight implicit in the saying: "A man never forgets where he has buried the hatchet." The effect accounts for much prisoner abuse by guards, increasing their dislike and hatred for prisoners that exists as a consequence of the guards' reciprocation of hostility from prisoners who are treated like animals. Given the psychology-based hostility natural in prisons between guards and prisoners, an intense, continuous effort should be made to prevent prisoner abuse from starting and to stop it instantly when it starts because it will grow by feeding on itself, like a cluster of infectious disease. More psychological acuity on this subject, aided by more insightful teaching, would probably improve the overall effectiveness of the U.S. Army.

So strong is Inconsistency-Avoidance Tendency that it will often prevail after one has merely pretended to have some identity, habit, or conclusion. Thus, for a while, many an actor sort of believes he is Hamlet, Prince of Denmark. And many a hypocrite is improved by his pretensions of virtue. And many a judge and juror, while pretending objectivity, is gaining objectivity. And many a trial lawyer or other advocate comes to believe what he formerly only pretended to believe.

While Inconsistency-Avoidance Tendency, with its "status quo bias," immensely harms sound education, it also causes much benefit. For instance, a near-ultimate inconsistency would be to teach something to others that one did not believe true. And so, in clinical medical education, the learner is forced to "see one, do one, and then teach one," with the teaching pounding the learning into the teacher. Of course, the power of teaching to influence the cognition of the teacher is not always a benefit to society. When such power flows into political and cult evangelism, there are often bad consequences.

For instance, modern education often does much damage when young students are taught dubious political notions and then enthusiastically push these notions on the rest of us. The pushing seldom convinces others. But as students pound into their mental habits what they are pushing out, the students are often permanently damaged. Educational institutions that create a climate where much of this goes on are, I think, irresponsible. It is important not to thus put one's brain in chains before one has come anywhere near his full potentiality as a rational person.

CURIOSITY TENDENCY

> The important thing is not to stop questioning. Curiosity has its own reason for existing.
>
> —Albert Einstein

There is a lot of innate curiosity in mammals, but its nonhuman version is highest among apes and monkeys. Man’s curiosity, in turn, is much stronger than that of his simian relatives. In advanced human civilization, culture greatly increases the effectiveness of curiosity in advancing knowledge. For instance, Athens (including its colony, Alexandria) developed much math and science out of pure curiosity while the Romans made almost no contribution to either math or science. They instead concentrated their attention on the "practical" engineering of mines, roads, aqueducts, etc. Curiosity, enhanced by the best of modern education (which is by definition a minority part in many places), much helps man to prevent or reduce bad consequences arising from other psychological tendencies. The curious are also provided with much fun and wisdom long after formal education has ended.

KANTIAN FAIRNESS TENDENCY

> Do the right thing because it is right
>
> —Immanuel Kant

Kant was famous for his "categorical imperative," a sort of a "golden rule" that required humans to follow those behavior patterns that, if followed by all others, would make the surrounding human system work best for everybody. And it is not too much to say that modern acculturated man displays, and expects from others, a lot of fairness as thus defined by Kant.

In a small community having a one-way bridge or tunnel for autos, it is the norm in the United States to see a lot of reciprocal courtesy, despite the absence of signs or signals. And many freeway drivers, including myself, will often let other drivers come in front of them, in lane changes or the like, because that is the courtesy they desire when roles are reversed. Moreover, there is, in modern human culture, a lot of courteous lining up by strangers so that all are served on a "first-come-first-served" basis.

Also, strangers often voluntarily share equally in unexpected, unearned good and bad fortune. And, as an obverse consequence of such "fair-sharing" conduct, much reactive hostility occurs when fairsharing is expected yet not provided.

It is interesting how the world's slavery was pretty well abolished during the last three centuries after being tolerated for a great many previous centuries during which it coexisted with the world's major religions. My guess is that Kantian Fairness Tendency was a major contributor to this result.

ENVY/ JEALOUS TENDENCY

> Envy is the most stupid of vices, for there is no single advantage to be gained from it.
>
> —Honore De Balzac

A member of a species designed through evolutionary process to want often-scarce food is going to be driven strongly toward getting food when it first sees food. And this is going to occur often and tend to create some conflict when the food is seen in the possession of another member of the same species. This is probably the evolutionary origin of the Envy/Jealousy Tendency that lies so deep in human nature. Sibling jealousy is clearly very strong and usually greater in children than adults. It is often stronger than jealousy directed at strangers. Kantian Fairness Tendency probably contributes to this result.

Envy/jealousy is extreme in myth, religion, and literature wherein, in account after account, it triggers hatred and injury. It was regarded as so pernicious by the Jews of the civilization that preceded Christ that it was forbidden, by phrase after phrase, in the laws of Moses. You were even warned by the Prophet not to covet your neighbor's donkey.

And envy/jealousy is also extreme in modern life. For instance, university communities often go bananas when some university employee in money management, or some professor in surgery, gets annual compensation in multiples of the standard professorial salary. And in modern investment banks, law firms, etc., the envy/jealousy effects are usually more extreme than they are in university faculties. Many big law firms, fearing disorder from envy/jealousy, have long treated all senior partners alike in compensation, no matter how different their contributions to firm welfare. As I have shared the observation of life with Warren Buffett over decades, I have heard him wisely say on several occasions: "It is not greed that drives the world, but envy."

And, because this is roughly right, one would expect a vast coverage of envy/jealousy in psychology textbooks. But no such vast coverage existed when I read my three textbooks. Indeed, the very words "envy" and "jealousy" were often absent from the index.

Nondiscussion of envy/jealousy is not a phenomenon confined to psychology texts. When did any of you last engage in any large group discussion of some issue wherein adult envy/jealousy was identified as the cause of someone’s argument? There seems to be a general taboo against any such claim. If so, what accounts for the taboo?

My guess is that people widely and generally sense that labeling some position as driven by envy/jealousy will be regarded as extremely insulting to the position taker, possibly more so when the diagnosis is correct than when it is wrong. And if calling a position "envy-driven" is perceived as the equivalent of describing its holder as a childish mental basket case, then it is quite understandable how a general taboo has arisen.

But should this general taboo extend to psychology texts when it creates such a large gap in the correct, psychological explanation of what is widespread and important? My answer is no.

RECIPROCATION TENDENCY

> Reciprocity is a deep instinct; it is the basic currency of social life.
>
> —Jonathan Haidt

The automatic tendency of humans to reciprocate both favors and disfavors has long been noticed as it is in apes, monkeys, dogs, and many less cognitively gifted animals. The tendency facilitates group cooperation for the benefit of members. In this respect, it mimics much genetic programming of the social insects. We see the extreme power of the tendency to reciprocate disfavors in some wars, wherein it increases hatred to a level causing very brutal conduct. For long stretches in many wars, no prisoners were taken; the only acceptable enemy a dead one. And sometimes that was not enough, as in the case of Genghis Khan, who was not satisfied with corpses. He insisted on their being hacked into pieces.

One interesting mental exercise is to compare Genghis Khan, who exercised extreme, lethal hostility toward other men, with ants that display extreme, lethal hostility toward members of their own species that are not part of their breeding colony. Genghis looks sweetly lovable when compared to the ants. The ants are more disposed to fight and fight with more extreme cruelty.

Indeed, E. O. Wilson once waggishly suggested that if ants were suddenly to get atom bombs, all ants would be dead within eighteen hours. What both human and ant history suggest is

1. that nature has no general algorithm making intra-species, turn-the-other-cheek behavior a booster of species survival;

2. that it is not clear that a country would have good prospects were it to abandon all reciprocate-disfavor tendency directed at outsiders; and

3. if turn-the-other-cheek behavior is a good idea for a country as it deals with outsiders, man's culture is going to have to do a lot of heavy lifting because his genes won't be of much help.

I next turn to man's reciprocated hostility that falls well short of war. Peacetime hostility can be pretty extreme, as in many modern cases of "road rage" or injury-producing temper tantrums on athletic fields.

The standard antidote to one's overactive hostility is to train oneself to defer reaction. As my smart friend Tom Murphy so frequently says, "You can always tell the man off tomorrow, if it is such a good idea."

Of course, the tendency to reciprocate favor for favor is also very intense, so much so that it occasionally reverses the course of reciprocated hostility. Weird pauses in fighting have sometimes occurred right in the middle of wars, triggered by some minor courtesy or favor on the part of one side, followed by favor reciprocation from the other side, and so on, until fighting stopped for a considerable period. This happened more than once in the trench warfare of World War I, over big stretches of the front and much to the dismay of the generals.

It is obvious that commercial trade, a fundamental cause of modern prosperity, is enormously facilitated by man's innate tendency to reciprocate favors. In trade, enlightened self-interest joining with Reciprocation Tendency results in constructive conduct. Daily inter-change in marriage is also assisted by Reciprocation Tendency, without which marriage would lose much of its allure.

And Reciprocation Tendency, insomuch as it causes good results, does not join forces only with the super-power of incentives. It also joins Inconsistency-Avoidance Tendency in helping cause:

1. the fulfillment of promises made as part of a bargain, including loyalty promises in marriage ceremonies, and

2. correct behavior expected from persons serving as priests, shoemakers, physicians, and all else.

Like other psychological tendencies, and also man's ability to turn somersaults, reciprocate-favor tendency operates to a very considerable degree at a subconscious level. This helps make the tendency a strong force that can sometimes be used by some men to mislead others, which happens all the time.

For instance, when an automobile salesman graciously steers you into a comfortable place to sit and gives you a cup of coffee, you are very likely being tricked, by this small courtesy alone, into parting with an extra five hundred dollars. This is far from the most extreme case of sales success that is rooted in a salesman dispensing minor favors. However, in this scenario of buying a car, you are going to be disadvantaged by parting with an extra five hundred dollars of your own money. This potential loss will protect you to some extent.

But suppose you are the purchasing agent of someone else – a rich employer, for instance. Now the minor favor you receive from the salesman is less opposed by the threat of extra cost to you because someone else is paying the extra cost. Under such circumstances, the salesman is often able to maximize his advantage, particularly when government is the purchaser.

Wise employers, therefore, try to oppose reciprocate-favor tendencies of employees engaged in purchasing. The simplest antidote works best: Don't let them accept any favors from vendors. Sam Walton agreed with this idea of absolute prohibition. He wouldn't let purchasing agents accept so much as a hot dog from a vendor. Given the subconscious level at which much Reciprocation Tendency operates, this policy of Walton's was profoundly correct. If I controlled the Defense Department, its policies would mimic Walton's.

In a famous psychology experiment, Cialdini brilliantly demonstrated the power of "compliance practitioners" to mislead people by triggering their subconscious Reciprocation Tendency.

Carrying out this experiment, Cialdini caused his "compliance practitioners" to wander around his campus and ask strangers to supervise a bunch of juvenile delinquents on a trip to a zoo. Because this happed on a campus, one person in six out of a large sample actually agreed to do this. After accumulating this one-in-six statistic, Cialdini changed his procedure. His practitioners next wandered around the campus asking strangers to devote a big chunk of time every week for two years to the supervision of juvenile delinquents. This ridiculous request got him a one hundred percent rejection rate. But the practitioner had a follow-up question: "Will you at least spend one afternoon taking juvenile delinquents to a zoo?" This raised Cialdini's former acceptance rate of 1/6 to ½ – a tripling.

What Cialdini's "compliance practitioners" had done was make a small concession, which was reciprocated by a small concession from the other side. This subconscious reciprocation of a concession by Cialdini's experimental subjects actually caused a much increased percentage of them to end up irrationally agreeing to go to a zoo with juvenile delinquents. Now, a professor who can invent an experiment like that, which so powerfully demonstrates something so important, deserves much recognition in the wider world, which he indeed got to the credit of many universities that learned a great deal from Cialdini.

Why is Reciprocation Tendency so important? Well, consider the folly of having law students graduate, and go out in the world representing clients in negotiations, not knowing the nature of the subconscious processes of the mind as exhibited in Cialdini's experiment. Yet such folly was prevalent in the law schools of the world for decades, in fact, generations. The correct name for that is educational malpractice. The law schools didn't know, or care to teach, what Sam Walton so well knew.

The importance and power of reciprocate-favor tendency was also demonstrated in Cialdini's explanation of the foolish decision of the attorney general of the United States to authorize the Watergate burglary. There, an aggressive subordinate made some extreme proposal for advancing Republican interests through use of some combination of whores and a gigantic yacht. When this ridiculous request was rejected, the subordinate backed off, in gracious concession, to merely asking for consent to a burglary, and the attorney general went along. Cialdini believes that subconscious Reciprocation Tendency thus became one important cause of the resignation of a United States president in the Watergate debacle, and so do I. Reciprocation Tendency subtly causes many extreme and dangerous consequences, not just on rare occasions but pretty much all the time.

Man's belief in reciprocate-favor tendency, following eons of his practicing it, has done some queer and bad things in religions. The ritualized murder of the Phoenicians and the Aztecs, in which they sacrificed human victims to their gods, was a particularly egregious example. And we should not forget that as late as the Punic Wars, the civilized Romans, out of fear of defeat, returned in a few instances to the practice of human sacrifice. On the other hand, the reciprocity-based, religion-boosting idea of obtaining help from God in reciprocation for good human behavior has probably been vastly constructive.

Overall, both inside and outside religions, it seems clear to me that Reciprocation Tendency's constructive contributions to man far outweigh its destructive effects. In cases of psychological tendencies being used to counter or prevent bad results from one or more other psychological tendencies – for instance, in the case of interventions to end chemical dependency – you will usually find Reciprocation Tendency performing strongly on the constructive side.

And the very best part of human life probably lies in relationships of affection wherein parties are more interested in pleasing than being pleased – a not uncommon outcome in display of reciprocate favor tendency.

Before we leave reciprocate-favor tendency, the final phenomenon we will consider is widespread human misery from feelings of guilt. To the extent the feeling of guilt has an evolutionary base, I believe the most plausible cause is the mental conflict triggered in one direction by reciprocate favor tendency and in the opposite direction by Reward Superresponse Tendency pushing one to enjoy one hundred percent of some good thing. Of course, human culture has often greatly boosted the genetic tendency to suffer from feelings of guilt. Most especially, religious culture has imposed hard-to-follow ethical and devotional demands on people. There is a charming Irish Catholic priest in my neighborhood who, with rough accuracy, often says, "The old Jews may have invented guilt, but we Catholics perfected it." And if you, like me and this priest, believe that, averaged out, feelings of guilt do more good than harm, you may join in my special gratitude for reciprocate-favor tendency; no matter how unpleasant you find feelings of guilt.

INFLUENCE-FROM-MERE-ASSOCIATION TENDENCY

> There is a natural human tendency to dislike a person who brings us unpleasant information, even when that person did not cause the bad news. The simple association with it is enough to stimulate our dislike.
>
> —Robert B. Cialdini

In the standard conditioned reflexes studied by Skinner and most common in the world, responsive behavior, creating a new habit, is directly triggered by rewards previously bestowed. For instance, a man buys a can of branded shoe polish, has a good experience with it when shining his shoes, and because of this "reward," buys the same shoe polish when he needs another can.

But there is another type of conditioned reflex wherein mere association triggers a response. For instance, consider the case of many men who have been trained by their previous experience in life to believe that when several similar items are presented for purchase, the one with the highest price will have the highest quality. Knowing this, some seller of an ordinary industrial product will often change his product's trade dress and raise its price significantly hoping that quality-seeking buyers will be tricked into becoming purchasers by mere association of his product and its high price. This industrial practice frequently is effective in driving up sales and even more so in driving up profits. For instance, it worked wonderfully with high-priced power tools for a long time. And it would work better yet with highpriced pumps at the bottom of oil wells. With luxury goods, the process works with a special boost because buyers who pay high prices often gain extra status from thus demonstrating both their good taste and their ability to pay.

Even association that appears to be trivial, if care-fully planned, can have extreme and peculiar effects on purchasers of products. The target purchaser of shoe polish may like pretty girls. And so he chooses the polish with the pretty girl on the can or the one with the pretty girl in the last ad for shoe polish that he saw.

Advertisers know about the power of mere association. You won't see Coke advertised alongside some account of the death of a child. Instead, Coke ads picture life as happier than reality.

Similarly, it is not from mere chance that military bands play such impressive music. That kind of music, appearing in mere association with military service, helps to attract soldiers and keep them in the army. Most armies have learned to use mere association in this successful way.

However, the most damaging miscalculations from mere association do not ordinarily come from advertisers and music providers.

Some of the most important miscalculations come from what is accidentally associated with one's past success, or one's liking and loving, or one's disliking and hating, which includes a natural hatred for bad news.

To avoid being misled by the mere association of some fact with past success, use this memory clue. Think of Napoleon and Hitler when they invaded Russia after using their armies with much success elsewhere. And there are plenty of mundane examples of results like those of Napoleon and Hitler. For instance, a man foolishly gambles in a casino and yet wins. This unlikely correlation causes him to try the casino again, or again and again, to his horrid detriment. Or a man gets lucky in an odds-against venture headed by an untalented friend. So influenced, he tries again what worked before – with terrible results.

The proper antidotes to being made such a patsy by past success are:

1. to carefully examine each past success, looking for accidental, noncausative factors associated with such success that will tend to mislead as one appraises odds implicit in a proposed new undertaking, and
2. to look for dangerous aspects of the new undertaking that were not present when past success occurred.

The damage to the mind that can come from liking and loving was once demonstrated by obviously false testimony given by an otherwise very admirable woman, the wife of a party in a jury case. The famous opposing counsel wanted to minimize his attack on such an admirable woman yet destroy the credibility of her testimony. And so, in his closing argument, he came to her testimony last. He then shook his head sadly and said, "What are we to make of such testimony? The answer lies in the old rhyme:

As the husband is, So the wife is. She is married to a clown,

And the grossness of his nature Drags her down."

The jury disbelieved the woman's testimony. They easily recognized the strong misinfluence of love on her cognition. And we now often see even stronger misinfluence from love as tearful mothers, with heartfelt conviction, declare before TV cameras the innocence of their obviously guilty sons.

People disagree about how much blindness should accompany the association called love. In Poor Richard's Almanack Franklin counseled: "Keep your eyes wide open before marriage and half shut thereafter." Perhaps this "eyes-half-shut" solution is about right, but I favor a tougher prescription: "See it like it is and love anyway."

Hating and disliking also cause miscalculation triggered by mere association. In business, I commonly see people underappraise both the competency and morals of competitors they dislike. This is a dangerous practice, usually disguised because it occurs on a subconscious basis.

Another common bad effect from the mere association of a person and a hated outcome is displayed in "Persian Messenger Syndrome." Ancient Persians actually killed some messengers whose sole fault was that they brought home truthful bad news, say, of a battle lost. It was actually safer for the messenger to run away and hide, instead of doing his job as a wiser boss would have wanted it done.

And Persian Messenger Syndrome is alive and well in modern life, albeit in less lethal versions. It is actually dangerous in many careers to be a carrier of unwelcome news. Union negotiators and employer representatives often know this, and it leads to many tragedies in labor relations. Sometimes lawyers, knowing their clients will hate them if they recommend an unwelcome but wise settlement, will carry on to disaster. Even in places well known for high cognition, one will sometimes find Persian Messenger Syndrome. For instance, years ago, two major oil companies litigated in a Texas trial court over some ambiguity in an operating agreement covering one of the largest oil reservoirs in the Western hemisphere. My guess is that the cause of the trial was some general counsel's unwillingness to carry bad news to a strong-minded CEO.

CBS, in its late heyday, was famous for occurrence of Persian Messenger Syndrome because Chairman Bill Paley was hostile to people who brought him bad news. The result was that Paley lived in a cocoon of unreality, from which he made one bad deal after another, even exchanging a large share of CBS for a company that had to be liquidated shortly thereafter.

The proper antidote to creating Persian Messenger Syndrome and its bad effects, like those at CBS, is to develop, through exercise of will, a habit of welcoming bad news. At Berkshire, there is a common injunction: "Always tell us the bad news promptly. It is only the good news that can wait." It also helps to be so wise and informed that people fear not telling you bad news be-cause you are so likely to get it elsewhere.

Influence-from-Mere-Association Tendency often has a shocking effect that helps swamp the normal tendency to return favor for favor, [especially when the favor recipient's] condition is unpleasant, due to poverty, sickness, subjugation, or something else. Sometimes, when one receives a favor, the favor may trigger an envy-driven dislike for the person who was in so favorable a state that he could easily be a favor giver. Under such circumstances, the favor receiver, prompted partly by mere association of the favor giver with past pain, will not only dislike the man who helped him but also try to injure him. This accounts for a famous response, sometimes dubiously attributed to Henry Ford: "Why does that man hate me so? I never did anything for him."

I have a friend, whom I will now call "Glotz," who had an amusing experience in favor-giving. Glotz owned an apartment building that he had bought because he wanted, eventually, to use the land in different development. Pending this outcome, Glotz was very lenient in collecting below-market rents from tenants. When, at last, there was a public hearing on Glotz's proposal to tear down the building, one tenant who was far behind in his rent payments was particularly angry and hostile. He came to the public hearing and said, "This proposal is outrageous. Glotz doesn't need any more money. I know this because I was supported in college by Glotz fellowships."

A final serious clump of bad thinking caused by mere association lies in the common use of classification stereotypes. Because Pete knows that Joe is ninety years old and that most ninety-year-old persons don't think very well, Pete appraises old Joe as a thinking klutz even if old Joe still thinks very well. Or, because Jane is a white-haired woman, and Pete knows no old women good at higher math, Pete appraises Jane as no good at it even if Jane is a whiz. This sort of wrong thinking is both natural and common. Pete's antidote is not to believe that, on average, ninety-year-olds think as well as forty year-olds or that there are as many females as males among Ph.D.'s in math. Instead, just as he must learn that trend does not always correctly predict destiny, he must learn that the average dimension in some group will not reliably guide him to the dimension of some specific item. Otherwise Pete will make many errors, like that of the fellow who drowned in a river that averaged out only eighteen inches deep.

SIMPLE, PAIN-AVOIDING PSYCHOLOGICAL DENIAL

> Pain in this life is not avoidable, but the pain we create avoiding pain is avoidable.
>
> —R. D. Laing

This phenomenon first hit me hard in World War II when the superathlete, superstudent son of a family friend flew off over the Atlantic Ocean and never came back. His mother, who was a very sane woman, then refused to believe he was dead. That's Simple, Pain-Avoiding Psychological Denial. The reality is too painful to bear, so one distorts the facts until they become bearable. We all do that to some extent, often causing terrible problems. The tendency's most extreme outcomes are usually mixed up with love, death, and chemical dependency.

Where denial is used to make dying easier, the conduct meets almost no criticism. Who would begrudge a fellow man such help at such a time? But some people hope to leave life hewing to the iron prescription, "It is not necessary to hope in order to persevere." And there is something admirable in anyone able to do this.

In chemical dependency, wherein morals usually break down horribly, addicted persons tend to believe that they remain in respectable condition, with respectable prospects. They thus display an extremely unrealistic denial of reality as they go deeper and deeper into deterioration. In my youth, Freudian remedies failed utterly in reversing chemical dependency, but nowadays Alcoholics Anonymous routinely achieves a fifty percent cure rate by causing several psychological tendencies to act together to counter addiction. However, the cure process is typically difficult and draining, and a fifty per-cent success rate implies a fifty percent failure rate. One should stay far away from any conduct at all likely to drift into chemical dependency. Even a small chance of suffering so great a damage should be avoided.

EXCESSIVE SELF-REGARD TENDENCY

> Too much self-regard has never struck me as dignified: trying to twist over my shoulder to view my own behind.
>
> —Marge Piercy

We all commonly observe the excessive self -regard of man. He mostly misappraises himself on the high side, like the ninety percent of Swedish drivers that judge themselves to be above average. Such misappraisals also apply to a person's major "possessions." One spouse usually overappraises the other spouse. And a man's children are likewise appraised higher by him than they are likely to be in a more objective view. Even man's minor possessions tend to be overappraised. Once owned, they suddenly become worth more to him than he would pay if they were offered for sale to him and he didn't already own them. There is a name in psychology for this overappraisal-of-our-own-possessions phenomenon: the "endowment effect." And all man's decisions are suddenly regarded by him as better than would have been the case just before he made them.

Man's excess of self-regard typically makes him strongly prefer people like himself. Psychology professors have had much fun demonstrating this effect in "lost-wallet" experiments. Their experiments all show that the finder of a lost wallet containing identity clues will be most likely to return the wallet when the owner most closely resembles the finder. Given this quality in psychosocial nature, cliquish groups of similar persons will always be a very influential part of human culture, even after we wisely try to dampen the worst effects.

Some of the worst consequences in modern life come when dysfunctional groups of cliquish persons, dominated by Excessive Self-Regard Tendency, select as new members of their organizations persons who are very much like themselves. Thus if the English department at an elite university becomes mentally dysfunctional or the sales department of a brokerage firm slips into routine fraud, the problem will have a natural tendency to get worse and to be quite resistant to change for the better. So also with a police department or prison-guard unit or political group gone sour and countless other places mired in evil and folly, such as the worst of our big-city teachers' unions that harm our children by preventing discharge of ineffective teachers. Therefore, some of the most useful members of our civilization are those who are willing to "clean house" when they find a mess under their ambit of control.

Well, naturally, all forms of excess of self-regard cause much error. How could it be otherwise?

Let us consider some foolish gambling decisions. In lotteries, the play is much lower when numbers are distributed randomly than it is when the player picks his own number. This is quite irrational. The odds are almost exactly the same and much against the player. Because state lotteries take advantage of man's irrational love of selfpicked numbers, modern man buys more lottery tickets than he otherwise would have, with each purchase foolish.

Intensify man's love of his own conclusions by adding the possessory wallop from the "endowment effect," and you will find that a man who has already bought a pork-belly future on a commodity exchange now foolishly believes, even more strongly than before, in the merits of his speculative bet.

And foolish sports betting, by people who love sports and think they know a lot about relative merits of teams, is a lot more addictive than race track betting – partly because of man's automatic overappraisal of his own complicated conclusions.

Also extremely counterproductive is man's tendency to bet, time after time, in games of skill, like golf or poker, against people who are obviously much better players. Excessive Self-Regard Tendency diminishes the foolish bettor's accuracy in appraising his relative degree of talent.

More counterproductive yet are man's appraisals, typically excessive, of the quality of the future service he is to provide to his business. His overappraisal of these prospective contributions will frequently cause disaster.

Excesses of self-regard often cause bad hiring decisions because employers grossly overappraise the worth of their own conclusions that rely on impressions in face-to-face contact. The correct antidote to this sort of folly is to underweigh face-to-face impressions and overweigh the applicant's past record.

I once chose exactly this course of action while I served as chairman of an academic search committee. I convinced fellow committee members to stop all further interviews and simply appoint a person whose achievement record was much better than that of any other applicant. And when it was suggested to me that I wasn't giving "academic due process," I replied that I was the one being true to academic values because I was using academic research showing poor predictive value of impressions from face-to-face interviews.

Because man is likely to be overinfluenced by face-to-face impressions that by definition involve his active participation, a job candidate who is a marvelous "presenter" often causes great danger under modern executive-search practice. In my opinion, Hewlett-Packard faced just such a danger when it interviewed the articulate, dynamic Carly Fiorina in its search for a new CEO. And I believe that Hewlett-Packard made a bad decision when it chose Ms. Fiorina, and that this bad decision would not have been made if Hewlett-Packard had taken the methodological precautions it would have taken if it knew more psychology.

There is a famous passage somewhere in Tolstoy that illuminates the power of Excessive Self-Regard Tendency. According to Tolstoy, the worst criminals don't appraise themselves as all that bad. They come to believe either (1) that they didn't commit their crimes or

(2) that, considering the pressures and disadvantages of their lives, it is understandable and forgivable that they behaved as they did and became what they became.

The second half of the "Tolstoy effect," where the man makes excuses for his fixable poor performance, instead of providing the fix, is enormously important. Because a majority of mankind will try to get along by making way too many unreasonable excuses for fixable poor performance, it is very important to have personal and institutional antidotes limiting the ravages of such folly. On the personal level a man should try to face the two simple facts:

1. fixable but unfixed bad performance is bad character and tends to create more of itself, causing more damage to the excuse giver with each tolerated instance, and

2. in demanding places, like athletic teams and General Electric, you are almost sure to be discarded in due course if you keep giving excuses instead of behaving as you should.

The main institutional antidotes to this part of the "Tolstoy effect" are:

1. a fair, meritocratic, demanding culture plus personnel handling methods that build up morale, and

2. severance of the worst offenders.

Of course, when you can’t sever – as in the case of your own child – you must try to fix the child as best you can. I once heard of child-teaching method so effective that the child remembered the learning experience over fifty years later. The child later became Dean of the USC School of Music and then related to me what father said when he saw his child taking candy from the stock of his employer with the excuse that he intended to replace it later. The father said, "Son, it would be better for you to simply take all you want and call yourself a thief every time you do it."

The best antidote to folly from an excess of self-regard is to force yourself to be more objective when you are thinking about yourself, your family and friends, your property, and the value of your past and future activity. This isn’t easy to do well won’t work perfectly, but it will work much better than simply letting psychological nature take its normal course.

While an excess of self-regard is often counterproductive in its effects on cognition, it can cause some weird successes from overconfidence that happens to cause success. This factor accounts for the adage: "Never underestimate the man who overestimates himself."

Of course, some high self-appraisals are correct and serve better than false modesty. Moreover, self-regard in the form of a justified pride in a job well done, or a life well lived, is a large constructive force. Without such justified pride, many more airplanes would crash. "Pride" is another word generally left out of psychology textbooks, and this omission is not a good idea. It is also not a good idea to construe the bible’s parable about the Pharisee and the Publican as condemning all pride.

Of all forms of useful pride, perhaps the most desirable is a justified pride in being trustworthy. Moreover, the trustworthy man, even after allowing for the inconveniences of his chosen course, ordinarily has a life that averages out better than he would have if he provided less reliability.

OVEROPTIMISM TENDENCY

> Overoptimism is more dangerous than overpessimism.
>
> —Miles Anthony Smith

About three centuries before the birth of Christ, Demosthenes, the most famous Greek orator, said, "What a man wishes, that also will he believe."

Demosthenes, parsed out, was thus saying that man displays not only Simple, Pain-Avoiding Psychological Denial but also an excess of optimism even when he is already doing well.

The Greek orator was clearly right about an excess of optimism being the normal human condition, even when pain or the threat of pain is absent. Witness happy people buying lottery tickets or believing that credit-furnishing, delivery-making grocery stores were going to displace a great many superefficient cash-and-carry supermarkets.

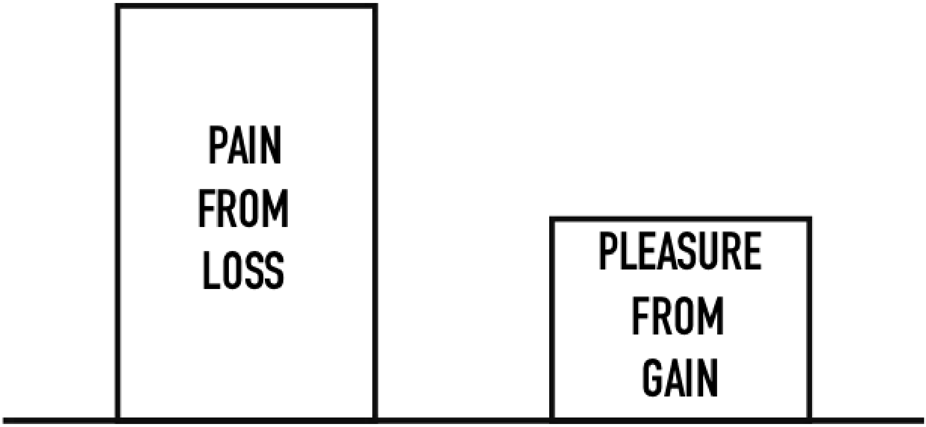
One standard antidote to foolish optimism is trained, habitual use of the simple probability math of Fermat and Pascal, taught in my youth to high school sophomores. The mental rules of thumb that evolution gives you to deal with risk are not adequate. They resemble the dysfunctional golf grip you would have if you relied on a grip driven by evolution instead of golf lessons.

DEPRIVAL-SUPERREACTION TENDENCY

> The concept of loss aversion is certainly the most significant contribution of psychology to behavioral economics.
>
> —Daniel Kahneman

The quantity of man's pleasure from a ten dollar gain does not exactly match the quantity of his displeasure from a ten-dollar loss. That is, the loss seems to hurt much more than the gain seems to help. Moreover, if a man almost gets something he greatly wants and has it jerked away from him at the last moment, he will react much as if he had long owned the reward and had it jerked away. I include the natural human reactions to both kind of loss experience – the loss of the possessed reward and the loss of the almost-possessed reward – under one description, Deprival Superreaction Tendency.

In displaying Deprival Superreaction Tendency, man frequently incurs disadvantage by misframing his problems. He will often compare what is near instead of what really matters. For instance, a man with $10 million in his brokerage account will often be extremely irritated by the accidental loss of $100 out of the $300 in his wallet.



The Mungers once owned a tame and good-natured dog that displayed the canine version of Deprival Super-reaction Tendency. There was only one way to get bitten by this dog. And that was to try and take some food away from him after he already had it in his mouth. If you did that, this friendly dog would automatically bite. He couldn't help it. Nothing could be more stupid than for the dog to bite his master. But the dog couldn't help being foolish. He had an automatic Deprival Superreaction Tendency in his nature.

Humans are much the same as this Munger dog. A man ordinarily reacts with irrational intensity to even a small loss, or threatened loss, of property, love, friendship, dominated territory, opportunity: status, or any other valued thing. As a natural result, bureaucratic in-fighting over the threatened loss of dominated territory often causes immense damage to an institution as a whole. This factor among others, accounts for much of the wisdom of Jack Welch's long fight against bureaucratic ills at General

Electric. Few business leaders have ever conducted wiser campaigns.

Deprival Superreaction Tendency often protects ideological or religious views by triggering and hatred directed toward vocal nonbelievers. This happens, in part, because the ideas of the nonbelievers, if they spread, will diminish the influence of views that are now supported by a comfortable environment including a strong relief-maintenance system. University liberal arts departments, law schools, and business organizations all display plenty of such ideology-based groupthink that rejects almost all conflicting inputs. When the vocal critic is a former believer, hostility is often boosted both by:

1. a concept of betrayal that triggers additional Deprival Superreaction Tendency because a colleague is lost, and

2. fears that conflicting views will have extra persuasive power when they come from a former colleague.

The foregoing considerations help account for the old idea of heresy, which for centuries justified much killing of heretics, frequently after torture and frequently accomplished by burning the victim alive.

It is almost everywhere the case that extremes of ideology are maintained with great intensity and with great antipathy to non-believers, causing extremes of cognitive dysfunction. This happens, I believe, because two psychological tendencies are usually acting concurrently toward this same sad result: Inconsistency-Avoidance Tendency, plus Deprival Superreaction Tendency.

One antidote to intense, deliberate maintenance of groupthink is an extreme culture of courtesy, kept in place despite ideological differences, like the behavior of the justices now serving on the U.S. Supreme Court. Another antidote is to deliberately bring in able and articulate disbelievers of incumbent groupthink. Successful corrective measures to evil examples of groupthink maintenance have included actions like that of Derek Bok when, as president of Harvard, he started disapproving tenure appointments proposed by ideologues at Harvard Law School.

Even a one-degree loss from a 180-degree view will sometime create enough Deprival Superreaction Tendency to turn a neighbor into an enemy, as I once observed when I bought a house from one of two neighbors locked into hatred by a tiny tree newly installed by one of them.

As the case of these two neighbors illustrated, the clamor of almost any group of neighbors displaying irrational, extreme deprival superreaction over some trifle in a zoning hearing is not a pretty thing to watch. Such bad behavior drives some people from the zoning field. I once bought some golf clubs from an artisan who was formerly a lawyer. When I asked him what kind of law he had practiced, I expected to hear him say, "divorce law" But his answer was, "zoning law."

Deprival Superreaction Tendency has ghastly effects in labor relations. Most of the deaths in the labor strife that occurred before World War I came when employers tried to reduce wages. Nowadays, we see fewer deaths and more occasions when whole companies disappear, as competition requires either takeaways from labor – which it will not consent to – or death of the business. Deprival Superreaction Tendency causes much of this labor resistance, often in cases where it would be in labor's interest to make a different decision.

In contexts other than labor relations, takeaways are also difficult to get. Many tragedies, therefore, occur that would have been avoided had there been more rationality and less subconscious heed of the imperative from Deprival Superreaction Tendency.

Deprival Superreaction Tendency and Inconsistency-Avoidance Tendency often join to cause one form of business failure. In this form of ruin, a man gradually uses up all his good assets in a fruitless attempt to rescue a big venture going bad. One of the best antidotes to this folly is good poker skill learned young. The teaching value of poker demonstrates that not all effective teaching occurs on a standard academic path.

Deprival Superreaction Tendency is also a huge contributor to ruin from compulsion to gamble. First, it causes the gambler to have a passion to get even once he has suffered loss, and the passion grows with the loss. Second, the most addictive forms of gambling provide a lot of near misses and each one triggers Deprival Superreaction Tendency. Some slot machine creators are vicious in exploiting this weakness of man. Electronic machines enable these creators to produce a lot of meaningless bar-bar-lemon results that greatly increase play by fools who think they have very nearly won large rewards.

Deprival Superreaction Tendency often does much damage to man in open-outcry auctions. The "social proof" that we will next consider tends to convince man that the last price from another bidder was reasonable, and then Deprival Superreaction Tendency prompts him strongly to top the last bid. The best antidote to being thus triggered into paying foolish prices at open-outcry auctions is the simple Buffett practice: Don't go to such auctions.

I myself, the would-be instructor here, many decades ago made a big mistake caused in part by subconscious operation of my Deprival Superreaction Tendency. A friendly broker called and offered me 300 shares of ridiculously underpriced, very thinly traded Belridge Oil at $115 per share, which I purchased using cash I had on hand. The next day, he offered me 1,500 more shares at the same price, which I declined to buy, partly because I could only have made the purchase had I sold something or borrowed the required $173,000. This was a very irrational decision. I was a well-to-do man with no debt; there was no risk of loss; and similar no risk opportunities were not likely to come along. Within two years, Belridge Oil sold out to Shell at a price of about $3,700 per share, which made me about $5.4 million poorer than I would have been had I then been psychologically acute. As this tale demonstrates, psychological ignorance can be very expensive.

Some people may question my defining Deprival Superreaction Tendency to include reaction to profit barely missed, as in the well-documented responses of slot machine players. However, I believe that I haven't defined the tendency as broadly as I should. My reason for suggesting an even broader definition is that many Berkshire Hathaway shareholders I know never sell or give away a single share after immense gains in market value have occurred. Some of this reaction is caused by rational calculation, and some is, no doubt, attributable to some combination of (1) reward superresponse, (2) "status quo bias" from Inconsistency-Avoidance Tendency, and (3) "the endowment effect" from Excessive Self-Regard Tendency. But I believe the single strongest irrational explanation is a form of Deprival Superreaction Tendency. Many of these shareholders simply can’t stand the idea of having their Berkshire Hathaway holdings smaller. Partly they dislike facing what they consider an impairment of identity, but mostly they fear missing out on future gains from stock sold or given away.

SOCIAL-PROOF TENDENCY

> Society exists only as a mental concept; in the real world, there are only individuals.
>
> —Oscar Wilde

The otherwise complex behavior of man is much simplified when he automatically thinks and does what he observes to be thought and done around him. And such followership often works fine. For instance, what simpler way could there be to find out how to walk to a big football game in a strange city than by following the flow of the crowd. For some such reason, man's evolution left him with Social-Proof Tendency, an automatic tendency to think and act as he sees others around him thinking and acting.

Psychology professors love Social-Proof Tendency because in their experiments it causes ridiculous results. For instance, if a professor arranges for some stranger to enter an elevator wherein ten "compliance practitioners" are all silently standing so that they face the rear of the elevator, the stranger will often turn around and do the same. The psychology professors can also use Social-Proof Tendency to cause people to make large and ridiculous measurement errors.

And, of course, teenagers' parents usually learn more than they would like about teenagers' cognitive errors from

Social-Proof Tendency. This phenomenon was recently involved in a breakthrough by Judith Rich Harris who demonstrated that superrespect by young people for their peers, rather than for parents or other adults, is ordained to some considerable extent by the genes of the young people. This makes it wise for parents to rely more on manipulating the quality of the peers than on exhortations to their own offspring. A person like Ms. Harris, who can provide an insight of this quality and utility, backed by new reasons, has not lived in vain.

And in the highest reaches of business, it is not all uncommon to find leaders who display followership akin to that of teenagers. If one oil company foolishly buys a mine, other oil companies often quickly join in buying mines. So also if the purchased company makes fertilizer. Both of these oil company buying fads actually bloomed, with bad results.

Of course, it is difficult to identify and correctly weigh all the possible ways to deploy the cash flow of an oil company. So oil company executives, like everyone else, have made many bad decisions that were quickly triggered by discomfort from doubt. Going along with social proof provided by the action of other oil companies ends this discomfort in a natural way.

When will Social-Proof Tendency be most easily triggered? Here the answer is clear from many experiments: Triggering most readily occurs in the presence of puzzlement or stress, and particularly when both exist.

Because stress intensifies Social-Proof Tendency, disreputable sales organizations, engaged, for instance, in such action as selling swampland to schoolteachers, manipulate targets into situations combining isolation and stress. The isolation strengthens the social proof provided by both the knaves and the people who buy first, and the stress, often increased by fatigue, augments the targets' susceptibility to the social proof. And, of course, the techniques of our worst "religious" cults imitate those of the knavish salesmen. One cult even used rattlesnakes to heighten the stress felt by conversion targets.

Because both bad and good behavior are made contagious by Social-Proof Tendency, it is highly important that human societies stop any bad behavior before it spreads and foster and display all good behavior.

My father once told me that just after commencing law practice in Omaha, he went with a large group from Nebraska to South Dakota to hunt pheasants. A South Dakota hunting license was, say, $2 for South Dakota residents and $5 for nonresidents. All the Nebraska residents, one by one, signed up for South Dakota licenses with phony South Dakota addresses until it was my father's turn. Then, according to him, he barely prevented himself from doing what the others were doing, which was some sort of criminal offense.

Not everyone so resists the social contagion of bad behavior. And, therefore, we often get "Serpico Syndrome," named to commemorate the state of a near-totally corrupt New York police division joined by Frank Serpico. He was then nearly murdered by gunfire because of his resistance to going along with the corruption in the division. Such corruption was being driven by social proof plus incentives, the combination that creates Serpico Syndrome. The Serpico story should be taught more than it now is because the didactic power of its horror is aimed at a very important evil, driven substantially by a very important force: social proof.

In social proof, it is not only action by others that misleads but also their inaction. In the presence of doubt, inaction by others becomes social proof that inaction is the right course. Thus, the inaction of a great many bystanders led to the death of Kitty Genovese in a famous incident much discussed in introductory psychology courses.

In the ambit of social proof, the outside rectors on a corporate board usually display the near ultimate form of inaction. They fail to object to anything much short of an axe murder until some public embarrassment of the board finally causes their intervention. A typical board-of-directors' culture was once well described by my friend, Joe Rosenfield, as he said, "They asked me if I wanted become a director of Northwest Bell, and it was the last thing they ever asked me."

In advertising and sales promotion, Social-Proof Tendency is about as strong a factor as one could imagine. "Monkey-see, monkey-do" is the old phrase that reminds one of how strongly John will often wish to do something, or have something, just because Joe does or has it. One interesting consequence is that an advertiser will pay a lot to have its soup can, instead of someone else's, in a movie scene involving soup consumption only in a peripheral way.

Social-Proof Tendency often interacts in a perverse way with Envy/Jealousy and Deprival Superreaction Tendency. One such interaction amused my family for years as people recalled the time when my cousin Russ and I, at ages three and four, fought and howled over a single surplus shingle while surrounded by a virtual sea of surplus shingles.

But the adult versions of this occasion, boosted by psychological tendencies preserving ideologies, are not funny – and can bring down whole civilizations. The Middle East now presents just such a threat. By now the resources spent by Jews, Arabs and all others over a small amount of disputed land if divided arbitrarily among land claimants, would have made everyone better off, even before taking into account any benefit from reduced threat of war, possibly nuclear.

Outside domestic relations it is rare now to try to resolve disputes by techniques including discussion of impacts from psychological tendencies. Considering the implications of childishness that would be raised by such inclusion, and the defects of psychology as now taught, this result may be sound. But, given the nuclear stakes now involved and the many failures in important negotiations lasting decades, I often wonder if some day, in some way, more use of psychological insight will eventually improve outcomes. If so, correct teaching of psychology matters a lot. And, if old psychology professors are even less likely than old physics professors to learn new ways, which seems nearly certain, then we may, as Max Planck predicted, need a new generation of psychology professors who have grown up to think in a different way.

If only one lesson is to be chosen from a package of lessons involving Social-Proof Tendency, and used in self improvement, my favorite would be: Learn how to ignore the examples from others when they are wrong, because few skills are more worth having.

CONTRAST-MISREACTION TENDENCY

> The greater the contrast, the greater the potential. Great energy only comes from a correspondingly great tension of opposites.
>
> —Carl Jung

Because the nervous system of man does not naturally measure in absolute scientific units, it must instead rely on something simpler. The eyes have a solution that limits their programming needs: the contrast in what is seen is registered. And as in sight, so does it go, largely, in the other senses. Moreover, as perception goes, so goes cognition. The result is man's Contrast-Misreaction Tendency. Few psychological tendencies do more damage to correct thinking. Small-scale damages involve instances such as man's buying an overpriced $1,000 leather dashboard merely because the price is so low compared to his concurrent purchase of a $65,000 car. Large-scale damages often ruin lives, as when a wonderful woman having terrible parents marries a man who would be judged satisfactory only in comparison to her parents. Or as when a man takes wife number two who would be appraised as all right only in comparison to wife number one.

A particularly reprehensible form of sales practice occurs in the offices of some real estate brokers. A buyer from out of the city, perhaps needing to shift his family there, visits the office with little time available. The salesman deliberately shows the customer three awful houses at ridiculously high prices. Then he shows him a merely bad house at a price only moderately too high. And, boom, the broker often makes an easy sale.

Contrast-Misreaction Tendency is routinely used to cause disadvantage for customers buying merchandise and services. To make an ordinary price seem low, the vendor will very frequently create a highly artificial price that is much higher than the price always sought, then advertise his standard price as a big reduction from his phony price. Even when people know that this sort of customer manipulation is being attempted, it will often work to trigger buying. This phenomenon accounts in part for much advertising in newspapers. It also demonstrates that being aware of psychological ploys is not a perfect defense. When a man's steps are consecutively taken toward disaster, with each step being very small, the brain's Contrast-Misreaction Tendency will often let the man go too far toward disaster to be able to avoid it. This happens because each step presents small a contrast from his present position.

A bridge-playing pal of mine once told me that a frog tossed into very hot water would jump out, but that the same frog would end up dying if placed in room-temperature water that was later treated at a very slow rate. My few shreds of physiological knowledge make me doubt this account. But no matter, because many businesses die in just the manner claimed by my friend for the frog. Cognition, misled by tiny changes involving low contrast, will often miss a trend that is destiny.

One of Ben Franklin’s best-remembered and most useful aphorisms is "A small leak will sink great ship." The utility of the aphorism is large precisely because the brain so often misses the functional equivalent of a small leak in a great ship.

STRESS-INFLUENCE TENDENCY

> It's not stress that kills us, it is our reaction to it.
>
> —Hans Selye

Everyone recognizes that sudden stress, for instance from a threat, will cause a rush of adrenaline in the human body, prompting faster and more extreme reaction. And everyone who has taken Psych 101 knows that stress makes Social-Proof Tendency more powerful.

In a phenomenon less well recognized, but still widely known, light stress can slightly improve performance—say, in examinations—whereas heavy stress causes dysfunction.

But few people know more about really heavy stress than that it can cause depression. For instance, most people know that an "acute stress depression" makes thinking dysfunctional because it causes an extreme of pessimism, often extended in length and usually accompanied by activity stopping fatigue. Fortunately, as most people also know, such a depression is one of mankind's more reversible ailments. Even before modern drugs were available, many people afflicted by depression, such as Winston Churchill and Samuel Johnson, gained great achievement in life.

Most people know very little about nondepressivemental breakdowns influenced by heavy stress. But there is at least one exception, involving the work of Pavlov when he was in his seventies and eighties. Pavlov had won a Nobel Prize early in life by using dogs to work out the physiology of digestion. Then he became world-famous by working out mere-association responses in dogs, initially salivating dogs – so much so that changes in behavior triggered by mere-association, like those caused by much modern advertisement, are today often said to come from "Pavlovian" conditioning.

What happened to cause Pavlov's last work was especially interesting. During the great Leningrad Flood of the 1920s, Pavlov had many dogs in cages. Their habits had been transformed, by a combination of his "Pavlovian conditioning" plus standard reward responses, into distinct and different patterns. As the waters of the flood came up and receded, many dogs reached a point where they had almost no airspace between their noses and the tops of their cages. This subjected them to maximum stress. Immediately thereafter, Pavlov noticed that many of the dogs were no longer behaving as they had. For example, the dog that formerly had liked his trainer now disliked him. This result reminds one of modern cognition-reversals in which a person's love of his parents suddenly becomes hate, as new love has been shifted suddenly to a cult. The unanticipated, extreme changes in Pavlov's dogs would have driven any good experimental scientist into a near-frenzy of curiosity. That was indeed Pavlov's reaction. But not many scientists would have done what Pavlov next did.

And that was to spend the rest of his long life giving stress-induced nervous breakdowns to dogs, after which he would try to reverse the breakdowns, all the while keeping careful experimental records. He found

1. that he could classify dogs so as to predict how easily a particular dog would breakdown;

2. that the dogs hardest to break down were also the hardest to return to their pre-breakdown state;

3. that any dog could be broken down; and

4. that he couldn't reverse a breakdown except by reimposing stress.

Now, practically everyone is revolted by such experimental treatment of man's friend, the dog. Moreover, Pavlov was Russian and did his last work under the Communists. And maybe those facts account for the present extreme, widespread ignorance of Pavlov's last work. The two Freudian psychiatrists with whom I tried many years ago to discuss this work had never heard of it. And the dean of a major medical school actually asked me, several years ago, if any of Pavlov's experiments were "repeatable" in experiments of other researchers. Obviously, Pavlov is now a sort of forgotten hero in medical science.

I first found a description of Pavlov's last work in a popular paperback, written by some Rockefeller-financed psychiatrist, when I was trying to figure out how cults worked their horrible mischief and what should the law say about what parents could do to "de-program" children who had become brainwashed zombies. Naturally, mainstream law objected to the zombies being physically captured by their parents and subjected to stress that would help to deprogram the effects of the stress they had endured in cult conversions.

I never wanted to get into the legal controversy that existed about this subject. But I did conclude that the controversy couldn't be handled with maximized rationality without considering whether as Pavlov's last work suggests, the heavy-handed imposition of stress might be the only reversal method that would work to remedy one of the worst evils imaginable: a stolen mind. I have included this discussion of Pavlov partly out of general antagonism toward taboos, partly to make my talk reasonably complete as it considers stress and partly because I hope some listener may continue my inquiry with more success.

AVAILABILITY-MISWEIGHING TENDENCY

> The nasty thing about the availability bias is that it insidiously distorts our view of the world by distorting our perception of past events and our environment.
>
> —Leonard Mlodinow

This mental tendency echoes the words of the song: "When I'm not near the girl I love, I love the girl I'm near." Man's imperfect, limited-capacity brain easily drifts into working with what's easily available to it. And the brain can't use what it can't remember or what it is blocked from recognizing because it is heavily influenced by one or more psychological tendencies bearing strongly on it, as the fellow is influenced by the nearby girl in the song. And so the mind overweighs what is easily available and thus displays Availability-Misweighing Tendency.

The main antidotes to miscues from Availability-Misweighing Tendency often involve procedures, including use of checklists, which are almost always helpful.

Another antidote is to behave somewhat like Darwin did when he emphasized disconfirming evidence. What should be done is to especially emphasize factors that don't produce reams of easily available numbers, instead of drifting mostly or entirely into considering factors that do produce such numbers. Still another antidote is to find and hire some skeptical, articulate people with far-reaching minds to act as advocates for notions that are opposite to the incumbent notions.

One consequence of this tendency is that extra vivid evidence, being so memorable and thus more available in cognition, should often consciously be underweighed while less vivid evidence should be overweighed.

Still, the special strength of extra-vivid images in influencing the mind can be constructively used

1. in persuading someone else to reach a correct conclusion or

2. as a device for improving one's own memory by attaching vivid images, one after the other, to many items one doesn't want to forget.

Indeed, such use of vivid images as memory boosters is what enabled the great orators of classical Greece and Rome to give such long, organized speeches without using notes.

The great algorithm to remember in dealing with this tendency is simple: An idea or a fact is not worth more merely because it is easily available to you.

USE-IT-OR-LOSE-IT TENDENCY

> Tell your readers to use it or lose it. If you don't use your muscles, they get weak. If you don't use your mind it begins to fail.
>
> —John Templeton

All skills attenuate with disuse. I was a whiz at calculus until age twenty, after which the skill was soon obliterated by total nonuse. The right antidote to such a loss is to make use of the functional equivalent of the aircraft simulator employed in pilot training. This allows a pilot to continuously practice all of the rarely used skills that he can't afford to lose.

Throughout his life, a wise man engages in practice of all his useful, rarely used skills, many of them outside his discipline, as a sort of duty to his better self. If he reduces the number of skills he practices and, therefore, the number of skills he retains, he will naturally drift into error from man with a hammer tendency. His learning capacity will also shrink as he creates gaps in the lattice-work of theory he needs as a framework for understanding new experience. It is also essential for a thinking man to assemble his skills into a checklist that he routinely uses. Any other mode of operation will cause him to miss much that is important.

Skills of a very high order can be maintained only with daily practice. The pianist Paderewski once said that if he failed to practice for a single day, he could notice his performance deterioration and that, after a week's gap in practice, the audience could notice it as well.

The hard rule of Use-It-or-Lose-It Tendency tempers its harshness for the diligent. If a skill is raised to fluency, instead of merely being crammed in briefly to enable one to pass some test, then the skill (1) will be lost more slowly and (2) will come back faster when refreshed with new learning. These are not minor advantages, and a wise man engaged in learning some important skill will not stop until he is really fluent in it.

DRUG MISINFLUENCE TENDENCY

> I don’t do drugs. I am drugs.
>
> —Salvador Dali

This tendency’s destructive power is so widely known to be intense, with frequent tragic consequences for cognition and the outcome of life, that it needs no discussion here to supplement that previously given under "Simple, Pain-Avoiding Psychological Denial."

SENESCENCE-MISINFLUENCE TENDENCY

> Senescence is an inevitability. All we can do is try to strike the balance between graceful acceptance and raging against the dying light.
>
> —Marty Nemko

With advanced age, there comes a natural cognitive decay, differing among individuals in the earliness of its arrival and the speed of its progression. Practically no one is good at learning complex new skills when very old. But some people remain pretty good in maintaining intensely practiced old skills until late in life, as one can notice in many a bridge tournament.

Old people like me get pretty skilled, without working at it, at disguising age-related deterioration because social convention, like clothing, hides much decline.

Continuous thinking and learning, done with joy, can somewhat help delay what is inevitable.

AUTHORITY-MISINFLUENCE TENDENCY

> As soon as we abandon our own reason, and are content to rely upon authority, there is no end to our troubles.
>
> —Bertrand Russell

Living in dominance hierarchies as he does, like all his ancestors before him, man was born mostly to follow leaders, with only a few people doing the leading. And so, human society is formally organized into dominance hierarchies, with their culture augmenting the natural follow-the-leader tendency of man.

But automatic as most human reactions are, with the tendency to follow leaders being no exception, man is often destined to suffer greatly when the leader is wrong or when his leader's ideas don't get through properly in the bustle of life and are misunderstood. And so, we find much miscognition from man's Authority-Misinfluence Tendency.

Some of the misinfluences are amusing, as in a case described by Cialdini. A physician left a written order for a nurse treating an earache, as follows: "Two drops, twice a day, r. ear." The nurse then directed the patient to turn over and put the eardrops in his anus.

Other versions of confused instructions from authority figures are tragic. In World War II, a new pilot for a general, who sat beside him in the copilot's seat, was so anxious to please his boss that he misinterpreted some minor shift in the general's position as a direction to do some foolish thing. The pilot crashed the plane and became a paraplegic.

Well, naturally, cases like this one get the attention of careful thinkers like Boss Buffett, who always acts like an overquiet mouse around his pilots.

Such cases are also given attention in the simulator training of copilots who have to learn to ignore certain really foolish orders from boss pilots because boss pilots will sometimes err disastrously. Even after going through such a training regime, however, copilots in simulator exercises will too often allow the simulated plane to crash because of some extreme and perfectly obvious simulated error of the chief pilot.

After Corporal Hitler had risen to dominate Germany, leading a bunch of believing Lutherans and Catholics into orgies of genocide and other mass destruction, one clever psychology professor, Stanley Milgram, decided to do an experiment to determine exactly how far authority figures could lead ordinary people into gross misbehavior. In this experiment, a man posing as an authority figure, namely a professor governing a respectable experiment, was able to trick a great many ordinary people into giving what they had every reason to believe were massive electric shocks that inflicted heavy torture on innocent fellow citizens. This experiment did demonstrate a terrible result contributed to by Authority-Misinfluence Tendency, but it also demonstrated extreme ignorance in the psychology professoriate right after World War II.

Almost any intelligent person with my checklist of psychological tendencies in his hand would, by simply going down the checklist, have seen that Milgram's experiment involved about six powerful psychological tendencies acting in confluence to bring about his extreme experimental result. For instance, the person pushing Milgram's shock lever was given much social proof from presence of inactive bystanders whose silence communicated that his behavior was okay. Yet it took over a thousand psychological papers, published before I got to Milgram, for the professoriate to get his experiment only about ninety percent as well understood as it would have immediately been by any intelligent person who used (1) any sensible organization of psychology along the lines of this talk, plus (2) a checklist procedure. This outcome displaying the dysfunctional thinking of long-dead professors deserves a better explanation. I will later deal with the subject in a very hesitant fashion.

We can be pleased that the psychology professoriate of a former era wasn't quite as dysfunctional as the angler in my next-to-last illustration of Authority-Misinfluence Tendency.

When I once fished in the Rio Colorado in Costa Rica, my guide, in a state of shock, told me a story about an angler who'd earlier come to the river without ever having fished for tarpon. A fishing guide like the one I had runs the boat and gives fishing advice, establishing himself in this context as the ultimate authority figure. In the case of this guide, his native language was Spanish, while the angler's native language was English. The angler got a big tarpon on and began submitting to many directions from this authority figure called guide: tip up, tip down, reel in, etc. Finally, when it was necessary to put more pressure on the fish by causing more bending of the angler's rod, the guide said in English: "Give him the rod, give him the rod." Well, the angler threw his expensive rod at the fish, and when last seen, it was going down the Rio Colorado toward the ocean. This example shows how powerful is the tendency to go along with an authority figure and how it can turn ones brain into mush.

My final example comes from business. A psychology Ph.D. once became a CEO of a major company and went wild, creating an expensive headquarters, with a great wine cellar, at an isolated site. At some point, his underlings remonstrated that money was running short. "Take the money out of the depreciation reserves," said the CEO. Not too easy because a depreciation reserve is a liability account.

So strong is undue respect for authority that this CEO, and many even worse examples, have actually been allowed to remain in control of important business institutions for long periods after it was clear they should be removed. The obvious implication: be careful whom you appoint to power because a dominant authority figure will often be hard to remove, aided as he will be by Authority-Misinfluence Tendency.

TWADDLE TENDENCY

> All this twaddle, the existence of God, atheism, determinism, liberation, societies, death, etc., are pieces of a chess game called language, and they are amusing only if one does not preoccupy oneself with 'winning or losing this game of chess.
>
> —Marcel Duchamp

Man, as a social animal who has the gift of language, is born to prattle and to pour out twaddle that does much damage when serious work is being attempted. Some people produce copious amounts of twaddle and others very little.

A trouble from the honeybee version of twaddle once demonstrated in an interesting experiment. A honeybee normally goes out and finds nectar and then comes back and does a dance that communicates to the other bees where the nectar is. The other bees then go out and get it. Well some scientist – clever, like B. F. Skinner – decided to see how well a honeybee would do with a handicap. He put the nectar straight up. Way up. Well, in a natural setting, there is no nectar a long way straight up, and the poor honeybee doesn't have a genetic program that is adequate to handle what she now as to communicate. You might guess that this honeybee would come back to the hive and slink into a corner, but she doesn't. She comes into the hive and does an incoherent dance. Well, all my life I've been dealing with the human equivalent of that honeybee. And it's a very important part of wise administration to keep prattling people, pouring out twaddle, far away from the serious work.

A rightly famous Caltech engineering professor, exhibiting more insight than tact, once expressed his version of this idea as follows: "The principal job of an academic administration is to keep the people who don't matter from interfering with the work of the people that do." I include this quotation partly because I long suffered from backlash caused by my version of this professor's conversational manner. After much effort, I was able to improve only slightly, so one of my reasons for supplying the quotation is my hope that, at least in comparison, I will appear tactful.

REASON-RESPECTING TENDENCY

> Reason is God's greatest gift to man.
>
> —Sophocles

There is in man, particularly one in an advanced culture, a natural love of accurate cognition and a joy in its exercise. This accounts for the widespread popularity of crossword puzzles, other puzzles, and bridge and chess columns, as well as all games requiring mental skill.

This tendency has an obvious implication. It makes man especially prone to learn well when a would-be teacher gives correct reasons for what is taught, instead of simply laying out the desired belief ex cathedra with no reasons given. Few practices, therefore, are wiser than not only thinking through reasons before giving orders but also communicating these reasons to the recipient of the order.

No one knew this better than Carl Braun, who designed oil refineries with spectacular skill and integrity.

He had a very simple rule, one of many in his large, Teutonic company: You had to tell Who was to do What, Where, When, and Why. And if you wrote a communication leaving out your explanation of why the addressee was to do what was ordered, Braun was likely to fire you because Braun well knew that ideas got through best when reasons for the ideas were meticulously laid out.

In general, learning is most easily assimilated and used when, life long, people consistently hang their experience, actual and vicarious, on a latticework of theory answering the question: Why? Indeed, the question "Why?" is a sort of Rosetta stone opening up the major potentiality of mental life.

Unfortunately, Reason-Respecting Tendency is so strong that even a person’s giving of meaningless or incorrect reasons will increase compliance with his orders and requests. This has been demonstrated in psychology experiments wherein "compliance practitioners" successfully jump to the head of the lines in front of copying machines by explaining their reason: "I have to make some copies." This sort of unfortunate byproduct of Reason-Respecting Tendency is a conditioned reflex, based on a widespread appreciation of the importance of reasons. And, naturally, the practice of laying out various claptrap reasons is much used by commercial and cult "compliance practitioners" to help them get what they don’t deserve.

LOLLAPALOOZA TENDENCY

> An investment decision in the common stock of a company frequently involves a whole lot of factors interacting ... the one thing that causes the most trouble is when you combine a bunch of these together, you get this lollapalooza effect.
>
> —Charlie Munger

This tendency was not in any of the psychology texts I once examined, at least in any coherent fashion, yet it dominates life. It accounts for the extreme result in the Milgram experiment and the extreme success of some cults that have stumbled through practice evolution into bringing pressure from many psychological tendencies to bear at the same time on conversion targets. The targets vary in susceptibility, like the dogs Pavlov worked with in his old age, but some of the minds that are targeted simply snap into zombiedom under cult pressure. Indeed, that is one cult's name for the conversion phenomenon: snapping.

What are we to make of the extreme ignorance of the psychology textbook writers of yesteryear? How could anyone who had taken a freshman course in physics or chemistry not be driven to consider, above all, how psychological tendencies combine and with what effects? Why would anyone think his study of psychology was adequate without his having endured the complexity involved in dealing with intertwined psychological tendencies? What could be more ironic than professors using oversimplified notions while studying bad cognitive effects grounded in the mind's tendency to use oversimplified algorithms?

I will make a few tentative suggestions. Maybe many of the long-dead professors wanted to create a whole science from one narrow type of repeatable psychology experiment that was conductible in a university setting and that aimed at one psychological tendency at a time. If so, these early psychology professors made a massive error in so restricting their approach to their subject. It would be like physics ignoring astrophysics because it couldn't happen in a physics lab, plus all compound effects. What psychological tendencies could account for early psychology professors adopting an over-restricted approach to their own subject matter? One candidate would be Availability-Misweighing Tendency grounded in a preference for easy-to-control data. And then the restrictions would eventually create an extreme case of man with a hammer tendency. Another candidate might be Envy/jealousy Tendency through which early psychology professors displayed some weird form of envy of a physics that was misunderstood. And this possibility tends to demonstrate that leaving envy/jealousy out of academic psychology was never a good idea. I now quit claim of all these historical mysteries to my betters.

Well, that ends my brief description of psychological tendencies.

QUESTIONS AND ANSWERS

Now, as promised, I will ask and answer a few general questions.

Isn't this list of psychological tendencies tautological to some extent compared to the system of Euclid? That is, aren't there overlaps in the tendencies? And couldn't the system be laid out just as plausibly in a somewhat different way?

The answers are yes, yes, and yes, but this matters only moderately. Further refinement of these tendencies, while desirable, has a limited practical potential because a significant amount of messiness is unfixable in a soft science like psychology.

Can you supply a real world model, instead of a Milgram-type controlled psychology experiment, that uses your system to illustrate multiple psychological tendencies interacting in a plausibly diagnosable way?

The answer is yes. One of my favorite cases involves the McDonnell Douglas airliner evacuation test. Before a new airliner can be sold, the government requires that it pass an evacuation test, during which a full load of passengers must get out in some short period of time. The government directs that the test be realistic. So you can't pass by evacuating only twenty-year-old athletes. So McDonnell Douglas scheduled such a test in a darkened hangar using a lot of old people as evacuees. The passenger cabin was, say, twenty feet above the concrete floor of the hangar and was to be evacuated through moderately flimsy rubber chutes.

The first test was made in the morning. There were about twenty very serious injuries, and the evacuation took so long it flunked the time test. So what did McDonnell Douglas next do? It repeated the test in the afternoon, and this time there was another failure, with about twenty more serious injuries, including one case of permanent paralysis.

What psychological tendencies contributed to this terrible result? Well, using my, tendency list as a check-list, I come up with the following explanation. Reward-Superresponse Tendency drove McDonnell Douglas to act fast. It couldn't sell its airliner until it passed the test. Also pushing the company was Doubt-Avoidance Tendency with its natural drive to arrive at a decision and run with it. Then the government's direction that the test be realistic drove Authority-Misinfluence Tendency into the mischief of causing McDonnell Douglas to overreact by using what was obviously too dangerous a test method. By now the course of action had been decided, so Inconsistency Avoidance Tendency helped preserve the near idiotic plan. When all the old people got to the dark hangar, with its high airline cabin and concrete floor, the situation must have made McDonnell Douglas employees very queasy, but they saw other employees and supervisors not objecting. Social Proof Tendency, therefore, swamped the queasiness. And this allowed continued action as planned, a continuation that was aided by more Authority Overinfluence Tendency. Then came the disaster of the morning test with its failure, plus serious injuries. McDonnell Douglas ignored the strong disconfirming evidence from the failure of the first test because confirmation bias, aided by the triggering of strong Deprival Superreaction Tendency favored maintaining the original plan. McDonnell Douglas' Deprival Superreaction

Tendency was now like that which causes a gambler, bent on getting even after a huge loss, to make his final big bet. After all, McDonnell Douglas was going to lose a lot if it didn't pass its test as scheduled. More psychology-based explanation can probably be made, but the foregoing discussion is complete enough to demonstrate the utility of my system when used in a checklist mode.

In the practical world, what good is the thought system laid out in this list of tendencies? Isn't practical benefit prevented because these psychological tendencies are so thoroughly programmed into the human mind by broad evolution [the combination of genetic and cultural evolution] that we can't get rid of them?

Well, the answer is that the tendencies are probably much more good than bad. Otherwise, they wouldn't be there, working pretty well for man, given his condition and his limited brain capacity. So the tendencies can't be simply washed out automatically, and shouldn't be. Nevertheless, the psychological thought system described, when properly understood and used, enables the spread of wisdom and good conduct and facilitates the avoidance of disaster. Tendency is not always destiny, and knowing the tendencies and their antidotes can often help prevent trouble that would otherwise occur.

Here is a short list of examples reminding us of the great utility of elementary psychological knowledge:

1. Carl Braun's communication practices.

2. The use of simulators in pilot training.

3. The system of Alcoholics Anonymous.

4. Clinical training methods in medical schools.

5. The rules of the U.S. Constitutional Convention: totally secret meetings, no recorded vote by name until the final vote, votes reversible at any time before the end of the convention, then just one vote on the whole Constitution. These are very clever psychology-respecting rules. If the founders had used a different procedure, many people would have been pushed by various psychological tendencies into inconsistent, hardened positions. The elite founders got our Constitution through by a whisker only because they were psychologically acute.

6. The use of Granny’s incentive-driven rule to manipulate oneself toward better performance of one’s duties.

7. The Harvard Business School’s emphasis on decision trees. When I was young and foolish I used to laugh at the Harvard Business School. I said, "They’re teaching twenty-eight year-old people that high school algebra works in real life?" But later, I wised up and realized that it was very important that they do that to counter some bad effects from psychological tendencies. Better late than never.

8. The use of autopsy equivalents at Johnson & Johnson. At most corporations, if you make an acquisition and it turns out to be a disaster, all the people, paperwork, and presentations that caused the foolish acquisition are quickly forgotten. Nobody wants to be

associated with the poor outcome by mentioning it. But at Johnson & Johnson, the rules make everybody revisit old acquisitions, comparing predictions with outcomes. That is a very smart thing to do.

9. The great example of Charles Darwin as he avoided confirmation bias, which has morphed into the extreme anti-confirmation-bias method of the "double blind" studies wisely required in drug research by the FDA.

10. The Warren Buffett rule for open-outcry auctions: Don’t go.

What special knowledge problems lie buried in the thought system demonstrated by your list?

Well, one answer is paradox. In social psychology, the more people learn about the system the less it is true, and this is what gives the system its great value as a preventer of bad outcomes and a driver of good outcomes. This result is paradoxical, and doesn’t remind one of elementary physics, but so what. One can’t get all the paradox out of pure math, so why should psychology be shocked by some paradox?

There is also some paradox in cognition change that works even when the manipulated person knows he is being manipulated. This creates a sort of paradox in a paradox, but, again, so what. I once much enjoyed an occasion of this sort. I drew this beautiful woman as my dinner partner many years ago. I’d never seen her before. She was married to a prominent Los Angeles man. She sat down next to me, turned her beautiful face up, and said, "Charlie, what one word accounts for your remarkable success in life?" I knew I was being manipulated by a practiced routine, and I just loved it. I never see this woman without a little lift in my spirits. And, by the way, I told her I was rational. You'll have to judge yourself whether that's true. I may be demonstrating some psychological tendency I hadn't planned on demonstrating.

Don't we need more reconciliation of psychology and economics?

My answer is yes, and I suspect that some slight progress is being made. I have heard of one such example. Colin Camerer of Caltech, who works in "experimental economics," devised an interesting experiment in which he caused high I.Q. students, playing for real money, to pay price A+B for a "security" they knew would turn into A dollars at the end of the day. This foolish action occurred because the students were allowed to trade with each other in liquid market for the security. And some students then paid price A+B because they hoped to unload on other students at a higher price before the day was over. What I will now confidently predict is that, despite Camerer's experimental outcome, most economics and corporate finance professors who still believe in the "hard-form efficient market hypothesis" will retain their original belief. If so, this will be one more indication of how irrational smart people can be when influenced by psychological tendencies.

Don't moral and prudential problems come with knowledge of these psychological tendencies?

The answer is yes. For instance, psychological knowledge improves persuasive power and, like other power, it can be used for good or ill. Captain Cook once played a psychology-based trick on his seamen to cause them to eat sauerkraut and avoid scurvy. In my opinion, this action was both ethical and wise under the circumstances, despite the deliberate manipulation involved.

But ordinarily, when you try to use your knowledge of psychological tendencies in the artful manipulation of someone whose trust you need, you will be making both a moral and prudential error. The moral error is obvious. The prudential error comes because many intelligent people, targeted for conscious manipulation, are likely to figure out what you are trying to do and resent your action.

Aren't there factual and reasoning errors in this talk?

The answer is yes, almost surely yes. The final revision was made from memory over about fifty hours by a man eighty-one years old, who never took a course in psychology and has read none of it, except one book on developmental psychology, for nearly fifteen years. Even so. I think the totality of my talk will stand up very well, and I hope all my descendants and friends will carefully consider what I have said. I even hope that more psychology professors will join me in:

1. making heavy use of inversion;
2. driving for a complete description of the psychological system so that it works better as a checklist; and
3. especially emphasizing effects from combinations of psychological tendencies.

Well that ends my talk. If in considering what I have said you had ten percent the fun I had saying it, you were lucky recipients.

Selections from three of Charlie Munger's talks, combined into one talk never made, after revisions by Charlie in 2005 that included considerable new material. The three talks were:

1. *The Bray Lecture at the Caltech Faculty Club, February 2, 1992;*

2. *Talk under the Sponsorship of the Cambridge Center for Behavioral Studies at the Harvard Faculty Club, October 6, 1994; and the extensive revision by Charlie in 2005, made from memory unassisted by any research, occurred because Charlie thought he could do better at age eighty-one than he did more than ten years earlier when he knew less and was more harried by a crowded life and was speaking from rough notes instead of revising transcripts.*

3. *Talk under the Sponsorship of the Cambridge Center for Behavioral Studies at the Boston Harbor Hotel, April 24, 1995.*

ECONOMICS

> It is no crime to be ignorant of economics, which is, after all, a specialized discipline and one that most people consider to be a *dismal science*. But it is totally irresponsible to have a loud and vociferous opinion on economic subjects while remaining in this state of ignorance.
>
> —Murray N. Rothbard

Economics is a social science that studies the processes of extraction, production, exchange, distribution and consumption of goods and services. In a figurative sense, economy means rule and moderation of expenses; saving.

The word economy comes from the Latin *oeconomĭa*, and this in turn from the Greek *οἰκονομία* (oikonomy), which is derived from the union of the Greek terms *οἶκος* (oíkos), which means *house*, *νόμος* (nómos), *norm*.

The concept of economy encompasses the notion of how societies use scarce resources to produce goods with value, and how they distribute goods among individuals.

ECONOMICS MODELS

The following ideas related to economics will give us a vision of the business world, and the most interesting ones will be those that apply to other areas, such as human relations, or even our own personal habits.

- Double Entry Accounting
- Opportunity Costs
- Circle of Competence
- Pareto Principle
- Creative Destruction
- Supply and Demand
- Moats
- Network Effects
- Switching Costs
- Specialization
- Tragedy of the Commons
- Mr. Market
- Principal-agent problem
- Skin in the game

DOUBLE ENTRY ACCOUNTING

> Few have probably ever heard of Fra Luca Pacioli, the inventor of double-entry bookkeeping, but he has probably had much more influence on human life than has Dante or Michelangelo.
>
> —Herbert J. Muller

The double entry system is an accounting method that consists of recording an operation twice, once in debit and once in credit. In this way, some relationships are established between the different patrimonial masses.

Accounting operations are carried out through so-called entries. These have two parts, the debit and the credit. In this way, by this method, every input operation involves an output operation. Or what is the same, every debtor has a creditor as a counterpart. It is necessary to clarify that the positive values go in the debit and the negative ones in the credit, in turn, with a positive sign.
The left-hand side is debit, and the right-hand side is credit. For instance, recording a sale of $100 might require two entries: a debit of $100 to an account named *Cash* and a credit of $100 to an account named *Revenue*.

The accounting equation:

ASSETS = EQUITY – LIABILITIES

For the registration of accounts according to the double entry rule, we must take into account that it will be entered in:

- **Debt**: increases in assets, decreases in liabilities and decreases in equity.

- **Credit**: decreases in assets, increases in liabilities and increases in equity.

The double entry system is based on a number of principles:

- In every accounting event there is always a debtor or debtors and a creditor or creditors for the same amount.

- In all accounting operations, the recipient is the debtor and the delivery creditor (if I buy, I owe the purchase. If I sell, they owe me).

- In every point, the sum of the amount owed must be equal to the sum of the amount paid).
- The sum of the debit must be equal to the sum of the credit.

OPPORTUNITY COSTS

> Intelligent people make decisions based on opportunity costs.
>
> —Charlie Munger

The opportunity cost is the cost of the alternative that we give up when we make a certain decision, including the benefits that we could have obtained by choosing the alternative option.

Therefore, the opportunity cost is those resources that we stop perceiving or that represent a cost due to the fact of not having chosen the best possible alternative, when there are limited resources (generally money and time). The term opportunity cost is also referred to as "the value of the best option not selected".

> The difference between successful people and really successful people is that really successful people say *no* to almost everything.
>
> —Warren Buffett

On certain occasions it will be subjective, so when assessing the opportunity cost, it is very important to keep in mind which are the objectives that you want to maximize, and the value that what we stop gaining has for us.

CIRCLE OF COMPETENCE

> Everybody's got a different circle of competence. The important thing is not how big the circle is. The important thing is staying inside the circle.
>
> —Warren Buffett

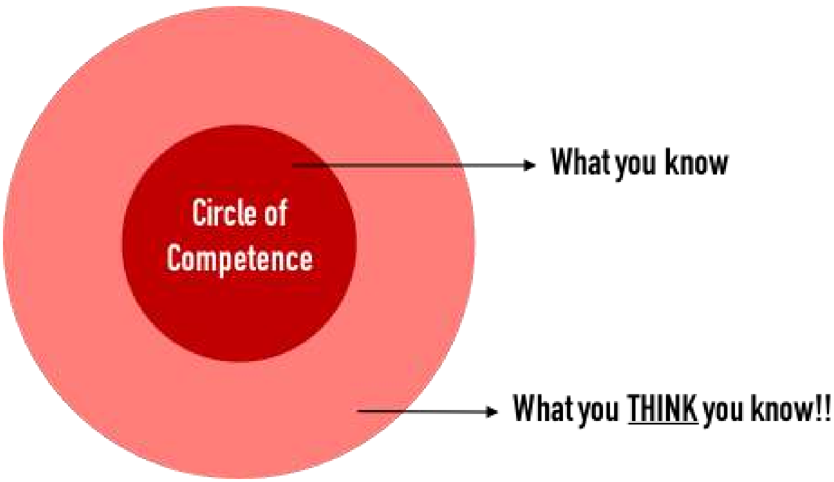
The circle of competence is the group of companies and / or sectors in which an investor is interested, and who is also capable of understanding. That is, the companies of which we have competence or knowledge.

This concept is important in the management of an investment portfolio. If the business model is understood, then its level of risk and return can be accurately calculated.

Buffett proposes making three lists when building a portfolio:

- **In**: Businesses that are very well understood
- **Out**: Companies that have been tried to understand without success.
- **Too Hard**: Companies that are too complex and in which the investor is not willing to devote part of his time to study them. Buffett summarized the concept in the motto, "Know your circle of competence and stick within

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



What kills you is not what you know, it is what you think you know, but you don't know.

> All I want to know is where I'm going to die so I'll never go there.
>
> —Charlie Munger

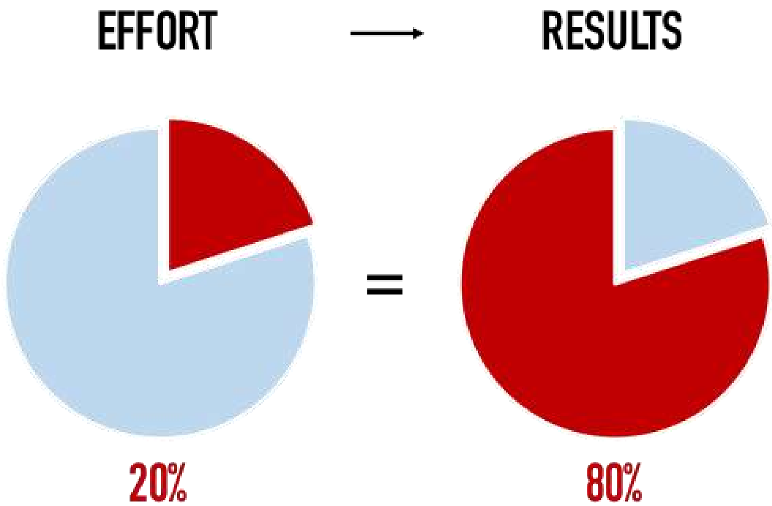
PARETO PRINCIPLE

> For many events, roughly 80% of the effects come from 20% of the causes.
>
> —Vilfredo Pareto

The Pareto Principle was described by the economist and sociologist Vilfredo Pareto, who specifies an unequal relationship between inputs and outputs.

The principle establishes that 20% of what is entered or invested is responsible for 80% of the results obtained. In other words, 80% of the consequences are derived from 20% of the causes; This is also known as the "Pareto rule" or the "80/20 rule."

The name comes from Italian economist Vilfredo Pareto, who noted the 80/20 connection while at the University of Lausanne in 1896, as published in his first work, *Cours d'économie politique*. Essentially, Pareto showed that approximately 80% of the land in Italy was owned by 20% of the population.



It is an axiom of business management that *80% of sales come from 20% of clients.*

More generally, the Pareto Principle is the observation (not law) that most things in life are not evenly distributed. For example:

- 20% of the consequences derive from 80% of the causes.
- 20% of workers produce 80% of the results.
- 20% of customers create 80% of revenue.
- 20% of software errors cause 80% of software failures.
- 20% of investors keep 80% of the profits obtained in the stock market, and this in turn has its origin in 20% of the values of an individual portfolio.

- And so on…

CREATIVE DESTRUCTION

> At the heart of capitalism is creative destruction.
>
> —Joseph A. Schumpeter

Creative destruction in economics is a concept devised by the German sociologist Werner Sombart and popularized by the Austrian economist Joseph Schumpeter in his book Capitalism, Socialism and Democracy (1942).

With it, he describes the innovation process that takes place in a market economy in which new products destroy old companies and business models. For Schumpeter, entrepreneurial innovations are the driving force behind sustained long-term economic growth, even though they can destroy the value of well-established companies along the way.

Schumpeter establishes five cases of innovation:

- The introduction of a new good.
- The introduction of a new method of production or marketing of existing goods.
- The opening of new markets.
- The conquest of a new source of raw materials.

- The creation of a new monopoly or the destruction of an existing one.

Schumpeter describes creative destruction as the "process of industrial mutation that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one."

> The opening up of new markets, foreign or domestic, and the organizational development from the craft shop and factory to such concerns as U. S. Steel illustrate the same process of industrial mutation-if I may use that biological term-that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism.
>
> —Joseph Schumpeter

> Situations emerge in the process of creative destruction in which many firms may have to perish that nevertheless would be able to live on vigorously and usefully if they could weather a particular storm.
>
> —Joseph Schumpeter

SUPPLY AND DEMAND

> All I ever did was supply a demand that was pretty popular.
>
> —Al Capone

The supply and demand model describes the interaction in the market of a given good between consumers and producers, in relation to the price and sales of that good. It is the fundamental model of microeconomics, and is used to explain a wide variety of microeconomic scenarios.

It establishes that, in a free and competitive market, the price is determined based on the request for goods and services by consumers and the quantity provided by the producers, generating an equilibrium point in which consumers will be willing to purchase. everything that producers offer at the price set by that point, and producers are willing to deliver the levels of production that consumers require, establishing and maintaining a point of equilibrium.

The supply-demand relationship is present in many aspects of life, from biology to architecture, as the architect Adolf Loos reminded us:

> Supply and demand regulate architectural form.

> —Adolf Loos

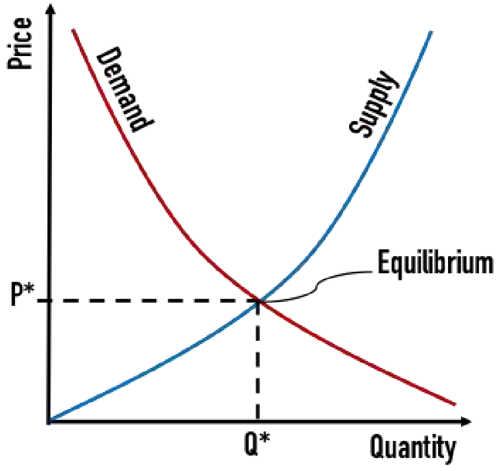
In a free competitive market, the quantity of products offered by producers and the quantity of products demanded by consumers depend on the market price of the product. The law of supply indicates that the supply is directly proportional to the price; the higher the price of the product, the more units will be offered for sale. On the contrary, the law of demand indicates that demand is inversely proportional to price; the higher the price, the less consumers will demand. Therefore, supply and demand make the price of the good vary.

The price of a good lies at the intersection of the supply and demand curves. If the price of a good is too low and consumers demand more than what producers can put on the market, a scarcity situation occurs, and therefore consumers will be willing to pay more. Producers will raise prices until the level is reached at which consumers are unwilling to buy more if the price continues to rise. In the reverse situation, if the price of a good is too high and consumers are not willing to pay it, the tendency will be for the price to fall, until the level is reached at which consumers accept the price and everything that is produced can be sold.

SUPPLY DEMAND MODEL

Thereby, the demand and supply of a product are interdependent, and they are sensitive with respect to the price of that product.

When the price is decreased, the demand increases, and its supply decreases. It is due to the reason that at lower prices, producers restrain from releasing more quantities of the product in the market.



The point of intersection of the supply curve and demand curve is known as the equilibrium point. And the price at that point is called the equilibrium point price.

MOATS

> In business, I look for economic castles protected by unbreachable 'moats.'
>
> —Warren Buffett

The economic moat is the competitive advantage that allows a company to protect its value and achieve higher long-term returns.

This term has been developed by Warren Buffett, probably the best investor alive. He defines them with a parallel between the defensive moats that were dug around the castles to protect them from threats and the sustainable advantages that companies have in order to defend their profits against the competition.

Remember that a competitive advantage is essentially any factor that allows a company to provide a good or service that is similar to those offered by its competitors and, at the same time, outperform those competitors in profits. A good example of a competitive advantage would be a low-cost advantage, such as cheap access to raw materials.

Very successful investors such as Buffett have been adept at finding companies with solid economic moats but relatively low share prices.

TYPES OF MOATS

- Switching cost
- Cost advantages
- Network effects
- Intangible assets
- Efficient scale

NETWORK EFFECTS

> Facebook is quite entrenched and has a network effect. It's hard to break into a network once it's formed.
>
> —Elon Musk

Network effects are said to occur when the value of a good or service depends on the number of people who use it.

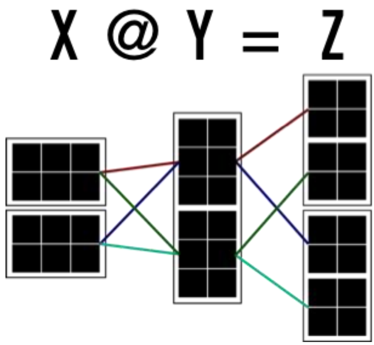
In general, when there is a network effect, the greater the number of users, the greater the value or utility that good or service will have.

Network effects were initially studied in the 1970s, in the context of long distance telephony. Today, they are a widely recognized phenomenon in the information and communication technology industry with a presence in various sectors such as software, electronic commerce, etc.

A good example of such effects is the internet. In its early days, it had very few users (mostly researchers and the military), so its value was relatively small.

As the number of users increased, more contacts were created, more sites to visit and more applications. In this way, the value of the Internet grew until it became the essential tool that it is today.

Facebook, JustEat, PayPal, eBay, Alphabet (the parent company of Google), Amazon or Visa are some of the global companies that have generated the highest profits on the stock market in recent years while they wove extensive user communities that the more participants add up, the more value they have. They are the clearest examples of companies that benefit from the competitive advantage derived from the network effect, whereby the value of a product or service for a user depends not only on the product or service itself, but the number of users who use it.



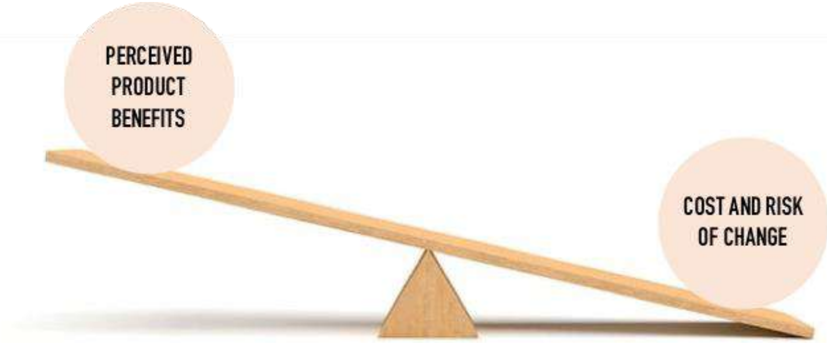
SWITCHING COSTS

> Task switching exacts a cost few realize they are even paying.
>
> —Gary Keller

Change costs are those faced by the consumer when changing a product, supplier or brand.

The switching costs are not only monetary, there are also psychological costs, effort and time. They can manifest themselves in various forms such as: cancellation penalties, the need to learn how to use a new product or technology, face the risk that normal operations will be interrupted or the risk that the change will not leave us satisfied.

Thus, these costs may arise naturally from the change process or may be artificially generated by companies. Thus, for example, the time needed to find an alternative supplier is a cost of the change process. In contrast, contracts that impose high penalties for terminating the service may be artificial costs that seek to discourage the change of provider.



TYPES OF SWITCHING COSTS

Procedural switching costs	Financial switching costs	Relational switching costs
• Economic risk costs • Evaluation costs • Set up cost • Learning costs	• Benefit loss costs • Monetary loss costs	• Personal relationship loss costs • Brand relationship loss costs

SPECIALIZATION

> Specialization and organization are the basis of human progress.
>
> —Charlotte Perkins Gilman

Work specialization consists of assigning the different tasks of a particular production process and its derived activities to different individuals or work groups according to their characteristics, abilities or resources.

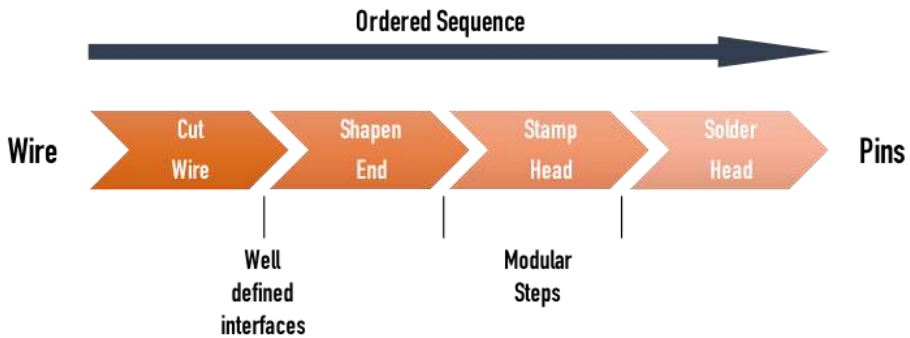
The concept of work specialization is studied by the strategic management of companies. Companies that opt for specialized work systems design an organization chart where each task is developed by a specialist.

The growth of mass production industries and taking advantage of economies of scale helped their expansion. The main sense of specialization is that each task is carried out by people previously directed to that part of the process.

Therefore, academic and professional preparation for according to what positions is important, distinguishing qualified and unskilled workers.

PIN FACTORY

When Adam Smith visited a pin factory, he noticed that each worker was producing his or her own pins. By the end of the day, the total production by the workers was 2,000 pins. He stated that each worker should specialize in the production stage rather than produce his or her own pins. Through specialization, the total output by the factory increased to 20,000 pins per day.



Three circumstances come from this specialization:

1. Increased *dexterity* (learning by doing).

2. *Saving time* (lose time when you move to different operations).

3. Invention of machines (fosters *inventiveness*).

TRAGEDY OF THE COMMONS

> Freedom in a commons brings ruin to all.
>
> —Garrett Hardin

The tragedy of the commons describes a situation in which individuals, motivated only by their personal interest, end up overexploiting a limited resource that they share with other individuals.

> The tragedy of the commons, explained by Garrett Hardin, shows how nonfunctional communities can rapidly destroy their own resource base. How good, rational people can form destructive communities, Instead of protecting their long-term future by conserving resources, they protect their short-term gains by competing, deplete their resources to the point of collapse, and bring about the failure of the community again, and again.
>
> —Steve Hallett

The tragedy of the commons reflects a social conflict over the use of common resources (such as fish from the sea, pastures, forests, etc.) where personal interests conflict with the common interest.

As we can see in the example below, the overexploitation of a common resource by an individual on many occasions ends up reducing social welfare and even harming the individual who is causing this overexploitation.

> What is common to many is least taken care of, for all men have greater regard for what is their own than what they possess in common with others.
>
> —Aristotle

The origin comes from 1833, when it appeared in a little-known pamphlet written by the mathematician William Foster Lloyd (1794–1852).

The term was later popularized by an article written by biologist Garrett Hardin, who applied the idea to analyzing issues such as the arms race, pollution, and overpopulation.

One of the most common examples of the tragedy of the commons concerns the use of fields for grazing.

The situation is this: all the herders in the area must decide how many cows to graze the commons.

Imagine a pasture open to all. It is to be expected that each herder will try to keep as many head of cattle as possible in the commons.

As a rational being, every shepherd seeks to maximize his profit. Explicitly or implicitly, consciously or unconsciously, he asks himself, what is the benefit to me of adding one more animal to my herd? This utility has a negative and a positive component.

1. The positive component is a function of the increase of an animal. Since the shepherd receives all the profits from the sale, the positive profit is close to +1.

2. The negative component is a function of the additional overgrazing generated by one more animal. However, since the effects of overgrazing are shared by all herders, the negative utility of any particular decision made by a herder is only a fraction of -1.

> By adding up all the partial utilities, the rational shepherd concludes that the only sensible decision for him is to add another animal to his flock, and yet another … But this is the conclusion reached by each and every sensible shepherd who shares common resources. And therein lies the tragedy. Each man is locked in a system that drives him to increase his livestock unlimitedly, in a limited world. Ruin is the destiny to which all men run, each seeking his best advantage in a world that believes in the freedom of common resources. The freedom of common resources is the ruin for all.
>
> —Garret Hardin

Use of the commons is below the carrying capacity of the land.
All users benefit.

If one or more users increase the use of the commons beyond its carrying capacity, the commons becomes degraded.
The cost of the degradation is incurred by all users.

Unless environmental costs are accounted for and addressed in land use practices, eventually the land will be unable to support the activity.

MR. MARKET

> Mr. Market's job is to provide you with prices; your job is to decide whether it is to your advantage to act on them. You do not have to trade with him just because he constantly begs you to.
>
> —Benjamin Graham

Benjamin Graham is considered the father of value investing. He was the teacher of many of the best investors in history, such as Warren Buffett, and was the author in 1949 of *The Inteligent Investor*, considered by many to be the bible of value investing.

In this book, Graham explains through an allegory the behavior of financial markets and how investors can benefit from the capricious fluctuations of the market.

Graham encourages us to imagine the market as an omnipresent partner, emotionally unstable and from which the investor must make the most of his mood swings. This partner is called *Mister Market.*

Mr. Market is an investor, who carries out daily purchases and sales of stocks. He is also very attentive and every day he tells the investor what he considers his share package worth, and even offers to buy it or sell him a portion of the participation that he also owns based on his own valuation.

There are days when Mr. Market is euphoric, at which time an investor would be delighted to sell him his shares since he would be offering a very high price for his shares, higher even than the intrinsic value of the company. But instead, there are other days when Mr. Market is depressed, in which a sensible investor would be interested in buying his shares, since they would be trading at a price below their intrinsic value.

> The true investor is the one who is in every position when he owns one common share. You can take advantage of the daily prices of the quotes or disregard them, carried out by your own judgment and inclination.
>
> —Benjamin Graham

This allegory explains in a simple way how the stock market fluctuates. Meaning that the prices of the quotations are influenced by the emotions of the market participants.

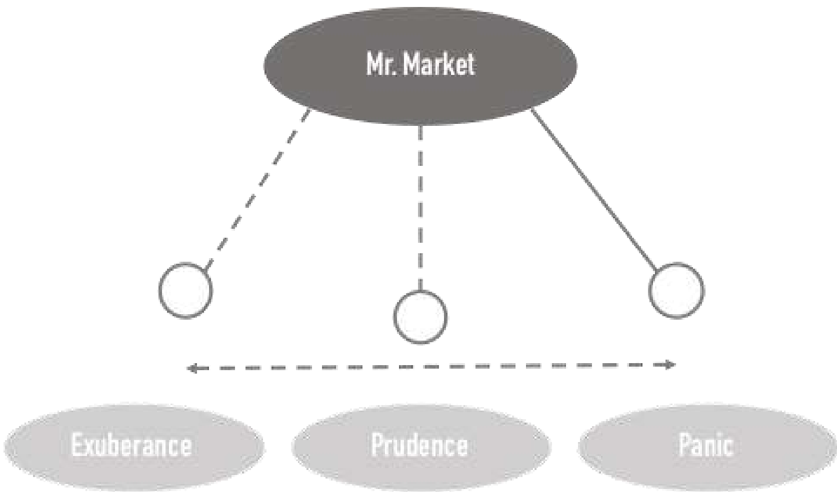
Ben is emphatic in saying that the most realistic distinction between an investor and a speculator is found in their attitude towards the movements of the stock market; the speculator is interested in anticipating and obtaining benefits from market fluctuations, unlike the investor, whose main objective is to acquire and maintain securities at adequate prices.

Characteristics of Mr. Market:

- He is emotional, euphoric and moody.
- He is often irrational.

- He is there to serve you, not to guide you.
- In the short term he is a voting machine and in the long term he is a scale.
- He will give you the option to buy at a low price and sell high.
- Sometimes he is efficient, but not always.

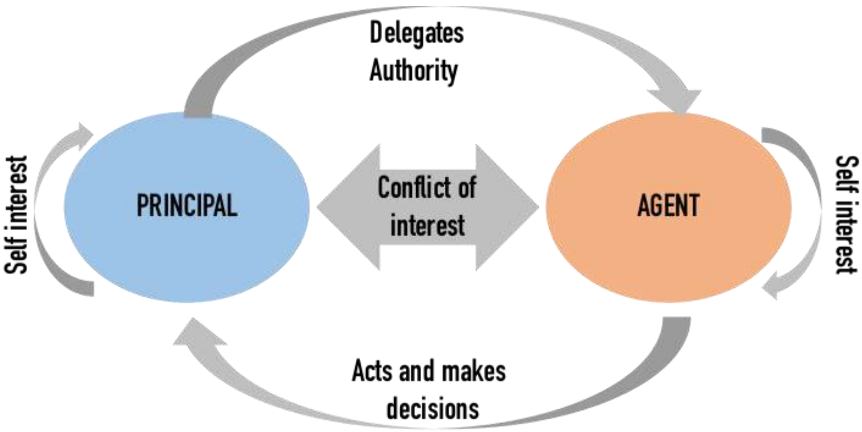
MR. MARKET'S MOOD SWINGS: FROM EXUBERANCE TO PANIC



PRINCIPAL—AGENT PROBLEM

> The relationship of agency is one of the oldest and commonest codified codes of social interaction. We will say that an agency relationship has arisen between two (or more) parties when one, designated as the agent, acts for the other, designated the principal, in a particular domain of decision problems. Examples of agency are universal.
>
> —Stephen Ross

The agency problem consists, basically, in solving how the principal can ensure that the agent performs the action in an optimal way for his (the principal's) interests, and not his own.



A typical principal-agent relationship is that of the employer who hires a worker. And, as is known, there are many ways to mitigate or try to solve the agency problem. Ultimately, it is about looking for mechanisms so that the interests of the agent align with those of the principal, who is the one who ultimately chose him and pays him.

These agency costs usually occur due to information asymmetries, that is, when shareholders and managers do not have the same information on the value of tangible or financial assets, for example. This causes opportunistic behaviors to develop in the company, that managers seek to achieve their own interests, that conflicts arise over the distribution of free cash flow, that the so-called managerial myopia occurs and that the manager worries about keeping his job. All these situations generate agency costs.

SKIN IN THE GAME

> Avoid taking advice from someone who gives advice for a living, unless there is a penalty for their advice.
>
> —Nassim Taleb

Having *skin in the game* means taking a risk while participating in the achievement of a goal. In this sentence, the *skin* would be a metaphor of the person involved and the *game* of the actions in the achievement of the objective.

Used by Warren Buffett and popularized by Nassim Taleb in his 2017 book, *Skin in the game*, this expression is common in business, finance, and gaming, and is also used in politics.

If decision-makers have *skin in the game* in their decisions, we guarantee symmetry between actors, both benefits and risks are shared, information concealment is reduced and the transfer of problems to the future is discouraged, improving the resilience of the stakeholders.

In short, Taleb solves the principal-agent problem by *principalizing* the agent. Posed like this, it seems clear and bright. He tells us that all that breed of opinion makers, decision makers and dilettantes who dedicate themselves to making decisions that affect the lives of others without risking their own skin are the problem.

In fact, Taleb goes further with his proposal. For him, the heuristic of gambling one's skin not only has a practical dimension ("it is better for those who make decisions to gamble their hides") but it also has a moral dimension ("only those who play their hides are entitled to make decisions for others").

Taleb summarizes this reflection in a blunt way: do not expose others to costs unless you are also, directly or indirectly, exposed to them.

NO SKIN IN THE GAME	SKIN IN THE GAME	SOUL IN THE GAME
Keeps upside, transfer downside to others	*Keeps his own downside, takes his own risk*	*Takes downside, gives upside to others*
Bureaucrats	Citizens	Saints, warriors, soldiers
Consultants	Merchants, businessmen	Prophets
Businesses	Artisans	Artists
Corporate Executives (with suit)	Entrepreneurs	Innovators
Theoreticians	Laboratory experimenters	-
Editors	Writers	Great writers
Journalists	Speculators	Rebels
Politicians	Activists	Revolutionaries
Bankers	Traders	-

HISTORY

> History is philosophy teaching by examples.
>
> —Thucydides

The meaning of history refers both to the discipline of the social sciences that studies and relates the past events of humanity, as well as to the narratives of the facts and events, true or fictitious.

The word history derives from the Latin *historĭa*, which arose from the Greek *ἱστορία* (history), and whose meaning indicates research, information.

HISTORY MODELS

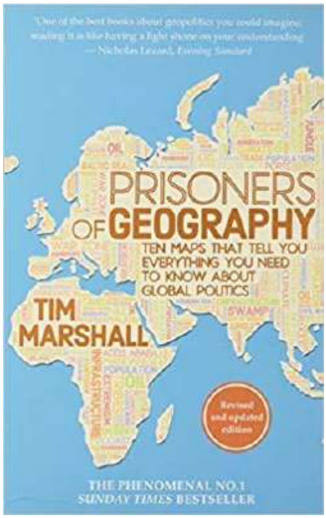
History has taught us many lessons. In the next 4 chapters we will see some basic ideas to understand our past, as well as to be prepared for our future.

- The importance of geography
- Inclusive economic and political institutions
- Extremely intense ideology
- Historic recurrence

THE IMPORTANCE OF GEOGRAPHY

> Vladimir Putin says he is a religious man, a great supporter of the Russian Orthodox Church. If so, he may well go to bed each night, say his prayers, and ask God: "Why didn't you put mountains in eastern Ukraine?"
>
> —Tim Marshall

All leaders are constrained by geography. Their choices are limited by mountains, rivers, seas, and concrete.



Indeed, to understand world events, you need to understand people, ideas, and movements ... but if you don't know geography, you'll never have the full picture.

To understand Putin's actions, for example, it is essential to consider that, to be a world power, Russia must have a navy. And if its ports freeze for six months each year, then it must have access to a warm water port—hence, the annexation of Crimea was the only option for Putin.

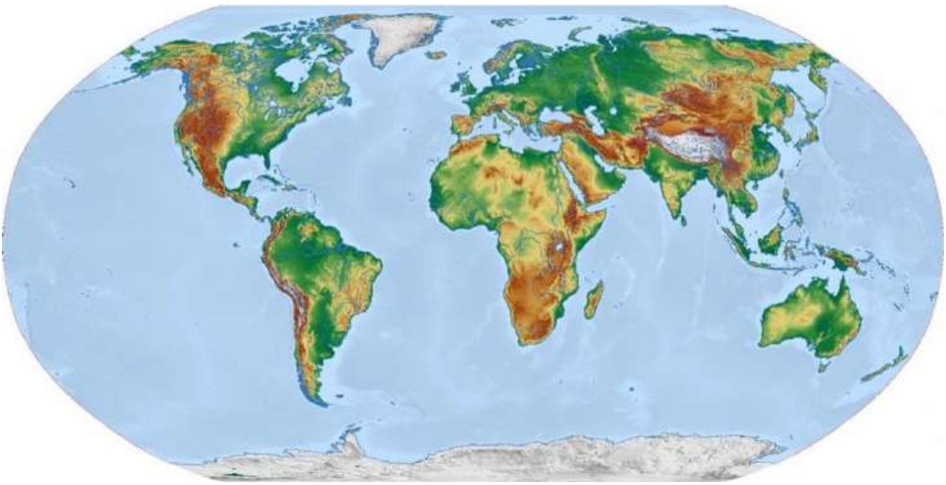
To understand the Middle East, it is crucial to know that geography is the reason why countries have logically been shaped as they are—and this is why invented countries (e.g., Syria, Iraq, Libya) will not survive as nation-states.

This model will serve to take geography into account in each situation. Especially relevant in politics, each movement in each country is strongly influenced by its geography.

As an example, Russia's continuous search for exits to the sea, or Europe's energy dependence abroad.

The energy dependence of the Strait of Hormuz and the commercial importance of China's trade routes are examples of the importance of geography.

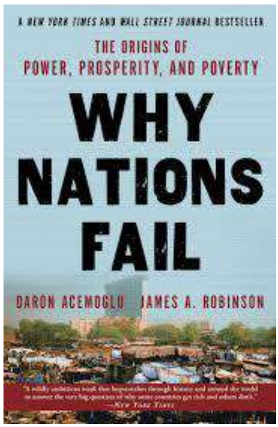
Thus, we will have to have a world map always present in every situation.



INCLUSIVE ECONOMIC AND POLITICAL INSTITUTIONS

> Nations fail today because their extractive economic institutions do not create the incentives needed for people to save, invest, and innovate. Extractive political institutions support these economic institutions by cementing the power of those who benefit from the extraction.
>
> —Daron Acemoğlu

> Economic institutions shape economic incentives: the incentives to become educated, to save and invest, to innovate and adopt new technologies, and so on. It is the political process that determines what economic institutions people live under, and it is the political institutions that determine how this process works.
>
> —Daron Acemoğlu



The book applies insights from institutional economics, development economics and economic history to understand why nations develop differently, with some succeeding in the accumulation of power and prosperity and others failing, via a wide range of historical case studies.

EXAMPLES OF ECONOMIC AND POLITICAL INSTITUTIONS, INCLUSIVE AND EXTRACTIVE

	Economic Institutions	Political Institutions
Inclusive	Secure property rights Effective education and job training systems Open markets with low entry costs Balanced fair employer-labor relations Consumer protections	Democratic pluralism Voting rights Free media Freedom of speech and other personal rights
Extractive	Weak property rights Crony capitalism Widespread anti-competitive monopolies Forced or extract labor Disregard of externalities	Monarchy/ Oligarchy/ Single-party rule System of elites or nobility Suppression of freedoms of expression Patronage networks Influential but opaque interest groups

RELATIONSHIP AND TENDENCY OF THE INSTITUTIONS:

		Economic Institutions	
		Inclusive	Extractive
Political Institutions	Inclusive	↻	← ↓
	Extractive	↑ →	↻

This model will help us understand the economic, political, and social situation of each country. It will help us understand the growth of certain countries, such as Singapore, the economic difference between North and South Korea, or the social situation in Venezuela.

EXTREMELY INTENSE IDEOLOGY

> Another thing I think should be avoided is extremely intense ideology.
>
> —Charlie Munger

> Another thing I think should be avoided is extremely intense ideology, because it cabbages up one's mind. You've seen that. You see a lot of it on TV, you know preachers for instance, they've all got different ideas about theology and a lot of them have minds that are made of cabbage.
>
> But that can happen with political ideology. And if you're young it's easy to drift into loyalties and when you announce that you're a loyal member and you start shouting the orthodox ideology out what you're doing is pounding it in, pounding it in, and you're gradually ruining your mind. So, you want to be very careful with this ideology. It's a big danger.
>
> In my mind, I have a little example I use whenever I think about ideology, and it's these Scandinavian canoeists who succeeded in taming all the rapids of Scandinavia and they thought they would tackle the whirlpools in the Grand Rapids here in the United States. The death rate

> was 100%. A big whirlpool is not something you want to go into and I think the same is true about a really deep ideology.
>
> I have what I call an iron prescription that helps me keep sane when I naturally drift toward preferring one ideology over another. And that is I say "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.
>
> —Charlie Munger

> For it is impossible for anyone to begin to learn that which he thinks he already knows.
>
> —Epictetus

> The ability to destroy your ideas rapidly instead of slowly when the occasion is right is one of the most valuable things. You have to work hard on it. Ask yourself what are the arguments on the other side. It's bad to have an opinion you're proud of if you can't state the arguments

> for the other side better than your opponents. This is a great mental discipline.
>
> —Charlie Munger

HISTORIC RECURRENCE

> Those who do not learn history are doomed to repeat it.
>
> —George Santayana

Historic recurrence is the repetition of similar events in history.

The concept of historic recurrence has variously been applied to the overall history of the world (e.g., to the rises and falls of empires), to repetitive patterns in the history of a given polity, and to any two specific events which bear a striking similarity.

Hypothetically, in the extreme, the concept of historic recurrence assumes the form of the Doctrine of Eternal Recurrence, which has been written about in various forms since antiquity and was described in the 19th century by Heinrich Heine and Friedrich Nietzsche.

Some examples could be:

- Economic cycles: times of crisis or recession, depression, recovery, and boom.
- Political: the emergence of political parties with extreme ideologies.
- Social: with the emergence of xenophobic ideologies.

RECAP

> Lessons in life will be repeated until they are learned.
>
> —Frank Sonnenberg

We have just seen the most important ideas of each science, summed up in 100 mental models. But this doesn't end here. It starts here.

The most disturbing bias listed by Dan Ariely in *Predictably Irrational* is the one that states that *knowing the biases does not free you from them*. This, in another example that shows that the idea that the best ideas can and should be applied to different areas of life, applies to mental models themselves.

Just knowing these mental models does not mean that you will start using them straight away. One will have to study them over and over, step by step, without hurrying nor abandoning until one is able to continuously apply them in every decision made.

Like with all habits, practice helps us to achieve our goals over time and will set us on a road of improvement that really does not end in a lifetime.

When using these models, it is recommended to think of science in blocks. Fix these ten blocks and treat them as drawers that we will fill with use over time. Thus, when we are faced with a situation that requires the use of models—practically all of our lives—it will be easier to ask ourselves: *What can physics contribute to this problem?* Instead of trying to first list all the models from physics.

When thinking about science, we will weave in a brief period of time a network that, although it still shows large holes, is large enough to sew each new mental model in the corresponding section.

When we start using it, we will notice new visions that translate into new worlds that we are seeing, new possibilities. Additionally, as a secondary benefit, the knowledge that we acquire, automatically and effortlessly, will be incorporated into our network of knowledge that we are weaving.

In this manner, when we read a biology book (for example), we will automatically explore the main ideas to include them, as new tools, in our mental models' drawer, in the biology department.

Just as we will automatically trace the relationship between these ideas and those of our mind.

Reading is not a monologue of the author about the reader. It should be a conversation between the author and the reader. A debate where our ideas are confronted with those of the author. Only in this way will we integrate the knowledge of the book into our network of mental models, merging, doubting, fitting, assimilating, and discarding ideas, between our network of mental models and the new ones that come from books.

In this sense, it is not strange to observe that many of the greatest intellectuals, as well as scientific studies, recommend taking notes of the books we read, either in their margin or in separate notebooks. This makes reading a debate of a certain class with the author, which adapts our thinking and sets the ideas.

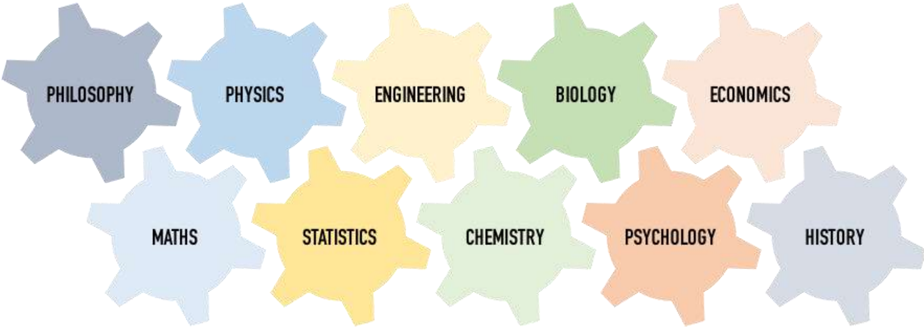
> The intellectual is, quite simply, a human being who has a pencil in his or her hand when reading a book.
>
> —George Steiner

In conclusion, the idea of creating a network of mental models in our mind is not an end but a means, a means in order to make better decisions, to improve the output, but that also affects the input, in the ideas that we feed on.

And the world will become a kind of great game (circus calls it Munger) where it is an integrated whole, where the book we are reading about chemistry can help us make better decisions about where to go on vacation with our family. That old idea by Daniel Kahneman will help us get our friend out of depression.

In one of the most imperative phrases, and that's saying a lot, Charlie Munger says that *reading is a moral duty*. From his ideas of mental models, we could take this idea further, stating that using a network of mental models should be a moral duty.

BRANCHES OF KNOWLEDGE



MENTAL MODELS

SCIENTIFIC METHOD	CRITICAL MASS	RECIPROCITY	VELOCITY	RELATIVITY	LEVERAGE	NEWTON'S LAWS OF MOTION	LAWS OF THERMO-DYNAMICS	CHAOS THEORY	COMPLEX ADAPTATIVE SYSTEMS	ACTIVATION ENERGY	HEISENBERG UNCERTAINTY PRINCIPLE
ALGEBRA	PERMUTATIONS & COMBINATIONS	ALGORITHMIS	SCALE	COMPOUND INTEREST	INFLECTION POINT	ATOMS, MOLECULES AND IONS	THE CHEMICAL BOND	MOLECULAR SHAPE	THE KINETIC THEORY	THE CHEMICAL REACTION	AUTOCATALYST
MODERN DARWINIAN SYNTHESIS	INCENTIVES	SCARCITY	COOPERATION	ADAPTATION	REPLICATION	HIERARCHICAL AND OTHER ORGANIZING INSTINCTS	SELF-PRESERVATION INSTINCTS	RESILIENCE	THE RED QUEEN EFFECT	ECOSYSTEMS	NICHES
DOUBLE ENTRY ACCOUNTING	OPPORTUNITY COSTS	CIRCLE OF COMPETENCY	PARETO PRINCIPLE	Mental Models		100 MENTAL MODELS - BE RATIONAL -		THE IMPORTANCE OF GEOGRAPHY	INCLUSIVE ECONOMIC AND POLITICAL INSTITUTIONS	EXTREMELY INTENSE IDEOLOGY	HISTORIC RECURRENCE
CREATIVE DESTRUCTION	SUPPLY AND DEMAND	MOATS	NETWORK EFFECTS	@wisdom_theory				THE MEANING OF LIFE	STOICISM	CAVE OF PLATO	GOLDEN RULE
SWITCHING COST	SPECIALIZATION	TRAGEDY OF THE COMMONS	MR. MARKET	PRINCIPAL-AGENT PROBLEM	SKIN IN THE GAME	REDUNDANCY: MARGIN OF SAFETY	BACKUP SYSTEM MODEL	BREAKPOINT	QUALITY CONTROL	FEEDBACK LOOPS	CONSTRUCTIVISM
PROBABILISTIC THINKING	BAYES THEOREM	POWER LAW	REGRESION TO THE MEAN	GAME THEORY	CORRELATION AND CAUSATION	STANDARD DEVIATION	LAW OF LARGE NUMBERS	INVERSION	FRAGILITY / ROBUSTNESS / ANTIFRAGILITY	BLACK SWAN	REWARD AND PUNISHMENT SUPERRESPONSE TENDENCY
LIKING/ LOVING TENDENCY	DISLIKING/ HATING TENDENCY	DOUBT/ AVOIDANCE TENDENCY	INCONSISTENCY-AVOIDANCE TENDENCY	CURIOSITY TENDENCY	KANTIAN FAIRNESS TENDENCY	ENVY/JEALOUS TENDENCY	RECIPROCATION TENDENCY	INFLUENCE-FROM-MERE-ASSOCIATION TENDENCY	SIMPLE, PAIN-AVOIDING PSYCHOLOGICAL DENIAL	EXCESSIVE SELF-REGARD TENDENCY	OVEROPTIMISM TENDENCY
DEPRIVAL-SUPERREACTION TENDENCY	SOCIAL-PROOF TENDENCY	CONTRAST-MISREACTION TENDENCY	STRESS-INFLUENCE TENDENCY	AVAILABILITY-MISWEIGHING TENDENCY	USE-IT-OR-LOSE-IT TENDENCY	DRUG MISINFLUENCE TENDENCY	SENESCENCE-MISINFLUENCE TENDENCY	AUTHORITY-MISINFLUENCE TENDENCY	TWADDLE TENDENCY	REASON-RESPECTING TENDENCY	LOLLAPALOOZA TENDENCY

LOGICAL FALLACIES

> All the fallacies of human reason had to be exhausted before the light of a high truth could meet with ready acceptance.
>
> —Friedrich Max Müller

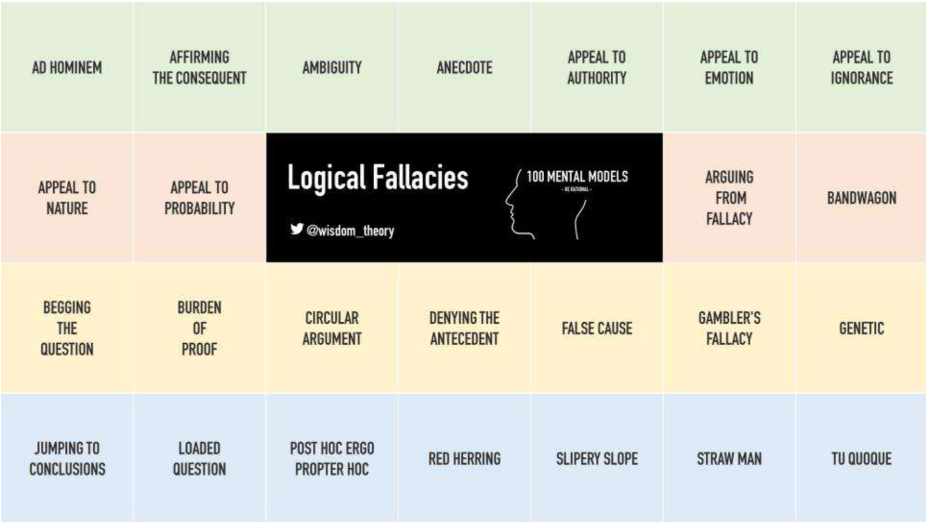
When challenging a claim, a fallacy is reasoning that is evaluated as logically incorrect and undermines the logical validity of the argument; permitting its recognition as unsound. Regardless of its apparent robustness, all registers and manners of speech can demonstrate fallacies.

Because of the variety of structure and application, fallacies are challenging to classify to satisfy all practitioners. Fallacies can be classified strictly by either their structure or content, such as classifying them as formal fallacies or informal fallacies, respectively. The classification of informal fallacies may be subdivided into categories such as linguistic, relevance through omission, relevance through intrusion, and relevance through presumption.

On the other hand, fallacies may be classified by the process by which they occur, such as material fallacies (content), verbal fallacies (linguistic), and again formal fallacies (error in inference). In turn, material fallacies may be placed into the more general category of informal fallacies, while formal fallacies may be clearly placed into the more precise category of logical (deductive) fallacies. Further, verbal fallacies may be placed into either informal or deductive classifications. Compare equivocation, which describes the use of ambiguity with words or phrases, e. g. "he is mad," which may refer to either him being angry or clinically insane, to the fallacy of composition, which is premise and inference based ambiguity, e. g. "this must be a good basketball team because each of its members is an outstanding player."

The conscious or habitual use of fallacies as rhetorical devices is prevalent in the desire to persuade when the focus is more on communication and eliciting common agreement rather than on the correctness of the reasoning. The effective use of a fallacy by an orator may be considered clever, but by the same token, the reasoning of that orator should be recognized as unsound, and thus the orator’s claim, supported by an unsound argument, will be regarded as unfounded and dismissed.

Next, we will see the 25 most common logical fallacies.



AD HOMINEM

Attacking a person or their character rather than making a claim based on reasoning. Ad hominem arguments include name-calling, labeling, and being offensive and show little intelligent thought.

> After Mery presents an eloquent and compelling case for a more equitable taxation system, John asks the audience whether we should believe anything from a woman who isn't married and probably eats her own boogers.

AFFIRMING THE CONSEQUENT

Assuming there's only one explanation for the observation you're making.

For example, marriage often results in the birth of children. So, that's the reason why it exists.

> If it's raining, then the streets are wet.
>
> The streets are wet. Therefore, it's raining.

AMBIGUITY

Using double meanings or ambiguities of language to mislead or misrepresent the truth.

> When the judge asked the defendant why he hadn't paid his parking fines, he said that he shouldn't have to pay them because the sign said 'Fine for parking here' and so he naturally presumed that it would be fine to park there.

ANECDOTE

Using personal or isolated experience as compelling and worthwhile evidence; suggesting that a personal or unique experience can be applied to other circumstances.

> Peter said that that was all cool and everything, but his grandfather smoked, like, 20 cigarettes a day and lived until 92 - so don't believe everything you read about meta-analyses of sound studies showing proven causal relationships.

APPEAL TO AUTHORITY

Using the opinion or position of an authority figure, or institution of authority, in place of an actual argument.

> Unable to defend his argument that the Earth is flat, Paul said that his friend Oliver was a qualified botanist who also believed the Earth to be flat, and had even seen it from up in a tree.

APPEAL TO EMOTION

Manipulating an emotional response in place of a valid or compelling argument.

> Liam didn't want to eat his sheep brains with chopped liver and Brussels sprouts, but his father told him to think about the poor, starving children in a third world country who weren't fortunate enough to have any food at all.

APPEAL TO IGNORANCE

Using human ignorance or the inability to prove something to make a claim.

> No one's ever been able to prove that ghosts exist, so it's obvious that they don't exist.

APPEAL TO NATURE

Making your claim seem truer by drawing a comparison with the *good* natural world.

> Of course, homosexuality is unnatural because you don't see same-sex animals copulating.

APPEAL TO PROBABILITY

A statement that takes something for granted because it would probably be the case (or might be the case).

> Murphy's Law — if something can go wrong, it will.

ARGUING FROM FALLACY

Also known as the *fallacy fallacy*.

As a result of a claim has been poorly argued, or a fallacy has been made, it is presumed that it is necessarily wrong.

> Recognizing that Emma had committed a fallacy in arguing that we should eat healthy food because a nutritionist said it was popular, Sophia said we should, therefore, eat bacon double cheeseburgers every day, assuming that if an argument for some conclusion is fallacious, then the conclusion is false.

BANDWAGON

Appealing to popularity or the fact that many people do something as an attempted form of validation.

> Ninety-three percent of the students surveyed said they believe the tuition spike was to pay for the college president's salary. How could it not be true?

BEGGING THE QUESTION

A circular argument in which the conclusion is included in the premise.

> The country's moral situation will only get worse if we continue to allow rated-R movies in public theaters. (This statement raises the question: but do rated-R movies actually decrease morality?)

BURDEN OF PROOF

Saying that the burden of proof lies not with the person making the claim, but with someone else to disprove.

> Amelia declares that a teapot is, at this very moment, in orbit around the Sun between the Earth and Mars and that because no one can prove him wrong, his claim is, therefore, a valid one.

CIRCULAR ARGUMENT

Using evidence that hasn't been proven to prove something else, then using that something else to prove the original claim; using X to prove Y, then using Y to prove X, when neither have been proven.

> You can't give me a C on this paper! I'm an A student! And A students don't get C's.

DENYING THE ANTECEDENT

There isn't only one explanation for an outcome. So, it's false to assume the cause based on the effect.

> If you got a degree, you'll get a good job. If you don't get a degree, you won't get a good job.

FALSE CAUSE

Presuming that a real or perceived relationship between different things means that one is the cause of the other.

> Pointing to a fancy chart, Lucas shows how temperatures have been rising over the past few centuries, whilst at the same time, the numbers of pirates have been decreasing; thus, pirates cool the world, and global warming is a hoax.

GAMBLER'S FALLACY

Believing that *runs* occur to statistically independent phenomena such as roulette wheel spins.

> That family has had three girl babies in a row. The next one is bound to be a boy.

GENETIC

Judging something good or bad based on where it comes from, or from whom it comes.

> Accused on the news of corruption and taking bribes, the senator said that we should all be very wary of the things we hear in the media because we all know how very unreliable the media can be.

JUMPING TO CONCLUSIONS

Drawing a quick conclusion without fairly considering relevant (and easily available) evidence.

> She wants a birth control in her medical cover? What a slut!

LOADED QUESTION

Asking a question that, if answered, will imply a shared agreement; forcing a person to agree to an assumption by them answering a question.

> When are you guys going to stop your wholly unethical practice of making people feel like their house is going to flood, then overcharge them to have their plumbing fixed?

POST HOC ERGO PROPTER HOC

Non Sequitur: Latin for, it does not follow.

Making a conclusion that does not follow from previously established premises or conclusions, *it happened after, so it was caused by.*

> The financial meltdown happened after republicans took office so we can blame the republicans for the crisis we're in.

RED HERRING

Diverting attention by changing the subject.

> Interviewer: Have you been overcharging customers without them knowing? Business owner: We take our business seriously, and we do everything we can to build a quality product.

SLIPPERY SLOPE

Asserting that if we allow *A* to happen, then *Z* will consequently happen too, therefore *A* should not happen.

> Colin asserts that if we allow children to play video games, then the next thing you know, we'll be living in a post-apocalyptic zombie wasteland with no money for guard rails to protect people from slippery slopes.

STRAW MAN

> Jason: NASA is spending too much money on space exploration.
>
> Kevin: What are you, anti-American? Space is the future of human exploration.

TU QUOQUE

Avoiding engagement with another's argument by arguing something unrelated in return, answering criticism with criticism.

> David: Vegetarianism is the best approach to reducing animal cruelty in this country.
>
> Ben: Well, I just watched you eat a pepperoni pizza last week, so anything you say about vegetarianism being worthwhile might as well be thrown out the window.

CONCLUSION

> Be rational.
>
> —Charlie Munger

In this book, we have detailed 100 mental models, 100 perspectives of seeing the world, of seeing each situation, each problem, and each opportunity.

You were probably already familiar with some of these ideas. Hopefully, you may have found others to be completely new to you.

When we first find out about and become aware of these powerful ideas, we are surprised and pleased. But afterwards, it can be overwhelming to realize we must now apply them continuously, and have them become second nature. However, we must be patient when putting these ideas in practice. It will be habit that facilitates the task of going through the sciences and models automatically.

Once we feel more at ease, we will wonder how we were able to live before without this knowledge. In fact, observing every situation we encounter from the perspective of each of these ideas makes us feel as if we were in a different world living a new life.

This book and its list of mental models will always be here for us to review the ideas contained in them. We may use this list as we please, prioritizing the mental models that we find more useful in practice and even adding new ones.

In this sense, Charlie Munger comments that he learnt the idea of the new Darwinian thesis relatively late in life and that for him, it was incredibly surprising and emotional for the new worldview it provided.

Life is a continuous learning process and every day our privileged species makes efforts to tear down the wall of ignorance, allowing new ideas to arise every few years within some science that revolutionizes our way of thinking about that same science and about the world.

One of the latest contributions which has overturned economics, by means of biology-based psychology, is the emergence in recent decades of behavioral economics. We are only witnessing the dawn of what this knowledge implies.

At the same time, the advances in physics are reaching levels that raise more questions than answers, especially in the quantum field.

All of this accumulated knowledge makes us live in the best time that has ever existed.

Scientific and technological advances will accelerate and, more importantly, knowledge will be increasingly available to anyone with access to the Internet.

We have a new world in front of us that is in constant evolution.

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The ideas of this book can be expanded in the specific books of each subject. Here, we collect a list of some of the most important works of each science.

This list—far from pretending to be complete, given the large number of influential books in each field of knowledge—has to be seen as a door to each of the sciences, an invitation to an infinite and interconnected world, our world.

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