Chapter 1 — The Deeper Valley

§1.1 World Models

"You don't change Bitcoin. Bitcoin changes you."

— Jack Mallers

Many good books have already been written about Bitcoin. This book is about **you**. About how Bitcoin changes you.

To exist across time, every living thing has to be able to predict the future well enough, from the single cell all the way up to you. Karl Friston was the first to put this far-reaching insight on a formal footing, in 2006[1]. It can be derived mathematically from just a few assumptions, and he calls it the **Free Energy Principle (FEP)**[2]. Better predictions of the future mean less free energy. **Bitcoin** is the first form of money that allows people to reliably predict aspects of their economic future. By design, Bitcoin reduces the free energy of its users.

What is Bitcoin?

If you already know, skip the box. Full architecture in Ch. 5 §5.5 and Ch. 6.

Bitcoin is not a company's product but an open global protocol for value. What the internet is for information, Bitcoin is for money. Four properties separate it from what you pull out of the ATM today (in what follows, **fiat money** or just **fiat**, Latin for *"let it be done"*, because the state puts it into the world by decree):

Aspect	Fiat (dollar, euro, yen)	Bitcoin
Rules	A central bank decides the money supply, interest rates, and who gets an account. Can be changed at any time by a vote.	Fixed mathematically in code. At most 21 million bitcoin will ever exist, new coins on a fixed schedule. Nobody can change the rule.
Security	Who had how much and when is recorded in bank databases that can be rewritten retroactively. You have to believe it does not happen. Can be manipulated and confiscated.	Stored in a continuous chain of entries. The past is nailed down thermodynamically. **Manipulation-resistant and confiscation-resistant by design.**
Access	You need a bank that accepts you. Accounts can be frozen, transactions blocked, payouts refused.	**Open**: anyone can take part, nobody needs permission, nobody can block a transaction. You have full control. **Censorship-resistant by design.**
Verifiability	You cannot check anything yourself. You have to trust the bank, the regulator and the state.	In a few minutes you can verify for yourself how many bitcoin exist, every entry, and its integrity. You do not have to trust anyone.

Four properties, one effect: your model of the economic world gets a floor that will still be there tomorrow. What held yesterday holds today and will hold in a hundred years. In the language of this book that means: less surprise, less free energy.

These four properties are not assumptions. They follow directly from Satoshi Nakamoto's whitepaper of 2008[3] and from the open-source code that fixes them cryptographically. You do not have to take anyone's word for it: the code is out in the open, anyone can check it, it has been running without interruption for more than fifteen years, and Andreas Antonopoulos derives these properties directly from that code in *Mastering Bitcoin*[4].

What matters here is understanding that you don't see reality as it is. You experience a simulation generated by your brain. It's corrected in real time by electromagnetic signals coming from your senses, and it rests on a kind of inner map: a model of reality that constantly optimizes itself by minimizing its free energy, so that it experiences fewer (unpleasant) surprises. This process, running without interruption, is what keeps you alive in the first place. So what exactly does Bitcoin do to you, to your brain, and to the models it uses to grasp the world?

Through the lens of the FEP, that question reveals a **physics of hyperbitcoinization**: the process in which Bitcoin becomes the global standard, that is, the base of our financial system. The FEP connects Bitcoin's properties to the human psyche and produces a **positive feedback loop** that drives a paradigm shift: Bitcoin stabilizes human expectations, people stabilize Bitcoin through adoption, and every round deepens the synchronization. In the end the loop converges on the **Bitcoin standard**: full symbiosis between the economic part of our world models (the layer we use to understand prices, scarcity and value) and the Bitcoin protocol.

The free energy landscape on the cover gives you one view of this physics:

Two valleys, separated by a hill. In the left one — the shallower valley, the energetically less favorable of the two — sits a ball with a dollar sign. In the right one, deeper and more stable, Bitcoin glows. And the question this book answers is simple enough to ask a child: *how does the ball get into the deeper valley?*

These valleys don't exist out there. They exist in your head. This hilly landscape is the free energy of the different models your brain uses to predict its sensory input. Karl Friston shows that less free energy *is* better predictive power[5]. Fewer unpleasant surprises. So the question is: which monetary system does your brain prefer when it has the choice? And why do so many stay stuck so stubbornly in the shallower valley?

The ball can't simply roll across. Between the valleys lies a hill, and to get over it the ball first has to go *up* before it can fall deeper. Without an energy boost it stays where it's. Forever.

An analogy makes it tangible: the singing bowl.

Strike it with a felt mallet. The tone is clear, pure, it carries. That's no accident: the atoms in the metal sit in an ordered structure. The bowl vibrates as a whole, and its shape determines the tone.

Now take a hammer and knock a few dents into the singing bowl. Strike it again with the felt mallet. The tone is off, dull, it dies immediately. The abrupt deformation has forced the atoms out of their equilibrium; they're now jammed into strained positions that are energetically less favorable.

This situation, too, can be described with the image on the cover. After the hammering it took, the total energy of the atoms sits in the shallower valley. Not at the lowest point, but in an energetically suboptimal well that the atoms can't get out of without help. The bowl stays strained as long as you leave it alone.

But there's a way back.

Heat the bowl until the metal glows. At five to six hundred degrees Celsius the atoms become mobile and the tensions dissolve. They are now free enough to overcome the barrier between the tensed and the relaxed arrangement, and all the while they migrate, try a spot, reject it, settle. Then you cool it slowly. Too fast, and they freeze somewhere in between, seized up again. Only with sufficiently slow cooling do they find their way back into the ordered arrangement. Not because someone tells them to, but because this order is the energetically more favorable state. Self-organization according to the principle of free energy minimization. They find their way into the deeper valley entirely on their own.

And now strike the bowl again. The tone is back. Slightly altered by the dents. But clear again. It carries. Pure. The tensions between the atoms have dissolved.

Physicists call this process **annealing**[6]. The heat gives the atoms the energy to leave the shallow valley and find the deep one. Without heat they stay stuck in the first arrangement they land in. With heat they find the best one. The same procedure is at work wherever structures have to find their optimal arrangement: smiths anneal the sword after hammering and cool it slowly — otherwise the blade breaks. Semiconductor chips are annealed at 500 to 950 °C after every ion bombardment so the atoms find their places in the crystal lattice again — the processor in your phone has been through this a few dozen times. Large telescope mirrors like Hubble's are cooled down degree by degree over weeks after casting, because rapid cooling locks internal stresses in and would distort the image. Even software uses the principle: *simulated annealing* finds the shortest route for a delivery service through a hundred cities, the best wiring of a microchip, or crew rosters for a railway[7]. On the level of information as

well, your brain does something similar under psychedelics or in deep sleep — entrenched beliefs soften, new configurations become accessible (*neural annealing*)[8].

Annealing works wherever there's a rugged energy landscape with local valleys — and a system that's looking for the deepest valley. Annealing is the *tool*. When a system uses it to tip out of one regime into a *qualitatively different* one, that has a name of its own: **phase transition**. Water freezes, iron becomes magnetic, applause synchronizes, a monetary system tips. Annealing often lowers the barrier that stands in the way of such a transition. Remember that word, it comes back.

What annealing really does is give the atoms more room to explore. How many of them are open to the atoms is what **entropy** measures. At room temperature most alternative configurations are energetically out of reach — every atom is effectively locked in its strained position. During annealing the barriers become surmountable: the atom can migrate, try, reject, and *therefore* finds the deeper spot.

And now to the point.

The same process happens in our brain when it optimizes its models of the world. When it settles on its own on the one world model that best explains and predicts its sensory input. Replace *"atoms"* with *"beliefs about the world"*, replace *"tensions in the metal"* with *"contradictions in the world model"* — and you've the same picture.

Instead of tensions between atoms, the brain dissolves tensions between pieces of information: contradictions, gaps. In the fiat system, the economic part of our world model is stuck in exactly that kind of strained structure. The difference from the singing bowl, however, is this: the fiat system raises its own entropy.

Every time a central bank prints money, bails out a corporation or bends interest rates, uncertainty arises, which is to say entropy. This uncertainty acts like heat, not on atoms but on information. More precisely, on the beliefs that make up the world model in the head of every single person: what money is, what a dollar will be worth tomorrow, which rules hold, what can still be taken seriously at all. Every intervention softens these beliefs: they come to count as less reliable. And a softer belief means the world model becomes more flexible, less rigid, and therefore more easily replaced by another. The fiat money sys-

tem knocks dents into the bowl *and* heats it at the same time. It produces the tensions and delivers the entropy needed to overcome them.

Fiat generates the entropy for its own phase transition.

The ball on the cover doesn't need a push. The shallow valley lowers the barrier all by itself.

One question remains open, and it leads straight into the next chapter. What actually makes your bowl vibrate? A bowl alone makes no tone. It needs something it can vibrate in sympathy with: a sound that fits it. What produces this sound, and why Bitcoin of all things is the gong whose tone synchronizes economic world models: *that* is what comes now.

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§1.2 The Thesis

Before the thesis is spoken out loud, here are the concepts it's built from.

Twelve central concepts

The following concepts are the building blocks this book's argument is made of. They build on each other and depend on each other. Don't worry if they don't land right away. The rest of the book deepens them and shows you how these concepts play together. This is very compressed information and it's worth reading these concepts again from time to time. There are three categories: **what a living system is**, **how its parts connect**, and **how it optimizes itself**.

What is it?

- **World model** — the inner map of the world that every living system — cell, brain, or society — carries. It encodes what the system fundamentally expects: what exists at all, what is connected to what, and what follows from what. The **world simulation** activates these expectations for the current moment: what you experience as "the world", including the prediction of what comes next. The simulation is readjusted in real time with every sensory impression; the world model itself learns only slowly, over time. World model is the structure, world simulation the running output. What you take to be reality out there is the simulation.

Picture it: the world model is like a musical instrument, the world simulation the music it is playing right now. (Ch. 2)

- **Belief** — building blocks of the **world model**. Each has four properties: **what** it is about (*"rain tomorrow"*), **which value** is most probable (*"around 3 p.m."*), **how certain** the system is (*"±2 hours"*), and how tightly it is **coupled** to other beliefs (the rain belief pulls beliefs about temperature and your own mood along with it, for example). (Ch. 2, 7)
- **Surprise** — the difference between what the **world model** expects and what the senses deliver. That is what happens when a **belief** is off. Living things minimize expected surprise, meaning surprises in the future. That is how their beliefs keep getting better. (Ch. 2)
- **Free energy** — the measure of expected **surprise**. Karl Friston has shown that every living system minimizes it incessantly. A system that keeps minimizing stays intact. One that stops falls apart. Deeper in the energy landscape means less surprise, a better world model and a more useful world simulation. (Ch. 2)

How do its parts connect?

- **Synchronization** — the dynamic process in which systems bring their information into alignment. What goes on in one is tied to what goes on in the other. That can be **a single world model** aligning itself with reality (cell to sensory input, brain to sensory impressions), or **many individual parts** coordinating with each other. Either with a conductor as in an orchestra, or **without**, as in the cases that interest us. The same thing happens on every level, from small to large: neurons in the brain, cells in an organ, metronomes on a board, soccer fans to a shared song, people to a shared currency. (Ch. 4, 6)
- **Information coherence** — the stable state that arises after **synchronization**, when many parts stay locked in a stable relationship to one another. Four directions: horizontal (between parts on one level), vertical (between levels: cell → organ → body → market), backward (memory), forward (prediction). All four are at work in the soccer fans singing their shared song. Without temporal and cross-scale coherence there is no living system. (Ch. 4)
- **Top-down causation** — when the whole influences its parts without commanding them individually. Precondition: vertical and temporal

coherence. Top-down causation then produces horizontal coherence out of it (Haken's slaving principle). Just as the shared song in the stands influences every single voice, Bitcoin shapes the economic **world model** of its users and synchronizes them horizontally into a shared economic reality. (Ch. 4)

- **Self-organization** — what **top-down causation** produces over time: systems slide into energetically more favorable states on their own, because every single part minimizes its **free energy**. No conductor, no plan, no choirmaster in the stands, and yet everyone sings the same song. Only physics and coupling. (Ch. 4, 6)

How does it optimize itself?

- **Deeper energy valley** — the point **self-organization** pulls a system toward. A stable state that is energetically more favorable than the alternatives. A system that finds the deeper valley does not need to know where it is going. An information system flows there because there is less surprise there. The cover of this book is built on this image. (Ch. 6, 8)
- **Entropy** — a measure of disorder or uncertainty. **The same measure in two languages**: for atoms, how chaotically they move, and for **beliefs**, how uncertain the system is. High means chaotic and flexible, low means fixed and ordered. **Annealing** raises entropy temporarily so that entrenched states can reorder themselves. Fiat's unreliability drives the entropy of economic beliefs upward. That is the mechanism by which fiat lowers its own barriers. (Ch. 7, 8)
- **Annealing** — how a system overcomes the barrier to the **deeper valley** through raised entropy. Entrenched structures soften, the system becomes mobile and finds the energetically more favorable state. The same in the head: when uncertainty rises, **beliefs** soften, and the world model can reorder itself. Analogy: the singing bowl. (Ch. 8)
- **Phase transition** — what happens when a system tips over qualitatively: one state becomes another with entirely different properties. Water freezes, iron becomes magnetic, applause synchronizes, a monetary system tips. With the monetary system, the barrier to the deeper valley has many layers: entrenched beliefs about money and social attachment to the status quo; the entropy that lowers it comes from fiat itself. (Ch. 6, 8)

And now the thesis. Don't worry if you don't understand it right away. Every term in it is defined above, and the seven steps that follow open it up so that in the end you can formulate it yourself.

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Bitcoin becomes the standard because through its properties it enacts a principle that is a precondition for life itself: in order to survive, every living thing, from the single-celled organism to the human being, has to constantly synchronize its world model with reality by minimizing its free energy and so reducing surprises.
Bitcoin does exactly that for the economic domain: compared to fiat it minimizes the free energy of its users, by letting them self-organize into a reliable economic reality. What drives this is top-down causation — everyone aligns with the same protocol. Bitcoin's properties produce information coherence across levels, between its users, and individually through space and time. This energetically more favorable state is a deep valley with the Bitcoin standard at its center.
The transition there is a phase transition, driven by the annealing of entrenched fiat beliefs through fiat's own increase in entropy.
One testable prediction from this: the three basic psychological needs that are hard to satisfy together, all of which fiat structurally violates, are fulfilled simultaneously — autonomy, competence, relatedness.

This densely packed thesis unfolds in seven steps, each with an image you can remember and a payoff that physics or math nerds can check. At the end of these seven steps you already have the whole idea in your hands. The rest of the book deepens it, develops intuition, presents examples and illustrations, fills in the missing details and makes the argument mathematically watertight.

First: you don't see reality as it is. You experience a self-generated simulation. Your own brain produces this simulation based on an internal model: a complex web of beliefs. What you experience is an expectation generated out of beliefs: a simulation. The electromagnetic signals coming from your senses don't generate your experience — they only correct it when it deviates from your expectations. Dreams prove the point: you have experiences even though no external signals are coming in. Here your brain is different from the singing bowl: the bowl stays silent unless you strike it, but your brain

doesn't. What connects the two: the inner structure determines what comes out, the tone in the bowl's case, the simulation in the brain's.

This model in your brain optimizes itself by minimizing **surprise**, meaning the difference between what it expects and what it experiences. When your salary suddenly no longer covers the rent, that's a surprise. Your body tries to keep such surprises small: either by learning (model adjustment: now I am poor) or by acting on the world (world adjustment: I work harder and earn more money).

Karl Friston, one of the most influential neuroscientists in the world, has shown[9] that this principle can be captured mathematically. He calls it **variational free energy** (we abbreviate it here as *free energy* or just F). The name sounds like physics, and that's no accident.

Who is Karl Friston?
Prof. Dr. Karl J. Friston (University College London) has for years been among the most cited living scientists. Semantic Scholar listed him in 2016 as the most influential neuroscientist worldwide. His **Free Energy Principle (FEP)** is the information-theoretic analog to the physical **principle of least action**: where physical particles follow the path of stationary action, living systems minimize free energy. Same mathematical depth, different substrate: information instead of particles.

Imagine a calendar in your head in which you enter, for every second, what is going to happen next: that bread will cost $2.50 tomorrow, that the bus comes in four minutes, that your boss is about to complain about the coffee. The worse your inner calendar, the more surprises you will experience. Friston calls this mismatch free energy. The worse the calendar, the higher you sit in the landscape on the cover. The better, the deeper. **Minimizing surprise means: finding a deeper valley, and with it a better calendar.**

Nerdbox — STEM Undergraduate Level: Two free energies, the same structure
Deepens the argument. Skip it and you lose nothing.
Free energy is a **balance between two opponents**. With Helmholtz, in thermodynamics[10]:

free energy = internal energy − bound energy

$$F = \underbrace{U}_{\text{internal energy}} - \underbrace{T \cdot S}_{\text{bound energy}}$$

The *internal energy* U is the entire energy *inside* the system: kinetic energy of the molecules plus binding energies plus all internal interactions. The *bound energy* — Helmholtz's original term for $T \cdot S$ — is the portion of U that cannot be converted into work at constant temperature (intuitively: trapped in thermal chaos). T is the absolute temperature, S the thermodynamic entropy (the measure of thermal chaos).
Karl Friston has shown that the same balance structure also holds for information. The *variational free energy*:

variational free energy = model complexity + model surprise

$$\mathcal{F}[q] = \underbrace{D_{KL}[\,q(\eta|m)\,\|\,p(\eta|m)\,]}_{\text{model complexity}} + \underbrace{(-\mathbb{E}_q[\ln p(o|\eta,m)])}_{\text{model surprise}}$$

$q(\eta \mid m)$ is your **updated belief** about the hidden world η under model m, $p(\eta|m)$ your **original belief** (prior). D_{KL} is the *Kullback-Leibler divergence* — it measures how far q had to move away from p, that is, how much model-bending the update cost. $\mathbb{E}_q$ is the expected value under q; $p(o \mid \eta, m)$ the probability of the observed data o under the model — the worse the model explains the data, the smaller $\ln p(o \mid \eta, m)$, the larger the *model surprise*. Living systems minimize $\mathcal{F}$ — less contradiction with the world for less bending of what is already believed. (In the standard literature the second term is called *negative accuracy*; not to be confused with the *surprisal* $-\ln p(o)$, a related but distinct quantity.) Full treatment in Ch. 2.
What does annealing have to do with both? In both cases there is a single parameter that sets the **scale** against which the landscape is measured — and it is exactly this scale that decides whether the system

stays stuck in the first valley or gets to wander further. Both times, the deciding factor is **entropy**.

With **Helmholtz**, temperature sets the scale against which energy differences are measured. At high temperature the thermal energy is comparable to the barrier heights — the landscape looks **flat**, the system flits over the barriers. At low temperature every barrier becomes towering — the system gets stuck in the first valley. The thermodynamic entropy (many accessible microstates at high temperature) is the mechanism behind it: many alternatives in play → relative energy differences less important → landscape flattens out.

With **Friston**, the **uncertainty of your beliefs** sets the scale — formally the inverse of the **precision** λ, that is, the variance $\sigma^2 = 1/\lambda$, whose logarithm determines the Shannon entropy of a Gaussian distribution: $h = \frac{1}{2}\ln(2\pi e\,\sigma^2)$. With **uncertain beliefs** (low λ) all models are about equally close — the model landscape is **flat**, the system explores freely. With **precise beliefs** (high λ) every deviation is penalized exponentially — the landscape has deep valleys. Here it is more uncertainty that flattens the landscape: many possible models in play → relative model differences less important → barriers surmountable.

The same mechanism, a different substrate: **entropy = how many alternatives are in play at the same time.** During annealing the entropy grows temporarily — the landscape flattens, the system finds new configurations. On cooling (low temperature, or **precise beliefs** again) the structure returns — but the system now sits in a better spot. Same mathematics, different substrate — once particles, once information. Minimize variational free energy and you live. Fail, and you fall apart. Life as the crystallization of information that withstands heat death.

Minimize free energy and you live. Fail, and you fall apart. Life is not a substance that also happens to minimize free energy. Life *is* what remains when the minimization succeeds long enough. Everything else falls apart and stops being an "it".

The FEP sits deeper than dopamine, hormones or the reward system. These are only the coarse evolutionary dials through which free energy minimization

was wired into flesh and blood. Dopamine does not reward the pleasure itself but the prediction error the model learns from — classically formulated as *reward prediction error*[11], in the FEP reading as precision assigned to the new prediction. More about this in Chapter 2.

Now scale the picture up to the global level: billions of people, each with their own world model, their own inner calendar, their own collection of beliefs. All somewhat different and yet all following the same principle: minimize free energy. But the individual optimum is not the global one. Only when the models couple to each other does the free energy fall for the individual **and** for everyone together. Exactly as in the experiment with 20 metronomes on a board[12]: each ticks to its own stubborn beat at first, but after a few minutes they all swing in synchrony, because the free energy of the coupled system is lowest in the shared beat, for every single metronome too.

The informational part of most world models has long been interacting. Chaotically, though, over the internet, full of contradictions, and depending on what you consume, this lowers the free energy or drives it through the roof. The economic part, by contrast, needs a reliable coupling. Exchange is a synchronous act: buyer and seller have to share the same rules *now*. Without this shared frame, economic action ranges from inefficient to impossible. Money can connect world models into a shared economic reality. But only if it has the right properties.

Second: minimizing free energy creates coherence. Coherence means that many parts fit together, across time, space and levels. Your cell sits in your organism, your organism in a society, your society in a market — four floors stacked on top of each other. Every level has to share information with the one above and below it, otherwise the story breaks down between them: that's **vertical** coherence. Added to that are **horizontal** (between the people on the same floor), **backward** (*memory*), and **forward** (*prediction*). Four directions, simultaneously.

Imagine soccer fans singing together in the stands: **horizontally** everyone sings the same song in the same beat; **vertically** every single voice shapes the choir's overall sound, which in turn forms the stadium atmosphere, which in turn acts on the players; **backward** the lyrics sit in shared memory, shaped by years of singing along; **forward** everyone knows what comes in the next bar — the chorus, the chant. All four directions active, simultaneously, without a conductor.

The real trick is in the interplay: with 50,000 fans nobody can negotiate directly with everyone else about whether they're on the beat right now. The **horizontal** coherence arises **indirectly** — every fan aligns with the **overall sound of the stadium** (that's the **vertical** coupling: the individual voice aligns with the macro level), and every fan carries an inner model of the song (the **temporal** directions: he knows where he is right now and which bar comes next). Out of the two indirect directions — *vertical* and *temporal* — the horizontal coherence emerges on its own. Hermann Haken calls this the **slaving principle**[13]: many individual parts align with a shared macro quantity and end up synchronous with each other, without being steered directly from outside.

If just one of these directions drops out, the powerful choir becomes a chaotic mess and the atmosphere hits the floor.

Remember these four directions — they come back. What physicists more precisely call **information coherence** is exactly that: many parts stay locked in a stable relationship to one another and add up to a coherent, contradiction-free overall picture — two brains that share the same reality; a society with a consistent notion of what money is. Exactly the same pattern holds for cells, brains and markets.

Nerdbox — STEM Undergraduate Level: Mutual information
Deepens the argument. Skip it and you lose nothing.

Information coherence is the umbrella term: many parts stay locked in a stable relationship to one another and add up to a coherent, contradiction-free overall picture. When the book speaks of brains and markets holding the same economic reality consistently, this is the formal basis: the **mutual information** — how much two quantities know together:

$$I(X;Y) = \underbrace{H(X) + H(Y)}_{\text{individual entropies, summed}} - \underbrace{H(X,Y)}_{\text{joint entropy}}$$

$H(X)$ is the *Shannon entropy* of X — intuitively: how uncertain you are about X when you know nothing else. $H(X,Y)$ is the *joint entropy* of the pair (X,Y). **Mutual information is the entropy that disappears when you look at X and Y together instead of separately.** If X and Y are independent, then $H(X,Y) = H(X) + H(Y)$

and therefore $I = 0$. The more they share, the smaller $H(X, Y)$, the larger I. Phase coherence, GPS atomic clocks and double-slit interference are manifestations of the same quantity — Ch. 4 spells them out as special cases of the four coherence directions.

In the FEP framework I turns up again as part of free energy itself. Concretely, Friston[14] decomposes the forward-looking free energy under a **policy** u (a plan of possible actions — in Friston's original notation π) as

$$\mathcal{G}(u) \;=\; -\underbrace{I(\eta; o \mid u)}_{\text{mutual information}} \;-\underbrace{\mathbb{E}_q[\ln p(o)]}_{\text{preference term}}$$

Here η is a hidden world state and o a future observation. Minimizing $\mathcal{G}$ maximizes the mutual information between hidden states and expected observations. That is the agent-internal variant: the inner beliefs about the world lock onto what the world actually offers.

That the same minimization also leads to mutual information *between agents* follows from a close relationship: **$\mathcal{F}$-minimization ↔ eigenmode formation ↔ synchronization**. When many agents minimize their free energy in parallel and share a common constraint, their slow modes couple, and the mutual information between them becomes generically high (necessarily so only under additional conditions — antagonistic preference priors over the same constraint can diverge instead of converge). *(Terminological clarification: "mode" here in the broad sense — a slow mode with self-consistency and its own relaxation time, like the market price in Ch. 3 §3.3. In the narrow operator sense $L\psi = \lambda\psi$ — the singing bowl mode, Bitcoin's three algorithmic rhythms — it holds as well, but is the special case of a translation-invariant coupling.)* In the linear-Gaussian coupling case with a shared constraint, the three operations can be traced back to the same variational condition; in the nonlinear case this holds near a bifurcation (Haken's slaving principle). Ch. 4 and Appendix A.1 give the formal development.

(The agent-internal part is shown in[14]. The multi-agent bridge is derivable in several equivalent formulations: mode formation, mean-

field aggregation, shared generative model. Millidge, Tschantz and Buckley[15] point out that the exact EFE decomposition does not follow uniquely from the variational free energy; all forms examined, however, deliver the same MI-max property.)

Now think of these four directions on a global scale, for the economic domain: between billions of people (horizontal), across levels from the individual through the local to the global market (vertical), through history (backward) and future (forward). A signal that carries all four directions would be a global coherence anchor. The next points show why fiat fails at this — and Bitcoin delivers exactly that.

Third: the whole influences its parts without steering them individually. The slaving principle from point two has a more general name: **top-down causation**. This is the mechanism without which nothing in life would work. The overall sound of the fans' choir does arise out of the individual voices — that's the classical bottom-up direction. But it also acts back on every single voice and shapes it. The classical physics instinct *"atoms determine the whole"* is only half the truth. The other half — the whole shapes its parts — is top-down causation. Constantly visible in everyday life: orchestras, language, social norms, market prices, festivals.

Do you remember the twenty metronomes from point one? Now we look at the mechanism more closely. Connected via the board they stand on, the metronomes establish a shared beat by themselves — not because someone steers them individually, but because the free energy of the coupled system is minimal in the shared beat. That's exactly what happens: through **vertical coherence** (between individual metronomes and board) **horizontal coherence** arises (between many metronomes). That's self-organization through emergent top-down causation.

That's exactly what Bitcoin does with the economic part of its users' world models. Just as the board connects the metronomes, Bitcoin connects people's world models. That's how the inner maps of economic reality synchronize in billions of heads.

Fourth: fiat breaks the coherence from point two in all four directions. The rules are shifted continuously: money supply, interest rates, bailouts, interventions. The price signal is manipulated continuously, every

run of the printing press adds noise to it. In our image: fiat is a clattering gong — structurally related to a ringing gong, but destroyed on the inside. The effect is as if a toddler with a hammer had found the gong: harder every time, timed differently every time. Instead of a clear beat: unpredictable noise that pretends to be signal.

Anyone who wanted to take out a loan, buy a house or even just budget a month's paycheck in March 2020 knows this: three sets of rules in four weeks, every position a bet on which one holds tomorrow. In the heads of most people that means their economic world model becomes more flexible, less rigid, too soft to bear any weight. Slowly it's becoming ever clearer: our financial system is stuck in an energetically unfavorable configuration. The shallower valley on the cover.

What would it take to bring back the coherence that fiat breaks? Three properties: **mathematically fixed rules**, an **automatic beat**, and an **economic incentive** that keeps the system alive. That's the checklist. And here comes the answer.

Fifth: Bitcoin generates coherence in all four directions, by ticking off this checklist point by point[3]. (1) **Hard rules**: at most twenty-one million bitcoin, anchored firmly in the protocol, not in a bank's promise. Every user checks the rule themselves, and there's no central lever for changing it. (2) **Automatic beat**: every ten minutes the globally shared transaction register (the **ledger**) grows by a new entry (a **block**), mathematically guaranteed in the long-run average. (3) **Economic incentive**: whoever secures the network through computational work (**mining**) gets paid in bitcoin. Bitcoin couples its survival to its miners minimizing their free energy. Chapter 2 explains why earning money minimizes free energy.

Bitcoin is, by design, a global synchronization mechanism for the economic part of your world model. It stabilizes the expectations of its users, synchronizes their economic reality (everyone sees the same ledger worldwide) and filters deviations deterministically (invalid transactions get rejected). So Bitcoin delivers coherence in all four directions from point two, exactly where fiat breaks it: the same ledger everywhere (horizontal), coupled all the way through from the single act to the whole, anchored to energy through **proof of work** and so to physics itself (vertical), an unchangeable past (backward), a predictable beat and deterministic inflation (forward). In our image: a ringing gong, hard and clear, with a natural vibration.

What Bitcoin delivers today is *structural* coherence, not stable purchasing power. Stable purchasing power follows only after the phase transition from the fiat valley into the Bitcoin valley. What you're seeing right now (violent price swings against fiat) is transition dynamics, not a flaw in the architecture. Chapters 7 and 8 work this through.

Three components, four directions, one architecture. Exactly the form the FEP demands for every living system: coherence across levels and time. **Bitcoin is itself an FEP system.**

The comparison table in Ch. 6 §6.1 shows how fiat breaks the four directions and why Bitcoin holds them — Bitcoin as architecture underpins all of Ch. 6. Which architecture makes these three properties possible in the first place (a decentralized network protects the rules, cryptography secures ownership, an energy anchor fixes the past) is spelled out in the compact Bitcoin fundamentals box in Ch. 5 §5.5.

Why not Ethereum, gold tokens, stablecoins, CBDCs? Because every candidate violates at least one of the four coherence directions or the stationarity precondition: issuance discretion, a fragile custodian layer, a fiat anchor or central bank programmability. Ch. 6 §6.4 works through them systematically.

Sixth: Bitcoin and humanity synchronize with each other. Here is the real payoff. When many singing bowls stand next to a vibrating gong and their frequencies match the gong's, the bowls begin to **vibrate in sympathy**, without anyone striking them. And the sound waves of these vibrations then drive the gong in turn. Acoustically this is called resonance, structurally it's synchronization. Many vibrating systems find a shared beat in a self-organized way. Exactly like the metronomes on the board, or the soccer fans who settle out of a tangle of individual voices into a shared song. What can be heard between singing bowls and gong as resonance happens between Bitcoin and the economic part of human world models at the level of information: a shared sense of what money is, what prices mean, what is scarce.

The coupling runs through the **economic part** of our world model, but it minimizes the free energy of the whole person. Here is why this lever reaches so far.

Your world model isn't a filing cabinet with separate drawers for *money*, *relationships*, *sleep*, *meaning*. It's a coupled web of beliefs: what you expect about one thing hangs on what you expect about many others. If one belief

wobbles, its neighbors wobble along. With the singing bowl it's the same: a dent in one place makes the whole bowl clatter.

Money is wired especially deeply into this web. It carries beliefs about security (can I still eat tomorrow?), time (can I plan?), relationship (can I provide for someone?) and self-efficacy (can I shape my life?). Someone who doesn't know whether their savings will still be worth anything in two years sleeps worse, snaps at people more and doesn't feel up to long-term projects. That isn't weakness but free energy that doesn't stay in the economic part and instead wanders through the whole world model.

The reverse holds too: when the economic part becomes stable, the free energy of the whole world model falls. **The economy is only the lever; the effect hits every area of life.**

Why does this lever work at all? Because two systems that run by the same rule meet here. You minimize free energy, like every living system. And Bitcoin does it too: it orders the constant swarm of unconfirmed payments into a coherent ledger and defends its ten-minute beat, no matter how many miners are competing right now. Its tools for that are the three properties from point five: hard rules, automatic beat, economic incentive. Precisely because Bitcoin minimizes its own free energy this way, it can become the stable anchor that *your* economic world model docks onto (Ch. 6 makes this formal).

But on the human side, does Bitcoin really stabilize what you need? That can be checked. Over four decades of motivation research, Edward Deci and Richard Ryan distilled three basic needs[16] that hold for every human being: **autonomy, competence, relatedness**. These three are not wishes but conditions: when they're fulfilled, your free energy falls; when they're violated, it rises.

Autonomy means: you act out of yourself, according to your own will, instead of being carried along by decisions that aren't yours. Bitcoin delivers that in the economic space: your key, your bitcoin; no state, no bank, no algorithm can take your property from you or block your economic activity at the level of the rules themselves.

Competence means: you feel that what you do actually holds up. Learning pays off again, saving pays off again, because purchasing power no longer decays exponentially and the hard rules don't shift underneath you. Bitcoin delivers that through open, checkable rules; the limit of twenty-one million isn't up for negotiation. *Don't trust, verify*.

Relatedness means: you live in a meaningful relationship to others, and that becomes possible only when you and the people around you live in the same economic world. Bitcoin delivers the *precondition* for it: all nodes see the same ledger, all calculate under the same mathematically fixed limit. A shared reality, instead of everyone in their own.

This shared reality doesn't only act on you — it also acts back on Bitcoin. What you do (buying, holding, mining) strengthens Bitcoin; and Bitcoin strengthens you. This mutual strengthening is what produces a **positive feedback loop** that runs in concrete rounds:

1. Bitcoin's hard rules (21M, 10-minute beat, consensus) stabilize our economic world model: less uncertainty about money supply and rules, therefore less free energy.
2. New users buy, hold, mine, and run their own nodes. That strengthens the network (hashrate, liquidity, decentralization), and their own free energy drops further. Deeper with every round (Ch. 6 shows the detailed mechanics, Ch. 8 the threshold dynamics).

Imagine humanity as a boat with billions of rowers. So far everyone rows in their own beat; the boat makes headway laboriously and is barreling toward icebergs like crises and wars. It constantly loses energy because people unintentionally (or intentionally) row against each other. It works partly against itself. Bitcoin is the drum on this boat, hard and clear. It's beaten not by a captain but by the rowers themselves. Self-organization, not dictate. As soon as the drum beats and everyone rows in the beat, the boat becomes faster and more coordinated and gets the rowers where they want to go sooner. The speed of this coherently rowing boat is a tangible measure of the rate at which our shared prosperity and our quality of life grow. That's the Bitcoin standard reality, a **Gestalt** in the precise sense: a whole that's something other than its building blocks.

And the boat isn't only faster, it lives. In the precise sense. Bitcoin, humanity and their interaction together form a new, narrowly coupled living system. That's more than a metaphor, but less than a new subject: the coupled system minimizes free energy only along a single axis, the economic one, with the Bitcoin ledger as a shared reference point. All other axes of your life (what you believe, with whom you share it, what excites you, where you live, what you

work on, how many children you want) are left entirely up to you. As discussed earlier, Bitcoin gives you more freedom and possibilities in these areas too, but doesn't dictate their content.

The image of a new life form isn't new. Merkle called Bitcoin the *"first example of a new form of life"* as early as 2016[17]; Gigi, Quittem and Strolight have developed it further since then, each with their own metaphor (organism, super-organism, meta-brain)[18–20]. What this book adds is not the image but the justification: why it has to be this way, as a direct consequence of the FEP. It shows the architecture: a narrow connection, only via the economic axis. And it draws a clear line: no new consciousness. It acts as a filter: some of these images hold up under analysis, others overreach. Chapter 6 separates the wheat from the chaff.

This isn't miraculous emergence but a consequence of the FEP — and the FEP is not a hypothesis that could be true or false. It follows necessarily as soon as you can cleanly separate a system from its environment at all and it stays stable over a longer period. The same mechanics underlie every living system made of interacting parts that minimize free energy: cell, brain, market (Ch. 2 makes this clearer, Ch. 3 shows in concrete cases how far the principle reaches). In the FEP framework, the Bitcoin-humanity living system is therefore not a special case but exactly the consequence you would expect: two systems that share a fixed, narrow reference point find a deeper minimum together, without losing their independence.

Important: this synchronization isn't forced conformity but a global nervous system that creates economic coherence. This coherence is generated by many autonomous and free people who sustain it precisely *through* their autonomous and free action (Ch. 3 §3.3 spells out why). Ch. 6 makes the architecture precise as an *informational holobiont*, and it also analyzes what this coupled system can do that an uncoupled humanity couldn't.

The human-fiat system, by contrast, is a living thing whose nervous system is constantly shocked from outside: every expansion of the money supply distorts the price structure through the **Cantillon effect**[21], not only the distribution (Ch. 6 §6.3 works this through), and the system is permanently occupied with repairing the damage. At some point the price signal stops signaling anything, and the whole system has to be revived through a reset. So far no truly healthy money-human system has ever been brought to life: fiat in its pure form (post-1971) was from the beginning a system with discretion, not a system of

fixed rules; gold had too few and too slow connections for a coherent whole (more in Ch. 5 §5.4).

A related dynamic has been at work once before in evolution, when single cells coupled and multicellular organisms arose[22]. Bitcoin-humanity follows the same logic one level higher, with the difference that human and Bitcoin reproduce separately (Ch. 6 works this through).

And the valley deepens itself — from two sides. Everyone who arrives in the deep valley strengthens the network: hashrate, liquidity and purchasing power per bitcoin rise, and the valley sinks for everyone already in it and for everyone still to come. **And everyone who arrives stops holding others back**: the people around them feel the peer pressure toward the fiat valley less, and the barrier sinks. A deeper valley *plus* a lower barrier. The Bitcoin standard is not a decree but a valley that deepens itself and at the same time lowers its barrier. But most aren't there yet. Two things stand in their way: **fog** (they don't yet see the deeper valley) and **barriers** (they see it, but conformity pressure, salary, rent and taxes glue them in place in the shallow fiat valley). Point seven shows how both fall.

Seventh: the transition is a phase transition, not a plan. Imagine a piece of iron. Iron consists of iron atoms (no shit) and every iron atom is a tiny little magnet. When all these magnets point in the same direction, the iron is magnetized. Let's call this direction the fiat direction. Now apply a weak external magnetic field in the opposite direction, the Bitcoin direction. That creates a second, deeper energy well, the Bitcoin standard, into which the system wants to fall. But a conformity barrier holds it back: every magnet lowers its energy by pointing in the same direction as its neighbors, and flipping costs energy up front. That's how the image on the cover comes about. This energy landscape is now no longer individual but that of the whole piece of iron: how much energy the system has in total, depending on how many magnets point in which direction.

Now raise the temperature. Heat makes the little magnets restless and the energy landscape flatter: the old valley becomes shallower, the conformity barrier lower. Above a certain temperature they all tip over together.

Nerdbox — STEM Undergraduate Level: Hamiltonian and free energy ▽

Deepens the argument. Skip it and you lose nothing.

The simple iron picture from the main text is mathematically the **Ising model with an external field**. Its Hamiltonian, that is, the energy of the whole piece of iron for a given configuration of all the magnets:

$$H = \underbrace{-J \sum_{\langle i,j \rangle} s_i s_j}_{\text{conformity}} \underbrace{- h \sum_i s_i}_{\text{external field}}$$

Every magnet s_i has two possible positions, $+1$ or -1. $J > 0$ is the conformity coupling: two neighboring magnets in the same direction lower the energy by J, in opposite directions they raise it by J. The first sum runs over all neighbor pairs $\langle i, j \rangle$ and delivers the conformity pressure. The second term is the external magnetic field h: it lowers the energy of all magnets that point in its direction and raises it for the others. In the Bitcoin picture, h is the individual Bitcoin advantage that each person feels.

The **free energy** $F = U - TS$ follows from the Hamiltonian and the temperature (in the Helmholtz-plus form from earlier in this chapter). The system minimizes F: at low temperature U dominates and ordered configurations with low energy win; at high temperature $T \cdot S$ dominates and disordered configurations with many microstates become favorable.

The energy landscape on the cover is also the plot of F as a function of the mean magnetization $m = \frac{1}{N} \sum_i s_i$. At low temperature and a weak counter-field, $F(m)$ has two minima: the old valley in the old magnetization direction and the new, deeper valley in the field direction. If T rises, the entropic share $T \cdot S$ grows, both wells flatten out, and the conformity barrier between them drops. Above a critical temperature the system tips into the deeper valley.

We develop the full Bitcoin variant, with all its extensions (Curie-Weiss term for global network effects, sighted-agent restriction, one-sided heat from fiat erosion, super-linear scarcity bonus, avalanche dynamics through Glauber updates, heterogeneous agents and life cir-

cumstances), in Ch. 8 §8.1 — the formal home of the Ising mathematics. ▽

Mathematically, the transition to Bitcoin follows the same logic. Except that in our case the individual parts are not atoms but people with their own world model, who all sit in the fiat valley at first. What pulls them toward Bitcoin, that is, the external magnetic field, is the lower free energy of the Bitcoin valley that we argued for above. In everyday life it acts as a practical advantage: store of value, self-custody, censorship resistance, real ownership. Anyone who has grasped the Bitcoin architecture, anyone for whom the fog over the Bitcoin valley has lifted, feels the field strongly; anyone still in the fog barely feels it.

The fiat heat isn't the same everywhere either. In Turkey the fiat valley is burning fiercely and is therefore shallow; in the stable Swiss franc it is still pleasantly cool and deep. Magnetic field, conformity barrier and heat are therefore different for every person, depending on their level of knowledge, personality and life circumstances. Someone with little to lose, living in a weak fiat world or going against the grain anyway, tips early; conformists in stable environments tip late.

But people aren't only magnets. Four more forces amplify the transition.

First, peer pressure. Family, colleagues, friends pull everyone in their direction. That's the human variant of the same interaction that, in the iron, already pulls each magnet into line with its neighbors and produces the conformity barrier described above.

Second, the fog dynamics. Only someone who can see the deeper valley will switch world models. The better world model first has to exist in the internal search space. The Bitcoin magnetic field can therefore act only on people whose fog has lifted sufficiently. The lifting of the fog, however, spreads like a virus for which there's no cure: whoever is infected once stays contagious to everyone around them forever.

Third, the asymmetric network effects. Every new bitcoin holder makes the network more attractive for everyone: more transaction partners, more security, more liquidity, more purchasing power stability. Fiat holders, by contrast, are captive users and don't strengthen the fiat system in the same way.

Fourth, fiat frays from within. Inflation, the Cantillon effect and monetary policy discretion soften the economic beliefs of every fiat user piece by piece, entirely on their own. Fiat produces its own heat. Bitcoin itself stays cool, because

its rules are mathematically fixed. Once someone tips in its direction, they almost never tip back.

We have modeled this scenario mathematically and simulated it with computers. The result is an avalanche, driven by the self-reinforcing feedback loop above. Even with only very weak self-reinforcement, the transition happens not gradually but abruptly. The reason is a chain reaction: everyone who tips deepens the Bitcoin valley for everyone else and lowers the conformity barrier for the next ones. That confirms mathematically what Parker Lewis captured in an essay: *gradually, then suddenly*[23]. Exactly when the transition starts is something we can only estimate roughly from empirical data. How fast it runs once it starts, we can say more precisely: years, not decades. And the adoption figures of the last ten years already sit at the very top of the range the model allows. Chapter 8 shows the details.

That's why Bitcoin becomes the standard. Not because it's morally superior. Not because someone wants it. But because two mechanisms are working at the same time. Fiat dismantles itself from within: every intervention raises the entropy of its users' beliefs, and the fiat valley becomes shallower. Bitcoin is the only system that delivers hard rules, a fixed beat, and an economic incentive at the same time, in all four coherence directions. It's therefore the only money with which human world models can enter a coherent, stable symbiosis: a gong that rings by itself and lets whatever strikes against it vibrate in sympathy. **Nobody chooses the Bitcoin standard. It's a consequence of the physics of life (the FEP), and once it arrives, it arrives faster than most would expect.**

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§1.3 Five predictions that could bring the model down

If the model is right, testable predictions follow from it. Three of them are especially provocative:

1. **Bitcoiners actively seek out annealing episodes and meaning-neutral qualia states:** meditation, psychedelics, therapy, breathwork, sauna, cold showers, deep journaling. Above average, compared with a matched control group.

2. **Bitcoiners simultaneously feel high autonomy, competence and relatedness** (Deci and Ryan's SDT scales): all three at once, which fiat societies structurally can't deliver.
3. **Bitcoiners have more sex.** Sex is a double tool here: an annealing episode and an act of procreation in one. Someone who anneals more often jumps into the deeper valley more often *and* more often has children who start out there already. Two effects, one cause.

The first three test what Bitcoin does to people. The last two test the transition itself: not *when* it comes, but *how* and *where*:

4. **Bitcoin spreads in bursts, not as an even wave.** *Gradually, then suddenly* is not just a turn of phrase but a measurable form: the model in Chapter 8 predicts a cascade of adoption bursts. Again and again many people tip at once, and the sizes of these bursts follow a power law, like the strengths of earthquakes. People have a typical height: almost every adult is between 150 and 200 centimeters tall. Earthquakes have none, and on this model, adoption bursts have none either: many small ones, few huge ones. The great avalanche from point seven is the largest of these bursts. If Bitcoin adoption instead grows as a steady swell, the model fails.
5. **The great leap to Bitcoin leads through the dollar, not past it.** Where fiat burns hottest, most people flee first into the next-coolest valley within reach, and that's (still) usually the dollar: holding it costs almost nothing, while only those who overcome fog and barriers get into the Bitcoin valley. You can already see exactly this happening: in emerging markets a growing share of savings flows into digital dollars, so-called stablecoins, not into Bitcoin. Those who have already taken the first step take the second one, from the dollar to Bitcoin, most readily: the already dollarized savers, burned by inflation. The spark of the great avalanche can therefore come just as well from this periphery as from the dollar center itself, once it gets hot. Quite a few do take the direct path from hot local fiat to Bitcoin, skipping the dollar, just not the masses. And that's where the model breaks: if the masses stay with the dollar permanently even though it's running hot itself, the thesis of this book is false.

Chapter 8 tests both transition predictions: the burst form against the mechanics, the starting place against mechanics and data. The epilogue works through all the other predictions: methodology, control groups, the sex-annealing mechanism and the structural falsification of the thesis (one assumption plus two structural criteria). That's also where you find the answer to the only fair question: what would have to happen for you to first insult the author of this book and then burn it?

But before we come to money, one question. What if what you're seeing right now (this page, your hand, the light on the paper) doesn't exist *out there* but in your head? What if everything you ever took to be the world is a prediction that your brain compares every millisecond against the tiny drop of information your senses can really deliver? What if your perception is a very arbitrary user interface, optimized to operate reality instead of experiencing it directly? That's what Chapter 2 is about.

1. Friston, K., Kilner, J. & Harrison, L. A free energy principle for the brain. *Journal of Physiology-Paris* **100**, 70–87 (2006).
2. Friston, K. A free energy principle for a particular physics. *arXiv preprint* **1906.10184**, (2019).
3. Nakamoto, S. Bitcoin: A Peer-to-Peer Electronic Cash System. (2008).
4. Antonopoulos, A. M. & Harding, D. A. *Mastering Bitcoin: Programming the Open Blockchain*. (O'Reilly Media, Sebastopol, CA, 2023).
5. Friston, K. The free-energy principle: A unified brain theory? *Nature Reviews Neuroscience* **11**, 127–138 (2010).
6. Callister, W. D. & Rethwisch, D. G. *Materials Science and Engineering: An Introduction*. (Wiley, Hoboken, NJ, 2018).
7. Kirkpatrick, S., Gelatt, C. D. & Vecchi, M. P. Optimization by simulated annealing. *Science* **220**, 671–680 (1983).
8. Carhart-Harris, R. L. & Friston, K. J. REBUS and the anarchic brain: Toward a unified model of the brain action of psychedelics. *Pharmacological Reviews* **71**, 316–344 (2019).
9. Friston, K. A free energy principle for biological systems. *Entropy* **14**, 2100–2121 (2012).
10. von Helmholtz, H. Die Thermodynamik chemischer Vorgänge. *Sitzungsberichte der Königlich Preußischen Akademie der Wissenschaften zu Berlin* 22–39 (1882).

11. Schultz, W., Dayan, P. & Montague, P. R. A neural substrate of prediction and reward. *Science* **275**, 1593–1599 (1997).
12. Pantaleone, J. Synchronization of metronomes. *American Journal of Physics* **70**, 992–1000 (2002).
13. Haken, H. *Synergetics: An Introduction — Nonequilibrium Phase Transitions and Self-Organization in Physics, Chemistry, and Biology*. (Springer, 1983).
14. Friston, K. *et al.* Active inference and epistemic value. *Cognitive Neuroscience* **6**, 187–214 (2015).
15. Millidge, B., Tschantz, A. & Buckley, C. L. Whence the expected free energy? *Neural Computation* **33**, 447–482 (2021).
16. Ryan, R. M. & Deci, E. L. *Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness*. (Guilford Press, New York, 2017).
17. Merkle, R. C. DAOs, Democracy and Governance. (2016).
18. Gigi. Proof of Life: Why Bitcoin is a Living Organism. (2019).
19. Quittem, B. Bitcoin is a Decentralized Organism (Mycelium). (2018).
20. Strolight, T. The Bitcoin Brain. (2021).
21. Cantillon, R. *Essai Sur La Nature Du Commerce En Général*. (Fletcher Gyles, London, 1755).
22. Maynard Smith, J. & Szathmáry, E. *The Major Transitions in Evolution*. (Oxford University Press, 1995).
23. Lewis, P. A. *Gradually, Then Suddenly: A Framework for Understanding Bitcoin as Money*. (Saif House, 2023).