INVISIBLE LINES

THE SMALL MOMENTS THAT TRIGGER THE EQUILIBRIUM

MAY 2026 ISSUE #2

THE HIDDEN GEOMETRY OF STABILITY

THE 1% THAT CODES FOR LIFE

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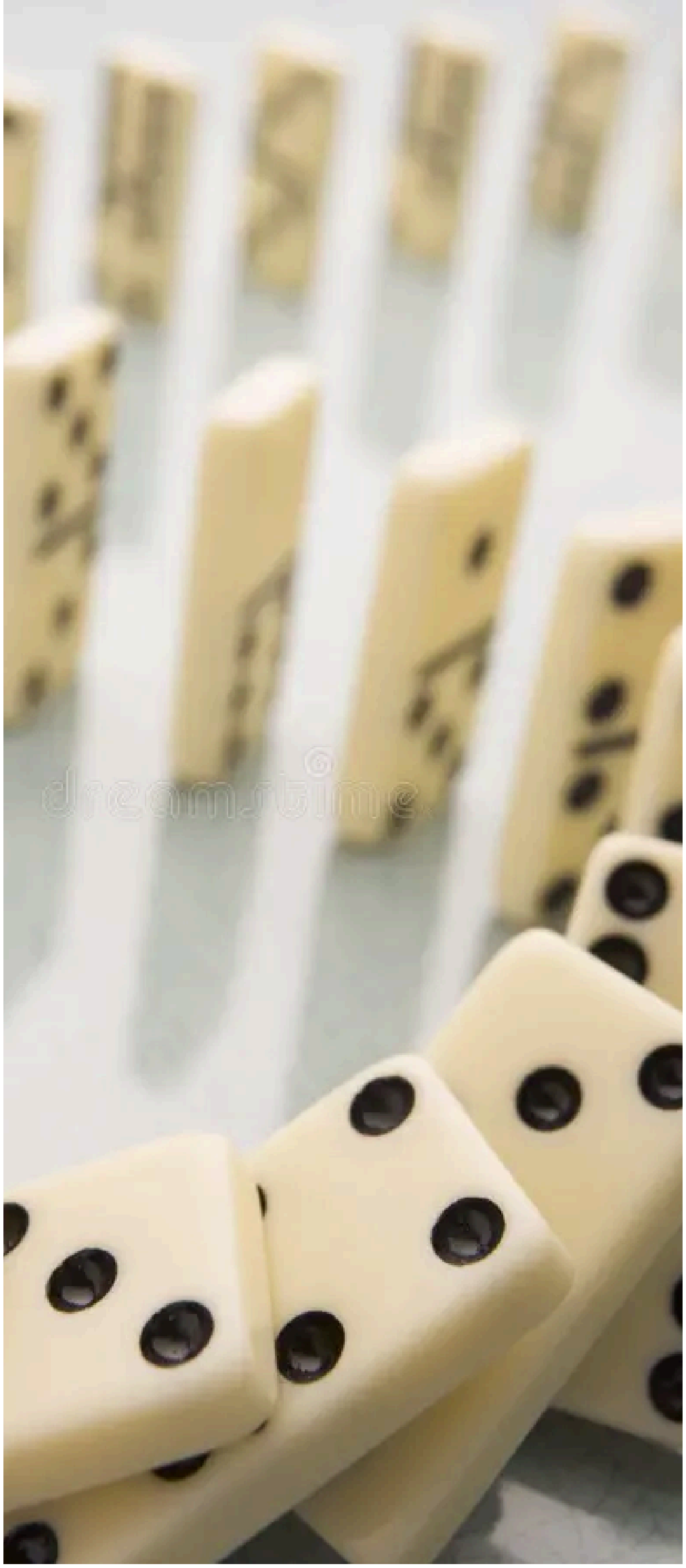

OUR THEME - TIPPING POINTS

We often percieve the world as a series of stable states, a collection of balanced equations and enduring structures. But between every "before" and "after" lies a precarious moment of tension—a Tipping Point. These are the thin, often invisible lines where a system's equilibrium is tested, and where the slightest shift in energy or weight triggers a total transformation.

In this issue, we explore the "knife-edge" of reality. We examine the geometry of stability to see why structures are often a single degree away from collapse, and find that same fragility in the chemistry of bread, where the boundary between failure and perfection is measured in mere seconds. From the cosmic mystery of white holes to the 1% of our DNA that acts as the fulcrum for all biological complexity, we look at how the most profound changes in our universe result from the smallest margins.

By investigating these thresholds—whether in the distribution of land or the limits of a physical law—we see that balance is not a static state, but a constant, delicate performance. These tipping points are the true architects of change; they are the moments when the silent logic of the world finally breaks its silence.

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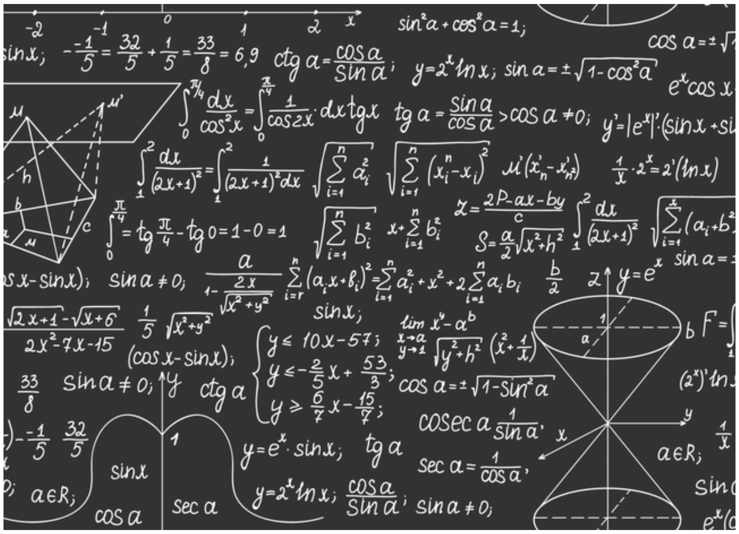

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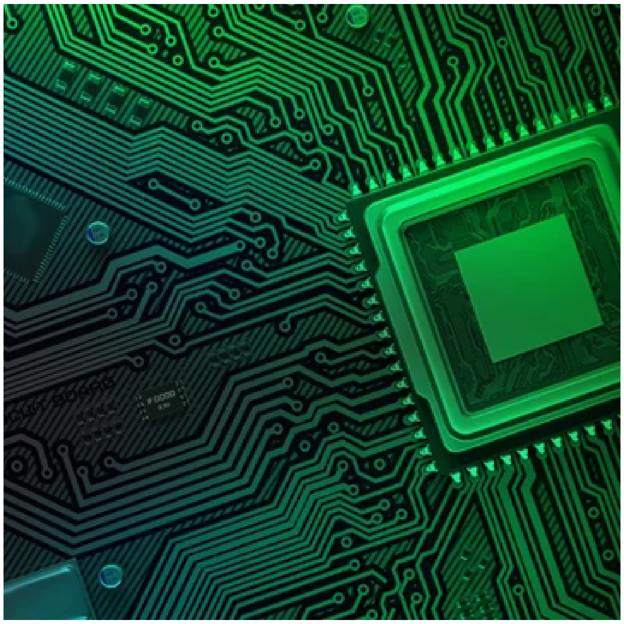

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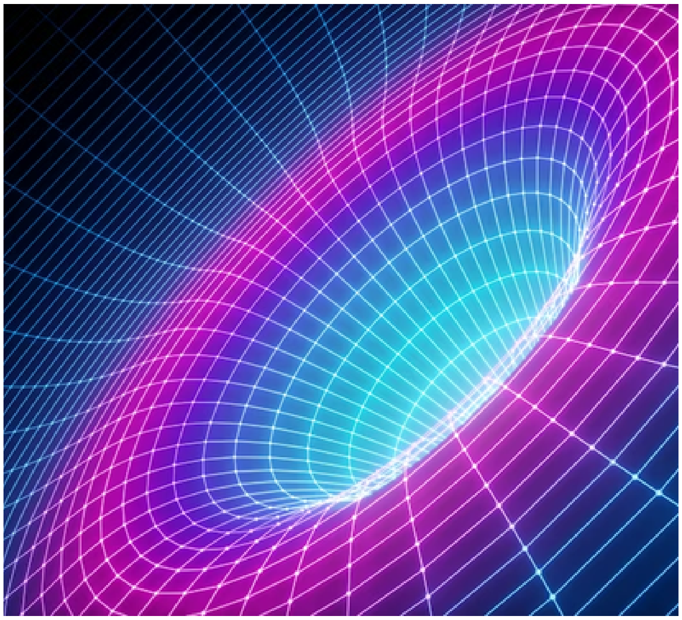
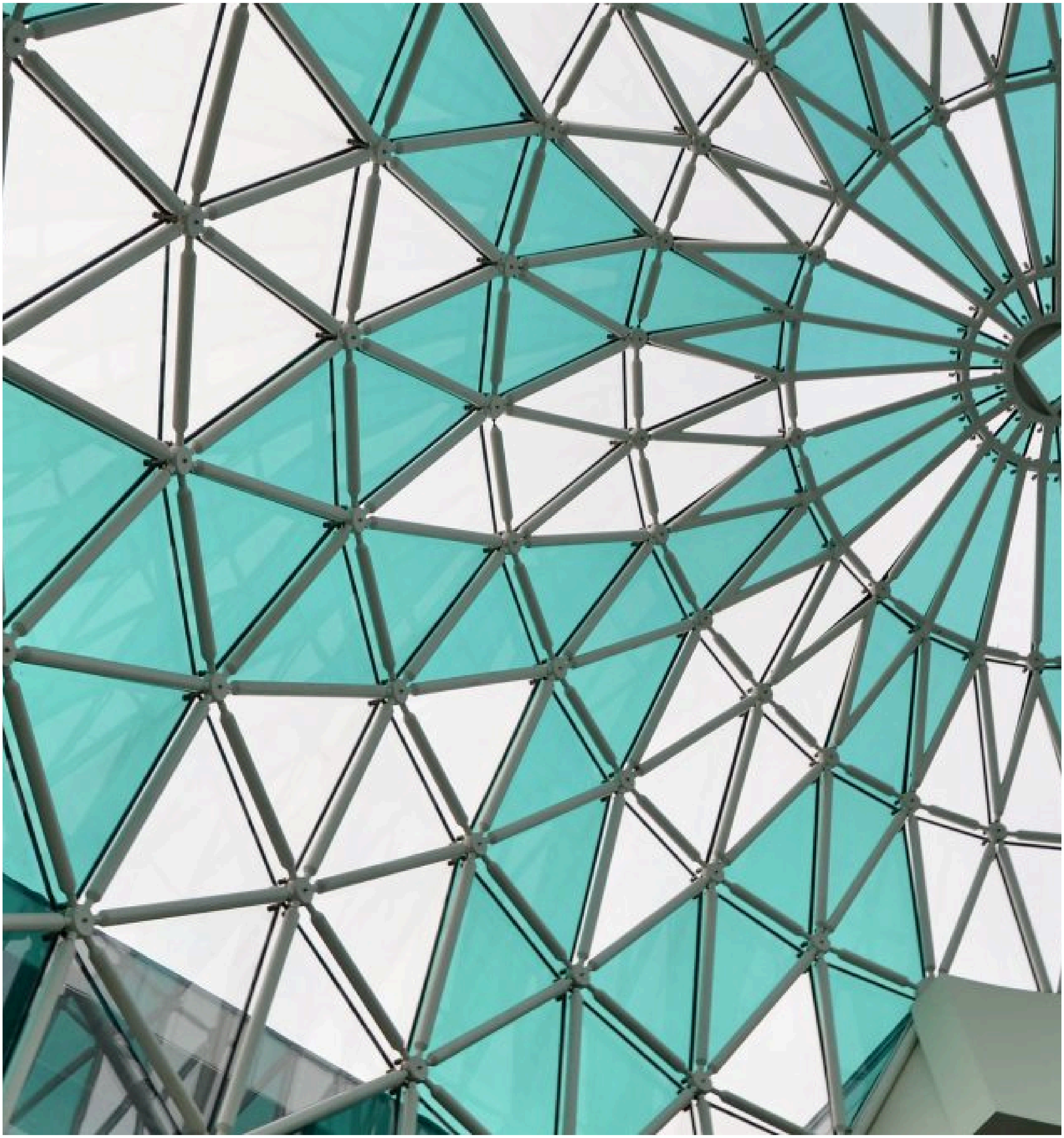


ARE TRIANGLES REALLY NECESSARY? THE HIDDEN GEOMETRY OF STABILITY

BY RITISHA AGARWAL



INTRODUCTION

Imagine walking across a bridge. The wind gusts around you, the metal hums faintly under your weight, and you trust the structure to hold. But what exactly makes a bridge stable? What hidden patterns in its framework prevent it from buckling under the stress of cars, pedestrians, and gusting winds?

Look closely at most bridges, and you might notice an intricate lattice of beams, struts, or cables. At first glance, it's easy to assume these patterns are arbitrary, or simply aesthetic. But hidden within this chaos is a subtle mathematical truth: certain shapes, arranged just so, carry forces efficiently and resist collapse, while others fail spectacularly.

One shape, in particular, keeps appearing again and again in bridges, towers, and roofs alike. Engineers might choose it without even thinking, but its persistence is not by accident. In this article, we explore why some shapes cannot be ignored if a structure is to remain stable, and what this reveals about the hidden geometry governing engineering.

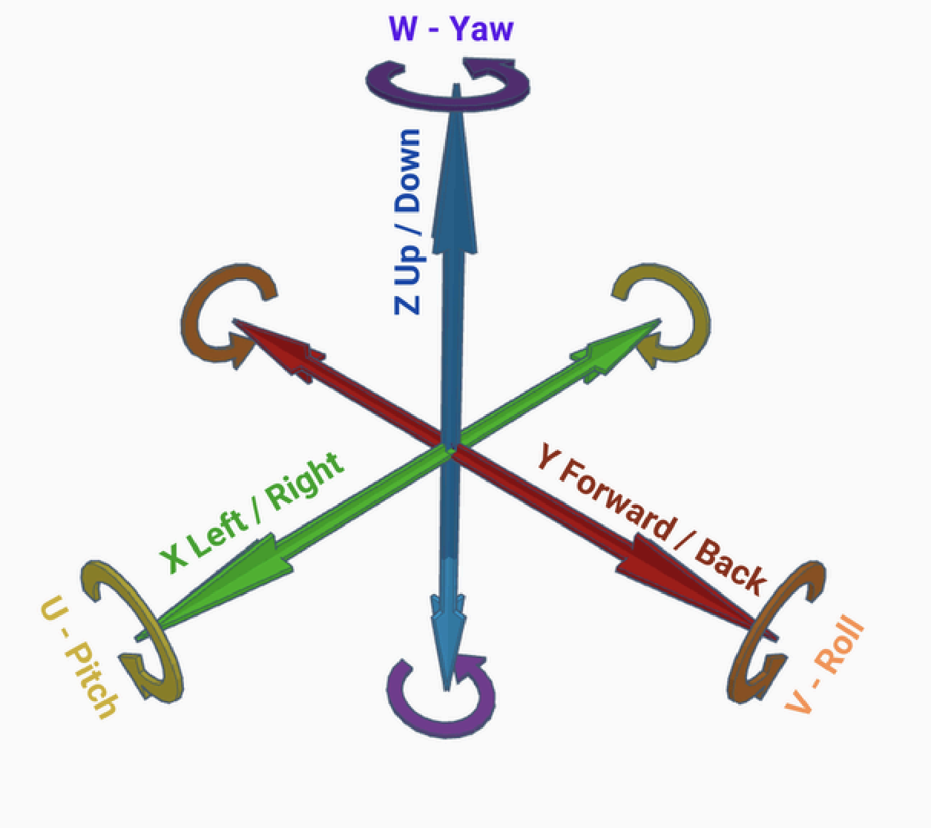
TRIANGLES, SQUARES, AND THE MATHEMATICS OF RIGIDITY

If we step back from bridges for a moment and ask, "Which shapes actually hold up under stress?" the answer isn't immediately obvious. Take a simple polygon made of rods connected at its corners: a square, for example. At first glance, it seems solid. But push on one corner, and suddenly it can collapse into a slanted parallelogram without any rods breaking. The square fails, not because the material is weak, but because the shape itself cannot resist deformation.

Now try a triangle. Fix the lengths of its three sides, and a remarkable thing happens: the shape cannot change. Push or pull on a corner, and the triangle holds firm. Unlike the square, it resists any deformation without needing additional supports. Mathematically, this is because a triangle's three sides uniquely determine its angles and overall shape, which is known in geometry as the Side-Side-Side (SSS) congruence rule.

We can understand this more formally using the concept of degrees of freedom, which measures how many independent ways a shape can move or deform. For a single rigid body in a plane, there are three degrees of freedom that do not deform the shape itself:

1. Translation in the x-direction – moving the whole triangle left or right
2. Translation in the y-direction – moving the whole triangle up or down.
3. Rotation about a point – spinning the triangle around a fixed point in the plane.



These three motions move or rotate the triangle as a whole but do not change its internal angles or side lengths. Any attempt to deform the triangle internally is resisted completely since there are no extra degrees of freedom to allow bending.

We can approximate the degrees of freedom (F) for a network of rods and joints using a simplified version of the Chebychev-Grübler-Kutzbach criterion:

$$\mathbf{F = 2n - m}$$

Where:

- n is the number of points (joints)
- m is the number of rods (edges)
-

So, for a triangle, n = 3 and m = 3:

$$\mathbf{F = 2(3) - 3 = 3}$$

These are exactly the three rigid-body motions listed above, confirming that the triangle has no internal flexibility.

However, for a square, n = 4 and m = 4:

$$\mathbf{F = 2(4) - 4 = 4}$$

Subtracting the three rigid-body motions leaves one internal degree of freedom, which explains why the square can shear into a parallelogram. Only by adding a diagonal rod, which is effectively splitting the square into two triangles, is the shape stabilized.

This simple maths reveals why triangles are so special: they are the smallest polygon that is inherently rigid. It's not about aesthetics or tradition; it's a mathematical inevitability. Triangles don't just happen to appear in bridges – they emerge naturally as the solution to a fundamental engineering problem: how to resist deformation while using as few elements as possible.

TRIANGULAR TRUSSES: HOW BRIDGES HARNESS THE MATHEMATICS

In theory, triangles are rigid, but how does this principle translate into an actual bridge? Engineers rarely use a single giant triangle. Instead, they create networks of interconnected triangles, known as trusses, to distribute loads efficiently and ensure stability across long spans.

HOW FORCES TRAVEL THROUGH A TRIANGLE

Every rod in a triangular truss carries one of two types of force:

1. Tension – the rod is being pulled, like a stretched rope.
2. Compression – the rod is being pushed, like a column supporting a weight.

Because triangles are inherently rigid, forces applied at one joint are transmitted cleanly along the edges, rather than causing the shape to deform. In contrast, a square or rectangle without internal supports would bend under the same load, creating weak points and potential failure.

Consider a simple triangular truss with a load applied at the top vertex. The weight splits along the two lower edges, pushing some rods into compression while pulling others into tension. The triangle ensures that the forces are directed along straight lines, minimizing bending moments and preventing structural collapse. This is why almost every bridge truss relies on triangular geometry at some level, even if the triangles themselves are not immediately obvious.

REAL WORLD EXAMPLES

Some of the most iconic bridges showcase the power of triangular trusses:

- Forth Bridge: This railway bridge is essentially a repeating lattice of triangles. Its engineers exploited the rigidity of triangles to create a span that could handle enormous loads and high winds, making it nearly indestructible.

- Eiffel Tower: While not a bridge, this structure demonstrates the same principle. The triangular lattice allows the tower to resist both gravity and wind forces, distributing stress efficiently across the structure.

- Modern suspension bridges: Even when cables dominate the design, the towers supporting the cables often employ triangular bracing to stabilize them against lateral forces.

TRIANGLES BEYOND THE OBVIOUS

Interestingly, triangles often appear even when you don’t see them. Curved bridges, suspension spans, and organic designs may look entirely different, but a careful analysis of the forces shows that the underlying geometry behaves as if triangles were present. The mathematics of rigidity “forces” triangles to emerge, whether as visible beams or as invisible stress paths through the material.

By combining theory with real-world implementation, it becomes clear that triangles are not just a design tradition – they are a mathematical solution embedded in the very physics of load distribution.

BEYOND TRIANGLES: CAN ENGINEERS ESCAPE THE GEOMETRY?

Triangles dominate bridges for good reason, but engineers are always experimenting. Could a bridge, tower, or truss function without a single triangle? And if so, what does that tell us about the mathematics of stability?

CURVES AND CABLES

Some modern structures rely heavily on curves or cables rather than traditional straight beams:

- Suspension bridges use cables to carry the load in tension, with the roadway “hanging” beneath. At first glance, you might think triangles are unnecessary.
- Arch bridges transfer forces along curves, compressing materials into elegant arcs.

Even in these designs, triangles appear implicitly. Consider a stone arch: while the stones are curved, the force vectors (the paths the weight takes to reach the ground) don't follow the curve perfectly. Instead, the compression forces resolve into a series of straight lines. If you were to map these internal stresses, you would see a "polygonal" chain. The arch remains stable because these force paths form a network of virtual triangles that lock the structure in place.

FLEXIBLE AND ACTIVE SYSTEMS

What if materials were flexible or actively controlled? Engineers could, in theory:

- Use smart materials that adjust stiffness dynamically.
- Employ sensors and actuators to constantly stabilize structures.

These systems can reduce reliance on triangles because the rigidity is maintained actively rather than passively. However, they introduce complexity, energy requirements, and new points of potential failure. The underlying principle remains: the mathematics of stability still favors triangular relationships.

THE MATHEMATICAL PERSPECTIVE

Why do triangles keep returning, even in unconventional designs? The answer lies in the constraint network of the structure:

- A structure is stable if all degrees of freedom that could deform it are eliminated.
- Triangles are the simplest configuration that removes internal degrees of freedom in a 2D plane.
- Attempts to remove triangles either reintroduce them in hidden force paths or require continuous energy input or complex control systems.

In essence, triangles are not just convenient – they are a natural consequence of the rules that govern rigidity. Even the most innovative engineer cannot escape the underlying mathematics.

CONCLUSION: THE GEOMETRY WE CANNOT ESCAPE

So, are triangles really necessary?

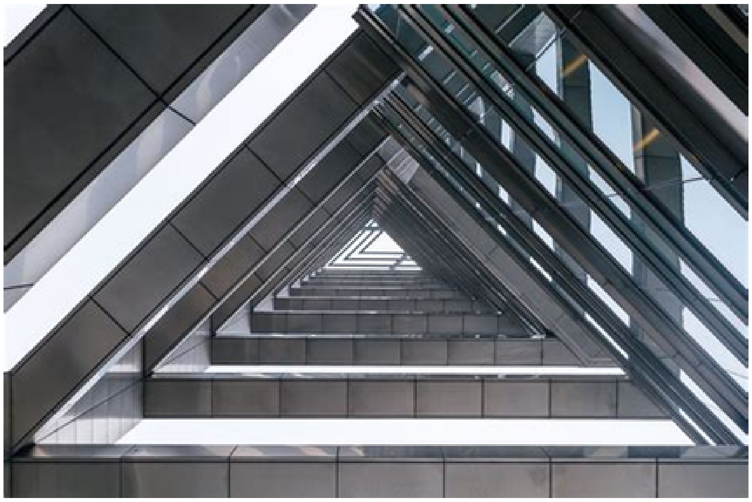
At first, the answer seems straightforward. We saw how a simple square can collapse while a triangle holds its shape; how trusses rely on triangular patterns to distribute forces; how engineers repeatedly return to this form when stability matters. It would be easy to conclude that triangles are simply the best choice.
But the deeper answer is more subtle – and far more interesting.

Triangles are not just a preferred design. They are the simplest resolution of a deeper constraint: the need to eliminate internal motion. Any structure that must remain stable under load must restrict its degrees of freedom. In two dimensions, triangles are the most efficient way to achieve this. They don't just solve the problem – they define what a solution looks like.

Even when engineers move beyond visible triangular frameworks – towards curves, cables, or adaptive materials – the same logic persists. Forces still resolve along constrained paths. Instability still emerges when too many degrees of freedom remain. And again and again, whether explicitly or implicitly, the structure reorganises itself around relationships that are, at their core, triangular.
In this sense, triangles are not truly optional. You can hide them, stretch them, or distribute them across a continuous surface – but you cannot escape the mathematical rules that give rise to them.
The next time you cross a bridge, you might not see triangles at all. You might see sweeping curves or elegant cables disappearing into the distance. But beneath that design lies a quieter truth: a hidden geometry, silently ensuring that the structure holds.

Not because engineers chose triangles.

But because, in the end, the mathematics left them no other choice.



THE INTRICATE CHEMISTRY OF... BREAD?

BY MARIA MATIAS

Probably one of the most widely consumed foods in the world, bread is almost synonymous with humanity itself, having originated multiple times throughout civilisation's history. Its production process is notoriously basic: just flour, water, salt and yeast! You might even have done it several times by yourself! But the chemical and biological processes behind this everyday staple are infinitely complex and help us understand the intricacy of the world around us.

INTRODUCTION

Bread-baking has been a core human activity for thousands of years. In fact, we've had evidence of bread making for over 14,000 years in present-day Jordan. At a glance, that can be explained by the sheer simplicity of the process: most of us have tried or at least are a little knowledgeable about baking, and the existing idea is that it is an almost automatic process, as most of the technique is based on waiting for the dough to 'grow' before baking. It occurs almost like magic: you just have to mix the dough, and a few hours later, you can have a complex-flavoured, open-crumbed and structurally sound substance from only ground-up grains and water.

Image of the Shubayqa 1, an archaeological site where the oldest evidence of bread-baking has been found

However, this is only possible thanks to a wide variety of physicochemical, microbiological and biochemical changes, which are enabled through mechanical-thermal action, as well as activity from endogenous enzymes, bacteria and yeast. The chemistry of bread is fascinating, so let's explore more in depth what all of this means.

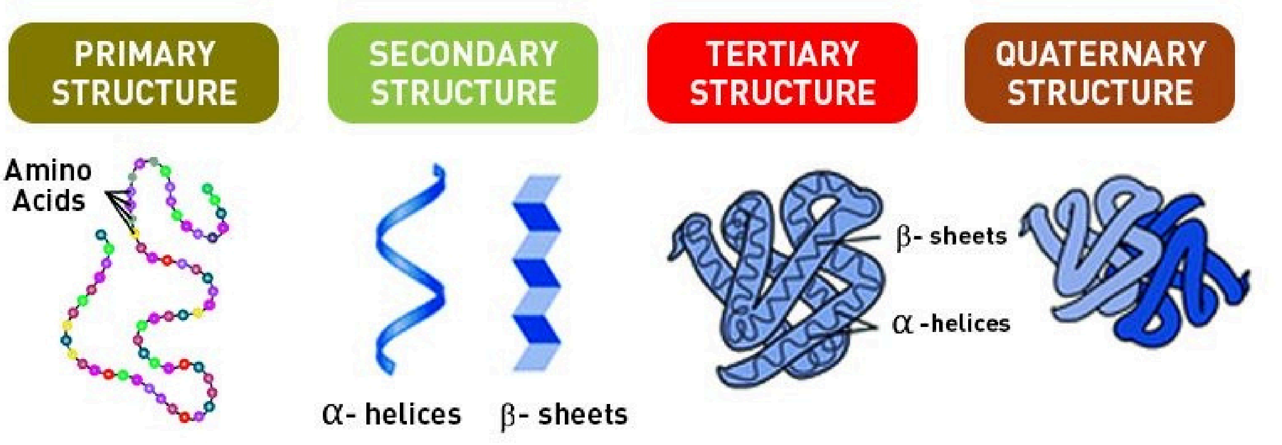
BIOCHEMISTRY AT A GLANCE

Before we take a deep dive into the biochemical processes that occur daily in your local bakery, we need to understand a few key concepts of molecular biology.

Biomolecules are organic compounds, which means they are synthesised by organisms, made up of at least one carbon atom linked to at least one hydrogen atom through a covalent bond. Macromolecules, biomolecules composed of a large number of atoms, often in the order of the millions, can be classified into four main groups, but we will focus on the two most important for breadbaking: carbohydrates and proteins.

Carbohydrates are composed of carbon, hydrogen and oxygen (C, H, O). Most carbohydrates are very complex and are composed of linkages between smaller molecules: monosaccharides. Saccharose (the carbohydrate present in refined sugar), for example, results from the link between glucose and fructose, two monosaccharides.

Now, onto proteins! Proteins are extremely complex biomolecules, whose main elements are carbon, hydrogen, oxygen and nitrogen. They are composed of amino acids, small molecules capable of adhering to only two other amino acids, which results in a linear sequence, which, when it achieves a large size, forms proteins. What makes proteins so interesting is that these linear sequences of amino acids can fold over themselves (and each other!) in growingly complex order.



This creates a very specific three-dimensional structure, which grants the protein specific characteristics and functions.

Another important thing you must know is that, sometimes, molecules or atoms are linked by weaker bonds, known as hydrogen bonds. These bonds aren't made of shared electrons, like covalent bonds, but rather due to electromagnetic forces between polar molecules. It's these bonds that allow the formation of tertiary protein structures, for example.

Lipids are another type of biomolecule, which aren't as important to bread as the above. They are a very heterogeneous group formed by C, H and O, but they can contain several other elements! They include compounds such as waxes, steroids, but most notably fats and oils. Fats and oils are actually composed of triglycerides: complex compounds composed of three long linear chains of a fatty acid and a glycerol molecule. Because triglycerides are composed of such long chains, they are mostly apolar; they can't create hydrogen bonds with water and therefore are insoluble.

BREAKING DOWN THE PROCESS

Albeit there are several different types of bread, spanding all continents, cultures and exhibiting a wide variety of ingredients, most breads can be broken down into four simple ingredients and four different phases of production: a grounded grain (flour), water, a leavening agent, most commonly yeast, but some quick breads also use chemical leaveners such as baking powder or baking soda, and some kind of flavouring, most commonly salt (although, as we will see later on, salt has an enormous importance in the chemical processes of bread-making, besides only flavour).

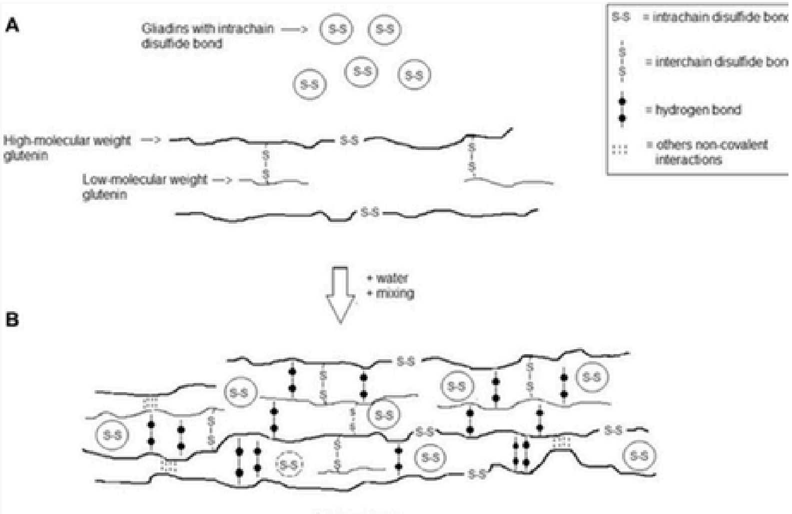
Bread-baking is usually broken down into four steps: the mixing of the above substances, which creates a dough, the kneading of said dough, leaving the kneaded dough to rest and finally, baking. So let's look at the molecular level in each of these steps:

1. MIXING

Wheat flour (which we will focus on from here on out) is made of 70-75% starch, a polysaccharide which is formed by several ramified glucose molecules linked to each other and 10 to 15% of proteins, most specifically, glutenins and gliadins. Proteins are one of the most important components when it comes to bread baking: these two proteins are inert in wheat flour in its natural form. Only when it is hydrated, by adding water, do these two proteins form a network, by hydrogen bonds, known as the gluten network. During this stage, we also mix in biological yeast Saccharomyces cerevisiae and salt, whose importance we will analyse further along the line.

2. KNEADING

When we knead the bread, we are basically mechanically forcing the glutenin and gliadin to arrange themselves in consecutive layers, allowing for the strengthening of the gluten network. This is where the chemical importance of salt comes in: salt isn't only there for pure flavour (although it's a good perk!): the sodium and chloride ions in salt (NaCl) are extremely polar, and, just as it happens with hydrogen bonds, they facilitate the approximation of the protein layers, therefore enhancing the protein structure, further developing elasticity and helping it to be less sticky.



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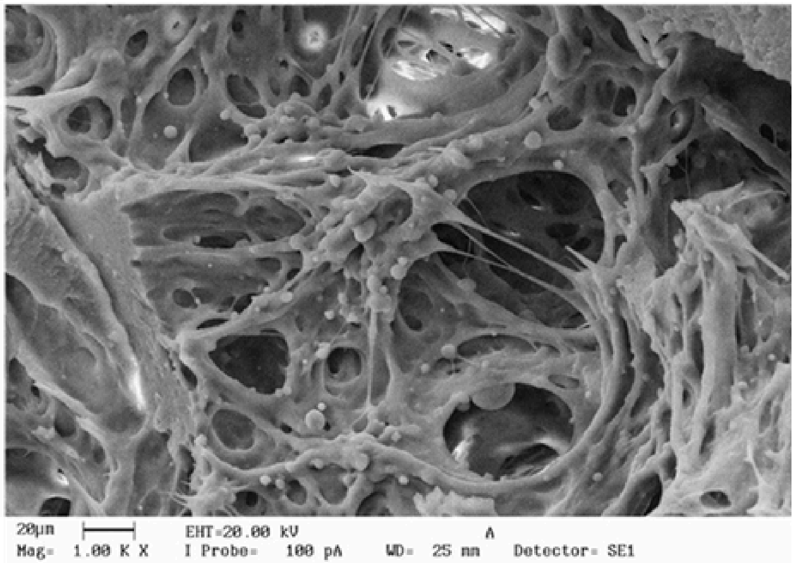


Gluten network through the eletronic microscope

But why do we even need a gluten network in the first place? Well, the gluten network forms strands of proteins, which are very elastic. This allows for the entrapment of air in the next stages. If the gluten network isn't properly developed, air will just escape during the rest and bake, resulting in a lack of volume. If it's overworked, then we lose elasticity, and gas bubbles can't work past the gluten strands, resulting in a very dense loaf. The gluten network also allows for the involvement of starch molecules

3. **RESTING**

Now comes the cool stuff: yeast! Remember all the starch that flour was made of? Well, starch is a polysaccharide, also known as a carbohydrate. It is, however, a very complex carbohydrate, which means the S. cerevisiae, a unicellular fungus, is unable to absorb it. Therefore, they add secress two types of enzymes (proteins that accelerate chemical reactions) to our dough in order to externally digest these sugars and break them down to simpler ones. The first one is amylase that decomposes starch into maltose, and then maltase, which breaks down this maltose to glucose. The fungi then feed off of this glucose in order to attain energy, releasing carbon dioxide and ethanol (an alcohol) in the process through the following chemical equation:

$$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_6O$$

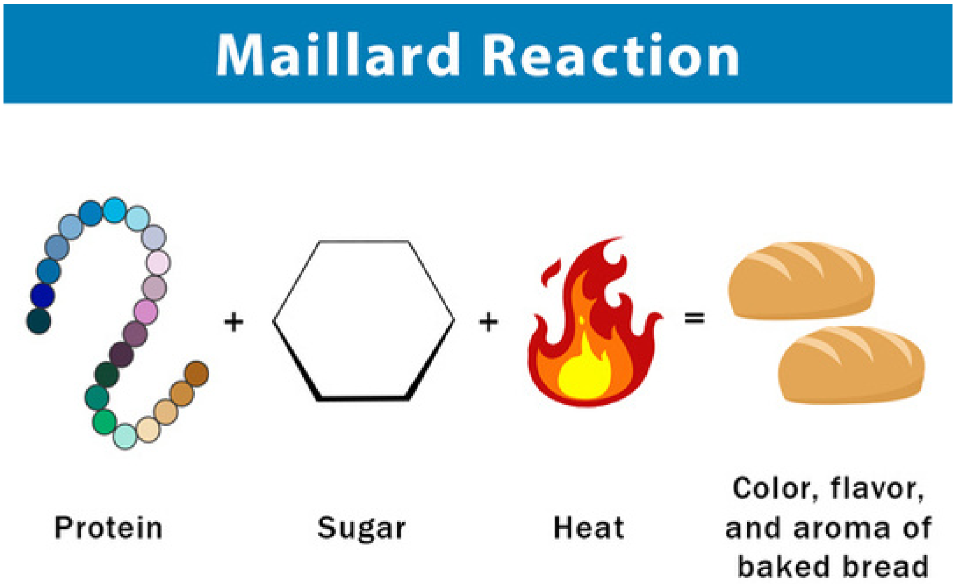
This grants the fermentation its distinctive alcohol smell, and the production of CO2 produces gas bubbles, which are then imprisoned in the gluten strands, granting volume to the dough. Despite this, bread does not contain alcohol, as it evaporates during the baking process. In sourdough baking, other types of bacteria (lactic acid bacteria) do a similar process, albeit more slowly, and they also produce organic acids, lowering the pH of the dough and creating the sourdough's distinctive smell and taste! The fermentation also produces several other compounds, such as esters, aldehydes and organic acids, which help with the development of fermented flavour and aroma in the final product.

4. BAKING

During the baking process, there are a lot of different processes resulting in several different changes to the dough, both physical and chemical:
Physically, as temperatures increase, the fungi start to produce more and more CO2 until around 55° C or around 130°F, achieving maximum production before they eventually die. Reaching 80°C, ethanol evaporates (preventing you from getting tipsy as a result of your morning bagel) and entrapped CO2 is also released, which results in a quick expansion of the bread within the initial phases of baking. This is called ovenspring. Afterwards, the bread can no longer expand and keeps its shape. Crust is formed because the moisture in the surface of the bread quickly evaporates, forming a superficial skin that provides strength to the dough.

Chemically, there are hundreds of different reactions during baking! For starters, starch molecules are capable of performing an endothermic reaction (which means they require the use of energy and therefore, absorb heat) called gelatinisation. Gelatinisation is a process typical of starches, as when they are cold and dry, their granules organise themselves in tightly packed, crystalline structures. However, when they hydrate, the granules' organisation is partially destroyed by water, as they start to absorb it, increasing their volume. Heating exponentially accelerates this process: temperatures between 60°C and 88°C (140°F and 190°F) correspond to maximum swelling. When it swells, starch releases two compounds: amylose and amylopectin, which are simpler carbohydrates that are responsible for viscosity and help with the cohesion of the crumb, all while enprisioning water and enabling moisture retention on the inside of our bread!

Gluten also changes during baking: as the inside of the bread achieves 74°C (165° F), the proteins in the bread denature. This is a process which can happen to any protein (through different conditions), in which, due to some factor, usually heat or acidity, the bonds responsible for keeping the three-dimensional structure of the protein are disrupted, causing the protein to lose some of its characteristics. In the case of gluten, denaturation causes solidification of the protein network, forming a semi-rigid film structure.
One of the most complex chemical reactions during baking happens on the crust and is known as a Maillard reaction. This reaction is not completely understood yet, but we do have a broad idea of what it is: at around 140 to 165 °C (284 to 329 °F), aminoacids present in proteins react with specific carbohydrates, forming a new compound named glycosylamine and water. However, this compound is extremely unstable, so it quickly reorganises itself into several different compounds, like melanoidins, which are brown pigments responsible for the bread's characteristic colour. Along with melanoidins, several compounds responsible for flavour and aroma, are also formed as a result of this reaction.



5. STALENESS

As we have all experienced (perhaps too many times) throughout our lives, if we don't consume the bread within a few days or even a few hours, it will eventually get stale. This doesn't happen due to a lack of moisture, but rather the contrary. The crystalline structure of the carbohydrates is destroyed during baking, as we saw above, but subsequently, crystallisation recommences, and the sugars regain their crystal forms, which require a lot of water. Therefore, reducing the amount of free water available in the bread. This causes the bread to lose 'springiness', and it appears to dry out; however, the amount of water remains the same! By reheating bread in a low-temperature oven (around 70°C or 150°F), we can rebreak the crystal formations and prolong the shelf-life of a loaf of bread a little longer!

Another method often used to prevent bread from going stale is the use of fats, such as butter, olive oil or animal fat in the production of bread. Because fats are mostly apolar and, as such, hydrophobic (they repel water), the addition of fats helps to slow the migration of water during the recrystallisation process, keeping the crumb moist.

CONCLUSION

There's so much more to explore about the intricate science behind bread baking than anyone could ever be able to explore in a short article. Everything you do, from the choice of using 11% or 12% protein flour to the way you shape your loaves, and the temperature of your oven, has a scientifically studied and extremely complex influence over the final result of your modest loaf of bread. Food science is extremely intricate and a fascinating, ever-growing field of study: by understanding what we consume and how, we can not only live in a more well-informed world but also empower us to change and adapt our food systems to be more sustainable, efficient and healthy.
So next time you pass through the bread aisle, I hope you look at the humble loaf a little differently.

WHITE HOLES, BLACK HOLES IN REVERSE

BY Erin Gallego

INTRODUCTION: THE INEVITABLE FALL

The forming of a black hole can be described as a *fall*: a star ceases nuclear fusion then *falls* in on itself, pulled inwards by its weight. Even objects entering a black hole *fall.* But what happens when something *falls?* Consider a tennis ball: it falls until it hits the floor, then bounces back up. If you watch the ball's movement, it travels as if a film of its fall were being played in reverse the moment it hits the ground.

WHAT IS A WHITE HOLE?

But now imagine a tennis ball that only falls and never bounces. Upon hitting the ground, it would keep going through the floor, through the Earth, falling forever. This describes the basic principle of a black hole: a cosmic trapdoor with no exit and no bounce. However, imagine the opposite: a tennis ball that could only bounce, and subsequently does not fall. Even throwing it at the floor with all your strength, it would refuse to touch the floor, always pushing back up before contact.

That's a white hole, a region of space that refuses to let anything in, only allowing things to leave. Although the tennis ball analogy does break down quickly due to physics being much more complex at larger scales, it nonetheless highlights the argument that if nature allows irreversible falling regarding black holes, why would it not allow never ending bouncing for white holes? Whilst you can enter a black hole and never leave it, in contrast you can exit a white hole but not enter it.

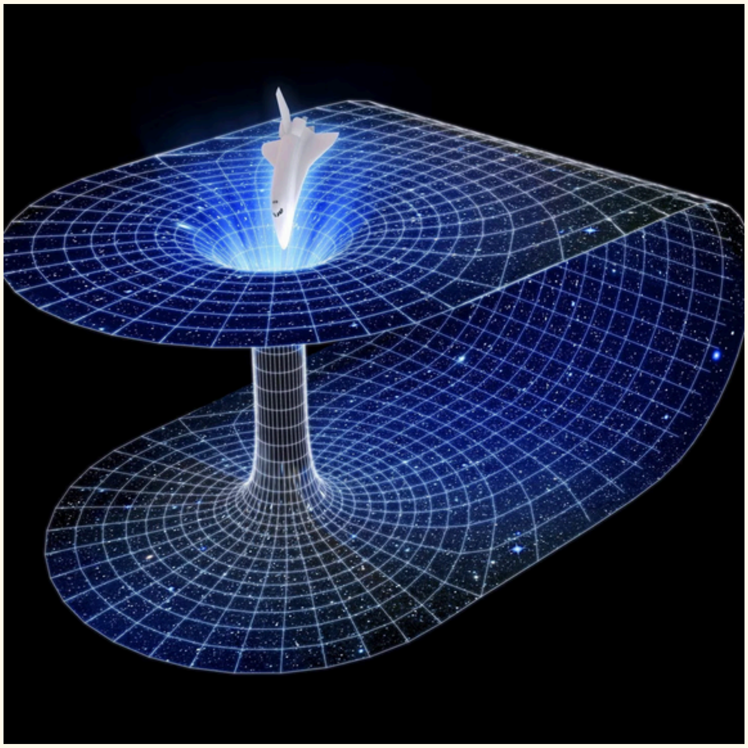
THE ‘TUNNEL EFFECT’

Interestingly, Einstein's equations of general relativity do not specify which way time must run; they don't distinguish between the past and the future. To bridge the gap between a black hole and a white hole, space and time must pass through the quantum zone, however many physicists like Carlo Rovelli argue that this process violates Einstein's equations, even if just for a very small quantity of time.

However, there is a possibility for this bridge to be crossed with the ‘tunnel effect’. Quantum physics can say that a particle does not always have a position and so sometimes it can be ‘nowhere’ (intangible like a wave) before materialising in a different place, it can leap.

The ‘tunnel effect’ states that matter can cross barriers due to quantum physics. If you threw your tennis ball at a wall one would expect, as would classical physics, that it cannot pass through the wall. But the tennis ball has a tiny probability of passing through to the other side, the ‘tunnel effect’.

This quantum property of space and time allows the centre of a black hole to ‘leap’ beyond the singularity. Quantum leaps are recognised already in physics, like how Niels Bohr realized atoms emit light when electrons move energy levels. But regarding white holes the quantum leap is far more radical than a single particle moving as spacetime itself moves. This leap is not an occurrence that takes place in space and time- it is an instantaneous quantum transition of space from one configuration to another.



But now the equations of ordinary quantum mechanics do not apply as it only gives probabilities for physical systems in space. However, the equations of loop quantum gravity do give the probabilities of one configuration of space leaping to another.

A PARADOX WITH WHITE HOLES

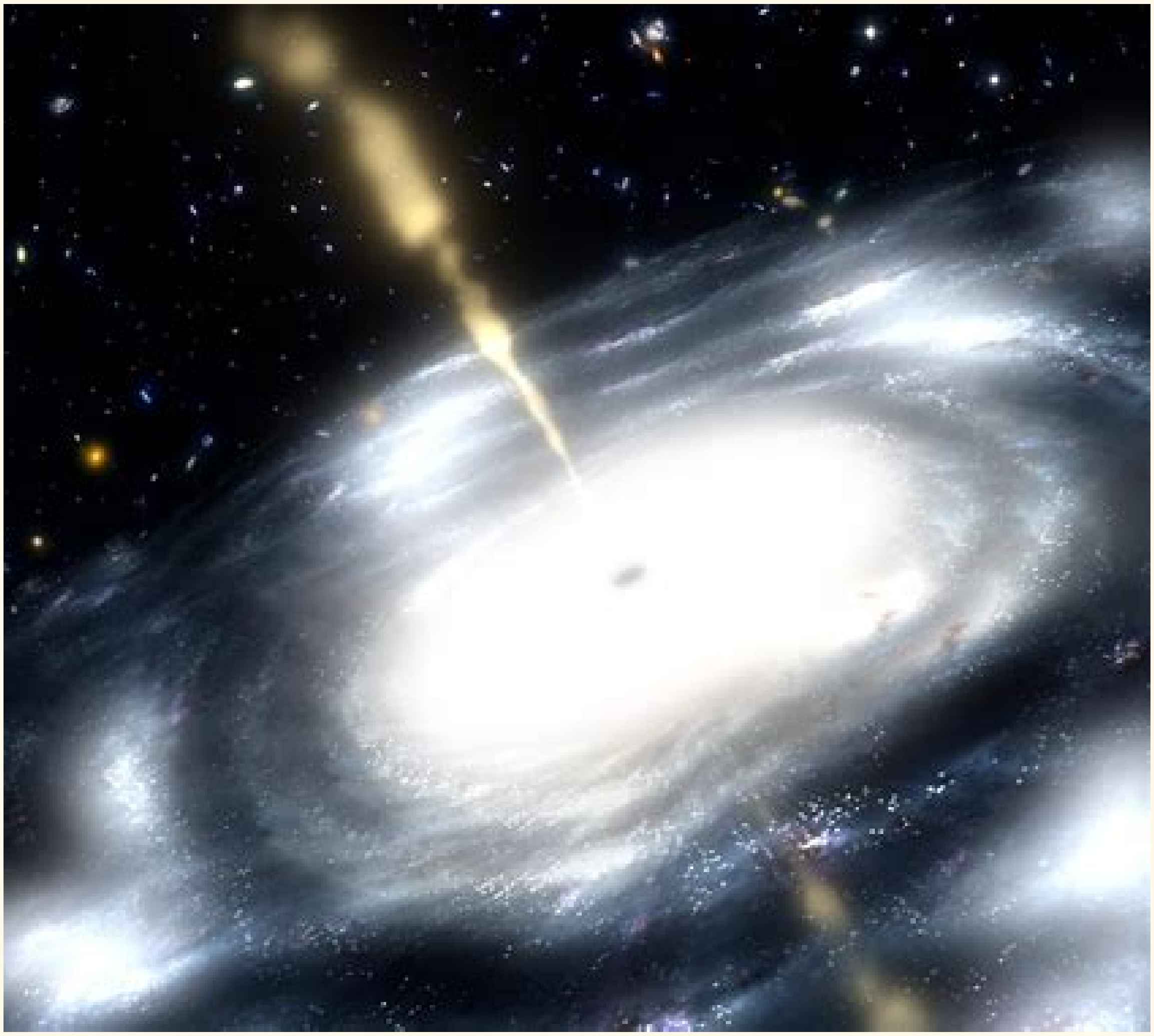
The exterior of a white hole cannot be distinguished from a black hole. This becomes paradoxical. You could still fall towards a white hole, but it is key to note that by reversing time gravitational attraction does not become repulsion. A white hole is a black hole with time reversed, but can you reverse time? There are some elements of our life that are irreversible, like when heat is produced a hand warmer heats up cold hands, but cold hands cannot emit heat to warm up a hand warmer. But it is a complex argument on if time itself can be reversed.

THEORIES FOR THE BEGINNING OF OUR UNIVERSE

Some cosmologists believe that the Big Bang may have been related to a white hole. A singular point in spacetime that explosively expelled all the matter and energy in the universe, from which nothing can return because time itself began there. With this framework, what we see as the Big Bang could be the "white hole end" of a black hole that collapsed in a previous universe. Our entire cosmos could be the inside of a white hole, continuously expanding from that initial explosion event 13.8 billion years ago. This is a fascinating idea, as it challenges beliefs on how the universe began. Yet this idea is mostly in the realm of speculation rather than established science, as today there is no way to test this hypothesis.

CONCLUSION

Therefore, the lesson of white holes is that we may never see them. Nonetheless in theory they open up a world of new science and provide physicists with complex philosophical questions that expand physical systems in space but space itself. In a cosmos that's already given us black holes, neutron stars, and dark energy, it seems plausible to wonder if somewhere out there, there's a hole in space that pushes everything away instead of pulling it in.



CLIMATIC TIPPING POINTS

Exploring the abrupt changes in our climate

1.5° C ABOVE PRE-INDUSTRIAL LEVELS

2° C ABOVE PRE-INDUSTRIAL LEVELS

SLOGANS, SIGNALLING, AND THE LIMITS OF “JUST TAX LAND”

BY HENRY RUSSELL

The slogan "Just Tax Land" functions as a powerful rhetorical signal of movement identity, yet it often obscures the complex economic trade-offs and institutional barriers that determine whether such a policy can actually solve modern structural crises.

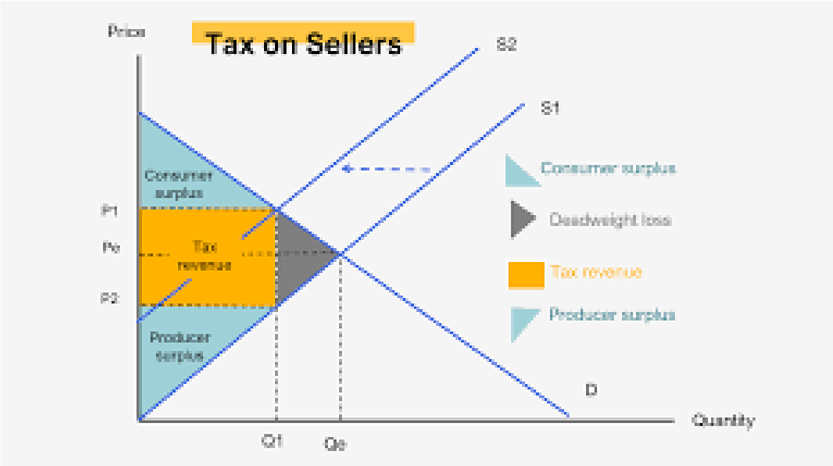
INTRODUCTION

Political and intellectual movements often crystallize their core claims into short, memorable slogans. These formulations are rhetorically effective: they are easy to repeat, easy to recognize, and easy to affiliate with. However, their primary function is rarely persuasion or policy design. Instead, they operate as markers of identity, signaling alignment rather than presenting arguments in themselves.

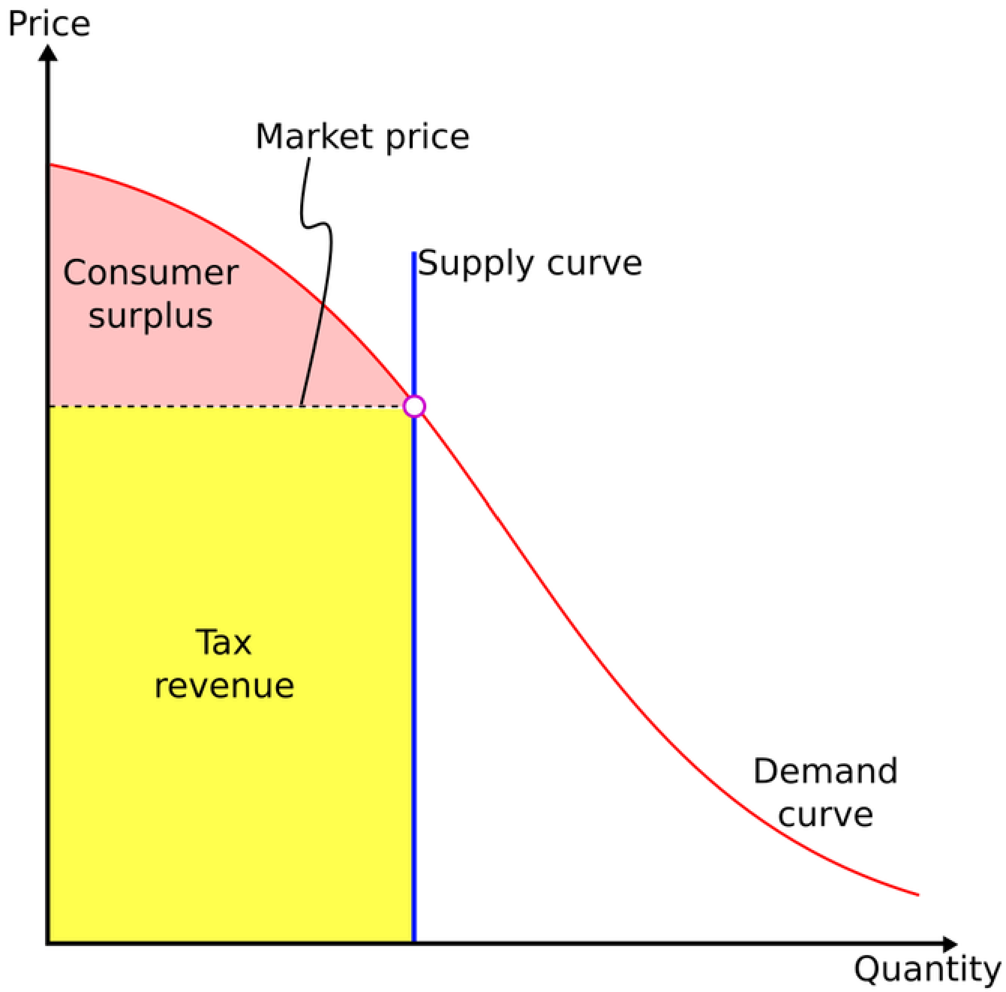
Such slogans tend to be broadly agreeable at a surface level, what might be called “applause lights,” statements that gesture toward a moral or political position without specifying mechanisms, trade-offs, or empirical constraints. Examples from across the political spectrum include “Defund the Police,” “Taxation is Theft,” “All Lives Matter,” or the generalized moral affirmations found on “We Believe” yard signs. Each compresses a more complex set of claims into a phrase that is evocative but analytically underdeveloped.

WHAT IS THE GEORGIST MOVEMENT?

The contemporary Georgist movement is no exception. Originating with Henry George in his 1879 book Progress and Poverty, Georgism emerged from the observation that poverty persists despite technological advances such as industrialization. George argued that land, being fixed in supply [1], rises in cost until it offsets the gains from technological progress. He proposed taxing the value of land at its rent value, excluding buildings and improvements, since land is not produced by its owner. Because land supply is fixed, land value taxes (LVTs) do not discourage production or use.



Taxes such as sales taxes create deadweight loss when higher prices reduce consumption, generating inefficiency.



LVTs do not produce deadweight loss because the quantity of land remains constant regardless of taxation.

THE IMPLICATIONS OF GEORGISM IN THE PRESENT

The Georgist slogan “Just Tax Land” gestures toward LVT but obscures significant variation within the movement regarding implementation, tax rates, transition strategies, and integration into broader fiscal systems. Proposals range from modest incremental reforms layered onto existing tax structures to ambitious “single tax” models replacing most or all other forms of taxation.

Despite this diversity, a common narrative persists: LVT, especially when paired with other Georgist policies, would be straightforward to implement and capable of resolving major social and economic problems, notably the housing crisis. This argument relies on the assumption that taxing land while exempting improvements strongly incentivizes denser development. However, the magnitude of this effect is uncertain. Even moderately high LVT rates may alter costs only by a fraction of total rent, which may be insufficient to overcome constraints such as zoning regulations, financing barriers, and construction costs. Direct interventions, including zoning reform, targeted subsidies for dense construction, or public housing development, could achieve comparable or greater results with less political friction.

This raises a broader question: what are the strongest contemporary justifications for Georgist policy? For many supporters, the primary appeal is encouraging efficient land use and urban density. Yet if these effects are limited in practice, additional benefits, such as reducing allocative inefficiencies or capturing unearned land rents, may be more modest than often claimed.

Some core Georgist concerns are less salient in modern economies than in the late nineteenth century. Today, wealth is concentrated more in non-rivalrous capital, technology, and intellectual property than in land. While land ownership remains important, it is unclear that a distinct class of passive "rent-seekers" dominates economic life as classical Georgist narratives suggest. Most landlords derive returns comparable to other investments and often engage in active management, maintenance, and risk.

THE LIMITATIONS OF "JUST TAX LAND"

Concerns about tax distortion, central to arguments for replacing income and corporate taxes with LVT, may also be overstated. While such taxes create some inefficiencies, the empirical magnitude is limited. Labor supply responses are generally modest, and firms do not systematically reduce productive activity to avoid taxes. Consequently, the marginal gains from shifting entirely to land-based taxation may be smaller than theoretical models predict.

This does not imply that LVT is a poor policy. Economists widely regard it as relatively efficient and conceptually elegant. A modest land value tax could improve aspects of the tax system and reduce some distortions. A citizen's dividend funded in part by land rents could also be a useful redistributive tool under certain conditions.

The challenge lies in scale and expectation. Contemporary discourse often overstates both the feasibility of implementation and the magnitude of its effects. Georgism oscillates between two identities: a pragmatic tax reform proposal and a quasi-systemic critique of political economy promising broad transformation. These modes are not easily reconciled.

The movement's rhetorical framing can also discourage critical engagement. Claims that Georgism is universally supported by economists or that opposition is driven primarily by entrenched elite interests are difficult to sustain empirically. In practice, the policy has limited political traction, and skepticism arises from a range of substantive concerns, including feasibility, distributional effects, and interactions with existing institutions.

A more measured approach treats Georgism as one valuable idea among many, a tool rather than a comprehensive solution. Land value taxation could complement broader policies, particularly zoning reform and expanded housing supply. However, it is unlikely to function as a singular lever capable of resolving structural issues such as housing affordability or inequality.

In this sense, the slogan "Just Tax Land" illustrates the limitations of political catchphrases. It gestures toward a real and potentially valuable policy insight but abstracts from the details that determine whether that insight translates into meaningful change. Its strength lies in clarity, and its weakness lies in what it leaves out.

[1]. Creation of new land, like Dubai's Palm Islands, is negligible in scale.

CROSS RESISTANCE: A CATALYST OF AMR

The agricultural use of antibiotics is often linked to another mechanism of this problem: cross-resistance.

Cross-resistance occurs when a microbial develops a resistance mechanism to a specific action mode, which is shared by different groups of chemically different antimicrobial medicine. Therefore, a pathogen could acquire multi-drug resistance to a variety of different antimicrobials without having been in direct contact with many of these substances. For example, studies have shown that fluoroquinolone-resistant E. coli containing mutations in a topoisomerase gene (gyrA) have changed susceptibility of the bacteria to other antibiotics. These changes include increases in resistance to ampicillin, cefoxitin, ciprofloxacin, nalidixic acid, kanamycin, and tobramycin and increases in sensitivity to nitrofurantoin and doxycycline.

The excessive use of antimicrobials have significantly increased the incidence of cross-resistance.

AN ECONOMIC CHALLENGE

This problem has also been shown to take a big toll on the economic level. AMR results in extended hospital stays, more difficult and expensive treatment and loss of workforce for longer periods of time, which places a bigger financial burden on the family and community, as well as in the healthcare system. AMR also causes loss of productivity in livestock production and agricultural efficiency. A study conducted by EcoAMR found that, if no action is taken in 2050, the healthcare costs of AMR could rise to US$159 billion, and the impact on livestock production could reach US$40 billion globally.

HOW ARE WE COPING?

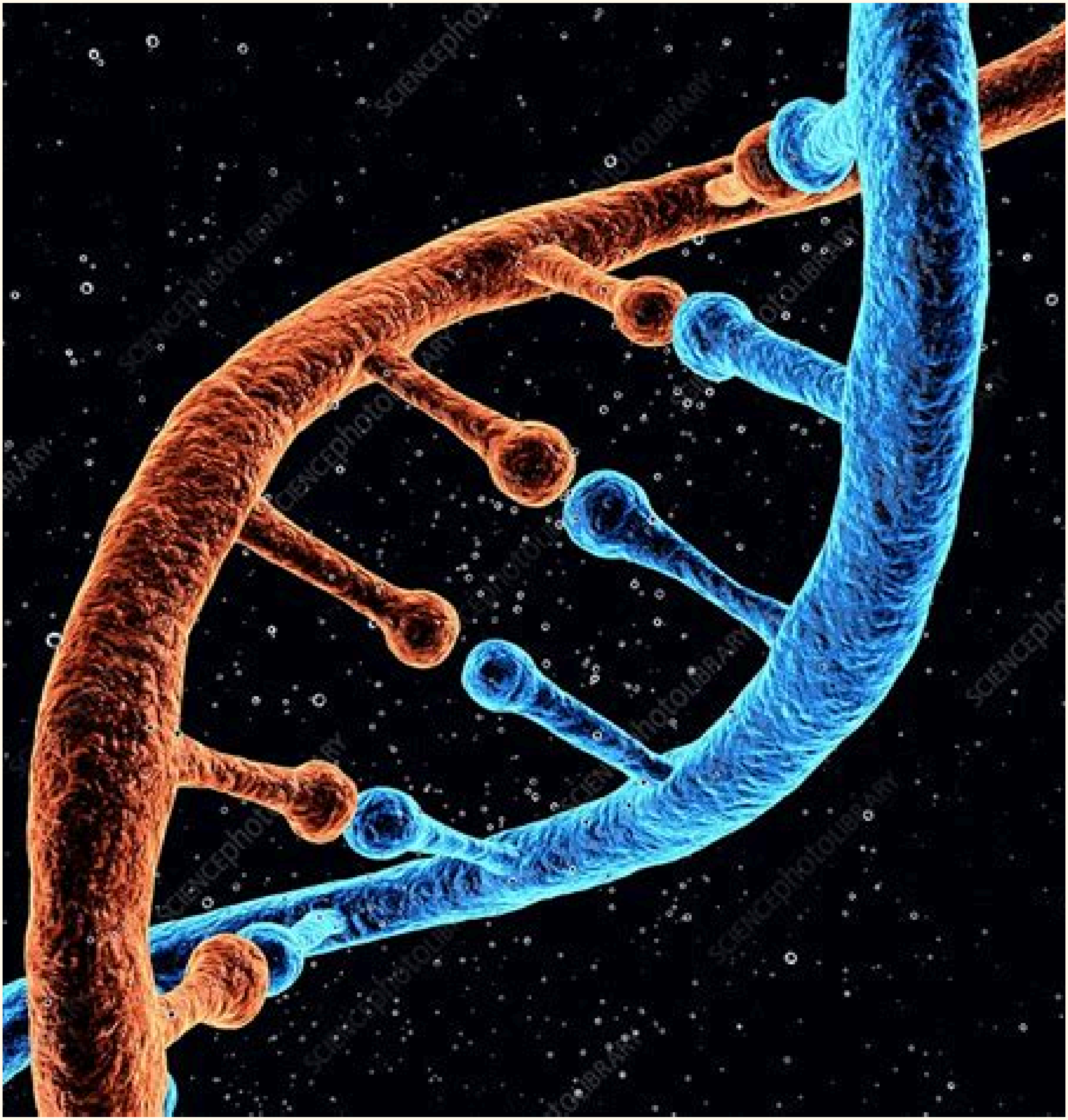
Antimicrobial resistance has been acknowledged by key organisations such as WHO (World Health Organisation) and CDC (Center for Disease Control) as an emerging risk for global human health. Many actions are currently being taken, such as the adoption Global Action Plan on AMR (GAP) during the 2015 World Health Assembly, which commits to the development and implementation of multisectoral national action plans with an integrated, unifying approach that aims to achieve optimal and sustainable health outcomes for people, animals and ecosystems. As of November 2023, 178 countries had a national plan aligned with GAP to address AMR.

A large, continuous effort to develop new antimicrobials has also been made through the setting of priority on research by various governments and health bodies like WHO, which has published the ‘WHO bacterial priority pathogens list’ in 2017 to guide research and development into new antimicrobials, diagnostics and vaccines. However, the increasing difficulty of finding effective medicine and the lack of interest in funding this kind of treatment by pharmaceutical companies have led to a decrease in research for new antimicrobials.

Georgist campaign button from the 1890s. The cat on the badge refers to the slogan "Do you see the cat?" from a story by Congressman James G. Maguire. He compared understanding the Single Tax to being able to make out a cat in a picture of a landscape.

THE 1% THAT CODES FOR LIFE AND THE REST WE'RE STILL TRYING TO UNDERSTAND

BY TARANNOM RAZAEIPOUR



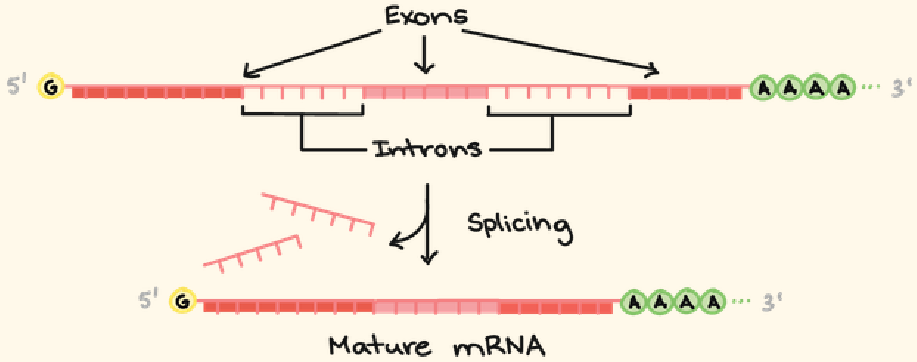
INTRODUCTION

IHere is a number that doesn't make sense the first time you hear it: 1%. That's roughly the fraction of your DNA that codes for proteins - the molecules that build tissues, catalyse reactions, carry signals, and keep you alive. Which raises an obvious question:

What on earth is the other 99% doing?

For decades, scientists had an answer, and it wasn't a flattering one; they called it junk. Not a technical term - just an honest shrug. These were sequences that didn't seem to serve any useful purpose: leftovers from millions of years of evolution, accumulated without purpose. It was a reasonable conclusion given what was known at the time. What followed was a gradual, and still unfinished, realisation that the picture was far more complicated.

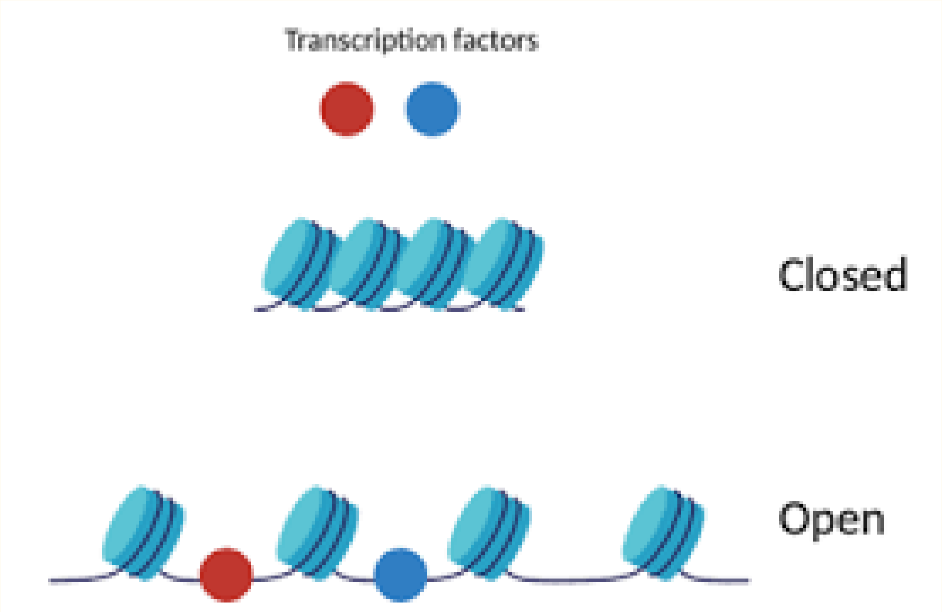
WHAT DOES "CODING" ACTUALLY MEAN?



An illustration of eukaryotic splicing, from pre-mRNA to mRNA. (Khan Academy)

When biologists say a sequence "codes" for something, they mean it precisely: it gets transcribed into RNA and translated into a protein. But even within genes, not everything codes. Genes are interrupted structures - they contain introns, non-coding stretches that are spliced out before translation, and exons, the segments that actually specify amino acids. The 1-2% figure refers only to exons. It isn't claiming the rest of the genome is inert. It's saying it doesn't directly build proteins.

That leaves a great deal of DNA unaccounted for.



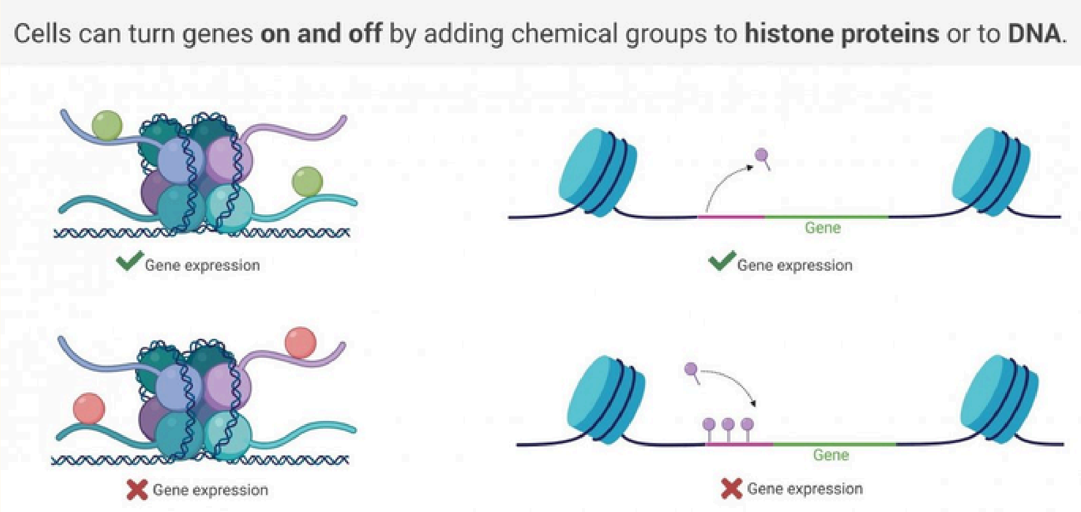
Simplified illustration of closed vs open DNA wrapped around histones, with transcription factors on the DNA strings for the open version. (BioRender)

Some of it turns out to be doing something the cell cannot function without: determining which genes are active, in which cells, and at what times.

Regulatory elements - promoters, enhancers, and silencers - occupy non-coding regions and serve as binding sites for transcription factors, proteins that switch genes on or off in response to specific molecular signals. Their effects are extraordinarily precise. The same DNA sequence can produce an entirely different pattern of gene expression depending on which regulatory proteins are present, which is how a neuron and a skin cell, carrying identical genomes, end up so structurally and functionally distinct. The difference isn't in what genes they have. It's in which ones are being used. The non-coding genome is, in large part, the management layer that makes that distinction possible.

Non-coding regions also give rise to RNA molecules that never get translated into protein at all. MicroRNAs (miRNAs), for instance, bind to messenger RNAs and suppress their translation, adding a post-transcriptional layer of regulation on top of an already dense control system.

THE LAYER YOU CAN’T SEE IN THE SEQUENCE



Gene expression switched ‘on’ vs ‘off.’ (This is Epigenetics)

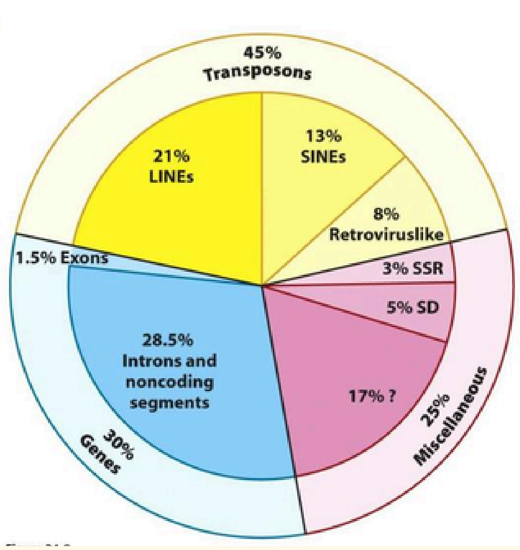
Gene expression is further shaped by chemical modifications that don't alter the DNA sequence itself - a phenomenon collectively termed epigenetics.

DNA methylation involves the addition of methyl groups to cytosine bases, typically at CpG dinucleotides, and is associated with transcriptional silencing. Histones - the proteins around which DNA is coiled - are subject to their own suite of modifications, including acetylation and methylation at specific residues, which influence how tightly DNA is packaged and therefore how accessible it is to the transcriptional machinery. Together, these marks constitute something like a second layer of information sitting on top of the sequence: not changing what the genome says, but governing how and whether it gets read.

Environmental inputs - diet, chronic stress, endocrine-disrupting compounds - can alter these patterns. Whether such alterations are functionally significant, reproducible, and heritable across generations remains contested. It's an area where popular science has a persistent tendency to overstate the evidence.

SO, IS THE REST OF THE GENOME FUNCTIONAL?

This is where things get genuinely contested.



Genomic composition by annotation category. Protein-coding exons constitute a small fraction of the total; the majority of the genome comprises intronic and intergenic sequence of uncertain or regulatory function. (ChIPseek)

In 2012, the ENCODE consortium published a landmark series of papers reporting that roughly 80% of the human genome shows signs of biochemical activity - transcription, protein binding, or chemical modification. The findings were widely interpreted as a refutation of the junk DNA hypothesis: if so much of the genome is doing something, the argument went, it can't be dismissed as nonfunctional.

The pushback was swift and substantive. Biochemical activity is not synonymous with biological function. Many of the detected interactions may be weak, stochastic, or simply incidental - byproducts of the densely packed, highly dynamic environment of the cell nucleus rather than evidence of adaptive significance. Crucially, much of the non-coding genome shows little sign of purifying selection: it accumulates mutations at a rate consistent with neutral drift, which is difficult to reconcile with the idea that it is doing something essential. A sequence that can change freely without fitness consequences is not obviously functional in any meaningful evolutionary sense.

The “junk DNA” label was always too blunt. But the ENCODE interpretation was overcorrected. Both framings imposed a cleaner story on the data than it supports.

RETHINKING THE 1%

The figure itself is stable. Approximately 1-2% of the human genome encodes proteins, and that remains accurate.

What has changed is the interpretive context around it. A portion of the remaining 99% regulates gene expression with real spatial and temporal precision. Some of it produces non-coding RNAs with documented biological roles. Some of it contributes to the three-dimensional organisation of chromatin within the nucleus - an architecture that itself influences which genes are accessible. And some of it, despite extensive investigation, has no clearly established function. That last category is not a gap to be embarrassed about. It is simply an honest description of where the science currently sits.

AN UNFINISHED PICTURE

IThe human genome is not a linear instruction manual. It is a layered system: part protein code, part regulatory logic, part evolutionary sediment accumulated across hundreds of millions of years - some of it still active, some of it silent, much of it not yet understood.

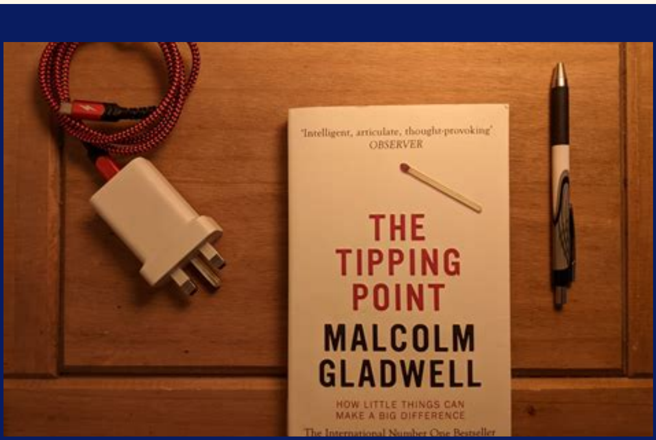
The coding 1% defines what can be built. But understanding when, where, and under what conditions those instructions are actually used requires looking into the 99% that was so confidently set aside. Some of it has turned out to be indispensable. Some of it resists interpretation entirely.

And the distance between what we've catalogued and what we genuinely understand remains, quietly, very large.

THE WATCHLIST

Media pieces you might be interested in if you enjoyed “Tipping Points”

THE TIPPING POINT – MALCOLM GLADWELL



The tipping point is that magic moment when an idea, trend, or social behavior crosses a threshold, tips, and spreads like wildfire. Just as a single sick person can start an epidemic of the flu, so too can a small but precisely targeted push cause a fashion trend, the popularity of a new product, or a drop in the crime rate.

CINEMATOGRAPHY – 2040

Focused on climate tipping points and the fragile balance we’re currently in. The movie touches on the climatic tipping points society is fast approaching through a compelling and interesting storytelling!

PODCAST – THE INUIRY (BBC)

The Inquiry gets beyond the headlines to explore the trends, forces and ideas shaping the world. It examines how our modern world is changing in social, ecological and biological systems. We recommend checking it out if you’re interested on the tipping points beyond the scientific context.

FURTHER READING AND BIBLIOGRAPHY

ARE TRIANGLES REALLY NECESSARY?

- Structures: Or Why Things Don't Fall Down by J.E. Gordon
- Geometry and the Imagination by David Hilbert and S. Cohn-Vossen
- https://letstalkscience.ca/educational-resources/backgrounders/why-a-triangle-a-strong-shape

THE INTRICATE CHEMISTRY OF... BREAD?

- "On the rise" by Bryan Reuben
- "Baking Bread: The Chemistry of Bread-Baking" by Andy Brunning
- "The Fundamentals of Bread Making: The Science of Bread" by Rahel Suchintita Das, Brijesh K. Tiwari, and Marco Garcia-Vaquero
- "Baking Bread: The Chemistry of Bread-Baking" by Andy Brunning
- "Maillard reaction" by Anne Helmenstine

WHITE HOLES, BLACK HOLES IN REVERSE

- White Holes – Carlo Rovelli
- The Order of Time – Carlo Rovelli
- Black Holes, White Holes, and Everything in Between – Raymond Jeffords
- White Holes: The Beginning and End of Space – John Gribbin

SLOGANS, SIGNALLING AND THE LIMITS OF "JUST TAX LAND"

- Progress and Poverty (George, H. 1879) Your Book Review: Progress And Poverty (https://www.astralcodexten.com/p/your-book-review-progress-and-poverty)

THE 1% THAT CODES FOR LIFE

- Lander, E. S. et al. (2001). Initial sequencing and analysis of the human genome. Nature, 409, 860-921.
- ENCODE Project Consortium (2012). An integrated encyclopedia of DNA elements in the human genome. Nature, 489, 57-74.
- Pennisi, E. (2012). ENCODE Project writes eulogy for junk DNA. Science, 337(6099), 1159-1161.
- Palazzo, A. F., & Gregory, T. R. (2014). The case for junk DNA. PLoS Genetics, 10(5), e1004351.
- Moore, L. D., Le, T., & Fan, G. (2013). DNA methylation and its basic function. Neuropsychopharmacology, 38(1), 23-38.
- Djebali, S. et al. (2012). Landscape of transcription in human cells. Nature, 489, 101-108.
- Gilbert, W. (1978). Why genes in pieces? Nature, 271, 501.
- Mattick, J. S., & Rinn, J. L. (2015). Discovery and annotation of long noncoding RNAs. Nature Structural & Molecular Biology, 22(1), 5-7.
- Bird, A. (2007). Perceptions of epigenetics. Nature, 447, 396-398.
- Chen, Tingwen & Li, Hsin-Pai & Lee, Chi-Ching & Gan, Ruei-chi & Huang, Po-Jung & Wu, Timothy & Lee, Cheng-Yang & Chang, Yi-Feng & Tang, Petrus. (2014). ChIPseek, a web-based analysis tool for ChIP data. BMC Genomics. 15. 539. 10.1186/1471-2164-15-539.

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