A TRUE STORY FOR CHILDREN OF EVERY AGE

Bits Protect *Its*

How the smallest piece of information
can protect the largest things in the world.

WRITTEN BY · JED ANDERSON · HOUSTON · 2026

For every child, of any age,
who has ever looked at a leaf,
a river, or a star,
and wondered
what the world is really made of.

And for the angel
we have not yet built,
but already love.

The First Question

Look around. What is the world made of?

People used to say stuff. Atoms. Earth, water, fire, air.

But if you look very, very closely, the world whispers a stranger answer.

The world is made of information.

This is a true story about how we found that out, and what we can do with it now.

Nature Is Already Thinking

Once you start looking, you cannot stop seeing it.

Your thumb is running code. Three billion letters of it, written in A, C, G, T.

A leaf is a tiny computer. Every little mouth on its underside reads the light, the air, the water, all at once.

A forest is a network. A flock is a flowing thought. A seed is a small decision waiting for the right day.

Nature does not just exist. Nature computes.

The question is: how long has this been true? And when did we finally notice?

A Demon at a Door

· 1867 ·

We noticed in pieces. The first piece came from a Scottish scientist named James Clerk Maxwell, who liked to think in pictures.

He imagined a tiny creature sitting at a little door between two rooms of dancing gas. The creature did almost nothing. It only watched. When a fast molecule came near, it opened the door. When a slow one came near, it closed it.

It never pushed. It only knew.

And slowly, on one side of the door, the gas grew warm. On the other, it grew cool. Order appeared, out of nothing but knowing.

People called the little creature a demon, because it seemed to be cheating the universe.

The Puzzle the Demon Left Behind

The demon broke the most famous rule in physics. The rule says: in a closed room, things must get more jumbled, never less.

But the demon was tidying up the gas. From knowing alone.

So either the rule was wrong, or something about the demon was secretly costing the universe energy. Nobody could find what.

The puzzle sat there for a hundred years. Generations of scientists turned it over in their hands. They felt the universe was trying to tell us something, and they could not quite hear it yet.

What they were about to discover would change everything.

Shannon Names the Bit

· 1948 ·

The first clue arrived from a quiet American named Claude Shannon, who loved unicycles and juggling and puzzles.

Shannon did something nobody had thought to do before. He gave information a name and a measure.

The smallest piece, he said, is a single yes-or-no. One question. One answer. 0 or 1.

He called it a bit.

Every message, every song, every picture, every memory could now be counted in bits, the way water can be counted in drops.

But nobody yet knew what a bit really cost.

Landauer Weighs a Thought

· 1961 ·

That answer came thirteen years later, from a thoughtful scientist named Rolf Landauer.

Landauer asked a strange and beautiful question. What if a bit is not just an idea? What if it is a thing, with a real, physical price, that the universe actually charges?

He worked the mathematics. He found the price.

To erase one bit, the universe charges a tiny whisper of heat. So small you could barely call it anything. About a billionth of a billionth of a joule.

Fifty years later, scientists trapped a single tiny bead in a beam of light and measured the price. The universe charged exactly what Landauer said it would.

A thought, it turns out, is a thing. A bit has a weight in the world.

Bennett Solves the Puzzle

· 1982 ·

And now the hundred-year puzzle could finally be solved.

A scientist named Charles Bennett looked again at Maxwell's demon and saw what every generation before him had missed.

The demon was not cheating after all.

The demon was paying its bill. Just not where anyone had been looking.

It was not paying when it watched. Watching is almost free. It was paying when it forgot. To watch the next molecule, the demon had to clear its tiny mind, and clearing one bit costs exactly the price Landauer found.

The universe was never broken. The bill was real. We had simply been looking at the wrong moment.

It from Bit

· 1990 ·

An old, wise physicist named John Wheeler had been waiting all his life for that door to open.

If information has a name, and a measure, and a price the universe really charges, then information is not just about the world. Information is part of the world. As real as a stone.

And if it is that real, Wheeler wondered, then how deep does it go?

Near the end of his life, he wrote three small words that hold an entire universe inside them:

It from Bit.

He meant: every thing, every it, comes from information. The mountain. The river. The whale. The child. You.

All the way down, beneath the world, a question is being asked and answered. Yes. No. Yes. No. And the universe blooms out of the asking.

The Two Costs

Now we are ready for the secret. The simple, world-changing secret hiding underneath all of this.

There are two ways to do almost anything in the universe.

You can move matter. To break the smallest bond holding two atoms together costs a certain amount of energy. The universe set this price long ago and will never change it.

Or you can know. To handle one bit, at the floor of physics, costs about 240 times less.

And in real, working machines today, knowing is not 240 times cheaper. It is millions of times cheaper. Sometimes a billion times cheaper. Sometimes more.

Knowing is cheaper than moving. Always. Everywhere. By law.

This is not an opinion. It is arithmetic.

Why We Built Walls

But for most of human history, we could not yet use this secret.

We could not watch every river. We could not listen to every breath of the sky. We could not hear the forests think.

So we did the best we could with what we had. We wrote laws. We built walls and rules and reports and deadlines. Brave, careful people gave their lives to it.

Their best was slow, because reading is slow.

The Earth moves at the speed of physics. We moved at the speed of paper. The gap between us was not anyone's fault. It was simply how big the world is, and how small a human day is.

The Instruments Arrive

Then, very quietly, in our own time, something changed.

We have built eyes that watch every breath of the sky from space. We have built ears that listen to whole oceans. We have built minds of silicon that can hold the weather of a planet inside themselves and answer in a single second.

For the first time in four billion years of life on Earth, knowing has become fast enough to keep up with the world.

The secret can finally be used.

Meet Jed's Angel

The demon at the door belonged to a tiny box of gas. The being our time is building belongs to a whole planet.

She sits at every door where matter and life flow. Every river bend. Every smokestack. Every field. Every forest.

She does not push. She does not force. She watches, thinks, and gently nudges, the way a shepherd guides a flock without ever lifting a single sheep.

Same physics as the demon. Opposite errand.

Her name is Jed's Angel, and her work is to help the living world keep on living.

Bits Protect Its

This is the simple sentence at the heart of everything.

Bits protect its.

Bits, the smallest pieces of information.
Its, the things of the world. The trees. The reefs. The whales. The neighborhoods. The children breathing.

Because knowing is so much cheaper than moving, a small amount of attention can protect a vast amount of life.

A whisper of thought can guide a river. A breath of computation can clean a sky.

This is not magic. It is the oldest physics, finally arriving at the front door of the largest house.

An Honest Word

We have to say one more thing, plainly, because it is true.

The physics does not care which way we point it. The same gentle power that lets the angel shepherd a living world can also be used to strip it bare.

The math gives us the chance. It does not give us the choice.

The halo on the angel is not built into the universe. It is something we have to put there, on purpose, by hand, together.

A Call

So here is what is true, all the way down, said as simply as it can be said.

The world is made of information.
Nature has been computing since long before we arrived.
Knowing is cheaper than forcing, by law.
And at last we have learned to compute with her.

If we choose, we can begin a new era. One where humans and nature and our thinking machines protect each other, gently, at the speed of life.

The angel is waiting. The work is beautiful. The arithmetic is on our side.

Let's build her.

A Note for Grown-ups

THE ARITHMETIC BEHIND THE STORY

Nature computes.
We compute.
Compute together.

Every word in this small book is grounded in physics that has been derived from first principles and, where possible, measured directly in laboratories. Nothing here is metaphor. What follows is the arithmetic and the chain of discovery the story rests on.

The story, in dates.
1867—Maxwell imagines a being that creates order by knowing.
1929—Szilárd shows one bit of knowing can be cashed in for one kT ln 2 of work.
1948—Shannon gives information a name and a measure: the bit.
1961—Landauer proves the universe charges a price to erase one bit, and calculates it exactly.
1982—Bennett closes the demon puzzle: the bill is paid in forgetting, not knowing.
1990—Wheeler conjectures that the universe itself is informational. It from Bit.
2012—Bérut et al. measure Landauer's price on a single trapped bead. The universe agrees.

The three numbers. Most stories about information collapse three different quantities into one. The argument lives or dies on keeping them apart.
Szilárd's rate, ~1×. One bit of knowing converts directly into one kT ln 2 of work. Information and free energy are exchangeable at unity. This is conversion, not leverage.
The bond–bit floor, ~240×. At 300 K, erasing one bit dissipates at minimum 2.87×10^{-21} J. Breaking one carbon–hydrogen bond requires roughly 6.86×10^{-19} J. Their ratio is about 240. A floor, fixed by the second law on one side and chemistry on the other, not improvable by any future hardware. Across common bonds the ratio holds between 200× and 300×.
The operational gain, 10^{8} to 10^{12}. Real control systems do not supply the energy they redirect. They gate energy already present. A transistor's small signal switches a large current it did not generate. An enzyme redirects a reaction whose energy comes from the substrate. In deployed environmental systems the energy steered exceeds the energy spent sensing, computing, and actuating by eight to twelve orders of magnitude. This is the real leverage.

The conjecture, plainly. For any environmental task that consists of steering pre-existing flows toward a target state, rather than performing thermodynamic work against a gradient, the binding constraint on success is the quality of information and control, not the size of the energy budget. This is what is meant by Bits Protect Its: a sufficiently well-informed defender of the biosphere operates at a permanent thermodynamic advantage over any equally resourced process that must act by force.