

Small and Everywhere

How nature makes a truth cheap to know and impossible to fake—and why that is the whole blueprint for protecting the living world.

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Look at the nearest solid thing. A chair, a cup, your own hand. You know it is there. You are certain of it. Ask yourself why.

There are two answers, and both of them matter.

The first: light has been pouring off that thing and into your eyes—not a little light, a flood of it, photon after photon, each one carrying the same shape, the same edges, the same news. Cover one eye. Still there. Turn off a lamp. Still there. The object is written into so many separate signals that no single failure can erase it. That is why you cannot doubt it. Certainty is what arrives when the same report comes from a thousand directions at once.

The second: you did not need much to know it. You did not count its atoms. You caught an outline, a few edges, a surface—and the whole object came along for the ride. You read the boundary and got the inside for free.

Hold those two answers side by side, because they look like opposite recipes.

I. The trap

Squeeze a message down to its smallest honest form and something strange happens. It turns fragile. Every part now matters, because you threw away every part that did not. A phone number is like this. Ten digits, none of them spare. Say it once across a noisy room and let a single digit slip, and the whole number is not close—it is wrong. Smallness and fragility arrive together. That is the price of making a thing small.

So how do you make a thing safe? The obvious way is to make it bigger. Say it again. Copy it. Spread it out until no single slip can kill it.

Small, or safe. It sounds like a choice you are forced to make. Compress a thing and it is fragile. Pad a thing and it is bulky. Pick one.

You do not have to pick. And the reason is the quiet hinge this whole essay turns on.

II. Two words wearing one coat

There are two different things people call redundancy, and they are not the same thing at all.

One kind lives *inside* the message—the predictable part, the already-implied, the part you could have guessed. That is the kind compression throws away. A page of the same letter repeated. A sky that is blue in every pixel. You can say it shorter and lose nothing, because nothing was there.

The other kind lives *across copies*—the same finished message, written down in more than one place. That is the kind that keeps a thing safe. Not a longer message. The same short message, said again.

Watch how you actually hand someone a phone number in a loud room. You do not add digits. You cannot—every digit is load-bearing. Instead you say the whole number twice. “Five-five-five, one-two-one-two. Got that? Five-five-five, one-two-one-two.” You compressed the message down to its bones, and then you repeated the bones. The safety wraps *around* the small thing. It does not swell the small thing.

So the two jobs never collide, because they act on different things.

“*Compression decides what to say. Redundancy decides how many times to say it.*”

One finds the smallest true description. The other prints that description in many places. Make it small so it is cheap to hold. Copy it so it is hard to lose. There was never a contradiction. There were just two words wearing one coat.

III. What nature was already doing

Now the part that should raise the hair on your arms, because nature has been running both moves since long before there was anyone to watch.

Take the first move. A fact is *knowable* when it is small—when you do not need the whole thing to grasp the thing. The health of a river lives on its surface: what flows in, what flows out, what the water carries as it passes. Measure the edges and the

inside follows, because the same laws that hold everywhere have already filled in the middle. You do not need every molecule. You need the boundary. The universe is generous this way. It lets the surface stand in for the volume. It lets a little honest data carry a whole world.

Take the second move. A fact is *real* when it is copied. This is not a figure of speech. It is the best account physics currently has of why the everyday world looks solid and single and agreed-upon at all. A pebble in sunlight scatters its shape into countless photons, and every photon is a tiny record that says *pebble, here, this shape*. Any one of them will do. So everyone who looks agrees, and no one can be argued out of it, because the fact is not kept in one fragile place—it is stamped, over and over, all across the light. What we call objective is simply what got copied the most.

“Reality is the fact the world could not stop repeating.”

Two moves. Small, so it can be known. Copied, so it cannot be denied. Knowability and incorruptibility—the same two moves, at every scale, from a grain of dust in a sunbeam to a planet full of weather.

I have called the first idea the Boundary Dominance Principle. The second is why I have argued that reality is the least corruptible grader we will ever have. This essay is just the recognition that they were one idea all along, seen from two sides.

IV. Why this could change how we protect the living world

Here is why this is not merely pretty.

We have always believed that watching over nature is expensive—too much ground, too many molecules, a thing too vast to see. The first move says otherwise. You do not have to know everything to know enough. The state of a forest, a river, an airshed lives largely on its boundary, in a description far smaller than the thing itself. Knowing is cheap. That is deep good news, because it means the eyes we would need are eyes we can actually build.

But cheap knowing carries that fragility. One gauge at the pipe can be spoofed—the needle reads clean while the water runs foul. A single record is one lie away from useless.

So you reach for the second move. You take that small honest description and you write it down in many independent places at once. The chemistry at the outfall. The isotopes three bends downstream. The dead growth on the bank. The satellite pass. The drone pass. The neighbor's cough. Each one an independent copy of the same fact. Now a lie has an impossible job. To keep the record reading clean it must corrupt every copy—and keep corrupting them—while the river keeps minting fresh copies for free, faster than anyone can forge them. The lie runs out of room. Being clean becomes the cheapest way left to look clean.

That is the whole thing, and it is small enough to hold in a single breath:

“Know it small. Keep it everywhere. The first makes truth cheap. The second makes lying expensive.”

V. Where the simple thing is not the certain thing

I want to be honest about how much of this is proven, because a claim that hides its seams is a claim hiding something—and simple is not the same as certain.

The clean part is old and solid. That you can separate the two jobs—shrink the message, then protect it—is a founding result of information theory, worked out by Claude Shannon in 1948. That a fact becomes objective by being copied into its surroundings is the heart of what physicists now call quantum Darwinism, developed by Wojciech Zurek and others. And the grandest version—that the deepest known laws seem to keep a whole volume’s worth of reality on its boundary, and to keep it in exactly the redundant, error-correcting way that keeps a record safe—is real too, but proven cleanly only in idealized model universes, not yet in the one we live in. So take the grand version as a guide-star, not a deed. The information theory is a theorem. The physics is beautiful and only partly settled. The leap to a living river is mine, and it is an engineer’s bet, not a law of nature.

And the bet rests on one word. *Independent.*

Copies only protect you if they can fail apart. A thousand records that all run through the same sensor, the same software, the same company, the same buried assumption are not a thousand records. They are one record wearing a thousand faces, and one clever lie corrupts them all at once. The strength was never the number of copies. It was the independence between them. That is the real work, and the real danger. Redundancy is not “buy more sensors.” It is “make sure no single failure can reach them all.”

VI. Try to break it

Trying to break an idea is the only honest way to hold one. Here is how this one dies.

It dies if copies buy you nothing—if someone shows a kind of environmental fact where faking many independent records costs no more than faking one. Then redundancy is theater.

It dies if independence is a fiction—if in the real world every sensor secretly shares a chokepoint, one model or one vendor or one feed, so that the thousand copies were always one. Then the safety was never there.

It dies if the boundary does not actually carry the inside—if there are living systems whose interior cannot be read from any small honest description of their edges. Then the first move fails and the cheap eyes were a dream.

And it has a soft spot even if all of that holds. Copies can tell you a reading is *true*. They cannot tell you which reading should count as *healthy*. What “clean” means, what “alive” means, what “well” even means—that choice is ours, and no amount of redundancy will make it for us. This idea guards the truth of a measurement. It does not choose the thing worth measuring.

Any one of those would wound it. I have looked hard for all four, and I think the idea survives—bruised, scoped, and more honest for the search. But that is where evidence, not argument, has to finish the job.

VII.

Look at the chair again. Small enough to know from a glance. Copied into so much light that you cannot doubt it. That is not two facts about the chair. It is one fact about how anything comes to be known and trusted at the same time.

Now do it on purpose. For the river, the forest, the air. Find the small true description. Write it everywhere, in ways that cannot all fail together. Make the truth cheap to hold and expensive to fake.

That is not a slogan. It is the oldest trick the universe has, and it has only been waiting for us to notice.

onward.

Sources and lineage. The separation of the two jobs—compress a source, then protect it across a noisy channel—is Claude Shannon, “A Mathematical Theory of Communication” (1948). The account of objectivity as redundant copying into the environment is Wojciech Zurek, “Quantum Darwinism,” *Nature Physics* 5, 181 (2009), with Ollivier, Poulin, and Blume-Kohout. The reading of holography as a quantum error-correcting code—where the boundary is at once sufficient and robust—is Almheiri, Dong, and Harlow, “Bulk locality and quantum error correction in AdS/CFT” (2015), and Pastawski, Yoshida, Harlow, and Preskill, “Holographic quantum error-correcting codes” (2015); the observation that such an encoding shows *both* compression and error correction is Pastawski, Eisert, and Wilming, “Towards holography via quantum source-channel codes,” *Physical Review Letters*

119, 020501 (2017). The environmental synthesis—that boundary sufficiency and redundant recording are one design principle for protecting the living world—builds on my own *The Boundary Dominance Principle, Nature & Simplicity, The Compression That Sings*, and *Reality as the Only Incorruptible Grader*, and is offered as motivated engineering rather than settled physics.

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