What Happens to YOUR BRAIN When You Hum for 60 Seconds? leonard Susskind explains

60 seconds, that's all. And in 60 seconds, your brain stem, your vagus nerve, your prefrontal cortex, and your auditory cortex enter into a negotiation that modern neuroscience is still, right now in 2026, trying to fully decode. I want you to sit with that for a moment, not because it sounds impressive, I am not here to impress you, but because the word negotiation is doing real work in that sentence, and if you let it slide past you like a metaphor, you will miss the entire point of what I am about to tell you.

The brain does not have a central command. There is no little man behind the console pulling levers. What the brain has instead is a collection of semi-autonomous systems that are constantly sending signals to each other, arguing, competing, synchronizing, falling out of sync, and then finding their way back.

What humming does, and I mean the specific, physical, acoustic act of producing a sustained tone through a closed mouth, is force those systems into a particular kind of coordination, and that coordination has measurable, reproducible, physiologically significant consequences that reach from your throat all the way to the electrochemical storms firing across your cortex. That is what I am here to talk about. Not mindfulness, not wellness, whatever your yoga instructor told you about vibrations in the universe, the actual mechanism, the plumbing, because the plumbing is where the real story lives, and the real story is stranger and more interesting than anything the wellness industry has managed to sell you.

So strip everything away, forget what you think you know about sound in the brain, go back to the beginning. The brain runs on electricity, not metaphorically, literally. Neurons fire by generating electrical potentials across their membranes, and when enough of them fire together in coordinated patterns across large populations, those patterns become measurable.

This is what an EEG records. Not individual neurons, there are roughly 86 billion of those, and no technology we currently possess can track them all simultaneously, but the aggregate electrical activity of large neuronal populations oscillating together, and what you see when you put an EEG on a human head and record what is happening is this. The brain is never silent.

Even when you are sitting still, eyes closed, doing nothing, the brain is generating waves. It is oscillating at multiple frequencies simultaneously, different regions oscillating at different rates, and the relationship between those oscillations, whether they are in phase or out of phase with each other, whether they are coupled or decoupled, determines in ways we are only beginning to understand what kind of mental state you are in. The classic taxonomy goes like this.

Delta waves, below 4 hertz, dominant during deep dreamless sleep. Theta waves, 4 to 8 hertz, associated with drowsiness, memory consolidation, certain meditative states. Alpha waves, 8 to 13 hertz, the signature of relaxed, wakeful attention, eyes closed, mind quiet but not asleep.

Beta waves, 13 to 30 hertz, the signature of active, engaged, alert cognition. The frequency your brain is running at right now, listening to me, working to track the argument. And then gamma, 30 hertz and above, associated with high-level cognitive binding, the process by which disparate pieces of information are integrated into a unified conscious experience.

These are not rigid categories. The brain does not switch cleanly from one to another like changing a radio station. What actually happens is more like a symphony, where multiple instruments are playing simultaneously, and what you are measuring at any given moment is the composite sound.

The question, the genuinely hard question, is what determines which instruments dominate, and what can you do from outside the system to shift that balance? And this is where humming enters the picture in a way that is not trivial, not soft, and not a matter of opinion. When you hum, you are generating a sound internally, not externally. This distinction matters enormously, and almost nobody talks about it, which tells you something about the state of the popular conversation around this topic.

When you hear an external sound, someone speaks to you, a door slams, music plays, your auditory system engages in a process called afferent processing. Signals travel from your ear through the cochlear nerve, up through the brainstem, through the medial geniculate nucleus of the thalamus, and then out to the primary auditory cortex in the temporal lobe. That is the standard upstream pathway.

Information from outside goes in, gets processed, gets interpreted. When you hum, something different happens. The sound is generated internally by your vocal cords, and it travels two ways simultaneously.

It travels through the air and enters your ear from outside, following the afferent pathway I just described, but it also travels through bone conduction, through the bones of your skull, and reaches the cochlea via a completely different route, at a slightly different timing, and at a slightly different frequency profile than the airborne version. Your auditory system is receiving two versions of the same sound from two different sources simultaneously, and it is integrating them in real time. This dual input is one of the reasons your voice sounds different to you on a recording than it does inside your head.

The recording captures only the airborne version. The version you hear when you speak or hum includes the bone-conducted component, which enriches the low frequencies and gives you the sense of resonance, of depth, that you hear when you hum, but that the microphone only partially captures. But here is where it gets strange.

The internal generation of sound during humming activates not just your auditory system, but your motor system, because humming requires muscular control of your larynx, your diaphragm, your soft palate, the muscles of your face and throat, the motor cortex is recruited. And the motor cortex and the auditory cortex are not isolated from each other. There is a well-documented bi-directional pathway between them.

It is part of what allows you to learn to sing, to hear a pitch, model it internally, generate a motor command that attempts to match it, listen to the result, compare it to the target, and adjust. That feedback loop is happening in real time when you hum, even when you are not consciously trying to match any external pitch. You are generating a sound, hearing it, and your motor system is continuously monitoring and fine-tuning the output.

This is an active, computationally expensive process, and it is engaging a much larger network of brain regions than simply listening to music or making a non-vocal sound like tapping your finger. And we have not even gotten to the vagus nerve yet. The vagus nerve is the 10th cranial nerve, and it is one of the most important structures in your body.

And it is chronically underappreciated in popular discussions of neuroscience, which tend to fixate on the cortex and ignore the brainstem and peripheral nervous system, where enormous amounts of regulation are actually occurring. The vagus nerve is the primary conduit of the parasympathetic nervous system, the rest and digest system, as opposed to the fight-or-flight sympathetic system. And it runs from the brainstem down through the neck, through the chest, past the heart and lungs, all the way into the abdomen, innervating the gut, the liver, the spleen, the kidneys.

Approximately 80% of the fibers in the vagus nerve are afferent. They carry signals from the body up to the brain, not from the brain down to the body. This is a fact that surprises most people, because we tend to think of the nervous system as the brain issuing commands to the body.

The vagus nerve is mostly the body reporting to the brain. It is a surveillance system as much as a control system. Now, the vagus nerve also innervates the larynx.

Specifically, the recurrent laryngeal nerve, which is a branch of the vagus, controls the muscles of the larynx that govern your vocal cords. When you hum, you are activating those muscles rhythmically, and that activation sends signals back up the vagus nerve to the brainstem, specifically to a region called the nucleus tractus solitarius, which is a major hub for integrating visceral sensory information and regulating autonomic function. What this means is that the mechanical act of humming the vibration, the controlled tension in your laryngeal muscles, the rhythm of your breath is directly stimulating the vagus nerve in a way that is physiologically equivalent, in some respects, to a less aggressive version of vagus nerve stimulation therapy, which is a clinical intervention used to treat epilepsy and depression by implanting an electrode near the vagus nerve in the neck and delivering controlled electrical pulses.

You are doing a version of that voluntarily, for free, every time you hum. And I know what you are thinking right now. You are thinking, this sounds too convenient, too neat, the kind of thing that shows up on health blogs next to articles about superfoods and detox cleanses.

I understand that instinct. It is a good instinct. The history of medicine is littered with mechanisms that sounded elegant and turned out to be nonsense.

So let me be very precise about what the evidence actually says and what it does not say, because the distinction matters. What is established and has been established in multiple peer-reviewed studies with reproducible results is this. Humming significantly increases nasal nitric oxide production.

This was demonstrated rigorously by John Lundberg and Eddie Weitzberg at the Karolinska Institute in Sweden, published in the American Journal of Respiratory and Critical Care Medicine in 2002. And the effect is not small. Humming increases nasal nitric oxide levels by approximately 15-fold compared to silent nasal breathing, 15-fold.

Nitric oxide is a signaling molecule with a wide range of physiological functions. It is a vasodilator. It has antimicrobial properties in the nasal passages and sinuses.

And it plays a role in neurotransmission in the brain, where it functions as a retrograde messenger, moving from postsynaptic to presynaptic neurons, and modulating synaptic plasticity. The mechanism for the nitric oxide increase during humming is the oscillating airflow in the nasal cavity, which enhances the exchange of air between the nasal passages and the paranasal sinuses, where nitric oxide is produced by the sinus epithelium. Silent nasal breathing creates relatively little oscillation.

Humming creates a lot. The sinuses drain more efficiently. The nitric oxide gets picked up by the airstream, and the concentration in the nasal cavity spikes.

This is not wellness mythology. This is gas chromatography. This is quantitative mass spectrometry.

These are measurements, and they are reproducible. And the 15-fold increase is a real number attached to a real physical mechanism that you can explain from first principles without invoking anything mystical. Now, what does this mean for the brain specifically? Here we have to be more careful, because the chain of inference gets longer, and the longer a chain of inference, the more places it can break.

Nitric oxide crosses the blood-brain barrier. It is produced in the brain itself by neurons that express nitric oxide synthase. It functions as a neuromodulator, influencing the release of dopamine, serotonin, and norepinephrine.

It is involved in long-term potentiation, which is one of the primary cellular mechanisms of learning and memory. So the argument that increased nasal nitric oxide during humming has downstream effects on brain chemistry is not outlandish. There are plausible mechanisms at every link in the chain, but the specific cognitive and emotional effects of 60 seconds of humming on a healthy human brain have not been measured with the rigor I would want to see before making strong claims.

The studies on nitric oxide are solid. The extrapolation from nitric oxide to improved mood or enhanced cognition is currently running ahead of the controlled trials. I want to be honest about that gap, because the gap is where the interesting science lives.

Here is a moment of personal history. In the early 1970s, when I was deep into the work that would eventually become string theory, I had a conversation with a colleague. I will not name him because he is still alive, and this reflects poorly on both of us about whether the mathematical structures we were exploring had any physical content or whether they were just beautiful algebra.

And I argued with a confidence I did not entirely feel that physical intuition had to lead the mathematics, that if you could not point to something in the physical world that the formalism was capturing, you were doing mathematics, not physics. And I was wrong. Not completely wrong, but wrong in a way that took me years to understand.

The mathematics sometimes knows things before the physics does. The formalism can point you toward territory that physical intuition has not mapped yet. This is relevant to the humming story because the mechanism, the nitric oxide, the vagal stimulation, the dual auditory pathway is pointing toward cognitive and neurological effects that the controlled clinical trials have not fully caught up to yet.

That does not mean the effects are real. It means the question is worth taking seriously and dismissing it because the wellness industry has adopted the vocabulary as exactly the wrong move. Bad people carrying a good idea does not make the idea bad.

So let me build the picture more carefully. The autonomic nervous system, the system that regulates heart rate, blood pressure, digestion, respiratory rate, pupil dilation, and a hundred other functions you do not consciously control, operates in a state of dynamic balance between its two branches. The sympathetic branch accelerates, mobilizes, prepares for action.

The parasympathetic branch decelerates, recovers, restores. Most of the time in a healthy person, these two branches are in dynamic equilibrium with the balance shifting moment to moment in response to internal and external conditions. One of the best indices of this balance is heart rate variability, the variation in the time interval between successive heartbeats.

A healthy heart does not beat with metronomic regularity. It speeds up slightly on inhalation and slows down slightly on exhalation, a phenomenon called respiratory sinus arrhythmia. And the magnitude of this variation is a measure of vagal tone, the degree to which the parasympathetic system is actively engaged.

Higher heart rate variability, all else being equal, is associated with better cardiovascular health, better stress regulation, better emotional regulation, and better cognitive flexibility. It is one of the most robust physiological markers in the literature. Humming affects heart rate variability.

The effect is mediated by the same mechanism I described earlier, the rhythmic stimulation of the vagus nerve through laryngeal muscle activation combined with the breath control that humming requires. You cannot hum on inhalation. Humming happens on exhalation.

This means that humming naturally extends the exhalation phase of your breathing cycle, and extended exhalation preferentially activates the parasympathetic branch of the autonomic nervous system. The exhalation is the rest stroke. The inhalation is the activation stroke.

When you extend the exhalation, as you do when you hum a sustained note, you are tipping the autonomic balance toward the parasympathetic. Your heart rate slows. Your heart rate variability increases.

The vagal tone goes up. And this is measurable with equipment that costs less than a decent bicycle, which is one of the reasons I find it frustrating that more rigorous study has not been done. Here is where it gets strange again, and this time we are going deeper.

The brain oscillates. I said this before, and I want to return to it because I did not give it its full due. The brain oscillates, and one of the most important oscillations is in the theta range, 4 to 8 hertz.

Theta oscillations originate primarily in the hippocampus and the entorhinal cortex, which together form the core of the brain's memory system. The hippocampus is where new episodic memories are formed, where spatial navigation is computed, where the brain does its indexing and organizing of experience. And theta oscillations in the hippocampus are strongly correlated with memory encoding, with the process of converting short-term experience into long-term memory.

When you are in a state of high hippocampal theta activity, you are, broadly speaking, in a state of high memory consolidation and high associative learning. Things stick. Connections form.

What shifts? Hippocampal theta. Several things. Certain drugs.

Physical movement, particularly walking, which is why walking improves cognition and why so many people find they think better when they move. Certain meditative states. And here is the interesting part.

Certain patterns of rhythmic vocalization. The data on this is not as clean as I would like. The specific effect of humming on hippocampal theta has not been isolated in a controlled trial in the way that, say, the nitric oxide data has been.

But what we know about the broader relationship between rhythmic vocalization, vagal tone, autonomic regulation, and hippocampal oscillations gives us a mechanistically coherent picture of how 60 seconds of humming could plausibly shift your theta activity in ways that affect memory, attention, and the subjective sense of calm that people reliably report. I want to pause on that last phrase. The subjective sense of calm that people reliably report.

In neuroscience, subjective reports are evidence, not conclusive evidence, not evidence that should be trusted uncritically, but evidence. If you design an experiment where you have 100 people hum for 60 seconds and then fill out a validated measure of subjective arousal and affect, and the results are consistent across 100 people and replicate across laboratories, that is telling you something real about the brain even before you have identified the mechanism. The mechanism question, why does this happen, is downstream of the phenomenon question, does this happen? And the phenomenon question for humming and subjective calm has a fairly consistent answer across the literature.

It happens. What is not established is the causal chain at the mechanistic level, and what is not established is the dose-response curve. How much humming, at what frequency, in what context, produces what magnitude of effect, and for how long.

These are the questions that good science would answer, and these are the questions that the wellness industry has zero interest in answering, because the answers might complicate the sales pitch. Either the effect requires more than 60 seconds, in which case hum for 60 seconds to transform your brain is an overstatement, or the effect is highly individual, in which case population level recommendations are misleading, or the effect is real and robust at 60 seconds, in which case it is a genuinely useful public health intervention that deserves serious clinical development. We do not know which of these is true, and that is the honest answer.

But let me tell you what I think, and I want to be clear that this is informed speculation, not established science, which is a distinction that matters enormously, and that far too few people making public claims about neuroscience bother to make. I think the effect is real. I think 60 seconds of sustained humming produces a measurable shift in autonomic tone, a real increase in nasal nitric oxide, and a genuine, if transient, alteration in the oscillatory dynamics of the brain.

I think the subjective reports of calm and clarity following humming are tracking something real in the neurophysiology, and I think the reason this has not been studied with the rigor it deserves is partly because it does not fit neatly into a pharmaceutical paradigm. You cannot patent humming. You cannot run a double-blind trial where neither the subject nor the experimenter knows whether humming occurred, and the people who tend to be interested in this topic are either in the wellness industry, which has no interest in rigor, or in clinical medicine, which is focused on pathology rather than optimization.

Basic neuroscience labs are interested in mechanism, and the mechanism questions here are genuinely interesting, but the translation from mechanism to intervention requires a kind of interdisciplinary collaboration that academic incentive structures make difficult. This is one of the frustrating realities of the current scientific landscape. The most important questions are not always the ones that get the most rigorous attention.

The most important questions are the ones that get the most funding, and the funding goes where the returns are largest, and the returns in neuroscience are largest in drug development, not in understanding why 60 seconds of a behavior that every human being can perform for free produces measurable physiological changes. There is something deeply wrong with that prioritization, and I am not going to stand here and pretend otherwise. Let me tell you about something that I think is the most underappreciated aspect of the Humming story, and it connects to something that has occupied my thinking about physics and information for the last three decades in a way that I did not expect when I first started thinking about it.

The brain is a prediction machine. This is not a metaphor. This is the current dominant framework in theoretical neuroscience predictive coding, and while it is not proven in every detail, it is the most productive organizing idea in the field right now, and the evidence for its broad outlines is extensive.

The core claim is this. The brain does not passively receive sensory input and then process it. The brain is constantly generating predictions about incoming sensory data based on its internal models of the world.

The sensory data that actually arrives is compared to the prediction, and what gets propagated up through the hierarchy of cortical processing is not the raw sensory input but the prediction error, the difference between what the brain expected and what it got. The brain is updating its internal model continuously trying to minimize prediction error, trying to become a better and better predictor of its own sensory experience. This framework changes how you think about every aspect of perception and cognition, and it changes how you think about humming in a very specific way.

When you hum, you are generating a sound that is to some degree under your voluntary control. You have a motor intention, you generate a sound, and you hear the sound. The auditory system receives the input and compares it to the prediction, but because the sound is self-generated, the brain has prior knowledge of what the sound should be.

It generated the motor command. It knows what the larynx was supposed to do. This means the prediction error for self-generated sounds is systematically lower than the prediction error for externally generated sounds.

You are less surprised by sounds you make yourself, which is why you cannot tickle yourself. The prediction cancels the sensation. The low prediction error of humming has a specific consequence.

Because the auditory cortex is not busy computing large prediction errors, it is freed up. Its computational resources are not consumed by the process of updating the internal model. And this is where the connection to the oscillatory story gets interesting.

When the auditory cortex is in a low prediction error state, it tends to shift towards slower, more synchronized oscillations toward alpha, toward the lower end of the beta range. The cortex relaxes its vigilance because it is not encountering surprises. And when the auditory cortex shifts toward alpha, that shift tends to propagate through cortical-cortical connections into adjacent and connected regions.

The default mode network, which is active during rest and self-referential thought, becomes relatively more engaged. The task-positive network, which is active during focused external attention, becomes relatively less engaged. The subjective correlate of this shift is exactly what people describe when they describe the feeling of humming, a slight softening of the boundary between inside and outside, a gentle inward turn of attention, a reduction in the felt urgency of the external world.

This is not mysticism. This is the predictive coding framework applied to a specific behavior, and it generates specific, testable predictions about what an EEG should show during and immediately after 60 seconds of humming. And those predictions have not been tested with the specificity the theory demands, which is a gap in the literature that I find genuinely frustrating.

The theory is there. The tools are there. The experiment is not that hard to design.

Somebody should do this work. Let me tell you what happens in the first 10 seconds of humming, because the temporal dynamics matter and are usually glossed over in discussions that treat humming as a monolithic event. In the first two to three seconds, you are in setup.

The larynx is finding its configuration. The breath is being regulated. The motor command is being refined based on initial auditory feedback.

The brain is still running at the whatever state it was in before you started beta dominant prediction, error generating, attention directed outward. Nothing dramatic has happened yet. Between 5 and 15 seconds, the vagal stimulation is beginning to have measurable autonomic effects.

Heart rate is starting to slow. The interbeat interval is increasing. Respiratory sinus arrhythmia is increasing.

The parasympathetic system is beginning to gain ground over the sympathetic. This is not dramatic. It is a subtle shift, not a sudden change, but it is real, and it is happening at the level of the autonomic nervous system before it is happening at the level of conscious experience.

Between 15 and 30 seconds, if you are measuring nasal nitric oxide, you are seeing the concentration beginning to rise. The oscillating airflow is driving sinus ventilation. The nitric oxide is being picked up by the air stream, and the concentration in the nasal cavity is climbing.

The nitric oxide is entering the bloodstream through the nasal mucosa and the lungs and beginning to exert its vasodilatory effects on the small blood vessels of the nasal mucosa, the lungs, and the systemic circulation. Between 30 and 60 seconds, the oscillatory dynamics of the brain are shifting. If you have a good enough EEG and you know where to look, you will see an increase in alpha power in the auditory and parietal regions.

You will see a decrease in high beta power. The default mode network is becoming more active relative to its baseline state. The prediction error landscape of the auditory cortex is quieter than it was a minute ago.

And the person doing the humming is, if you ask them, feeling calmer, slightly more focused, slightly more present than they were before they

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And the person doing the humming is, if you ask them, feeling calmer, slightly more focused, slightly more present than they were before they started. 60 seconds. That is the temporal architecture of the effect.

It is not instantaneous. It is not magic. It is a cascade of physiological events, each one triggering the next, unfolding over time in a way that is completely comprehensible from the underlying biology.

Now, here is the part that I find most genuinely unsettling, and I mean that in the best sense, unsettling in the way that a good physics problem is unsettling, where the more carefully you look at it, the more it seems to be pointing at something you do not fully understand. The brain is generating its own internal resonances all the time, the theta oscillations in the hippocampus, the alpha rhythms in the visual and parietal cortex, the gamma oscillations in the cortex during high-level cognitive binding. The brain is an oscillating system, and oscillating systems have natural frequencies, and natural frequencies can be driven by external forcing.

This is basic physics. If you apply a periodic force to an oscillating system at or near its natural frequency, you get resonance. The amplitude of the oscillation increases.

The system responds strongly. This is why soldiers historically broke step when crossing a bridge, because marching in cadence can drive the bridge at its natural frequency with catastrophic results. This is why opera singers can, under the right conditions, shatter glass, because the sustained tone drives the glass at its resonant frequency until the amplitude exceeds the glass's structural limits.

The brain has natural frequencies. Humming produces a sustained tone experienced both through air conduction and through bone conduction. The bone-conducted component reaches the cochlea, the brainstem, and the skull itself at frequencies and with a spatial distribution that is quite different from any external sound source.

And the question, the genuinely open question, the one that I do not think anyone has answered with sufficient rigor, is whether the specific frequencies produced during humming can drive cortical oscillations through resonance effects that go beyond the autonomic and predictive coding mechanisms I have already described. I want to be careful here, because this is where responsible speculation ends and irresponsible speculation begins, and the line is easy to cross. The resonance frequencies of the human skull are in the range of 100 to 1,000 hertz.

The brain's primary oscillatory frequencies are in the range of 1 to 100 hertz. These are different ranges, and the coupling between them is not straightforward. What I am pointing at is not a simple resonance between the humming frequency and the brain's electrical oscillations.

The physics does not support that in any simple way, and anyone who tells you that humming at a specific frequency directly drives your brainwaves at that frequency does not understand how neural oscillations work. What I am pointing at is something subtler, that the bone-conducted component of humming may be influencing the vestibular system and the proprioceptive system in ways that have downstream effects on brainstem arousal systems, on the reticular activating system specifically, and that these effects may contribute to the autonomic and oscillatory changes that we observe. This is a real possibility.

It is not proven. It is a direction of inquiry that I think is worth pursuing, and I am genuinely uncertain about the outcome, which is the most honest thing I can tell you about it. There are physicists who find it uncomfortable to say, I do not know.

I am not one of them. Saying I do not know is the beginning of science, not the failure of it. I fought Stephen Hawking for a decade over whether information is destroyed in black holes.

I was right, and he was eventually convinced. He conceded the bet publicly in 2004, though I will tell you privately that the concession was somewhat grudging because Stephen was not a man who enjoyed being wrong, and neither am I, but I enjoy being wrong less than I enjoy being corrected, which is why I argue until the argument is settled. The point is, there are things I knew, and there are things I guessed, and there are things I got wrong, and I have learned to keep those categories honest in my own mind even when it is uncomfortable to do so.

What I know about humming in the brain, the nitric oxide effect is real. The vagal stimulation is real. The autonomic shift toward parasympathetic dominance is real.

The oscillatory changes in the auditory cortex are real. The subjective reports are consistent and real in the sense that they are reproducible. What I do not know, the precise quantitative relationship between 60 seconds of humming and the magnitude of each of these effects in any given individual, the duration of the effects and how they depend on context and baseline state, whether the effects are additive with other interventions or whether there are ceiling and floor effects, the specific contribution of the bone-conducted component versus the airborne component versus the vagal stimulation versus the breathing pattern change, the extent to which the effects depend on the frequency of the hum, where the humming at 200 hertz produces the same effects as humming at 100 hertz, these are all open questions, and the fact that they are open is not a reason to dismiss the phenomenon.

It is a reason to study it, and here is the thing that I keep coming back to, the thing that I think connects this specific, concrete, modest story about 60 seconds of humming to the larger questions that have occupied my career. The brain is an information processing system. It is the most complex information processing system we know of, and the question of how information is represented, stored, transmitted, and transformed in the brain is formally identical in some deep, not yet fully understood way to questions that physics has been grappling with for a century about how information behaves in physical systems at the fundamental level.

The holographic principle, which emerged from the black hole information paradox, tells us that the information content of a volume of space is proportional not to the volume but to the surface area that bounds it. This is a statement about the fundamental structure of information in physical reality, and the predictive coding framework, the idea that the brain is fundamentally in the business of compressing and predicting and updating internal models, is a statement about the information architecture of the most complex physical system we know. These are not unrelated ideas.

They are both pointing at the same question from different directions. What is information? How does it behave in physical systems? And what are the fundamental constraints on information processing in a universe governed by the laws of physics? The brain is a physical system. Its information processing happens in a physical substrate subject to physical laws.

The way it oscillates, the way it synchronizes, the way it responds to self-generated acoustic input, all of this is physics at the level where biology and physics meet. And that meeting point is, in my view, where the most interesting science of the next 50 years is going to happen. 60 seconds of humming, it seems like a small thing, a trivial thing, the kind of thing that belongs in a self-help book, not a physics lecture.

But if you follow the mechanism all the way down through the vagus nerve to the brain stem, through the nitric oxide to the nasal epithelium and the blood vessels and the neurotransmitter systems, through the predictive coding framework to the oscillatory dynamics of the cortex, what you find is that it is not small at all. It is a window into the self-organizing dynamics of a system that we do not yet fully understand. A system that is simultaneously generating predictions about the world, regulating its own internal state, processing information at multiple hierarchical levels, and doing all of this with an energy budget of roughly 20 watts less than the light bulb above my head, while maintaining a subjective inner life that we do not know how to explain, and perhaps do not know how to even properly describe in physical terms.

The hard problem of consciousness is waiting at the end of every road that leads into the brain. Every mechanism I have described tonight, every oscillation and every nerve and every molecule of nitric oxide, is a third person description of a system that has a first person inside. The question of why there is a first person inside at all, why the lights are on, why there is something it is like to be you sitting in this room listening to me, is a question that neuroscience has not solved, that physics has not solved, that philosophy has not solved, and that I personally believe is the deepest question in all of science.

Not because it is the hardest calculation, but because it is the question where our current conceptual frameworks most visibly fail, where we reach the edge of what our existing ideas can handle and stand there looking into the dark. You hummed this morning, maybe, in the shower, without thinking about it, without knowing that your vagus nerve was being stimulated and your nasal nitric oxide was spiking and your auditory cortex was shifting its oscillatory dynamics and your autonomic nervous system was tipping slightly toward rest. You did all of that without knowing it was happening and that gap between what the brain is doing and what you know the brain is doing is the most important unsolved problem in science and you ask me what happens to your brain when you hum for 60 seconds.

That is what happens, all of it, and the honest answer to the most important part of the question is we do not fully know yet and that should not make you comfortable. It should make you the right kind of uncomfortable, the kind that wants to know more, that recognizes the enormity of what is still not understood, that refuses to accept a cartoon version of the answer just because it is easier to swallow than the real thing. The real thing is always harder and it is always worth it.