CARDIOLOGY AND FAR INFRARED LIGHT
RELAX SAUNA SCIENCE

There is a structure inside your blood vessels that most physicians were not taught about in medical school. It lines every artery, vein, and capillary in your body. It regulates what gets through the vessel wall and what doesn't. It keeps your blood from clotting when it shouldn't, prevents inflammatory cells from adhering to vessel walls, and senses blood flow to help the vessel dilate and contract appropriately. It is so thin — measured in microns — that it went largely undetected for most of the history of medicine.

It is called the glycocalyx. And the emerging science around it may be one of the most important stories in cardiovascular and metabolic health that almost no one outside of research circles has heard.This piece is about that structure, what destroys it, and what the latest science says about protecting and restoring it. It is also about a second discovery — stranger and more fundamental — about the nature of water inside living tissue, and why far infrared light may be doing something considerably more interesting than simply making you warm.

THE FOREST INSIDE YOUR VESSELS

Imagine the interior of a healthy blood vessel not as a smooth pipe but as a dense forest floor — a mesh of sugar-protein chains, proteoglycans, and glycoproteins projecting inward from the vessel wall, creating a living filter between the bloodstream and the endothelial cells beneath. This is the glycocalyx. In a healthy individual it can extend several micrometers into the vessel lumen, forming what researchers have described as a gel-like coat that is simultaneously structural, biochemical, and mechanical. Its functions are extraordinary in their scope. The glycocalyx regulates vascular permeability — deciding what molecules can cross the endothelial barrier and what cannot. It inhibits thrombosis by preventing platelets and clotting factors from reaching the endothelial surface. It repels white blood cells, preventing the inflammatory adhesion that initiates atherosclerotic plaque. It acts as a mechanosensor, detecting shear stress from blood flow and translating it into nitric oxide production — the signal that tells vessels to dilate. Tomita and colleagues, writing in Frontiers in Cardiovascular Medicine, described it as a structure playing a key role in microvascular and endothelial physiology, regulating vascular tone, endothelial permeability, leukocyte adhesion, and antithrombotic function (T omita et al., 2022). A healthy glycocalyx, in other words, is not a passive coating. It is an active participant in vascular biology — one that is required for the vessel to behave as it should. The glycocalyx may be the most important structure imost people have never heard of.

WHAT DESTROYS IT

The glycocalyx is also extraordinarily fragile. It can be damaged within minutes by acute physiological insults and eroded chronically by conditions that are now near-universal in modern life.

Oxidative stress — the excess of reactive oxygen species produced by chronic inflammation, poor metabolic health, and environmental exposures — strips the glycocalyx directly. Hyperglycemia is particularly damaging: elevated blood glucose activates enzymes called heparanases that enzymatically shear the glycocalyx chains from the vessel wall. A 2024 editorial in Frontiers in Cell and Developmental Biology noted that chronic conditions including diabetes, aging, and hypertriglyceridemia all injure glycocalyx structure and cause degradation, with downstream effects on endothelial permeability, immune regulation, and thrombotic risk (Zeng and Fu, 2024).

Inflammation is both a cause and a consequence of glycocalyx damage. When the glycocalyx degrades, the inflammatory cytokines it was holding at bay — interleukin-6, tumor necrosis factor-alpha, reactive oxygen species — gain access to the endothelium directly. The vessel becomes inflamed. More glycocalyx is shed. The cycle accelerates. COVID-19 became a case study in catastrophic glycocalyx degradation: the SARS-CoV-2 spike protein, acting through inflammatory mediators and matrix metalloproteases, caused rapid glycocalyx shedding that contributed to the coagulopathy and multi-organ vascular dysfunction that defined severe cases (Zha, Fu, and Qian, 2022).

The clinical implication is significant. Syndecan-1 — a major glycocalyx component shed into the bloodstream during degradation — is increasingly used as a biomarker of vascular injury. Elevated serum syndecan-1 correlates with plaque vulnerability in atherosclerosis, with severity in sepsis and trauma, and with poor outcomes across a range of cardiovascular conditions. You can now measure glycocalyx health in a blood test. Which means the question of what restores it is no longer merely academic.

SHEAR STRESS, NITRIC OXIDE, AND THE FIR CONNECTION

One of the primary mechanisms by which the glycocalyx is maintained and repaired is shear stress — the mechanical force of blood moving across the vessel wall. Laminar flow, the smooth, organized blood flow of a healthy cardiovascular system, continuously stimulates the endothelium to produce nitric oxide through endothelial nitric oxide synthase (eNOS). Nitric oxide both dilates the vessel and is required for glycocalyx biosynthesis and repair. Disturbed flow — turbulent, oscillatory, or insufficient — withdraws that signal and the glycocalyx degrades.

This is where far infrared therapy enters the picture with a precision that is not incidental. Far infrared irradiation has been shown in multiple studies to upregulate eNOS expression and increase nitric oxide production in endothelial cells. A systematic review by Lin, Liu, and colleagues documented that far infrared therapy inhibits vascular endothelial inflammation

through induction of heme oxygenase-1 (HO-1) and increases eNOS activity (Lin et al., as cited in PMC review). A separate PMC systematic review confirmed that several weeks of sauna therapy markedly enhanced flow-mediated endothelium-dependent dilation of the brachial artery — a direct measure of eNOS function and nitric oxide bioavailability — with effects associated with improved cardiopulmonary exercise tolerance (Beever, 2009).

The FIR mechanism on eNOS is well-characterized. Repeated FIR sauna therapy upregulates eNOS expression in animal models of heart failure (Ikeda et al.) and induces angiogenesis through the same pathway in hindlimb ischemia (Akasaki et al.), as reviewed in the Journal of Biomedical Science (Lin et al., 2012). FIR also reduces circulating IL-6 and TNF-α — the same inflammatory cytokines that drive glycocalyx degradation — while recovering eNOS RNA expression in peripheral blood mononuclear cells (Beever, 2009).

Far infrared therapy upregulates the same nitric oxide path way that maintains and repairs the glyccoalyx — while suppressing the inflammatory signals that destroy it.

The logical inference — not yet tested directly in a glycocalyx-specific FIR trial, but mechanistically coherent — is that regular far infrared exposure creates the vascular biochemical environment in which glycocalyx maintenance is supported: elevated eNOS activity, increased nitric oxide, reduced oxidative stress, suppressed pro-inflammatory cytokines. Heat shock proteins induced by thermal stress add another layer. HSP70, robustly elevated by FIR exposure, has been shown to regulate the quality control of interendothelial junctions, maintain endothelial barrier function, and support eNOS levels — functioning as a molecular chaperone for the very proteins that keep the vessel wall intact (Yuan et al., 2020).

THE FOURTH PHASE OF WATER

Now the science gets stranger. And considerably more interesting. Gerald Pollack, professor of bioengineering at the University of Washington, has spent the past two decades investigating what he calls the fourth phase of water. Not liquid, not solid, not gas — a structured, gel-like, electrically charged state that forms wherever water contacts a hydrophilic surface. Pollack's laboratory named it exclusion zone water — EZ water — because the first thing they observed was that it profoundly excludes everything: solutes, particles, even small molecules are expelled from the zone. The EZ water that forms is not H_2O in the conventional sense. Structurally it is closer to H_3O_2 — a hexagonal, liquid crystalline arrangement that carries a net negative charge and stores energy in a way that bulk water does not (Pollack, 2013).

The Pollack laboratory's finding on what builds EZ water is the detail that changes everything for the FIR discussion. From the lab's own published research: 'The energy responsible for building this charged, low entropy zone comes from light. We found that incident radiant energy including UV , visible, and near-infrared wavelengths induce exclusion-zone growth in a spectrally sensitive manner. IR is particularly effective' (Pollack Lab, pollacklab.org). Infrared

light — and specifically wavelengths in the far infrared range — is among the most potent stimuli for EZ water formation that the laboratory has identified.

Pollack himself has written about the sauna connection directly: 'Why you feel good after a sauna now seems understandable. If radiant energy drives capillary flow and ample capillary flow is important for optimal functioning, then sitting in the sauna will inevitably be a feel-good experience. The infrared energy associated with heat should help drive that flow' (Pollack, bio4climate.org). The mechanism he proposes is that infrared light builds EZ water around proteins and along biological interfaces, restoring the ordered aqueous environment that cellular function depends on.

Infrared light — particularly in the far infrared range — is one of the most potent stimuli for exclusion zone water formation that Pollack's lab has identified. Every session is charging the water inside your cells.

The biological significance of EZ water extends far beyond hydration in the conventional sense. EZ water surrounds proteins and maintains their functional conformation. It provides the structured aqueous environment in which enzymatic reactions proceed correctly. It creates the charge separation that Pollack argues is a primary driver of cellular energy — a biological battery charged by light. When EZ water is depleted — by dehydration, illness, oxidative stress, electromagnetic noise, or simply the absence of infrared input that natural outdoor environments provide — cellular function degrades at a foundational level.

THE GLYCOCALYX IS AN EZ WATER GENERATOR

Here is where the two threads of this piece converge into something genuinely remarkable. The glycocalyx is itself a hydrophilic surface. Its sugar-protein chains are water- attracting by nature — they hold water within the vessel lumen as part of their structural f unction. Which means, by Pollack's model, the glycocalyx is continuously generating EZ water along its entire surface — creating a structured, negatively charged aqueous layer between the bloodstream and the vessel wall. That EZ water layer is not incidental to glycocalyx function. It may be central to it. The charge separation at the EZ interface creates an electrostatic environment that repels positively charged platelets and inflammatory cells — contributing directly to the anti-thrombotic and anti-adhesive properties the glycocalyx is known for. The exclusion zone physically excludes solutes from the endothelial surface — reinforcing the permeability barrier the glycocalyx maintains. The structured water may be the mechanism through which the glycocalyx accomplishes what it does, not merely a byproduct of its presence

Far infrared therapy, then, is operating on both structures simultaneously. It upregulates the nitric oxide pathway that maintains glycocalyx integrity. It builds EZ water along every hydrophilic surface in the body — including the glycocalyx itself. It reduces the inflammatory burden that degrades both. And it induces heat shock proteins that protect the endothelial junctions beneath. These are not independent effects added together. They are a

coordinated biological response to a specific type of radiant energy input — one that the body has been receiving from the natural infrared spectrum of sunlight for the entirety of human evolution, and one that modern indoor life systematically removes.

THE RAAS, HYPERTENSION, AND VASCULAR CALCIUM.

The vascular science around FIR has expanded significantly in the past two years. A 2025 study examining far infrared irradiation in spontaneously hypertensive rats identified a dual mechanism for blood pressure reduction: modulation of the renin-angiotensin-aldosterone system (RAAS) — the primary hormonal regulator of blood pressure — and activation of the nitric oxide- soluble guanylate cyclase-cyclic GMP pathway in vascular smooth muscle. Blood pressure reductions after seven weeks of FIR exposure were comparable to pharmaceutical intervention in the animal model.

A separate 2025 paper added another layer that deserves attention: FIR irradiation was found to attenuate vessel contraction by activating SERCA2 — the sarco/endoplasmic reticulum calcium ATPase pump — through disruption of its inhibitory interaction with phospholamban. The result is improved calcium handling in vascular smooth muscle, independently of any thermal effect. This is a non-thermal photobiological mechanism — FIR producing a specific molecular outcome in vascular tissue that does not depend on the tissue simply being warmer. If replicated, it would fundamentally reclassify FIR from a heat therapy to a photobiological intervention with specific molecular targets.

A 2025 study found FIR attenuated vessel contraction through a non-thermal mechanism — directly activating a calcium pump in vascular smooth muscle at the molecular level. Heat is not the whole story.

THE DEPRESSION DIMENSION

Cardiovascular and vascular biology are not separate from mental health — they share the autonomic nervous system, the inflammatory milieu, and the endothelial environment as common substrates. The glycocalyx is present in the brain's vasculature as well, where its degradation contributes to neuroinflammation and blood-brain barrier disruption. Which is why the growing psychiatric evidence for FIR is not a separate story from the vascular one. It is the same story told from a different vantage point.

Dr. Ashley Mason's work at UCSF, published across three successive trials from 2021 through 2025, showed that combining far infrared whole-body hyperthermia with cognitive behavioral therapy produced remission from major depressive disorder in 86.2% of participants — 25 of 29 completers — with retention of 96.7% (Mason et al., Global Advances in Integrative Medicine and Health, 2025). The proposed mechanism involves the spinoparabrachial tract, a warm-sensitive pathway that projects from skin thermal receptors to the raphe nuclei, the brain's

serotonin-producing region. Heat input activates the pathway. Serotonin synthesis increases. The thermoregulatory dysregulation that characterizes depression — chronic elevated core body temperature, impaired cooling — is corrected. Overlaid on this is the inflammatory mechanism. Chronic low-grade inflammation — elevated IL-6, CRP , TNF-α — is now recognized as a driver of treatment-resistant depression in a significant subset of patients. Far infrared therapy suppresses exactly this cytokine profile. A 2023 study in Translational Psychiatry by Flux and colleagues found that plasma cytokine levels predicted antidepressant response following whole-body hyperthermia — directly linking the anti-inflammatory effects of heat to mood outcomes. The vascular glycocalyx protection story and the depression story share the same inflammatory architecture.

WHAT A SESSION ACTUALLY DOES

A Relax Sauna session — twenty to thirty minutes of far infrared exposure at therapeutic dose — initiates a coordinated biological response that touches every system described in this piece. Core and skin temperature rise. The thermoregulatory system activates. Blood is redistributed from core to periphery, increasing shear stress across the endothelium. eNOS is upregulated. Nitric oxide production increases. Vessels dilate. Inflammatory cytokines — IL-6, TNF-α — are suppressed. Heat shock proteins are synthesized and distributed to endothelial junctions. The spinoparabrachial pathway is activated. Serotonin and beta-endorphins rise. The autonomic nervous system moves from sympathetic activation toward parasympathetic recovery. EZ water is built along hydrophilic surfaces throughout the body. The glycocalyx receives the biochemical environment it needs to maintain and repair itself. None of this happens from a single session in isolation. The research showing glycocalyx protection, eNOS upregulation, HRV improvement, and mood stabilization is built on repeated exposure — studies typically running three to four sessions per week over four to twelve weeks. The body adapts to the stimulus. The vascular system calibrates to the new normal. The gains compound.

The Relax Sauna's semiconductor-grade emitters — producing therapeutic- band far infrared at 4–14 μm with a peak near 9.4 μm, at power densities of 40– 50 mW/cm² at the skin surface — deliver this stimulus with a consistency and precision that matters for the EZ water and glycocalyx story specifically. Power density determines how efficiently EZ water is built along biological interfaces. It determines how strongly the spinoparabrachial pathway is activated. It determines how rapidly core temperature reaches the threshold at which heat shock protein synthesis is triggered. A weaker emitter at greater distance produces a qualitatively similar but quantitatively lesser response. The physics of radiant energy does not permit otherwise.

THE BIGGER PICTURE

Modern life has removed the body from most of the inputs it evolved to receive.
We are largely indoors, under artificial lighting that delivers minimal infrared. We

are largely sedentary, denying the vessel wall the shear stress that stimulates glycocalyx maintenance. We are chronically inflamed by diet, stress, environmental toxins, and disrupted sleep — all of which enzymatically strip the glycocalyx from the vessel wall. We are insufficiently exposed to the thermal cycling — warm days, cool nights, exercise-induced heat production — that our vascular biology expects.Far infrared therapy is not a magic bullet. It is a restoration of input. A way of returning to the body's biology a form of radiant energy it evolved over thousands of years to use — for vascular maintenance, cellular hydration, thermal regulation, neurochemical balance, and the repair of the fragile protective layer inside every vessel in the body. The glycocalyx story is just beginning to reach mainstream medicine. The EZ water story is still largely in the research community. The FIR story sits at the intersection of both.

Somewhere in the microns between your bloodstream and your vessel wall, right now, there is a living structure doing more work than any drug you will ever take. The question is whether you are giving it what it needs to do that work. The science says far infrared is part of that answer. A well-constructed session, practiced consistently, is a meaningful investment in the infrastructure your cardiovascular system depends on. Not as a treatment. As maintenance — of a biological system that was always meant to be bathed in light.

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