Understanding Redox Signaling Molecules, Healing, and Inflammation

R. D. Lee

A whitepaper excerpted from *Gut-Brain Secrets, Part 2: How Nature Nurtures and Man Manipulates.*

Visit GutBrainSecrets.com/shop/ to learn more about the 6-part series that explains the causes, effects, and solutions to gut-brain problems.

Email: info@gutbrainsecrets.com.

(Based on the work of Gary Samuelson, Ph.D, and Dr. Zach Bush)

Why oxidation and reduction matter

Oxidation and reduction are important to human health because oxidation-reduction cycling – the giving and taking of electrons – happens in all life on earth and is a fundamental part of every biochemical reaction.

Specifically, oxidation and reduction reactions control youth, healing, energy production, immunity, detoxification, hormonal response, and support of the microbiome – when it's working properly.

And it causes a lack of cell repair, a long list of chronic, degenerative problems, and accelerated aging when it's not. So it's more than important to all life on earth. It's essential. Life would cease to exist very quickly without oxidation and reduction.

Oxidation and reduction, or redox signaling (they're the same system), is the biggest, most important story for medical science to research today, and you to learn about, in our on-going effort to get healthy and stay healthy. It's right up there with the gut-brain connection.

In fact, the two phenomena, the gut-brain connection and cell-cell communication, are partners in corrupting our health or making us well. They're inseparable links in the same chain of events that manifests as ADD, GAPS, and a truly staggering array of diseases and dysfunctions skyrocketing in every statistical category and population group on earth.

Redox reactions are the basis of all communication, healing, and repair when it's working (i.e. balanced)... many break downs and failures when it's not

- Metabolism/energy production.
- Healing at cell level.
- Communication to and from cells (redox signaling).
- Defense, antimicrobial.
- Proliferation of mitochondria (which make energy and redox molecules).
- Increase diversity of microbiome – particularly rare species of beneficial bacteria.
- Suppress pathogens in micrbiome.

Negative charge and alkalinity are synonymous with health and healing, while positive charge and acidity creates inflammation, disorder, and disease

If you had to pick only one measurement to assess your relative state of health or sickness, a person that knows their stuff would pick electrical charge and pH. You can think of the two as pretty much the same thing in the body, because they're like twins or dance partners.

When oxidation steals electrons (which are negatively charged), cells and atoms become positively charged. That means greater instability, increased reactivity, acidity, corrosion, and inflammation that doesn't know when to quit. It means your cells and atoms are literally falling apart and not repairing themselves efficiently, which is imbalance, sickness, and aging, in a nutshell.

On the other hand, when your immune system is good at making antioxidants, your cells and atoms have all the electrons they need to replace those that are lost through oxidation. We call this neutralizing oxidative stress. And that equates to greater negative charge, higher alkalinity, better cell-cell communication, inflammation that starts and stops appropriately (aka acute inflammation), and healing capacity to spare.

Intertwined with all that, acids have more protons than electrons, which gives them a positive charge. The more extra protons a substance has, the more acidic it is. And the opposite is true – the more extra electrons something has in relation to positively charged protons, the greater its alkalinity. Hence, many alkaline foods and substances are famous for their healing/antioxidant effects.

In short, extra electrons are *negative charge* and *healing capacity* through oxidation-quenching and helping the immune system hear when inflammation needs to be shut down (alkalinity supports cell-cell communication). On the flip side, electron deficiency is *positive charge* and *poor healing ability* through corrosion and failure to realize inflammation is not working the way it should. Acidity aids and abets that.

We used to think free radicals were harmful by-products of exercise

Until just a few years ago, pretty much everyone in the wellness field thought free radical oxidation harmed cells and accelerated the aging process … and that was all there was to it.

It was part of this whole "exercise-induced free radical damage and antioxidant protection" paradigm pretty much everyone was preaching at the time. Researchers and educators basically thought aerobic exercise and cellular energy production make reactive oxygen species by accident.

Because oxidants are very good at destroying things, they believed the resulting free radicals were responsible for randomly injuring cells and making us age before our time. Therefore, we need to protect ourselves against this sort of cell damage by eating foods high in antioxidants.

But science has since come to its senses as research has revealed reactive oxygen species (ROS) are not harmful by-products of metabolism that you need to eliminate, else they

harm cells and cause premature aging. Instead, they're made for a very good reason – many beneficial reasons, actually.

Researchers have come to realize the body uses oxidants in a controlled manner to selectively repair or replace injured cells, depending on the extent of the damage. Even more pertinent to this discussion, mitochondria make redox molecules to send signals about what's happening inside the cell.

So redox molecules are both the communication network of the mitochondria, and they're the disinfectant that wipes out unwanted material to make way for healthy, new cells.

But up until just 5-10 years ago, scientists didn't realize that a healthy system purposely makes an equal amount of destructive oxidants and neutralizing reductants to maintain balance. In other words, good health is a balanced redox system.

In fact, large amounts of both ROS and RS are made when you exercise. So, oddly enough, taking a redox molecule supplement does many of the same things that exercise does; whereas, ingesting antioxidants right before you exercise negates much of its benefit, because the cleansing/restorative benefit of exercise gets negated.

We used to think antioxidants came from food

We now know our own cells make large quantities of antioxidants that are far superior in reach and capacity to those supplied by foods. In fact, most antioxidants that come from foods can't get inside cells, so they don't do what scientists thought they did (Vitamin C is an exception).

That said, they do offer some benefit quenching free radicals in the blood and extra-cellular matrix. For instance, alkalizing foods (and substances) such as raw vegetables contain an abundance of negatively-charged hydrogen ions. These act as electron donors (aka antioxidants). And that's one of the primary reasons raw, naturally-grown vegetables are so good for you.

Therefore, antioxidants from food are hugely beneficial. They're just not as all-powerful as those the body makes internally.

Our new understanding of oxidation and reduction

We now know oxidation and reduction is a carefully orchestrated, essential process the body uses to protect itself from threats and clear up damage, so that repair and renewal processes have a pristine environment in which to rebuild.

It's fundamental to human life because the body uses oxidation to destroy everything it deems undesirable – microbial pathogens, toxins, heavy metals, dead cells, and unrepairable cells. Without oxidation and reduction, you'd have mere hours to live … a day or two max.

However, oxidants are like wild beasts in that they're useful (crucial, really) when kept under control, damaging and problematic when they get out of control. Therefore, when inflammation is done blowing its target to bits with oxidants, antioxidants bring unused oxidants together with reductants and make them exchange electrons.

This neutralizes the oxidant of its destructive capacity, and turns both of them back into harmless salt water. The body's own antioxidants like glutathione can do this tens of millions of times per minute.

James Watson, Ph.D. (Nobel Prize Laureate who discovered the structure of DNA with Francis Crick, Ph.D.):

> *"In the chemistry of oxidation and reduction reactions, the body cannot survive without making both oxidants and antioxidants. There is a delicate balance between the two. Physical exercise prompts the body to make large numbers of oxidants – molecules called reactive oxygen species, or ROS."*

Exercise benefits the body by enhancing oxidation, reduction, and redox signaling

Exercise is oxidative stress. Oxidative stress is exercise. First and foremost, exercise is an oxidative activity. It's controlled oxidation. That's *why* it's good for you, and *how* it benefits the body. It leads to very important mechanisms of cell regeneration, exercise capacity, and speed of recovery.

For instance, exercise, oxygenation, and resulting oxidation capacity… they help regulate electrical charge (i.e. lots of negative charge and antioxidant activity), pH balance (deep breathing is alkalizing because it releases carbon dioxide, which acidifies the blood), and cell wall permeability through greater charge (i.e. better hydration, nutrient exchange, and detoxification).

As we discussed in the previous chapter "The Wisdom of Nature vs. the Fallibility of Man," those are several key factors that promote either a high state of health and healing when they're present, or disease conditions that favor pathogenic activity and the breakdown of the body when they're absent.

Point is, exercise, oxygenation, and oxidative activity are precious to your wellness. But as you already know, it takes time to build up a capacity for exercise, which is another way of saying *antioxidant capacity*. They're the same thing.

Exercise makes mitochondria burn fatty acids or sugar along with oxygen to power cells. That mitochondrial metabolism, as just described, produces large amounts of oxygen redox molecules that act as both universal cleansing agents and message carriers.

Through redox molecules (reactive oxygen species and reduced species), exercise dramatically increases protection of cells, healing of cells, balance, and a laundry list of good things. When well-controlled, oxidative reactions represent most of the body's mechanisms of youth and healing.

Conversely, when those systems are overwhelmed or fail altogether (i.e. ROS not being neutralized properly), oxidative damage is the mechanism of imbalances, exposure to genetic weaknesses, breakdowns, and rapid aging.

So when we talk about health or disease, we're primarily talking about various states of our body's capacity to repair or replace damaged cells. And that's controlled by the efficiency with which the body oxidizes, reduces, and does its redox signaling.

Add to that what you eat, which is the raw material used by redox reactions to rebuild, and you have over 90% of the ingredients that either lead you to good health or into disease.

Cells communicate with redox molecules

Like a vast military operation with a lot of moving parts, both mitochondria and bacteria in the microbiome need excellent communication to perform efficiently and effectively under all conditions. Redox molecules are that communication network enabling cells to talk to each other and "command central," thereby allowing immune cell armies to do their jobs.

Through redox signaling, the body is able to …

- detect when cells are under stress,
- tell DNA to activate coping mechanisms,
- call in the immune system to fight off threats,
- repair mildly damaged cells,
- hit the self-destruct button on badly damaged cells,
- regulate hormonal response,
- regulate mitochondrial metabolism,
- turn off coping mechanisms after a threat subsides,
- plus a whole lot more.

To illustrate how redox molecules work, when cells become damaged for any reason – toxicity, infection, physical injury, lack of oxygen, or even malnutrition – they enter a state of oxidative stress, which means more reactive oxygen species are supplied to the area than there are antioxidants and reductants to neutralize them.

High amounts of reactive oxygen species are the "S.O.S. distress signal" that tell cells and systems that there's a problem that needs to be addressed, where it's coming from, and how dire the situation is.

Like smoke coming out of a burning building, the more oxidant molecules the immune system finds leaking out of cells (because they were never neutralized by antioxidants/reductants), the more emphatic the distress signal is deemed to be.

Later, when the situation has been resolved, the lack of free-floating redox molecules inside and outside cells prompts nuclei and the immune system to turn off those coping mechanisms and go back to business as usual (i.e. homeostatic balance).

So it's through mitochondrial redox signaling that the nucleus "reads" the condition of oxidative stress occurring in the cell and can activate a variety of genetically-controlled coping mechanisms to deal with the threat and restore balance to the system.

Of course, the majority of the time a cell reads its status report and realizes it's fine and doesn't need repair. Still other times, cells take a look around them and realize they're different from that of the host organism. They realize they're a cancer cell and need to be sacrificed to protect the health of the whole.

But the thing is, without a large vocabulary with which to communicate, cells don't even realize what a healthy cell is supposed to look like, versus what a cancer cell looks like. They don't talk to each other fluently about their status and their needs. And they don't relay that information to the organ systems that need to know such things, such as the immune system.

Summary: In the same way that analyzing a car's exhaust tells a car mechanic how well an engine is running, the ratio and volume of ROS to RS indicates whether the cell is happy or distressed. Mitchondria, cell nuclei, and organ systems can then use this information to activate healing, or turn it off.

Here are some of the "buttons" the nucleus can push to call for help

1. **The DNA Repair** "button" mobilizes the DNA damage detection and repair crew.
2. **The Antioxidant Boost** button makes more antioxidants to neutralize the potentially harmful surplus of oxidants.

3. **The Intercellular Communication** button strengthens lines of communication between cells.
4. **The Increase Blood Supply** button dilates blood vessels to cells that could use more resources.
5. **The Stronger Cell Adhesion** button makes cells hold more tightly to each other.
6. **The Inflame Tissue** button stops damage from spreading.
7. **The Secrete Antibiotics** button deploys antibacterial substances to fight foreign invaders.
8. **The Stop Cell Division** button prevents distressed/damaged cells from replicating.
9. **The Send Distress Call** button sends a distress signal to the immune system.
10. **The More Energy to Repair Crew** button brings in more energy for repair processes to work with.
11. **The Prepare Cell for Shutdown** button places the decision to euthanize a cell with its neighbors.
12. **The Master Shutdown** button kills and demolishes the cell.

That's healing at a cellular level

In case you didn't catch it, those buttons are basically healing on a cellular level. Those genetically-controlled processes that the nucleus activates in response to redox distress signals are the mechanisms by which cells are instructed to activate the repair process when repairable, or make way for their replacement when gravely injured.

These are the mechanisms that heal cells and prevent aging. A perfect example is Button #12: The body is supposed to shut down attempts to repair cells after two hours if they were unsuccessful, and then turn on cell suicide (apoptosis). But poor redox signaling fails to make this happen. So damaged cells are allowed to persist and replicate. In a word, that's aging.

Oxidative therapies all operate on the same principles of oxidation and reduction (albeit using quite different approaches)

- Hydrogen peroxide.
- Ozone therapy.
- Hyperbaric oxygen chambers.
- Chlorine dioxide.
- Pulsed electro-magnetic frequency.
- Photonic therapy (infrared light).
- Redox molecules.

- Exercise.

What happens when your redox system fails?

Poor cell to cell communication (referring to both kinds) causes breakdowns and failures to occur in protection, detection, repair, and replacement, which leads directly to

- slow cell repair,
- low energy,
- premature aging,
- fewer species of beneficial bacteria and more pathogens in the microbiome,
- tight junction injury,
- leaky gut and leaky membranes,
- food allergies and intolerances,
- immune system dis-regulation,
- autoimmune problems,
- neurotransmitter and hormonal imbalances,
- psychological disturbances,
- chronic inflammation,
- and much more.

… for real. This is the very foundation of where all chronic, degenerative diseases come from – lack of communication at the cell level, which is another way of saying *impaired redox functioning*. With poor redox function, cells can't protect themselves from injury. They don't know they've been injured. They don't call for repair mechanisms. And cells don't replace themselves when they ought to.

These imbalances and repercussions express themselves symptomatically wherever the body is weakest or hardest hit by the ensuing hormonal, neurological, and immunological stresses (i.e. rate of injury outstrips rate of repair) – taking their toll as

- poor brain function in autism, Parkinson's and ADD;
- digestive disorders like irritable bowel syndrome and Chron's Disease;
- insulin dysfunction in diabetes;
- nerve impairment in neuropathies; or
- blood vessel problems in heart disease.

All of them are caused by failure of cells to communicate and repair appropriately, which, for all intents and purposes, is the same as *chronic inflammation*. Loss of cell-cell communication is virtually synonymous with chronic inflammation. Chronic

inflammation more or less equals loss of communication at the cell level. They're nearly one and the same.

Rate of injury vs. Rate of repair

Cells in your body are constantly being injured and killed every minute of every day. At the same time, the body's healing mechanisms continually repair damage cells and replace dead ones with healthy new cells. So there's always some rate of injury happening versus some rate of repair.

That ratio determines your resistance to dysfunction and disease. It greatly influences your energy level – physical and mentally. It controls your recovery time from exertion, injury, and illness. It has a lot to do with your rate of detoxification. And it's a primary factor in the rate at which you age biologically.

Point being, both of those states – damage and repair – can change quickly through interventions, or gradually through natural processes. But you seldom ever notice any of these changes because the human body has a built-in buffer zone of coping mechanisms – a reservoir of healing capacity – that's designed to favor life and healing until your compensation mechanisms are stretched past their limits of competency.

So you only notice three conditions:

1. When repair has fallen far behind and injury is clearly winning (aka "disease").
2. When your rate of new injury increases rapidly due some event or circumstance (e.g. major infection or massive toxin exposure).
3. When your rate of healing improves quickly from a lifestyle change like a healthy new diet, a detox program, or some therapeutic effort.

You see, all life forms are designed to start their lives with a full bucket of life force, if you will. They spend the majority of their lives with healing capacity to spare in the form of compensation mechanisms, emergency procedures, and various workarounds that the body uses to cope with less than optimal conditions.

It's only when injury exceeds the body's ability to repair by a wide margin that you see acute disease take place, or you die. Nowhere is this teeter-tooter effect better portrayed than the classic image of a bed-ridden, comatose, gravely ill person who's fighting for their life after being given their last rites.

The determining factor in whether they live or die is which of these will ultimately prevail: repair or injury. Not discounting supernatural influences, the phrase "now it's in God's hands" is another way of saying 'injury and repair' are locked in a fight to the death … or life, literally.

In daily life, however, you typically don't even notice gradual augmentation or erosion of your healing or repair because your buffer zone absorbs slow changes with any excess healing capacity you may have. Your body just does its normal healing thing and you're none the wiser.

But our multitude of sins against Nature have stretched our coping mechanisms to the limit

Our irresponsibilities and excesses have exhausted our healing capacity at all levels – cell, organ system, individual, society, and planet. So now the majority of people are living their lives on a razor-fine edge between sickness and health, with dangerously little safety margin to spare.

That's important because the slightest new insult in diet, lifestyle, or internal milieu can push a person over the tipping point into dysfunction and disease … which we're now seeing explode in our lives, families, doctor's offices, public places, the news, and every health statistic you'd care to measure.

To venture a guess, probably 35% of the population is slightly over the edge into the disease/dysfunction side (minor disease), 15% is well into disease (intractable disease), 35% is slightly on the desirable side of health (occasional health problems/annoyances), and 15% of the population has a fair amount of excess healing capacity to overcome further insults.

In other words, almost everyone is on the verge of manifesting a chronic, degenerative disease – they just don't see it that way. So as soon as the body uses up the last trick it has in its arsenal to keep you running incident-free, that's when serious disease suddenly appears out of nowhere – and won't go away.

Chronic inflammation drives all degenerative diseases

Healers of every modality and mindset are slowly, but surely, coming to the realization that all chronic, degenerative diseases are driven by unrelenting inflammation. Chronic inflammation is directly responsible for doing the vast majority of immune system dis-regulation, cell-cell communication failure, mitochondria injury, metabolic disruption, DNA replication error, and cell destruction.

Therefore, the majority of damage that a disease causes is not done by the imbalance, symptoms, or germ itself, but by inflammation that the body employs to fight the disease. In other words, most infectious pathogens, disease processes, and toxins are not what harm cells, structures, and systems the most.

Rather, the body's own threat annihilation system – inflammation – is far stronger at wiping out friendly cells than the menace itself. Inflammation itself is the mechanism that, when allowed to persist (i.e. chronic inflammation), causes the symptoms we collect into categories and call disease.

In fact, the more perceptive practitioners among us have come to realize, barring trauma, most modern diseases – as defined by symptom clusters, rather than root causes – are nothing more than a variety of different locations and ways that chronic inflammation can be exhibited by the body, as repair fails to keep up with injury.

Simply put, failure of cells to repair is what causes all disease. And that's caused by poor redox signaling, which is partners in degeneration with chronic inflammation.

Cancer cells are the quintessential example of what happens when inflammation persists and cell's distress signals go unanswered. Cancer is believed to take place after a cell has borne the brunt of some 20-25,000 unrepaired injuries to its DNA (i.e. failure to repair/replace).

How inflammation repairs damage

The body uses inflammation to repair pretty much any sort of damage that can happen anywhere in the body – including

- cuts, bruises and overuse injuries;
- damage to bones, muscles, tendons, blood vessels and internal organs;
- infection;
- radiation damage;
- chemical and heavy metal poisoning;
- as well as ordinary wear and tear.

It does this by first increasing permeability of blood vessels so that immune cells like white blood cells can pass through the vessel wall to fight invading pathogens. This also lets more blood into an area, which we call swelling. Furthermore, swelling makes movement painful, thus limiting mobility and further damage.

Inflammation then launches an oxidative attack on everything in the area it doesn't recognize as your own healthy cells. Through oxidation, the first stage of inflammation kills infectious microorganisms, neutralizes toxins and heavy metals, and it destroys your own damaged, diseased and dead cells.

When inflammatory processes are working correctly (i.e. acute inflammation), the first phase of inflammation eventually shuts down and the second phase takes over. In the

second phase of inflammation – the repair phase – unhealthy cells and debris are replaced with new cells and collagen fibers (made from protein and cholesterol).

On the other hand, when inflammation doesn't stop (i.e. chronic inflammation) both phases are active at the same time – destruction and creation. And that's the leading cause of chronic, degenerative disease today – inflammation that doesn't stop destroying tissue.

Acute inflammation vs. Chronic inflammation

There are two kinds of inflammation: Acute inflammation, which is temporary and beneficial, and chronic inflammation, which is persistent and harmful.

Acute inflammation heals and protects you on a daily basis from threats that can damage tissue such as cuts, bruises, infectious organisms, ordinary wear and tear, oxygen deprivation, and toxin exposure. Common occurrences like exercise and sun exposure also turn on inflammation without you ever knowing it.

Through acute, "fast-acting" inflammation, the immune system gets called into action. It wipes out the threat in a matter of hours to days using a four-step process whereby (1) oxidants *destroy*, (2) antioxidants team up with reductants to *neutralize* the oxidant, (3) redox signaling partners with the immune system to *repair/replace* damaged cells.

Then (4) when that process is finished – if everything's working properly (i.e. complete healing and the redox signaling to match) – inflammation shuts down, and the body resumes normal operation.

On the other hand, chronic inflammation is where the same processes get activated, but they are unable to turn themselves off. Step 4 *shut down* gets started, but never gets turned off completely. Instead, the first three stages get stuck in a vicious circle of destroying and repairing cells repeatedly, which can smolder along unbeknownst to you for years or decades.

The reason the immune system is not able to turn itself off after the initial burst of activity is one or more of the following circumstances:

#1 – Overwhelmed antioxidant system

First, some significant insult takes place requiring the immune system to use its oxidative stress tool – often between ages 10-30. This could be a sports injury, a major infection, or an acute poisoning event (like injury resulting from a major round of vaccines).

In this situation, cells don't have antioxidant and reductant reservoirs large enough to neutralize the oxidation being done. So the repairing and replacing of damaged cells is done slower and less completely than it should.

Cells then eke by and reproduce themselves in a partially damaged state, which is frustrated by lingering attempts by the immune system to simultaneously *destroy* with low-grade oxidative stress and *heal* using redox signaling and repair processes.

This smolders along below your awareness until, later in life, your cells are being injured by oxidative stress faster than they're able to heal. At that point, you get symptoms that bother you. But all the while you've had chronic inflammation that only bothered you occasionally (like an old knee injury that hurts only when cold weather returns).

#2 – Unending exposure perpetuates inflammation

The insults that triggered the acute inflammation persist for one reason, or several reasons, to complicate matters. Examples would be

- you continue to eat pro-inflammatory foods like fabricated vegetable oils;
- Corrupted Gut causes poor digestion, leaky membranes, food sensitivities, immune system hyper-activation, and autoimmune conditions;
- you continue to stress that old knee injury with the help of painkillers (or another medication that adds fuel to the inflammation fire);
- you come down with a long-term illness like Lyme;
- or you continue to take in toxins faster than you release them.

#3 – Fewer reductants, diminished redox signaling capacity, and shortage of energy prolong inflammation

As we age, we lose mitochondria. Less mitochondrion mean fewer reductants are made, diminished redox signaling capacity, and less energy for all bodily processes. Plus, the mitochondria that do stick around age with us. Their DNA gets damaged just like ours does.

As our mitochondria age, our once-balanced blend of oxidants to reductants tends to tip toward a surplus of oxidants, and a deficiency of reductants. That pushes us increasingly in the direction of oxidative stress as we grow older. (However, too much of either one – oxidation or reduction – results in unregulated oxidation and cell damage.) In addition, inefficient redox signaling sends unclear messages to the nucleus, which then makes fewer antioxidants.

So in this situation, any sort of severe or prolonged damage can cause the immune system to dump oxidant in an area that the cell's not able to clean up quickly due to a deficiency of reductants and/or antioxidants. As oxidative stress, positive charge, and acidification build up in the cell, the clarity of the message conveyed by redox molecules declines.

From that point on, the immune system's oxidative response becomes its own worst enemy. Oxidant is dumped in the area to start the clean-up process, but the cells don't have antioxidant reservoirs large enough to counteract the oxidation effect.

Full healing never takes place. The immune system senses something's wrong, but it gets confused by the mixed signals and failure of its tools to do their jobs properly. So it continues to promote the destructive component of inflammation as it tries in vain to rebuild as best it can.

Neither side – destruction or healing – is able to seize control while the immune system is caught in this vicious cycle of antioxidant/reductant deficiency and imbalanced/unclear redox messages.

That's how acute inflammation turns into chronic inflammation. And that's how chronic inflammation causes disease: It's the failure of cells to repair or replace themselves efficiently and effectively. Thus cells continue to live and reproduce in an unrepaired state.

Most important, that's a large part of what drives all the degenerative diseases you know by name, including heart disease, arthritis, Alzheimer's, cancer, diabetes, and GAPS conditions.

Repeatedly icing painful joints undermines the healing process

Some people ice and wrap swollen areas of their body to reduce swelling. This interrupts inflammation and shortcuts the healing process. For instance, you'll see many NBA players icing their knees when they're taken out late in a game and don't expect to return.

This restricts blood flow to the area in an effort to ease the pain, maintain their mobility the next few days, and reduce their downtime. But using this trick to keep them in the game and productive often comes at a cost, because it defeats the healing benefits that inflammation is trying to bring to the area.

It makes them feel better short-term so they can continue playing more pain-free during the season. But minute damage tends to accumulate over the course of their hectic schedule and turn into weaknesses and susceptibility. And that leads to injury – both acute injury and the repetitive/overuse variety that often returns to haunt them (1) during their career when they least expect it, (2) later in their career, or (3) later in life.

Insulin triggers inflammation, and redox molecules mediate hormone response

The hormonal system (endocrine system) regulates blood-sugar levels by releasing varying amounts of insulin, which unlock the "doors" that drive sugar into cells. Insulin also causes the liver to store sugar for future use.

When you eat lots of sugar, mitochondria crank out redox molecules as a by-product of ATP production. Problem is, the more corrupted your energy production system gets to be, the more oxidant tends to be made relative to reductant.

That extra oxidant increases the build-up of uncontrolled oxidative stress, which can threaten cells all over the body with oxidative damage, including insulin-producing beta cells in the pancreas.

To protect itself from this rapid burst of oxidative damage, the pancreas is programmed to pump out insulin as fast as it can in order to store that sugar in the liver, instead of burning it immediately and overwhelming the system with oxidants.

Unfortunately, it has the opposite effect. What ends up happening is insulin drives the sugar into cells faster and more furiously, which only increases oxidative stress and inflammation. So basically, eating lots of refined carbs and sugar is similar in a lot of ways to pouring gasoline on a fire. It's a sugar-induced explosion of oxidative stress that can only be controlled (hopefully) by flooding the system with insulin.

This isn't a problem when antioxidant supplies are capable of handling the increased load. But, more and more often, that's not the case as our population loses its healing capacity (yet another coping mechanism stretched to the limit). Thus you've got yet another factor, among many, that increases inflammation.

This is one of several vicious cycles involving redox reactions that elevate and perpetuate inflammation. In this case, with antioxidant reserves exhausted throughout the body, insulin conspires to keep the destruction phase of inflammation going longer than it's supposed to.

In short, frequent high levels of insulin cause the battle between inflammatory *destruction* and *repair* to rage on continuously. Of course, excess insulin also leads to diabetes (another pathway by which poor redox signaling turns into disease).

Disease is made possible by a shortage of cellular energy

Lack of energy at a cell level is involved in the inception and continuation of virtually every disease process. When cells don't get enough energy to function properly, they malfunction. They then react, interact, and replicate improperly. This is one of the root causes of dysfunction and disease, among several interrelated conditions.

That is, cells consume ATP for energy. ATP is made in the cell by mitochondria. So mitochondria are the power plants of the cell. Unfortunately, a large percentage of GAPS individuals are genetically predisposed to having mitochondrial insufficiency.

In other words, they can't make enough energy to satisfy all the demand. And when a resource is scarce, something's got to give. In autism, that often means the body will then rob from "brain function and detoxing" in order to allocate whatever energy it has to "basic life support and gratuitous muscle activity."

To complicate matters further, cells that can't make enough ATP revert to a much less efficient fallback mechanism of fermentation (called glycolysis), which is sugar-based energy production. Energy-starved cells basically resort to consuming sugar in an effort to sustain themselves. And that manifests as sugar and carb cravings, which contributes to gluten sensitivity and candida overgrowth.

Largest energy-consuming processes in the body

If I had to guess, this is how I imagine the body normally allocates its energy:

1. **Basic life-support.** Heart, blood vessels, lungs.
2. **Physical activity.** Muscles and nerves.
3. **Brain function** (5% of body weight, but consumes 20% of the body's glucose).
4. **Digestion**.
5. **Production/rebalancing of biochemicals.** Neurotransmitters and hormones.
6. **Cell replication.**
7. **Fighting infection.** Innate and adaptive immune response.
8. **Muscle repair after exercise.**
9. **Fighting aging**.
10. **Detoxing.** Heavy metals, chemicals, metabolic waste products.

Of course, this is a highly dynamic list that's always fluctuating. The body definitely changes its priorities in response to shifting demands, which makes for occasional conflicts, postponements, and cancellations of bodily processes.

For example, the tummy will put digestion on hold when you exercise intensely on a full stomach. Mental acuity drops in the latter stages of an endurance race when you need that energy to power muscles. And, the granddaddy of them all, the body virtually throws this list on the back burner and activates survival mode when it's fighting a major illness like cancer or the flu.

Point is, quite a few systems and processes are vying to get their piece of the limited supply of energy the body is able to extract from food, air, water, etc. And when there isn't enough to go around, the body has to make compromises. It has to make choices and accept

sacrifices. This comes into play in a big way when a major health challenge chronically restricts energy production throughout the body.

The best example occurs in autism. The factors that combine to cause autism invariably lower energy production throughout the entire body, and increase demand, if anything. You can tell how bad the discrepancy is in autism by how many areas are hit by shortages, and how high up the ladder they go. Nearly every physical and mental process is compromised by lack of energy … and it shows.

What are mitochondria?

Mitochondria are the power plants of cells. They are essential to the life of every multi-celled organism (e.g. humans, animals, plants, protozoa) because they make the only form of energy their host's cells can use – ATP. Cells, mitochondria, and the body also talk with each other via molecules made during ATP production, called redox molecules.

About 200 to 5000 mitochondria live inside most of your cells. They take care of the cell in so many ways (or not). However, they are their own life form (organelles, actually) and possess their own DNA. So they ride along inside each cell, yet they reproduce, live, and die separately from the cells that host them.

Somewhere along the line, eukaryotes (multi-celled organisms) and mitochondria made a deal to work together in a cooperative arrangement. Mitochondria agreed to take up residence inside the cells of eukaryotes, get fed on a regular basis by the organism, and, in exchange, they produce ATP to power our cell's activities.

Basically, the more mitochondria you have, the more energy you can produce, and the more efficiently your cells operate in so many ways. Conversely, depressed mitochondria populations equates to chronic low energy (like chronic fatigue syndrome), poor cell-cell communication, poor cell repair, and accelerated aging.

Unfortunately, mitochondria populations naturally diminish (1) as you age, (2) when their communication network breaks down, (3) when toxins upset them, (4) when the both of you are malnourished, and many other things.

How mitochondria make redox molecules

Animals like us can't access any energy directly from the food we eat. Instead, we need mitochondria, and a number of processes, to make ATP.

First, bacteria and your digestive system have to break down the food you eat. Then, the liver converts those food constituents into two things – fat or sugar. After finding their way into cells (which can be a challenge when you've got insulin problems), mitochondria burn that fat or sugar in the presence of oxygen and turn it into electrons.

As electrons are moved through the electron transport chain to make ATP, the process produces redox molecules as a by-product. Note how many steps there are between the food you eat and fuel your cells can actually use.

Unfortunately, as we age, we lose about 1% of our mitochondria population per year. And with their demise, we lose their energy production and redox signaling capacity. So by the time we're 70, we're down to about 10% of the energy output, and healing capacity, that we had as teenagers.

And since mitochondrial redox molecules are the communication network of cell repair, at least 50% of the aging process is a loss of redox molecules.

Both cell-cell communication networks come from mom

Curiously enough, you inherit all your mitochondria from your mother. They're present only in the egg. There are no mitochondria in sperm. Mitochondria then reproduce as welcome guests inside each new human cell made. So you acquire half your cellular communication ability from your mother in the form of mitochondria and their oxygen redox molecules.

You inherit the other half of your cell-cell communication ability from your mother in the form of bacteria and the carbon redox molecules they make. As described in the chapter "How the Microbiome Gets Established, and How It Gets Corrupted," the microbial starter cultures that seed your microbiome come from mother's birth canal as you're being born (natural childbirth).

Those first bacteria populate the GI tract and make the carbon redox molecules that form the communication network of the microbiome. So as it turns out, fathers are almost useless in the world of communication… on a redox level. Their role happens very much on the periphery of all the action.

The human body has incredible machinery to repair itself, but it's useless without effective redox signaling

Our DNA is the same as it was decades ago. Our machinery for cell repair is the same. Our enzymes for detoxing haven't changed. Everything is the same as it always has been. But they're not doing their job.

It's all sitting there ready to kick into action. But if the signaling network goes down, cells can't protect themselves like they're supposed to. Perhaps even worse, cells don't even realize when they've been injured, let alone call for help.

With our rate of injury so high, and our rate of repair so low, cells are not repairing and replacing themselves like they used to. Our cells are now accumulating toxins and

repeated damage to DNA, rather than constantly rejuvenating themselves, as they're designed to do. So those imperfect cells persist and replicate in an unrepaired state, which we call aging.

The smartest scientists in the field said it couldn't be done: Stable redox molecules outside the body

Thousands of researchers have been studying redox reactions in earnest for the past 10+ years. There are now some 100 scientific papers being published in peer-reviewed journals each month on the subject of redox reactions, representing about 300 months' worth of research coming out every 30 days.

And the prevailing opinion was that it couldn't be done: Redox molecules stabilized outside the body. Reason is, when mitochondria make reactive oxygen species, they only live a fraction of a second. They're so reactive they bond immediately and they're gone. So the idea of stable redox molecules, in any way, shape, or form, was preposterous to the researchers who would know.

But that didn't keep one adventuresome startup company from trying: Unfortunately, after 12 years and $15 million dollars of research, the best they could do was keep oxygen redox molecules stable for ten minutes. But that wasn't long enough to make a viable product people could benefit from. They went bankrupt.

With a good head start, Gary Samuelson, Ph.D (medical atomic physicist) did the impossible: Having access to the first team's research materials, Dr. Samuelson took 18 months to come up with a method to keep oxygen redox molecules stable for well over a year.

At a half-life of two years, Samuelson created a viable product that could actually help people. The product, called Asea™, was launched in 2010 as a network marketing company. It was the first redox signaling molecule supplement of its kind.

Diversity of species and fluent communication gives the microbiome its strength and resiliency, not the absence of pathogens

So this is one of the rare cases where the alternative/holistic crowd, and the conventional medicine crowd, are both going to discover they were close to the truth about the microbiome. However, they were both off-base just a little bit with their beliefs and therapies, because they lacked crucial pieces of information.

A few years from now, people are going to realize all practitioners in the 90's and early 2000's made a number of incorrect assumptions about why gut dysbiosis compromises your health and indicated certain treatments.

To give you some idea what happens when you're in the right ballpark, but you're not quite hitting the nail on the head, let's look at a few of the popular approaches practitioners have used to improve digestive health in the decades leading up to said discoveries… and how they've worked out.

The long-term benefits of digestive remedies has been disappointing (e.g. probiotic supplements, acid blockers, acid supplement (HCL), and digestive enzymes)

When probiotic supplements first became popular in the 1990's and 2000's, clinicians thought they'd do a lot more good for people than they actually have. Eager to use this promising "new" healing tool, practitioners of all types recommended that their clients take probiotics to rebalance their gut flora and reverse their chronic conditions.

But the results have been mixed. Many would say their pathogen overgrowth like candida seemed to recede while taking the probiotic. Many would say their symptoms subsided and they felt better for a while, but not necessarily well. Clinically, a modest percentage of people in the thousands of studies showed marginal results.

Supplements may have helped a good number of people, a decent amount, for a reasonable amount of time. But most would say, probiotic supplements don't get your gut anywhere near fully healthy as a standalone or complementary treatment.

They haven't met people's admittedly high expectations when the theories were first raised in public. Probiotics weren't the complete solution people were looking for. And the probiotic brand/formulation they took is partly to blame for the disappointing results.

That is, impotent probiotics (for whatever reason) can only give you limited benefits. But probiotics made from wild sources will naturally have wider diversity (which, like all naturally-sourced supplements, can't be quantified on the label the way synthetic/processed supplements can). Wild-sourced probiotics can get you much closer to the results you would hope for.

Digestive enzymes, HCL, and acid-blocking drugs have shown similar results

They've shown decent utility among many folks. But none of these has earned a reputation as a go-to solution for flawless digestive health. Reason is, probiotic supplements, acid blockers, acid enhancers, and digestive enzymes are attempts to solve the wrong problem. They're close. And you may get decent results being in the right ballpark.

But restoring cell-cell communication looks like it's more valuable to the microbiome than simply driving pathogens out, or covering up symptoms for a while. Diversity appears to be what the body's looking for, even over strength of individual bacterial strains.

In contrast, almost all commercially-produced probiotic supplements are made from a very limited number of species of bacteria (usually 2-7, sometimes as much as 24) originally taken from cow intestines and cultured in isolation. Problem is, those bacteria are not prevalent colonizers of the human gut due to vast differences in pH, digestive enzymes, and overall design (four stomachs instead of one).

But as crazy as that sounds to be ingesting cow bacteria, they can provide some benefit for a really screwed up microbiome that's filled with weeds of the gut (e.g. candida, klebsiella, pseudomonas, E. coli). They can do some of the things our native bacteria do. But nowhere near the whole shebang of systemic benefit we rely on to have complete health.

Bottom line: It's better to get the biodiversity back in the microbiome than the artificial environment of (most) probiotic supplements, digestive enzymes, acid enhancers, or acid blockers.

Wild ferments are the exception to the rule

Most store-bought fermented foods such as yogurt, sauerkraut, and kimchee are made from a very limited number of bacterial species added as starter culture (usually one species). This applies pressure to the microbiome to narrow its diversity of species.

Yogurt's the naughtiest one here due to its very limited number of bacteria species (usually one species), high sugar content, casein, and bare minimum fermenting time. Plus, yogurt's digestive benefits tend to be greatly oversold by food companies, giving you a false sense of security.

In contrast, you don't add any starter culture to make a batch of wild fermented vegetable. You simply let the microbes that found their way on to the surface of the vegetable do the work. So you may get hundreds of potent, soil-based microbes to join the party.

Bottom line: Wild fermented veggies – great for you. Standard fermented veggie products – good for you. Conventional yogurts and fermented dairy products: generally neutral overall to detrimental.

Bacteria use carbon redox molecules as both a communication network and a nutrient-rich soil

Bacteria need to communicate with each other, the gut lining, and surrounding organ systems (like the gut associated lymphoid tissue, or GALT), to let their needs be known… almost like they function as one organism (hint, hint).

But bacteria don't have mitochondria. So they make their own communication network comprised of redox molecules with a carbon backbone, instead of mitochondria's oxygen-based redox molecules. Produced by bacteria's metabolism, these carbon redox molecules send and receive information related to the wellness or sickness of various cells in the microbiome.

All signaling between microorganisms happens through carbon redox molecules, thus the awesome intelligence of the microbiome is transmitted through carbon redox molecules. Rich in minerals, carbon redox molecules also provide the nutrients that feed bacterial growth.

So bacteria take care of the health of the microbiome, the gut, and the entire organism through their communication network of carbon redox molecules. Carbon redox molecules are the microbiome's greatest strength when diverse and fully fluent. Conversely, they're the microbiome's glaring weakness when depleted and uncommunicative.

How bacteria make and use carbon redox molecules

Each of the tens of thousands of bacterial species makes its own family of about 10-15 distinct carbon redox molecules, resulting in hundreds of thousands to a million unique variants of these carbon redox metabolites.

Dubbed "carbon snowflakes" due to their extremely varied molecule structure reminiscent of conventional snowflakes, carbon redox molecules are both a communication medium for cell-cell signaling, like a smoke signal. And they're a source of minerals for microbiota to grow in, like compost-rich soil for gut flora.

Each type of carbon snowflake has its own specialized role to play in the language of cell-cell communication. Like words of a language, each variant may communicate a slightly different message, be used for slightly different purposes, and do things others can't.

That fluency permits an unimaginable variety of messages to be transmitted and interpreted loud and clear. For instance, rare species of bacteria, possessing their own unique abilities, may communicate using their own family of scarce redox molecules.

When those redox messengers are present, depleted populations realize they're endangered and can then send out a signal to neighboring species requesting space in the microbiome to grow. Other species give them that room, and they go into rapid replication mode.

But if that redox smoke trail is absent, those bacteria (and the group) can't tell how many others of their species are living in the gut (it's a big place to them). And without any way of talking amongst their family, they're not able to sense when their kind are depleted and need to repopulate. Hence, they stay an endangered species, or go extinct. That's one of the main mechanisms by which diversity in the gut has plummeted.

On the other hand, when probiotic bacteria sense an overgrowth of pathogenic microbiota like candida, they'll sound the alarm for the whole probiotic team to start making more anti-microbial compounds (anti-fungal, anti-viral, anti-bacterial, etc.) to knock the bad guys back.

Those are two of the most important functions of carbon redox molecules – supporting diversity of beneficial bacteria, and suppressing pathogenic microbes in the microbiome.

However, when you lose biodiversity in the microbiome, you lose that fluent communication our microbiomes once had many decades ago. Like a cell phone with poor reception, bacteria then can't talk to each other and figure out what they or the group need.

Bacterial redox molecules are also the nutrient medium from which microbiota receive minerals to grow. Like compost of the gut, carbon redox molecules are the bacteria's broken down food particles that feed biology in the gut ecosystem.

The human digestive tract used to host about 20-30,000 species of bacteria

This booming ecosystem in a healthy person once contained the biodiversity you might see in a coral reef or thriving rain forest. However, all the questionable choices we've instituted as a society, and as consumers, have taken a huge toll on that variety and balance. Assailants include

- chemical fertilizers,
- herbicides like glyphosate,
- antibiotics in meat and medicine,
- pharmaceuticals like NSAIDS, birth control pills, and steroids,
- heavy metals and other toxins in personal care products, and
- processed foods.

So today you'd be fortunate to have 10,000 species. This was demonstrated by a 2010 NIH study to map the genome of the human microbiome. It took 44 participants to reach 10,000 species of bacteria.

That narrowing of species has put an enormous dent in the microbiome's ability to protect us from tight junction injury and toxin exposure, as well as take care of the gut, which then takes care of the rest of the body.

Lack of diversity in the microbiome starts with lack of diversity in the soil

For millennia, traditional farming techniques supported diversity in the soil through natural fertilizers (e.g. manure), polyculture crops, crop rotation, and composting. But nowadays, Big Ag is fond of growing one type of plant on a plot of land over and over, using inorganic chemical fertilizers, applying crop amendments like glyphosate, in an increasingly lifeless growing medium – and worse. All this destroys microlife in the soil.

That broken ecosystem in soil then gives the plant fewer nutrients and more toxins for us to ultimately receive. Fewer nutrients in plants mean fewer nutrients for our beneficial bacteria to feed on. That means the rare bacteria which are skilled at digesting rare trace minerals for us – they get malnourished and neglected.

So with nothing to eat – (1), handicapped awareness they're endangered – (2), and us ingesting fewer microbes because of our germaphobic culture – (3), rare species of bacteria are under a lot of pressure to disappear from our microbiomes.

Meanwhile, animal antibiotics and human antibiotics positively devastate our microbiomes directly. Then all the other contaminants in our food, air, water, medicine, and personal care products annihilate all the less resistant microbiota.

Beneficial bacteria are your front line of defense against tight junction injury

Your good bacteria protect you from tight junction damage by gobbling up toxic peptides, and other toxins, before they've had a chance to make zonulin. They control pathogen populations that further stimulate zonulin production (like candida). And they increase production of the DDP4 enzyme that breaks down zonulin after it's been made.

Good bacteria nourish and protect the enterocytes that line the gut wall. They reduce inflammation and immune activation in the GALT. Their redox molecules provide the minerals that help rare species of probiotics proliferate. And, let's not forget, diverse species of bacteria create the carbon redox molecules that are the communication network of awareness, defense, repair, and replacement amongst microbes in the gut.

Every protective membrane in the body is tied together by tight junctions (e.g. gut, brain, blood vessels, kidneys, liver, and more)

Membranes. Membranes are a specialized layer of tissue just one cell thick that acts like a firewall between the outside world (pre-absorption) and you (post-absorption). At just 50 microns, or about half the thickness of a human hair, they fulfill barrier functions against toxins, as well as nutrition, hydration, and detoxification roles, by actively keeping harmful things out, while letting beneficial things through.

Every membrane in your GI tract is protected by these dynamic, intelligent membranes that run from your sinuses and mouth, to your throat and stomach, through the small and large intestine, all the way out your rectum. In fact, virtually every major organ in your body relies on a membrane to separate its innards from its "outards."

Tight junctions. Just as important, every cell in every membrane is held to its neighbor by a set of interlocking protein fibers called a tight junction. These cross-linking fibers remind one of Velcro, because they have the ability to open and close whenever the immune system needs to send its forces through the membrane to fight off a threat on the other side.

Tight junction intelligence. That ability to open and close on purpose is what gives membranes the intelligence it then loses when tight junctions are damaged by toxins that stimulate zonulin production.

Cells communicate through tight junctions. Like fiber optic cables connecting neighboring cells, tight junctions are wiring through which cells talk to each other. That means breaking tight junctions "cuts the cord" between cells and organs that need to talk to each other about inflammation, health status, stressors like toxins, nutritional status, etc.

Zonulin is the naughty substance that dissolves tight junctions when it's allowed to run amok. The gut wall makes excessive amounts of it in response to the presence of glyphosate, gluten, cholera, clostridium difficile, and/or candida.

More than any other toxin, it's directly responsible for billions of people now suffering from leaky gut, leaky membranes, chronic inflammation, GAPS conditions, and chronic disease. Sad thing is, probably 95% don't know it.

Sources of tight junction damage

The biggest threats to tight junctions and human health today (by potency and prevalence) are glyphosate (active ingredient in pudnuoR), gluten (its breakdown product is gliadin), NSAID pain-killers like ibuprofen, pathogens like candida, and steroids.

Tragically, they're everywhere. Take the most damaging of them all – glyphosate. It's the active ingredient found in the vast majority of herbicides in use commercially and residentially throughout the world. So it's in our soil. It's in our drinking water. And it's in organic food.

It's in our blood. It's in our breast milk. And it's in our urine. You can't avoid it. In fact, recent reports say 75% of rain falling on the planet is tainted with harmful levels of glyphosate.

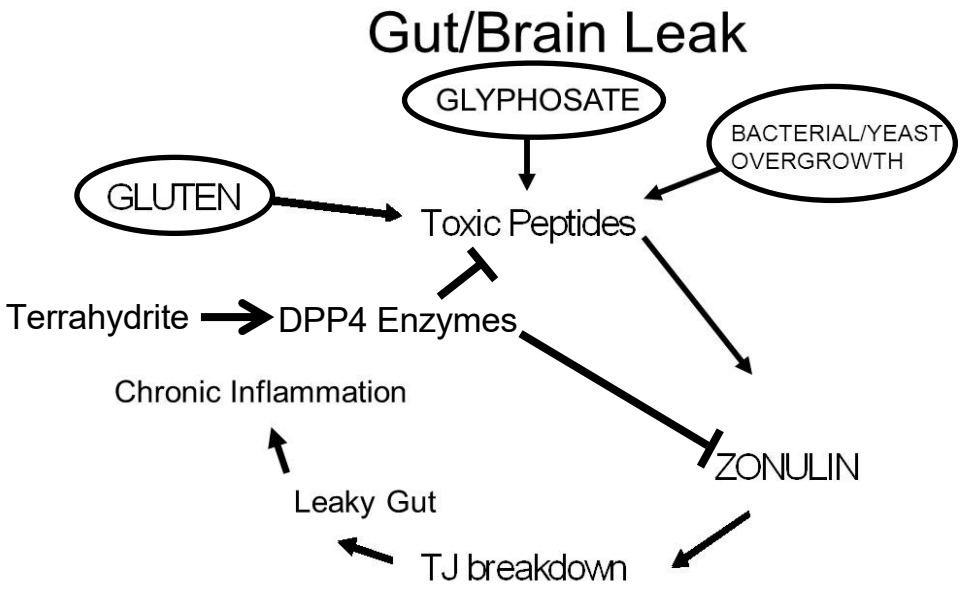
And we have the US Environmental Protection Agency to thank for setting up the rules and regulations that permit (condone) that reckless assault on the health of every man, woman, and child presently being exposed. It's a horror show of big corporations and government agencies in cahoots we each other.

One instance: Already toxic beyond question, in 2013 alone, the US EPA passed a 30-fold increase in allowable limits of glyphosate on many food crops in the US – all because glyphosate does wonders for the bottom line of those involved. More incriminating evidence to come.

Dr. Zach Bush on *how you can tell if you've got a leaky gut*

> *"If you've got a gut, and you live on planet earth,* ***you've got a leaky gut****. That's pretty much where we're at right now."*

How glyphosate and gluten cause leaky membranes, chronic inflammation, and degenerative diseases



(Graphic used courtesy of Dr. Zach Bush)

The diagram above illustrates the pathway through which toxins in the diet, and pathogens in the gut, trigger a cascade of events that breakdown tight junctions, turn membranes leaky, induce chronic inflammation, and cause dis-regulation and disease throughout the body.

First, gluten (gliadin), glyphosate, and pathogens like candida introduce toxic peptides that make the gut mucosa produce large amounts of zonulin. This zonulin dissolves tight junctions in the gut wall that would normally keep it virtually impenetrable to inappropriate material.

That's what causes leaky gut. That leaky gut then leaks zonulin into the bloodstream, which goes everywhere. Zonulin proceeds to attack membranes all over the body, resulting in leaky blood-brain barrier, leaky blood vessels, kidney tubules, liver cells, and more.

Meanwhile, just behind the gut wall sits the gut associated lymphatic tissue (G.A.L.T. for short) which makes 80% of the immune system's antibodies – which is why they say some 80% of your immune system is located in the gut. Broken tight junctions expose the GALT to every inappropriate substance that enters the digestive tract.

This irritates the lymphatic system, which exhausts its antioxidant reservoirs, dis-regulates the immune system, and unleashes chronic inflammation. And, as just discussed, unrelenting inflammation drives all degenerative diseases, most notably ADD and GAPS conditions.

Immune system irritation in the nose creates seasonal allergies

When you have intact membranes in the sinus passageways, you can breathe pollen and pet dander all day long and not have any problems. But when broken tight junction cause faulty membranes to let allergens into sinus tissue inappropriately, the immune system overreacts.

Responding to the intrusion, the immune system in the sinuses releases antibodies to fight the foreign matter, which triggers the release of histamine. That's what we call seasonal allergies. Of course, conventional medicine combats this effect by blocking histamine, which is the symptom, not the source.

Other devastating effects of tight junction injury and leaky membranes

A core component of Corrupted Gut, *tight junction injury* spreads toxicity, imbalance and dysfunction throughout the body. This shows up as a loss of integrity/intelligence to membranes, dehydration, nutrient deficiency, and loss of cellular communication.

Collecting and directing fluids where they need to go: The second way leaky membranes harm cells is by dehydration. When membranes lose their selectivity over what they let through vs. what they block – when membranes lose their intelligence – they lose their ability to control where the fluid you drink goes in the body.

You could be drinking your recommended 8 glasses of water a-day. But if the colon can't pull water out of the food you eat properly, distribute it to cells via the bloodstream, and get it into cells the way it should – all tight junction dependent – you could suffer dehydration in the cells. At the same time, water is the vehicle by which nutrients are taken into cells. So **lower water volume also restricts the flow of nutrients in, and toxins out.**

Mitochondrial insufficiency lowers electrical charge: To make dehydration worse, when redox molecule production in the mitochondria slows down, the cell loses electrical charge. Electrical charge is what pulls water into cell. So as mitochondrial activity goes down, dehydration goes up inside the cell (where it counts).

Nutrient overload and nutrient starvation: Another way tight junction injury harms cells is by nutrient deficiencies and toxic overload. Every type of cell has different nutritional needs.

For instance, muscles may need more proteins (as amino acids). Nervous system cells love fatty acids and cholesterol. Thyroid cells are big fans of iodine. And liver cells can use all the antioxidant vitamins they can get. Point being, cells are picky about what they like and what they don't like.

As a result, leaky membranes cause a surplus of nutrients for some cells that can become toxic to them in excess, while others starve downstream because they were supposed to get those nutrients delivered to them. So no one's happy when membranes fall apart.

Fortunately, Nature stored the antidote to man's own self-destruction in the ground beneath our feet

In 2012, William Vitalis showed Dr. Bush a white paper about soil science in the hopes they could find out why roughly half of Dr. Bush's patients responded well to an aggressive food-based diet, while the other half didn't get better, or even got worse.

As Dr. Bush flipped through the pages, a molecule jumped out at him that looked like the compounds he had been researching involving mitochondrial communication – only this one was carbon-based, rather than oxygen-based. The molecule looked like it had greater redox signaling potential. And it looked like it was significantly more stable than the molecules he had been researching.

Might this have been used for cell-cell signaling by whatever made it? Might it be useful therapeutically if they could find out how to make it and keep it stable? Long story short, it took his group two weeks to find out the molecule found in soil was indeed made by a bacteria … and it definitely had redox potential.

This led Dr. Bush to the astonishing conclusion that bacteria make their own communication network with by-products of their own metabolism. Namely, they make carbon-based redox molecules when they digest their food.

Now a big piece to the whole picture is bacteria are prokaryotes. That means they don't have mitochondria. So they can't communicate using mitochondrial (oxygen-based) redox molecules. However, bacteria still need a way to communicate with each other and their host's cells.

So both in soil, and inside you, they use their own metabolic end products to form their own communication network, which are carbon redox molecules. That's how they talk to each other in the same way that mitochondria send and receive messages using their metabolites – oxygen redox molecules.

In other words, the molecule depicted in the white paper led Dr. Bush to the stunning revelation that bacteria have a communication network, first of all. And it's the same whether the bacteria live in soil or in a microbiome (whatever creature that may be).

This was a brand new idea to medical science. The field was already studying mitochondria and their redox signaling molecules into oblivion. But bacterial redox molecules had yet to be discovered and studied as such. That begged the investigation into what carbon redox molecules are designed to do, and what they potentially could do when put to good use.

Dr. Bush's team invented a way to make carbon redox molecules

Turns out, each bacteria species makes its own family of these carbon redox molecules. So when you have an ecosystem as diverse as that found 200 years ago, before industrialization, there might be upwards of a million variants of these signaling molecules.

Knowing it would be darn near impossible to find someone today with a perfect microbiome, Dr. Bush set off on a quest to find soil that had the diversity he was looking for, yet hadn't been tainted by modern pollution.

That ruled out wet climates, and all soil exposed to today's atmosphere. So he ended up finding sediment buried under the desert southwest of the United States to find the highly compressed, now fossilized remains of soil. Dating back 50 million years, this layer of "terrahydrite extract" is 8 feet thick and biologically inert when it's pulled from the ground.

He took that carbon-rich sediment to back his lab, and a colleague of his taught him how to reanimate its bioactivity by restoring the mineral ratios and amino acid balance the soil once had back to that of living soil.

When he did that, voila, the oxygen and hydrogen binding sites the carbon molecules use to communicate with regain their biological activity. What's more, the compound stays stable. So finally, here was the very same signaling system bacteria use to communicate with each other – in a bottle, and shelf stable. Think of what it could do.

Redox communication in action

First order of business with any new substance intended to heal people is to test it for toxicity. So Dr. Bush put the compound through the industry standard test.

He applied the compound to kidney tubule cells and was amazed (but not really surprised) to find out it's one of the least toxic substances ever discovered, considering how biologically active it is (i.e. potency). It's far less toxic than water. You can drown in it,

but exposure to ridiculously high concentrations just makes extremely sensitive cells live longer.

Next thing he did after getting carbon redox molecules stable in a bottle is he went straight to his lab to see what the compounds did to cancer cells, because that's his background. At this point, he wasn't thinking about what this discovery might mean to the microbiome and systems that depend on it.

After exposing cancer cells in a petri dish to these stabilized carbon redox molecules, Dr. Bush saw a burst of reactive oxygen species shooting out from the mitochondria, which means the need for more oxidation was detected and deployed. Then he put the compound on healthy control cells and the exact opposite happened: their ROS production went down, which means less oxidation was needed and produced.

In other words, if cells were healthy, the immune system turned down the stress load placed on them by oxidation, which is destructive. But if cells seemed to be hurting, more potent healing mechanisms were deployed to accelerate repair and replacement of cells (i.e. turned destruction up).

This shocked and amazed him and his team even more than the toxicity test, because it was the first time anyone had seen one supplement produce two completely different reactions based on how stressed the cells were at the moment, and what they actually needed.

He points out Restore™ does not treat cancer, or any disease for that matter. Instead, it re-establishes the redox signaling network by which bacteria communicate, proliferate, and support the health of the gut. And that helps the body heal itself.

Dr. Bush makes a connection with monumental implications

The carbon redox molecules he and his colleagues were able to stabilize in the lab were the very same molecules that bacteria use to communicate with each other and our own cells. Mitochondria do this with similar molecules they produce. So bacteria must be doing the very same thing with their carbon metabolites.

Further study has revealed this is indeed the case: Bacteria use these carbon molecules for cell-cell signaling. And the diversity found in ancient ecosystems can be supplied as a supplement. Keep in mind, in 2012, the concept of stable, renewable carbon redox molecule were brand-new to the literature.

Eventually the magnitude of the discovery hit him: This could have monumental implications to the health of people around the world, on every level imaginable –

individual microbes, microbiome, systemically, family, healthcare system, society, and planetary population.

Dr. Bush then asked a seminal question: *"What happens if we stop trying to micro-manage and over-engineer our gut bacteria (with probiotics, etc.), and instead just give back the cell-cell signaling the gut is supposed to have?"*

Answer: Put the communication network back in and immediately everyone knows what the other one needs. Restoring the redox signal communication network dramatically increases the body's fighting, coping, and recovery mechanisms. The compound literally turns the clock back many years to decades on your body's ability to heal and protect itself from injury.

The carbon redox molecule supplement now called "Restore™" (generically called "terrahydrite") completely blocks tight junction damage all over the body. Toxins are blocked from getting in. They're neutralized in the gut probably 10 to 50 times better. Toxins can be collected in detox organs and eliminated properly. And the strength of the microbiome is revived. All it takes is fluent communication to make it all work again.

Restore™ (for bacterial communication and gut health) does at least six things to repair tight junctions and create a thriving ecosystem in the gut

1. Breaks down toxic peptides that trigger zonulin production.
2. Breaks down zonulin itself.
3. Restores proper balance of minerals in the microbiome so enzymes can work.
4. Restores the communication network between bacterial species.
5. Increases glutathione production 1200% in the gut.
6. Increase stem cell activity by 30% in the gut.

The carbon redox molecules in Restore™ enable the thousands of species of bacteria to talk to each other and the immune system. That helps create balance and diversity in the microbiome, which creates a cascade of positive protective and restorative effects to happen in previously corrupted systems.

Fluent communication between bacteria lets them first become aware when beneficial species are depleted (particularly rare species). This makes them go into rapid replication mode, bringing balance back to a previously Corrupted Gut. For instance, fluent communication system makes the group aware when pathogenic microbiota have overgrown, so they can produce more anti-microbial compounds to drive pathogen populations down.

Restore™ also rebalances the mineral composition of the microbiome to that of a healthy gut – somewhat like a bio-friendly fertilizer for the microbiome. This makes micronutrients available for the production of enzymes that drive most cell activities.

Finally, Restore™ increases breakdown of toxic peptides that stimulate zonulin production – before zonulin is ever made. And it breaks down zonulin after the gut lining makes it. These actions and reactions give the microbiome the resources it needs to overcome communication blocks, a broken ecosystem, and tight junction injury.

The microbiome can then revive its balance and numbers from the 5-10,000 species it now has, to something closer to 20-30,000 species people used to have. Our microbiomes then have the tools to prevent or repair injury from the most damaging tight junction toxins known to man – glyphosate, gluten (gliadin), NSAID pain killers, and steroids.

Two more mechanisms by which terrahydrite cleanses and repairs: When terrahydrite touches the wall of the small bowel, there's a 1200% increase in glutathione production in a matter of hours, which is the body's most powerful antioxidant. Last but not least, one tablespoon of terrahydrite increases stem cells activity by 30%.

Bottom line: When the gut has what it needs to thrive – that is, when man gets out his own way and lets Nature do what it's designed to do – the body's innate intelligence knows what needs to be done, and it has the machinery to do it. Restore™ helps do that while toxins are an unavoidable part of our lives.

Plants love Restore™

Not unexpected, but still fascinating to watch, Restore™ actually makes plants grow quite a bit faster. When you feed Restore™ to plants, their growth accelerates. Indeed, this is exactly what we would expect, considering the raw material in Restore™ is the very same medium of bacterial communication that helped ancient plants grow abundantly once-upon-a-time.

Stable redox molecules in supplement form are a major leap forward in human health

Restore™ rejuvenates gut health

Using Restore™, you can keep every membrane in your body perfectly protected from tight junction injury. This seals your gut lining and helps it heal. You can keep toxins out, and make toxins leave. You can improve hydration and nutrient absorption. And you can reduce the chronic inflammation that leads to dysfunction and disease.

Simply put, when you have strength of diversity in your microbiome, a lot of health problems go away, and are replaced with excellent mental and physical fortitude.

Of course, you still need to eat well

Dr. Bush and those involved in redox science are quick to point out that having immaculate tight junction protection is not a license to eat horribly. You can't just eat anything you want and hope to stay in excellent health for very long.

You still need to eat nutritious food, and avoid exposure to injurious substances, in order to keep your rate of healing up, and your rate of injury down.

The field of redox science has only just begun

The last 15-20 years of research into redox reactions have propelled medical science into new paradigms of healing, repair, and optimal aging. As a result, DNA and genetics are now believed to play a much smaller role in those processes than previously thought.

Over the last 4-8 years, medical scientists Gary Samuelson, Ph.D, and Dr. Zach Bush have successfully learned how to stabilize redox molecules and present them as supplements to the universal benefit of many thousands now taking Restore™.

The field has learned a great deal in the last 15 years. Yet everyone agrees, the majority of discoveries in the field of redox reactions have yet to be made. This is only the tip of the iceberg in understanding how redox molecules work, and in harnessing their ability to defend, heal, balance, and power our bodies.

The implications of redox science are staggering, as we can begin to see from a new discovery:

Scientists recently discovered something new about the gut that amazed, but didn't surprise, them

They found out that neural dendrites, which are remote extensions of the brain, actually poke through the lining of the gut, and hang out amongst the bacteria in the microbiome, without a membrane between them.

Presumably the brain and nervous system are literally reaching out into gut's ecosystem with nerve sensors to gather information about what's happening in the GI tract. **So it's possible that carbon redox molecules convey messages to the brain through these neural dendrites about the gut's inhabitants, its contents, and the condition of its cells.**

That's likely to be one of the reasons Dr. Zach Bush is seeing such rapid improvements in brain function when his redox molecule supplement Restore™ seals up the gut wall and

rebalances the microbiome – including improvements in concentration, sleep quality, memory, and brain fog when taking Restore™.

Terminology

Elements of the "oxidation-reduction" cycle in the rapidly emerging science of Oxidative Medicine, or Oxidative Sciences – now called "redox" in many instances:

Oxidation-reduction: Simply put, oxidation and reduction describe the exchange of electrons.

Electrical charge: Electrons are negatively charged. So *removing* electrons through oxidation increases positive charge and acidity, while *adding* electrons through reduction/antioxidant activity does the opposite – it increases negative charge and alkalinity. This is important because most pathogens, toxins, and free radicals are in their comfort zone when positively charged and acidic, while antioxidant activity fights those threats by donating electrons, thus increasing a molecule's negative charge and alkalinity.

Oxidation is the "stealing" of electrons from a molecule – or an *increase* in the state of oxidation. So molecules with the propensity to oxidize substances are called "oxidants." To illustrate, when oxygen takes electrons slowly from iron, that's a form of oxidation we call rust. When a flammable material burns or explodes – again, with oxygen – that's oxidation happening rapidly right before your eyes.

Oxidants, aka reactive oxygen species: In biological systems, oxidation destabilizes the matter inside cells by stealing their electrons, which makes them blow apart in a hurry unless they find an electron to pair up with and zero out their charge. For that reason, oxidants are used by our immune systems as the ultimate antimicrobial, detoxifying agent.

Most oxidants, as the name would suggest, are predominantly oxygen-based molecules, so they're called "reactive oxygen species" (ROS). Nitrogen and sulfur also form their own less-common reactive species. Oxygen, hydrogen peroxide, ozone, and chlorine dioxide are some of the best-known oxidants in the functional medicine field.

Free radicals: When a molecule with a balanced pair of electrons loses one of those electrons due to oxidation, the resulting molecule can become a "free radical" because of its extra, unpaired electron, which is highly reactive and potentially damaging to cells. Its destructive effect on cells is why the public was taught to fear free radicals in the 1980's-

2000's, and why we were instructed to get plenty of antioxidants to combat free radical damage.

Reduction is the opposite of oxidation. It's the giving of electrons, or a *decrease* in the state of oxidation (hence the term "reduction").

Reductants: Molecules that give up their extra electron in chemical reactions are called "reductants" (even though that sounds backwards), or Reduced Species (RS).

Antioxidants are tiny molecular catalysts that make oxidants give their extra electron(s) to reductants, thereby neutralizing (balancing) them both of electrical charge and biological reactivity. The body's naturally-produced antioxidants such glutathione can perform tens of millions of these reactions per minute. Reactive oxygen species and reductants then turn back into salt water (from which they came).

Redox: Not too long ago, redox scientists realized that saying the words *oxidation, reduction,* and *reactive oxygen species* out loud made them sound like nerdy chemists who use big words to confuse or impress people. So they came up with a cooler sounding umbrella term to describe the players and processes (e.g. redox molecules, redox reactions).

The field swapped and shortened oxidation-reduction to "redox," which is short for REDuction-OXidation. And it seems to have a ring that's right for the mainstream.

Redox molecules: Reactive oxygen species (ROS), and reductants/reduced species (RS), are collectively called "redox molecules" or "redox signaling molecules." Redox molecules are by-products of metabolism that (1) mitochondria use to support cells in many ways, or that (2) bacteria use to support the microbiome.

Mitochondrial redox molecules: Without the concentrated heat of a conventional fire, mitochondria burn fat or sugar in the presence of oxygen to make ATP to fuel cells. This produces oxygen redox molecules as a by-product.

Otherwise known as "metabolism," aerobic exercise dramatically increases the need for, and rate of, this process. Made principally of oxygen, mitochondria's *oxygen redox molecules* are the communication network between mitochondria and human cells.

Bacterial redox molecules: When bacteria metabolize food, they spit out their own variety of redox molecules as a by-product. Made principally of carbon with about 17 potential binding sites (representing its signaling capacity), each of the tens of thousands of bacterial species makes about 10-15 different varieties of these carbon-based redox molecules.

Oxidative stress: Oxidative stress is the amount and duration in which oxidants outnumber reductants. Oxidative stress can be damaging when insufficient antioxidants and reductants are available to neutralize the oxidants – particularly, in chronic, uncontrolled circumstances. Oxidative stress can be beneficial when used therapeutically.

Tight junctions are the filaments that normally hold the cells of all our membranes together and keep unwanted things out. They also open and close on-demand to let authorized things through. However, when tight junctions become damaged, they stay open and let unauthorized substances through, causing myriad health problems.