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Biochemical Health: Reduction and Oxidation

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(Transcribed by Giraffe and Burtlancast)

JB - John Barkhausen
RP - Ray Peat

JB: *Today we're gonna be talking about human health and the physiological implications of some of the chemical processes that happen in the body, namely reduction and oxidation, and some of the other factors. My guest today is Dr. Raymond Peat. He has a PhD in biology and speciality in physiology. Ray, do you want to add anything to that?*

RP: Yah, when I was studying for my degree at the University of Oregon, I got interested in oxidative processes as they relate to aging. And I've been thinking about what oxidation means, and all the ramifications, for 40 or 50 years. And still, I'm curious how it really works.

JB: *I see, so it's an ongoing scientific endeavor, I suppose, understanding it ?*

RP: Yah, the idea of electrons moving around in matter, that's one of my longest-standing interests (i think, I struggled since I was a little kid, probably). But I am still not satisfied that anyone knows, what an electron is, or how it works. But without knowing that, you really don't understand what's going on in oxidation, reduction, pH, free radicals, and so on.

JB: *Maybe you could give us a little sense of the history of people trying to understand biochemistry? How did it all start, do you think?*

RP: Oh well, the famous first demonstration that life processes are material chemistry was when a guy synthesized urea. And people had believed that that was maybe done by something special in the life process, that couldn't be imitated in the real, inert world. But just heating, I think, ammonia and carbon dioxide (i don't remember the exact chemicals)...But it was demonstrated that you can make urea simply mechanically. So people started thinking about the chemical processes that make up life and gradually getting away from the idea that there is something unique about the life process that is distinct from chemistry.

JB: *I was just reading about.. There was some Swedish person - Is that correct? - who figured out urea?*

That was around the revolutionary war in 1760 something. But people must have experimented with bodily fluids before then. Was there much research done?

RP: In the 18th century people were really figuring out a lot about how organisms work. But the official science, the stuff that got published and approved up by the government, that was a very slow process that was usually a hundred years behind the people on the ground who were really thinking about [how things work].

JB: *Science for a large part was actually a private affair done by usually wealthy people sometimes? Not always, I suppose, but...*

RP: Yah, the rich cranks... [Ha-ha]. So they often put their particular philosophical or religious bent into the physical ideas. And it was because of that personal quality that science was really more literary and interesting and artistic before the universities took it over. And gradually, in physics, I guess, the universities took control of it away from the cranks and the rich guys in the mid-19th century. And that was the physics that Einstein, for example.... The leading academic physics was being done in Germany, and Einstein being Jewish, resented the authoritarian dogma of the professors. So he invented something that outwitted the authoritarian physics establishment.

JB: *He sure did. That sorts of reminds me of what the general law of institutionalization, that I am making up here on the spot, but it seems like it takes the interest out of most fields, once it gets franchised like that. Religion, I think used to be more of a personal experience before the church took over. It sounds like it's the same with science.*

RP: Yah. I think, Einstein himself succumbed somewhat to the authoritarian attitudes in the case of saying what an electron is. And 30 years later, I think he regretted having set things in motion in that particular direction when he never accepted the quantum mechanics view of reality as based on randomness. But he was largely responsible for setting that in motion with his theory of the photoelectric effect. And the idea of the electron as a discrete particle interacting with a proton as a discrete particle was the key idea in that photoelectric effect.

A photon of a given energy would dislodge an electron from the solid state, giving it a certain voltage. So you can talk about the electron energy or voltage of a given frequency of light. That particularized, or atomized the idea of both light and electrons. And that's something that allowed theory to take over and cover up and reject a lot of empirical factual observations relating to light, color, electrons, molecules and so on, and I think life.

JB: *It's interesting. Once you become an icon you have to be very careful what you say because people might take you seriously.*

RP: Yah, I don't know how conscious he was of that, but he was very persistent in not entirely going along with the drift of the quantum physics establishment.

JB: *So that view of the electron, and atoms in general, I imagine (seeing the electron is an essential part of atomic structure): can you explain further how that actually set us on the wrong track?*

RP: Around the time of the first World War, Michael Polanyi had demonstrated a continuous potential description of how gases are bound or absorbed onto solid surfaces. And that was a smooth sort of process, a straight relationship between the pressure on the gas and the thickness of the absorbed layer. And when he went to Berlin to present his experimental work and theory [to] Einstein and others, that was already ten years beyond the total electric theory, and the particularization of light and electron energy or structure. And Einstein was one of the people that said, "In the advanced science world here in Germany, we know that that just is impossible because matter is particulate and you just aren't going to get forces smoothly extending away from the surface if the surface has an electrical property, and the gas has an electrical property, the first layer of gas atoms hitting that surface is going to perfectly neutralize that. So there is no potential extending through space."

But Polanyi 's results clearly showed that something like that was happening, a continuously thickening layer. So, Polanyi was defeated, and the people like Irving Langmuir fifteen years later got the Nobel prize for his idea that gases can only condense in a mono layer. Polanyi knew it was wrong, but he was a physics professor and he had to teach the Langmuir isotherm. But in his own experimental

work, Polanyi went along examining how molecules and crystals, solid state things, work.

In one area of research after another he kept seeing continuity, things extending. For example, in the behavior of a crystal, were previously he had shown that gases on the surface of activated charcoal for example, formed multi-layers. Working with crystals, he found that the events on the surface of a crystal affected its elasticity and resistance all the way through. So, physically, the surface doesn't have the meaning that it seems to [have] in geometry. For example in working a crystal back and forth, it gets weaker and weaker as it accumulates some kind of fatigue or memory. J. C. Bose had demonstrated that sort of thing and found that the fatigue could be recovered (from) in a crystal, but Polanyi was interested in the fact that the weakening involves energy flowing over long distances, creating areas of exaggerated weakness.

That was the same sort of effect that he saw when the surface of a crystal was wet. The surface effect modified the resistance and elasticity property of the depth of the crystal. So it was analogous probably to the idea of conduction bands in which, in a metal, the electrons are delocalized. And you can think of particulate electrons acting this way, but Polanyi's work suggested that maybe that isn't the only and necessary way to think of electrons.

When I was in graduate school 1969-70, I was reading surface physics especially as a way to help understand oxidation biologically. And in one of the physics journals, a man named Helmut Schwarz published a description of a funny experiment in which laser light is shined horizontally through a crystal while a beam of electrons goes through the other dimension of the crystal, through this thin layer less than half a micron thick. And the electrons passing through the crystal are deflected into a certain pattern by the electronic property of the crystal atoms that they passed by. So you can see the shape of the crystal reflected in the image of where the electrons hit. Ordinarily, that's done exposing electrons passing through the crystal exposing a piece of photographic film to the electrons and getting a chemical change producing the image. But he found taking even a fluorescent screen away, putting an aluminum oxide coated layer at the bottom that was very non-reflective, he found that the electron spots were still there, but they had the blue tint of the laser light going sideways through the crystal. So the spots had to be the supposedly discrete particulate electrons for them to be deflected to exactly the right spots, which are used to identify crystal structures and such, but at that spot there shouldn't have been any light that it was the color of the laser light modulating in effect the beam of electrons. And that, when I tried to talk to physics professors about it they simply said, "It can't happen. You can't modulate one electron."

JB: *When you say modulate, you mean you mean change color, or actually...?*

RP: Yah. The color of an electron is supposed to be its relationship to the atom. And what it's doing is absorbing, or interacting, with a particular wave length of the light, so the atom is subtracting or maybe fluorescing a color, but it's always subtracting or adding something according to the way it is bound to the atom. So, an electron flying through space just wasn't acceptable. They preferred to say that the person was simply hallucinating or something. But it was done at Rensselaer Polytechnic Institute, and they had the best equipment of that sort in the world at that time. A lot of people immediately trying to replicate it didn't have the same degree of vacuum in their electron microscope, or they didn't have the same power of laser, or the same quality of crystal making, and so on... Great planeliness and so on was part of the original experiment. So a lot of people...Sort of like cold fusion: if it violates the theory, and you don't have the same equipment exactly, it's very easy to debunk something, just by doing a slightly different setup and getting different results.

JB: *Today's crackpot is possibly tomorrow's genius, in many cases.*

RP: Very recently, Helmut Schwarz, who became the head of Germany's research granting institution (the government's money dispenser for research), he said that outsiders are important everywhere, not just in science. You don't get advance unless you have people somewhat on the fringe.

JB: *Yah; if anybody wants to google "minority opinions in science", there is actually a huge amount of information out there: Scientists who had have been sidelined for their viable research because it's bucking the current institutions or the money that's coming into those institutions. They are not getting any traction with any of their work, and in fact, a lot of their research is taken away from them research facilities. It's a lot bigger faction of science than anybody hears about because of course they don't get any press either.*

RP: And I've been noticing that institutions like the Wikipedia, supposedly the internet should be an opportunity to disseminate dissenting ideas, but the culture of authoritarian science is so strong that you see it affecting the way Wikipedia works. It's sort of like a sounding word for the most authoritarian viewpoints in science.

JB: *Yah, that makes sense because if you have the money of an institution behind you, you have the money to pay a staff member to keep updating Wikipedia and editing anybody's other input. So it's kind of like he who has the most resources wins the argument.*

I was a little confused about that particulate electrons versus... Is it a wave theory? Is it one of the alternatives to that? What's wrong with the particles?

RP: Since you can't explain many events in terms of particles, it becomes sort of mathematical magic to try to make up theories to explain results like Polanyi 's or Schwarz's. And Albert Szent-Györgyi used conventional quantum thinking about electrons, and went a long way towards explaining some of the biological phenomena that the people hadn't been able to even perceive. But that doesn't mean that it necessarily validates the particulate electron, just because you can explain some important phenomena. I think it should mean that the whole idea of what matter is, how an electron works, whether it might be that there is an electrical ether-like material which breaks up in different ways into apparently discrete electrons. But that rather than being an internally discrete particle (like a proton is supposed to be), the electron might be sort of an ad-hoc division, which the wave interpretation is approaching that idea. And some of the sub-atomic thinkers are saying that maybe this great variety of sub-atomic particles being seen with high energy research, maybe these are just sort of an ad-hoc response of matter to a particular context, or environment, or stimulation.

JB: *So it might just be an aspect you are seeing depending on the medium you are using to see it with.*

RP: Yah, exactly. And that would say that in a different solar system or different galaxy the atoms aren't necessarily going to be the same, exact, [or] have the same functionality. And that is an implication of Halton Arp's comments on his galaxy photographs .

JB: *OK, now that you have brought up that, you better explain what that means again.*

RP: He showed that what appeared to be continuously connected groups of stars, one of the parts of what seems to be a continuous stream of stars, one of the parts will have an extreme red-shift difference from the other one, meaning that they should be very remote in space.But his pictures show connections, like one is being shut out of the other. And he suggests that the one being shut out is newly created

and that new matter has a different way of vibrating which shows up as a redshift. In other words: the atoms are different when they're fresh.

JB: *Redshift means something is moving away from you in space?*

RP: That's the standard mechanical physics connection like the doppler effect, when [inaudible] passes, the frequency drops.

JB: *You're saying it could also have other implications.*

RP: Yah, for example light passing close to a star has a frequency shift. An Israeli physicist astronomer named Dror Sadeh was working in the US. He was studying at different times the light of the stars passing close to the sun and a beeping Quasar Pulsar that sends out a certain frequency passing close to the sun. He kept seeing what seemed to be a time change (or frequency change) depending on how close the beam came to the sun. And he got an atomic clock at the US Bureau of Standards and mounted another one on a truck and connected them by radio, so that they could be synchronized, and then drove up the coast (I think he went up towards Maine) and meanwhile recorded the relationship between these two clocks as he went. And saw that every morning at sunrise, Washington DC seemed to be redshifted away from his truck. And his argument was that something about the field of the sun coming on the scene was shifting the radio waves that were connecting the two clocks. Otherwise it would look like you have an expanding universe to a ridiculous extend, in which Washington was moving at a million miles an hour away from Maine.

JB: *I think that may be. They seem remarkably out of touch with real life anyway.*

That's fascinating, Ray. We are talking about the nature of the universe and ourselves. And particularly electrons and electrical fields. You are saying that the wave of radiation from the sun is possibly altering time, slightly.

RP: I think he was thinking in terms of gravitational fields. But I don't know exactly what sunrise would mean in terms of his thinking.He was killed by radiation poisoning in the non-atomic bomb laboratories in Israel.

JB:*... the non-atomic bomb laboratories making the bombs that they don't have [chuckle]*.

RP: Yah. [chuckle].

JB: *That's terrible. So obviously it makes a difference how you think about electrons and if you're trying to figure out how these molecular processes are happening. And this show is going to be about physiology, but I guess it makes a real difference what your general theory of atomic structure is.*

RP: The idea of a particular nature of matter sort of spread or diffused into the thinking process, so that atoms... The same way Einstein couldn't tolerate multilayer absorption in 1915, biochemists can't tolerate the long range processes in biochemistry.

One of the things in chemistry that resembles what Polanyi was seeing in crystals and his other experiments, the inductive effect, is at the basis of the really fundamental biological thinking about coacervates, for example. Bungenberg de Jong founded a line of thinking that eventually led to Gilbert Ling's way of seeing the cell as a special state of matter.

One of the basic and simple chemical physical principles necessary to think this way is called electronic induction in a molecule. And when you have atoms that are electron withdrawing, or they have an affinity for electrons, you put them in a molecule and the charge or the intensity of the electron's effect shifts down the molecular chain towards that electron withdrawing atom or group. So it's like a

partial electron. That's an essential part now of organic chemistry, that you have partial charges. But when you really take that seriously and see that this effect exists everywhere in every molecule in the cell, it goes to another level which is the coordinated or coherent effects of the electron-inducing groups.

So you have a collective kind of reaction in which you pass a threshold. Sort of the way liquid water passes to solid water. They can be at the same temperature, but someone has to start the process, and then it can go like a cascade: all at once the atoms will fall into place and change the state. So, you can have solid water at somewhat above the melting temperature, or liquid water well below the freezing temperature (if you don't have this cooperativity of molecules and atoms).

When you combine these ideas of cooperativity and induction, you get these group effects where you have a change of state in effect which will pass through the bulk of the material. So that you can start thinking about how it works with looking at the effects of pH on a protein. That's the simplest effect of the pH; the same all the way through a solution. And a protein with its various charged groups responding to that pH. So that the internal fields are intensified or decreased according to the pH.

So you can have a protein expanding or collapsing according to the pH of its surroundings. But then, when you add other molecules binding or associating with that protein, and those have electron withdrawing or donating properties: then the way that protein responds to a certain pH is different.

And these electron withdrawing molecules are, in a sense, a “partial oxidation” (oxidation being “the taking away of electrons”). So that the degree of oxidation in a molecule defines how “electron-withdrawing” it is. And the totality of molecules with that quality in a system such as a protein or a group of proteins in a solvent, will affect the global degree of oxidation in the system. And when it reaches a certain point, instead of just one protein collapsing or expanding, you get the same freeze-melt transition in which one protein triggers another one, and so on. So, you get coherent cooperative types of changes throughout the system.

That's where the tending to think discretely has been so strongly affected by the particulate electron, particulate proton, particulate photon. The type of thinking. So that people don't like to get involved in those cooperative global effects.

JB: *It sounds like there are several things that affect how quickly a chemical change happens in the body or elsewhere. One of them is the environment, so the pH surrounding the substance where the change might happen is key, and then the other part is the materials that are attached to that substance. So if you tie a protein, and then the protein might have other molecules attached to it, that actually enhance or deter the change happening.*

RP: Yah. And that's one of the complexities of the living state: If you kill it, it doesn't work the same. So you have to think of it always in a certain environment. You have to really think of it as a flow from the environment, in and out; and the rate of flow, and intensity of flow, and so on.

The way people think about anti-oxidants even tends to turn into a static description rather than a flowing process. A cell is always (when it's alive) maintaining a delicate balance between oxidation and reduction. And so, anti-oxidants are a dynamic process in which they’re also oxidants. If you push towards a dominance of reduction, then you kill the cell in a different way.

JB: *Ray, can you back up a little bit and just explain the origin of the word “oxidant” and what it means?*

RP: In the 18th century, when they were thinking of phlogiston, that you had to dephlogisticate something...

JB: *What does that mean?*

RP: It was something that left a burning substance. It meant the exhaustion: when phlogiston had filled up the space, you couldn't bring anything more in it. And it made it very hard to understand chemical reactions. But then Priestley, and I guess Lavoisier was another one, two or three people around the same time were seeing that there was something being consumed from the air in the process of burning rather than added to it.

When they started studying what was being consumed in the air, they saw that it generally made an acid form. And so, I think it was Priestley who named it; the substance that makes burning possible in the air, he called the acid-former, or the oxygen ("oxy" [greek] being the root for "acid" or "sour"). And so many acids were formed by oxygen that it got its name as the source of acid.

It isn't an absolute: there are acids without oxygen. And that leads into the whole issue of pH. But thinking of oxygen in relation to its ability to form acids, that's a very important integrate with your thinking of what a cell is doing. And people tend to have begun thinking of carbon dioxide as simply a waste product; but if you think of the electronic balance between oxidation and reduction holding the proteins and other things at the cell in a certain very specific state or conformation, changing the pH is crucial. And this partial oxidation that you get at a lower pH, which governs the arrangement of the protein and other substances, carbon dioxide turns out to be a universal balancing factor or an adjustor of the acidic properties of the protein.

So the acid formed by oxygen in this case, carbon dioxide, in itself, it's an acid as defined by Gilbert Lewis. It doesn't have the protons; so you needn't talk about the pH, really, because it's a non-protic acid, just two oxygens and a carbon. But this arrangement-an oxygen doubly bonded to a carbon-creates that electron withdrawing property. The intrinsic partial oxidizing property of that molecule, which when it attaches to a protein, it increases the acidity of the protein making it slightly, partially, more oxidized, more acidic. And that changes its affinity for other things, according to how negatively charged its groups are. This is the kind of thinking that then, up to the Gilbert Ling orientation accounting for cells and their metabolism without the hypothetical membrane and its pumps...

The pH and the acid-property of the protein system maintained by the carbon dioxide produced by oxidation: this is the central thing in explaining why cells can discriminate between sodium and potassium, and calcium and magnesium, and all of the discriminations that cells make. You don't need a little magic pump moving things in and out. That would consume more energy than the cell has. The energy of the cell is really being produced to form carbon dioxide. And the carbon dioxide is changing and maintaining the properties, preventing excess electron accumulation. Since it is a continuing streaming process, you have oxygen streaming in and carbon dioxide streaming out, and the carbon dioxide reacting as an acid with water shifts the property of the water atom.

So, the water joins with the carbon dioxide forming carbonic acid, which ionizes. You now have a negative charge on the carbon dioxide streaming out of the cell. It takes positive charges out with it. Otherwise the cell would quickly become highly electrically charged. So the movement of oxygen in, carbon dioxide out is taking out the sodium and calcium as a streaming continuous maintenance process.

JB: *Most people have heard of the membrane theory of cells, that they are basically bags holding the cytoplasm in. And (In case you didn't get this) this is an alternative theory: that it's actually being regulated by the products of the mitochondria. Is that right, Ray? So the mitochondria is producing the CO2 when it makes the energy we all use, the ATP. And so the CO2 starts off as an electron acceptor, but then it*

becomes negatively charged and that bonds with the positive metal ions (magnesium and calcium)?

RP: It doesn't necessarily bond with them, but in leaving, they tend to get dragged out, too.

***JB:** I see. And why is the CO2 leaving?*

RP: Just because it's being constantly formed inside, and just diffuses out, down a gradient.

***JB:** So that's like an osmotic pressure?*

RP: Well, the diffusion pressure. It's going down the gradient, like if you put alcohol against water: they will tend to make the alcohol move into the water, and the water into the alcohol. Until they are more or less even. And when you have a high concentration of CO2 in the cell, at a certain point it starts being more at ease outside of the cell.

***JB:** I see. So it's a diffusion process?*

RP: Yah. And that accounts for taking it out into the extracellular space and the blood. And when it gets into the blood, it's taken the sodium and some other things with it. It circulates to the lungs and changes back to carbon dioxide which is again going down its gradient from a high concentration in your blood to a lower concentration in the fresh air you breathe. So the carbon dioxide is leaving the blood and it leaves behind the molecules or ions that it took out of the cells. So the absence of the acidic carbon dioxide in the blood leaves the blood now with a higher pH because of the movement of sodium and such out of the cell.

So the normal situation is for a healthy cell to be just faintly under neutrality, and for the blood to be definitely over neutrality (inside the cell 6.9 pH, and in the blood 7.4 pH, roughly).

***JB:** So that's a little bit higher than the cell is low.*

RP: A lot of people have seen disease as caused by a low pH, or too much acidity. And in the case of stress and cancer, a tumor will become very acidic. So that traditional idea has a basis. In an infection or a tumor, the inflammation produces a high concentration of lactic acid, and a very low pH in that area, which does have disruptive toxic effects [on that area]. So the body is able generally to correct that and reduce the inflammation and stop the production of lactic acid. But when lactic acid is formed, the conversion from pyruvic acid to lactic acid is drawing an extra proton out of the NADH catalyst that causes the conversion, taking away this extra proton as it leaves [the cell]. In its formation, it raises the pH inside the cell. So, even though a tumor or an infection it is...locally, you see excess acid (high lactic acid inside the cell, that's doing that) it's the reverse process: you get an increase in the pH inside the cell. So the cell, if it gets stuck in producing lactic acid because it can't produce CO2, then that means it also tends to get stuck at a higher pH. And this higher pH changes the whole system. And that's where you tend to get a self-replicating tumor; because the normal acidic conditions maintained by the CO2 are lost.

***JB:** You are talking about cellular respiration. When you're talking about the process of making the energy we all use; can you give us a little cliff note version of that?*

RP: Yah. Looking at us in our environment, we are really sort of sandwiched between the sugar energy we get from plants and the carbon dioxide that we make as the final product of the energy from the sugar. A series of changes in the sugar molecule, each oxidation of that molecule adds a little chemical energy to the cell, that the cell can use to make proteins. As it degrades the sugar, it builds up amino

acids and proteins and fats. When you are unable to oxidize the sugar all the way down to carbon dioxide, and produce lactic acid instead, halfway, you are losing the greatest part of the energy stored in the glucose molecule. And that lack of energy has its repercussions.

But when there is really a lack of oxygen to continue the oxidation, that NADH, which allowed pyruvic acid to take this shortcut off into the semi-toxic lactic acid, that has to be renewed before you can even make another lactic acid. So, without oxygen, you need some kind of oxidant to even continue producing that kind of low energy from the sugar to pyruvate and lactic acid. And to do that, cells can produce fat and get rid of their electrons by building them into fat. So building fat in a way is an alternative (very bad one) to using up oxygen and making CO2.

So, interestingly, cancers, which get stuck in the exclusive use of converting glucose or amino acids to lactic acid as their energy supply, they also get stuck making fat. Fat becomes their oxygen in effect. And then, when they still have mitochondrial function, the cell burns fat as its energy. So it's really a deranged and crazy kind of metabolism to produce an irritant lactic acid, and to do that it has to make fat which is then used as fuel with its own consequences.

JB: *That's called glycolysis?*

RP: It's aerobic glycolysis when you make lactic acid in the presence of oxygen, and ordinary anaerobic glycolysis is what happens when you exercise too hard. You can build up lactic acid in getting out of breath. The blood lactate increases if you exercise faster than you're breathing, and that's normal. You can a little later consume and oxidize the lactic acid and that's OK. But when you start producing lactic acid even in the presence of oxygen, as in the case of cancer, or extreme trauma or shock, the same thing happens; something turns the trigger, so that even though oxygen is present in shock, you will waste your sugar and make lactic acid.

JB: *I see; oxygen is there, but you are unable to use it.*

RP: Yah, and in the case of shock at least, the nervous system is involved in making that aerobic glycolysis. So there are quite a few people who have suggested that the nervous system is involved in the cancer transition, doing the same thing that shock and trauma can do acutely.

JB: *I want to ask you more about not being able to use oxygen, even though it's there. It's called anaerobic glycolysis ?*

RP: No. Aerobic glycolysis (or "Warburg effect": it's the observed phenomenon that cancer cells ferment the glucose even in presence of adequate oxygen) ("Anaerobic glycolysis" means "fermentation", the conversion of glucose to lactic acid in the total, or partial absence of oxygen).

JB: *How does the mitochondria burn fat ? How is that even possible ? What are the problems with that ?*

RP: It produces less carbon dioxide, for example. I think that's the main problem. If you develop fat stores, you get particles of fat accumulating in the cytoplasm, and maybe even in the nucleus. That, probably, have a disruptive effect, from your...heavily shifted over to a fat economy. The tumor makes saturated fat, as it's first product in converting sugar to saturated fat. But when it's shifting in the presence of stress, when it shifts to burning fat, usually that will go through your fat stores, burning up your subcutaneous fat quickly. So, when a person is very sick with cancer, for example, they get a gaunt, emaciated look as their superficial fat

stores are used up. And at the same time, they convert amino acids to energy, converting some of it to sugar, and some of it to fat. And so, it starts a wasting process. But, our stores, the older a person gets, generally the higher the amount of polyunsaturated fat in their stores. And when you're oxidizing polyunsaturated fats, that produces more oxidative damage to the mitochondria. So, it tends to lower the oxidative part of the metabolism, and slow things down in general.

JB: *And then people end up feeling weak: their energy level get run down, overall.*

RP: Yes. That happens in mid-life to lots of people; it resembles the cancer metabolism, but it shows up as fatigue, low energy use in general. Some people... were textbook used to say that you would always lose weight if you ate less then 1700 calories per day. Lots of people can maintain their weight on 700 calories/day. And that requires turning off of the thyroid function to a great extent.
And so, you're being wasteful, even though you're not using very much energy at all; what you are using tends to be poorly used and destructive. So you tend to reduce your connective tissues, your muscles and digestive system, and so on, rather than just living on what you're eating, or stored fat.

JB: *So you're basically hibernating. Are fats always the part of the process of respiration, oxidizing fats ? Or is that only when you're ill ?*

RP: Yeah. It's only under stress, generally. And starvation. Or diabetes. Or high level of stress.

JB: *A lot of people are under these ketosis diets, where they don't eat any carbohydrates. And does that cause you to burn fats and proteins ?*

RP: Yes. Your brain especially, and some other tissues (the intestines, and red blood cells, and some other little areas) have an absolute requirement for some sugar (glucose); and they all get it by breaking down amino acids. And they get that from eating your tissues if you aren't eating enough amino acids. But if you're eating amino acids as your energy source (fats and amino acids), you turn on the machinery for turning amino acids into glucose and fat. And running that machinery involves turning on the stress hormones. A whole range of hormones adjust to it. And i think that those have chronic harmful effects.

JB: *When people do it, they take blood and urine samples, so they make sure not to endanger themselves.*

RP: Most of the proteins that are being eaten under those systems, most are too high in phosphate. And usually too high in methionine, cysteine and tryptophane. And cysteine is an excitotoxic amino acid. And methionine is involved in stress and aging, in proportion to it's excess. So that one of the most effective life-extending diets is simply to reduce drastically the amount of methionine in the diet. So that the sulfur amino acids and tryptophane are stress and aging promoters, especially excitotoxic damage to the nerves. And the high phosphate for most of the popular high phosphate proteins has a lot of excitatory, harmful effects. The KLOTHO gene and protein that is deficient in animals that have a very quick aging process: that's largely a phosphate-handling protein. And the rapid aging produced by lacking that protein and gene involves accumulating excess phosphate.

JB: *You get phosphate from eating meat, primarily ?*

RP: Meat is one of the highest ratio of phosphate to the other minerals. But several of the very high quality proteins...eating mushrooms have a pretty high ratio of phosphate to calcium. Milk and cheese are about half and half. Which is probably safe. Fruits and leaves, leafy green vegetables, have a very safe low phosphate content relative to calcium and magnesium and potassium.

JB: *So fruits and vegetables are the best. You're not getting much protein in that case; so, you need some milk and cheese too ?*

RP: Yes. And probably a fairly low protein diet is very good for health, in the sense of living longer. But for maintaining tissue renewal, you can't go below a certain amount of tryptophane, cysteine and methionine. Those are rapid turnover proteins.

JB: *Last week you talked about Luca Turin and his research on odors (the electrical nature of odors). What's your take on multiple chemical sensitivity ? This is pretty common these days. Lots of people can be made ill by the smell of a perfume. Does it relate to Turin's work ?*

RP: Yes, i think it does. He was talking specifically about smell and psychoactive-like antidepressant chemicals. When you look at what's in common between smelling and having the anti-depression effect of some chemicals, what's in common is the resonance state, or the tunning of the molecule to the oxidation state, which is in this context of partially oxidized proteins in a coherent cooperative system. The whole system has to be tuned to a certain level of reduction and oxidation. And the addition of the chemical (whether it's an antidepressant or a perfume molecule) passes along the conductive pathways of the nervous system. And cells all throughout the body are involved in the delicate nerve balances. The vegetative (or autonomic nervous system) regulates the state of inflammation (of the tissues, for example). There are lots of cells closely associated with fibers of the nervous system; cells called mast cells, for example, that can regulate inflammation all throughout the body, in the brain as well as all the other tissues. And these are connected and balanced with the nervous system. So a slight shift in your autonomic nervous system can globally change the degree of inflammation all throughout your body, increasing the amount of histamine and insertion, and the various products of the mast cells. When a person is under stress chronically, these inflammatory things tend to rise. And when you increase your intensity of mitochondrial respiration and your level of carbon dioxide, that stabilizes the system back, away from that excess inflammatory reductive impulse. But, when you're right on the edge, just balanced, not intense enough oxidation going on, then a perfume molecule, or a psychoactive chemical, or a food molecule can send impulses through your system shifting you away from the oxidative excitatory processes, towards the side of your nervous system that becomes dominant in shock. So i think the chronic fatigue and the chemical sensitivity inflammatory states are in effect a variation on the physiology of shock.

JB: *It's amazing people can wear a nice smelling product that would make someone else deadly ill.*

RP: Yes. I think it depends on the way your nervous and chemical system is tuned up.

JB: *I mean all our chemical processes involve oxidation and reduction.*

RP: Yes. Lactic acid is a reductant, as well as a product of being reduced. And turning it into lactic acid from pyruvic acid involves an electronic addition or reduction. Then, when it goes to a balanced or healthy cell, it shifts the balance towards reduction. And if you add oxygen into that cell, it's ok; the electrons will be consumed. But lactic acid itself has this potential for shifting the balance. For example, in the mast cells (that are signals for more inflammation), too much lactic acid will activate their releases. So, systemically, letting too much lactic acid circulate is adding to the inflammatory state.

JB: *You already mentioned you're not very fond of yogurt, because of the lactic acid you absorb from it.*

RP: There are some kind of yogurts that have very little lactic acid. You can thicken the milk enzymatically, rather than with a lot of acid. Those very mild yogurts aren't specially harmful. But if you're very sour with lactic acid, and if your liver is on edge (not enough thyroid function) that's like shifting towards the reducting side; it can have systemic effects and can bring on allergic reactions (migraine headaches and such).

JB: *Does the age of the yogurt influence the lactic acid content ? The longer it sits, the more lactic acid content ? How does the lactic acid appear ?*

RP: The bacterias are making it.

JB: *So, a young yogurt would be fine ?*

RP: Yes, i think so.

JB: *And you can also strain your yogurt, which is the same as buying Greek yogurt. And that gets rid of it, and makes it basically thicker, or cheesier.*

RP: Yes, that's the idea of cottage cheese. The drain away of most of the fluid (the whey) and that takes away almost all of the lactic acid from most cheeses.

JB: *Ok, that's good to know that fresh yogurt is ok. A caller says he once bought a perfume so toxic, UPS refused to deliver it. On the MSDS (manufacturer's safety data sheet) toxicity scale, it was a 6 (normal goes from 1 to 4). He concluded that perfumes are very poisonous. He also wants to know if you contribute to Wikipedia ?*

RP: No. Someone has asked me to comment on the association-induction hypothesis particle, a very good, long particle, described in Gilbert Ling's theory. A lot of people are jumping on it, saying it should be eliminated from Wikipedia because it's wrong.

JB: *I wonder if Gerard Pollack, who also derived openly a lot of his work from Gilbert Ling's, would defend it?*

RP: Yes. I don't know how you get involved; when i find out, i think i will say: "Keep it, please."

JB: *That would be good. A listener asks if he could have gotten his type 1 diabetes from x-rays at the dentist ? He takes daily insulin, aspirin, Vit A, Vit E, Vit K, B1, B3, glycine, pregnenolone, magnesium glycinate. He's still into a "honeymoon"*

phase, and would like to prolong that phase and/or even getting off insulin. Do you have any tips for him ?

RP: Before i was born, my father had extreme diabetes. Went down to something like 90 pounds or less, couldn't assimilate any kind of food. Even pure protein raised his urine glucose tremendously. And looking at old naturopathic remedies, he started eating as his only food brewer's yeast. About 2 cups a day, at first. And immediately stopped producing so much glucose in his urine. And in a few months, was completely well. Maybe 5 years or so after that, he would eat some extra brewer's yeast, but never had any symptom of diabetes after that. And i think part of that effect is the hormones in the yeast which stimulate regeneration, and high potassium content, which has an insulin-like action, and the high B vitamins. But, having enough glucose, so you don't draw any polyunsaturated fats out of storage- those are very toxic to the insulin-producing cells in the pancreas. There, normally, they are constantly turning over (the Beta cells are being renewed constantly). And in a diabetic, they are being renewed, but they die quickly. And sugar is a factor that will prolong their lifespan. It doesn't need anything to stimulate renewal. Just to prevent them being killed, primarily by the polyunsaturated fats and the nitric oxide. Soon after it was discovered that the body produces it's own nitric oxide, in the early 1990's, many articles came out demonstrating that nitric oxide is specifically what kills the Beta cells. So you definitely don't want to do anything that would increase your nitric oxide production.

JB: *Which activity would do that ?*

RP: Supplementing arginine or foods high in arginine wouldn't probably be desirable. And i think the effects of aspirin, and the B vitamins, and Vit E, pregnenolone and progesterone and DHEA... Around 1985, i think it was, someone, gave rabbits diabetes with a chemical toxin, and then gave them a supplement of DHEA. And that was the only difference. The ones that got DHEA regenerated healthy insulin producing pancreases.

JB: *DHEA need to be taken in small amounts, or it will convert to estrogen ?*

RP: Yes. 10 to 15mg is probably a safe amount.

JB: *People will be surprised that you are advocating taking sugar (or glucose).*

RP: Yes. I have a couple of articles on my website guessing the history of that; in the late 19th century, a couple of doctors described cases that they cured from really advanced, terminal diabetes; people losing weight at a terrific rate. They added something like 12 ounces per day of sugar to an otherwise good diet, regular high protein and vegetables and milk and so on. But just by adding 12 ounces of sugar to that diet, in just a few weeks, people came back from near death.

JB: *And i guess their logic was to replace the sugar lost in the urine ?*

RP: Yes. Exactly. The reasoning at first was: they're dying so fast, they're putting out the equivalent of a pound of tissue converted to sugar every day. And just to slow down their starvation process, they said, and they craved sugar; why not let them eat what they crave, and maybe slow down their death ? But instead, they stopped waisting away, and came back.

JB: *What can somebody do if they suffer from multiple chemical sensitivity ?*

RP: Supplementing thyroid is the usual thing. But sometimes, they're very low in cholesterol. And since thyroid works practically through converting cholesterol to hormones like progesterone, DHEA, and pregnenolone, if your cholesterol is too low, thyroid alone doesn't necessarily do it. So, supplementing one or more of those will very quickly often relieve the exaggerated sensitivity.

JB: *You said rabbits were given diabetes just by being poisoned with a toxin. And a lot of our diseases are environmentally caused. They say a lot of people have per-dispositions to cancer, and diabetes, etc...But i suspect a lot of it is environmentally caused by pollution.*

RP: Yes. When i was starting on my dissertation project, i wondered what the factors were that slowed down oxidative processes in aging. And as i looked around at the possibilities, i saw that the same type of deteriorations, the same biochemical patterns of the interference with mitochondrial respiration were produced by a great variety of stresses: ionizing radiation, or even UV to excess, had an effect similar to all of the estrogens and the aromatic hydrocarbon carcinogens. And hydrocarbons are produced by excitation and inflammation. And polyunsaturated fatty acids produce the same pattern of deterioration. And the Vit E supplement was found to stop the characteristic damage they were seeing in lab rats and industrial animals from feeding them too much unsaturated fats. And my thesis adviser found that the effects of too much estrogen were corrected by a very large Vit E supplement. And others were finding that Vit E protects even against radiation and sunburn. And so, some of the processes, like the breakdown of polyunsaturated fats are increasing our susceptibility to damage from all of those stressors (radiation, estrogen, toxic heavy metals, and so on).

JB: *Thus, all the vegetable oils, except olive and coconut, are not a good idea.*

RP: Yes. Olive oil has only 8-10% of the unstable polyunsaturated. Butter and coconut oil have 2-3% of the unstable ones. I've recently finally shifted, in accordance with something that I've read about 40 years ago, on the absence of cancer in animals that were fed different types of oils (coconut oil was safer than olive oil, which was safer than safflower oil and the polyunsaturated. But the safest of them all was hydrogenated coconut oil). And recently, I've found a place to get some of , just to try it out; and it has a very nice, clean taste and texture, and it's free of trans fatty acids, as well as polyunsaturated fats. The trouble is, the supplier doesn't supply it retail; only in bulk.

JB: *So, did you get a semi, parked behind your house (laughs)?*

RP: It was a very involved process to get a few gallons of it.

JB: *Did some of the animals get to eat butter ?*

RP: Oh yeah. Butter and coconut oil were the safest natural oils.

JB: *The terms oxidation and reduction can refer to hydrogenation and dehydrogenation, right ?*

RP: Yeah. It's just the movement of electrons. They're talking about when we turn saturated fat into unsaturated fat in our own bodies; we dehydrogenate it. And when a cow turns unsaturated fat from their food into saturated fat for the butter, it's

bacteria in their intestine and rumen which is saturating it (hydrogenating it). So, dehydrogenation is something that we do in our own bodies.

JB: *Is the hydrogen atom removed ?*

RP: They are actually referring to the electron; the movement of electrons out of the bonds. It's what makes the difference. The usual thing that you move is a hydrogen (2 hydrogen atoms). And when you take those away... like if it's on the 2 adjacent carbon atoms in a fat molecule; there was a bond of 2 electrons between the carbons; you take away a hydrogen from each one, and it takes...it's one proton and one electron that leave, in each case. And they combine: 2 hydrogen atoms turn into hydrogen gas. Or go to some other molecule. And the left behind electrons join with each other. So you get a double bond. Four electrons are joining those carbon atoms. And the absence of this space filling hydrogen seems to leave that range of electrons between carbons open and more reactive. So, when you get a lot of hydrogens removed, that makes access of oxygen atoms to the fat molecule easier.

JB: *That's why CRISCO is actually a liquid oil. but it has had an hydrogen added to it, and that makes it more stable.*

RP: Yes. And if they would complete the process the way they do in changing coconut oil from 2-3% Pufas to 0% Pufas, you wouldn't get the trans fats in it. So, you would have totally saturated, mostly stearic acid in CRISCO. And that would be safe. One group of researchers found that aged, defective mitochondria that were not respiring properly...when they gave them fully saturated, hydrogenated, peanut oil, it restored mitochondrial function.

JB: *Wow. So, it's a way of purifying it.*

RP: Yeah. And it eliminates the unstable quality that makes things susceptible to oxidation. Physiologically, there's something called the "saturation index"; you can look at a person's red blood cells and find the ratio of stearic acid (fully saturated) to linoleic acid (or linolenic: different degrees of unsaturation) and the longer ones (even more unsaturated). And people with cancer have a low saturation index. It's a very stabilizing thing to.....like a newborn baby is highly saturated in it's fats. In recent years, a lot of nutrition-oriented doctors are saying "You must give babies fish oil, and other highly polyunsaturated things, because most babies are born deficient in the essential fatty acids". But that's the normal state of the newborn animal.

JB: *It shows how disconnected are the medical authorities with nature. The newborn baby is a great example of perfection.*

RP: Yes. The rate of oxidation is highest; I'm not sure how you compare the primal oxidative state. But the newborn...the consumption of oxygen and sugar per grain of tissue is higher than it will ever be later. And it decreases especially at puberty, with the rise of the sex hormones. The oxidation rate decreases more sharply. And mortality rate increases as the oxidation rate decreases.

JB: *That makes perfect sense. A caller has 3 questions about salt:*

1. *Can salt ingestion trigger migraines in some predisposed people (example: Max Gerson) ? And what would be the physiological explanation ?*
2. *Do you believe salt restriction was useful in the University of Munich's 1928 tuberculosis trial on with Max Gerson's diet under the supervision of*

Ferdinand Sauerbrush ? If yes, was the beneficial effect due to a release of excess intracellular water ?

3. *If salt restriction is useful in evacuating excess intracellular water present in degenerative diseases, is it useful to keep restricting it once this excess intracellular water has been evacuated ? Should cancer patients keep avoiding salt after a few months of a saltless diet ?*

RP: I've read Gerson's book and he was very, very good, thorough. He saw the effects of the diet first on migraines and then tuberculosis and then cancer. And he tried to understand it. And he seems to have read just about everything in the first half of the century on the subject. And the salts are extremely important. The other contemporaries of this cancer researcher had a very interesting parallel: a set of facts regarding salt. William Frederick Koch, who was a chemistry professor at the University of Michigan, early in the century, was studying the removal of the parathyroid glands. And a calcium supplement was the technical remedy for the cramping reaction to the removal of the parathyroids. And the doctrine was developed that the parathyroids regulates calcium. And so you need to replace calcium when the gland is removed. But Koch did the surgery on animals and found that if he gave them extra potassium, or sodium, or magnesium, it had the same curative effects. And the essential fact was that one of these can makeup for a deficiency of the other. And the Gerson diet was extremely high in the other minerals, especially potassium. And the diet always had the amount of sodium that you would have in juice, leaves and fruits and vegetables and so on. So it was always a physiological amount of sodium. But often, a very excessive large amount of potassium and magnesium. And i think that these were the essence of Gerson's success, rather than just the reducing sodium. Because when you look at particular experiments, sodium can stimulate the respiration of the cell and cause it to unswell, give up excess water. If you lower the other minerals and give it too much sodium, you can force it to swell, to take up water. But sodium's normal physiological function is to act as a stimulant. Calcium tends to do the same. But the cell normally is excluding sodium. And it perceives sodium as an irritant (or stimulant), and revs up it's oxidative metabolism when it has a little extra sodium. And the increased oxidative metabolism produces carbon dioxide and restores the balance. So, when we're in balance, the right amount of sodium is increasing energy production and decreasing cell water content. And much of the stuff hadn't been specifically examined during Gerson's lifetime. But he was definitely on to something, and was curing migraine and cancer. But he very typically would give his patients a couple of grains of Armour thyroid, and very often, coffee enemas. And they were always having a very high ratio of carbohydrates to protein. So they were low on methionine, tryptophane, and the potentially toxic amino acids. And generally, lots of things in his program were very well founded. But there just wasn't enough information at that time about how the balance of the alkaline minerals works.

JB: *Yes, there's so many physiological variables, it's hard to pin down a specific one.*

RP: About aldosterone: one of my first physiological experiment was on myself; when i worked in the woods, our cook was cracked on the idea that hard physical labor meant you sweated a lot and needs to replenish your salt. And so he would put about a tablespoon of salt in everyone's porridge in the morning. If you didn't eat your porridge, you didn't get your ham and eggs and steak. So everyone was doing it. And within a few days of doing that, i found that the sweat that gripped down my forehead was leaving salt crystal trails on my glasses, and my eyebrows looked like they were coated with snow from the salt crystals. And i thought of the trick of

saying that i had been put on a low salt diet. So i got normal porridge from then on. And immediately i could sweat distilled water. And on the high salt diet, i had to take salt pills at about 11 o'clock in the morning, otherwise i started to getting feint; i needed to replenish the salt which was pouring out so fast. But after the low salt diet, i never needed after any salt pills again.

JB: *You mean the overdose of salt stopped your body from being able to regulate it properly ?*

RP: Yeah. And when you're cutting back on the sodium, one of the first reactions is that your aldosterone is increased. And aldosterone lets you retain the sodium; but it does it at the expense of losing some potassium and magnesium. So if your diet is high in calcium and magnesium, and potassium, then there isn't any problems with the low sodium intake. But chronically, that high aldosterone has a pro-inflammatory effect. And so, chronically, getting more of all of the alkaline minerals (mainly: calcium, magnesium, sodium and potassium) than you really need is a safety precaution that will suppress your aldosterone, and protect your heart from inflammation and fibrosis and hypertension and so on. So, in the long run, sodium has this protection against cell swelling, inflammation, fibrosis.

JB: *And if taken in reasonable amounts, it tastes good too, right ? What about "can salt ingestion trigger migraines in some predisposed people" ?*

RP: Yes. When you're already on a low salt diet and take salt, one of the common physiology experiments is to have people drink a quarter of plain water or a quarter of plain water with a heaping teaspoon of salt added to it. And at the end of the physiology lab, everyone who got the unsalted warm water would have formed about a quart of urine. And the ones that got the salt didn't have any extra forming. It took usually a couple of days for that excess water to come out. So if you take a sudden dose of salt, it makes you swell up and retain water, until your aldosterone has adjusted downward.

JB: *I see; so it just takes a while to adjust to it.*

RP: Yeah. And you'll notice that anything that's susceptible will swell up; your fingers and toes and lips and eyelids and such might swell up in the first day after eating lots of salt. But people who, for example, on a long airplane trip would always got swollen feet; if they adjusted 2 or 3 days in advance by eating extra salt and some baking soda, they didn't get the swollen feet from sitting still anymore.

JB: *So you're retaining the liquid then in a different place ? Or..*

RP: No. You're suppressing the aldosterone, so it gets the water out of you. And one of the ways sodium works is the albumin molecule is full of negative charges, and it holds the sodium in association. So you get a cloud of positive-negative charges which hold under water. It keeps the water osmotically held in your bloodstream. If you're low in either albumin or sodium, your blood itself loses the osmotic quality. And the water stays in your cells and extra-vascular spaces. But when the combination of albumin and sodium is present in the blood, water flows out of the tissues into the blood. And blood passing through the kidneys then can get rid of the water that otherwise would sit around in your tissues. And that same situation impairs circulation, because your blood volume is low, and the fluid volume outside the blood vessels is too high. And the anti-diuretic hormone (ADH: vasopressin) is another side of this. But it's a lot more complicated than a response

to stress, estrogen and a lot of other things, for the aldosterone is pretty closely related to the mineral balance.

JB: *And what is the anti-diuretic hormone ?*

RP: It's a pituitary hormone that causes water retention with sodium loss. And a low thyroid person...old people, people after accidents, anyone in serious stress...they call it "Inappropriate secretion of anti-diuretic hormone syndrome". And that's very common where edema is what is really harmful. The brain swells up, for example, because the body has too much water and not enough salt. And the remedy for that is just adding sodium. But that's not fundamental; and if you do it too fast, you disturb the balance in the different compartments. But the basic reason for it is that you aren't producing the carbon dioxide from a thyroid deficiency. And the absence of the high production of the carbon dioxide means that you're enable to retain the sodium in your kidneys, as the water passes through. And so, the low thyroid person loses sodium, because the reverse of the process that happens in other cells. In the kidneys, carbon dioxide allows the cells to catch and retain sodium.

JB: *That's fascinating. Anything you want to add about staying healthy and keeping your oxidation working well ?*

RP: Just keeping stress down and fun up. Judging food by largely how it tastes rather than by what the experts say.

JB: *Thank you Ray.*