April 4, 2021
New Orleans, LA

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Dr. Noble,

I hope you will please excuse my intrusion; this is Dr. Robert Mumford's nephew Charlie again writing you. I was terribly grateful for your reply to my email, and I have been hoping that you might have time to digest what I wrote there, but I am quite sure that your schedule has been very hectic, and it is probably the last thing on your mind, as it should be. But I am such an impatient person; it is one of my congenital faults. I am writing again in the hopes that you might have some thoughts about the ideas I discovered after reading your book... or anyway that have come to me, that your book helped crystallize.

After reading Dance to the Time of Life I continued with Capra + Luisi, The Systems View, and then with Maturana + Varela, learning about the Santiago theory of cognition. I was thrilled to discover that there is a way of looking at living systems, a body of work already out there, that expresses much of the intuitions I have had about biology. After reading Iain McGilchrist's The Master + his Emissary, about the divided brain + the different styles of cognition in either hemisphere, I am now more certain that what I have discovered is important, and (I think, maybe) I have now understood why it may have been overlooked. One purpose of this letter is just to bounce this idea off of someone with a tremendous amount of context in the field of physiology, to see if this way of looking at sleep and cognition is already out there, if it has a name and a community of adherents.

The thought begins like this:

The Neo-Darwinist view of life attributes all of the creativity of species, all of the epistemological success, all of the built knowledge in the world, ultimately to the changes in DNA sequence we call mutations. Viewing this as a process, you can say that the genome of a species has a certain plasticity. This must be determined by the evolved life span of a species, their evolved reproductive strategy, which sets an average length between generations + an average number of offspring + a way of recombining DNA. But it also must depend on the fragility of the DNA molecule itself, and since mutations are not equally common all along every part of the chromosome, the fragility of different parts of the genetic structure must itself be under evolutionary control. Each part of the genome, in other words, has an evolved level of plasticity, resulting from its likelihood of being broken, and its likelihood of being fixed by the repair process that runs in the germline cell. So, that means evolutionary change must depend on a sort of dialectic between damage and repair, and the manner of damage + the manner of repair are under evolutionary control.

My dedication was this: If this is true of the DNA molecule, it must also be true of every other part of the organism. Every structure in a living organism must have an evolved level of sensitivity to damage, both from trauma of various sorts and from the general disarray that occurs spontaneously when complex molecules are heated. So the bones, the blood vessels, the skin, the nerves, the brain, everything in the body, has a certain evolved susceptibility to damage, and that means that it undergoes damage continually, and in order for the organism to function, a repair algorithm must be present in every living cell, tissue

organ, + system that returns it to a functional state.

The first step in my awakening, pun intended, was to realize that this is the purpose of sleep. Sleep could not have evolved for energy conservation, because first, it doesn't conserve very much energy. Sleep in humans only saves 10-15% energetic output. Hibernation, which does conserve energy, is a very different process, and there is new evidence that hibernators accumulate a sleep deficit. So sleep must have evolved as a consolidated phase when all the body systems are directed primarily at recovery from trauma and disarray. It is a consolidated phase because it involves all body systems, and we can't "repair on the go" because we have to use all the tools in the whole system to assist with the repairs. It is as if the wheels are loose in the car, and you have to take out the gearshift + use it as a wrench to tighten the wheels, and so forth. You can't both drive + repair at the same time in a system where function depends on the entire whole, and not just a sum of parts working independently.

So this explains why sleep has remained mysterious to the reductionist method of science. If fatigue is a sort of disarray of the whole system, you can never measure it precisely, or make any sense of it ~~by~~ by measuring any part of the system by itself. You can't measure it, but we know it's real because we can feel it! When you remove all energy sources from an organism for a long period of fasting (I have done this experiment on myself for up to 8 days) the organism sleeps less, not more. And of course when we become fatigued, we still have month's worth of energy supplies in our bodies. You cannot run until you starve to death.

The obvious question this raises is why we

would evolve a body that is so sensitive to trauma that it needs to become prone, paralyzed, and unconscious for a third of its life "in the shop" for repairs. If I am a DNA sequence, wouldn't I want a more rugged "survival machine?" Why aren't we made of more durable stuff, made out of processes that can run autonomously and repair themselves "on the go" while other parts of the organism are still engaged in survival & reproduction. If a living organism was really a reductionist machine, it would be organized this way, to have independent systems that could repair on the go while other systems kept active. But that is not the case. Instead, we dedicate our whole body to a process of repair that leaves us entirely helpless and vulnerable for at least a third of our lives. So what is the tremendous benefit of doing this?

Your book helped me see the answer to this question. Like bodies, genomes work as a whole. As your book shows, a genetic sequence cannot move or replicate on its own. Even a whole set of DNA is still inert, dead. And even a whole organism cannot exist alone; it is embedded in another system called the niche without which it will quickly disintegrate. So, genomes can build knowledge of how to survive and reproduce as an organism; but to do so they need the whole system. They need everything in the cycle of life between the DNA and the niche in order to return that knowledge to them. As the Santiago authors say, life has a "circular form of organization." If there is an evolutionary benefit to plasticity in the genomes, and genomes work as wholes, then the same is true of organisms. Organisms "work" as wholes. In other words, they "know" as wholes. How do we tell if someone knows something? It's how they act as a whole unit, a

whole body. The brain is not a container of knowledge, but just a way of integrating all of the knowledge distributed through the whole system. That's why REM sleep, which seems to be a primarily neural repair algorithm, is only one phase of sleep, and it happens last, after the other phases have been accomplished repairing the rest of the system. So the body is plastic in every dimension for the same reason that the genome is plastic: that's the only way to build knowledge. The whole structure has to change, to undo itself and redo itself, to know. This is why all complex organisms sleep, and why there is convergent evolution on sleep and even on REM sleep in particular, for example in mollusks like octopuses and cuttlefish.

From what we know about healing and trauma in general, we can imagine what the details of this repair process might look like. Every network re-establishes itself, but not into its exact previous configuration. Rather, the healed unit is a bit stronger in places and a bit weaker in others. All that really matters when a wound heals is that function is recovered. But much stress and trauma, for example exercise, results in recovery to a superior state of function. The same could be said of much mental exertion. So body networks must be healing the parts that were used by making them stronger, and decaying the parts that were unused into an atrophied, weakened state, where they may be reconfigured into new structures later. It seems to me that this is all that really matters. My biggest realization here is that since the system works as a whole, and ultimately the form + degree of the trauma that causes the damage comes from the niche, the details of how exactly the neural system, for example, repairs itself, as in what precise algorithms it uses, are not very important. All that matters is that

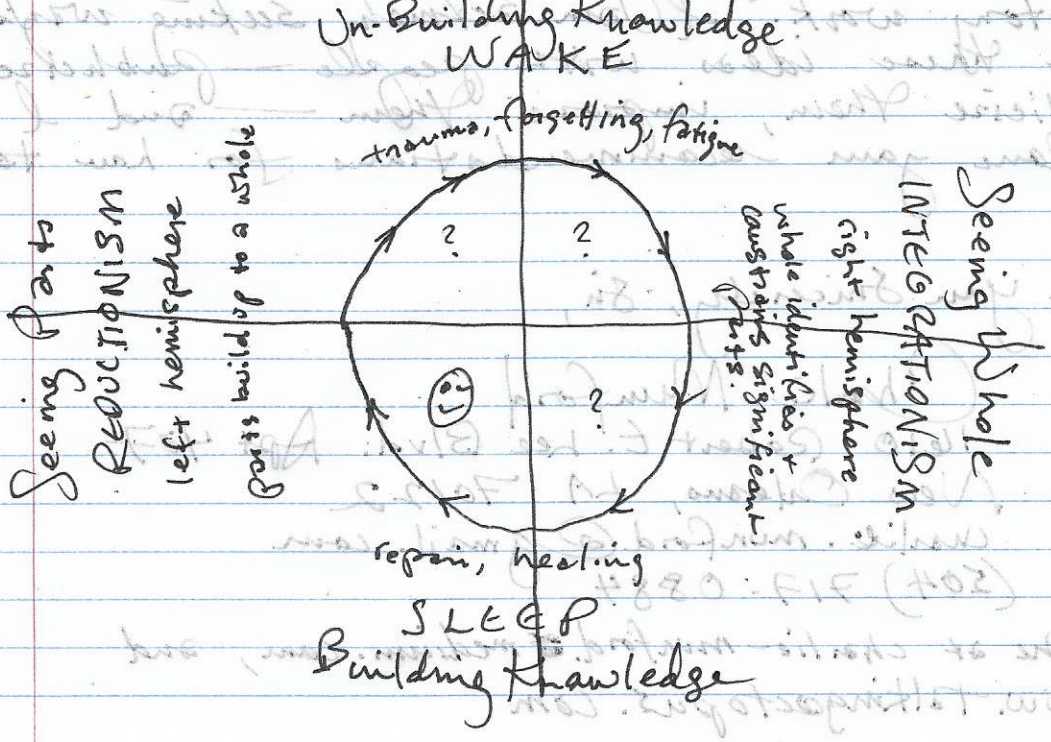
a connection that is used is strengthened, while a connection that is disused is weakened by stochastic decay until it is reconfigured later by another form of trauma.

The plasticity of a nervous system must lead directly to plasticity of behavior, just as the complexity of a nervous system must lead to complexity of behavior. It's the combination of these two factors, complexity and plasticity of behavior, that we call "intelligence." If I've seen it this way, then it makes sense that we don't have a good sense of what intelligence really is, or how to precisely measure it. If my explanation above is correct, then complexity and plasticity on their own will not lead to a system that can communicate in a decipherable way, and share any knowledge. ~~The octopus is a perfect example.~~ The system must inhabit, and have been "trained on," a similar niche, so that it will have common frames of reference with our own. The octopus is the best example. We can see that its nervous system is enormously complex. And that it is much more plastic than our own, indeed its whole body is highly changeable and malleable. But octopuses are solitary creatures. They learn independently without imitation or social interactions with their parents. And they only live a few short months. Their niche is so profoundly different from our own that we can barely share any knowledge at all... yet we can recognize their intelligence in that changeable, complex behavior.

People eat octopuses, and pigs for that matter. It occurred to me immediately when I thought of this model of intelligence that we could build a machine on the principles shown, but in order for anyone to wake up and say, "Wow, that thing is smart!" the machine would have to

take as its input "data" much of the same sensory world that we humans inhabit, and be able to act, to play + experiment, with things much as a child can. Crows, dogs, dolphins, elephants, monkeys, all of them lack either suitable voices or suitable appendages or both. It's these features that determine the niche the organism inhabits, and therefore its apparent intelligence to us. Even other humans can be extraordinarily sensitive to things, but we cannot be reached unless those are things we are sensitive to as well. Communication requires a (partially) shared niche.

After this, I happened to find Iain McGilchrist's book, and I realized now I had an explanation for the peculiar architecture of the brain as well as the peculiar sleep/wake cycle. In both dimensions, cognition has this "circular organization". Epistemology itself requires processing the same "data" from either end (parts to whole + whole to parts) just as it requires both building and unbuilding.



This diagram makes sense of why the nervous system is divided, and half of our neocortex inhibits the other half much of the time. It also makes sense of why the process of life is divided into sleeping and waking. In both dimensions, the whole system can only occupy one location at a time. Epistemology requires revolving through these cycles, and an organism can't be in two places on either the x-axis or the y-axis at once. The world can either be looked at as a whole to identify parts, or parts looked at by themselves to build toward the whole. Today's science spends too much time in the lower left quadrant, but the science of the future will be more integrated, I suspect.

I have handwritten this letter because I find that my letters are more thoughtful when written by hand. No reply is required, but if you do want to reply, you may not care to go scribbling for hours. My email address is below.

Thank you so much for your book; it was truly a revelatory work. I am actively seeking ways to engage these ideas with people — publicize them, criticize them, improve them — and I would love your recommendations for how to do that.

Thank you sincerely, sir,

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