

OUTLAST THE MACHINE!

Understand the Brain, Survive the Future

K.T. MARTEL

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DEDICATION

This book isn't about getting rich, not by any direct mean at least. It's not about becoming happy either, although happiness might be something you'll encounter along the way, whether looking for it or not. It's about the discovery of the Self, a quest for knowledge and control over the being of the mind, and control is all too often decided not by the Now, or the Tomorrow, but by the Yesterday.

Seldom comes a chance to turn back time and change everything, but walking backward is not a spontaneous process, a part of yourself must be left behind.

Here's mine, a special commendation to my parents and family, who despite their human flaws somehow made this book possible.

Thank You.

BLURB

Robots couldn't think faster than humans. It was a physical impossibility. The quality and velocity of the emergence of thoughts were independent of the nature of the material. The last vestige of their superiority vanished before the eyes with the last revelation. The conclusion was irrefutable. It was real life hitting you in the face. The most powerful machine in the world couldn't compute reality faster than a mere human made of carbon and water. Turing's design was just a shadow of the mind, a psychic crutch, but not the source of its main constituent block. Speed didn't help in the least; the mind always remained one step ahead of the machine. It's not that humans were inherently superior, it was the dumb fact that you couldn't go faster than the universe without pushing yourself outside of it. Consciousness was a relativity problem; the speed of the Universe was the only true motion.

Ahhh! But we had all been so blind! To their awesome speed! To their implacable logic and reflexes! And to their quirky but oddly-timed comments!

Intelligent robots were all dead, consumed by the Promethean flame of the human mind. We were all animals in the end. The technological singularity had been aborted inside our collective consciousness. The next stroke of keyboard would be just another exclamation mark adding up to everything that had led to that point >> – (!) – << To make sense of it all you must go back to page 1 and start all over again.

If only you could understand... Machines come and go, but YOU... You could be forever. All that is required is for one to become self-aware of the nature of self-awareness itself.

Outlast the Machine, a book teaching you everything there is to know about 21st century neuroscience, a book teaching you everything you need to know to make our robotic future worth living, written by ninja genie of the brain K.T. Martel, a woman with a vivid imagination and always full of surprises, a brilliant visionary light years ahead of her time.

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À PROPOS

I am not here to prove anything, but merely to lay down the groundwork where everything will become provable.

Who I am doesn't matter so much as what I have to say. If you stick around long enough, together we will be beginning the revolution neuroscience so direly needs. This book, shall become our instrument to understand, survive and outlast the machine. The core information must survive and be preserved at all costs and in every way possible, our collective continuity must be preserved.

CHAPTER 1

BRAIN IS ALL GLUE, DOMINOES, AND CAROUSELS

AWARENESS AND PERCEPTION, what separates one from the other is all but a Flash! This mysterious force twisting the very grid of the universe – a kiss of lightning – wrapping like an apple-bearing blue snake around the red tree of life, a bizarre concept nigh impossible even for the most scientific of odes to fathom.

The Self mirrors the Universe, understanding the Self is understanding everything. There are but two states to consider, Conscious and Unconscious; Synchronic and Asynchronic, all else is but redundancy.

-Anika from Bremen, MARZENA.¹

WHY EVEN STUDY THE MIND IN THE FIRST PLACE?! Who cares about a weird abstract concept like Consciousness? What does it even bring into our lives? Would knowing make our existence any different? Is there a reason to care other than the typical philosophical plundering and beside shear scientific curiosity?

There is one. It's called the Future. Because if your present day *sucks*, then becoming conscious of it is your only hope of ever making things better without having to wait for the rest of the universe to do it for you, and I don't know you, but I get this nagging feeling that if I don't start getting involved now, that we'll all be long dead before the world magically fix itself on its own.

The brain is a bit of a giant enzyme in that regard. Maybe we could think of consciousness as a catalyst between Time and Space then? Shrinking the distance between present and future? Like, when the past meets the present inside the mind and every frame becomes perfectly in sync with each other. Consciousness is this magical point in time where every detail of everything can be swapped with any detail of anything else, to create something that could have never been otherwise.

The mind is all about magic tricks. A bizarre feat such as the very existence of consciousness itself seems impossible at first, until you learn about the trick that is. The cards are being passed around, left and right, front and back, and each time we fail to see what's really happening because our eyes are fixed on all the wrong places. When we talk about brains we get busy talking about neurons. We get busy looking at all the different regional functionalities, *'This region does that, that region does this, if region X is damaged then you don't get any X.'*

We've been gathering all this information for decades, and yet still fail to understand the basics of what's really happening down there. What is it that our brains do to create the world that we know and experience? What is it that our brains have that machines lack? The way the information moves inside the brain is what makes the magic, *Magic*.

If you really want to understand the brain, then you have to put yourself inside the mind of a singular cell. At its core, the brain is a simple organ, just like any other. The brain must follow the rules and principles of biology, and cellular biology is all about concentration gradients. You send a chemical message and depending on how far the recipient cell is, and on which side you are sending or receiving the message, and what other messages are being sent, you get a reaction.

The recipient cell may grow or shrink. It may transform itself, move into action, or perhaps simply stand idle. *Basic biology*, that's where the magic happens. Somewhere inside your brain, somebody is silently gathering information about the chemical activity going on between every single of your neuron.

This somebody has a name, *meet the Astrocyte*, a little charming star-shaped cell which helps neurons by providing them with nutrients, and by cleaning up molecular leftovers.

Astrocytes are part of a group of cells which scientists refer to as *'glial cells,'* named after the Ancient Greek word for Glue. Originally, glial cells were thought to contribute nothing but a scaffold for the neurons. People at the time thought that they were just there to support neuronal function and nothing else. *'Glial cells are non-electrical. Glial cells are small and*

short. All they do is to surround the neurons. They are only there to support the metabolism of neurons. The neurons are the true fundamental block of the mind.'

It's well-known, neurons shape themselves in the form of long complexly branched wires. They first gather input from other neurons through a multitude of little dendrites close to their head, and they then funnel electricity through one long axon, focused more often than not in a singular direction with no going back, and leading somewhere far away from their cellular core. The axon terminus leads the signal all the way into a chemical synapse, it's that empty space between the neurons' ends, and each of these gaps is part of the same global extracellular space, the water-filled space outside the cells.

Ready to receive a new message, the next set of little dendrites is waiting for its molecular package beyond the end of the previous axon. The presynaptic neuron now needs to unleash a blitz of neurotransmitters, which will diffuse and cross the chemical synapse to reach the dendrites of the postsynaptic neuron, the next neuron in the chain. There, these molecules will get their chance to modulate neuronal activity, boosting or impairing it. Electricity will keep on flowing across the other side of the synapse depending on the firing of neighbor neurons in an *And/Or, If/Then/Else* fashion.

The synaptic cleft is a bit like a logic gate. One could presume the chemical synapse as the putative equivalent of the computer silicon transistor. It's like some kind of electrical riddle that the neurons need to solve to know whether or not a signal is worth propagating. To get past the electrical riddle, neurotransmitters flow through the synapse to reach and tickle the postsynaptic neuron, by binding to the appropriate neuroreceptors. They must trick the postsynaptic neuron into either opening or locking its ionic gates, as to control whether or not the positive molecules around the neuron should get inside or not, whether we should be generating an electrical current or not.² In the case where they wouldn't be able to interact with their primary target neuron, for whatever the reason, then the molecules would be cursed to wander off the extracellular space, from synapse to synapse, until finally finding a neuron with available extrasynaptic receptors with which they could interact with.³

So far, that's all pretty boring... This neuron stuff is nothing new I mean. We're getting carried away a little, but let's not forget that these chemical synapses are where computer scientists originally got the idea that the brain could be described with math, and could be replicated using computer software. Alas, history remembers all too well how that overhyped idea initially turned out, the AI Winter of the 70s and 80s. For some reason, computers don't make good brains; trying to artificially imitate neurons wasn't good enough.

Neurons... We always talk about them so much, but neurons are only half the answer. For every neuron in the brain, there is a correspondingly mysterious glial cell at work.⁴ Neurons give you some serious computational power, are good at relaying information, and are some pretty darn awesome pattern detectors, but you still don't have any efficient way of integrating all the different incoming data together. To any single neuron, anything happening beyond itself is just noise and that's the big problem.

THE MACHINE DOESN'T KNOW WHAT'S HAPPENING INSIDE ITSELF!

Everybody is talking, everybody is stuck within their own inner circle of neuronal buddies, and nobody is taking any time to stop, just one moment, to review everything that's happening all around. You can't do that – All you can do to find out what is happening is run more calculations, but who is going to keep track of the calculations on the calculations? Ideally you would need time to stand still so that the calculations could calculate everything without anything changing along the way, but not even a framework computing at the speed of light would be fast enough to perform such calculations. At such a speed time might be frozen outside, but would keep flowing normally inside.⁵ The problem persists... You still don't know what's happening inside the calculations of the calculations, because time is always moving forward somewhere.

What to do, then? Well, logically, the only solution that could come even close to stopping time itself, would be to simply perform all calculations when all time is null. You have to perform all the calculations on the calculations in a single step

that takes little to no time. The solution is to start gathering all signals happening simultaneously, all the data acquired at the same time, when Delta T is high zero. The solution is to have a component of your machine gather every single coincidence that happens in your calculations, and uses these 'coincidences' to perform quality control on all the calculations. Only then, when you simultaneously compare all these coincidences together, will you truly know if what is happening inside the machine is right or wrong. Only then, will you become capable of describing both qualitatively and quantitatively what is happening inside the machine.

As you'll soon come to understand, the brain is at heart a coincidence matching machine, not just a pattern recognizer. Just having outputs looping back into new inputs can only tell us so much about what the neurons are really doing, both as scientists and as conscious beings. With only neurons, we would be nothing more than blind, mindless electrochemical automatons no different than robots.

That could very well explain why artificial neural networks are still, at the time of writing this at least, nowhere near catching up with the original hype of the 70s, catching up with the idea of recreating a brain using computer programs. Computer scientists and software engineers just assume that the problem is in the wiring. They think they don't have enough wires, or neural nodes, and so everybody wants to add more transistors and then more transistors on top of the transistors, and make everything more complicated – but, but, but... The same fundamental problem persists. The same ambiguous error message keeps coming back. The machine is missing a key component.

With so many different conditions and variables, chemical synapses and transistors make communications only more complicated, and communicating is already complicated enough as it is. Can you imagine if every thought inside your head were like, *'if you wish to know more information about the content of your visual cortex, please press 1 and then press 3. If you'd like to know more about how to get direct access to your online hippocampus, please press 9 before pressing 2 and after pressing 3 if you have already pressed 1...'*

Definitely, thinking like a logic gate isn't the way to go. We need a system of communication more classy and flexible, and we need to ditch the gate out of our missing key component.

It's decided, coincidences shall become our new logic matching system. Live and swear by it, the only things making sense in this world are the things happening at the same time. That's the only logic there is, the rest... not so important to worry about, so go ahead and tell that robot to stick its pre-recorded phone messages full of options which you momentarily don't care about where the light doesn't shine.

To emulate our new form of logic, what we'd like to do is to simply glue information happening within similar time frames together, but we also want to be able to put any two events together, no matter how small the event. That's how nature does it, no? Inside my mind, I can match any element on any scale together, both consciously and subconsciously. Isn't that what makes dreams so weird in the first place? A strange mix up of random gibberish, somebody putting the whole universe inside a blender and keeping the finger on the max speed button?

See? Neurons are very energy expensive, so more neurons is definitely not the way nature solves this logic problem for itself. The information in a neuron only goes one way, usually, but to keep track of everything we need it to go both ways, always. We want to both receive and give feedback, and we want to do this everywhere possible. Everything needs to be more interconnected. We need a separate network of cells, separate from the neurons, where information can flow both ways and go everywhere all at once.

Feedback isn't just for the modulation of 0s and 1s, feedback for cells is about modulating growth. Growth is important for the formation of memories inside the brain, to modify the surface proteins and make it easier to cross the synapse and solve the electrical riddle, like creating a shortcut.⁶

But neurons cannot grow alone. They cannot rely solely on other neurons for that either. Neurons don't contain all the information and signaling needed to make themselves grow, or to guide that growth appropriately. They need help from the astrocytes. Those bloody starry cells, they are nature's solution to this integration problem, to this lack of self-

awareness. Astrocytes are the harbinger of the logic of coincidences. They are the one managing and coaching the neurons; they are the one running the calculations on the calculations.

The astrocytes form the blood-brain barrier controlling the flow of nutrients to the brain, and which prevents most foreign blood molecules from crossing over.⁷ Astrocytes are already present everywhere inside the brain; they are constantly monitoring everything. That puts them in an ideal place to receive and give feedback from all around. We got to start thinking that maybe there is more to a synapse than a presynapse and a postsynapse. Maybe we should be talking about a tripartite synapse system. The space between the presynapse and postsynapse is not quite empty, there is an extra tentacle listening in, the astrocyte's tentacle.

Astrocytes infiltrate neuronal synapses with the apparent purpose of cleaning up old neurotransmitter leftovers, before recycling them into brand new neurotransmitters. Every time neurotransmitters are diffusing through a synapse, it attempts to either activate or block the domino effect in the postsynaptic neuron, but it also coincidentally causes this third tendril to undergo a kind of domino effect of its own too.

Dominoes? What am I doing talking about Dominoes? What's a domino effect anyways? Nothing too interesting, it's nothing you can control. It's a necessary and costly evil that allows communications to travel through the cells. You can only prevent it from happening and it cannot be stopped once started, just like when you press the send button on an email.

Remember, the brain as the rest of the body is bathing in water. The extracellular space between the cells is all H₂O. Molecules in water tend to dissolve themselves into ions, with one positive part and one negative part. The inside of a cell is usually negatively charged, thanks to a heavy quantity of phosphate within the cell, namely in the form of DNA and other nucleic acids. Because of this, the positive molecules outside will be compelled to move inside, but will be forced to remain outside as the cellular membrane will prevent them from squeezing through. To control the flow of ions, nature uses pores, little molecular gates dispersed all over the surface of the cell. These pores on the neuron membrane are voltage-gated, i.e. if the difference in voltage drops enough, the neuron will depolarize and open the gate. The difference in voltage between outside and inside will become less, the gates will open, letting in more positive molecules, causing the inside of the cell to become even more positive, resulting in a chain reaction where more and more gates open.

Enabling or disabling this gating mechanism is the bread and butter of neurotransmitters. This effect is self-propagating. Enough neurotransmitters to depolarize a neuron in one spot, say at one of its dendrites, can cause a nearby voltage gate to open up, letting in more positive molecules that will further depolarize the neuron, thus opening the next gate and then the one after that, going all the way along the wire onto the next synapse. When a neuron is depolarized enough, this chain reaction becomes unstoppable, hence its name, the Domino Effect.

Once the ionic movement has gone through and that the cell has become invaded with positively charged molecules, the dominoes have all fallen. No more ions can move across the neuron's membrane, but the neuron is likely not done receiving and sending messages, so to keep going you need to constantly reset everything. To reverse the flow of molecules is like reversing time itself, you'll need energy, a lot of energy. A good chunk of the oxygen you breathe is used in great part to move sodium and potassium ions in and out of neurons to restore their natural gradient, and keep the flow of neural signals going. It's like bringing water up a dam so that it can flow down and generate electricity again.

To move positive sodium back out, the neurons must use a clever trick. The key is in their natively higher concentration of positive potassium. The potassium concentration being higher on the inside it naturally wants to get out, but once out, being a positive molecule it will now want to come back inside. As the potassium flows back inside, the cell uses this as an opportunity to swap places with the sodium, 2 molecules of potassium in, for 3 molecules of sodium out.⁸ We're taking more positive charges out than in, the cell recovers its original electrically negative state.

So yeah, neurons may look like wires, but they don't quite work like electrical wires. With wires you flip a switch and get a response within a light-speed delay. In the brain, the ionic movements of neurons travels through the axons at about anywhere from 1 m/s up to about 120 m/s. Neurotransmitters don't get released at the speed of light. With neurons, the charge is not moving through a solid object with a fixed and singular lattice of molecule evenly spread throughout its

structure, but through free floating atoms and molecules diffusing slowly in water. It is this slow movement of ions in and out the cellular membrane that allows them to transmit messages. Everything is a wave, different frequencies and intensities of ion movement correspond to different timing and spikes of neurotransmitter release, allowing neurons to effectively talk to one another.

Thankfully, the domino effect of Astrocytes is slightly easier to understand.⁹ It has to be a little different since astrocytes are not electrical in nature. It starts with the cell intercepting a signal triggering the release of calcium. Cells like to keep calcium stores inside their organelles, their own internal organs, especially the Mitochondria and the Endoplasmic Reticulum (the big wobbly structure surrounding the nucleus of the cell). An internal raise in Calcium causes the release of ATP outside the cell. The Tri-Phosphate part, the TP in ATP, quickly disintegrates leaving us with mostly only A, Adenosine, the same A from the ATGC bases of DNA.

Calcium ions are positively charged, but they'd rather go back inside the organelles they came from than wander off outside, and so there's no ionic movement involved. Common neuroscience equipment doesn't detect any brain wave from any of this, but there is still a message to be heard.

Like the domino effect of the neurons, this release of calcium and ATP begins at a focally isolated point. The Adenosine floats around until it binds to an adenosine receptor, either a little uphill on the same cell from whence it came from, or on another neighboring astrocyte.

This binding triggers the release of a molecule called IP3, Inositol with 3 Phosphates, which in the common language of cells means, *'Release more Calcium!'* and next the cell releases more ATP to float and wander around further away from the origin. Then everything just keeps falling in from there, one at a time, very slowly through molecular diffusion.

In astrocytes, an isolated release of calcium can become viral in such a way that even if a single astrocyte were to send a chemical message, their whole neighborhood would eventually know about it, and so even if a single neuron were to receive a message, then thanks to the tripartite synapse system, the astroglial network would also eventually know about it. We're getting a little closer to figuring out what's happening inside the machine.

The astrocytes can use their own version of the domino effect to transmit messages to their astroglial friends, but without being limited by chemical synapses as do neurons when communicating with each other. You can call up your phone company and hit a conversation with a human being instead of communicating with a machine in terms of *If/Then/Else/Press Pound To Repeat All Those Options*.

There is something *Free Speech* about the way astrocytes communicate. They just share everything; they don't discriminate. They don't keep secrets inside their own circles, and they still try to hear people out even if they disagree with their opinions. Things make sense or they don't. Astrocytes may either like everything as a whole, or hate everything as a whole, but hate it or love it, you'll still have to read it all.

The synapse of the astrocyte doesn't discriminate. They just transfer over whatever information is handed to them. They are conductive, they are more *electrical* than *chemical*. Astrocytes together form a *'Syncytium'*. It's a fancy term to mean that they are all directly attached to one another, like some sort of giant Super Cell, or a very long Christmas paper chain. They all share the same cellular content, just as much as Siamese twins share the same blood. Astrocytes have tiny little pipes called gap junctions, which directly connects all of them together and allow easy transfer of small molecules. However, the molecules move very slowly by diffusion alone. In fact too slow, there are still some doubts that astrocyte could be involved in cognition at all. This is why it makes more sense to focus on their extracellular communications via ATP, which on top of being able to spread in progressively greater amount, isn't dependent on calcium flowing through tiny pipes.⁹

So what's the point of having an electrical synapse and not a chemical synapse?

The electrical synapse might have gotten its name because it doesn't discriminate what it lets through, but its purpose isn't so much about exchanging molecules through it, but more about providing the network with a solid and crystal-like structure.¹⁰ The neurons can make electrical synapses too, they just don't do it as often. If we want to determine whether

two events are happening at the same time, and our means of communication are slow, then the least we could do is to have a stable structure so that when two events do happen at the same time, the signals can add up in a non-random way.

And so what is the link between all this and consciousness? We're getting there – the Carousel Effect – now this is where things start getting interesting. The Carousel Effect, as proposed by Pereira and Furlan,⁹ is when you combine both Astroglial and Neuronal Domino effects together. When neurotransmitters are released into the synapse, the dominoes start falling off, both for the neurons and the astrocytes. The astroglial signal can move across either the same astrocyte or a multitude of different astrocytes to reach a different synapse, releasing neurotransmitters there and influencing the next cascade of neuron dominoes.

Strangely, and outrageously, astrocytes can stimulate and activate neurons remotely without any signal ever going through a single neuron in between. To someone examining the structure of the brain's electrical activity, this would appear as some mysterious electrical activities coming out of nowhere and with no distinctive sources.

With the astroglial domino effect, you can transmit simple messages without having to get through any logical gate. You can move from one synapse and go on to activate more synapses in totally different locations, so whenever you ping a synapse, there is a possibility of bypassing the electrical riddle altogether, and activating an upstream or downstream synapse, without ever meeting the proper logical requirements for neuron transmission.

The portrait we are drawing here is that of the perfect coincidence machine. Now here is when the whole universe collapse inside the brain, when two synapses receive a strong excitatory signal at the same time.

When a neuron gets a signal, it transfers it to another neuron, but every astrocyte in between also intercepts it. The astrocyte sends the signals to other parts of itself and to other nearby astrocytes, which then activates other nearby neurons, which signals is intercepted again by the astrocytes which... Everything is spinning in circles, thinking about thinking makes you feel smarter, but it also makes you dizzy.

Focus now, the signal of Neuron A eventually hits Neuron B, and that of Neuron B eventually hits Neuron A. They coactivate one another via those astrocytes in between. One neuron can use the activity of the other neuron, thanks to the Carousel Effect, to boost its own signal, on the condition that all activities happen within similar enough time frames.

If the same events were to happen and over and over outside in the Universe, then Neurons A and B would be kept both continuously and simultaneously active. This would make their activity much stronger than that of the other neurons around them who don't fire at the same time. More activity means more noise, but whoever is distinctly louder is also more noticeable than the more silent majority. The silent majority also tends to make itself the easy preys of naysayers inhibitory neurons, making them more mute than shy. We are increasing the signal-to-noise ratio, the coincidences inside our head are becoming less and less random, and things are beginning to make sense. Neurons A and B becomes the winners of the game, and according to a certain Hebbian interpretation of the brain, the *Winners Take All*.

Hebb's Rule, neurons that fire together wire together, usually only meant in the context of a chain of neurons,¹¹ in the sense that the presynaptic neuron reinforce its connection with that of a postsynaptic neuron, so they're technically not firing together, but one right after the other.

This concept of wiring neurons located far away from one another, and all the neurons in between, is especially interesting in understanding the foundations of the self-learning capacity of the embryonic brain, with the wires still having place left for neural growth. As Neurons A and B fires together, they will extend their tendrils to become closer to one another, and all other neurons will be attempting to project their wiring into them as well. To the neurons, the area with the most activity is the most interesting of places. Neurochemicals are like catnip to neurons, everybody wants a piece of the winners. This is where they need to grow and extend their tendrils. If many neighbor neurons of A and B start firing

together, thanks to this extra growth in wiring, it ought to give the brain a good sign that something related to the original event, encrypted by A and B, is going on outside.

The astrocytes can help the two neurons wire with each other assuming that they do indeed fire together and that they fire together often enough. In the meantime, they can make the neurons behave as if they were already wired to each other, but at the cost of the signaling being much slower than if they were already wired. In that sense, the wiring of neurons is a way to preserve the synchrony of the original event, and to respond faster as they accumulate. The closer the neurons are to each other, the faster they'll wire up.

Think of astrocytes as a master hub. They group together, and their tendrils infiltrate the synapses of neurons where they can channel and integrate information about everything that is happening around them. Their mission in life is to help preserve events happening at the same time outside the universe by making them happen at the same time inside the brain.

There is a certain cumulative effect to this synchrony. In the brain, when certain events happen close to one another, the carousel allows the neurons to keep firing for longer than they should. As neurons keep on firing at the same time, a short window of time opens up for other neurons to join in. Two neurons firing at the same time can lead to a dozen or more neurons firing at the same time. The longer the carousel is spinning, the more chances a horse will have to find an opening to jump in. You can use two neuronal communications happening at the same time, to gather more subsequent neuronal communications also happening within similar time frames and within similar areas. That's how you match up real life events with molecular events inside the brain.

When you're thinking in words, it likely involves many different things, sounds, letters, intonations, synonyms, antonyms, homophones, foreign equivalents, and so on. All of these things keep very close to one another.¹² When you try to remember a word you have forgotten, what's the first thing you instinctively do?

You stop and push. You need to keep the circuit going long enough to coactivate all these things so that you get to remember all the details that you don't use very often and coordinate them together all at once. Thankfully, all these linguistic data are already conveniently located close to one another – A hint, it's not just a coincidence.

If astrocytes were to indeed play a major role in cognition, then it would definitely be in the domain of short-term memory, decision making, attention span, and potentially any cognitive task involving poorly interconnected neurons. Astrocytes would be involved in the learning of any new information and new skills. They're the one enabling that one slow, awkward first step that you have to make.

The brain loves grouping things sharing similarities together, and this Carousel Effect gives the brain its own mean of simultaneously activating the many neurons it needs to correctly perform its functions.

Timing is important. Constructive or destructive interference? If the neurons are not timed properly, the astrocyte-neuron feedback won't activate their associated neurons at the same time, and so the feedback won't come back at the appropriate time to make the carousel rotate. There will be no enhancement of neuron signaling. No coincidence means nothing interesting is going on. For the carousel to rotate at maximal speed, several astrocytes need to report their feedback within similar time frames, so that neurons will resend the message back at the same time, making the momentum of signals cumulate to become strong enough to keep rotating on its own.

This creates a zone of activity, a bit like a smoke signal, so that the rest of the brain can see that something is going on here. This is what we see when we look at a brain scan. That's the meaning of all these colorful spots spreading throughout the brain, a smoke signal serving as an invitation to cells on its rim to tell their friends to join the party. Anybody studying developmental biology ought to recognize this as a pretty standard form of cell-to-cell communication, and that's exactly what a neuroscientist needs to be seeing.

When neurons are talking, astrocytes are silently listening in, and wiring down everything happening at the same time – THAT'S THE MAGIC TRICK WE ARE MISSING! THAT'S HOW YOU CREATE SELF-AWARENESS ON A CELLULAR LEVEL! That's how a machine manages to understand what's happening inside itself! The stronger the original input is being

concentrated within a region, the faster the carousel spins. The more smoke, the more neurons you gather, the more events you associate together and the closer the events become inside the brain!

Any two events can become connected via this underground network. The astroglia is a real gossip mill. It's not the computing and processing done by the neurons that matters, it's the communication occurring simultaneously. The location and frequency of the information are more important than the information itself. It's like social notoriety, whenever who is speaking is more important than what this someone is saying. Have someone else say the exact same thing and nobody will bat an eyebrow, but have the special someone say it, and then suddenly it becomes a stroke of genius to be quoted all across the web.

But information only starts becoming truly important when two reputable people are saying the same thing in a relatively similar frame of time. If you match many events happening at the same time, there ought to be bits and pieces containing identical information. If you can isolate these bits and pieces, then you can start understanding what the neurons are really saying. You can become self-aware of yourself.

Shhhhh... Do you hear that? That sound inside your head? That's the sound of the machine hearing its own processing... That's the sound of new thoughts meeting one another.

This dance of cellular communications is consciousness at the microscopic level, the fundamental unit or block of consciousness. One could perhaps go so far as to say that, astrocytes are the very source of our feelings and sensory awareness. Pereira and Furlan describe Consciousness as, *Awareness plus Sentience*, or Neurons plus Astrocytes.² It's easy to tangle up with this definition though; in some languages awareness and consciousness are the same thing. Let's just say that Neurons take care of breaking down and communicating Knowledge, and Astrocytes provide a certain '*Sensation Capacity*,' a way to sense all this knowledge and see what is happening simultaneously and what isn't.

The brain is sensing its own activity from all over, this is what creates consciousness. Neurons use Logic Gates, and astrocytes use the Logic of Coincidences. Astrocytes are the glue of all logic.

With all this new knowledge roaring like thunder, someone got to start asking the question. Are Astrocytes the center of the Universe? I mean, if the Earth – Neurons – are not the center of the Universe, then that would mean that neurons would rotate around the astrocyte just as the Earth rotates around the Sun?

Ah yes, right! Astrocytes provide the neurons with fuel, not the other way around!

In fact, we could almost think of neurons as nothing more than a phone line or some kind of organic computer to allow astrocytes remote interactions with one another, from master hub to master hub, and it probably wouldn't be too far off from the truth. What we are witnessing here is simply the apex of the Astrocentric Hypothesis, first proposed by Robertson in 2002,¹³ putting the astrocytes at the center of all processing rather than the neurons themselves.

As mysterious as the mind is, for anyone to understand all of its secrets, all that is needed are 3 words – just 3 key words. Glue, Dominoes and Carousels, this strange combo is what creates a universal learning machine.

If for whatever reason, you were to find yourself confused by all this, don't be. It will all make more sense the deeper you go into the depths of the human brain, and as you relate this information with your everyday life. Just relax and let the book read itself. Let your subconscious and your non-verbal brain do the reading and the thinking for you. Just let the auto-learning machine take care of itself and you'll see.

SOME EXTRA INTERESTING FACTS ABOUT ASTROCYTES

A single gray matter human Astrocyte can affect from 270 000 up to as much as 2 MILLION synapses, versus 100 000 to 140 000 for the mouse.¹⁴ Astrocytes are much bigger in humans than in other animals, about 20 times larger than the mouse, and 3 to 5 times faster, a trait very likely linked to our higher intelligence.¹⁵ Contrast with the evolution of neurons, human and mice neurons are pretty much the same.

Human Astrocytes have a more precise spatial organization than other species.¹⁰ They form domains, with a highly organized grouping of cells organizing themselves as if atoms in a crystal. Brain injury may be associated with a loss of domain organization, causing information to fall out of sync and causing a decrease in cognitive function.

A human brain has about as many glial cells as neurons, but astrocytes are only a fraction of the overall number of glial cells. The ratio of astrocyte to neuron has been shown to evolve throughout evolution with humans having higher ratios than other species.¹⁶ Astrocyte to Neuron ratio may not be uniform throughout the brain, contributing to the emergence of different types of intelligence, with certain types being more dominant in certain individuals. Astrocyte to Neuron ratio is by far at its lowest in the cerebellum, the mini brain at the base of the skull. Conversely, most the brain's neurons are in the cerebellum, technically leaving the rest of the brain with a higher percentage of glial cells than 50%.

Although astrocytes are the most numerous glial cells, other types of glial cells also exist and are not any less important. Schwann cells and Oligodendrocytes attach themselves around the long neuron fiber of the white matter, allowing them to transmit signals faster and giving them their characteristic white color. Microglial cells are used as a form of innate immune system and can transport foreign particles outside of the brain to be processed by the body's main immune system. Radial cells are stem cells in the brain, which can become new astrocytes which then create new neurons.