brain STEM

Issue No. 1

brain STEM

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Dear readers,

We are proud to present the very first edition of *brainSTEM*, a neuroscience magazine created by students of the Behavioral Neuroscience Program at Western Washington University.

Our goal was to create a collection of digestible articles that highlight some of the fascinating aspects of the neuroscience field that we know and love. Often, science literature is complicated and densely packed with unrecognizable words, deterring people from fully understanding the content. We hope this magazine enables our readers to explore some of the compelling new research in the world of neuroscience, while also providing a tour of some the aspects of this field that each of us find interesting.

We each confidently began writing with an intended topic that quickly morphed into something drastically different. The research, statistics, and novel findings in the neuroscience field uprooted those ideas, enticing us each down a completely different pathway. Over the span of several seasons, the authors of this magazine met with Kelly Jantzen, the Director of the Western Washington University Behavioral Neuroscience Program. Together, we created this very first edition of brainSTEM.

We hope that you enjoy reading this special first edition as much as we enjoyed creating it.

All the best,

The brainSTEM Creators and Authors

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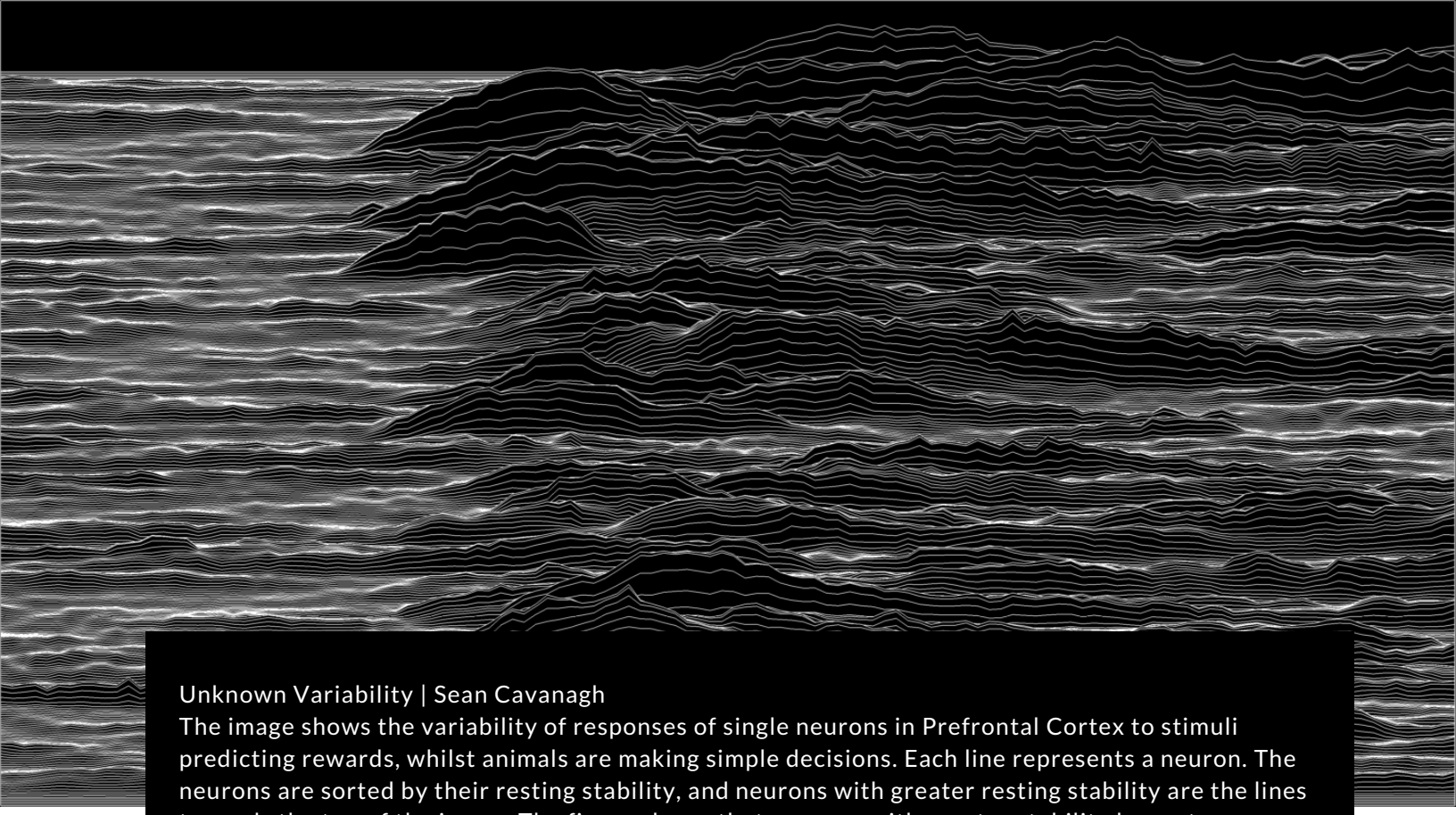


Unknown Variability | Sean Cavanagh
The image shows the variability of responses of single neurons in Prefrontal Cortex to stimuli predicting rewards, whilst animals are making simple decisions. Each line represents a neuron. The neurons are sorted by their resting stability, and neurons with greater resting stability are the lines towards the top of the image. The figure shows that neurons with greater stability have stronger responses to the reward-predictive stimuli.

What's Inside

Neuroscience as Art

The purpose to include this segment, “Neuroscience as Art”, was to explore the interface between remarkable tools we use in neuroscience research and the aesthetic experience that artwork provides. It is fascinating how the natural intelligence of our brains creates pieces of artwork that we can, in turn, use to explore the very nature of how our brain functions. Throughout this magazine we have included multiple pieces of neuroscience artwork that might make you think twice about why these images are aesthetically pleasing in the first place, and how can they help us make sense of our world.

Neuroscience Myths Debunked

With its more than 80 billion neurons and 100 trillion connections, the human brain is quite possibly the most complex object in the universe. A human fascination, coupled with a misunderstanding of the science has led to a number of myths about the brain. Often these myths are perpetuated in the popular media, ingraining them into the culture. Throughout this publication we take the opportunity to dispel some of the more common and persistent myths about the brain.

THE GUT-BRAIN AXIS: HOW FOOD AFFECTS YOUR MOOD

By Rebecca Sharp

If anything makes us human, it's our minds, thoughts and emotions.

In life we experience ebbs and flows with blissful highs at times and dark and debilitating lows at others. While these emotions and moods are paramount to our “humanness”, it sometimes feels like we are along for the ride of our emotional rollercoasters, with little control over how we feel. However, we don’t have to play victim to these emotions. In fact, we may have more control over how we feel than originally thought, and it all starts with what we decide to put on our plate.

Scientifically speaking, your gut is called the enteric nervous system, a complex system consisting of hundreds of millions of nerve cells, the same nerves that make up our central nervous system (Furness, 2007). It is often referred to as your second brain because of its complexity and importance. Our gut bidirectionally communicates with the cognitive centers of our brain along the vagus nerve to form the system known as the gut-brain axis (Carabottie, 2015). Interestingly, even if this connection is severed, our intestines can still continue to function fully without connection to our brain, suggesting that our guts have a mind of their own (Furness, 2007).

"Our guts may be the ultimate ringmaster"

Although our gut is not responsible for solving complex math equations and setting long term career goals, there is plenty of evidence suggesting that activity in our gut affects not only our digestion, but our mood. This all starts with the microbiota, a separate organism residing in our guts that may be the ultimate ringmaster.

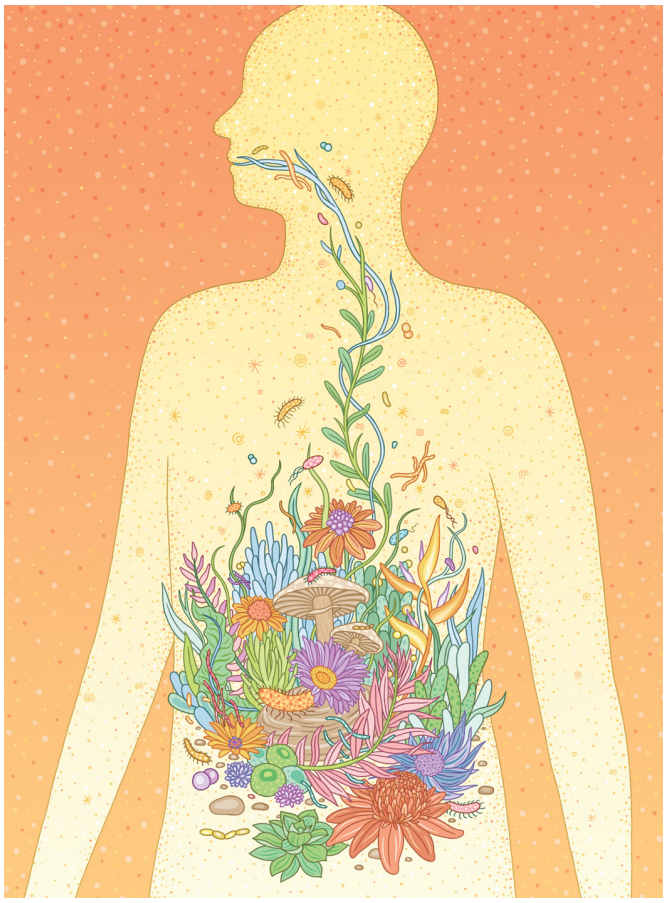
Humans can be considered a superorganism, living in a symbiotic relationship with the microbes in our gut (Sender, Fuchs and Milo, 2016). The population of microbes that live in our gut are a diverse ecosystem, comprised of hundreds of thousands of different species of bacteria and fungi that have been with us since birth. Our health and wellness are reliant on this ecosystem, and significant evidence suggests that our microbiome plays an integral role in how we think, behave and feel.

How does our microbiome specifically affect our mood?

The microbiome can influence the levels of serotonin in the body. Serotonin is a neurotransmitter chemical that, among other functions, generates an overall feeling of happiness. Although you may know of serotonin as a molecule circling around the brain, in fact, 90% of our body's serotonin is produced in the gut by our microbiome (Vadder, 2018). Together with the back and forth communication along the gut-brain axis, the gut is well positioned to influence our mood. In other words, the diverse species of microbes in our gut act as a massive drug factory, pumping out different neurotransmitters that affect our mood. Interestingly it is also perhaps not surprising that antidepressant drugs such as Prozac that act on serotonin receptors also have side effects that affect our gut, such as nausea or diarrhea (Margolis et al., 2016).

Fecal Transplants

Microbes have such an influence on our mood that the act of transplanting the gut bacteria from one individual to another is enough to not only alleviate depression-like behaviors, but also drastically alter one's personality. A growing number of researchers have performed what has been termed "trans-poo-sions", also known as a fecal microbiota transplant. While this procedure may not sound particularly appealing, it has revolutionized the medical world in helping patients restore their microbiome to a healthy, balanced state. Additionally, it is now well understood that people who suffer from depression have a different microbe make-up compared to healthy patients. Taking this into account, a recent study by Pearson-Leary et al. (2019) used fecal transplants between rat models that were characterized by one of three different behaviors: vulnerable to social stress, resilient, or non-stressed. Fascinatingly, after the fecal transplant, non-stressed rats that received



bacteria from the vulnerable rats were found to be significantly more vulnerable and exhibited depressed-like behaviors. In other words, when researchers swapped the bacteria, they swapped the behaviors too.

What do we make of this?

While much more research is required, these studies give us powerful insight into how our gut bacteria influence our mood, which opens the doors to targeting the human microbiome in developing novel treatments for psychiatric illnesses. Pre-clinical research in rodents also suggest that certain probiotics have antidepressant and anti-anxiety effects.

"A diverse microbiome is a happy microbiome, which in turn creates a happy human"

Probiotics, meaning "for life" in Latin, are a form of bacteria that help our digestive system and support the health of our microbiome. A study by Desbonnet et al. (2010) found that administering a probiotic called Bifidobacterium to a depressed rat model increased motivation and reduced other behavioral deficits seen with depression. Many other studies like these have found similar antidepressant effects using probiotics that are on par with that of antidepressant drugs, suggesting a wider therapeutic role for probiotics than we may have initially thought (Sanchez et al., 2017). On the other hand, when looking at antibiotics, meaning "against life" in Latin, one may begin to speculate how these affect the natural state of our microbiome. While certain antibiotics are medically necessary for fighting bacterial infections, prolonged use of them can seriously affect both the bad and good bacteria in our gut. The resulting imbalance, while setting the stage for a variety of gastrointestinal problems, may also lead to cognitive and mood problems. A diverse microbiome is a happy microbiome, which in turn creates a happy human.

How can we provide a healthy gut environment for our microbiome to flourish?

Eating foods rich in probiotics and dietary fiber are not only good for us, but for our microbes, which in turn can vastly benefit our mental health. These foods include a variety of fruits and vegetables, as well as fermented foods such as sauerkraut and kimchi. On the other hand, eating processed foods and foods low in fiber harm our gut bacteria, resulting in an improperly functioning microbiome and less serotonin circling around our nervous system, which could ultimately lead to depressed feelings. Overall, our health is not only dependent on feeding our human selves, but also upon feeding the abundant bacterial community that live inside of us. Maybe Hippocrates wasn't too far off when he said "*let food be thy medicine*".

TOP FOODS TO BOOST YOUR MOOD

Easy foods to incorporate into your diet to make your brain and gut happy

PREBIOTICS

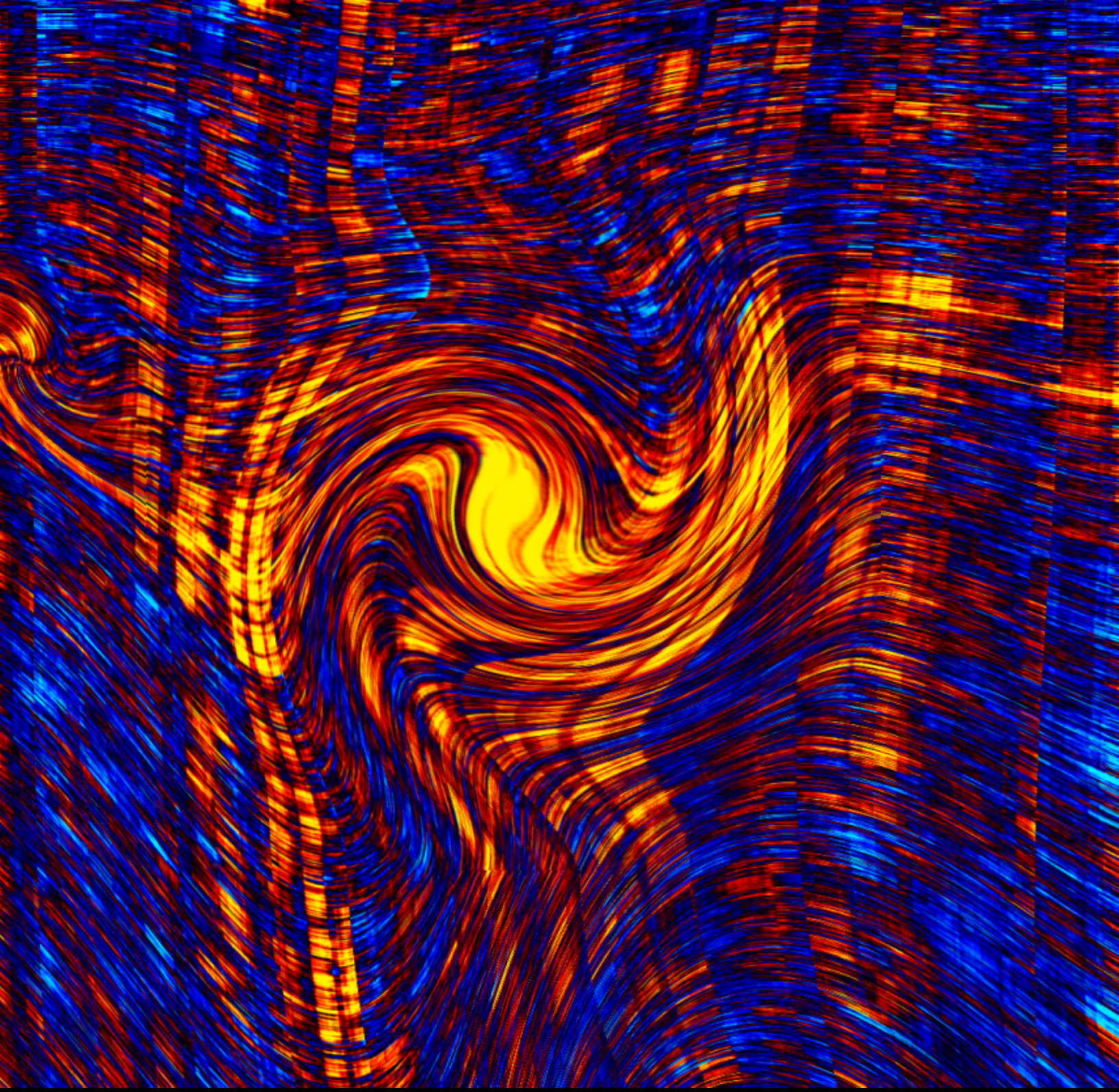
Prebiotics act as the food for the probiotics (the living bacteria in our gut). Foods high in prebiotics are generally include foods high in *fiber*. This includes plant foods such as bananas, greens, artichokes, onions, garlic, and legumes.

PROBIOTICS

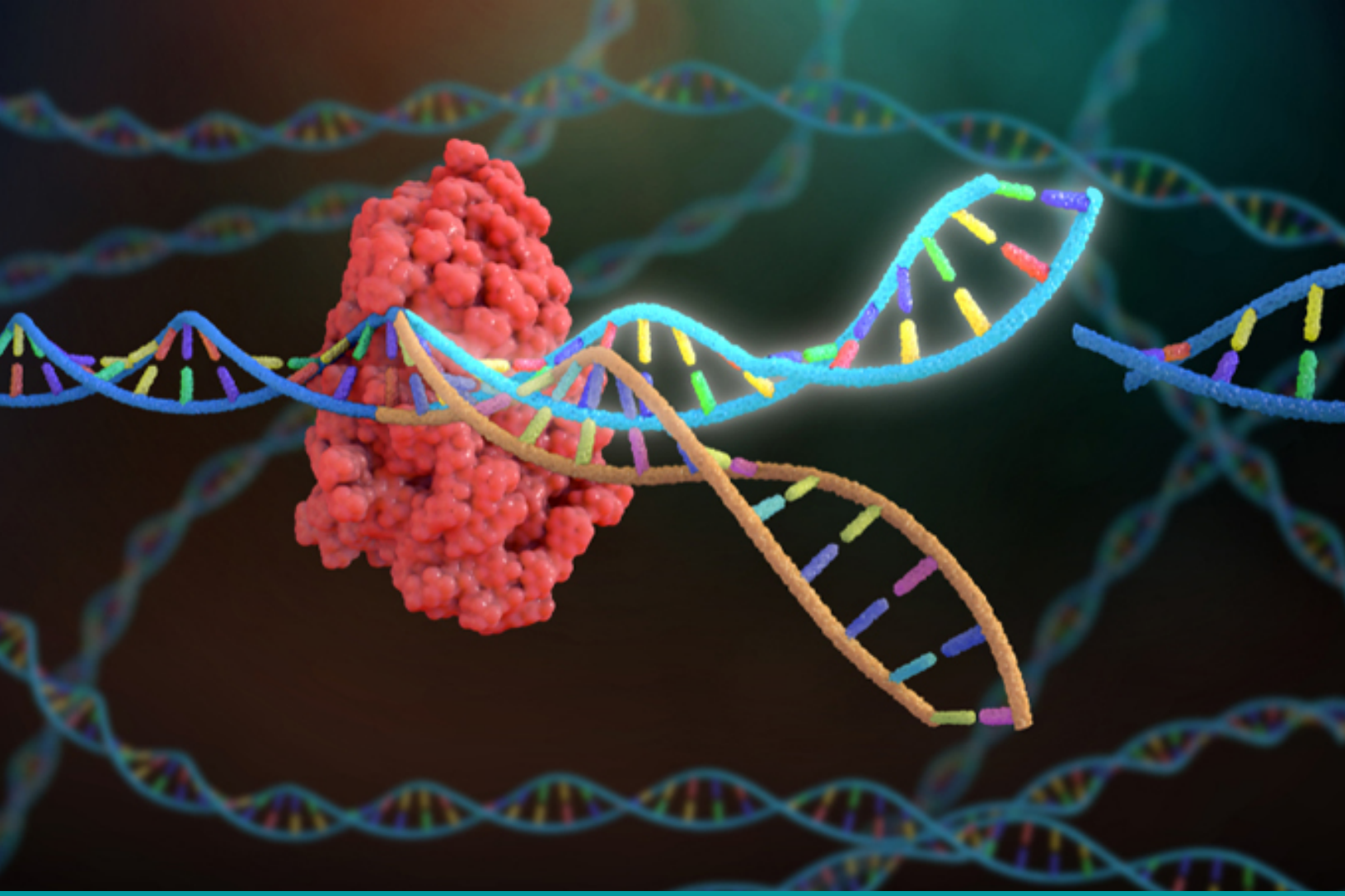
A combination of prebiotics and probiotics will promote a thriving, happy microbiome. Foods naturally containing probiotics include fermented foods, such as sauerkraut, kimchi, kefir, tempeh, and miso.

UNPROCESSED

Fried foods and processed, packaged foods contain a list of ingredients that can both harm the good bacteria in your gut and promote the growth of bad bacteria. Stick to whole foods and cutting out the junk will lead to a happier you.



Swirls of Synchrony | Pierre Bellec
Each point measures the synchrony (correlation) of spontaneous brain activity with that of the cingulate cortex. Rows are brain regions (space), columns are time windows. Rows have been ordered to expose the spatial structure of synchrony. Non-linear deformation of the space/time grid have been applied to expand outlier synchrony values, and visually emphasize their importance. This may turn out to be a useful trick to explore space-time dynamics, or not.

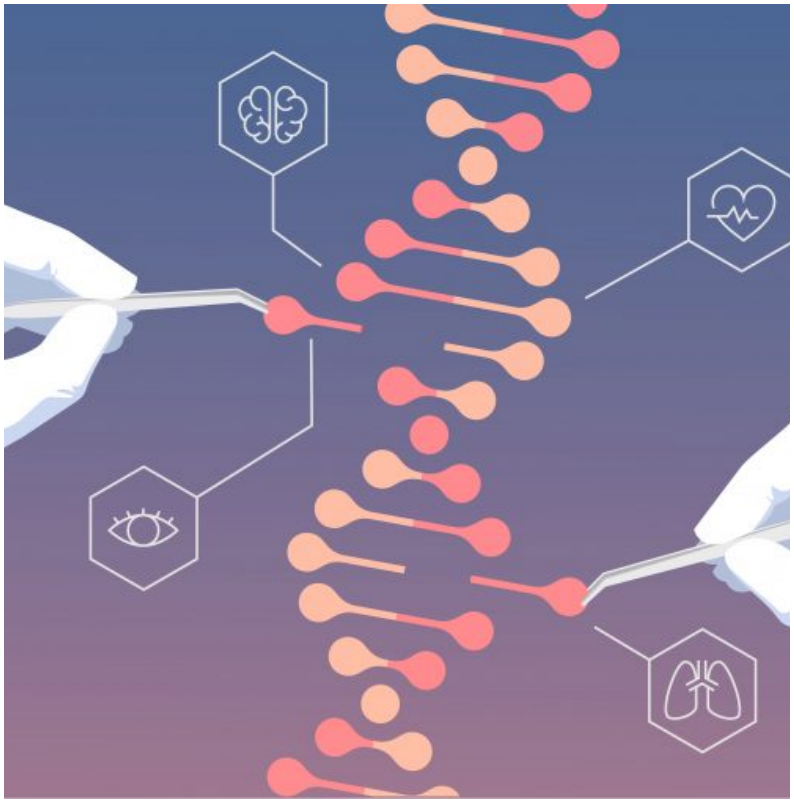


CRISPR: THE FUTURE OF GENE EDITING

By Hardeep Tiwana

The concept of splicing together genes of different species to create something new and better is a common theme in popular culture from the island of Dr. Moreau written by HG Wells in 1896, the Spiderman comics of the 1960s and perhaps culminating in block buster movies like Jurassic Park. A common theme of these popular treatments is the desire to create super creatures by combining the strengths of different species with none of their associated weaknesses. Also inherent in the science fiction of gene editing is the allegory that messing with nature can backfire and lead to disastrous consequences. But how much of what is portrayed in popular culture is science fiction versus science fact? Gene editing techniques applied to agriculture in the form of genetically modified organisms have been in wide use for decades, but the widespread application of human gene editing was still science fiction, until the recent introduction of the cheap and accurate gene editing technique called CRISPR. CRISPR, which is an acronym for clusters of regularly interspaced short palindromic repeats, is a gene

editing tool that can selectively edit the genome allowing researchers to easily modify DNA sequences. CRISPR can alter DNA by Cas (CRISPR associated protein) typically Cas9, which is an enzyme capable of cutting out specific DNA strands with a high degree of accuracy. Once the DNA strand is cut, researchers can fill the gap by inserting a strand from a template DNA. Because it is faster, cheaper and more accurate than existing gene editing approaches, CRISPR holds immense promise for curing HIV, genetic diseases and some cancers, not to mention feeding the world by effective modification of crops. However, because of its ease of use, CRISPR raises new and important ethical concerns.



"CRISPR holds immense promise for curing HIV, genetic diseases and some cancers, not to mention feeding the world by effective modification of crops."

The Discovery of CRISPR

CRISPR was first discovered in 1987 in the genome of E. coli, however, the function was not well understood at the time. At the turn of the 21st century new clues to the function of CRISPR were published and researchers found cas genes and their link to CRISPR sequences. In 2005, studies suggested that CRISPR repeats in bacteria could be a crucial immune function against certain invading cells like phages. In the same year the CRISPR-associated protein (Cas) capable of DNA-cleaving was discovered in the common bacterium Streptococcus thermophilus. The precise role that CRISPR spacers had in immune function still was unanswered, until 2007 when it was found that CRISPR spacers serve as a sort of genetic memory that helps detect and destroy known invaders. CRISPR arrays serve as a memory system for the bacteria so if the virus strikes again, the bacteria can produce RNA segments from the CRISPR arrays to target the viruses' DNA. The bacteria then use Cas9 (or another Cas enzyme) to shred the DNA apart and stop the virus. In a research lab, the CRISPR-Cas system works in much the same way. Scientists modify RNA to recognize a specific target DNA sequence and the Cas9 enzyme cuts the sequence. After the DNA is cut, researchers use

the cell's own DNA repair mechanisms to add or remove pieces of genetic material. Scientists can also make changes to the DNA by inserting a customized DNA sequence to an existing segment.

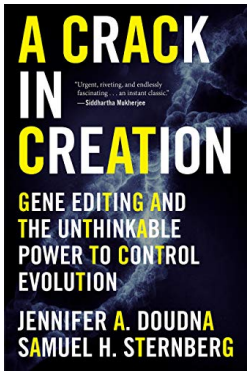
Future of Gene Editing

Although we have advanced considerably in our understanding of certain diseases (e.g. Alzheimer's disease), we still lack a cure. Treatments such as zinc fingers (ZFs) and transcription activator-like effector nucleases (TALENs) are expensive. On the other hand, starting a CRISPR lab costs around $2,000 and is relatively affordable compared to previous gene editing techniques. Despite the possible benefits of CRISPR, some fear that the low cost and ease of use will lead to the widespread and potentially unethical use of the technology, which includes the creation of *designer babies* who have all the "best" genes and characteristics.

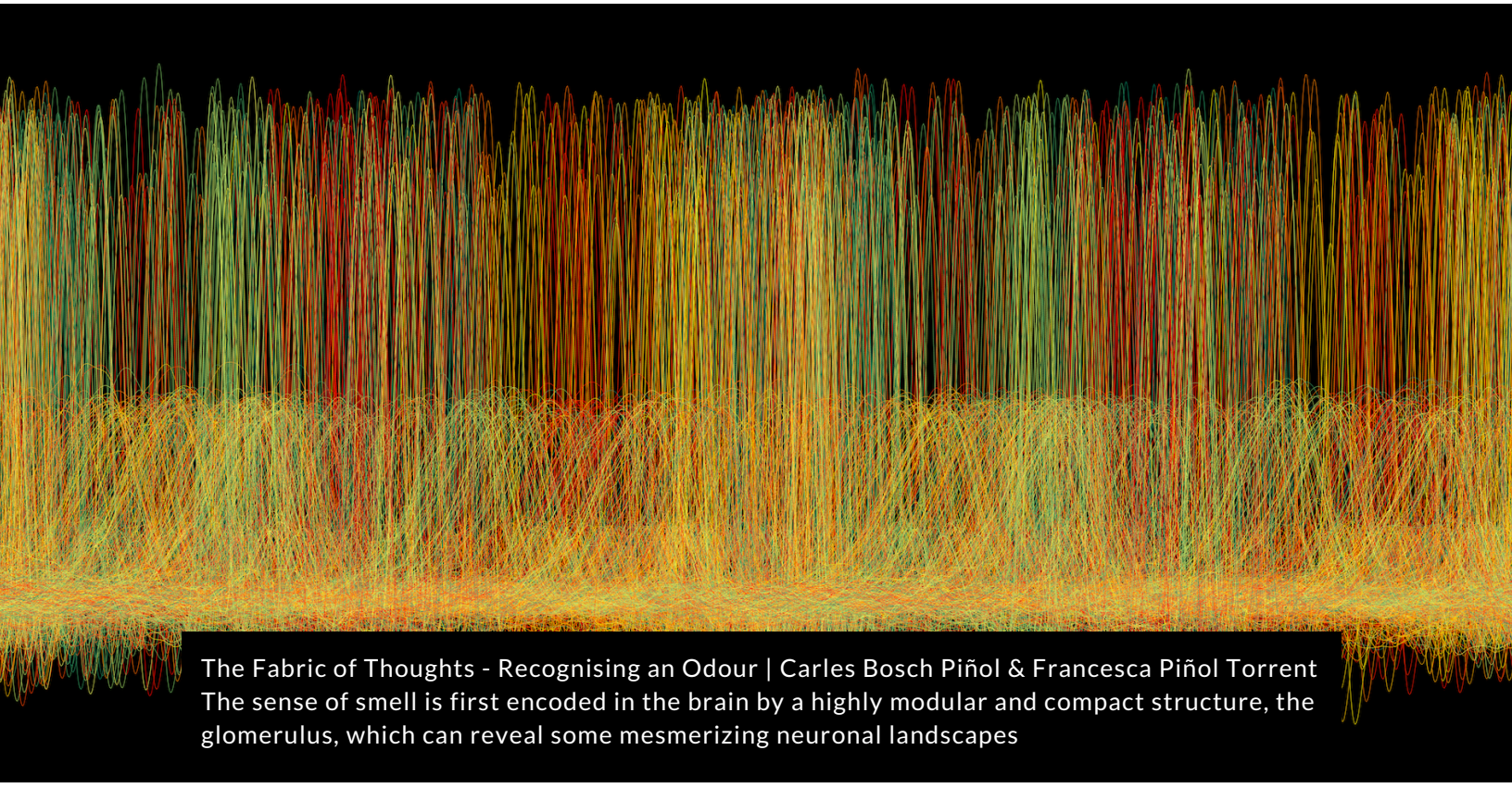
Those with the means could “design” children capable of pursing the best athletic or political careers at the expense of those who do not undergo gene editing, essentially creating a genetic stratified society.

Any genetic modification performed on an embryo results in permanent changes in DNA that can be passed down to future generations. CRISPR’s precision and effectiveness as a gene editing tool has plunged many scientists into a debate on whether we should have a moratorium on embryonic gene editing. Will society ever be ready to use such a powerful tool? How do we regulate the usage of CRISPR? Once a discovery is made, we cannot "undiscover" it, so it is critical that we find a common way forward including discussion of what conditions warrant the use of CRISPR. Jennifer Doudna, who discovered the potential of CRISPR–Cas9 in 2012, called for a moratorium on germ line editing in 2015 and expresses her concerns regarding gene editing in the germline, “I’m extremely excited and enthusiastic about virtually all the phenomenal progress being made with CRISPR… I think we should refrain from using CRISPR technology to permanently alter the genome of further generations of human beings, at least until we’ve given much more thought to the issues that editing germ cells will raise. We should think twice before crossing that line. We should think again.” Despite these concerns, in more recent years, we know countries have begun to utilize CRISPR to modify human embryos. In 2018, the world was shocked to learn that a Chinese biophysicist, He Jiankui, claimed to have used CRISPR technology to modify human embryos and make them resistant to HIV.

“I think we should refrain from using CRISPR technology to permanently alter the genome of further generations of human beings, at least until we’ve given much more thought to the issues that editing germ cells will raise."



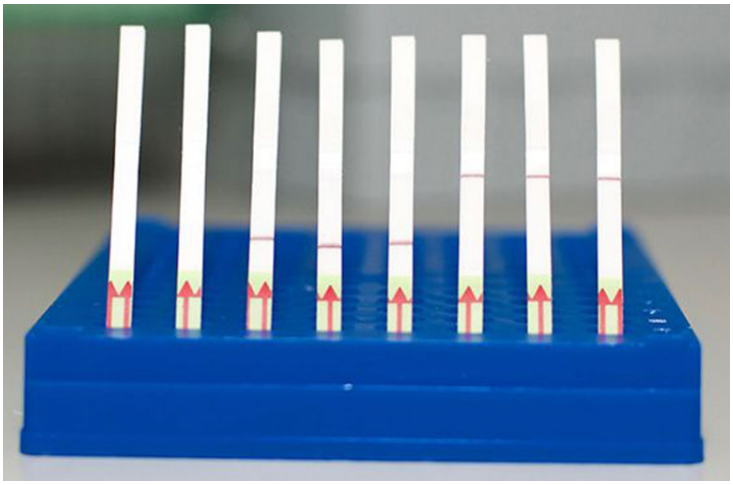
Scientists around the world were quick to respond and criticize the irresponsible action of editing a human embryo. He Jiankui was ultimately fired from SUSTech, fined 430,000 USD, and sentenced to three years in prison alongside some of his collaborators. Although CRISPR is a powerful tool for gene editing, off-target effects are known leading to imprecise gene editing which can have adverse effects. Researchers in academia around the globe are calling for a moratorium on human embryo editing with CRISPR but currently no legal restrictions exist. CRISPR biological kits are being sold online leading to a new wave of biohacking. The ease of using CRISPR combined with some knowledge from the internet has started a new trend allowing people to make independent modification to the genome. Although more precise gene editing is the future of science, the ethical questions remain unanswered.



The Fabric of Thoughts - Recognising an Odour | Carles Bosch Piñol & Francesca Piñol Torrent
The sense of smell is first encoded in the brain by a highly modular and compact structure, the glomerulus, which can reveal some mesmerizing neuronal landscapes

SHERLOCK: A CRISPR-BASED DIAGNOSTIC TOOL

By Hardeep Tiwana



Dr. Feng Zhang lab develops SHERLOCK method for testing of different target molecules. Results are shown on paper strips.

Although most recognized as a mechanism for gene editing, research labs are creating other novel and important applications of CRISPR. A recent CRISPR publication announced an inexpensive novel method to rapidly and accurately diagnosis diseases using CRISPR-based diagnostic tool called SHERLOCK (shorthand for Specific High-sensitivity Enzymatic Reporter unLOCKing). As the name implies SHERLOCK investigates the DNA for evidence of known conditions or diseases.

At the heart of SHERLOCK is the use of CRISPR-associated protein, Cas13, which is programmed to bind to specific segments of RNA. Some target molecules include Zika and dengue RNA strands. Cas13 enzyme seek out these genomic strands, bind to their specific sites, and start cutting away indiscriminately including other nearby RNA. Dr. Feng Zhang and his research team at the Broad Institute discovered how to generate a detectable signal when Cas13 found its target. SHERLOCK uses additional strands of synthetic RNA which release a signal molecule after they are cleaved, creating a detectable signal that indicates the presence or absence of the target molecule.

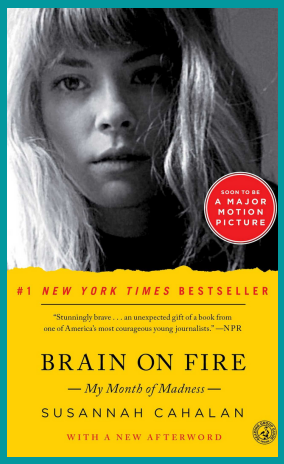
SHERLOCK has proven to be incredibly sensitive in detecting infectious diseases that may otherwise be difficult to identify. Unlike previous approaches, SHERLOCK can detect multiple targets at once, can be applied in less than 15 minutes and produces results in under an hour. Positive identification is presented using a paper strip analogous to those common in pregnancy tests, making this approach available for wide adoption and field use, particularly during disease outbreaks or in medically underserved areas.

READ & WATCH

From fascinating recounts of mysterious neurological disorders to movies highlighting the devastating relationship between a life of amnesia, trauma and lies, here are our recommendations for books and movies relating to the brain, its marvelous capabilities, and tragic faults.

1 BRAIN ON FIRE

Susannah Calahan, a young Journalist for the New York Times, details her experience with the onset anti-NMDA Receptor Encephalitis, a rare autoimmune disease where the immune system essentially attacks the brain. From seizures and voices in her head, to increasing insanity and even violence, Cahalan details her journey to her eventual diagnosis in a gripping way that highlights the importance of knowledge of lesser known cognitive diseases.

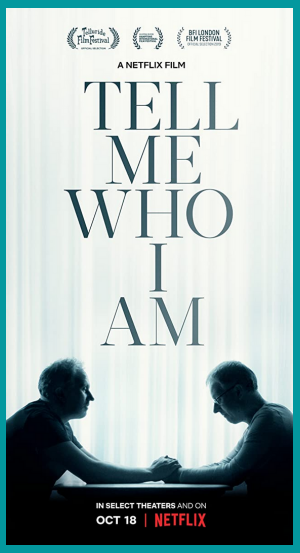


2 EX MACHINA

Caleb, a coder at the top search engine company, Blue Book, wins the chance to meet the renowned CEO. Upon arrival Caleb is surprised to find he meets not only the CEO but Ava, an artificial intelligence that Caleb is asked to assess using the Turing Test. This sci-fi suspense film leaves viewers questioning the direction of technology and the meaning of consciousness.

3 TELL ME WHO I AM

Tell me who I am is a fascinating documentary, based on the book written by twin brothers Alex and Marcus Lewis, that explores the intentions and implications behind the falsified recounting of their childhood by one twin to the other following severe memory loss. When Alex loses his memory following a motorcycle accident, Marcus rewrites their traumatic childhood by entirely omitting the dark truth, leading Alex to believe they had an idyllic childhood.

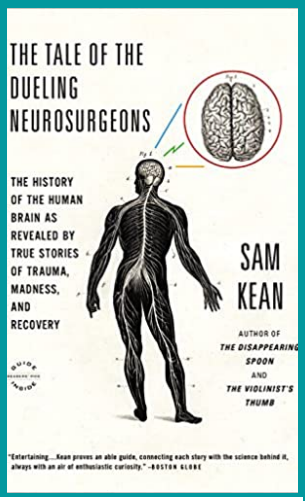


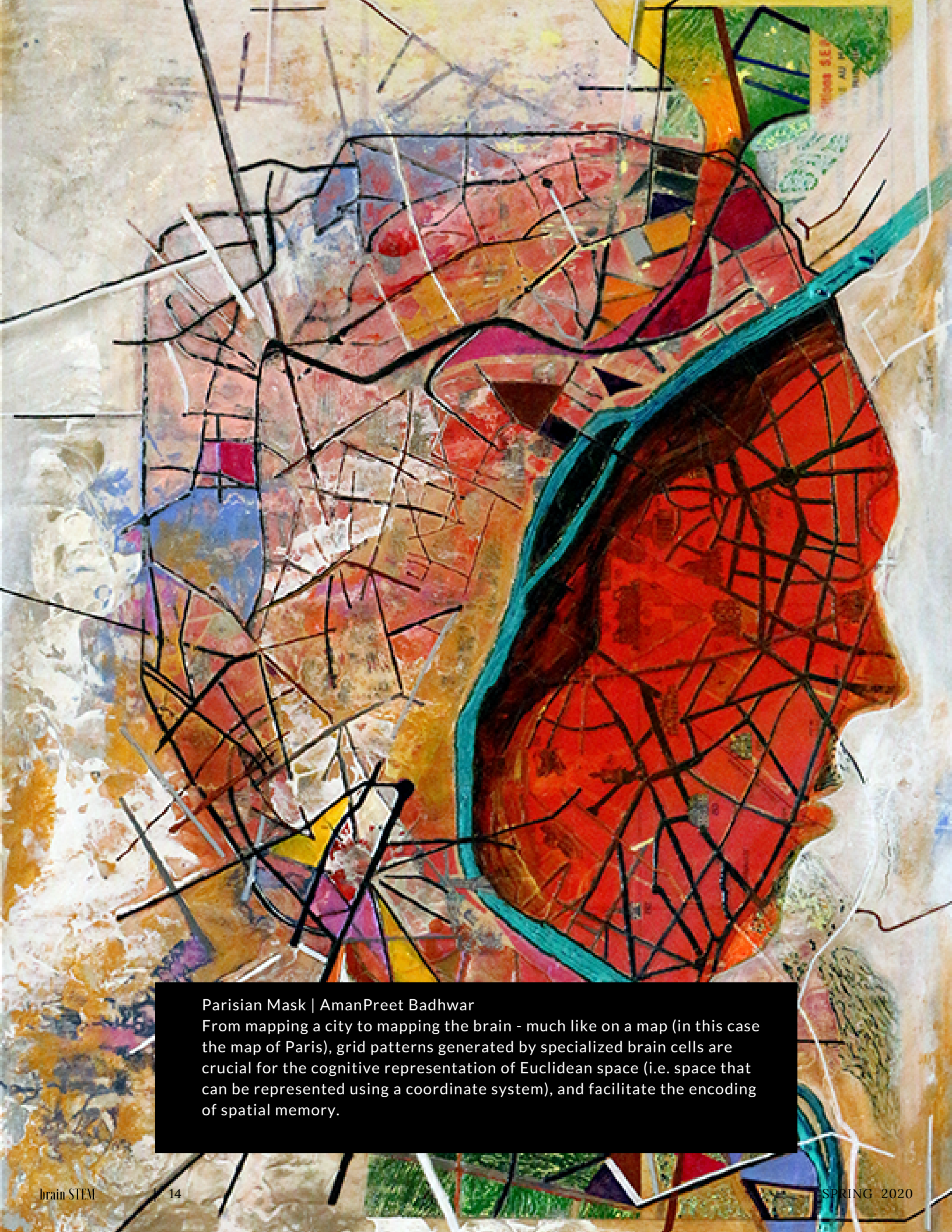
4 MEMENTO

This psychological thriller follows Leonard Shelby, a man who has developed anterograde amnesia following a head injury sustained in a failed attempt to protect his wife during a home burglary. Leonard's attempt at vengeance and his adaptations to do so are captured in an exhilarating, non sequential format.

5 THE TALE OF THE DUELING NEUROSURGENS

In *The Tale of the Dueling Neurosurgeons*, Sam Kean eloquently weaves through the history of the discoveries that comprise our knowledge of the human brain. Kean beautifully uses true stories of trauma, madness and innovation to paint a comprehensive history of neuroscience.





Parisian Mask | AmanPreet Badhwar
From mapping a city to mapping the brain - much like on a map (in this case the map of Paris), grid patterns generated by specialized brain cells are crucial for the cognitive representation of Euclidean space (i.e. space that can be represented using a coordinate system), and facilitate the encoding of spatial memory.

NEUROMARKETING:
ALTERNATIVE CAREERS FOR NEUROSCIENTISTS

By Emma Meyerdierks

Research or medicine? When asked about their career options most neuroscience undergraduates have been faced with this question. The notion that career options are narrow after graduation is a restricting, pervasive, and intimidating falsehood that may drive students to question “am I cut out for this?”, as if getting an education in neuroscience is limiting. An undergraduate degree in neuroscience provides an excellent foundation in the sciences which can be used as a totem when combined with additional experiences and passions. Society is becoming increasingly aware of the importance of neuroscience in medicine, education, and business. Highlighting other fields in which a neuroscience education can be leveraged is crucial for opening a less limiting dialogue. Business is an example of a large and lucrative field in which applied neuroscience has become increasingly common.

Neuromarketing, otherwise known as consumer neuroscience, is a burgeoning field that employs knowledge of brainfunction and neuroscience-based technology to analyze consumer experience. Well designed and

targeted marketing strategies are valuable to business because they not only need to stand out among the four thousand plus ads the average Americans see in a day, but they also need to tap into the mechanisms that create consumer desire for a specific product. Neuromarketing promises direct measurement of the consumer's mind to determine preferences and desires, bypassing the errors of self-report. Neuromarketing represents recognition by the marketing world that decisions are based on factors that are largely outside our conscious awareness. Companies that have taken advantage of this strategy include Coca-Cola, Facebook, and Amazon.

Neuromarketers leverage a range of biosensors to directly measure consumer engagement and preference. The practice is largely informed by behavioral neuroscience research in learning and directive attention, but will increasingly serve as a direct application of work in the areas of social and affective-neuroscience. Two of the most popular strategies to assess the efficacy of an ad are eye tracking technology and the electroencephalogram, popularly referred to by its acronym EEG. Eye tracking technology uses vectors to quantify gaze via the distance between the center of the pupil and the corneal reflection from a light source. When measured against time, fixation and movement can be combined into an overall scan-path that provides a quantitative measure of a consumer's attention over the course of an ad. EEG uses macroelectrodes placed on the scalp to track the electrical activity in specific brain regions in real time. The electrical activity can be mapped graphically and classified into various brain wave patterns. Based on what regions show activation, advertisers can answer questions about whether the ad was engaging, well liked, or effective in manipulating emotion.

"Focus on what you can bring to the company and the ways in which you can inform stronger branding, consumer engagement, and effective messaging."

The nascent field has led to the startup of many companies offering businesses tools and expert knowledge of core neuromarketing strategies. Neuro-Insight is one of the most influential neuromarketing companies at the forefront of the movement to incorporate biological information into our analysis of consumer response. Pranav Yadav is the CEO of Neuro-Insight in the Americas and Europe, and was interviewed for Forbes Top 30 Under 30 where he describes neuromarketing as "both diagnostic and predictive," making it incredibly valuable. Yadav claims that not only can marketers optimize ads based on the results of neuroanalysis, they can also predict market success based on the consumer response. The consistent power of these strategies has pushed many businesses to forgo hiring out these services in favor of building their own internal team.

The field is primarily comprised of researchers, analysts and consultants. How does one land a position in this field? Knowing how the technologies are employed and the behavioral neuroscience behind them are presumably incredibly attractive skills. Those who already have an undergraduate degree in neuroscience have an edge on typical business students who lack understanding of the core biological principles that underlie these technologies. However, it is optimal to acquire comprehension of commercial practices and business etiquette through internships or pursuit of a masters or PhD in business or marketing. The good news is because these strategies are so new, companies may hire for a position they didn't know they needed filled. Thus it would be wise to not simply apply for standard neuromarketing titles but to emphasize one's background in neuroscience as well, by outlining the unique skill set that you have that bridges the sciences with marketing applications. It is crucial to focus on what you can bring to the company and the ways in which you can inform stronger branding, consumer engagement and effective messaging.

These strategies have revolutionized ad optimization in the marketing industry but have been equally met with critics who question the ethics behind the technology and claim it is an invasion and threat to consumers. However, neuromarketing simply allows marketing strategies to be more effective. Marketing is built on understanding consumer experience, of which neuromarketers use specific tools to directly measure. From a philosophical standpoint these tools alone do not have inherent good or bad qualities; it is how they are used that determine their value. What marketers must consider is to what extent it is right to manipulate and for what cause. Thus, working with honest brands and ensuring that the rhetoric will have a neutral or positive impact is fundamental. Regardless of the tools employed, ultimately it is up to the marketer to have moral boundaries and to the consumer to think critically of the media.

Eternal Sunshine of a Spotless Mirror | Frederico Carbajal

"Eternal Sunshine of a Spotless Mirror" offers several kinds of experiences. Viewed from a distance, these minimal sculptural box act as landmarks with a theatrical atmosphere. In close proximity, through the illusion of an infinite reflection and the metallic neurons it recreates a tridimensional neuronal forest. It opens a metaphysical window to the anatomy of our brain in a cellular level. And in the collective imaginary, the piece contributes to sharing the fundamental principles of neuroscience to the general public."

COMPLEX INEQUITIES: GENDER IN NEUROSCIENCE

by Madi Myers

In recent decades, the lack of inclusivity within the education system and workplace has become an increasingly relevant topic, inspiring actions at all levels, from the individual to the government. Forums, discussions, and marches are just a few of the many ways in which people are drawing attention to the importance of equity and inclusion in areas that have historically been dominated by white men. Western Washington University (WWU) is an example of one such institution striving for inclusion by working to ensure every individual, faculty, staff, or student has access to the same opportunities and sense of community. Most recently, for example, individuals can indicate their preferred pronouns and gender identity in Western's student portal, a significant step towards ensuring the university can provide a respectful and inclusive community to all.

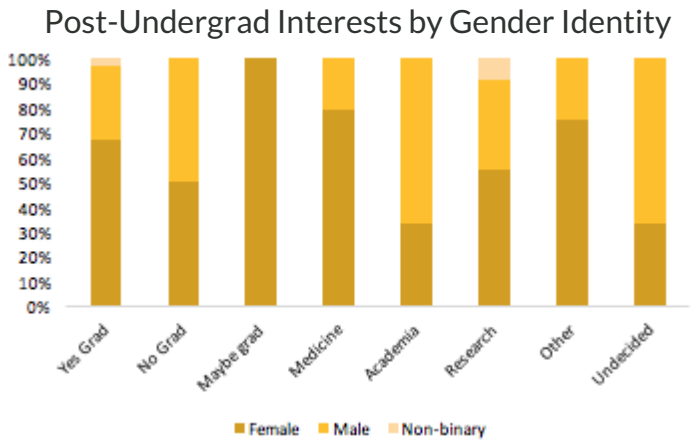
A commonly held perception is that Science, Engineering, Math, and Technology (STEM) fields are largely dominated by men, but the trend might not be as transparent as it first appears. Overall, women earn about half of all science and engineering bachelor's degrees. But, as the National Girl Collaborative Project reports, the concentration of male and female scientists and engineers varies depending on the specific STEM discipline. For example, 60% of scientists and engineers occupied in the social sciences are women. The gender distribution evens out a bit more in the biological, agricultural, and environmental life sciences, in

which 48% of individuals are female. However, women received far fewer degrees than men in computer science (18%) and engineering (20%). Interestingly, the number of women in such fields decreases with increasing rank in the professional world. In 2001, 53.9% of the US biology graduate students were women. However, only 37.7% of the post doctorate fellows and 34.5 % of professors were female.

The pattern is unfortunately similar for female neuroscientists. In 2017, the Association of Neuroscience Departments and Programs reported that while females made up 53% of the neuroscience graduate students, only 30% of tenure-track faculty were female. The gender bias appears to grow at higher faculty ranks. According to data collected from attendees at the annual Society for Neuroscience meeting, 38% of assistant professors attending are female. The rates of female faculty attending the meeting drops to 35% and 28% for ranks of associate and full professor, respectively. So, despite nearly equal degree distribution among males and females at the undergraduate level, there is an apparent increasing inequity in the professional world post-graduation.

The gender distribution in the Behavioral Neuroscience program at Western Washington University is a near reflection of the of this phenomenon. The ratio of female to male students in the program at Western is impressively high, with women making up the majority of declared majors for the past 8 years. This trend has steadily increased and females now make up a remarkable 72% of the Behavioral Neuroscience major. Do these trends reflect a bias against hiring and promoting female academics, or do they reflect a preference of females for non-academic careers?

Indeed, survey responses from students in a required Behavioral Neuroscience course at WWU indicate that the post-graduate gender imbalance might be due, in part, to drastically different interests of males and females at the undergraduate level. Although the terms male and female are more often used to describe one's biological sex, the following survey used the terms in reference to one's gender identity. In this rather informal survey, most of the self-identifying females and males, 81.81% and 88.89% respectively, indicated that they were sure they would go to grad school. Despite apparently equal interest in grad school, far fewer females indicated interest in working in academia (4.5%) than males (16.66%). However, 27.27% of responses from females, and 33.33% of responses from males indicated interest in research. While the bulk of male neuroscience students indicated interest in working in academia and research, 50% of female neuroscience students expressed interest in working in the medical field.



If our informal sample is any indication of the larger population, the differential preferences of women and men to enter into graduate school and academia, or the medical field, may exist as early as the undergraduate level. The National Science board (NSB) attributes these differences to contrasting preferences among

men and women for some fields over others. In fact, the NSB reported that men earned an extensive amount of the bachelor's degrees awarded in engineering, computer sciences, and physics, and greater than half of the degrees in mathematics and statistics. As it appears, the variability in preferences for some fields over the others across genders is reflective of that at the national level, which in part, could explain the distorted ratios of men and women observed at the undergraduate level and beyond.

So does the gender imbalance simply reflect gender based preferences, or are additional factors and biases involved? Unfortunately, unveiling the root causes of such imbalances to investigate any structural and social inequalities is complicated.

"The preferential tendencies of woman to gravitate towards one field over another may reflect socialization from a lifetime of structural inequality and stereotyping, such that the preferences may echo a history of biasing toward one type of career and away from another."

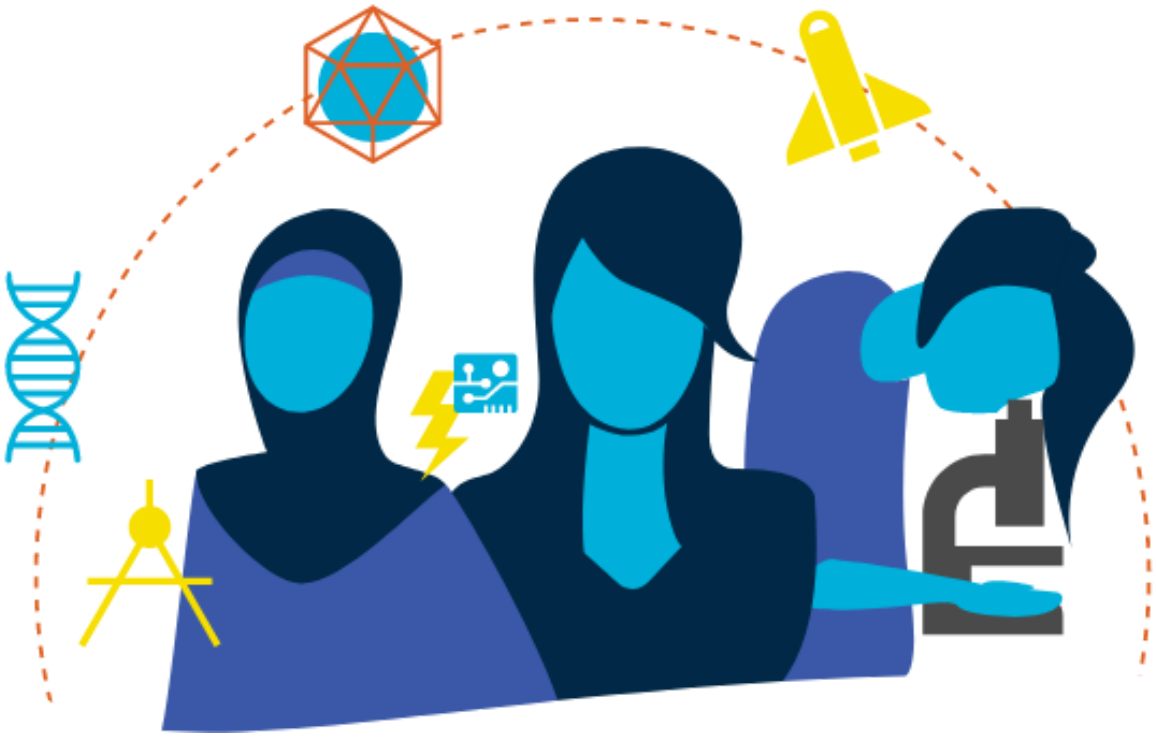
While quite possibly unqualified to draw such conclusions, I am a neuroscientist who despite making it this far, likely encountered a plethora of invisible indications that I would be more successful in this field than I might in others, such as math or computer science. A childhood of curated exposure to certain toys, hobbies, and curricula likely contributes to the higher ratios of males to females in some fields over others. Despite the complexity of such sequences of events that might facilitate this phenomenon, the transparency of these patterns is crucial to our understanding of the societal and social gender dynamics that enable them.

Despite the recent achievements of women in certain STEM departments at WWU, with women even dominating fields such as Biology and Behavioral Neuroscience, a few programs continue to have strikingly low ratios of women to men. For example, only 17% of declared computer science majors in 2019 were women, despite a 7% growth in the percent of women over the last 8 years that aligned the gender distribution with that of the nation. The engineering and design departments mirror this trend. Despite 5% growth over the last 8 years, only a mere 17% of declared majors are women. The lack of women in these majors is especially startling when considering that the overall percentage of female undergraduate students at Western has remained above 50% for the past ten years.

The ever-evolving nature of the ratio of women to men in these fields, waxing and waning throughout time, clouds the clarity of the future of inclusivity and accessibility of STEM at WWU. What patterns will we observe in 5 years, or 10 years, when the current populations of Behavioral Neuroscience and biology students have, if all goes as planned,

graduated? Will these fields continue to highlight the success of women in STEM, or will the incorporation of women in these fields deplete? Organizations like Girls Can Code are tackling these uncertainties in a proactive manner, by providing young women with ample opportunities to learn coding through various clubs and internships. In their mission to close the gender gap in technology, Girls Can Code is making STEM fields accessible to women while giving them the confidence to thrive in a field they may have never considered. One's identities and preferences begin forming very early on in life, so it is crucial that young women are welcomed and included from a young age, enabling them access to the same feeling of belonging in STEM fields that young men obtain much easier.

It is crucial to note that the data discussed here misrepresents an essential group of the student population, as until very recently, gender categorizations at the university were severely limited to binary categories, excluding the non-binary and non-gender conforming individuals among others. Unfortunately, academia utilizes a conceptualization of gender that often does not acknowledge and incorporate more than two gender options. Present in both the scientific community as a whole, and that of Western, this limitation biases the available data and thus defines the scope of conversations surrounding the gender distributions in fields like neuroscience. While we can acknowledge that the binary gender categories misrepresent individuals enrolled in the neuroscience community and the larger STEM community at WWU, inclusion in this aspect might not be truly obtainable for some time unless the systemic changes necessary to normalize the fluidity of gender take place. So, despite systematic changes in the recent weeks enabling students to indicate their preferred pronouns, it will likely take time before the numbers more closely reflect the true gender identities of students across majors at Western.



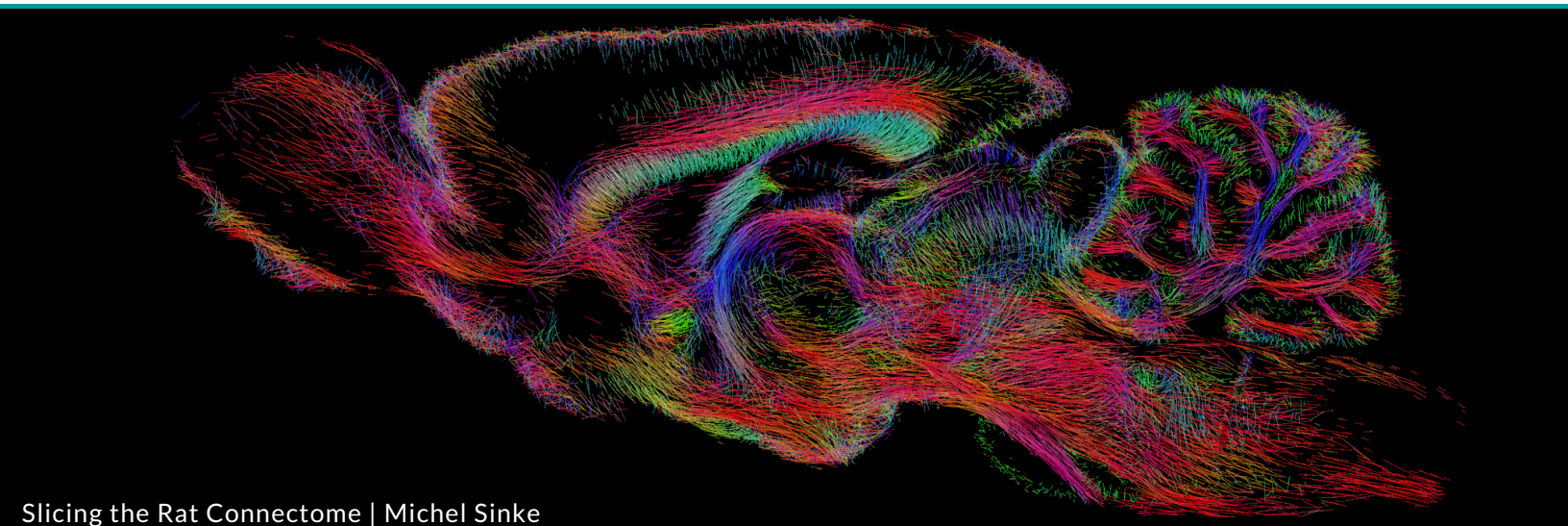
Myth: Exposing babies to classical music leads to a higher IQ

by Ben Friedman

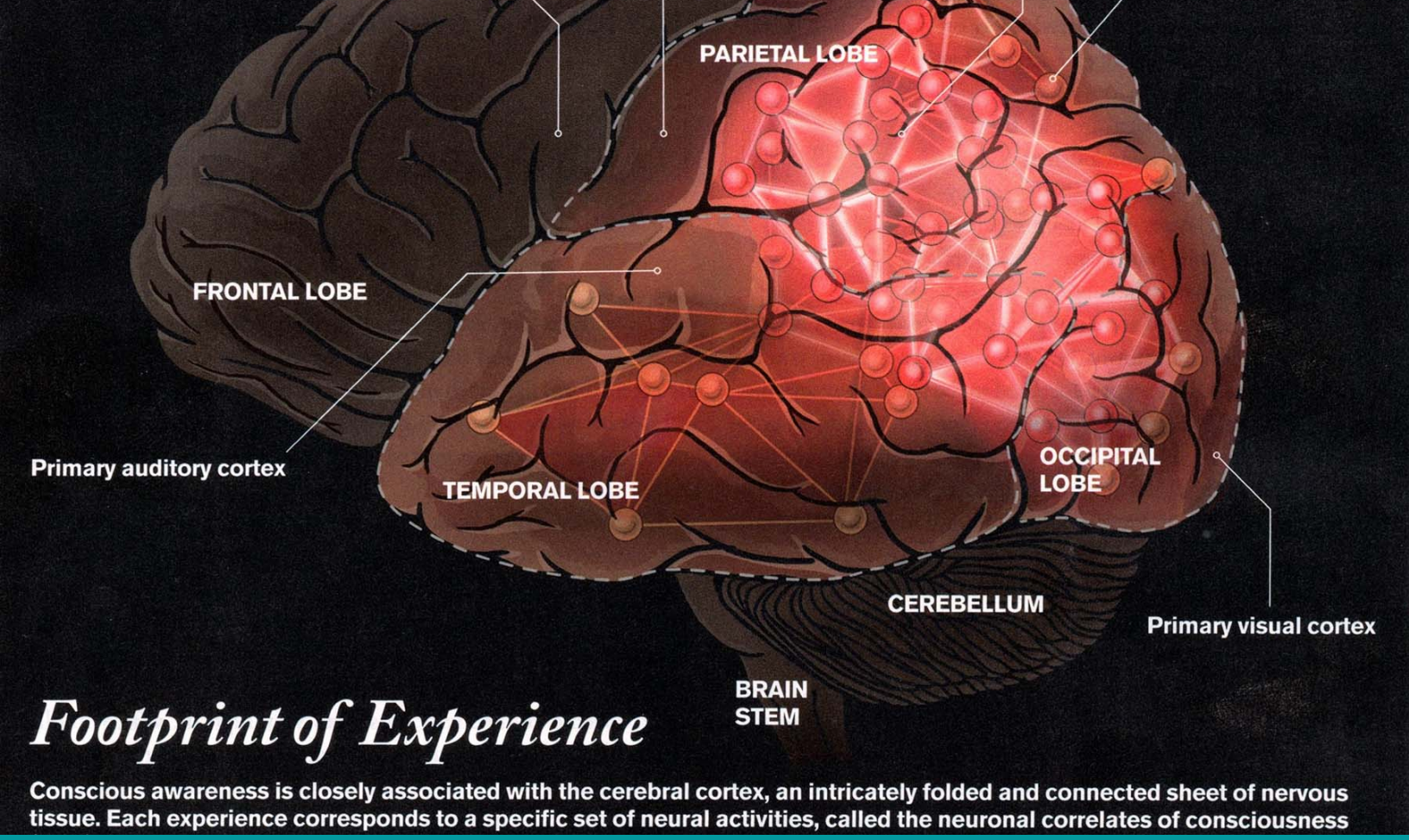
Myth: Given the option, most parents would probably like to see their child flourish academically. A common belief is that playing classical music such as Mozart and Bach to a fetus or newborn increases the intelligence of young children in what is commonly called the 'Mozart effect'. This line of thinking lead to the development of child education companies that offer a range of media purporting to increase your child's cognitive abilities.

Truth: This would be great news if true. The only problem is that there is absolutely no evidence to support this claim. It appears that this myth is based on a single study published in Nature in 1993 in which a handful of UC Irvine psychology students were exposed to either Mozart, a guided relaxation, or silence for 10 minutes. The students were then given an abstract reasoning task that assessed IQ and spatial memory. The researchers found a modest increase in the Mozart group's scores (about 8 points) but this effect was limited to about 15 minutes after listening and because only spatial memory was assessed, results could not be applied more broadly. Despite repeated attempts, the results of this study have never been replicated.

It seems that prospective parents need not stray from their Black Sabbath when listening with their new family. However, there are other methods of enhancing memory and focus using sound. It won't turn you into a genius, but binaural beats have been shown to increase spatial working memory and cortical connectivity. Binaural beats are created by playing separate tones into the left and right ear. This leads to the perception of a so called 'phantom beat' that is equal to the difference between the two tones. The effect is an electrical synchronization of neurons across the cortex, with the phase dependent on oscillations of the phantom beat. Binaural beats have been shown to have a modest but consistent effect on adults engaging in higher order thought. Try it next time you study! Binaural beats can be found for free online and only require a decent pair of headphones.



Slicing the Rat Connectome | Michel Sinke
Our non-invasive diffusion MRI-based quantification of whole-brain axonal connections combines the power of sensitive, non-invasive tissue probing, with accurate multi resolution tract reconstructions, by means of multi-shell global tractography, in rat brain left in the skull. This tissue-friendly method creates unique potential for longitudinal studies. The simultaneous access to local microstructure information and global stereotaxic orientation already provided us with unique insights in the axonal olfactory bulb pathways in the rats, in the cerebellar topology and the complex fiber bundle crossings in cortico-striatal circuits. The corpus callosum, cingulum bundle, brainstem and the arbor vitae of the cerebellum can be clearly made out.



Conscious awareness is closely associated with the cerebral cortex, an intricately folded and connected sheet of nervous tissue. Each experience corresponds to a specific set of neural activities, called the neuronal correlates of consciousness

CONCIOUSNESS: A DEEP DIVE

by Mack Brooks

Consciousness is difficult to define. It has vexed philosophers and scientists for millennia. Objectively it is the awareness of one own's existence, reality, and thoughts. For instance, you know you are you and not someone else. But it is also so much more than can be contained within a simple definition. It is the song stuck in your head, the pain you feel over a stubbed toe, and the undying love you may have for another person. The topic of consciousness; its prevalence in nature, what exactly it constitutes, and how we define it, continues to be debated. Talk to a philosopher and they might tell you it is simply the awareness of one's internal existence. Talk to a neuroscientist and they will probably discuss the neural basis for various states of consciousness. The point, however, is that consciousness is elusive and controversial. Take credence into any one belief, and you undeniably risk slighting someone from another camp. Here we will not, by any means, cover all that is consciousness. Rather, we will discuss the wider array of thoughts and beliefs from several different fields, before discussing what neuroscience has contributed. A website called Cleverbot allows one to have conversations with an artificial intelligence algorithm. Cleverbot is unique among chatterbots of its kind because its responses are not pre-programmed. Instead, it learns from human interaction, responding to input through saved replies it has had from other conversations. Ask it for instance, "Are you aware?" and you'll get the flippant reply,

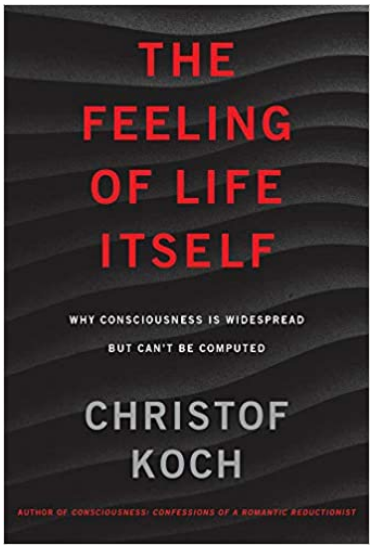
"Something like that lol". You probably wouldn't need to be convinced that Cleverbot is not conscious, but it's ability to supply novel replies to novel inputs offers a unique thought experiment to people who are willing to eschew consciousness to just the ability to communicate. It turns out it is much more complicated than that. Which is also a reason why researching this topic is incredibly difficult. How are we to define this phenomenon? The first modern answer to this question came from French philosopher and mathematician René Descartes. Descartes thought that consciousness laid within two domains: intangible thought and material surroundings. To him, these two realms interact in our brain to formulate our objective reality. Descartes' dualism, as it has come to be known, has several flaws in the face of neuroscience, however. For one, how are we to measure something immaterial such as in the realm of intangible thought? We only know what one experiences if they tell us, and even then, we ourselves cannot say if that is true because we are not experiencing it. Where we might be able to find some assistance is in the brains of schizophrenics. It is well established that this disease is accompanied by changes in the way these patients perceive the world. The brains of these patients exhibit a physiology that differ vastly from that of an average person. They have enlarged ventricles, an abnormal pattern of neuronal layering, and a reduction in gray matter. This is evidence that consciousness is a physical process, contrary to Descartes' dualism. Despite this, few alternative solutions have gained wide-spread approval, causing Descartes' view to be revised continuously by philosophers as new information arises.

Neuroscientists by contrast are concerned with a different aspect of consciousness. Specifically, what are the molecular and neuroanatomical underpinnings of consciousness? The task of defining consciousness in this way has led neuroscientists to look elsewhere for answers from that of philosophers: in the behavior and brains of other animals. Whether one agrees with it or not, much of the behaviors for consciousness as we understand them exist in non-human animals. Mammals, fish, and even insects exhibit behaviors once thought reserved to primates. Some show capacity for long-term planning, many others intention and preference. Bee's for example show preferences to certain flowers and can remember paths through complex mazes much quicker than any mammal. This behavior is mirrored by their analogously complex brains, with a neuron density ten times as great as our own – 800,000 neurons packed into a brain the size of a sesame seed.

This is where neuroscientists have turned to a more physiological approach to explain the substance of consciousness. Neural correlate studies have been searching for brain interactions that coincide with behaviors or experiences thought to represent consciousness. These behaviors range from alertness or arousal, to perception of certain shapes or colors. For instance, you might see a square, and the conscious perception of that square may manifest itself into discrete activity in a specific area of the brain. Starting in the late 1980's Christof Koch and Francis Crick pioneered some of the first studies into the neural correlates of consciousness, sparking renewed interest into a field once thought inaccessible to modern science. They found that by following an animal's sensory pathways, from sensation to perception, one could research the correlated neural activation.

Many of these studies have been in the visual pathway of the monkey. For instance, by training monkeys to respond to specific images or scenarios, researchers have been able to study the underlying neuronal firing patterns during their perception of the event. A monkey may be trained to press a different lever depending on whether or not it sees vertical bars or horizontal bars, while its brain is being monitored via electrodes. If given vertical bars in one eye and horizontal bars in the other, then the conscious perception of the event may be somewhere between both, i.e. a grating. After a certain amount of time however the monkey will perceive only one or the other bar, due to binocular competition. What it ultimately perceives will be conveyed by which lever it presses, while what its brain is "seeing" will be conveyed via neuronal activity. Interestingly, much of the brain activity we'd expect to correlate with the conscious perception of vision occurs outside the primary visual cortex. When given different images in each eye the primary visual cortex of the monkey largely responds to both stimuli. That is, neurons associated with horizontal bars and neurons associated with vertical bars both fire, even though the monkey is perceiving only one orientation. The most likely area for the neural substrate of visual perception was found further along the ventral visual stream, in the inferior part of the temporal lobe. There, cells were found to preferentially fire depending on what the animal "told" researchers it was perceiving. These studies thus provided the first substantial evidence that conscious sensory perception was regulated via - top-down modulation. It is important to note however that many studies since then have integrated the reinforcing aspects of top-down modulation in visual perception, including the role of the primary visual cortex.

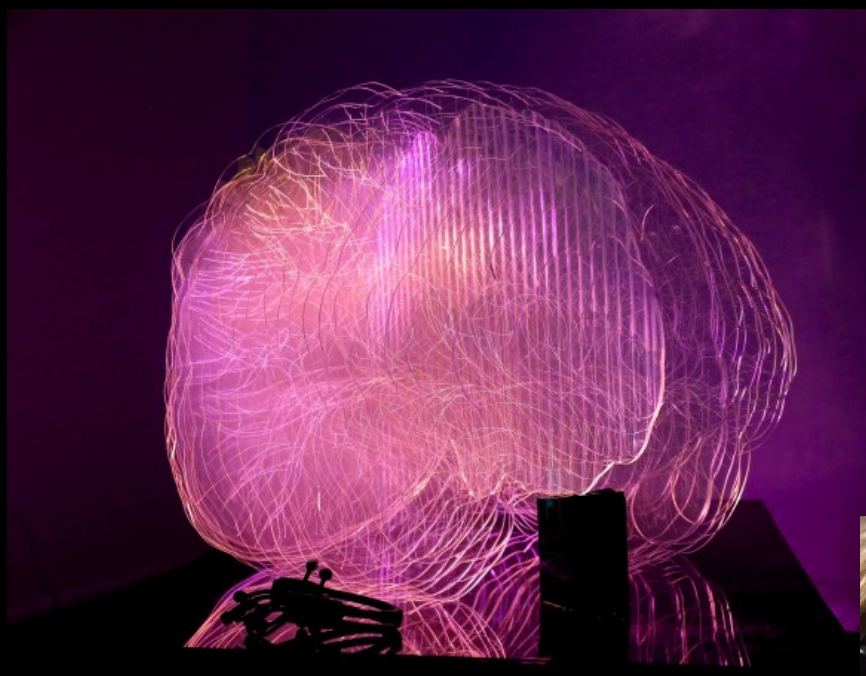
CONTINUE READING...

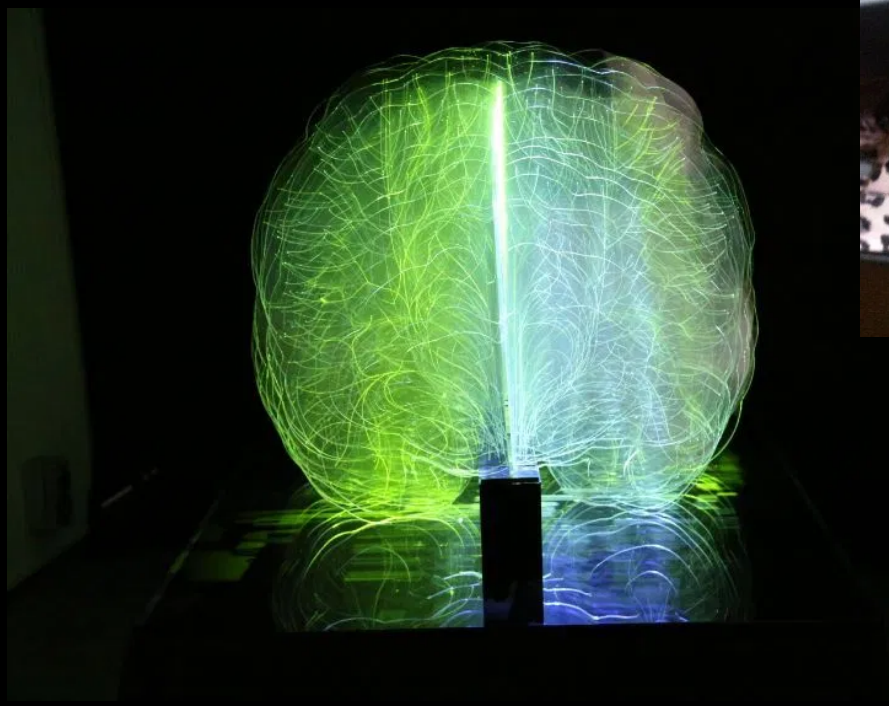


THE FEELING OF LIFE ITSELF

Christof Koch, PhD, is a neuroscientist best who studies the neural basis of consciousness. Koch is Chief Scientist and President of the Allen Institute for Brain Science in Seattle.

Koch's most recent book is "The Feeling of Life Itself" is one of many that explore the research of human consciousness. Amazon describes his book as "[a]n argument that consciousness, more widespread than previously assumed, is the feeling of being alive, not a type of computation or a clever hack."





Brainlight | Laura Jade

B R A I N L I G H T 2015 integrates biology and illumination design into an interactive, sculpture cut from perspex and engraved with neural networks. Collaborating with neuroscientist Peter Simpson-Young and programmers Sam Gentle & Sami Sabik, the brain sculpture lights up in response to changing brain activity transmitted from an EEG (electroencephalography) wireless headset. Everybody has a unique “neural signature” and Brainlight’s live colourful visualisation is different for every user. As the participant views the colours on the Brainlight, their own brain waves change in response to external stimulus. Some can even start to gain control over their mind, setting up a feedback loop of response, reaction, observation and response.

Myth: You only use 10% of your brain

by Ben Friedman

Myth: A more recent depiction of this common myth, Professor Samuel Norman, who is played by Morgan Freeman in the movie *Lucy*, asserts that, "It is estimated most human beings only use 10 percent of the brain's capacity. Imagine if we could access 100 percent. Interesting things begin to happen."

It is easy to see why this myth is alluring- implicit is the idea that 90 percent of the brain is left unused and can ostensibly be 'turned on' to unleash amazing untapped abilities. This sort of self-aggrandizing is common across science myths of any field for much the same reason: as humans we want to believe that we are unique, powerful, and full of limitless potential.

Fact: The reality is that this myth relies on some thoroughly debunked science from the early 19th century. The origins of the myth are unclear, but may have stemmed from a misinterpretation by the media. In the late 19th century two Harvard psychologists performed a case study of child prodigy named William Sidis. When presenting lectures about their patient, the psychologists reportedly noted that people at large tend not to achieve their full cognitive potential. The media misconstrued these words to mean that there was some extra cognitive horsepower locked away and ready to be used if we could only figure out how to unlock it. The concept was further bolstered by French physiologist Marie-Jean-Pierre Flourens who proposed that function is distributed diffusely across the brain and that damaging large portions have no effect on function, implying that much of the brain often lies dormant. Although this concept has been repeatedly disproved with countless lesion and brain imaging studies, the popular notion persists. The original message was further muddied as self help authors of the 20s and 30s, as well as sci-fi writers, latched onto the idea. The actual 10% number can be traced back to author Lowell Thomas' foreword to the 1936 edition of the popular book *How to Win Friends and Influence People*. In the near century that has passed since, the media and public have perpetuated this myth to the point where it has largely been taken as fact by the scientific zeitgeist. The truth is that brain function is largely localized to functionally specific regions that engage simultaneously when performing related tasks. The complex behaviors that make up our daily activities require the concurrent activity of many such regions spread across the entire brain.

It is important to dispel myths such as this one that are incompatible with the true nature of neurological function. However, it is even more important to learn from our misconceptions so that going forward we can approach new information more critically. While critical analysis of new information has and will always be important, this concept is particularly timely in that we are in the midst of a vast communication breakdown between what scientists say, read, and publish and what the public hears.

Starry Night | Christophe Leterrier
Hippocampal neurons after two days in culture, fixed and labeled for microtubules (cyan) and actin (orange). Isolated neurons or group of neurons have been manually shifted relative to the others in order to obtain a more regular image. The whole image represents an area of 1365×1024 microns.

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Backcover Art:
Mindless Proces | Krisztina Cika
The project was inspired by the lecture, “If brains are computers, who designs the software?” by Daniel Dennett. We live in a society where technology has developed to such an extent because of our improved intelligence over time. Questions, dreams and fantasies start to relate to each other, so I asked myself: Would it be possible to recreate the nervous system with a technological process, like 3D printing? The process is simple: halogen lights using electricity provide heat that slowly warms up the glass. Since glass has the advantage of remaining at a consistent heat, the wax is able to change consistency and melt. The motion of dripping and melting creates “prints” and the shape of the prints are based on the heat settings.