Neuroscience Dept

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Social Evolution in Primates

Erasing Memories • Coloring the Cosmos • Quorum Sensing • Cochlear Chairs
Alternative Health Careers • Interview with William Fuchsman

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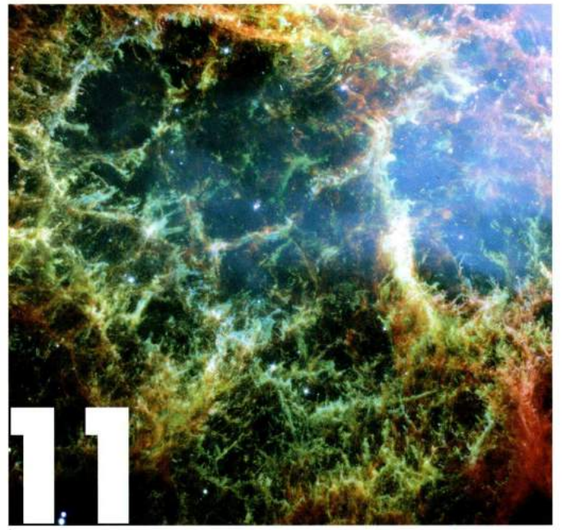

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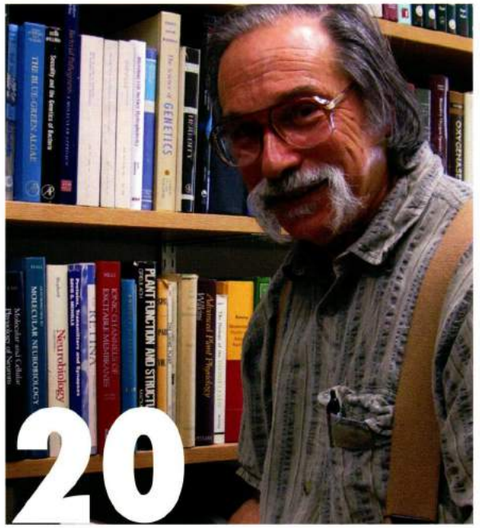

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Ginger to the Rescue!

Shoshana Gordan

By Sesha Nandyal

Some may only know of ginger, or *Zingiber officinale*, as a pungent and spicy flavor used in Asian cooking or the secret ingredient in grandma's dessert. Astonishingly, this root has been used to cure ailments of all kinds since the 16th century. Ginger has been shown to relieve nausea, intestinal problems, heart conditions, and the common cold. Scientists are interested in ginger because of the health value its unique chemistry offers.

Growing from the ground in broad stems with green leaves, ginger contains an arsenal of chemical compounds. Over the last 25 years, laboratories across the globe have repeatedly confirmed ginger's anti-inflammatory properties. Compounds found in ginger and other anti-inflammatories prevent the unwanted symptoms of inflammation: vasodilation, pain, and fever. However, ginger is better than other anti-inflammatory drugs because it allows the beneficial components of our natural inflammatory response, namely the binding and admittance of white blood cells to tissue. Scientists believe that this could make ginger a superior option to pharmaceutical drugs with fewer side effects and more therapeutic qualities.

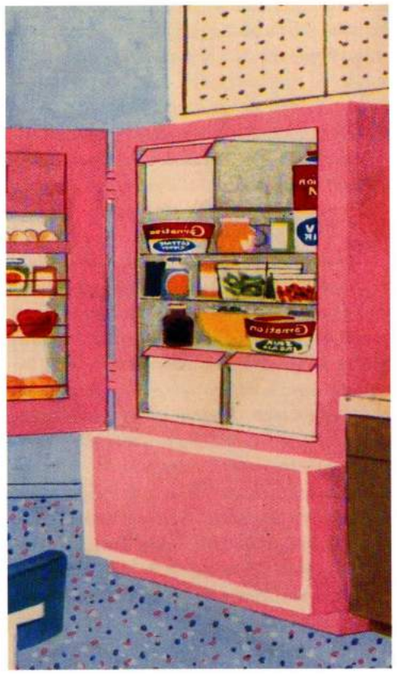
In addition to anti-inflammatory characteristics, ginger could play a key role in cancer treatment. Scientists of Yonsei University in South Korea found that another compound ginger contains, gingerol (a phenol), inhibits the proliferation of human endothelial cells. While testing melanoma-injected mice, they found that gingerol reduced lung metastases (the spread of cancer to or through the lungs) without a deterioration in overall health. Moreover, Taipei Medical University researchers have seen that gingerol can induce cell death in leukemia cells grown *in vitro*. On the whole, these studies show that gingerol could be used to treat tumors and inhibit metastases in lung and other types of cancer.

After finding out about all of the great properties of ginger, should people eat as much ginger as they can stomach? More research needs to be done before concluding that ginger is a viable cancer treatment or headache medicine. Ginger may interfere with blood-thinning, diabetes, and blood pressure medications, so one should consult botanically-informed health care professionals before supplementing with ginger. Ginger should not be ingested by persons with heart conditions, bleeding disorders, or those with super taste buds. Aside from these rare side effects, ginger is proving to be something to root for.

Appliance Science: Microwaves and Refrigerators

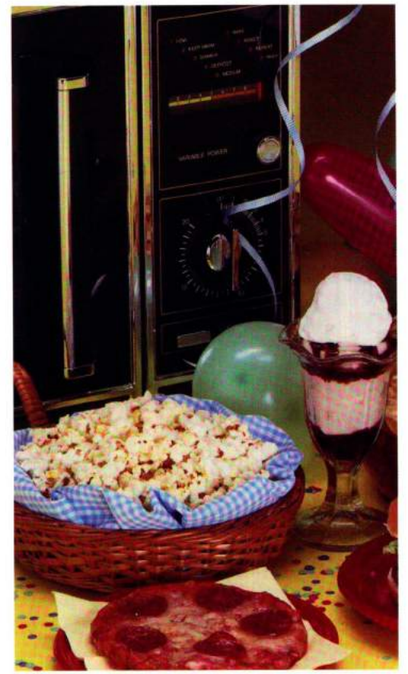
By Lizzie Roberts

Inside your refrigerator is a complex network of pipes filled with tetrafluoroethane, a chemical refrigerant with a boiling point below freezing. A compressor makes up the basic machinery in your fridge; two sets of heat-exchanging pipes, a small throttling passageway, and a fan. The compressor pressurizes the gaseous refrigerant until it becomes a super-heated vapor. The refrigerant loses heat as it passes through external heat-exchanging coils, causing the vapor to condense into a liquid. The slightly cooler liquid refrigerant is sucked through the expansion valve, a region that separates the high-pressure area from the low-pressure area. This is where the compressor sucks the gaseous form of the refrigerant out of the coils. The only thing holding the refrigerant back from instantly returning to its gaseous state is its high-pressure environment. About half of the refrigerant boils as soon as the hot liquid hits the low-pressure chamber, evaporating and taking heat from the refrigerant that remains in liquid form. The half-liquid, half-vapor refrigerant is now considerably colder than room temperature, and it continues to evaporate as it travels through the coils, pulling even more heat from the air



blown over the coils by a fan. This cold air is circulated throughout the freezer and refrigerator. Eventually, the completely vaporized refrigerant returns to the compressor, and the process begins all over again. A thermostat makes sure the fridge does not drop below the desired temperature by shutting off the compressor's electricity.

What about the magical machine that heats up your leftover Chinese food at 4 A.M. during finals? Microwaves are a form of light, or electromagnetic radiation, with a wavelength 10,000 times longer than that of visible light. Imagine each photon, or particle of electromagnetic radiation, as a little packet of energy; the shorter the wavelength of the radiation, the more waves you can fit into a single packet and the greater the energy of the photon. It just so happens that the amount of energy contained in each photon of a microwave is enough to cause molecules of water and fat to rub up against one another, creating friction and heat energy. A microwave releases streams of photons at your food, and the friction created by the motion of water molecules causes your food to heat up rapidly. A device known as a cavity magnetron converts the high-voltage electrical power of the machine into microwave radiation. The cavity magnetron works by 'blowing' electrons past cylindrical cavities, causing resonant, high-frequency radio fields in the vacuous spaces — similar to how blowing gently over the mouth of an empty bottle creates sound waves. The device is called a magnetron because it uses a magnet to create a field that causes electrons in the magnetron to spiral away from the positive electrode in the center of the pipe-shaped device, 'sweeping' them across the openings of the cavities. A small metal tube then shepherds the microwaves into the cooking chamber, which is lined with mesh squares too small for the microwaves to penetrate. This handy tube keeps you from cooking along with your food.



Hannah Daneshvar

Kinship Between the Kingdoms: Quorum Sensing

Quorum Sensing: A biological sensory mechanism that allows organisms to detect population density and respond appropriately.

Darrin Shultz

Ben Garfinkel

What is smaller than dust and undetected when alone, but, in large groups, puts on a light show more spectacular than all of the glow parties on East Lorain Street combined? *Vibrio fischeri* (pronounced fisher-eye), the bacterium, of course!

These tiny flecks of life swim every ocean in solitude, feeding off even more insignificant specks of dead fish flesh and whale poop. Seemingly boring, *Vibrio fischeri* are hot commodities to many marine organisms. Glowing fishes, squids, and corals all selectively recruit *V. fischeri* to live temporarily in specialized organs in their bodies.

These fleshy homes provide the bacteria with nutrients and a safe environment to multiply rapidly. In return, our bacteria friend offer the host luminence. By sending molecular "triggers" to its colony of *V. fischeri*, the host makes them glow in patterns of short flashes or sustained subtle emissions. Known as bioluminescence, these emissions can function to illuminate prey, communicate with other fish of the same species, and even keep squid from casting shadows as they hunt. Remember the glowing blue lantern that tried to eat Dori and Nemo? That was *Vibrio fischeri* living in a female anglerfish host.

How do the bacteria know to only luminesce when living in their hosts? Well, the bacteria constantly secrete a molecular signal into their surroundings. Think of a dirty sock. You wouldn't smell one sock in a large room, but if several million friends threw their socks in also, the stench would be overwhelming. Similarly, the bacteria have receptor proteins that only cause luminescence when the "stench" of the signaling molecules reaches a threshold.

This phenomenon is known as quorum sensing. Different species throw their proverbial dirty socks around in order to sense how many similar organisms there are in the area, knowledge which aids in many biological processes. As humans, we perform this task with our eyes while bacteria, plants, individual cells, *et cetera* must accomplish this through other means.

Remember when you were little and the clothes you bought only a year prior had become awkwardly tight against your fast-growing frame? Believe it or not, this phenomenon is quite common in the world of social insects. Take, for example, honeybees (*Apis mellifera*). By way of quorum sensing, groups of these backyard foragers annually vacate their long-settled nest for greener pastures when life at the colony gets too cramped.

Finding a new nest is not easy, and it takes significant teamwork. Every spring, colony fission occurs wherein the queen and half of her colony split off in order to seek out a new home. The scouting party starts by forming a cluster on a nearby branch that will serve as their home base for the expedition.

Then, scouts fly near and far looking for good nesting locations. If a suitable location is found, they will return and deliver the news in the form of a "waggle-dance", which communicates the site's location relative to the sun, via a series of wiggles and circular motions. The more the scout likes the site, the longer it will dance, thereby increasing its chances to recruit other bees to investigate the site for themselves.

It is here where quorum sensing plays an important role. By keeping track of time between meeting other bees, these insects are able to sense the density of their dancing counterparts. Based on this calculation of density, uncommitted bees are either recruited by a dancer to investigate the site, or go out and scout again. If a site is popular enough to reach a threshold of 10-20 dancers, the scouting party will move as a collective to their new home. Even as a relatively simple physiological event, quorum sensing is crucial to the success of this decision making process and the eventual relocation to an area with more safety or better resources.

Recent research argues the inner-workings of honeybee communities may lead to new insights in cognitive science, as the way in which each bee affects each other's behavior can be equated to the neural interactions in primate brains. Bee colonies work as a single functional "mind" by way of thousands of participatory organisms working together, similar to the intermingling neural networks of more complex organisms, like humans.

Why Not Telfon?

Science's Battle with Non-Stick

Erin Adair

The kitchen section at the Oberlin Walmart has a myriad of pots and pans, but non-stick pans are clearly the dominant option. On a shelf to the side, amid assorted culinary oddities, there's one stack of cast iron skillets, in one size. This contrast mirrors a common belief that new technologies are better than old ones. Now, only 50 years after the American introduction of non-stick pans, the 3,000-year-old technology of cast iron is obsolete to most consumers.

Polytetrafluoroethylene, or PTFE, commonly known by the DuPont trade name Teflon™, was invented in 1938 at DuPont during work related to the development of safer refrigerants and was the first non-stick surface. The chemical was noted to have extremely low friction and to be highly heat- and chemical- resistant. In 1951 DuPont began manufacturing commercial Teflon bakeware, but did not make consumer pans, due to worries that toxic gases could be released when Teflon was overheated. The invention of non-stick consumer cookware was patented in France in 1954, and the company, Tefal, began production in 1956. In 1960, the United States Food and Drug Administration (FDA) approved Teflon for contact with food, following tests where aged non-stick cookware produced higher levels of Teflon in a hamburger. The FDA, however, judged the measured levels to be insignificant.

Since then, non-stick consumer cookware has flourished and can be found in home kitchens around the world. Over the years, both environmental and health concerns have been raised about the safety of these products. The highest-profile case is that of Perfluorooctanic acid, or PFOA. PFOA was a chemical solvent used in production of Teflon coatings. The US Environmental Protection Agency (EPA) has been concerned about PFOA because it decays very slowly and has been found at detectable levels in the environment and in human bloodstreams, although it is not produced naturally. Furthermore, it has been found to cause various health defects in lab animals, including cancer and developmental problems.

PFOA isn't the only concerning aspect of Teflon cookware. The Environmental Working Group surveyed peer-reviewed literature about the thermal degradation of Teflon, including several studies by DuPont scientists, which detected emissions of toxic particulates at temperatures as low as 464°F, and emissions of toxic gases at temperatures of 680°F and above. Both of these temperatures can be easily reached on a stovetop. Additionally, a syndrome known as "Polymer Fume Fever" was identified in many DuPont workers, with symptoms similar to the common flu. It is unknown whether any in-home use of Teflon products have resulted in Polymer Fume Fever, which was often initially mistaken for the flu.

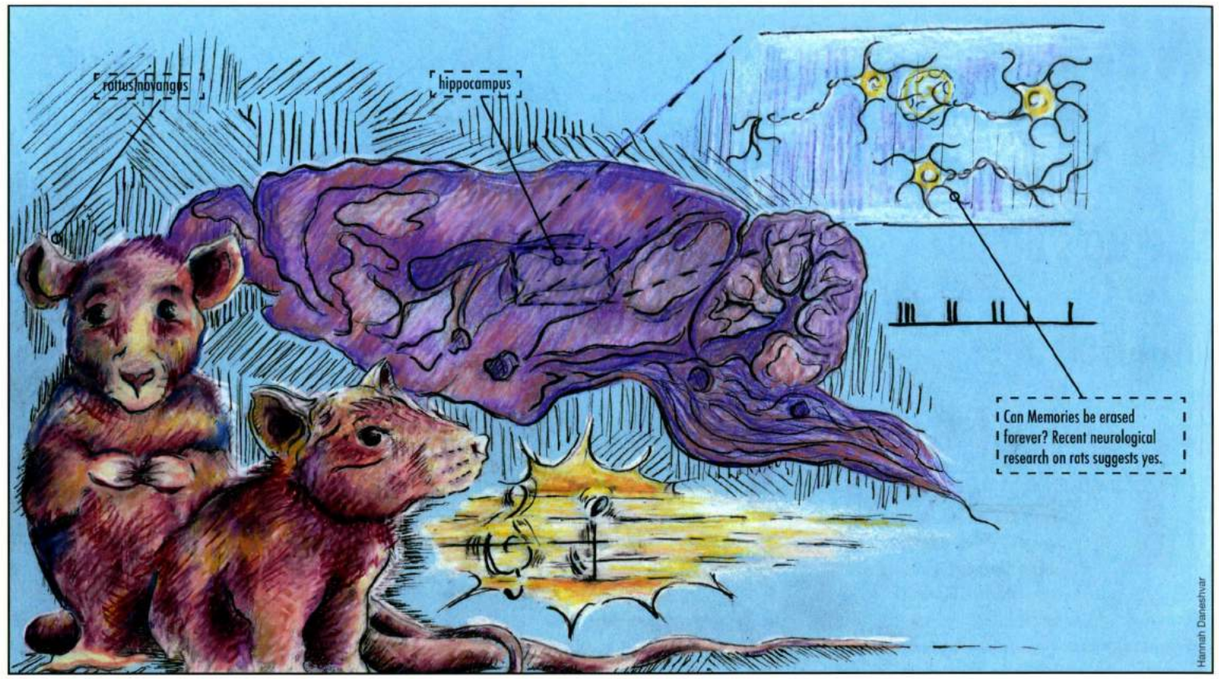
The industry has responded to these concerns by looking for new ways to produce alternative non-stick surfaces. Several companies, including DuPont, now produce Teflon coatings without using PFOA, while others have developed coatings that are supposedly safe. Two examples are Ecolon, which uses a type of nylon as a non-stick coating, and Thermolon, which uses a mineral-based coating. According to these responses, it is believed within the industry that advances in new technology will solve the problems of conventional non-stick products.

Before non-stick pans existed, cast iron was very popular for cookware, particularly skillets and dutch ovens. Cast iron cookware has been used for over 3,000 years. Cast iron was valued for its high heat retention, long lifetime (individual pans have been known to be used for more than 100 years), and, believe it or not, for its non-stick properties. Bare cast iron is far from non-stick, but when oil is heated in cast iron, it polymerizes and forms a nonreactive coating that clings to the porous structure of the iron through a process known as "seasoning". Cast iron is also known to have at least one adverse health effect: small amounts of iron seep into the food. While this can have detrimental effects in people who have excessively iron-rich diets, this supplemental iron is considered beneficial in most cases.

A trouble with cast iron is that it is not quite user-friendly. Most cast iron pans come unseasoned, so you must learn to season them. Additionally, the seasoning may be damaged by acids, and it thus takes knowledge and practice not to damage the seasoning with overly acidic foods. Cast iron has a high heat capacity, which means you have to preheat pans for longer and wait longer for them to cool. But if you take some time to master the use of cast iron, there are endless benefits, such as more even cooking, non-stick properties with benefits both for cooking and cleaning, the option of using pans in the oven as well as on the stovetop, and genuine improvement of the pan over time.

So what drove the success of non-stick cookware? It seems to have been due in large part to the convenience of non-stick. The main reason that DuPont cites for buying Teflon cookware is that the pans are easier to clean. But are they truly easier to clean than cast iron? There is no sure way to test this claim, but many people claim that with properly seasoned cast iron, a rinse with hot water is the only cleaning necessary. Non-stick pans have been said to require less oil than conventional pans, thereby producing healthier food, but experienced cooks assert that one can cook on seasoned cast iron with as little oil as desired.

The one disadvantage of cast iron is that it requires some practice to use correctly, but that is a relatively minor inconvenience. The view that modern technologies, despite poorer cooking performance, are preferable to older technologies, which require some skill, has clearly won out in this case. Despite real worries about the safety of new technologies, companies would rather invent even newer technologies than support old technology that is certified as safe. While there is a fringe of people who appreciate old cooking technologies (discussing them, sometimes heatedly, in online forums), many people don't even notice that there is a choice. It's hard to tell whether most consumers actively embrace modern non-stick cookware over cast iron, or whether they have passively succumbed to the industry's push to profit from new technology.



500 Milligrams for Arachnophobia, 1000 for the Ex-Wife: The Science of Memory Erasure

By Elie Goldberg

Science has made us gods even before we are worthy of being men. Jean Rostand, a French biologist, expressed this fear nearly 70 years ago. Today, science has advanced to a state where there is more convergence between scientific research and ethical concerns than ever before. At the core of this convergence — between philosophical anxieties, progress, knowledge, creativity, hubris, and imagination — lies neuroscience, the magnum opus of the life sciences. Each day, we are expanding our understanding of the brain to new and unprecedented levels. Recent advances in memory research have enabled scientists to target and erase specific memories in live animals. Ironically, if Rostand were still alive today, his fears of scientific progress could soon be targeted and erased, without affecting any of his other mental capabilities. Of course, surrounding this scientific power is an ominous cloud of dystopian mind control, reeking of the spotless mind and the matrix; but at least we might one day be able to sleep soundly without the haunting memories of Krislov's naked body and scary clowns.

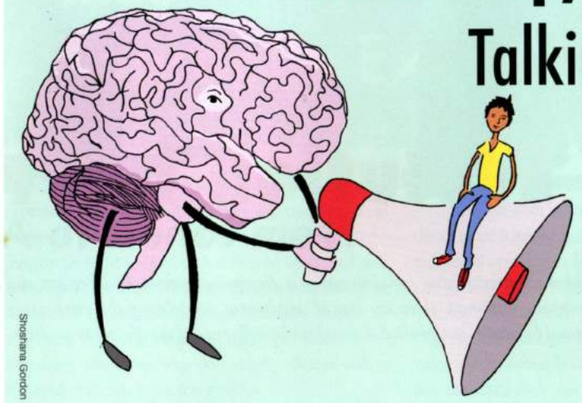
Before elaborating on the breakthroughs in research surrounding memory erasure, a cursory understanding of memory formation and maintenance is required. Scientists do not claim to understand the entire biological basis of memory formation, but one crucial process is fairly well documented. The process of long-term potentiation, or LTP, has been observed as one of the major cellular mechanisms that is crucial to memory formation in the hippocampus, cortex, amygdala, and many other areas of the brain. Simply, "memories" are formed by the steady chemical and electrical communication between neurons. This type of steady communication between cells, which causes the process of LTP, is largely driven by two membrane receptors, the *a*-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid (AMPA) receptor and N-methyl-D-aspartate (NMDA) receptor. The membrane receptors on one cell receive electrical and chemical signals from another cell. Consequently, the concentration of these receptors determines the strength of the connection between the two neurons; the presence of more receptors indicates a stronger connection. Interestingly, the process of LTP automatically increases or decreases the number of AMPA receptors on a neuron based on how frequently that neuron is activated. In other words, the neuronal connection responsible for a memory becomes stronger or weaker, depending on how frequently it is activated, or "remembered". If this neuronal connection is not frequently stimulated, it will die out and be forgotten. However, the agent responsible for regulating the number of membranous AMPA receptors, and consequently the strength and permanence of a memory, had not been discovered, until recently.

Perhaps the most shocking part about this recent breakthrough is not its potential ethical reprucussions but rather how simple the science of memory erasure seems to be.

Perhaps the most shocking part about this recent breakthrough is not its potential ethical repercussions but rather how simple the science of memory erasure seems to be. The breakthrough here was twofold. First, the specific agent responsible for increasing the strength of the neuronal connection (the increase in membrane receptors) was found. This was mainly accomplished by Todd Sacktor in the 1980's through a series of experiments at Columbia University. Sacktor discovered that an enzyme called "protein kinase C, zeta" or PKMzeta, played a crucial role in LTP, specifically in the process of strengthening neuronal connections by increasing membrane receptor concentrations. The second breakthrough was simply the realization that by inhibiting PKMzeta one could inhibit the recollection of memories with astonishing specificity. The reason is almost too simple to be true — a freebie handed to us by nature. We know that consistent activation and strengthening of these neuronal connections, driven by PKMzeta, is necessary to keep memories strong. But Sacktor's theory is that the activation of PKMzeta only occurs in the neurons responsible for a memory while you are remembering it! So by inhibiting PKMzeta activation during the recollection of a specific memory, you can weaken or extinguish that neuronal connection, without impacting anything else.

Over the past 20 years, and most recently in his 2007 paper, Sacktor and other scientists have, in rats, been able to fully extinguish memories of taste preferences, taste aversions, and the association of certain tones with painful shocks. For example, in one experiment rats were trained to associate a single note or tone with a painful shock, so that just hearing the tone would cause the rats to "freeze" or stop moving for long periods of time — a telltale sign of fear. Then, researchers would elicit the memory of this fear by playing the tone and quickly administering the PKMzeta inhibitor. The rats would no longer freeze following the tone, even days, weeks, and months after the administration of the inhibitor. Many similar experiments were repeated with conditioned taste aversion and preference, all with equally successful results.

Exciting benefits and terrifying uses of this research are palpable. Never before have humans had such potential control over their own minds. With this new knowledge of memory, post-traumatic stress disorder can be an ailment of the past, and Alzheimer's disease may soon be solved. Yet, one's memories inform everything — emotions, decision-making, lifestyle, *etc.* It was once an undeniable and sometimes comforting truth that you could not choose what to remember and what to forget. Now, we have to face the terrifying fact that, as a species, we can tinker with things we once thought to be beyond even our most ambitious reach. Eventually, someone is going to have to decide how this scientific power should be exercised. But how can we possibly wield the power of gods before we have properly wielded the power of man?


Shobhana Gordon

What's Up, Weelic? Talking Aloud

By Weelic Chong

My neuroscience research over Winter Term made me think. It made me think about poking needles in rat brains, it made me think about how rats might secretly like morphine injections, and it made me think about how terrible an evening commute in a city like Madison can be. (edit: But I still love Madison!) Anyway, it made me think so much that I just had to record my thoughts on the way home while standing in a bus with 60 other commuters. My caffeinated neocortex was in overdrive, and I dodged this way and that to keep pen on paper while the bus swayed. But finally, it was just too much for my wimpy vestibular system. I wasn't on a mission to write until I puked, so I stopped. Now, why couldn't this be easier?

Maybe I could use voice recognition software like Google Voice, Apple's Siri, or Android's Vlingo. Could I face the awkward, crimson faces on the bus while I dictate in lucid detail the going-ons of a typical college life? I guess not. So follow me as I dream a little bigger. What if someone could telepathically communicate with a device?

In my search for such a device, I discovered that NASA tackled this problem a decade ago. A basic biology class taught the NASA scientists that when muscles move, tiny currents are generated. With this information, they turned to the electromyogram, a common medical device that diagnoses muscle aches and used it to analyze the tiny currents at the nerve endings of the vocal cords. Using this, they hoped to discern what you are trying to say, even if you have a sore throat, a blocked nose, or are in a loud place, like the 'Sco.

Unfortunately, as with most NASA science, funding cuts have spelled doom for this endeavor. It was so bad that "subvocalization analysis" became a dirty word; it was as credible as say, "crystal healing". But it was not long before someone else tried a new approach. Rather than analyze throat muscle movements, the lab of Professor Frank Guenther, from Boston University, decoded signals directly from the motor region of the brain that controls nerves in the throat. Brain implants were inserted into the speech area of the left precentral gyrus, a part of the brain that controls the shape of the mouth, larynx, and throat. Brain waves were then recorded and sent wirelessly to a computer that decoded them into auditory signals in real time. However, with current technology, only vowels were distinguishable with sufficient accuracy.

What about locked-in patients who cannot control their muscles? To benefit such patients, other researchers are sidestepping the indirect approach of measuring motor activity altogether. One team is tapping directly into the superior and middle temporal gyri, which translate acoustic information into phonetic representations. At UC Berkeley, the lab of Professor Micheal I. Jordan pioneered this approach, and these scientists are now matching all kinds of acoustic information with brain recordings. However, according to Steven Laureys at the University of Liege in Belgium, it is crucial to develop evidence demonstrating that thinking words produces brain activity similar to that produced from the perception of those same words when spoken aloud. Indeed, such evidence is crucial for inventing products that may eventually read minds.

In the meantime, a company called Ambient Corp is marketing products based on NASA research to the public. One of these products, the Audeo, connects to an iPhone, wraps around the neck like a hairband, and is touted to be the future hands-free, "voice free" form of communication. It interfaces with Siri, too. An alternative to Futurama's eyePhone? Let's wait and see.

Shoshana Gordon

Social Evolution in Primates

From Loners to Altruistic Flea-Pickers

By Jessica Lam

Traditional theories of social behavior assert that social structure is determined primarily by recent and contemporary ecological conditions. Although these are logical conclusions considering the importance of adaptation in shaping animal behavior, such beliefs downplay the influence of specific genes in determining social structures.

In a recent study published in *Nature*, scientists from the University of Oxford studied the social organizations of 217 primate species through the lens of evolutionary genetics. The results of their research suggest a strong genetic basis for both social behavior and the changes from one type of social organization to another over time.

The researchers began their study by classifying the social behavior of each primate species into four groups: solitary, pair-living, or group living, which itself was subdivided into single-male and multi-male groups. A single-male harem consists of one adult male and multiple adult females, whereas a multi-male group consists of several males and several females. The divided 217 species were subsequently arranged onto a primate consensus tree, which summarizes the inferred evolutionary history of the primate species.

Like a typical phylogenetic tree tracing ancestry, a primate consensus tree maps out our current understanding of the species' evolutionary history. Researchers color-coded each species on the tree according to its social organization. This organization of data revealed that, more often than not, closely related species on this tree were the same color, indicating that genetically-related species often have similar social organizations. These statistically significant similarities led the researchers to conclude that each species' social organization was strongly based on genetics.

Using four different models to interpret the data and characterize the species' changes, the researchers were able to evaluate the rate and manner of transition between the four groups (solitary, pair-living/family groups, single-male, multi-male). The first model of transitions between patterns of social organization claims a single rate of transition between all patterns, with all of the changes occurring at the same rate. In contrast, the second model employs variable rates of transition, implying that some transitions are more likely to occur than others (although the model does not provide which of the transitions are more likely to occur, just that some are). The third model restricts the transitions to direct step-wise changes only. The fourth model, or the "reversible-jump-derived" model, on the other hand, uses information derived from the phylogenetic data to identify likely transitions.

Of the four, the researchers found that the reversible-jump-derived model fit the data most closely and best explained primate sociality. This model suggests that social behavior evolved from solitary to multi-male groups, and then from multi-male to either pair-living or single-male harems. The study identifies the switch from a nocturnal to a diurnal lifestyle as a possible catalyst for primate social evolution from solitary to group structures, as it would have forced the primate ancestors, exposed during the hours of daylight, to seek safety in numbers from predators. The researchers hence recreated the evolutionary history of social organization using the reversible-jump-derived model.

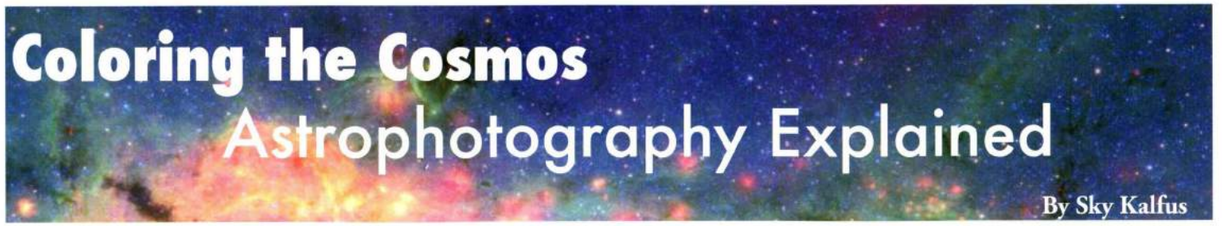
While the transitions from smaller groups to larger ones have previously been assumed to occur at a consistent rate across species, evidence from this study does not support that theory. Rather, the phylogenetic data suggests the transitions occurred mostly unilaterally. The shift from solitary living to multi-male groups occurred roughly 52 million years ago, which coincides with the change from nocturnal to diurnal activity. From this, more stable social structures emerged, eventually leading to pair-living and single-male groups that emerged around 16 million years ago. Many of these landmark changes in sociality occurred at points where one primate family divided into multiple evolutionary groups.

Researchers explored sex-biased dispersal as another possible catalyst for primate social evolution. In sex-biased dispersal, which occurs in many primate species, one sex (typically male) disperses much further from the birth site than members of the other sex. It has been theorized that this allowed members of the sex that remain at the birth site to form cooperative relationships with each other, resulting in increasing sociality within the group.

The data places sex-biased dispersal patterns as appearing after the shift from solitary to multi-male groups. Thus, these findings discredit the once accepted idea that cooperative relationships led to increasing sociality and therefore larger groups. However, even though the change to sex-biased dispersal did not prompt social living, it can still be credited as a secondary catalyst towards more stable social groups.

Dr. Joan Silk, an expert in primate social behavior at UCLA, asserts, "The existence of a strong phylogenetic signal spells trouble for socioecological models that aim to explain the evolution of primate social organization." In other words, if ecological conditions, such as resource distributions, were the primary determinant of social behavior, then related primate species in different ecological environments should display a wide range of social organizations. Furthermore, if this theory were correct, primates in similar environments should have similar social structures regardless of genetics or evolutionary history. This study shows that neither of those hypotheses is true. These results will undoubtedly play an essential role in future studies seeking to model the evolution of social behavior in primates.

As stated in the study, "Anthropoids [monkeys and apes] differ from other social vertebrates in the prevalence of stable groups and bonded relationships between individuals." Additionally, this study's conclusion supports the results of a previous experiment, which demonstrated that male monkeys have a biological predisposition towards certain toys. In the 2008 study, the researchers found that the male monkeys overwhelmingly preferred to play with "masculine" (i.e. wheeled toys), rather than more "feminine" stuffed dolls. The fact that these two separate studies came to similar conclusions involving genetically-determined innate behaviors, confirms that gender roles and social behavior are based largely upon genetic components. Studying primate social behavior will also be revealing of human behavior, serving as a way to understand the underlying basis of our own social structures.



Coloring the Cosmos

Astrophotography Explained

By Sky Kalfus

Let's imagine you're in deep space. Behind you, our sun is indistinguishable from the billions of stars that compose the Milky Way Galaxy. In front of you, 4,000 light years away, you're able to make out the bright light of the Crab Nebula, a cloud of gas and dust left over from a violent supernova explosion. You recall seeing photographs of the Crab Nebula when you were back home and remember an ethereal crimson cloud with a center of brilliant white. Or was it a green-and-gold ring of algae-like filaments, focused around a haze of blue smoke? Suddenly, it occurs to you that you've seen many photos of the Crab Nebula. Each was entirely unlike the others, and each was entirely unlike the white smudge of light that barely makes itself visible to you from your vantage point in space.

What's going on? Photographs of deep space would have us believe in a Day-Glo universe. We're accustomed to gorgeous, detailed depictions of nebulas and galaxies, rendered in brilliantly saturated hues. But if you've ever been in space, or at least looked at a deep space object through a telescope, you know that those colors aren't visible to the human eye. In fact, many of the colors you see in astrophotographs were never there to begin with. Typically, we expect photographs to show us the world — and the universe — roughly as if we were seeing it with our own eyes. But astrophotographs aim to serve a higher scientific purpose, and can show us much more than that.

Catching Rays

To understand how astrophotographers take pictures, it helps to think of a camera as a data-collecting device. It records the wavelength, frequency, and amplitude of the light it receives. Encoded in this data is valuable information. Chemical elements emit light at specific wavelengths, and if we can identify the wavelengths of light produced by a galaxy or a nebula, we can also identify the chemical elements that compose that galaxy or nebula. We can then infer its origins, its evolution, and the temperatures of its individual stars. A photograph is literally a graph that depicts this information. Color represents wavelength; intensity of the color represents amplitude. (When you get sunburned, your skin is a negative photograph; darkness corresponds to level of light exposure.) In a family photograph, the colors correspond almost exactly to the wavelengths they represent. But in astrophotography, two chemical elements might emit similar but distinct wavelengths of light — say, two different shades of red. It's important that we distinguish these two elements, so an astrophotographer might choose to represent one wavelength of light with a contrasting color, the same way you might choose colors to represent data on a bar graph.

Visible Light

To distinguish the wavelengths of light recorded by a camera, it's easiest to control the light the camera receives. Astrophotographers use a tool called a filter, a piece of colored glass that blocks all but certain wavelengths of light. A filter allows astrophotographers to take a photo of, say, just red light. Typically, astrophotographers will take three photographs of an object, each through a different color filter — red, blue, and green. Separating the wavelengths of light into three photographs makes it possible to adjust the brightness and contrast of specific colors. The three modified photographs are layered to produce a single full-color image with important features made visible.

> We expect photographs to show us the world roughly as if we were seeing it with our own eyes. But astrophotographs can show us much more than that.

Most nebulas are surrounded by an abundance of ionized hydrogen gas. Hydrogen is the most plentiful element in the universe, but the red light it produces is faint. By amplifying the red layer of a three-color photograph, the hydrogen becomes visible. The rosy haze that characterizes many photographs of nebulas indicates an abundance of hydrogen gas. A bluish-white fog, like that seen in visible-light photos of the cloud nebula, indicates synchrotron radiation, a bright light emitted by charged, fast moving particles passing though magnetic fields. In the case of the Crab Nebula, it suggests the presence of a rapidly spinning neutron star at its center.

Narrow Band Imaging

The pinkish color of nebulas can also be indicative of ionized helium gas, which, like hydrogen, emits red light. In fact, helium and hydrogen are so similar in color that they're impossible to visually distinguish. When astrophotographers want to differentiate between two elements of the same color, a simple red, blue, or green filter won't do. Instead, they use filters that only let in one specific wavelength of light — say, light emitted by sulfur. With one photograph that only shows light emitted by hydrogen and another that only shows light emitted by sulfur, they can assign an arbitrary contrasting color to one of the photos. When the photos are layered, the contrasting color stands out and separates the wavelengths.

Non-Visible Light

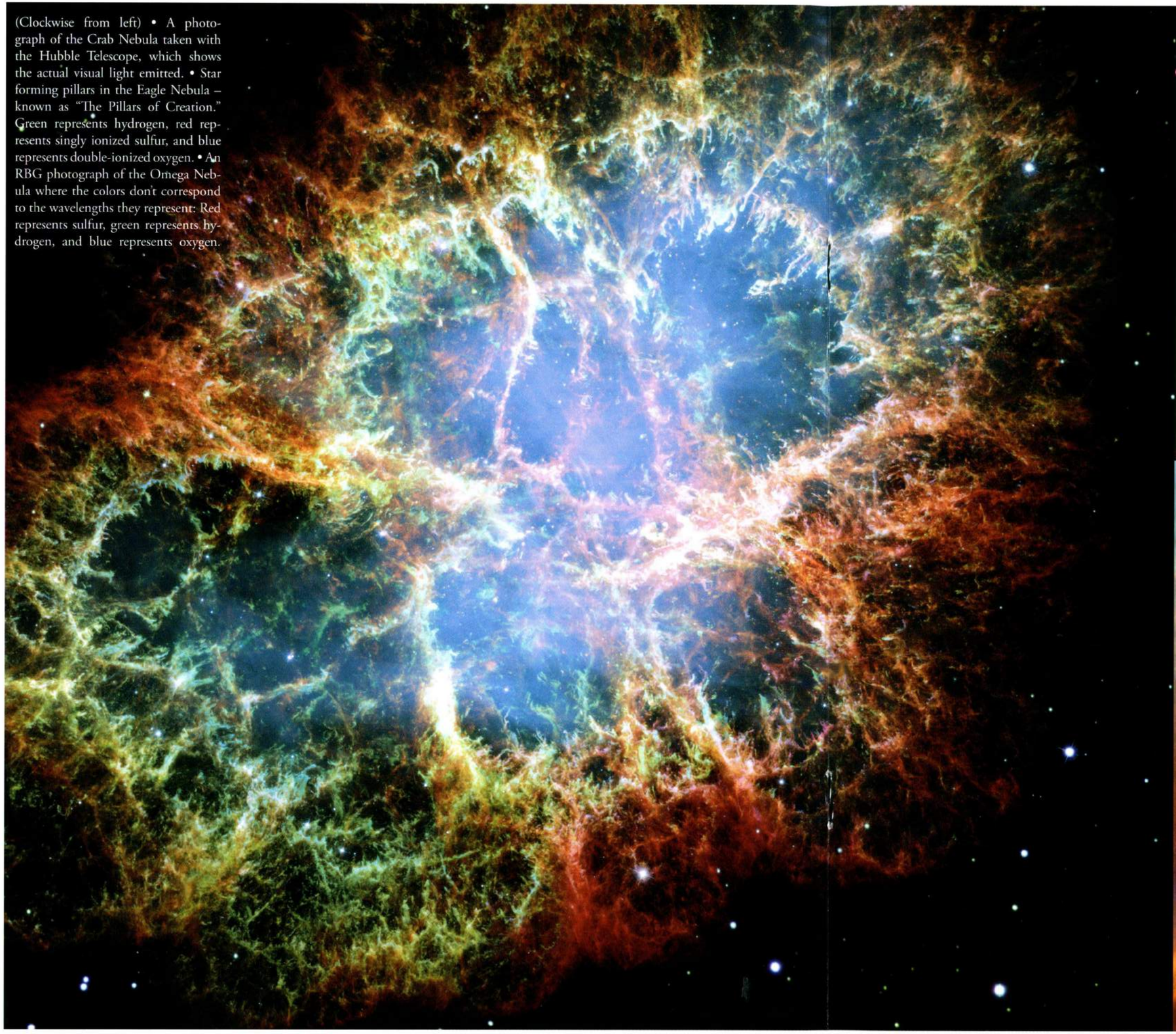
While the visible light emissions of celestial bodies are interesting, space objects emit way more than just visible light. That's why we photograph at nearly every wavelength of electromagnetic radiation there is — x-ray, gamma ray, ultraviolet, infrared, microwave, and radio.

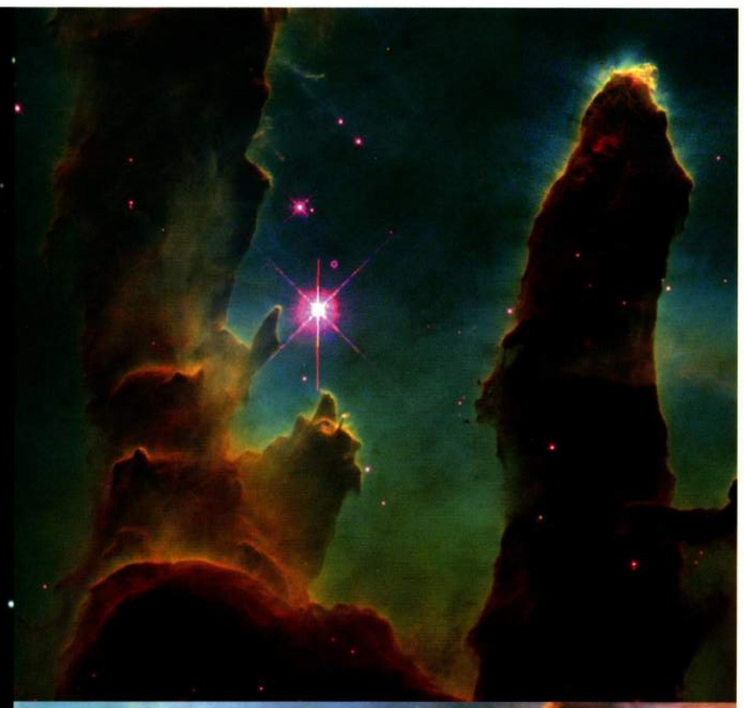
Astrophotographers can represent photos taken in non-visible forms of light by arbitrarily assigning colors to different wavelengths. Since most astrophotographs you see are taken in non-visible wavelengths, most of the colors you see have no basis in fact. Usually, astrophotographers represent low-wavelength light with low-wavelength colors, like red, and high-wavelength light with high-wavelength colors, like blue.

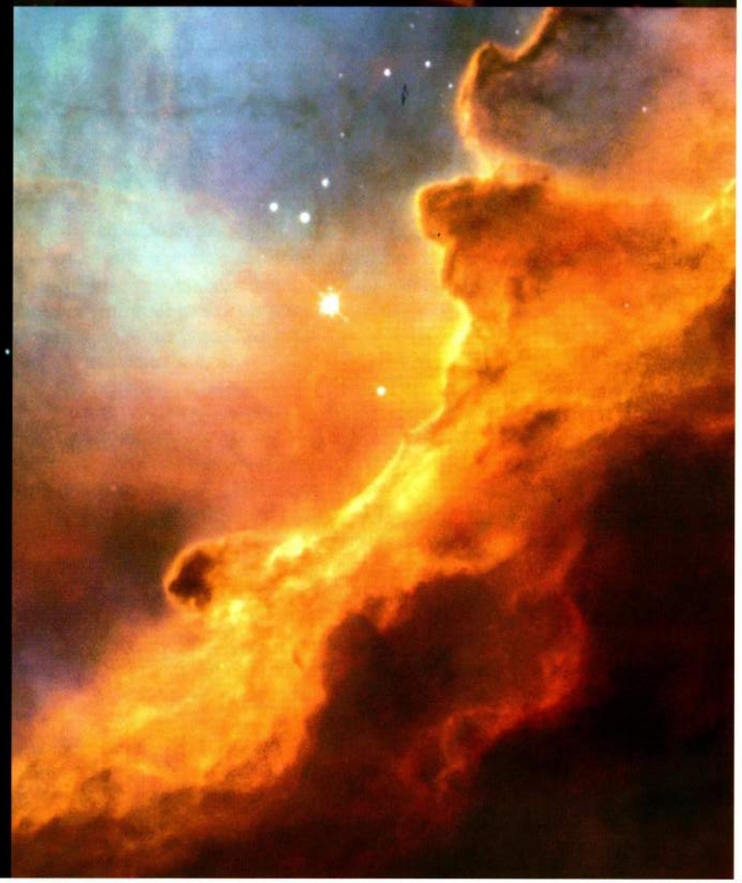
True or False

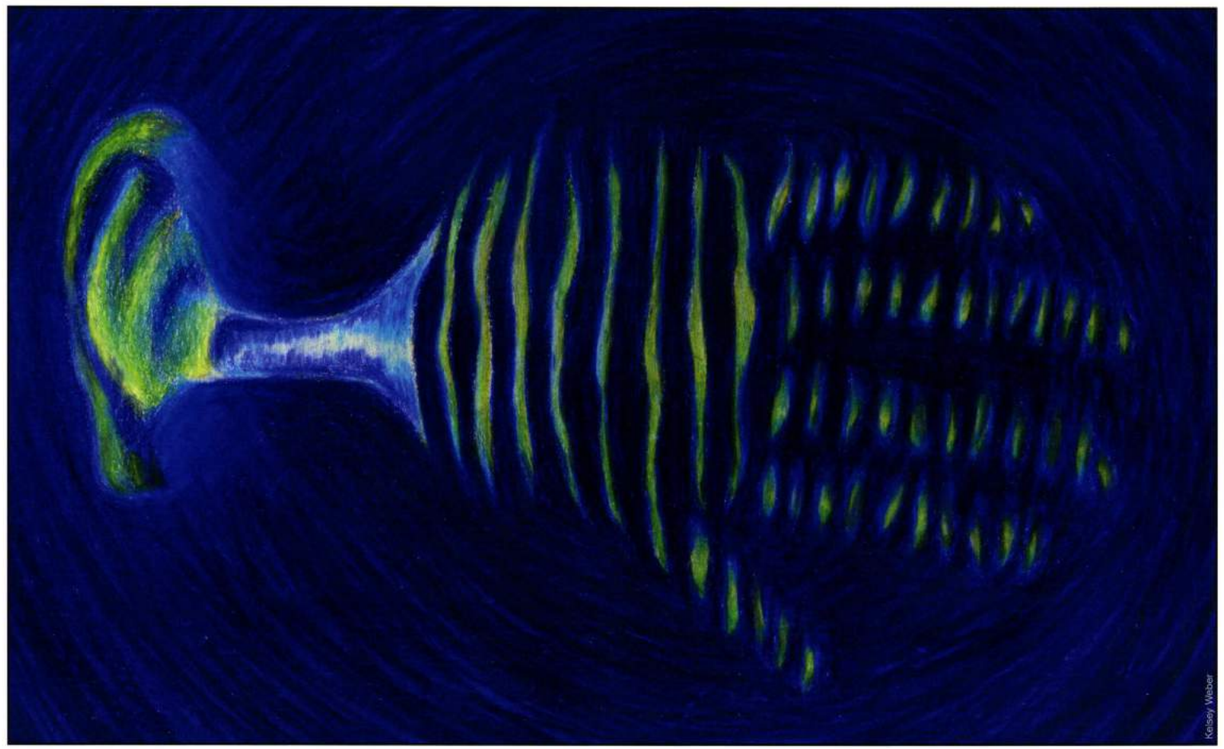
Are manipulated astrophotographs in "false-color"? Many scientists argue that there's no such thing as "true color". After all, organisms — dogs, lizards, possible extraterrestrials — perceive color in all kinds of ways. It's hard to define what "true color" is. What's important to astrophotographers is to preserve information about the wavelengths of light. Wavelength is an objectively measurable quality. Color is not. Astrophotographs don't show us space as we'd see it with our own eyes. Instead, they give us a kind of super vision, the ability to identify the chemical composition of celestial bodies thousands of light-years away. Through the careful manipulation of the faint fragments of light that reach our astronomical instruments, the universe becomes knowable.

(Clockwise from left) • A photograph of the Crab Nebula taken with the Hubble Telescope, which shows the actual visual light emitted. • Star forming pillars in the Eagle Nebula – known as "The Pillars of Creation." Green represents hydrogen, red represents singly ionized sulfur, and blue represents double-ionized oxygen. • An RBG photograph of the Omega Nebula where the colors don't correspond to the wavelengths they represent: Red represents sulfur, green represents hydrogen, and blue represents oxygen.









Frontiers of Cross-Modal Display:

The *Emoti-Chair* as a Model Human Cochlea

By Adrian Jewell

At Ryerson University, the laboratory of psychologist Frank Russo has developed the technology to convey musical emotion through vibrotactile stimuli. Cleverly named the "Emoti-chair", the apparatus channels vibrations through the seat via embedded speakers. Ultimately, the participant feels, rather than hears, the music.

Many have already experienced such phenomena, but more as a supplement to our acoustic experience. One may have, for instance, attended a party where the beat of the music, in addition to being heard, could be felt, coursing through the body. Additionally, one may have relaxed into the massaging vibrations and ambient soundscapes of a spa chair. Another way to take advantage of the cross-modal display is to watch the iTunes visualizer.

The visualizer takes the structural content of the sound recording to produce a visually stimulating animation. These examples demonstrate that today's commercial cross-modal technology is readily available, but primarily supplementary. While the aforementioned recreational experiences with vibrotactile information supplement and enhance the music going through the ears, Russo aims for a freestanding musical experience that can be felt on the body.

One's intuition may offer an easy solution to this goal: simply output the composite audio signal of a song through speakers, then touch the speakers. This will likely cause a general buzzing sensation. Where's the emotion? The problem is that the small patch of skin that touches the speaker cannot discern the intricate patterns of sound. This is because the ear is far superior to the skin in sensitivity to vibrations. It can hear from 20 Hz to 20,000 Hz, while the skin senses within the range of 5 Hz to 1,000 Hz. As such, pitches must not only be translated but also manipulated to fit within the skin's sensitivity range.

The solution, therefore, is to decode sound into its component layers and present them in such a way that we perceive all of them simultaneously. For a solution, researchers analyzed the human cochlea, an organ in the auditory system that resembles a spiraled sea shell and naturally deconstructs complex sound into its component parts. The cochlea decodes complexity in sound waves by separating the derivative frequencies along its length. For example, high frequencies in the sound activate the entrance to the cochlea, and the bass frequencies activate the center of the spiral. This is the process of place coding, a central feature that will allow researchers to translate sound into another sensory modality.

A structural analysis of melody will better explain the importance of place coding. Consider the physical properties of melody.

“ The ear is far superior to the skin in sensitivity to vibrations. It can hear from 20 Hz to 20,000 Hz, while the skin senses within the range of 5 Hz to 1,000 Hz. As such, pitches must not only be translated but also manipulated to fit within the skin's sensitivity range. ”

A sound that ascends in frequency corresponds to a rise in pitch. Similarly, a lowering of frequency corresponds to a lowering of pitch. The dynamic qualities of frequency provide emotional content related to the patterns of changes in frequency. Remember that a rise in pitch means a change in place code in the cochlea. It may be that people seem to hear pitch at different locations because the cochlea actually registers different pitches at different locations. This is why a deep grumble can emerge from the ground, and a beautiful, luminous melody can seem to "descend from the heavens." This considered, location frequencies can be placed along a gradient, with the higher frequencies closer to the head and lower frequencies nearer to the lower back. When researchers map pitches in this way, one can effectively translate a melody, as if the human body itself were the cochlea: thus, a model human cochlea (MHC).

Designing the chair poses a considerable challenge. First, researchers do not yet have the technology for a body "pad" on which one could present any conceivable vibration at any conceivable point. The substitute consists of specialized speakers embedded into the back of the chair. These speakers, coined "voice-coils", are organized into rows and columns down the back. The prototype design went through several phases. The current model includes voice-coils down the entire back as well as some smaller ones in the arm-rest.

Two models currently exist to utilize the advantages of the MHC: Track Model (TM) and Frequency Model (FM). TM is the process by which a multi-track master recording is channeled through the voice-coil configuration. TM tracks can be created by recording each layer of music individually. FM is the method used to deconstruct composite sound files into segmented audio tracks based on frequency. Note that it does not separate tracks, but frequencies. For example, in a piece of music that uses a drum set, some parts of the drum set will be high frequency and other parts will be lower. These two components of the sound will end up on different audio tracks. To clarify further, if one were to play all the resulting frequency tracks at the same time, one would hear the original piece of music. The resulting frequency bands are channeled through corresponding voice coils. In an ideal world, a TM would be reconstructed from a composite sound file.

The first official study on the Emoti-chair sought to test FM as an effective way to apply sound to the MHC. Researchers asked, "Does the FM method convey emotion better than a control method?" They found that it did, but a portion of the results were controversial. Participants experienced eight different audio samples through the Emoti-chair both with FM processing and in a control situation. In the control, the sound was transmitted through the chair without place coding. The selections were chosen to cover a swath of emotions (joy, anger, fear, and sadness). After the participants experienced the sample, researchers measured three things: valence (amount of positive energy), arousal, and enjoyment. Additionally, researchers asked for specific comments on the chair.

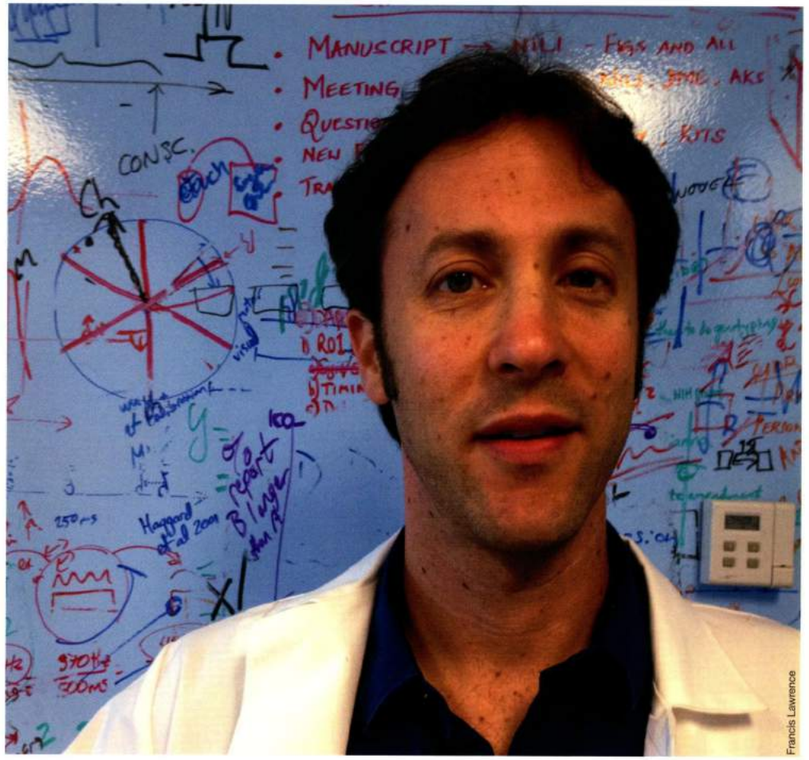
On average, participants rated the samples in FM as having stronger valence than the control method. More specifically, valence ratings did not differ significantly between joyful and sad music. This is to be expected, because joyfulness and sadness are two high-valence emotions on the circumplex model of emotion. This reflects Emoti-chair's still primitive qualities. On a more positive note, the mean enjoyment ratings for joy were significantly higher than those of sadness and anger. Enjoyment ratings for sad music also topped those for anger and fear. This is also an expected result because sadness is actually a very popular style across genres. Just imagine how many popular songs and non-vocal works are laments, ballads, or pieces with qualities of pain and sorrow. The reason that joyful music carries a comparably high enjoyment rating may be for reasons intrinsic to the qualities of the FM, rather than just the music itself. Joyful music typically has a wider range of frequencies as well as more rapid movement and development of musical content. A more varied, and therefore more stimulating, set of frequencies might just feel more arousing. The researchers endorse this opinion.

The subjects provided qualitative remarks on the selections. As a general remark about the FM selections, one person said, "I'm enjoying the track with a wide range much better than the one that stays within a tight range." This should be expected of FM tracks, which present a wide range of frequencies across the back. Participants described a selection from FM-Fear as "military, urgent, impatient" while the same track as a control was "boring, didn't say anything." Other comparisons between FM and control had less clear distinctions. A control selection for joy ranged from "too low, too weak to express anything" all the way to "epic, energetic, and proud." In spite of these examples, it was still observed that participants more clearly characterized their emotions after FM experience than after experiencing a control stimulus, suggesting a more vivid comprehension of emotional experience.

Ultimately, the Emoti-chair provokes a philosophical re-contextualization of music. In the past, music meant sitting in a hall with only acoustic amplification. Now, venues have multimedia presentations and amplification technology. In the future, one may don a bodysuit of vibrotactile stimulators. With this garb, Mozart might blissfully massage while metal or filthy dubstep may grind one's innards. One should consider the question of whether quality of musical experience improves with technology. This invention suggests that music may eventually synthesize the senses into one conglomerate modality; already, those without hearing disabilities describe listening to music with the Emoti-chair as immersive.

David Eagleman

a renaissance man of modern neuroscience



Dr. David Eagleman is a prominent neuroscientist currently rooted at Baylor College of Medicine in Houston, Texas. Dr. Eagleman is a best-selling author of both non-fiction and fiction works, including Incognito, *which explores the unconscious brain, and* Sum, *a collection of vignettes.* Sum *is an international best-seller and was recently adapted into an opera, which will be performed at the Royal Opera House in London this year. Eagleman's lab is working on a variety of projects which explore the complex inner workings of the human brain, and what the discovery of these processes means for the human race. Editor-in-Chief, Francis Lawrence, spent his winter term in Eagleman's lab, and took the opportunity to have a nice chat.*

What are your areas of research?

There are several prongs to the laboratory. The overarching umbrella ... is how the brain constructs reality and how that can be very different inside different people's heads. I [also] study time perception and how that can work in different situations. [Thirdly, I] study synesthesia, which is a good in road to understanding how one tiny genetic change can make someone different from someone else. I study neurolaw, how this all matters on a societal level ... the fact that people can be very different on the inside and how that makes a difference in how you run the society or how you run social policy. I'm also interested in ... issues of empathy, how people view in-group and out-group distinctions. Finally, the fifth prong is plasticity — how the brain rewires itself, changes itself — and so we are just launching several projects that will take advantage of plasticity to feed new kinds of data streams into the brain through neural channels.

What is something that most people don't realize about time perception?

That time is not necessarily a fixed flowing river, but [it] is a construction of the brain and it is malleable, so that under different circumstances you can think that things are longer or shorter. Maybe people do realize that, but I don't think people have any notion of the degree to which we can manipulate that in a laboratory and make people think something lasted longer or shorter than it did.

What is synesthesia?

It is a blending of the senses where some sensory stimulation leads to an anomalous or unusual sensory consequence. For example, hearing music that causes someone to see a color or shape or texture, or eating something [that] puts a feeling on your fingertips or hearing something [that] puts a feeling in your mouth. So it is a ... merging of the senses. It used to be thought people were just being poetic or metaphorical, but now it is clear that it is a genuine perceptual phenomenon triggered by cross talk in the brain.

Could you talk about something you are wondering currently or found out recently about synesthesia?

Well two things are going on currently. One, [synesthesia] appears to be genetic. It runs in family trees, so we are trying to figure out the genetics of it. It is a real challenge because like many conditions, it may be different genes in different families. It may be polygenetic even within a family, so it's a heck of a challenge to try to find this. We have been working for many years, so I hope not to fail there. Currently we are [also] pursuing a hypothesis that sensory processing dysfunction in autism is actually a form of synesthesia. A lot of autistic kids can't stand certain words or sights or touches or smells. What I realized in looking at this carefully is, it's not necessarily that everything sounds louder to them — because if that were the case they would not like loud sounds equally — but it is very particular. It's particular sounds that matter to them and that made me wonder if it was a network property, just like synesthesia, but instead of the sound triggering a color or a texture or a shape, it is triggering nausea or dizziness or aversion or something like that.

Would you say you found your niche or the best way for you to investigate the world?

I think there are many ways of investigating the world and so this is one approach [which] is very fruitful, but it is not the only one. Personally I spent a fraction of [my] time exploring the world through literature also, which is a different way of understanding humans and motivations and desires and loves and things that science is a little impotent on. [But] as far as a day-to-day job, yeah, I think it is optimal for me as far as how to spend my daylight hours.

What do you feel is your role in the neuroscience community?

Well ... sometimes I describe myself as a theoretician — which is not quite correct — and people don't understand that, because what I do is experiments all day. I work with numbers and data and fMRI and so on, but the reason I think of myself ... [as a theoretician] is because there are laboratories that study the brain at all these different levels — from molecules to synapses to neurons to networks of neurons — and what's needed is a theoretical framing to stitch all these pieces and parts together, and find out how they fit together. That's the part that I do.

Now what would you say is the most important thing from neuroscience to communicate to laymen?

It depends what we mean by important. I've been really interested in social issues lately. One of the things I think is underappreciated is the degree to which half of us, as people, are products of our culture, our communities, our family, the movies we watch, [and] the fables in our culture. All those things make us who we are, so there is no sense in imagining yourself back as a caveman because you would be so totally different, in ways you can't even imagine ... We all think there is this hardcore version of us that ... has some decorations of culture on [it], but it's probably not that. Very little of that hardcore [self] is in there. I think that is a very important concept for people when they think of people from other cultures and choices they make and wonder, "Oh how could they make that sort of choice?" It's actually a big pluralistic world.

What was your purpose in writing *Incognito: The Secret Lives of the Brain*?

Ah interesting question ... it was probably multipurpose. When I write a book, it allows me to crystallize my thoughts on something, and I'm always about three times smarter when I finish the book than when I start it. I think there is this illusion that people have when an author sits down and writes a book it's because the author has got all the stuff figured out and wants to express it to the world. But in fact the process of writing a book translates into figuring a lot of stuff out — really crystallizing ideas on the fly. You sort of know generally where you are going and you sort of know what's happening in front of you, but you figure a lot of stuff out along the way about the route. I always learn things from writing a book.

Like by making connections?

Yeah ... so there's that and the other half of it, as far as purpose goes, is I believe strongly in the endeavor of popular science. I don't understand why, but popular science sometimes has a bad reputation within the science community, where there is a lot of pettiness about this. People feel like if you are spending your time doing that at night, then you aren't reading academic papers or writing academic papers. But the fact is ... [with] *Incognito*, I spent a lot

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of time writing that book, polishing that book, making the best book I possibly could. I didn't know if anybody would be interested in it by the time it was done, but then it became a *New York Times* bestseller for almost four months, and what that tells me is there is a real public appetite for science and these ideas ... Instead of writing an academic paper that is read by 17 people on the planet, here was an opportunity to turn a lot of people on to a lot of ideas. You know, I think it is so critical for the future of education, for our legislation eventually, for our future of warfare, just in terms of ... teaching people what is known [and] what has good evidence behind it. It changes how people look at the world, what people think about social policy, how they think about international policy, how they think about what they want to teach their own children. I feel like *Incognito* is probably the biggest impact that I have had in my life so far, in terms of actually being able to turn people on to a whole constellation of ideas.

You, in the book, discuss the mind as being unaware of many of these processes of the brain and you say that throughout. These terms, "mind" and "brain", what do they mean to you and how are you using them?

The way I try to phrase it most consistently in the book is the conscious mind and the unconscious brain. The conscious mind is the part that flickers on when you wake up in the morning. It is the part that wasn't there when you were sleeping but is there when you are awake. The surprise to me when I got into neuroscience and studied it (for the last 18 years now) is to get this deeper and deeper understanding of how little the conscious mind has to do with what is actually happening under the hood. The vast activity in your brain is unconscious. You don't have access to it.

Would you say that the conscious mind is still a physical section or constellation of the brain?

Well, okay, it probably isn't a section in terms of the geography. And the reason we know that is because you can damage essentially any part of the brain and, so far as we know, there aren't lesions that cause someone to be a zombie in that they keep doing the same things with their conscious mind ... That [the] mind arises as a property of the brain may be an epiphenomenon, and that's probably the best guess. But as I talk about in the last chapter of the book, I devote it to this issue [of whether there are] other possibilities.

What is our evidence consistent with? Does it necessitate that consciousness is an emerging property of the physical pieces and parts? And the answer is: not necessarily. I mean that is the operational hypothesis that all of us come into lab every day with and we pursue this in lab — how the physical structure of the brain translates to consciousness — but we are absolutely certain that is an unsolved question. Not only do we not know how to translate the physical activity of the pieces and parts into consciousness, but nobody even has a good idea, even a seed of a shadow of an idea about what such a theory would look like.

To figure out how you could make a theory that translates one into another ... leads to a whole branch of philosophy that suggests that consciousness is an inherent property of the world, a part of the fabric of the cosmos, like gravity. It might be a special thing.

Interview by Francis Lawrence

Want to learn more about Dr. Eagleman's research and views on life? Read the entire interview online at TheSynapseMagazine.com

Where to Next?

Alternative Career Options in Health-Related Fields

By Brett Kingsley

Graduation. Whether this word means one more month to you, or you still feel like you just arrived here at Oberlin, graduation is the result we are all striving for. For science majors, the path may be tedious at times and filled with many different obstacles. However, what we ultimately decide to pursue following the ceremony is what's truly important. A large portion of students who spend their undergraduate careers studying science goes on to pursue medical careers. While choosing to become a doctor or a nurse is most common, there exist many other less obvious options.

1. **Occupational therapist** — Individuals in need of this service may have a physical, mental, or even developmental impairment that does not allow them to function in an independent manner on a daily basis. This job may involve re-teaching the task of buttoning up a shirt to a man who has had a stroke, or possibly teaching a teenager with autism how to jump rope or juggle to improve coordination skills. You will strive for your patients to come out of your treatment feeling independent so that they may have more control of their lives. This may appeal to neuroscience majors who have a greater understanding of how to get the brain and body working in unison to perform certain tasks, or to biology majors interested in the way in which different body parts collaborate.

2. **Nuclear medicine technologist** — This is similar to a pharmacist, but with a twist. Being a nuclear medicine technologist can be quickly described as using radioactivity not only to treat disease, but also to diagnose it. Nuclear medicine technologists prepare and administer radiopharmaceuticals. Additionally, they take x-rays and develop different types of images which they often supply to physicians. This occupation may be fit for those majoring in physics, or those majoring in chemistry, who enjoy working hands-on in a laboratory setting with the different chemicals involved.

3. **Applied behavior analyst** — An applied behavior analyst is a certified specialist who is concerned with how people interact with their environment. Being an applied behavior analyst, you will be working with various people on different behaviors such as communication, reading, social skills, and work skills. The program may involve training patients to respond appropriately to punishment, reinforcement, and verbal communication, or lack thereof. Becoming an applied behavior analyst may interest those who are majoring in psychology or neuroscience, since all behaviors stem from the brain and make up the personality of the clients.

4. **Chiropractor** — The main task of a chiropractor is to manipulate the spine into its proper formation. The job also calls for manipulating other soft tissues and points. To someone not knowledgeable in the field, it may look like a deep massage. Yet along with these sessions, chiropractors perform various other treatments for a patient, involving weights, head slings, and different stretching apparatuses. Chiropractic may be a medical career choice for those majoring in biology or neuroscience, because of their knowledge of the parts of the body and the connections between the spine and the brain.

Ben Garfinkel

5. **Clinical dietitian** — These are dietitians who work in health care facilities. Their patients include those who have various health conditions pertaining to their diets. They review medical charts and work with medical professionals to develop nutrition plans for their patients. Clinical dietitians may also provide seminars or public information sessions pertaining to proper health and nutrition in communities and schools. Chemistry and biochemistry are two areas of study which could lead to becoming a dietitian, along with academic background involving food and nutrition.

6. **Anatomist** — These biological scientists focus on the structure of living organisms. In most cases, anatomists actually work with human anatomy because most professionals in this field focus their research on humans. Anatomists work at universities and medical centers, where they teach the structure of organisms or conduct research. They help to train many medical professionals on their way to becoming pharmacists, nurses, and doctors. Those who may be interested in becoming an anatomist may be majoring in biology or neuroscience due to the fact that they already have a general understanding of human anatomy.

Perhaps you're certain that you want to attend medical school, or maybe one of these alternative choices sounds appealing to you and you might want to learn more. The possibilities are truly endless, and while considering your future may seem a bit overwhelming, if you dig around a little you will always be able to find options you haven't yet considered. We hold all the keys to our future; it's up to us to decide which door to open and which path to take, or even to create new paths ourselves. We're given the tools to make ourselves exactly who we want to be, so consider your options. Don't wait; start exploring.

OP-Ed: Lorain County Health

One Obie's Take on Healthcare Outside the Oberlin Bubble

By Sesha Nandyal

As Oberlin College students, we spend about four years of our lives in a rural town with a population of 8,300. The citizens and local businesses are reliably gracious. There is, however, a remarkable difference between the typical Oberlin College student and the members of the surrounding community.

College students usually have access to a much higher standard of healthcare than the Oberlin townspeople. The Lorain County demographics show a 17% minority population, 13.6% over the age of 65, and 7.3% unemployed. With 9.1% of the population uninsured and 23.2% below twice the federal poverty level, health risks become a major issue. Difficult economic circumstances and the lack of insurance greatly limit access to primary care. There are 211 primary care physicians in Lorain County, meaning that there are roughly 1,400 patients per doctor. Of course, with varying population densities and eligibility requirements, the number is often much higher. Only 81 of these doctors serve Medicaid recipients, which further deteriorates the primary care accessibility, as many people are not eligible for government health programs. Thus, this situation causes a type of healthcare isolation for the uninsured populations, including those with government assistance.

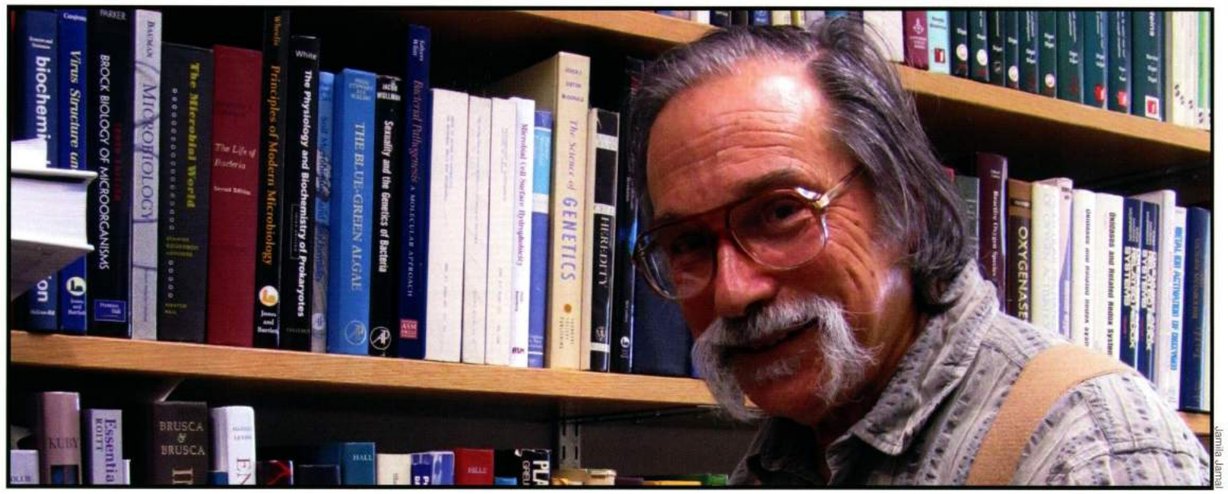
Little or no access to primary care correlates with a 7.6% incidence of low birth weight, 33.6% of adults having high cholesterol, and higher rates of infant mortality than peer counties in the United States. The United Way of Greater Lorain County produced a *Community Health Status Report* showing a large population suffering from breast cancer, lung cancer, and coronary heart disease. The most disparaging results, however, are seen in the minority populations. In 2008, the infant mortality rate was 24.1 per 1000 births for African-Americans and 9.0 per 1000 births for Hispanics, as compared to 4.2 per 1000 births for the Caucasian population. The discrepancy between minority infant mortality rates in Lorain County is particularly large when compared to other areas of Ohio. This disparity could be due to the large percentage of minorities who lack insurance or do not have access to primary care nor prenatal care.


Kelsey Weber

Lorain County's African-American residents have a 10.1% rate of low birth weight and only 52.9% receive prenatal care in the first trimester (the three most critical months) of fetal development. According to a recent World Health Organization survey, Zimbabwe, a country typically representative of the third-world, has a 12% incidence of premature births, and only 44% of people have four or more antenatal consults. These statistics demonstrate that the African-American population of Lorain County, a locality within the United States, has two important health indicators within 9% of those of a third-world country.

The reasons for such a stark contrast may lie in a lack of primary care or insurance coverage, or a phenomenon such as vitamin D deficiency. Whatever the cause, it is completely unacceptable for a county within such a privileged nation. As college students, it may be easy to take access to healthcare for granted, but it is important to acknowledge this privilege and help this community. For Oberlin College to be a truly great institution of higher learning, its students, many of whom are pursuing at least one social cause, must maintain awareness of and be prepared to challenge the Oberlin city health disparities.

The views expressed in this work are those of the author and do not necessarily represent the views of, and should not be attributed to, *The Synapse*.



Jamie Jasper

An Interview with William Fuchsman

The Life and Work of Oberlin's Retiring Chemistry Professor

In his many years as a valued professor at Oberlin College, Dr. William Fuchsman has taught a number of chemistry and biochemistry courses. Now in his final semester here at Oberlin, Fuchsman is teaching Bioorganic Chemistry, the couse he is most well known for, and finishing up a number of research projects. The Synapse sat down with him to discuss his research, career, and various other pursuits.

I was trying to understand your research. Among other things, you're trying to characterize the abilities of hemoglobin and myoglobin [proteins in red blood cells and muscles, respectively] to catalyze reactions of oxygen, right?

That's what it [says online]. My background from graduate school on has had something to do with heme proteins, if that has meaning for you. The heme is the red component of hemoglobin [the protein which transports oxygen on the red blood cell], and it's found in other proteins, and it's important. Hemoglobin, myoglobin, that's what makes muscle red. The heme is ... an aromatic, organic material. That's where the color comes from. It's also a very good ligand [or binding molecule], and it's a ligand to iron. When the iron is in the plus 2 state, and hemoglobin or myoglobin [and] oxygen combine, ... hemoglobin carries oxygen around and myoglobin serves as a depository for oxygen in muscle cells and also facilitates and speeds up diffusion [movement to areas of lower concentration] of oxygen. Oxygen is very small, so it should move rapidly. However, its diffusion requires a concentration difference. Since oxygen is practically insoluble in water you can't get much of a concentration difference, but you can sure get a concentration difference for oxygenated myoglobin in two places. ...[T]hen oxygen is getting where it needs to be in a cell. And it's going there, being carried by myoglobin.

So there are a lot of heme-containing proteins, [like] the soybean leghemoglobin. It turns out that in legumes — soybeans are one of those legumes — nitrogen fixation [plant pulls in atmospheric nitrogen, necessary for survival], which requires a lot of ATP [cellular energy], and one of the ways of making a lot of ATP is by using oxidative phosphorylation.

So you need a lot of oxygen, and the only problem is that the enzyme that does nitrogen fixation is very sensitive to destruction by oxygen. So what you need is to have something that can carry oxygen, something like myoglobin [but functions at very low oxygen concentrations], in the plant cells that have the symbiotic bacteria in them, because the symbiotic bacteria are the things that under low oxygen conditions will [fix nitrogen in the plant]. So you've got to keep low oxygen conditions and provide lots of ATP. This is essential for the plant cell to provide an environment in which the symbiotic bacteria will actually fix nitrogen, [and leghemoglobin serves the role of facilitating oxygen diffusion at very low oxygen concentrations].

I'm still winding down. This is my last year of teaching here at Oberlin.

It is?

Yeah. So I'm trying to finish up. The faculty have a career sabbatical for the semester and winter term after stopping teaching, so I still can do some research, but [after that] there's not room. I can't stay here.

I did a kind of triage on my many unfinished laboratory research projects, to try to figure out which ones nobody would do if I don't. Which ones also do I have a chance of getting done before I retire? And one that I've been playing around with for literally decades, which is not my main line of research, was something I had found by just investigating a little further a procedure that we used to measure quantities of reducing sugars ... Reducing sugars are a class of sugar ... You can detect their presence quantitatively or qualitatively because they serve as reducing agents. They will reduce certain things whose reductions you can monitor [with] a spectrophotometer, or [by] looking at color change for quantitative or precipitation for qualitative assays.

And it is well established in the literature — what happens to reducing sugars — they either have or form aldehyde groups and the aldehyde groups get oxidized to carboxyl groups at high pH ... and I just started checking out one such procedure that I was using in teaching laboratories first in the biochemistry course and then I shifted those experiments to the bioorganic chemistry course ... that I am now teaching.

I found that the behavior of this procedure did not fit what people said was going on when reducing sugars acted like reducing sugars. And so I've been exploring that because that's been a settled issue for generations, and what all the textbooks ... say is wrong! That's not what's happening to the reducing sugar.

Are you going to write to textbooks?

No, we'll publish this in a journal and hope that textbook writers ... notice.

I'm sure they would be reading it, right?

One hopes.

You've mentioned you had a graduate school background in hemes and hemoglobins. How did you first get led into that area?

Well, I was doing graduate work in a biochemistry department and I had known that I was interested in biological chemistry, probably before I even went to college. I was just interested in chemistry particularly, and I was interested in living things also, and I was interested in combining that. When I got to graduate school, I found that I was more interested in doing… more chemical aspects of biology, rather than more biological aspects. In the department that I was in, the major researcher who was doing more chemical work was the one who was working on hemes, so that's what started it.

So it was kind of almost accidental, then, it was just that he happened to be working on hemes.

Right, because I didn't know much about hemes before starting work there.

You said that you were interested in biochemistry before you even went to college. Do you remember what got you interested in it to begin with or was it just school in general?

The things I was interested in doing, as ... a child was collecting insects ... [and keeping] various creatures as pets. In high school, I worked at the Cleveland Natural History Museum. I went to high school in the Cleveland area, and before that I was in south Texas. I was fascinated by marine biology. Before Padre Island became a national seashore and a "spring break" destination, it was a place near where I lived... We could drive to Padre Island. We could drive on that beach, and we could go where there weren't other people. And I spent some time when I was in ... junior high school ... with a family friend who was a marine biologist, to learn some more about purple sea snails, [and various other marine creatures]. So I was fascinated by these living things and was also interested in chemistry, so I wanted to combine those interests.

Why Oberlin? How did you end up here and why have you stayed?

I had not intended, necessarily, to be teaching at a liberal arts college. Oberlin was the only college I applied to. I was interested in academic work and I applied to some university jobs as well, but I got the Oberlin job, and I have not had any regrets.

What's crucial to my satisfaction in the Oberlin job is two things: working with motivated and capable and interesting students, in terms of courses, but also being able to do serious research. Because there are, as you may know ... liberal arts colleges where the faculty are so pressed to teach what they have to teach that there is no opportunity ... or very little opportunity to do research. Oberlin not only has the opportunity, but expects faculty to be active in their fields.

I like both the teaching and research aspects of my job.

So you've really enjoyed leading a focused academic life.

Yes. But, as you know, it is not so completely focused [on academics]. I am also involved in the Guatemala work, which has nothing to do with my scholarly work.

And how did you fall into that?

During a period of time, when terrible things were happening to Mayan people in Guatemala, there was a human rights effort by people were working with refugees who were then in Mexican refugee camps — refugees from Guatemala. And then [there was] the coincidence of two people who had been working in human rights work in Guatemala, coming to live in Oberlin at the same time as [former Dean of Students Linda] Gates' daughter was about to graduate from Grinnell College. She wanted to do human rights work and the people who moved into Oberlin wanted to form a new organization to help with human rights work in Guatemala. My wife, who has long been interested in anthropology, has a master's degree in [anthropology] from Oberlin College, which once upon a time, offered such degrees. [She] knew terrible things were happening to the Maya but couldn't ... do anything about it, didn't know details. It all came together and they formed an organization, which is SEPA [Santa Elena Project of Accompaniment]. And I was not involved in it for the first two years of SEPA's existence, But when SEPA's first delegation was being organized to visit Santa Elena in Guatemala ... I said two things to my wife. One was, "That's not a safe place to go. You're not going alone. I will go, too!" And the other thing I said was, "Why don't you schedule it for January?" Because then we can take Oberlin College students. ... January 1999 was the first time I went to Guatemala with my wife and some other townspeople ... We met [the student group] in Guatemala City and all went to Santa Elena and I was hooked and I have been back many times since ... and have been involved for many years as the SEPA treasurer and ... have been the faculty sponsor ever since [1999] for the winter term Guatemala project.

Do you have any other main interests or hobbies outside of academia, which you like to pursue or are active in?

I do enjoy gardening. My house is one [where] ... most of the front yard is garden; the entire tree-lawn is garden. My wife and I like to plant. We do a lot of planting of native [to Ohio] plants.

My interest in animals has continued, so I do have pets at home. Currently it's just cats, parrots, turtles, and fish.

I had a pet skunk [once]. I had a hedgehog. The skunk was an interesting character, but the hedgehog seemed really much less interesting ... in terms of its interaction with us.

If you had any advice for young science majors, what would it be, as they try and pursue their careers and get jobs in the academic market?

My advice would be to students who think they are interested in the sciences: at some point, earlier is better, get some experience in a research lab, and find out. Because for some people, research is really attractive, and it's maybe what in the end turns people on to a career in science. And for other people, research is not a comfortable activity. You want to find out early on, instead of thinking that research seems like a very attractive thing to do, and perhaps finding out once you have committed to doing it, say in graduate school, that actually you don't like it so much after all.

Interview by Lizzie Roberts

Lab Hierarchy

Undergrads have more power than you think

By Hillary Mullan

Kelsey Weber

Many people share the perception that working in a research lab as an undergraduate is analogous to voluntarily giving yourself up for slavery. You do the mind-numbing tasks that the post-doc has been putting off for the past three months and in return you are offered "experience". As someone who spent her summer sitting in front of a computer counting cells for eight hours a day, I can attest to the fact that there is some truth in the "mind-numbing" part of this statement. However, I would say slavery is much too harsh a term. Instead, I would compare the relationship between an undergraduate intern and research scientists to that of a king and a court jester, with the scientists playing the role of the jester.

Yes, I am here to argue that undergraduates have a lot more power in research labs than most people will acknowledge. And before you launch into some counterattack that highlights the difference between a stipend and a six figure salary, hear me out. As an undergraduate student walking into a scientific lab, you feel the researchers, technicians, and post-docs make a conscious effort to keep you entertained. They provide you with stimulating conversation and let you play with the buttons of the PCR machine. In return for lending them your undivided attention, they give you tokens of appreciation in the form of Excel spreadsheets or pyrex jars full of solution. Granted, these items may be required for your experiment, but the fact that they were willing to do the grunt work setting you up demonstrates their desire to please you.

One of the biggest perks of being an undergraduate in lab work is the almost unlimited mistake quota. People expect you to break test tubes, bend electrode tips, rip tissue samples, and turn on all the wrong things at the wrong times. When an experiment does not go as planned, someone is there with a broom and a list of suggestions for next time. It isn't like in chemistry labs, where you are limited to ten dollars worth of clumsiness before a professor starts giving you the evil eye.

Finally, as an undergraduate, you have the power to ask whatever you want and it is the lab's obligation not only to provide you with the answer, but not to judge you for asking the question in the first place. If someone doesn't know the answer, it is quickly researched and you can expect the prompt arrival of a set of journal articles in your inbox. The fact is, in lab, research scientists will cater to you, your interests, and your goals. If they learn you are interested in microscopy, they will search through their data for a particularly stunning image or schedule an experiment at a time when you will be free to observe. They want to impress you. These people get a kick out of watching you learn. And while "test tube defroster" or "cell-counter" may not be the first skill you put on your resume, these people have been there, have survived, and are ready at any time to pull out their pom-poms and cheer you on.

Upcoming Seminars

- ***Archeology***
  2012: 40th Anniversary of the UNESCO World Heritage Convention: Reflections on US Participation.
  Stephen Morris (OC '82), Office of International Affairs, National Park Service. (April 23rd, 4:30pm in Classroom II, Art Building)

- ***Neuroscience***
  PKMZeta and Memory (see article on page 8).
  Todd C. Sacktor, MD, Professor of Physiology, Pharmacology, and Neurology at SUNY Downstate Medical Center. (April 27th, 12:10pm in Wright Lecture Hall - W201)

- ***Biology***
  Stephen A. Smith, PhD, Professor of Ecology and Evolutionary Biology at University of Michigan. (May 11, 12:10pm Location TBA)

Seminar: Stuart McDaniel '94

Using moss model systems to clarify patterns of biodiversity

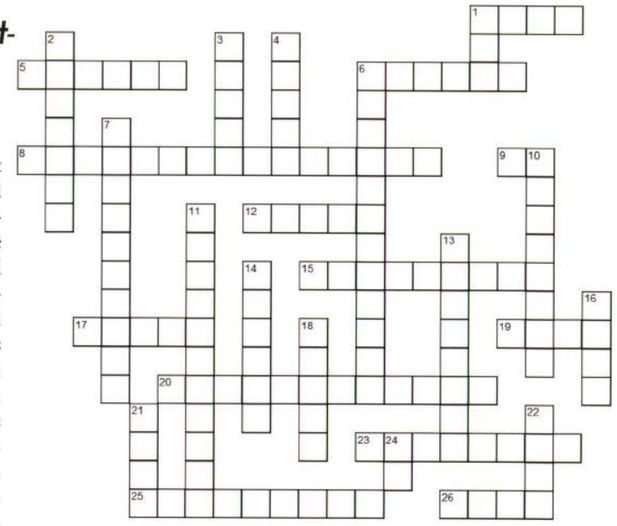
By Sesha Nandyal

On February 10th, Stuart McDaniel (OC '94), a fourth generation Obie and current Assistant Biology Professor at the University of Florida, presented a riveting description of his research concerning the evolution of reproductive isolation in moss species. After getting his Ph.D. from Duke University in 2005, he decided to continue with his research in the genetics of adaptation and reproductive variation. He is currently working on the exploration and identification of genes involved in sex-ratio distortion, adaptive life-history variation among populations, and the consequences involved in crossing divergent populations and species.

Physcomitrella patens and *Ceratodon purpureus*, two interesting moss model systems, have convenient haploid genetics and highly developed gene targeting tools that simplify McDaniel's research of genetic distortion. Using these strains of moss, sampled from the East Coast, he and his team of postdoctoral researchers study variation. His presentation, titled *Genomic and macroevolutionary consequences of dioecy: insights from moss model systems*, highlighted the ability of certain organisms to change sexual systems within a species over time. These sexual systems, namely dioecy and monoecy, respectively consist of: 1) two sexes, male and female, offering the promise of genetic diversity, and 2) hermaphroditism, which carries the benefit of reproductive assurance.

By using phylogenetic reconstructions for hermaphroditic mosses and checking them by identifying sister groups, McDaniel found that 60 percent of switches were from single sex to two sexes. This showed a slight trend toward diversification by sexual dimorphism. McDaniel then proceeded to grow different strains of moss under ideal conditions for crossing and finally achieved a cross that supported the pattern. This led him to conclude that the benefits of sexual dimorphism outweigh those of hermaphroditic systems. According to McDaniel's research, this phenomenon fuels the evolution of mating systems in certain moss species.

For further information on his project, check out his most recent article, *An experimental method to facilitate the identification of hybrid sporophytes in the moss Physcomitrella patens using fluorescent tagged lines.*



ACROSS

1 Oberlin's resident developmental biologist
5 Opposite of ventral
6 Alliterative phrase, "_____ Tough!"; refers to a material discussed in this issue
8 A hormone largely involved in chronic and acute stress
9 A unit of sound frequency
12 O_3 in the atmosphere
15 A bioluminescent bacterium
17 Whose free energy?
19 What dissipates from your hand when you stick it into cold water
20 A type of genetic "tree"
23 An organism which does a "waggle-dance"
25 Someone who studies the structure of living organisms
26 A color which often depicts oxygen in NASA photographs

DOWN

1 An aldehyde functional group. Also, like a sneeze when coupled with "A" and "O"
2 A part of the inner ear
3 What a computer programmer's first program says (or prints) to the world; a greeting
4 In $E = mc^2$, c = the speed of _____
6 Dr.David Eagleman's self-titled role in the neuroscience community
7 Current Oberlin environmental competition
10 Ginger's genus name
11 A neurological "blending of the senses"
13 Cl_2; a compound you might out in your pool
14 The skies have a "Crab" one
16 Abbreviation for a certain non-stick surface
18 What igneous rocks are made from
21 A receptor type involved in long-term potentiation
22 An organic material which is the focus of Dr. Fuchsman's research
24 A functional group which creates an alcohol

References, full interviews, and applications to join our fall staff (available May 1) can be found at **TheSynapseMagazine.com**

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/syn·apse/ *noun* **the point at which a nervous impulse passes from one neuron to another**

The Synapse is a relay point of science-related information with a twofold objective. First, we aim to stimulate campus interest in science by exposing students to its global relevance and contributions. Second, we strive to facilitate collaboration between members of the Oberlin College community, especially within the math and science departments.