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Dye-Sensitized Solar Cells: The Safer, Less Expensive Energy Device You Haven't Heard Of

By Yusef Farah

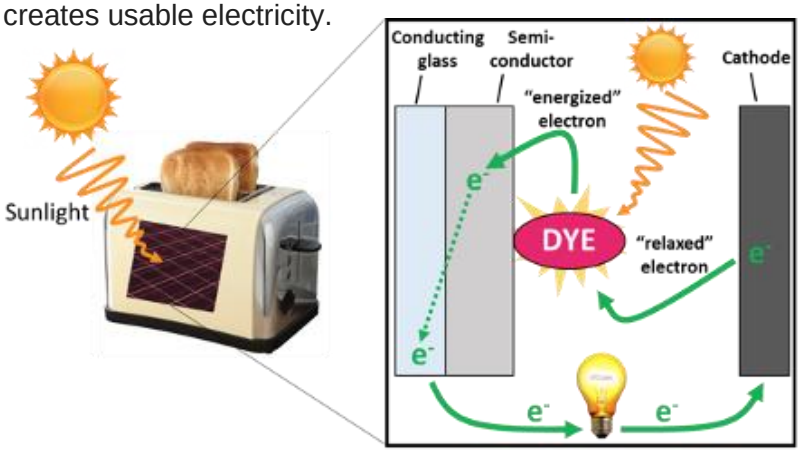
Humans must develop new, alternate sources of energy to meet today's energy demand without depleting finite resources here on earth. Solar energy is a prominent renewable source to compete with fossil fuels in the forthcoming energy economy. A **recent report** shows that during 2018 and 2019, the solar energy sector provided more new American jobs compared to the coal, natural gas, and oil energy sectors combined – a foreshadowing of the future energy economy. The sun supplies immense amounts of energy to the earth's surface every day. In fact, if we could capture all the sunlight's energy in an area of 1000 square miles (about the size of Rhode Island), we would be able to supply the entire world's electricity needs. While solar energy devices have been around for nearly 80 years, scientists are continuing to develop innovative and creative inventions to harness the enormous amounts of energy provided by the sun. One such solar energy device is the **dye-sensitized solar cell** (DSSC).

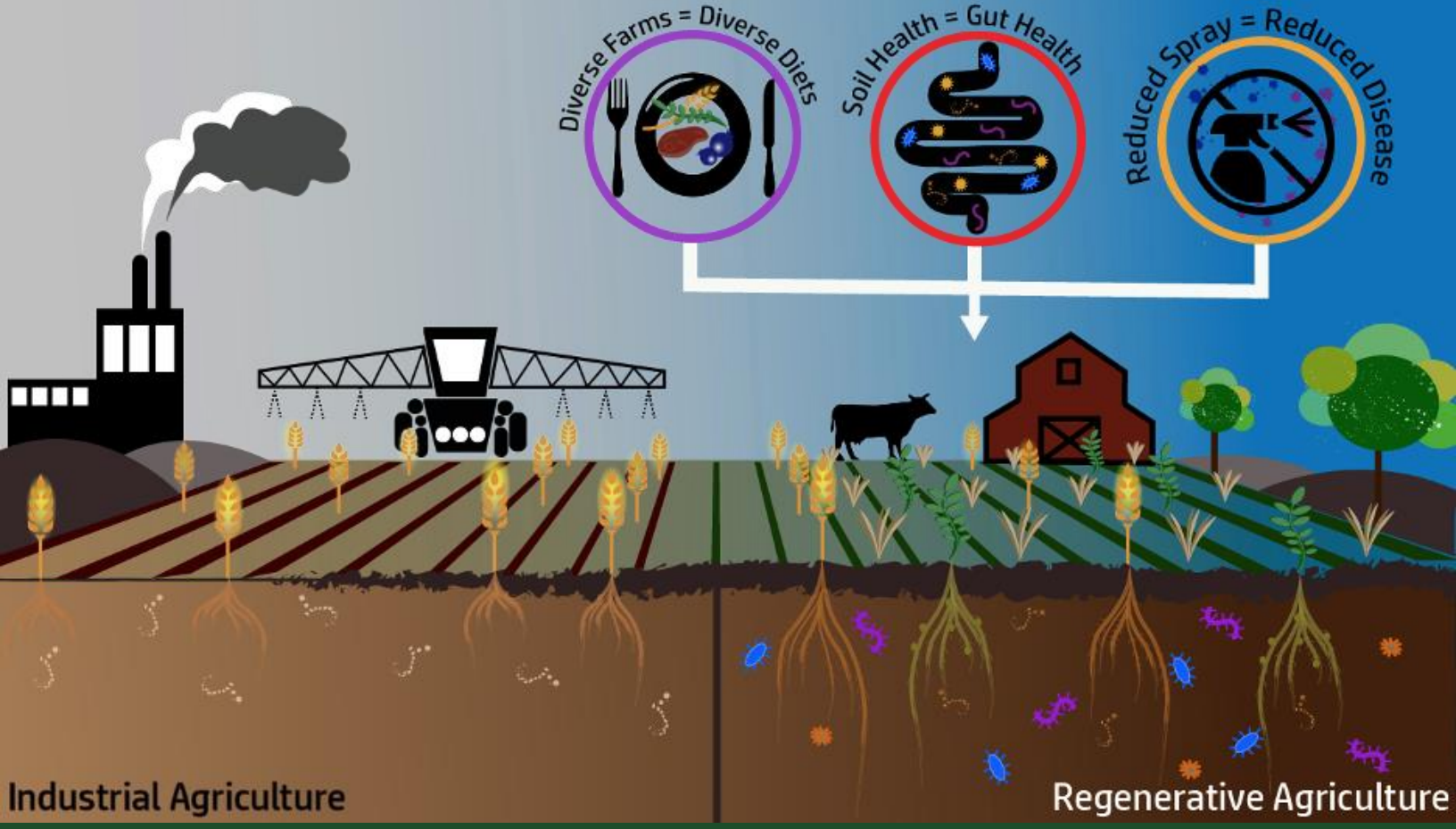
Solar panels transform the continuous flow of energy from the sun into accessible electricity. DSSCs are a type of thin-film solar cell that are comparatively less expensive, non-toxic, and easier to manufacture than conventional solar panels. They have also been around for the last 30 years – so why haven't you heard of them? DSSCs have remained unbeknownst to the public because they aren't as efficient at producing electricity as conventional solar panels despite decades of research and development. A lot of components make up a DSSC device (see diagram), however a simple way to think of it is that everything starts and ends with the dye molecule. Their basic working principle starts with the dye absorbing the sunlight's energy, then passing along an "energized" electron to a closed circuit and ends with a "relaxed" electron returning to the dye. This cycle repeats to create a steady flow of electrons through the circuit, and the flow of electrons creates usable electricity.

Researchers are now borrowing ideas from nature and taking new approaches to designing DSSCs that could make them more applicable to our everyday lives.

Scientists have recently been looking into making the dye out of safe and inexpensive **organic molecules**. Dyes can be naturally derived from **beet juice** or **blueberries** – it's true! The same molecules that make beets red can be used to harvest sunlight and create electricity. Instead of mining and depleting the earth of precious materials for typical solar panels, these new dye molecules used in DSSCs are safe for humans, better for the environment, and cheap to make. Other components of the DSSC can also be made from safe and inexpensive materials. For example, the cathode can be made from **activated carbon** (used in water filters) and the semi-conductor can be made from **titania nanoparticles** (used in sunblock). Altogether much simpler, more harmless, and cheaper than conventional solar panels. Other new developments in DSSC research have been inspired by nature's own solar energy, photosynthesis. During photosynthesis a plant makes sugar (energy) and oxygen from water and carbon dioxide. DSSCs can be created to execute a **similar process**, that is, the DCCS can be designed to make hydrogen (instead of sugar), oxygen, and electricity at the same time. Hydrogen is a clean-burning fuel, oxygen is nice to breathe, and the electricity can be used to toast some bread! This new photosynthesis-inspired development could never be achieved by conventional solar panels.

The exciting new prospects for DSSCs are promising and can lead to their eventual integration into general everyday use, reducing our overall reliance on non-renewable fuel sources.





PLANTING THE SEEDS OF WELL-BEING

HOW REGENERATIVE AGRICULTURE NURTURES THE CONNECTION BETWEEN SOIL AND HUMAN HEALTH

BY ELLIE ELLIS

In 1905, **Sir Albert Howard** ventured to the British colony of India to study the country's soils and agricultural systems. He was surprised to find that traditional Indian food production systems were notably fruitful and self-sustaining. He observed that crops were planted in methodical rotations, crop growth was not limited by scarce rainfall, and the essential role of microscopic organisms in the soil was recognized and valued. Importantly, Howard understood the essential link between **soil health and human wellbeing**, which Indian agriculture was founded upon. Following these experiences, Howard published a **series of books** to bring these revolutionary ideas to the West, but the future of agriculture was already headed in another direction. Post-World War II, agricultural programs aimed to increase yields using a combination of genetically engineered seeds, synthetic chemicals, and robust irrigation. Despite good intentions, this period, now known as the "**Green Revolution**," led to detrimental effects on human and ecosystem health.

Today, half our calories come from just **three staple crops**, air and waterways are **polluted** by agricultural chemicals, and **topsoil** is lost ten times quicker than it is formed. Amidst growing concerns, "**regenerative agriculture**" is gaining traction as a possible solution.

Regenerative agriculture has origins in Indigenous agricultural traditions. For a movement with such ambitious goals, regenerative agriculture lacks a consistent definition. According to Dr. **Rattan Lal**, regenerative agriculture "encompasses a wide range of farming and grazing practices" intended to restore the health of the soil, improve biodiversity, and **draw CO2 out of the atmosphere** for storage in the land. This includes practices that minimize soil disturbance, maintain soil plant cover, and combine livestock and crop systems. Regenerative food systems provide an opportunity to repair the severed connection between ecosystem health and human wellbeing.

Diverse Farms = Diverse Diets.

Over 6000 species of food crops have been cultivated throughout human history, yet today we grow only 170 on a commercial scale. Regenerative agriculture encourages the cultivation of **diverse crop species** and the reintroduction of native plants to the farm system, which subsequently promotes diversity in our diet. Researchers from the Colorado State University **Crops for Health** program recommend eating foods from many different branches of the **plant evolutionary tree.** One such branch is the Fabaceae group, which includes beans and other legumes. According to CSU researcher Dr. Henry Thompson, adding more beans to your diet may reduce your risk of obesity. Aside from their health benefits, legumes maintain relationships with soil bacteria that transform nitrogen in the air to a form that can be used by plants. Thus, planting legumes is an important tenant of regenerative agriculture as it reduces the use of synthetic nitrogen fertilizers.

Soil Microbial Health = Gut Microbiome Health.

Research into the diverse **microscopic ecosystem** that exists within our soil has showed us the essential role microbes play in ensuring crop vitality. Interactions between roots and the soil are critical for nutrient uptake, and ultimately dictate the nutrient quality of food. For example, researchers have gained insight into the link between soil microbe health and our **gut microbiome**, an important mediator of human health and disease. Research indicates that soil microbes and human gut **microbes evolved simultaneously**, and are continuing to co-evolve with changes in our diet and lifestyles.

Reducing Agricultural Chemical Pollutants in Our Environment.

Regenerative agriculture calls for a reduction in or **elimination** of pesticides and herbicides from the farm system. Rather than killing unwanted pests with chemicals, their populations can be managed by promoting farm biodiversity. Additionally, reducing the abundance of agricultural chemicals in the environment will help support **human wellness**. Over application of agricultural chemicals is linked to an elevated risk of certain cancers, as well as reproductive, endocrine, and immune system disorders.

IMAGE: IMAGINING A FOOD SYSTEM THAT SUPPORTS SOIL HEALTH AND HUMAN WELLNESS, SIMULTANEOUSLY.

Food Communities: How Proximity To Nutritious Food Affects Your Gut Microbiome

BY IKAIA LELEIWI

There are few things more fulfilling in life than a sense of community. Communities include households, neighborhoods, and cities, anywhere groups of people live and interact with one another. Similarly, microorganisms exist in communities, inhabiting every environment on Earth including our bodies. Microbes that live in our digestive system contribute to the gut microbiome, a collection of microbial genes and biological reactions that take place in our gastrointestinal tract. Here, microbes express these genes in an interconnected ecosystem where each member is involved in a complex economy of molecules. Perhaps the most important microbiome to human health is that of the gut. The biggest factor determining which microbes make up our microbial community is what an individual chooses to consume. Each community affects the health of the other, human and microbe, shaped by the same food and its availability in the environment.

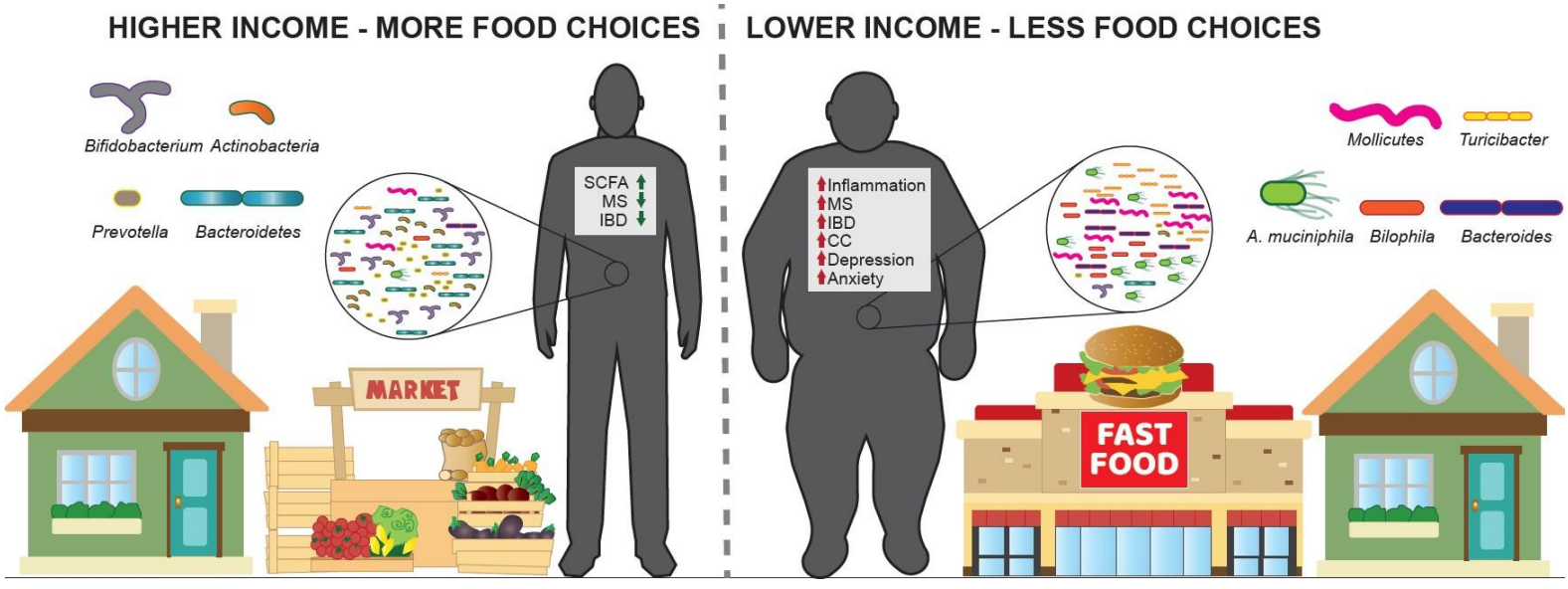
Gut-microbiome and our health

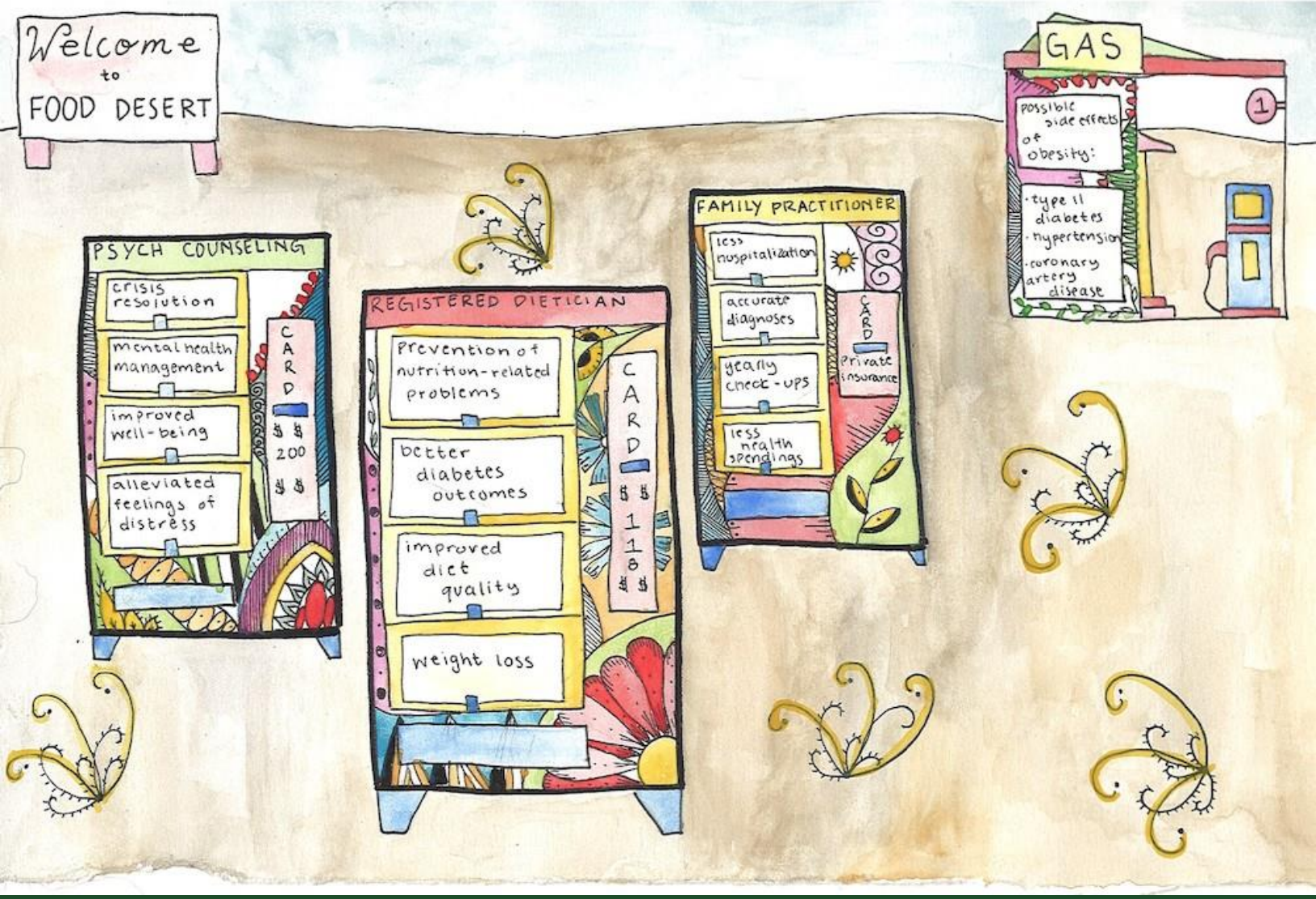
The gut microbial community is instrumental to both physical and mental wellbeing. Microbes in the gut can increase our nutrition and heighten disease resistance by fending off pathogens and transforming food into forms more accessible to our bodies. Humans affect which organisms thrive in their intestines by eating different foods. For example, a diet high in fiber encourages bacteria like *Actinobacteria, Bacteroidetes, Bifidobacterium*, and *Prevotella* to **increase in abundance**. These bacteria are associated with **higher short-chain fatty acid (SCFA) production/utilization and fewer incidence of metabolic syndrome (MS) and irritable bowel disease (IBD)**. On the other hand, a diet high in saturated fats and processed meats can increase the abundance of *Bacteroides*, *Turicibacter, Mollicutes*, and *Bilophila spp*., bacteria associated with promoting intestinal inflammation.

Gut communities with this type of membership are linked to **higher occurrences of MS, colon cancer (CC), and IBD**. Diets **lacking fiber and high in red and processed meats** have been connected to blooms of *Akkermansia muciniphila*, a species known to **degrade the protective mucus barrier** within the gut causing inflammation. Additionally, highly processed foods containing **emulsifiers and artificial sweeteners** encourage similar shifts in microbial communities and are also associated with inflammation in the gut. The impact of **gastrointestinal inflammation** is far-reaching, as high levels of circulating pro-inflammatory cytokines are thought to contribute to the development of **depression and anxiety**. It's clear that food choices shape the microbial ecosystem in the gut and that membership in these communities is strongly correlated with our health.

Where we live influences communities in our bodies

The communities in which we live are largely influenced by **income and social and cultural norms**, however, they also determine the **availability, convivence, and affordability** of our food choices. On average higher-income communities have more supermarkets and/or farmer's markets than **lower-income neighborhoods**, which by comparison have a higher prevalence of fast-food chains. Hence, a person's income and resulting geography have a huge impact on what is affordable for them to eat, what choices of food they have, and the convenience of consuming nutritious calories. As such, people living in lower-income areas eat more highly processed foods and less fiber than those in higher-income areas, which as previously mentioned leads to negative alterations in gut microbial communities. Collectively, our geographical communities significantly contribute to the gut microbial communities we promote in our bodies and thus influence our health and wellbeing.





FUTUREHEALTHPROFESSIONALS: WILLWESTANDFORORAGAINSTHEALTHCARE INEQUALITY?

BY LUKE WHITCOMB

Each year, thousands of CSU students enroll in programs designed to prepare them for careers in health and medicine. For those students interested in the link between lifestyle factors and chronic disease, one of the first topics they encounter is obesity. Excessive weight gain, leading to the development of obesity, is associated with many comorbidities, including type II diabetes and coronary artery disease. Although previously thought to result from a simple imbalance between calories in and calories out, we now know that obesity is the culmination of a **complex interaction** of genetics, sex, individual behavior, food availability, and cultural norms, making prevention and treatment incredibly complex. Despite our improved understanding of **obesity's impact on health outcomes**, its prevalence continues to rise. Potent, sustainable solutions to this worsening public health crisis requires interdisciplinary collaboration between the health professions.

Medical providers must team up with fitness coaches, dieticians, psychologists, and community organizers to ensure patients receive the tools and resources they need to stay healthy.

Among these health professionals, **Registered Dietitians (RD) are best equipped** to provide personalized, effective weight management counseling. Patients who receive RD consultations **lose more weight** and see greater improvements in **diet quality** and diabetes outcomes. Healthcare models that have **integrated RDs** into Family Practice clinics report improvements in prevention, assessment, and treatment of nutrition-related problems. Though a clinically powerful tool, services offered by RDs are often inaccessible to lower-income patients as their average national rate is around **$118 per hour**.

This barrier alludes to a broader relationship between wealth and health. Though multifactorial, a clear negative correlation between socioeconomic status and obesity exists. Reports have shown that Medicaid recipients - some **76.5 million individuals** - are **26% more likely to be obese** than those who have commercial insurance. Although Medicaid coverage for nutrition services has increased since the passage of the Affordable Care Act (ACA) in 2010, only **21 state programs** currently cover RD consultations for adult obesity. Even for patients living in these states, additional barriers continue to limit access.

Because physician referrals are often required for RD services to be covered under Medicaid, impoverished individuals may have trouble finding doctors willing to take their insurance. This is largely due to reimbursement, as Medicaid routinely **compensates physicians and their staff less** than private insurers. Of course, for the approximately **30 million Americans** who lack health insurance altogether, seeing an RD is even more challenging. Access to health care in the US is far from equitable, particularly for people of color. Black, Latino and Native American individuals consistently experience **higher rates** of uninsurance compared to white individuals. It is also this demographic which reports **disproportionately higher** rates of **obesity**. Regrettably, under our current system, those who might benefit most from nutritional counseling cannot afford it.

As health professionals, we must advocate for social justice and ask a critical question: should an individual's ability to receive quality healthcare be determined by their socioeconomic status? We will soon inherit a healthcare system full of inequality. If current trends continue without reform, many of us may end up serving primarily white, middle-to-upper class clients and patients, leaving under-privileged and historically marginalized groups without access to critical services. We can and must do better!

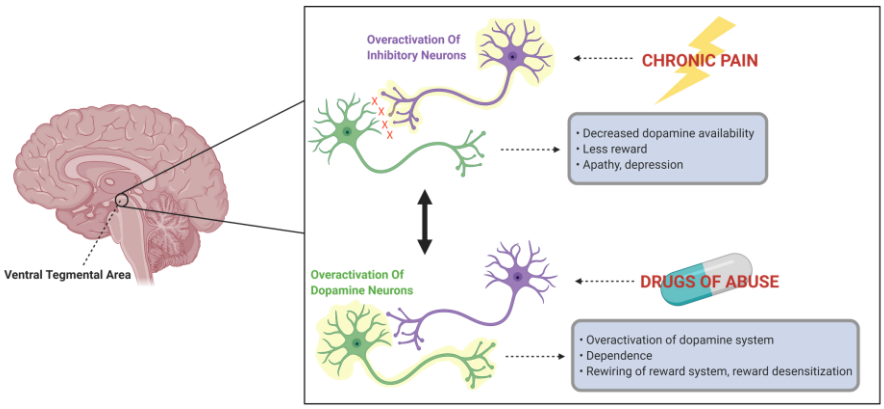
To learn more about equitable solutions to health care reform:

- **Extending Access to Health Care**
- **Comparing Health Insurance Reform Options: From "Building on the ACA" to Single Payer**

IMAGE CREDIT: ELINA GENTILHOMME

Why Neuroplasticity Isn't Always Helpful, And What We Can Do To Control It

By Marissa Metz



Fun Facts:

- A consistent lack of ability to feel pleasure is a criteria for the diagnosis of major depression, according to the DSM-5.
- Most drugs of abuse hijack the dopamine system so that it is initially overactivated, and then it adapts to become less sensitive. The resulting need to compensate with escalating substance doses to achieve the same level of reward is a hallmark of drug dependence.

What Is Neuroplasticity?

In popular media, the word "neuroplasticity" is generally presented in a positive context. While the meaning of this word varies among neuroscientists, the general definition of neuroplasticity is the ability for neurons to physically change the way they connect and communicate. The positive view of neuroplasticity usually stems from the idea that connections can be enhanced and can increase the activity of brain regions involved in desirable processes, such as positive emotion or learning and memory. However, there are many neurons in the brain that, while necessary, are detrimental to normal functioning when overactive.

Neuroplasticity Controls A Delicate Balance

One group of neurons whose activity must be tightly controlled is located in the middle of the brain in a region important for feelings of pleasure, the ventral tegmental area or VTA. Within the VTA are a group of neurons that produce the chemical dopamine, some of which are associated with feelings of reward. Dopaminergic neurons associated with reward can be thought of as party-goers at a high school dance. When they are moderately active, everyone is having a good time and the brain is motivated to enjoy pleasurable activities. However, too much rambunctiousness can be a bad thing. Therefore, like chaperones at the dance, there are neurons in the VTA that keep these dopamine neurons in check, working to **inhibit dopaminergic neuron activity** and prevent overactivation of the system. Yet, just as too much fun at a high school dance can be destructive, too much chaperoning can kill the mood at the party. Overactivity of the inhibitory neurons of the VTA dampens the dopamine system and leads to a decrease in the motivation to feel pleasure.

Chronic Pain Upsets The Balance Of The Reward System

One case in which inhibitory VTA neurons become overactive and neuroplasticity imparts negative effects is in the context of chronic pain. Chronic pain comes in many forms and can be induced by something obvious like an injury or something less visible like autoimmune disorders. Depending on what precipitates it, chronic pain lasts or reoccurs for at least **3-6 months** Estimates suggest that in some cases **up to 85%** of patients with chronic pain are at risk of developing mental health disorders like depression. To study this association, researchers utilize rodent models to see how chronic pain alters the reward system and induces depression and negative emotion. Results from these studies demonstrate that the **inhibitory VTA neurons show enhanced activation** in rats with chronic pain, working to dampen the dopamine system and decrease feelings of reward. This would be analogous to chaperones at the high school dance breaking up the party-goers; the vibe has been ruined and the brain begins to spiral towards depression.

Combatting Neuroplasticity With Neuroplasticity

Fortunately, specific lifestyle interventions can help reverse the inhibition of reward-associated dopamine neurons to improve mood and decrease pain. Human and rodent **studies** have shown that voluntary physical activity can reverse inhibition of reward-related dopamine systems as well as the inhibition of other reward-associated regions in the brain. One does not need to become an olympic athlete to see this type of positive neuroplasticity either. For example, one study found restoration of altered brain connectivity after patients with chronic pain exercised **only twice per week** over the course of a few months. Therefore, although chronic pain can induce a problematic form of neuroplasticity, lifestyle interventions such as exercise provide us with a potent way to fight back and regain the balance critical to a well-functioning reward system.

about the Gold Papers

From deep within the belly of the Food Science and Human Nutrition department at Colorado State University, came the idea for this project. A motley group of graduate students decided to clarify some of the confusion surrounding "health" while honing their scientific communication skills. The result of their efforts gave rise to the birth of the *Gold Papers* - a CSU flavored spinoff to White Papers, which aims to summarize current research and perspectives in their fields.

about us

Ellie Ellis is a first-year PhD student in the Department of Soil and Crop Sciences at Colorado State University. She is studying the impacts of regenerative agriculture on soil health, ecosystem resilience to climate change, and farm economics. In her free time, she enjoys outdoor adventures, cooking, and dancing as much as she can.

Yusef Farah is a Ph.D. chemistry graduate student at CSU and performs research in the Krummel laboratory. His research focuses on studying the behavior of molecules in new solar energy devices with the goal to improve solar energy technology. Yusef enjoys reading, golfing, playing guitar and he is passionate about science communication, policy, and intellectual property.

Jessica Hill is a postdoctoral researcher in the Nishimura lab within the department of Biochemistry and Molecular Biology at Colorado State University. She works with the model organism Caenorhabditis elegans to study host-microbe interactions within the intestine. At her leisure, Jessica likes to spend time outside with her family.

Kara McIver is pursuing a Master's degree in Food Science and Human Nutrition with a focus on Community Nutrition. In the future, she plans to secure licensure as a Registered Dietitian, specializing in chronic disease prevention through diet and lifestyle. In her free time, she is a competitive CrossFit athlete and coach.

Marissa Metz is pursuing her doctoral degree in biomedical sciences, where she has studied natural opioid systems in the brain and how those systems can be altered. She hopes to work in medical communications to help medical professionals make evidence-based decisions that improve patients' livelihoods. In her spare time, Marissa enjoys long hikes and anything DIY.

Ikaia Leleiwi received his Master's of Science in Microbiology in 2019 and he's currently pursuing his doctorate in Cell and Molecular Biology at CSU. His field of research is the gut microbiome during enteric infection. Upon graduation, Ikaia hopes to pursue a career in computational biology in Colorado. Outside of the lab, Ikaia enjoys spending time with his 5-month-old son and making doodads with his 3-D printer.

Raj Trikha graduated with his Master's of Science in Human Nutrition in May of 2020. He will begin medical school this fall in hopes of working in academic medicine one day communicating the science of health to the general public. In his free time, Raj performs with a local improv team refining his craft of communication while trying, desperately, to make people laugh.

Luke Whitcomb is working towards his Master's degree in Biomedical Science, researching metabolic dysfunction in heart and muscle cells. His interests lie in reducing the burden of chronic disease and combating health care inequity - as well as understanding how those two are linked. He plans to go on to medical school to pursue physician training, medical research and leadership in health care policy reform. In his free time, he enjoys black coffee, quirky podcasts and fast longboards.