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Nothing Novel: Championing Preceding Knowledge in the Age of Materials Innovation

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Nothing Novel: Championing Preceding Knowledge in the Age of Materials Innovation

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Abstract:
In recent years, a surge of interest in 'natural' methods across various billion-dollar industries has emerged, reflecting a rising popularity of environmentalism. This article explores the societal implications of this shift, particularly concerning the mitigation of toxic exposure, as it has been co-opted by both consumers and material scientists. The discussion features an examination of the exploitation of preceding knowledge, gender disparities within material science, and the role of hetero-patriarchy and settler colonialism in these dynamics. Through these lenses, this paper navigates the paradox of progress and the concurrent erasure of preceding technologies. As part of the Humanities Informed STEM Curriculum at UCLA (Carbajo, 2024), this paper urges a critical evaluation of engineers' approach to sustainability and, on a broader scale, their overall relationship to notions of progress.

Introduction: engineering in the era of 'natural' solutions

In the wake of the COVID-19 pandemic, there has been a resurgence of interest in 'natural' methods across many industries, echoing a growing sentiment towards health and environmental consciousness (Devenyns, 2020). A manifestation of this shift is a rise in alternative approaches to avoiding exposure to toxics, from beauty products to synthetic dyes in textiles and food. Practitioners of this shift are multiple, but notably host a couple unsuspecting groups. The dyad of interest subsists of the short-form social media wielding health-conscious citizen, who fears toxicity and longs for a ‘return to a simpler time,’ and the material scientist, whose industry is racing to innovate in this field. In part, this race to innovate is done to profit from the former. Material scientists themselves are comprised of a group in proxy to white manhood within a field that has a notable gender disparity, even among unbalanced representation in the sciences. Beneath a veneer of eco-friendliness lies a complex tapestry of social and environmental implications built on and perpetuated by the same dyad. As this paradigm shifts, the demographics in proximity to white manhood have the luxury of electing healthier options, at times concurrently appropriating practices without an understanding of where they originated. Any acknowledgment of who is actually in the line of fire by the most toxic parts of existing systems is notably lacking. The engineers and scientists in this niche, but powerful, discipline guide countless industries and are poised to be at the forefront of ‘progress’ towards eco-friendly alternatives, often without an understanding of greater impacts. The siloing of education in the field of engineering lends itself to this end, as experts in cutting-edge research lack either the desire or incentive to assess the greater landscape. While this paper focuses on synthetic dyes, this phenomenon is pervasive across the greater field of engineering, where engaging standpoint theory would serve to bolster these pursuits.

One stark example of this is the improvement of Lithium-ion (Li-ion) batteries, an energy-efficient and lightweight champion in the electric vehicle market. Progress in electric vehicles contributes to a lessened demand for fossil fuels and resulting lower overall greenhouse gas emissions (GHG) from the transportation sector. While at face value it can be celebrated as a world-saving advancement, the extraction of Lithium to manufacture Li-ion batteries results in soil degradation, water shortages, biodiversity loss, and ecosystem damage, along with highly toxic work conditions (Campbell, 2022). These effects are out of sight, out of mind for the consumer. For those who engage in these discourses, an oft-contended buzz hovers around areas of technological advancements like those integral to Li-ion batteries. Those at the forefront of humanitarian, environmental, and engineering advancement weigh the potential threats to their desired outcomes. A notable difference between these groups lie in who possesses the actual power to direct the zeitgeist – and it isn’t the humanitarians. A notable disconnect here is in believing issues are solvable in isolation, when in fact they are so entangled that any kind of ‘progress’ implicates them all. Take the root issue that electric cars try to solve; yes there are fewer GHG emissions from the travel sector, but what does that mean for other facets of the environment? What does that mean for the people supplying the raw materials?

Unraveling power structures: the gendered ‘homesteading trend’

Hidden in the shadow of this behemoth are a plethora of issues perpetuated by those with the power to influence the adoption of sustainable materials, albeit inadvertently. As the field of material science exists within a

long-established hetero-patriarchy, and it is designed to work in service of it. It does so efficiently, creating partial solutions to issues in a way that upholds the power structure it is born of. Take again the example of Li-ion batteries – the divestment from fossil fuels will happen slowly enough to allow the hydras in charge of them to switch over to the next big thing. This is a paradigm that requires intentionality by those within positions of privilege to disrupt. However, the development of disruptors is lacking as gender disparities contribute to the overlooking of issues that disproportionately affect women and minority groups furthest removed from places of power. As this imbalance perpetuates social injustices, similar imbalances in representation within the field result in overlooking important perspectives in sustainability and environmental justice. As is seen in the paradox of our emerging electric world, imagining sustainable solutions without addressing underlying power dynamics only serves to reinforce existing inequalities and systemic injustices. While the future will likely be electric, the solution heralds new horrors for those with the least proxy to white-manhood not only in The United States of America, but also in counties of production with less influence and wealth on the global stage. Pressure in materials engineering and concurrent trends in similarly privileged circles overwrite preceding knowledge in efforts to 'live sustainably.'

Under this system an unintentional ally to the heavily siloed field of materials engineering appears on social media apps around the world. A growing consideration for limiting exposure to toxics is taking hold in those privileged enough to care about it. It takes having survival essentials covered and a surplus of resources to begin critical control of toxic exposure from the aforementioned essentials. Even this concern is done in allowance by the established hetero-patriarchy, as this concern is seen quickly filing participants into gender roles. Concurrently, a resurging homesteading kitchen science trend encourages women to 'go back to basics' and make consumables for their families. By framing it as taking control of what they and their family unit consume, it dons a guise of control and power that serves to oppress them. This narrative, tagged by the name of 'Homesteading,' on social media, references The Homestead Act of 1862. Enacted during the Civil War this act permitted 'any adult citizen' to claim 160 acres of surveyed government land (Homestead Act, 1862). Of course, the definition of 'citizen' at this time was extremely conditional, and did not grant this personhood to people of color, immigrants, or women, to name a few exclusions. Claimants of this offer were required to live on and "improve" their plot by cultivating the land, which discounts the fact that indigenous habitants had been engaged in active stewardship for centuries. Investigating this alongside sustainable materials development serves to problematize a trend that, at face value, is benign. While it seems innocuous and unrelated, homesteading as a trend enforces binary gender roles, co-opts traditional knowledge, and shuns communities at the highest risk. In the same vein, the processes of novel materials development marginalize women of color in rural areas while overwriting the people responsible for the original development of these technologies – a betrayal made more insidious by the fact that they are often, in fact, the same group of women. We will be investigating textile dying as a case study for this multifaceted issue which, in its unraveling, serves as a poignant cautionary tale for material scientists.

Journey to the origin: from mountain vats to textile mills

To understand this relationship we have to first look at ourselves. Not a 'psychoanalysis of your relationship with consumption' look, but literally look at yourself – unless for some reason you elected to read this in the nude, you are likely wearing fabrics dyed in an industrial garment factory. These factories are behemoths, employing hundreds of millions of people in primarily poor, rural areas (UNEP, 2020) that stake their claim on surrounding land through pollution of a magnitude visible from space (Regan, 2020). True to the ever-insidious trends of settler colonialism, exploitation of the land yields supreme value and is an effective agent of the colonialist agenda (Morril et al., 2013). Exploited it gets, through processes which churn out toxic wastes and pollutants, the garment industry is valued at $316 billion in China alone (UNEP, 2020). Preparation of one tonne of fabric requires 200 tonnes of water, which is then flushed into waterways, creating thick, inky rivers that leach toxins into the surrounding farmland (UNEP, 2020). These toxic rivers snake around billowing smoke stacks which churn out tonnes of greenhouse gas emissions and exports for the Western world. Textile sludge carry high loads of micronutrients, heavy metal cations, and pathogenic microorganisms which plague surrounding rural communities (Bhatia, 2017).

Following a cleaner, upstream branch of these rivers to the origin of dyes, we travel to the Wuyi Shanmai mountain range and jump back about 3,400 years. It was here that the longest-used stable blue dye was invented by the Chinese and used widely. It only saw a decrease in use once synthetic dyes popped onto the market in the late nineteenth century (Li, 2019). The epistemology of this technology is important – the use of Indigo dye in this region employed advanced chemistry. Typical steps involved in indigo dye extraction necessitated the construction of a dye vat, fermentation and removal of the leaves from indigo-producing plant species, incorporation of lime, oxygenation, subsequent collection, and stable storage of the completed indigo paste (Li 2019). Dyeing cloth

entailed preparing the dye solutions, dyeing the cloth, washing, and air drying textiles (Li, 2019). Remnants of cloth that have survived the centuries evidence millennia of inhabitants of modern-day Asia engaged in the science of dying fabrics. Including examples of indigo dye, there are natural dye processes endemic to nearly every territory in the region (China Silk Museum, 2019). The preceding knowledge that developed these techniques was built on rigorous research and development, which rivals modern R&D and in turn, challenges the assumptions that older knowledge is for some reason less scientifically stringent.

In contemporary assessment of these methods, there's often a tendency to judge technology based on its ability to stand up to modern methods and standards of validation. Even as modern science looks back (and down its nose) at ancient innovation, they remain a gold standard for environmental sustainability and human health. Even at their largest scales, the relationship between land and output was sustainable, a balance that is far from true today. The use of dyes was confined close to this scale until 1856 CE, when the first synthetic color mauvine was mistakenly invented by a teenage scientist attempting to synthesize quinine. (Quinine, a common drug of the time, was used to treat malaria, and is still used to that extent today (Achan et al., 2011).) Underscoring the relationship between the advent of synthetic dye and pharmaceutical industries, they propped up one another's development as factories began spawning all over the country in both pursuits. In this way they are siblings, or maybe they are better considered some kind of mutualistic parasite, ushering in both a world of possibilities and a profound amount of suffering. Without rehashing every humanitarian nightmare heralded by these dark twins of the Industrial Revolution, the total death toll of these industries combined is impossible to quantify. A century and a half, and plenty of toxic innovations later, there is renewed interest in the world of natural dyes as fueled by consumers' growing concern about the substances they wear, consume, and come into contact with. Ironically, a newfound consciousness towards synthetics-related health risks emerged as traditional expertise in traditional indigo dyeing is at an all time low across China (Li, 2019).

A tale of two industries: synthetic dyes, pharmaceuticals, and environmental consequences

As traditional knowledge of dyestuff wanes in one region, a facsimile takes root in others. In recently remodeled kitchens across the United States, a rise in the homesteading aesthetic ushered in a dramatic uptick in DIY-ing. This rise in homemade, toxin-free products continues after the 2020 spike in home remedies when quarantining COVID fear-ers led to traffic for 'DIY' related searches to skyrocket in the United States (Google Trends, 2024). The interest as mentioned earlier in health and wellness coincides with a period in which individuals possess the financial means and societal privilege necessary to prioritize such concerns. The time and resources to be selective in consumption is not a privilege awarded to everyone, as nearly half the global population lives in poverty (United Nations, 2020). As the narrative of these trends claims a 'return to simplicity,' they are emulating a ghost of the technology that preceded even the dyes which cause concern. Instances of this encapsulate the harmless fun of home-baked bread and dyes from the garden, grounded in the COVID drive to stay entertained while locked inside. For the billions living in poverty, a hobby switch to sustainability is not a luxury afforded. When the pendulum of fads inevitably swings back to maximalist consumerism, workers in textile dying facilities will feel an uptick in production demand.

The other side of this coin is equally cyclic – material scientists' pursuit of eco-friendly alternatives without proper understanding or respect for indigenous technologies perpetuates the erasure of valuable knowledge systems. Even as material science approaches the issue of natural dyes, innovation does not arise from concern for the textile workers but is driven by the public interest of health-conscious consumers. There is money to be made by pushing 'natural' alternatives to usual mass consumed products. The only prerequisites for this nomer are that the product is marketed as, or at least perceived by consumers to be, natural (Koeller et al., 2019). Through the late 2010s revenue from natural products grew by 25%, from $51 billion to $64 billion (Koeller et al., 2021). While institutions pour resources and funding into staying at the forefront of technological developments, there exists a vast repository of millennia-old technology, uniquely adapted to specific locations, that is now being ignored to maintain the power imbalance which affords the 'white man' of materials science more power. As large grant incentives are being offered for topics like sustainable dyes and colorants, it appears contradictory for material scientists to overlook existing technology in these areas (Mosely, 2019). This prompts a critical question posed by the framework of Native Feminism: how do we innovate in a way which resists the erasure of preceding knowledge and strives for more than mere inclusion?

Reimagining innovation: the role of preceding knowledge in sustainable developments

As a newer and evolving field, material science finds itself increasingly at the forefront of solving massive issues in society and the environment. However, the gendered structural dynamics of the field perpetuate disparities in

addressing environmental issues, often at the place where the most people are affected. Therein exists a caution to reinventing the wheel; a researcher will receive a slap on the wrist for wasting resources to recreate technology that already exists, and is expected to maintain current knowledge of the field. Yet, the desire to validate existing knowledge with revaluation through modern methods serves to not only reinvent the wheel but simultaneously crush the very people who originally developed this technology beneath it. Still, material science seems to turn a cold shoulder to issues that affect women in the workforce, which is compounded by a proxy to white manhood emulated by the field. Abysmally limited diversity in the field structures allows the occasional hand to be extended to women and people of color in very limited quantities, as evidenced by a remarkable imbalance in representation. Gender disparities within material science contribute to overlooking issues that disproportionately affect women, perpetuating social injustices. As is seen in many STEM fields, aside from the life sciences where women are represented in nearly equal amounts up to the PhD level, materials science is only 11 - 35% women depending on the focus (Abraham, 2023). The effects of this are unimaginable, as materials development directly influences eco/socio/economic systems. To name a few, novel nano-materials are used in cosmetics, food; paints and coatings, and of course, our favorite dynamic duo; pharmaceuticals and textiles.

Focusing specifically on industries that disproportionately target and exploit women, we turn our attention to the beauty and fashion sectors. The beauty industry is a $532 billion business which focuses largely on women consumers (Danziger, 2022). A popular phenomenon in marketing titled ‘The Lipstick Effect’ posits that in the face of financial struggles, women will always find a way to acquire beauty products – like lipstick. And as such, these markets are somewhat immune to the dips in demand that other industries experience when money gets tight. This, as a symptom of both consumerism and enforced gender roles, goes to show that the importance of looking our best under the male gaze harms women at all levels. Concurrently, fashion constitutes a colossal $2.4 trillion sector which sustains a workforce of 300 million individuals, of which approximately 80% are women within the age range of 18 to 35 years (Michelson, 2022). Trends in fashion and beauty perpetuate these industries, and place massive demand on the the factories employing, and exploiting, women. Based on findings from a survey conducted by China Labour Action, less than 30% of workers in the garment manufacturing sector receive standard wage compensation (BHRRC, 2024). Materials science is a silent player in both these fields, and as we see with synthetic dyes, enabled the development of the fashion and beauty industries at the scales they exist at today. In the manifestation of ‘The Lipstick Effect’ the wheel turns regardless of what is happening in global finance. First there is a demand for more natural products pushed by marketing, influencers join in on the capitalization of this, pressure drives innovation and funding pops up for materials focused on natural dyes. All of this transpires in ignorance of existing technology like those born in the Wuyi Shanmai mountains thousands of years ago, and concurrent to the exploitation of garment workers in this same region.

The rise of interest in 'natural' methods is reflected in material science innovation, and vice versa. This dual trend is a chicken-egg question of influence and collective consciousness. In turn, both embody a societal shift towards environmental awareness, or at least, the appearance of it. However, this trendiness has implications far beyond the eco-friendly facade presented. Considering the wider landscape of material science, a newer facet is arising in bioinspired materials, which look to nature as inspiration for technology. Bioinspired materials refer to materials designed to replicate the structure, properties, or functions found in natural materials or even living organisms. Examples include light-harvesting photonic materials mirroring photosynthesis, structural composites emulating nacre, and actuators drawing inspiration from jellyfish movements (Nature Publishing Group, 2022). This focus of the field is not as new as it is oft considered, as millenia of people have been inspired by nature in their inventions; the synthetic nature of newer advancements do not grant them inherent superiority. In a field driven by forward progress, material scientists must heed preceding knowledge, and consider the impact existing and future systems have on affected communities. This cannot be accomplished without a simultaneous assessment of the structure which built the field and keeps it afloat as a profitable and admired discipline. Heeding lessons imparted from Native Feminism, mere inclusion will not suffice to rectify the challenges the field faces. The case of the textile dye industry and its wide-reaching pollution effects call for an evaluation of the social and environmental ramifications of “innovations,” which should be employed in every materials science pursuit. In a field driven by what is new and novel, importance must be placed on challenging existing paradigms, problematizing structures of development, and advocating for alternative perspectives.

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