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Let Them Eat Bread

Consider the humble sandwich. It is ordinary in the truest sense of the world, it is the bread and butter of, well, bread and butter. Few things are as culturally ubiquitous as a flat-ish, wheat based vehicle for meat, vegetables, or jams. From the plebian PB&J to the gauchely ostentatious "Bacon Bling Sandwich", a gold-dusted monstrosity available for $211 in a ritzy London suburb, nothing seems to delight humanity quite like a good ol 'sammy. But there's more to the sandwich than meets the eye. A ham and cheese sandwich, for example: it is modest at best, and yet these simple ingredients are the miraculous result of over 4 billion years of Earth's processes. We know ham has been around since at least 116 BC, since it was documented by the great Roman scholar Marcus Terentius Varro. Mayonnaise is graced to us by a chemical emulsion process using eggs, the shelled amniote egg which we recognize as chicken-like having evolved 325 million years ago (to answer the age-old question: it was the egg that came first, modern chickens evolved from ancestors already capable of producing shelled reproductive bodies). There is much to say about cheese, which first enchanted the tastebuds of pharaohs in Middle Kingdom Egypt, though the processes by which it is produced have changed significantly since the days of goatskin churning and papyrus mat straining. And our bread—the real star of the show, the backbone of our hypothetical ham and cheese—is made from wheat, which takes on its own fascinating evolutionary and production history of its own.

Wheat domestication is thought to have originated roughly 10,000 years ago in the Tigris-Euphrates river basin [1]. This time frame—around 9500 BCE—marked the beginning of a drastic change in human lifestyle: the shift from nomadic to agrarian societies, for which we owe the development of written language, division of labor, political hierarchies and, eventually, the Hot Pocket. The domestication of wheat, in this case Einkorn, an ancient form of the grain, did much to change humanity. But humanity changed Einkorn, too.

The chief difference between wild Einkorn and domesticated Einkorn is that the seed heads on the wild grain shatter and disperse, whereas in the domesticated grain the kernels stay intact—the result of a mutation unsustainable in the wild, but through selection by human harvesters has evolved into its own genetically distinct species [2]. The co-evolutionary manipulation doesn't end there. Since the original domesticated Einkorn was bred all those years ago, something in the neighborhood of 25,000 different cultivars have been developed [3]. Einkorn, widely accepted as *the* original ancient grain, has 14 chromosomes. Emmer, another ancient grain (often sold under the name of farro in the US, perhaps most recognized as a base for Greek farro salads), has 28 chromosomes. Modern wheat, meanwhile, has 42. It is just four chromosomes shy of the human genome, and yet wheat's genetic identity is marvelously complicated: while human chromosomes come in 23 groups of two, modern wheat chromosomes

come in six groups of seven. It is what Atlantic writer Ed Yong describes as “a hexaploid genome, [or] a gigantic pain in the ass” [4]. The human genome, the basis for everything from your ability to breathe, to thermoregulate, and to pick an outfit this morning, consists of a whopping three billion DNA letters [5]. The wheat genome, the basis for Uncrustables, towers over the measly human genome with a staggering *sixteen billion* DNA letters. What this means is that the genetic identity of modern wheat is ruthlessly complex, even as it evolved entirely dependent on human manipulation. Human DNA was first sequenced in 2003; wheat’s genetic code wasn’t cracked until fifteen years later. The significance of this scientific breakthrough largely centers around improving wheat varieties and better understanding the causes of gluten sensitivity, celiac disease, and inflammation. Because like the wheat genome itself, the health consequences of wheat consumption are convoluted and poorly understood.

Fewer aspects of nutrition and diet have been more hotly debated than our dear friend the gluten protein. Gluten is not actually one protein, per se, but a combination of hundreds of related proteins, the main ones being gliadin and glutenin [6]. It is heat stable and acts as a binding agent, which is what gives bread, pasta, and other grain products their pleasant chewiness that any gluten free shopper will sorely miss in their gummy pasta alternative. When wheat flour is soaked in water long enough, the starches and other water-soluble compounds dissolve, leaving behind a mass of the wheat protein storage mechanism of gluten. This results in seitan, or “wheat meat”, a common vegetarian meat alternative. It is a boon to any baker and a delight to any vegan with a chicken craving. Despite its useful culinary properties, both gluten and wheat consumption in general have been under significant scrutiny as of late. Gluten intolerance was not a widely acknowledged medical condition until more recently; celiac, an autoimmune disease involving altered small intestine function, was the only reason a doctor would ever tell someone to avoid gluten. Now, gluten intolerance is more commonly accepted, though still only between 6 and 7 percent of Americans are considered gluten intolerant [7]. Despite this, a staggering *thirty percent* of Americans avoid gluten (not carbs or grains, gluten specifically) to some degree [8]. Cutting out gluten has been reported to alleviate a wide variety of conditions, ranging from irritable bowel syndrome to lingering concussion symptoms to fibromyalgia to even, surprisingly, chronic yeast infections. The medical consensus is that if you have some chronic disease or condition, removing gluten from your diet is still neither a cure nor the first place to start, though this is less often the case outside of western medicine. I recall asking a friend of mine about her experience with seeing an acupuncturist for the first time. She asked, “Will this treatment help with my depression?” to which her practitioner immediately responded not with notes on the actual needling treatment but a comment on her diet.

“You need to eat less gluten!” he said instantly. “You Westerners are always eating *way* too many grains.”

There are several reasons gluten may be the culprit for such a wide array of conditions. The strongest evidence of this is that gluten, no matter your celiac status or any other facets of health, increases intestinal permeability: it widens the space between the cells of your intestinal lining. Gliadin specifically is made up of peptide sequences that are resistant to gastric, pancreatic, and intestinal proteolytic digestion in the gastrointestinal tract. In simpler terms, it doesn’t go down easy. The intestinal barrier covers roughly 400 square meters (just a little over the size of an IMAX screen) and requires about 40% of the body’s energy expenditure [9], so needless to say it is a significant part of our bodily functions. Although a certain degree of intestinal permeability is required for nutrient absorption, larger than necessary gaps put the

human body at much greater risk of foodborne illness, and can cause gut dysbiosis, inflammation, food sensitivities, and uncomfortable bloating. Intestinal hyperpermeability is thought to be one of the contributing issues in both Crohn's disease and celiac disease [10].

But gluten's inflammatory effects persist outside of the gut. Gluten proteins have been linked to activation of inflammation in multiple sclerosis, asthma, and rheumatoid arthritis [10]. Gluten quantity in the human diet has been found to alter the gut microbiome [11], which plays a significant role in not only digestion, as one might expect, but also mood regulation, immune function, hormonal balance, and even cholesterol levels and heart health [12]. As you are reading this, about 100 trillion microscopic little friends (and a good deal of enemies too, though your immune system is hopefully keeping those in check) are plugging away in your intestine. Invisible to the human eye but enormous in terms of significance, these bacteria are synthesizing the serotonin crucial for mood stability and neuron communication, interacting with the immune system to respond to both bacterial and viral pathogens [13], and synthesizing up to half of the vitamin K in your body that keeps you from bleeding to death each time you nick your finger [14]. To say that the human microbiome is an enormously important nexus of health and bodily function is probably an understatement.

It is no wonder that 30% of the U.S. population is nixing gluten in some way or another. With a proven impact on such a crucial and extensive facet of health, gluten is an immediate culprit for the ailments of the modern age. The fountain of youth might be found not in experimental stem cell research or million dollar antioxidant infusions, but in the gluten free aisle at Krogers. Right?

Unfortunately it's not that simple.

"I think, oftentimes, people vilify wheat," says Dr. Liz Carlisle [15], an assistant professor of Environmental Studies at the University of California, Santa Barbara. To get a clearer understanding of the alleged detrimental effects of gluten on human health, we must zoom out from the gluten proteins and look at wheat itself—not flour, not the harvestable seed, but the entire plant, stems, roots, leaves, and all. From sow to store, each step of wheat's processing will affect the final product and ultimately, what that final product does to our health. "All three steps are important," reiterates Carlisle. "The seed itself, how it's bred, the way it's produced—is it grown organically, or with chemicals, and then how it's being processed."

The final step of this operation—the processing—considerably affects how wheat is digested. "Processed foods" have earned quite a bad reputation among the health conscious, and for good reason—from addictive properties to association with a higher risk of cancer to excessive caloric density, it doesn't take a hypochondriac to consider removing these foods from the diet [16]. But what does "processed" really mean? There's a pretty large discrepancy between organic peanut butter—processed, as in whole ingredients ground up in a food processor—and your run of the mill Hostess treats, which start with a wheat grain that is mostly removed, then what is left is bleached and mixed with a laundry list of additives. *Processed* might not necessarily be bad, but the method of processing certainly alters the health benefits. And this is what we see in the case of wheat, illustrated by a simple loaf of bread.

Standard white bread is characterized by its very soft, fluffy texture. The rampant success of this type of bread is greatly owed to the high loaf volume its fluffiness achieves, meaning less wheat is needed to make more bread. To make this type of bread, first processors remove the bran and the germ, leaving only the endosperm [17]. Once milled and bleached, this type of flour

has a longer shelf life than its whole wheat counterparts. It is quick, cheap, and devoid of nutrients.

A whole wheat sourdough is our foil to the soft, hasty Wonderbread. Pre-industrialization, the processing of bread, usually including a long fermentation time and allowing the entire wheat product to be used, is significantly easier on the digestive system. "In a sourdough bread, if you have a 48 hour fermentation, that eliminates around 97% of the gluten, so the bacteria are pre-digesting it for you," explains Carlisle. This makes it easier on the digestive system and prevents much of the undesirable intestinal permeability.

The breeding of wheat, too, delivers significant alterations to the health impacts of consumption. Modern wheat breeding has been adapted for not only high yield, but also for loaf volume. It is not just the processing of white bread that gives it its softness, but also the wheat itself. Through selective breeding and genetic alteration, two broad categories of wheat exist: "hard" and "soft" wheat [18]. Hard wheat is bred for its high gluten content, whereas soft wheat is bred for a lower gluten content. Gluten's elasticity properties mean the hard wheat puffs up, giving breeders and manufacturers the desired high loaf volume.

"But you can imagine how a very elastic gluten molecule that allows, you know, this kind of '*eeeeeeerp*'" Dr. Carlisle laughs while making an expanding motion with her hands, "maybe isn't so awesome for your stomach."

Interestingly, there are quite a lot of anecdotal incidents that confirm the digestive effects of different types of wheat. In Europe, hard wheat never quite caught on (if there's one thing the French can pride themselves on it's bread). An estimated 60% of the wheat grown in the US is hard wheat, whereas in Europe most of the wheat yield is soft wheat [19]. What this means for vacation goers is that most wheat products in Europe cause considerably less, if any at all, of the negative reactions to consuming wheat products. Some might actually be able to chow down on a fine bowl *Pesto alla Genovese* in Rome but feel ill from doing the same in the nearest Little Italy. While these reports are mostly anecdotal, our understanding of the inflammatory effects of high gluten content and overly processed food certainly does well to corroborate them.

Both the processing and the breeding of the wheat play considerable roles in the impact of the final product. But going even further back from the rising of dough in the oven, back from the harvesting of the grain on the field, we arrive at the wheat plant itself. And these 16 billion DNA letters have proven themselves to be quite tricky.

If you'll recall the remarkable success of modern scientists in sequencing wheat's genome, you might be led to believe that, at long last, we can engineer our way out of the problems wheat has had for millennia. Not so. Beyond the processing and breeding factors, our species of wheat itself, in its modern form, *Triticum aestivum,* garners a good deal of the blame on its own.

In come ancient grains. The aforementioned Einkorn is considered the original wheat, but it is joined by more intermediary wheat species such as emmer, spelt, and Kamut. Other members of the gluten grains include rye and barley, and under the broad umbrella term of ancient grains fall crops like amaranth, sorghum, millet, and the more commonly known quinoa and buckwheat (which despite the name is not, actually, at all related to wheat). "Ancient grains" have become a bit of a buzzword on health food packages, though buyers must beware of this marketing ploy as a few ancient grains sprinkled in on a highly processed, sugar laden product won't tout the health benefits one would hope for. Nevertheless, there is much to be said for ancient grains in terms of health benefits, especially in comparison to their modern counterparts. Einkorn has been found to have higher protein content, trace elements, antioxidants, and

unsaturated fatty acids than its polyploid counterparts [20]. In fact, it has twice as much Vitamin A, three times as much beta carotene, and four times as much riboflavin [21]. While the additional macro and micro nutrients are quite obviously helpful, the real nutritional concern with wheat, as we have established, is the gluten and its effects on the microbiome. Einkorn, and other ancient grains, have a lower gluten content than modern wheat (even the soft wheat varieties). In intestinal biopsies of celiac patients, Einkorn bread was found to elicit no toxicity response, whereas consumption of modern wheat did [22]. Additionally, Einkorn doesn't have a D chromosome, which is possibly connected to human consumptive wheat intolerance [23]. It begs the question, why go through all the trouble of breeding and genetically modifying new wheat when a healthier, more digestible alternative already exists?

There are, of course, always trade offs. The most obvious argument for keeping modern wheat around is the economics of a high loaf volume--it is cheaper to make more bread with less wheat, and theoretically could feed more people, too. But in our current agricultural system, despairingly little of the profits actually return to the farmers: the average salary for a wheat farmer in the US is $42, 311[24]. The number is drastically lower for the farmworkers, who average between $15,000 and $17,000 a year in the US [25]. This number might be inflated still by the fact that many of these farmworkers are immigrants (an estimated 73% of the farmworker labor force, in fact) and may not be guaranteed a paycheck due to the exploitative and unregulated conditions they face. For comparison, the CEO of Flower Foods (Wonder Bread's parent company) earned a total of $5,055,390 during the 2020 fiscal year alone [26]. In her book *Grain by Grain,* co-authored with midwestern farmer Bob Quinn, Carlisle posits a solution to both our digestive woes and economic imbalances: ancient grains.

"Commodity wheat is sold for very low prices, and those prices are controlled by the handful of very large corporations that dominate that market," Carlisle explains to me. "So if you're growing commodity wheat, by definition, you're basically not getting paid your cost of production. So that means farmers are sort of externalizing that... just to make ends meet." By "externalizing that", Carlisle is referring to the use of pesticides, herbicides, antibiotics, and chemical fertilizers, in addition to a complete reliance on government farm subsidy programs. Wheat farming as it is currently practiced is by no definition sustainable, both environmentally and socio-economically. Diversifying grain farming, instead of just planting the same one species of wheat, presents economic resiliency in that if the market is unusually bad for a crop, they have their eggs in more than one basket. The same is true for extreme weather events: certain species might be more resistant to a type of pest, a persistent drought, or unusual flooding, all of which we will see more of in the coming decades.

If, for some reason, the promising economic and public health benefits of reinvigorating ancient grains does not seem like enough to usurp white flour, consider the environmental benefits. Many species of ancient grains do well with lower levels of irrigation, pesticides, and herbicides in comparison to their modern wheat counterparts [26]. Monoculture crops, the kind of which one might see peering out the window of an airplane over Iowa, are at higher risk for disease and pests, and therefore require greater quantities of pesticides and herbicides [27]. Many ancient grains including Einkorn, millet, and spelt, grow with hulls around the consumable part of the grain, making them further resistant to pests [21]. Ancient grains can play an important role in permaculture, a type of farming that focuses on nourishing the soil and working with our understanding of ecology for the most sustainable product possible. Increasing widespread production of ancient grains seems overwhelmingly like a good choice, but at this point it is beginning to look less like a choice and more like the *necessary* alternative. If current farming

practices are maintained, we have an estimated 60 growing seasons left before the soil is completely degraded, and unable to support agriculture of any kind [28]. As our earth warms, weather grows unstable, topsoil depletes, and food systems collapse, integration of ancient grains into our agricultural system and onto our grocery store shelves begins to feel less like a personal dietary choice and more like a necessary and life-preserving action. Seldom in history has a sandwich ever been so pivotal.

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