Food Properties

Food Science & Technology 100B

A comprehensive review of material presented by Dr. German

by Joanna Wirkus

Sensory Science:

An inside view of the senses. How do they influence our food choices? Why does it matter?

Food Safety:

What you don't know can kill you. A complex problem on a microscopic and macroscopic level.

Nutrition:

Processing a food for shelf stability strips essential nutrients. Is fortification the right solution for all? Considering the balance between risk of deficiency and toxicity.

Food

/food/

Noun: Any nutritious substance that people or animals eat or drink, or that plants absorb, in order to maintain life and growth.

Properties

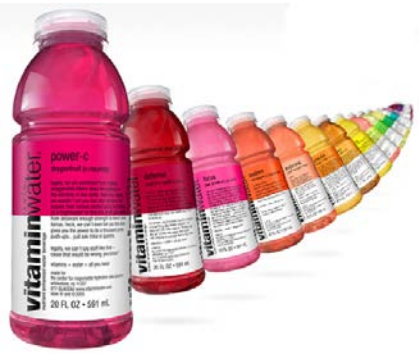
/prop-er-teez/

Noun, Plural: a quality or trait belonging and especially peculiar to an individual or thing. An effect that an object has on another object or on the senses

A fascinating and increasingly complex food system aims to nourish over 300 million people in the United States. As a future professional in the food industry, an understanding of this system is integral to success. Decision making by the consumer, the industry, and the government all influence the dynamic dance of inputs, processes, and outputs. Despite variables galore, consumers expect, and producers aim to deliver, consistent products in a commercially competitive battleground.

Introduction- past, present, future

Three important aspects of food include sensory perception, food values, and nutritional properties. Sensory perception pertains to how we perceive foods. The color, smell, taste, sound, and texture of food all play an important role in helping us decide what to eat. The sensory aspect of food also deals with the mysterious realm of how we choose to prefer certain foods over others. Food values are often underappreciated and overlooked since eating is not only mere habit for many people, but often taken for granted. Food must be safe and stable. Convenience and the delight experienced while enjoying food may be the most important deciding factors for consumers. The nutritional properties of food are quite possibly the most interesting aspect of food from the perspective of a nutrition student. However, a great paradox exists in the supermarket. Foods are often greatly processed in a way that is detrimental to their nutritional value. Nutrients are sometimes added back to compensate for this loss. A perfect example is flour, which is nearly always enriched with B vitamins. Vitamin D milk is another great example. **A great hypocrisy, however, is the phenomenon: vitamin water.** A product that in essence is no better or healthier



than a soda is dressed up like a health drink by the addition of a few vitamins. The beverage is sweetened with pure fructose, which is arguably worse than high fructose corn syrup. The success of this drink is proof that the consumer may not fully understand the implications of nutritional properties of whole foods vs. processed foods. There is, of course, interplay between taste, cost, and convenience here to consider as well.
This leads to the pressing issue at hand; what we choose to eat and why. From the perspective of an aspiring registered dietician, understanding how to change what people choose to eat is vital. This is also a very hot topic for corporations who stand to profit based on consumer preferences and choices. Some expected trends for 2013 are summarized in the following article
http://www.cookinglight.com/healthy-living/health/2013-food-trends-00412000079925/

In the last 100 years, agriculture has been greatly altered. The landscape of consumers, economy, and environment are also forever changed. Needless to say, defying the density dependent growth rate that all other species demonstrate is made possible by human ingenuity. However, if we cannot commit to sustainable practices this beautiful planet Earth will never be the same for future generations.

Chemistry's great minds have lent to collective consciousness of scientists an understanding of what constitutes matter, and the implications. Two indispensable methods in the scientist tool kit include density separation and distillation. Both were born of early food science; the pursuit of novel beverages and food products by meddling in kitchens. Creaming butter out of milk led to a separation of molecules by density. Who would have thought while churning cream this knowledge could one day be applied to everything from nuclear power to processing blood samples? In search of higher spirits, the distillation of alcohol resulting from fermentation produced a variety of liquors. This technology today is used commonly for separation, including in the petroleum industry. The idea of separation was applied to nutrients until all the nutrients necessary for human development were identified. This gave us the power to eliminate diseases caused by deficiency. Society had a theoretical choice between education and fortification. We could educate individuals about their food choices and where to get necessary nutrients, or enrich foods in a way where all had enough. While the latter approach was adopted, it is important to recognize that education could have been difficult to achieve in a land so large and so diverse where so many languages are spoken. Teachers may be able to reach students in school. In fact, it should be a required part of the curriculum considering the importance of nutrition to life. This method would not reach all individuals indiscriminately however. We can't forget those who don't attend school here and immigrated, and those who have food traditions different than our own. Cost may have been a huge deciding factor. While any university student or professor would praise the importance of educating individuals on the best sources of required nutrients, the theory is easier than the application. Nutrition and foods should be a stable of the American curriculum. I think of all the possible information to be included in the curriculum, nutrition is one of the most basic and important life skills one can learn, and while some of our habits our passed down through families it is also possible to teach good habits in school. We are lacking in this basic knowledge and this is proven with the fact that nutrition is often only a short topic briefly mentioned in health class and sometimes even an elective course.

With enrichment of the food supply, all who eat from our collective nourishment system are universally cured from the detriment of rickets, goiter, scurvy and other deficiency based diseases. With the many benefits that emerged from the study of science, inducing understanding of medicine, germ theory, cleanliness, and nutrition, our lifetimes have been extended greatly. Capitalism, with the pursuit of profit at the forefront, is the great driving force for economic growth in this country. It has created a food environment overwrought with choices and uneducated consumers. The obesity epidemic is less of a mystery with this fact elucidated. The 21st Century will be dominated with biology and with a special perspective on evolution. The interplay between genes and the environment is a fascinating emerging felid. Chemistry's accomplishments have allowed biology to progress greatly.

"With today's technology we have the possibility of experiencing the greatest health ever and while some are, most are not." JBG

This statement is proof of the value of nutrition in the society of the future. Obesity is a vital issue in the population that must be addressed. It is not as easy eating less and exercising more, although we all wish it were. There is a complex interplay between genes and environment that has shaped you to be who you are from conception to utero and everything following. Most importantly our gene expression can be changed. Proof exists that exercise actually alters DNA methylation and therefore gene expression. See the link below!

http://www.npr.org/2012/03/09/148306989/a-workout-can-change-your-dna

From an evolutionary perspective, it is interesting to consider what makes us human. Our brains have increased in size. Cro Magnon man over time had lost some senses and gained others. We don't have the best vision or the best sense of smell, taste, or hearing either. Humans collectively made it to the top of the food chain, regardless. As omnivores, we do not have a monotonous diet of grass, bamboo, or eucalyptus, like the herbivorous horse, panda or koala. Humans can eat nearly anything, provided it is digestible and not toxic. In the early stages of human evolution this flexibility in diet and increasing brain size provided an advantage. Humans could remember where the best places to find food were. They committed to memory what foods were acceptable and which to avoid. They could strategize how to hunt. Culture and oral tradition perpetuated learning through the generations. Evidence suggests humans may have developed the ability for language when the environment became harsh and unforgiving.

The freedom of choice in the arena of food that exists today is enormous. Choices are made based on sensory perceptions of food products. Flavor must be one of the most important deciding factors. Food that isn't safe poses a huge public health threat in an economy that feeds over 300 million strong here in the US. Convenience and affordability are also deciding factors in the food market. In today's industrialized society, division of labor is what makes so much possible for so many people. The largest employer in the US is the food industry because, let's face it, we all need to eat. Heat and eat meals, restaurants, fast food, have allowed time previously spent on finding, preparing, and eating food to be a much smaller part of ones day than it has been previously, at a cost. With all this new found time, individuals are free to pursue hobbies they may have never otherwise been able to do.

Food must be stable. An unstable food is not suitable for the modern industry where food is transported thousands of miles. Inventions in the area of maintaining food stability, wax coating on fruits and vegetables for example, have been profitable and are now commonplace. Nutrients are the sole purpose for eating food, but one could arguably say that the most enjoyable part of food is the sensory experience. Now, a population of individuals who is largely unaware of nutrition, or who may overly rely on the opinion laden internet for their facts, is faced with a million different choices about what to eat in a profit driven market, where manufactures will do anything within constrains of the law to earn your dollar.

Sensory

Vision

The senses have evolved to keep us evolving. Correctly interpreting quality attributes to avoid toxic substances while obtaining optimum nutrition. Food materials have a variety of attributes. Our brain puts together a neat picture from all the sensory input. Humans are vision oriented. Our brain has invested a lot of real estate to this peculiar sense. Vision is the first sensory filter an object must gain approval of before it can be consumed. If it doesn't look appealing it probably isn't very tasty.

The eyeball is basically a sensory apparatus that envelops an extension of the brain.

http://www.britannica.com/EBchecked/topic/500012/retina

Light bounces off an object and the electromagnetic waves within a narrow range are able to be perceived by the light sensing cells, the rods and cones, on the retina. The rhodopsin molecule undergoes a change when it is stimulated by a photon. In this manner, the retina senses the light waves and sends electric signals to the brain. The brain is responsible for decoding electric signals into images and creating a visual map. This sensory system is prone to mistakes as is apparent with optical illusions. Our brain uses our memories and anticipations to recognize patterns. The actual optical information is mostly a preconceived expectation with surprisingly minimal visual input. Personal history and memory greatly influences perception. Without a filter for determining necessary from unnecessary incoming information the brain would be literally overwhelmed.

Quality assessments with food are often based on previous experience. However, this system fails when faced with an unfamiliar food. Our brain sees food and elicits the physiological reaction of salivation in anticipation of nourishment.

Color is a way to determine quality without even touching the potential food product. A discrete messaging system is encoded by pigments, perceived by electrical signals, and interpreted by the brain. Vegetables, for example, come in a rainbow of colors. Different pigments even have potential health benefits. One can quickly judge the position on the scale between unripe and rotten when looking at a piece of fruit.

Grocery stores maintain vegetables misted with water in order to maintain a crispy, hypotonic appearance. Pigments are secondary metabolites. They are often stored in the vacuole. Only if the vacuole is intact will the color maintain its integrity. If the cell is compromised, pH changes will affect that color and result is a good quality indicator.

Sensation: our perception of the world. Our sensory organs attempt to gather information while our brain processes and interprets signals from our surroundings. In essence, there are a **centillion things going on around you at all times. Only a fraction of those are occurring at a level you can even perceive. Of those perceivable blips form the universe, only a fraction is picked up by our senses. Of that fraction, only a tiny fraction is actually trickled through the subconscious to the consciousness. What we actually perceive is a slight notion of what is really there. It's a negative, all perceived 1/10th of a second after it occurs. Our eyes see what the product is reflecting not the wavelengths it is absorbing. So when you eat a red apple, its skin is everything but red. We put foreign material into our bodies on a daily basis. It is important that this matter is nourishing. Such a vulnerable act must be filtered through our senses in order to determine if that food is safe to eat and nourishing. Our senses perceive the kinetic energy in matter though the perception of temperature. Volatile compounds can be perceived with the nose. The tongue can sense chemical composition and texture. It is interesting to ponder that, quite possibly, no two people perceive the sensory world in the same way.**

Unreal Color?

Our acute sense of vision allows us to make quality assessments of food long before we eat it. The decision if a food is fresh and suitable for consumption is nearly automatic. Once food chemists learned how to isolate color compounds and add them into food the playing field of food production was forever changed. Food manufacturers were able to conceal a less than ideal product with colorants. When we previously relied on our sight to determine the acceptability of consuming a food, people could now be easily fooled. Colorants changed the whole food system including food processing and manufacturing practices as well as the consumer choices. Butter has been the long standing traditional added fat to the western diet. Magnesium and copper was added to canned vegetables to help them maintain their green color. *Subpar products could be sold with added food adulterants and consumers would never know the difference*.

Although food dye was used for other purposes too. At one point laws required all margarine to be died pink in order to inform people they were eating an imposter!

Sensory

Audition Texture

Every sense is involved with the food sensory experience. Audition is not excluded regardless of its proximity, or lack thereof, to the masticating apparatus. Sound waves travel through the bone of the teeth and jaw and reach the cochlea internally as well as externally. A novelty lollipop radio once took the youth by storm utilizing this technique.

Our preferences for sounds are learned. Although it is safe to assume there is a great deal of societal conditioning involved. Children learn to mimic the pleasurable reactions to sounds of adults around them. In the feeling realm of sensation lie pain, cold, heat and pressure. Each with a unique receptor. The tongue is very sensitive to particles in the mouth as they are consumed. The difference in just a few micrometers is the difference between creamy, powdery or gritty.

For more info on a pioneer in the realm of texture sensation and research done by Lina Engelen
http://www.med.uu.nl/BTHK/res_engelen.htm

Glycemic index is the measure of how quickly a food causes a rise in blood sugar. Glycemic load incorporates the amount of food usually consumed into this value to give a more accurate description of the effect of a food on the pancreas and insulin levels.

An aside on Food

Bread, cheese & ice cream, popcorn, chocolate

Texture/flavor/functionality

Food has been an arena of innovation and a creative outlet for humans throughout history. **Bread**, for example, combines preferred texture and flavor with improved digestibility. Most processed dairy products, including **cheese** and **ice cream**, are also inventions utilizing favorable texture matrix. Fat suspensions are undeniably pleasing to the palate. Harnessing the power of steam, a hard kernel of corn, previously inedible can be transformed into a delightful morsel of foamy starch aka **popcorn**. **Chocolate** is unique due to its fat content melting right at body temperature. This melt in your mouth sensation is quite desirable when one is chewing an already sweet and fatty substance. The food industry discovers and utilizes pleasing textures. *Bread, cheese, ice cream, popcorn, chocolate are all foods that are a result of pure human ingenuity*. People harnessed a particular property and popularized it throughout the global taste preference. It may be true that the first cheese ever made was probably made by accident, but the vast variety of cheese on the market today alludes to the amount of creativity people have invested in these products. These food commodities are desirable because of their relatively long shelf life. They are revered as an indulgence food or a good snack. An increase in demand of these products by consumers has led to an increase in supply of the constituents which make up these foods: milk, corn, cocoa butter, wheat. It has also lead to an increase in the number of manufacturers of these products and inevitable ingenuities in the processing of these products. The end result: these products are readily available everywhere you go. There isn't a store in the United States that sells food and doesn't carry at least one, of these popular commodities.

Fat: the instinctually desirable yet vilified macronutrient

Fat prior to today's modern day and age was a difficult to obtain commodity. Animal fat was common but meat was more plentiful. Plant oils were not useful due their tendency to go rancid and oxidize quickly. Fats and oils were expensive and not used nearly as frequently as they are today.

With the advent of hydrogenation that removed pesky cis double bonds and made trans double bonds (partially hydrogenated) or fully saturated fats (fully hydrogenated). The newly hydrogenated fats were not only more shelf stable but also solid at room temperature. This increased melting point lead to a new product commodity "margarine". Butter was scrutinized and ostracized while the new "healthy" plant oils were praised. The industrial processing expanded and increased while the demand grew and farmers started planting oil bearing seeds like rapeseed for the production of canola oil. A special kind of canola oil was bred and genetically modified which had a lower level of undesirable erucic acid. The result was readily available and affordable solid fats made from vegetable oil. The French fry industry was forever changed. Restaurants could boast "fried zero cholesterol oil". Little did people know that dietary cholesterol was less detrimental to health than trans fats and saturated fats. This new cheap commodity found its way into most people's diets in increasing quantities. The eventual demonization of fats and their inseparable connection with coronary heart disease led to an increased demand for the pleasure of fat without the guilt. Eventually fat substitutes were ushered in as fats earned a bad reputation. Their purpose was to lower the calorie content of a food that could now claim to have reduced fat. With the appropriate texture and mouth feel and flavor these fakers were too shuttled into the food system. Fat substitutes, replacers and mimetic were made of carbohydrates, proteins or sometimes fats which were indigestible or contained less calories. For example, olestra was a modified fatty acid ester on a sucrose backbone. Passing undigested through the GI tract meant it was easy to cut out the 9 kcal/gram that fat was contributing to the diet.

Olean literally ruined Proctor and Gamble who invested a fortune expecting their new product to be a giant success. This product was fortified with fat soluble vitamins to mitigate the potential deficiency that could arise with eating an indigestible fat. Today, one would be hard pressed to find a product that contains Olean on the market. This product was an absolute failure. Trying to trick nature and biology and metabolism is proving to be more difficult than expected. Some who ingested Olean experienced abdominal cramping and discomfort. Other less desirable side effects and even embarrassing oily stains also occurred. The produce was required to carry a label warning consumers of the potential abdominal side effects. This undoubtedly created consumer alienation and prevented the success of this product in the marketplace.

Sensory

Taste

5 basic taste sensations

The tongue can detect chemical molecules present in the mouth. While most of what we consider flavor is scent, taste is a very automatic sense. Taste is perceived subconsciously and hardwired into the brain. The five basic tastes include sweet, salty, umami sour, and bitter.

Disaccharides and monosaccharaides are detected as **sweet** and always perceived as pleasant. Sugars are easy energy for the body and early in evolutionary history, were difficult to find. Honey would be a challenging, yet rewarding treat, as would berries and fruit. This type of food would have been a relative minority in the early human diet, yet there was a strong sectional pressure to pursue this flavor. The importance of the sweetness sensation is evident when one considers the fact: no sweet food is poisonous. Sweetness must be present at relatively high concentrations of at least 0.01M to be detected.

The **salty** flavor needs to be present at similar concentrations in order to be detected. Sodium is an essential nutrient. It has a bad reputation in today's society because of our tendency to concentrate and overuse anything preferable to the senses. However, without electrolytes like sodium, especially in the heat, one could die quickly. Sodium is important for fluid balance, and is one of the several ions that make nerve signaling possible. Salt was so valuable in Roman times, soldiers were paid in salt. Hence the phrase "worth one's salt". The word "salary" also comes from the same Latin root as salt. In Africa, people trade salt for gold. No wonder the mouth contains a built-in receptor for this essential nutrient that our brain perceives as desirable.

Umami is a relatively recent addition to the scientific knowledge of the tasting palate. Glutamate receptors on the tongue sense protein and illicit a savory, brothy, flavor that is also desirable. Umami can be detected at .0007M.

Sour and bitter are two chemicals that, early on, signaled danger. Sour is detectable at .0009M and bitter at even lower .000008M concentrations. **Sour** indicated the presence of caustic acid. **Bitter** signaled the presence of toxins, especially from plant origin. I do find it interesting that with enough sugar, sour can be something desirable, as is exemplified by sour candy. Bitter can also become an acquired taste and is mitigated by the presence of sweet.

Taste:

The taste buds

The buds are contained inside fungiform, foliate and circumvallate papillae which are distributed variably all over the tongue. The conical filliform papillae are designed only to sense the texture of and to hold food but lack taste buds. Papillae come in different shapes. Fungiform, as the name might suggest, look like button mushrooms and are located at the tip and sides of tongue. An adult tongue contains many of these papillae yet each one only has a few individual taste buds. Circumvallate are round mounds concentrated on the back of the tongue in the shape of an inverted V. These are not numerous on the tongue but contain many taste receptors. The foliate papillae folds are located on the sides of the tongue near the back and are vestigial in humans. We only have a few of these papillae and they have few taste receptors. One of the falsehoods of taste is the idea of the tongue map. This idea suggests that one area is dedicated to a specific taste. This idea arose from a failure in translation and is still perpetuated today. While taste buds are concentrated on the papillae they do exist in other parts of the mouth as well. An individual taste bud is formed of several cells including a receptor cell and supporting basal cells. There is a small opening where a food particle must enter in order to be detected. Once the molecule binds to the receptor a signal is sent to the brain informing the decision maker what types of chemicals are contained in the food material. Sweet, bitter and umami utilize the G protein cascade when sensing a molecule. Ion channels indicate the presence of saltiness. Sour taste receptors use a GPI anchored protein receptor.

For more information on current research surrounding taste and perception click here: http://www.hhmi.org/research/investigators/zuker_bio.html

The last taste that has not yet been addressed is the sensation of spiciness. However odd, some humans have conditioned themselves to prefer and tolerate the sensation of pain and irritation. Spicy peppers have evolved this mechanism as a way to deter consumption. It seems like this trait has worked in the opposite way. This trait has promoted their propagation and use all over the planet. Spiciness from capsaicin and piperin and other sensations like irritating ammonia and tannins are transmitted to the brain by the trigeminal nerve.

Taste:

Preferences rooted in genetics

What leads some people to like certain tastes over others? Some sources of variations in the population have been identified. While assisting with the Phenotyping Metabolic Health conference in June 2012, I was able to assist in phenotyping the participants of the conference based on their taste preferences. We tested participants for PROP receptors and counted taste bud density. PROP is a chemical that is similar to some bitter compounds found in beer, coffee, and raw broccoli, for example. Some people have a recessive trait and are not able to detect this bitter flavor. They tend to tolerate bitter vegetables better and like coffee and beer more than the average PROP taster. Confirmed by the PTC test in high school biology and again with the PROP chemical, I am a taster. Tasters are less likely to foods containing bitter compounds. The next level of variation is in the number of papillae on the tip of the tongue. Some individuals, including myself have a low density of taste buds, also known as non-tasters, although the term is less than appropriate. Some have average densities and are normal tasters while others have high densities and are termed super tasters. About half of individuals are normal tasters while the other half is somewhat evenly distributed between super tasters and non-tasters. Gender differences do exist. Women are more often super tasters presumably to avoid toxin exposure in the child bearer. Super tasters are rarely overweight and don't like sugar much. Normal tasters think bitter foods are ok. Non tasters do not avoid bitter foods but are more likely to become overweight from eating too much and enjoying salt and sugar more than the average person. Because non-tasters do not avoid bitter vegetables, epidemiological evidence suggests that they may have a decreased risk for heart disease certain cancers and increased risk of obesity.

In my own observation and implications for my individual phenotype finding, I am the opposite of a picky eater and enjoy all foods including those that contain bitter compounds including lots of raw vegetables. I love sweets too. This all makes sense, although sensitive to the bitter compounds, my lack of taste bud density makes these sensations associated with bitter containing foods mild and tolerable.

An article on some other taste variations and their implications:

http://www.sciencedaily.com/releases/2013/02/130213152120.htm

Taste:

Perceptions in the market place

Isolating these individual compounds has led to a revolution of the food industry. Now literally any food product, even one devoid of essential nutrients, can be made delicious with some sugar and salt. This is how I describe the majority of processed foods. However, even with the knowledge of this sensation deception, I still can't resist to indulge these foods if they are right in front of me. I imagine this is the case with other individuals as well. We eat foods we know are not healthy because of the taste. Our brain says "GOOD! EAT MORE!" Even though the chemist designed to detect these food molecules has only been exposed to them at such great quantities with such easy access for a relatively short time. Sugar is a good example. Sugar cane was used locally in some places in the world, but once it was introduced to western civilization by Columbus, the world's flavor perception and expectation was forever changed. People loved and craved and demanded this new sweet flavor. A new commodity and cash crop was born. Beets were also used when sugar cane was not available. This white gold will forever be a part of our food industry. Sugar cane was grown; sugar was extracted and used in everything from baked goods to sweeten tea. It also became a good preservative with its ability to lower water activity. Now, you would be hard pressed to find a processed food with no added sugar. Most manufactures have high-jacked this pleasing taste to sell products. Today cheap high fructose corn syrup has pushed down the cost of adding sugar to products. This subsidized sweetener is sold at less than the cost of production and once corn syrup is purified and isomerized it is added to sodas, ketchup, peanut butter and countless other consumer commodities. Most restaurants have salt, pepper, sugar, ketchup, and hot sauce available to customers. It's a small flavor island that most consumers now expect to have at their fingertips at every meal

In the 50's, artificial sweeteners were discovered. With a product as successful as sucrose, "calorie-less" sweetness (stimulators/simulators) were too a hit. The war era also ushered in artificial sweeteners with sugar rations. Increasingly cheap sources of sugar meant more people were able to over consume non nutritious food with lots of calories. A new never-before-seen product hit the market. It was something our physiology was not at all accustomed to: sugary sweetened drinks like Coca Cola. They are widely popular today. Nearly every store carries these bottled empty calories. Evidence exists that if a person overeats on calories from a food source their natural hunger and satiety hormones will eventually equal out their caloric intake. For example if a person eats 500 calories of jelly beans as a snack they will over the next day or two equalize their calorie intake as to not overindulge. However, our physiology has no means of dealing with liquid calories the way it deals with food based calories. With a sugary drink of 500 calories studies show the person will continue to pursue to eat the same amount of food they would had they not indulged in the sugary drink. Over time this leads to an overall increased intake of calories. Think: supersized big mac extra-large fries and a diet coke.

http://www.bodyrecomposition.com/research-review/a-short-history-of-beverages-and-how-our-body-treats-them-research-review.html

This phenomenon leads some experts to link sugary dink consumption to increasing obesity. Artificial sweeteners were first marketed as a coffee sweetener to substitute sugar. Today the most popular uses of artificial sweeteners are sweetened drinks. Evidence suggests artificial sweeteners may be helpful for diabetics. They are also touted to prevent tooth decays since they are not a food source for mouth bacteria. However, soda itself contributes to tooth enamel erosion. One must also consider the consequences of tricking our taste buds and cheating our metabolism. Some studies have linked artificial sweetener consumption with increased weight gain. The thought is that the metabolism slows as it is conditioned to associate sweetness with zero incoming calories.

http://www.sciencedirect.com/science/article/pii/0091743586900897

Some may over compensate and continue to eat more calories. However, harnessing self-control one could theoretically replace multiple sugary drinks with zero calorie substitutes and smaller meals to achieve a lower calorie diet. Other research suggests that over stimulating the taste buds with ultra sweeteners leads individuals to dislike fruits and vegetables while seeking more and more high intensity sweeteners. Animal studies have shown that rats will prefer oral saccharin to IV cocaine.
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0000698
Not to say that sugar isn't addictive, it is!

Olfaction:
A Scent for Aromas

Much of what we consider flavor is actually sent. Many more and much more sensitive receptors sit at the olfactory bulb. The olfactory sensory apparatus is comprised of receptor cells as well as supporting and basal cells ng. There are approximately 1000 genes that code for the olfactory genome. Many
The signals are sent through the First Cranial Nerve. The may nerve cells
This information travels to the brain where it is interpreted by the very primitive basal limbic area. Scent has the ability to trigger very deep memories. The thalamus and neocortex also receive sensory information. The advantage of the nose is the chemistry in our skull can detect volatile compounds before they are even close to being consumed. Offending scents like rotting smell can be detected very quickly and.
For an odorant to be detected by the nose it must be somewhat soluble hydrophobic
s volatile some solubility hydrophobic regions

A single odor receptor is capable of detecting different odorants but to a different extdn.t this creates an odor map of the odorant.
The brain assigns an identity to this particular scent and understands the complex waft of chemicals as the chemical signal of that particular product
. Scent preferences are learned. While this may not be intuitive. There is a huge role that society plays in this important. If a scent is perceived as pleasant and is associated with nourishing food, this is a positive correlation and becomes a preference. The smell of fresh baked bread is one example of a strategy grocery stores use to encourage consumers to purchase more items for what they intended to shop for. However if a smell has a negative correlation. Like spoiled milk for example the person will avoid that smell for the rest of their lives. This simple preference avoidance system can be observed
in animals as simple as the C. Elegans
I would like to argue the fact that ALL smell is learned. I believe that some basic even subconscious decisions are made based on smell. Research and example of the effect of body odor on mate choice is an example of how our sense of smell may have evolved to help reduce inbreeding. This ability to choose mate based in part on smell is rooted on the subconscious level.
http://www.ncbi.nlm.nih.gov/pubmed/10380676

It seems though that humans, who are not entirely reliable on their sense of smell for survival have lost quite a bit of their olfactory ability already, and may continue to loose their sense of smell as time progresses

http://online.wsj.com/article/SB10001424127887323696404578300182010199640.html
Article on Scent and how to sharpen it

A Nobel Prize was awarded to these two scientists who made discoveries about olfaction and genes. more info h: http://www.nobelprize.org/nobel_prizes/medicine/laureates/2004/press.html

The science of understanding smell could be a huge asset to companies who carry products that are highly reliant on the olfactory experience such as coffee. Understanding which molecules are present and how they are perceived and what goes into making a good coffee is a huge asset for a company like Starbucks who's success is reliant upon a very stable and consistent product despite volatility in the coffee bean production markets

The million dollar question on the manufacturing side of the food industry is how do we get people to prefer our product? The industry has been hard at work predicting consumer preferences. Investors and food companies alike stand to profit immensely if they can build a loyal consumer base.

Flavor = taste + smell

Tastes and scents come together to form a flavor experience. Eating food is inherently physiologically rewarding. However, based on past experiences especially upbringing, people possess varying flavor palates that respond differently to the same foods. The taste palate also changes once maturity is reached. The imprint of nourishment preferences begins even with the breast feeding of an infant. Mammals have evolved to be quite successful creatures in this era. Lactation came at a huge cost to the mother. The mother must literally pull form her own body tissues to produce milk as well as intake enough food to support her and her baby. If the mother is not successful in her environment the baby will not thrive. In an environment with plenty food the baby and mother will have an increased chance of survival. While carbohydrates and proteins for milk are synthesized by the mothers body and have a relatively stable composition, Lipids are half way diet derived. Many non-polar scent and flavor molecules association with the non-polar fraction of foods. In this method the fats and their flavors in the mother's diet are reflected in the baby's diet. Their very first feeding experiences are laden with chemical messages from the outside world that begin to code the brain with sensory information about the food available in this world. Researchers believe this is an important way that taste preference is passed on and that it serves to help the baby adapt to the diet present in the current environment.

Advertisement and other profit generators have been heard at work trying to unravel the gears that turn to cause an individual to prefer one type of food over another. Happy experiences intertwined with the scent in the air and the flavor while eating the food could cause an individual to associate an emotion with the smell and flavor of your food. This subconscious advertisement has been very effective and it is evident why hosting birthday parties and creating happy meals is an effective business strategy when trying to turn children in life long loyal consumers.

Human beings are variable creatures. Their preferences are based on many different things including their particular mood. Due to past experiences or beliefs they are biased in towards one thing or another. In order to gain reliable data in the field of sensory science a good experiment must have a large sample size with a diverse group of people. People must also be isolated from distracting outside stimuli while gathering sensory data. As long as we have had our taste buds they have reacted positively to sweet and salty while negatively to sour and bitter. A company seeking to subject a product to human sensory science evaluations must consider what the possible sensory attributes of this food are. Wine for example can be described with a wide variety of different words like acid, astringent, earthy, sweet, fruity or woody (and many more!).

Each different taste and aroma experienced in a particular wine has varying degrees of intensity too. How sweet or how sour? A common way of evaluating two food products is to ask testers if two products are distinguishable from one another. As a manufacture considering who to include in the study is importan.t one could recruit untrained subjects which is easier than training subjects to detect certain qualities, attributes, or aromas. The company should also consider potential audience and target population or age group when designing the product.

Why perform taste tests? Performing sensory evaluation is important also for companies who are investing in a new product formulation. Also reformulating a product to lower costs or improve nutrition, is good reissue cause for sensory evaluation’s A true expert taster is a very rare commodity. These well paid industry experts are valuable asset to a company as previously mentioned whose products success is based on flavor and consistency of flavor like Starbucks coffee.

Sensory Science

In summary, sensory science is employed by the food industry processors to gain a better understanding of what consumers prefer in the market place. Difference sensory tests are designed to determine if a consumer can detect the difference in a product. This is used when a new formulation is used or when a generic brand is trying to imitate a brand name. The duo trio or the triangle tests are both method's that can be used for difference test.
Consumers expect a consistent product. Difference tests are useful in maintaining quality a from plant to plant or throughout the years. Reformulating a

Preference or liking of a consumer product is highly subjective due to the variation between individual senses and perception as described earlier. Positive memories and early childhood experience may influence perception and appreciation. Companies spend a lot of money and go to great lengths to determine how consumers use the product in order to improve product development. With the introduction of brain scanning imaging technology consumer preferences can be tracked by seeing which part of the brain lights up upon stimulus. The reaction the brain has does not lie. Pleasure versus displeasure are apparent in the brain .Food companies can base an evaluation off imaging technology without as much bias. Preference for a food product at one end of the supply chain influences the agricultural commodities that will be profitable in the market.
It is impossible to understand why we eat what we eat without understanding how we taste, smell, hear, touch, see, and taste food. More importantly how all those signals are are perceived by the brain. Our flexibility with eating and being able to eat such a wide variety of foods has allowed us to be a very successful species

A huge value we attest to food is the deliciousness and delight experienced during consumption.

FOOD SAFETY

What is the most important value when considering food?

An often overlooked aspect of food quality is **safety**. We truly assume that all the food that is a product of the industrial food system is safe to eat. Whether it comes from a restaurant or the grocery store; it rarely occurs to me that what I am eating may make me fall ill (assuming, of course, that it was properly prepared). My ability to sense food does not extend to the microscopic level of certain toxins or microbial threats. The food safety dilemma must be viewed as interplay between the costs risks and benefits involved with maintaining a safe food supply for most people.

All heterotrophic beings from the single celled to multi-cellular must eat to survive. In seeking nourishment, they are vulnerable to being consumed themselves. They are also at risk of consuming other undesirable products including toxins. The dilemma of any organism with a gut is that the organism must consume constituent molecules in order to survive. The organism must ingest and integrate the same molecules it is made of. But how does one consume what the self needs without consuming the self? A very elegant system has evolved where the gut is actually continuous with the outside environment.

Specialized cells abound and energy is expended on consuming, digesting, metabolizing, and absorbing food molecules. The gut is lined with special polysaccharides termed mucins. These protective mucins form a barrier between the yet to be fully digested complex polysaccharides and proteins and the absorbable and digestible monomers like amino acids and mono and di-saccharides. The amino acids and sugars are soluble while the large polymers are not. A beautiful example of biology's solution to problem encountered by increasingly complex life forms. Nothing in nature lacks enemies. The enemy of mucins protective layer includes some pathogenic bacteria that eat mucin like H. pylori

Lactation: Evolution and Current Research

Earth was not always ruled by mammals as it is today. Cold blooded dinosaurs once dominated the landscape and shrew-like warm blooded animals could not compete. Once the dinosaur reign ended, the mammals began to fill niches left behind and create a new ecosystem. Lactation has been under extreme evolutionary pressure and has proved to be beneficial enough from the perspective of the infant to sacrifice the mother's tissues, to a point. It is thought that lactation evolved as a secretion that protected an egg. Monotremes are the last of the egg laying warm blooded animals. They also secrete protective milk from their epidermis rather than specialized nipples. In time, live births became more common place and the egg was abandoned from the mammal lineage. Babies who had nourishment to help them build strength until they were old enough to fend for themselves had a huge advantage to those who did not have the luxury of lactation in early life. For a newborn who is naïve to the environment, lactation is the best form of nutrition. It contains all the important bio-active molecules a baby needs to survive, including macronutrients, micronutrients, antibodies, and even prebiotics that help establish a healthy microflora. Milk is the ultimate nourishment. Milk Oligosaccharides have been the subject of intense research especially at UC Davis. Using mass spectrometry. Dr. Carlito Lebrilla helped identify the structure of these indigestible molecules. Dr. Davis Mills works on identifying lactic acid bacteria and other potential probiotics in food. His work was very important in understanding the transfer of a healthy mircobiota from mother to baby

Researcher Spotlights

Dr. Carlito Lebrilla
http://ffhi.ucdavis.edu/people/directory/lebrilla
Dr. David Mills
http://wineserver.ucdavis.edu/people/faculty.php?id=5
Dr. Mark Underwood
http://ffhi.ucdavis.edu/people/directory/munderwo

As the two articles below describe the *Bifidobacterium infantis* has adapted to growing in the human gut. Furthermore, they are specialized to consuming these Human Milk Oligosaccharides. Oligosaccharide supplementation has a wide variety of potential uses. It can be used to help premature babies whose bowls are susceptible to necrotizing enterocolitis. However, as Mark Underwood discovered, babies without the proper bacteria cannot utilize the HMO found in milk. B. infantis and milk oligosaccharides can potentially be used in individuals with acute or chronic gut inflammation.

Articles for more information:
Genome adaptation of *B. Infantis*
http://www.pnas.org/content/105/48/18964.short

HMO and *B. Infantis*
http://aem.asm.org/content/72/6/4497.short

Long ago illnesses were explained using superstitions. Many more deaths were due to acute occurrences of illness and infection. Today, with a better understanding of the microscopic world around us, we have better strategies for winning the microbial war waged against us on a daily basis. Death rates for chronic lifestyle and diet related diseases have risen, while infection related deaths have decreased. Increased awareness and scientific knowledge has led to a world where people are living longer and end of life is more frequently caused by heart disease, cancer, stroke, diabetes.

When consuming food, one has the opportunity to ingest both toxicants and nutrients. It is necessary to consume nutrients at the appropriate amount or else a deficiency can result leading to bodily harm. A toxicant, if concentrated enough can cause bodily harm. We must be aware of and properly deal with potential biological and chemical dangers in food. Biological dangers include pathogenic microbes. Poisonous plants and animals (blowfish, certain insects, and amphibians) could also contain offending biological chemicals. The evolutionary interplay between plants, microbes, and animals is such that they have all been at odds with competing for resources for eons. Plants have developed toxins to deter consumption. Animals have developed methods of detecting toxins. This cycle has been revolving full circle to create a kingdom of life equipped to take on a dangerous and hostile world. Environmental sources of hazardous chemicals include arsenic in rice. To better understand toxins, it's crucial to measure how toxic it is. How much of a dose does it take to kill a model animal, for example? Long term toxicity and bioaccumulation is more difficult to measure, but important to understand, as well. One could eat a food containing a pathogen and never fall ill, while someone else may, in fact, be very susceptible to food borne illness. Variables including health, age, intestinal health, previous, food choices, and other foods consumed along with the pathogen all play an important role in determining if you are to fall ill after consuming food that is potentially contaminated with pathogenic bacteria. If a food is to be sterilized, it is important that this food still be eatable and pleasing to the senses afterwards. An acutely poisonous toxin could kill you after one dose. An allergic reaction to a benign substance could also have to potential to kill. Older and younger individuals are especially susceptible to potential death when faced with a food borne infection. The entire food system is laden with potentials for food to become unsafe. In response, manufactures have, often from pressure from the government, implemented ways to protect consumers.

At every stage of a food product, beginning with the plant grown in the ground and ending with consumption, there is a possibility for something to go wrong. Manufactures are always vigilant for ways to improve the shelf life of a product so that the product can be stored longer and shipped farther. Decreasing spoilage through drying, refrigeration, freezing, and limiting water activity by increasing polar solutes like sugar, and charged solutes like salt, are stapes in the preservation of food in the industry today. The industry is responsible for protecting the food supply. A transgression in the safety of food that causes consumers to be ill or be put in harm's way could tarnish a brand name and demolish customer loyalty. The brand's name and trustworthiness in the market place is one of its most important assets. A trusted name is truly valuable. Companies strive to create brand names that are familiar and recognizable to consumers. Clorox didn't change the name of Burt's Bees when they acquired the company. A huge investment in any company goes towards brand name development. If a food industry brand fails to uphold its duty of delivering safe convenient food to the consumer, the media ensure everyone knows about it. I'm sure Taco Bell saw losses when they were traced as sources of *E. coli* tainted spinach.

The industry is not able to combat this gigantic problem alone, which is why food safety laws and regulatory oversight is required. Local, state, federal and, international laws exist in order to control and contain potential food safety issues. Individuals are in charge of maintaining these standards. The health department is responsible for making sure restaurants pass health code inspection. This is a perfect example of legislative involvement with the standards of food preparation for the protection of the public.

This entire system of creating safe food is pointless if the food is to be mishandled in the consumer's home. Through cross-contamination any food could potentially become re-inoculated and microbial spoilage could lead leading to unsafe food that could cause illness. Consumer education is crucial, especially when it comes down to heating foods to ensure their safety like eggs and meat. This is also why some foods must carry a warning label encouraging consumers to heat the food product to appropriate temperatures before consuming.

More info here:
http://www.foodsafety.gov/
While this site is geared for prevention of food borne illnesses, it is more often used in retrospect.

The education system we have here in the US is effective but still lacks the caliber of that found in other countries. One fault of the education system is the lack of nutritional and food education. Truly, education about food is nearly non-existent, or at best skimmed over briefly which was the case with my education. I remember a somewhat arbitrary pyramid was the scheme preached to us while I was in grade school; however I doubt it made an influence on my food choices.

Several levels of food safety need to be understood: microbial spoilage, nutritional deficiencies, environmental exposures, natural toxicants, pesticides residues, and food additives. An inherently nourishing food material exists in a biotic world full of competition. Anything seen as food to us is also food to the vast number of microorganisms in our world. Realisticall, ***we are living in their world***, not vice versa as is our perspective. Food intended to be consumed by a human is often prepared by a human who could potentially be harboring harmful food borne pathogens. In the case of nutritional deficiencies, innovations with fortification have led nearly all deficiency based diseases to be eradicated. This is a true feat of our industrial food system. People who choose to eat a restricted diet are still at risk for developing certain deficiencies, however. It is important to understand where natural toxic materials occur, and how exposure can be minimized. The FDA believes that food borne illness is the most important food safety concern. Consumers on the other hand, believe that food additives (the least of the FDA's concerns) are the most pressing issue at hand. I'm sure if the FDA's top priority were not food borne illness, there would be many more cases than we have today.

Pathogens and highly toxic molecules like potent neurotoxins could kill after a single dose. Today's agricultural staples have been bred over time in a way that selected against undesirable traits such as toxic compounds. Some foods still have some slightly toxic compounds but if you eat a variety of foods you can avoid any adverse effects. Eating one food every single day, like broccoli for example, is not something that is desirable to any human being. We have a natural tendency to seek variety and pursue new and novel food experiences. Boredom that arises with monotonous foods is an advantageous trait. Ricin and saponins are examples of compounds in foods that are slightly toxic but not a threat at normal consumption levels.

The immune system is a unique bodily system unlike any other. Ever-present in the body, its job is to protect the whole from any and all invasions. It must learn to differentiate between self and non-self, threat and benign, sick and healthy cells. Autoimmune disorders result from an immune system that is unable to differentiate self from non-self. An immune system that reacts to a benign molecule as if it is a threat results in allergies. Allergic responses in some cases can be so violent that they can harm and pose a risk to the individual's livelihood. Peanut allergies often come to mind. The body must become sensitized to molecules like pollen in the air, or pet dander. Many who don't become properly sensitized suffer around pets or during allergy season. Prostaglandins and a healthy microbial population are important aspects of developing a healthy immune system. The rate of inappropriate allergic reactions, especially in children, is on the rise, especially in California. Everything from food allergies to dermatitis is becoming more common. One explanation might be the following progression of events: a young child goes to the doctor for an ear infection and is prescribed antibiotics. Aspirin is also given to combat associated pain. Both the prostaglandins and the microbial population suffer a decline. Oftentimes parents will ask if it is appropriate to start introducing solid foods. To add new antagonists to a system that lacks important players in the development of a healthy immune response, can be a recipe for allergies later in life.

Aspergillus is a mold which grows on corn and other grains and creates potent and dangerous mycotoxins. In high enough doses, a person could die from mycotoxins poisoning. In China where food safety laws are not as strict and mycotoxins are a common contaminant in the food supply, rates of liver cancer are much higher. In a third world country where corn and grains are unable to be stored in the ultra-low humidity environment necessary for starving apergillus, what is one to do? Mixing corn with alkali wood ash actually breaks down mycotoxins. The niacin which was previously not bioavailable becomes easier to absorb with the method too. Something that was probably discovered by accident can now mitigate the food safety issues that arise with toxins and nutrient deficiency

Unbalanced diets put people at risk of having too much of the undesirable components in food and not enough of the necessary components. Today, we like to blame diet and lack of exercise for the rise in heart disease. There is evidence however that our ancient modern human ancestors had heart disease as well.
http://www.voanews.com/content/mummies-heart-disease-sendentary-lifestyle/1620605.html
Does this mean that heart disease might be a natural part of human ageing? We can't really say exactly what their diet and lifestyle consisted or if they smoked. However, it is still a significant discovery that makes us question our assumptions. Of course, poor diet and lifestyle choices still contribute to and exacerbate any potential pathology associated with ageing.

As was mentioned before, the world is full of hazard. Every living being has evolved with the need to protect itself from a hostile environment. The world is full of poisons and toxins and in no way does nature want to take care of you. Evolution says only the fittest survive. This is true in every case besides humans who have changed the course of evolution, and what it means to be the fittest.

[We have outsmarted evolution with medicine allowing those who should not be alive to survive. We have also eliminated individuals and their genes from the gene pool with war fought with increasingly complex weapons. Guns have changed the course of human history greatly. One could argue that the definition of "the fittest" has changed. But instead of the survival being of those who were fit to the environment, it became the survival of those who had the guns. This was the case with the inhabitation of North America by Europeans.]

A granola bar would love to tout that this is what nature intended, to make you happier and healthier. A grand delusion on the part of the consumer and to the advantage of the advertiser is occurring. Just because something is natural doesn't mean it is benign, or even helpful. There are so many harmful natural compounds.

In a world where sub-par foods were adultered in order to be sold to unknowing consumers, laws needed to be passed in order to protect the public. There had to be some sort of rules limiting the exposure of chemicals through food. The 1906 Pure Food Act was Theodore Roosevelt's way to attempting to tackle this problem. Contaminants were considered adulterants and food was meant to be only wholesome and pure

The Delaney Clause uses language that even today sounds wonderful. It prohibits the addition or presence of any carcinogenic substances in food. While tremendously well-meaning, it is somewhat impossible to comply with, considering carcinogens are everywhere. It is sensical to minimize exposure. However, the presence of the carcinogen is not always as important as the level. While a known carcinogen is not going to be given free range food additive status, small levels of natural occurring potential carcinogens are unavoidable in the food, water and air. The provision also stated that no level of any harmful adulterant may be present in food. For a substance to be added to food, it must be proven to be safe at established level. The term used today is GRAS or Generally Recognized as Safe. In 1958, the industry realized that the potential for a substance to cause harm needs to be taken into account. This is directly correlated with how much of this product is consumed. Like artificial sweeteners for example, the logic stands that at current intake levels their usage is safe. Prior to this delineation, toxicity was the most important deciding factor which did not take into account the level of usage and rather considered the inherent toxicity of a substance. The Delany Clause still stands and known carcinogens to animals and humans are not permitted in food, rightfully so.

Who is responsible for food safety in the United States?

Several governmental agencies work together in order to tackle this huge public health consideration. Under the umbrella of the USDA, the FSIS is responsible making sure meat, poultry, and eggs are properly packed and labeled. The FDA's branch looks over other all other foods besides meat, poultry, and eggs. The CDC is the main hub of contact for food borne illnesses. The USDA, EPA and US Public Health Services also pay a role in the complex food safety web.

In order to properly understand the issue at hand it is important to create a language that professionals can use to describe what is happening. For example, the descriptive categories of direct, indirect additives can be contrasted with unavoidable contaminants. Direct additives are intentionally added to a product for an intended purpose. Indirect additives come from packaging or processing and migrate into the food. Unavoidable contaminants occur naturally in the food material, like arsenic in rice. The most recent piece of legislation to change the landscape of the food industry is the Food Safety Modernization Act of 2011. It focuses on preventing issues with food by analyzing potential hazards through inspection. In an attempt to mitigate issues which compromise food safety tracking. Analysis and training, new standards of certification, inspection and location of imported foods were also established.

USDA = United States Department of Agriculture

FDA= Food and Drug Administration

CFSAN = Center for Food Safety and Applied Nutrition

CDC = Center for Disease Control and Prevention

FSIS = Food Safety and Inspection Service

EPA= Environmental Protection Agency

Acute vs. Chronic Toxicity

Acute: eating a poisonous mushroom can cause an individual to fall ill or even die very quickly. Poland, where I'm from, people still gather some sustenance from the forest; mainly blueberries and mushrooms. Whether it's for personal use or to sell on the side of the road, it's is a common summer hobby for families and aspiring roadside entrepreneurs alike. Vigilant training starts in childhood to figure out where to find the best mushrooms (chanterelles prefer the shade of a birch tree) and how to identify the good mushrooms from the poisonous one. Societal stories exist that engrain negative connotations and portray the amanita as evil to reinforce the idea of a "bad mushroom". In a society that has been gathering in the same forest for thousands of years this type of cultural education is exactly what one would suspect in order to maintain a healthy population. Aflatoxins can post an acute or chronic threat. They can cause damage at high concentrations but are often found in the food supply, on grains like corn and nuts, at low concentrations. Unlike other molds, the Aspergillus mold can survive at very low humidity levels making the spread hard to curb unless one is using a very controlled environment. This risk of having the toxin present in the food at low levels includes potential liver cancer. How can we moderate the potential damage toxins can cause? Avoidance, dilution, destruction and diversity are several approaches currently employed. Both biotic and abiotic toxins are present in nature and pervasive. Heavy metals, like lead and mercury, are poisonous and can be found in some drinking water supplies. Other toxic chemicals are naturally present in foods. Toxins that are harmful to us are in fact oftentimes natural. A product that prides itself by displaying the word *"Natural"* **means nothing, essentially**.

Some toxins of concern are, in fact, manmade, including chemicals used in agriculture like pesticides and herbicides. BPA estrogen like action has been of particular concern in drinking water bottles, but other toxic chemicals can arise from food packaging too. Food additives can also be toxic at high levels. Acrylamide is an interesting example to examine. The product is carcinogenic, and naturally present in many cooked and roasted foods. It is found at higher levels in certain foods like potato chips, for example.

The melamine example discussed in class hit home for me. Melamine is a nitrogen rich compound. In an effort to increase the "nitrogen content" which was a measure of protein content (however error prone), some pet food manufactures add melamine to their product to cheat the system and illicit a falsely higher protein score. Melamine in itself is not toxic. However, cheap forms of melamine occur with the contaminant, cyanuric acid. If these are consumed together they accumulate as crystals in the kidneys. My cat was an unfortunate victim of this adulteration. A trip to the veterinarian was in order and the vet techs didn't explain much besides the fact that the problem occurs because of his food and put him on a prescription diet. I didn't realize in 2007 this was a widespread phenomenon and my cat was not the only animal to suffer through the pet equivalent of kidney stones. I was horrified to learn that the same contaminant was found in infant formula in China, as well. Preposterous!

http://www.washingtonpost.com/wp-dyn/content/article/2007/05/06/AR2007050601034.html Story about pet food contamination

http://www.who.int/foodsafety/fs_management/Melamine.pdf WHO report

For a toxic compound to be understood its power must be quantified. The LD50 is often used as a reliable lethal dose that will kill 50% of organisms tested. This allows scientists to quantitatively describe the toxicity of a substance from practically nontoxic to super toxic.

It is interesting to consider that not only are we threatened by too much of a bad thing, but we are also at risk when we don't get enough of what we need. It is apparent to scientists that our genetic programing occurs from the moment of conception, and throughout prenatal environment, and infancy. Our genotype and phenotype are shaped throughout life, but some crucial developmental milestones are reached in those early years. Mothers who were starving when they were pregnant, as happened during wartime, give birth to babies whose metabolisms are so conservative they tend to store more than they should and are at higher risk for obesity. Improper nutrition can lead to improper growth as was the case for my Great Aunt who was a toddler during World War 2. Her stories of eating watered down potatoes and even the husks of grains were haunting. Early malnutrition was apparent in her short stature and she explained that she was bow legged although one would not assume so just by looking at her. The development of strong immune system is reliant on exposure and nutrition. Some argue that living in a sterile world surrounded with hand sanitizer and antibiotics is not the best method for developing a healthy resilient immune system. Reproduction, lifespan, health, and even brain development all rely on a supportive environment to be fully realized. Some interesting insights can be gained when studying primate nutrition. Some primates will sacrifice the mother to feed the infant. Some infants will be sacrificed in the event the mother is not well nourished. Stephen J Suomi identified early nutrition's link to behavior. High quality energy laden milk from a happy healthy mother led to a stable, happy, active, curious, playful monkey baby who did well when faced with novel situations. Conversely, baby monkeys with lower energy content in their mother's milk were more apt to become delinquents who were not well socialized. On a molecular level transcription, translation, and expression of serotonin receptors was regulated by the quality of the mother's milk and also reverberated in the monkey's behavior.

Watch a video to learn more about his research here:
http://vimeo.com/18707247

Food borne illness

Even Galileo knew, it is important to find a way to measure parameters, in the world of science. We cannot manage anything without a means to measure it.

Microbiology is a huge aspect of food safety. From *E. coli* outbreaks to mad cow disease, this science studies both what multiplies in food and what multiplies in humans. All too small to see or detect with our current sensory apparatus. Virus, prions, and parasites multiply in humans and a very small amount need be present to make a person sick. Fungi and bacteria can multiply in our food and are potential hazards, as well. Although there are quite a few species we have harnessed to work for us.

Microorganisms are everywhere. The live in the air, water, soil. They can come from insects, animals, humans. Food can acquire undesired pathogens from the packaging, preparation surfaces, or raw ingredients may themselves be inoculated and disease causing organisms to other foods. The worst part is a food containing listeria or salmonella doesn't look, smell, or appear in any way to be different from food that is safe.

OUTBREAK: For foodborne illness to be considered an outbreak, 2 or more individuals need to fall ill from eating a common food. Many wait out food poisoning and avoid the doctor. Many cases of food borne illness are unreported. In those reported cases, the source or cause is not identified.

COST: The cost of food borne illness is huge. While it is impossible to put a definite dollar value on loss caused by food borne illness, estimates are 6.5 -35$ billion dollar annually in the United State. The costs are incurred by the industry that must deal with lost business, lawsuits, legal battles, and recalls. People who suffer a food borne illness must deal with the mental and physical distress, not to mention the loss of workplace productivity. Medical costs can sometimes be incurred and in the worst case scenario, life can be the ultimate price to pay from an illness of this caliber.

Food borne illness can in 2 ways. The bacteria can multiply inside the gastrointestinal tract or bacteria growing on food can produce a toxin that can make a person sick. Let's start with microbes that grow inside the gut and caused illness.

BACTERIA

Bacteria are as ubiquitous as they are innumerable. From harmless, beneficial, to harmful, their range of metabolic abilities is unparalleled.

Salmonella, E. coli, and *Listeria*, are all bacterial infections.

Typhoid fever is caused by the *Salmonella typhi* and is rare here. There are many other types of *Salmonella* that are dangerous to us. ***Salmonella*** is often associated with birds. Bird to food transmission is common. Reptiles can also be a source. Oftentimes, minute amounts of infected feces are ingested and cause illness. Gastrointestinal symptoms include vomiting, nausea, diarrhea and pain and fever are common with this infection, and usually take 8 hours to 3 days to manifest. After an infection, one is a carrier for up to 2 months. The unusual and dangerous fact about *Salmonella* is it only takes a few (1-10) cells to cause infection.

E. coli is a natural inhabitant of the healthy human colon. However, a pathogenic strain (O157:H7) has been wreaking havoc. They are usually found in ruminant animals like cattle. Infected feces are a source. This bacterium causes 3 potential severe disease states. Hemolytic Uremic Syndrome strikes the kidneys is associated most commonly with children and is 30% fatal. The elderly and immune compromised are at risk of developing thrombotic thrombocytopenic purpura which leads to the destruction of platelets and organs and even dementia. Hemorrhagic colitis is common and leads to cramps, vomiting, nausea, and bloody diarrhea. The incubation is anywhere from 1 day to 2 weeks with the infection itself lasting up to a week.

Listeria monocytogenes is a gram positive bacterium that is very dangerous to pregnant woman and immunocompromised individuals. Infected pregnant woman in their third trimester will experience flu like symptoms and the infection often leads to pregnancy complications like stillbirth, early labor, or newborn infection. The immune compromised may suffer from a blood or nervous system infection. Many people with healthy immune systems do not become ill or if they do fall ill will have some level of gastroenteritis. Listeria is everywhere. It's in the ground, in animal feed, in sewage, it can be found in animals and plants and even 10% of healthy humans. Animals or humans can be the source.

To avoid food borne illnesses like those described:

1. Wash hands before handling food
2. Wash fruits and vegetables thoroughly
3. Do not use fresh manure to fertilize food gardens.
4. Ensure foods are heated to the proper temperature
5. Especially if pregnant or immune compromised do not consume unpasteurized milk or juice. Do not eat uncooked meat.

VIRUS

Viruses cause a host of food borne infections too. **Norovirus** and **Hepatitis A** and E are common culprits. Norovirus is responsible for the majority of food borne illness and many go unreported due to a low severity of symptoms that do not require hospitalization. Norovirus results in relatively few deaths compared bacterial infections. Norovirus often infects via an oral fecal route. Food handlers are a common source of norovirus. Symptoms include nausea and vomiting and diarrhea that may last up to a few days
Hepatitis infects the liver and has a long incubation period. Luckily, there is a vaccination for Hepatitis A.

PARASITES

Some parasites like to call humans home. Infections can happen due to global food market, raw foods like sushi, and international travel.
Giardia infections happen in the industrialized nations, but are very common in developing nations. It comes from contaminated food and water and people. Chlorination does not kill this protozoan.

BACTERIAL INTOXICATIONS

Intoxications arise when bacteria creates toxins in a food.
Botulism and *Bacillus cereus* fall in this category.
Bacillus cereus is associated with cereal crops and causes 24 hour flu like illness. It is a very common pathogen that has evolved to infect humans. This bacterium forms resilient spores. This bacterium can make 2 different peptide toxins.

One of the toxins is found in ingested food. Vomiting is likely to occur with this type. Heating a food will not deactivate the toxin. This illness is common in Asia.

The other type of toxin is released in the small intestine and diarrhea results. Luckily, heat will kill the problem if cooked long enough. This type of illness is more common in N. America and Europe.
This bacterium occurs in the soil, so uncooked foods of plant and animal origin can be a source.

To prevent this illness, make sure to heat food toughly before eating it. Do not let warm foods stay out long without refrigeration. Make sure the person preparing food has good hygiene and all utensils are clean.

Botox has led botulism to be well known in its effects. ***Clostridium botulinum*** is the microorganism responsible for the food borne illness and the cosmetic preparation. A microgram of botulism toxin is enough to kill a human being. Infants are very susceptible to botulism. Some suspect this microorganism plays a role in sudden infant death syndrome. This is why honey is labeled with the warning not to be fed to infants less than one year. Adults who ingest the toxin experience symptoms including nausea, vomiting, weakness and dry mouth. Flaccid paralysis results for 2-9 days and infected individuals have trouble breathing, since their muscles cannot properly contract. 20% of people die from internal contact with this toxin. As an obligate anaerobe this microbe needs anaerobic environments to grow. It is an inhabitant of the soil. The severity of this illness means that most cases are reported. Foods that commonly contain this toxin include meat, tofu, and vegetables. Homemade sealed foods that trap the organism in an anaerobic environment allowing it to propagate and produce its potent toxin.

Molds are often the cause for spoilage and are usually quite visible and easily avoidable.

Many variables play a role when controlling detrimental microorganisms in food. Their life cycle and their means of reproduction must be taken into account; also the rate at which they grow and reproduce. Their preferred environment and food source, as well as their metabolic products must be well understood. What is detrimental to their growth, for example, their heat susceptibility is also a key factor.

To maintain a safe food supply one must understand the risk this organism poses to the population. This must be statistical evidence. Numbers speak volumes. Risk benefit analysis can determine which sections of the populations may require special treatment and which subsets are resilient. What is an acceptable risk? Ideally none, but with limited resources this must be decided. The market players, including manufactures, must be aware of and utilize best practices regarding minimizing pathogen contamination.

To assure quality and safety of food, surveillance can be used place to monitor hazard in the agricultural operations and in the industrial processing. Distribution must also be well controlled and under surveillance. Pathogens must be eliminated. Spoilage bacteria cannot be allowed to grow.

The separation of animals and plants from the farm has led to factory farming cattle and monoculture plant production. Factory farming manure lagoons are toxic, dangerous, and can harbor pathogens. When these waste puddles fail to contain sewage, food borne illnesses can spread to produce which is meant to be consumed raw. This is how many food borne illnesses, including outbreaks involving spinach, are assumed to have originated. On an agricultural level, this is a risk that can be measured. The government can step in and dictate the distance between land for animals and land for produce. High cost is what prevents surveillance from being a common aspect of the agricultural system.

Heat is the most effective and reliable way of killing microorganisms that cause food borne illness. Not surprisingly, humans have been using heat to cook food for a very long time. Current beliefs include the fact that fire has been a huge shaping factor in our history. Evidence suggests that our small jaws, intestines are adapted to cooked food while the large intestines and large jaws and teeth of chimpanzees not. We have much bigger brains than our chimpanzee cousins. Our brains need to be maintained and this is calorically expensive. To get all the calories we need to maintain our big brains with our small teeth and jaws, cooked meat must have been an important role in our evolution. It would be impossible for a human brain to evolve on chimpanzee diet of plant material. Cooking has distinguished us among our primate ancestors.
Heat has been an important sterilizing agent in our evolution as well.

This video with Richard Wragham elaborates his theory in this video http://vimeo.com/10325384

Thermal processing is a very important part of our food industry today.

A technology without an application is like paint without a canvas. An important innovation must be married with proper application for it to be spread as a successful means of attaining a goal.
It usually takes brains from one end and business for the other. Science and application can and have rarely come from one person. Pasteurization is an example of this "it takes 2" idea. Undoubtedly, this was one of the most important innovations in the field of food safety. Pasture's idea of heat induced microbial decline was made practical of Appert's idea of sealing the product. Without "sealing" the product, even milk that had been heated to a sufficient temperature is at risk of re-inoculation.
Today the technology of pasteurization is an integral part of our food supply chain that effectively supplies nutrient dense food to hundreds of millions of people in the United States, not to mention worldwide.
I've never doubted that this society places the wrong people on pedestals. Those with little noteworthiness are not only stalked, but also worshiped all for minimal contributions to society beyond entertainment. Salary can be a crude estimate of value in a society. With that said, our values are hugely misplaced as can be seen by the overpaid Hollywood actor compared with the meager wage of a teacher.
We all recognize the faces of celebrity stars but not one recognized the face of the man who could, in his lifetime help minimize the occurrence of cancer from infectious sources like the Human Papilloma Virus. A vaccination that can prevent cancer is quite a feat and noble contribution to the human condition.
Harald zur Hausen was very deserving of the Novel Prize he won in 2008.
http://www.nobelprize.org/nobel_prizes/medicine/laureates/2008/press.html

To sterilize foods, heat is often used. However, after a food is rendered safe post heat treatment, it can be re-infected with bacteria quickly. Refrigeration can be used to slow reproduction.

The beverage industry sometimes utilizes a filter method to sterilize their products. The filter must be 0.45 micrometer pores in order to be effective.

The topic of irradiation produced a lively debate in class that I wish we had more time to address. Irradiation uses gamma rays or x rays to sterilize foods. DNA is highly susceptible to radiation and this is an effective method of making food safe from bacteria without cooking it. It is commonly used in meat. The concern some students had was the fact that radiation is known to fragment DNA. It is also known that bacteria have the ability to take in DNA from the environment and incorporate it into their own DNA though the horizontal gene transfer method known as transformation.
http://en.wikipedia.org/wiki/Transformation_(genetics)
The concern would be that the bacterium in our gut, for example, might be able to pick up novel genes. However, with the acid environment of the stomach and many DNAases and RNAases present in the digestive system, this concern was dismissed as unlikely. I know many people who are in opposition to the increased use of irradiation even though it seems like it will be a common and necessary implementation in the future.

Spoilage microorganisms include bacteria, yeasts and molds. To prevent the growth of these, anti-microbial compounds must be added. These preservatives include sulfur dioxide which prevents microbial spoilage and oxidation. Sulfites can be used as preservatives, however, they can cause allergic reactions, with symptoms of pulmonary constriction, in some sensitive individuals. Nitrites are used to prevent botulism and preserve red color. Antibiotics are not approved for use in foods as a preservative. To prevent yeasts and molds, Benzoic acid, sorbic acid, and propionic acid can be used. Sometimes a variety of methods are utilized to prevent the growth of microorganism. Fermentation, dehydration and added salt and spices are used in cheeses and meats like peperoni.
To quantify microorganism decline or growth in a food medium is important in determining cost benefit analysis of preserving foods using one method over another.

We are living in their world. Our food is always at risk of becoming food for the microscopic world of yeasts and bacteria. Their ubiquitous nature made any discovery leading to the preservation of food against microorganism spoilage a revelation. Drying foods and thereby reducing the water content was an effective way of preservation. Jerky and dried fruit are an example. Spices are often used as preservatives as well. Salt is a very effective preservative and also a delicious addition in some cases. The taste of salt pairs well with meat. Fermentation was a way to lower the pH of the product which would prevent future colonization of more common microorganism that was not pH resistant. Trial and error led people to realize they could recruit microorganisms on their behalf as is done with cheese and wine. One of the most common and reliable method of deactivation of potentially harmful organisms is heating. There is a predictable measureable outcome between the temperatures in degrees the length of exposure that leads to pasteurization of food. One way this information is mathematically expressed is the D value. This is the time needed to kill 1 log (90%) at a given temperature. This D value must be determined for the most stable bacteria present. It would be safe to assume that less stable bacteria would be destroyed at adequate numbers had the more stables ones been heated according to their D value. A Thermal Death Time plot is used to find the time it takes to kill 90% of cells at ever temperature. A Z measures the stability of the organism and is determined by finding the temp needed to increase the D by a factor of 10. Heating food to kill bacteria leads to a loss of nutrients. To find the ideal temperature for pasteurization of a food to make it sufficiently safe is a balancing act between nutrient loss and the required temp to kill the most stable organisms. Luckily however, enzymes vitamins and pigments are more stable than with the lowest Z value. This risk benefit assessment must be concerned with individual susceptibilities including genetics, sensitivities, and age. Common food allergens are milk, peanuts, fish, nuts, and gluten. HACCP stands for Hazard Analysis Critical Control Points and is a system designed by NASA to prevent food borne illnesses in space. NASA enlisted the help of the Pillsbury Company to design such a system to keep astronauts safe. This process was designed to address every step of food production and drew on the insights of individuals ranging from microbiologists to engineers. They determined the maximum and minimum tolerable heat limits for foods like the proper temperature to kill E. *Coli* in beef. They also implicated alarm systems that could inform officials if the temperature fell outside the established parameters

NUTRIENTS

The distance a food item travels from the place it is produced to the place it is consumed is now surprisingly huge. This is a recent phenomenon of the food industry, and interestingly enough, people are beginning to understand the ecological (and nutritional) implications of this practice and the slow food movement, which encourages the consumption of local and organic foods, is gaining momentum. In California, it is possible to eat local, even all year round. However, places like New York are not as fortunate, especially in the winter.

The heterogeneous population needs to obtain proper nutrition. People have unique energy requirements and even energy requirements, based on a variety of factors including age, sex, and activity level. Our metabolism can utilize fats, carbohydrates and proteins for energy. There is a natural tendency for biological systems to conserve energy. Many animals expend a lot of their energy in the pursuit of food. Humans, on the other hand, no longer need to expend much energy in order to obtain food. Obtaining food is an effortless task. Escalators and other inventions to help us conserve energy have become widely popular.
Micronutrients are also required for body maintenance. The government has determined levels of nutrients that are required to avoid deficiency. The level between meeting adequate requirement and toxicity is quite large. This means that we can consume nutrients in excess without any negative effects.
It is important to understand how nutrient requirements are quantitatively described.

EAR: Estimated Average Requirement
RDA: Recommended Dietary Allowance
DRI: Dietary Reference Intake
AI: Adequate Intake
UL: Tolerable Upper Intake Level
AMDR: Acceptable Macronutrient Distribution Range

- EAR is the requirement for 50% of the population. It has been suggested that this would be a more appropriate for nutrient labeling
- The RDA meets the needs of 97.5% of the populations' requirements. The RDA is 2 standard deviations away from the EAR
- The following are DRIs
- AI experimentally determined levels of a nutrient necessary to sustain a population at a proper nutrient state.
- UL is the highest intake level of a nutrient that does not cause any adverse effects. This is not a level that should be a goal to maintain for individuals. It is the borderline between toxic and enough.
- Lastly the AMDR is the acceptable macronutrient distribution range. This range is used to describe macronutrient intake recommendation.

MORE ≠ BETTER

Some people try to say that "if getting enough of a nutrient is good, then more is better." The supplement industry has used this as a promotional campaign. This statement is not only unfounded in scientific evidence it was brought about by an individual that was a qualified chemist, but an amateur nutritionist
Linus Pauling, who was a Nobel Prize winner in chemistry, dabbled in diet and health. He was aware that vitamin C was an antioxidant that scavenges free radicals and that aging was a result of oxidation damage. Pauling looked at the vitamin C levels of animals that had not lost their

ability to synthesize this vitamin. Wolves for example make much more than we do and he continued to supplement vitamin C for the rest of his life. He lived a long life and died at 90 of cancer. Even at high consumption levels the plasma levels of vitamin C stay constant and most of the excess is lost in the urine.

Even though we know *what* people need to consume in order to survive, is no set scientific evidence that there is one definite macronutrient ratio that is ideal for all. Some epidemiological evidence suggests that one diet pattern may be preferable to another, but genetic variation across the globe is not taken into account with these assumptions.

Darwinian evolutionary pressure has not created a landscape ripe with nutritious delicious foods. In fact, humans who attempt to create monocultures of nourishment must wage chemical warfare on the multitude of pests who would love to munch on all the free food. Early on, a food ideal in terms of nutrition and taste would be consumed and disappeared from the gene pool. Many plants evolved in a way that left there nutrients unavailable so animals could not benefit from destroying the plant. Plants also developed toxins and spines.

To learn more on Jared Diamond's unique opinion on agriculture

http://www.zo.utexas.edu/courses/Thoc/Readings/Diamond_WorstMistake.pdf

Today's commodity crops are the results of plants whose toxicity is the result of one gene. It was possible to find a mutant who did not carry the trait that would be toxic. This was a process that happened by a mix of random chance and careful monitoring by early farmers. The intentions of agriculture have been to isolate desired genes and breed commodities that demonstrated desirable traits. Today, we are still breeding fewer and fewer cultivars, but there is a push to find original genetic diversity in the gene pool. For example, the ancestor of corn tiosinte has been the subject of research and finding new traits that may be desirable to reintroduce to corn.

The science of analyzing foods for their micronutrient and macronutrient content is a well-established science. Nitrogen is measured for protein content. Moisture is a measure of water content. Ash is the term used for non-organic minerals. Ether can be used to extract fat. Fiber is all the non-digestible carbohydrates. Whatever is left over are the carbohydrates in the food. When a new nutrient of interest is identified, like trans fats for example, all foods must be reanalyzed again.

USDA Analyzes food commodities and maintains a database of the information
http://ndb.nal.usda.gov/ndb/search/list

Common analytical methods for measuring dietary fiber include gravimetric measurement. Spectrophotometers can be used to measure ascorbic acid. Thiamin and riboflavin are measuring using florometric analysis. Chromatography is used for a variety of different applications. B6 and folate utilize microbiological approach.

The amount of a nutrient in a food is rather useless on its own. What does 1 gram of fiber really mean? To be an accurate measurement there needs to be a comparison between how much of this nutrient does this food provide and how much do I need to eat in a day. The number used for comparison, the denominator if you will, is a controversial number. They are estimates rather than accurate numbers. It would be good to say eat 30 grams of fiber per day. It seems like an adequate amount and studies show that it may be beneficial for intestinal health. Another

important measurement is serving size. Surely the serving size for a dried and fresh fruit could not be equal. Standardization is vital.

How do we get the nutrients we need?
How do we get the population nourished?
What are we eating now and how should we change it
A study called the national health and Nutrition Examination Survey selects random families and individuals from the population to measure diet and lifestyle, anthropometric, activity levels. This is a costly study and the nutrient analysis sis expensive. They look at what these individuals consume and what they should be consuming. This is where the "average American eats ___ fat per day" data comes from. There are some nutrients when compared to the RDA are in adequate intake in the population. This type of research has led to the understanding of nutrients of concern in the population. It should be mandatory to learn about foods and proper nutrition in school. Guidelines for healthy eating are updated every 5 years with the current model being MyPlate. This is the approach the government takes to attempt to educate and guide the public on making healthier food choices. See http://health.gov/ for more information

Even if a generic human feed were available, I'm sure our curious nature that seeks new experiences and often lives vicariously through food would reject the idea. The goal of an industrialized food industry is to ensure everyone is getting proper nutrition. Within our population, various ideas about the healthiest diet arise. People always jump on any dietary trend bandwagon. The "paleo diet" aims to emulate the paleolithic man in consumption. However, one would be hard pressed to find a modern individual with a life style that rivals the robust and athletic paleolitic man.

An essential nutrient is one that must be obtained from the diet. This chemical was historically present at adequate levels and the loss of ability to synthesize, vitamin C for example, was not deleterious for the propagation of our species. Today, the choices for diet are very likely more vast than they have ever been. The government attempts to provide guidelines for diet through todays MyPlate.

More info:
http://www.choosemyplate.gov/

Bioavailability

The way foods are grown, processed, stored, and prepared affects their nutrient content and bioavailability. Bioavailability is an interesting parameter to consider in food. Variations exist based on one's age, lifestyle, and genetics. Bioavailability is measured by injecting a nutrient in the blood then comparing plasma levels of the nutrient when the same amount is ingested. Some nutrients are 100% bioavailable. Others are highly insoluble and are not easily absorbed, like lycopene. Nutrients are inadvertently removed from foods with processing though physical removal, chemical instability, conjugation, and the formation of complexes. The concentration of the nutrient may influence its bioavailability. The carrier of the nutrients, the complex food matrix, often dictates the level of bioavailability. How digestible the food is will affect the bioavailability. The overall state and health of the intestines also plays a role in nutrient absorption.
When vegetables are blanched and grains are milled, physical separation leads to a loss of nutrients. The hard hull of the grain makes it a resilient seed that is not susceptible to desiccation. The coating does make the grain hard to digest. If one is consuming the whole grain, assuming it is made more digestible by cooking, soaking, or grinding, there are many more nutrients contained in the bran and germ. These are stripped away so the starches in the endosperm can be utilized in flour. One innovation on the whole grain forefront is paraboild rice. Parabolied rice is processed in a way where the nutrients that are usually stripped away in milling are driven into the grain, leading to a more nutritious product that white rice. B vitamins are retained. Some fiber is still lost, however.

Nutrient Loss

For **vitamin C** to be retained in a commercial orange juice, the juice must be prepared in a zero oxygen environment without metals. Both metals and oxygen will utilize the antioxidant capabilities of vitamin c turning it into a non-nutrient molecule. Chelating molecules can also be added in order to prevent the loss of vitamin C. Vitamin C in vegetables changes based on the time from harvest to consumption. Boiling vegetables causes this water soluble vitamin to be destroyed by heat and lost the water. If a vegetable is blanched for freeing or canned some nutrient loss can occur. Dried vegetables are exposed to air which oxidizes available vitamin C as well. Potatoes are a staple in many European countries especially in the UK. Even though Vitamin C is not super abundant in the commonly cooked commodity the levels are high enough to maintain vitamin C status in the population. Potato flake products saved time as opposed to the labor intensive preparation that included peeling, cutting, cooking, and mashing. However, the vitamin C status of the population also declined. With the appearance of scurvy in the population, vitamin C had to be supplemented in the new dehydrated potato flake product. It is important to obtain adequate nutrition though a variety of foods for this very reason.

Photo-oxidation of **riboflavin** leads to an undesirable off-flavor. This is often a concern with milk since it is a good source of riboflavin. Clear glass bottles symbolized the white purity of milk. Today the containers are white and opaque to diminish nutrient loss due to fluorescent grocery lights.

Vitamin B6 and lysine react together in foods forming a Schiff base, leading to loss of both essential nutrients.
Folate is lost similarly to vitamin C. Some individuals need more folate than others due to genetic variation. Also folate absorption decreases with age. **Folate** is a vital nutrient especially to women who are of child bearing age. Pregnant mothers who do not consume enough folate are at risk of having babies with neural tube defects like spina bifida. While low folate status can lead to cancer in some individual, high folate status may lead to the progression of cancer in others. The supplementation paradox here is evident. While fortification may be beneficial to some, especially women, it may be detrimental to a small subset of the populations. Fortification of food requires a cost benefit analysis. Folate is currently enriched in certain grain products. The supplementation of folate in the food supply has led to a dramatic decrease of neural tube defect attesting to the success of this method.

B12 is a vitamin that is commonly fortified in many foods. B12 is the vitamin that is always mentioned in any conversation about vegan or even vegetarian diets. This vitamin is present in animal products that are not highly processed. It is assumed that for this reason the vitamin remains bioavailable.

Niacin is stable in corn. However, it is not very bioavailable which returns us to the corn processed with alkali example mentioned previously.

Fat soluble, carotenoid pigments in plants are used to prevent oxidation. The molecules absorb and reflect certain wavelengths making them pigments. It is possible for this molecule to become oxidized itself especially in the presence of lipid oxidation. If the compound becomes compromised the color is affected. **Vitamin A** is present as retinol in animal products. Carotenoids our body can turn into vitamin A are now quantified using Retinol Activity Equivalents. Some carotenoids do not have Vitamin A activity, like lycopene. Consumption of lycopene has been epidemiologically associated with protection against certain types of cancer. Lycopene is not very bioavailable as previously mentioned.
Tocopherol has recently been discovered to only have 4 active isomers which are used as vitamin E in the body. Vitamin E breaks radical forming reactions, but is therefore likely to become oxidized in the right conditions.

Amino Acids are considered either essential in which case the must be obtained from the diet or non-essential where they can be synthesized by the body from non-protein precursors. A food that contains both reducing sugars and **lysine** is susceptible to Maillard browning reaction where lysine is eliminated. Because lysine is an essential amino acid, its loss can create a limiting amino acid in the food source. Some diets are already low in lysine exacerbating this problem concerning nutrient loss.

In an attempt to find a substitute for animal based protein, the food industry looked to microbial (algae fungi bacteria) products. The idea was that the protein from these single celled organisms could be processed to look and taste and imitate meat. In the processing of these proteins for the desired organoleptic properties, alkali was used. This in turn, led to the destruction of lysine by the binding with alanine.

Nutrient loss as a function of temperature can be described mathematically as a first order reaction. One could describe nutrient loss at high temperatures for a short time and at lower temperatures for a longer amount of time. This data is important to consider when determining thermal processing of food. A food scientist would need to compare the thermal inactivation of microbial pathogens with the thermal inactivation of nutrients in order to determine the ideal heating time to maintain nutrient density and eliminate the threat of a microbial hazard. Luckily, for us, enzymes, colors, textures flavors and vitamins, are more heat stable than bacterial cells. However some spores are more heat resistant and their destruction may lead to the destruction of some enzymes.

Nutrients are often rendered unavailable by plants. Sometimes the plant is a seed that needs to maintain viable nutrients for growth until it can turn into a whole plant without being eaten

Wheat, for example, contains phytic acid. Phytic acid makes minerals unavailable to any animal who eats it. If this animal were to only consume cereal grains then the animal would die from a nutrient deficiency. Cereal grains were a good addition to the diet as long as they were not the sole food. Our long standing relationship with wheat has led us to some remarkable discoveries that have improved its digestibility. Grinding the grain, adding water to the mixture and allowing microorganisms to grow on the grain has greatly improved digestibility by utilizing phytase that will degrade phytic acid. Minerals that were previously unavailable are now more bioavailable and cereal grains became a diet staple. How was this notable innovation that has nourished many humans since discovered? Evidence points to alcoholic beverages fermented by yeast being the driver for this advancement.

Beans are another example from the plant world of preservation of nutrients to prevent elimination from the gene pool. Beans contain protease inhibitors which inactivate animal proteases. An animal would surely die from protein malnutrition if one tried to live on beans alone. Humans have the innovation of cooking their food at their advantage. The enzyme inhibitors are inactivated with heat and cooked beans are in fact a good source of protein. Fermentation products like wine, beer, cheese, yogurt, bread, coffee, and chocolate are staples of the food system. A commodity is combined with a microorganism and a specific process to yield a product that becomes revered by cultures. Fermentation yields a product that has spurious organoleptic properties including taste. The food is delicious and also safer. Fermentation can effectively preserve a product. The safe food is also shelf stable. The nutrient availability is improved. All goals of processing are realized with fermentation. This was all achieved before the advent of modern science and will likely continue in the future possibly even finding new applications

Proteins are important to understand in terms of the limiting amino acid. To determine a limiting amino acid one must compare the food in question to a food with an exceptional essential amino acid score. An egg is often used as the gold standard in this case. If one were to eat eggs as a protein source, no amino acid deficiencies would occur. If one were to eat, corn as the sole food source one would become deficient in lysine. Other amino acids that tend to be limiting in plants include lysine, threonine, tryptophan, methionine and cysteine. It is very easy however to complement plant proteins in order to maintain a diet that is sufficient in all amino acids. Beans and rice complement each other well. Beans are low in sulfur containing amino acids and high in lysine.

Grains tend to be low in lysine and high in sulfur containing amino acids. Another approach to improving protein quality is to supplement plant based diet with a small amount of animal products. This leads to an overall high level of protein quality. In order to understand how effectively the body utilizes protein one can use the protein digestibility corrected amino acid score. Protein efficiency ratios are used to determine growth rate in a biological model with a certain protein source. Some definitions to understand in the language of supplementation of diets include fortification, enrichment and compensation. Fortification is the generic word used a nutrient is added to the food supply. Enrichment is a specific supplementation of cereal grains with thiamin, riboflavin, niacin, iron and folic acid. Compensation means to compensate for reductions in bioavailability. Adding iodine to salt was very successful in eliminating goiters and iodine deficiency in the population. Since butter is a significant source of vitamin A, replacements for butter like margarine are supplemented with the vitamin. A meal replacer designed to fortify the diet of an elderly individual for example must be supplemented with calcium and vitamin D among many other nutrients. Products with Olean had additional fat soluble vitamins added so they would not be rendered un-absorbable from the diet.

In all these cases the nutrient of interest was a nutrient of concern in a large part of the population. The food that is the target carrier food for the supplement must be consumed regularly enough to meet the needs of the majority of the population. Salt is a good example since nearly all foods contain at least a little bit of salt. Adding this nutrient to the food supply cannot cause a negative ripple effect with other essential nutrients. The nutrient must be bioavailable its supplemental form. The rate at which it will be consumed cannot be toxic. The nutrient needs to be stable in the food and it must be present uniformly throughout the food. It cannot have a huge impact on the organoleptic properties associated with that food. It's also important that there are not adverse effects if a person was to consume enough food to reach the AL. Another important concept is are there any nutrient interactions in absorption or metabolisms to consider.

The goal of encouraging the food industry to label products is to use money as a driver to incentivize industry leading companies to make their products healthier. The idea is that if consumers see that one product is healthier they will make their choices based on the healthier product. This sometimes works but not for everyone. Food labels all contain pertinent information about the content of the container, what is inside and how much. The statement of identity is sometimes a misleading marketing ploy employed by the food industry for its advantage.

The information panel must contain the ingredients, the nutrients in the food and the manufacture, and or distributor. Any health claims can be present on the food lapel and warnings and handling information are also to be included.

A critique on this presentation: Think the food label needs to remain the same thought and the ingredient list show was not for the frosted mini wheats shown which was also confusing.

Health claims have revolutionized the competitive environment of the food industry. Kellogg's was eager to boast its fiber content and potential for fiber to improve overall health including cardiovascular health. Claims were required to use language that included "may" or "might", rather than will. The claim is accompanied with a qualifier "with a diet that is also low in fat…" Claims can be made about the lack or low level of nutrients that are undesirable like fat sodium or calories. I think it is somewhat confusing and nonsensical for a food they never contained sodium or fat to boast this as a positive aspect of their product. A person might think that the food they are consuming is healthy when in fact it is laden with loads of sugar and empty calories. Claims can be based on nutrient content. Claims can also be made based on a food and health relationship, as is the case for the dietary fiber claim. Other claims can be made about the fat content. For example free, low, lean, or extra lean are used to describe fat content. Reduced, less, and light must have a specified amount fewer calories than the reference food. For something to be a good source of a nutrient it must provide 10-19% of the Daily Value. For a food to be high in a nutrient it must have 20% or more of the daily value of that nutrient. High calcium is a claim that is often seen.

Nutrient labels allow consumers to compare two items based on macronutrient and micronutrient content. Listed are nutrients that we don't want to consume too much of like fat cholesterol and sodium. Fiber, vitamin a, c iron and calcium are nutrients of concern that we want to make sure we are getting enough of. I realize that all nutrient labels require the listing of all these two minerals and two vitamins. My question is: if the government realized some nutrients were of concern in the diet to a degree that required fortification, why are these not required on the label as well? This would help individuals potentially avoid toxicity of over consuming and ensure they are maintaining proper levels. Salt does generally include how much iodine is in a serving of salt. I see that some products do list B vitamins in their nutrition panel but not all. Ideally new recommendation for dietary values would include information for special populations like children and pregnant or lactating mothers. Room for improvement exists.

Percent daily values are calculated based on RDAs with are basically estimates of averages.

The 20th century saw the elimination of deficiency based diseases. The 21st century will need to continue to promote health all the while preventing diseases. How do we define health and wellbeing? Is health the freedom from disease and the absence of deficiency? I think there needs to be more in our definition of health. Protection from future diseased and improved metabolic function are two more ideas to incorporate in our vision of improving health for the future.

The relationship between LDL cholesterol and death from heart attack was elucidated but the MRFIT study.

While the relationship was well established by a large sample size the opposite effect was more of an assumption rather than evidence based. The assumption was that if more cholesterol increased death from heart attacks that decreasing cholesterol would have a positive impact on mortality. Plant sterols were identified in their cholesterol lowering ability. These products were rather dilute in their constituent foods and to consume enough plant material to gain a therapeutic effect from plant sterols would be impossible. Functional foods were born. Margarine was supplemented with plant sterols and repackaged with claims about potential to improve health and lower cholesterol.

Our system of understanding health is the absence of disease. I greatly appreciate the notion that nutrition and health must be integrative. A problem cannot be examined and solved in isolation of the system. A complex web of life must be considered in order to find true health. Does a strict diet prevent the development of one disease but promote the development of another? Will a medication have undesired side effects that could affect quality of life? To be truly integrative, a healthy lifestyle approach must be just that in all aspects. Promoting health in all ways and not detrimental in anyway. It's been found that in an attempt to prevent one type of disease another disease develops. Each person is a unique being. Our unique physiology and metabolism should be taken into account when deciding the best course of action for future health and longevity. For someone to embrace a healthy life style plan in terms of diet and exercise compliance is vital. Health cannot be separated from self-knowledge. Genetics and age and lifestyle must be variables in the equations of health. Diet must be composed of many different healthy foods that can work together to meet the needs of the individual. Which genetic markets should be targeted for personalizing diet and nutrient requirements in terms of nutrigenomics? A few important markers have been established for the relationship between diet and genetics. Of the several different places on the plant where ruminant mammals have been domesticated for their milk, lactase persistence is seen very commonly. Individuals who come from a lactase persistent region need more calcium to retain enough. LDL and HDL have been common targets for intervention for their relationship with heart disease. While both can respond to dietary fats, there are genetic susceptibilities that can lead to an increase or decrease in HDL depending on dietary fat intake. Some people who have a genetic mutation need more vitamin E.

In conclusion, there is much research to still be done to elucidate the relationship between genetics and nutrition. It is an exciting field of study and personalized nutrition may very well be part of integrated health care of the future.

Critique of flow of ideas: After a comprehensive review and summery of the topics presented in class, I am hard pressed to find a negative critique of the examples presented. On one of the last days the experiment presented that explained cortisol levels in response to stressors and the difference between males and females first seemed nonsensical. In retrospect however it makes sense that the point here was to understand there is a difference between men and women. The slides however were a little hard to interpret because of the color. Most of all, examples of current research and researchers in class were very relevant and interesting. I appreciate the focus on the researchers doing the work to uncover new ideas because so often we learn about prominent celebrities who are famous wrong reasons. I am more thankful to those who contribute to the progression of scientific knowledge than those who contribute to mindless entertainment. I appreciated learning about all the new innovations that were previously unbeknownst to me. I really enjoyed learning about nutrigenomics and wished we had learned more about genetic polymorphisms that influence nutritional status and possibly dietary recommendations. I'd like to hope that as a future professional in the field of nutrition and dietetics a DNA sample and analysis will be standard procedure. I also hope we will be doing DNA analysis (or NMR) to determine gut microbiotoa composition and its implications on health. I really enjoyed learning about lactation in this class. I feel like I learned a great deal being an intern on the FFHI Lactation Study. Reviewing this information, and more, in class made me grateful for the opportunity to assist with research with FFHI because I realize how much I've already learned with the hands on experience I've gained. I thought it was interesting how lactation was touched on in different lights throughout the presentation. I wonder if it would make sense to talk about all important aspects of lactation on one particular day? I also feel like there was a lot to be said about the important topics reviewed in the beginning of the class including the obesity epidemic and the role that industry play s in perpetuating eating habits that are pursued purely on a pleasure and deliciousness basis. It seems that any stand the government wants to make against corporations free will in the market place is often refuted with great fervor, in pursuit of wealth. Only issues that have the potential to be acutely toxic like food borne illness receive much attention in the light of our current government and economy. I realize that in the end even the choice to indulge in a donut is a personal choice. Who is to say that if a person enjoys a donut once a month, this dietary indulgence going to have a huge detrimental effect on their entire life? However, the individual who eats several donuts for breakfast every day will undoubtedly suffer some sort of consequences metabolically over the long term. Unless they are in the small subset of the population that have genetics that enable them to eat whatever they want without a change in blood lipids or body fat. Considering the chance of that is small and my review is becoming more of a ramble, I digress from the point. Who is at fault for over indulgence and obesity? Is it our genetic programing that says sugar and fat = good energy source? Is it self-control? Is it a thrifty metabolism seeking to store everything in fear of famine? There are variables abound including belief's surrounding food choices and longevity.
I feel like this class should also attempt to address how to convince people to change what they eat. I feel like this was one of the original goals. I could understand that providing personalized nutritional information could be beneficial in the way that the patient would be able to own the information they receive.

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