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What should I eat? A literary analysis on food, its biological mechanisms, and diets

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WHAT SHOULD I EAT?

A LITERARY ANALYSIS ON FOOD, ITS BIOLOGICAL MECHANISMS, AND DIETS

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ABSTRACT:

"I'm on a diet." How many times have you heard that phrase, or thought it to yourself? Society has often emphasized diets as a positive practice to be "healthier", especially if one is deemed "overweight" or "obese". Yet, current literature provides evidence that weight does not need to be scrutinized so critically. Extra weight is not the cause of health problems, and dwelling on the "fat" itself only holds to increase stigma and shame around something of which one should not be shameful. The falsity and lack of scientific evidence behind diets can be helpful for those selling diets, but is it beneficial to your health? What are you really doing to your body when you go on a diet, and do diets even work? An analysis of the history of food behavior shows how common habits and understanding of health developed. While understanding the biological mechanisms involved in satiety and hunger, such as ghrelin and leptin, increase understanding of how our bodies respond to food. To assess the current diet climate, I analyze how diets came about, and how food interacts through biological mechanisms in the body. Then I will acknowledge the eating behaviors that are backed with sound research versus what may not be fully understood or may just be false. This will help to develop a deeper and more full understanding of food and how it plays a role in health, and the problems to which a disordered relationship with food might lead. Evaluating literature available on food, feeding behaviors, and diets allow us to understand what is truly sustainable health, and how society's common practice of short term dieting will not benefit ones health in the long term, and can even effect the body negatively through the development of disordered eating or by misbalancing our body's natural functions through periods of restriction.

Keywords: Diets, Eating Disorders, Food, Health, Leptin, Ghrelin, Obesity, Normal Eating

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INTRODUCTION

Food has always been an important and necessary part of life, yet its effects on the body are not fully understood and are always being further investigated. The basic understanding of why we eat can be boiled down to two basic hypotheses of feeding behavior. These hypotheses have been around since the beginning of scientific investigation into food intake and ingestion behavior. One hypothesized that eating is a form of response priming, "a situation in which a participant is reacting to a target stimulus as quickly and accurately as possible"[1]. This states that an animal will eat if the opportunity presents itself unless it is specifically inhibited[2]. A second general hypothesis about food consumption outlines the basic motivation in feeding behavior. It is known as the "depletion–repletion" hypothesis, based on a caloric set point, [2] and assumes that animals deficient in a nutrient are motivated to consume that nutrient because the depletion of it is associated with a specific stimulus that will elicits ingestive behavior[3]. More recent research into human feeding behavior has since proposed that the motivations to eat may not be as simple as originally postulated yet still follow these two basic hypotheses. Today taste, nutrition, cost, convenience, and weight control influence personal dietary choices and food intake[4] [5]. Additionally, the role of socially prescribed norms on body shapes, body shape concerns and eating, have all contributed to increased efforts to more strictly control food intake[6]. In today's society, dieting is seen as the primary way to control the effect of food on the body, yet this can often lead to a disordered relationship with food and has led to the rise in a variety of eating disorders[7] [8].

Our understanding of food cannot be boiled down to any simple hypothesis, but must be assessed through historical, cultural, mental, and physical lenses in order to best understand

how the role of food in society has developed and influenced our feeding behavior today. Most importantly one should assess food with respect to culture and the context in which a certain food culture arose. Varying cultures have differing views on what should be eaten, when one should eat, and the atmosphere in which one should eat. The cultural aspects of food have changed as food has developed, but they are still very prevalent in how food is viewed today.

HISTORY OF HEALTH AND FITNESS

Prior to the late 1700's much of our food consumption was based on the availability of certain resources. It was only relatively recently in history that food culture begun to develop and expand away from the farm-to-table notion. In the late 1700's and early 1800's a rise in consumerism triggered the commercial food trade[9]. Once the commercial food trade began, access to food of all kinds began to expand. As time went on, people were no longer limited by what they grew, but rather by what they could afford. This dynamic changed the culture of food, as new food choices were created through a melting pot of foods from every part of the world.

As new foods were introduced and created, the way food was viewed also changed, and the socio-cultural role that food played in our world was greatly affected[10]. With modern advancements in the 1900's there began a shift away from more simplistic whole fresh foods, to foods that where cheaper, more accessible, and more enticing than people had experienced before. We see this with the rise of TV dinners from major food producers including Maxson Food Systems, Inc. as early as 1945, and further developed by Gerry Thomas and the Swanson Brothers in 1953[11]. The invention of TV dinners was incredible to many, and included food like Salisbury steak, meatloaf, fried chicken, or turkey served with potatoes and bright green peas.

Later desserts were even added. TV dinners neatly grouped foods into 3 or 4 separate compartments, unknowingly creating a suggestion of what one should eat at a meal[12]. This led to one of the first, commercially prescribed norms of what an American dinner should include[12]. Additionally, TV dinners drew families away from the typical family style meal around the table, to a more secular, individualized experience focused less on the food itself, and more on convenience[13].

With this convenient style of frozen food meals, scientists began to investigate what occurred when vegetable oils were turned into solid fats through the increased processing and freezing of food, a process known as partial hydrogenation[14]. This created a larger movement against the resulting "trans-fat" and the negative health correlations it had [14] [15] [16]. TV dinners were an novel invention that many enjoyed, but these and food developments like them also started to draw greater attention to the ingredients in meals that were being marketed to the general population, and how they affected one's body and health.

The 19th century can be sighted as a major time for the development of food and its "healthiness". During this time, the concept of healthy began to change. A societal and cultural movement emerged that could be compared to Charles Darwin's "survival of the fittest", where the common consensus was that only the fit and healthy would survive. Yet the definition of "fit" and "healthy" was still to be defined.

George Hebert, in Europe in the early 1900's, was one of the first to address the concept of "fit". He proposed a "Natural Method" of fitness made popular through the first gyms, known as exercise clubs at the time, and published some of the first fitness journals that captured the physique of male and female athletes[17]. Although introduced in the early 20th

century, exercise only became a commonplace concept in the late 1950's with increased public communication and endorsement of exercise through shows like the "Jack Lalanne Show"[17]. It was during this time that organizations including the American Health Association (AHA), the American Medical Association (AMA), the American Association for Physical Education, Recreation, and Dance (AAPHERD), and the President's Council on Youth Fitness all began to take initiative in educating the general public on exercise and the consequences of low fitness levels[18]. Since then these organizations have adapted and grown their programs on fitness education and implementation. Today the AHA suggests that children should get at least 60 minutes of moderate to intense aerobic activity per day, while suggesting adults get 2.5 to 5 hours of moderate to intense aerobic activity per week[19]. These organizations established the definition of fit as the amount of exercise a person obtains in a week, and their ability to complete the prescribed exercise.

One of the first widespread suggestions on what was healthy eating came in 1916 when the United States Department of Agriculture, USDA, published their first food guide separating food into 5 categories: milk and meat, cereals, vegetables and fruits, fats and fatty foods, and sugars and sugary foods [20] [21]. The USDA's first Recommended Dietary Allowances (RDAs) were developed in 1943 and led to the publishing of the "Basic Seven Food Guide". This guide introduced seven main categories of food in the late 1940's. It included "milk and milk products; meat, poultry, fish, eggs, beans, peas and nuts; bread, flour, and cereals; leafy green and yellow vegetables; potatoes and sweet potatoes; citrus, tomato, cabbage, salad greens; and butter, fortified margarine" [20] [22]. The "Basic Seven" was then simplified into the "Basic Four" in 1956 including: milk, meat, fruits and vegetables, and grain products [22]. These "Basic

Four" food groups set up a foundation for a daily diet. It was additionally noted that these four groups contributed to, but were not all, the calories and nutrients needed to properly fuel one's body. In 1979 the "Basic Four" changed to the "Basic Five" with the addition of a "fats, sweets, and alcohol" group[20]. It took over 60 years for the USDA to critique their definition and settle on a recommendation of the what the basic food groups were, yet the developments of nutrition and health did not end there.

In the 1970's the understanding of food and health continued to change as the relationship between food intake and chronic disease began to be noted and studied. A scientist named David Barker noted that food intake effected health at the earliest stages of life through his investigations into the relationship of chronic disease and nutrition in fetal development[23]. He proposed a "fetal origins" hypothesis stating that "alterations in fetal nutrition and endocrine status result in developmental adaptations that permanently changed structure, physiology, and metabolism, thereby predisposing individuals to cardiovascular, metabolic, and endocrine diseases in adult life"[24]. Specifically, Barker's earlier work related to insulin and glucose production was noted to affect prenatal infants to 2-year-old toddlers[23 25]. These findings, and developments from Kent Thornburg and others have established the significance of nutrition in the earliest stages of life, and that it has a lasting effect on health by contributing to chronic diseases[23 25]. In addition, it emphasized that one cannot control all their body's ingestion and digestion behavior simply through controlling their diet. Since a body's responses and functions can be permanently altered before one is old enough to have control of their diet [25].

Findings such as Barkers and Thornburg's led the USDA and Department of Health and Human Services to release another dietary "Guideline for Americans" in 1980. These guidelines developed into the Food Guidance System illustrated in the commonly known Food Pyramid presented in 1992 [26] [27]. The Food Pyramid was one of the first publicly available recommendations from the government that was aimed at maintaining health and reducing the risk of chronic diseases, with the primary assumption being "fat is bad" and "carbs are good"[27]. This case is one that displays the problems in following simple dietary suggestions without further scientific investigation. For in reality, scientists and nutritionists at the time had realized the "fat is bad" correlation was only prevalent with trans-fat, yet decided this distinction would be too difficult to educate the public on, and therefore simplified the message to "All fat is bad". The rational on simplifying the message, was that a low-fat diet would naturally decrease the overall fat consumption in the U.S., and thus decrease the trans-fat consumption which made up, on average, 40% of all fat consumed in the U.S. [27].

Willett and Stampfer, having investigated these claims, realized the negative implications of saying "all fat is bad, and all carbs are good". This led them to propose a new pyramid in 2003, noting their studies had found "a high intake of starch from refined grains and potatoes is associated with a high risk of type 2 diabetes and coronary heart disease"[27]. These findings again altered the dietary guidelines being given to the general public, but now classifying a high intake of carbohydrates as negative rather than fats.

Since 2003, the discussion on what is the best way to eat has exploded, and Willett and Stampfer's proposal has been overlaid too many times to count. Since 1916 the USDA has put out many reports on dietary recommendations, and it took them over 100 years of critiquing

these food groups to present the general recommendation we have today for healthy food intake. An analysis of the history behind the general dietary recommendation proposed today is important. It highlights how there is not a simple answer of what to eat, or how to feed and move one's body to be the most "fit" or "healthy", and that society's idea of health and fitness is highly influenced by the current culture of thought at that time.

BMI: FACT OR FICTION?

- Quetelet never advocated for his ratio to be used as any kind of general measure of body "build" or fat.
- Despite extensive sources in Keys paper Quetelet's papers were never cited.
- The BMI just estimates the amount of adipose tissue we have, without differentiating between fat and muscle.
- It is notably inaccurate in athletic populations, and for those who are especially tall or short.
- The BMI only focuses on a person's weight in relation to their height, and does not take into account other factors.
- Keys noted that "Average values for weight and height for given age and sex for a given population do not necessarily apply to other populations or even to the same population at another time. Further, there is no present prospect of obtaining for any population true average values of weight for given height, age and sex.
- Research is now in support of waist-to-height ratios as a better indicator of health.

(Keys et al. 1972)
(Ashwell & Gibson, British Medical Journal, 2016)

Often one of the most widely used references to health is the Body Mass Index, developed in 1972 by Ancel Keys[28]. He stated this as the "ratio of weight to height squared", a formula initially proposed by Quetelet, a Belgium astronomer[28]. This scale was adopted and used by insurance companies and doctors and is still used today. Yet this ratio was developed from a Belgium astronomer's idea in the 1800's which did not focused on obesity, but rather on defining an "average man" in his efforts to fit his distribution of data around the norm to form a Bell curve[29]. When the BMI was accepted by insurance companies in the 1940's as the common way to assess a person's health, it was done so before common scientific data supported the relationship between the BMI and health[30]. Additionally, standards of the BMI have been redefined to reclassify people and

narrow what the BMI classified as healthy. In 1998 the federal government lowered the BMI criteria for those classified as “overweight” and “obese”, therefore making 29 million people “fat” in one day, who were not the day before [30].

Today all these measures, although having basic merit, are supported by incomplete data and analysis. For example, Thornburg notes a relationship between a mother’s health and their baby’s health, and development[23] which was not considered when many of these concepts were initiated. These previous theories have led the International Journal of Obesity to note the common misclassification of cardiometabolic health when using the BMI scale [31]. Today the more accepted research-supported belief is that waist-to-height ratios are a better indicator of health[32]. Although this belief can problematic as well. From a better understanding of Keys’ study, Hebert hypothesis, AHA history, AMA history, and other resources, one can see how an analysis of health cannot simply be made from the amount of exercise they performed, nor off of the foods eaten, or the amount of adipose tissue that is a part of their body.

It is important to note that the development of the concepts of fitness and health are not stagnant, and that the many beliefs we have of fitness and health are highly influenced by the current culture, and therefore may be inaccurate. Herbert introduced an idea of an athlete’s physique being the standard for health, while the AHA, AMA, and other organizations defined a set amount of exercise to qualify someone as fit. Early versions of the food pyramid have told people certain foods are good, while others are bad, yet today current USDA recommendations have changed to incorporate all foods to be important in maintaining health.

To assess the current diet climate, it is fair to say it is just one fad of many that have occurred throughout time. As they are just fads, many diets cannot be taken at face value.

Willett and Stampfer noted the challenge to ensure that information on nutrition given to the public is based strictly on scientific evidence. Additionally, it is not appropriate to simply use weight as an indicator of health, as Scientific America has noted in a recent article "Doctors Need to Focus Less on a Patient's Weight"[33]. To better understand how to be healthy, evidence-based practices must be used, rather than fad diets. Evidence that is proven and is strongly supported, not simply by those who have alternative motives such as diet companies, but rather evidence proven with scientific merit. One must understand how our bodies interact with food and understand food not in terms of good or bad, but it in terms of energy input into the body. Lastly, to best understand how food plays a role in health we must not fall victim to the general social structures that demonize foods, fat, or larger bodies as these practices can actually do harm to one's body instead of benefiting it, leading to disordered eating habits and an unhealthy relationship with food.

NEUROBIOLOGY OF HUNGER AND FULLNESS

As interest into fitness and health grew, investigation into the neurobiology of how food intake was motivated also began. The motivation behind eating is, for most, hunger. Yet hunger itself can be motivated by many varying mechanisms. It is essential to understand the physiology of how hunger and fullness are mediated within the body to understand how one's body should naturally respond to food. We can understand the basic function of food as energy, through the first law of thermodynamics. Energy input into the body in the form of food will equate to energy expended through exercise, basal metabolism, thermogenesis, and fat

synthesis[34]. This understanding motivated early investigation into how the body signals worked to influence food and energy intake, as an emphasis on the control of body weight grew.

In the 1940's the ventromedial hypothalamus began to be investigated when lesions on the VMH in mice were found to cause obesity[35]. This led to two important correlates of glucose utilization[36] and body temperature[37]. A decrease in these two mechanisms was found to motivate eating, while an increase in both was correlated with decreased motivation to eat. Eventually glucostatic and thermostatic controls of eating were found to primarily operate during hypoglycemia and in low temperatures[3], yet this paved the way for another hypothesis. In 1953, Kennedy proposed the lipostatic hypothesis, which postulated that "an inhibitory control was mediated by a humoral signal from white adipose tissue onto the VMH". In 1994, the inhibitory molecule of this hypothesis was identified as leptin[38]. The discovery of the hormone ghrelin, by Kojima, came shortly after in 1999[39]. Ghrelin was discovered to work as an orexigenic, by transmitting a hunger signal from the stomach, periphery, into the central nervous system. It is then secreted from the stomach and circulates in the blood under fasting conditions[40]. Together the hormones leptin and ghrelin have become known as some of the main hormones that tell the body when it is hungry and full. With these discoveries an understanding of the control of body weight, associated with the control of adipose tissue and the role of the hypothalamus has been developed[34].

There has long been evidence of a homeostatic regulation of body weight. This idea was first proposed by Kennedy[38], who noted energy stored in adipose tissue was a result of ingested calories and energy expended. This led to the hypothesis that there was some mechanism to monitor and regulate these changes to obtain a stable body mass. Coleman used parabiosis to

conclude that the ob gene encoded an appetite-suppressing hormone, and the db gene encoded its receptor[41]. This discovery first noted the importance of recessive mutations which led to obesity in mice. These results, later confirmed, suggested the importance of an "obese" ob gene locus and its role in the signaling pathways from adipose tissue that regulates body fat and responses to satiety[41 42]. These discoveries aided Friedman in explaining how a stable weight was maintained over a long period of time to balance caloric output to energy expenditure, commonly understood as a set point for weight[43].

LEPTIN

There are many mechanisms involved in the body's response to food through satiety and hunger signaling. To understand the basic mechanisms involved in the body's homeostatic regulation of weight it is important to evaluate leptin, one of the earliest discovered hormones, and its effect on the body. An understanding of leptin's role in the body helps to address other molecules involved in hunger and satiety behaviors. With Coleman's discovery[41] of the recessive mutations, obese (ob) and diabetes (db), which lead to hyperphagia, decreased energy expenditure, and early onset obesity in mice, the concept of a circulating satiety factor, leptin, was discovered[44]. Leptin, from the Greek root "leptos" for "thin" is one of the main hormones in the body that contributes to the regulation of body weight[42 45]. It was first identified as an adipocyte hormone which "functioned as the afferent signal in a negative feedback loop that maintains homeostatic control of adipose tissue"[45]. Leptin has since been found to prevent obesity by decreasing appetite and increasing thermogenesis and metabolism[46 47]. Since these discoveries, the understanding of leptin and its signaling pathways

has developed to explain how it regulates metabolism, neuroendocrine function, immune function, and development [44].

Leptin is mainly synthesized in adipose tissue, and additionally in the placenta, gastric fundic mucosa, skeletal muscle, and mammary epithelium[44 48]. The main leptin receptors have been found to be derived from the ob gene 7q31.3[42 45]. For leptin to work, it must be maintained at appropriate levels in the central nervous system, CNS[41 46 47]. An increase in fat, energy storage in adipose tissue[49], in a person's diet evokes a sustained increase of circulating leptin[50]. This is caused by food intake and insulin administration which increases the expression of the ob gene. The ob gene product, leptin, then acts to reduce food intake and increase energy expenditure[51]. Leptin levels will then decrease after food intake has stopped[51 52].

Leptin is synthesized in many places in the body, yet its secretion and function vary depending on where it is synthesized. Leptin secretion from the placenta is stimulated by hypoxia, insulin, and glucocorticoids[53]. While leptin synthesized in mammary epithelium is secreted by the colostrum, and then is absorbed by the infant[54]. Additionally, gastric leptin is involved in early CCK-mediated effects activated by food intake[48]. Bado noted that feeding and administration of CCK-8, a digestive hormone, results in a rapid and large decrease in leptin cell immunoreactivity and leptin in the fundic epithelium, while increasing leptin plasma levels[48]. This suggests that changes in gastric and plasma leptin levels in response to food intake are involved in the short-term regulation of appetite[44]. Overall, each of these syntheses of leptin is stimulated by hyper-glycaemia or hyper-lipidaemia indicating that leptin does indeed act as a sensor, responding to nutrient influx in adipose tissue and skeletal muscles[49].

Once synthesized, leptin circulates as a 16-kDa protein to trigger a signal of fullness[55]. In heavy individuals with more adipose tissue most leptin circulates in free form, as a bioactive protein. While in lean subjects with less adipose tissue most circulating leptin is in the bound form, which makes it less available to bind to brain receptors to inhibit food intake[56]. Leptin enters the brain through saturable transport mechanisms and binds to a soluble Leptin receptor (LepR/Ob-Re)[45 56]. It is most closely associated with the hypothalamic arcuate nucleus (ARC) and leptin-sensitive neurons are present in the arcuate, ventromedial, and dorsomedial hypothalamic nuclei[44]. There are two forms of the leptin receptors (leptin sensitive neurons) that each function with varying molecules to trigger a signal of satiety in the brain[57 58].

Leptin is a complex hormone, and therefore requires two main forms of receptors to fully transport signals to the brain. The first population, the long form leptin receptor, is colocalized with STAT3 and neuropeptide mediators like neuropeptide Y (NPY), agouti-related protein (AgRP), proopiomelanocortin (POMC), a precursor of a-melanocyte stimulating hormone (a-MSH), as well as "ob-R-containing neurons of the parvocellular paraventricular nucleus and lateral hypothalamic area"[57 58]. The second population, short leptin receptors, is strongly expressed in microvessels, the choroid plexus, and leptomeninges[59], as well as vascular endothelium, and peripheral tissues including the kidney, liver, lungs, and gonads[58 59]. Once leptin binds and sends the appropriate signals, it is cleared mainly by the kidney, which expresses high amounts of obRa, an enzyme for receptor-mediated degradation of leptin[60]. Leptin is then filtered by the glomeruli and is thought to be degraded by renal epithelial cells[55]. All these mechanisms help to distribute leptin through various tissues, and in the brain so that it can bind to the appropriate receptors and send signals of satiety.

Satiety Signals: POMC, MSH, MC4 & PYY

POMC, MSH, MC4, and PYY all work in the body to signal that the body is satisfied, to prompt a decrease of food intake. The MC4 receptor, a g-protein-coupled melanocortin receptor in the hypothalamus, provides a crucial inhibitory tone to prevent food intake. With a disruption of the MC4 receptor, large increases in body weight, adipose tissue, and food intake have been found[35]. POMC, including MSH, and CART are expressed in the lateral arcuate nucleus [61]. An injection of alpha-melanocyte stimulating hormone (α-MSH), a precursor protein of POMC, works as an MC4 agonist. Alternately, POMC deletion and selective deletion of leptin receptors within POMC neurons will result in an obese, ob, phenotype[58]. Indicating POMC's proper function as a key component in the catabolic system that decreases food intake and lowers body energy stores[35]. ASP, agouti signaling protein, and AgRP, agouti-related protein found almost exclusively in the arcuate nucleus, have been found to be antagonists for a-MSH at MC4 receptors making it orexigenic. In contrast to ghrelin, the gut hormone PYY_{3-36} is secreted into circulation after meals. It acts as an NPY-Y2 receptor antagonist, causing a reduction in food interest and intake[62] and works by increasing POMC firing[62] [63]. Each of these molecules work to maintain the body's homeostatic relationship with weight by signaling the brain that the body is full.

Hunger Signals: NPY, AgRP, MCH, & Ghrelin

In contrast to satiety hormones, NPY, AgRP, MCH, and ghrelin, all contribute to increasing ones feeding response. NPY and AgRP are expressed in the medial arcuate nucleus[64] [65]. A central injection of either NPY or AgRP leads to a profound increase in food intake, and acute ablation of these neurons has been found to lead to hypophagia and weight loss in

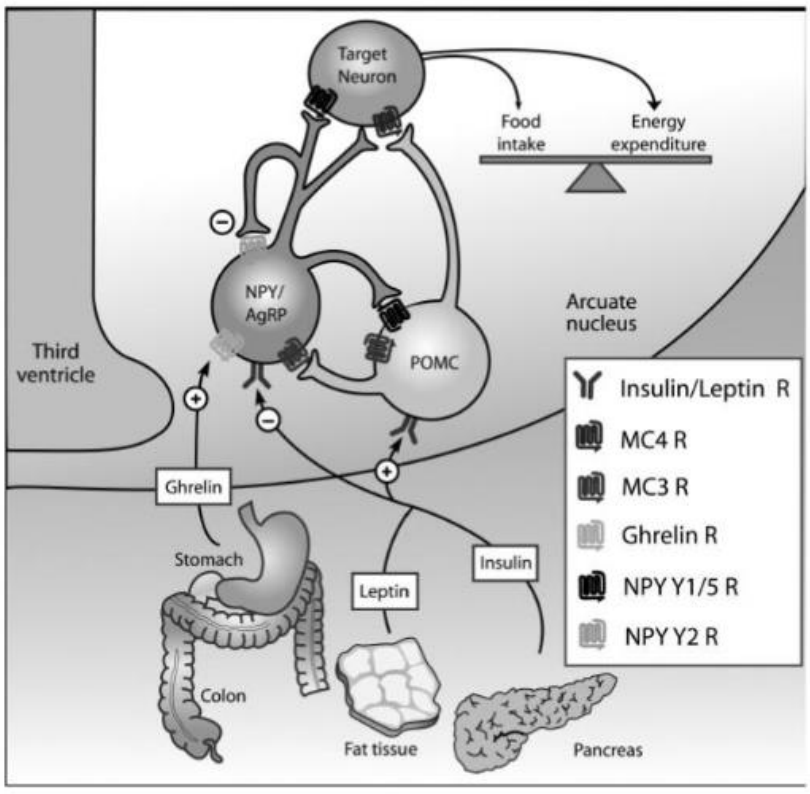
animals. This indicates the importance of NPY and AgRP neurons in food intake, and leptin's actions[66]. Interestingly it has been found that Neuropeptide Y (NPY), a 36-amino-acid neuromodulator greatly expressed in the brain, is important in regulation of food intake and body weight[65]. Data suggests that "NPY's stimulatory effect on appetite is transduced by the g-protein-coupled NPY-Y5 receptor (Y5R)" [67]. Although deficiency of NPY or its receptors has not been found to reduce feeding behavior, prevent weight gain, or responsiveness to leptin[65], leptin is found to inhibit NPY[67]. Notably the chronic administration of NPY into the hypothalamus of normal animals will mimic phenotypic effects of leptin deficiency, including obesity, hyperphagia, reduced thermogenesis, decreased fertility, and inhibition of growth hormone production. As a result, it appears NPY contributes to hyperphagia, obesity, and neuroendocrine abnormalities[64].

AgRP is co-expressed with NPY to increase appetite, while decreasing metabolism and energy expended. AgRP is only synthesized in cell bodies that contain NPY in the ventromedial arcuate nucleus, and is one of the longest lasting appetite stimulators, encoded by the AGRP gene[68]. Additionally, AgRP neurons strongly inhibit POMC neurons[69]. MCH, melanin concentrating hormone, expression is increased with fasting[61], and intracranial MCH administration has been found to produce a reliable increase in food intake[35]. In contrast, MCH deficiency can cause hypophagia and failure of weight gain, in agreement with its suggested role as an orexigenic peptide, as these have signals notable with those that limit food intake[61].

As food intake greatly involves your gut, there are additional hormones that are important in the arcuate nucleus of the hypothalamus, and the melanocortin system, MC[35]. Specifically, ghrelin, a 28 amino acid peptide hormone, produced mainly by the stomach, has

been discovered to increased food intake. It is an endogenous ligand for the growth hormone secretagogue receptor (GHS-R), and potentially stimulates growth hormone, GH[39 70 71]. Within the hypothalamus, ghrelin is bound mostly on presynaptic terminals of NPY neurons, stimulating the activity of arcuate NPY neurons and mimicking the effects of NPY, specifically in the paraventricular nucleus of the hypothalamus (PVH)[63]. Additionally, ghrelin decreases the activity of POMC and increases the activity of AgRP neurons[62 63]. Each of these molecules work to oppose the actions of leptin and contribute to our body's homeostatic maintenance of weight.

Anabolic and Catabolic circuitry of the Arcuate Nucleus of the Hypothalamus



(Stricker & Woods, pg 118 2006)

Insulin and glucocorticoids

Interactions of leptin with insulin and glucocorticoids have been noted to regulate the expression of similar neuropeptides in parts of the brain implicated in feeding behavior and body weight regulation. Glucocorticoids have been found to stimulate appetite, despite increased leptin levels, for they interfere with leptin actions, but are partially independent of NPY[72] [73]. Insulin has been found to have an additive effect with leptin, and shares neuropeptide signaling pathways. Insulin can therefore reduce food intake in similar ways to leptin[74].

Leptin, Satiety, and Hunger Signals

Satiety and hunger mechanisms all effect feeding behavior and energy metabolism. Ghrelin releases substances like NPY, AGRP, and MCH, which stimulate food intake as their levels increase with leptin deficiency; whereas Leptin, MC4, PYY, POMC, and MSH, anorexigenic peptides, each work to decrease food intake[34] [75]. The signals of varying hypothalamic

Partial List of Hormones & Neurotransmitters Reported to Act on the Hypothalamus to Alter Food Intake and/or Body Weight (Stricker & Woods, p120, 2006)

Anabolic	Catabolic
Agouti-Related Protein	α-Melanocyte Stimulating Hormone
Beacon	Amylin
β-Endorphin	Ciliary Neurotrophic Factor
Corticosterone	Cocaine- and Amphetamine-Related Transcript (CART)[a]
Dopamine	Corticotropin Releasing Hormone
Dynorphin	Galanin-Like Peptide
Endocannibinoids	Glucagon-Like Peptide 1
Ghrelin	Glucagon-Like Peptide 2
Interleukin-1 Receptor Antagonist	Histamine
Melanin Concentrating Hormone	Insulin
Neuropeptide Y	Interleukin-1
Norepinephrine	Interleukin-2
Orexins/Hypocretins	Leptin
	Neurotensin
	Oxytocin
	Prolactin-Releasing Peptide
	Serotonin
	Tumor Necrosis Factor-α
	Urocortin
	Urocortin II
	Urocortin III

neuropeptides and neurotransmitters, along with many more, including corticotropin-releasing hormone (CRH), cholecystokinin (CCK), glucagon-like peptide-1 (GLP-1), urocortin, bombesin, and serotonin,[44] help to mediate how one's body interprets fullness and hunger.

Overall, all these neuropeptides, neurotransmitters, molecules, and hormones help us to better understand how our body's maintain weight and food intake. The hypothalamus is the key in the control of hunger and fullness, as it contains the lateral hypothalamic nuclei, the "hunger" center, and the ventromedial nuclei, the "satiety center"[34]. The peripheral and central modulators are the neural, mostly vagal, and humoral inputs that act through specific receptors in afferent nerves and hypothalamic neurons. This process affects the ARC and causes a physiological response in the body that regulates adiposity signaling, appetite, satiety, and ultimately food intake[34]. These circuits and many more are understood to be important in regulating intake and resource utilization in the body.

The neurobiological mechanisms referenced above suggest there are different thresholds for leptin synthesis for various functions, and responses to physiological alterations in leptin. Importantly, one must note that all these physiological functions are in place to stop one from losing or gaining too much weight[76]. The body already has a homeostatic system in place that performs the actions for which people presume diets are needed. Dieting presents a multi-model problem for the body as restriction of food intake causes a vast amount of circuits in the body to respond in order to compensate for this decrease[77]. The body does not understand what dieting is. Therefore, decreasing energy intake and losing weight will put the body into a stage of deprivation and starvation, increasing activation of hormones like ghrelin, and causing one's homeostatic regulation supported by leptin to be thrown out of balance. As a

result, once dieting ceases, the body will not simply return to its original homeostatic state but must again respond to an increase in food intake, often causing one to regain lost weight and even put on added weight. Ultimately, this increased understanding of the biological mechanisms of hunger and satiety in the body stand to argue for a more wholistic and connected approach with our bodies. This requires one to be attuned to hunger and fullness cues presented through these mechanisms in order to have a healthy relationship with food, and a healthy lifestyle.

SOCIETY'S APPROACH TO FOOD

The mechanisms of why we feel hungry and full are well known, yet today many people often try to manipulate their biological cues in an aim to control their weight. Starting with the BMI, introduced to insurance companies in 1972 by Ancel Keys[28], there has been an increased focused on the fat that is on one's body in relation to health. Today many people choose to manipulate their weight in an effort to be "healthier", "more fit", "leaner", etc. as that is often what is publicized to many people as the thing they should be doing. Yet when one diets to achieve an advertised "healthier life", how can one be sure that a diet is not hurting them? Having assessed the neurobiology of how hunger and fullness work it is important to acknowledge our common understanding of a healthy diet, and then assess the negative effects that can come when food intake is manipulated with dieting.

What should we eat?

Today, the USDA suggests five main food groups: fruits, vegetables, grains, proteins, and diary with an emphasis on oils[78]. As the USDA is a universally excepted organization, their

suggestions provide a good basis to explain what one should be eating, yet the classifications and divisions may vary based on which source you consult. When one takes into consideration what one is eating every day, they should try to intake each of these groups at an amount appropriate for one's size, age, weight, and sex[79]. First fruits are highlighted, where any fruit or 100% fruit juice can count towards the 1-2 cups recommended per day. Similarly, nutrients from vegetables, the second group, can be obtained through 1-3 cups per day of any vegetable or 100% vegetable juice. Third, the USDA recommends 5-8 ounces of grains per day which include wheat, rice, oats, cornmeal, barley, and other cereal grains. Fourth, one should have proteins in their diet. The USDA separates proteins into two categories of proteins and dairy, but they can be combined to include "All foods made from meat, poultry, seafood, beans and peas, eggs, processed soy products, nuts, seeds, and any milk products". It is recommended that one has 2 to 6 ounce-equivalents of non-dairy proteins, and an average of 2-3 cup equivalents of milk proteins per day. Lastly, oils and fats are noted[78]. Although the USDA does not qualify them as an official group, they do say that oils and fats should be consumed in a range of 5-6 teaspoons a day for the average adult, and can include any oils, and things like salad dressing, some condiments, avocados, and nuts. Each of these foods are needed by the body for the neurobiological systems in the body to maintain proper function and maintain a homeostatic environment[79].

When addressing what one should eat, it is important to address two current myths of food culture associated with carbohydrates and oils/fats. Often it is assumed that carbs and fats are not good for our bodies, but that is simply false. Carbohydrates are one of the three macronutrients required by your body to maintain energy. Although society has labeled carbs

as bad, the U.S. National Library of Medicine and the American Diabetes Association note that the main purpose of carbs in one's diet is to provide energy to your body[80]. As your brain uses 20% of your energy stores, carbohydrates are critical in brain function. Additionally, it has been noted that foods with whole grains are associated with a reduced risk of obesity, T2D, and CVD[81 82 83]. Your body turns all three types of carbs: sugars, starches, and fiber into energy and without them your body will consume protein as fuel, which can break down muscle and bone[80]. Additionally, refined grains, such as white bread and white rice, are not necessarily worse for you than whole grains, as long as you incorporate both into 5-8 ounces of grains per day[79]. Refined grains are more highly processed which causes them to lose some fiber, iron, and B vitamins, but most refined grains are enriched with vitamins and iron. Like carbs, we also need oils and fats in our diets as they provide essential fatty acids and nutrients to our bodies that we cannot internally manufacture[84]. The body requires both carbohydrates and fats to function, and therefore they should never simply be cut out or significantly limited in a diet.

Overall, the common consensus on a healthy diet required to maintain a healthy body is to consume about 5 fruits and vegetables a day with 1-2 ounces of grains per meal, and 2-4 ounces of protein, incorporating meats and dairy products. Additional fats and snacks should also be structured in 2-3 times a day to complete any remaining food requirements[78]. Complimentary to this suggestion is the suggestion that colorful foods and a variety of carbohydrates, lipids, proteins, minerals, and vitamins are all crucial in a well-balanced diet.

An imbalanced relationship with food: Disordered eating and Eating Disorders

Society has long since placed an importance on body size, starting with the prevalence of the BMI, and continuing with scientific investigations into the detrimental effects of

obesity[85]. Pressures including sociocultural factors (media and peer influences), family factors (enmeshment and criticism), negative affect, low self-esteem, and body dissatisfaction all manifest from this increased emphasis on body size[86]. Psychological factors in relation with the practice of dieting can manifest into eating disorders when one does not intake enough of the food their body requires, intakes an excessive amount of food, or uses alternative methods to dispel unwanted foods from their bodies.

These disordered eating practices can be identified and evaluated through the Eating Pathology Symptoms Inventory (ESPI), and the DSM5 in combination with consultation from care providers[87]. The EPSI is one of the common inventories to help assess eating pathology systems to see if they have manifested beyond disordered eating, into an eating disorder[87]. The DSM5 has eight classifications of "feeding and eating disorders" along with diagnostic criteria to assist health professionals in diagnosing these disorders. The eight classifications include[88]:

1) Anorexia Nervosa (AN)
2) Avoidant/Restrictive Food Intake Disorder (ARFID),
3) Bulimia Nervosa (BN)
4) Binge Eating Disorder (BED)
5) Pica
6) Rumination Disorder (RD)
7) Other Specified Feeding or Eating Disorder (OSFED)
8) Unspecified Feeding or Eating Disorder (UFED).

The primary eating disorders include anorexia nervosa, binge eating disorder, and bulimia nervosa, yet all other eating disorders are just as serious and harmful to the body. Anorexia nervosa is categorized by restriction of energy intake, and a fear of gaining weight which leads to restricted eating and weight loss[89]. Binge eating disorder is categorized by a lack of control over a short period of severely increased eating that occurs repeatedly[89]. Bulimia nervosa is categorized by a period of overeating followed by induced vomiting[89]. Most recently,

orthorexia has gained importance as society partakes in dieting. This is not formally recognized in the DSM5 but is noted as a form of disordered eating. Orthorexia refers to one becoming so focused on "healthy eating" that they are actually damaging their body[90]. All these disorders illustrate the ways society's emphasis on "being thin" and dieting as a requirement to be healthy, can lead to an imbalance in the body's ability to regulate weight and can manifest in dangerous health consequences.

Are diets good for you?

In today's society there are many conflicting messages about what is good to eat and what one should eat. Weight loss has become a major obsession for the US population, as overweight and obesity rates have increased steadily[91]. Approximately one third of American's are classified as overweight as of 2014[92]. This has created the idea that excess weight is the problem since it has been correlated with increased mortality[93], morbidity[94], and an increased rate of other diseases such as CVD, T2D, and hypertension[95]. These correlations paint excess weight and obesity as unhealthy, contributing to how our society stereotypes weight as bad, and can negatively effects those in larger bodies. Yet it is important to note that these are correlations, and do not necessarily imply causation, as excess weight is never the sole reason for any of these diseases[24 25 30 31 35]. At the beginning of the 21st century, these correlations contributed to the suggestions that low-fat, low-calorie diets were the best solution in solving these problems[91 96]. Today research is pointing in a different direction, but the misplaced stereotypes implanted by these early suggestions are often still the go to motivation and solution for those trying to lose weight.

Obesity is caused by the consumption of excess calories, which can be viewed as a failure of the homeostatic systems that control body weight and energy balance[97]. Therefore, the common solution to decrease body weight is to decrease calories, otherwise known as "dieting". Yet with so many resources available, the intention to be healthy is often difficult[98] [99] as many diets are actually unsafe, unsuccessful, and can lead to further harmful effects even if properly followed. Often people are driven to diet because of medical and social pressures[98]. Additionally, the newer concept of "thin privilege" has created a process of exclusion and marginalization of those in larger bodies, which has further negative impacts on those who are considered overweight[100]. It is important to assess the effects that societal stigma of weight has on those in larger bodies to address the consequences of dieting, and to demystify the concept that going on any diet is a good thing.

SO, WHAT IS WRONG WITH DIETS?

With information from the USDA, and other sources similar to it, we know that grains (carbohydrates), proteins (vitamins, minerals, amino acids), fruits and vegetables (vitamins and minerals), and fats/oils (lipids) are all important in a balanced diet[78]. This assumption suggests that diets which propose weight loss by excluding any of these groups may be faulty and not a healthy choice. This claim is one that is not easily accepted among many, therefore an analysis into how diets work in the body and ultimately affect the body over a long period of time is critical. I will do this by looking at one of the first "starvation experiments" and then will assess the validity and successfulness of the Keto and Paleo diets in relation to the long-term effects of dieting. This assessment can provide a better understanding of what is normal eating and why

restricting food intake below what one's body requires for fuel (dieting) is not healthy or safe for a person's body.

The Minnesota Starvation Experiment

In introducing this topic, it is interesting to note a study from World War II that has been noted as one of the first studies to investigate human starvation, called the "Minnesota Starvation Experiment"[101]. This study helped to give insight into physical and psychological effects of semistarvation to address the refeeding of civilians who had experienced starvation during the war. An analysis of this study has helped further our understanding of how people's bodies deal with a significant decrease in their diet, similar to what one would experience when they embark on a diet. During this experiment 32 individuals experienced an average diet cut of 50% of their caloric intake going from around 3,000 to about 1,500 calories a day[101]. The original study ran 24 weeks, resulting in most participants loosing 25% or more of their body weight. Many reported anemia, fatigue, apathy, weakness, irritability, neurological deficits, depression, and edema[102]. Refeeding and rehabilitation of the patients was then run for 12 more weeks after the original deprivation period[101 102]

A 57-year follow-up investigation and review of this study and its relevance to eating disorders was performed by Dr. Eckert and his team in 2018[103]. Here 19 out of the 36 male participants were further evaluated for long term effects as a source of information for understanding eating disorders[103]. The aim of this analysis was to re-examine the acute effects of 24 weeks of restriction and examine the relevance of the "starvation induced symptomatic changes" in regards to eating disorders and disordered eating[103]. Overall, once all candidates were interviewed, it was noted that reestablishment of normal body weight took significantly

longer than expected, and "many participants reported maintaining a higher than normal weight and had abnormal eating habits for many months and even years before returning to a normal state"[103]. Six of the 19 interviewed experienced binge eating in rehabilitation, and body fat was restored to above what it was before the study had begun[103]. We can use this study, in conjunction with others, to report the overall effect of starvation over an extended period of time, as having clear negative impacts on the human body.

Starvation in this study was noted as eating around 1,500 calories per day, which when compared to diets of today, is what many people consume when they are on various diets. This study suggests that once one goes on a diet and then returns to normal eating habits, their body would gain weight and return to the state they were in before the diet began, and possibly even gain back additional weight. These findings support results found by researchers at UCLA in 2012 when they complied the 20 best and longest studies to analyze the changes in weight that had occurred[104]. They found short studies, 2-3 years in length, resulted in an average of 0-5kg of weight loss. The further the study ran beyond three years, the less likely the subject was to keep the weight off. Studies that ran for 8-10 years had significant drop out rates, presumably because the diet could not be maintained, and participants were found to have gained the weight back.

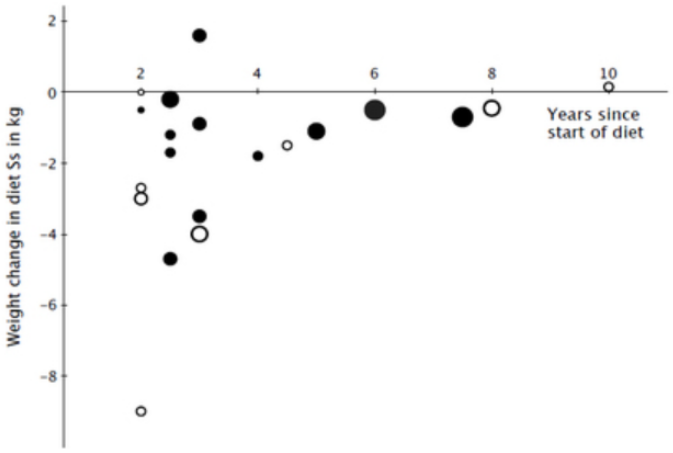


Figure 1. Average weight change among diet subjects in 20 studies by length of follow-up. The symbol size (smallest to largest) indicates starting sample size: <100, <200, >200, >1,000, and >10,000. Solid circles indicate <20% drop out rate. Open circles indicate >20% dropped out rate. (Tomiyama, A. J., Ahlstrom, B., & Mann, T. 2014)[105].

These studies support the increasing evidence that weight loss interventions are not as helpful as one may assume and can even be associated with negative outcomes, including but not limited to: weight cycling[106], increased risk of osteoporosis[107], increased chronic psychological stress and cortisol production, increased anxiety about weight[108], eating disorder behaviors, weight gain in the long term[106], and weight stigma. Many articles and sources highlight the negative aspects of dieting. Therefore, before one decides to go on a diet, they should assess the foods they will be restricting to understand how improper fueling of their body could appear beneficial in the short term while really being harmful in the long term.

Popular diets: Keto and Paleo

In today 's culture there are many diets and diet programs that have become prevalent and then phased out over the years. It is important to note that if one chooses to be Vegetarian or Vegan and follow a plant-based diet that it is different than a fad diet that is promoting weight loss. As one can still meat all their basic fuel and energy needs without consuming

animal products but must be conscientious to still obtain the appropriate nutrients as higher intake is often required from these lower fuel foods[114].

Today, two popular and more general diets that are often seen as ultra-healthy, and the best way to control weight are the Paleo diet and the Keto diet. The Paleo diet draws people in by suggesting that we should eat as our ancestors did in the paleolithic era, emphasizing increased consumption of lean meats, fish, shellfish, fruit, vegetables, eggs, nuts, and seeds while excluding grains legumes, cereals, dairy, processed foods, refined sugars and salts[109]. This diet has been cited by many as having great short-term health benefits, hence its popularity among many. Yet there have been no long-term studies of large groups of people who have followed the current version of the Paleo diet to assess the impact on health by excluding two of the main food groups from one's diet[110].

Sources and studies, including the Mayo Clinic, site the major dietary concerns in excluding whole grains and dairy products from one's diet as they provide key nutrients to our bodies including fiber, vitamins, protein, calcium, and other nutrients[110]. Additionally, we should be cautious to not eat as our paleolithic ancestors did because the Paleolithic era spanned 2.5 million years and involved a great variety of peoples with a great variety of dietary needs, who are genetically different from us today. Studies into the Paleo diet have noted that it is associated with unfavorable changes to blood lipids in previously healthy individuals as it promotes saturated fats in large quantities[111]. Health professionals should be wary of this diet as it leads to inadequate calcium intake and low fiber[112]. Additionally, studies which investigated its benefits for people with T2D have been found to be inconclusive and cannot support the claims that the Paleo diet makes[113].

Diets that have come from the Paleo diet such as the recently trendy "Whole 30" diet should be avoided for the same reasons. Sharon Palmer RDN, nutritionist, and author of The Plant-Powered Diet, sites five major issues with this diet. Stating that it interferes with digestion, can induce food insensitivities, increase food cravings, heighten one's risk of chronic disease through malnutrition, and is simply not sustainable[114].

Along with the paleo diet, the keto diet has also been an attractive diet, as it is one that can boast of fast weight loss through restriction of grains, fruits, many vegetables, plant proteins, many nuts, and meats, while increasing fat intake. This aims to drive the body into "ketosis", a mild form of ketoacidosis[115]. Yet what is not understood about this is that ketosis is a survival mechanism our bodies will induce to provide us nutrients in the short term in states of famine. The initial weight loss is often achieved through water loss through loss of glycogen from loss of carbs and can induce fatigue, diarrhea, ketoacidosis, and loss of muscle mass[116 117]. Studies supporting this diet do not provide evidence of positive long term effects, and can even be harmful to the body says Dr. Katz, MD, director of the Yale-Griffin Prevention Research Center[43] and can lead to increases in binge eating and a dysfunctional relationship with food.

The Paleo, Whole 30, and Keto diets are all examples of diets that should be avoided as their claimed benefits are not supported with scientific research. Each of these diets induce varying starvation responses in the body which cause the hypothalamus, lateral hypothalamic nuclei, the "hunger" center, and the ventromedial nuclei, the "satiety center",[34] to be effected. Improper nutrients to the brain not only damages brain function, but also causes these centers to deviate from typical hormonal expression in respond to a lack of resources[118]. The evidence

in support of the harmful effects of these diets shows why they are not actually heathy to pursue.

CONCLUSION: WHAT IS NORMAL EATING?

Normal eating is eating free of the restrictions of diets. Normal eating is not advocating for one to just eat everything all of the time, rather one should not restrict their food below what their body requires to meet their basic needs. Additionally, normal eating provides sustainable long-term health, which diets that exclude of any of the five main food groups and fats/oil, cannot provide. No one can diet successfully for their whole life and saying something is a lifestyle change verse a diet, does not make it any less of a diet. Many popular diets today, still label foods as “bad”, yet one can still enjoy those “bad” foods and be healthy, as your body is biologically wired to maintain a set point[119] and healthy weight[120]. I would encourage you to try to intuitively eat and to just “eat normal”.

Overall, normal eating, as put by Ellen Saturn[121], is “going to the table hungry and eating until your satisfied”. You can choose to eat foods you enjoy while giving some thought to nutritious foods, but not being so selective and restrictive as to miss out on enjoyable foods. Sometimes one will eat too much, and sometimes one will eat to little. Normal eating involves trusting that your body will make up for these “mistakes” in eating without feeling the compulsion to exercise, restrict, or binge. Normal eating is flexible and should not override your time and attention, rather your attention to it can vary in response to hunger, fullness, time, food availability, and even emotional state. There is no magic diet to make you healthier. Therefore, one should work to find a balance of all foods, and not feel restricted to a certain body size simply because society discriminates against large body types. Weight is not what

makes a body unhealthy in itself. Rather it is the food, and the lack of or excess of foods that one puts into their bodies that determines health. The best way to keep your body healthy is not to go Keto, take up the next fad diet to lose five pounds, or by eating a lot of one food group, while excluding the other. The best way to keep your body healthy is to adequately nourish your body with all foods in moderation, and to not focus on weight as a measure of health.

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