Obesity Theories

The Interaction Between Host and Environment

The emergence of the obesity epidemic has fostered considerable debate as to the particular circumstances that led to its development. How do we explain the growing population of individuals with excess adiposity when research also tells us that most adults exhibit fairly stable body composition — with weight cycling fluctuating within 2 to 5 kg of their typical weight. If there are genetic origins, why is it only now manifesting within the past few decades? If it is environmental, shouldn't everyone be obese?

Topics: Thrifty Gene Theory — Set-Point Theory — Neural Circuitry in the Hypothalamus — Social Learning Theory — Community Impacts — Epigenetics — Thrifty Phenotype Theory — Behavioral Influences — Theory of Effort Minimization

Thrifty Gene Theory — Some individuals may be genetically predisposed to more efficient fat storage and lower metabolic rates.

First put forth in 1962, the Thrifty Gene Theory suggests that a genetic tendency to rapidly accumulate/deposit fat would have been particularly advantageous to human survival. The presence of this gene/genetic tendency would enable accumulation of excess adiposity when food was in surplus that would allow the population to be more likely to survive when food became scarce. Interestingly, despite assumptions that food scarcity was a common environmental pressure for early humans; anthropological evidence suggests that famines and seasonal food shortages were rare in hunter-gatherer populations. However, with transitions from hunter-gatherer to agrarian societies, famines and seasonal food shortages became more commonplace. As a result, passing on such genes to enable more efficient fat storage and lower metabolic rates represented a critical need.

However, the Thrifty Gene Theory actually argues that **the genetic advantage is not in protection from starvation**. Anthropological evidence indicates that famines and seasonal food shortages have relatively little impact upon mortality. Reproductive fertility on the other hand appears particularly sensitive to famines and seasonal food shortages. Since conception rates are reduced in association with declining maternal energy status, **the genetic advantage of the thrifty gene is in enabling individuals to continue to reproduce**

when others without such genes become infertile.

Despite the relatively short period in which humans have lived within agricultural societies (around 12 thousand years); alterations in fertility have enabled the thrifty gene to exert selective pressure on the human genome. The extent to which this is manifested as a single mutation on one gene or dozens of minor mutations on many genes is still unknown. The important point however, is that storage of excess adipose tissue and lower metabolic rate is ultimately in service of promoting fertility (survival of the population), rather than survival of the individual.

The central criticism of the Thrifty Gene Theory is that it reflects an overly simplified model of how body composition is regulated that may inhibit a full understanding of how systems interact. Further, although this model does not actually argue that genetic factors are entirely responsible for an individual's body composition, the way it is traditionally characterized assigns a substantial portion of individual variation to genetic components. However, **genetic theories only suggest that as much as 25% of the risk of becoming obese is the result of genetic factors**. The remaining 75% of the risk is attributed to interactions between the host's behavior and the environment.

Set–Point Theory — An individual's fat storage and metabolic rate are dictated through a proportional feedback control system to align the body to a genetically programmed set-point.

The Set–Point Theory (sometimes referred to as the **Settling–Point**) attempts to explain why most individuals appear to have a relatively constant body weight/level of adiposity throughout their adult life. Although they may lose or gain weight/adiposity for a period, they fall back to that constant level eventually. The Set–Point Theory proposes that this 'constant level' reflects a genetically programmed set-point, that the body attempts to reach by adjusting food intake or energy expenditure (or both) in proportion to the difference between the current body weight/level of adiposity and the set point weight/level of adiposity. As a result of the body's set point, occasional over-eating usually does not result in weight gain and dieting is usually followed by rebound weight–gain.

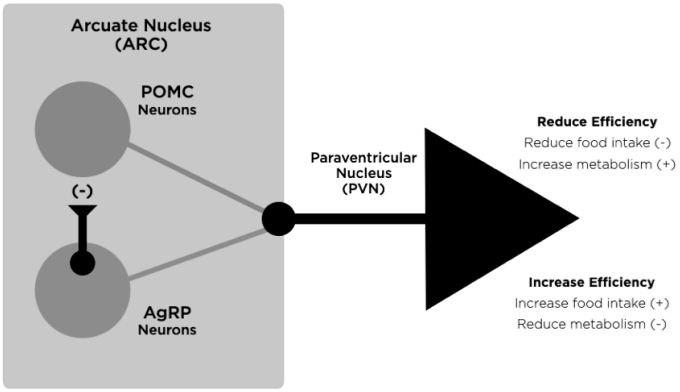
Findings from the classic Minnesota starvation study in 1950, which had participants reduce their energy intake by 50% for 24 weeks observed a 66% reduction in fat mass. However, once participants returned to an unrestricted diet, fat mass increased to 145% of their original levels (i.e., there was an overshooting of fat mass, known as the **catch-up fat phenomenon**). Since the set–point cannot distinguish between stringent dieting and starvation, the body reacts

by dramatically reducing the metabolic rate to conserve calories. This metabolic slowing enables conservation of existing adipose tissue during the dieting period and more rapid accumulation once food becomes available, and persists for a prolonged period following the stringent diet.

Participants in the Minnesota starvation study took nearly a year for fat mass to return to within 5% of their initial levels. One of the central mechanisms that is involved in this feedback control system originates from adipose tissue. As **leptin** is a hormone secreted by white adipose tissue, changes in the accumulation of white adipocytes are reflected by changes in the circulating levels of leptin. These alterations in leptin are detected by the hypothalamus and integrated along with other signals to regulate food intake and metabolism.

The **hypothalamus** is part of the limbic system and is located in the ventral (lower) portion of the brain just above the brainstem. The hypothalamus acts to orchestrate homeostatic functions (e.g., food intake, energy expenditure, glucose metabolism, and circadian rhythm) in response to changing internal and external contexts. Within the hypothalamus, the **arcuate nucleus** (ARC) integrates hormonal and metabolic signals (such as leptin, insulin, and glucose) as well as peripheral and central neuronal inputs to generate a coordinated feedback response. The **paraventricular nucleus** (PVN) of the hypothalamus then acts on the feedback response to alter energy intake and energy expenditure. Specifically, activation of **POMC neurons** within the ARC signal the PVN to reduce food intake and increase energy metabolism (become less energy efficient). Whereas, activation of **AgRP neurons** within the ARC suppress the activity of POMC neurons as well as signal the PVN to increase food intake and reduce energy metabolism (become more energy efficient). As leptin has an excitatory effect on POMC neurons and an inhibitory effect on AgRP neurons, increases in circulating leptin will result in compensatory reductions in the drive for food intake and increases in energy metabolism. Whereas decreases in circulating leptin will result in compensatory increases in the drive for food intake and reductions in energy metabolism.

Figure: Neural Circuitry in the Hypothalamus.



Genetically modified mice who lack or have low leptin levels, exhibit more frequent feeding, higher levels of insulin and body fat, and have low thyroid and metabolism levels. Interestingly, leptin primarily plays a role in protecting the body against fat loss. Injections of leptin typically result in minimal changes to body composition. However, in individuals who have lost substantial adipose mass, injections of leptin appear to enable the maintenance of the lower levels of adipose tissue.

Research on the role of leptin and other hormones led to the development of GLP peptides such as Semaglutide which have gained wide–spread public attention given their success in regulating appetite and metabolism. Although these drugs are still listed as in development, they have undergone phase 2 clinical trials and their mechanisms are quite well established. Semaglutide is a single agonist peptide that mimics the GLP–1 hormone that ultimately is excitatory for **POMC neurons** and indirectly inhibitory for **AgRP neurons** within the ARC. As a result, the ARC signals the PVN to reduce food intake and increase energy metabolism. Tirzepatide is considered a dual agonist peptide as it not only mimics the GLP–1 hormone but also acts upon another receptor within the ARC to increase the strength of the signal to the PVN to reduce food intake and increase energy metabolism. Triple agonist peptides such as Retatrutide build upon the dual agonist pathways but also mimic a hormone that activates receptors in the PVN (bypassing the ARC) to further strengthen signals to increase energy metabolism. Thus, while these peptides also have effects on other systems; their primary mechanisms each ultimately act upon the ARC–PVN pathways to alter food intake and energy metabolism.

Environmental Influences on Obesity

Although traditionally thought of as only encompassing the physical build environment in which a person lives, environmental influences on obesity represent a broad array of factors including parents/family, friends, social networks, economics, neighborhoods, green spaces, community resources, means of transportation, safety, food availability,

and food production (just to name a few). While genetic factors may alter an individual's susceptibility to becoming obese, understanding how and why environmental influences change risk profiles is essential to primary prevention efforts. Take for instance the evidence that there is a 50% chance that a child will become obese if they have one parent who is obese; but an 80% chance if both parents are obese.

Similarly, an individual's **social network** has been observed to play a role in altering their risk of obesity. Over a 32 year period, data from the Framingham Heart Study observed that an individual's risk of becoming obese increased by 57% if they have a friend that became obese, increased by 40% if their sibling became obese, and increased by 37% if their spouse became obese — accounting for potential influences associated with proximity in geographic location. So even when the individual has the autonomy over their life, the social networks that surround an individual appear to be influential over the adoption of behaviors that may result in obesity.

Social Learning Theory — Attitudes, values, and behaviors (attributes) are acquired through the process of socialization; where we interact with the environment, observe the attributes of others that serve as a reference of correctness, and attempt to reproduce those attributes.

To understand why parents, family, peers, and even extended social networks that we might never personally interact with influence our risk of obesity; we have to understand how we learn to be functioning members of society. Social Learning Theory encompasses a broad array of more discipline specific theories that attempt to explain how attitudes, values, and behaviors associated with a given social role or situation are acquired and refined (e.g., table manners, cultural customs, attitudes towards elders/individuals in authority, political views, appropriate school attire).

The essential principle is that through an individuals socialization with the environment, we are exposed to models of behavior — we see what others do and do not do, we see how certain behaviors are rewarded or reprimanded. We then form an internal reference of the **model** behavior that informs our own behaviors. As we reproduce those behaviors in a variety of situations, we continue to observe the behaviors of others and how our own behaviors are **reinforced** (rewarded or reprimanded). Through this interactive process we refine our attitudes, values, and behaviors to fit the particular environment we are in. Interestingly, we do not have to consciously engage in this learning process — although we can be cognitively engaged in this process or make deliberate choices to deviate from modeled behavior

to meet desired goals. Often, however, this is reflected in adopting a new 'model' that better aligns with the given social role we aspire for or situation we are responding to.

Application of social learning theory in the case of social environment related influences on obesity risk suggests that as we interact with parents, family, peers, and even extended social networks we are exposed to their attitudes, values, and behaviors. Through the social learning process we begin to incorporate aspects of their obesogenic (tending to cause obesity) behaviors into our idealized model of behavior and begin reproducing some of those same behaviors. As a child we may have limited ability to deviate from the behaviors of our parents and family as the economic status of the family, availability of and exposure to activities, and availability of and exposure to healthy food choices all fall outside of the direct control of the child. But those patterns of habitual behavior set and reinforce the model behavior for the child. Similarly, even as an adult we are driven through social comparison to exhibit behaviors in an effort to 'fit in'. So as we adapt our own behaviors to match the behaviors within the social environment; we may unintentionally be incorporating obesogenic attitudes, values, and behaviors that result in our increased risk.

Community design has emerged as a particularly relevant factor in understanding regional differences in obesity rates as well as for attempting to intervene in obesity related morbidity. Consider the stories your grandparents told you about having to walk to school every day, uphill both ways, in the 100 degree heat, pouring rain, and freezing cold (likely all on the same day if they lived in Michigan). As community designs have transitioned to center around cars instead of walking or biking, for most individuals walking or biking to school is not an option. Compounding this, over 90% of elementary schools do not provide daily opportunities for physical education, and nation wide states and school districts have drastically reduced the amount of time allocated for physical activity even in the form of recess. Communities have chosen to invest in subsidizing 'strip–mall' development making available a larger number of 'quick'/'fast' food establishments while also failing to invest in parks and recreation centers. As a result, some communities have created the perfect environment for obesity to thrive.

From a health equity standpoint, **socioeconomic status** is also a particularly problematic environmental factor. Socioeconomic status is a strong predictor of obesity such that being overweight has replaced malnutrition as the most prevalent nutritional problem for poorer individuals. This is attributed to a number of factors surrounding food (however it is important to note that economically disadvantaged areas also have decreased access to medical care and screening services which also play a role). In particular, a healthy basket of food has

been found to cost more in disadvantaged economic areas than in affluent areas. This is often attributed to simply supply and demand, in affluent areas there are a wider assortment of supermarkets that must compete so they supply food at lower retail cost. While in disadvantaged economic areas, local residents may only have a single small market to supply food. An often overlooked issue is that community design often restricts the ability of economically disadvantaged individuals to shop outside of small geographic areas as a result of lack of transportation, the time necessary to travel, and delivery restrictions. Additionally, a criticism of the food industry has been the trend to market high–volume, low–quality products with higher fat and sugar content to economic sectors with less purchasing power. When faced with making the economic choice of spending more money for a small quantity of healthy food vs spending less money for a large amount of unhealthy food, the unhealthy food is often the only realistic choice. In particular, individuals who have lesser food security, indicating poorer availability and access to food, have higher incidence of obesity than those with greater food security. Beyond this, in contrast to popular stereotypes, children in disadvantaged economic areas tend to participate less in physical activities in and out of school.

Epigenetics — Behaviors and environmental exposures can cause small changes in the way genetic information is expressed.

Thrifty Phenotype Theory — Exposure to inadequate or fluctuating nutrition during early pregnancy and development results in the generation of adaptive methods to increase energy efficiency.

A central focus of research over the past two decades has been on how the specific environment an individual is exposed to may alter the way their genetic information is expressed (without changing the underlying genes). This research has specifically attempted to help explain individual variation in sensitivity to obesogenic environments by using rodent models which enable studying the influences of maternal and early life exposures on genetic expression within genetically identical individuals.

In rodents who are genetically susceptible to diet–induced obesity, consuming high caloric diets while pregnant resulted in an upregulation of gene expression in the pup at birth that resulted fetal overgrowth, glucose insensitivity, and leptin dysregulation. Thus offspring born to mothers consuming high caloric diets while pregnant were heavier at birth and continued to accumulate excess adipose tissue during

development. In contrast, consuming very low caloric diets while pregnant resulted in low birth weight of the pup, but those pups exhibited more efficient accumulation of adipose tissue and lower metabolic rate; compared to those born to mothers who consumed normal caloric diets during pregnancy.

Such **fetal–adaptive responses** associated with both maternal over– and undernutrition appear to result in permanent (or at the very least persistent) changes in the hypothalamus and metabolism to increase energy efficiency. Similarly, in humans examination of population level data following the Dutch famine in 1944–1945, observed that exposure to famine conditions (reduction in food rations from 1800 calories per day to 580 calories per day) during the first and second trimesters of pregnancy was associated with an increased risk of obesity for the infant 20 years later. And epidemiological studies have suggested that maternal undernutrition results in lower birth weight but greater risk of becoming obese later in life.

Although much of the focus on epigenetics has been on environmental exposure in utero or early in development, it is important to acknowledge that changes in gene expression occur throughout the lifespan and at different developmental stages. Similarly, despite a particular focus on maternal influence, evidence suggests that there are potential epigenetic effects arising from paternal contributions as well. In particular, it appears likely that alterations in gene expression are also passed down generational lines and result in more dramatic alterations in expression if persistent environmental or behavior characteristics are present for more than three generations. Thus, if a family is exposed to consistent environmental pressures or exhibits a consistent need for certain behaviors for three successive generations, it is advantageous to bring on–line more permanent adaptations or dramatic changes to support the context in which the family lives.

Behavioral Influences on Obesity

Beyond genetic and environmental influences, behavioral lifestyle choices also play a critical role in the risk of obesity. The central framework of behavioral perspectives on obesity revolve around patterns of behaviors and decision making over **food consumption** and **physical activity**. While these undoubtedly relate to environmental influences, at the end of the day the individual makes lifestyle choices over what they do and what they eat. From a historical perspective, there appears to be consistent evidence of changing lifestyle behaviors. In particular, there has been a dramatic rise in **food away from home**. In the 1950′s approximately 18% of food spending occurring outside of the home. By the 1980′s, approximately 27% of food spending occurring outside of the home. And in 2003, meals prepared outside the home

accounted for 53% of total food spending.

Problematically, the portion sizes of food away from home within the U.S. is four times what it was in the 1950's and twice as large as the 1980's, with a single meal eaten away from home now accounting for nearly two–thirds of the daily recommended calories. Beyond portion sizes, there are also historical changes in the U.S. related to the nature of the foods consumed; with reductions in the consumption of 'green' vegetables and legumes, and increases in the consumption of sugar and sodium. In the 1950's, snacks accounted for less than 10% of total daily calories, with over 70% of adults in the 1970's snacking only a single time or not at all during the day. In 2007, over 70% of adults snack at least two or more times a day, with 18% snacking four or more times per day. As a result, snacks now represent nearly a third of the daily recommended calories.

Unfortunately historical trends in physical activity behaviors also indicate reductions in general levels of activity. Much of the changes in physical activity behaviors over the last century reflect alterations in occupational levels of physical activity as individuals have moved from agricultural, to factories, to commercial industries. As a result within the U.S., adults now engage in 33% less occupational physical activity then they did in the 1960's. Similarly, transportation related changes from horses, to bikes, to automobiles have reduced physical activity associated with transportation by nearly 15% over the last few decades. While overall active leisure–time physical activity has increased population wide, nearly 25% of children and 40% of adults report engaging in no leisure–time physical activity. Within the U.S., the vast majority of the population fails to meet minimum physical activity recommendations.

Theory of Effort Minimization — There is a dominant behavioral tendency to minimize energy expenditure and maximize energy intake.

The theory of effort minimization attempts to explain societal level changes in behavioral patterns as representing a behavioral bias. From a biological standpoint, there is an innate drive for energy conservation. As such, there is a strong tendency to favor behavioral actions that result in excess food intake with minimal energy expenditure. Consider that for much of human history, the hunter-gatherer lifestyle required excessive energy expenditure to reap relatively minimal energy intake. As such, humans needed to adapt highly efficient means of locomotion, energy storage, and metabolic processes to compensate. These same compensatory processes also encouraged a bias in behavioral patterns

to minimize excess energy expenditure.

Within an environment that requires excessive energy expenditure to obtain food, minimizing unnecessary expenditure of energy while maximizing energy intake reflects a highly efficient behavioral state that incurs a biological advantage (survival, reproduction). It is only now that environmental changes have drastically reduced the energetic needs of procuring food while also increasing the energetic density of those foods that this behavioral bias has become maladaptive. So the theory of effort minimization suggests that shifts in food consumption patterns are simply a manifestation of this behavioral bias. It is far less energetically costly to have someone else obtain and prepare food for you than to go grocery shopping and then cook the food yourself. At the same time, food production systems have made snack foods readily available to obtain and consume with minimal effort. So this behavioral bias drives us to obtain food outside the home and consume snack foods more frequently. When faced with readily available sources of food, there is not a need for high levels of energy expenditure.

Additional Resources:

Prentice, A. M., Hennig, B. J., & Fulford, A. J. (2008). Evolutionary origins of the obesity epidemic: Natural selection of thrifty genes or genetic drift following predation release?. International Journal of Obesity, 32(11), 1607-1610. https://doi.org/10.1038/ijo.2008.147

Lieberman, D. E. (2015). Is exercise really medicine? An evolutionary perspective. Current Sports Medicine Reports, 14(4), 313-319. https://doi.org/10.1249/JSR.0000000000000168

Genetic Theories of
Obesity

Thrifty Gene Theory

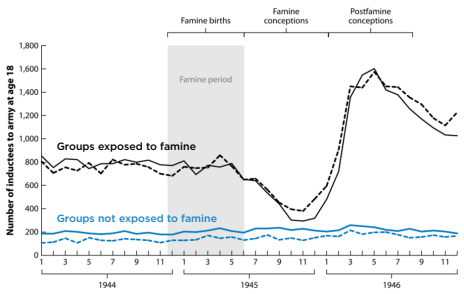
- Some individuals may be genetically predisposed to protection against starvation through more efficient fat storage and lower metabolic rates.
- The presence of this gene/genetic tendency would enable accumulation of excess adiposity when food was in surplus that would allow the population to be more likely to survive when food became scarce.

Genetic Theories of
Obesity

Thrifty Gene Theory

- Based on assumptions that food scarcity was a common event for early humans.
  - Anthropological evidence suggests that famines and seasonal food shortages were rare in hunter-gatherer populations.
  - Famines and seasonal food shortages are much more common within agrarian societies.

Reproductive fertility appears particularly sensitive to famines and seasonal food shortages



Genetic Theories of
Obesity

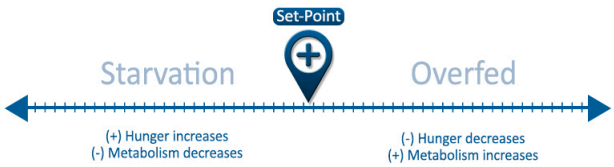
Thrifty Gene Theory

- The genetic advantage of the thrifty gene is in enabling individuals to continue to reproduce when others without such genes become infertile.
  - The ability to store excess adipose tissue and have lower metabolic rate is ultimately in service of promoting fertility.
    - Population level survival.
- Alterations in fertility have enabled the thrifty gene to exert selective pressure on the human genome.

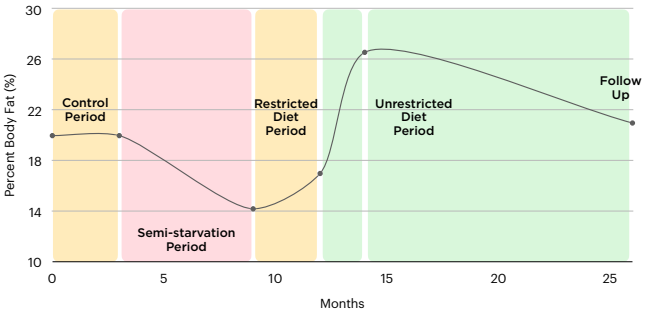
Genetic Theories of
Obesity

Set Point (settling point) Theory

- Each person has a genetically programmed control system which dictates how much fat they should have.
  - In essence, a "thermostat for body fat."
- Attempts to explain why some individuals cannot lose weight with dieting.
  - Rebound weight-gain among dieters
  - Occasional over-eating usually does not result in weight gain.



The body attempts to reach the set point by adjusting food intake or energy expenditure (or both) in proportion to the difference between the current level of adiposity and the set point level of adiposity.

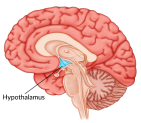


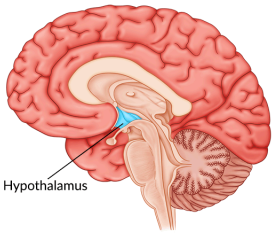
Genetic Theories of

Obesity

Set Point (settling point) Theory

- Leptin is thought to be one of the central mechanisms enabling this.
  - Leptin is a hormone secreted by white adipose tissue.
  - Circulating concentrations of leptin mirror white adipose cell stores, increasing with overfeeding and decreasing with starvation.
  - The hypothalamus uses information about circulating levels of leptin to regulate food intake and metabolism.



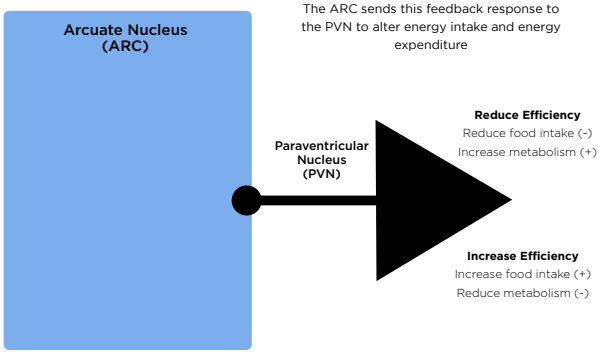


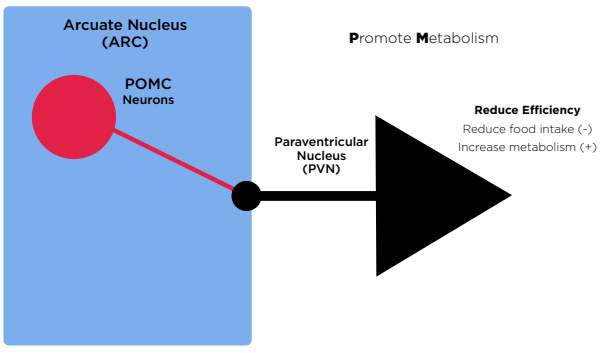
Hypothalamus

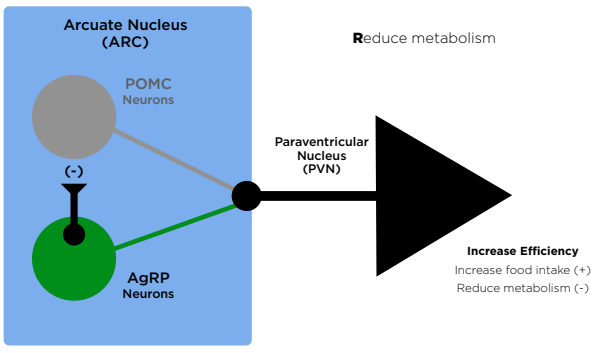
Part of the limbic system
(behavior, emotion, drives)

Located in the ventral portion of the brain just above the brainstem.

Orchestrates homeostatic functions
(e.g., food intake, energy expenditure, glucose metabolism, and circadian rhythm)
in response to changing internal and external contexts







Genetic Theories of

Obesity

Set Point (settling point) Theory

- Genetically modified mice who lack or have low leptin levels, exhibit more frequent feeding, higher levels of insulin and body fat, and have low thyroid and metabolism levels.
- Leptin primarily plays a role in protecting the body against fat loss.
  - Injections of leptin typically result in minimal changes to body composition.
  - In individuals who have lost substantial adipose mass, injections of leptin appear to enable the maintenance of the lower levels of adipose tissue.

If **one** parent is obese, there is a **50**% chance that the children will also be obese.

If **both** parents are obese, the children have an **80**% chance of being obese.

Genetic

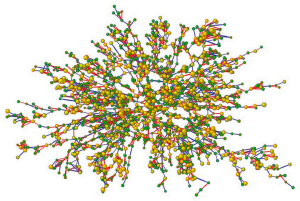
Environmental

Environmental

- Parents/family
- Friends
- Social networks
- Economics
- Neighborhoods
- Green spaces
- Community resources
- Transportation
- Safety
- Food availability
- Food production

Framingham Heart Study

Subanalysis of social networks over a 32 year period



57% increase in obesity risk if they have a friend that became obese.

40% increase in obesity risk if they have a sibling that became obese.

37% increase in obesity risk if their spouse became obese.

Accounting for potential influences associated with proximity in geographic location.

Social Learning Theory

Attitudes, values, and behaviors (attributes) are acquired through the process of socialization.

We interact with the environment and observe the attributes of others that serve as a reference of correctness.

We attempt to reproduce those attitudes, values, and behaviors.

We refine those attributes through reinforcement until our actions match our model.

Social Learning Theory

Attitudes, values, and behaviors (attributes) are acquired through the process of socialization.

- Parents constrain the potential behaviors of their children.
  - Economic factors.
  - Access to foods and activities.
- Parents and family provide strong early-life socialization
  - Serve as a model of attitudes, values, and behaviors
  - Reinforce those attitudes, values, and behaviors
- Through social comparison, peer-groups provide additional sources of socialization.

How does community design influence
Risk of Obesity

- Community designs are centered around cars instead of walking or biking.
- States and school districts have reduced the amount of time students are required to spend in physical education classes.
  - 92% of elementary schools do not provide daily PE.
- Communities have failed to invest in parks and recreation centers.

Environmental Influences on
Risk of Obesity

Economics

- Being overweight has replaced malnutrition as the most prevalent nutritional problem for the poor!
  - Adolescents in families with lower socioeconomic status have the greatest incidence of obesity.
  - Adolescents in families with higher socioeconomic status have the lowest incidence of obesity.

Environmental Influences on
Risk of Obesity

Economics

- A healthy basket of food has been found to cost more in disadvantaged economic areas than in affluent areas.
  - 'Supermarkets' can supply food at lower retail cost.
  - There are 3 times as many 'supermarkets' in wealthy neighborhoods as in poor neighborhoods.
  - Competition for consumers drives costs down further.
- The Food Industry markets mass, low-quality products with higher fat and sugar content to economic sectors with less purchasing power.

Environmental Influences on
Risk of Obesity

Economics

- Food availability has been found to negatively relate to obesity.
  - Individuals who have greater food security, indicating greater availability and access to food, have a lower incidence of obesity.
  - Individuals who have lesser food security, indicating poorer availability and access to food, have a higher incidence of obesity.
- Children in disadvantaged economic areas tend to participate less in physical activities in and out of school.

Epigenetic Influences on
Risk of Obesity

In rodents who are genetically susceptible to diet–induced obesity

- Consuming high caloric diets while pregnant resulted in an upregulation of gene expression in the pup at birth that resulted fetal overgrowth, glucose insensitivity, and leptin dysregulation.
  - Pups were heavier at birth and continued to accumulate excess adipose tissue during development.

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  - Pups were heavier at birth and continued to accumulate excess adipose tissue during development.
- Consuming very low caloric diets while pregnant resulted in low birth–weight of the pup, but those pups exhibited more efficient accumulation of adipose tissue and lower metabolic rate.

Epigenetic Influences on
Risk of Obesity

Fetal-adaptive response

Adaptive mechanisms are brought online in response to environmental context experienced in utero or early development.

- Maternal over- and under- nutrition both appear to result in changes in the hypothalamus and metabolism.
  - These changes appear to bias the system towards energy efficiency.
  - Changes appear to have substantial persistence and in some cases may be permanent.

Epigenetic Influences on
Risk of Obesity

Thrifty Phenotype Theory

- Similar in concept to the Thrifty Gene Theory proposed by Neel (1962).
- Posits that those who are exposed to inadequate or fluctuating nutrition during early pregnancy and development generate adaptive methods to increase energy efficiency.

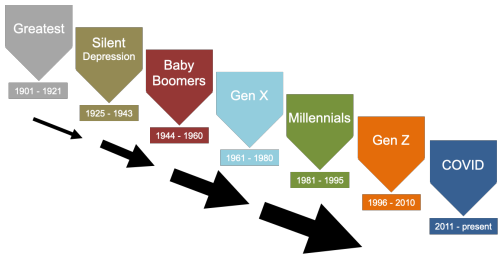
Dutch Famine

(Near the end of WWII)

Food rations were reduced from 1800 calories per day down to 580 calories per day for a period of approximately 6 months.

- Maternal exposure to famine conditions during the first and second trimesters of pregnancy:
  - Reduced birth weight of the infant.
  - Increased risk of obesity later in life.
  - Increased risk of cardiovascular disease.

Evidence suggests these epigenetic changes are more dramatic after 3 generations of persistent environmental or behavioral characteristics



Behavioral Influences on
Obesity Risk

Food Consumption

1950's	1980's	Today
Approximately 18% of food spending occurring outside of the home.	Approximately 27% of food spending occurring outside of the home.	Approximately 53% of food spending occurring outside of the home.

Behavioral Influences on
Obesity Risk

Food Consumption

Portion Sizes

1950's	1980's	Today
Approximately 350 calories.	Approximately 660 calories.	Approximately 1300 calories.

Behavioral Influences on
Obesity Risk

Food Consumption

Overall Calories

1970's	**Today**
Average American consumes 1,800 calories per day.	Average American consumes 3,800 calories per day.

U.S. Department of Agriculture, 2021

Behavioral Influences on
Obesity Risk

Food Consumption

- Reductions in the consumption of 'green' vegetables and legumes, and increases in the consumption of sugar and sodium.
- In the 1950's, snacks accounted for less than 10% of total daily calories, with over 70% of adults in the 1970's snacking only a single time or not at all during the day.
- In 2007, over 70% of of adults snack at least two or more times a day, with 18% snacking four or more times per day.
  - Snacks now represent nearly a third of the daily recommended calories.

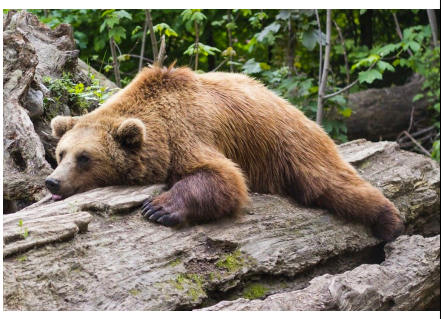
Behavioral Influences on
Obesity Risk

Physical Activity

- While active leisure-time physical activity has increased population wide, nearly 25% of children and 40% of adults report engaging in no leisure-time physical activity.

Theory of Effort Minimization

There is a dominant behavioral tendency to minimize energy expenditure and maximize energy intake.



Behavioral Influences on
Obesity Risk

Behavioral Bias towards Energy Conservation

- Behavioral actions that result in excess food intake with minimal energy expenditure will be favored.
- Within an environment that requires excessive energy expenditure to obtain food, minimizing unnecessary expenditure of energy while maximizing energy intake reflects a highly efficient behavioral state that incurs a biological advantage.
- Humans have needed to adapt highly efficient strategies to maximize success.

Behavioral Influences on
Obesity Risk

Behavioral Bias towards Energy Conservation

- Historical changes in food consumption reflect shifts towards easy food.
  - More energetically efficient to have someone else obtain and prepare food.
  - Snack foods are readily available and easy to consume.
- There is not a need for high levels of energy expenditure.