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Viewpoint

Good Calories, Bad Calories by Gary Taubes; New York: AA Knopf

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Summary

Good Calories, Bad Calories has much useful information and is well worth reading. Gary Taubes's tenets related to obesity can be summarized in four statements (i) He believes that you can gain weight and become obese without a positive energy balance; (ii) He also believes that dietary fat is unimportant for the development of obesity; (iii) Carbohydrate, in his view, is what produces obesity and (iv) Insulin secreted by the carbohydrate is the problem in obesity. However, some of the conclusions that the author reaches are not consistent with current concepts about obesity. There are many kinds of obesity, and only some depend on diet composition. Two dietary manipulations produce obesity in susceptible people: eating a high-fat diet and drinking sugar- or high-fructose corn syrup-sweetened beverages. Insulin is necessary but not sufficient in the diet-dependent obesities. When diet is important, it may be the combination of fat and fructose (the deadly duo) that is most important. Regardless of diet, it is a positive energy balance over months to years that is the *sine qua non* for obesity. Obese people clearly eat more than do lean ones, and food-intake records are notoriously unreliable, as documented by use of doubly labelled water. Underreporting of food intake is greater in obese than in normal-weight people and is worse for fat than for other macronutrient groups. Accepting the concept that obesity results from a positive energy balance *does not* tell us why energy balance is positive. This depends on a variety of environmental factors interacting with the genetic susceptibility of certain individuals. Weight loss is related to adherence to the diet, not to its macronutrient composition.

Keywords: Diet, energy expenditure, food intake, nutritian.

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Diseases of modern society and the nutrition transition

> I believe no age did ever afford more instances of corpulency than our own.
>
> Short, T. 1727 (1)

> If the increase of wealth and the refinement of modern times have tended to banish plague and pestilence from our cities, they have probably introduced to us the whole train of nervous disorders, and increased the frequency of corpulence.
>
> Wadd, W. 1810 (2)

> Some factor of diet and/or lifestyle must be driving weight upward, because human biology and our underlying genetic code cannot change in such a short time.
>
> Taubes, G. 2007 (3)

Industrialization of food production

The quotes by Short (1) in the early 18th century and by Wadd (2) from the early 19th century indicate that obesity has been a growing problem for more than two centuries. The current rise in the rate of increase serves to make solutions to the problem more urgent. Clearly genetic and environmental factors such as the food we eat, the relative affiuence of individuals, and the predisposing genetic basis upon which these factors act in each of us play a role in the obesity problem.

Many revolutions characterize the changing human diet. The first of these revolutions began with the domestication of animals and cultivation of crops more than 10 000 years ago (1). As rice, wheat and corn became staple commodities, hunter-gatherers abandoned their migratory life and gradually turned to the cultivation of plants to provide food for the human species, which supported the development of nation states.

Sugar first appeared some 2500 years ago, probably in India, and spread slowly throughout the world. With the discovery of the New World at the end of the 15th century, the sugar industry blossomed to provide a major source of caloric sweeteners (4).

The industrial revolution of the 18th century had a major impact on agriculture and food production. With machine farming, processing and storage of crops, and the use of chemical fertilizers, human beings were able to move from farms to cities. At the beginning of the 20th century, farming provided a major need for human labour, but as the century progressed, we moved to the point where only a small percentage of the population working on the land could provide food for the city dwellers.

As nations became wealthier in the 20th century, one society after another entered a nutrition transition, shifting dietary intake from simple unprocessed foods to highly processed foods with larger quantities of meats, added sugars, fats, and sweetened foods (5). Although it occurred in Western countries during the 19th century and early part of the 20th century, it has been the reduced burden of infectious disease and the 'Westernization' of diets around the world that have led to the rapidly rising incidence of heart disease, obesity, diabetes, and cancer. This 'nutrition transition' has brought with it all of the chronic diseases that afflict Western society (5). The impact of diet on disease is the subject of *Good Calories, Bad Calories* by Gary Taubes (3).

Summary of *Good Calories, Bad Calories*

Good Calories, Bad Calories is a scholarly book that musters the evidence for the case against the high-fat hypothesis for heart disease, cancer and obesity and in favour of the carbohydrate-insulin hypothesis. The bibliography is robust and contains a wealth of information. The page notes provide detailed references to the sources. It is well worth reading. The descriptions of important scientific contributions are well written.

The book begins with Mr William Banting and the diet he published in 1863 as a small pamphlet called '*A Letter on Corpulence Addressed to the Public*' (6). In this pamphlet, Banting described his dietary success with a low-carbohydrate diet. The hostility that Mr Banting aroused among the 'medical establishment' in the 1860s is reminiscent of some of the comments about popular diets that have come from the 'medical establishment' in the last half of the 20th century. Throughout *Good Calories, Bad Calories*, there are historical vignettes about the men and women who made the discoveries. The calorie-restriction studies of Benedict and the studies by Ancel Keys *et al.* (7) published in *The Biology of Human Starvation* are well worth reading. Having lived through and testified before the Senate Select Committee on Nutrition in the 1970s, I found it fascinating to see an analysis of the impact of this political approach to dietary advice for Americans and the *Dietary Guidelines* that followed. The description of the Pima Indians and their history during the 20th century are well done. The background work on energy expenditure in human beings from Antoine Lavoisier, Hermann Helmholtz, Robert Mayer Carl Voit, Max Pettenkoffer, Max Rubner and Wilbur Atwater is very nicely detailed by Mr Taubes. In addition to these, there are many other descriptions of scientists and their work that make this book particularly fascinating to read.

Good Calories, Bad Calories is divided into three main parts. The first part is a critique of the Diet-Heart hypothesis, and the idea that dietary fat was the principal culprit in the rising incidence of heart disease during the 20th century. From an analysis of published data and discussion with many leaders, Taubes concludes that the Diet-Heart hypothesis detracted from our understanding of the relation of diet to heart disease. As Taubes sees it, Ancel Keys played the role of major villain in selling the idea that dietary fat was the major contributor to the increased risk of heart disease. Read and decide for yourself.

The second part of *Good Calories, Bad Calories* sets forth the 'carbohydrate hypothesis'. This hypothesis is Taubes's basis for explaining the evils of the 'nutrition transition' that have afflicted countries moving from their traditional diets to the Western type of high-fat, high-sugar, high-salt diet. The carbohydrate hypothesis is described in detail in this section and is related to the increasing development of diabetes, cancer, ageing and dementia.

In the third part of *Good Calories, Bad Calories*, called the 'Mythology of Obesity', the author argues that the energy-balance equation does not adequately explain obesity because obese people do not eat more than lean

ones, and because they can lose weight eating a large number of calories, provided that the calories are very low in carbohydrates – that is, high in protein and fat.

It is clear, as the author says, that 'Some factor of diet and/or lifestyle must be driving weight upward, because human biology and our underlying genetic code cannot change in such a short time. The standard explanation is that in the 1970s we began consuming more calories than we expended and so as a society we began getting fatter, and this tendency has been particularly exacerbated since the early 1980s. Data from the US Department of Agriculture as well as those from the National Center for Health Statistics show that the rise in food intake has been in the range of 150–350 kcal d^{-1} in the last 30 years. These increased calories would more than account for the obesity epidemic.

As I read through *Good Calories, Bad Calories*, I found a number of errors of omission or commission that are important when relating diet to disease. There is no mention in the Diet-Heart section of low-density lipoprotein-cholesterol ('bad cholesterol') or of high-density lipoprotein-cholesterol ('good cholesterol'). The cholesterol receptor, the discovery of which earned Brown and Goldstein the Nobel Prize, is not mentioned, nor are the statin drugs that arose from this discovery. The statin class of drugs has been very important in reducing the deaths from heart disease. Also absent is any mention of *trans*-fats, which, along with saturated fats in animal and dairy products, are the dietary fats most predictive of heart disease.

In the section on 'The Mythology of Obesity' and the carbohydrate-insulin hypothesis, there is no mention of doubly labelled water, a sophisticated technique that has allowed us to 'check' on the accuracy of self-reports of food intake. Also missing is a discussion of the 'nutrient' balance hypothesis. These limitations may change the conclusions that are reached from reading *Good Calories, Bad Calories*.

The final section of this book summarizes the lessons that the author learned. They are reproduced in the left-hand column of Table 1. I have added my comments in the right-hand column.

Critique of *Good Calories, Bad Calories*

Positive energy balance causes obesity: calories do count – food-intake records are unreliable – a case study

One summer I admitted a group of four overweight teenagers to our clinical research unit at the Harbor UCLA Medical Center and put them on a 1000-cal diet under direct observation. As expected, all of the girls lost weight and were delighted with the result. When they left at the end of the summer, one of the girls, who lived only a short distance from the hospital, wanted to come back to see us so she could continue to lose weight. We instructed her on how to keep a food diary. When she returned 2 weeks later, she had gained a few pounds. She showed us her diary, which was very neatly and carefully kept. The average daily food intake was about 300–400 kcal d^{-1}. As she had lost weight eating 1000 kcal d^{-1} while directly observed in the hospital, we were sceptical of the accuracy of her outpatient recording. We instructed her again on keeping food records. She returned after another 2 weeks, having gained even more weight and with records still showing she only ate 300 kcal d^{-1} or so. There was an obvious discrepancy, reflecting the difficulty of keeping reliable records. It was thus clear that this girl was either kidding herself or trying to kid us about how much she was eating. We have subsequently had the opportunity to study weight loss in a number of subjects in both the metabolic unit and then on similar diets in an outpatient setting. Weight loss under observation is about 50% faster than with the equivalent 'prescribed' energy deficit in an outpatient setting (8). The difference is adherence to or compliance with the diet.

Let me make my position very clear. Obesity is the result of a prolonged small positive energy surplus with fat storage as the result. An energy deficit produces weight loss and tips the balance in the opposite direction from overeating.

The Law of Conservation of Mass and Energy (9) (the first law of thermodynamics) applies to humans as it does to other species. Over the period of about 100 years from 1787 to 1896, the Laws of Conservation of Matter and Energy were shown to apply to human beings, just as they do to animals.

From my reading of *Good Calories, Bad Calories*, the author seems to misinterpret what this relationship means. The thermodynamic laws relate overall changes. They are so-called 'state' equations. That is, they tell us what happens to the system under the specified conditions (dieting or overeating). They do not tell us how the change occurred (composition of the diet or type of activity). I see nothing inconsistent with the truth of the idea that a positive energy balance produces obesity and the idea that it does not tell us why this imbalance occurred.

Leptin is an important hormone produced by adipose tissue. When it is deficient, massive obesity from overeating is the result (10). Treatment with leptin will reverse this type of obesity. Before we knew that leptin existed or how leptin worked, the positive energy balance that occurs in its absence still occurred, with the resulting obesity. The Law of Conservation of Mass and Energy still applies.

The challenge to those of us working in the field of obesity research is to identify those factors that produce the small increases in energy intake or the small decreases in energy expenditure in a way that will produce the long-

Table 1 The author's ten conclusions from *Good Calories, Bad Calories* and my comments

Author's comments	My response
1 Dietary fat, whether saturated or not, is not a cause of obesity, heart disease, or any other chronic disease of civilization.	Dietary fat produces obesity in mice, rats, dogs and human beings. On a low-fat diet, the type of solid carbohydrate in the diet does not affectobesity.
2 The problem is the carbohydrates in the diet, their effect on insulin secretion, and thus the hormonal regulation of homeostasis – the entire harmonic ensemble of the human body. The more easily digestible and refined the carbohydrates, the greater the effect on our health, weight and well-being.	The problem is a positive energy balance persisting over an extended period of time, which may be exacerbated by high-fructose/high-fat foods and other environmental agents acting on genetically susceptible individuals.
3 Sugars – sucrose and high-fructose corn syrup (HFCS) – are particularly harmful, probably because the combination of fructose and glucose simultaneously elevates insulin levels while overloading the liver with carbohydrates.	Fructose – found both in sucrose and HFCS – is mainly metabolized in the liver; glucose (also in HFCS and sugar) is distributed throughout the body. The effects of fructose in the liver may be particularly undesirable.
4 Through their direct effect on insulin and blood sugar, refined carbohydrates, starches and sugars are the dietary cause of coronary heart disease anddiabetes. They are the most likely dietary causes of cancer, Alzheimer's disease, and the other chronic diseases of civilization.	There is no convincing evidence that carbohydrates are producing cancer, Alzheimer's disease, type 2 diabetes, or coronary artery disease.
5 Obesity is a disorder of excess fat accumulation, not overeating, and not sedentary behaviour.	Obesity is the result of a small positive energy balance occurring over time. The Laws of Conservation of Energy (First Law of Thermodynamics) do not tell us why this imbalance occurs.
6 Consuming excess calories does not cause us to grow fatter any more than it causes a child to grow taller. Expending more energy than we consume does not lead to long-term weight loss; it leads to hunger.	Consuming excess calories routinely produces obesity, and consuming fewer calories than your body needs produces weight loss.
7 Fattening and obesity are caused by an imbalance – a disequilibrium – in the hormonal regulation of adipose tissue and fat metabolism. Fat synthesis and storage exceed the mobilization of fat from the adipose tissue and its subsequent oxidation. We become leaner when the hormonal regulation of the fat tissue reverses this balance.	Fat accumulation cannot occur without caloric intake exceeding expenditure. Fat deposits differ in their health risks: visceral fat is strongly related to heart disease and diabetes; subcutaneous abdominal fat much less so; and fat on the legs may be 'protective'. These differences in fat locations partly determine the differences in life expectancy between men and women.
8 Insulin is the primary regulator of fat storage. When insulin levels are elevated – either chronically or after a meal – we accumulate fat in our fat tissue. When insulin levels fall, we release fat from our fat tissue and use it for fuel.	Insulin is needed for fat storage, but it is for the purpose of storing the 'extra' calories not needed for daily energy expenditure. Chronic elevation of insulin, as in insulinoma, has only a modest effect on weight – something else is needed for 'obesity' in addition to insulin.
9 By stimulating insulin secretion, carbohydrates make us fat and ultimately cause obesity. The fewer carbohydrates we consume, the leaner we will be.	Calories count. Fructose (HFCS or sugar) plus a modest- or high-fat diet enhance the risk of overpowering the homeostatic feedback system.
10 By driving fat accumulation, carbohydrates also increase hunger anddecrease the amount of energy we expend in metabolism and physical activity.	The quantity of fat we eat in a day is less than 0.5% of the fat we have stored, and these changes in fat deposition do not lead to increased appetite, as they are hardly seen on the concentration of leptin and other adipose tissue-related peptides.

term imbalance that we call obesity. It is what the Law of Conservation of Mass and Energy does *not* tell us that is most important when it comes to dealing with the public health aspects of obesity. This law does not explain biological differences in food intake or in the regulation of fat distribution. The hedonic effects of food are not explained by this Law, and it contains no information about how prices of food influence food choices. The first Law also does not help us to understand genetic influences, which we know account for a significant amount of the susceptibility to obesity (11). It is 'environmental' agents, such as tasty, inexpensive food in large portion sizes, inactivity, viruses, toxins, and social interactions, that interact with the genetically susceptible host to produce obesity.

Lean people adjust energy intake or energy expenditure over an extended period of time better than people who become obese do. In classic experiments on this problem, Edholm *et al.* (12) (omitted from the bibliography of *Good Calories Bad Calories*) showed that the daily intake of food was not significantly related to energy expenditure on that day. Only over a period of several days were food intake and energy expenditure significantly related. This longer term adaptation is critical for understanding the mechanism(s) that allow some people to maintain body weight while others fail to do so (13). The quotation from Boswell cited in *Good Calories, Bad Calories* clearly summarizes the idea of positive caloric balance as the cause of obesity:

> Talking to a man who was growing very fat, so as to be incommoded with corpulence;
>
> Johnson said, He eats too much sir
>
> Boswell: 'I don't know, Sir; you see one man fat who eats moderately, and another lean who eats a great deal-
> Johnson: 'Nay, Sir, whatever may be the quantity that a man eats, it is plain that if he is too fat, he has eaten more than he should have done'.
>
> Boswell, J (14)

Energy expenditure and food-intake records

Obesity has been a fact of human existence as far back as the Old Stone Age (15). The extent to which any given instance of obesity is dependent on diet, and to what extent, vary from one individual to another. The fact that obesity has occurred in every culture would indicate that some individuals in each culture are 'susceptible'. Individuals identified with obesity through the ages are much more likely to come from the wealthy and aristocratic members of that society than from the peasants and labourers. This implies an interaction between environmental factors and genetics.

In developing his ideas about calories and obesity in *Good Calories, Bad Calories*, Taubes argues that obese individuals do not eat more than lean ones do. The data for his belief come from the *Diet and Health Report* (16) prepared by the National Academy of Sciences. This report said 'Most studies comparing normal and overweight people suggest that those who are overweight eat fewer calories than those of normal weight'. Further on, the author says 'Even if it could be established that all obese individuals eat more than do the lean – which they don't – that only tells us that eating more is associated with being obese'. As a member of the committee drafting the *Diet and Health Report*, I was responsible for writing this section. The data used in this report were based on food-intake records and reflected the information of the day. Even then, however, there was a paradox. Measurements of energy expenditure using oxygen consumption showed a nearly linear increase in energy expenditure as body weight increased. This meant that heavier people were expending more energy than were leaner ones. How did the overweight people keep up their higher energy expenditure if they did not ingest more food?

We now know that the data used in the *Diet and Health Report* were wrong and that obese people eat more food energy than do lean ones. The answer to this apparent paradox came from a new technique for measuring total daily energy expenditure (17). This technique allows us to measure total energy expenditure over an interval of 7–10 days and cannot be influenced by the subjects' food intake. As information obtained from this technique began to appear, it was compared with the information from food records. The data showed that normal-weight people underreport what they eat by 10–30%. This means that dietary food-intake records underestimate energy expenditure by nearly a quarter. For overweight people, the degree of underreporting is higher, varying from 30% to 50%. Thus, food records as a measure of 'real' calorie need are unreliable, as for any individual you do not know how much he or she actually underreports. Moreover, underreporting seems to be higher for dietary fat (18). When food-intake records are used, the greater discrepancy reported by the obese would make their data closer to those of normal-weight people who underreport less. The data on energy requirements based on doubly labelled water measurements from many laboratories were compiled in the Recommended Dietary Intakes (19), one of the sources that are not cited in *Good Calories, Bad Calories*. Table 2 compiles some of these data. The body mass index (BMI) is 5–7 units higher in the overweight group than in the normal-weight group and the overweight men expend 300–500 calories more per day than do the normal-weight men, meaning that they must eat more food just to maintain their weight. The women are even heavier, with a 6- to 10-unit BMI difference and energy expenditures that are 100–500 calories more per day. To maintain this extra weight the women have to eat enough food to provide this extra energy.

In *Good Calories, Bad Calories*, Taubes says that 'All those who have insisted (and still do) that overeating and/or sedentary behaviour must be the cause of obesity have done so on the basis of this same fundamental error: they will observe correctly that positive caloric balance must be associated with weight gain, but then they will assume without justification that positive calorie balance is the cause of weight gain. This simple misconception has led to a century of misguided obesity research'. Again, the author has repeated his misunderstanding of the Law of Conservation of Mass and Energy. When we heat a closed vessel and note that the temperature and pressure rise, that is what the Laws of Thermodynamics predict will happen. It is irrelevant whether the heat is chemical or electrical. Experiments in which human subjects voluntarily overeat (20,21) provide the link between calorie intake and calories going into body fat stores. The weight and fat gains that follow conscious overeating in human subjects are a clear test of the cause-and-effect relation of the energy-balance concept. The author of *Good Calories, Bad Calories* seems to miss this point. The concept of energy imbalance as the basis for understanding obesity at one level does not preclude any of the influences that affect or modify food intake or energy expenditure, including the quantity and quality of food, toxins, genes, viruses, sleeping time, breast feeding, medications, etc. They are just the processes that modify one or other component of the energy-balance system.

Table 2 Total daily energy expenditure for normal-weight and overweight males and females using doubly labeled water*

Age group	Normal weight		Overweight	
	Body mass index	Mean total energy expenditure (kcal d^{-1})	Body mass index	Mean total energy expenditure (kcal d^{-1})
Males				
3–8	15.4	1441	19.8	1,728
9–13	17.2	2079	25.4	2,451
14–18	20.4	3116	–	–
19–30	22.0	3081	29.6	3,599
31–50	22.6	3021	30.8	3,598
51–70	23.0	2469	29.6	2,946
>70	22.8	2238	27.8	2,510
Females				
3–8	15.6	1487	20.3	1,669
9–13	17.4	1907	24.7	2,346
14–18	20.4	2302	27.6	2,798
19–30	21.4	2436	29.8	2,677
31–50	21.6	2404	31.9	2,895
51–70	22.2	2066	30.4	2,176
>70	21.8	1564	27.6	1,763

*Adapted from the Recommended Dietary Intakes (19).

This scientific journey through the limitations of food-intake records and the new framework for interpreting food intake by using doubly labelled water has been nicely captured in the quotes from Canguilhem (22) and from Sarton (23). Our progress involves curves and bumps in the road.

> The history of truth is neither linear nor monotone.
>
> Canguilhem, G (22)

> When we say that science is essentially progressive this does not mean that in his quest for truth man follows always the shortest path. Far from it, he beats about the bush, does not find what he is looking for but finds something else, retraces his steps, loses himself in various detours, and finally after many wanderings touches the goal.
>
> Sarton, G (23)

In science, you test hypotheses by examining their predictions. Producing positive energy balance by asking human subjects to eat extra food has routinely produced fat gain (20,21). Similarly, inducing energy deficit by asking human beings to exercise more or by restricting food intake has routinely produced fat and weight loss (24). If the author of *Good Calories, Bad Calories* wishes to challenge these fundamental controlled experiments, he needs to provide data showing that they are wrong.

Brillat-Savarin, who is discussed in *Good Calories, Bad Calories*, has very nice quotes that summarize the issues related to the causes of obesity and its treatment (25).

Brillat-Savarin on the causes of obesity:

> The first is the natural temperament of the individual . . . The second principal cause of obesity lies in the starches and flours which man uses as the base for his daily nourishment . . . A double cause of obesity results from too much sleep combined with too little exercise . . . The final cause of obesity is excess, whether in eating or drinking.

Brillat-Savarin on the treatment of obesity:

> Any cure of obesity must begin with the three following and absolute precepts: discretion in eating, moderation in sleeping, and exercise on foot or on horseback'. 'Such are the first commandments which science makes to us: nevertheless I place little faith in them.
>
> Brillat-Savarin JA 1826 (25)

Diet and weight gain

Weight gain independent of diet

Regulation of body weight gain can be viewed as a homeostatic system. The word 'homeostasis' was introduced into biology nearly a century ago by the great American Physiologist, Walter B. Cannon (26). It describes the overall way in which the body adapts to internal and external information to remain on an 'even keel'. During the year, the 'average' man will ingest nearly 1 million calories, and the average woman will eat nearly 750 000 calories. A weight gain of 0.5 kg (1.1 lb) during the year represents the storage of about 3500 calories, or less than a 0.5% error. The homeostatic system that we call 'weight regulation' has worked pretty well over this year, as an error of 0.5% is small, and for most people the weight gain may be even smaller, meaning the operation of this homeostatic system is functioning quite well.

Under some circumstances, however, the system fails – that is, weight is not maintained this precisely, and we gain 0.5–2 kg year^{-1} (1.1–4.4 lb year^{-1}). With the wide variety of 'tasty' and energy-packed foods that we can eat, I view this as a problem of a pleasurable or hedonic environment overriding our homeostatic system. That is, for some people who are susceptible to obesity, in an environment where there are pleasurable rewards from food, the homeostatic system is not able to maintain body weight. Two important hedonic factors are dietary fat and dietary fructose [from sugar or high-fructose corn syrup (HFCS)], which together make what I would call the 'deadly duo' (4).

This homeostatic system can also be disturbed by a number of environmental agents. Some of the medications we use can either lower or raise body weight over extended periods of time by 'resetting' the homeostatic system. One example is nicotine in tobacco. In human beings and animals, this drug reduces food intake and stimulates energy expenditure. Individuals who smoke weigh less on average than those who do not. The weight gain that occurs when smoking stops is a significant problem. A second example are the antipsychotic drugs. Several of the second generation of antipsychotic drugs (e.g. olanzepine and clozepine) produce significant weight gain and increase the risk for diabetes. A final example is from the drugs intended primarily for weight loss. Rimonabant is a cannabinoid antagonist that produces weight loss. When individuals were randomly switched back to placebo after 1 year of treatment with this drug, their rate of weight regain was almost the mirror image of their weight loss during the first year. Those who stayed on the drug for 2 years maintained their weight loss. In each case, we have adjusted the homeostatic system by changing the gain. If you turn down a radio and other noise occurs in the background, the radio will not make more noise. It has been reset. The problem for most treatments of obesity is that they do not reset the system at a sufficiently low level.

In *Good Calories, Bad Calories*, the author says 'Some factor of diet and/or lifestyle must be driving weight upward, because human biology and our underlying genetic code cannot change in such a short time. The standard explanation is that in the 1970s we began consuming more calories than we expended and so as a society we began getting fatter, and this tendency has been particularly exacerbated since the early 1980s'. The detrimental impact of the Western diet on health is easy to see all around us. It is also easily demonstrated in epidemiologic studies. Individuals moving from Japan to Hawaii or to the USA (27) shift their dietary and disease patterns towards those in the USA. Immigrants from Europe show the same shift. To put this into the context of the homeostatic model, the Western diet has provided a hedonic override for their homeostatic system of weight regulation and disease prevention.

We have learned a lot about obesity during the 20th century. One of the recurring themes during this time was the idea that people could consume extra calories and 'burn' them up. The term for this, coined by German investigators, is 'luxuskonsumption' – dissipation of calories when we overeat. Although this idea has raged up and down, most scientists no longer believe it. Part of this conclusion comes from a careful reanalysis of the data originally thought to support luxuskonsumption. In the discussion of luxuskonsumption in *Good Calories, Bad Calories*, the author fails to note the reanalysis by Gilbert Forbes (28) of the data published by Gulick (29) and by Neumann (30) in the early 20th century. Neumann and Gulick each conducted experiments on themselves. They varied the amount of food they ate and recorded their weights. Each claimed that the changes in their body weight did not reflect the amount of food they ate. When Forbes re-plotted their small weight changes against their actual calorie intake the lines were linear and could account for essentially all of the extra calories consumed.

Obesity is not a single entity and many different ways have been described to produce and classify it. One of the leaders in the field of obesity during the latter part of the 19th century was von Noorden (31), who identified three types of obesity (i) diabetogenous obesity; (ii) endogenous obesity and (iii) exogenous obesity. He noted that obesity and diabetes were related. This relationship is particularly clear in the Pima Indians and other South-western Indian Tribes. Pima Indians have one of the highest rates of diabetes in the world. The BMI of Pima Indians living in southern Arizona, where fat and fructose (from beverages) are readily available, is several units higher than their close relatives living a more 'primitive' life in northern Mexico, demonstrating again the importance of the 'Western' diet in the fattening of America (32).

von Noorden's two other types of obesity – endogenous and exogenous – correspond to what I will call diet-independent and diet-dependent (33). At one extreme are the types of obesity that develop independent of diet composition. At the other extreme are those where diet composition plays a major role. The most obvious examples of obesities that are independent of diet composition are those resulting from single-gene defects and neuroendocrine disorders. Children with leptin deficiency are very obese (10). Individuals who lack leptin receptors or who fail to produce pro-opiomelanocortin or have abnormalities in the melanocortin-4 receptor provide other clear-cut examples of genetic disturbances where the drive to eat is overwhelming. The type of diet is irrelevant to these types of obesity. The affected individuals will eat just about anything.

A second group of obesities where diet is secondary are those associated with neuroendocrine diseases, including hypothalamic obesity, Cushing's syndrome and polycystic

ovary syndrome (33). Injury to the ventromedial hypothalamus produces a disturbance in the control of food intake *and* in control of the autonomic nervous system. These animals are very hyperphagic, but this hyperphagia is not necessary for them to become obese. Increased activity of the parasympathetic nervous system *and* decreased activity of the sympathetic nervous system combine to increase insulin levels and allow these animals to shift nutrients from metabolism and growth into storage as body fat (34).

Diet-dependent obesity: high-fat diets product obesity – high-carbohydrate diets with low fat do not

At the other extreme are the types of obesity in animals and human beings that depend on the composition of the diet. The two principal dietary components are fat and fructose.

In the theme line of *Good Calories, Bad Calories*, the author argues that dietary fat is not important in the development of obesity. For example, he says, 'But there is no evidence linking obesity to dietary fat consumption – neither between populations nor in the same population'. Yet, in the bibliography, there is a reference titled 'Dietary fat affects obesity rate' published in the *American Journal of Clinical Nutrition* by Bray and Popkin (35), which outlines precisely these data, both between populations and within populations. High-fat diets consistently produce obesity in mice, rats and dogs. Without regard for the data, the author says, 'But some strains of rats, perhaps most of them, will not grow obese on high-fat diets, and even those that do will grow fatter on a high-fat, high-carbohydrate diet than a high-fat, low-carbohydrate diet'. Among rodents, it is the exception that does not become obese to some extent while eating a high-fat diet. It is also true that the magnitude of obesity varies from eating a high-fat diet. Mixing fat with sweet-tasting carbohydrates (fructose alone or in sugar or HFCS) will accentuate the weight gain.

Weight loss with high-fat diets has been examined in at least two meta-analyses (35,36). In one study, a reduction of 10% in the proportion of energy from fat was associated with a reduction in weight of 16 g d^{-1}, which translates into a 1.4- to 2.8-kg weight loss over 3–6 months (35). In a second meta-analysis of 12 intervention trials, the reduction in fat intake was 10.2%(95% CI 8.1–12.3%). The low-fat intervention groups showed a greater weight loss than did control groups (3.2 kg 95% CI 1.9–4.5) Astrup *et al*. (36) found a weighted mean change of energy intake of 1138 kJ d^{-1} (about 275 kcal d^{-1}). Having a body weight 10 kg higher than the average pretreatment body weight was associated with a 2.6-kg greater difference in weight loss. Thus, reducing dietary fat is associated with significant weight reduction over 3–12 months.

Rodents have a marked capacity for synthesis of fatty acids in adipose tissue, where they can then be stored. In contrast, human beings produce very few fatty acids in the fat cell. Rather human beings produce fatty acids in the liver and then transport them to the fat for storage. This important difference in metabolism and the fact that the metabolic products of fatty acids cannot be converted back to glucose put glucose in a very special position. We generally eat each day about as much carbohydrate as we can store. As storage capacity is limited, dietary carbohydrate must be metabolized. In contrast, the amount of fat we eat each day is well under 1% of the fat we have stored in our bodies, even those with a normal body weight. Thus, maintaining fat balance and carbohydrate balance is an integral part of the concept of energy balance that is at the heart of obesity.

There seems to be a lower limit to the amount of dietary fat that is essential for animals to become obese. Once this level is surpassed, carbohydrate may well enhance the obesity. There is one dose–response study (37) to various levels of fat. There was a rapid increase in body fat as dietary fat increased from 20% to 40%, with an inflection point between 30% and 40% fat. Below 20% fat, it is difficult to become obese. This would be consistent with the lack of obesity among Japanese eating their traditional very low-fat, high-starch diet.

Fat balance – the flatt hypothesis

Why is a high-fat diet conducive to the development of obesity? First, fat has a higher energy density than do other foods. Second, metabolic adaptation to a high-fat diet requires a longer time than to a high-carbohydrate diet (38,39). To put the problem in perspective, we need a brief detour into the way the body handles fat and glucose. Glucose can be converted into fat, and this happens relatively easily in small animals, but in human beings there is very limited conversion of glucose carbons into the carbons of long-chain fatty acids. In contrast, fatty acid carbons cannot be converted back into net glucose by either rodents or humans.

To explore the concept of 'nutrient balance', a concept that is not discussed in *Good Calories, Bad Calories*, Flatt measured the oxidation of dietary glucose and fat in mice housed individually (40). He found that there were variations in glucose and fat use from day to day in individual animals. If more glucose was used than eaten on 1 day, the animal would make a correction and eat more glucose the next day. These corrective responses were much less evident for fat. For energy balance to occur, we must also be in fat balance. As glucose stores are limited, reductions in dietary sources of glucose will reduce the utilization of glucose and favour fat. In his studies, Flatt showed that animals eat for carbohydrate and that when carbohydrate in the diet is limited, which is what happens with a high-fat diet, one response is to expand fat stores until the rate of fat oxidation increases to match the fat in the diet. This is why high-fat diets are a problem for people who are susceptible to obesity.

Fructose and weight gain: sucrose and HFCS in drinking solutions

The second dietary component that readily produces obesity in animals is access to sucrose (fructose-glucose) in their drinking water. The response of the common laboratory rodent to sucrose solutions is very different than when sugar is mixed with the solid ingredients in their diets (41). Rodents love sugar-containing water. When bottles with solutions of sucrose are available, animals drink up to 50% of their daily energy from the sucrose solution and gain weight. There is a failure to compensate when the sweet calories are in a drinking solution.

In the American diet, the relation of fructose to obesity has been the subject of many recent publications. The introduction of HFCS just before 1970 provided a cheap caloric sweetener that has replaced about half of the sucrose in the American food supply and increased overall intake of fructose (42). The sweet taste of this mixture, made by converting glucose from hydrolysed starch into fructose, has several commercial advantages. First, it is cheap to produce from corn starch. Second, the sweetness can be varied by changing the relative amount of fructose to glucose. Third, it retains moisture in products better than sugar and thus prolongs shelf life and reduces freezer burn. Fructose intake has risen and with it more fructose and fat – that tasty sweet mixture – has increased and may well be playing a role in the epidemic of obesity. Almost all studies (43) show a significant relationship between intake of calorie-sweetened soft drinks and energy intake.

Weight-loss diets

Do differences in dietary composition influence the rate and degree of weight loss? In the paper titled 'Calories do Count', Kinsell *et al.* (44) showed clearly that changes in the composition of the diet had little or no influence on weight loss when individuals were maintained in a hospital setting and given a fixed energy intake.

The discussion of this problem in *Good Calories, Bad Calories* comes to a different conclusion. The discussion of diets in treating obesity in *Good Calories, Bad Calories* is divided into two parts. In the first part of chapter 19, the author gives us a very nice description of the development of dietary treatment of obesity during the 20th century.

In the second part of his discussion of diets in *Good Calories, Bad Calories*, the author turns to what he calls the use of 'Unconventional Diets' and the role of insulin. He highlights the work on 'low-carbohydrate diets' published by Dr Pennington, Dr Robert Atkins and Dr Charlotte Young. Part of this discussion of very low-carbohydrate diets relies on the author's earlier argument that calories are not the underlying basis for obesity. He says 'But if a calorie is a calorie, why is it that a diet restricted in carbohydrate . . . leads to weight loss, largely if not completely independent of calories?' A few pages later he says '. . . weight loss can be largely independent of calories'.

His evidence that you can lose weight without reducing calories is 'anecdotal'. What is missing in the reports that he cites are direct measurements of energy expenditure with doubly labelled water to get around the problem of 'under-reporting' of food intake. Also missing are measures of 'adherence' to the diet. The importance of adherence was nicely documented by Lyon *et al.* (45), who prepared food grown with a stable isotopic form of carbon, which allowed them to measure the amount of food eaten by collecting $^{13}CO_2$. With this technique, they showed that the amount of weight loss was related to the adherence to the diet.

Also missing in this book is a recent review of popular diets by Freedman *et al.* (46). They showed from an analysis of published diets that the levels of calories were very similar – in the range of 1400–1600 cal day^{-1} (Table 3). I have reproduced their table below.

In *Good Calories, Bad Calories*, the author views the very low-carbohydrate diets as the most beneficial dietary approach for weight loss and uses their effects on insulin as the basis for this view. He believes that insulin is the 'culprit' behind the problem of obesity. Insulin is secreted by the pancreas in response to blood glucose and the glucose derived from food in the intestine. As the glucose absorbed from the intestine is stored in tissues stimulated by the insulin released from the pancreas, both glucose and insulin return to their pre-meal levels. Fructose, which is half of the sugar (sucrose) molecule, or as found in HFCS, does not directly stimulate insulin release from the pancreas. Insulin is clearly needed for synthesis of fat and for storage of other nutrients after a meal. The secretion of insulin varies to keep glucose within narrow limits. Insulin levels also increase in obesity.

Table 3 Data on energy intake associated with the three major types of diets (46)

Type of diet	Calories kcal	Fat g (%)	Carbohydrate g (%)	Protein g (%)
Typical American	2200	85 (35)	274 (50)	82 (15)
High fat, low carbohydrate	1400	94 (60)	35 (10)	105 (30)
Moderate fat	1450	40 (25)	218 (60)	54 (15)
Low and very low fat	1450	16–24 (10–15)	235–271 (65–75)	54–72 (15–20)

Table 4 Comparison of maximal weight loss for several diets

Author (reference)	Low fat		Low carbohydrate		High protein		Other			
	Ornish	Other	Atkins	Other	Zone	Other	Balanced deficit	Weight watchers	Rosemary conley	Slim-fast
Foster (48)		3.2%	7.0%							
Brehm (49)		3.9 kg		8.5 kg						
Samaha (50)*		2.0 kg	6.0 kg							
Stern (51)*				5.8 kg			3.1 kg			
Dansinger (52)	6.2 kg		5.5 kg		5.0 kg			4.5 kg		
Gardner (53)	2.0 kg		6.0 kg			1.8 kg		2.5 kg (LEARN)		
Howard		2.3 kg								
Heshka								5.5		
McManus (54)†		2.9 kg					4.1 kg			
Gerhard (55)‡		1.5 kg								
LeCheminant (56)		0.3 kg		+0.1 kg						
Luscombe-Marsh (57)§				10.2 kg		9.7 kg				
McLaughlin (58)		5.7 kg					6.9 kg			
Skov (59,72)¶		5.1 kg				8.9 kg				
Noakes (60)		7.3 kg				7.3 kg				
Petersen (61)		6.9 kg					6.6 kg			
Truby (62)			6.0 kg					6.6 kg	6.3 kg	4.9 kg
Volek (63) Males		4.3 kg		8.1 kg						
Females		2.8 kg		3.1 kg						
Yancy (64)		12.9%		6.7%						

*The Samaha and Stern papers are the same population – the data from Samaha are 6 months; the data from Stern are 12 months.
†Sacks data at 18 months – moderate-fat (Mediterranean-type diet) vs. low-fat diet.
‡Six-week crossover diet in diabetics comparing high mono-unsaturated against low fat. Only the low-fat diet caused weight loss.
§Low fat/high protein (29%/35%) vs. high fat/standard protein (45%/18%).
¶Both diets contained 30% fat – the one listed as low fat had 12% protein and the one listed as low carbohydrate had 25% protein.

The question is, however, whether insulin is both necessary and sufficient to produce obesity and whether reduced-carbohydrate diets are really better than other diets. That is, does the macronutrient composition of the diet matter during weight loss? Kinsell provided his answer in 1964 (44) when he compared variations of diet composition within a fixed caloric intake for individuals who lived on a metabolic ward for up to 6 months. He concluded that calories, not macronutrients, counted. In chapter 21, Taubes tries to convince us that low-carbohydrate diets are 'better', as he claims they lower insulin, which is the 'driving' force for obesity. If the thesis of *Good Calories, Bad Calories* is correct, then repeated injection of insulin produces massive obesity. Insulin injections do produce some weight gain but also produce a significant fall in glucose (hypoglycemia). Taubes cites the experience of Rony, who used insulin to increase appetite in markedly underweight patients with anorexia nervosa. There was an increase in appetite and weight gains of 20 pounds over 3 months, but this would still leave most anorexics underweight. The fact that it is no longer used raises concerns about the 'risk' of hypoglycemia vs. the 'benefit' of the small weight gains. The weight gain with insulin in diabetics is also modest – some 5 kg (11 pounds) in 5 years and 8 kg (17.6 pounds) after 15 years (47). Although insulin injections will produce some weight gain, patients with insulinoma, who secrete insulin continuously, are at most only modestly overweight. Although insulin is 'necessary' for obesity, it is not 'sufficient' and not driving the current epidemic of obesity (34).

Are low-carbohydrate diets the most effective treatment for obesity? The obvious test of this idea is to examine studies that have compared low-carbohydrate diets with other diets. I have summarized a number of such trials in Table 4. I selected 3–6 months, as this is the period of maximal weight loss, and avoided the issues of weight maintenance. There are four published reports that have examined the effect of diets using meta-analysis, a technique which allows for pooling of data from several studies. One meta-analysis compared 12 studies that used low-calorie diets vs. a control (65). At the end of 12 months, the difference between control and treated groups in these 12 weight-loss studies was –5.31 kg (95% CI –5.86 to –4.77 kg). This number of –5 kg is a good bench-mark for comparing macronutrient-specific studies. A second, larger meta-analysis focusing on 'diet counseling' found nearly identical results with a 'net mean treatment effect of approximately 2 BMI units (5 kg) of weight loss at

1 years' (66). In a meta-analysis of six trials with low-fat diets, Pirozzo *et al.* (67) concluded that '. . . low-fat diets are as efficacious as other weight-reducing diets for achieving sustained weight loss, but not more so'. In the final meta-analysis (68), which examined five (49,48,53,50,64) of the six studies (52 not included) that have included an 'Atkins-like' diet, the authors found this low-carbohydrate diet produced a net overall effect of –3.3 kg (95% CI –5.3 to –1.4). In the diets summarized in Table 4, those that used generic low-carbohydrate strategies did not find significant effects (69,70,57,58,71,60). This raises the concern of whether other 'lifestyle' or 'expectation' issues might have biased the outcome of the studies with 'Atkins-like' diets. It is more than just the level of carbohydrate, but is undefined and does not support the central thesis of *Good Calories, Bad Calories*. In any case, there is certainly no impressive difference in the effect of any diet, and one can, in my judgement, attribute the effects to the differences in calories, not macronutrient composition.

I would thus agree with Kinsell *et al.* when they said:

> Calories do Count.
>
> Kinsell *et al.* 1964 (44)

Additional comments

Psychological or physiological explanations of obesity?

One theme of *Good Calories, Bad Calories* is that the research agenda shifted strongly to the behavioural side during the 1950s and 1960s. I think this does not adequately describe the developments during this period. There were clearly strong psychological and behavioural currents in the work of Stunkard, Stellar and Stuart. But there were equally strong physiological and genetic influences identified in the work of Jean Mayer and his student, Judy Stern, Ethan A.H. Sims and his students Elliot Danforth and Edward Horton, George Cahill and his students, Thomas Aoki and Oliver Owen, Theodore van Itallie and his students Sami Hashim and F. Xavier Pi-Sunyer, Jules Hirsch and his students, M.R.C. Greenwood and Rudoph Leibel, and Edwin B. Astwood and his student, George Bray. In *Good Calories, Bad Calories*, we are introduced to Dr Edwin B. Astwood, one of the leading endocrinologists of the 20th century, who gave his Presidential address to the Endocrine Society in 1962 with the title 'The Heritage of Corpulence'. He believed that obesity and the disposition to fatten are genetic disorders. Study of animals with genetically inherited obesity is where I began my work on obesity with Professor Astwood at the New England Medical Center in 1962. This was the same year that he gave his Presidential Address on 'The Heritage of Corpulence'. Dr Astwood suggested that finding out why genetically obese animals got fat would provide valuable insight into this problem. It was clear that they did not have a 'lack of willpower' that is so often attributed to obese individuals. Rather they had a recessively inherited genetic defect that drove them to eat. We now know that these animals lack the leptin receptor or leptin itself. Using myself as an example of an investigator who is an endocrinologist and a specialist in obesity, I can state that the field of obesity research has always had people from a number of medical disciplines, including endocrinology, gastroenterology, nephrology and surgery. In his assessment of the research agenda of this field of study, the author of *Good Calories, Bad Calories* seems to have misinterpreted the development of the field of obesity research.

Concluding remarks

Although *Good Calories, Bad Calories* has much useful information, the part on obesity, at least, needs to be read and interpreted in the light of the more complete story of developments in this field. The important contributions resulting from the discovery that energy expenditure could be measured using doubly labelled water make non-sense out of the claims that 'calories don't count'. However, the energy-balance concept does not provide the explanation for why some people become obese and others do not in the same food environment. There are many kinds of obesity, and only some depend on diet composition. Genetic factors play a role as do the contributions of other environmental agents. Eating a high-fat diet and drinking sugar- or HFCS-sweetened beverages are two of them. When diet is important, it may be the combination of fat and fructose (the deadly duo) that prevents energy balance from occurring. Regardless of diet, it is a positive energy balance over months to years that is the *sine qua non* for obesity. Obese people clearly eat more than do lean people, and food-intake records are notoriously unreliable. Underreporting of food intake is greater in the obese than in normal-weight people and is worse when the foods are high in fat than with other macronutrients.

Conflict of Interest Statement

No conflict of interest was declared.

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