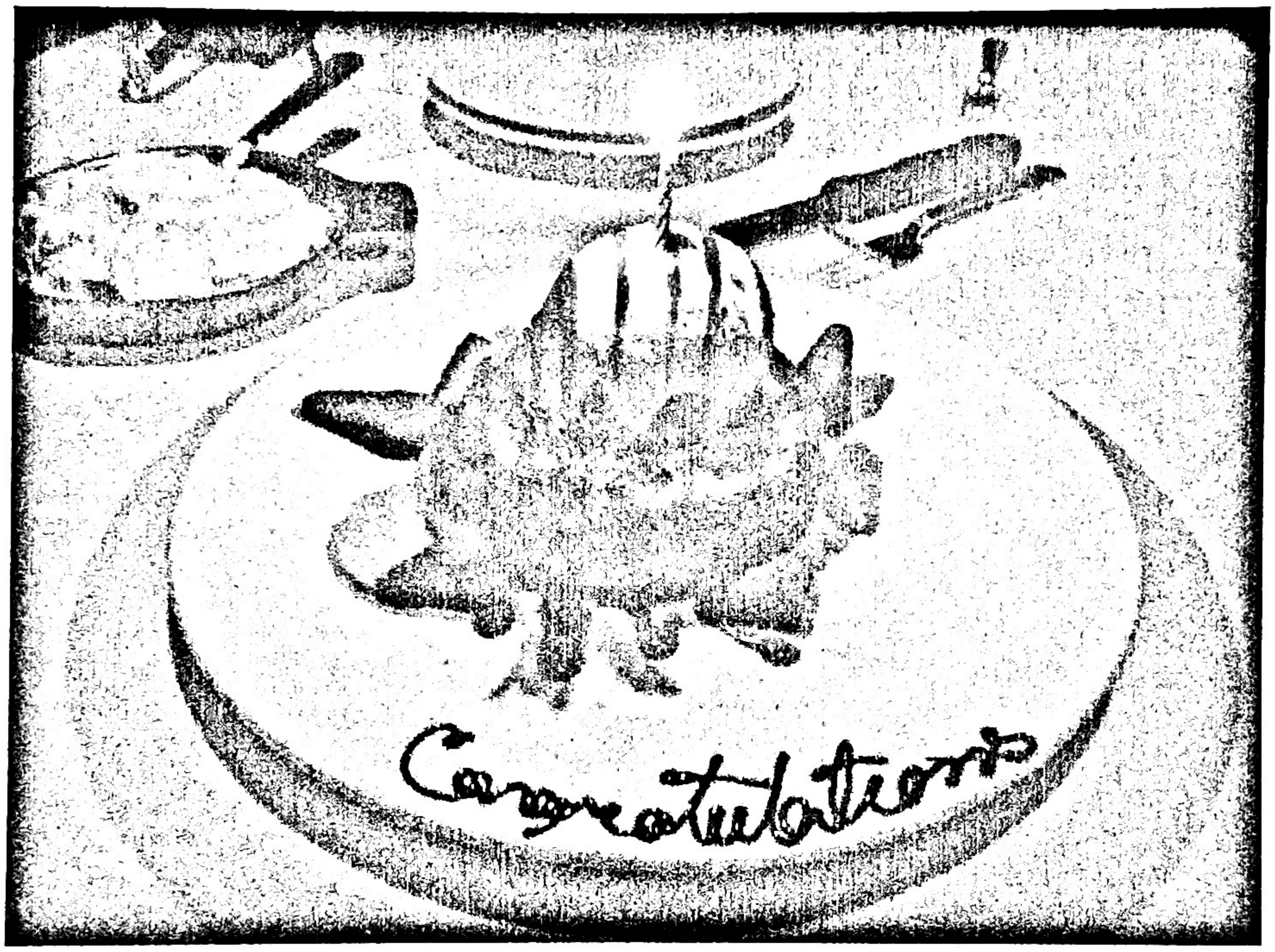
CHAPTER

# 3 The Brain and Food




Courtesy of Maria Napoli

*The battle between my brain and desire*
*Continue to challenge each other*
*I will strive to eat only when hungry*
*Allow myself to say no to foods that do not serve me*
*Know that when I indulge in eating treats they are just that "treats"*
*The battle is over as I make conscious decisions*
*My brain and desire are in balance*

(Napoli)

Eating is personal. We choose food for many reasons; cultural practices, habits, connection to our family traditions, comfort, ease, health, and taste preferences are some of the reasons. At the same time, we struggle in America with conditions related to eating too much food, what scientists call over nourishment. In other parts of the world, people are starving. In our land of plenty there are ample opportunities to eat anything, at any time of year, whatever we desire, independent of growing season, climate, or proximity. All our desires can be satisfied by a trip to the supermarket or fast food outlet, whenever we want.

This chapter is a story of the brain, and how our moods are affected by certain food choices. We are just beginning to understand its complexity and how we may affect different mood states based on many things, including food choices. Remember as you read through this chapter that there is no judgment intended about the choices you make; rather, the journey is about noticing how you feel in the present moment without judgment. In this fashion, we know there is no "good" food or "bad" food, but simply food. Different foods have different consequences. Let's learn more about the food and mood connection now.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Is satisfying hunger the same as eating for the sake of indulging in delicious foods? When we eat a meal, we become calmer, and more lethargic. We share this in common with any other animal. Hunger has the opposite effect—we become irritable, alert, and often short tempered. In biological terms, the drive to find food is part of the evolutionary goal to stay alive. When feeling out of sorts, especially irritable, we are driven to seek a feeding opportunity that leads to the biological rest and digest response, part of the parasympathetic nervous system. This relationship, eating is good; not eating is bad, is only one part of the complicated and complex relationship we have with food, our brain, and our moods.

This primal reaction to hunger and feeding is more complex than it appears. The details of the relationship between food and mood end up being a little confusing and a lot complicated. Humans eat for many different reasons, under a variety of different circumstances. Some are connected with our emotions, and others are less clear. However, looking at why we eat and the effect on our brain framed against the modern backdrop of ever present quantities of all types of foods, constant stimulation to eat driven by advertising and abundance, and manipulations of taste by savvy food marketers, can begin to shed light on the nuanced and messy relationship we have with biology, choice, and overeating.

## Why Do We Eat?

In simplest terms, we eat to stay alive. In Chapter 2, we discussed the energetics of food in a holistic and integrated way. Let's look at the science of assimilation. Assimilation is the dynamic interaction of the forces of food with the forces of our human bodies. Humans convert the energy from plants and animals into our own cellular fuel. Using cellular respiration, the body releases energy that is used to produce energy molecules. Cellular respiration is the process in which our bodies' cells produce the energy they need to survive. In cellular respiration, cells use oxygen to break down the sugar **glucose** and store its energy in molecules of adenosine triphosphate (ATP). Cellular respiration is critical for the survival of most living things because the energy in glucose cannot be used by cells until it is stored in ATP. Cells use ATP to power virtually all of their activities—to grow, divide, replace worn out cell parts, Eating is personal. We choose food for many reasons; cultural practices, habits, connection to our family traditions, comfort, ease, health, and taste preferences are some of the reasons. At the same time, we struggle in America with conditions related to eating too much food, what scientists call over nourishment. In other parts of the world, people are starving. In our land of plenty there are ample opportunities to eat anything, at any time of year, whatever we desire, independent of growing season, climate, or proximity. All our desires can be satisfied by a trip to the supermarket or fast food outlet, whenever we want.

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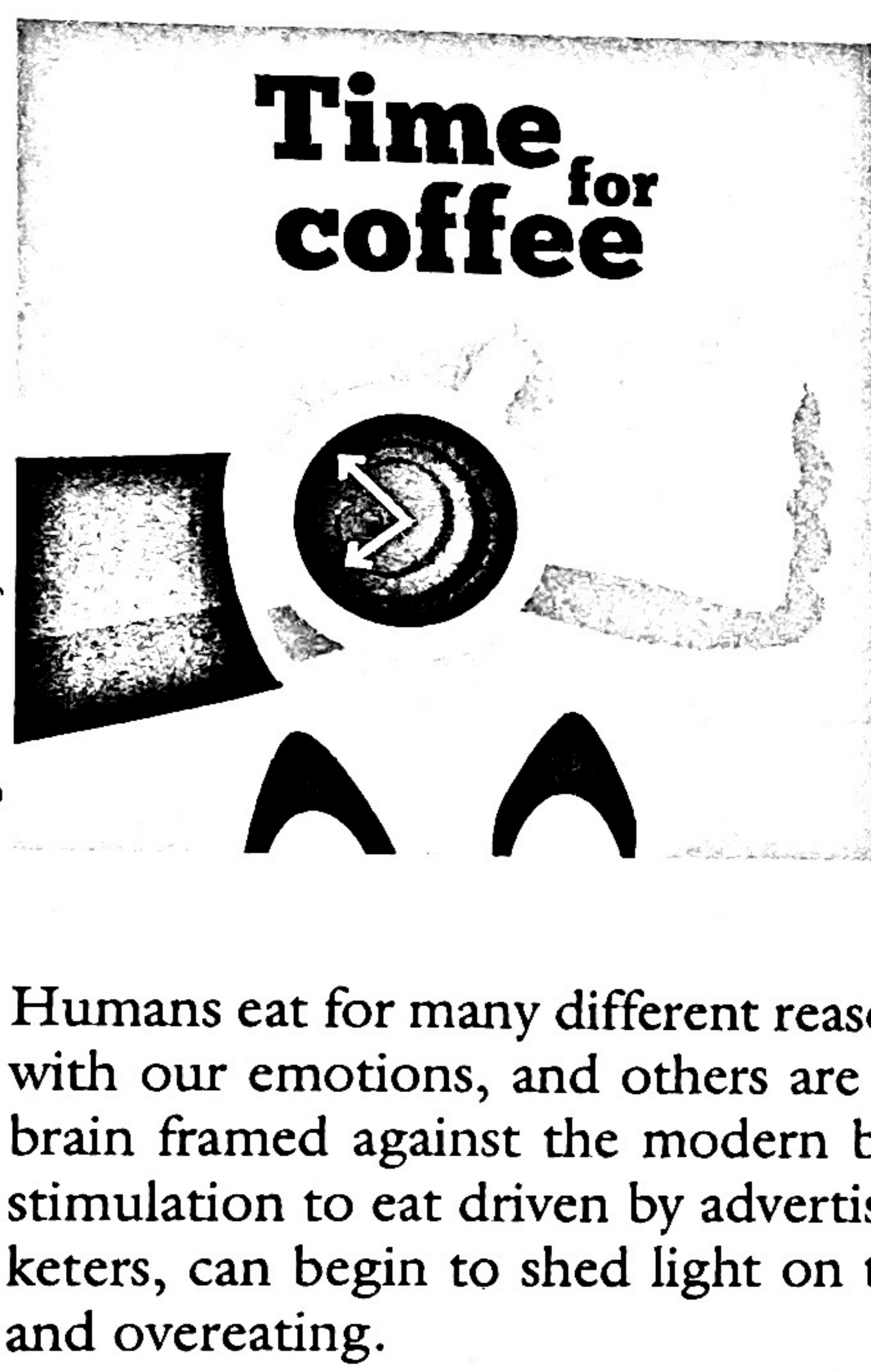


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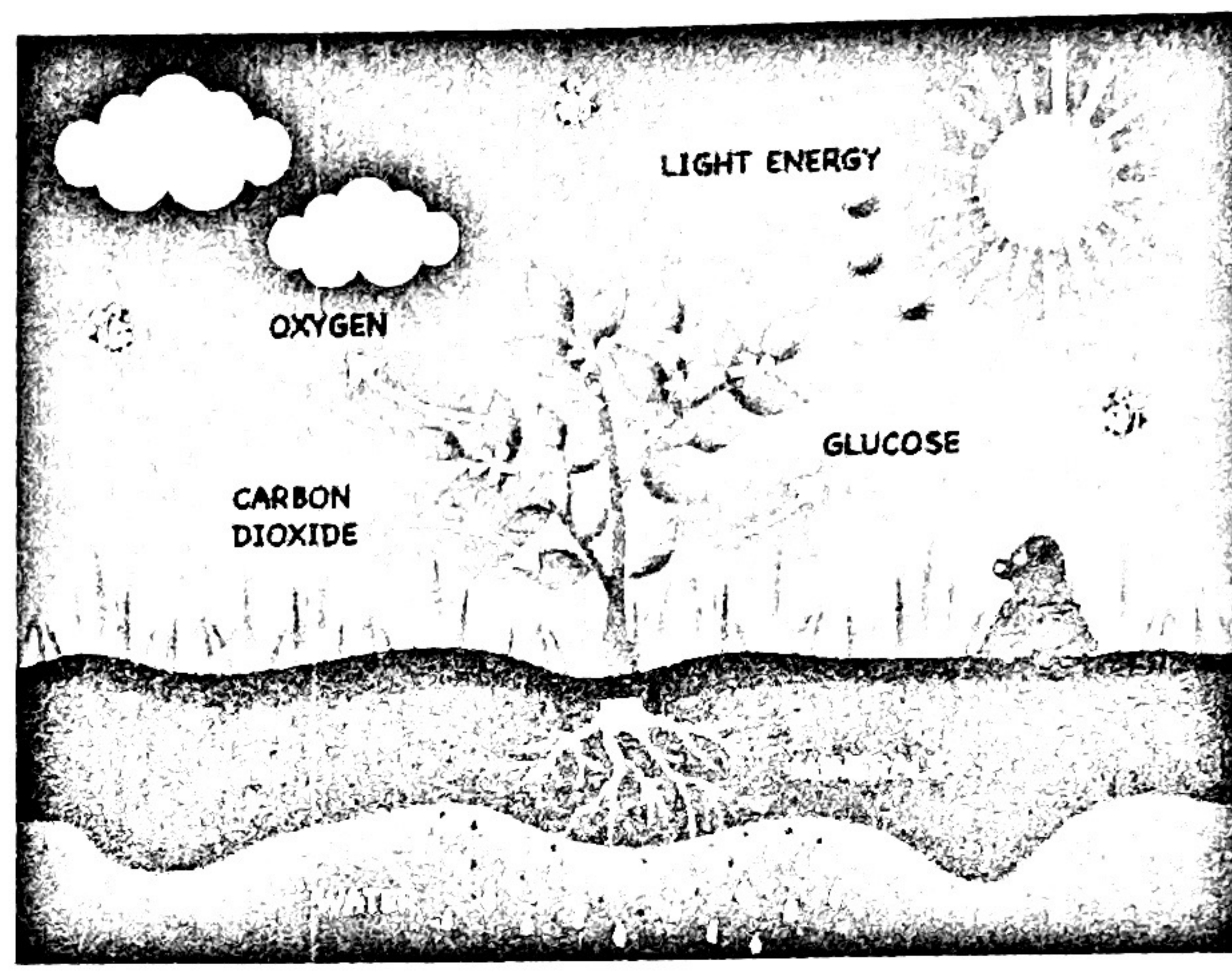
Two critical ingredients required for cellular respiration are glucose and oxygen. The glucose used in cellular respiration enters cells in a variety of ways. Plants, algae, and certain bacteria make their own glucose through photosynthesis, the process by which plants use light to convert carbon dioxide and water into sugar. Animals (including humans) obtain glucose by eating plants and other animals, and fungi and bacteria absorb glucose as they break down the tissues of plants and animals. Regardless of how they obtain it, cells must have a steady supply of glucose so that ATP production is continuous.



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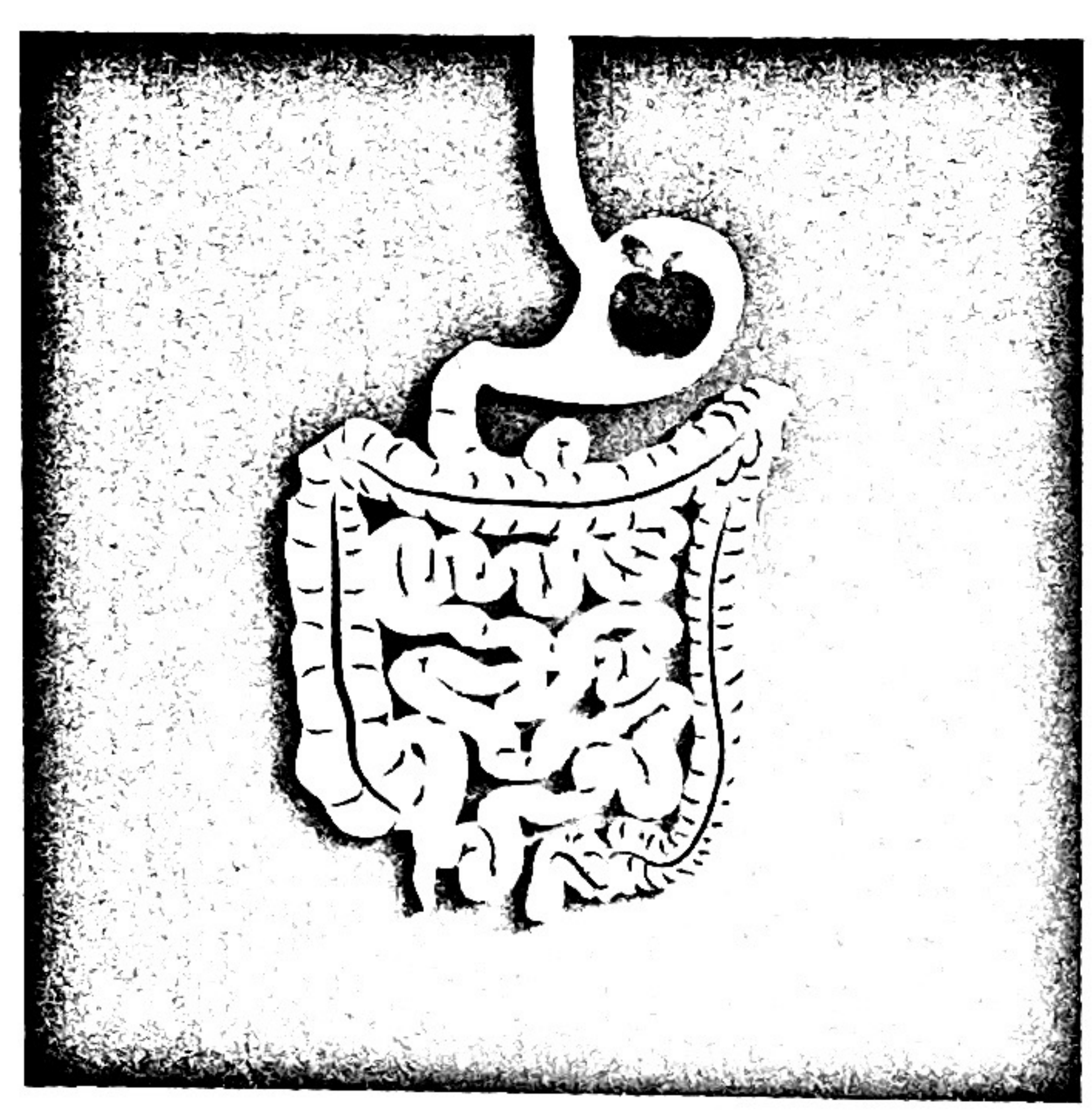
Oxygen is present in the air, and is also found dissolved in water. It either diffuses into cells—as in bacteria, fungi, plants, and many aquatic animals, such as sponges and fish—or it is inhaled—as in more complex animals, including humans. Cellular respiration, sometimes, is referred to as aerobic respiration, meaning that it occurs in the presence of oxygen.

Cellular respiration transfers about 40% of the energy of glucose to ATP. The rest of the energy from glucose is released as heat, which warm-blooded organisms use to maintain body temperature, and cold-blooded organisms release to the atmosphere. Cellular respiration is strikingly efficient compared to other energy conversion processes, such as the burning of gasoline, in which only about 25% of the energy is used and about 75% is released as heat (1).

When we eat a meal, nutrients are released from food through digestion. Digestion begins in the mouth by the action of chewing and the chemical activity of saliva, a watery fluid that contains enzymes, certain proteins that help break down food. Further digestion occurs as food travels through the stomach and the small intestine, where digestive enzymes and acids liquefy food and muscle contractions push it along the digestive tract. Large food molecules, such as fats, carbohydrates, and proteins, are broken apart releasing glucose and other nutrients. This released energy is then used in many ways, including the buildup of other large molecules. One example of a large molecule the body needs to build are proteins which make up the body's structure, and temporary energy storage "places" such as fat and glycogen.

Nutrients are absorbed from the inside of the small intestine into the bloodstream and carried to the sites in the body where they are needed. At these sites, several chemical reactions occur that ensure the growth and function of body tissues. The parts of foods that are not absorbed continue to move down the intestinal tract and are eliminated from the body as feces (2).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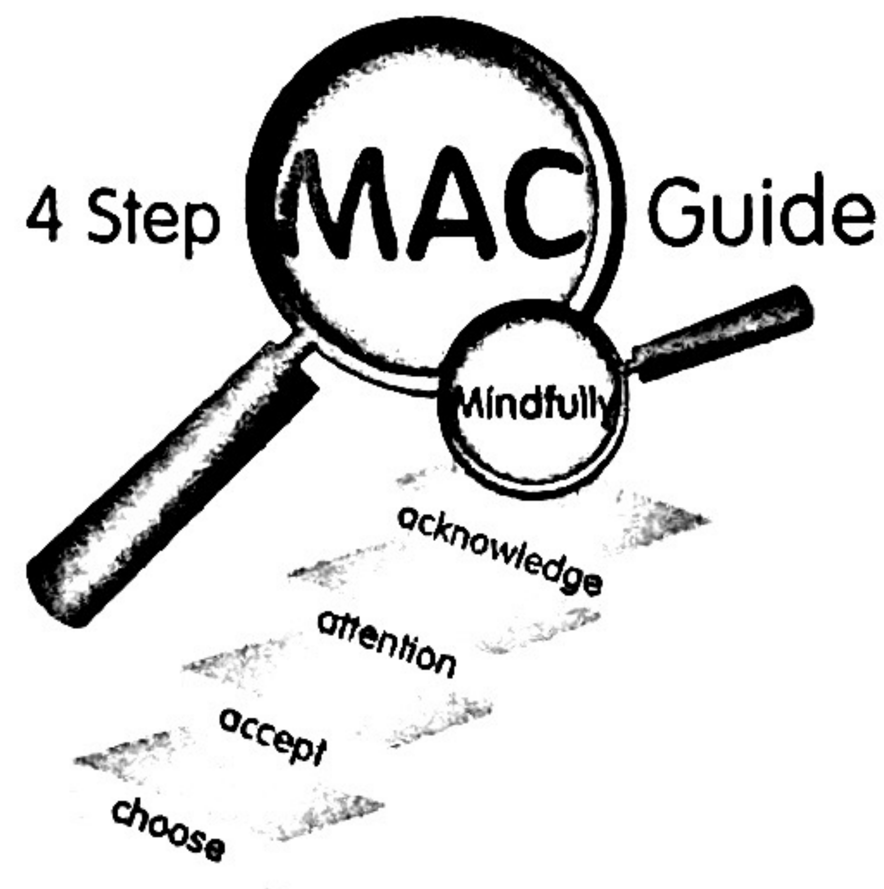
Once digested, carbohydrates, proteins, and fats provide the body with the energy it needs to maintain its several functions. Scientists measure this energy in kilocalories, the amount of energy needed to raise 1 kilogram of water to 1 degree Celsius. In nutrition discussions, scientists use the term calorie instead of kilocalorie as the standard unit of measure in nutrition.

The drive to eat is biologically based (3). Mood regulation is also biologically based, with feeding leading to ease, and hunger leading to restlessness and discomfort (4). Sounds simple. The ancient practices of Ayurveda and Chinese Medicine understand this model of the body and our innate self-regulatory mechanisms of biological drives as part of the process for diagnosing diseases caused by eating too much, too little, or by eating food in the wrong combinations. However, in modern times, we suffer from diseases related to overeating such as obesity, diabetes, irritable bowel syndrome, and heart disease. Experts believe all are related to eating too much food or the wrong *types* of foods including those that are highly processed. In addition, research now focuses on how eating certain foods affect our brain, leading to difficult moods including anxiety and depression (5).




***We now wonder what comes first, the chicken or the egg? Do our food choices affect our moods, or do our moods lead to the "wrong" choices of food?***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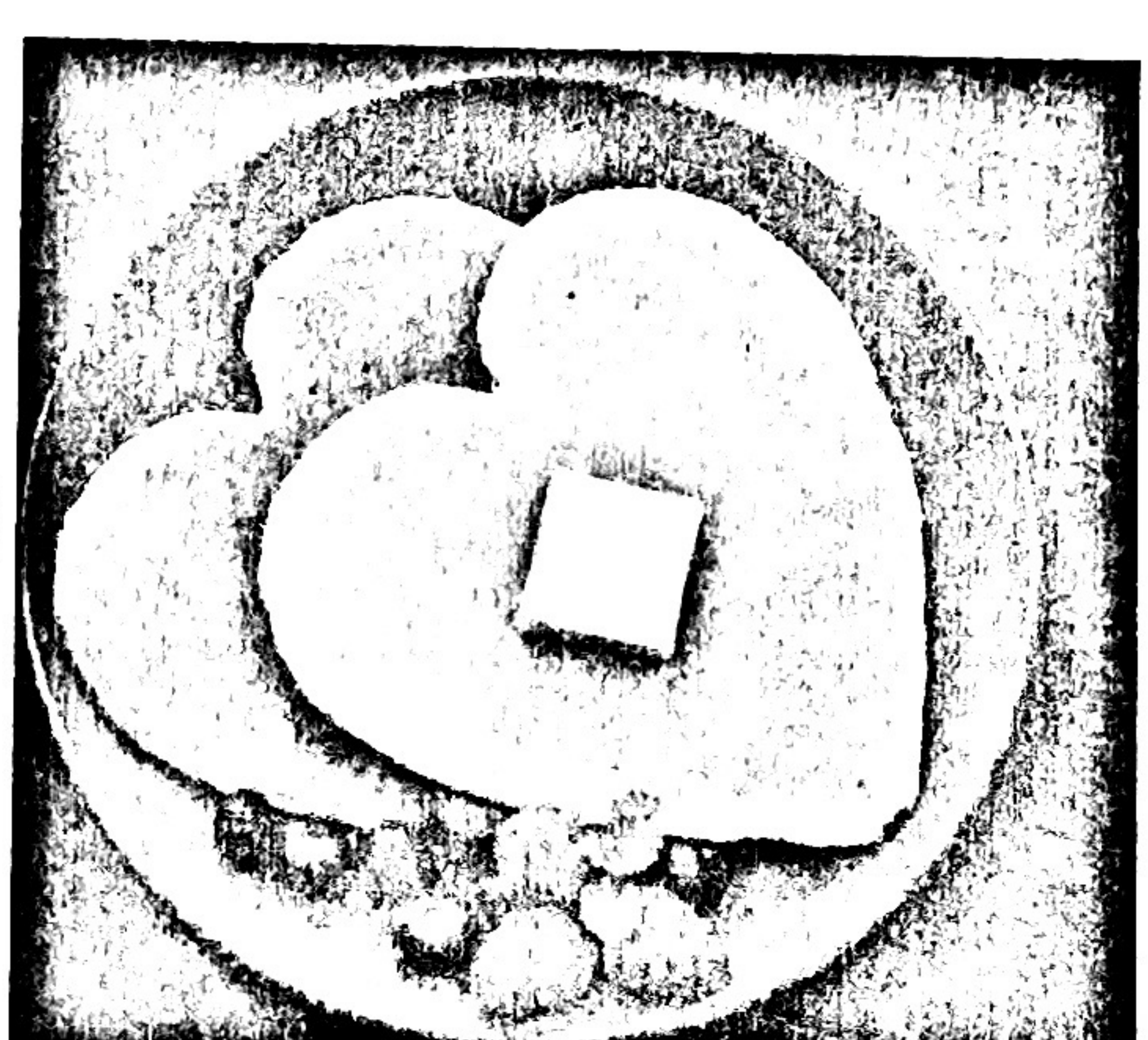
In a recent study (6), researchers considered this question and looked at food choice and moods. In a summary of the existing research (what is referred to as a "meta-analysis"), they found a connection between negative emotions and choosing unhealthy foods. When we are in a bad mood, we tend to reach for highly processed sugary treats such as cookies, candy, and snacks. The researchers also wondered if there was any connection to food choice and positive moods. When they surveyed the literature, there were mixed findings, so the study authors attempted to test their hypothesis: if they injected the element of time into the scientific equation, would that change the relationship between food and mood? What they found was regardless of mood, *long-term, future focused thinking* led to healthier food choices.

Their finding suggests that being in a good mood helps us take a longer-term perspective. But does choosing healthier foods, such as fresh fruits and vegetables, lean protein, whole grains, and drinking plenty of water, lead to a sustained good mood? Conversely, if we eat what we might describe as comfort food, which nutritionally might mean primarily carbohydrate and fat-laden cookies, cakes, chips, crackers, and other processed snack foods, does this put us in a bad mood? And finally, how does our brain regulate how much we eat?

Before we answer that question, let's go back to the brain and the biological response. For thousands of years, human food consumption was regulated through a complex hormone response that was designed to get us to find food and eat when hungry, and stop eating when satisfied. In addition to the hormones involved in the stress response (which cause us to seek out and find food), there are hormones that regulate our digestive response, signaling that it's time to stop eating and focus on digestion. The brain, through the HPA Axis, controls these responses. Scientists believe we rely on a remarkable, naturally occurring hormone called leptin to regulate what we eat, and it also tells our brain when we've had enough. However, it appears that leptin's ability to regulate appetite has gone awry, leading to overeating and obesity. But why are we eating more?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It is suggested that leptin's signals to the brain are not being "heard" (7). The hormone leptin, which comes from the Greek *leptos*, meaning thin, has a role in energy balance and metabolism. Leptin is secreted by fat cells, and when working properly, your body responds to leptin by signaling the brain to decrease your appetite after you've eaten. Leptin also promotes calorie burning. It was discovered by accident in the mid-1990s when researchers found that mice treated with leptin ate considerably less, and mice with less leptin overate. It works the same way in people, with a twist: obese people have high levels of leptin, but researchers at Harvard and elsewhere think their bodies are less sensitive to its effects. Leptin resistance, as it's known, results in "unnecessarily high food intake," and low leptin levels are a precursor to obesity (7–10).

So why then, if the body has an innate system, honed by eons of trial and error to regulate fat stores and keep the body in homeostasis, is the United States and many other countries facing an obesity epidemic of unprecedented scale? What causes leptin resistance? Research shows a connection to overexposure to high levels of leptin hormone, caused by eating too much sugar (11).

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Scientists have known about this process ("resistance") occurring with the hormone insulin. Insulin regulates how the body uses and stores glucose and fat. High blood sugar levels cause repeated surges in insulin, and this causes the body's cells to become "insulin-resistant", which leads to the production of even higher levels of insulin, eventually leading to type 2 diabetes (12). It is much the same as being in a room with a strong odor for a period of time. Eventually, you stop being able to smell it, because the signal no longer gets through. The same process also occurs with leptin. It has been shown that as sugar gets metabolized and stored as triglycerides in fat cells, the fat cells release surges of leptin, and those surges result in leptin-resistance, just as it results in insulin-resistance. When you become leptin-resistant, the body can no longer hear the messages telling it to stop eating and burn fat–so it remains hungry and stores more fat.

This will not only contribute to weight gain, but also increase the risk of many chronic illnesses, as leptin plays a significant, if not primary, role in heart disease, obesity, diabetes, osteoporosis, autoimmune diseases, reproductive disorders, and perhaps, the rate of aging itself (13).

The science of leptin research is producing astounding findings. Researchers in 2013 studied the relationship between diet, body weight, and leptin regulation (9). Observing that chronic consumption of a Western-type diet, containing both high levels of sugar and fat results in leptin resistance, they hypothesized that fructose, as part of the sugar component of Western-type diets, is one cause ingredient in the development of leptin resistance. In their research, they speculated that if they removed fructose they would then prevent leptin resistance even if subjects (rats) ate a high fat diet. They fed study rats a sugar-free high fat diet or a high-fructose high fat diet for 134 days. The high-fructose diet resulted in impaired responses to leptin. They saw that the rats who were on a sugar free, high-fat diet had no problem with leptin response. They then switched the groups, and showed the opposite effect—rats that were completely responsive to leptin and body weight regulation when on a sugar-free high fat diet lost their regulatory ability, and became leptin resistant (and gained weight). The other rats, which had previously been leptin resistant, regained their ability to regulate their weight when they got off fructose and went on a sugar-free high fat diet. The study authors concluded that a diet containing both fructose and fat (which is very much like the standard American diet) leads to leptin resistance, while a sugar-free high fat diet does not. Especially important is that *removing* fructose from the diet reversed the leptin resistance (9).

We'll read more about sugar in the next chapter, but the implications are chilling. It appears that our Western high sugar, high fat mostly processed food Standard American Diet (SAD) diet is to blame for its impact on elevated body weight. So we can conclude that the brain is responsible for weight gain, with leptin being the hormone that's not properly "heard" by the brain. But back to the brain and mood regulation—is a highly processed food diet responsible for mental health disturbances such as anxiety and depression? In other words, does our food affect our mood?

For thousands of years, people have believed that food could influence their health and well-being. During the Middle Ages, people started to take great interest in how certain foods affected their mood and temperament. Many medical culinary textbooks of the time described the relationship between food and mood. For example, quince, dates, and elderberries were used as mood enhancers, lettuce and chicory as tranquilizers, and apples, pomegranates, beef, and eggs as erotic stimulants (14). The past

80 years has seen immense progress in research, primarily short-term human trials and animal studies, showing how certain foods alter brain structure, chemistry, and physiology. This affects mood and performance. These studies suggest that foods directly influencing brain neurotransmitter systems have the greatest effects on mood. In turn, mood can also influence our food choices, and *expectations* on the effects of certain foods can influence our perception.

## The Complex Mood–Food Relationships: Why It Matters

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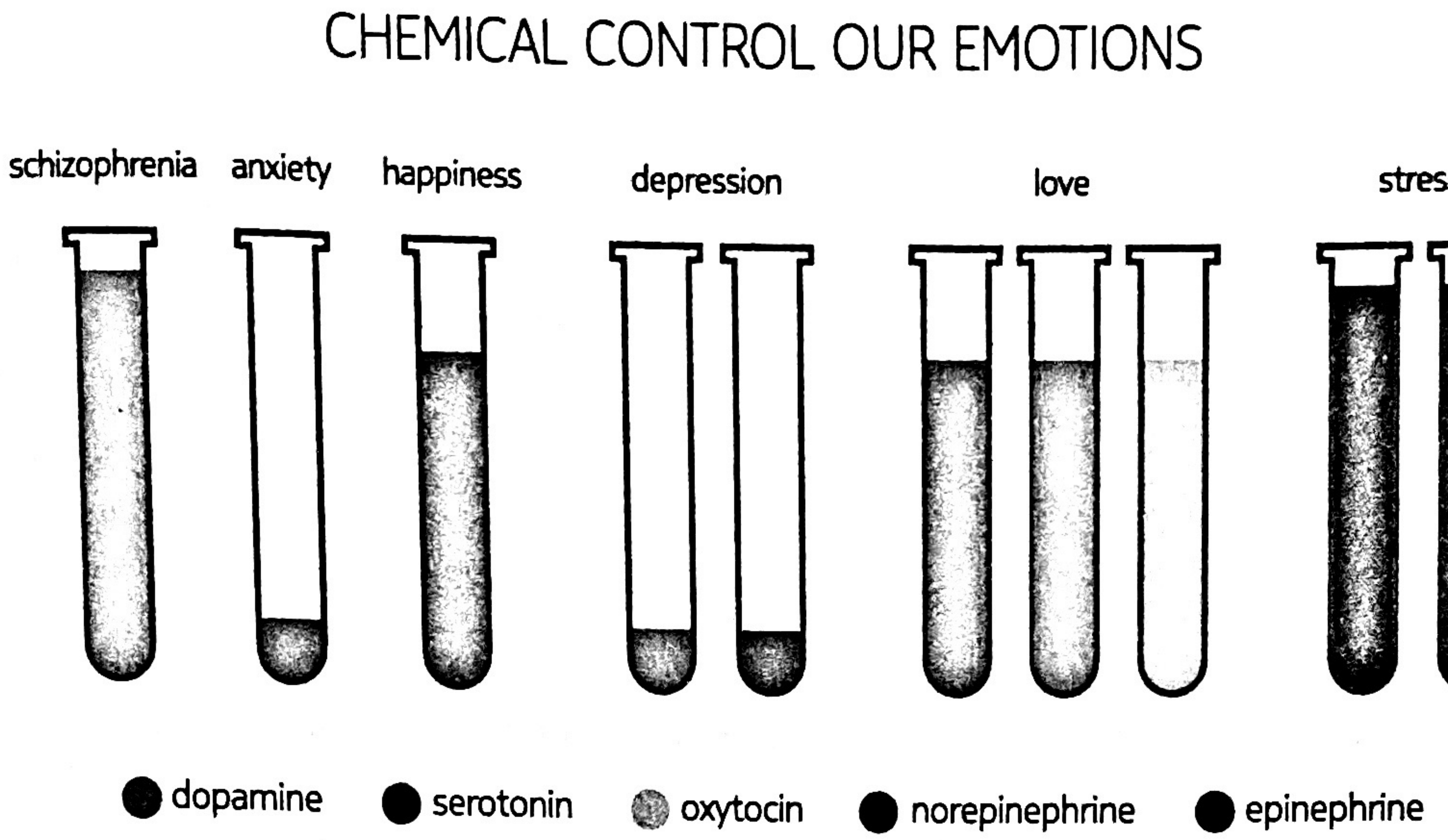
The relationship between food and mood in individuals is complex and depends "on the time of day, the type and macronutrient composition of food, the amount of food consumed, and the age and dietary history of the subject" (15). Modern scientific nutrition research has demonstrated what Ancient Wisdom held to be true: there is an individual nutritional prescription that "fits" each person, since the complexity of biological interactions is quite individualized. For example, in one study by Spring et al. (16), 184 adults either ate a protein-rich or carbohydrate-rich meal. After 2 hours, their mood and performance were measured (16). The effects of the meal different for female and male subjects and for younger and older participants. For example, females reported greater sleepiness after a carbohydrate meal and males reported greater calmness. In addition, participants aged 40 years or older showed impairments on a test of sustained focused attention after a carbohydrate lunch.

Circadian rhythms also influence energy levels and performance throughout the day. People who describe themselves as "early birds" feel most productive in the first part of the day, and their food choices become particularly important during lunch and throughout the afternoon. Those who are "night owls" feel most energetic later in the day and should pay attention to their breakfast choices as they can increase or decrease energy levels and influence cognitive functioning. These findings were suggested in another research study. Michaud et al. (17) found if you are an evening person and you skip breakfast, your cognitive performance might be impaired. A large breakfast rich in protein could improve your recall performance but might impair your concentration. This illustrates just how complex the relationship between food and mood are. It also suggests that Ancient Wisdom knew best—we must match our own individual patterns with the right food choices to find a healthy balance.

# Serotonin: The Impact of Carbohydrates and Protein

Serotonin is an important neurotransmitter that the brain produces from tryptophan contained in foods such as clams, oysters, escargots, octopus, squids, banana, pineapple, plum, nuts, milk, turkey, spinach, and eggs. Functions of serotonin include the regulation of sleep, appetite, and impulse control. Increased serotonin levels are related to mood elevation. Researchers have considered theories suggesting that a diet rich in carbohydrates can relieve depression and elevate mood in disorders such as carbohydrate craving obesity, pre-menstrual syndrome, and seasonal affective disorder (SAD) (18). They theorized that increased patients' carbohydrate intake associated with these disorders represented self-medicating attempts and that carbohydrates increased serotonin synthesis. A protein rich diet, in contrary, decreases brain serotonin levels.

Controlling the amount of serotonin in the brain is limited by the availability of its precursor tryptophan, an amino acid. The large amino acids such as tryptophan, valine, tyrosine, and leucine share the same transport carrier across the blood–brain barrier. They then compete with each other for the ability to pair up with a transporter to take serotonin into the brain, boosting mood. Eating foods high in protein increases the amount of many amino acids in the blood but not of tryptophan, which is only found in low doses in dietary protein. This means that many large amino acids compete with a small amount of tryptophan for transport into the brain, meaning that less tryptophan is available for serotonin synthesis.

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We can theoretically change this through consuming foods high in carbohydrates, which changes amino acid levels in the blood. As blood glucose (sugar) levels rise, insulin is released and enables muscle tissues to take up most amino acids except for tryptophan, which is bound to albumin in the blood. As a result, the ratio of tryptophan relative to other amino acids in the blood increases, which enables tryptophan to bind to transporters, enter the brain in large amounts, and stimulate serotonin synthesis (18).

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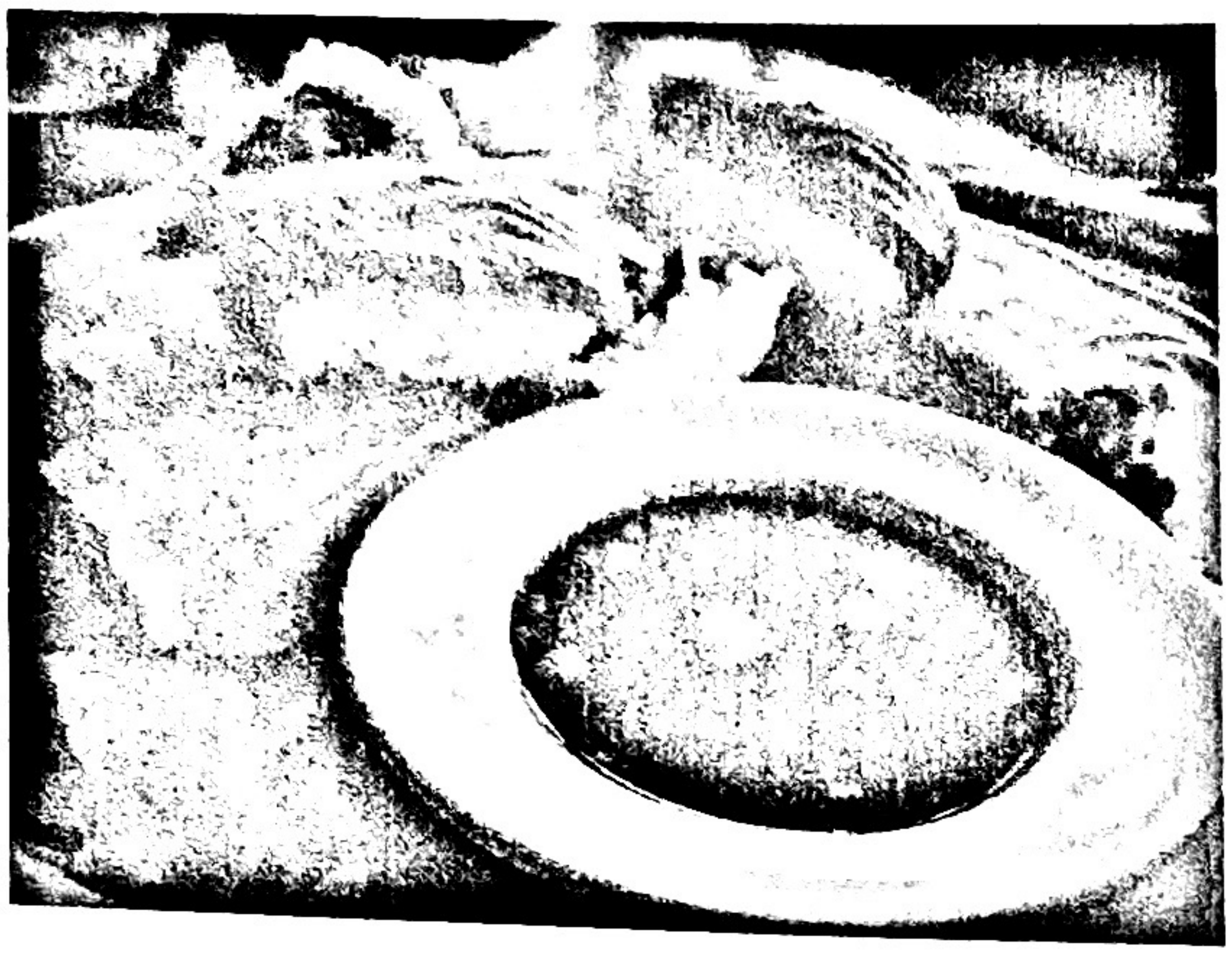
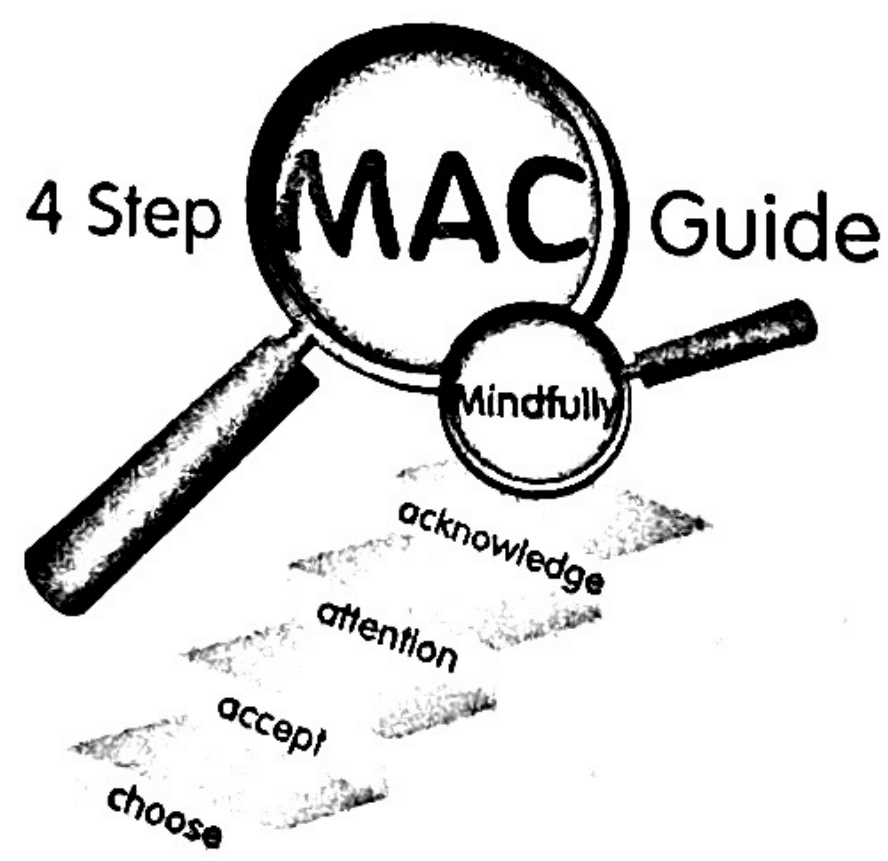
Does this mean that if we're depressed we should eat a lot of carbohydrates? Not so. Benton and Donohoe (18) found that only a protein content of less than 2% of a meal helped raise serotonin levels. Foods high in carbohydrates such as bread and potatoes contain 15% and 10% of calories, respectively, that come from protein thereby undermining the effects of carbohydrates on serotonin levels. This does not mean that "carbohydrate craving" is an explanation for our desire for foods such as chocolate, ice cream, and other sweets. Some think that these cravings are one way to get serotonin levels raised. However, most of their calories come from fat and contain enough protein to undermine any effect of carbohydrates on serotonin levels (19). Cravings for sweets may come from birth, and we'll read more about this in the next chapter.

Omega-3 fatty acids can influence mood, behavior, and personality. Low blood levels of polyunsaturated omega-3 fatty acids which are found in flaxseed oil, walnuts, soybeans, and salmon (as four examples) are associated with depression, pessimism, and impulsivity, according to a study by the University of Pittsburgh Medical Center (20). In addition, they can play a role in major depressive disorder, bipolar disorder, schizophrenia, substance abuse, and attention deficit disorder. In recent decades, people in Western developed countries have consumed greater amounts of omega-6 polyunsaturated fatty acids, contained in foods such as eggs, poultry, baked goods, whole-grain bread, nuts, and many oils, that outcompete omega-3 polyunsaturated fatty acids. Especially docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), both members of the omega-3 fatty acid family, contribute to the fluidity of the cell membrane, thereby playing an important role in brain development and functioning. Omega-3 fatty acids are found in fish, other seafood including algae and krill, some plants, meat, and nut oils. Many foods such as bread, yogurt, orange juice, milk, and eggs are oftentimes fortified with omega-3 fatty acids as well.


Courtesy of Maria Napoli

Micronutrients such as thiamine (found in cereal grains, pork, yeast, potatoes, cauliflower, oranges, and eggs) can help boost overall energy levels and lift moods. A deficiency in iron status can result in depressed mood, lethargy, and problems with attention (14). Iron deficiency also results in a decreased ability to exercise. Foods rich in iron include liver, vegetables such as broccoli, asparagus, and parsley, seafood, iron-fortified grains, greens, nuts, meat, and dried fruits. The micronutrient folic acid also plays an important role in the brain. Folic acid deficiency, which is rare in the general population, is associated with depressed mood. Psychiatric patients are particularly at risk for developing folic acid deficiency because of possible disordered eating habits caused by a loss of appetite and anticonvulsant drugs, which inhibit folic acid absorption (19). Foods rich in folic acid include dark, leafy green vegetables, liver and other organ meats, poultry, oranges and grapefruits, nuts, sprouts, and whole wheat breads.

Although the interaction between food and mood is complex, there are a number of dietary interventions that can help relieve anxiety and depression. Recommendations include:




- Follow a diet plan that prevents hypoglycemia (e.g., eliminate or reduce refined sugar, alcohol, caffeine, and tobacco; eat 4–6 small meals throughout the day; eat plenty of dietary fiber.
- An elimination or rotation diet will help to decide whether or not you have sensitivities to particular foods.

*Helpful Foods*

- Foods high in omega-3 fatty acids for growth and repair of nervous tissue: nut, seed, cold water fish (salmon, halibut, mackerel) and vegetable oils (safflower, walnut, sunflower, flax seed), evening primrose oil (500 mg/3 times per day).
- Foods rich in vitamin B6—needed for normal brain function: Brewer's yeast, bok choy, spinach, banana, potato, whole grains.
- Foods rich in tryptophan—precursor to neurotransmitter serotonin: white turkey meat, milk, nuts, eggs, fish.
- Liver cleansing foods—proper liver function helps to regulate blood sugar: garlic, onions, broccoli, cauliflower, cabbage, Brussels sprouts, beets, carrots, artichokes, lemons, parsnips, dandelion greens, watercress, burdock root.
- Magnesium rich foods—important for nerve conduction: seeds, legumes, dark green leafy vegetables, soy products, almonds, pecans, cashews, wheat bran, meats.

*Avoid*

- Tobacco, alcohol, caffeine, artificial sweeteners
- Refined sugar and processed foods
- Be aware of your specific food sensitivities

Try a meal or snack with fiber-rich complex carbohydrates and low-fat protein to help balance your mood.

**Spicy Tofu Salad**
with Basalmic Dressing
makes four servings

1 pound firm-style tofu or Tempeh

3 cloves garlic, minced (separate into two small bowls)

Juice from 1 lemon

¼ tsp. chili flakes

½ tsp. chili powder

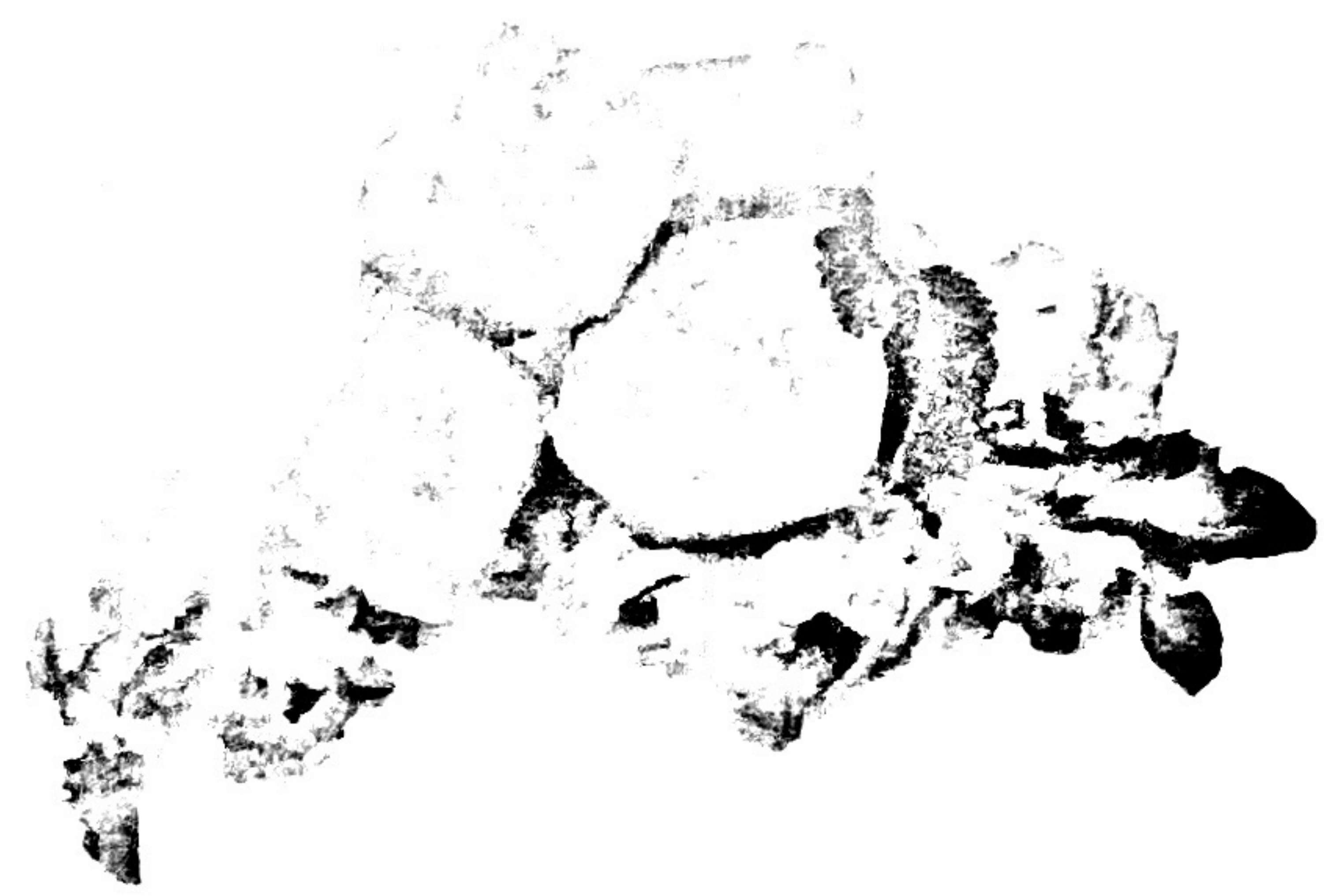
1 small jalapeno, seeded and minced

2 tbsp. olive oil

1 tbsp. basalmic vinegar

2 tsp. Dijon mustard

2 tsp. Maple syrup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4 cups organic salad greens including:

dandelion greens, watercress, arugula, baby kale, romaine, spinach, and swiss chard

½ cup organic shredded carrot

⅓ cup thinly sliced celery

¼ cup thinly sliced red onion

1 – 2 tablespoons canola oil

Drain tofu, cut into ½-inch thick slices, press briefly with paper towel to absorb excess water. If using tempeh, simply slice tempeh into ½-include slices.

In a shallow bowl, mix together half of the minced garlic, lemon juice, chili flakes, chili powder, and minced jalapeno; coat tofu/tempeh in liquid and allow it to marinate for 30 minutes. Drain and discard marinade; pat tofu/tempeh dry.

Preheat heavy iron skillet or wok. Lightly coat skillet with vegetable oil. Pan fry or stir fry tofu/tempeh for 4–5 minutes on each side or until lightly browned.

In small bowl, wisk together olive oil, basalmic vinegar, Dijon mustard, maple syrup, and the rest of the minced garlic.

Arrange salad greens on serving plates. Arrange tofu/tempeh evenly over greens. Garnish each salad with carrot, celery, and red onion. Top each portion with about 1 tablespoon of the dressing. Garnish, if you wish, with sliced jalapenos.

*Tofu and tempeh are good sources of magnesium. Deficiencies in magnesium have been linked to depression, irritability, and confusion.

## References


1. Alberts, B., Johnson, A., and Lewis, J. 2002. *How Cells Obtain Energy from Food.* [webpage] *National Institutes of Health*, 4th edition. [January 10, 2015]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK26882/.