

Chapter 12: Celiac Disease and Food Reactions

Summary

Celiac disease is a lifelong immune reaction to gluten that damages the tiny, finger-like villi lining the small intestine, and it affects about 1 in 100 people worldwide. This chapter explains why only people with certain gene variants get it, how a blood test and a small bowel biopsy confirm it, why the gluten-free diet is the only proven treatment, and how celiac disease can reach the nervous system. It then sorts out the confusing family of food reactions: food allergy, food intolerance (such as lactose intolerance), and non-celiac gluten sensitivity, where blinded trials suggest a carbohydrate called fructan may often be the real trigger. Along the way you will see why cutting out foods without a reason can backfire.

Concepts Covered

1. Celiac Disease
2. Gluten
3. HLA-DQ2 and HLA-DQ8
4. Intestinal Villi
5. Villous Atrophy
6. Tissue Transglutaminase Antibody
7. Small Bowel Biopsy
8. Gluten-Free Diet
9. Gluten Ataxia
10. Peripheral Neuropathy
11. Non-Celiac Gluten Sensitivity
12. Fructan
13. Food Allergy
14. Immunoglobulin E
15. Food Intolerance
16. Lactose Intolerance
17. Unneeded Restrictive Diet

Prerequisites

- [Chapter 3: Meet the Microbiome](#) (correlation vs causation)
- [Chapter 4: The Immune System as a Sense Organ](#) (gut immune cells and cytokines)
- [Chapter 10: IBS and Disorders of Gut-Brain Interaction](#) (FODMAPs and the placebo response)

Not every food reaction is the same reaction



Gluten-free labels are everywhere, and almost everyone knows someone who "can't eat" some food. Some of those reactions are serious immune diseases, some are digestion problems, and some are still a scientific puzzle. By the end of this chapter you'll be able to tell them apart, and you'll know why the order of testing matters so much.

12.1 The Gluten-Free Puzzle

Sam's older cousin, the one who keeps posting about supplements, has a new announcement. He has gone gluten-free, and he says his "brain fog" is gone. His post ends with a link to a gluten-free snack brand and the line "Gluten is poison for everyone's brain." Sam rolls his eyes, but he also wonders. Gluten-free menus are at every restaurant in town. Is gluten actually bad for everyone? (Sam, Riya, and their friends are fictional students who appear throughout this book.)

Meanwhile, Riya has a real reason to care about gluten. A girl in her orchestra section, Mei (also fictional), was diagnosed with celiac disease last year. When Riya and her grandmother bake for the orchestra potluck, Mei can't eat anything made with regular flour, and she can't even eat a gluten-free cookie if it was cut with the same knife as a regular one. For Mei, gluten is not a lifestyle choice. It is a trigger for an immune attack on her own intestine.

Here is the puzzle. A [2018 review of 96 studies](#) estimated that about 1 in 100 people worldwide has celiac disease. Yet in a US national survey, the share of people who avoided gluten *without* having celiac disease more than tripled in just a few years, from 0.5% in 2009 to 2010 to 1.7% in 2013 to 2014, according to a 2016 analysis by [Choung and colleagues](#). By then, more people were avoiding gluten without a diagnosis than had celiac disease at all (about 0.7% of people in the same survey). So who actually needs to avoid gluten, and why? To answer that, we need to look at the lining of the small intestine up close.

12.2 A Carpet That Feeds You: The Intestinal Villi

Picture two bath mats. One is a flat rubber mat. The other is a thick, shaggy towel-like mat with thousands of soft loops. Spill a glass of water on each. The flat mat barely holds any; the shaggy one soaks it up, because all those loops add up to a huge surface. Your small intestine is built like the shaggy mat.

Intestinal villi are tiny, finger-like projections of the small intestine's lining that greatly increase its surface area for absorbing nutrients. According to the open textbook *Anatomy and Physiology 2e* from OpenStax, each villus is only about 0.5 to 1 millimeter long, and there are about 20 to 40 of them in every square millimeter of lining. Inside each villus is a tiny bed of blood capillaries and a lymph vessel, which carry absorbed nutrients away.

The surface gets even bigger at a smaller scale. Each absorbing cell on a villus is covered with **microvilli**, hair-like extensions of the cell membrane about 1 micrometer long. Under a microscope, they look like the bristles of a brush, so together they are called the brush border. Enzymes stuck to the brush border finish digesting carbohydrates and proteins. One of those enzymes, lactase, breaks down the milk sugar lactose, which will matter in Section 12.9.

OpenStax notes that the folds of the lining, the villi, and the microvilli together increase the small intestine's absorptive surface more than 600-fold compared with a smooth tube. That is the whole point: food is broken into small molecules, and those molecules must touch a cell to get into your body. More surface means more absorption.

Level	Structure	Rough size	What it adds
Biggest	Circular folds of the lining	Ridges you can see with the naked eye	Slow food down and add surface
Middle	Villi	About 0.5 to 1 mm long	Tens of villi per square millimeter
Smallest	Microvilli (brush border)	About 1 micrometer	Huge membrane surface plus digestive enzymes

Now imagine someone mowing the shaggy mat down until it is nearly flat. The mat still exists, but it can't soak up much. That is what celiac disease does to the small intestine.

12.3 What Celiac Disease Is

Celiac disease is a lifelong, immune-driven disorder in which eating gluten triggers the immune system to damage the lining of the small intestine. [The American College of Gastroenterology \(ACG\) 2023 guideline](#) defines it as a permanent immune-mediated response to gluten. [The National Institute of Diabetes and Digestive and Kidney Diseases \(NIDDK\)](#) calls it a chronic digestive and immune disorder. Many scientists describe it as **autoimmune**, meaning the immune system attacks the body's own tissue, because the immune reaction damages the person's own intestine and produces antibodies against one of the body's own enzymes (more on that in Section 12.4).

Gluten is a group of proteins found naturally in wheat, barley, and rye. It gives bread dough its stretch. According to NIDDK, gluten is in obvious foods like bread, pasta, cookies, and cakes, but also in many

processed foods, because ingredients such as some starches, flavorings, and malt are made from these grains.

Who can get it: the gene "key"

This next fact surprises many people: celiac disease almost never develops unless a person carries certain gene variants. Think of it like a lock and key. The genes make a "display stand" on immune cells, and only some display stands hold gluten pieces in a way that sets off an alarm.

HLA-DQ2 and HLA-DQ8 are versions (variants) of immune-system genes in the human leukocyte antigen (HLA) family that make proteins on certain immune cells; nearly everyone with celiac disease carries one or both. MedlinePlus Genetics, a US National Library of Medicine site, explains that HLA proteins hold up small protein fragments so other immune cells can check whether they are "self" or "foreign." In celiac disease, the immune system wrongly treats fragments of gluten as a threat.

But carrying the key is not enough. NIDDK says about 30% of people have DQ2 or DQ8, yet only about 3% of those carriers develop celiac disease. A person also has to eat gluten, and other genes and environmental factors (such as early infections, which researchers are still studying) probably play a role. That means a genetic test is more useful for ruling celiac disease *out* than for ruling it *in*: if you don't carry DQ2 or DQ8, celiac disease is very unlikely.

How common is it?

Measure	Figure	Source
Worldwide, positive blood test	1.4% (in 275,818 people)	Singh et al. 2018 meta-analysis
Worldwide, confirmed by biopsy	0.7% (in 138,792 people)	Singh et al. 2018 meta-analysis
North America, confirmed by biopsy	0.5%	Singh et al. 2018
United States, estimated number of people	About 2 million	NIDDK

So "about 1 in 100 people worldwide" is a fair summary. Singh's review also found celiac disease more common in females than males (0.6% vs 0.4%) and in children than adults.

NIDDK notes that many people with celiac disease have not been diagnosed, that some people have celiac disease along with other immune-related conditions such as type 1 diabetes or thyroid disease, and that it is more common in people with certain chromosome conditions such as Down syndrome. It also runs in families: MedlinePlus Genetics says parents, siblings, and children of someone with celiac disease have about a 4 to 15% chance of developing it.

A gene that's necessary, not sufficient



I like to think of DQ2 and DQ8 as a ticket to a concert: almost nobody gets in without one, but holding a ticket doesn't mean you'll go. About 30% of people hold the ticket, and only about 3% of them ever get celiac disease.

12.4 Villous Atrophy: What the Damage Looks Like

What happens when someone with celiac disease eats gluten? The chain of events goes like this.

1. **Gluten arrives.** Gluten proteins are tough, and some fragments survive digestion and reach the lining of the small intestine.
2. **An enzyme changes the fragments.** An enzyme in the intestine called tissue transglutaminase (tTG) chemically modifies gluten fragments. A 2021 trial report by [Schuppan and colleagues](#) in the *New England Journal of Medicine* explains that this change makes the fragments stimulate immune T cells more strongly.
3. **The display stand shows them.** Immune cells carrying DQ2 or DQ8 hold up the modified fragments, and T cells (white blood cells that direct immune attacks) react as if they had found an invader.
4. **Inflammation follows.** The activated immune cells release inflammatory signals (cytokines, which you met in [Chapter 4](#)), and immune cells crowd into the lining.
5. **The villi shrink.** The lining is damaged faster than it can rebuild. The villi get shorter and blunter, and in severe cases flatten almost completely.
6. **The body makes antibodies against itself.** The immune system also makes antibodies against tTG, the body's own enzyme. That's part of why celiac disease is called autoimmune, and it is what the main blood test looks for.

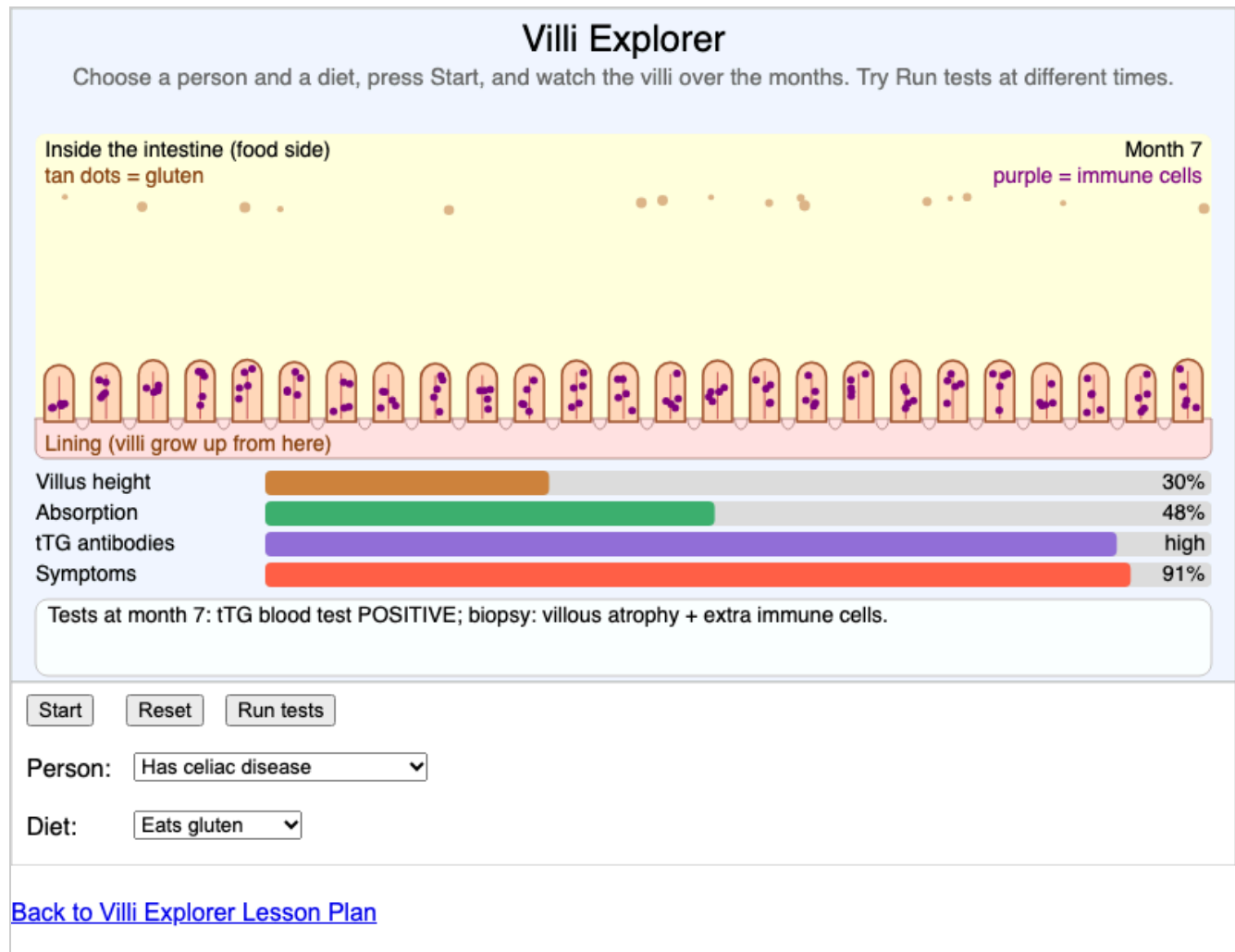
The result is **villous atrophy**, the shortening and flattening of the intestinal villi, seen under a microscope, that is the hallmark damage of celiac disease. MedlinePlus Genetics describes the villi in celiac disease becoming shortened and eventually flattening out. A 2018 *Lancet* review by [Lebwohl, Sanders, and Green](#) says the diagnosis requires villous atrophy in the first part of the small intestine (the duodenum).

With less surface, the intestine absorbs less. That one fact explains many celiac symptoms, which NIDDK lists as including diarrhea, bloating, gas, belly pain, and greasy stools; in children, slow growth, weight loss, delayed puberty, and damage to tooth enamel; and in anyone, fatigue, anemia (low red blood cells, often from poor iron absorption), and weak bones. Damage to the brush border can also reduce lactase, so NIDDK notes that some people with celiac disease become lactose intolerant until the lining heals.

Symptoms vary a lot. NIDDK says digestive symptoms are more common in children than adults, and some people have no obvious symptoms but still have damage. MedlinePlus Genetics notes that, on average,

diagnosis comes 6 to 10 years after symptoms begin, partly because tiredness and belly pain have many other causes.

Diagram: Villi Explorer



Interactive simulation: <https://aaryavvatts-lab.github.io/gut-brain-textbook/sims/ch12-villi-explorer/main.html>

Open the Villi Explorer fullscreen



MicroSim specification: Villi Explorer



Type: microsim **sim-id:** ch12-villi-explorer

Library: p5.js

Status: Implemented

Bloom Level: Understand

Bloom Verb: explain

Learning Objective: The learner will explain how gluten exposure in celiac disease shortens the intestinal villi and reduces absorption, why the villi stay normal in a person without celiac disease, and why testing must happen before a gluten-free diet starts.

Canvas: 440 px drawing area plus 120 px controls (iframe 562 px); responsive to about 380 px wide.

Controls: Start/Pause, Reset, Run tests; Person select (Has celiac disease; Does not have celiac disease); Diet select (Eats gluten; Gluten-free diet).

Rules: Time advances in months. With celiac disease and gluten, inflammation and tTG antibodies rise over weeks and villus height falls toward a flat lining over a few months. On a gluten-free diet, symptoms and inflammation settle within weeks, antibodies fall over months, and villi regrow slowly (many months to years). Without celiac disease, villi stay normal on either diet. Run tests reports a tTG blood test (positive above a set level) and a biopsy result (villous atrophy when villi are clearly shortened).

Feedback: Meters show villus height, absorption, tTG antibody level, and symptoms; a status panel explains the current state and the last test result.

Provenance: Sections 12.2 to 12.6 (OpenStax A&P 2e; NIDDK; Lebwohl 2018; Rubio-Tapia 2010 for slow mucosal recovery). All rates and percentages are illustrative.

Start with **Has celiac disease** and **Eats gluten**, then press Start. Over the first few simulated months, purple immune cells crowd into the lining, the villi shrink, and the absorption meter drops. Press **Run tests** once the villi look short: the blood test and biopsy both come back positive. Now switch the diet to **Gluten-free diet** and keep watching. The symptom meter falls fast, but the villi take much longer to grow back, and the antibody meter falls slowly.

Now try the key experiment. Press Reset, let the villi shrink again, then switch to gluten-free *before* running the tests. Wait about a year and a half of simulated time and press **Run tests**. The tests may now come back negative, even though the person still has celiac disease. Finally, choose **Does not have celiac disease** and run either diet: the villi stay tall no matter what.

What this model leaves out

- Real villous damage is patchy and graded by pathologists on scales with several levels; the sim shows one smooth "height."
- The timing is illustrative. Real people vary a lot: NIDDK says symptoms often improve within days to weeks, while healing of the lining can take months to years, and in one study of adults only about two thirds had confirmed healing by 5 years.
- The sim leaves out the genes (DQ2 and DQ8), the many immune cell types, and the tTG chemistry; "has celiac disease" stands in for all of it.
- Real gluten exposure is rarely all or nothing. Small amounts from cross-contact can keep damage going.
- The "absorption" and "symptom" meters are teaching cartoons, not measurements, and symptoms don't always match the amount of damage.

12.5 Testing: The Blood Test and the Biopsy

Because celiac symptoms overlap with IBS, lactose intolerance, and many other conditions, NIDDK says doctors don't diagnose celiac disease from symptoms alone. They use two main tests.

Tissue transglutaminase antibody (tTG antibody) testing is a blood test that measures antibodies against tTG, the body's own intestinal enzyme; high levels suggest active celiac disease. The ACG 2023 guideline says tTG antibody testing is very helpful for the first screening of people suspected of having celiac disease. The standard tTG test measures antibodies of a type called IgA. NIDDK notes that selective IgA deficiency, in which the body makes little or no IgA, is more common in people with celiac disease, so doctors may check a person's overall IgA level along with the tTG test.

A **small bowel biopsy** is the removal of tiny pieces of tissue from the small intestine, usually the duodenum, during an upper endoscopy, so a pathologist can look for villous atrophy and immune cells under a microscope. In an upper endoscopy, a doctor passes a thin, flexible tube with a camera through the mouth and stomach into the first part of the small intestine, according to NIDDK. The ACG guideline says a biopsy is required to confirm the diagnosis in most patients, although a no-biopsy route can be used for selected children who meet strict criteria.

Under the [2020 European pediatric guidelines \(ESPGHAN\)](#), this route can be used in children whose tTG antibody level is at least 10 times the upper limit of normal, confirmed by a second antibody test (endomysial antibodies) on a separate blood sample; symptoms are no longer required.

Why "go gluten-free first" is a trap

Both tests look for the immune system's response to gluten. Take the gluten away, and the response fades: antibodies drop and the villi start to heal. That's great for treatment, but terrible for diagnosis. NIDDK states

plainly that doctors don't recommend starting a gluten-free diet before diagnostic testing, because the diet can affect test results.

Think of a smoke detector test. If you want to know whether the detector works, you have to make smoke while you test it. If you clear the room first, the detector stays silent, and you learn nothing about whether there was ever a fire.

Someone who has already gone gluten-free and wants to be tested should talk with their doctor about what to do. Reintroducing gluten for testing is a medical decision, so it should be planned with the care team, not done alone.

Test first, then change the diet



The most common mistake I see is someone cutting out gluten "just to see," feeling a bit better, and then getting a negative test months later. If you think gluten bothers you, the first step is a conversation with a doctor while you're still eating your usual diet.

12.6 The Gluten-Free Diet: Simple to Say, Hard to Do

The **gluten-free diet** is an eating plan that strictly avoids wheat, barley, rye, and ingredients made from them; for people with celiac disease it is lifelong and is the only proven treatment. The ACG 2023 guideline says treatment requires strict adherence to a gluten-free diet and lifelong medical follow-up, and that most patients respond very well. NIDDK says that for most people the diet heals the small intestine and prevents further damage, and many people notice symptoms improve within days to weeks.

"Strict" really means strict. NIDDK describes several challenges:

- **Hidden gluten.** Many additives, such as malt flavoring and some modified food starches, can come from gluten grains.
- **Cross-contact.** A gluten-free food can pick up gluten from a shared toaster, cutting board, fryer oil, or knife, like Mei's cookie in Section 12.1.
- **Labels.** In the United States, the FDA requires foods labeled "gluten-free" to contain less than 20 parts per million of gluten, an amount NIDDK says is too small to cause problems for most people with celiac disease.
- **Oats.** NIDDK says research suggests most people with celiac disease can safely eat moderate amounts of oats, but oats are often contaminated with other grains, so this is a question for a doctor or dietitian.
- **Cost.** NIDDK notes that packaged gluten-free foods tend to cost more than the regular versions.

That's why NIDDK recommends a registered dietitian, a nutrition professional who can teach label reading, plan balanced meals, and check for nutrient gaps. Many foods are naturally gluten-free, including rice, potatoes, corn, beans, fruits, vegetables, meat, and fish, so the diet doesn't have to be bland. Riya's

grandmother, who cooks a lot of rice and lentil dishes, discovers that many family recipes were gluten-free all along; the things to watch are spices or mixes that may contain wheat, and utensils that need to stay separate.

Follow-up matters too. NIDDK says doctors may recheck antibody levels, which typically return to normal on the diet, and sometimes repeat a biopsy. About 20% of people with celiac disease have symptoms that continue or return on a gluten-free diet, according to NIDDK. Causes include small amounts of hidden gluten and other health problems. A rare form called refractory celiac disease doesn't heal even on a strict diet and needs specialist care.

Healing is slower than feeling better. In a 2010 Mayo Clinic study of 241 adults with biopsy-proven celiac disease, [Rubio-Tapia and colleagues](#) found confirmed healing of the lining in about 34% by 2 years and about 66% by 5 years, and feeling better did not reliably predict whether the lining had healed.

If you're going through this

If you've just been diagnosed with celiac disease, it's normal to feel overwhelmed, or even to grieve foods you love. You're not being dramatic; food is tied to family, culture, and friendship. A dietitian can help you find safe versions of your favorite meals, and many teens find it easier once they have a few go-to snacks and a short script, like "I have celiac disease, so I can't share, but thanks." If you keep having symptoms on the diet, tell your care team instead of assuming you failed. Hidden gluten is common and fixable.

12.7 Beyond the Gut: Celiac Disease and the Nervous System

Celiac disease is not only a gut disease. The ACG guideline describes it as resembling a multisystem disorder. NIDDK lists nervous system symptoms such as headaches, balance problems, seizures, and peripheral neuropathy, as well as mental health problems such as depression or anxiety.

Peripheral neuropathy is damage to the peripheral nerves (the nerves outside the brain and spinal cord), often causing numbness, tingling, burning, or weakness, usually starting in the hands and feet. You can picture it like a frayed phone cord: messages from the skin arrive garbled or not at all.

Gluten ataxia is a problem with balance and coordination linked to gluten sensitivity, thought to involve immune damage to the cerebellum, the part of the brain that fine-tunes movement. (For a refresher on the cerebellum, see [From Neuron to Bedside, Chapter 7](#).) "Ataxia" means unsteady, uncoordinated movement.

How common are these? A 2019 systematic review by [Mearns and colleagues](#) pooled 16 studies of people with celiac disease. Neuropathy was reported in **up to** 39% of patients across 13 studies, while gluten ataxia was much less common, from 0% to 6% across 9 studies. The numbers vary widely because the studies were small and used different methods, so "up to 39%" is the top of a wide range, not a typical rate. The review also found that sticking to a gluten-free diet appeared to improve both conditions. Note that several authors of that review worked for or consulted for a drug company (Takeda), which the paper discloses.

Neurological problems in people with celiac disease have been reported since 1966, according to a 2010 *Lancet Neurology* review by [Hadjivassiliou and colleagues](#), but exactly how a gluten-triggered immune reaction leads to nerve damage is still being studied.

What about mood? A 2012 meta-analysis by [Smith and Gerdes](#) of 18 depression studies found that depression was more common or more severe in adults with celiac disease than in healthy adults, but about the same as in adults with other long-term physical illnesses. Anxiety was not reliably different. That pattern suggests the link may come partly from the general stress of living with a chronic illness, not from something unique to gluten. It's a correlation, so it can't tell us the cause.

Hype Meter: "Celiac disease can affect your nerves and brain, not just your gut"

Strong

Moderate

Preliminary

Hype

Verdict: Moderate. Human studies consistently link celiac disease with peripheral neuropathy (reported in up to 39% of patients across small studies) and, less often, gluten ataxia (0% to 6%), and NIDDK lists nervous system symptoms as part of the disease. But the studies are small and varied, the exact mechanism is unclear, and the evidence that the gluten-free diet helps comes from observation, not randomized trials. **What would change the grade:** Large studies that follow people from diagnosis with careful nerve testing, plus a clear mechanism, could move it to Strong.

"Gluten is poison for everyone's brain"

Sam's cousin made a much bigger claim: that gluten harms *everyone's* brain. Popular books and posts have spread this idea, often by stretching what is true for people with celiac disease to the whole population.

Hype Meter: "Gluten damages everyone's brain"

Strong

Moderate

Preliminary

Hype

Verdict: Hype. The best available test in people without celiac disease, a 2021 study of 13,494 US women, found no difference in memory and thinking scores between women who ate the most gluten and those who ate the least, over decades of diet records. The authors concluded their results do not support cutting gluten to protect thinking in people without celiac disease or established gluten sensitivity. Nervous system problems are a real concern for people *with* celiac disease, not proof of harm for everyone. **What would change the grade:** Repeated randomized trials showing that people without celiac disease think better after cutting gluten than after a disguised placebo diet. No such evidence exists.

Here is a closer look at that 2021 study by [Wang, Lebwohl, and colleagues](#). It used the Nurses' Health Study II: women filled out food questionnaires from 1991 to 2015, then took computer-based tests of attention,

memory, and overall thinking between 2014 and 2019. After adjusting for other factors, gluten intake was not linked to any of the three scores.

How to read a gut-brain claim: gluten and thinking in 13,494 women	
Question	This study
Mouse or human?	Human: 13,494 US women without celiac disease, average age about 61.
Correlation or cause?	Correlation (an observational cohort). It found <i>no</i> link, which is good evidence against a large harm, but it can't prove zero effect.
How many?	Large: 13,494 women. All were women, mostly middle-aged, so results may not apply to teens or men.
How long?	Diet tracked from 1991 to 2015 (about 24 years); thinking tested once, from 2014 to 2019.
Who paid for it?	US National Institutes of Health grants, plus foundation and research awards to some authors; the paper says funders had no role in the study's design or conclusions.
Is something being sold?	No product. Some authors reported personal fees from drug or nutrition companies for work outside this study, as disclosed in the paper.

The careful conclusion: for people without celiac disease, there's no good evidence that eating gluten harms thinking, and decent evidence against a big effect. It doesn't prove nobody is sensitive to wheat, which is the next question.

12.8 Non-Celiac Gluten Sensitivity and the Fructan Twist

Some people without celiac disease or wheat allergy say they feel better when they stop eating wheat. Their symptoms, often bloating, belly pain, tiredness, or "fog," are real. The question is what causes them.

Non-celiac gluten sensitivity (NCGS) is a condition in which people without celiac disease or wheat allergy report gut or other symptoms after eating gluten-containing foods that improve when they avoid them; unlike celiac disease, it doesn't damage the villi, and it has no biomarker. NIDDK notes that gluten sensitivity does not damage the small intestine. Because there is no blood test for NCGS, a 2015 group of experts (the Salerno criteria, [Catassi and colleagues](#)) proposed a standard test: a double-blind, placebo-controlled gluten

challenge. In plain words, the person eats food that secretly contains gluten for a week and food that doesn't for another week, and neither the person nor the researchers know which is which until the end.

When scientists run blinded tests like this, something surprising often happens.

- In a 2013 study by [Biesiekierski and colleagues](#), 37 adults with self-reported gluten sensitivity and IBS first ate a diet low in FODMAPs (fermentable carbohydrates you met in [Chapter 10](#)). Their symptoms improved. Then, when they were secretly given gluten or a placebo protein, symptoms got worse by similar amounts with both. Gluten-specific effects showed up in only 8% of participants.
- In a 2017 meta-analysis of 11 gluten rechallenge studies, [Lionetti and colleagues](#) found that about 30% of people with suspected NCGS had symptoms return on gluten, but overall, relapse on gluten was not significantly different from relapse on placebo. In the studies that followed the stricter Salerno method, though, more people relapsed on gluten than on placebo (40% vs 24%), so a small group may truly react to gluten.
- In a 2018 study by [Skodje and colleagues](#) in Norway, 59 people on a self-chosen gluten-free diet (with celiac disease ruled out) ate muesli bars containing gluten, fructan, or neither, for a week each, in random order, without knowing which. Symptom scores were highest with fructan, and gluten was no different from placebo.

That last study introduces a new player. A **fructan** is a carbohydrate built from linked fructose (fruit sugar) units that the human small intestine can't break down; it is a type of FODMAP found in wheat and some other foods, and once it reaches the colon it can draw in water and increase gas, which can trigger symptoms in sensitive people. Wheat, barley, and rye contain both gluten (a protein) and fructans (carbohydrates). So when someone stops eating wheat and feels better, they've cut both at once, and the gluten-free label gets the credit.

There's also the placebo and nocebo side. When people expect a food to make them sick, they often feel worse after eating it, even when it is secretly a placebo. That is visible in these trials, where symptoms rose with the dummy food too. This doesn't mean the symptoms are "fake." Expectation changes how the brain processes gut signals, a real gut-brain effect you studied in Chapter 10.

Hype Meter: "Many people who think they're gluten sensitive are really reacting to fructans"

Strong

Moderate

Preliminary

Hype

Verdict: Preliminary. Blinded studies point away from gluten for many people: in one double-blind crossover trial of 59 adults, symptom scores were highest with fructan (clearly higher than with gluten), while gluten matched placebo, and an earlier trial of 37 adults found gluten-specific effects in only 8%. But these are small, short studies of adults, results differ between trials, and other wheat components may matter for some people. **What would change the grade:** Larger blinded trials in several countries, including teens, that test gluten, fructans, and other wheat parts separately and find the same pattern would raise it to Moderate.

The honest summary: NCGS is debated, not disproven. The symptoms are real; the trigger is uncertain, and for many people it may not be gluten. Because celiac disease must be ruled out first, and because diet changes have costs, the right path for anyone who suspects a wheat problem starts with a doctor.

12.9 Allergy, Intolerance, and Everything in Between

People often use "allergy," "intolerance," and "sensitivity" as if they mean the same thing. They don't, and mixing them up can be dangerous in one direction and wasteful in the other.

Food allergy: the immune system's alarm

A **food allergy** is a harmful reaction caused by a specific immune response that happens reliably every time a person is exposed to a particular food. That definition comes from the [2010 US food allergy guidelines](#) written by an expert panel sponsored by the National Institute of Allergy and Infectious Diseases (NIAID). The guidelines say most food allergies are driven by a particular antibody, though some are not.

Immunoglobulin E (IgE) is a class of antibody that drives immediate allergic reactions; in food allergy, IgE made against a food protein sits on immune cells and triggers them to release chemicals within minutes when the food is eaten. Picture a smoke alarm wired directly to a sprinkler system: IgE is the hair-trigger sensor, and the immune cells it sits on (such as mast cells, which you met in earlier chapters) are the sprinklers. The NIAID guidelines describe upper gut symptoms of IgE food allergy appearing within minutes, and the most serious reaction, anaphylaxis, as a rapid, whole-body allergic reaction that can cause death. People with food allergies work with their doctors on an emergency plan.

A wheat allergy is a food allergy, and it is different from celiac disease. NIDDK explains that in both, the immune system reacts to wheat, but wheat allergy can cause symptoms like itchy eyes or trouble breathing and does not cause long-term damage to the small intestine. The NIAID guidelines describe celiac disease as an immune reaction to food that does *not* involve IgE.

Food intolerance: a processing problem

A **food intolerance** is a reliable, unpleasant reaction to a food that does not involve the immune system, often because the body can't fully digest something. The NIAID guidelines use exactly this distinction: reactions without an immune mechanism are intolerances, not allergies.

The classic example is **lactose intolerance**, digestive symptoms such as bloating, gas, and diarrhea after eating or drinking lactose (milk sugar), because the small intestine can't break down all of it. According to NIDDK, the problem underneath is lactose malabsorption: the small intestine makes low levels of lactase, the brush-border enzyme that breaks down lactose, and in many people lactase levels drop after infancy. Undigested lactose passes into the colon, where bacteria break it down and create fluid and gas.

NIDDK estimates that about 68% of the world's population has lactose malabsorption, and about 36% of people in the United States, though not everyone with malabsorption has symptoms. NIDDK says it is most

common in Africa and Asia and least common among people whose families come from Europe; in the United States it is more common among African American, American Indian, Asian American, and Hispanic or Latino people. Since most adults worldwide have it, lactose malabsorption is the *typical* adult human pattern, not a defect. Most people with lactose intolerance can handle some lactose.

NIDDK draws the contrast clearly: lactose intolerance is a digestion problem, while milk allergy is an immune system disorder. Someone with lactose intolerance who drinks a milkshake may have a miserable afternoon. Someone with a milk allergy could have a life-threatening reaction.

	Celiac disease	Food allergy (IgE)	Lactose intolerance	Non-celiac gluten sensitivity
Immune system involved?	Yes (T cells, tTG antibodies; not IgE)	Yes (IgE antibodies)	No	Unclear; no biomarker
Typical timing	Damage builds over weeks to years	Minutes to a few hours	Within a few hours of eating	Hours to days, varies
Intestine damaged?	Yes, villous atrophy	Not long-term (for IgE allergy)	No	No
Can be life-threatening right away?	No	Yes (anaphylaxis)	No	No
How it's diagnosed	tTG antibody blood test, small bowel biopsy	Allergy specialist testing and history	History, sometimes a hydrogen breath test	Ruling out other causes; blinded challenge in research
Trace amounts matter?	Yes, strictly	Often yes	Usually no; many tolerate some	Varies

Use the right word



Words matter here. Calling an intolerance an "allergy" at a restaurant is understandable. But when someone with celiac disease or a true allergy speaks up, staff need to know that trace amounts count. Being precise helps everyone get the right level of care.

12.10 When Avoiding Food Backfires

If gluten-free food is easy to buy, why not cut gluten (or dairy, or anything else) "just in case"? An **unneeded restrictive diet** is cutting out foods or whole food groups without a diagnosed medical reason, which can bring costs such as nutrient gaps, missed or delayed diagnoses, extra expense, and social stress, without a proven benefit. Here's what can go wrong:

- **A missed diagnosis.** As Section 12.5 explained, going gluten-free before testing can make celiac tests falsely negative. Someone who actually has celiac disease may never get a clear answer, and might later return to gluten without knowing their intestine is being damaged.
- **Nutrition gaps.** Whole food groups carry nutrients. NIDDK notes, for example, that people avoiding dairy need other sources of calcium and vitamin D. This is one reason NIDDK recommends that people with celiac disease work with a dietitian, and the same logic applies to anyone cutting out foods.
- **Cost and hassle.** NIDDK notes that packaged gluten-free foods tend to cost more.
- **Social stress and worry.** Constantly checking labels and avoiding shared meals can make eating feel stressful and isolating. For some people, focusing intensely on "bad" foods can turn into an unhealthy relationship with food. Food is not good or bad in a moral sense; it's a question of what a particular body needs.
- **Wrong conclusions.** As the NCGS trials showed, feeling better after cutting a food doesn't prove that food was the problem. Expectation, other changes made at the same time (like eating fewer FODMAPs or less processed food), and natural ups and downs in symptoms can all play a part.

None of this means food reactions are imaginary. It means the order matters: get checked first, while eating normally, and change your diet with professional help.

For families

If your teen has celiac disease, the biggest help is often practical: a gluten-free shelf, a separate toaster or cutting board, and relatives who understand that "just a little" isn't okay. Try not to describe foods as "good" or "bad," and avoid comments about weight; the goal is safety and health. If someone in the family wants to go gluten-free without a diagnosis, encourage a doctor visit first, because celiac disease runs in families and testing works best while still eating gluten. Ask the care team whether other relatives should be tested.

At the Bedside: Tired, Pale, and Not Growing



Meet the patient (fictional)

Lucía is 14 and in ninth grade. For about a year she has felt tired all the time, even after a full night of sleep, and she gets belly pain and bloating several times a week. Her parents notice she hasn't grown much since last year while her friends shot up. Her school nurse sees that she looks pale and suggests a checkup. Lucía figures she's just stressed about starting high school.

What the doctor checks: Her pediatrician reviews her growth chart (her height has fallen off her usual curve), asks about stools, diet, periods, and family history (no one in her family is known to have celiac disease, which doesn't rule it out, since many people with celiac disease are undiagnosed), and examines her belly and skin. Blood tests show iron-deficiency anemia. Because the symptoms could fit celiac disease, the doctor orders a tTG antibody blood test while Lucía is still eating her usual diet, and checks her total IgA level. Her tTG antibodies come back clearly high. She is referred to a pediatric gastroenterologist, who performs an upper endoscopy and takes a small bowel biopsy.

Connecting the signals: Fatigue plus iron-deficiency anemia plus slow growth points to poor absorption, not just poor eating. The pathologist sees shortened, flattened villi and extra immune cells in the lining. With fewer villi, Lucía's small intestine has much less surface to absorb iron and other nutrients, which explains the anemia, the tiredness, and the slowed growth.

Diagnosis: Celiac disease.

Why it happens: Lucía carries a DQ2 or DQ8 variant (most people with celiac disease do), and when she eats gluten, modified gluten fragments trigger T cells in her intestine. The resulting inflammation causes villous atrophy, the same process you watched in the Villi Explorer, and her immune system makes antibodies against tTG, which the blood test detected.

The mind-body side: At first Lucía is relieved to have an answer. Then the hard part starts: school lunches, sleepovers, and a family that bonds over home-cooked meals. She feels embarrassed asking friends to check ingredients, and anxious about getting sick at a party. Her care team names this social stress as part of the illness, not a side issue. A dietitian helps her plan safe options for school and events, the team screens her for anxiety and low mood at visits, and she joins a teen celiac support group online where other teens share practical tips. Her parents learn to set up the kitchen so she isn't the only one adjusting.

Treatment today: A strict, lifelong gluten-free diet, taught by a registered dietitian, is the only proven treatment. Her team checks for and treats nutrient shortfalls such as low iron, monitors her growth, and rechecks her antibody levels over time. They also suggest that her close relatives talk to their doctors about testing.

What's new in research: Scientists are testing medicines that might reduce damage from accidental gluten exposure. In a 2021 trial in the *New England Journal of Medicine*, Schuppan and colleagues gave 163 adults with well-controlled celiac disease either a placebo or an experimental pill (ZED1227) that blocks the tTG enzyme, while all of them ate a measured amount of gluten daily for 6 weeks. Biopsies showed less gluten-induced damage to the villi in the drug groups than in the placebo group. The trial was funded by the drug's developer. **Evidence grade: Preliminary.** It was a short, early trial in adults; the drug is experimental and is not

an approved treatment, and it was tested as an add-on to the diet, not a replacement. As of October 2026, no medicine is FDA approved to treat celiac disease, though several are being tested in trials.

 Your turn: reason through a variation

Lucía's older brother, 17, has no symptoms, but after her diagnosis he decides to stop eating gluten "to be safe." Two months later, his doctor orders a tTG antibody test, and it is normal. Does this show he doesn't have celiac disease?

Answer: Not necessarily. tTG antibodies fall when gluten is removed, so a normal result after two months gluten-free could be a false negative. He might not have celiac disease, but the test can't tell well in this situation. His doctor might discuss options such as genetic testing for DQ2 and DQ8 (if negative, celiac disease is very unlikely) or a planned, supervised return to gluten before retesting. This is why testing should happen before a diet change.

This is a fictional teaching case. It is not medical advice. If you or someone you know has symptoms like these, talk to a doctor.

Common Misconceptions

Myth: Celiac disease is a type of food allergy.

Reality: Celiac disease is an immune disorder, but it doesn't involve IgE, the antibody behind classic food allergies, and it damages the villi over time instead of causing an immediate allergic reaction. Wheat allergy is a separate condition.

Myth: If you think gluten bothers you, going gluten-free first will help the doctor figure it out.

Reality: NIDDK says doctors don't recommend starting a gluten-free diet before testing, because removing gluten can make the blood test and biopsy look normal even in someone with celiac disease.

Myth: A gluten-free diet is healthier for everyone.

Reality: For people with celiac disease it's essential, but in people without celiac disease, a 2021 study of 13,494 women found no link between gluten intake and thinking scores. Cutting gluten without a reason can cost more, complicate diagnosis, and narrow the diet.

Myth: Lactose intolerance is a milk allergy.

Reality: Lactose intolerance is a digestion problem: the small intestine can't break down all the lactose. A milk allergy is an immune reaction to milk protein that can be dangerous. NIDDK estimates about 68% of the world's people have lactose malabsorption, so it's very common and usually not dangerous.

Myth: If the genetic test shows DQ2 or DQ8, you have celiac disease.

Reality: About 30% of people carry DQ2 or DQ8, and only about 3% of carriers develop celiac disease. A negative gene test helps rule celiac disease out; a positive one doesn't rule it in.

Your Gut Check

Test yourself. Try each one before you open the answer.

- ? 1. Claim Check: "Gluten-free cured my brain fog. Gluten is inflammatory for EVERYONE, so ditch it today! Use my code for 20% off." ✓**

Grade: Hype. One person feeling better isn't evidence of cause: expectation, other diet changes, and natural ups and downs could explain it, and blinded trials of self-reported gluten sensitivity often find gluten no worse than placebo. In people without celiac disease, a study of 13,494 women found no link between gluten intake and thinking scores. And there's a discount code, so someone profits from the claim. A careful version: "Gluten triggers real immune damage in people with celiac disease, about 1 in 100 people. If you think gluten affects you, get tested before cutting it out."

- ? 2. Predict: Riya's orchestra friend Mei has celiac disease and has followed a strict gluten-free diet for a year. At the potluck, she eats a gluten-free brownie that was cut with the same knife as a regular brownie. Predict what might happen in her intestine, and why. ✓**

The knife could transfer a small amount of gluten (cross-contact). In someone with celiac disease, even small amounts can restart the immune reaction: tTG-modified gluten fragments activate T cells, inflammation increases, and repeated exposures can shorten the villi again. One small exposure may or may not cause noticeable symptoms, but NIDDK notes symptoms can return with small amounts of gluten, which is why separate utensils matter.

- ? 3. Explain: A 15-year-old with untreated celiac disease starts having more bloating and gas after drinking milk. Explain how celiac disease could cause this. ✓**

Lactase, the enzyme that digests lactose, is part of the brush border on the microvilli of the small intestine. In untreated celiac disease, villous atrophy damages the lining and its brush border, so less lactase is available. Undigested lactose reaches the colon, where bacteria ferment it, producing gas and bloating. NIDDK lists lactose intolerance due to intestinal damage as a celiac symptom, and it often improves as the lining heals.

- ? 4. Apply: Sam's friend Jordan (fictional) gets hives and a swollen lip within 10 minutes of eating a shrimp dish. Jordan's sister gets bloated and has diarrhea a few hours after eating ice cream. Classify each reaction and explain the difference. ✓**

Jordan's reaction fits a food allergy, most likely IgE-mediated: it happened within minutes and involved the skin and lips, which is how IgE-triggered immune cells release chemicals fast. That kind of reaction can become serious, so Jordan should see a doctor about it. The sister's reaction fits a food intolerance such as lactose intolerance: a digestion problem without an immune attack, appearing hours later with gut symptoms. Only a doctor can confirm either, but the timing and symptoms point in different directions.

5. Read the data. In the 2018 Skodje trial, 59 adults with self-reported gluten sensitivity (celiac disease ruled out) ate muesli bars containing gluten, fructan, or neither (placebo) for a week each, in random order, without knowing which. Symptoms were scored on a gut symptom scale where higher means worse. Here are the published results:

Challenge	Average overall symptom score	Number of people whose worst week was this one
Gluten	33.1	13
Fructan	38.6	24
Placebo	34.3	22

? 5. What does this data show, and what can't it show? ✓

On average, symptoms were highest during the fructan week, and the gluten week was no worse than placebo (33.1 vs 34.3). The paper reports fructan as significantly worse than gluten; its gap over placebo (38.6 vs 34.3) was smaller. Notice that 22 people had their worst week on placebo, which shows how strongly expectation and day-to-day variation affect symptoms. The data can't show that *no one* reacts to gluten, since averages can hide a few true responders, and it can't be generalized to teens or other countries from 59 adults in Norway tested for one week per food. A useful follow-up would be a larger blinded trial, including teens, that repeats each challenge more than once per person to see whether individual reactions are consistent.

Exercises

Remember

1. Name the three grains that naturally contain gluten.

 Answer ✓

Wheat, barley, and rye.

1. What are the two main tests used to diagnose celiac disease?

 Answer ✓

A tissue transglutaminase (tTG) antibody blood test, and a small bowel biopsy taken during an upper endoscopy to look for villous atrophy.

Understand

1. Explain why villous atrophy leads to poor absorption of nutrients.



Answer



Villi and their microvilli give the small intestine a huge surface for absorbing nutrients. When the villi shrink and flatten, there is much less surface touching digested food, so less iron, vitamins, and other nutrients get absorbed. That can cause anemia, fatigue, and slow growth.

1. Explain the difference between a food allergy and a food intolerance, using one example of each.



Answer



A food allergy is a reproducible reaction caused by the immune system, often driven by IgE antibodies and appearing within minutes; a peanut or milk allergy is an example, and it can be life-threatening. A food intolerance doesn't involve the immune system; lactose intolerance, where the gut can't fully digest milk sugar, is an example, and it causes uncomfortable but not dangerous gut symptoms.

Apply

1. Use the Villi Explorer. With "Has celiac disease" and "Eats gluten," let the villi shrink, then switch to "Gluten-free diet." Record roughly how many simulated months it takes the symptom meter to drop below 20% and how long the villus height takes to return above 80%. What real-world idea does the difference illustrate, and why can't you use the sim's exact numbers for a real person?
2. A classmate says, "My mom is going to test me for celiac disease next month, so I'm going gluten-free now to get a head start." Using what you know about tTG antibodies and biopsies, write the advice you would give, and explain who they should talk to.

Analyze

1. Compare the 2021 Wang study (13,494 women, gluten and thinking) with Sam's cousin's personal story about brain fog. For each, answer at least three of the six claim questions. Which tells you more about whether gluten harms the brain of a typical person, and why?
2. Wheat contains both gluten and fructans. Analyze why a person who feels better after cutting wheat can't conclude that gluten was the cause, and explain how the Skodje trial's design separated the two.

Evaluate

1. A school is considering making its whole cafeteria gluten-free "to be healthier for everyone." Evaluate this plan using evidence from this chapter, considering students with celiac disease, students without it, cost, and nutrition. What would you recommend instead?
2. Evaluate the claim that non-celiac gluten sensitivity "isn't real." Use the blinded trials, the placebo results, and the Salerno criteria to argue for a more careful statement.

Create

1. Design a blinded experiment to test whether a group of teens who say dairy gives them stomachaches are reacting to lactose. Describe your groups, how you would hide which drink is which, what you would measure, and what result would support the lactose explanation.
2. Create a one-page "eating with celiac disease" guide for a school's cafeteria staff. Include what gluten is, what cross-contact means, the US "gluten-free" labeling rule, and two respectful phrases staff can use with students, without making any medical recommendations about individual diets.

Key Takeaways

- Intestinal villi and their microvilli give the small intestine an enormous absorbing surface. In celiac disease, the immune reaction to gluten causes villous atrophy, which reduces absorption and can cause anemia, fatigue, and slow growth.
- Celiac disease affects about 1 in 100 people worldwide (1.4% by blood test, 0.7% confirmed by biopsy) and about 2 million people in the US. It requires HLA-DQ2 or HLA-DQ8 gene variants plus gluten, but only about 3% of carriers develop it.
- Diagnosis uses a tTG antibody blood test and, for most people, a small bowel biopsy. Testing must happen before going gluten-free, because the diet can make tests falsely negative.
- A strict, lifelong gluten-free diet is the only proven treatment. Symptoms often improve in days to weeks, but the lining can take months to years to heal, so follow-up matters.
- Celiac disease can affect the nervous system, including peripheral neuropathy and, less often, gluten ataxia (Moderate evidence). The claim that gluten harms everyone's brain is Hype.
- Food allergy (often IgE-driven, fast, possibly dangerous), food intolerance (non-immune, like lactose intolerance), celiac disease, and non-celiac gluten sensitivity are different conditions. Blinded trials suggest fructans, not gluten, may trigger symptoms in many people with self-reported gluten sensitivity (Preliminary).
- An unneeded restrictive diet can delay diagnosis, leave nutrient gaps, cost more, and add stress. Get checked first, then change your diet with professional help.

You can sort a food reaction like a scientist!



You now know why celiac disease is an immune disease, not an allergy or a fad, and why the order of testing matters. Next, in Chapter 13, we'll look at autism, ADHD, and the gut, where separating a real difference from a confounder matters a great deal.

Quiz: Celiac Disease and Food Reactions

Test your understanding of Chapter 12. Choose the best answer, then click **Show Answer** to check.

Question 1

Which grains naturally contain gluten?

- A. Rice, corn, and potatoes
- B. Wheat, barley, and rye
- C. Oats, quinoa, and buckwheat
- D. Wheat, rice, and soy

 **Show Answer**



The correct answer is **B**. Gluten is a group of proteins found naturally in wheat, barley, and rye. Rice, corn, potatoes, quinoa, and buckwheat are naturally gluten-free. Oats don't naturally contain gluten but are often contaminated with other grains, which is why option C is a tempting mistake.

Concept Tested: Gluten **Bloom's Level:** Remember

Question 2

What are intestinal villi?

- A. Muscle rings that squeeze food through the small intestine
- B. Glands in the stomach that make acid
- C. Bacteria that live on the lining of the colon
- D. Tiny finger-like projections of the small intestine's lining that increase its surface area for absorption

? Show Answer



The correct answer is **D**. Villi are about 0.5 to 1 millimeter long, are covered in microvilli, and give the small intestine a huge surface for absorbing nutrients. Option A describes the gut's smooth muscle, which moves food but doesn't absorb it.

Concept Tested: Intestinal Villi **Bloom's Level:** Remember

Question 3

Which antibody drives immediate allergic reactions, such as those in many food allergies?

- A. Immunoglobulin E (IgE)
- B. Tissue transglutaminase
- C. Lactase
- D. Gluten

? Show Answer



The correct answer is **A**. IgE is the class of antibody behind immediate allergic reactions; it sits on immune cells and triggers them to release chemicals within minutes. Tissue transglutaminase (option B) is a body enzyme, and antibodies *against* it are a marker of celiac disease, which doesn't involve IgE.

Concept Tested: Immunoglobulin E **Bloom's Level:** Remember

Question 4

Why does carrying the HLA-DQ2 or HLA-DQ8 gene variant NOT mean a person has celiac disease?

- A. Because the gene test is usually wrong
- B. Because only people over 40 can develop celiac disease
- C. Because about 30% of people carry these variants, but only about 3% of carriers develop celiac disease
- D. Because these variants cause wheat allergy instead

 Show Answer



The correct answer is **C**. The variants are almost always needed for celiac disease (nearly everyone with it has one), but they are not sufficient: about 30% of people carry them and only about 3% of carriers develop the disease. That's why a negative gene test helps rule celiac disease out, but a positive one can't rule it in. Option A is wrong because the test reliably detects the variants; the issue is what they mean.

Concept Tested: HLA-DQ2 and HLA-DQ8 **Bloom's Level:** Understand

Question 5

Why does villous atrophy in celiac disease often lead to anemia and fatigue?

- A. Because gluten directly destroys red blood cells
- B. Because flattened villi give less surface for absorbing nutrients such as iron
- C. Because the villi make red blood cells
- D. Because the gluten-free diet lacks iron

 Show Answer



The correct answer is **B**. When the villi shrink and flatten, the small intestine has much less surface touching digested food, so it absorbs less iron and other nutrients, which can cause iron-deficiency anemia and tiredness. Option D reverses cause and effect: the anemia comes from the untreated disease, and a well-planned gluten-free diet helps the lining heal.

Concept Tested: Villous Atrophy **Bloom's Level:** Understand

Question 6

What is the key difference between lactose intolerance and a milk allergy?

- A. Lactose intolerance is a digestion problem without an immune attack, while a milk allergy is an immune reaction to milk protein.
- B. Lactose intolerance is an immune reaction, while a milk allergy is a digestion problem.
- C. They are the same condition with different names.
- D. Lactose intolerance damages the villi, while milk allergy does not.

 Show Answer



The correct answer is **A**. In lactose intolerance, the small intestine makes too little lactase to digest all the milk sugar, and colon bacteria break down the rest, causing gas and bloating. A milk allergy is an immune system disorder that can be dangerous. Option B swaps the two, which is the most common confusion.

Concept Tested: Lactose Intolerance **Bloom's Level:** Understand

Question 7

Dev, 16 (fictional), has had belly pain and tiredness for months. His appointment for celiac testing is in three weeks, and he plans to stop eating gluten today "to get a head start." What is the best response, based on this chapter?

- A. Good idea, because a gluten-free diet makes the tests more accurate.
- B. Good idea, because if he feels better, he won't need the tests.
- C. It doesn't matter, because celiac tests don't depend on what he eats.
- D. He should talk to his doctor first, because going gluten-free before testing can make the tests look falsely normal.

 Show Answer



The correct answer is **D**. Both the tTG antibody test and the biopsy detect the immune response to gluten, and removing gluten lets that response fade. NIDDK says doctors don't recommend starting a gluten-free diet before testing. Option B is a trap: feeling better on the diet doesn't show what caused the symptoms.

Concept Tested: Tissue Transglutaminase Antibody **Bloom's Level:** Apply

Question 8

Within 10 minutes of eating a peanut cookie, Aaliyah (fictional) gets hives and her lips swell. Which condition does this pattern fit best?

- A. Celiac disease
- B. Lactose intolerance
- C. A food allergy, likely driven by IgE
- D. Non-celiac gluten sensitivity

 Show Answer



The correct answer is **C**. A fast reaction (within minutes) involving the skin and lips fits an IgE-mediated food allergy, in which IgE on immune cells triggers a rapid chemical release. This kind of reaction can become serious and needs a doctor's evaluation. Celiac disease (option A) involves the immune system too, but it doesn't use IgE and its damage builds over weeks to years.

Concept Tested: Food Allergy **Bloom's Level:** Apply

Question 9

In the 2018 Skodje trial, adults with self-reported gluten sensitivity secretly ate gluten, fructan, or placebo for a week each. Average symptom scores were 33.1 (gluten), 38.6 (fructan), and 34.3 (placebo). What is the best conclusion?

- A. In this group, fructan raised symptoms more than gluten, and gluten was no worse than placebo.
- B. Gluten caused the most symptoms, proving gluten sensitivity is common.
- C. The participants have undiagnosed celiac disease.
- D. Placebo caused more symptoms than fructan.

 Show Answer



The correct answer is **A**. Fructan produced the highest average score, and gluten (33.1) was about the same as placebo (34.3). That suggests fructans, a FODMAP in wheat, may be the trigger for many people who think they react to gluten, though one small, short study can't prove it for everyone. Option C is wrong because celiac disease had been ruled out before the study.

Concept Tested: Fructan **Bloom's Level:** Analyze

Question 10

A friend without celiac disease cut out gluten, dairy, and several other foods after reading a wellness post, and says, "It can't hurt." Which response best analyzes the risks of an unneeded restrictive diet?

- A. There are no risks, because gluten-free foods are always healthier.
- B. Restriction can delay or hide a real diagnosis, leave nutrient gaps, cost more, and add stress, so diet changes should start with a doctor.
- C. The only risk is that it might be boring.
- D. Restriction is risky only for people with celiac disease.



Show Answer



The correct answer is **B**. Cutting foods without a diagnosed reason can make celiac tests falsely negative, remove sources of nutrients like calcium and vitamin D, raise food costs, and make eating stressful. Option A is a common belief, but a large study of women without celiac disease found no benefit of low gluten intake for thinking scores.

Concept Tested: Unneeded Restrictive Diet **Bloom's Level:** Analyze
