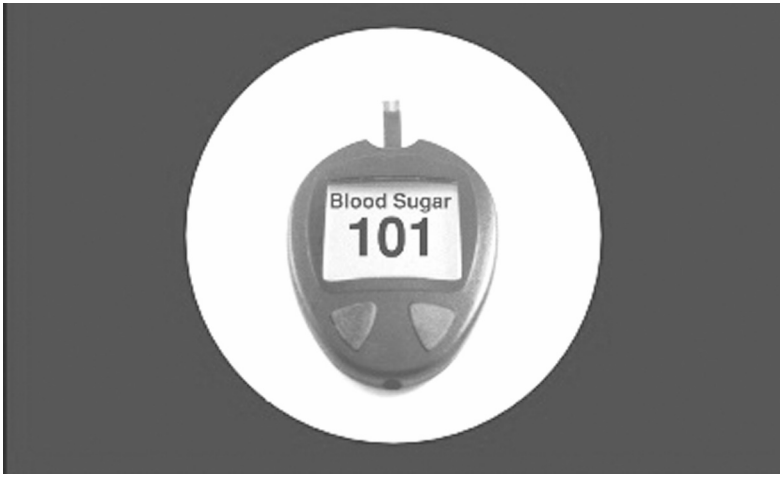
JENNY RUHL

# Blood Sugar 101




## What They Don't Tell You About Diabetes

Second Edition

TECHNION Books

Published by Technion Books
P.O. Box 402
Turners Falls, MA 01376
technionbooks@outlook.com



ISBN-13: 978-0-9647116-6-2
ISBN-10: 0-9647116-6-4

Printed in the United States of America

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# Preface to the Second Edition

Over the eight years that have passed since the first edition of this book was published, there have been significant changes in how doctors treat patients with Type 2 Diabetes. This has made it necessary to do a major revision of this text.

Most of these changes have occurred in response to the flood of new, expensive, patented drugs that have come to market over this period. In many cases they have replaced the drugs that were popular almost a decade ago when the first edition of this book was released.

Fortunately for the readers of the earlier edition, the scientific discoveries that have occurred during this period have only strengthened the case for the approach we took in the original version of this book. The simple, moderate, but powerful approach to diet we laid out still works brilliantly. Hardly a day passes when I don't hear from readers who write to tell me of the dramatic improvements they have made in their health after following the advice you will read in these pages. They have lowered their blood sugars to normal levels, lost weight, healed painful feet, and kept their eyes and kidneys healthy.

In addition, with the insights they have gained from these pages, these readers have learned how to evaluate any new strategy their doctors might recommend, be it taking a brand new drug, trying an innovative but extreme diet, or choosing an irreversible surgical intervention.

In this new edition, you will still find the information and advice they found so helpful, along with a greatly expanded discussion of the pros and cons of the many new drugs that have recently entered the marketplace. You will also learn more about what researchers have learned about currently fashionable dietary and surgical approaches your doctor might suggest to you. We have also added several new research-based insights that can help you make healthier choices when choosing from the many foods that will lower your blood sugar.

It is our hope that this new edition will give another generation of readers the tools they need to join the growing ranks of those who have overcome diabetes and restored themselves to completely normal health.

# Introduction

Type 2 Diabetes is a terrible disease. It causes impotence, blindness, kidney failure, amputation, and heart attack death.

But Type 2 Diabetes is also a wonderful disease because all these dreadful outcomes are optional. No matter how severe your diabetes might be at diagnosis, it is unique among the serious chronic diseases in that it is the *only* condition where you, the patient, with only a small amount of help from your doctor and no heroic medical interventions can achieve normal health.

This is probably not what you have heard from your doctors. They probably told you it is *normal* for someone with diabetes to suffer foot pain, impotence, slow wound healing, low physical energy, and even a heart attack. So why should you believe me when I tell you it isn't true?

For a very good reason: Over the past two decades diabetes treatment has been revolutionized by the emergence of what is often called "The Wisdom of the Web." This term refers to the phenomenon where many thousands of people, each drawing on their own knowledge and experience, create information resources as good or better than those produced by so-called authorities.

## Diabetes on the Web

Diabetes was one of the first diseases to benefit from the Wisdom of the Web because people with diabetes have always been expected to do most of the work involved in managing their disease. They've tested their own blood sugar. They've adjusted their own insulin doses. So even before the advent of the Web they had a lot of information about how their blood sugar responded to changes in their diet, medications, and exercise. What they didn't have was any idea of how their own experience might compare with that of others.

With the emergence of the Web, people with diabetes began to talk to each other on newsgroups and discussion forums. They exchanged information they'd gotten from their solitary testing. They started comparing notes. When they did this, they soon discovered that they weren't the only ones who were having problems with the diets and drug regimens prescribed by doctors and dietitians.

Some people who were active on the Web started trying out alternative diets and drug regimens and reporting their results to each other

in the discussion groups. Others started combing through the thousands of peer-reviewed journal articles that had been made available for free on the Web, searching for studies that might point to more effective diabetes treatments. Over time, using the information they found and shared made big improvements in their health.

## The 5% Club

Since my own diabetes diagnosis in 1998 I have participated in thousands of Web discussions with hundreds of people with diabetes. Like myself, many of them had science, software, or engineering backgrounds. This gave them a penchant for critical thinking and the skills needed to read and understand journal research. Working together, we learned that it *is* possible for people with diabetes to achieve normal blood sugars. We also uncovered research that suggests that if we maintain truly normal blood sugars we will avoid or even reverse the terrible complications our doctors told us were inevitable.

Some of us call ourselves "The 5% Club" because our goal was to keep our A1c test results under 6%. That is the level most doctors consider to be the normal range. Using a selection of techniques I've learned from participating in Web discussion groups, I've managed to stay in The 5% Club for almost all of the 18 years that have followed my diagnosis. Though it has been that long since I was diagnosed, my endocrinologist sometimes refers to me as "recently diagnosed" because she is used to seeing A1cs that low only in people who are new to diabetes.

## Why This Book?

In 2005, after realizing that many people were unaware of the wealth of information to be found in Web discussion groups, I decided to put the most important information on a Web site where people doing Google searches could easily find it. The heart of my Web site was what I'd learned after spending several months reading through medical journals, hunting for studies that answered two questions: "What is a truly normal blood sugar level?" and "What blood sugar levels cause organ damage?" The result was my web site **Bloodsugar101.com**.

This site is different from most other diabetes web sites because the information you find on it includes links to studies published in top-rated peer-reviewed medical journals. Visitors to the site don't have to take anything on trust. They can follow the links and read the research papers themselves. My web site is also updated any time something significant turns up in the medical news that is relevant to a topic discussed on its pages.

Over the years, the site grew huge. Visitors started asking me if I could put the mass of information stored on the web site into book form so they could read it more easily. They explained that because the site has grown so large, they could not read the whole thing on the web and worried that they might be missing out on critical pieces of information buried in its pages.

Since I had already published seven previous books of nonfiction, including a business bestseller, I was excited by the challenge of turning the site into a book. My enthusiasm for the project grew when I began to write it, as I began to see another advantage to putting what I'd written about diabetes into book form: A book is better than a web site at explaining ideas that can't be compressed into a few simple paragraphs, because the sequential structure of a book ensures that every concept you encounter in its pages builds on what you have already read. A book is also free of the distractions inherent in the web's hypertextual design.

Since its original launch in 2008, it has become clear that this book adds value to the web site by providing, in a compact and portable form, an orderly examination of the crucial concepts that pervade it. In its pages you will find the explanations that will make you understand, as you never have before, how your blood sugar works, what happens when your blood sugar control breaks down, what blood sugar levels damage your organs, and how you can safely lower your blood sugar enough to prevent any further diabetic complications from occurring.

Every scientific concept presented in the text is backed up by peer-reviewed research papers that were published in highly regarded medical journals. If you want check out this research, you can find the citations in the "References" section at the end of this book. You can find the links to these studies and to any new relevant scientific findings online at **Bloodsugar101.com**. You can also keep up with important new research published since this book went to press by following the blog, "Updates to Blood Sugar 101." That blog can be found at:
**http://phlauntdiabetesupdates.blogspot.com**

However, there are some very important issues that people with diabetes must deal with that are not discussed in peer-reviewed research. Here the Wisdom of the Web comes into play as I draw on the experiences reported by the hundreds of knowledgeable people with diabetes who have posted messages on the web over the decades. When I cite this type of information, I make it clear that anecdotal reports are its source.

## No One Way

Unlike most other diabetes books on the market, this book does not tell you what to eat or what medications to take. If there is one thing we have learned from the Wisdom of the web, it is that each of us is different and that a strategy that works well for one person may not work for another.

Instead we will teach you how to tell if *any* diabetes strategy you are using is working. By "working" we mean giving you blood sugars low enough to prevent any further organ damage. We'll show you how to find out if your current diabetes diet is doing the job and, if it isn't, we'll show you how to improve it. If you need more than a change of diet to get your blood sugars back into the safe zone, we'll explore what the diabetes drugs available to you are good for and discuss their drawbacks, putting particular emphasis on some cheap but effective diabetes drugs that doctors may overlook because they aren't being promoted by drug company marketing campaigns.

## What's in It for You?

When you are done reading this book, you will know enough to hold an intelligent conversation with your doctor about your treatment choices. You'll be better able to evaluate the latest "breakthroughs" you read about in the diabetes news. And most importantly, you'll have the information you need to keep yourself safe, no matter what current fad is sweeping the medical community. In short, when you are done with this book, you will have the tools you need to join "The 5% Club." So welcome aboard!

Chapter One

# What is Normal Blood Sugar?

Diabetes is not a disease, it's a symptom.

Everyone diagnosed with any type of diabetes shares a single symptom with every other person with diabetes. That symptom is high blood sugar.

Anything that interferes with the complex mechanisms that the body uses to regulate blood sugar may cause diabetes. It may occur when the cells that secrete insulin get poisoned and die off or when those cells fail to respond to the signals that tell them to make insulin. It may even occur when those cells are making plenty of insulin but insulin receptors in the cells have lost their ability to respond to it. Diabetes can be caused by abnormalities of the adrenal glands or problems with hormones in the gut that inform the body of the presence of food.

It is also possible for one person to have more than one of these metabolic problems at the same time. For example, the most common form of diabetes, which doctors call Type 2 Diabetes, is frequently described as being caused by insulin resistance, the condition where cell receptors stop responding properly to insulin. But scientists have recently discovered that almost one in twelve of those diagnosed with insulin resistant Type 2 Diabetes also have markers in their bloodstream that show they have been the victim of an autoimmune attack that has killed off the cells that make insulin.

What does this mean for you?

Simply this: Though you may have been diagnosed with diabetes, all that your diabetes, my diabetes, and the diabetes of the person sitting across from you at the diabetes support group meeting have in common is that they cause all of us to have abnormally high blood sugars. The causes of our high blood sugars may be different, how high our blood sugars rise after we eat the identical meal may be different, how our bodies respond to the same dose of the same drug may be dramatically different, and, most importantly, what it takes to bring our blood sugars back into the normal range, which prevents complications, will be different.

Because we are all so different, the key to recovering good health is to figure out how your own individual version of diabetes works. The first step toward doing this is to learn how blood sugar is regulated in a normal person and how normal blood sugar control breaks down. Armed with this information you will be better able to understand what the various interventions used to treat diabetes do—and which ones might be right for you. So take the time to understand the information you'll find in the next couple pages. It will give you the background you need to take control of your health.

## Blood Sugar Control in Normal People

All your cells require a steady supply of fuel to continue functioning. The most essential of these fuels is a sugar called glucose. It is the sugar we refer to as **blood sugar**. Some glucose always circulates in the bloodstream, where it is available to any cell that might need it. Though most cells can survive by burning fat when no glucose is available, important cells in your brain cannot. Deprived of a steady supply of glucose for as little as five minutes these cells will die and so will you. So keeping a steady supply of glucose flowing in your veins is essential to survival.

When you read that your blood sugar is 100 mg/dl, what this is really telling you is that there are 100 milligrams of glucose—one tenth of a gram—in every deciliter of your blood. A deciliter is one tenth of a liter. So if your blood sugar is 100 mg/dl you have 1 gram of glucose in every liter of blood.

Everywhere except in the United States, the concentration of glucose in your blood is measured using a different unit: mmol/L, which stands for millimoles per liter. To convert mg/dl into mmol/L you divide mg/dl by 18.05. Appendix A gives you a table you can use to find the mmol/L equivalent of any blood sugar mentioned in these pages.

Before most cells can use glucose, it must be transported inside the cells. Insulin is the hormone that makes this happen. That is why insulin is so important to blood sugar control. If there is no insulin available, no matter how much glucose is circulating in your bloodstream most of your cells will not be able to use it. And if the sugar in your blood isn't taken into cells, it will build up to dangerously high levels that will damage your organs and can even lead to death.

Insulin is produced by special cells called **beta cells**. These tiny cells are found in structures called the Islets of Langerhans, which are scattered throughout your pancreas. The pancreas is an organ located near your liver that also secretes digestive enzymes. The job of the beta cell is to manufacture insulin, store it, and release it into the bloodstream

when appropriate. Healthy beta cells are continually making insulin and storing it within the beta cell in the form of tiny granules.

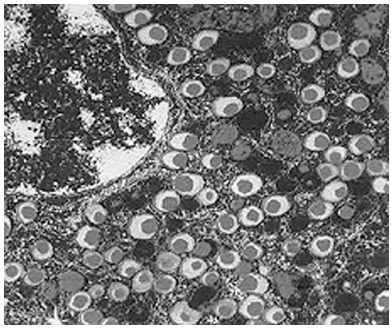

**Figure 1. Beta cells in an Islet of Langerhans. The beta cells in this picture are marked with gray dots**

The beta cells release this insulin into the bloodstream in two different ways. They release a continuous trickle of what is called **Basal Insulin** throughout the day and they also release larger bursts of insulin after you eat a meal. The meal time releases are called **First- and Second-Phase Insulin Release**.

### Basal Insulin Release

The purpose of basal insulin release is to keep a small amount of insulin flowing in the bloodstream at all times. The beta cells of a healthy person release insulin into the bloodstream in small pulses that occur every few minutes throughout the day and night. Scientists have discovered that even when beta cells are capable of producing insulin, diabetes may develop when something disrupts the timing of this pulsed basal insulin release.

During periods between meals healthy beta cells also manufacture extra insulin and store it in the form of granules for use at meal time. Problems with basal insulin production can also keep the beta cells from storing these granules of insulin. This will make it much harder to avoid high blood sugar peaks after meals.

When you test your **fasting blood sugar** after not eating for eight hours or more, you are checking your ability to secrete basal insulin. A normal or near normal fasting blood sugar means that your ability to secrete basal insulin is still intact. Truly normal fasting blood sugar values fall in the range between 70 and 85 mg/dl. Doctors will tell you that the normal range for a fasting blood sugar extends up to 100 mg/dl, but research has shown that people whose fasting blood sugar is over 92 mg/dl are much more likely to develop diabetes within a decade, which suggests that it is not truly normal.

### Insulin Levels Signal the Liver Whether More Glucose Is Needed

One of the liver's important functions is to top off the level of glucose in the blood if it starts to drop too low. When basal insulin production is working properly, the steady flow of insulin it supplies to the bloodstream sends the signal to the liver that all is well and that no more glucose is needed. But if the insulin level drops during a fasting pe-

riod, or if the liver becomes insulin resistant and does not respond to insulin signaling, the liver will assume that the glucose in the bloodstream is almost used up and more glucose is needed.

To supply that glucose, the liver turns to **glycogen**, a starchy carbohydrate that it has stored for just this purpose. **Carbohydrates** are a group of edible molecules that include sugars, starches, and some kinds of fiber. Glycogen is made up of a long chain of glucose molecules that have been bonded together. When the liver needs to raise the blood sugar, it converts this glycogen back into glucose and then dumps that glucose into the bloodstream. This raises the blood sugar back to its normal level and ensures that cells will continue to have the fuel they need.

If the liver doesn't have enough glycogen stored, it can convert protein into glucose, too. First it will convert protein derived from food you have recently eaten. If you aren't eating enough protein, the body will break down the protein that makes up your muscles to get the glucose you need. This ability of the liver to turn muscle into glucose is why dieters on stringent diets lose muscle mass if they don't eat enough protein.

### First-Phase Insulin Release

As soon as a healthy person starts to eat a meal, the parasympathetic nervous system sends out signals that begin the process that causes beta cells to release insulin into the bloodstream, beginning with the insulin they previously stored in granules.

As food reaches the stomach, the carbohydrates in that food start to digest. Any pure glucose that's been eaten goes immediately into the blood stream, as it doesn't need to be broken down any further. Pure fructose gets whisked away to the liver, which converts it into fat. Digestive enzymes then break down the rest of the complex sugars and starches supplied by the meal into the two simple sugars, glucose and fructose. That glucose goes into the bloodstream, too. It takes no more than 15 minutes after a person has eaten a meal containing sugar or starch for the first glucose from the digested food to reach their bloodstream and begin raising the concentration of glucose in their blood.

Rising blood sugars now stimulate the beta cells to secrete more insulin. At the same time, as blood sugars rise to a threshold—somewhere between 100 and 120 mg/dl—**incretin hormones** released by the gut also stimulate the beta cells to secrete insulin. These early releases of insulin that occur as soon as we begin eating a meal are called **first-phase insulin release**. In a healthy person first-phase insulin release keeps the blood sugar from rising much over 125 mg/dl.

What cells take up that glucose? The brain and muscles have first

dibs. Then the liver will use some glucose to top off its store of glycogen. But if your brain and muscle cells have enough glucose, and your liver has enough glycogen, insulin pushes glucose into *fat* cells. Insulin plays an important part in the process that transforms glucose into fat.

The amount of insulin a normal person's beta cells secrete during this first-phase insulin release is believed to be very close to the amount they needed to process the glucose produced by previous meals. If they usually eat a lot of carbohydrate, their body will release more insulin at the start of the next meal, even if that meal doesn't contain much carbohydrate. If this large dose of first-phase insulin doesn't meet up with enough incoming carbohydrate, it may drive the normal person's blood sugar low. When blood sugar drops too low, the brain senses it and sends out hunger signals that ramp up carbohydrate cravings. This is suggested as a reason why people with normal or near-normal metabolisms who have been eating a lot of carbohydrate may find themselves craving carbohydrates if they try to cut down on their carbohydrate intake.

If the normal person doesn't respond to the low blood sugar attack by eating more carbohydrate, their liver will transform more stored glycogen into glucose and release that glucose into the blood stream until it has raised the blood sugar back to a normal level. When that person eats the next meal after the meal that resulted in a low blood sugar, their beta cells will release less first-phase insulin and avoid causing another low blood sugar.

In a healthy person, the first-phase insulin release peaks shortly after they've started their meal. The highest blood sugar level they will experience usually occurs by 45 minutes after they started eating.

The rising insulin level in the blood caused by this first-phase insulin release also signals the liver that there is no need to add additional glucose to the blood, shutting down the glucose dumping the liver does during periods of fasting.

### Second-Phase Insulin Release

After completing this first-phase insulin release, the beta cells pause. But if the blood sugar is still not back under 100 mg/dl ten to twenty minutes later, beta cells start to secrete more insulin and provide another, smaller, **second-phase insulin release** whose job is to mop up the rest of the excess glucose circulating in the bloodstream. This second-phase insulin release continues as long as it is needed—until the blood sugar is back down to its fasting level. In a normal person, this usually takes about an hour to an hour and a half after the start of a meal.

It is this combination of a robust first-phase insulin release of stored

insulin and a strong second-phase insulin release of secreted insulin that keeps the blood sugar of a normal person almost always under 100 mg/dl except for the first hour following a meal. This system ensures that the brain and organs get a steady supply of glucose to fill their needs but prevents the build up of excess glucose in the blood stream that might clog up capillaries, gum up the kidneys, or inhibit the activity of nerves.

### What Are Truly Normal Blood Sugar Levels?

An illuminating research study presented by Professor J. S. Christiansen at the European Association for the Study of Diabetes conference in September of 2006 depicted the daily pattern of blood sugars in a group of normal subjects as it was revealed by the use of a **Continuous Glucose Monitoring System** (CGMS). The CGMS is a small computer attached to a probe. The probe is inserted under the skin where it samples the blood sugar every few minutes for a period lasting from a few days to several weeks. The computer stores and graphs this information.

Dr. Christiansen's data is summarized in Figure 2. A group of normal people wore the CGMS during the period spanning from when they woke up and ate breakfast until just before lunch. The heavy line shows the median blood sugar of the group as a whole. Next to it are thinner lines showing the top and bottom of the range within which most of their blood sugars fell. The lower set of lines represents their insulin and C-peptide levels. (C-peptide is a byproduct of the manufacture of insulin. Measuring it is a way of measuring insulin production.) The vertical line indicates the time when the study subjects ate a high carbohydrate breakfast.

The data collected from these normal people shows how throughout the night their median fasting blood glucose concentration remained flat in the low 80 mg/dl range. After a high carbohydrate meal, their blood sugar rose to a median value near 125 mg/dl for a brief period. This occurred about 45 minutes after they ate. In all but the people with the highest readings, blood sugar dropped back under 100 mg/dl by one hour and fifteen minutes after eating and it returned to 85 mg/dl by one hour and forty-five minutes after eating.

Note that even the highest of these normal readings is far below the cutoff most doctors consider to be the high end of "normal." That cutoff, established decades before continuous glucose monitoring was available and based on outdated data, is still officially defined as being 139 mg/dl measured *two hours after eating*!

**Figure 2. CGMS Study: Normal Blood Sugars**