DIYCGM

https://personalscience.com

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Contents

Chapter 1

Prerequisites

Continuous glucose monitoring (CGM) is among the most exciting personal science experiments you can conduct on yourself. This book will explain how to get started.

Before you buy one of those expensive kits from one of the many commercial companies that offer the devices as part of their diet and nutrition programs, learn how to do it yourself for about $30 - $50. All of the direct-to-consumer kits use the same FDA-regulated device that is available at your local pharmacy for fraction of the price.

This site will show you step-by-step how to get the same results as the expensive products: an instant look at your glucose levels at any time day or night. After that, you can decide for yourself it it's worth it for you to buy the other services.

Chapter 2

Introduction

This is a list of resources useful for building products that work with continuous glucose monitoring devices. Consider this document to be in the public domain, free to use however you like (but of course with absolutely no guarantees of accuracy).

Start with this article by Richard Sprague at NEO.LIFE: “Personalized Health Advice Every 60 Seconds”.

Also read this good overview by Henrik Berggren from Steady.Health.

Chapter 3

News and User Experiences

- **New York Times Health Reporter Anahad O'Connor** wrote about Nutrisense, January.ai, and his personal experience using Levels Health. https://www.nytimes.com/2021/02/08/well/diet-glucose-monitor.html
- **Lydia Ramsey**, senior reporter at Business Insider wrote a detailed summary of using a Dexcom G6: https://www.businessinsider.com/what-its-like-to-track-blood-sugar-with-a-continuous-glucose-monitor-2019-11
- **Eric Jain** wrote a short, highly-readable account of his month-long experience: https://eric.jain.name/2018/11/25/tracking-blood-sugar/
  - And a Hacker News thread about his post
- **Quantified Diabetes** does rigorous self-experimentation at https://quantifieddiabetes.com/p/experiments.html.
- **Lily Nichols** is a registered dietitian who wrote "What I Learned as a Non-Diabetic"
- **Jimi S,** a 25-year-old diabetic wrote a lengthy review: Review: FreeStyle Libre — Abbott Diabetes Care | by Jimi S.
- **"Quantified Bob" Troia** wrote "How to measure personal glucose response to foods"
- **Jennifer Wang** writes "Am I Crazy Because I Eat Too Much Sugar?": https://medium.com/@neogeo25/am-i-crazy-because-i-eat-too-much-sugar-a-cgm-experiment-5b310f334f10
- Follow Jessie Inchaspe's incredible Instagram account on her experiences with food and CGM: https://www.instagram.com/glucosegoddess/

Figure 3.1: Glucose Goddess

- **Kevin Bass n-of-1**: A PhD student kept (2018-19) alive Twitter feed of his CGM data
- Why Perfectly Healthy People Are Using Glucose Monitors:Time Magazine article from 2017
- Hacker News thread about CGMs and sugar metabolism
- Interactive web app with daily updates from the Personal Science glucose monitor.
- How accurate it is: a user posts side-by-side comparisons of Freestyle Libre vs pinprick
- Reddit forums Lots of posts in diabetes-related forums

Libre2 announcement (Oct 2018)

Chapter 4

How to get your CGM

The FreeStyle Libre is available over-the-counter at most pharmacies throughout the world (including Mexico and Canada), but requires a doctor's prescription in the United States.

A month's supply of sensors costs under US$100, so don't bother trying to get your health insurance to reimburse you unless you have a specific medical reason, in which case consult your doctor.

There are three ways to get one in the US:

1. Ask your doctor to prescribe one for you. The Freestyle Buying Guide gives detailed information about how the product works, and what to tell your doctor. Most doctors will be happy to prescribe it if you explain that you'll be paying out of pocket.

2. Tastermonial will connect you with a doctor who can provide a prescription for $29. This is the easiest solution for most people.

3. If you're traveling to Canada, Mexico, or other countries, you can pick them up locally, or you can order one to be shipped into the US. Michael Cohn describes how he got one from Canada for about $100

4.1 What to buy

Buy the 14-day sensor by itself. If you have an iPhone 7 + or an Android, don't bother buying the Reader (which is an additional US$200).

4.2 Companies and CGM-Based Products

Several companies will give you a month's worth of CGM with an app and nutrition advice for under $500. See link below.

Figure 4.1: January, Inc.

https://january.ai/ $499 4-week program includes 2 Freestyle Libre devices and an app to guide your eating, fasting, and exercise choices.

Figure 4.2: Nutrisense

https://www.nutrisense.io/: Join their "cohort" and receive 2 CGM devices/month and 24/7 nutritionist advice with an app that tracks your glucose, fasting, and more.

Figure 4.3: Steady Health

https://steady.health/ a San Francisco-based clinic providing CGM-centric diabetes care. Their programs cost about $60 / month and include AI-aided smartphone-based coaching and education around food and exercise, plus data interpretation with an endocrinologist. This is a good choice if your doctor has diagnosed you with diabetes.

Figure 4.4: Levels Health

https://www.levelshealth.com/ offers "metabolic health" services, including a CGM and nutritionist consultation for about $400/month. You'll need to request access for a specific quote and availability.

Chapter 5

Diet and food-tracking

Apps and websites useful for nutrition tracking

Bitesnap: take a photo of your food and get an AI-based identification, plus macronutrients and calories. Recognizes 1300+ foods.

https://getbitesnap.com/

LoseIt: Food database with 7 million+ foods, restaurant items and brands from around the world, hand curated by our on-staff nutrition experts.

https://www.loseit.com/

MyFitnessPal : 6 million foods, largest online community, connects to 50+ apps

https://www.myfitnesspal.com/

Cronometer

Large, curated food database. Widely used among professionals due to its in-depth tracking of nutrients and comprehensive data export.

https://cronometer.com/

Chapter 6

Using Your CGM Data

Websites and apps that help you track glucose numbers.

6.1 Use the Personal Science App

The best way to analyze your CGM data is with the CGM app from Personal Science (makers of this web site). You can upload your data and study it for free here:

https://cgm.personalscience.com

6.2 Abbott Labs Official

The most important software for Freestyle Libre downloading is the officially-supported one here:

https://provider.myfreestyle.com/freestyle-libre-resources.html

Create an account on Libreview and then you can download your data as a CSV file here:

https://www.libreview.com/meter

Then click here: https://www.libreview.com/glucosereports

If you have the Abbott custom reader device, you can also download a Mac or Windows version of Freestyle Libre personal CGM

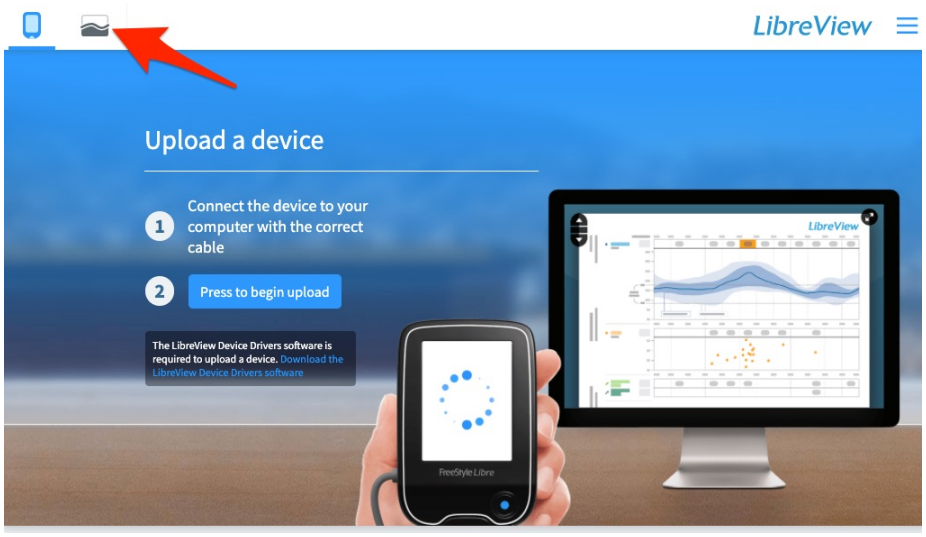

Figure 6.1: Libreview main page

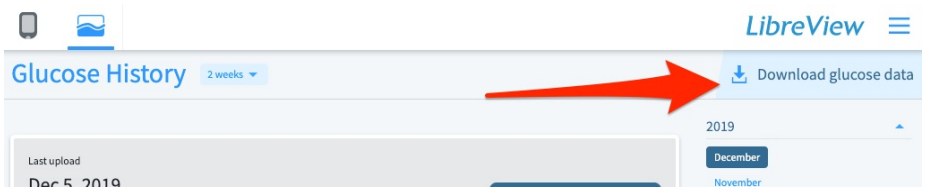

Figure 6.2: Click to download

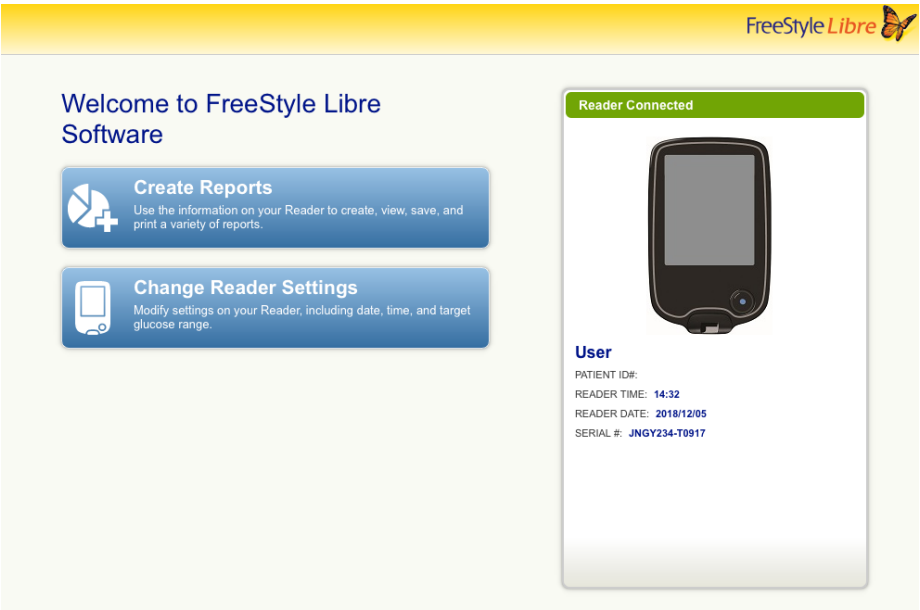

Figure 6.3: Freestyle Libre Software

6.3 International versions

Freestyle Libre devices sold in other countries will generally work everywhere if you use the app downloaded specifically for that country.

This [table by Chuck Kub] is a little old, but gives a sense of which models are available in which countries.

China: buy a reader plus 3 14-day sensor packs through Taobao for about 1800 RMB (USD$270)

6.4 Third Party

Many organizations now offer ways to upload and use your Freestyle (or other CGM) data.

Nightscout

"an open source, DIY project that allows real time access to a CGM data via personal website, smartwatch viewers, or apps and widgets available for smartphones"

See their app https://spike-app.com/

http://www.nightscout.info/

Diasend

(formerly called Glooko) tries to let you upload data from anywhere

https://diasend.com/us

Tidepool https://app.tidepool.org/patients

Open-source non-profit place to upload glucose data

https://tidepool.org

Diabetes:M

https://diabetes-m.com/

Glimp : popular Android app

https://play.google.com/store/apps/details?id=it.ct.glicemia

Chapter 7

Open Source Software

- **Nightscout xDrip+**: https://github.com/JoernL/xDrip-plus
  - supports wireless connections to G4, G5, G6, Medtrum A6, Libre via NFC and Bluetooth, 630G, 640G, 670G pumps and Eversense CGM via companion apps. Bluetooth Glucose Meters such as the Contour Next One, AccuChek Guide, Verio Flex & Diamond Mini as well as devices like the Pendiq 2.0 Insulin Pen
  - 44 contributors, very active since Nov 2014 (latest checkin Dec 2018)
  -
- **OpenLibreReader** iOS: https://github.com/blueToolz/openLibreReader-iOS-
  - a project to connect the various Libre Transmitters to the iPhone.
  - Blog post (Jan 2018) summarizing goals and status.
  - latest commit Apr 2018; Started in Nov 2017 by 2 Germans
- https://github.com/UPetersen/LibreMonitor iOS NFC reader, includes hardware instructions
  - last active: Nov 2018. Started in 2016 by 3 guys from Germany
- **nahog / freestyle-libre-parser-viewer:** https://github.com/nahog/freestyle-libre-parser-v tiewer
  - A parser library and viewer for CSV generated by the Abbott Freestyle Libre flash glucose meter.
  - From 2016, last commit June 2018; One guy from Ireland
- cgmnalysis: R Package on CRAN and Github cleans up data from multiple CGM devices
  - Last update October 2019

Chapter 8

Advanced Topics

8.1 Other Sites

Sites that are useful for general background

- **Abbott Freestyle Libre Users (Facebook):** https://www.facebook.com/groups/748445301888935/
  - Active (20K members) and includes people from Abbott
- **Diabettech site:** https://www.diabettech.com/freestylelibre/
- **QS Guide: Testing Food with Blood Glucose:** another nice overview: https://quantifiedself.com/blog/qs-guide-testing-food-with-blood-glucose/
- **Quantified Self Conference 2018** had a breakout session: see their notes here: https://forum.quantifiedself.com/t/qs18-links-and-resources/5885/4 which are based on a lengthy May 2017 thread by Gary Wolf in the same forum.
- **Freestyle Libre Tips and Hacks**: Youtube videos by Nerdabetic

  https://www.youtube.com/watch?v=o7R5Of-iWfk
- **Reddit: /r/Diabetes**
  - Especially check the thread on "Things you wished you knew about the Freestyle sensors"

8.2 Hardware

8.2.1 Freestyle Libre hardware information

- Freestyle Libre sensor teardown: Blogger Ido Roseman takes one apart, with photos.
- Reddit forum says: "it would appear that Libre sensors use NfcV, while S8 does not support NfcV (ISO 15693) but happily talks over NfcA and NfcB (ISO/IEC 14443). "
- Insulin calculator: settings/professional and password = CAA1C

8.2.2 Freestyle-compatible

Hardware devices that work with the Freestyle Libre. Using an NFC reader that talks directly to the Libre sensor, they send information to a bluetooth phone.

- **MiaoMiao** Shanghai company $200
- **Ambrosia Systems Nightrider**: $110 NFC-to-bluetooth device
- **Bubblan**: Supports All Libre Sensors except US Libre2 version : 139.99€

8.2.3 Other hardware

- Bionous: Seattle-Bellevue company that claims to have a low-cost non-invasive glucose reader (PHWare)
- Jobst Technologies Biosensors: hardware company that sells biosensors that detect glucose.
- http://tula-health.com/content/tech.html is raising money for a non-invasive CGM.
- OnDuo: An open resource doc about Google-Verily and Sanofi's diabetes program that features CGM.
- Medtronic Guardian: open resource doc about another sensor+phone integrated CGM with prediction capabilities

8.3 Scientific articles

- Journal of Diabetes Science and Technology (2020) concludes that Freestyle Libre 2 performs within 20% of blood values.
- Lancet article (2016) that established the accuracy of the underlying CGM technology
- Glucotypes (2018): Stanford study claims people respond differently to foods
  - See news article summary

  - Upload your data to their online app here: https://abreschi.shinyapps.io/shinySpecClust/
- Personalized Nutrition by Prediction of Glycemic Responses (Cell: Zeevi et al 2015)
  - Highly-cited study showing differences are driven by the microbiome
- "Continuous Gluose Profiles in Healthy Subjects" (2007) study.
- FDA approval document: more details about Freestyle Libre and its authorized uses
  - (see similar approval for Dexcom, a *de novo* iCGM)
- "Hunting the Deceitful Turkey" 100+ page book about the tech behind non-invasive glucose monitoring

A handy table of CGM clinical trials (via AMJC)

TABLE. Selected Randomized Clinical Trials of CGM [15-22]

Name (reference)	Population	Design	Goal(s)	Device(s)	Key Outcome(s)
DIAMOND Type[15]	T1D A1C 7.5%-9.9%	Randomized 2:1 to CGM (*n* = 105) or usual care (*n* = 53) for 24 weeks	A1C reduction	Dexcom G4	Between-group difference of 0.6 percentage points in favor of CGM (*P* <.001). Significant reduction in hypoglycemia in the intervention group.
DIAMOND Type 2[16]	T2D A1C 7.5%-9.9%	Randomized 1:1 to CGM (*n* = 79) or usual care (*n* = 79) for 24 weeks	A1C reduction	Dexcom G4	Between-group difference of 0.3 percentage points in favor of CGM (*P* = .022).
GOLD[17]	T1D A1C ≥7.5%	Crossover CGM vs usual care; Randomized 1:1 to 26 weeks of CGM before (*n* = 82) or after (*n* = 79) 26 weeks of usual care	A1C reduction	Dexcom G4	Between-group difference of 0.43 percentage points in favor of CGM (*P* <.001). Significant reduction in hypoglycemia in the intervention group.
I HART CGM[18]	T1D GOLD score ≥4 or recent severe hypo	Randomized 1:1 to CGM (*n* = 20) or flash glucose monitoring (*n* = 20) for 8 weeks	Hypoglycemia reduction, CGM vs flash glucose monitoring	Dexcom G5, Abbott FreeStyle Libre	CGM reduces hypoglycemia more effectively than flash glucose monitoring.
HypoDE[19]	T1D History of impaired hypo awareness or severe hypo in past year	Randomized 1:1 to CGM (*n* = 75) or usual care (*n* = 74) for 26 weeks	Hypoglycemia reduction in high-risk individuals	Dexcom G5	Incidence of hypoglycemic events fell by 72% for CGM group (*P* <.0001).
Comisair[20]	T1D/MDI or CSII A1C 7.0%-10%	Nonrandomized: CGM (n = 27) or SMBG (n = 38) for 52 weeks	A1C and hypoglycemia reduction	Dexcom G4, Medtronic Enlite	Comparable reductions in A1C and hypoglycemia in CGM/MDI and CGM/CSII groups
IN CONTROL[21]	Adults T1D/MDI Impaired hypo awareness (Gold score ≥4)	Randomized crossover: CGM then SMBG (n =. 26) or SMBG then CGM (n = 26)	Hypoglycemia reduction in high-risk individuals	Medtronic Enlite	Periods of CGM use associated with more TIR, less time in hypo- and hyperglycemia, fewer severe hypoglycemic events
CONCEPTT[22]	T1D with existing or planned pregnancy	Parallel arms, to 34 weeks in pregnant women; for 24 weeks in those planning pregnancy	A1C reduction	Medtronic Guardian REAL-Time	Between-group difference of 0.19 percentage points in favor of CGM (*P* = .02) in pregnant women; no difference in women planning pregnancy. CGM group had fewer LGA babies, fewer ICU stays of >24 hours, and fewer neonatal hypoglycemia events

A1C indicates glycated hemoglobin; CGM, continuous glucose monitoring; CSII, continuous subcutaneous insulin infusion; ICU, intensive care unit; LGA, large for gestational age; MDI, multiple daily injections; SMBG, self-monitoring of blood glucose; T1D, type 1 diabetes; T2D, type 2 diabetes; hypo, hypoglycemia; TIR, time in range (70-180 mg/dL).
*Dexcom G4 Platinum CGM System with an enhanced algorithm, Software 505, the same algorithm used in Dexcom G5

Figure 8.1: alt_text

Chapter 9

Other Summary Resources

Other places to find more links and other information

Continuous Glucose Monitor page for the open source Loop project.