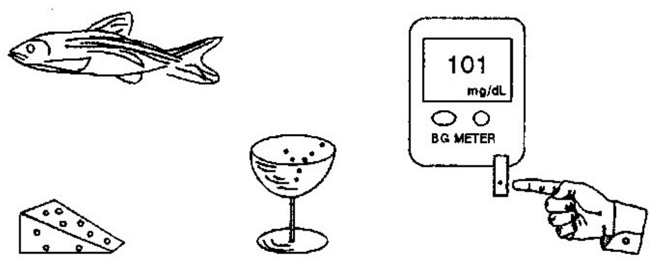
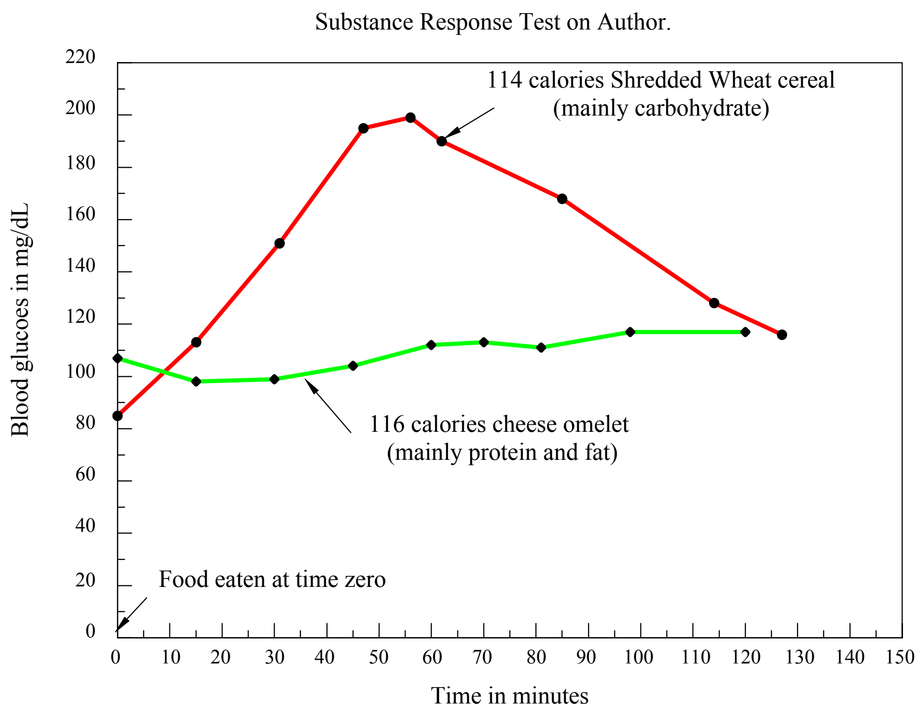
Diabetes and Diet:

A Type 2 Patient's Successful Efforts at Control





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Note: Capitalized names of foodstuffs may be registered trade marks.

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In 2003 this book was made available for viewing on the Internet. The contents are not to be construed as offering any type of medical advice or recommendation.

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PREFACE

In 1990 I noticed unusual tiredness after eating and I consulted with a doctor. She had me do a simple test to check for sugar in the urine. The result was positive, and further testing established that I had type 2 diabetes. After that diagnosis I cut down on my sugar input and generally watched my diet. Despite these lifestyle changes, however, after 5 years I noticed that my blood glucose readings were getting higher. Also, side effects such as more frequent urination, and pain in the legs, were getting worse. On a routine visit to my doctor I had a blood sugar level of 294 milligrams per deciliter (mg/dL). This is far too high, and I decided to get more involved in my diabetes control. I set out to conduct a series of experiments on the effects of different foodstuffs. To me the results were amazing and surprisingly straightforward. I found that my blood glucose levels were simply related to the type of food I ate. I wondered why the simple relationships between blood glucose levels and the carbohydrates, protein, and fat that I ate hadn't been explained to me earlier when I was first diagnosed and received "diabetes training." Also I wondered why these critical relationships are not stressed in the magazines I read that deal with diabetes issues. Thinking that maybe the results were peculiar to me, with type 2 diabetes, I continued testing my sensitivity to various foodstuffs. The result was a number of graphs from which I could select appropriate foods to eat. I also developed a means to determine whether my diabetes was getting better or worse. I made good progress with this technique and was understanding the importance of different foodstuffs when Dr. Richard Bernstein's book *Dr. Bernstein's Diabetes Solution* became available [1]. His discussions tied all my experimental results together, and the critical importance of carbohydrates became clear. It seemed there were no technical reasons why I could not enjoy excellent blood glucose control.

In discussions with others having diabetes I found that despite Dr. Bernstein's book, the vital link between carbohydrates and the blood glucose level was still not universally recognized. Phrases like "your results may vary" are true in the sense that the response to one type of food may vary from one person to another, but there are some universal basic relationships between food types and the manner in which blood glucose is generated.

This book summarizes over 80 experiments with numerous graphs and charts, and it includes five blood assays over a 1-year period. Pictures can sometimes be of great help in explaining basic ideas. I hope this applies to the glucose response graphs given in this book. Figure 1-1 on page 3 is one of those graphical pictures that enabled me to understand the simple relationship between blood glucose and food types. From that moment on I knew what tests I needed to make to get good control of my diabetes.

In mid 1997 the threshold at which diabetes should be suspected was lowered from a fasting blood plasma measurement of 140 to 126 mg/dL. The new blood plasma glucose level of 126 mg/dL corresponds to a whole-blood reading, as measured by many but not all home BG (blood glucose) meters, of about 112 mg/dL. With these changes the number of people diagnosed with diabetes is certain to increase dramatically. The good news is that this gives the opportunity to prevent the complications that can occur when the disease is left untreated.

One cannot make dietary changes to improve blood glucose control without consideration of the effects on other parts of the body, especially as regards the effect of medications. Thus any changes must be decided only after consultation with your physician.

Using results from my own experiments and reading books such as those by Dr. Bernstein, I have changed my eating habits, and my own diabetes is now under excellent control without medication or insulin. A factor in blood analysis called HbA1c is used to measure the average blood glucose level and indicates the degree of control. My HbA1c number went from 9.0% (poor control) in 1993 to 5.4% (excellent) in 1997. I look forward to many more years without the need for insulin injections. For those with type 1 diabetes and others in whom insulin injections are essential, I believe that an understanding of the body's responses to different foods will aid in determining insulin doses. Medications and treatments are especially effective when they are tailored to the specific needs of the individual. The testing methods described in this book will help you find your own specific response to different foods.

Detailed experiments were made over a 4-year period thus there is a time factor to be considered in evaluating some of the test results. In 2000, the book was out of print, but requests for it were still being received. This edition is to support those requests, but it is more than a reprint because it includes substantially more data, especially as regards the glycemic effects of different foods. For convenience this additional information has been added in the form of a supplement to the original work.

I have had type 2 diabetes for 11 years and still manage to obtain good control simply by selection of appropriate foods with a low SGI (substance glycemic index). In June of 2000 I had an HbA1c of 5.2%. I manage my control by paying careful attention to each and every meal. Once it is accepted that good control is vital to one's health this careful attention to diet is not onerous. I usually eat out at least once a week and even on a 15-day vacation in which I ate out every day I was able to select low SGI meals.

One of the ways in which I monitor my progress is simply by measuring fasting blood glucose (FBG) each morning. If it is higher than my goal of 100 to 110 mg/dL (plasma) then I probably made a mistake in my eating the day before. For me the FBG seems to be a good indicator of my type 2 diabetic condition. I speculate that the "Dawn Effect" in which the liver releases hormones and glucose into the body each morning is in effect a miniature built-in daily glucose tolerance test. My FBG results reflect my response to that daily test.

From the moment of my very first test I knew that in conjunction with my physician I could find better ways to control my diabetes, and it is happening. I hope my experiments, described in this book, will be of similar help to you.

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ACKNOWLEDGMENTS

The major source of technical assistance for this book is in the written works itemized in the reference section; however, informal discussions through the Internet, the Diabetic mailing list at Lehigh University and America Online-bulletin boards, were invaluable. The Lehigh University list is very active: more than 50 messages a day is not uncommon, and the information given there is so helpful, ranging from detailed technical discussions to uplifting support for a member in need. Many people share their thoughts and personal stories on these mailing lists and bulletin boards. We are indebted to them. It was there that I learned from Jenny McGrorey that Merlot wine reduces blood glucose levels; also Dan Pipes reported, and Liz Tannenbaum confirmed, that onions had a similar glucose-lowering effect. I used these observations for one of the experiments reported here.

Gretchen Becker, another on-line correspondent, encouraged me to document my test data in an appropriate book so that others might benefit. She also provided very valuable technical discussion regarding diabetes and book-presentation issues. Lyle Taylor, a long-time colleague, provided valuable suggestions after reviewing a much earlier version of this book. My personal physician monitored my overall performance with routine checkups and blood assays.

Dr Bernstein not only reviewed the original book, but encouraged me to publish it and I am indebted to him for that. I trust that he will find the information in the supplement equally worthy of being published. Dr. Jennie-Brand Miller, lead author of the original *the G.I. Factor,* published in the USA as *The Glucose Revolution,* has from time-to-time offered helpful comments as also has my on-line colleague Rick Mendosa.

If there are any inadequacies in this book they are mine alone.

Finally, I want to acknowledge the contribution of my wife Joan who willingly undertook a glucose tolerance test to generate data for a nondiabetic response curve. Her contributions to my well being by helping develop low glycemic recipes, three of which are included in this book, have been invaluable. Also, her tolerance and understanding of all those early-morning experiments made this book possible.

1.0 INTRODUCTION

In managing diabetes the patient holds the key. Physicians and others can explain effects and make recommendations, but as yet there is no magic pill to cure diabetes. Once diabetic patients accept responsibility for their care, however, I believe good blood glucose (BG) control is possible for many.
The body includes numerous complex chemical control systems, many of which are adaptive. One of the body's systems controls BG levels when ingested food is converted into glucose. The hormone insulin is produced by beta cells in the pancreas and helps transport glucose into various body cells. Type 2 diabetes, also known as non-insulin-dependent diabetes mellitus (NIDDM), occurs when inadequate insulin is produced, or the body's cells have a reduced ability to use the insulin that is produced (insulin resistance), or combinations of these two limitations. Ways of combating these limitations are addressed.

In engineering it is common to characterize the performance of a machine by establishing what happens to the output for various inputs while other parameters remain nearly constant. The same characterization process can be applied to the human body. I am a 68-year old research engineer who has had type 2 diabetes for more than 7 years. By simply treating my body as a machine and determining input (food) to output (BG level) I was able to characterize my basic glucose control system and from that knowledge take steps to maintain good BG control. Tests on a single diabetic person have limited statistical significance because of individual variations; however, as with any machine, some of the basic issues are readily defined.

Subjecting the body to various food inputs and measuring the resulting BG level versus time is here defined here as a substance response test. This method can be used by the patient to evaluate his or her own glucose response to specific stimuli using a simple BG meter. The results for any one patient are unique; however, some general conclusions can be drawn from my specific results. For example, **I found that carbohydrates had a rapid and major impact on my BG levels, whereas protein had a smaller and much slower effect. Fat seemed to have no direct effect.** The results agree perfectly with the low-carbohydrate diet recommendations of R. K. Bernstein, M.D. [1]. I also found that fiber reduced the rate at which the BG level increased, and fat when present in a large amount reduced the effects that the carbohydrate in bread had on my BG level.

Knowledge of my test results should help others gain a better understanding of how their own bodies may respond to different food inputs; and the test procedure I use has widespread application. However, results from my experiments will likely be somewhat different from those with type 1 diabetes and different from those with more severe type 2 diabetes. Thus your results may vary. My tests highlight some of the fundamental dietary issues that those with diabetes must address in controlling their BG level each and every day. It is much more than simply counting calories.

The numerous experiments reported (a) show the dramatic effects of diet and different foodstuffs, (b) highlight the concept of glycemic index, and (c) show deteriorating BG responses when good control is not maintained.
The graphs are powerful aids to learning; from them I was able to characterize my body's response to food and then maintain good BG control. Using the test results in this book I reduced my hemoglobin A1c measurement (HbA1c), which reflects long-term average BG levels, from 9.0% in 1993 to 5.4% in 1997.

At the outset I needed some sort of baseline reference to determine the extent of my diabetes and to gauge any changes that occurred. A goal for the body's BG response was obtained from tests on a nondiabetic person, and then a search was made for substances that might help me, a type 2 diabetic person, to emulate that response. Tests were made on over-the-counter and prescription substances; however, some substances caused unacceptable gastric upsets, and nothing was found to improve my basic body performance. Much more helpful results were obtained by determining responses to different foodstuffs.

The key for excellent control of my diabetes is in the data presented here. I hope these results are equally helpful to others and their medical advisors.

1.1 Interpreting the Graphs

his book summarizes over 80 experiments and includes more than 20 graphs to highlight important results. It has been said that a picture is worth a thousand words. This is only true of engineering "pictures" if you know how to interpret them. At the risk of explaining something that is already clear to many readers, I'll discuss how the pictures I present can be obtained and understood. This is done using an example. Figure 1-1 is a continuous graph that enabled me to understand the simple relationship between the BG level and food types. Along the bottom horizontal line is a scale marked in minutes of time, and along the left vertical line is a scale marked in milligrams per deciliter (mg/dL) of BG, such as measured from a drop of blood obtained by pricking your finger.

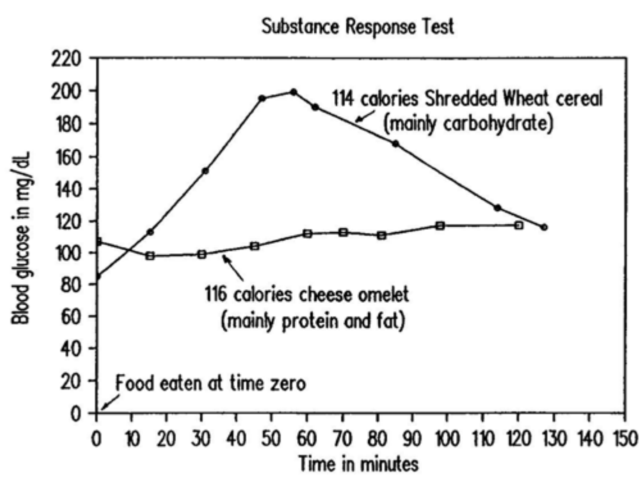

Figure 1-1 Major impact of different food types (presented in a continuous graph).

At the start of a test, time is considered to be zero and the food or substance being tested is eaten as rapidly as possible. During the course of digestion the BG rises and its value is determined using the BG meter. Readings are taken at appropriate intervals, say 15 minutes or less, and the results recorded. You can see individual results in figure 1-1, where they are represented in one case by small circles and in the other by small squares. Each of those points is fixed in relation to the time and mg/dL lines. For example after 15 minutes a small circle shows that the BG level was about 113 mg/dL in the test with Shredded Wheat. When all the points are obtained they are interconnected by straight lines to give a graph (picture) showing how BG varies with time. A dashed line represents extrapolation.

Another way to present a "picture" of the measurements is to use a bar graph in which the height of the bar shows the measurement. This type of chart may be familiar to many. It is often used to present financial data, but it is more difficult to display multiple sets of data on the same graph. Figure 1-2 is an example of this type of graph using data I had recorded over the years on my fasting BG level.

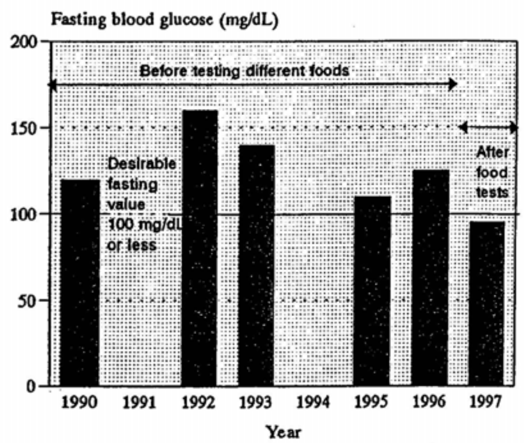

Figure 1-2 Fasting blood glucose levels (presented in a bar graph).

The fasting values presented in this graph are only from single test points, but they give a picture that shows how improvements had occurred in 1997 after a lower-carbohydrate diet was implemented

2.0 MEASURING TECHNIQUES

2.1 Home Tests

Responses to different stimuli were primarily monitored using an Accu-Chek Advantage home-test meter. This meter measures the glucose concentration in whole blood and is calibrated to read whole-blood values. Because of this it gives results about 12% lower than the data obtained from laboratories, which separate the blood plasma with a centrifuge and then measure the glucose in the blood plasma.

Accuracy is affected by a number of variables, which are discussed by the manufacturer. A few home meters, such as the Glucometer Elite, are purposely calibrated to try to match the plasma readings obtained by laboratories, so it is important to know what your meter reads. In this book all readings are whole-blood readings unless indicated otherwise. Most of the data relate to the BG level after a given stimulus. The peak BG and the time to reach it are easily determined. There is no specific definition for what constitutes an acceptable maximal BG value, but my goal was to prevent my BG from exceeding 140 mg/dL (157 mg/dL plasma) at any time. Although individuals may vary, the BG level at which appreciable amounts of glucose appear in the urine (glycosuria) is about 180 mg/dL (plasma). My goal is 13% less than this value.

2.2 Laboratory Tests

Glucose becomes chemically incorporated into proteins, including hemoglobin in the red blood cells, at a rate determined by the BG level. This process (glycosylation) provides a way to determine the average BG level over a period of about 120 days, the lifetime of a red blood cell. The HbA1c value measures this glycosylation and is useful for determining whether the average BG level is being controlled satisfactorily. Because it provides a 120-day averaged result, it does not change significantly over a short period. For this reason some people recommend waiting 6 to 8 weeks between HbA1c tests [2]. Other methods to measure average BG levels are available; for example the fructosamine test measures the average BG level over about a 3-week period. The relationship between the HbA1c test and the assessment of quality of control may vary from one laboratory to another. Table 1 gives an example.

Table 1 Comparison of Blood Glucose Control Levels *

HbA1c (%)	Quality of Control	Average Blood Glucose (mg/dL) (plasma)
Less than 6.4	Excellent	Less than 128
6.4 to 7.6	Good	128 to 152
7.6 to 8.8	Fair	152 to 176
More than 8.8	Poor	Greater than 176

* This is only a guide. Different laboratories may use different numbers.

3.0 EXPERIMENTAL METHODS

3.1 Changing the Body's Performance

To determine the effects of medications or dietary supplements, I first determined my body's basic response to a glucose stimulus. This glucose response test was then repeated after some period of time, usually 2 to 3 weeks, during which the medication or the supplement under test was used. Although this was the usual procedure, another test that monitored fasting BG over a similar-duration test period was also implemented in one of the supplement evaluations. Exercise effects were evaluated in a similar fashion.

3.2 Changing the Body's Dietary Input

This approach was found to be very enlightening. For results to be compared, tests are done from the same starting conditions. Most of my tests were carried out from the early morning fasting condition. For those who experience significantly increased BG levels in the morning (dawn phenomenon), a different time might be necessary. The procedure was to eat the test substance and measure the BG level at appropriate intervals for a period of about 2 hours. By drawing the graph as the test proceeds, one can anticipate an appropriate time for the next reading before too large a change in BG occurs. The final graph was analyzed to determine the peak BG level (usually occurs after 30 to 75 minutes), and in some cases an average BG level over the 2-hour period was determined. Substance response test results helped me choose appropriate foods for my diet.

4.0 EXPERIMENTS TO CHANGE THE BODY'S PERFORMANCE

Figure 4-1 illustrates the response of a person without diabetes and myself (with type 2 diabetes) to a 12-gram glucose stimulus obtained by ingesting glucose tablets. In this experiment, we each ate the 12 grams of glucose in less than 4 minutes. You can see that initially my BG increased almost 60% faster than that of the nondiabetic person. Also it took my body 32 minutes to start reducing the BG, whereas the nondiabetic person started to reduce her BG after only 23 minutes. Finally it is seen that the average BG for me is much higher than that of the nondiabetic person. To improve my body's response I wanted to reduce the peak and the 2-hour average BG to more closely match that of the nondiabetic person.

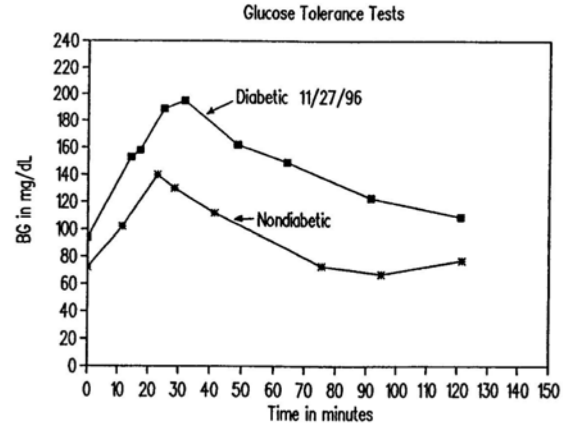

Figure 4-1 Comparing responses of a diabetic and a nondiabetic person. (Oral input was 12 grams of glucose.)

Trying to change the body's performance was unsuccessful. The data presented here are focused over a 12-month period, but test data taken 7 years ago are similar except there has been a general worsening of performance. The diabetic condition is indeed stubborn. This section contains a brief summary of experiments in which I tried to improve my basic body performance.

Prescription medications were attempted, but in each case I suffered gastric upsets that prevented a full 2-week trial from being completed. These medications included glyburide, metformin (Glucophage), and troglitazone (Rezulin.) All of these medications have been reported in the literature to reduce the HbA1c results, and Rezulin (withdrawn from the market in 2000) appears to change the body's response function in a very desirable way by reducing insulin resistance. Further testing with these drugs is left for others. Mineral supplements like chromium, magnesium, and zinc had no discernible effect, and vanadyl sulfate, which was found to reduce my fasting BG level, was discontinued because it caused me unexplained chest pains.

In this phase of testing to change my body's basic performance, I found it beneficial to incorporate a high-fiber cereal such as Kellogg's All-Bran into my diet. This had the effect of slowing down the rate at which my BG increased and also the peak BG. The effect is presumably due to some sort of filtering action, and I emphasize that the All-Bran was not ingested at the same time as the glucose: thus improvement is caused by fiber ingested at least 24 hours earlier. Whether this is truly changing the body's performance or is in effect a diet change is debatable. Measurements during this period indicated that the increased fiber also helped reduce my cholesterol level.

Figure 4-2 compares the performance in response to a glucose stimulus before and after All-Bran was added to my diet. To emphasize the results and eliminate any differences in fasting BG, only the changes in BG are plotted in this figure. The results were sufficiently encouraging for me to add All-Bran and later Bran Buds to my diet.

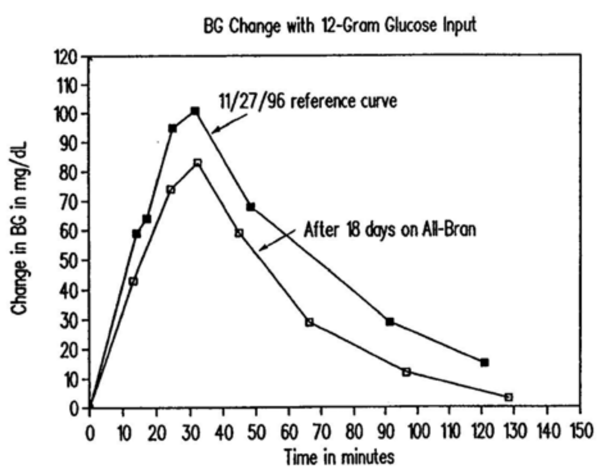

Figure 4-2 Benefits of fiber on blood glucose level after a glucose input.

Acarbose, a prescription medication taken before eating, is touted to achieve similar or more pronounced reductions in BG levels for "double sugars" (disaccharides) like sucrose or complex carbohydrates like starch, but not for "single sugars" (monosaccharides) like glucose [3, 4]. However, no tests were made with acarbose.

Conclusions from the experiments shown in figure 4-2 are summarized as follows:

1. The peak BG increase was reduced by 18%.
2. The average BG increase was reduced by 29% over a 2-hour period.
3. The initial rate at which the BG increased was reduced by about 20%

(similar results were found after 32 days on the All-Bran breakfast diet).

5.0 EXPERIMENTS VARYING THE BODY'S DIETARY INPUTS

This section describes my responses to various foodstuffs. It consists primarily of graphs that are labeled to indicate the substances under test. Each test is briefly discussed. The actual data points are given and connected by straight lines. In some of the graphs this gives rise to small perturbations, rather than a smooth curve. No explanations are attempted for these perturbations. They are believed to be real and not simply the result of meter errors. However, it is easy to visualize a smooth curve interpolated between the points to give the average BG, which is the prime interest. The main focus of the work took place over a period of about 12 months and involved testing many different foodstuffs. There is a chronological factor to be considered in the results because as time progressed I observed improvements in my glucose system response because of the integrated effects of a different diet. Thus, for example a BG response in November 1996 will not appear as favorable (low) as one made in July 1997. It transpires that the low-carbohydrate diet used to control the BG level on a day-to-day basis also improved my body's basic response to glucose. Thus the low-carbohydrate diet had a compounding effect.

The results given in figure 5-12 cover a span of 7 years. These data illustrate gradual deterioration of the transient BG response when control is not especially good. The increase in fasting BG level is also evident. The eventual effects of good control on the fasting BG level are also apparent in this figure.

5.1 Experiments With Equal Calorie Inputs

Figure 5-1 shows the effect of different substances with a similar calorie content.

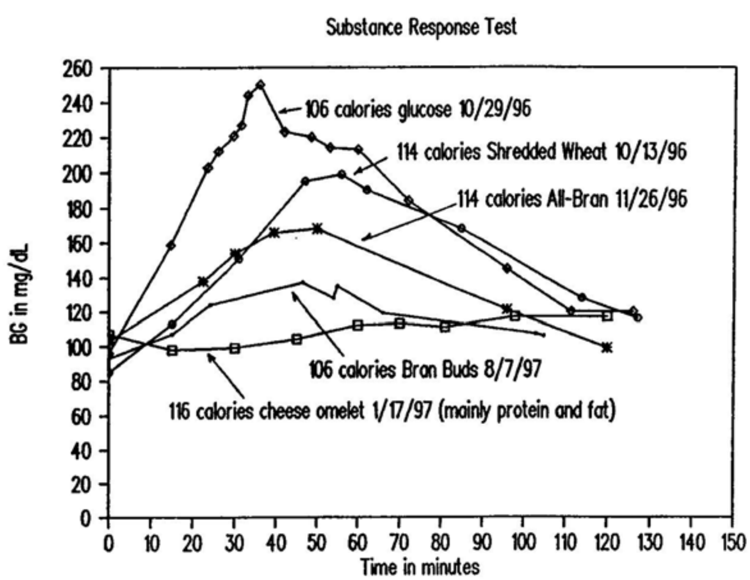

Figure 5-1 Response to inputs with nominally equal calories.

Comments on figure 5-1

During the tests shown in figure 5-1, a cup of hot decaffeinated tea with nondairy creamer was consumed to facilitate ingestion of the substances being tested. The creamer adds about 6 grams of carbohydrate to the substance under test.

The major conclusion evident from these curves is that ***it is carbohydrates that quickly raise BG***. The mainly protein and fat in a cheese omelet had little effect on my BG level. These results are in line with the writings of Richard K. Bernstein, M.D. [1].

It is also observed that the high-fiber, carbohydrate cereals such as Kellogg's All-Bran and Bran Buds produced a lower BG level than the Shredded Wheat cereal, which has less fiber. Also the simple sugar glucose caused a much higher peak BG level than that caused by any of the other substances tested.

5.2 Experiments With Various Inputs and Amounts

Figure 5-2 shows some results obtained with various inputs and with different amounts of the same type of input.

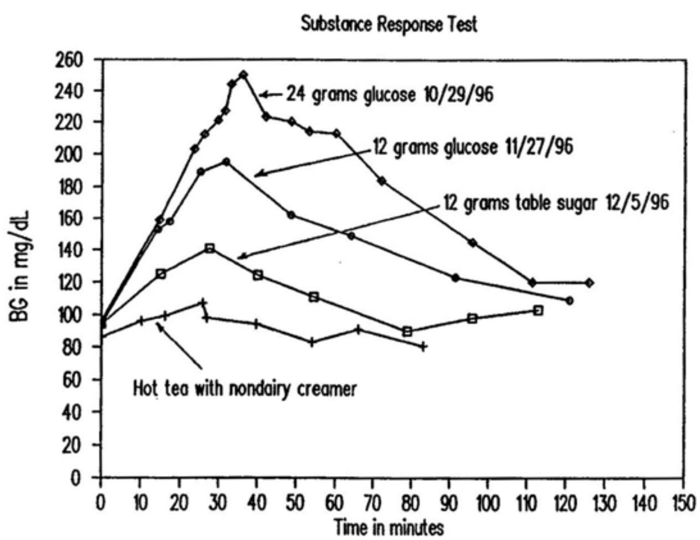

Figure 5-2 Substance response tests with varied inputs.

Comments on figure 5-2

Table sugar (sucrose) is seen to have far less effect on my BG than glucose. A hot drink (decaffeinated tea with nondairy creamer) ingested at the same time as the sugars adds 6 grams of carbohydrate to the input. Thus the total carbohydrates in the 12-gram and 24-gram glucose tests are actually 18 grams and 30 grams, respectively. When the total carbohydrate input increased by 67%, I measured a 52% increase in the change from fasting to peak BG and a 58% increase in the average BG over a 2-hour period. More detailed discussion on the amount of food and BG level is given on page 21.

A typical estimate for the increase in the BG level for someone weighing 140 pounds is 5 mg/dL per gram of carbohydrate ingested [1]. In my tests, carried out when I weighed about 175 pounds, the BG increase per gram of carbohydrate varied from 5.2 to 5.6 mg/dL for total carbohydrate inputs of 30 grams and 18 grams, respectively.

5.3 Response to Snacks

Figure 5-3 shows the results of tests on some of the items that I regularly use as snacks. Response graphs could be developed for many other foods; however, as I got to understand how my body reacted, producing a peak in the range of 40 to 75 minutes with most whole foods (i.e., not simple sugars) a single test was usually sufficient to qualify acceptable snacks.

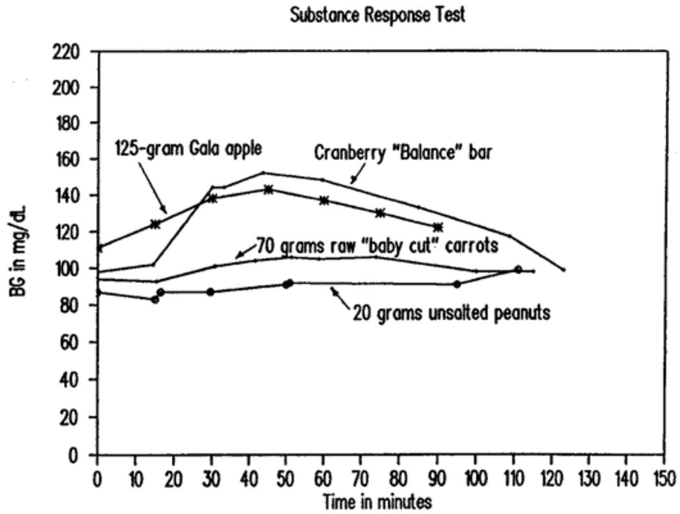

Figure 5-3 Response to some snacks.

Comments on figure 5-3
The cranberry Balance bar (distributed by Bio-Foods Inc) contains 21 grams of carbohydrate, 14 grams of protein, 6 grams of fat, and 3 grams of fiber for a total of 180 calories. These ingredients have a nominal calorie content in the ratio of 40% carbohydrates, 30% protein, and 30% fat, as recommended in the Zone diet proposed by Barry Sears, Ph.D. [5]. Not all apples will show the same response, and each person must evaluate his or her own response to determine what part these snacks can play in the diet.

Other snacks tested for ΔBG (average increase in BG level caused over a 2-hour period) include, 30 grams of chocolate liqueurs causing ΔBG = 19 mg/dL, 60 grams of sausage rolls causing 37 mg/dL, and 30 grams of cheese scones causing **ΔBG =** 17 mg/dL.

5.4 Response to Different Breakfast Meals

Figure 5-4 Illustrates some items that I use in my breakfast menu.

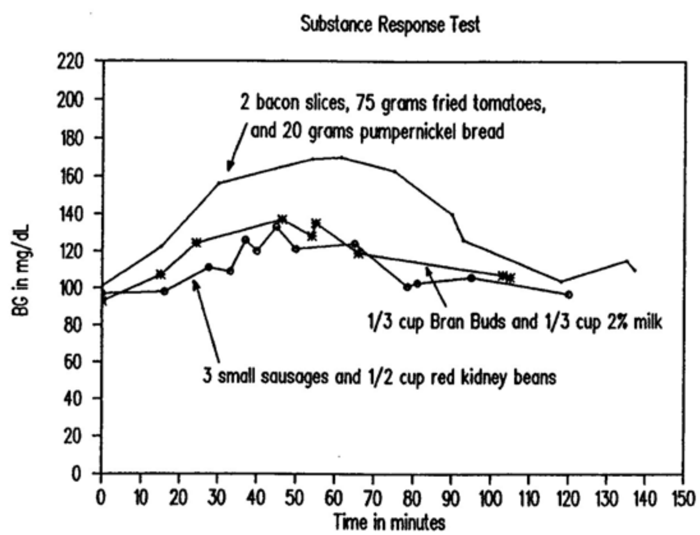

Figure 5-4 Response to different breakfast meals.

Comments on figure 5-4
These curves show once again the significant effect that carbohydrates have in raising my BG level, whereas protein and fat have a small effect. For example, if we incorporate this data with that shown in figure 5-1, it is clear that an egg omelet with sausages

would raise my BG very little. The highest curve, which includes the effect of pumpernickel bread, includes significantly more carbohydrates than I would normally have for breakfast, but it is given as an example. Pumpernickel bread was selected because it has a reduced glycemic index, which is a measure of a substance's effect on the BG level over a 2- or 3-hour period. As noted before, different individuals would have different response curves, although the relative effects may be similar.

5.5 Short-Term Exercise Effects

Figure 5-5 shows how upper body exercises over the period of 10 through 17 minutes affected the BG response. In this test the response curve without exercise is different from the original BG response curve shown in figure 4-1. It is believed to be better because as testing progressed I was achieving better control and becoming "less diabetic." Figure 5-9 further highlights these effects. Day-to-day variations can also be expected.

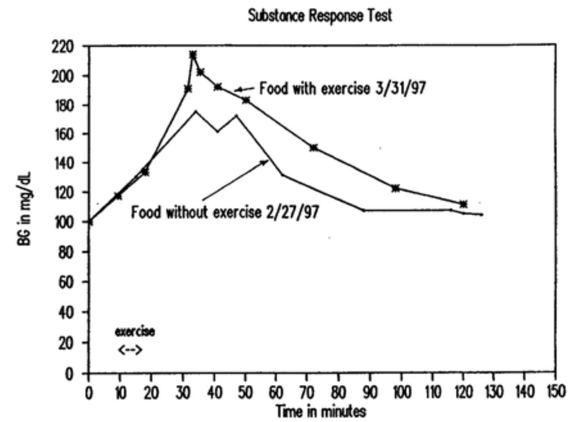

Figure 5-5 How short-term (7 mins.) exercise raised the blood glucose level.

Comments on figure 5-5

In each test the food input was 12 grams of glucose and a cup of hot tea with nondairy creamer. The test was to find the effect of short term exercise on my BG level. Results are adjusted to begin at the same BG level. I found that starting from the fasting condition, short-term (7 minutes) exercise raised my BG whether food was ingested or not. This is likely caused by the liver, which converts stored glycogen to glucose to supply the muscles. For this reason, exercise is not advised when the BG level is high. I did not test the effects of a long-term exercise program, but its advantages are discussed in Bernstein's book [1]. Exercise is seen to be one of the many variables that can affect your measurements.

5.6 Effects of One Type of "Fast Food" With and Without Wine

It may not be feasible to consume wine with fast food at restaurants, but it is viable in the home providing that it has no adverse reactions with one's medications or BG levels, or other medical conditions. These details can only be satisfactorily resolved in conjunction with one's physician. In my case no medication is involved, and Figure 5-6 shows how my BG level was affected by one type of fast food meal, consumed both with and without red wine (Merlot).

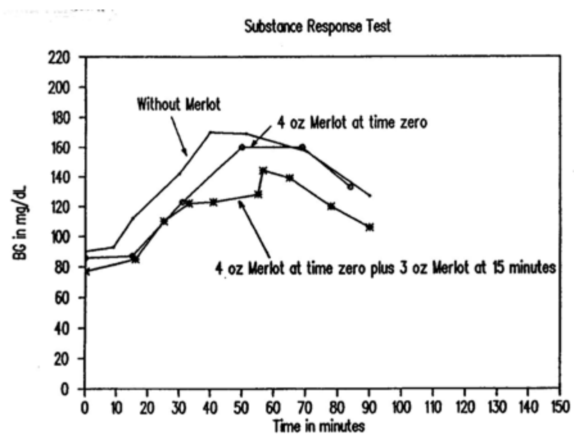

Figure 5-6 Effect of fast food and wine.
(Fast food was from Wendy's--a small chili and half a baked potato.)

Comments on figure 5-6
The weight of the food inputs was not as well controlled as in home-prepared meals; also the meals were eaten in late afternoon after only 4 hours of fasting, however, due care was exercised to try to make valid comparisons. The food was purchased at Wendy's and then consumed at home where the effects of a red wine (Merlot) on the meal could be determined. Merlot was found to reduce BG, that is, it acted as an oral hypoglycemic agent in these tests. Further tests with Merlot, shown in figure 5-7, support this finding.

5.7 Effects of Beer, Wine, and Distilled Spirits

Figure 5-7 shows the transient effect of alcoholic drink inputs. These somewhat unpleasant tests were carried out after overnight fasting and do not represent the way the drinks are expected to be used.

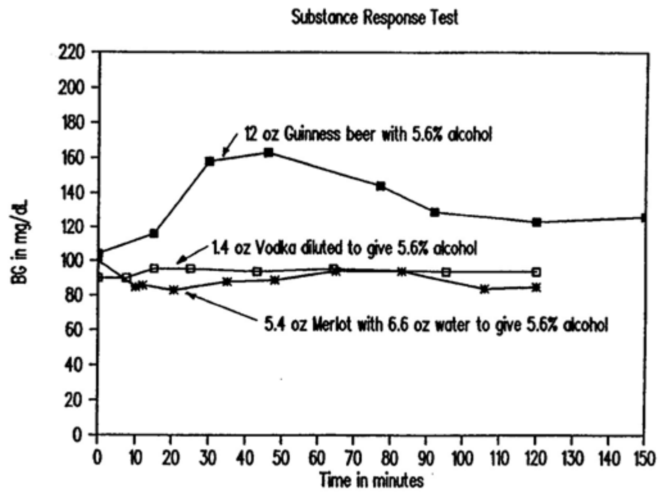

Figure 5-7 Effect of different alcoholic drinks.

Comments on figure 5-7
For equivalent amounts of alcohol, the Guinness beer raised my BG level, but the wine (Merlot) and spirits (Vodka) had small effects. Since the beer includes carbohydrates, it is presumed that these simply overwhelmed any glucose-lowering effects of the alcohol. In the test with Merlot, some BG reduction was observed, but it is too small to define precisely. Dr. Bernstein notes that alcohol can indirectly lower BG of a type 1 diabetic if consumed at the time of a meal because it impairs the ability of the liver to convert protein to glucose. Fortunately a precise understanding of the operating mechanism is not essential to apply the response test results, and on the basis that red wine is also believed to raise high-density lipoprotein (HDL) cholesterol (the good cholesterol) I added it to my diet and regularly have a 4-oz glass with my dinner. Whether fortuitous or not my HDL level increased from 39 mg/dL to 60 mg/dL during the 12-month testing period.

5.8 Foods That Reduce Blood Sugar

Alcohol and onions were reported in the Diabetic mailing list at Lehigh as two substances that reduced BG level under some conditions. These reports illustrate the power of the Internet for people to share their experiences. The test conditions were not defined exactly by those reporting, but because the tests were not immediately after overnight fasting, it is quite possible that the BG reduction came from inhibited protein conversion effects as indicated by Bernstein [1]. My tests show a small hypoglycemic effect for both red wine (Merlot) and onions when ingested after overnight fasting.

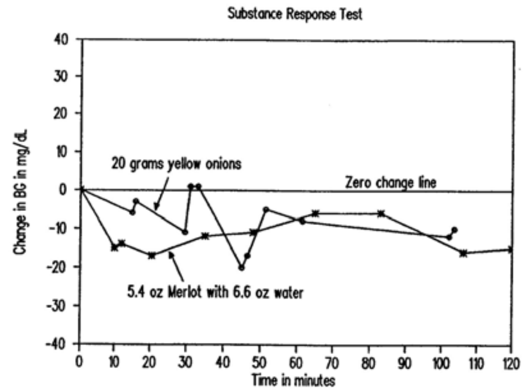

Figure 5-8 Reduction of blood glucose levels by onions and alcohol.

Comments on figure 5-8
To emphasize the hypoglycemic characteristics displayed by onions and alcohol, only the BG changes from the fasting position are plotted. For the fasting test with onions, 20 grams of yellow onion were fried and ingested. As with the Merlot, the changes are too small for a home BG meter to define with precision however, the tendency is to reduce BG. Based on these results I can enjoy my hamburger and onions, but without the bun, which for me has too many carbohydrates!

5.9 Effects of Improved Blood Glucose Control on Glucose Tolerance Tests

Figure 5-9 shows three identical glucose tolerance tests taken at different times.

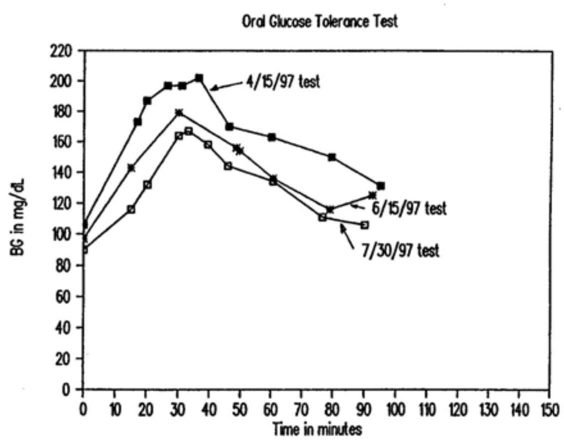

Figure 5-9 Variation in glucose test as blood glucose control improves.

Comments on figure 5-9
In each of these tests the input was 12 grams of glucose and a cup of hot decaffeinated tea with dairy creamer, which included about 6 grams of carbohydrate. The tests were taken during a period when the BG control was being improved by means of a low-carbohydrate diet. The results do not show any increase in body sensitivity to glucose when a low-carbohydrate diet is in place, as reported for some healthy individuals elsewhere [6]. In fact just the opposite occurred. My body was better able to accommodate a glucose challenge when it had enjoyed a rest period with reduced BG values. Of particular interest is the slower initial increase in BG in the most recent test, as if my basic body response has been improved. These results lend support to the expectation that insulin resistance will decrease and some beta cells will recover when a lower BG environment is maintained [7].

5.10 Effects of Bread in Consecutive and Single Meals

Using whole-wheat bread, I determined the difference between consuming one large meal and two small meals. In test 1, two 30-gram pieces of bread were eaten, one at time zero and the other after 2 hours. The BG level was measured during a 4-hour period. In test 2, a 60-gram bread meal was eaten at time zero and the BG was monitored until the fasting value was reached again. Two small meals appear favorable because the peak BG and average BG over a 2-hour period are lower.

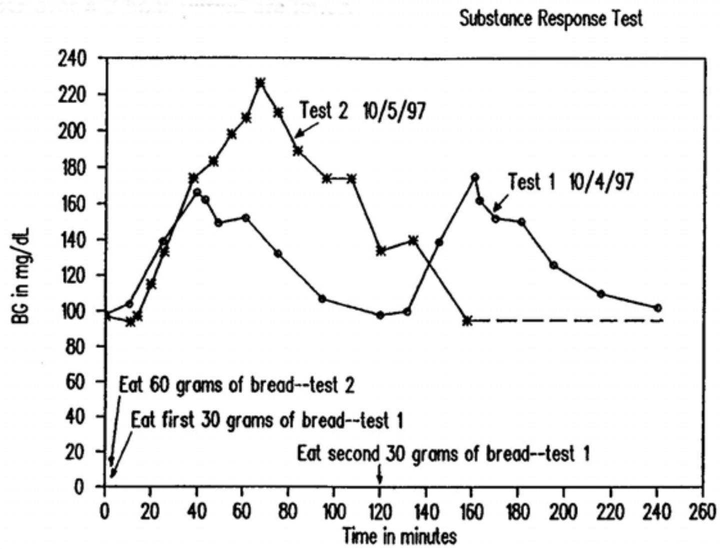

Figure 5-10 Comparing two small meals versus one large meal.

Comments on figure 5-10

Thirty-six finger pricks over a period of 2 days were used to develop accurate data to make comparisons. Fortunately, far fewer measurements are required for normal practical BG control! Table 2 summarizes the results.

Table 2 Comparing Different Quantities of Bread Meal

	Peak BG (mg/dL)	2-Hour Average (mg/dL)	4-Hour Average (mg/dL)
One 60-gram piece	226	166	134.9
Two 30-gram pieces	175	127.4	127.5

5.11 Comparing Whole-Wheat and Pumpernickel Bread

In this experiment 30 grams of two different types of bread were tested. One cut slice weighs about 30 grams, but minor trimming was used to make the weights as nearly equal as possible. In one test, sausages were eaten with the bread so as to observe the effects of a large input of dietary fat. To facilitate comparisons, the results shown in figure 5-11 have been scaled to reflect the same starting position; also the BG level scale is enlarged.

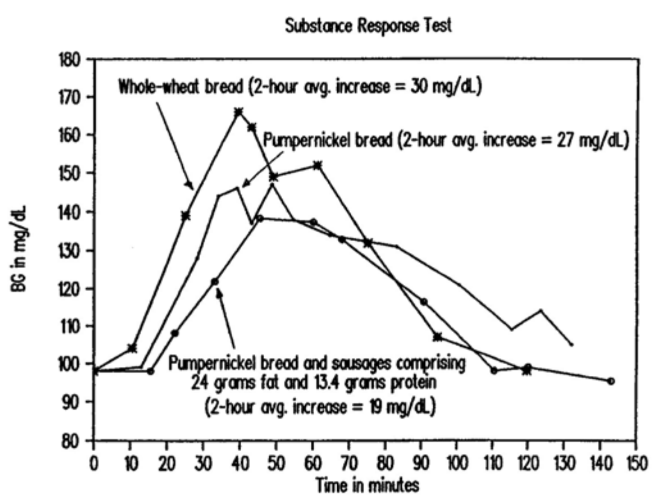

Figure 5-11 Response to two types of bread and the effect of fat.

Comments on figure 5-11
Analysis of the results leads to the following conclusions:

1. Increases in the peak BG level and 2-hour average values are higher for whole-wheat bread than for an equal weight of pumpernickel bread.
2. With 24 grams of fat and 13.4 grams of protein added to 30 grams of pumpernickel bread, the 2-hour average increase in the BG level was reduced from 27 to 19 mg/dL.

From this data and taking note of the glycemic index data described in section 6.0, I selected a small amount of pumpernickel bread to be used in my normal daily diet; also sausages are frequently included.

5.12 Effects of 7 Years of Type 2 Diabetes on Response to the Same Input

When I was diagnosed with type 2 diabetes in 1990 I carried out response tests to determine how my diabetes might change with time. In those days I was unaware that glucose tablets were available and used a different, but similarly predictable, input food. Fortunately, good records were kept on the computer, and they are reported here.

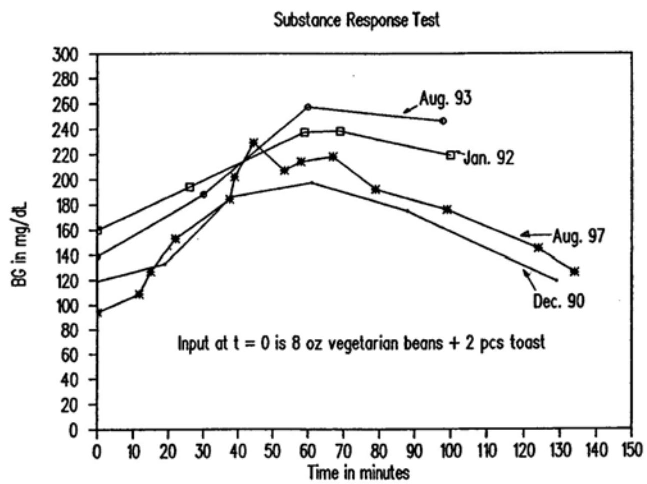

Figure 5-12 Effects of baked beans and toast input over 7-year period.

Comments on figure 5-12
Figure 5-12 shows the author's response to a small can (226 grams) of Heinz vegetarian beans with two pieces of toast when he was first diagnosed and then repeated at intervals over a period of 7 years. The beans comprise 50 grams of carbohydrate, 2 grams of fat, 9 grams of protein, and an estimated 9 grams of fiber. The results clearly show the deterioration of fasting BG level until 1997, when restricted carbohydrate meals were incorporated 3 months before the 1997 test. The results are very encouraging for me. They show how my BG deteriorated with poor control and improved when excellent control was implemented with a low-carbohydrate diet. In my case it appears I implemented good control in time to see some improvements.

6.0 ANTICIPATING THE EFFECTS OF DIFFERENT FOODS

Substance response tests demonstrate the significantly greater glucose-raising effect caused by any type of carbohydrate compared with protein. However, carbohydrates vary among themselves. The glycemic index (GI) gives a way to compare different carbohydrates within different foodstuffs [8]. The higher the GI, the quicker that carbohydrate is converted to glucose and the higher one's BG level will rise. A wide range of GI data are provided by Rick Mendosa in his web site (www.mendosa.com/gilists.htm). Typical numbers that relate to equal amounts of carbohydrate, not equal amounts of food, are reproduced with permission in the abbreviated list below.

GLYCEMIC INDEX BASED ON FIXED AMOUNT OF AVAILABLE CARBOHYDRATE.

BREADS		CEREALS	
White bread	100	All-Bran	60
Whole-wheat bread	105	Special K	77
Pumpernickel bread	71	Shredded Wheat	99
DAIRY		FRUIT	
Milk (full fat)	39	Apple	54
Ice cream (low fat)	71	Grapefruit	36
LEGUMES		ROOT VEGETABLES	
Baked beans	69	Sweet potato	77
Kidney beans	42	Potato (baked)	121
Soybeans	25	Potato (boiled)	104
SNACKS		SUGARS	
Potato chips	77	Honey	104
Popcorn	79	Glucose tablets	146
Peanuts	21	Sucrose (table sugar)	92
Pretzels	116	Fructose (fruit sugar)	32

Tests with different foods convinced me that I needed to define the effects of different amounts and types of food, not just carbohydrates. This led to a method for characterizing the glucose-raising effect of food in which the effects of any type of food such as carbohydrate, protein, and fat, are compared with a reference food such as 60 grams or 2.1 ounces of white bread. In this method it is not necessary to know the food composition, just the weight. The characterization factor is here defined as *substance glycemic index* (SGI). Appendix A-5 gives examples of curves used to generate SGI data and values for various foods are given on page 19. In conjunction with the SGI only the weight of food is required to predict the effect on BG level. The method can be used by individuals to develop a list of SGI numbers that reflect their own response to different food substances.

7.0 OTHER FACTORS

Dietary supplements were tried in small amounts with little success. Vanadyl sulfate in the amount of 10 mg/day was found to reduce fasting BG levels by about 8 mg/dL but was discontinued after about 4 weeks because of unexplained chest pain. Two attempts to restart the dose gave similar pains, and the vanadyl sulfate was permanently discontinued.

Ganong explains that beta cells hypertrophy and die when continually overstressed, and this is an important consideration for type 2s wishing to remain free of insulin injections [9]. A high glucose environment has been found to be toxic to beta cells and muscle cells [7, 10]. I believe these are very good reasons for maintaining a normal BG level at all times as recommended by Dr. Bernstein. If a normal BG level is obtained without overstimulating the pancreas, as I have now been able to do, then so much the better.

In practice a low-carbohydrate diet, which reduces the BG level, may result in increased protein consumption to maintain caloric needs. Possible effects of protein input on kidney performance are addressed by J. Whitaker, M.D. [6]. Creatinine results give one measure of kidney performance, and my creatinine levels remained within the normal ranges on a low-carbohydrate input. Bernstein provides significant discussion of the kidney issue and includes a number of reference papers that make me very comfortable with the low-carbohydrate diet. However, your situation may be different. Once my BG level was lowered to the point where it rarely exceeded 140 mg/dL, the number of daily bathroom visits was greatly reduced. In fact I made a point of increasing my water input just to keep my kidneys active.

8.0 BLOOD ASSAYS

At different times laboratory blood tests were ordered to give a more detailed review of my clinical parameters. Table 3 gives blood assays, which provide a chronological view of my progress over a period of 12 months, in which the last 4 months were on a low-carbohydrate diet. The improvements in BG and cholesterol levels with the introduction of a lower- carbohydrate diet in June 1997 are very gratifying.

Table 3 Summary of Fasting Blood Assay Results						***
Parameter	9/18/96	11/11/96	4/10/97	7/8/97	9/18/97	6/29/00
BG (plasma mg/dL)	101	113	111	99	88	106
HbA1c* %	6.2	6.1	6.4	5.9	5.4	5.2
Creatinine (mg/dL)	0.9	0.9	0.8	0.7	–	0.7
Triglycerides (mg/dL)	109	134	81	60	73	76
Total cholesterol (mg/dL)	218	205	218	192	215	232
HDL (mg/dL)	38	39	49	58	60	66
LDL** (mg/dL)	158	139	153	122	140	156
Total protein (g/dL)	6.9	6.5	6.3	6.7	–	6.9
Albumin (g/dL)	4.1	4.1	4.1	4.3	–	4.4
Weight (lb)	175	177	174	168	164	167

←Lower-carb/lower SGI diet →

* My highest recorded HbA1c was 9.0% in October 1993.
** LDL (low-density lipoprotein) is calculated from:
LDL = total cholesterol - HDL - (triglycerides/5)
*** This column, added with Supplement in January 2001, is not included in discussion below.

The blood assays provide a convincing story of progress in maintaining good BG control while experimentation on different foodstuffs was carried out. After the lower-carbohydrate diet was started in June 1997, not only was the BG control improved as evidenced by the HbA1c and fasting BG level, but the total cholesterol was reduced, and the HDL level was increased. Also triglycerides, low density lipoprotein (LDL), and weight were reduced. The increase in total cholesterol in the last column is believed to result from a reduced input of fiber (All-Bran) in the previous 4 weeks. A fiber source (Bran Buds) was reinstated and after 1 month the total cholesterol level had reduced to 184 mg/dL. One factor indicating the risk of a heart attack is the ratio of total cholesterol to HDL. Over a 1-year period this ratio went from a high of 5.73 (above average risk) to a final value of 3.6 (almost half the average risk). I was not trying to lose weight during this period, but my weight decreased by 11 pounds. Figure 5-13 is a bar graph showing the HbA1c and fasting plasma glucose levels. One can see a correlation between these two parameters, as might be expected.

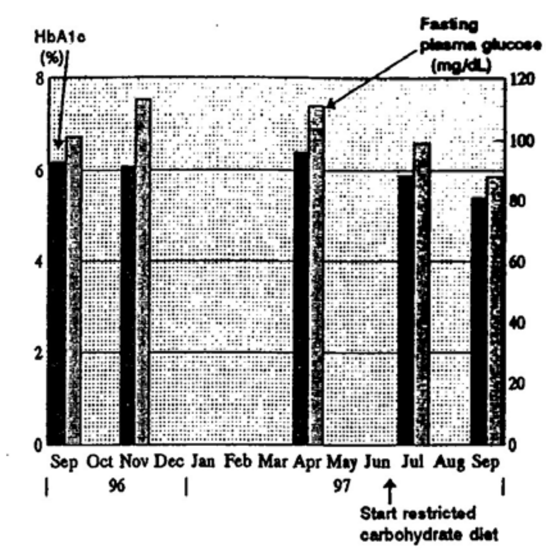

Figure 5-13 HbA1c and fasting plasma glucose level over the testing period.

9.0 SUMMARY AND CONCLUSIONS

First it must be recognized that others will get results that are unique to their own body's response. However, I believe that my results have highlighted some basic issues; also my testing methods are straightforward. I found that dietary changes greatly affected my medication needs.

As noted previously one cannot make dietary changes to improve blood glucose control without consideration of the effects on other parts of the body, especially as regards the effect of medications. Thus any changes must be decided only after consultation with your physician. I hope that my results will be of help to both patients and physicians.

After analyzing my substance response test data, I reached these important conclusions about factors that affect my ability to maintain good BG control:

1. For nominally equal amounts of food calories, high glycemic index carbohydrates caused my average BG increase over a 2-hour period to be about 10 times greater than that caused by a mostly protein meal.

2. Carbohydrates increase the BG level 3 to 20 times faster than protein, depending on the glycemic index of the carbohydrate.

3. By means of substance response tests I was able to select foods with lower glucose-raising effects and thereby improve my BG control. Improved control appeared to make my pancreas perform better, or reduce insulin resistance, or do both of these things.

4. Fat had little direct affect on my BG level, but on a short-term basis reduced the glucose-raising effect of high glycemic index bread.

5. I am trying to prevent my momentary peak BG level from exceeding 140 mg/dL, and for me this goal appears to be feasible by simply restricting my carbohydrate input. The resulting HbA1c has been in the region of 5.4%.

10.0 ON-LINE DIABETES SUPPORT GROUPS

The Internet is a great tool for learning about medical issues and provides access to a staggering amount of technical and anecdotal data. Groups that I have found especially useful for discussion of diabetes issues are as follows:

Diabetic The creator of this list, R. N. Hawthorn, says it was created for "the diabetic patient to exchange any ideas, comments, gripes, fears, or whatever, related to your condition." It succeeds in doing that and much more. You can see samples of these helpful postings without joining the list by accessing the site at **www.lehigh.edu/lists/archives/diabetic/.** Subscription information can be found at **www.lehigh.edu/lists/diabetic/.**

The Diabetes List is a spin-off from the diabetic mailing. As the site says, "The World list is unique because the list owner is an endocrinologist well-experienced with Diabetes. Dr. Arturo Rolla practices at Deaconess Hospital in Boston." The URL is **http://www.zoomph.net/diabetes.world/**

LC-Diabetes is a support list for all persons interested in controlling carbohydrates as a method to control and manage diabetes. The list owner is STONE and SPEAR. Subscription information is at the following URL,
http://msnhomepages.talkcity.com/SupportSt/stoneandspear/lcd.html/.

www.mendosa.com/faq.htm is a Web page titled "On-Line Diabetes Resources, by Rick Mendosa." Here you will find a great deal of useful information including descriptions of numerous other diabetes-related sites with their addresses and subscription protocols.

11.0 MORE DATA ON SGI *(SUBSTANCE GLYCEMIC INDEX)*
(THIS SUPPLEMENT WAS ADDED IN JANUARY 2001)

11.1 Purpose and Benefits of the SGI

It is evident from substance response tests that a single BG reading cannot properly explain the effect of any particular food. The AUC (area under the curve) gives a much greater understanding. The SGI has a similar purpose to the GI factors described by Janette Brand Miller et al. [8], and also to the insulin index of foods as described in [11]. The goal is to help predict the effect that certain foods will have upon the body. The GI and insulin index approaches are generalized, because tests were carried out on a large number of subjects. However, each method has a specific focus: the GI relates to a fixed amount of carbohydrates and the insulin index relates to a fixed number of calories. There is a large amount of GI data available to help determine which carbohydrates convert to glucose more slowly.

The SGI method relates to any weight of any food substance and is specific to an individual. I have found this easier to apply in my day-to-day control of diabetes because it requires no knowledge about the food composition in terms of carbohydrates, protein, fat, or calories—just the weight! To control my BG without recourse to insulin or medications which stimulate the pancreas it is clear that I have to eat foods that cause only a slow and hence small increase in BG level. I simply select foods with a low SGI number.

By means of this food-selection strategy, I have been able to reduce my average BG and HbA1c so much that now I have excellent control. Using foods that cause only a slow increase in BG level has also been shown effective at helping with control in those with type 1 diabetes [1].

The Diabetes Control and Complications Trial (DCCT) has clearly established a relationship between lower average BG levels and complications of diabetes for those with type 1 diabetes. Also, the UK Prospective Diabetes Study (UKPDS) published in 1998 showed that tight control is just as important for type 2 diabetes. No relationships between complications and momentary BG levels have been defined, however, in practice, high transient BG levels lead to higher average values.

To achieve low HbA1c levels it is desirable to prevent higher than normal blood glucose at all times. Dr. Richard K. Bernstein is a proponent of a low-carbohydrate diet and wrote that he has a target BG level of 85-90 mg/dL for type 2 diabetics depending upon whether or not they are using insulin. However, he points out that it is not possible to secure precise BG values if you are not using insulin since set points are determined in part by the patient's own physiology. My initial personal goal of keeping my peak transient BG level from ever exceeding 140 mg/dL is not as demanding, but so far has resulted in greatly improved, near normal HbA1c results.

11.2 Individual Foods

As anticipated on page 14, testing of food substances has continued. Table 4 gives the SGI for various foods as a percentage relative to that for 60 grams of whole-wheat bread. By using the SGI to help select what I eat I am getting good BG control, e.g. in June 2000 my HbA1c was 5.2%.

To perform more detailed calculations, note that the increase in the AUC for whole-wheat bread is 9288 mg/dL minutes. The AUC for a different food can be estimated using its SGI. Limited testing suggests that for weights less than 60 grams, the AUC is roughly proportional to the amount of food. Thus 30 grams of Cadbury's dairy milk chocolate has an estimated AUC of about $0.5\times(62/100)\times9288$ i.e. 2880 mg/dL minutes. Tests gave a 6% higher result. In contrast, the measured value for 30 grams of whole-wheat bread was appreciably less than the scaled value.

The conclusions from table 4 are straightforward. Not all high-carbohydrate foods have the same effect, and protein foods have only a small effect on my BG. These are similar to the conclusions that I developed and quantified in section 9. I routinely use the relative value for SGI, and the GI [8], to help select appropriate foods which do not raise my BG level unduly. For example, looking at table 4 it is clear why I incorporate egg omelets in my diet. Also by the same reasoning it is clear why I avoid eating bread.

11.3 Applying the SGI Table

The results given in table 4 provide relative SGI numbers which are applicable to a type 2 person with the same severity and variation of diabetes as myself. Your results may be different. However, it is not too difficult to establish your own list of SGIs which are then directly applicable to your own conditions. Testing in a large group such as described in [8] would be desirable to verify a probable range for these relative values.

Table 4 Relative SGI Factors for the Author (Test substance weight = 60 grams {2.1 oz} unless otherwise noted)	
Type of food substance tested	SGI %
Whole-wheat bread (Publix white bread is practically identical [8])	100
Pumpernickel bread (Publix)	70
Cadbury's dairy milk chocolate	62
Cheese pizza	59
Sausage rolls (with regular flour)	56
Tiger's milk protein bar * 35 grams	50
Carbolite bread mix (mix has 7g of protein per 2g of carbohydrate)	38
Nut Berry "Balance Bar" * 50 grams	36
French style cheesecake (store-bought)	34
Milk chocolate ("Estee" fructose sweetened)	33
Cadbury's chocolate biscuits * 18 grams	32
Cheese scones (made using 63% soy flour)	29
Brownies (made with 50/50 soy and regular flour)	29
Kellogg's Bran Buds (30 grams) plus 2% milk (30 grams)	25
Dried fruit/soy flour scones	23
Carbolite and soy flour 50/50 bread mix	22
Green peas (average from tests with regular and baby peas)	20
Fuji apple	19
Soy flour and rye flour 88/12 bread mix (added 2003. See p 26)	17
Atkin's diet "Advantage bar" (chocolate raspberry	17
Steak	17
Buttered pecan ice cream * 30 grams	15
Brownies using 100% soy flour (see also page 25)	15
Apple scones using 100% soy flour	14
Cantaloupe melon * 178 grams	12
Cheese scones (using 100% soy flour)	11
Nectarine * 90 grams	9
Tomatoes (raw)	9
Carrots (raw)	8
Grapefruit (fresh)	7
Cauliflower (cooked)	7

Table 4 continued	
Grapefruit	7
Sausages (Jimmy Dean; precooked)	6
Cheese omelet (50 grams of "Eggbeaters" and 10 grams of cheese)	6

Once you establish your own SGI factors you have a unique view of how specific foodstuffs affect your own body. In some cases one can anticipate the SGI value from a similar type of food. For example the SGI for cabbage is expected to be similar to that for cauliflower. If there is any doubt then a test is recommended. Occasionally I introduce a completely new type of food into my diet. If it is a high-carbohydrate food, I first consult the basic GI data [8] and page 15. Personal SGI testing requires a certain commitment of time, but then so does diabetes control in general. I now have an adequate database to predict results such that I only need to test once a day, unless something unusual happens to my meal plans.

Eating with careful regard for SGI is what I call a LOSS diet. (Low Sugar Score diet) I and many others have found that not only does this way of eating lead to lower BG levels, but it also helps to reduce weight.

11.4 Effects of Composite Foods

Like most people I incorporate a variety of different foodstuffs in any particular meal and the question arises as to what effect this has on the SGI. I found this to be a complex subject because the different foods appear to react with each other and generally reduce the SGI over what might be expected by simply adding the SGI values. A clue to these effects is given in reference [11] (see p. 51), where it is noted that protein-rich foods, or the addition of protein to a carbohydrate-rich meal, can stimulate a modest rise in insulin secretion without increasing blood glucose concentrations, particularly in subjects with diabetes. Also, without speculating on the mechanism, it is noted that the addition of fat to a carbohydrate-rich meal reduces the rate of increase in BG level. Table 5 summarizes experiments in which I first added cheese (mainly protein and fat) and then sausages (mainly fat) to pumpernickel bread. It is encouraging to note that sometimes you can eat more and yet get a smaller increase in BG!

Table 5 The Effect of Adding Substances to Bread		
Test Substance	SGI %	Calories
30 grams of pumpernickel bread alone	35	48
30 grams pumpernickel bread plus 30 grams of sharp cheddar cheese	29	138
30 grams of pumpernickel bread plus 73 grams of sausages	25	314

Table 5 shows that fat and protein act to reduce the effect of the carbohydrate on my BG. Also the meal with the highest calorie content has the lowest effect on BG. These data reinforce the fact that one may not be able to control BG simply by limiting calories.

It is clear that accurately estimating the effects of composite foods is a significant problem. In engineering the solution to this type of multivariable problem is often to assume a "worst case" condition. A similar approach is proposed here for SGIs. In the problem with the bread plus fat, the "worst case" approach would be to simply ignore the fat, because it is not directly converted to glucose. The calculated result is then conservative i.e. worse than the measured value.

11.5 Combining Two Substances

Consider combining 40 grams of whole-wheat bread with 40 grams of cooked green peas. Then a worst case approach which ignores any interaction between bread and peas would indicate a combined SGI effect of:

$$100 \times (40/60) + 20 \times (40/60) \text{ i.e. } 66.7 + 13.3 \text{ i.e. } 80.0$$

In terms of AUC this is (80/100) × 9288 i.e. 7430 mg/dL minutes.

In a test with this food combination I measured an AUC of 4733 mg/dL minutes, only about 64% of the calculated value. Thus in this case, and in the others shown in table 5, the combination of two different foods causes appreciably less BG increase than expected. This is anticipated by the work described in [11]. It seems to be an area worthy of further investigation.

11.6 Different Portion SGIs

One can anticipate that a larger meal will cause a proportional increase in AUC, for example, twice as much of the substance will cause twice as much AUC. The measured results shown in figure 11-1 show some nonlinearity, but the assumed proportional relationship is not unreasonable for practical calculations. If the BG response curve is assumed to be triangular then the peak increase in BG level will vary as $(\text{weight of substance})^{0.5}$, but this too is only very approximate since the response is not exactly triangular.

The severity of diabetes in individuals will be different and could lead to different results for varying food amounts, however, the simple proportional formula that I use for different weights of a given substance might be a good starting formula for other experimenters to try. In the final analysis any concerns over the statistical validity of this and any of the test data described in this book are best resolved by performing your own experiments. My results give a guide as to what sort of experiments may be most effective.

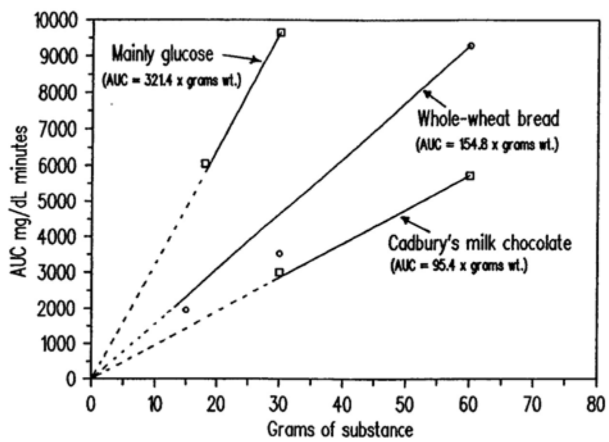

Figure 11-1 Showing the effect of the amount of a substance.

11.7 Meal Glycemic Index

Extending the concept of composite meals even further, we can characterize complete meals. If we think of a substance as comprising unknown constituents, then a complete meal can be characterized with a substance glycemic index, i.e., the effects of the meal can be expressed relative to the glucose-raising effect of 60 grams of whole-wheat bread. A meal will likely weigh more than 60 grams and the overall test time may be substantial. For example figure 11-2 shows the results of a meal plotted over a period of about 5 hours. A potential problem with this duration of testing time is that other factors may start to influence the BG level. Also, such commitment of time is a deterrent for many experimenters. These issues can be addressed by extrapolating the results, for example as in the chili and hamburger meal shown in figure 11-2. The steak meal response in figure 11-2 was plotted over a period of more than 5 hours to show its full effect.

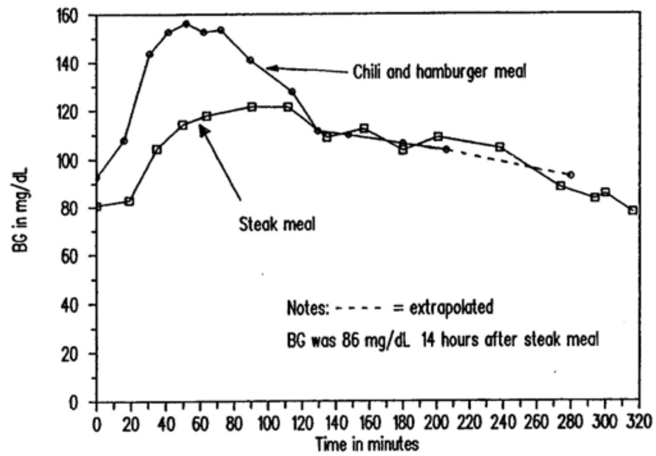

Figure 11-2 Response to complete meals.

Details of the meals used for the data in figure 11-2 and their SGI factors are given in sections 11.8 and 11.9. It is especially interesting that the very substantial meal described in 11.9 actually has about the same blood glucose-raising effect as only 46 grams of whole wheat-bread. Figure 11-3 illustrates this equivalency and dramatizes the advantages of using the SGI concept.
It explains how I can eat satisfying meals and still get good BG control.

11.8 Chili Soup and Hamburger Meal (Wendy's)
SGI relative to 60 grams of whole-wheat bread = 76%

1 small cup of chili soup
½ pound hamburger with cheese (omit the bun)
6 oz Merlot wine
4 oz sugar-free gelatin dessert
5 tablespoons whipped real cream (2.5 grams carbohydrate)
1 cup decaffeinated coffee with nondairy creamer

11.9 Steak Meal (Dinner)
SGI relative to 60 grams of whole-wheat bread = 77%

8 oz steak
20 oz cooked cabbage
6 oz Merlot wine
4 oz sugar-free gelatin dessert
6 tablespoons whipped real cream (3 grams carbohydrate)
1 licorice and 1 regular peppermint candy
1 cup decaffeinated coffee with nondairy creamer

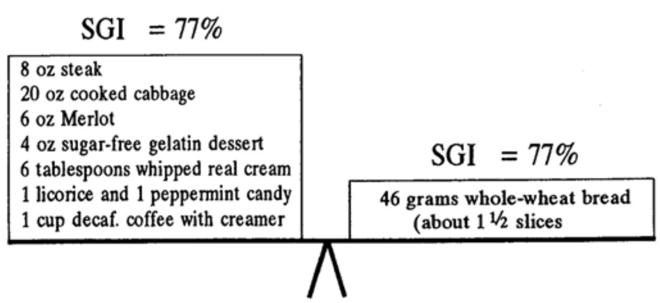

Figure 11-3 Illustrating equivalent-BG-effect meals.

12 KEEPING A CHECK ON YOUR PROGRESS

This discussion is directed at those with type 2 diabetes who want to know if their diabetes is getting worse. Generally one wants to know if/when insulin injections will be necessary. I do not have to use insulin, but have experimented so that I'm comfortable with its use. This could be helpful, for example, when other factors stress the body in emergencies such as an accident or a heavy cold.

At diagnosis many type 2s enthusiastically take care of their diabetes with diet and exercise and see good results. However, without any obvious untoward symptoms it is difficult to maintain the required level of effort needed for good control and BG levels may increase. Their diabetes progresses and eventually the insulin output from their own pancreas is insufficient. They need external insulin shots to control blood glucose levels. This deterioration depends upon numerous factors, but many people report requiring insulin after one to five years. Occasionally people manage to go without external insulin for 10 to 20 years after diagnosis, but this is the exception and requires diligent control. Maintaining good, near normal, control requires much effort. The disadvantages of not achieving good control may not show up for ten years or more, but by then some problems may be irreversible. Diabetes is a silent killer.

To see how my diabetes is progressing I devised a home-based test that determines my response to 12 grams of pure glucose. The glucose is ingested at a time when BG level would normally be relatively stable. In my case this is in the early morning fasting position. After eating the glucose I plot BG level versus time and then calculate the AUC, incremental area under the glucose versus time curve, over a period of 90 minutes. Typically I reach a peak BG level after about 30 minutes. I use the AUC number to see how my response to the glucose stimulus has changed. I first started this test procedure in 1997, at a time when my BG meter was calibrated to read whole blood. Also I included a drink of hot decaffeinated tea in which carbohydrates were added from a nondairy creamer. Later I switched to a BG meter calibrated in terms of plasma and I also eliminated the nondairy creamer that added to the carbohydrate stimulus. My results, recalibrated to be on the same whole blood basis, are tabulated below:

Date	AUC mg/dL minutes	Comment
4/15/97	5833	Start "good' control using low carbohydrate diet.
6/15/97	4464	
7/30/97	3577	
7/5/99	4318	
7/29/99	4628	Start 8 units of Ultralente insulin daily
9/9/99	3499	Discontinue use of insulin 42 hours before test.
2/12/00	3982	
10/28/00	4314	

These tests continue, but some interim conclusions are:

1. A low carbohydrate diet to achieve good BG control initially improved my response to a glucose stimulus. However, I'm still a type 2 diabetic and must maintain good BG level control to prevent my diabetes from worsening.
2. A test in which I used eight units of insulin daily over a six-week period subsequently improved my response to a glucose stimulus. Insulin gives the pancreas time to rest and the resulting improvement is anticipated in [1].
3. Over a 3½-year period my response to a glucose stimulus has worsened a little, but use of a low carbohydrate, low glycemic index diet to achieve near normal HbA1c appears to have prevented significant deterioration in my diabetes condition.
4. Results from the glucose tolerance test encourage me to keep doing whatever I can to maintain good control.

My HbA1c during the test period varied from 4.9 to 5.4%. Not as good as the 4.7% recommended by Dr. Bernstein, but better than many other type 2s seeking control by diet. During the testing period my weight was fairly steady at 168 lb. ± 4 lb.

My numerous tests with various foodstuffs have helped me predict what my BG level will be at any time. However, to make sure that there are no surprises I measure my fasting BG level at about the same time every morning. Also I measure BG at other times as necessary. It has been my experience that if my fasting BG level increases it is because I did not maintain good control the previous day.

13 TECHNICAL ASPECTS OF THE SGI

13.1 The Reference Substance and Weight

The use of 60 grams of substance for much of the testing is arbitrary, but it meant that I could test most substances without my BG going very high. Also since 60 grams is about 2.1 oz., it represents a weight that is perhaps readily visualized. Since the SGI can be personalized, others may choose their own weight or substance reference. However, it might be useful to use 60 grams and whole-wheat bread, because you can then compare your data with mine. As noted previously, the AUC for 60 grams of white bread is practically identical to that for 60 grams of whole-wheat bread, but I found there were so many varieties of white bread available that whole-wheat seemed to be a more readily identifiable reference.

13.2 Analysis Methods

Figure 13-1 sets the stage for discussion of SGI calculations. Figure 13-1a illustrates the shape of a basic food response curve, and figure 13-1b shows the same curve with a straight line that represents the background or fasting BG level. It also includes a small hatched area which has a trapezoidal shape. By determining the area of this trapezoid and all the others like it, the total incremental area under the curve can be calculated. This area shown as A1 in figure 13-1c represents the effect of the food substance in increasing the AUC. Calculations are made to derive the area in terms of mg/dL minutes. If the amount of food tested is different from 60 grams, a relative SGI factor is still appropriate. The AUC is compared with that of the reference. Figure 11-2 gives an example for a complete meal.

When the SGI was conceived and reported in the first edition of this book, it was considered to divide the AUC by an arbitrary time such as 120 minutes (2 hours) to relate it to an average BG increase over a 2-hour period. This approach has merit because it gives a "feel" for how much the food affects one's BG, however, it is less useful when the test time is substantially different from 2 hours. Accordingly, the SGI values such as those given in table 4 on page 19 are based simply on relative AUC effects without regard for test-time duration.

To achieve accurate test results, it is necessary to determine the initial BG value as precisely as possible. For this reason I determine the initial value at the beginning of the test from the average of at least two BG readings taken less than 2 minutes apart.

Relative values for the SGI are obtained by comparing the individual AUC results with that for whole-wheat bread. For practical purposes white bread has almost the same SGI as whole-wheat bread. Whole-wheat bread is a convenient reference food because it produces a high value for AUC and is a common food component—at least for those not having diabetes! A manual method for calculating AUC was given in the first edition of this book and is given in a modified version of appendix A-5, on page 27.

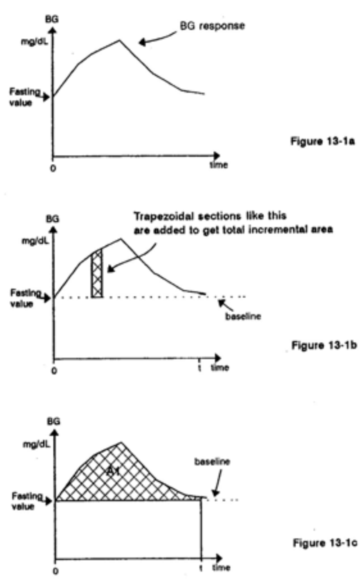

Figure 13-1 Defining area under the curve for calculations.

To calculate SGI values for the different foods in table 4 some important assumptions are used, namely:

(1) A fixed weight of food (60 grams) is used in most tests.
(2) Changes in BG are assumed to be due only to the food under test.
(3) The baseline BG used to calculate average AUC, is the BG at time zero. (Most of my tests started from a fasting condition.)
(4) Tests are conducted for a long enough period that BG has returned to within 10% of the starting value.

Assumption (1) enables me to make substance tests without incurring very high BG values. It may be helpful to use different amounts, for example when a meal is being tested. The results can still be referenced to the AUC for 60 grams of whole-wheat bread, as shown in figure 11-3.

Assumption (2) can be affected by the same sort of factors that effect determination of GI. The tester should avoid exercise during the test period and choose a time of day when BG levels are expected to remain reasonably steady. Clearly these factors will vary from one individual to another.

Assumption (3) is arbitrary, but straightforward. It seems that any other criteria would require extensive reasoning to justify.

Assumption (4) requires that sufficient time be allowed for the test. This will vary from one tester to another and on the quantity of food under test. The author found that for himself a 3-hour test period was acceptable for a 60-gram stimulus for all of the individual foods tested. However, a longer test period was required for complete meals.

13.3 Value of Calculations

For those who might question the validity or purpose of doing all these tests and then making the food choices, I would say that without a doubt it is worth the effort. Not only has my HbA1c been greatly reduced, but some of the nerve impairment (neuropathy) that I was experiencing has disappeared.

13.4 Computer Analysis of Results

The process for estimating area under the curve is not difficult, but it is tedious and just the sort of job for a computer. I wrote a program to do this in QBasic, but other methods are possible. PSI-Plot available from Poly Software International is an effective graph-plotting software package that with a little effort can be used to calculate the AUC.

14.0 SOME LOW SGI RECIPES (Contributed by Joan and Derek Paice)

14.1 SOY FLOUR AND CARROT BROWNIES

(SGI = 15% for 60 gram (2.1 oz) helping)

INGREDIENTS (For two "13 x 9" baking pans - about 2 pounds).

5 Full squares of Baker's unsweetened Chocolate.
12 oz (3 sticks) of margarine or butter.
3/4 cup of Splenda sweetener.
4 teaspoons of vanilla.
8 eggs.
16 oz soy flour (less than 120 days old-see note below).
5 teaspoons of baking powder.
4 to 6 oz of 2% milk.
8 oz of finely cut fresh carrots.

PREPARATION

Heat oven to 350° F (325° F for glass baking dish).
MIX the flour into a bowl and add 5 teaspoons of baking powder.
MICROWAVE chocolate and margarine in suitable large bowl on *HIGH* for 2 minutes, or until margarine is melted. Stir until chocolate is completely melted.
STIR Splenda into chocolate until well blended. Mix in eggs, vanilla, and carrots.
STIR in the soy flour and milk to get a smooth consistency.
SPREAD mixture onto a GREASED FOIL-LINED 13 x 9 baking pan (2 required).

BAKE for about 27 minutes on shelf C until cooked.

Note: For best results the soy flour should be purchased within 120 days of manufacture, but it will keep up to about one year once it's stored in the refrigerator. For Arrowhead Mills soy flour the 5 digit code number is interpreted as follows: The first 3 digits give numerical day of the year of manufacture; the 4th digit is the year; the 5th digit is a shift code.
For example, flour with the code 07002 was manufactured on the 70th day (March 10) of the year 2000 by the second shift.

14.2 LOW SGI BREAD

(SGI estimated as 17% for a 60 gram *(2.1 oz)* helping)

INGREDIENTS FOR THREE SMALL LOAVES.

3 oz - rye flour.
22 oz - soy flour.
20 to 24 oz - water.
3 tablespoons - oil.
5 teaspoons of baking powder.
6 eggs (whisk in a suitable container)

METHOD

Thoroughly mix the soy flour, rye flour and baking powder in a suitable bowl.
Add water, oil, and whisked eggs, then knead to get a batter.
Press the dough into appropriate aluminum containers. I use three ungreased E.Z Loaf Pans 8in x 3¾ in. x 2½ in. and a knife to flatten the dough in place.
Bake at 350° for about 80 minutes or until the top is a golden brown color.
Allow to cool and remove.

Soy flour bread has excellent glycemic qualities for those with diabetes. The addition of a little rye flour, as in the above recipe, considerably enhances the taste, at the expense of a small increase in glycemic index.

14.3 SAVORY CHEESE SCONES

(SGI = 11% for 60 gram (2.1 oz) helping)

INGREDIENTS FOR 16 TO 17 SCONES

8 oz Soy flour
2 teaspoons of baking powder
2 oz margarine or butter
5 oz grated sharp cheddar cheese
1 egg
1 tablespoon of minced dehydrated onions (reconstitute with a little cold water)
3 oz of 2% milk

METHOD

Sift the flour and baking powder into a bowl then mix in the margarine. Add 4 oz of the grated cheese and the onions. Beat the milk and egg together, add gradually to the dry ingredients, and mix to form a soft dough.

Using half of the dough at a time, roll out to about 1/2 inch thickness on a surface lightly covered with regular flour, then cut into muffin-size sections 2 1/4 inches in diameter. Place scones on a lightly greased baking tray and sprinkle a small amount of grated cheese on top of each scone. Bake at 400˚ for about 16 minutes, or until fully cooked.
Note: See above for notes on soy flour freshness.

APPENDIXES

A-1 Conversion of Carbohydrate to Blood Glucose

For an adult person weighing about 140 pounds and producing little or no insulin, 1 gram of carbohydrate raises the BG level by about 5 mg/dL [1].
My test results (p.15) illustrate this effect on someone with type 2 diabetes.

A-2 Conversion of Protein to Blood Glucose

Because I have some pancreas function, I could not test myself to find the maximum potential effect of protein. However, from data in [1] I estimated a potential BG increase of 1.6 to 4.7 mg/dL per gram of dietary protein (about 20% of protein weight) for a 140-pound adult making little insulin.

A-3 Steady-State Performance Effects

From A-1 and A-2 it is concluded that for a 140-pound adult:
1. Carbohydrate can quickly raise BG level by about 5 mg/dL per gram.
2. Dietary protein can slowly raise BG level by about 1.6 to 4.7 mg/dL per gram.
In practice either internal or external insulin sources reduce these effects.

A-4 Transient Performance Effects

Carbohydrates raise the BG level quickly. From my November 1996 test with an 18-gram stimulus (12 grams of glucose + 6 grams of creamer carbohydrates), there was an *average* rate of rise of about 3.1 mg/dL per minute. The peak BG level was reached in about 32 minutes. For the nondiabetic person tested, the *average* rate of rise of BG was similar, 2.9 mg/dL per minute, but the peak BG level was reached sooner, after only 23 minutes. Carbohydrates with a lower GI would cause the rate of rise to be lower, and a range of say 7 to 1 is feasible for practical meals. Thus an *average* rate of change in BG levels ranging from about 3.1 to 0.44 mg/dL per minute seems feasible for carbohydrate inputs.

Protein raises the BG level slowly. Using data incorporated in figures 1-1 and A-5 it was estimated that 18 grams of protein will raise my BG level by about 0.15 mg/dL per minute. Comparing with the results for 18 grams of carbohydrate it is found that carbohydrates will raise my BG level from 3 to 20 times faster than protein, depending on the carbohydrate's GI. With some amount of beta cell function, a type 2 diabetic person may be able to accommodate protein without an excessive peak BG level. This is the case for me as evidenced by figure 5-1.

A-5 Response Tests for Calculation of Substance Glycemic Index

The BG level versus time curves shown in figure A-5 are typical of those used to determine the SGI *(substance glycemic index).* Starting at time zero, the test food is eaten and BG level is plotted against time until the peak has passed and BG has fallen back to near its starting level. For protein in which only small increases in BG may occur, the duration of the test will likely be longer than that for carbohydrates. The increase in area under the glucose versus time curve, from the time the food is eaten to the time when BG falls back to within 10% of its initial value, is here defined as the AUC. The SGI is a relative number and is the AUC of the test food expressed relative to the AUC obtained from eating a reference food. I use 60 grams of white bread as the reference food. To combat possible meter errors the initial fasting BG level is determined from the average of at least two BG readings. The AUC can be calculated by splitting the curve into trapezoidal sections and summing the area in each section. For example, if the BG level is initially 100 mg/dL and 20 minutes later has increased to 140 mg/dL the average increase in BG is (40-0)/2 i.e. 20 mg/dL. The AUC for that trapezoid is 20 × 20 i.e., 400 mg/dL minutes. If after say a further 15 minutes the BG has reached 176 mg/dL then the area of the next trapezoid is (76 +40)/2 × 15, i.e. 870 mg/dL minutes. These calculations are conveniently made with a QBasic or Excel spreadsheet program.

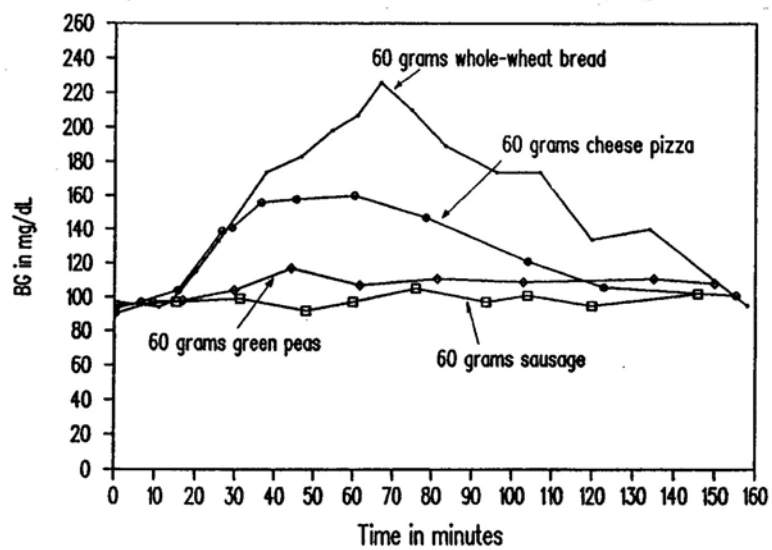

Figure A-5 Typical responses to determine *substance glycemic index.*

A-6 ESTIMATION OF AVERAGE BG AND HbA1c USING THE SGI

The substance glycemic index can be used to calculate average blood glucose levels which in turn can be used to estimate HbA1c. Recalling that for me an SGI of 100 corresponds to an AUC of about 10,400 mg/dL minutes (plasma), here is an example of a typical day's food input.

MEAL	SGI
Breakfast	30
Morning snack	10
Lunch	30
Afternoon snack	10
Dinner	77
Evening snack	18

As a worst case, the total SGI in a 24-hour period is the sum of these SGIs, namely, 175. The corresponding total AUC is 1.75 × 10,400 i.e. 18,200. The average BG increase in a 24-hour period is this AUC total divided by the number of minutes in a 24-hour period. Therefore:

Average increase in BG due to meals = 18,200/ (24 × 60) i.e. 13 mg/dL.

My FBG (fasting BG) is about 100 thus average BG level over a 24-hour period is (100 + 13) i.e. 113. The importance of FBG in determining average BG level is very evident in this calculation.

If this average BG level is maintained each day then we can convert it to an approximate HbA1c in the following manner. Assume that an HbA1c of 5% corresponds to an average BG level of about 100 mg/dL, also that HbA1c varies proportionally with average BG over a reasonable range. Thus expected HbA1c = (113/100) × 5 = 5.6%. Not as low as recommended by Dr. Bernstein, but lower than many with type 2 diabetes controlling without medications. My most recently measured HbA1c was 5.2% thus the above calculations appear to be conservative.

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REVIEWS

"Thanks for sending me your book *DIABETES AND DIET.* I find it very fascinating . . ."

- Richard K. Bernstein, M.D., F.A.C.E., F.A.C.N.
author of *Dr. Bernstein's Diabetes Solution*

"I think that your experiments on yourself and what you have written about them are a great service to the diabetes community."

- Rick Mendosa
a journalist specializing in diabetes

" Too bad that it is not required reading for diabetics, especially for those who have just recently been diagnosed.

- a reader