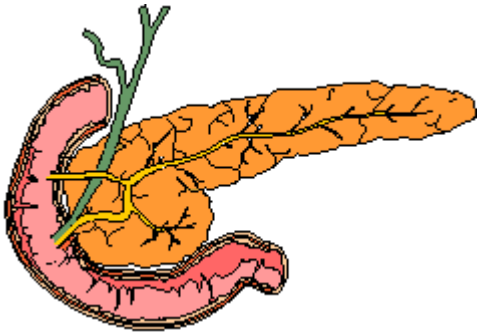
Endocrine Tumors of the Pancreas

A patient Information Guide to Insulin, Glucagon, Somatostatin & Gastrin.

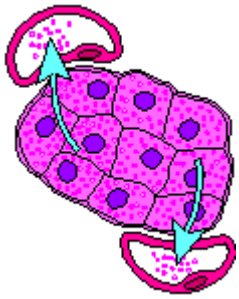


The human pancreas is an amazing organ with two main functions: **[1] to produce pancreatic endocrine hormones** (e.g., insulin & glucagon) which help regulate many aspects of our metabolism and **[2], to produce pancreatic digestive enzymes.** The hormone function of the pancreas is the emphasis of this portion of Endocrine Web ~ this is referred to as the Endocrine Pancreas. Pancreatic production of insulin, somatostatin, gastrin, and glucagon plays an important role in maintaining sugar and salt balance in our bodies and therefore any problem in the production or regulation of these hormones will manifest itself with problems with blood sugar and fluid / salt imbalances.

The digestive portion of the pancreas makes up more than 90 percent of its total cell mass. The digestive (or exocrine) pancreas is responsible for making digestive enzymes which are secreted into the intestines to help digest (break down) the food we eat. These enzymes digest proteins, fats, and carbohydrates into much smaller molecules so our intestines can absorb them. The picture above is an accurate representation of the pancreas which lies next to the duodenum (the first part of the small intestine right after the stomach). The actual size of the pancreas is similar to a banana which has been stepped on...it has a slight curve to it, and its about the same length, width, and thickness. The yellow "tube" running through the middle of the pancreas is called the pancreatic duct. It drains all the digestive enzymes from the pancreatic cells where they are made into the duodenum where they mix with food as it comes out of the stomach.

The Endocrine Pancreas

The emphasis of the remainder of these pages within Endocrine Web is on the Endocrine Pancreas. Approximately 5 percent of the total pancreatic mass is comprised of endocrine cells. These endocrine cells are clustered in groups within the pancreas which look like little islands of cells when examined under a microscope. This appearance led to these groups of pancreatic endocrine cells being called "Pancreatic Islets". Within pancreatic islets are cells which make specific pancreatic endocrine hormones, of which there are only a few (the most famous of course being insulin). These cells within the islets are called "Pancreatic Islet Cells".



Pancreatic islets are scattered throughout the pancreas. Like all endocrine glands, they secrete their hormones into the bloodstream and not into tubes or ducts like the digestive pancreas. Because of this need to secrete their hormones into the blood stream, pancreatic islets are surrounded by small blood vessels. This relationship is shown in the picture of a pancreatic islet where islet cells are secreting their hormones into nearby blood vessels. Remember, the purpose of endocrine cells is to make hormones which are secreted into the blood stream where they gain access to other cells very far away with the goal of making those cells respond in a specific fashion.

Pancreatic Endocrine Hormones and Their Purpose

Insulin

Purpose: Regulate blood glucose (sugar) in the normal range (lots more about this)
Action: Forces many cells of the body to absorb and use glucose thereby decreasing blood sugar levels
Secreted in response to: High blood glucose
Secretion inhibited by: Low blood glucose
Disease due to deficient action: **Diabetes** (large section of Endocrine Web is devoted to Diabetes).
Disease due to excess action: Hypoglycemia
Tumor called: Insulinoma. Please see this link for more information "Insulinoma.Net".

Glucagon

Purpose: Assist insulin in regulating blood glucose (sugar) in the normal range (actions are **opposite** of insulin)
Action: Forces many cells of the body to release (or produce) glucose (increasing blood sugar)
Secreted in response to: Low blood glucose
Secretion inhibited by: High blood glucose
Disease due to deficient action: Some times nothing, sometimes hypoglycemia
Disease due to excess action: Hyperglycemia
Tumor called: Glucagonoma (new page about this soon)

Somatostatin

Purpose: Regulate the production and excretion of other endocrine tumors
Action: Slows down production of insulin, glucagon, gastrin, and other endocrine tumors
Secreted in response to: High levels of other endocrine hormones
Secretion inhibited by: Low levels of other endocrine hormones
Disease due to deficient action: Poorly defined
Disease due to excess action: Diabetes (inhibits insulin production), gallstones, and dietary fat intolerance.
Tumor called: Somatostatinoma (new page about this soon)

Gastrin

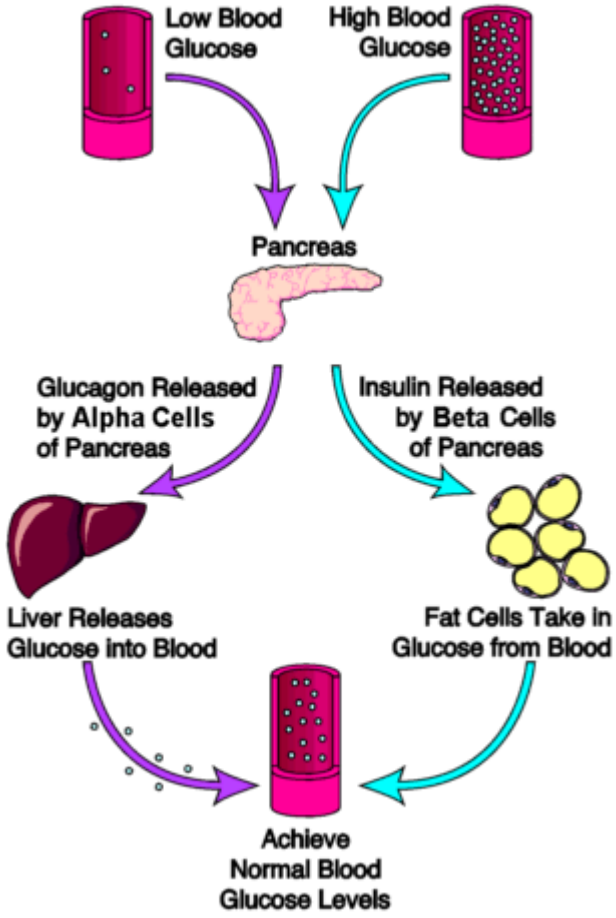
Purpose: Assist in digestion within the stomach
Action: Induce acid producing cells of the stomach to produce acid
Secreted in response to: Food in the stomach and intestines
Secretion inhibited by: Absence of food in stomach and intestines
Disease due to deficient action: Poorly defined, some times no symptoms at all
Disease due to excess action: Stomach ulcers due to excess stomach acid
Tumor called: Gastrinoma (also called Zollinger Ellison Syndrome) (new page about this soon)

Vasoactive Intestinal Peptide (VIP)

Purpose: Help control water secretion and absorption from the intestines
Action: Causes intestinal sells to secrete water and salts into the intestines (inhibit absorption)
Secreted in response to: Unclear
Secretion inhibited by: Unclear
Disease due to deficient action: No symptoms at all
Disease due to excess action: Severe watery diarrhea and salt (potassium) imbalances
Tumor called: VIPoma (new page about this soon)

Normal Regulation of Blood Glucose

The important roles of insulin and glucagon:
Diabetes and Hypoglycemia



The human body wants blood glucose (blood sugar) maintained in a very narrow range. Insulin and glucagon are the hormones which make this happen. Both insulin and glucagon are secreted from the pancreas, and thus are referred to as pancreatic endocrine hormones. The picture on the left shows the intimate relationship both insulin and glucagon have to each other. Note that the pancreas serves as the central player in this scheme. It is the production of insulin and glucagon by the pancreas which ultimately determines if a patient has diabetes, hypoglycemia, or some other sugar problem.

Insulin and glucagon are hormones secreted by islet cells within the pancreas (more about islet cells of the pancreas). They are both secreted in response to blood sugar levels, but in opposite fashion!

Insulin is normally secreted by the beta cells (a type of islet cells) of the pancreas. The stimulus for insulin secretion is a HIGH blood glucose...its as simple as that!

Although there is always a low level of insulin secreted by the pancreas, the amount secreted into the blood increases as the blood glucose rises. Similarly, as blood glucose falls, the amount of insulin secreted by the pancreatic islets goes down. As can be seen in the picture, insulin has an effect on a number of cells, including muscle, red blood cells, and fat cells (shown in the picture). In response to insulin, these cells absorb glucose out of the blood, having the net effect of lowering the high blood glucose levels into the normal range.

Glucagon is secreted by the alpha cells of the pancreatic islets in much the same manner as insulin...except in the opposite direction. If blood glucose is high, then no glucagon is secreted. When blood glucose goes LOW, however, (such as between meals, and during exercise), more and more glucagon is secreted. Like insulin, glucagon has an effect on many cells of the body, but most notably the liver. The effect of glucagon is to make the liver release the glucose it has stored in its cells into the blood stream, with the net effect of increasing blood glucose. Glucagon also induces the liver (and some other cells such as muscle) to make glucose out of building blocks obtained from other nutrients found in the body (e.g., protein).

Our bodies desire blood glucose to be maintained between 70 mg/dl and 110 mg/dl (mg/dl means milligrams of glucose in 100 milliliters of blood). Below 70 is termed "hypoglycemia". Above 110 can be normal if you have eaten within 2 to 3 hours. That is why your doctor wants to measure your blood glucose while you are fasting...it should be between 70 and 110. Even after you have eaten, however, your glucose should be below 180. Above 180 is termed "hyperglycemia" (which translates to mean "too much glucose in the blood"). If you have two blood sugar measurements above 200 after drinking a sugar-water drink (glucose tolerance test), then you are diagnosed with diabetes. We have many pages on diabetes which go into this in much

The Diabetes Center

~ Introduction to Diabetes ~

Diabetes is a very big topic! To make the diagnosis, complications and treatment of diabetes more understandable, we have broken it into several dozen diabetes topic pages which go into more and more detail. Our diabetes search engine will help you find specific diabetes information, or you can come back to this introduction page to see each of the diabetes topic pages listed.

Diabetes is a disorder characterized by hyperglycemia or elevated blood glucose (blood sugar). Our bodies function best at a certain level of sugar in the bloodstream. If the amount of sugar in our blood runs too high or too low, then we typically feel bad. Diabetes is the name of the condition where the blood sugar level consistently runs too high. Diabetes is the most common endocrine disorder. Sixteen million Americans have

diabetes, yet many are not aware of it. African Americans, Hispanics and Native Americans have a higher rate of developing diabetes during their lifetime. Diabetes has potential long term complications that can affect the kidneys, eyes, heart, blood vessels and nerves. A number of pages on this web site are devoted to the prevention and treatment of the complications of diabetes.

Types of Diabetes

Although doctors and patients alike tend to group all patients with diabetes together, the truth is that there are two different types of diabetes which are similar in their elevated blood sugar, but different in many other ways. Throughout the remainder of these web pages we will be referring to the different types of diabetes when appropriate, but when the topic pertains to both types of diabetes we will use the general term "diabetes".

Diabetes is correctly divided into two major subgroups: **Type 1 diabetes** and **Type 2 diabetes**. This division is based upon whether the blood sugar problem is caused by **insulin deficiency (Type 1)** or **insulin resistance (Type 2)**. Insulin deficiency means there is not enough insulin being made by the pancreas due to a malfunction of their insulin producing cells. Insulin resistance occurs when there is plenty of insulin made by the pancreas (it is functioning normally and making plenty of insulin) but the cells of the body are resistant to it's action which results in the blood sugar being too high.

Endocrine Web's Diabetes Center

Type 1 Diabetes

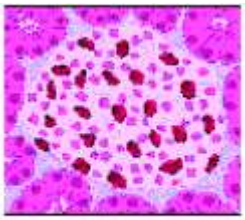
Symptoms, Diagnosis, & Treatments

Type 1 Diabetes is much less common than Type 2 Diabetes and typically affects younger individuals. Type 1 Diabetes usually begins before age 40 although there are exceptions. In the United States, the peak age at diagnosis is around 14. Type 1 Diabetes is associated with deficiency (or lack) of insulin. It is not known why, but the pancreatic islet cells quit producing insulin in the quantities needed to maintain a normal blood glucose level. Without sufficient insulin, the blood glucose rises to levels which can cause some of the common symptoms of hyperglycemia. These individuals seek medical help when these symptoms arise, but they often will experience weight loss developing over several days associated with the onset of their diabetes. The onset of these first symptoms may be fairly abrupt or more gradual.

Incidence of Type 1 Diabetes

It has been estimated that the yearly incidence of Type 1 diabetes developing is 3.7 to 20 per 100,000. More than 700,000 Americans have this type of diabetes. This is about 10 percent of all Americans diagnosed with diabetes...the other 90 percent have Type 2 Diabetes.

Causes of Type 1 Diabetes



Pancreatic Islet inside pancreatic digestive cells

Type 1 Diabetes usually develops due to an autoimmune disorder. This is when the body's immune system behaves inappropriately and starts seeing one of it's own tissues as foreign. In the case of Type 1 Diabetes, the islet cells of the pancreas that produce insulin are seen as the "enemy" by mistake. The body then creates antibodies to fight the "foreign" tissue and destroys the islet cells ability to produce insulin. The lack of sufficient insulin thereby results in diabetes. It is unknown why this autoimmune diabetes develops. Most often it is a genetic tendency. Sometimes it follows a viral infection such as mumps, rubella, cytomegalovirus, measles, influenza, encephalitis, polio or Epstein-Barr virus. Certain people are more genetically prone to this happening although why this occurs is not know. Thus, two people may be infected with the same virus and only one of them who is genetically prone will go on to develop diabetes. Other less common (very rare) causes of Type 1 Diabetes include injury to the pancreas from toxins, trauma, or after the surgical removal of the majority (or all) of the pancreas.

Herititary Tendencies in Type 1 Diabetes

Type 1 Diabetes tends to have less tendency to have other family members affected with diabetes than Type 2. In the first large family study of diabetes, less than 4% of parents and 6% of siblings of a person with diabetes also had diabetes. In studies with identical twins less than 50% of the siblings of a person with diabetes also had diabetes versus almost 100% of siblings of people with Type 2 Diabetes. Children of Type 1 diabetic fathers are more likely to develop Type 1 autoimmune diabetes than children of Type 1 diabetic mothers.

Treatment of Type 1 Diabetes

Type 1 Diabetes must be treated with insulin shots. This involves injecting insulin under the skin -- in the fat -- for it to get absorbed into the blood stream where it can then access all the cells of the body which require it. Insulin cannot be taken as a pill because the juices in the stomach would destroy the insulin before it could work. Remember, insulin is a hormone, and like all other hormones, insulin is a protein and therefore it has a very important 3-dimentional structure which is destroyed by the acid in the stomach. Even if it did make it through the stomach, the digestive enzymes secreted by the digestive part of the pancreas would digest the insulin protein molecule. Scientists are looking for new ways to give insulin. But today, shots are the most widely used method. Some new insulin pumps are being developed and tested

Endocrine Web's Diabetes Center

Type 2 Diabetes

Type 2 Diabetes is more common than Type 1 Diabetes. Whereas Type 1 Diabetes was characterized by the onset in young persons (average age at diagnosis = 14), Type 2 Diabetes usually develops in middle age or later. This tendency to develop later in life has given rise to the term "adult onset diabetes". The typical Type 2 Diabetes patient is overweight although there are exceptions. In contrast to Type 1 Diabetes, symptoms often have a more gradual onset. Type 2 Diabetes is associated with insulin resistance rather than the lack of insulin like seen in Type 1 Diabetes. This often is obtained as a hereditary tendency from one's parents. Insulin levels in these patients are usually normal or higher than average but the body's cells are rather sluggish to respond to it. This lack of insulin **activity** results in higher than normal blood glucose levels.

Incidence of Type 2 Diabetes:

Type 2 Diabetes is the most common type of diabetes. This disease exists in all populations, but prevalence varies greatly, i.e., 1% in Japan, and greater than 40% in the Pima Indians of Arizona. In whites the figure is somewhere between 1-2 percent of the entire population. The high incidence of Type 2 Diabetes in certain groups such as the Pima Indians appears to be a relatively recent development that followed a change in the type of food intake (from relatively little food to plenty of food). With this came the

development of obesity within their culture which results in diabetes developing in those that are genetically predisposed. This "urbanization phenomenon" has been most carefully studied in nonwhite populations, but is probably ethnically and racially nonspecific. In other words, obesity tends to promote diabetes in those genetically predisposed regardless of where you live and what your racial background is.

Hereditary aspects of Type 2 diabetes:

Type 2 diabetes tends to be fairly hereditary in contrast to Type 1 diabetes. Approximately 38% of siblings and one third of children of people with type 2 diabetes will develop diabetes or abnormal glucose metabolism at some point. The degree of obesity also seems to be a factor with a larger percentage of diabetes developing in those who are more obese. Studies with identical twins showed that 90-100% of the time when diabetes developed in one it would also develop in the other compared with 50% in Type 1 Diabetes.

Causes of Type 2 Diabetes

Development of Type 2 diabetes seems to be multi-factorial...that is, there are a number of issues to blame. Genetic predisposition seems to be the strongest factor. Obesity and high caloric intake seem to be another. Twenty percent of people with this Type 2 Diabetes have antibodies to their islet cells which are detectable in their blood resulting in the expected low levels of insulin, suggesting the possibility of incomplete islet cell destruction (see discussion about autoimmune diabetes in the Type 1 diabetes section). These patients often tend to respond early to oral drugs to lower blood sugar but may need insulin at some point.

Diagnosing Diabetes

The two primary tests and their results which combine to make the diagnosis of diabetes

In diagnosing diabetes, physicians primarily depend upon the results of specific glucose tests. However, test results are just part of the information that goes into

the diagnosis of diabetes. Doctors also take into account your physical exam, presence or absence of symptoms, and medical history. Some people who are significantly ill will have transient problems with elevated blood sugars which will then return to normal after the illness has resolved. Also, some medications may alter your blood glucose levels (most commonly steroids and certain diuretics (water pills)). The two main tests used to measure the presence of blood sugar problems are **[1]** the direct measurement of glucose levels in the blood during an overnight fast, and **[2]** measurement of the body's ability to appropriately handle the excess sugar presented after drinking a high glucose drink.

[1] Fasting Blood Glucose (Blood Sugar) Level:

✔The "**gold standard**" for diagnosing diabetes is an elevated blood sugar level after an overnight fast (not eating anything after midnight). A value above 140 mg/dl on at least two occasions typically means a person has diabetes. Normal people have fasting sugar levels that generally run between 70-110 mg/dl.

[2] The Oral Glucose Tolerance Test

✔An oral glucose tolerance test is one that can be performed in a doctor's office or a lab. The person being tested starts the test in a fasting state (having no food or drink except water for at least 10 hours but not greater than 16 hours). An initial blood sugar is drawn and then the person is given a "glucola" bottle with a high amount of sugar in it (75 grams of glucose), (or 100 grams for pregnant women). The person then has their blood tested again 30 minutes, 1 hour, 2 hours and 3 hours after drinking the high glucose drink.

For the test to give reliable results, you must be in good health (not have any other illnesses, not even a cold). Also, you should be normally active (for example, not lying down or confined to a bed like a patient in a hospital) and taking no medicines that could affect your blood glucose. The morning of the test, you should not smoke or drink coffee. During the test, you need to lie or sit quietly.

The oral glucose tolerance test is conducted by measuring blood glucose levels **five times over a period of 3 hours**. In a person **without** diabetes, the glucose levels in the blood rise following drinking the glucose drink, but then then fall quickly back to normal (because insulin is produced in response to the glucose, and the insulin has a normal

effect of lowing blood glucose.) In a diabetic, glucose levels rise higher than normal after drinking the glucose drink and come down to normal levels much slower (insulin is either not produced, or it is produced but the cells of the body do not respond to it) (see details on type 1 and type 2 diabetes for more information on this topic).

As with fasting or random blood glucose tests, a markedly abnormal oral glucose tolerance test is diagnostic of diabetes. However, blood glucose measurements during the oral glucose tolerance test can vary somewhat. For this reason, if the test shows that you have mildly elevated blood glucose levels, the doctor may run the test again to make sure the diagnosis is correct.

Glucose tolerance tests may lead to one of the following diagnoses:

Normal Response

A person is said to have a normal response when the 2-hour glucose level is less than or equal to 110 mg/dl.

Impaired Fasting Glucose

When a person has a fasting glucose equal to or greater than 110 and less than 126 mg/dl, they are said to have impaired fasting glucose. This is considered a risk factor for future diabetes, and will likely trigger another test in the future, but by itself, does not make the diagnosis of diabetes.

Impaired Glucose Tolerance

A person is said to have impaired glucose tolerance when the 2-hour glucose results from the oral glucose tolerance test are greater than or equal to 140 but less than 200 mg/dl. This is also considered a risk factor for future diabetes. There has recently been discussion about lowering the upper value to 180 mg/dl to diagnose more mild diabetes to allow earlier intervention and hopefully prevention of diabetic complications.

Diabetes

A person has diabetes when oral glucose tolerance tests show that the blood glucose level at 2 hours is equal to or more than 200 mg/dl. This must be confirmed by a second test (any of the three) on another day. There has recently been discussion about lowering the upper value to 180 mg/dl to diagnose more people with mild diabetes to allow earlier intervention and hopefully prevention of diabetic complications.

Gestational Diabetes

A woman has gestational diabetes when she is **pregnant** and has any two of the following: a fasting plasma glucose of more than 105 mg/dl, a 1-hour glucose level of more than 190 mg/dl, a 2-hour glucose level of more than 165 mg/dl, or a 3-hour glucose level of more than 145 mg/dl.

Endocrine Web's Diabetes Center

Symptoms of Hyperglycemia

The signs and symptoms which suggest the presence of high blood sugar

The basic defect in all patients with diabetes is the decreased ability of insulin to induce cells of the body to remove glucose (sugar) molecules from the blood. Whether this decreased insulin activity is due to a decreased amount of insulin produced (e.g. Type I Diabetes), or from the insensitivity of the cells to a normal amount of insulin, the results are the same...blood glucose levels which are too high. This is termed "hyperglycemia" which means "high glucose in the blood".

Note: *hyper* = high, *glyc* = glucose, and *emia* = of the blood.

Common Symptoms of Hyperglycemia

The Classic Symptoms	Other Symptoms Might Include
Polyphagia (frequently hungry)	Blurred vision
Polyuria (frequently urinating)	Fatigue
Polydipsia (frequently thirsty)	Weight loss
	Poor wound healing (cuts, scrapes, etc.)
	Dry mouth
	Dry or itchy skin
	Impotence (male)
	Recurrent infections such as vaginal yeast infections, groin rash, or external ear infections (swimmers ear)

It is important to remember that not everyone with diabetes will have all these symptoms. In fact, many people with Type 2 diabetes may not have any of them.

The classic symptom of **being hungry frequently** stems from the fact that the diabetic can not utilize glucose well as an energy source within cells. The glucose is circulating in the blood, but the cells can't absorb it to use it as a fuel. The excess blood sugar molecules also "spill" into the urine, meaning that as the blood filters through the kidneys, some of the sugar comes out of the blood and is not reabsorbed. The extra sugar which is now in the urine causes water molecules to follow (a normal physics principle) and therefore the **diabetic urinates** frequently (the second classic symptom of diabetes). This obviously leads to the third classic symptom which is **frequently being thirsty**. The body can sense that excess water is being lost because of the frequent urinating and the normal response is to become thirsty.

Endocrine Web's Diabetes Center

Treatment of Diabetes

There are several aspects in the treatment of diabetes, each one with a very important role.

The mainstays of treatment are:

1. **Working towards obtaining ideal body weight**
2. **Following a diabetic diet**
3. **Regular exercise**
4. **Diabetic medication if needed**

Note: Type 1 Diabetes must be treated with insulin. This involves injecting insulin under the skin for it to work. Insulin cannot be taken as a pill because the digestive juices in the stomach would destroy the insulin before it could work. Scientists are looking for new ways to give insulin. But today, shots are the only method. There are, however, new methods to give the shots...Insulin Pumps are now being widely used and many people are having great results. A new page on insulin pumps will be on line soon.

Working towards obtaining ideal body weight.

An estimate of ideal body weight can be calculated using this formula:

For women: Start with 100 pounds for 5 feet tall. Add 5 pounds for every inch over 5 feet. (If you are under 5 feet, subtract 5 pounds for each inch under 5 feet). This will give you your ideal weight. If you have a large frame, add 10 percent. If you have a small

frame, subtract ten percent. (A good way to decide your frame size is to look at your wrist size compared to other women's)

Example: a woman who is 5' 4" tall and has a large frame.

100 pounds + 20 pounds (4 inches times 5 pounds per inch) =120 pounds.

Add 10% for large frame (in this case 10% of 120 pounds is 12 pounds).

120 pounds + 12 pounds = 142 pounds ideal body weight.

For men: Start with 106 pounds for a height of 5 foot. Add 6 pounds for

every inch above 5 foot. For a large frame, add 10%. For a

small frame, subtract 10 percent. (See above for further details).

The Diabetic Diet

Diet is very important in diabetes. There are differing philosophies on what is the BEST diet but below is a guideline with some general principles.

Patients with Type 1 diabetes should have a diet that has approximately 35 calories per kg of body weight per day (or 16 calories per pound of body weight per day). Patients with Type 2 diabetes generally are put on a 1500-1800 calorie diet per day to promote weight loss and then the maintenance of ideal body weight.. However, this may vary depending on the person's age, sex, activity level, current weight and body style. More obese individuals may need more calories initially until their weight is less. This is because it takes more calories to maintain a larger body and a 1600 calorie diet for them may promote weight loss that is too fast to be healthy. Men have more muscle mass in general and therefore may require more calories. Muscle burns more calories per hour than fat. (Thus also one reason to regularly exercise and build up muscle!) Also, people whose activity level is low will have less daily caloric needs.

Generally, carbohydrates should make up about 50 percent of the daily calories (with the accepted range 40-60 percent). In general, lower carbohydrate intake is associated with lower sugar levels in the blood. However the benefits of this can be cancelled out by the problems associated with a higher fat diet taken in to compensate for the lower amount of carbohydrates.. This problem can be improved by substituting monounsaturated and polyunsaturated fats for saturated fats.

Most people with diabetes find that it is quite helpful to sit down with a dietician or nutritionist for a consult about what is the best diet for them and how many daily calories they need. It is quite important for diabetics to understand the principles of carbohydrate counting and how to help control blood sugar levels through proper diet. Below are some general principles about the diabetic diet.

Understanding Food Groups

There are three basic food groups: fats, proteins and carbohydrates. The carbohydrates are the foods that can be broken down into sugar. It is essential to have all three food groups in your diet to have good nutrition.

1. Why count carbohydrates?

Carbohydrate makes your blood glucose level go up. If you know how much carbohydrate you've eaten, you have a good idea what your blood glucose level is going to do. The more carbohydrates you eat, the higher your blood sugar will go up.

2. Which foods contain carbohydrate?

Most of the carbohydrate we eat comes from three food groups: starch, fruit and milk. Vegetables also contain some carbohydrates, but foods in the meat and fat groups contain very little carbohydrate. Sugars may be added or may be naturally present (such as in fruits). The nutrient term for sugars can also be identified by looking for -ose at the end of a word (i.e. glucose, fructose, sucrose, etc. are all sugars). Look for these on food labels to help identify foods that contain sugar.

Below are some examples of carbohydrate grams for some common food items:

Food	Amount	Carb grams	Food	Amount	Carb grams
1 % fat milk	1 cup	12	yogurt fruited	1 cup	40
Bran Chex	2/3 cup	23	yogurt fruit	1 cup	19
Frosted Flakes	3/4 cup	26	Raisin Bran	3/4 cup	28
fruit juice	1/2 cup	15	bread/toast	1 slice	15
banana	1/2	15	sugar	1 tsp.	4
pancake syrup	2 Tbsp.	30	pancakes - 4	2	15
low-fat granola	1/2 cup	30	sugar-free syrup	2 Tbsp.	4

To make things easy, many people begin carbohydrate counting by rounding the carbohydrate value of milk up to 15. In other words, one serving of starch, fruit or milk all contain 15 grams carbohydrate or one carbohydrate serving. Three servings of

vegetable also contain 15 grams. Each meal and snack will contain a specific total number of grams of carbohydrate.

For example: Each gram of carbohydrate provides 4 calories. A diabetic on a 1600 calorie diet should get 50% of these calories from carbohydrate. This would be a total of 800 calories or 200 gms of carbohydrate (at 4 calories per gram) spread out over the day. At 15 grams per exchange, this would be about 13 exchanges of carbohydrate per day.

The amount of food you eat is closely related to blood sugar control. If you eat more food than is recommended on your meal plan, your blood sugar goes up. Although foods containing carbohydrate (carb) have the most impact on blood sugars, the calories from all foods will affect blood sugar. The only way you can tell if you are eating the right amount is to measure your foods carefully. Also, it is important to space your carbohydrates out throughout the day to avoid sugar "loading." Measuring your blood sugar regularly also provides important feedback on how high your sugar went based on what you ate and your level of activity.

Where do you get carbohydrate information?

The "Nutrition Facts" label on most foods is the best way to get carbohydrate information, but not all foods have labels. Your local bookstore and library have books that list the carbohydrate in restaurant foods, fast foods, convenience foods and fresh foods. You will still need to weigh or measure the foods to know the amount of grams of carbohydrates present.

How do you count carbohydrate?

Carbohydrates can be counted in number of grams or can be counted as exchanges. One carbohydrate exchange equals 15 grams of carbohydrate. A good reference for learning how to count calories in this manner will be on line here

soon including a calorie computer.

Free Foods:

These are foods that you can eat without counting. A free food or drink is one that contains less than 20 calories and 5 grams or less of carbohydrate per serving. If your serving or a food contains more than 5 grams of carbohydrate, you should count it in your meal plan.

Examples of free foods:

Bouillon or broth
Carbonated or mineral water

Club soda
Coffee or tea
Diet soft drinks
Drink mixes, sugar-free
Tonic water, sugar free
Sugar-free hard candy
Sugar-free Jell-O
Sugar-free gum
Jam or jelly, light or low-sugar, 2 tsp.
Sugar free syrup, 2 tsp.

You should spread out free foods throughout the day and not eat them in one sitting.

Fitting Sugar in Your Meal Plan

It is commonly thought that people with diabetes should avoid all forms of sugar. Most people with diabetes can eat foods containing sugar as long as the total amount of carbohydrate (carb) for that meal or snack is consistent. Many research studies have shown that meals which contain sugar do not make the blood sugar rise higher than meals of equal carbohydrate levels which do not contain sugar. However, if the sugar-containing meal contains more carb, the blood sugar levels will go up.

Does this mean I can eat cake and not worry about it?

No! A slice of white cake with chocolate icing (1/12 of a cake or 80 gram weight) will give you about 300 calories, 45 grams of carb and 12 grams of fat. That is three starch servings and over 2 fat servings. Before you have a slice of cake, ask yourself the following questions: Will that small piece of cake be satisfying or will I still be hungry? How it will fit into my meal plan? Do I have 300 calories to "spend" on this? Are there other choices I could make which would contribute less fat? A 1/12 slice of angel food cake has less than 1 gram of fat and only 30 carb. This may be a better choice.

Controlling all carbohydrates

It is important to realize that sugar is not the only carbohydrate that you have to "control". The body will convert all carbohydrates to glucose - so eating extra servings of rice, pasta, bread, fruit or other carbohydrate foods will make the blood sugar rise. Just because something doesn't have sugar in it doesn't mean you can eat as much as you want. Your meal plan is designed so that the carbohydrate content of your meals remains as consistent as possible from day to day.

A word of caution:

Although sugar does not cause the blood sugar to rise any higher than other carbohydrates, it should be eaten along with other healthy foods. If you choose to drink a 12 ounce can of a sugar-sweetened soft drink, that would use up about 45 grams carb - and you wouldn't have gotten any nutrition (protein, vitamins or minerals). What a waste of calories! High sugar foods are more concentrated in carb. Therefore the volume would be smaller than a low sugar food. High sugar foods might not be a good choice if they will just tempt you to eat more. If you would rather eat larger portions, select low sugar choices. Look at the differences in portion size you get for equal amounts of carbohydrate in these cereals!

Granola	Frosted Flakes	Corn Flakes	Cheerios	Puffed Wheat
1/4 cup	1/3 cup	3/4 cup	1 cup	1 1/4 cup

In addition, many sugar-containing foods also contain a lot of fat. Foods such as cookies, pastries, ice cream and cakes should be avoided largely because of the fat content and because they don't contribute much nutritional value. If you do want a "sweet" - make a low-fat choice, such as low-fat frozen yogurt, gingersnaps, fig bars or graham crackers and substitute it for another carbohydrates on your meal plan.

Endocrine Web's Diabetes Center

Assessing How Well Diabetes is Controlled

Better Control Means Better Health

There are two common ways that physicians assess how well diabetes is controlled: **[1] Frequent Measurements of Blood Glucose**, and **[2] Measurement of Glycohemoglobin**. Each method has its good and bad points, but combined they give a fairly accurate picture of the state of glucose control in a diabetic. Most physicians will use both methods.

Measurement of Blood Glucose (Blood Sugar)

When we speak about measuring blood glucose levels, it can be done two different ways. Blood glucose can be measured randomly from a sample taken at any time (called a "**random blood sugar**" or RBS). Blood glucose can also be measured in the "**fasting**" state, meaning that the person has not eaten or taken in any calories in the past 8 hours (usually this is done overnight and it is referred to as an overnight fast and is called a "**fasting blood sugar**" or FBS). In a person with normal insulin production and activity (a non-diabetic) blood sugar levels will return to "fasting" levels within 3 hours of eating. Diabetics (type 1 and type 2) may not be able to get their blood glucose down this quickly after a meal or drinking a calorie-containing drink. More about this can be found on our Diagnosing Diabetes page.

Remember, the normal fasting blood glucose level is between 70 and 110 g/dl.

Frequent Measurements of Blood Glucose. The goal in this part of diabetes management is to strive to keep fasting blood sugars under 140 mg/dl and preferably closer to the 70-120 mg/dl range. Ideally, one could monitor blood sugars four times per day (or more) to follow how well the sugars are controlled. This information could be used to adjust their diet and medications to achieve this goal. Usually blood glucose measurements are done before each meal and at bedtime. Occasionally a doctor may want a diabetic patient to test their blood sugar at 2 a.m. to assess what the blood sugar is doing overnight. Generally it is desirable to have blood sugars at 2 a.m. run greater than 65 mg/dl to avoid overnight hypoglycemia  (low blood sugar). It is VERY desirable for patients to keep a diary of these blood sugar measurements since this information will be a great help to the treating physician as he/she makes decisions regarding how best to treat the diabetes. Bring this diary with you when you go to your doctor! He/she will be quite pleased, but don't fudge the results in an attempt to please your doctor, this will prevent the appropriate changes (if any) to be made in your management.

Measurement of Glycosylated Hemoglobin (Glycohemoglobin or Hemoglobin A1c)

Periodic measurement of Glycosylated Hemoglobin. Another method to monitor the control of blood sugar in diabetics is through a blood test called Hemoglobin A1c or Glycohemoglobin (or glycosylated hemoglobin). This test can be done through a local laboratory or can be drawn at a doctor's office, but unlike simple measurement of blood

glucose levels, this cannot be done at home. The level of glycosylated hemoglobin correlates very well with a person's recent overall blood sugar levels. Hemoglobin A1c will tell what the diabetic's blood sugar levels have been running for the past 2-3 months. If the blood sugars have generally been running high during the previous few months, the level of hemoglobin A1c will be high. If blood glucose concentrations have been running close to normal during this time, the hemoglobin A1c level will be close to values seen in normal persons. It is an important value to monitor periodically. Studies have shown that glycohemoglobin values in the "better ranges" correlate with less incidence of diabetic complications later in life. Type 1 Diabetics will typically have hemoglobin A1c levels determined every 3 to 4 months, while Type 2 Diabetics will often require measurements less often.

Values vary from lab to lab but below is a common value system for Hemoglobin A1c:

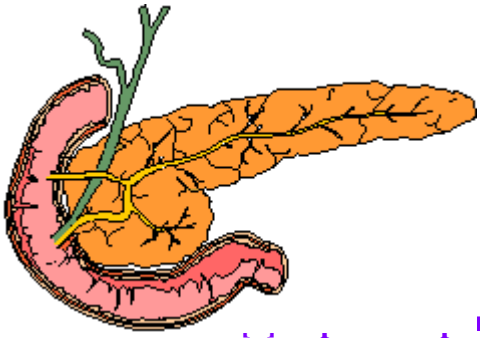
Hemoglobin A1c
Normal: Less than 6.5
Excellent: 6.5-7.5
Good: 7.5-8.5
Fair: 8.5-9.5
Poor: Greater than 9.5

Why is it important to have good control of diabetes?

Studies have recently shown that overall good control of blood sugar in diabetes does correlate with decreased incidence of diabetic complications. So, the answer is yes, it is important to control glucose levels as best as possible. In Type 1 diabetics who are on insulin and in some Type 2 diabetics, efforts to have control too tight may result in too many episodes of hypoglycemia (low blood sugar). Therefore, the goal is to balance trying to have control as near normal as possible while trying to avoid hypoglycemic episodes

Endocrine Tumors of the Pancreas

A patient Information Guide to Insulin, Glucagon, Somatostatin & Gastrin.

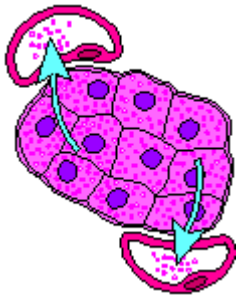


The human pancreas is an amazing organ with **eatic endocrine hormones** (e.g., insulin & glucagon) which help regulate many aspects of our metabolism and **[2], to produce pancreatic digestive enzymes.** The hormone function of the pancreas is the emphasis of this portion of Endocrine Web ~ this is referred to as the Endocrine Pancreas. Pancreatic production of insulin, somatostatin, gastrin, and glucagon plays an important role in maintaining sugar and salt balance in our bodies and therefore any problem in the production or regulation of these hormones will manifest itself with problems with blood sugar and fluid / salt imbalances.

The digestive portion of the pancreas makes up more than 90 percent of its total cell mass. The digestive (or exocrine) pancreas is responsible for making digestive enzymes which are secreted into the intestines to help digest (break down) the food we eat. These enzymes digest proteins, fats, and carbohydrates into much smaller molecules so our intestines can absorb them. The picture above is an accurate representation of the pancreas which lies next to the duodenum (the first part of the small intestine right after the stomach). The actual size of the pancreas is similar to a banana which has been stepped on...it has a slight curve to it, and its about the same length, width, and thickness. The yellow "tube" running through the middle of the pancreas is called the pancreatic duct. It drains all the digestive enzymes from the pancreatic cells where they are made into the duodenum where they mix with food as it comes out of the stomach.

The Endocrine Pancreas

The emphasis of the remainder of these pages within Endocrine Web is on the Endocrine Pancreas. Approximately 5 percent of the total pancreatic mass is comprised of endocrine cells. These endocrine cells are clustered in groups within the pancreas which look like little islands of cells when examined under a microscope. This appearance led to these groups of pancreatic endocrine cells being called "Pancreatic Islets". Within pancreatic islets are cells which make specific pancreatic endocrine hormones, of which there are only a few (the most famous of course being insulin). These cells within the islets are called "Pancreatic Islet Cells".



Pancreatic islets are scattered throughout the pancreas. Like all endocrine glands, they secrete their hormones into the bloodstream and not into tubes or ducts like the digestive pancreas. Because of this need to secrete their hormones into the blood stream, pancreatic islets are surrounded by small blood vessels. This relationship is shown in the picture of a pancreatic islet where islet cells are secreting their hormones into nearby blood vessels. Remember, the purpose of endocrine cells is to make hormones which are secreted into the blood stream where they gain access to other cells very far away with the goal of making those cells respond in a specific fashion.

Pancreatic Endocrine Hormones and Their Purpose

Insulin

Purpose: Regulate blood glucose (sugar) in the normal range (lots more about this)
Action: Forces many cells of the body to absorb and use glucose thereby decreasing blood sugar levels
Secreted in response to: High blood glucose
Secretion inhibited by: Low blood glucose
Disease due to deficient action: **Diabetes** (large section of Endocrine Web is devoted to Diabetes).
Disease due to excess action: Hypoglycemia
Tumor called: Insulinoma. Please see this link for more information "Insulinoma.Net".

Glucagon

Purpose: Assist insulin in regulating blood glucose (sugar) in the normal range (actions are **opposite** of insulin)
Action: Forces many cells of the body to release (or produce) glucose (increasing blood sugar)
Secreted in response to: Low blood glucose
Secretion inhibited by: High blood glucose
Disease due to deficient action: Some times nothing, sometimes hypoglycemia
Disease due to excess action: Hyperglycemia
Tumor called: Glucagonoma (new page about this soon)

Somatostatin

Purpose: Regulate the production and excretion of other endocrine tumors
Action: Slows down production of insulin, glucagon, gastrin, and other endocrine tumors
Secreted in response to: High levels of other endocrine hormones
Secretion inhibited by: Low levels of other endocrine hormones
Disease due to deficient action: Poorly defined
Disease due to excess action: Diabetes (inhibits insulin production), gallstones, and dietary fat intolerance.
Tumor called: Somatostatinoma (new page about this soon)

Gastrin

Purpose: Assist in digestion within the stomach
Action: Induce acid producing cells of the stomach to produce acid
Secreted in response to: Food in the stomach and intestines
Secretion inhibited by: Absence of food in stomach and intestines
Disease due to deficient action: Poorly defined, some times no symptoms at all
Disease due to excess action: Stomach ulcers due to excess stomach acid
Tumor called: Gastrinoma (also called Zollinger Ellison Syndrome) (new page about this soon)

Vasoactive Intestinal Peptide (VIP)

Purpose: Help control water secretion and absorption from the intestines
Action: Causes intestinal sells to secrete water and salts into the intestines (inhibit absorption)
Secreted in response to: Unclear
Secretion inhibited by: Unclear
Disease due to deficient action: No symptoms at all
Disease due to excess action: Severe watery diarrhea and salt (potassium) imbalances
Tumor called: VIPoma (new page about this soon)