

**Nutrition and Medicine, 2006**  
**Tufts University School of Medicine**  
**Macronutrients / Carbohydrates:**  
**Learning Objectives**

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1. Define “simple” and “complex” carbohydrates and non-starch polysaccharides.
2. Identify simple carbohydrate foods and complex carbohydrate foods.
3. Identify the four food groups that are significant contributors to our intake of CHO.
4. List the physical properties of fiber that make it important to overall health.
5. List the physiologic outcomes of fiber intake that are important for health.
6. Identify 5-10 foods that are good sources of fiber (>3 g/serving).
7. Explain the meaning and purpose of the glycemic index of foods and the glycemic load of a meal.
8. Identify the vitamins that are required in the metabolism of carbohydrate.
9. What are the issues concerning total intake of carbohydrate and type of carbohydrate consumed?
10. What are the pros and cons of a diet low in carbohydrates?
11. What is the evidence that the glycemic index/glycemic load of a food, mostly carbohydrate foods, can affect weight and risk of type 2 diabetes?
12. What is the DASH Diet? What are the Four Messages of the “Modified DASH Diet” and why is it a good starting point for making dietary changes in Hypertension, CVD, Type 2 Diabetes and Weight Loss/ Maintenance?

## Macronutrients / Carbohydrates: Answers to Learning Objectives

### 1. Define “simple” and “complex” carbohydrates.

Carbohydrates are classified by the number and complexity of “saccharides” that they contain. A “saccharide” refers to the number of simple sugars (molecules with 3-5 carbons). A “monosaccharide” is the smallest sugar molecule, made up of 3-5 carbons, and is unable to be hydrolyzed to a simpler form. A “disaccharide” can be hydrolyzed to two monosaccharides and a “polysaccharide” yields > 10 monosaccharides.

“**Simple**” carbohydrates is a term referring to the mono- and disaccharides. They are often referred to as the “sugars.” They are as follows:

#### Monosaccharides:

- Glucose
- Fructose (fruit sugar)
- Galactose (not found free in nature, but is produced from lactose)

#### Disaccharides:

- Sucrose = 1 glucose + 1 fructose
- Maltose = 1 glucose + 1 glucose
- Lactose = 1 glucose + 1 galactose

“**Complex**” carbohydrates refers to the polysaccharides – a carbohydrate that contains more than 10 monosaccharides.

#### Polysaccharides:

##### Digestible polysaccharides:

- Starch
- Dextrins
- Glycogen

##### Non-starch polysaccharides (FIBER):

- Cellulose
- Hemicellulose
- Pectin
- Gums and mucilages

### 2. Identify simple carbohydrate foods and complex carbohydrate foods.

Foods that contain simple carbohydrates – the mono and disaccharides – are table sugar (sucrose) and foods with sugar (soda, candy, cookies, pies, cakes, etc); fruit and fruit juices (fructose); and milk and milk products (lactose).

Foods that contain complex carbohydrates – the polysaccharides – are starchy foods like breads, breakfast cereals, pasta as well as grains like rice, wheat, oats, etc. Whole grain foods contain both starches and fibers. The skins and pulp of fruit contain fibers too, although the majority of carbohydrate in fruit is fructose, a sugar. Vegetables contain polysaccharides, both digestible and indigestible. The starchy vegetables like potatoes, corn, and peas, contain much more complex carbohydrate than nonstarchy vegetables (all the rest). There are 15 grams of carbohydrate in a serving of bread, pasta, rice; 15 grams in a serving of potatoes, corn or peas; yet only 5 grams of carbohydrate in a serving of broccoli, carrots, green beans, lettuce, etc.

**3. Identify the four food groups that are significant contributors to our intake of carbohydrates.**

1) Grains and cereals 2) Fruit 3) Vegetables 4) Dairy Products

**4. List the physical properties of fiber that make it important to health.**

Particle size, ion-binding capacity, viscosity, water-holding capacity, bile acid binding capacity, fermentability, and a substrate for microbial degradation and energy source.

**5. List the physiologic outcomes of fiber intake that are important for health.**

- **Aids digestion**

Fiber encourages chewing and increases saliva flow and gastric juice secretion, delays gastric emptying time, increases fecal bulk which decreases colon intraluminal pressure, normalizes intestinal transit time, provides beneficial short chain fatty acids from microbial degradation which is useful to the colonic tissue.

- **Decreases blood cholesterol**

Several dietary fiber sources lower blood cholesterol levels, specifically LDL cholesterol. According to the recent (July 2002) American Dietetic Association position paper on fiber, the one characteristic common to all cholesterol-lowering fibers is viscosity. Viscosity increases absorption of bile acids from the ileum. In response, LDL cholesterol is removed from the blood and converted into bile acids by the liver to replace the bile acids lost in the stool. Some evidence also indicates that changes in the composition of the bile acid pool accompanying ingestion of some viscous fibers dampen cholesterol synthesis. Because endogenous synthesis accounts for about three quarters of total body cholesterol pool, slowing synthesis, as do the “statin” drugs, could have a favorable impact on blood cholesterol concentrations. Fibers that lower blood cholesterol levels include foods such as apples, barley, beans and other legumes, fruits and vegetables, oatmeal, oat bran and rice hulls; and purified sources such as beet fiber, certain gums, pectin, psyllium seed husk and soy polysaccharide.

- **Dietary fiber, satiety, and blood glucose regulation**

A fiber-rich meal is processed more slowly, and nutrient absorption occurs over a greater period of time. In addition, a diet high in fiber is usually lower in calories and larger in

volume than a low fiber diet. This larger volume of food takes longer to eat and its presence in the stomach may bring a feeling of satiety sooner. When foods with viscous fibers are added to the diet, the rate of glucose appearance in the blood is slowed, and insulin secretion is subsequently reduced. These beneficial effects on blood glucose and insulin concentrations are most evident in individuals with diabetes mellitus.

- **Dietary fiber and colon cancer**

Although recent studies have challenged the existing opinion that dietary fiber prevents colon cancer, we do know that fiber removes carcinogenic bile acids from the intestine and promotes the growth of favorable bacteria necessary for a healthy intestine.

**6. Identify 5-10 foods that are good sources of fiber (>3 g/serving).**

Legumes (dried beans, like kidney, black, garbanzo); dried peas (split peas, lentils)

Bran, bran cereals

Fruits - especially apples, pears, berries

Vegetables - especially green peas, corn, lima beans, broccoli, Brussels sprouts, celery

**7. Explain the meaning and purpose of the glycemic index of foods and the glycemic load of a meal.**

Glycemic Index (GI) is a standardized system to grade single foods according to the time and peak of glucose rise in the serum. The standard of comparison is usually 100 g of white bread or 100 g of glucose, which is set at 100. Foods with a lower glycemic index (~<60) cause a slower release of glucose into the bloodstream and thus a decreased insulin response. The glycemic index is being researched as a useful tool for blood glucose control for people with diabetes. In addition, lower glycemic index foods help to achieve and maintain satiety and have been shown to be helpful as a treatment for obesity. Because the glycemic index measures the response to a standard amount of glucose in a food, foods with very little carbohydrate (like high protein foods -- tofu, poultry, meats, cheese and fats) are very low on the glycemic index.

**Low glycemic index, carbohydrate-containing foods include legumes, fruits (not juice) and vegetables, and whole grains like whole wheat, old-fashioned oatmeal, and barley. In practice it is useful to explain to patients that most foods low in GI are high in fiber so fiber content can be used as a marker of general GI effects of foods. Glycemic load (GL) of a food, meal, or day gives a better idea of the physiological effect of one food or a contribution of foods. One can calculate the GL of a meal by multiplying the glycemic index of the food by the grams of carbohydrate in the serving size eaten. In this case food low in total CHO will contribute less to the overall score than foods high in GI and high in grams of carbohydrate. (Example: Carrots which have a high GI (101) have a very low content of CHO in ½ cup (8 grams). Therefore its contribution to the GL of the meal is low compared to cornflakes (GI = 112) with 30g of CHO in 1¼ cups. The glycemic load is used predominantly in research studies to compare metabolism effects (post-prandial glucose levels, post-prandial insulin levels, triglyceride levels, etc.) of different foods, meals, and eating patterns.**

See article by D. Ludwig on Glycemic index.

**8. Identify the vitamins that are important in the metabolism of carbohydrate.**

The “B” vitamins are important in the metabolism of carbohydrate in the TCA cycle:

- Thiamin – thiamin pyrophosphate, TPP
- Riboflavin – FAD, FADH
- Niacin, nicotinamide to form NAD and NADH
- Vitamin B<sub>6</sub> – pyridoxine – which is converted to pyridoxal phosphate that is bound to glycogen phosphorylase

**9. What are the issues concerning total intake of carbohydrate and type of carbohydrate consumed?**

A. **Amount of Carbohydrate.** The current controversy is about the total carbohydrates versus the types of carbohydrates. Carbohydrates are usually 55-75% of calories and are in vegetables, fruits, grains, beans and dairy products. Reducing the total intake of carbohydrates can be a problem since it is difficult to get adequate nutrition without carbohydrates. However, there are many carbohydrates in our diet that are very low in nutrients and these can easily be removed.

B. **Type of Carbohydrate.** Carbohydrates that are high in fiber, high in nutrients, low in glycemic index and glycemic load are generally the types of carbohydrates we want to keep in our diet. These types of foods do not raise our serum blood levels very high or very rapidly, do not cause high levels of serum insulin and keep our serum triglycerides low (<150 mg/dl). They are high fiber vegetables and fruits, whole grain products and beans/legumes. Type of carbohydrates eaten are important for persons with type 2 diabetes in which foods low in glycemic index/load and high in fiber are very desirable to maintain glycemic control or low levels of serum glucose.

**10. What are the pros and cons of a diet low in carbohydrates?**

Pros	Cons
<p>Usually a low CHO diet is low in candies, soda, cakes, cookies, donuts, bagels, white bread, muffins, French fries, white rice and white flour pasta. These foods provide calories with little nutrition or fiber. If the product contains fat, it is usually saturated or trans fats which are not good.</p> <p>The elimination of the above foods often results in more rapid weight loss initially (but with the same final weight at 12 months as other diets).</p>	<p>Usually a low CHO diet is low in vegetables and fruits which are low in calories but high in nutrition. Therefore, this diet is not a nutritious diet and should not be followed long term. A vitamin supplement is always recommended but it does not substitute for a high quality diet.</p> <p>A low CHO diet is low in not only vegetables and fruits but also whole grain products and beans which are all high in fiber – so it is a low fiber diet. By default a low CHO diet would be high in fat and protein. The protein might be</p>

<p>Following this low CHO diet might teach one to eliminate the unnecessary foods cited above and if one later adds back only high fiber vegetables, fruits, whole grain products and beans you would have a healthy diet with only the best high carbohydrate foods without the undesirable high CHO foods.</p>	<p>OK but if one is taking a lot of animal products you will have a diet high in saturated fat and dietary cholesterol which increases risk of CVD and type 2 diabetes. This is especially a problem when you weight plateaus. (While you are losing weight the benefits may balance off the deficits.)</p> <p>High fat diets have the strongest association with high BMI or weight. Therefore, this is not a good long term eating plan and does not teach eating the most beneficial diet.</p> <p>Patients go on and off this low CHO diet with detrimental effect to quality of diet and serum lipids.</p>
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**11. What is the evidence that the glycemic index/glycemic load of a food, mostly carbohydrate foods, can affect weight and risk of type 2 diabetes?**

- A. Foods high in GI/GL raise serum glucose and insulin and result in greater AUC for both glucose and insulin. Insulin levels may be as much as 4 x higher after foods high in GI. Increased levels of serum glucose and insulin are associated with increased risk of type 2 diabetes.
- B. Foods low in GI/GL result in higher IGFBP-3 which binds IGF-1 so that it is not biologically active. High IGF-1 is associated with increased risk of cancer.
- C. Milk, a low GI food is associated with lower weight gain and consistently is associated with IGFBP-3 which would predict lower unbound, biologically active IGF-1. (New literature on role of milk and weight maintenance and loss.)
- D. In rats, a diet low in GI vs. high GI resulted in less body fat in weight matched animals.

**12. What is the DASH Diet? What are the Four Messages of the “Modified DASH Diet” and why is it a good starting point for making dietary changes in Hypertension, CVD, Obesity/Weight Maintenance and type 2 diabetes? (This is a detailed synopsis which is central to your understanding of this course. Please review carefully.)**

**DASH DIET BACKGROUND:**

The DASH Diet was developed to represent an “eating plan” that delivered a diet high in calcium, magnesium, potassium and fiber while keeping sodium intake moderately low (<2400 mg/day). It was shown to be very effective in preventing and treating hypertension that involved getting persons off the first line of medications and keeping many persons off all medications. It was later found to be useful in prevention and treatment of CVD. It is relatively high in carbohydrate but they are ones that are low in glycemic load and high in fiber. This diet has also been modified to use in persons with type 2 diabetes and for obesity/weight maintenance.

## **FOUR MESSAGES OF THE “MODIFIED” DASH DIET:**

We are using this approach in this course to serve as the cornerstone of a nutrition intervention for these four conditions. Four Messages have been constructed to “translate” the eating pattern into food-based guidelines. This diet would be recommended to everyone as the diet most likely to KEEP you healthy. This makes it useful to recommend to the entire family even when one person has type 2 diabetes, another is concentrating on preventing CVD or hypertension, and other members are healthy.

### **THE FOUR MESSAGES ARE:**

- 1. Consume a combination of vegetables and fruits that add up to 5-6 cups/day.**
- 2. Choose only lean meat, chicken and fish and limit daily intake to 2 servings of 3 ounces each (3 oz. = size of a deck of cards). Choose only low-fat dairy products and consume 2-3 servings a day.**
- 3. Consume a serving of beans (1/2 cup) or nuts (1/4 cup) every day.**
- 4. Choose carbohydrate foods that are unprocessed and high in fiber (>3 g/serving). These are low in glycemic index.**

You will use these Four Messages as part of evaluating your current eating pattern (Small Group #1) and the entire class will be asked to try and follow this eating pattern for 3 days and evaluate the change in macro and micro-nutrients as an outcome of this exercise (Small Group #2).

See Patient Handout on the Four Messages called **Feeling Great with Good Nutrition: What, Why & How** (*see Supplementary Material folder*), explaining the application of the Four Messages for the 4 chronic health conditions Hypertension, Cardiovascular Disease, Obesity/Weight Maintenance, and type 2 diabetes. The Four Messages are useful to give to patients since they are written in terms of food, not nutrients. You will need to be able to explain why each message is important for their health risk profile or for general health. Below is the background the physician needs to know in order to provide the context and rationale for these changes.

### **EFFECTIVE USE OF THE FOUR MESSAGES OF THE MODIFIED DASH DIET IN NUTRITION COUNSELING:**

**This material supports the Four Messages and includes the background information the physician must know to effectively educate their patients in how and why to utilize the Four Messages.**

#### **1. HYPERTENSION:**

On the **Mind Mapping for Nutrition handout** (*see Supplementary Material folder*), you see the targeted issues to decrease risk of hypertension:

↓ **Weight (Messages 1, 2, 3, 4) (See also Obesity/Weight Maintenance, below)**

**WHY?** The DASH diet was originally conceived and developed to provide the amount and type of dietary factors that were shown to result in decreases in blood pressure and resulted in a large % of hypertensives going off the first line of medications. Decreases in blood pressure were also seen in normotensives. Previous studies had focused on one nutrient at a time which resulted in statistical changes that were not clinically important. Only when the five (increased calcium, potassium, magnesium, fiber with moderate sodium) were combined did a clinically significant change occur. This supports the importance of a “multi-factorial, composite diet” and not a single nutrient approach to most chronic diseases which has subsequently been shown in the use of the DASH diet for CVD, type 2 diabetes and weight maintenance. The DASH diet (4 MESSAGES) results in higher intakes of **Calcium** (~1,200 mg/day), **Potassium** (~4,500 mg/day), **Magnesium** (~500 mg/day) and **Fiber** (>25 g/day) than is consumed in the general population. It also achieves a moderate level of dietary **Sodium** (<2,400 mg/day).

**MECHANISM:** This diet acts as a general diuretic similar to the first line medications used in the treatment of hypertension and results in a significant decrease in diastolic and systolic blood pressure. ANIMAL PRODUCTS should be REDUCED since they are major sources of saturated fat and hypertensives are at increased risk for CVD. (See CVD and saturated fat section below.)

**HOW?** Follow the Four Messages. Start by increasing intake of vegetables and fruits and including nuts or beans each day in your diet. These changes will result in increases in the 4 nutrients. Dairy products should be reduced fat since they contain high levels of saturated fat in their full fat form but are good sources of calcium. All animal products should be evaluated to find the leanest alternative and to cut down on portion size of some of the animal products, especially red meat which contains high levels of saturated fat. Hypertensives are at increased risk of CVD, and saturated fat is the first line of dietary change to decrease serum cholesterol. Decrease use of processed foods which are our major source of added salt. Decrease use of salt in home cooking by using more herbs, spices and wine for flavoring. Check food products for sodium content and remember the goal is <2,400 mg/day.

## **2. CARDIOVASCULAR DISEASE:**

On the **Mind Map** you see that the target nutrients to decrease risk of CVD are:

### **↓ Total Fat to 30% of calories or less (Message 2)**

**WHY?** This is because our intake of fat has risen over the years and peaked in the 1960s and 1970s. The majority of our fat comes from saturated fat found in animal products.

**MECHANISM:** Fat intake increases the caloric density of a diet. It is very easy to overeat when eating a high fat diet – one can consume a lot of calories very quickly since fat contains 9 kcal/g while protein and carbohydrates only contain 4 kcal/g. A diet of <12% of fat is not palatable and 3-5% of calories needs to be from essential fatty acids (linoleic acid, 18:2, and linolenic acid, 18:3). Overweight and obesity are currently major concerns for many of the chronic diseases including CVD, hypertension and type 2 diabetes (T2DM). Weight loss does decrease serum cholesterol and triglycerides which are risk factors for CVD.

**HOW?** Decrease high fat foods which include most animal products, desserts, full fat dairy products like cheese, milk, cream, butter, and decrease use of fried foods.

Alternatively cut down on the portion size of these types of foods or substitute lower fat alternatives. However, be aware of low fat products that just add sugar to replace the fat which results in a food with a high glycemic index/load and is generally low in nutrient density. When you take out the fat in your diet you lose satiety or the sense of being “full.” Use high fiber foods to replace the fat since they also give a sense of “fullness,” take longer to digest and therefore provide more satiety. They also generally are higher in nutrient density.

↓ **Saturated Fat by almost half (from the current ~13% to 7% of calories) (Message 2)**

**WHY?** Saturated fat is the largest dietary factor that contributes to one’s serum cholesterol levels. One can have the biggest effect on decreasing serum cholesterol by decreasing saturated fat intake. (\*See the Mensink and Katan Equation below that predicts serum cholesterol values by evaluation of current intake of saturated fat, monounsaturated fat and dietary polyunsaturated fatty acids, PUFA). **MECHANISM:** It is known that increasing serum saturated fat down-regulates the number and activity of the LDL-receptors on cellular membranes, that remove the lipoproteins from the serum and take it into the cells where it subsequently can down-regulate cellular cholesterol synthesis.

**HOW?** Since most of the saturated fat comes from animal products, they become the “target” for change by: 1) leaner choices of animal protein, 2) smaller portions, or 3) less frequent consumption. Red meats have the highest % of saturated fat along with full fat cheeses, butter and cream. Chicken and turkey have a smaller % of saturated fat and more polyunsaturated fat in their meat but not in their fat or skin. Most fish have lower levels of total fat and the fat is more PUFAs, and even contain the omega-3 fatty acids (marine fatty acids EPA and DHA) which are protective in CVD and have been reported in over 30 studies to lower serum triglycerides and decrease fatty livers. The red meats that are leaner include round steak, extra lean ground round, and lean roast beef. In addition the white meat of chicken and turkey is lower in total fat than the dark meat. Reduced fat cheeses are now available as well as reduced fat milk. Skim milk or 1% milk are best.

↑ **Polyunsaturated fatty acids (PUFAs) to get a ratio of saturated fat to polyunsaturated fat of 1:1. (Message 2 and also 3 since beans and nuts are higher in PUFAs)**

**WHY?** The current intake in the US is twice as much saturated fat as PUFA or a 2:1 ratio. Our high intake of animal products is the main reason for a high ratio. We don’t need to increase our PUFAs as much as just lower the saturated fat. Looking at the Mensink and Katan equation you can see that PUFAs result in a decrease in serum cholesterol levels which will reduce risk of CVD. **MECHANISM:** PUFAs have been shown to increase the synthesis and activity of the LDL-receptor which will remove the cholesterol from the serum and work in a feedback loop to down-regulate the cellular synthesis of cholesterol.

**HOW?** By using vegetable oils instead of animal fats of lard or butter. Choose oils that are high in PUFAs such as canola, safflower, sunflower, corn or soy. Nuts are also a good source of PUFAs and they also contain vitamin E. Canola oil and olive oil are also good since they

contain high levels of monounsaturated fat which have been shown to be “neutral” regarding risk of CVD. Use all fats sparingly since we do not need to increase our intake of fat but know that if fats are “called for” the better ones are the PUFAs. Most recipes can be modified to decrease their fat level without a loss in the quality of the preparation. In baked goods, however, more skill is required and substituting of margarines with a higher ratio of PUFA to saturated fat can be useful. Usually olive oil or canola oil can be used in place of butter in savory main dishes and nuts can be used as snacks, in salads and in some dessert baked goods.

**↑ Fiber to 30 or more grams per day – A good source of fiber has at least 3 g of fiber per usual serving. (Message 1, 3 (beans) and also 4)**

**WHY?** Fiber provides “bulk” and “satiety” to a diet, which is especially needed if one is decreasing the fat in one’s diet. In addition foods high in fiber are usually more nutrient dense and less processed. This does not include processed foods to which fiber has been added. Fiber also binds cholesterol in the gut and decreases its absorption. This is mainly accomplished by the soluble fiber. High fiber foods are also more slowly absorbed which decreases the calories that rapidly flood the liver with excess calories that it then converts to triglycerides which are packaged into the lipoprotein chylomicrons and LDL particles. A high fiber diet can also help to decrease caloric intake while still giving the sensation of being full.

**HOW?** High fiber foods include vegetables, fruits, legumes, and whole grains. Some are better than others. Check the **Fiber Content of Selected Foods charts in the Supplementary Material folder** to compare individual foods or products. By choosing a high fiber bread and breakfast cereal, a person can be well on their way to dramatically increasing their fiber intake. By increasing intake of vegetables and fruits you can meet your requirement of >30 g/day. Especially helpful is to find ways to add beans to your diet. This may be using lentil, bean, minestrone, split pea soup or adding beans (chickpeas or kidney beans) to a salad, regular soup or even many main courses. Soluble fiber is mainly in beans, fruits and vegetables. Whole grains contain more insoluble fiber.

**↑ Folate (+ B<sub>6</sub> and B<sub>12</sub>) to decrease serum homocysteine, a risk factor for CVD (Message 1)**

**WHY?** Folate is found in green leafy vegetables, oranges and strawberries. **MECHANISM:** Folate is needed, along with vitamins B<sub>6</sub> and B<sub>12</sub>, to convert homocysteine to methionine. The buildup of homocysteine in the blood has been identified as a marker for increased risk of CVD and a myocardial infarct (MI). The mechanism is not clear but it may have something to do with homocysteine increasing inflammation in the arteries which is a critical step in the etiology of cardiovascular disease. As a country, we do not eat many green leafy vegetables so our intake of folate may be low. However, we have now started to fortify our white flour with folate which should prove very helpful in getting adequate folate. Fortification of white flour with folate was motivated by its role in preventing spinal bifida. (Vitamin B<sub>6</sub> is found in whole grain products and B<sub>12</sub> is found in all animal products but not in vegetable products. Vegetarians appear to change their intestinal flora to include organisms that can synthesize adequate B<sub>12</sub> but blood levels of B<sub>12</sub> should be checked in vegans, as a precaution.)

**HOW?** Increase intake of green leafy vegetables which are very nutrient dense. Find ways to add extra vegetables to salads, soups and main dishes. Make desserts that contain fruit and use fruit as a snack.

**↑ Omega-3 fatty acids, especially the marine fatty acids, EPA (eicosapentenoic acid, 20:5n-3) and DHA (docosahexanoic acid, 22:6n-3) (None of the 4 message addresses increasing intake of fish or taking fish oil capsules.)**

**WHY?** Intake of omega-3 fatty acids (or increased consumption of fish to >2 times/week) were reported to decrease chances of sudden death in the Physician's Health Study and later in other studies. Some meta-analyses, however, do not support this. However, there are over 50 studies in humans that have reported that supplementation with 1-3 g of fish oil/day decreases serum triglycerides (TG), a risk factor in CVD. **MECHANISM:** Animal and some human studies indicate that omega-3 fatty acids stabilize the heart and decrease chances of fibrillation. Regarding TGs, more information is known, and it has multiple effects in the liver. It has been shown to shift metabolism in the liver to burn fat for energy, thereby decreasing available fatty acids that would be "packaged" into the lipoproteins and secreted as VLDL and LDL. It also inhibits the enzyme that adds the 3<sup>rd</sup> fatty acid onto the TG molecule and thereby decreases production of liver TG. It decreases the production of apo b protein needed for production of VLDL and LDL which encourages metabolizing of liver fatty acids for fuel. It decreases development of fatty livers in some conditions. The importance of the n-6/n-3 ratio of fatty acids in our diet is currently being debated.

**HOW?** Encourage people to eat more fish each week. The fatty fish (salmon, swordfish, mackerel, blue fish and sardines) have more omega-3 fatty acids than the standard white fish (cod, haddock, sole, etc.). See the patient handout on **sources of n-3 fatty acids in the Supplementary Material folder**. Omega-3 supplements are available and the general recommendation is for 1 g/day. Our current intake is very low, especially of the marine n-3 fatty acids.

**↓ Trans fatty acids. (Not addressed by any of the messages.)**

**WHY?** Trans fatty acids act metabolically as saturated fat and increase risk of CVD. They are present only in small amounts in "natural" products but are in larger amounts of processed foods. Vegetable oils (soybean, corn, safflower, sunflower) which are high in PUFAs are often used in making margarine. However to convert a vegetable oil (liquid) to a solid margarine can be accomplished by hydrogenating (adding a hydrogen) to one or more of the double bonds in the PUFAs. **MECHANISM:** The natural configuration of PUFAs is cis (with a molecular kink which cannot be tightly packed in the cell membranes), while the hydrogenation process converts the molecule to the trans formation which can be tightly packed like a saturated fat. It also down-regulates the synthesis and activity of the LDL-receptors on cells. It is more metabolically stable and less likely to be oxidized and get rancid which is why these hydrogenated fats are used in most baked goods and bake mixes. It has a long shelf life without giving an "off" flavor.

**HOW?** Check labels to see if they list "hydrogenated" oil. The most common products that contain trans fats are margarines, crackers, cakes, cookies, and some peanut butters. Buy

margarines without trans fats and with a higher amount of PUFAs compared to the saturated fat. Look for recipes that use liquid vegetable oils instead of hard margarines or butter. Use olive oil for cooking main courses and canola oil for baked goods, if possible.

### ↑ **Vitamin E (Messages 3 and 4)**

**WHY?** Animal studies and observational studies indicated that higher intakes of vitamin E were associated with lower CVD mortality. However, current meta-analyses do not support this conclusion. The vitamin E researchers have subsequently found some new functions for  $\alpha$ -tocopherol and the research is continuing. **MECHANISM:** Vitamin E is known to act as an antioxidant and decreases the formation of oxidized LDL which is more susceptible to be picked up by “scavenger” receptors than the LDL-receptor. This leads to increases in macrophage infiltration in the blood vessels which accentuates the process of coronary artery disease. However, most of this data has come from animal studies.

**HOW?** Eat more nuts, legumes and whole grains. Increase intake of nuts as a snack and use oils in cooking and baking, whenever possible. Whole wheat contains vitamin E that is lost when it is milled to produce white flour. White flour is not fortified with vitamin E, however. Whole grain cereals and breads (unprocessed food) will also increase intake of vitamin E.

### **3. OBESITY AND WEIGHT MAINTENANCE:**

On the **Mind Map** you see that the targeted issues to address Obesity/Weight Maintenance are:

#### ↓ **Total Fat to 20-25% of calories (Message 2)**

**WHY?** Fat has 9 kcal/g while carbohydrate and protein have 4kcal/g so it is very calorie dense.

**HOW?** (See HOW? for reducing fat in the CVD section.) One of the common changes found in “successful” weight losers is their effective decrease of the total fat in their diets. Watch out for “low-fat products” that are not reduced in calories but have just substituted more sugar for the fat that was removed and are low in nutrient density and fiber. These will not bring satiety and are usually high in glycemic index (see below).

#### ↑ **Dietary Fiber to >25 g/day (Messages 1, 3 and 4)**

**WHY?** As stated in the CVD section, if you take out fat, which adds satiety to a diet, you have to replace it with something that also provides satiety, and that is dietary fiber. In a low-fat diet you can eat a larger volume of food but you want that larger volume of food to be high in fiber, otherwise you can still overeat calories.

**HOW?** (See HOW? for increasing fiber in the CVD section.)

#### ↓ **Glycemic Index of Food Consumed (Message 1, 3, 4)**

**WHY?** Glycemic Index (GI) is a standardized system to grade single foods according to the time and the peak in blood glucose that occurs after consuming a set amount of the food, compared to 100 g of glucose or 100 g of carbohydrate from white bread, which are set at 100. The amount of an individual food used in this test is the amount that contains 100 g of carbohydrate so that the volume or grams of total amount of the food may vary greatly, since the carbohydrate content of a food can vary greatly. **MECHANISM:** GI basically measures how long it takes to digest and absorb our common foods, but you can understand that foods high in carbohydrate are going to have higher values of the GI because they are already made up of glucose units while high fat or protein foods are made up of fatty acids or amino acids, respectively, and need to be converted into glucose first. Fiber in high carbohydrate foods greatly decrease the speed in which they are absorbed and slow down the appearance of glucose in the blood and generally sustain that lower level for longer periods of time. Therefore, one can generally use the fiber content of carbohydrate foods to estimate if they are low or high in GI. Fiber content of >3-4 g/serving are required. Foods that are high in GI and attain a high peak of blood glucose will also trigger insulin release which will then drop the blood glucose levels more precipitously, usually resulting in hypoglycemia and increased sensations of hunger 1 ½ to 2 hours after eating the high glycemic index food. (Glycemic Load [GL] is used to calculate the overall effect of a meal made up of many foods and corrects for the carbohydrate present in each individual item times the GI that results in the overall measure which is called the GL.)

**HOW?** Check the fiber content of your most common foods high in carbohydrate and choose those with >3-4 g of dietary fiber/serving. The foods high in carbohydrate are vegetables, fruits, beans, and grains. (Dairy also contains carbohydrate in the form of lactose.) It is soon clear that our commonly consumed carbohydrate foods such as: white bread, rolls, bagels, muffins, cookies, cakes, brownies, soda, candy, white rice and pasta are low in fiber and high in GI. Most vegetables, fruits, beans and whole grain foods are low in GI. (See the information on the fiber content of food on pages C21-C23.) Therefore, eating more vegetables, fruits, beans and whole grain foods will decrease the GI of your diet and slow the digestion of your food to increase satiety and decrease wide swings in blood sugar and insulin.

### ↓ Snacking on desserts (Message 1, maybe 3)

**WHY?** They are generally high in sugar and therefore high in Glycemic Index that will not give you satiety for very long. However, it is often what is very generally available at machines or in convenient stores. Therefore, one has to plan ahead for better snacks that you can buy or bring from home. **MECHANISM:** the high GI of these sweets will rapidly raise your blood sugar levels but will also trigger insulin release which will make you more hungry 1 ½ to 2 hours later and likely to “grab” another quick food.

**HOW?** Plan for your need for a snack and carry nuts, raisins, baby carrots, an apple, orange, pear, etc., with you to use when you get hungry. Noodle soups are not recommended since they are low in fiber and protein and very high in salt. A vegetable spread on a whole grain cracker or bread can be a good snack. After a meal you should be “satisfied” for 3-4 hours if the meal contained enough protein and fiber. Rethink some of your meals, if necessary. Remember liquid calories are not well registered by the body so it is easy to overeat if you are taking a lot of

calories via liquids. Choose snacks that require a lot of chewing since that slows down the consumption in order to allow time to register that you have had enough.

### ↓ **Portion Size (Message 2)**

**WHY?** It is generally our portion size of animal products that is causing the biggest problem because they are our greatest source of total fat and saturated fat which are both issues for weight (due to caloric density of fat) and CVD (due to detrimental effects of saturated fat on serum cholesterol). The portion size of meat that is recommended for adults is 3 oz. This is a serving size that approximates the size of a deck of cards. Most of our restaurants serve 5-6 oz of meat and at home we expect the “meat” to cover ½ of the plate. **MECHANISM:** This is simply the expectation of a large portion of a food that is high in calories, fat and saturated fat which we get used to consuming and feel “unsatisfied” if not present. It is a learned behavior. We do not need this amount of animal foods to meet our protein needs and we can often eat so quickly that we do not register that we have overeaten until 10-15 minutes after we have completed the meal. It takes 15-20 minutes to register “fullness.” We can easily “learn” to accommodate larger meals but that does not mean we “need” larger meals.

**HOW?** Think of your plate as ½ vegetables, ¼ protein and ¼ high fiber carbohydrate (brown rice, whole wheat pasta, lentils, corn, peas, chick pea salad, white bean salad, spiced bulgur wheat, etc.). Be aware of the portion size and think of a deck of cards. Decrease the amount of meat you purchase or add to a recipe and consider adding beans or vegetables to add more bulk to the dish. Use less meat in your spaghetti sauce, add more “filler” to your meatloaf recipe, add more vegetables to your stir fry and less meat. Also slice your meat thinner. Cut back on the amount of meat in sandwiches and add other ingredients to add interest. Think about only eating half a dessert or cut smaller portions and only eat one portion. Dessert is just a “taster” not a course. Consider that every meal is just an excuse to eat vegetables, but make them tasty. The message is “half as often or half as much” for high calorie, high fat, or low nutrient density foods.

### ↓ **Stress (not listed in the messages)**

**WHY?** This is a non-nutrition suggestion, but we often eat when under stress, bored or restless. It does seem to “calm us down” and it brings almost instant satisfaction. There is accumulating data that stress has significant effects on metabolic pathways that register hunger/satiety and also alter our metabolic pathways that impact our immune system.

**HOW?** Explore activities that help you relax. This may include meditating, re-structuring how you see some problem to defuse the anxiety, lightening up on life, taking time out to be with friends, finding your own private time to relax, staying in tune with “balancing” your life, being clear about what is important in life and what is not. “Life is not a stress rehearsal.”

### ↑ **Activity (not listed in the messages)**

**WHY?** This is another non-nutrition suggestion but it is intimately linked to well being and maintaining a healthy body weight. It increases circulation, improves muscle tone, improves

balance and flexibility and maintains lean body mass as we get older. (Review lecture on Exercise.)

**HOW?** The new message is to “DECREASE INACTIVITY.” This gives people permission to come up with whatever they want that just keeps them moving and not sitting. Decrease time watching TV and doing computer games or searching the web in order to decrease sitting time. Set up a walking group, join an exercise program, join a sports club, take a dog for a walk, use the stairs whenever possible. Use every opportunity to move and forgo “conveniences” that decrease activity.

#### **4. TYPE 2 DIABETES:**

On the **Mind Map** you see the target issues to decrease risk of type 2 diabetes and also to treat the disease. They are:

##### **↓ Body Weight**

**WHY?** A BMI of <25 is considered “normal” and a higher BMI is highly associated with the development of our chronic diseases. A BMI of >27 is the more dramatic turning point where weight has an abrupt and significant impact on disease morbidity and mortality. However, even a weight loss of 10-15 pounds has been shown to have a significant impact on risk factors for our chronic diseases. This is a more realistic goal for most people. We do not have a recognized successful “WEIGHT REDUCTION PROGRAM” to offer our patients, unfortunately, so it is a learning experience. See the section on Obesity/Weight Maintenance. Often it is best to focus on changing quality of diet before working on the quantity of diet since it is easier to be successful with the first rather than the second. In addition, quality of diet at the same BMI is associated with better health markers.

**HOW?** (See section on Obesity/Weight Maintenance.) In order to be successful in weight loss one has to have: 1) an eating plan which will reduce calories, 2) nutrition information to make better choices, 3) behavioral skills to handle this change process, 4) social support to receive encouragement and positive feedback to stay on the plan, 5) an exercise plan to maintain your lean body mass (protein) as you lose weight and 6) a “recovery from relapse” plan that recognizes that we cannot be 100% in our adherence. Remember that our basal metabolic rate (BMR) is dependent on how much body protein or lean muscle mass we have. When you lose weight you can lose from your fat mass or lean mass and you want to do everything to lose from your fat mass, or else with decreasing muscle mass your caloric needs will decrease as you are losing weight and you are working against increasing odds. Exercise (in the presence of adequate protein) is the only thing that can maintain your lean body mass.

##### **↓ Glycemic Index of your foods (Message 4)**

**WHY?** (See the section on Glycemic Index in Obesity/Weight Maintenance). Remember that a lower glycemic index food or a lower glycemic load meal results in a slower absorption, a slower release of glucose into the blood and a lower peak of blood glucose. The lower peak of blood glucose will decrease or eliminate the insulin response to the food intake and thereby allow the

blood glucose to stay above the “baseline level” or not fall to the “hungry” level. A person will have the sensation of being “satisfied” longer when consuming foods of low glycemic index. This index is most useful in identifying carbohydrate foods, as the main target. Those carbohydrate foods that are high in fiber have the lower glycemic index.

**HOW?** See the section on Glycemic Index in Obesity/Weight Maintenance.

#### **↑ Dietary Fiber (See Message 1, 3, and 4)**

**WHY?** The effect of fiber in type 2 diabetes is generally related to its ability to decrease the speed of absorption of foods high in carbohydrate, which is important to the diabetic or pre-diabetic. Currently there is no large randomized, controlled trial (RCT) to support the specific role of fiber but there are several small studies that have reported it having a significant effect on improving glucose tolerance by decreasing fasting glucose levels. Fiber has also been reported to decrease serum triglyceride levels which are known to increase insulin resistance and high serum triglycerides are often an early sign of developing type 2 diabetes or metabolic syndrome. Often there is a recommendation to diabetics to decrease intake of carbohydrates, although it is more the type, not the amount of carbohydrate that is important. Carbohydrates with a high glycemic index and low in fiber are the main carbohydrates to avoid.

**HOW?** See HOW? in CVD for increasing fiber in the diet.

#### **↓ Saturated Fat to <7 % of calories (Message 2)**

**WHY?** Persons with type 2 diabetes are at increased risk for CVD so this preventive recommendation is very important. (See the section on saturated fat in the CVD section WHY? and HOW?.)

#### **↑ PUFAs, or particularly n-3 fatty acids (Message 2 and also 3 since beans and nuts are higher in PUFAs)**

**WHY?** There is mounting information that type of fat is important in insulin sensitivity with PUFAs improving insulin sensitivity compared to saturated fat or monounsaturated fat. This data comes from animal studies, observational studies and some metabolic studies. Omega-3 fatty acids appear to be the most protective but there are no RCTs that have been done to prove causality. However, this recommendation is in line with recommendations to decrease risk of CVD to which the person with type 2 diabetes is prone so that the suggestions are consistent.

**HOW?** See the HOW? section on PUFAs for CVD.

\*The Mensink and Katan equation is:

$$\Delta\text{LDL} = 1.28(\Delta\text{Sat}) - 0.24 (\Delta\text{Mon}) - 0.55 (\Delta\text{Poly})$$

The equation is used on p. 658 of Howard BV, et al. Low-fat dietary pattern and risk of cardiovascular disease: the Women’s Health Initiative Randomized Controlled Dietary Modification Trial. *JAMA*. 2006 Feb 8;295(6):655-66. This is required reading for Small Group III: Nutrition and Cardiovascular Disease.

