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NUTRITIONAL  
ENDOCRINOLOGY

# Macronutrients: Sugar Structure and Function

**Dr. Ritamarie Loscalzo**

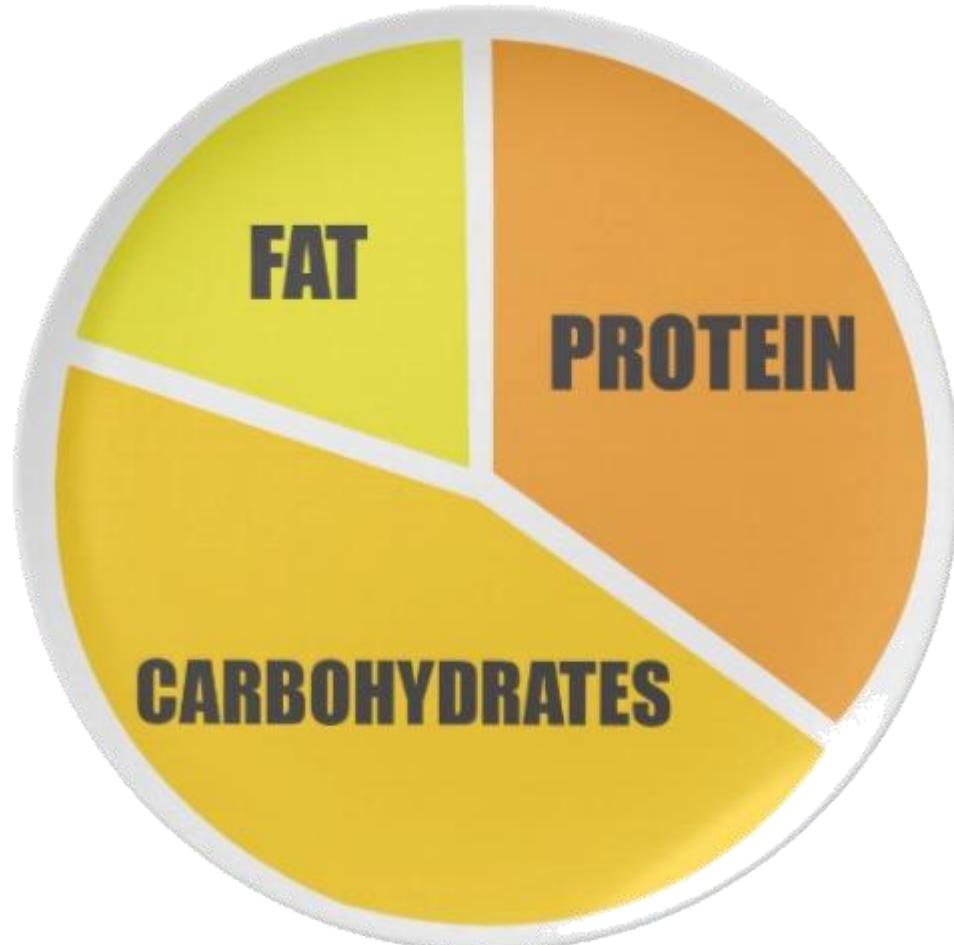


**Medical Disclaimer:** The information in this presentation is not intended to replace a one-on-one relationship with a qualified health care professional, and is not intended as medical advice. It is intended as a sharing of knowledge and information from the research and experience of Dr. Ritamarie Loscalzo, [drritamarie.com](http://drritamarie.com), and the experts who have contributed. We encourage you to make your own health care decisions based upon your research and in partnership with a qualified health care professional.



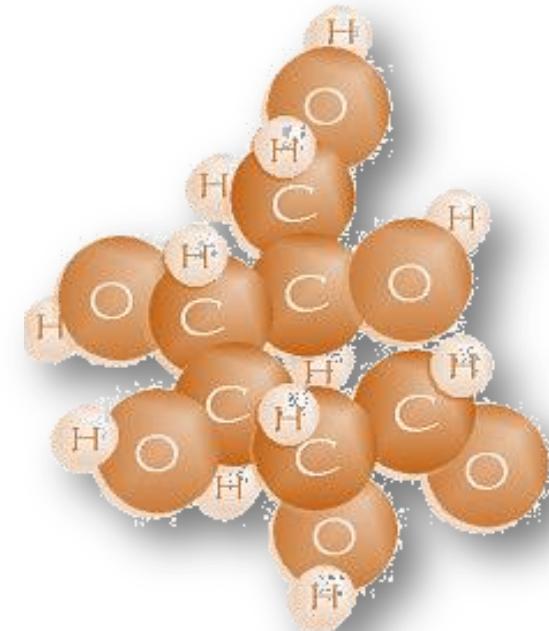
# Primary Macronutrients

- ✓ Water
- ✓ Fat
- ✓ Protein
- ✓ Carbohydrate



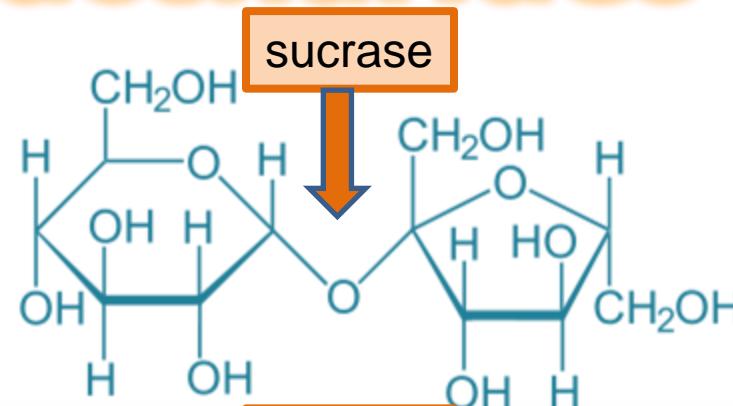
# Review: Sugar on a Molecular Level

- ✓ Review: Sugar on a Molecular Level
  - Monosaccharides
  - Disaccharides
  - Oligosaccharides
- ✓ Why you need sugar
- ✓ Where sugar comes from in the diet
- ✓ What affects rate of absorption and uptake into cells
- ✓ How sugar is converted to energy
- ✓ What's needed for sugar to be efficiently utilized
- ✓ The negative effects of simple sugars
- ✓ Alternatives to sugar for satisfying your sweet tooth

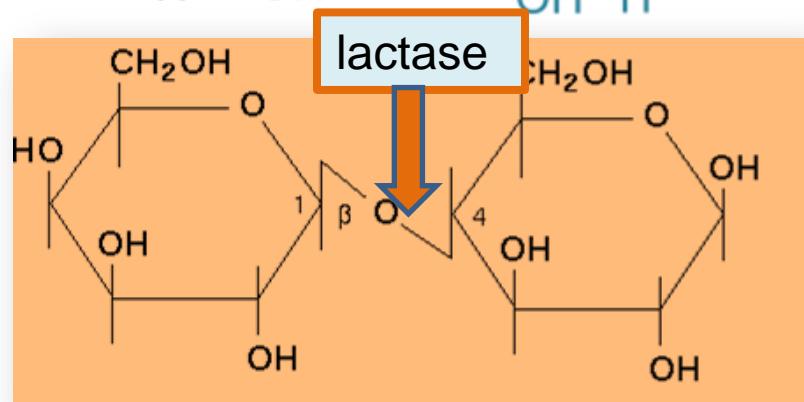


# Disaccharides

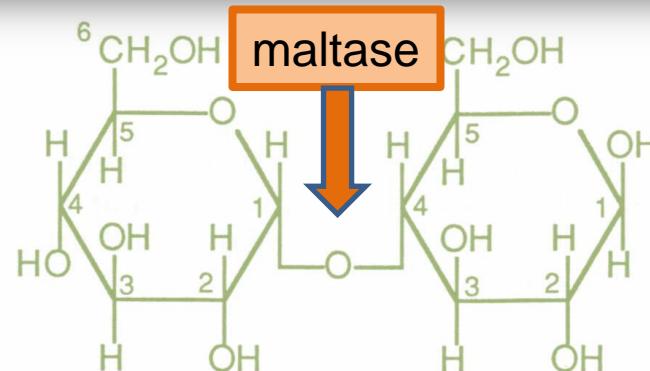
Sucrose



Lactose

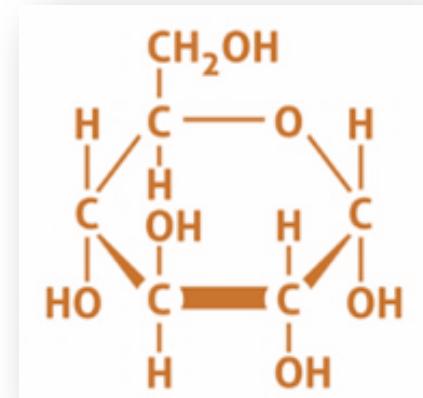


Maltose

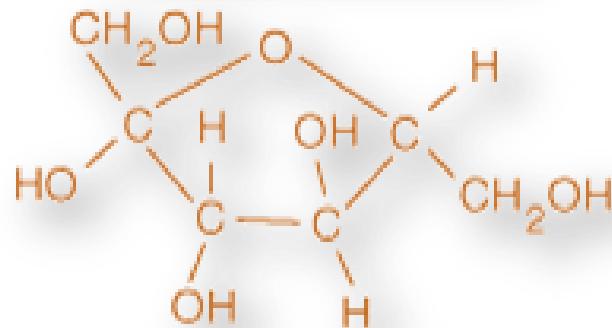


# Monosaccharides

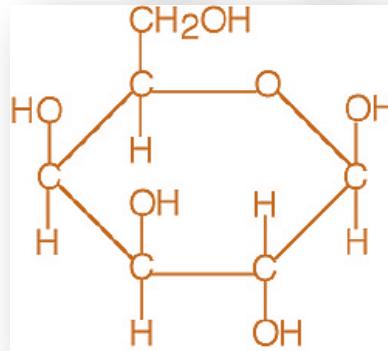
## Glucose



## Fructose



## Galactose

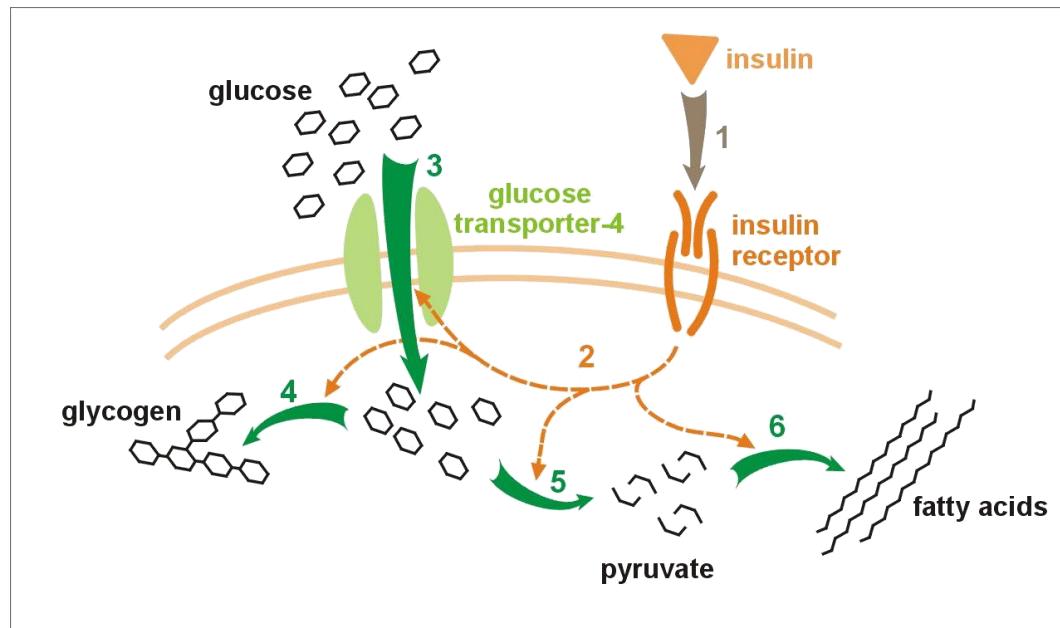


# Glucose

- ✓ Transported across intestinal brush border by the sodium-dependent hexose transporter, SGLUT-1

([http://www.vivo.colostate.edu/hbooks/pathphys/digestion/smallgut/absorb\\_sugars.html](http://www.vivo.colostate.edu/hbooks/pathphys/digestion/smallgut/absorb_sugars.html))

- ✓ Requires insulin to enter cells and be converted to ATP



# Fructose

- ✓ Does not require insulin
- ✓ Only tiny amounts circulate in blood
- ✓ Requires GLUT5 transporter to enter cells
- ✓ Converted to triglycerides in the liver
- ✓ Consumption of high-fructose meals reduces 24-h plasma insulin and leptin concentrations, increases triglycerides, and does not suppress ghrelin; thus, does not turn off appetite
- ✓ Hepatic metabolism of fructose favors lipogenesis
- ✓ High fructose consumption correlated to smaller LDL particle size and increased cardiovascular risk

<http://ajcn.nutrition.org/content/86/4/895.full>



# Fructose From Added Sugar

- ✓ Increases plasma uric acid
- ✓ Contributes to advanced glycation end products
- ✓ Can change metabolic hormonal response, possibly contributing to decreased satiety
- ✓ Highly lipogenic when consumed in high quantities
- ✓ Contributes to hepatic insulin insensitivity, chronically elevated insulin levels, increased cholesterol and triglycerides levels, and the development of a prediabetic state

<http://www.ncbi.nlm.nih.gov/pubmed/20086073>



# Fructose In Whole Fruit

- ✓ Fruits have lots of water, fiber, and a low energy density. They take a while to chew and are filling. It's **almost impossible** to overeat fructose by eating fruit.
- ✓ When people add fruit to their diet, they reduce their calorie intake elsewhere to compensate.
- ✓ Fructose from added sugars is bad, and it does NOT have the same effect if from real foods like fruits.



Table 1. Sugar content of selected common plant foods (g/100g)<sup>[24]</sup>

Food Item	Total Carbohydrate including "dietary fibre"	Total Sugars	Free Fructose	Free Glucose	Sucrose	Fructose/Glucose Ratio	Sucrose as a % of Total Sugars
<b>Fruits</b>							
Apple	13.8	10.4	5.9	2.4	2.1	2.0	19.9
Apricot	11.1	9.2	0.9	2.4	5.9	0.7	63.5
Banana	22.8	12.2	4.9	5.0	2.4	1.0	20.0
Fig, dried	63.9	47.9	22.9	24.8	0.9	0.93	0.15
Grapes	18.1	15.5	8.1	7.2	0.2	1.1	1
Navel orange	12.5	8.5	2.25	2.0	4.3	1.1	50.4
Peach	9.5	8.4	1.5	2.0	4.8	0.9	56.7
Pear	15.5	9.8	6.2	2.8	0.8	2.1	8.0
Pineapple	13.1	9.9	2.1	1.7	6.0	1.1	60.8
Plum	11.4	9.9	3.1	5.1	1.6	0.66	16.2
<b>Vegetables</b>							
Beet, Red	9.6	6.8	0.1	0.1	6.5	1.0	96.2
Carrot	9.6	4.7	0.6	0.6	3.6	1.0	77
Corn, Sweet	19.0	6.2	1.9	3.4	0.9	0.61	15.0
Red Pepper, Sweet	6.0	4.2	2.3	1.9	0.0	1.2	0.0
Onion, Sweet	7.6	5.0	2.0	2.3	0.7	0.9	14.3
Sweet Potato	20.1	4.2	0.7	1.0	2.5	0.9	60.3
Yam	27.9	0.5	tr	tr	tr	na	tr
Sugar Cane		13 - 18	0.2 – 1.0	0.2 – 1.0	11 - 16	1.0	high
Sugar Beet		17 - 18	0.1 – 0.5	0.1 – 0.5	16 - 17	1.0	high

<http://en.wikipedia.org/wiki/Fructose>



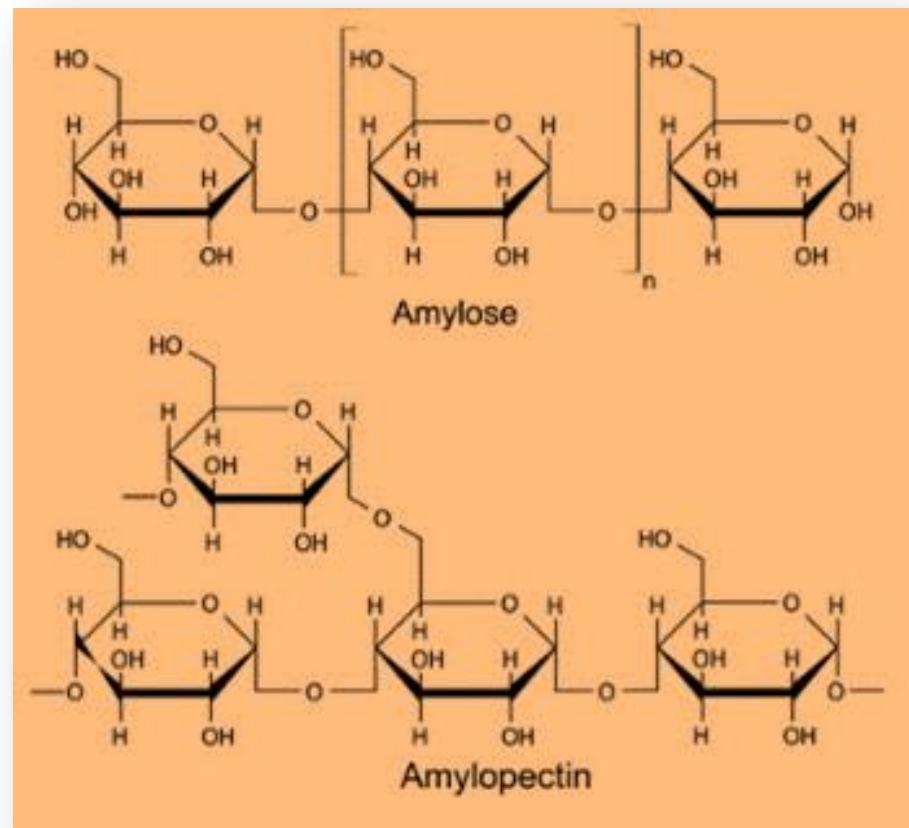
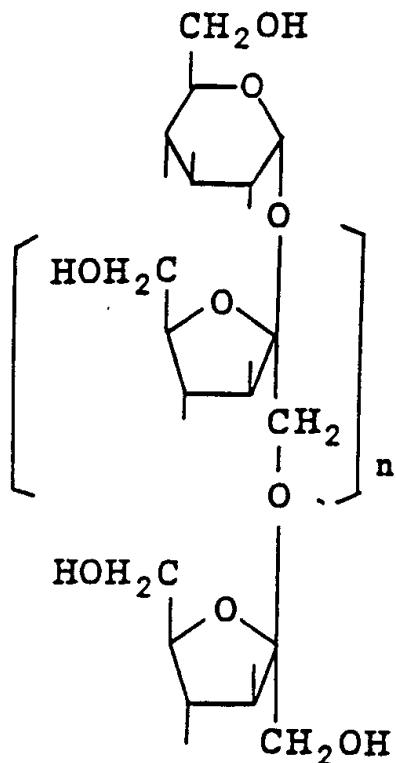
# Galactose

- ✓ Transported across intestinal brush border by the sodium-dependent hexose transporter, SGLUT-1
- ✓ Can be converted to glucose-6-phosphate  
<https://www.inkling.com/read/marks-medical-biochemistry-lieberman-marks-4th/chapter-29/ii--galactose-metabolismmetaboli>
- ✓ Some studies show correlation with ovarian cancer
- ✓ Galactose is a component within the ABO blood group system. O and A have two galactose, whereas there are three galactose in B.
- ✓ Alpha-1,3-galactose, or Alpha-Gal for short, has been recognized as a delayed allergy to mammal meat  
[http://www.vivo.colostate.edu/hbooks/pathphys/digestion/smallgut/absorb\\_sugars.html](http://www.vivo.colostate.edu/hbooks/pathphys/digestion/smallgut/absorb_sugars.html)



# Oligosaccharides

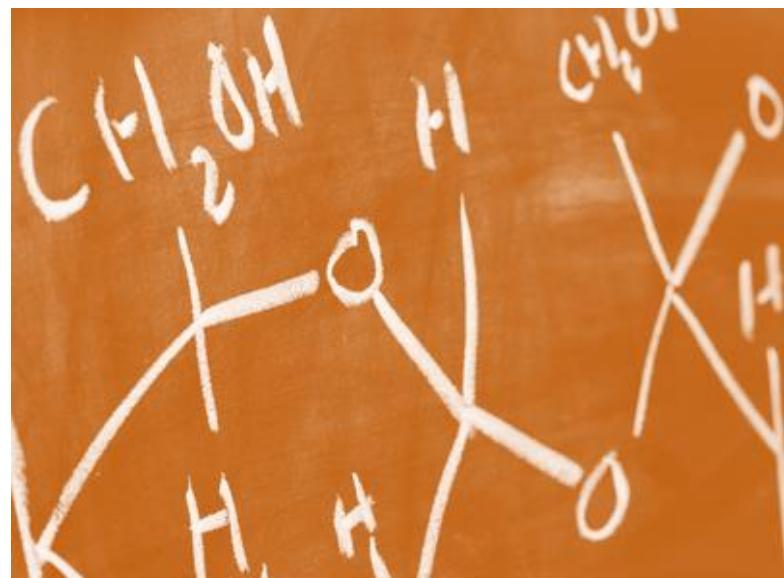
## Fructooligosaccharides



# Why You Need Sugar

## ✓ Energy

- For optimal cellular growth and repair
- For gland and organ function
- For mental clarity, attention, and focus
- For steady moods
- For having fun
- For meaningful relationships
- For achieving success in your chosen career



# Where Sugar Comes From In Foods

## Best Sources (Complex)

- ✓ Green leafy vegetables
- ✓ Rainbow-colored vegetables
- ✓ Root vegetables and tubers
- ✓ Fruit
- ✓ Whole, non-gluten grains
- ✓ Legumes
- ✓ Nuts and seeds



## Less Desirable Sources (Simple)

- ✓ Table sugar (sucrose)
- ✓ Fructose
- ✓ Glucose syrup
- ✓ High fructose corn syrup
- ✓ Maple syrup
- ✓ Agave nectar
- ✓ Coconut nectar
- ✓ Palm sugar
- ✓ Honey
- ✓ Refined grains

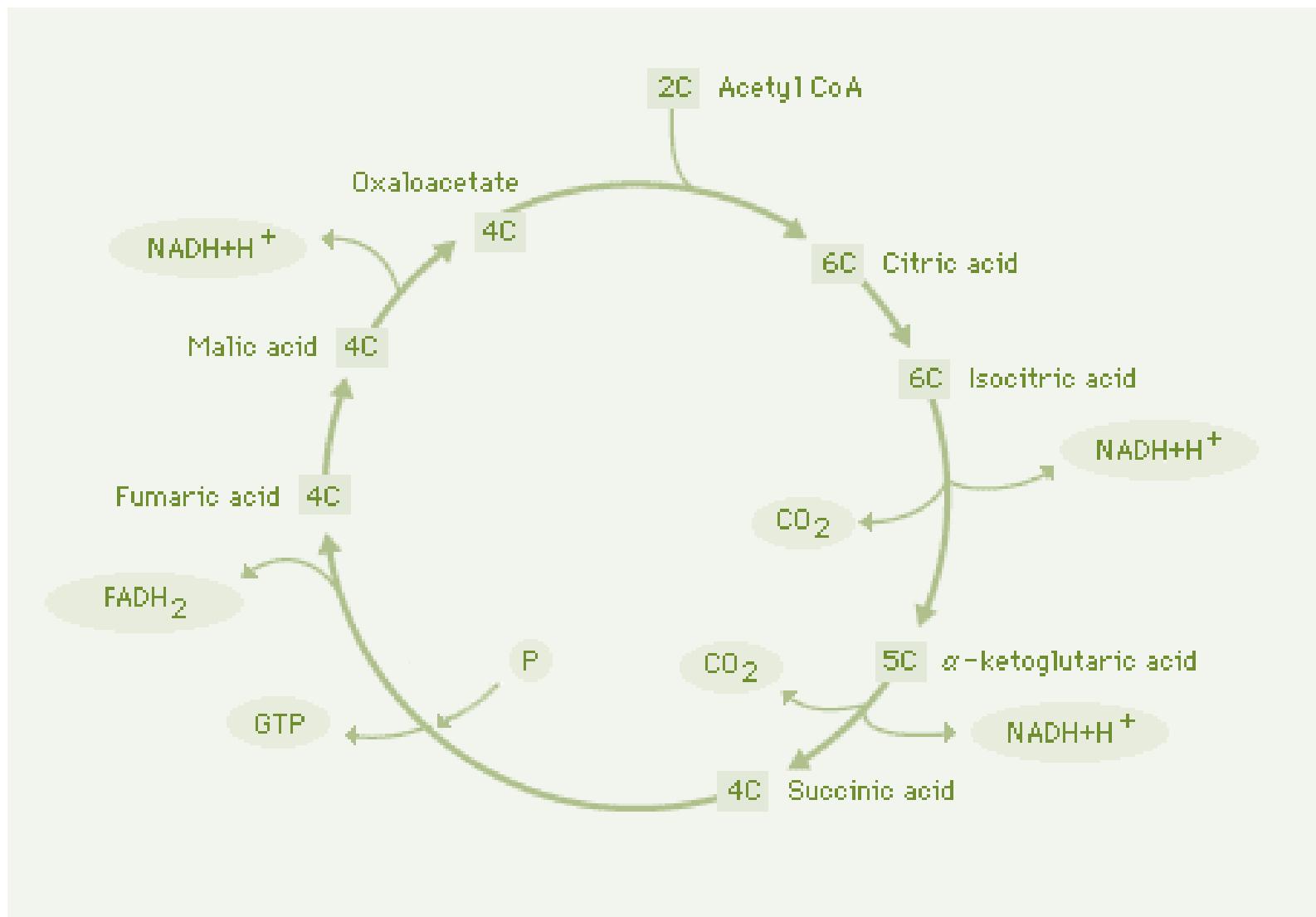


# Getting Sugar Into Cells

- ✓ Insulin
- ✓ Healthy Insulin Receptors
- ✓ Nutrients



# Converting Sugar into Energy



# Negative Effects of Simple Sugars

- ✓ **Blood sugar imbalances** leading to insulin resistance, diabetes
- ✓ Dental cavities
- ✓ **Decreased immunity**
- ✓ Accelerated cancer cell growth
- ✓ **Premature aging**
- ✓ Hostility and aggressiveness
- ✓ **Decreased libido**
- ✓ Mental decline – **Alzheimer's**



- ✓ **Depletion of B vitamins** and other nutrients required for energy production
- ✓ Intestinal distress
- ✓ **Candida overgrowth**
- ✓ Mood swings
- ✓ **Depression**
- ✓ Addiction
- ✓ **Inflammation**
- ✓ ...many, many more



# Assessing Tolerance To Various Sugars

## ✓ Home Testing

Check blood sugar for several hours after eating a variety of foods

## ✓ Lab Testing

- Fasting blood glucose
- Hemoglobin A1C
- Fructosamine
- Insulin



# Best Alternatives To Sugar For Satisfying Your Sweet Tooth

✓ **Stevia:** Green plant

- **fresh is best,**
- **then green powder,**
- **then SweetLeaf concentrate**



✓ **Lo Han:** Chinese herb

✓ **Erythritol:** Sugar alcohol

✓ **Chicory root inulin:**

Maybe – test



✓ **Yacon:** Maybe – test



# Alternatives To Sugar: Products

✓ **Zero:**  
Organic erythritol



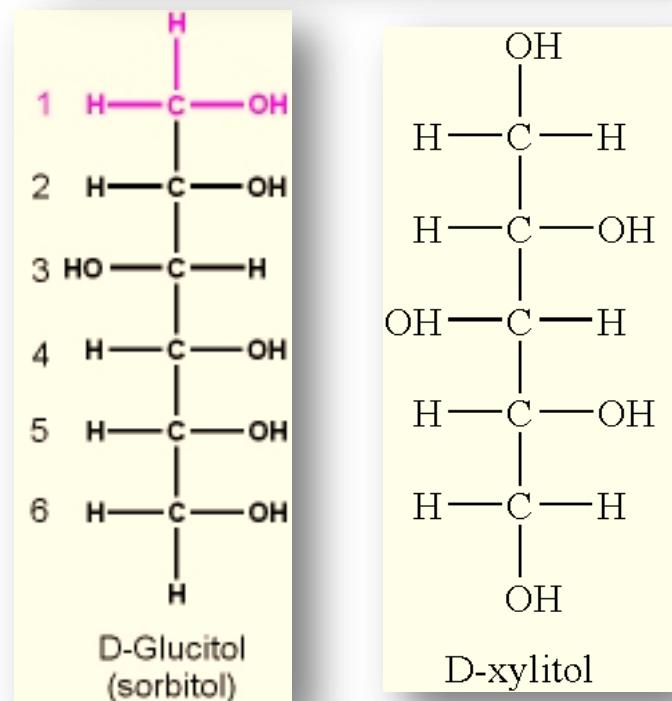
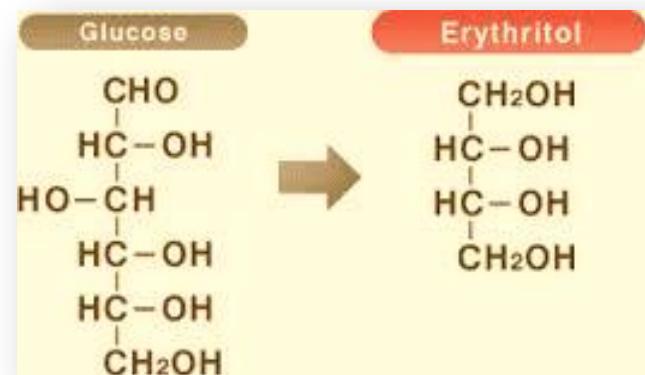
✓ **Lakanto:**  
Lo Han and erythritol

✓ **Just Like Sugar:**  
Chicory root



# Sugar Alcohols

- ✓ Also known as polyols
- ✓ Do not contain ethanol
- ✓ Sweetness similar to sucrose
- ✓ Fewer calories than sugar
- ✓ Naturally occurring and chemically derived
- ✓ Do not raise blood sugar



# Sugar Alcohols Compared

Name	Sweetness relative to sucrose	Energy (kcal/g)	Sweetness per food energy, relative to sucrose
<b>Erythritol*</b> (4 carbon)	0.812	0.213	15
<b>Mannitol</b> (6 carbon)	0.5	1.6	1.2
<b>Sorbitol</b> (6 carbon)	0.6	2.6	0.92
<b>Xylitol</b> (5 carbon)	1.0	2.4	1.6
Compare with: <b>Sucrose</b>	1.0	4.0	1.0

\* *Erythritol is by far the best choice, sorbitol the worst*



# Erythritol

- ✓ Most absorbed in the small intestine and excreted unchanged in the urine and feces
- ✓ About 10% enters the colon - does not normally cause laxative effects
- ✓ Free of side effects in regular use
- ✓ Doses over 50 grams (1.8 oz) can cause nausea and stomach rumbling
- ✓ More difficult for intestinal bacteria to digest than other sugar alcohols, so it's less likely to cause gas or bloating
- ✓ Naturally occurring in pears, melons, grapes, mushrooms, wine, soy sauce, and cheese



Smart Sweet Erythritol 4.5lbs  
by Smart Sweet  
★★★★★ 1 customer review

Price: \$36.50 + \$6.91 shipping

Note: Not eligible for Amazon Prime.

In Stock.  
Ships from and sold by Global Sweet Polyols, LLC.

- All Natural, Free of GMO, Gluten, Wheat, Soy & Corn
- Zero Calories, Zero Glycemic Index
- Safe for Diabetics, High Digestive Tolerance
- 70% as Sweet as Sugar



# Resources for Deeper Understanding

*Advanced Nutrition and Human  
Metabolism Chapter 4*

*Sugar Shock – Connie Bennett*

