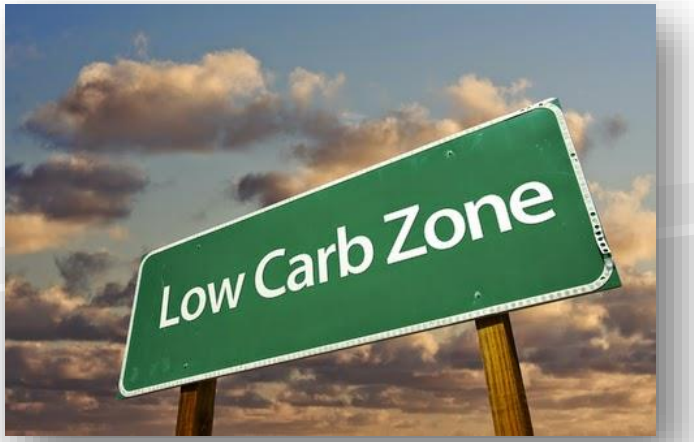
NTR 306: Fundamentals of Nutrition

Chapter 4: Carbohydrates

Carbohydrates: The Underdog of the Diet World

- Carbohydrates: sugars, starches, fibers
  - Known as 'Carbs' or 'CHOs'
  - Sources of carbohydrates: plant foods (grains, vegetables, fruits and legumes) and milk
  - "Fattening" – not necessarily!
- Brain and red blood cells
  - Fueled by glucose
- Muscles: energy for movement
  - Glycogen (stored form of glucose): ~50%

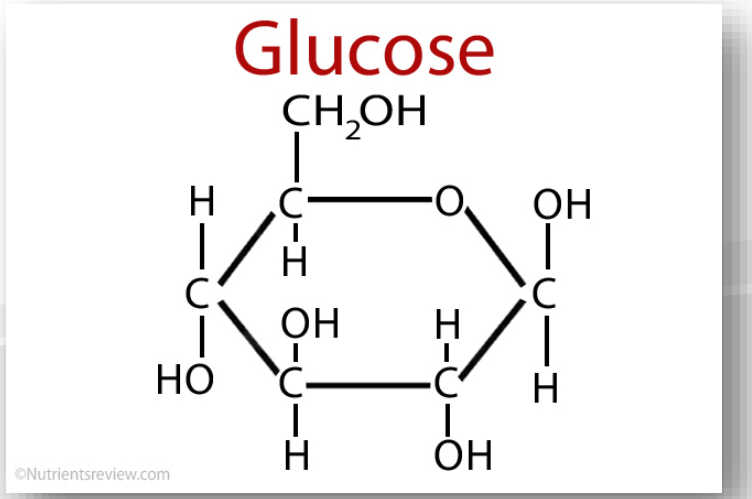


Whitney & Rolfes, Understanding Nutrition (15th ed.)

Chemist's View of CHOs

- CHO family:
  - Monosaccharides: single sugars
    - ✓ *Simple carbohydrates*
    - ✓ Chemical composition: $C_6H_{12}O_6$
    - ✓ Glucose, fructose, galactose
  - Disaccharides: pairs of monosaccharides
    - ✓ *Simple carbohydrates*
    - ✓ Maltose, sucrose, lactose
  - Polysaccharides: strings of monosaccharides
    - ✓ *Complex carbohydrates*
    - ✓ Glycogen, starches, and fibers

Each atom has a characteristic number of bonds it can form with other atoms.



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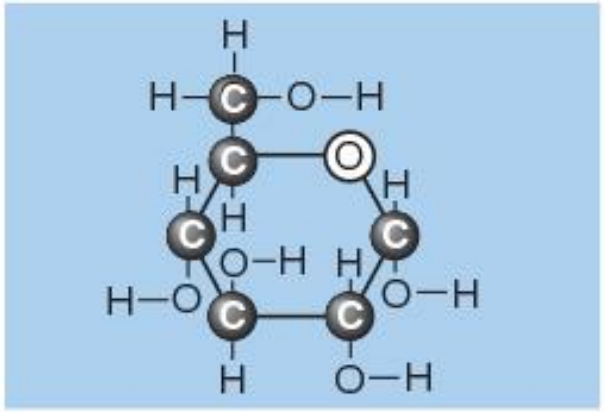
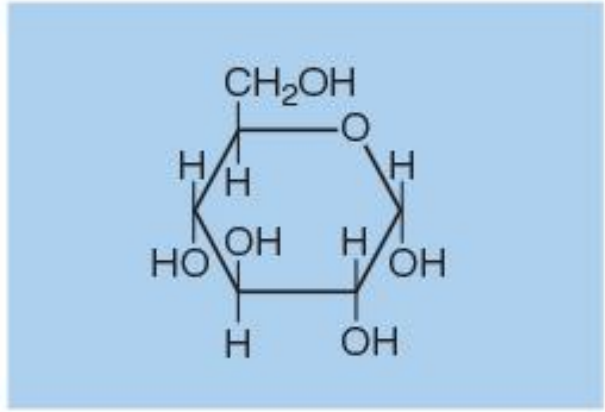
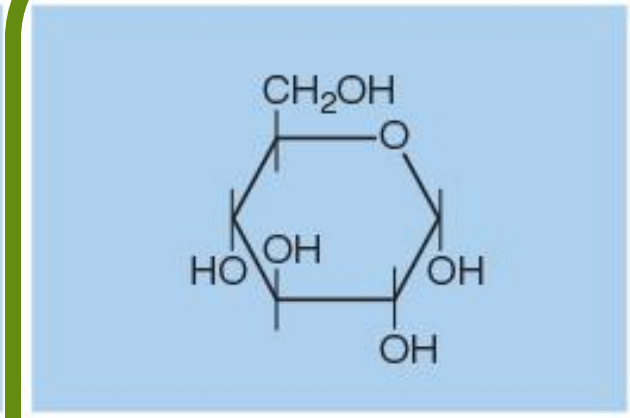
Chemist's View of Carbohydrates



The structure of glucose has to be drawn flat, but in nature the five carbons and oxygen are roughly in a plane. The atoms attached to the ring carbons extend up and down from the plane.



The lines representing some of the bonds and the carbons at the corners are not shown.

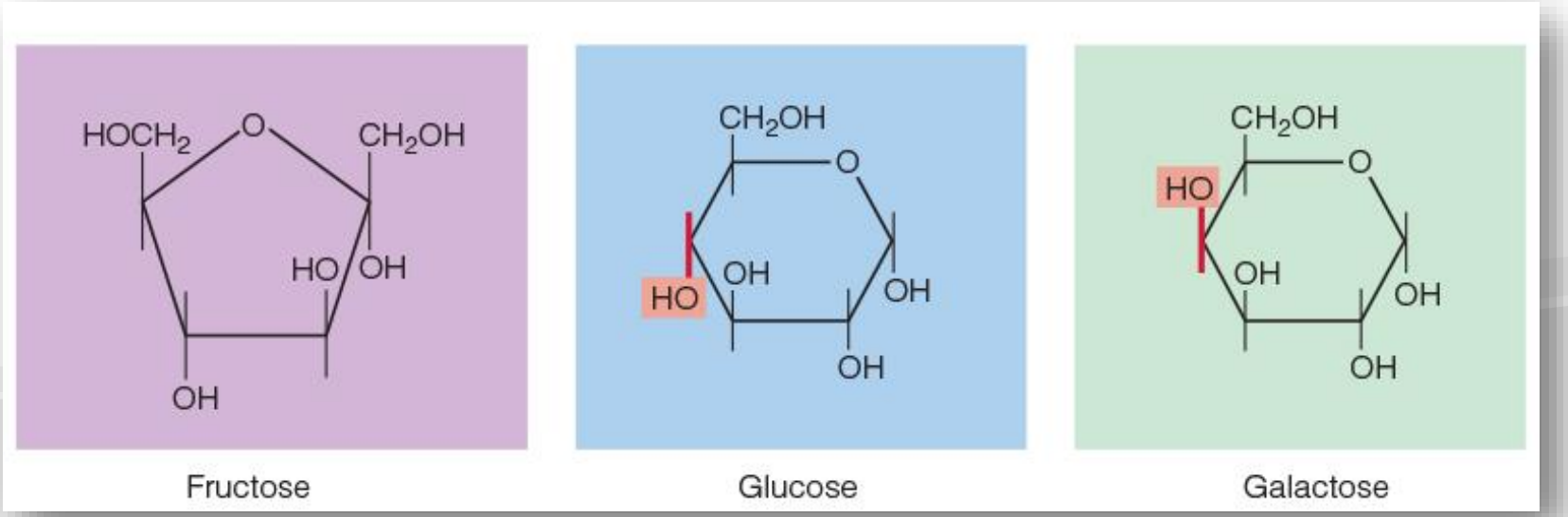


Now the single hydrogens are not shown, but lines still extend upward or downward from the ring to show where they belong.

Whitney & Rolfes, Understanding Nutrition (15th ed.)

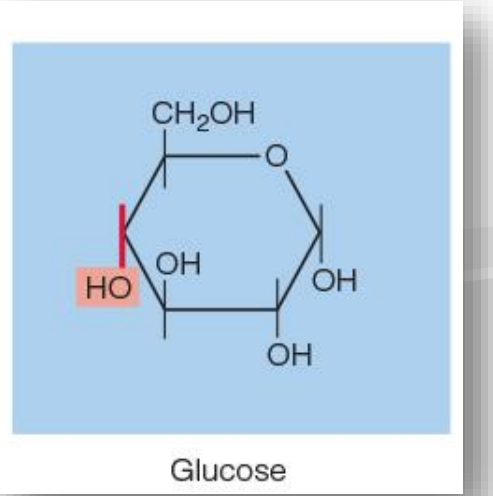
Monosaccharides

- *Simple* CHOs
- Most abundant organic (carbon-containing) molecules in nature
- Galactose, glucose, fructose
  - Same molecular composition ($C_6H_{12}O_6$), but different arrangements
    - ✓ **Different sweetness**



Monosaccharides: Glucose

- Most abundant monosaccharide in nature
- aka: blood sugar, dextrose (manufactured from corn, chemically identical to glucose)
- Broken down in cells → produces energy
  - Essential for all body activities
- Can be found in:
  - Disaccharides: maltose, sucrose, and lactose
  - Polysaccharides: glycogen and starch.



Glucose

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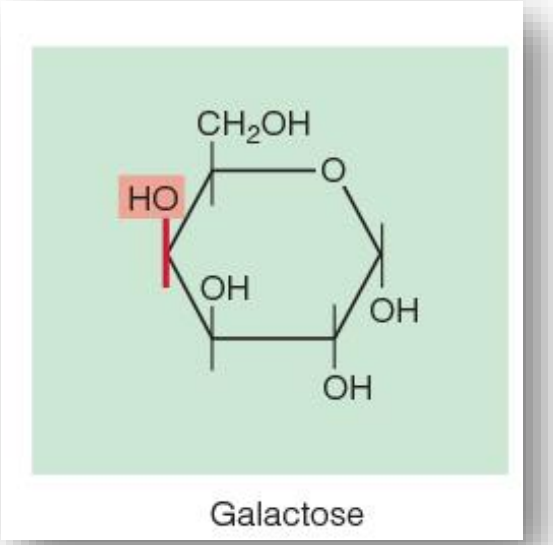
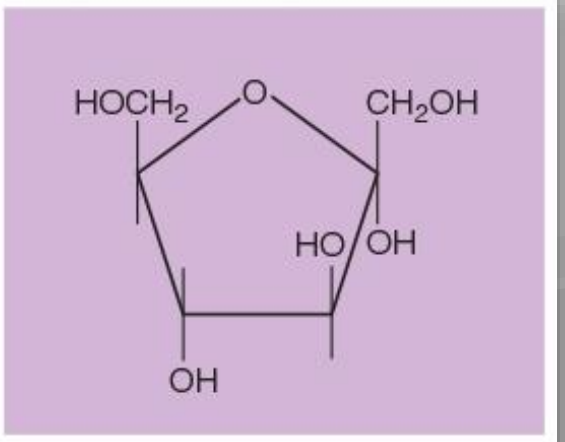
Monosaccharides: Galactose and Fructose

- Galactose:
  - Very small amounts found as single sugar in foods
  - When combined with glucose = lactose (disaccharide in milk and other dairy products)
- Fructose:
  - One of the sweetest sugars: stimulates taste buds to produce sweetness
  - Occurs naturally in fruit, honey, and vegetables
    - ✓ aka: fruit sugar
  - When combined with glucose = sucrose (table sugar)



Galactose



Fructose

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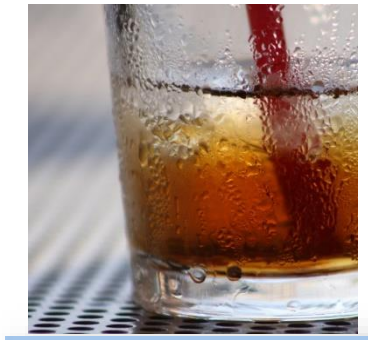
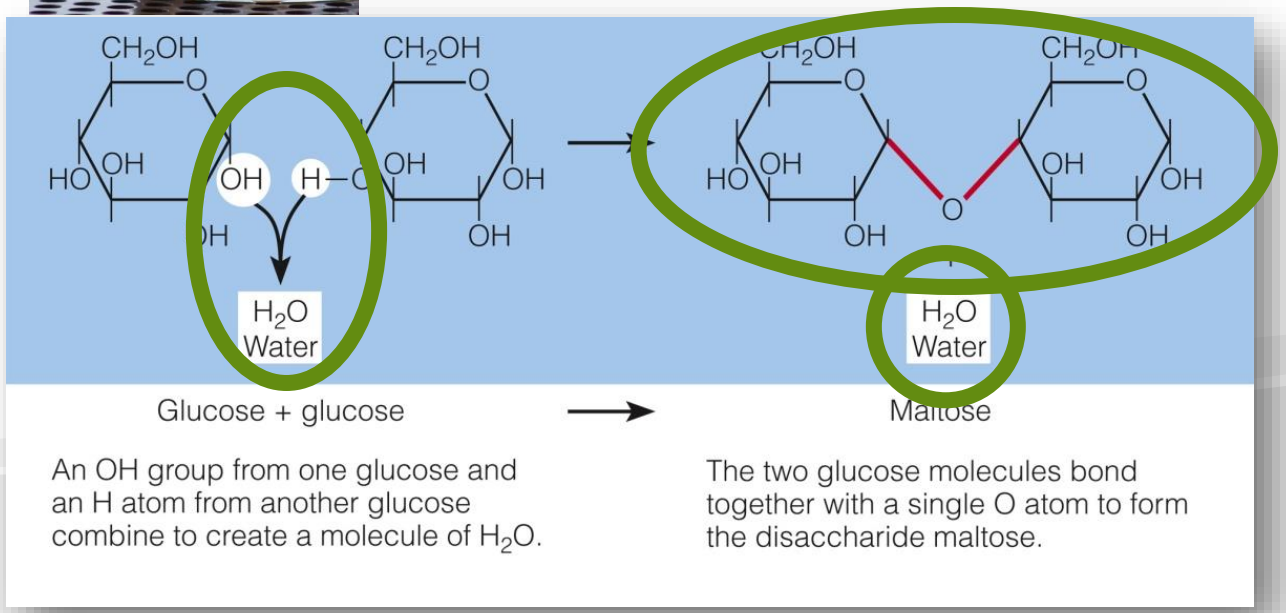
Disaccharides

- *Simple* carbohydrates
- Pairs of monosaccharides (all containing glucose)
  - Maltose = glucose + glucose
  - Sucrose = glucose + fructose
  - Lactose = glucose + galactose
- Condensation
  - Links two monosaccharides together
  - **Releases** water (H_2O) as by-product



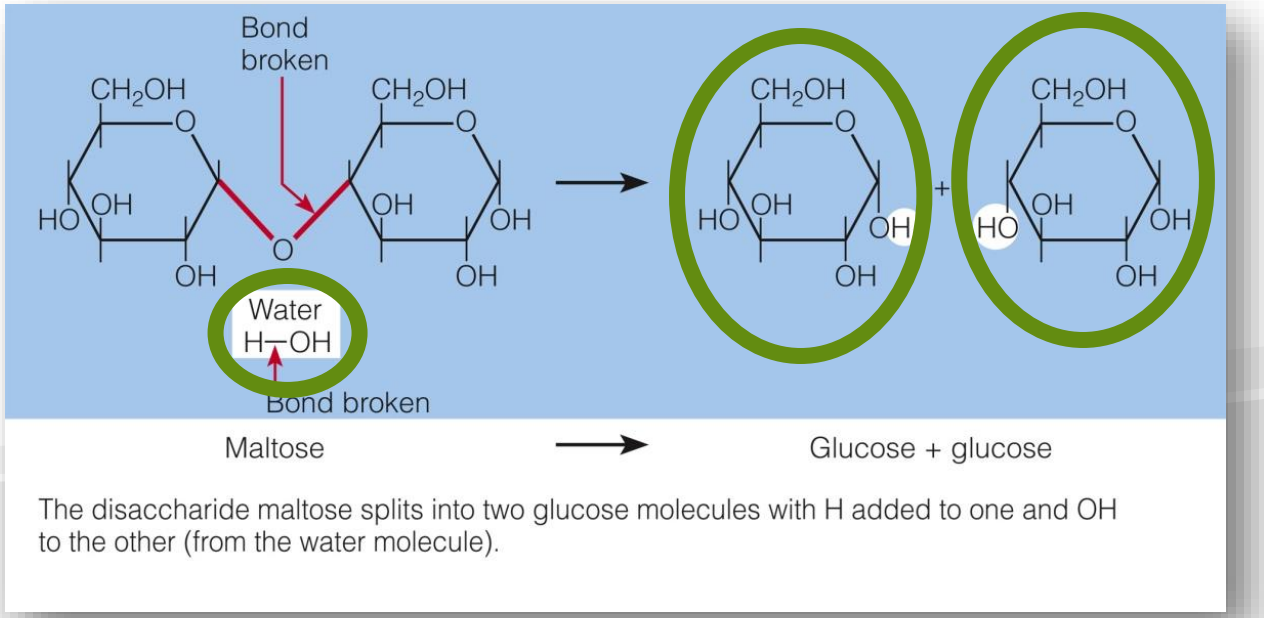
Condensation



Disaccharides

- Hydrolysis
  - Breaks a disaccharide in two
  - **Requires** water (H_2O) to take place
  - Commonly occurs during digestion

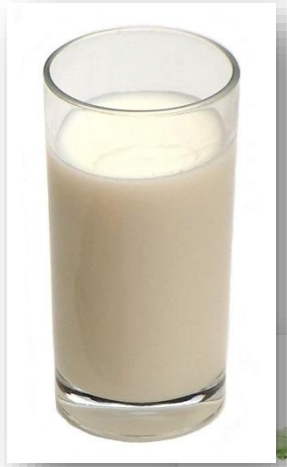
Hydrolysis



The disaccharide maltose splits into two glucose molecules with H added to one and OH to the other (from the water molecule).

Disaccharides: Maltose, Sucrose, Lactose

- Maltose (**glucose** + glucose):
  - Produced by breakdown of starch (e.g. during digestion)
  - Involved in fermentation (e.g. alcohol production)
    - ✓ Minor constituent of only a few foods: barley (key ingredient in beer)
    - ✓ aka: malt sugar
- Lactose (**glucose** + galactose):
  - Found in milk and milk products
    - ✓ Lactose = provides over ½ of total kcalories from skim milk
    - ✓ aka: milk sugar
- Sucrose (**glucose** + fructose):
  - Sweetest disaccharide
  - Most abundant disaccharide found in nature
    - ✓ Sugar cane, sugar beets, fruits, vegetables, grains
    - ✓ aka: table sugar



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Polysaccharides

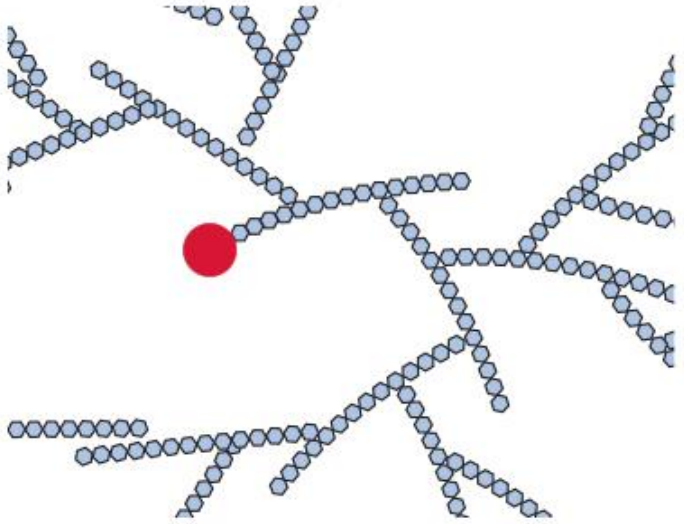
- *Complex* carbohydrates
- Formed by many **glucose** units *plus* other monosaccharides; connected through carbon bonds
  - Glycogen: storage (glucose) – animals
  - Starches: storage (glucose) – plants
  - Fibers: structure (various monosaccharides) – plants

Polysaccharides: Glycogen

- Storage form of energy in the body
- Glucose units
- Found in: meat to a limited extent, not found in plants
  - Food ≠ significant source
  - Liver: up to 8% by weight = glycogen (significant source of carbohydrate)

> FIGURE 4-6

For details of the chemical structures, see Appendix C.

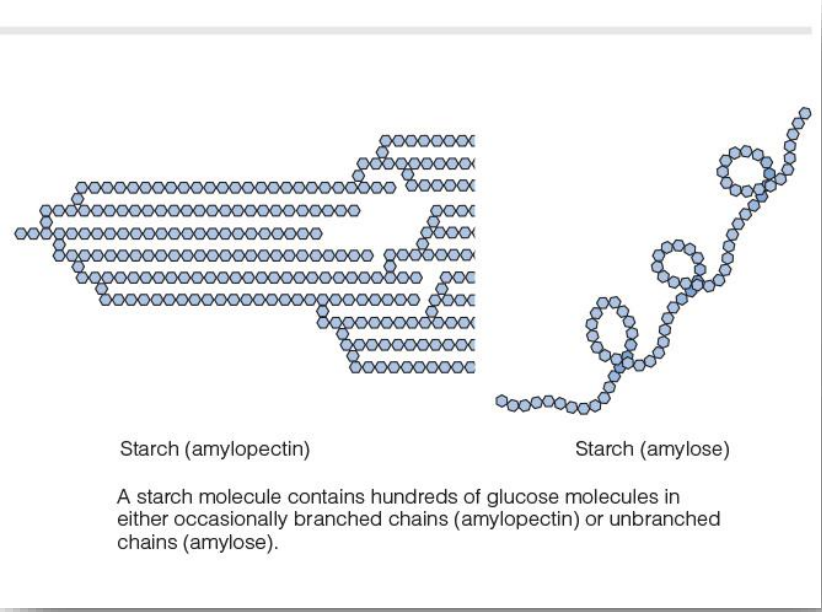


Glycogen

A glycogen molecule contains hundreds of glucose units in highly branched chains. Each new glycogen molecule needs a special protein (shown here in red) for the attachment of the first glucose.

Polysaccharides: Starch

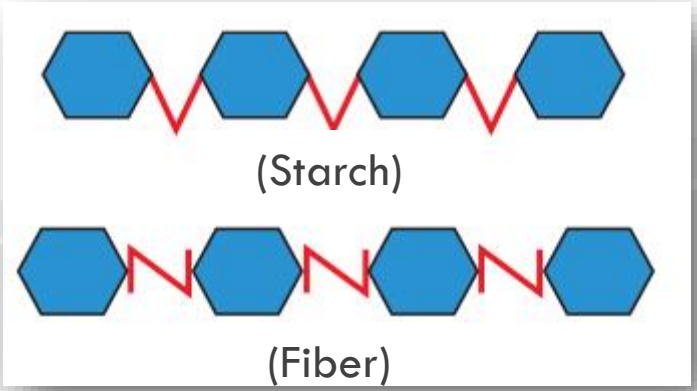
- Storage form of energy in plants
- Glucose units
- Found in: grains, root crops, tubers, legumes
  - Grains = richest source
  - Body hydrolyzes starch to glucose, uses glucose for energy
  - Global food staple



A starch molecule contains hundreds of glucose molecules in either occasionally branched chains (amylopectin) or unbranched chains (amylose).

Polysaccharides: Dietary Fiber

- Found in all plant-derived foods
  - Provide structure in stems, leaves, roots, skins, and trunks
  - Made from a variety of monosaccharides (not just glucose)
  - Bonds between monosaccharides **cannot be broken by digestive enzymes** (unlike starches)
    - ✓ aka: nonstarch polysaccharides
    - ✓ Pass through the body undigested (don't release any glucose)
    - ✓ Don't contribute energy / kcalories



Polysaccharides: Fiber (two types)

- Classified by solubility in water:
  - **Insoluble fibers**: cannot dissolve in water
    - ✓ Example: skins of corn kernels, celery strings
  - **Soluble fibers**: can dissolve in water; more viscous and fermentable
    - ✓ Viscous fibers: form gels in GI tract
    - ✓ Fermentable fibers: digested by GI bacteria
    - ✓ Example: fruit pectin
- ***Functional* fiber**: natural fiber extracted from plants or manufactured, then added to foods or supplements to provide health benefits
  - **Total fiber** in foods = dietary + functional

CHO Digestion

Goal: Break foods into smaller molecules for use by the body

Digestion:
Break foods into smaller molecules

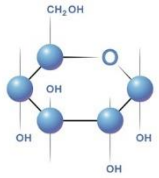
Absorption:
Move the smaller molecules out of the GI tract and into the vascular system

starch → → → glucose

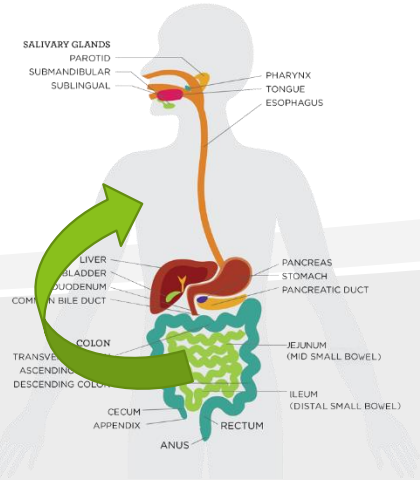
glucose (digestive tract) → blood → body

Long polysaccharide chains

→→→

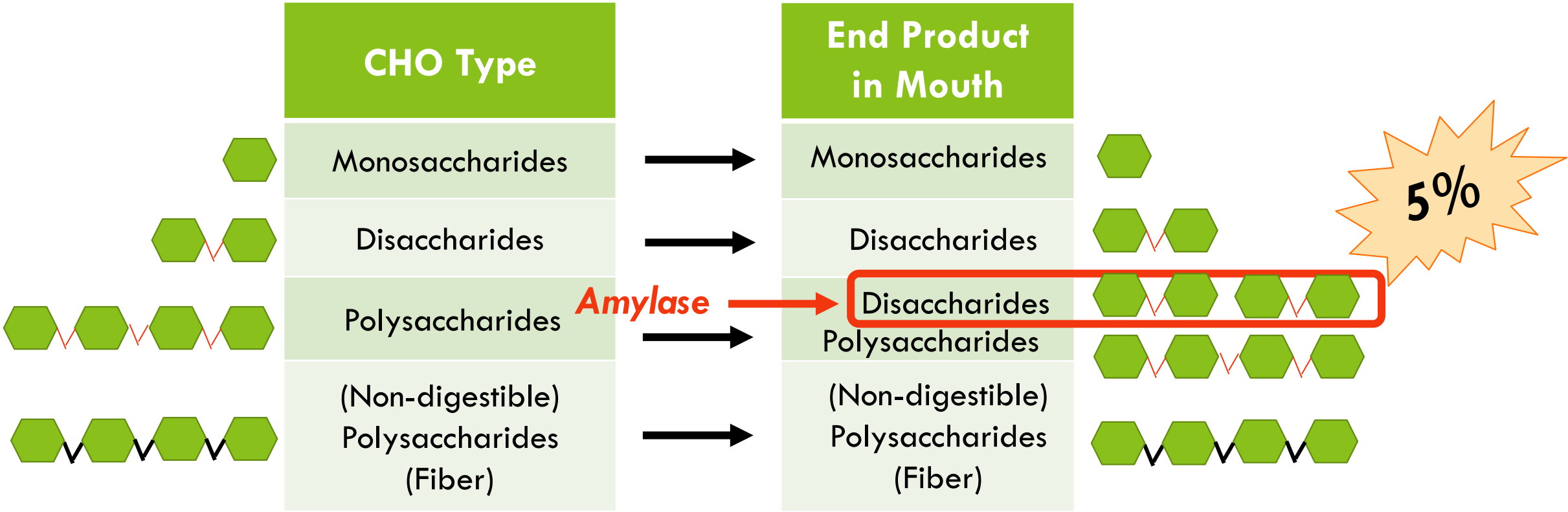


monosaccharides



CHO Chemical Digestion – Mouth

- Small amount of digestion (~5%)
  - Salivary Amylase (from salivary glands)

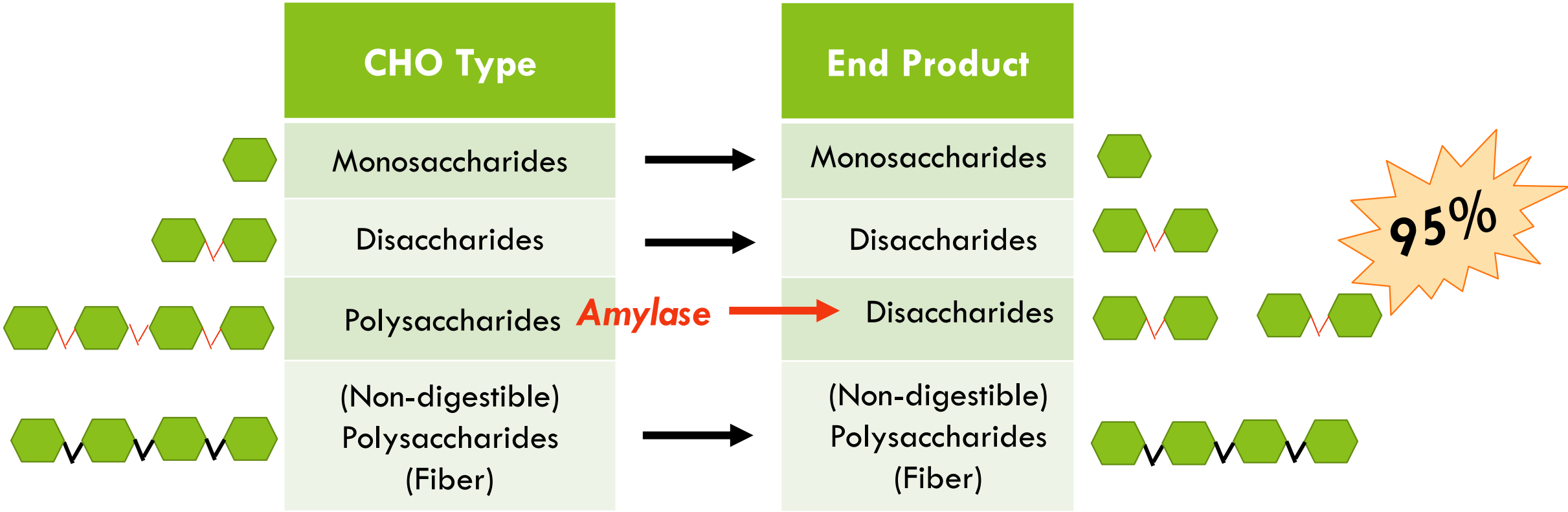


CHO Chemical Digestion – Stomach

- None!
  - Stomach acid (HCl) neutralizes salivary amylase
  - No enzymes in stomach for CHO digestion
- Role of Fiber
  - ✓ Delays gastric emptying
  - ✓ Increases fullness/satiety

CHO Chemical Digestion – Small Intestine

- Most digestion happens here (~95%)
  - Pancreatic Amylase (from pancreas)



CHO Chemical Digestion – Small Intestine

- Other enzymes (from small intestine)

Disaccharides		Monosaccharide Products in Sm. Int.
Maltose	Maltase →	Glucose & Glucose
Sucrose	Sucrase →	Glucose & Fructose
Lactose	Lactase →	Glucose & Galactose






CHO Chemical Digestion – Large Intestine

- None (but fermentation happens here)

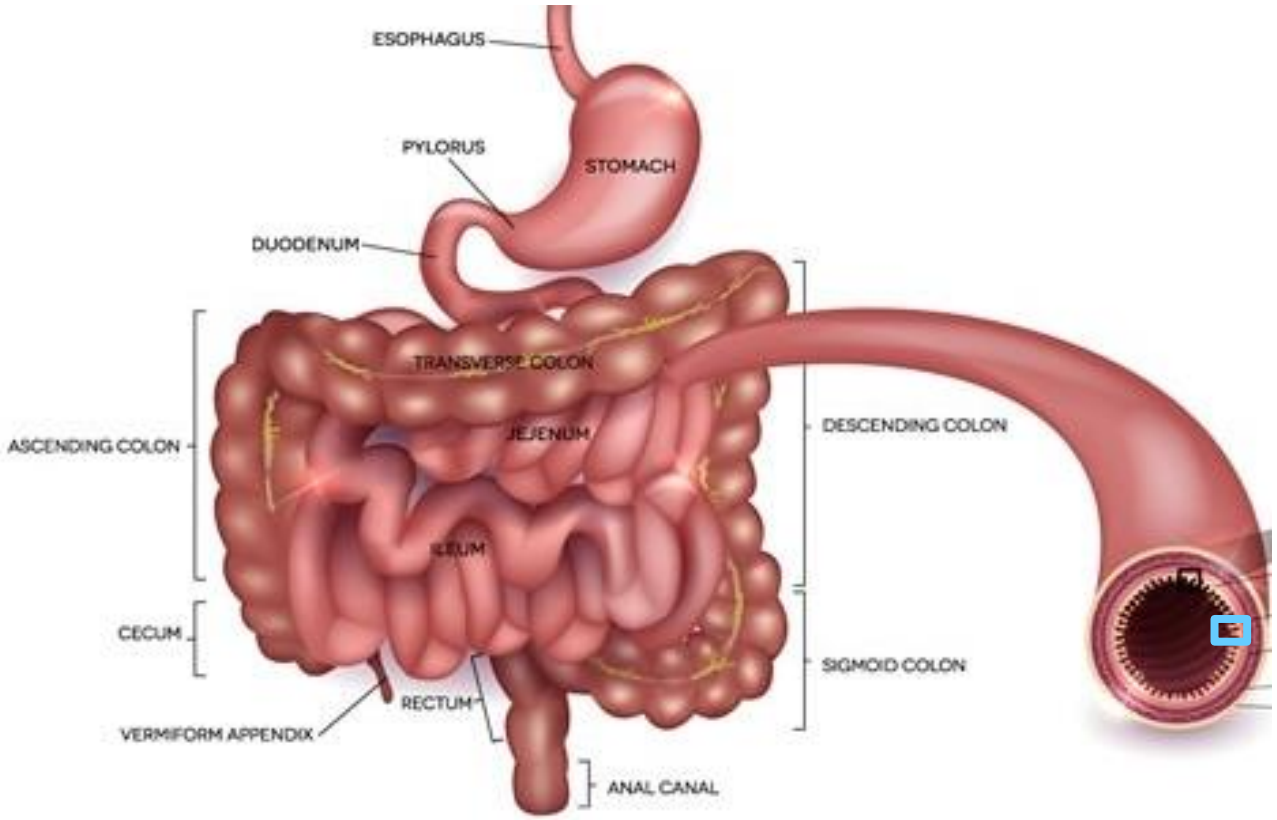
Remaining Products		End Products in Large Intestine
Soluble Fiber (Non-digestible Polysaccharides)	Bacterial Enzymes →	Water & Gas Fatty Acids (Energy)
Insoluble Fiber (Non-digestible Polysaccharides)	→	Excreted

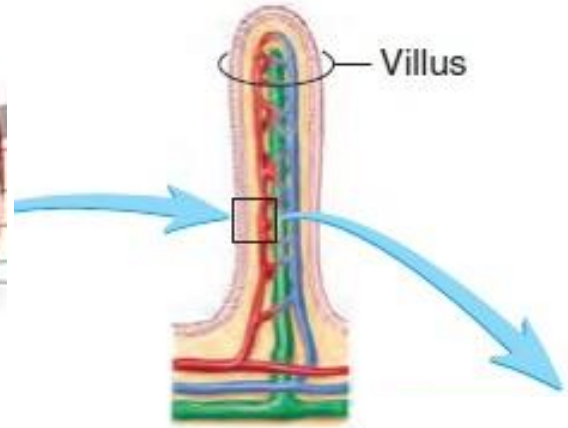
Soluble: Dissolves in water

Insoluble: Does not dissolve

- What happened to the monosaccharides?

CHO Absorption (Small Intestine)



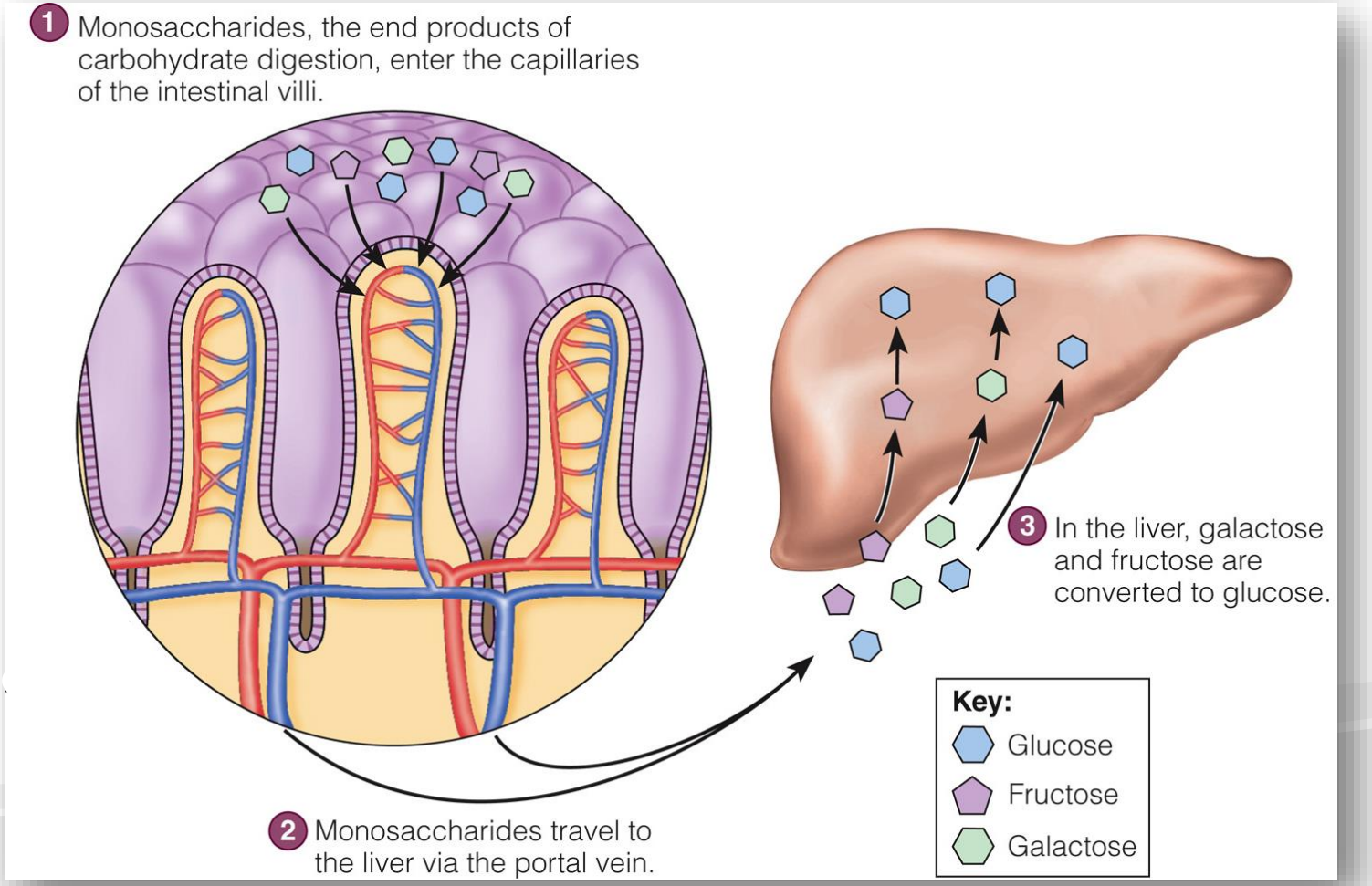


1 enterocyte:

(cell in the intestinal wall)

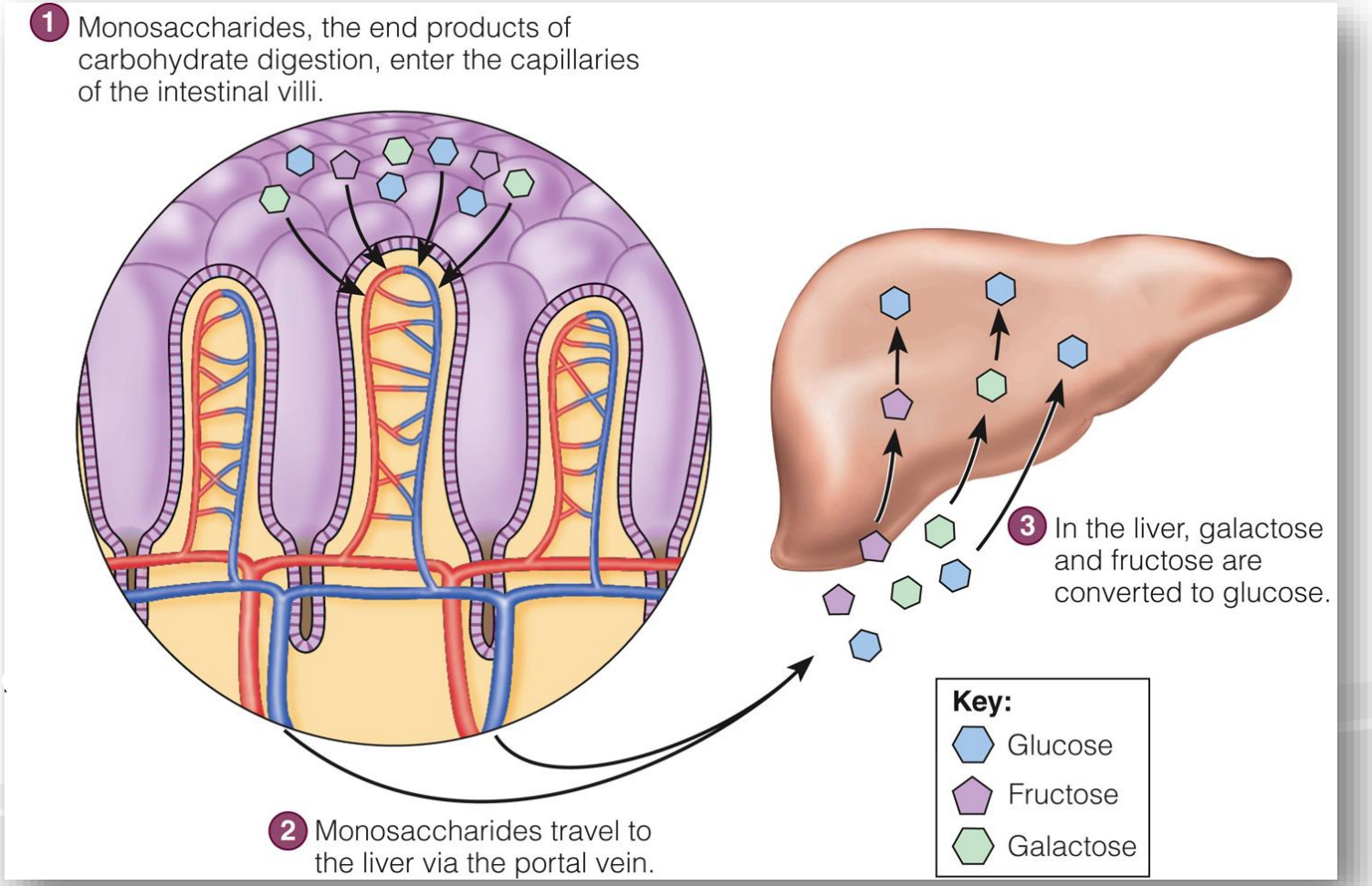
CHO Absorption: Glucose

- Glucose
  - Enter cells via active transport (requires energy and specific transporter)
  - May also enter via facilitated transport (requires different transporter)
  - Sent out to body's cells to provide energy



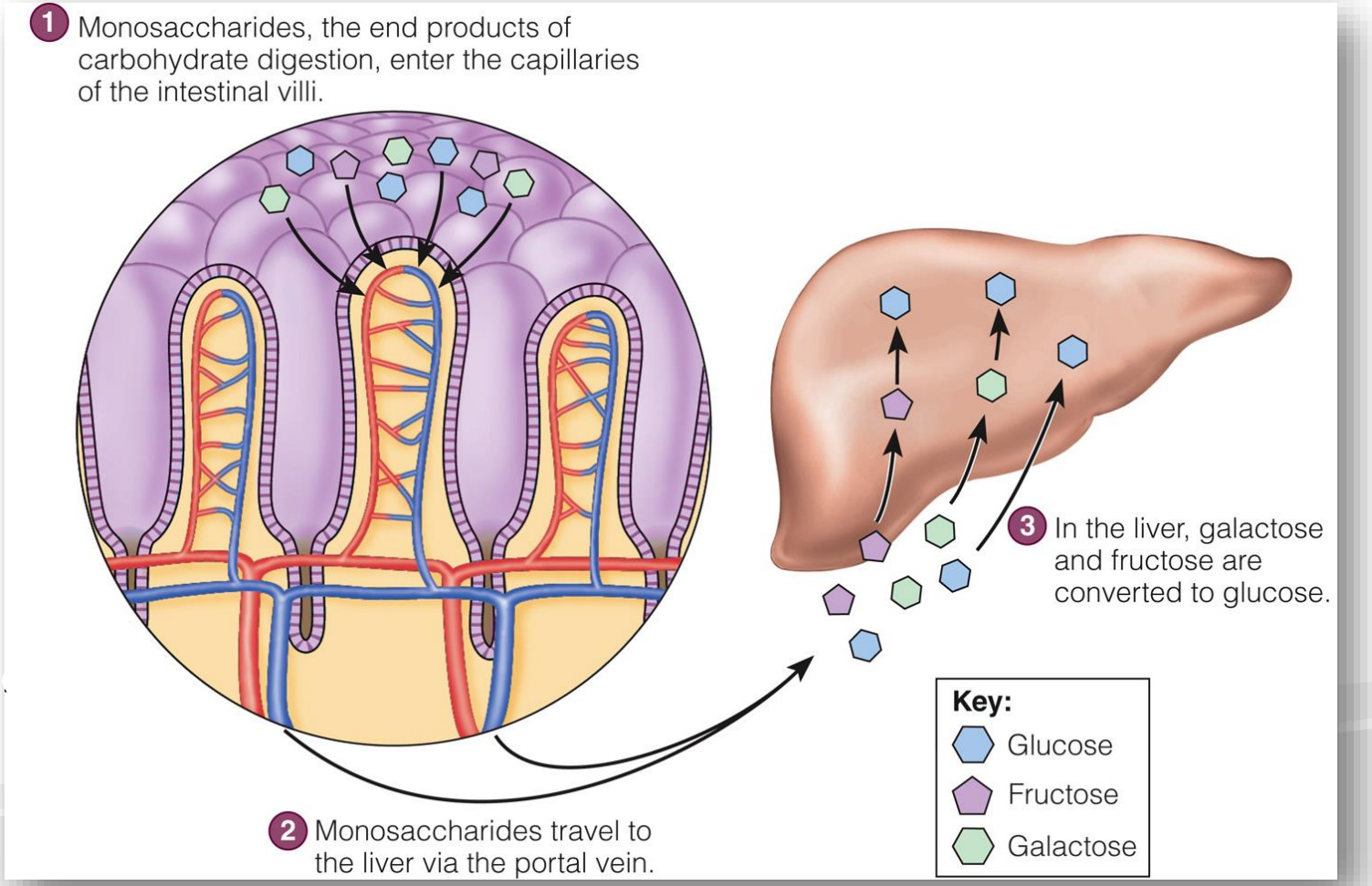
CHO Absorption: Galactose

- Galactose
  - Enter cells via active transport (requires energy and specific transporter)
  - May also enter via facilitated transport (requires different transporter)
  - Metabolized in liver → follows same metabolic pathways as glucose



CHO Absorption: Fructose

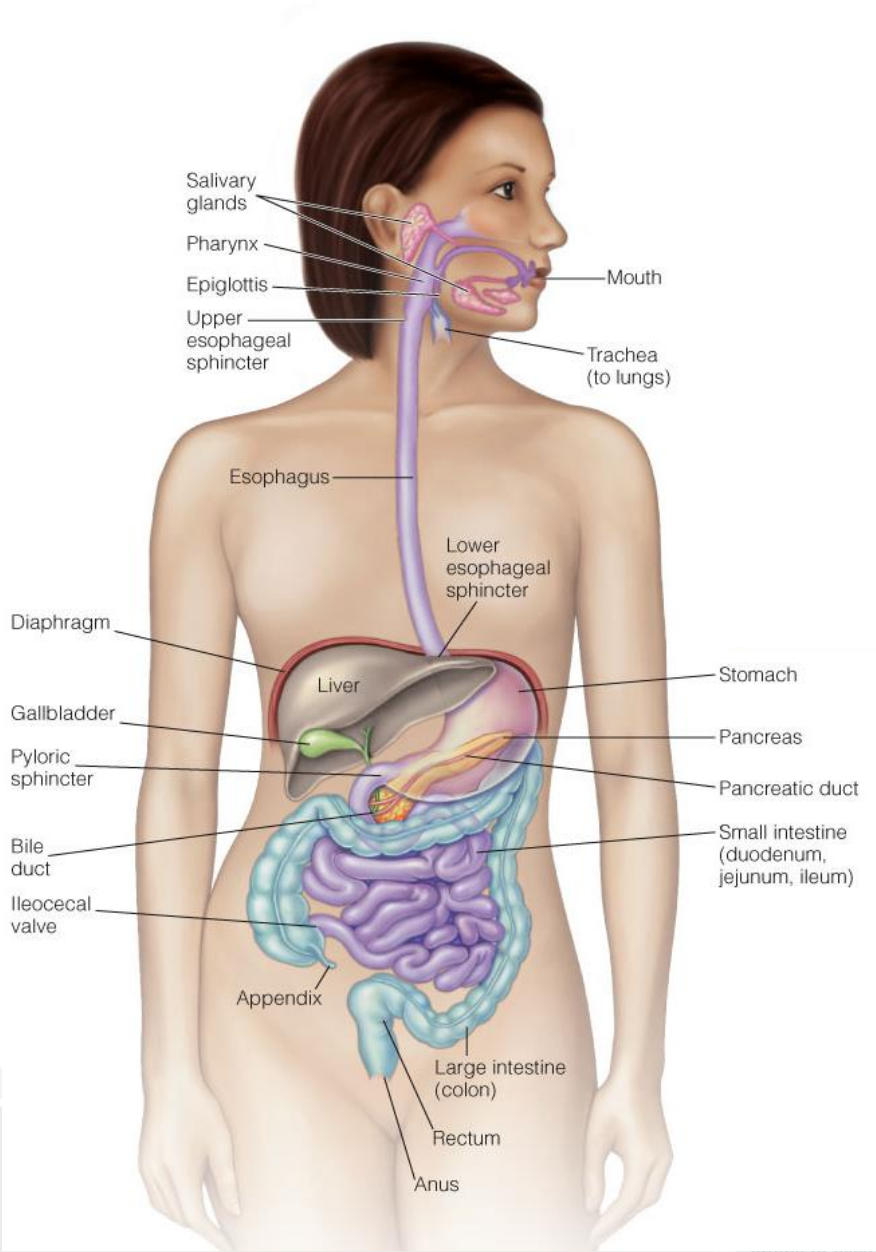
- Fructose
  - Enters cells via facilitated transport (requires different transporter)
  - Metabolized in liver → follows same metabolic pathways as glucose



Instapoll

Where do all digestible CHOs end up (before being absorbed)?

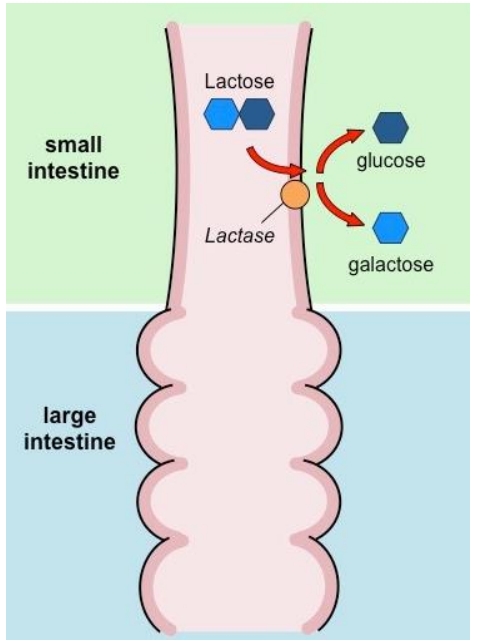
- Stomach
- Small Intestine
- Large Intestine
- Colon
- Bladder
- Adipose Tissue



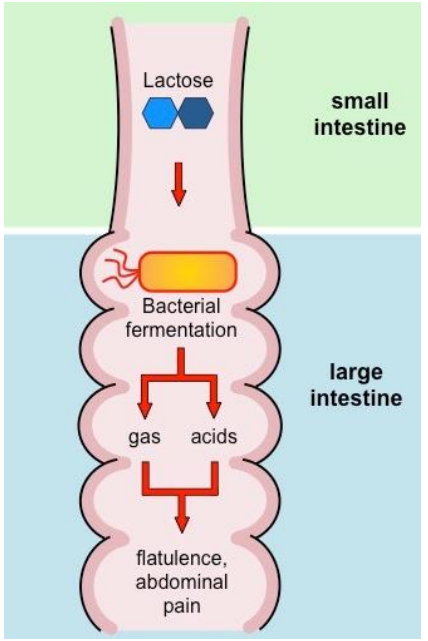
Digestion/Absorption Issues

- Lactose Intolerance: inability to digest and absorb lactose
  - Symptoms:
    - ✓ (Severe) Bloating, abdominal discomfort, gas, diarrhea due to an increase in water & bacteria fermentation
  - Cause:
    - ✓ Reduction in lactase
  - Other causes:
    - ✓ Age (highest after birth; 90% ↓with age)
    - ✓ Genetics
    - ✓ Infrequent consumption of dairy
    - ✓ Diseases/Medications

Lactose Tolerant



Lactose Intolerant

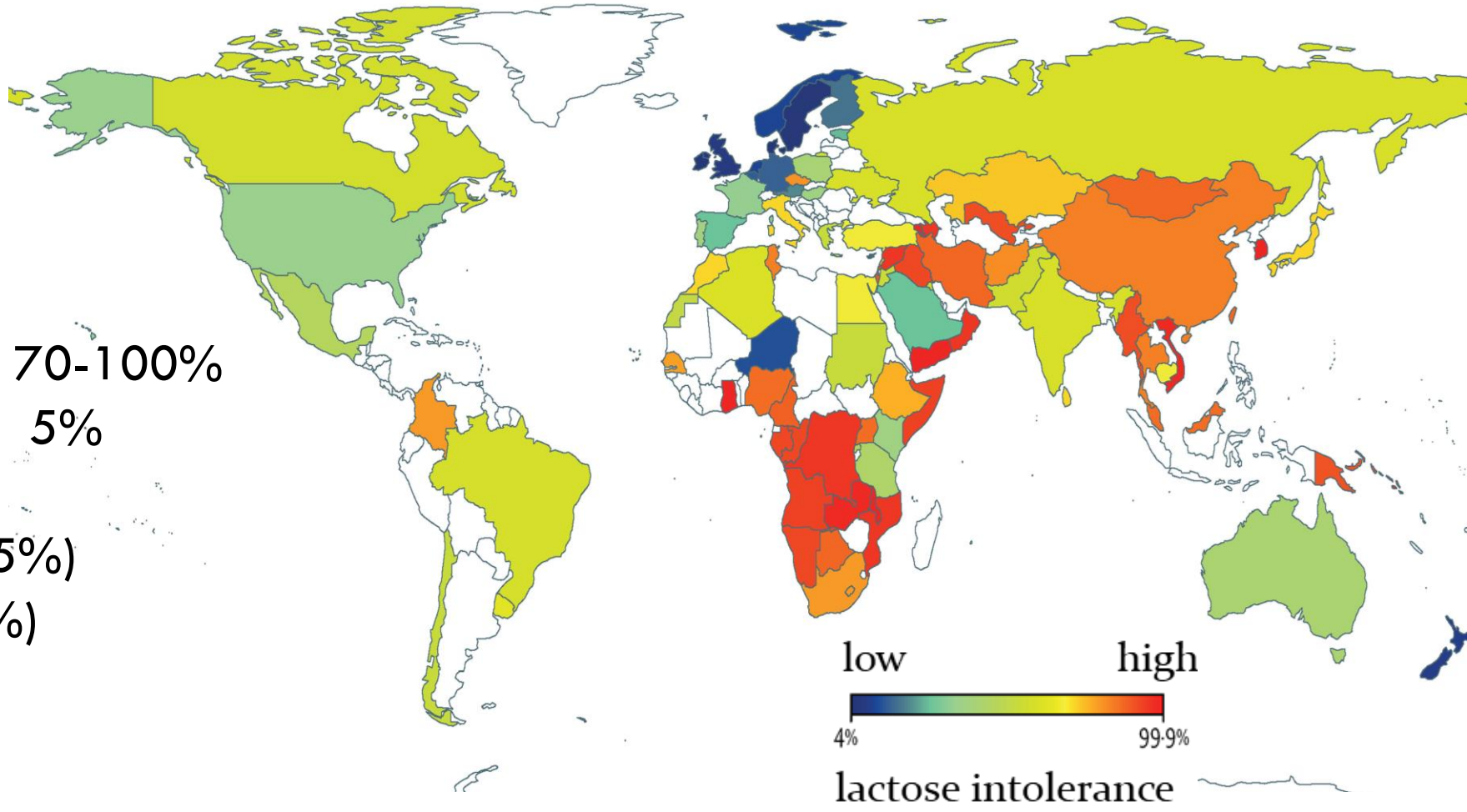


https://www.thelancet.com/journals/langas/article/PIIS2468-1253(17)30154-1/fulltext

Lactose Intolerance: Prevalence

Lactose Intolerance

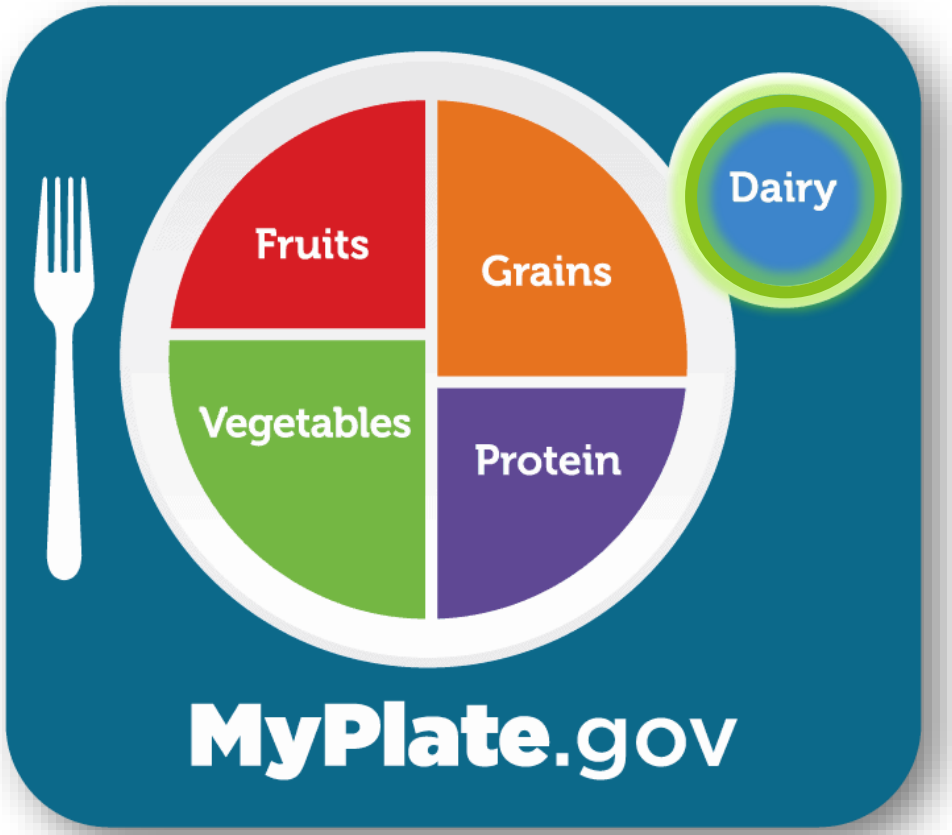
- Global population: 65%
- East Asia & South Africa: 70-100%
- Lowest among Europeans: 5%
- US Overall: 38%
  - African American (75%)
  - Asian American (90%)
  - Hispanic (50%)



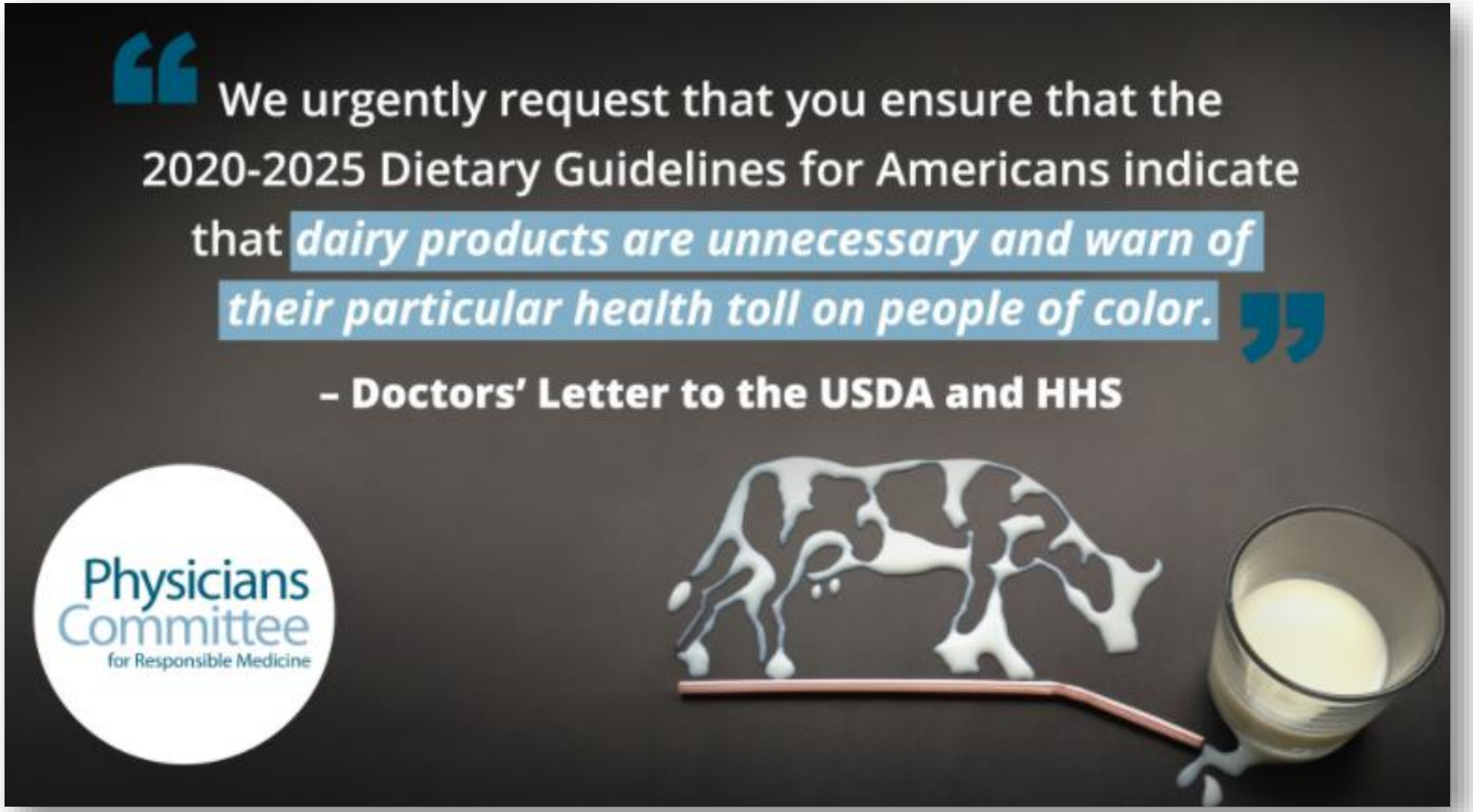
Lactose Intolerance: Dietary Strategies

- Manage dairy consumption rather than eliminate
  - Potential for malnutrition for some nutrients – even with substitutes
    - ✓ Calcium, potassium, vitamin D, vitamin B12, protein, etc.
- Most can tolerate up to 6g lactose (1/2 cup milk)
- Gradually increase milk intake (with other foods, etc.)
    - ✓ GI bacteria: adapt to milk consumption
    - ✓ Note: <u>not</u> increasing lactase concentrations
- Consume yogurt (bacteria feeds on lactose) or lactose-free milk

Why Cow's Milk?



Why Not Cow's Milk?



Milk Comparison

- All milk options below are lactose-free and unsweetened

Energy & Macronutrients	Cow (Lactose-free)	Soy	Oat	Almond	Coconut
Energy (kcal)	80	80	45	30	40
Total Fat (g)	0	4.5	0.5	3	4
Sat. Fat (g)	0	0.5	0	0	4
Total CHO (g)	6	4	8	<1	2
Added Sugar (g)	0	0	0	0	0
Total Protein (g)	8	7	1	1	0

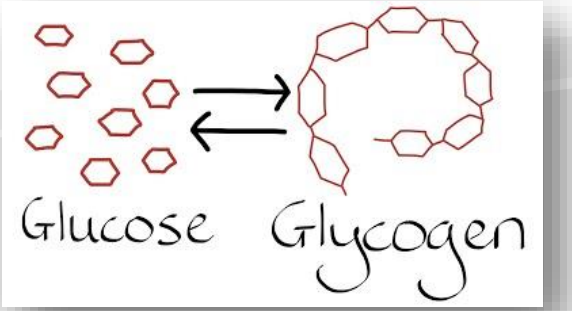
Milk Comparison

10	2	0	0	0
Cow's Milk	**Soy Beverage**	**Oat Beverage**	**Almond Beverage**	**Coconut Beverage**
Calcium	Calcium	Calcium	Calcium	Calcium
Protein	Protein			
Phosphorus		Phosphorus		
Riboflavin	Riboflavin	Riboflavin		
Vit B12	Vit B12	Vit B12		Vit B12
Pantothenic Acid				
Niacin				
Zinc				
Selenium	Selenium			
Iodine				
Potassium		Potassium		
Vit A	Vit A	Vit A	Vit A	Vit A
Vit D	Vit D	Vit D	Vit D	Vit D
$0.22 $0.64	$0.48	$0.50	$0.37	$0.50

Naturally Occurring
Fortified

CHO Metabolism – Glucose (Central Focus)

- Glucose as immediate energy to produce ATP
- Glucose as stored energy in the form of glycogen
  - <u>Glycogen is made when blood glucose is high (after a meal)</u>
    - ✓ *¾ glycogen stored in muscle*
    - ✓ *¼ glycogen stored in liver (1-day's worth)*
    - ✓ *Tiny amount stored in brain (few min's worth) – emergency use only*
  - <u>Glycogen broken down when blood glucose is low (between meals/overnight)</u>
    - ✓ *Muscle – keeps it for itself (to be used during exercise)*
    - ✓ *Liver – as needed for the rest of the body*



CHO Metabolism – Organ Use

- Brain → Primary user of glucose
  - ✓ Uses ~60% total glucose (~120 g/d; ~420 kcal)

    If available glucose drops to less than ~60g/d, problems occur…
  - ✓ Power transmission of nerve impulses; synthesize neurotransmitters

    Thinking, memory, learning, initiating movement, etc.
  - ✓ Can use ketones (when needed)

Ketones: acidic compound produced by the liver from fatty acids (lipids) when CHOs aren't available; alternative energy source

- Muscle, liver, adipose, kidneys, red blood cells (RBCs)
  - ✓ All of these (except RBCs) have additional energy sources

CHO Metabolism – Overview

- Abundance/Surplus of CHO (Glucose)
  - Body uses glucose instead of fat (fat is conserved)
  - Body converts excess glucose into fat for storage (fat is created)
    - ✓ *Fat cells can store almost unlimited stores of fat*

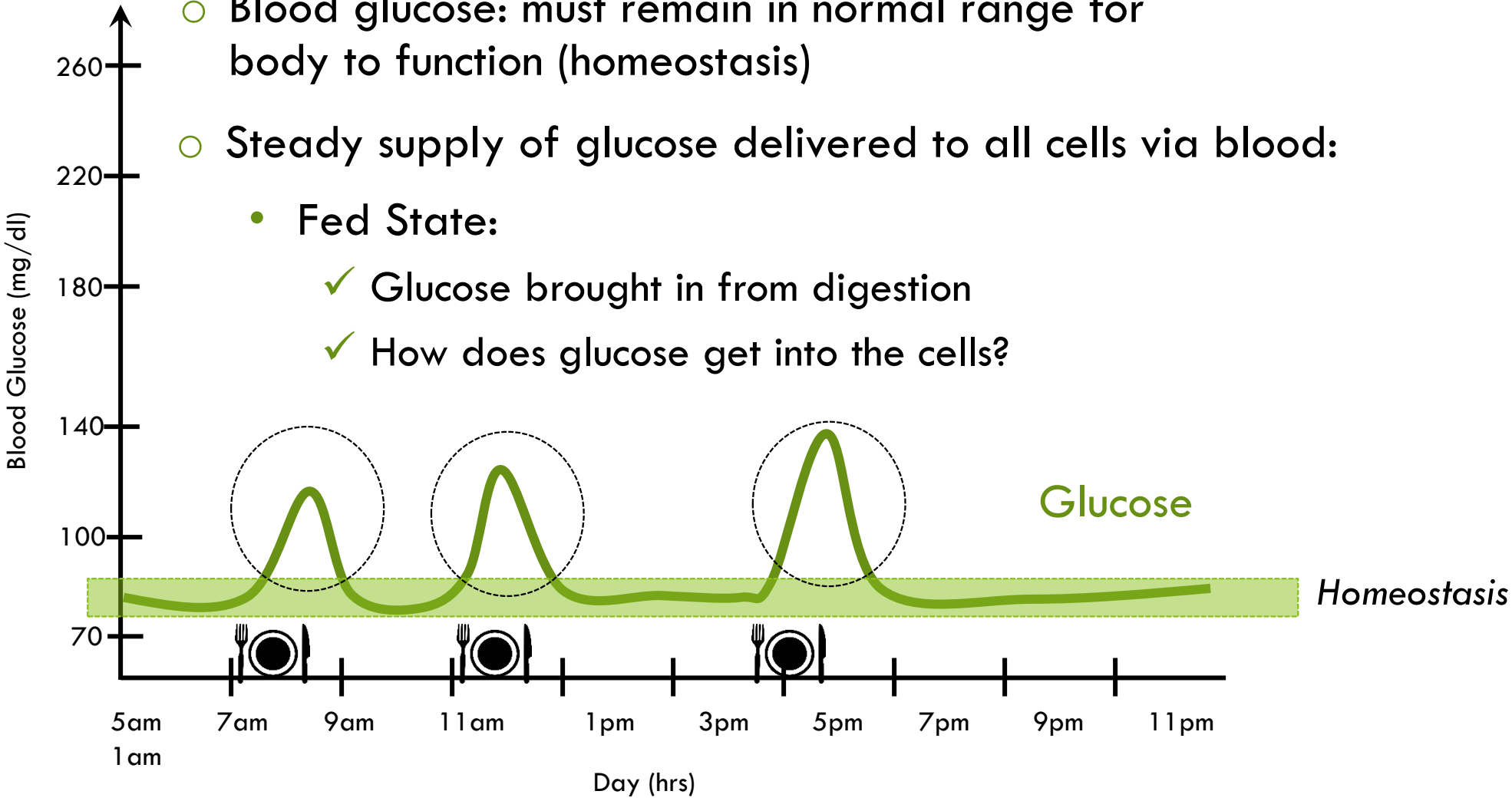
CHO Metabolism – Overview

- Inadequate Amount of CHO (Glucose)
  - Fat molecules are broken down and form ketone bodies (acidic)
    - ✓ *Alternative fuel during severe energy deficits/starvation/low-carb 'ketogenic' diets*
    - ✓ *Disrupt body's acid-base balance*
    - ✓ *Excessive ketones → accumulate in blood → ketosis → ketoacidosis*

      Ketoacidosis generally only occurs in diabetics
  - Cells can convert amino acids (from protein) → glucose
  - Body needs ~60-100 g of CHO/day to:
    - ✓ *Prevent ketosis*
    - ✓ *Spare body proteins*

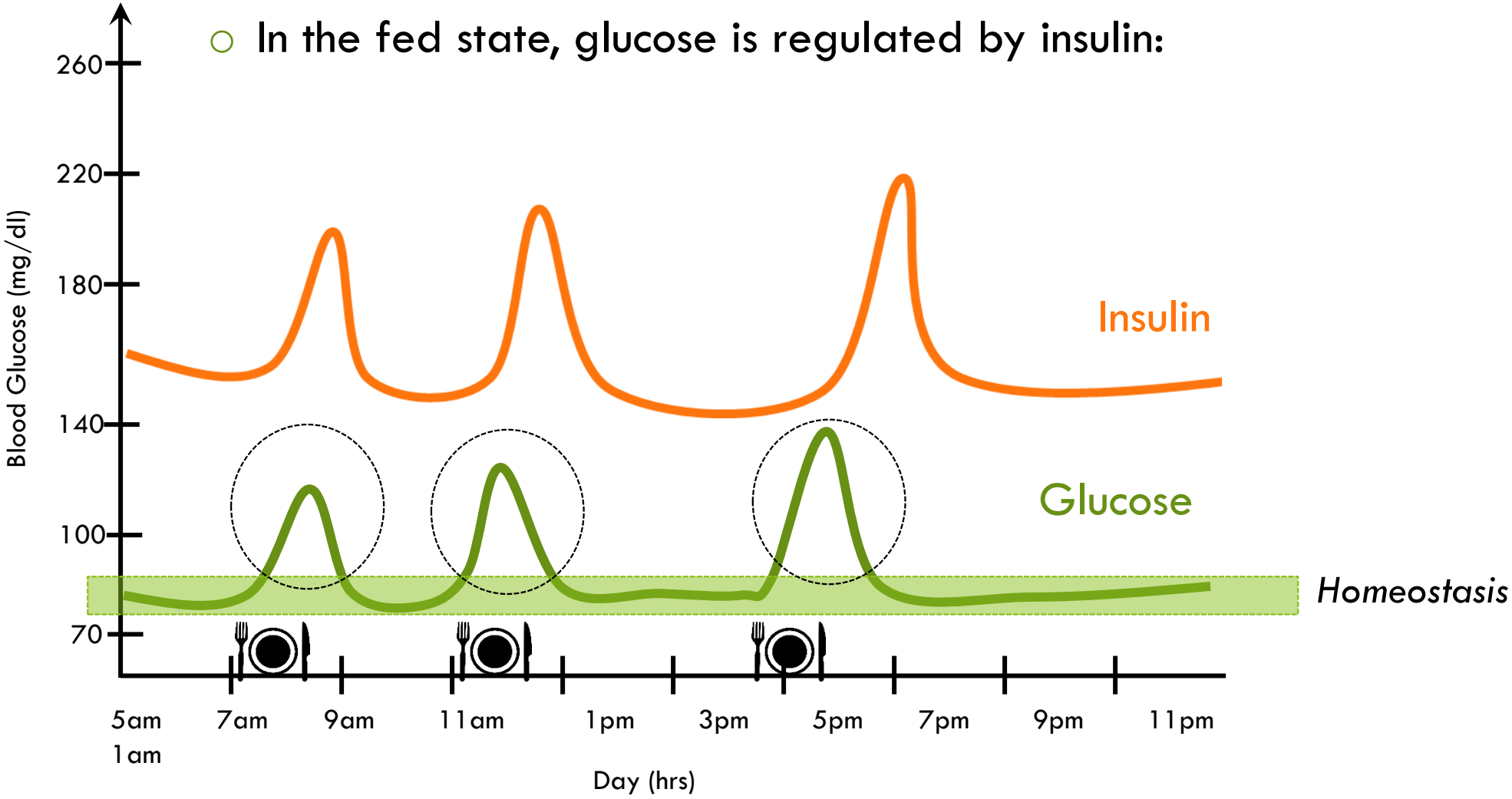
Glucose Regulation

- Blood glucose: must remain in normal range for body to function (homeostasis)
- Steady supply of glucose delivered to all cells via blood:
  - Fed State:
    - ✓ Glucose brought in from digestion
    - ✓ How does glucose get into the cells?



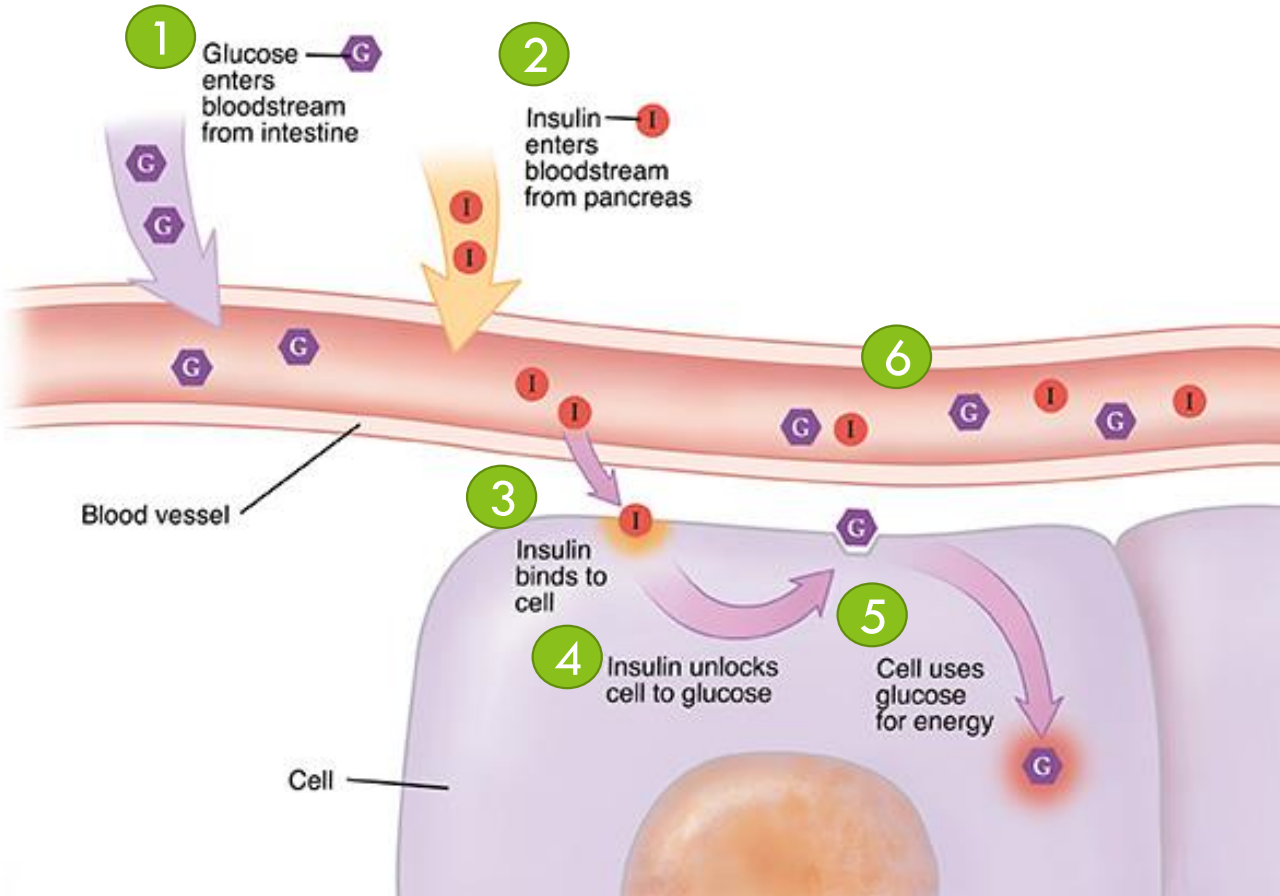
Glucose Regulation

- In the fed state, glucose is regulated by insulin:



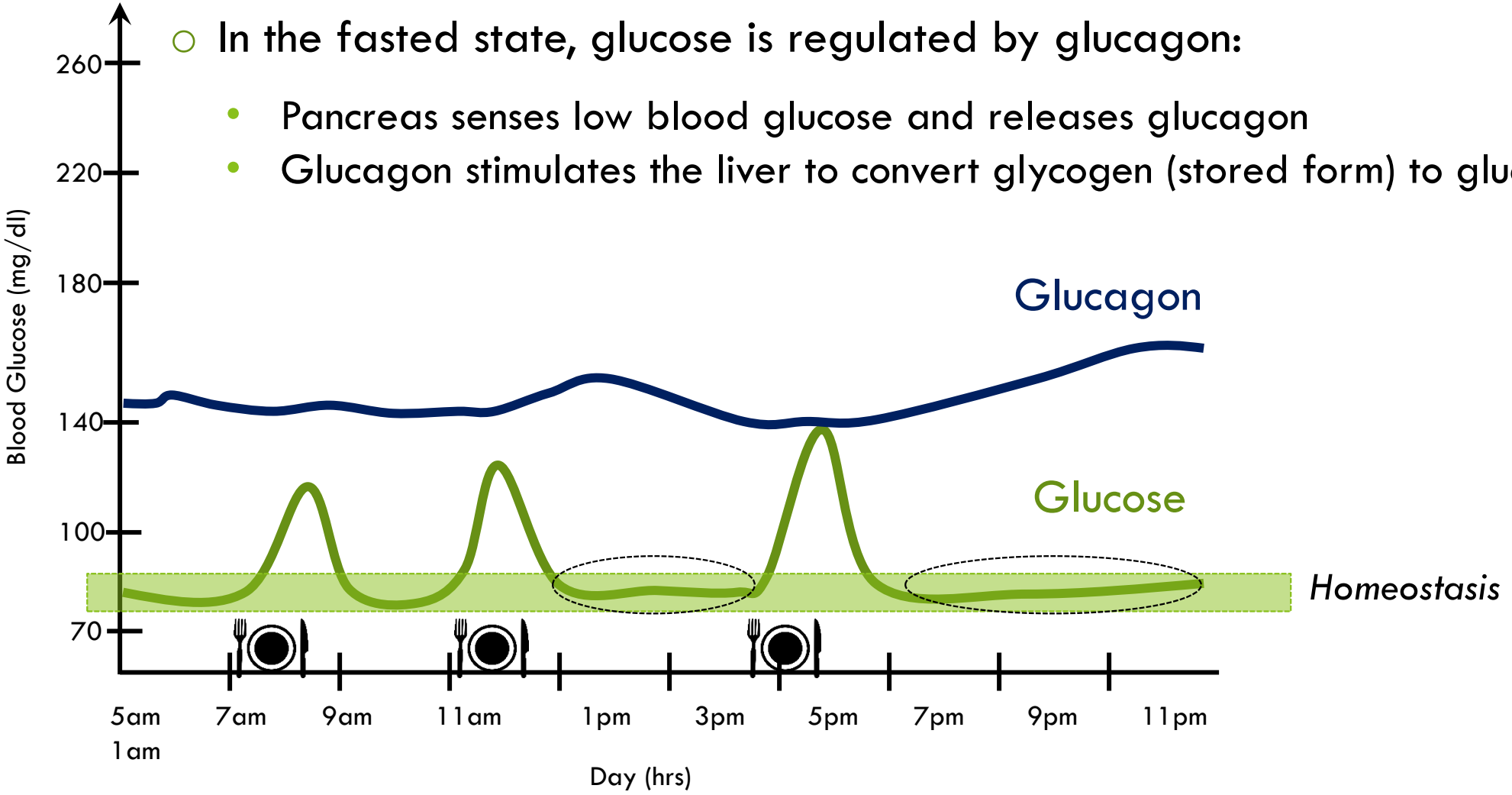
Glucose Regulation – Fed State

1. Glucose moves from intestine into bloodstream
2. Pancreas senses high blood glucose and releases insulin into the bloodstream
3. Insulin binds to a cell that needs energy (like muscle, liver, and adipose cells)
4. Insulin 'unlocks the cell' to allow glucose to enter
5. Glucose enters the cell and is used for fuel
6. Blood glucose is maintained (homeostasis)

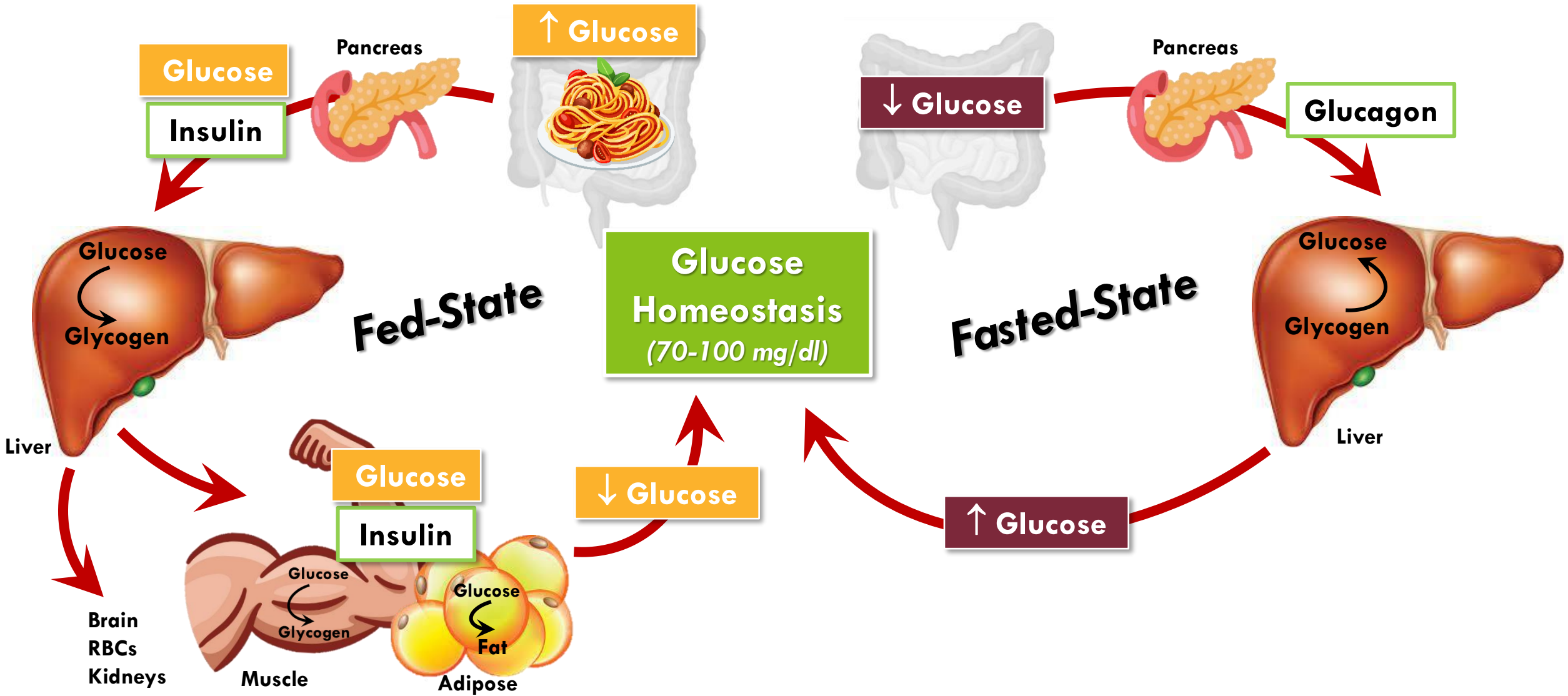


Glucose Regulation

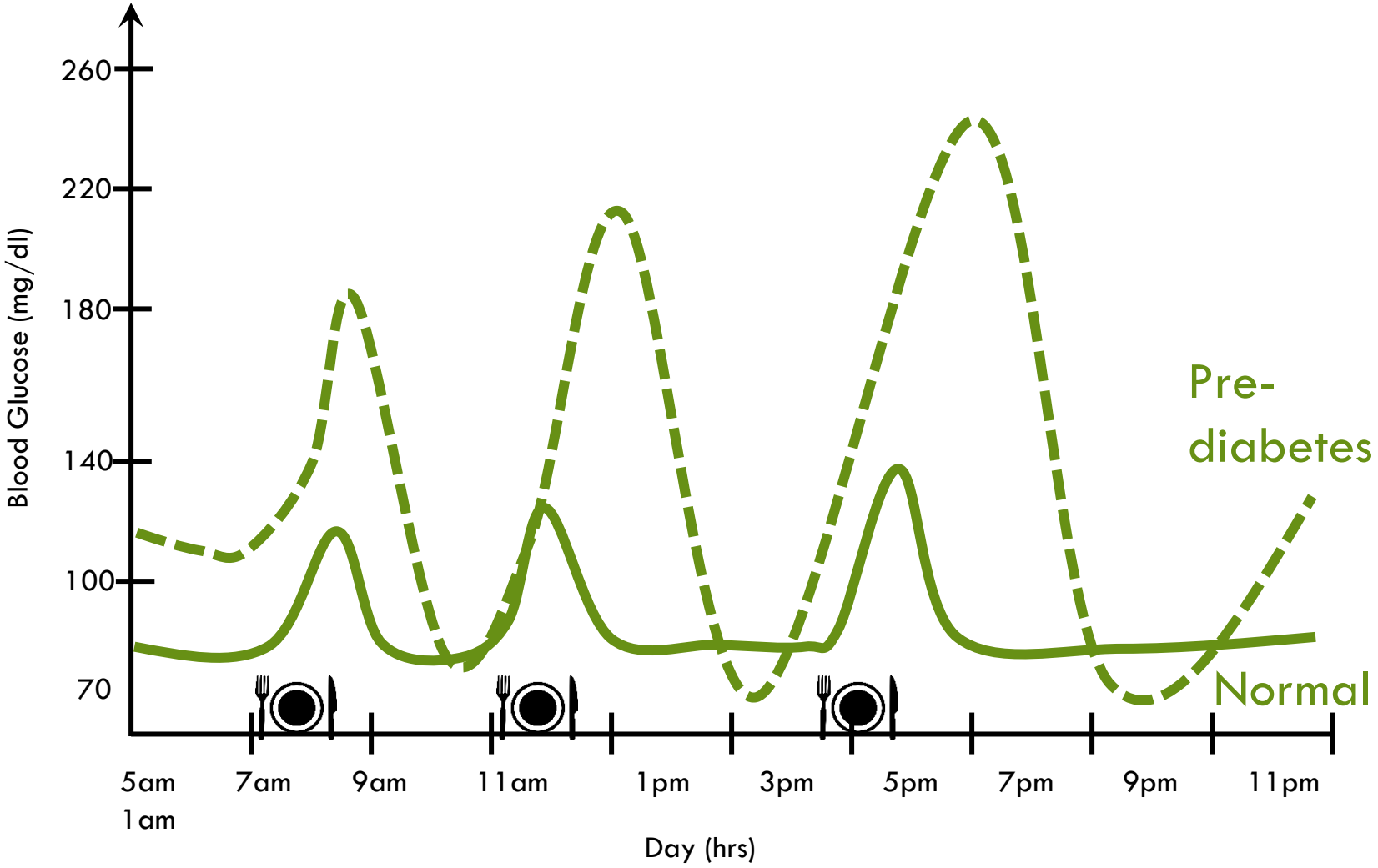
- In the fasted state, glucose is regulated by glucagon:
  - Pancreas senses low blood glucose and releases glucagon
  - Glucagon stimulates the liver to convert glycogen (stored form) to glucose



Glucose Regulation - Summary



Glucose Dysregulation

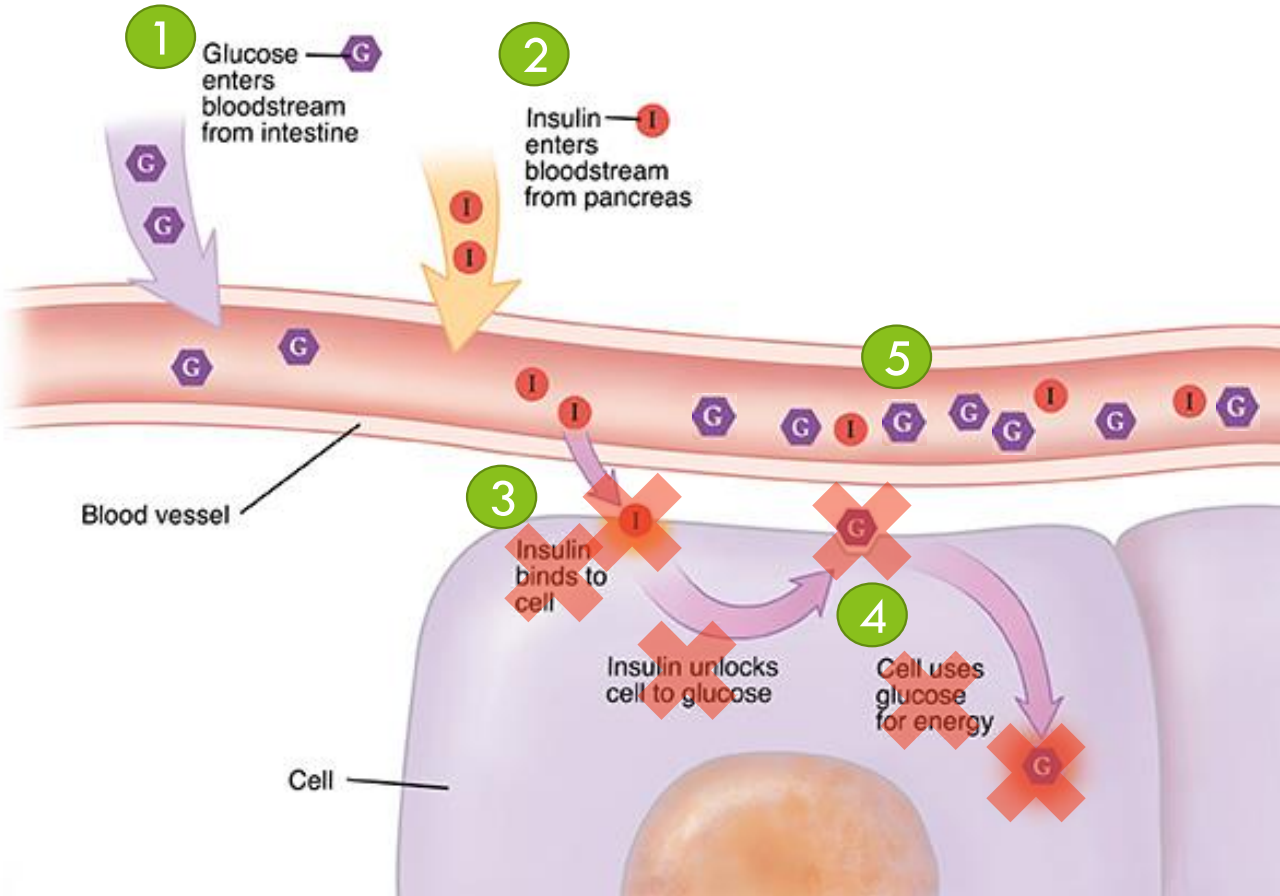


Glucose Dysregulation

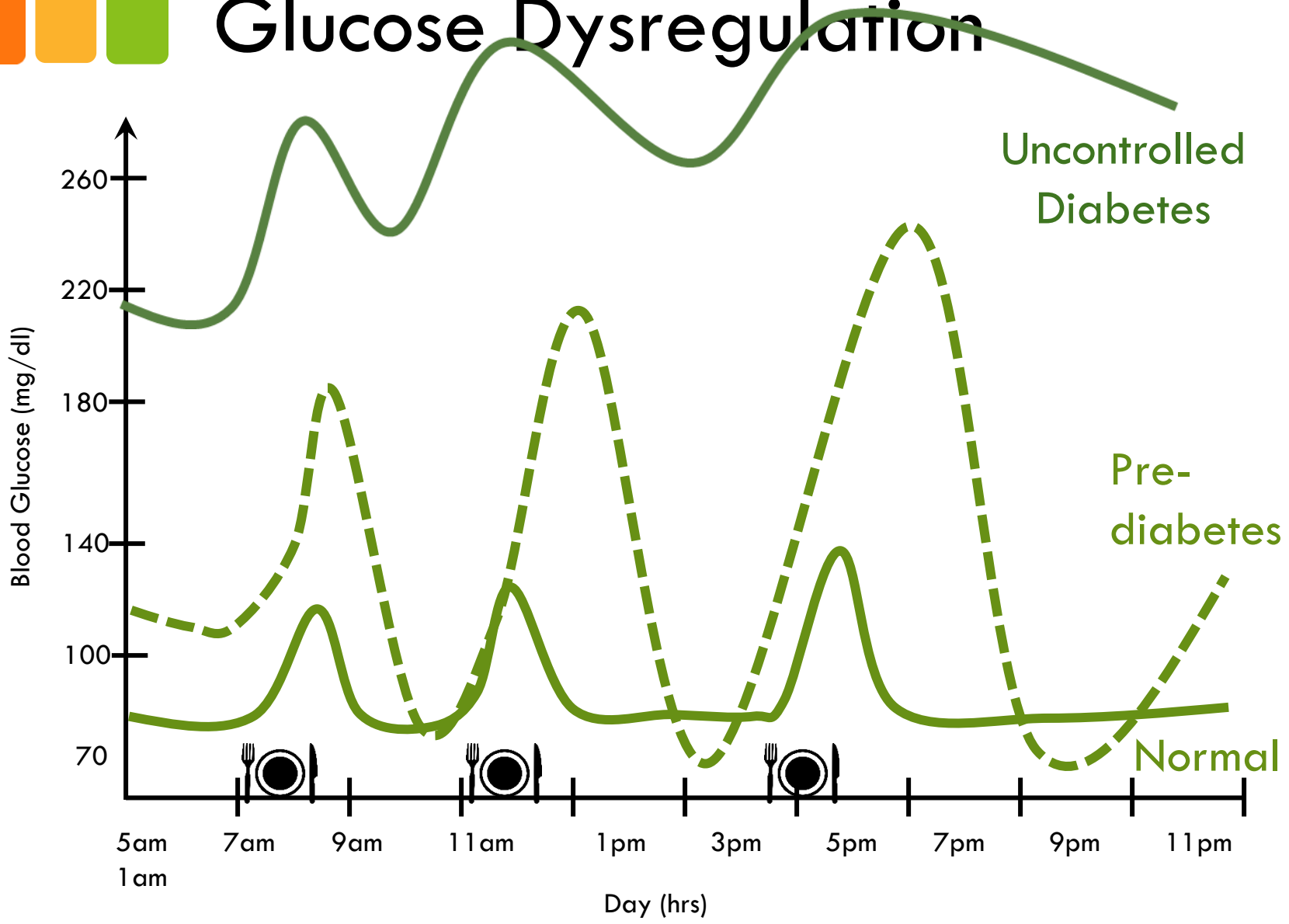
Early Phase*:

1. Glucose enters the bloodstream from the intestine
2. Pancreas senses high blood glucose and releases insulin into the bloodstream, BUT
3. The cell does not always respond to insulin and sometimes does not 'unlock' to allow glucose to enter
4. Glucose cannot be used for fuel, remains in bloodstream
5. Blood glucose starts to rise

*Gradual process…



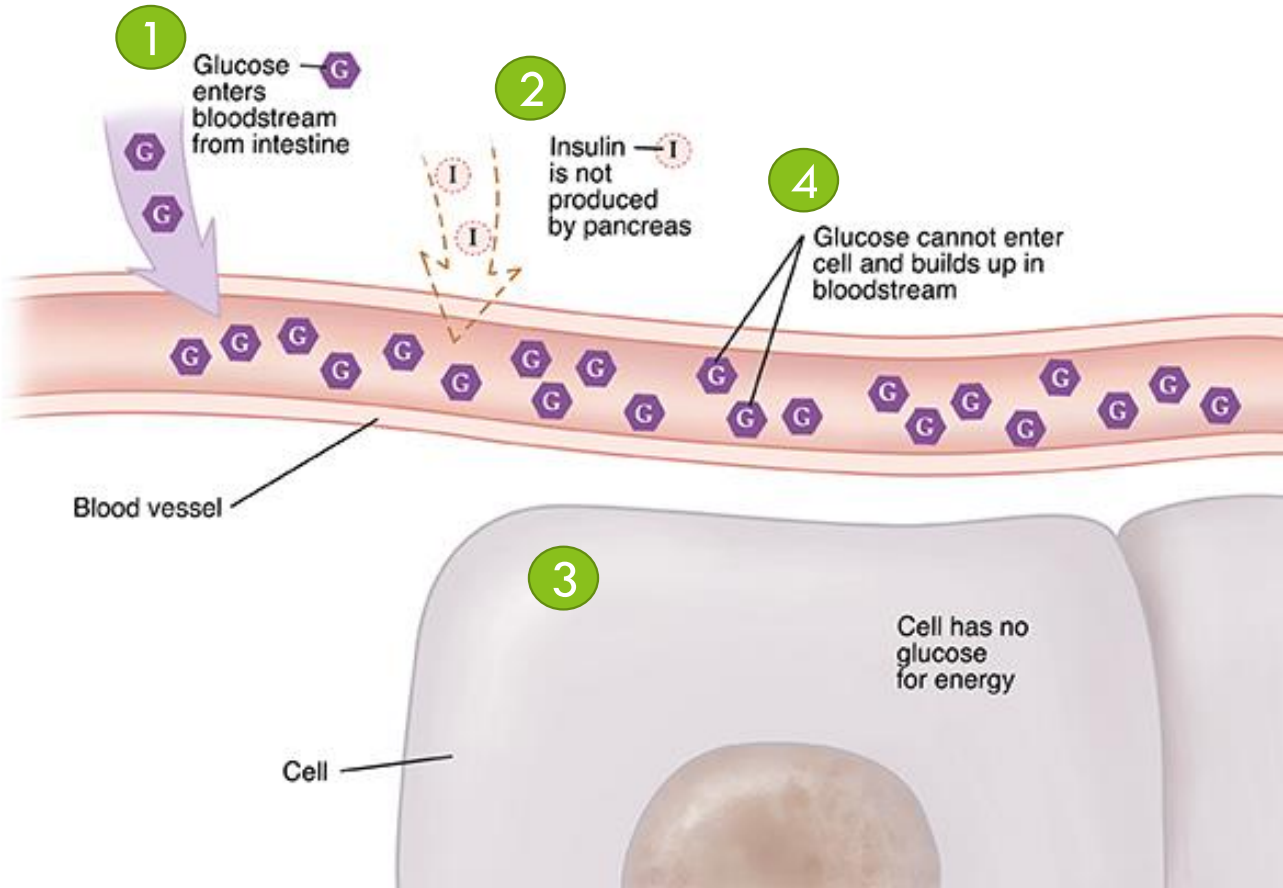
Glucose Dysregulation



Glucose Dysregulation

End Phase:

1. Glucose enters the bloodstream from the intestine
2. Pancreas stops sensing high blood glucose and no longer releases insulin into the bloodstream
3. Glucose cannot enter cells, therefore cells have no energy supply
4. Blood glucose rises



Glucose Dysregulation

- Diabetes: disease in which the body's ability to respond to or produce insulin is impaired, leading to elevated blood glucose
  - Type 1 diabetes:
    - ✓ Autoimmune disease → body destroys pancreas
    - ✓ No insulin production
  - Type 2 diabetes:
    - ✓ Preventable condition
    - ✓ Cells of the body do not respond to insulin
    - ✓ Eventually the pancreas quits producing insulin
    - ✓ Risk Factors: age, physical activity, family history, high blood pressure, overweight (poor diet quality)

Fasting Blood Glucose is a **biomarker** of metabolic health

Health State	Fasting Blood Glucose
Normal	70-100 mg/dL
Prediabetes	100-125 mg/dL
Diabetes	>125 mg/dL
Hypoglycemia	<70 mg/dL

Glucose Dysregulation

- Diabetes: disease in which the body's ability to respond to or produce insulin is impaired, leading to elevated blood glucose
  - Type 1 diabetes:
    - ✓ Autoimmune disease → body destroys pancreas
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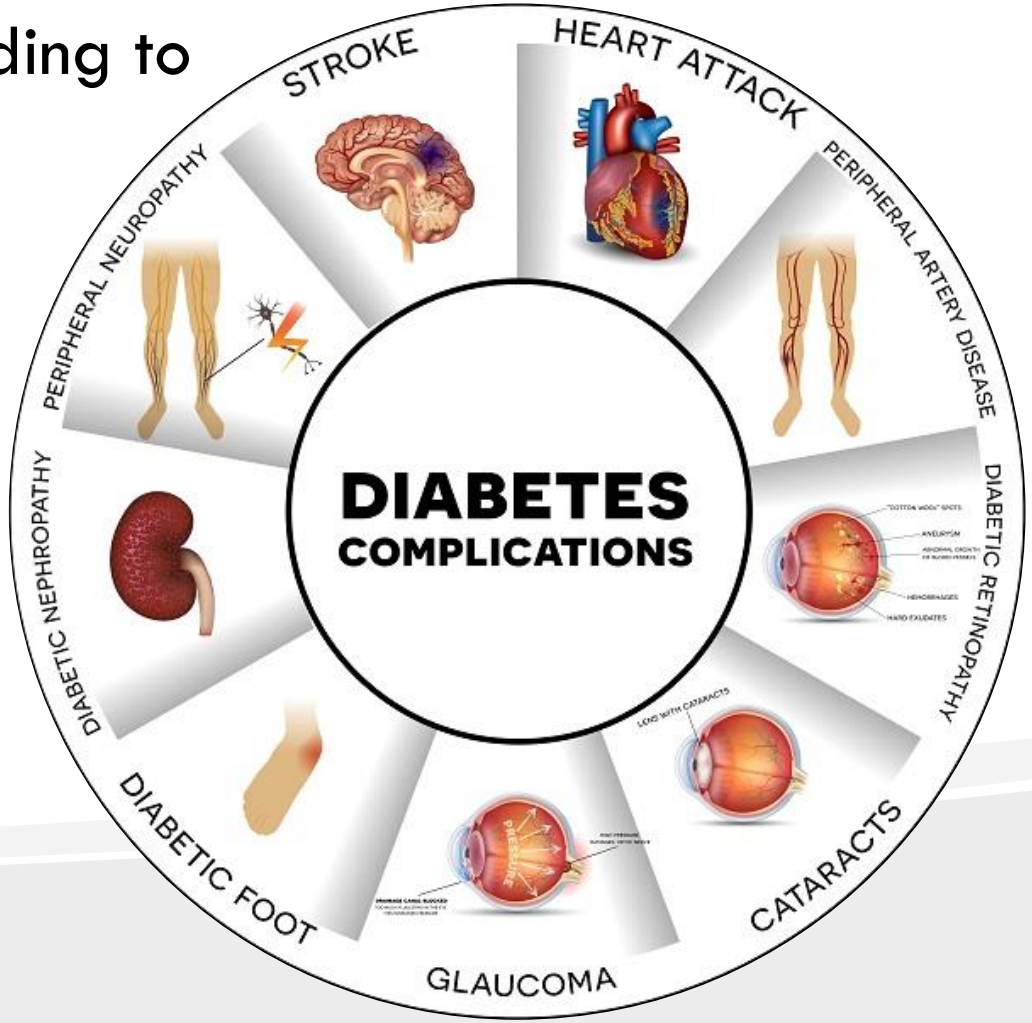


CHO DRIs

- RDA is set to meet brain needs
  - AMDR (lower range) set to include whole-body requirements
  - RDA ≠ AMDR (lower range)
- No UL → CHOs aren't toxic, but…
- AMDR (upper range) set to prevent excess CHO intake → obesity

Total CHOs DRIs (19-30yo)		
RDA	**AMDR**	**UL**
130 g/d	45-65%	N/A

Example CHO amounts within AMDR for a 2000 kcal diet:

- ✓ 2000 kcal x 0.45 (AMDR lower range) = 900 kcal/4 kcal/g = 225 g/d
- ✓ 2000 kcal x 0.65 (AMDR upper range) = 1300 kcal/4 kcal/g = 325 g/d

CHO DRIs and Habitual Intake

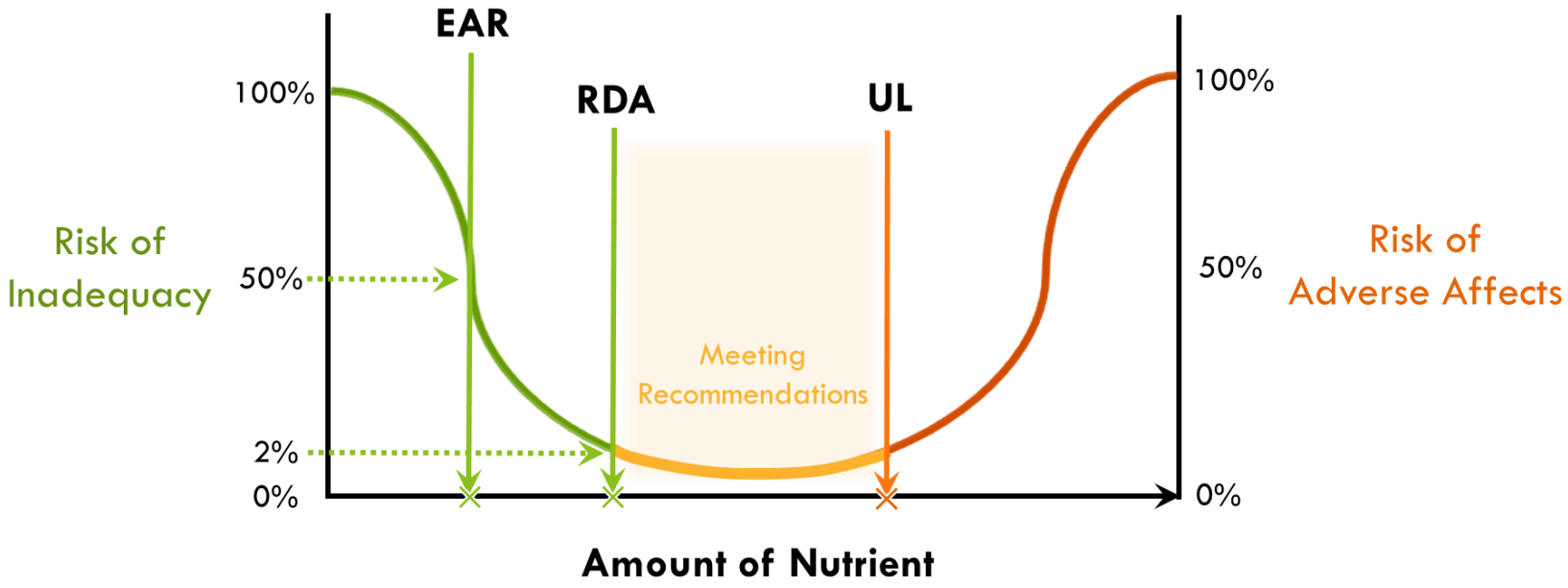
- RDA is set to meet brain needs
  - AMDR (lower range) set to include whole-body requirements
  - RDA ≠ AMDR (lower range)
- No UL → CHOs aren't toxic, but…
- AMDR (upper range) set to prevent excess CHO intake → obesity

Total CHOs DRIs (19-30yo)		
RDA	AMDR	UL
130 g/d	45-65%	N/A

Habitual Intake (19-30yo)	
250 g/d	50%

Instapoll

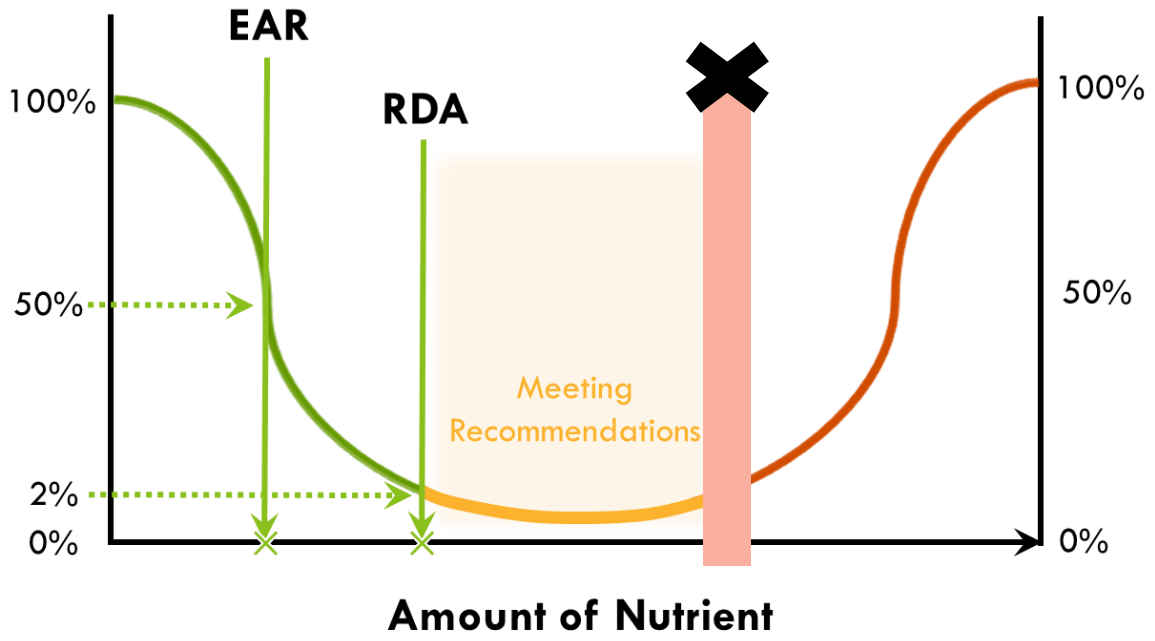
Based on the DRI recommendations and habitual intake data, which statement is correct for <u>total CHO intake</u>?



- We are not meeting DRIs because we are below the RDA
- We are not meeting DRIs because we are above the RDA
- We are meeting DRIs because we are above the RDA & there is no UL
- There are no DRIs for CHO

CHO Habitual Intake

Total CHOs DRIs (19-30yo)			Habitual Intake (19-30yo)	
RDA	AMDR	UL		
130 g/d	45-65%	N/A	250 g/d	50%



- In the US, we **are** meeting carbohydrate DRIs because we are above the RDA and there is no UL
- What about CHO *quality*…?

Fiber DRIs

- Recommendations for TOTAL fiber
  - No separate soluble/insoluble recommendations

	Total Fiber DRIs (19-30yo)	
	RDA	UL
Males	34 g/d	N/A
Females	28 g/d	N/A

Food labels:
2.5g/serving = "good source"
5g/serving = "excellent source"

Health Benefits: Soluble Fiber

- Fiber-rich foods: fruits, vegetables, and whole grains

1) Decreases risk of heart disease:
   - Lowers blood cholesterol by binding to bile (which is made from cholesterol) causing cholesterol to be excreted
   - Leads to reductions in blood pressure and inflammation

2) Decreases risk of Type 2 diabetes:
   - Slows glucose absorption by decreasing gastric transit time

3) Decreases risk of colorectal cancers:
   - Removes cancer-causing agents
   - Activates cancer-killing molecules
   - Inhibit inflammation via bacterial fermentation

4) Aids in weight management:
   - Increases satiety by decreasing gastric transit time and increased feelings of fullness due to water binding with fiber

Health Benefits: Insoluble Fiber

- Fiber-rich foods: fruits, vegetables, and whole grains

1) Improves gut function and prevents constipation by:
   - Increasing fecal weight
   - Easing passage through the colon
   - Decreasing pressure/strain on GI muscles
2) Decreases risk of colorectal cancers:
   - Removes cancer-causing agents
3) Aids in weight management:
   - Increases satiety by decreasing gastric transit time and increased feelings of fullness due to water binding with fiber

Fiber: Habitual Intake

- In the US, we do **not** meet fiber recommendations (DRIs)

	Total Fiber DRIs (19-30yo)	
	RDA	UL
Males	34 g/d	N/A
Females	28 g/d	N/A

	Habitual Intake (19-30yo)
Males	17 g/d
Females	16 g/d

Vegetables - DGAs

Food Groups	CALORIE Level (within the Healthy US Dietary Pattern)											
	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
Vegetables (cup eq/day)	1	1 ½	1 ½	2	2 ½	2 ½	3	3	3 ½	3 ½	4	4

- Choose a variety within each of the 5 vegetable categories:
  - ✓ Dark-green: Spinach, Broccoli, Kale, Romaine, Brussels Sprouts
  - ✓ Red & orange: Red/Orange Bell Peppers, Sweet Potatoes, Carrots
  - ✓ Beans, peas, lentils: Black Beans, Black-eyed Peas, Red, Brown, Green Lentils
  - ✓ Starchy: Corn, Plantains, White Potatoes
  - ✓ Other: Avocado, Cauliflower, Cucumbers, Onions
- Include veggies with **soluble fiber** &/or insoluble fiber

Vegetables - DGAs

Food Groups	CALORIE Level (within the Healthy US Dietary Pattern)											
	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
Vegetables (cup eq/day)	1	1 ½	1 ½	2	2 ½	2 ½	3	3	3 ½	3 ½	4	4

- Choose a variety within each of the 5 vegetable categories:
  - ✓ Dark-green: Spinach, Broccoli, Kale, Romaine, Brussels Sprouts
  - ✓ Red & orange: Red/Orange Bell Peppers, Sweet Potatoes, Carrots
  - ✓ Beans, peas, lentils: Black Beans, Black-eyed Peas, Red, Brown, Green Lentils
  - ✓ Starchy: Corn, Plantains, White Potatoes
  - ✓ Other: Avocado, Cauliflower, Cucumbers, Onions
- Include veggies with **soluble fiber** &/or insoluble fiber
- Be mindful of kcals with starchy foods & beans, peas, lentils
  - *Remember that beans, peas, & lentils also are higher in protein & fiber*

Fruit - DGAs

Food Groups	CALORIE Level (within the Healthy US Dietary Pattern)											
	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
Fruits (cup eq/day)	1	1	1 ½	1 ½	1 ½	2	2	2	2	2 ½	2 ½	2 ½

- Choose a variety, especially high in soluble / insoluble fiber and with less sugar
  - ✓ High soluble fiber: Pears, Nectarines, Apricots, Apples, Oranges, Bananas
  - ✓ High insoluble fiber: Grapes, Kiwi, Berries, Pineapple, Guava
- Fruit mainly contains mostly natural sugar and fiber
- Most sugar in fruit is fructose (similar to added sugars)
  - ✓ *Foods with added sugar tend to have high amounts*
  - ✓ *Eat in moderation (even fruit)*
  - ✓ *Fruits differ in sugar content: **lower-sugar**; higher sugar*

Fruit - DGAs

Food Groups	CALORIE Level (within the Healthy US Dietary Pattern)											
	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
Fruits (cup eq/day)	1	1	1 ½	1 ½	1 ½	2	2	2	2	2 ½	2 ½	2 ½

- Choose a variety, especially high in soluble / insoluble fiber and with less sugar
  - ✓ High soluble fiber: Pears, Nectarines, Apricots, Apples, Oranges, Bananas
  - ✓ High insoluble fiber: Grapes, Kiwi, Berries, Pineapple, Guava
- Fruit mainly contains mostly natural sugar and fiber
- Most sugar in fruit is fructose (similar to added sugars)
  - ✓ *Foods with added sugar tend to have high amounts*
  - ✓ *Eat in moderation (even fruit)*
  - ✓ *Fruits differ in sugar content: **lower-sugar**; higher sugar*

Dairy - DGAs

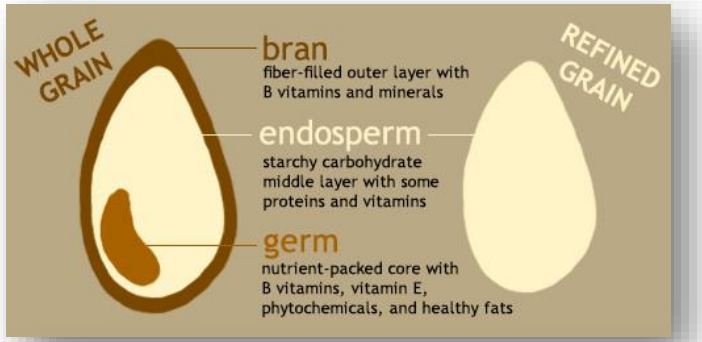
Food Groups	CALORIE Level (within the Healthy US Dietary Pattern)											
	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
Dairy (cup eq/day)	2	2 ½	2 ½	3	3	3	3	3	3	3	3	3

- Recommendations only include versions that:
  - Are low-fat (1%) or fat-free (skim)
  - Have no added sugar
- No fiber or starch; CHOs in dairy are sugar (lactose)
- Foods/Beverages include:
  - ✓ Milk (lactose-free/ultra-filtered)
  - ✓ Yogurt (Greek/American)
  - ✓ Cheese (including cottage cheese)
  - ✓ Soy alternatives (others are not recommended)

Grains - DGAs

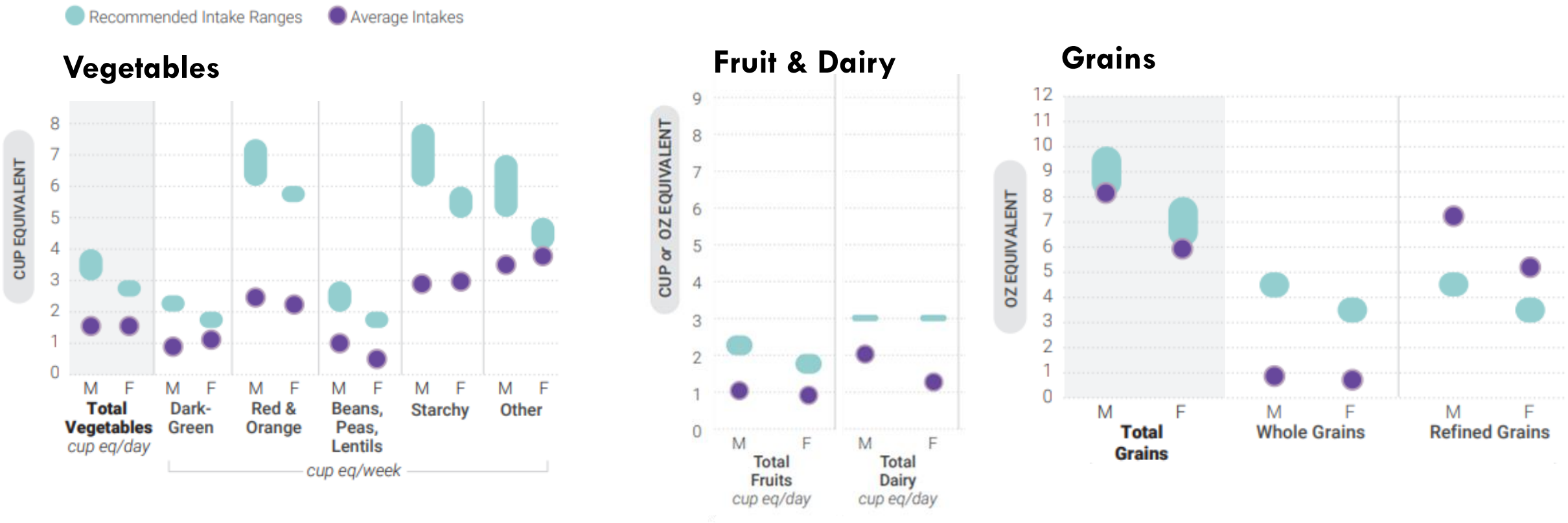
Food Groups	CALORIE Level (within the Healthy US Dietary Pattern)											
	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
TOTAL GRAINS (oz eq/day	**3**	**4**	**5**	**6**	**6**	**6**	**7**	**8**	**9**	**10**	**10**	**10**
½ as Whole Grains (oz eq/day)	*1 ½*	*2*	*2 ½*	*3*	*3*	*3*	*3 ½*	*4*	*4 ½*	*5*	*5*	*5*

- ½ of grains consumed should be whole grains
  - ✓ High soluble fiber: Barley, Oats, Rye,
  - ✓ Hight insoluble fiber: Brown Rice, Wheat, Quinoa
- Check labels – look for:
  - ✓ Fiber content
  - ✓ Order of ingredients
  - ✓ Whole grain stamps



CHO Food Groups: Habitual Intake

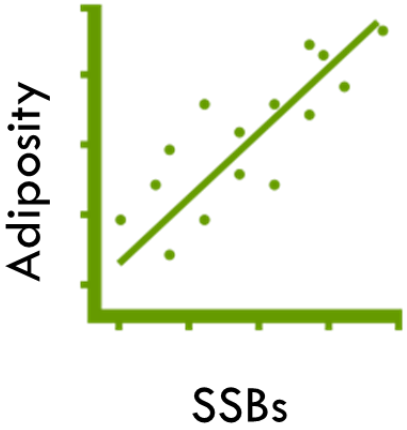
- In the US, we do **not** meet most carbohydrate-rich food group recommendations (DGAs)



In Real Life

Added Sugars and Health Risk

- Added Sugar: Sugars and syrups added to foods/ beverages during processing
  - Sucrose (glucose and fructose) or
  - High-fructose corn syrup
    - Sugar-sweetened Beverages (SSBs):
      - Moderate evidence that increased SSB consumption is associated with increased adiposity (in children)



- Sugar on the Brain?

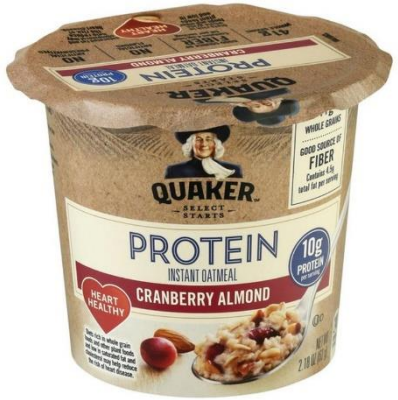
Instapoll

Added sugar is everywhere, even “healthy” breakfast foods

- Which of the following breakfast foods has the most added sugar?

Whole Grain Cereal

Greek Yogurt



High-Protein Oatmeal

Breakfast Bar

All have the same amount

Added Sugars – DRIs + DGAs

- DRIs: No RDA, AI, or UL for *Total Sugar* or *Added Sugar*
- DGA recommendations for added sugar are based on:
  - No *direct evidence* related to health (except for dental caries)
- Recommendations: <10% of daily energy intake from added sugar
- Remember: included in discretionary calories
  - Discretionary calories: "allowance" left over after nutrient needs are met from whole food groups

Food Groups/Subgroups	CALORIE Level (within the Healthy US Dietary Pattern)											
	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000	3200
Limit on 'Discretionary' Calories for Other Uses (kcal/day)	<100	<120	<140	<160	<180	<200	<220	<240	<260	<280	<300	<320

Added Sugars - Habitual Intake

- In the US, we do **not** meet added sugar recommendations

13% daily intake (~300 kcal/d)

Top Sources of Added Sugars: