


Milk - What's in it for you?

Jana Kraft, Ph.D.

Department of Animal Science, University of Vermont

VDIA/VFD Fall Conference

September 16, 2014

Composition of cows' milk

Minerals (Ash)	0.7 %
Protein	3.3 %
Carbohydrate (Lactose)	4.8 %
Fat	3.8 %

Solids

Water	87.4 %

Milk is a naturally nutrient-dense food

→ Supply a high concentration of many nutrients in relation to its energy (caloric) value

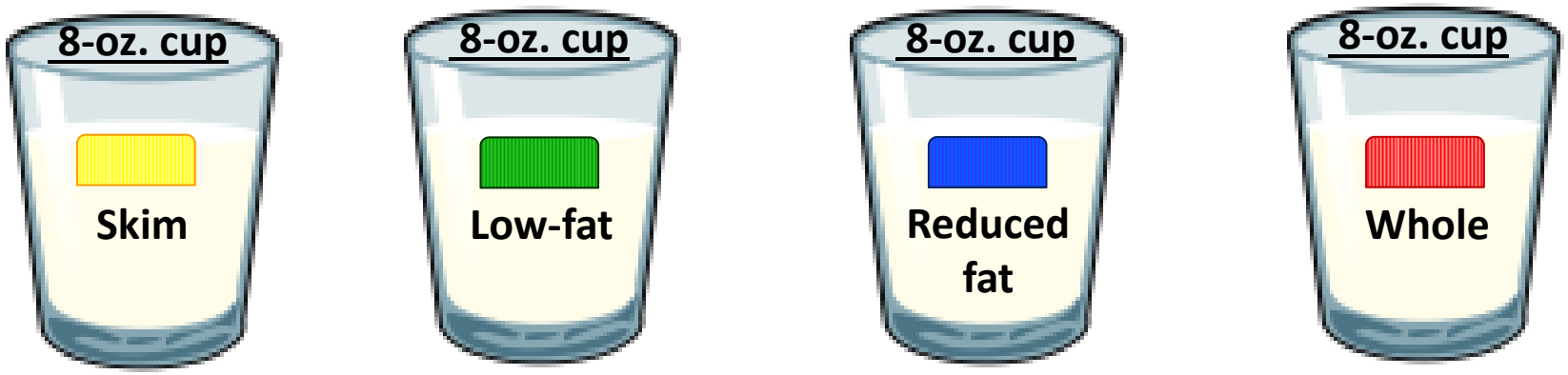
Nutrient	%
Energy	9.1
Protein	19.4
Fat	11.8
Carbohydrate	4.5
Calcium	72.2
Phosphorus	32.7
Vitamin A	22.1
Vitamin B12	20.3

Source: USDA, Economic Research Service

Nutrient contribution of dairy to the U.S. food supply (per capita)

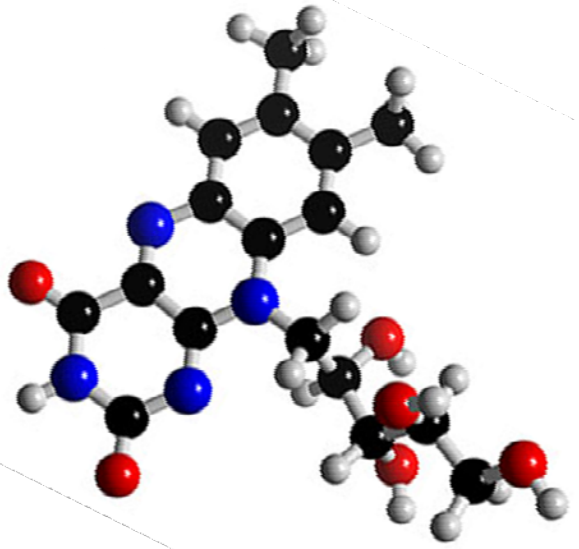
Milk's calories depend on its fat content

- Fat-free (Skim, Nonfat) < **0.5% fat**
- Low-Fat **1% fat**
- Reduced-Fat **2% fat**
- Whole **3.25% fat**



90 calories **102 calories** **122 calories** **146 calories**

Vitamins in milk



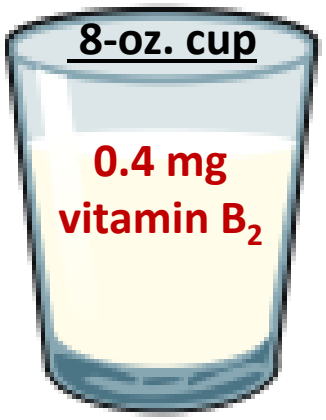
- **Fat-Soluble Vitamins**

  - Vitamins **A**, (D), E, and K

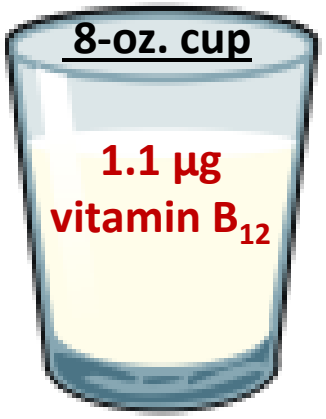
- **Water-Soluble Vitamins**

  - Vitamins **B_1**, **B_2**, B_6, **B_{12}**, C, pantothenic acid, niacin, biotin, and folic acid

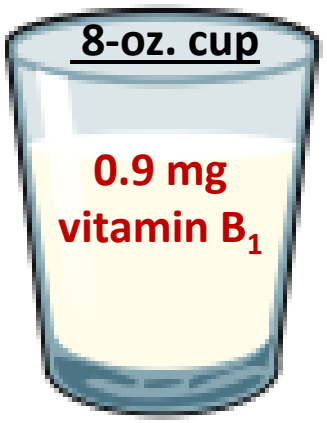
Milk contains appreciable amounts of B vitamins



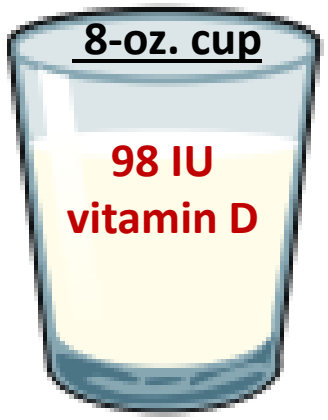
26% daily value



22% daily value



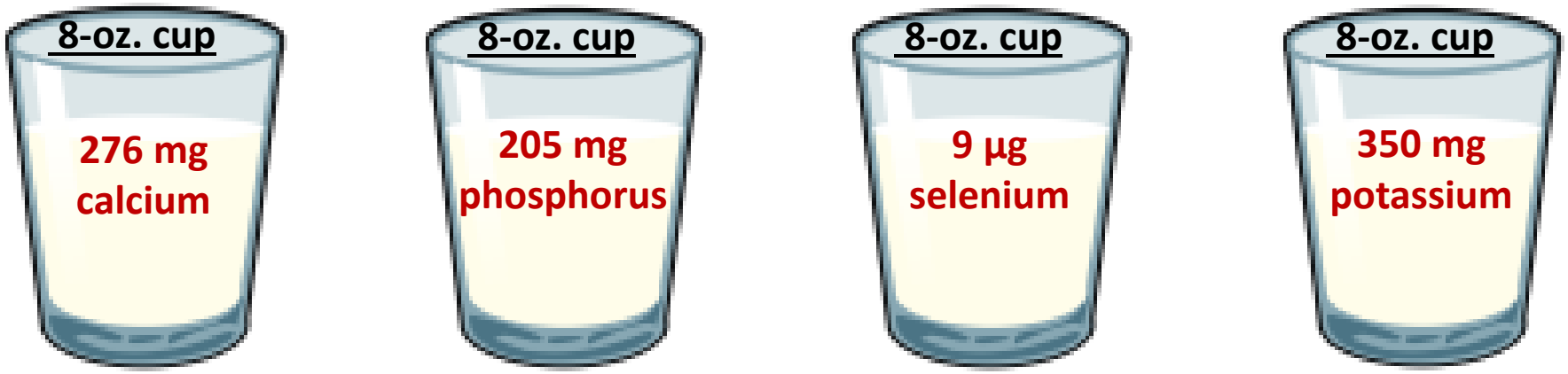
15% daily value



24% daily value

Milk is an important source of minerals

- Contains **calcium**, **phosphorus**, selenium, potassium, zinc, and magnesium



Milk Protein

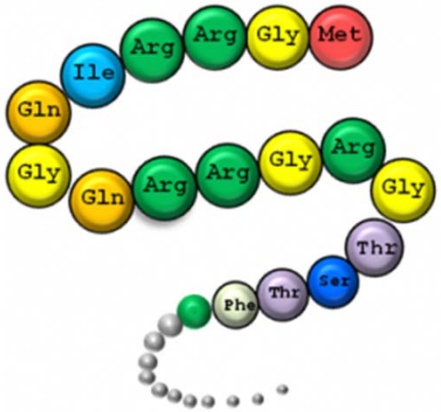
Cow's milk protein is a heterogeneous mixture of high-quality protein

→ **Provides 16% of the daily value**

High quality source of amino acids

Protein	Content (%)
Caseins	**80**
α_{S1}-casein	32
α_{S2}-casein	8
β-casein	32
κ-casein	8
Whey proteins	**20**
β-lactoglobulin	12
α-lactalbumin	4
Immunoglobulins	3
Serum albumin	1

Milk is a source of “high biological value” protein

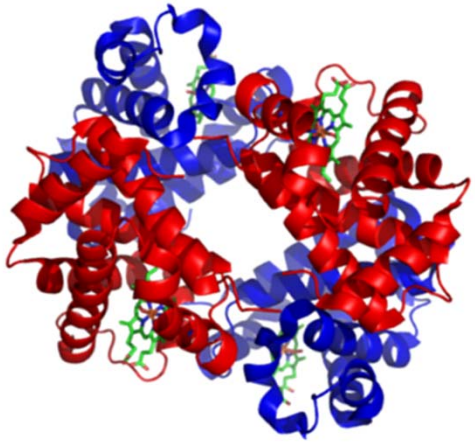


→ Contains **all nine essential amino acids** in proportions resembling amino acid requirements

→ Used as a **standard reference protein** to evaluate the nutritive value of other food proteins

Individual milk proteins have been shown to exhibit a wide range of beneficial functions

- Glycemic control and weight management (Anderson et al. Nestle *Nutr Workshop Ser Pediatr Program*, 2011)
- Food intake regulation and satiety (Luhovyy et al., *J Am Coll Nutr*, 2007)
- Muscle metabolism (Tipton et al., *Med Sci Sports Exerc*, 2004)
- Hypertension (Jauhiainen & Korpela, *J Nutr*, 2007)
- Reduction of dental caries (Aimutis, *J Nutr*, 2004)



The A2 milk case

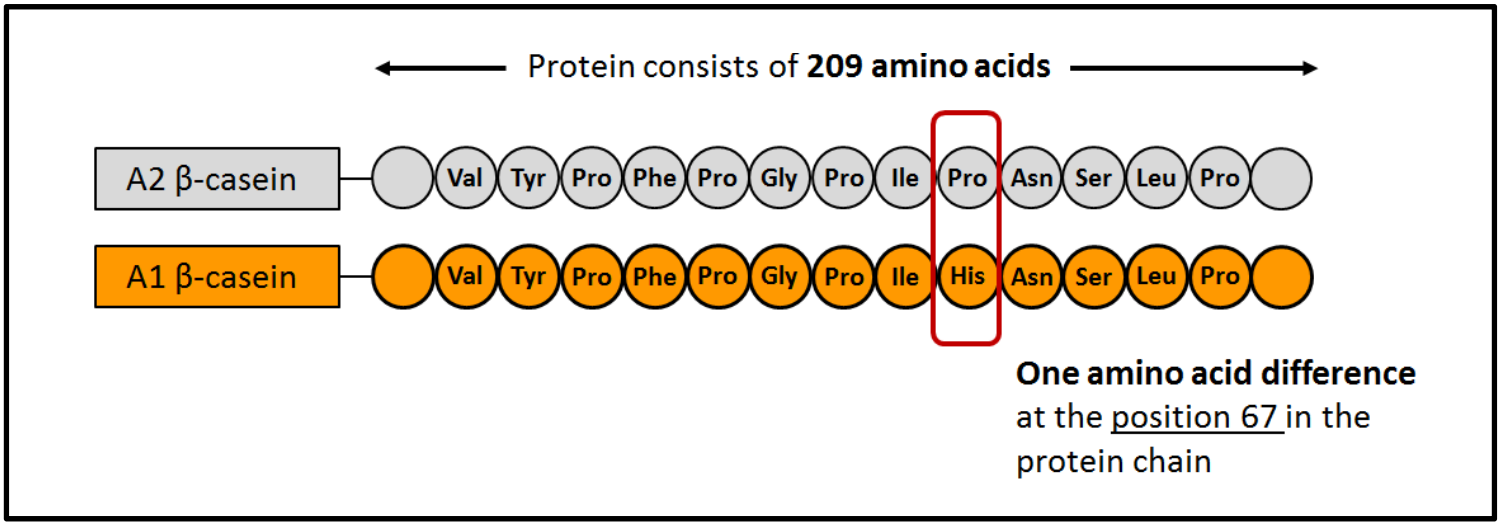
- Commercialized by A2 Corporation
- Available in New-Zealand, Australia, and UK
- Contains **only** the **A2 type of β-casein** but no A1 type of β-casein

Claim

Milk containing A1 β-casein proteins is harmful to human health whereas milk containing only A2 β-casein is better for health

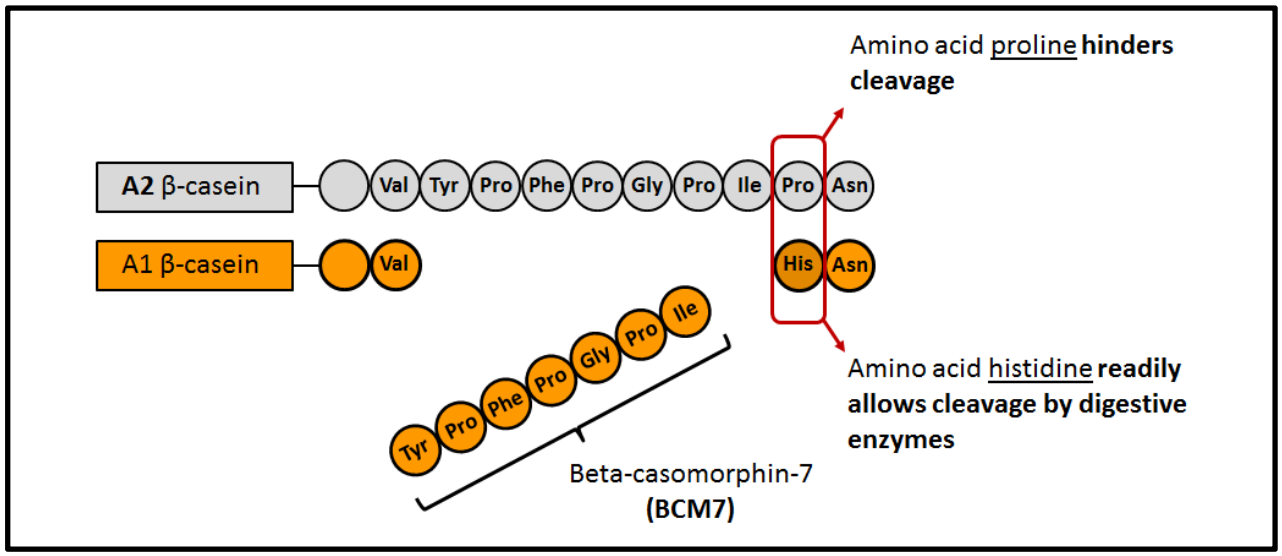
The A2 milk case

- A1 type and A2 type of β-casein differ by **one** amino acid

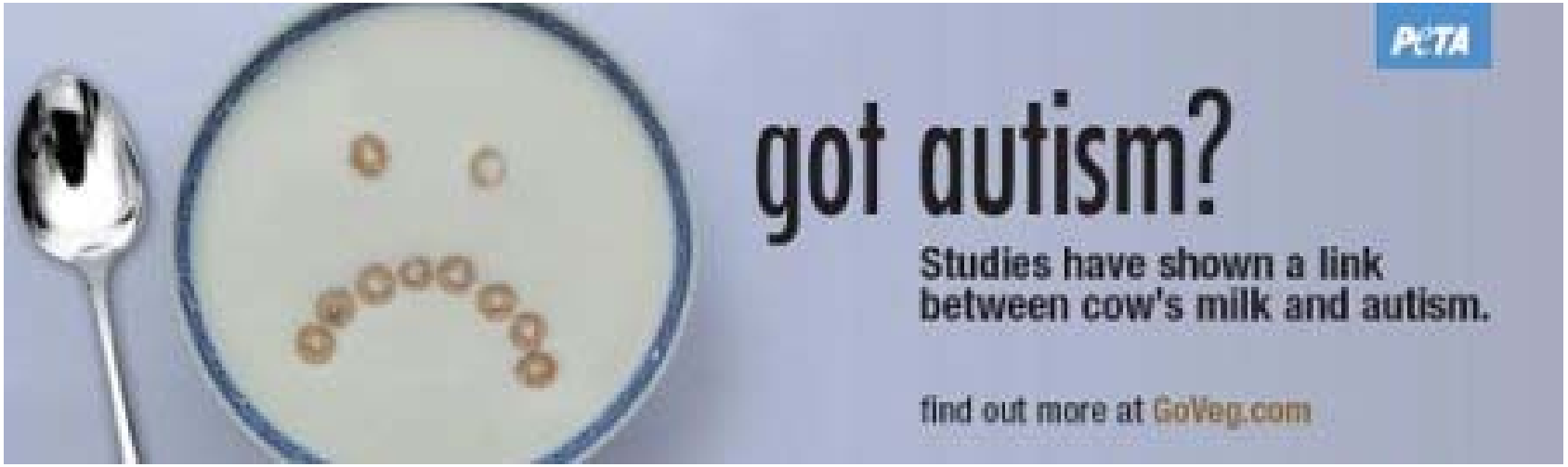


- Difference originated as a **mutation** that occurred ~5,000-10,000 years ago
- Prevalence of the A1 and A2 β-casein protein varies between herds of cattle and countries

Studies in cells found that A1 and A2 β-casein proteins are processed differently and thus posses different health effects



- "BCM7" has been suggested to contribute to an increased risk for certain diseases such as type 1 diabetes, heart disease, schizophrenia, and autism


PETA
got autism?
Studies have shown a link
between cow's milk and autism.
find out more at GoVeg.com


PETA
got autism?
Studies have shown a link
between cow's milk and autism.
find out more at

A2 company's claims were not confirmed by European Food Safety Authority

"Based on the present review of available scientific literature, a cause-effect relationship between BCM7 and etiology or cause of any suggested non-communicable diseases cannot be established."

EFSA Scientific review, 2009
http://www.efsa.europa.eu/en/efsajournal/doc/231r.pdf

→ **Advertising/health claims by A2 corporation are misleading**

Milk allergy is a food allergy

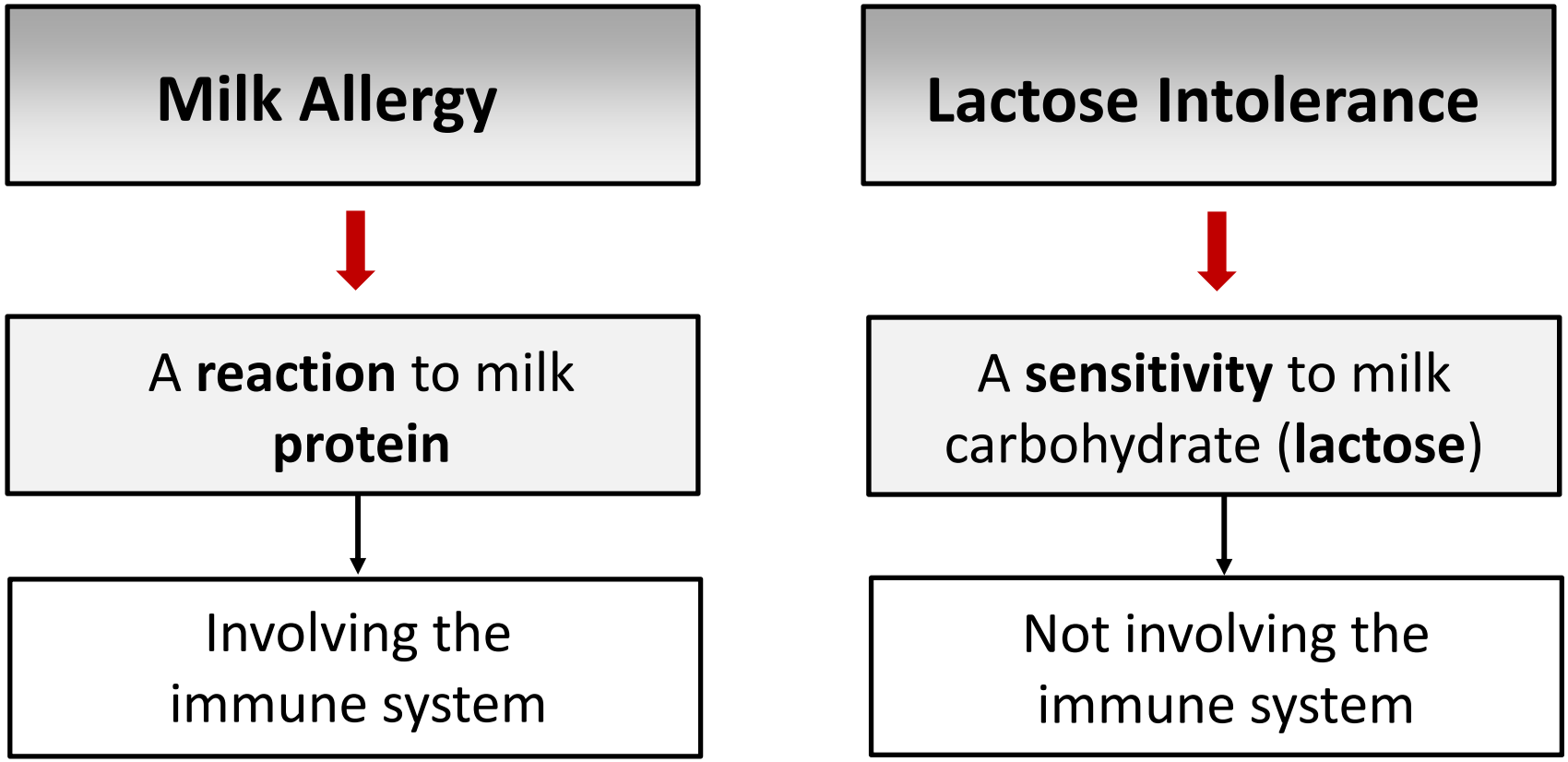
→ **An abnormal response by the body's immune system to the protein found in dairy**

- Most common food allergy in early childhood (present in about **2 - 5% of children**)

  → 85 - 90% of affected children **lose clinical reactivity** to milk once they surpass 3 years of age

- Prevalence in **adults** is between **0.1% and 0.5%**

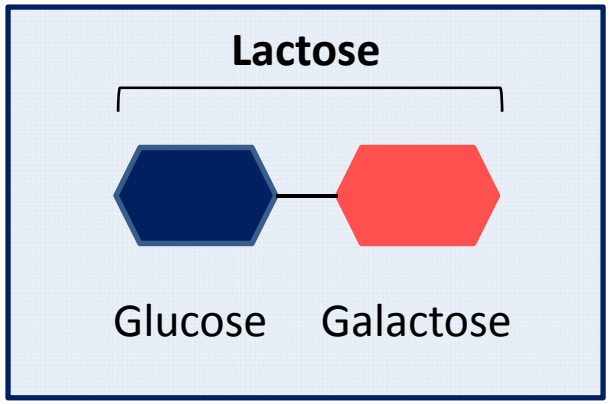
Milk allergy should not be confused with lactose intolerance

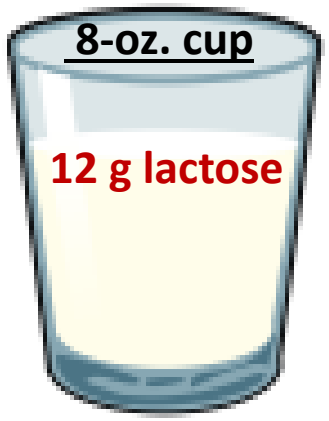


Milk Carbohydrate

Lactose is the primary carbohydrate in milk

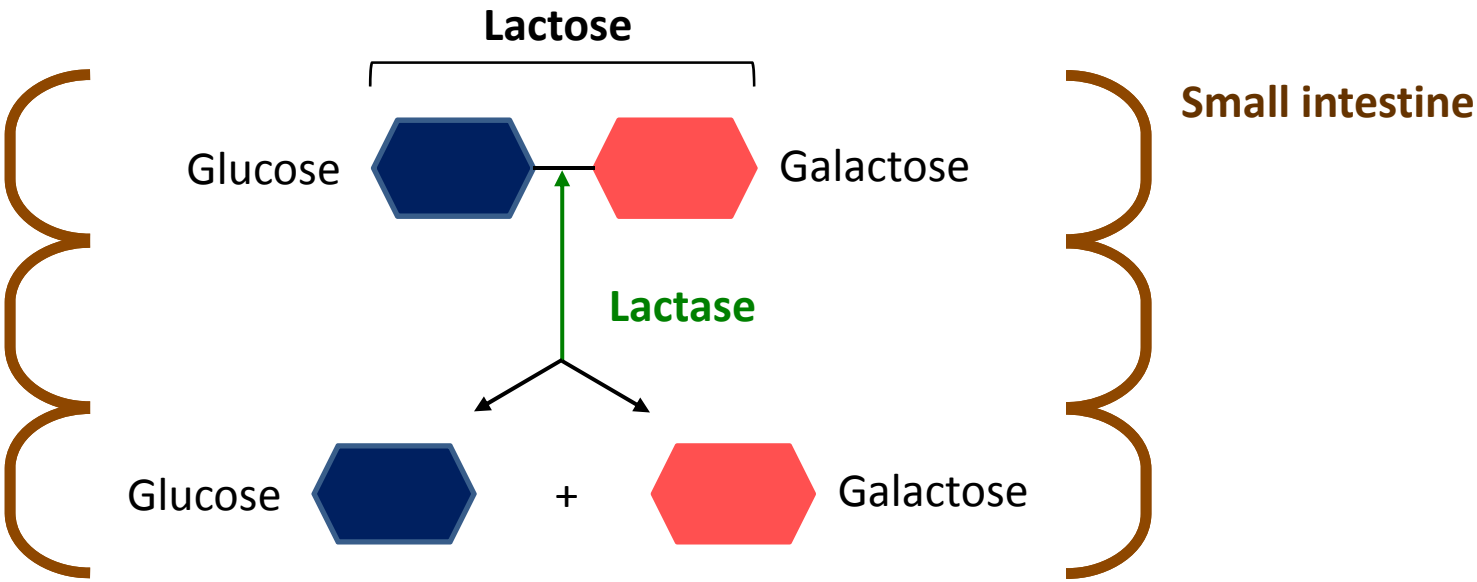
- Milk contains ~4.8% carbohydrate that is predominately **lactose**



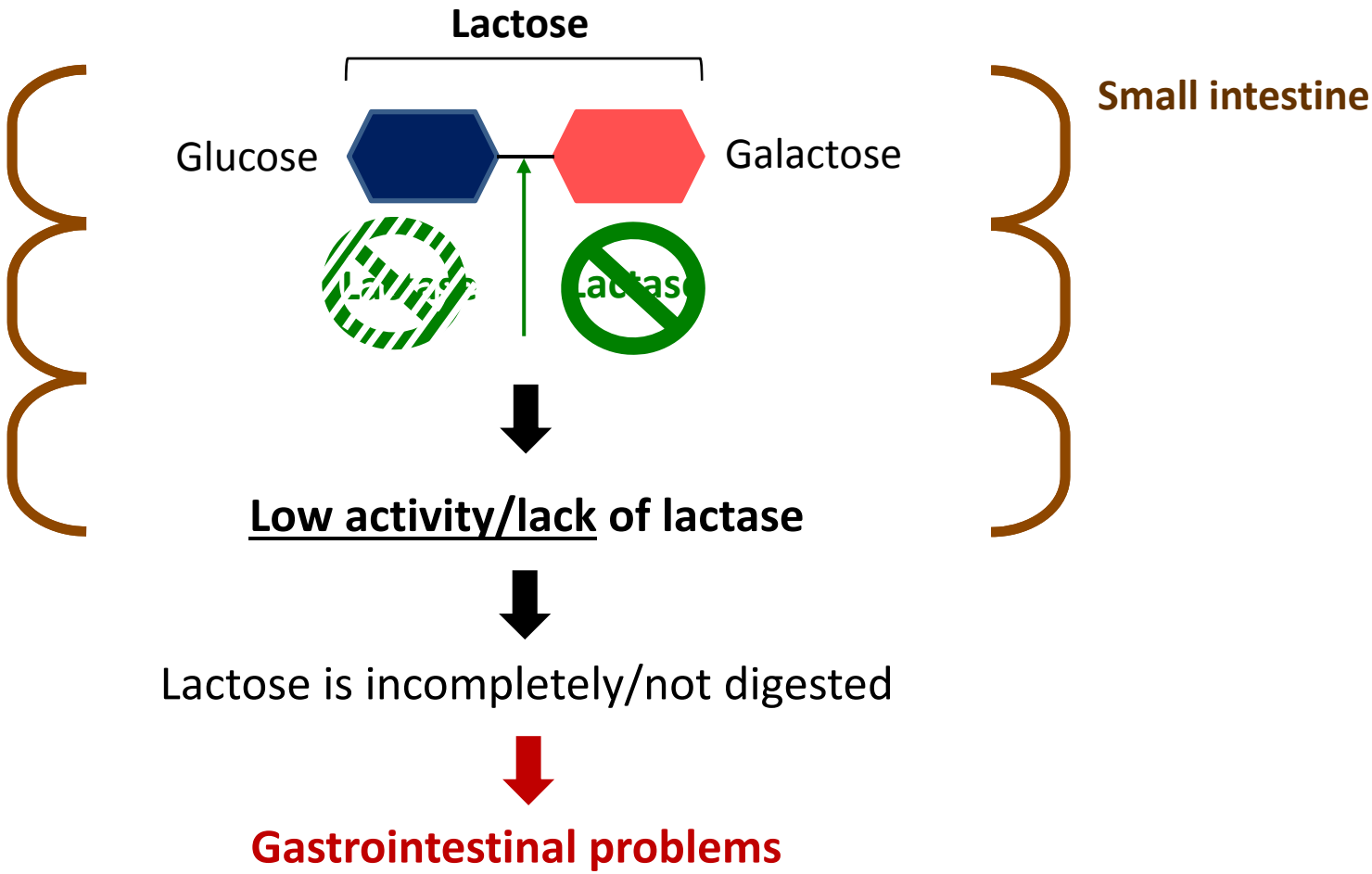


- In the human body lactose is an excellent **source of energy**

Lactose needs to be broken down before the body can use it

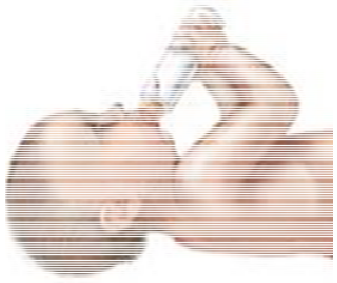


Lactose intolerance is the impaired ability to digest lactose



Lactose intolerance is not a disease, but rather the normal physiologic pattern

Infant



- produces lactase
- successfully digests lactose provided by human milk

after weaning

Toddler

- a genetically programmed decrease in lactase occurs in most children worldwide

Only 35% of the human population can digest lactose

Ethnic Group	% with Lactose Intolerance
Northern Europeans	2-15
American Whites	6-22
Central Europeans	9-23
Indians (Indian Subcontinent)	
Northern	20-30
Southern	60-70
Hispanics	50-80
Ashkenazi Jew	60-80
Blacks	60-80
American Indians	80-100
Other Asians	95-100

Adapted from: Schaafsma, *Int Dairy J* 18, 2008; Harrington & Mayberry, *Int J Clin Pract*, 2008

Persistence of significant lactase activity into adult life in European populations is a mutation

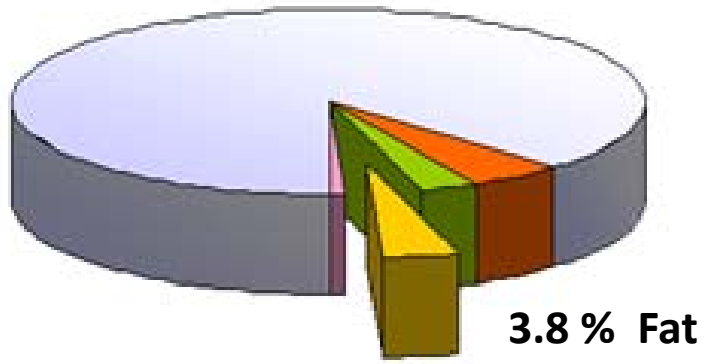
- Due to the introduction of a dairy-based culture in some populations 10,000 years ago

- Mutation responsible for that may be between 2,000 and 12,000 years old (estimates vary)

Malmstrom et al. *BMC Evol Biol*, 2010

Milk Lipids (Fat)

Commercial whole milk is 97 % fat free



→ **Milk fat** is the **most variable component of milk**

→ **Fat content varies** from 3.0 to 7.0% (typical range: 3.5 to 4.7%)

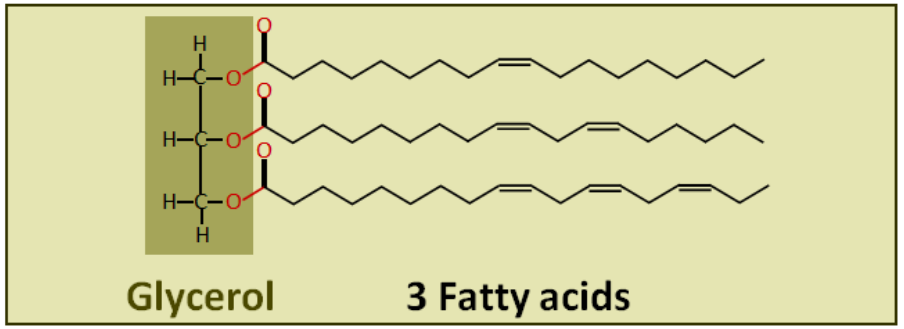
→ **High nutritive and technological value**

Milk fat is composed of a complex mixture of lipids

Lipid class	Amount (%, w/w)
Triglycerides (TAG)	98.3
Diglycerides (DAG)	0.3
Monoglycerides (MAG)	0.03
Free fatty acids (FFA)	0.1
Phospholipids	0.8
Sterols	0.3
Carotenoids	trace
Fat-soluble vitamins	trace
Flavor compounds	trace

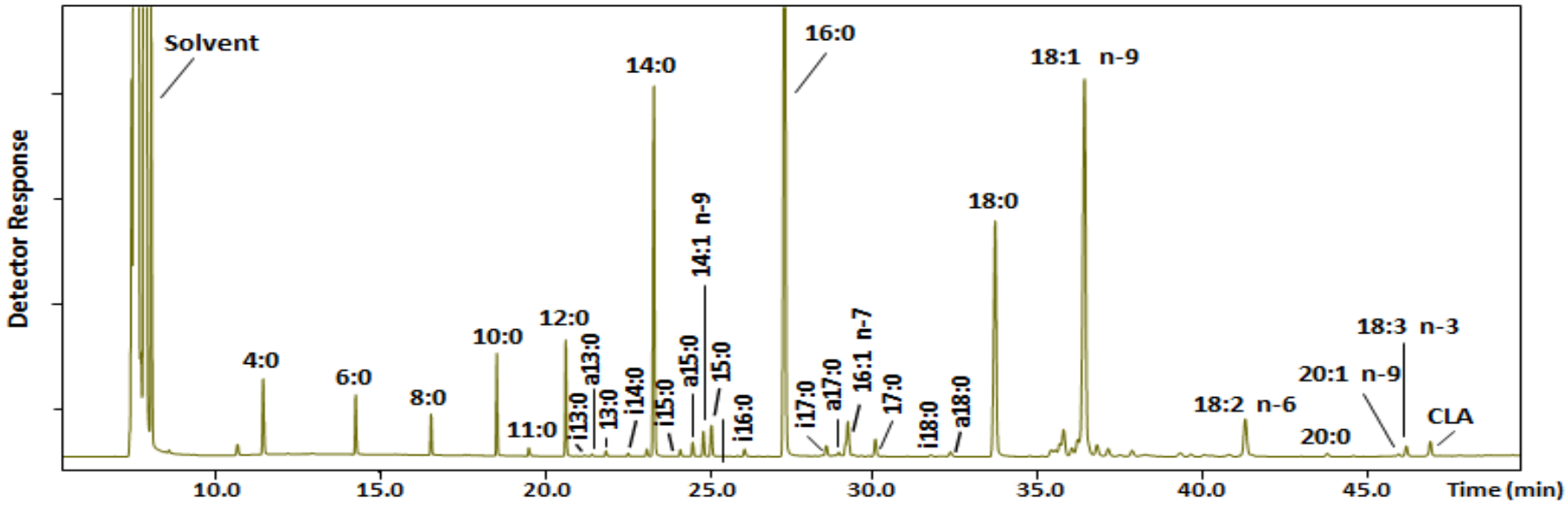
Walstra & Jenness (1984)

→ **Triglycerides** are the **major type** of **lipid** in **milk fat**



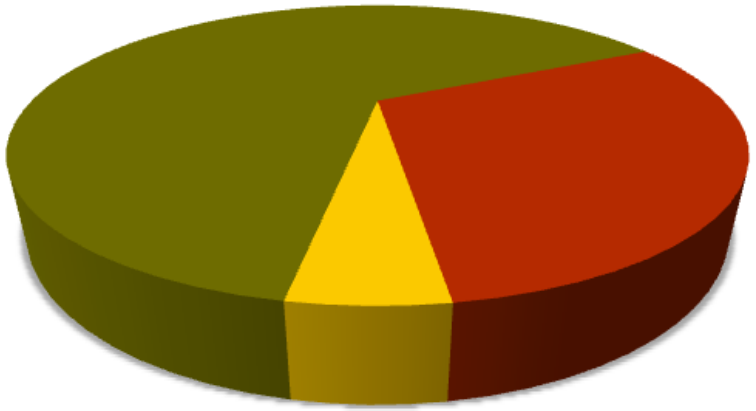
Milk fat is composed of a complex mixture of lipids

- **> 400 fatty acids** have been identified in **milk fat** (C4:0 to C26:0)
- **15 - 20 fatty acids** make up **90% of the milk fat**
- **Majority** is present in extremely **small quantities** (**<0.01%**)

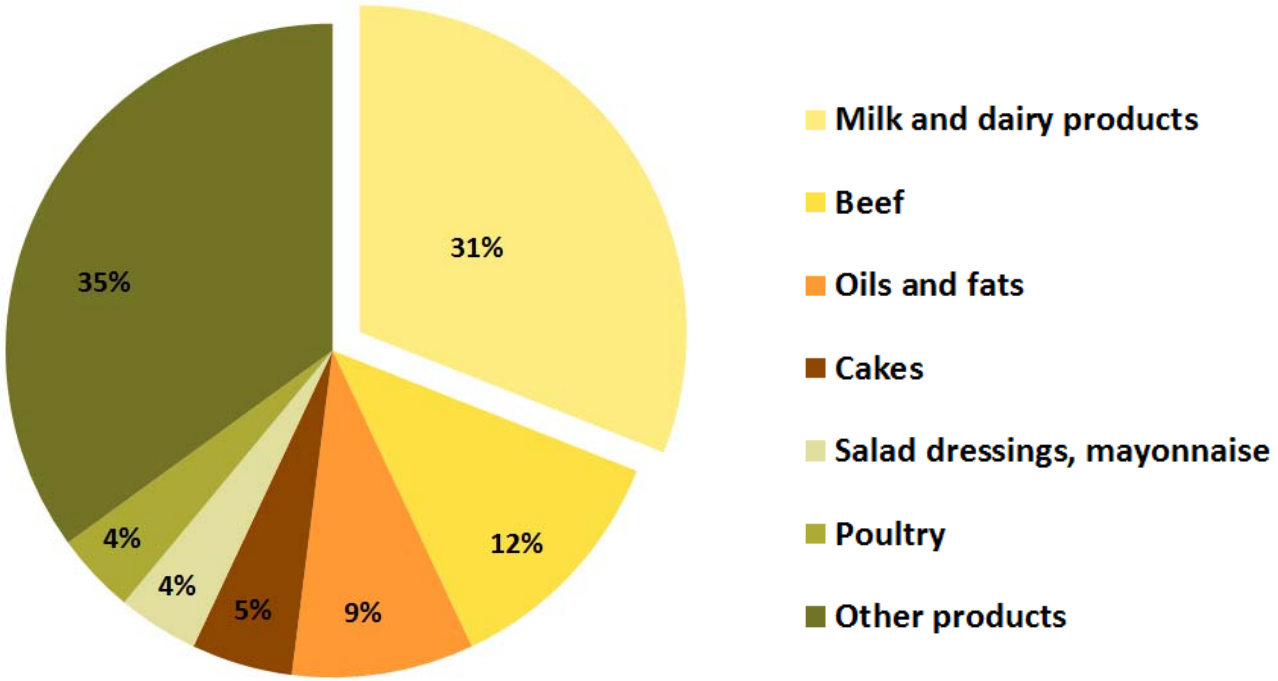


Fatty acid classes in milk fat

- **Saturated fatty acids (SFA)**
  - **55 - 75%** of total fatty acids
  - No double bond
  - Related to some health concerns



Milk and dairy products are the greatest single source of saturated fatty acids in the U.S. diet

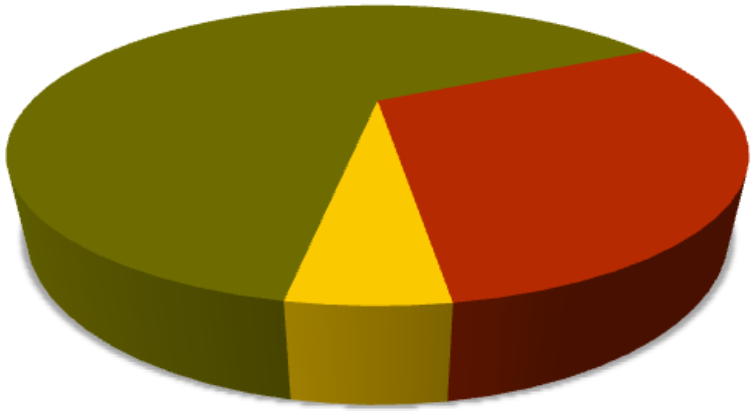


[National Health & Nutrition Examination Survey (NHANES) 2003 -2006]

Fatty acid classes in milk fat

Saturated fatty acids (SFA)

- **55 - 75%** of total fatty acids
- No double bond
- Related to some health concerns



Monounsaturated fatty acids (MUFA)

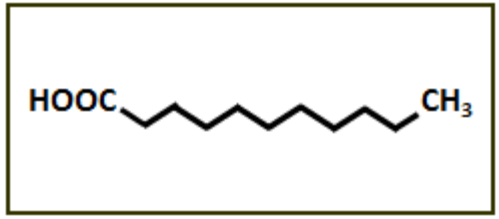
- **20 - 33%** of total fatty acids
- One double bond
- Regarded as healthy

Polyunsaturated fatty acids (PUFA)

- **3 - 6%** of total fatty acids
- More than one double bond
- Regarded as healthy

Saturated vs. unsaturated fats

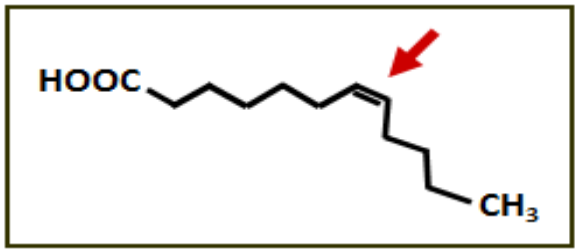
Saturated fats



- **No double bonds**
- Straight structure
- Making fats solid at room temperature

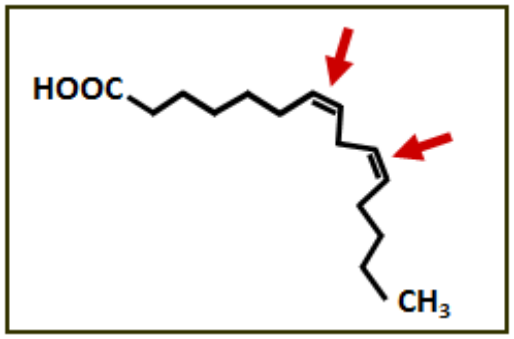
Unsaturated fats

Monounsaturated fats



- **1 double bond**
- Causes bend structure
- Making a fat liquid

Polyunsaturated fats



- **>1 double bond**

Fatty acids in milk fat

Fatty Acid	Mean	Range
	g per 100g fatty acids	
Saturated fats	**70.1**	**55.4 - 80.1**
12:0 (Lauric acid)	2.8	0.4 - 4.1
14:0 (Myristic acid)	11.1	9.1 - 11.9
16:0 (Palmitic acid)	27.9	23.6 - 31.4
18:0 (Stearic acid, SA)	12.2	10.4 - 14.6
Other	13.1	11.2 - 18.2
Monounsaturated fats	**25.4**	**19.6 - 26.6**
18:1 n-9 (Oleic acid, OA)	19.2	17.6 - 22.2
18:1 n-7 (Vaccenic acid, VA)	2.2	0.6 - 4.2
Other	6.2	0.9 - 1.4
Polyunsaturated fats	**4.5**	**3.0 - 6.0**
18:2 n-6 (Linoleic acid, LA, omega-6)	1.4	1.2 - 1.7
18:3 n-3 (α-linolenic acid, ALA, omega-3)	1.0	0.9 - 1.2
Conjugated linoleic acids (CLA)	1.1	0.7 - 1.8
20:5 n-3 (Eicosapentaenoic acid, EPA)	0.1	0.1 - 0.7
22:5 n-3 (Docosapentaenoic acid, DPA)	0.1	0.1 - 0.2
Other	0.8	0.8 - 1.2

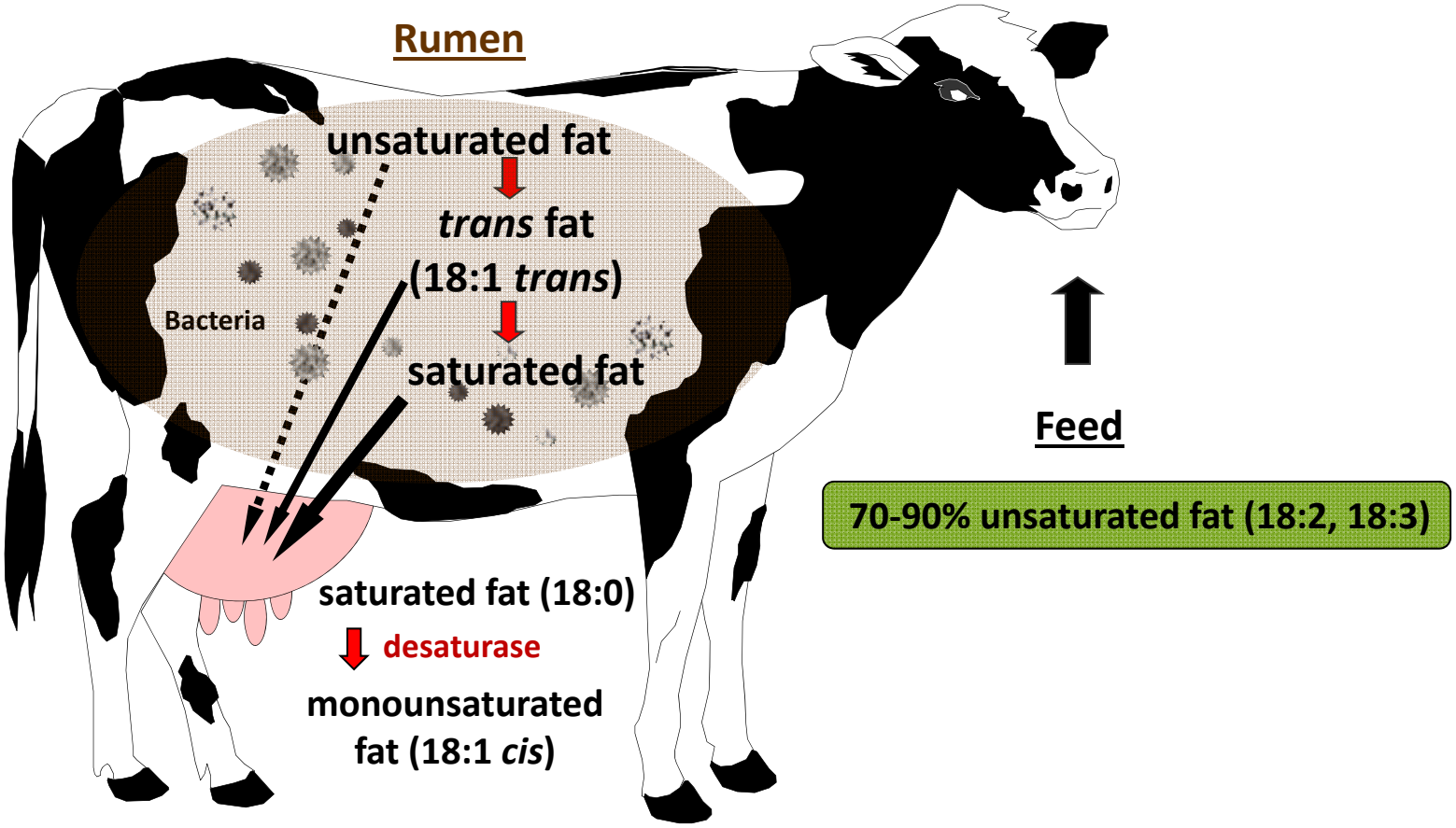
Fatty acids in milk fat originate from different sources

Fatty acid	Mean	Range
	g per 100g fatty acids	
MUFA	**25.4**	**19.6 - 32.6**
PUFA	**4.5**	**3.1 - 6.0**
SFA	**70.1**	**55.4 - 80.1**
4:0	3.9	3.1 - 4.4
6:0	2.5	1.8 - 2.7
8:0	1.5	1.0 - 1.7
10:0	3.2	2.2 - 3.8
12:0	3.6	2.6 - 4.2
14:0	11.1	9.1 - 11.9
14:1 (n-5)	0.8	0.5 - 1.1
16:0	27.9	23.6 - 31.4
16:1 (n-7)	1.5	1.4 - 2.0
18:0	12.2	10.4 - 14.6
18:1 *cis*	17.2	14.9 - 22.0
18:1 *trans*	3.9	2.8 - 7.5
18:2 (n-6)	1.4	1.2 - 1.7
18:2 conjugated	1.1	0.7 - 1.8
18:3 (n-3)	1.0	0.9 - 1.2
Minor fatty acids	6.0	4.8 - 7.5

- ***De novo* synthesis (ca. 40%)**
  within the mammary gland (synthesis of new molecules of fatty acids from precursors)

- **Blood lipids (ca. 60%)**
  dietary, microbial, and adipose fatty acids absorbed from the blood stream

Unsaturated fatty acids from the feed are biohydrogenated in the rumen of the cow



Milk fat contains many bioactive fatty acids with beneficial health effects

→ **Functional (bioactive) fatty acids**

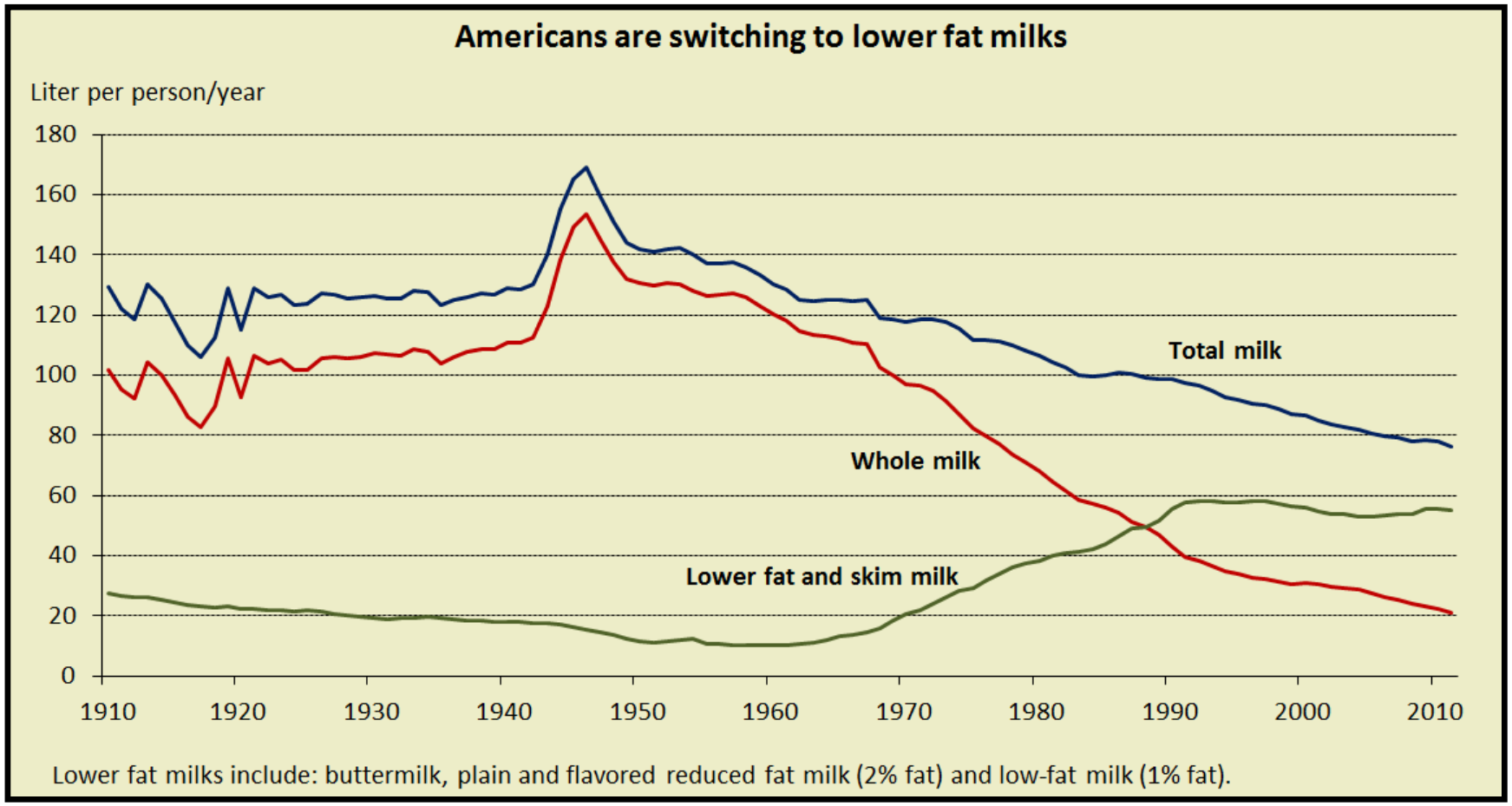
- Conjugated linoleic acids (CLA)
- Short-/medium-chain SFA (4:0 - 10:0)
- Oleic acid (*c*9 18:1)
- n-3 (omega-3) fatty acids

Exhibit beneficial health effects

- Anticarcinogenic
- Bacteriostatic/bactericidal
- Cardiovascular benefits
- Essential for growth and development

The saturated fat issue

Americans are switching to lower fat milks



Source: USDA, Economic Research Service

Public health policy continues to recommend reduction in saturated fat intake

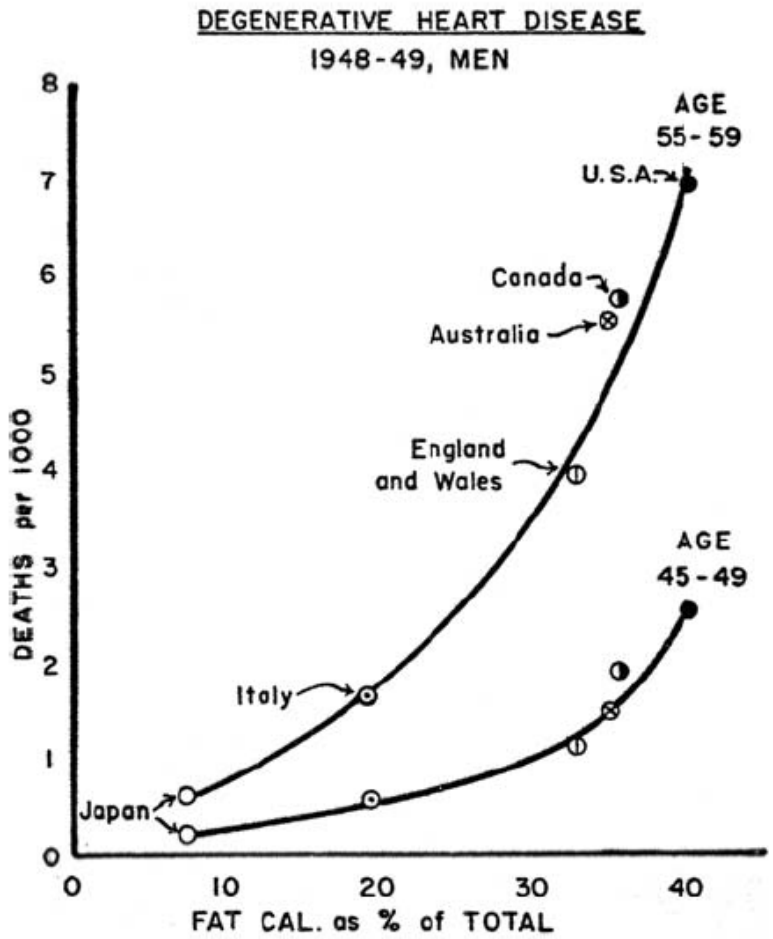
Dietary Guidelines for Americans

- Consume less than **10 percent** of total daily calories from saturated fatty acids
- Choose fat-free or low-fat milk and milk products

American Heart Association (AHA)

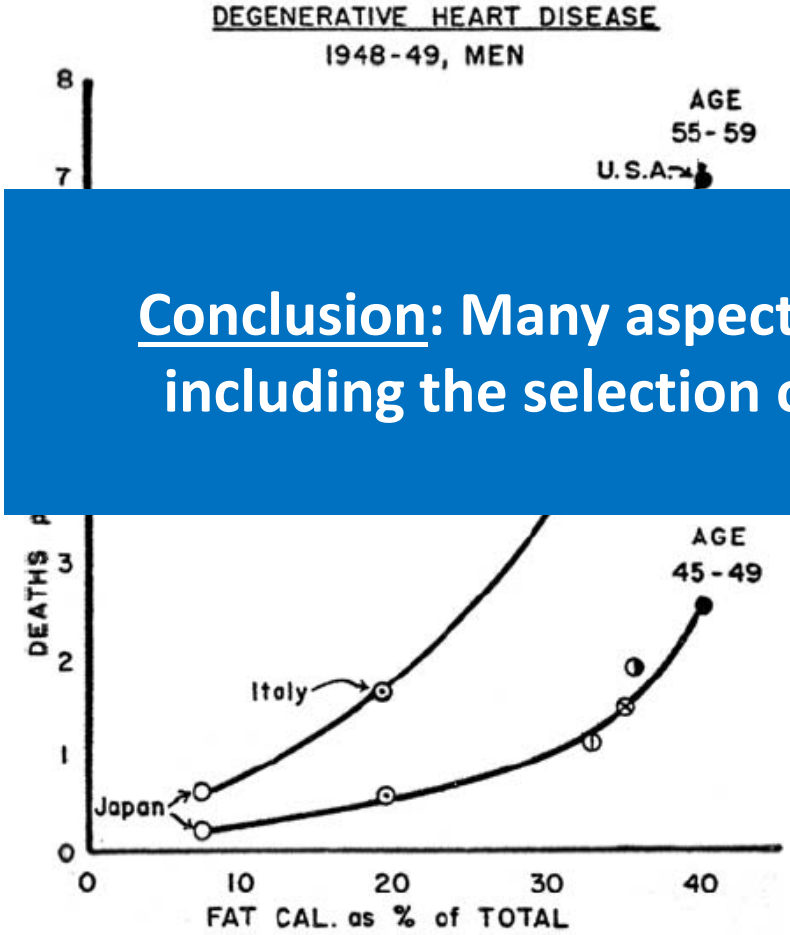
- Limit the amount of saturated fatty acids to less than **7 percent** of total daily calories
- Select fat-free (skim), 1%-fat, and reduced fat (2%) dairy products

Ancel Keys originated “Diet-Heart Hypothesis” that fat was the cause of heart disease

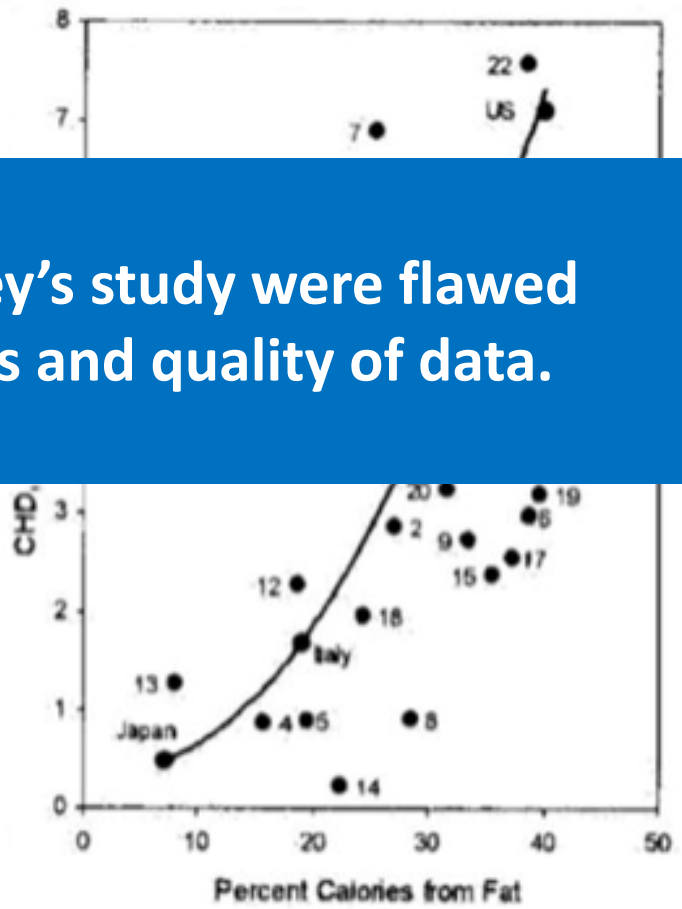


Keys, *J Mt Sinai Hosp*, 1953

Ancel Keys originated "Diet-Heart hypothesis" that fat was the cause of heart disease



Keys, *J Mt Sinai Hosp*, 1953



Yerushalmy and Hilleboe, *N Y State J Med,* 1957

Conclusion: Many aspects of the Key's study were flawed including the selection of countries and quality of data.

REVIEW | *Ann Intern Med.* 2014;160:398-406. **Annals of Internal Medicine**

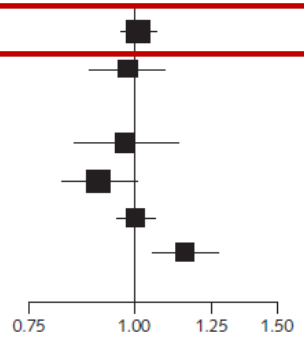
Association of Dietary, Circulating, and Supplement Fatty Acids With Coronary Risk

A Systematic Review and Meta-analysis

Rajiv Chowdhury, MD, PhD; Samantha Warnakula, MPhil*; Setor Kunutsor, MD, MSt*; Francesca Crowe, PhD; Heather A. Ward, PhD; Laura Johnson, PhD; Oscar H. Franco, MD, PhD; Adam S. Butterworth, PhD; Nita G. Forouhi, MRCP, PhD; Simon G. Thompson, FMedSci; Kay-Tee Khaw, FMedSci; Dariush Mozaffarian, MD, DrPH; John Danesh, FRCP*; and Emanuele Di Angelantonio, MD, PhD*

Figure 1. RRs for coronary outcomes in prospective cohort studies of dietary fatty acid intake.

Dietary Fatty Acid Intake	Studies, *n*	Participants, *n*	Events, *n*	RR (95% CI)*
Total saturated fatty acids	20	283 963	10 518	1.02 (0.97–1.07)
Total monounsaturated fatty acids	9	143 985	6020	0.99 (0.89–1.09)
Total ϖ-3 fatty acids				
α-Linolenic	7	154 338	6615	0.99 (0.86–1.14)
Total long-chain ϖ-3	16	422 071	8313	0.93 (0.84–1.02)
Total ϖ-6 fatty acids	6	169 935	5884	1.01 (0.96–1.07)
Total trans fatty acids	5	155 270	4662	1.16 (1.06–1.27)



Conclusion: Current evidence does not clearly support cardiovascular guidelines that encourage high consumption of polyunsaturated fatty acids and low consumption of total saturated fats.

- **Saturated fats** have been **under constant scrutiny** for their **role** in the development of **chronic diseases**

- **Health authorities/agencies promote fat-reduced** or **fat-free dairy products** of as part of a healthy diet

Milk fat has been suffering from a negative nutritional image

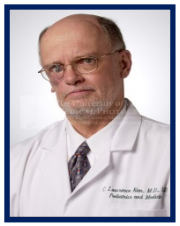
Research at UVM

→ **Examining the effects of consuming a diet comprising of milk fat on metabolic health markers**

Funding

- New England Dairy Promotion Board
- Vermont Dairy Promotion Council
- Dairy Research Institute
- The University of Vermont (Clinical Research Center)

Research Team



C. Lawrence Kien, M.D., Ph.D.

College of Medicine

Helen Walsh, Ph.D.

Project Coordinator/
Postdoctoral Fellow

Emily Tarleton

Bionutrition Manager,
Clinical Research Center

Andre Wright, Ph.D.

Animal Science
Department

Hira Haq

Junior in Biochemistry

Project rationale

- **Evidence** associating the consumption of **saturated fat** related **to full-fat milk** and **dairy products** with an **increased risk of Metabolic Syndrome** is **insufficient** and **inconclusive**.

➡ Milk fat contains **bioactive fatty acids**

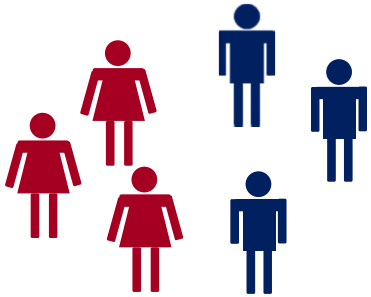
- Oleic acid
- Short-/medium-chain fatty acids
- Conjugated linoleic acids (CLA)
- Branched-chain fatty acids
- Omega-3 fatty acids
- Vaccenic acid

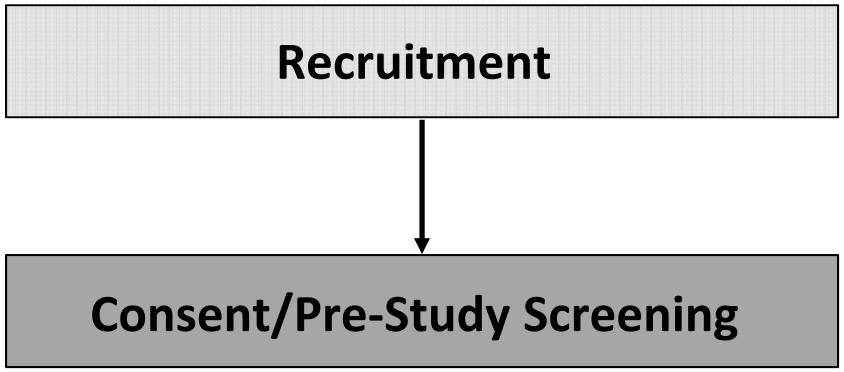
Exhibit beneficial effects

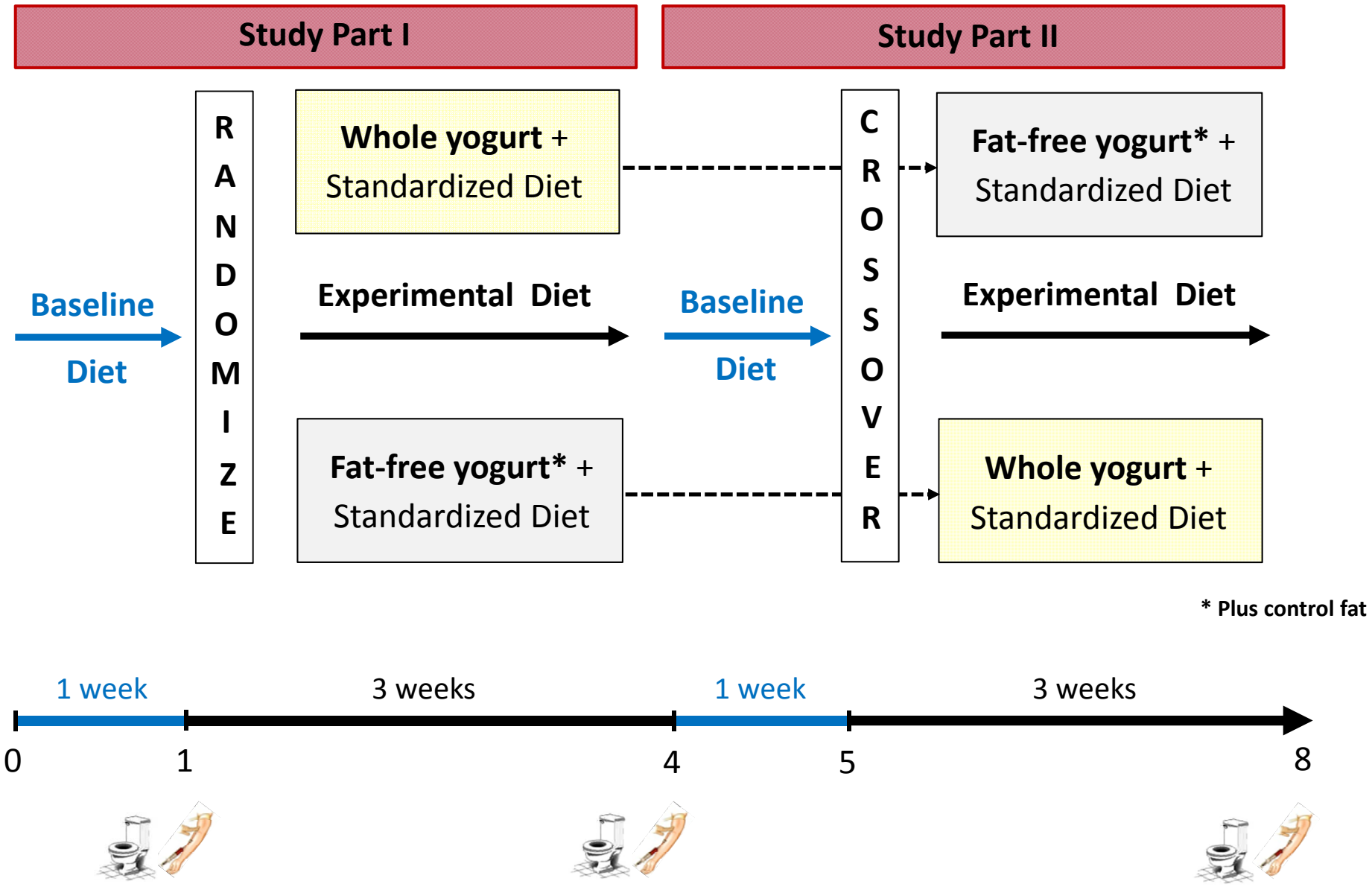
Overview of study design

Study population

- 10 female and 10 male participants (total: 20)
- Normal and overweight (BMI: 18.5 and 29.9 kg/m^2)
- Age 18-40






Study Part I
Study Part II
RANDOMIZE
Baseline
Diet
Whole yogurt + Standardized Diet
Experimental Diet
Fat-free yogurt* + Standardized Diet
CROSSOVER
Baseline
Diet
Fat-free yogurt* + Standardized Diet
Experimental Diet
Whole yogurt + Standardized Diet
* Plus control fat
1 week
3 weeks
1 week
3 weeks
0
1
4
5
8

Standardized diet during the study

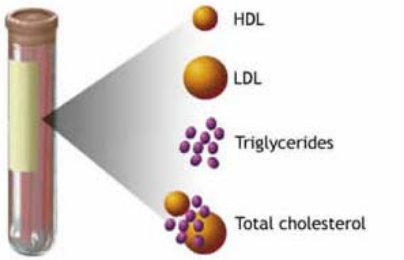
Standardized diet during the study

Study endpoints (outcome measurements)

- **Primary endpoints**

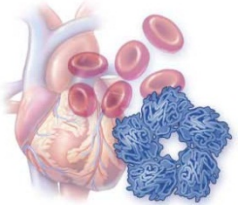
  → Blood glucose and insulin levels

  → Blood triglyceride and cholesterol levels



- **Explanatory endpoints**

  → Inflammatory markers (TNF-α, IL-2, IL-6, hsCRP)



  → Gut microbes

Significance of the project

- **Develop scientific evidence on the neutral or beneficial effects of milk fat on metabolic health markers**

→ Consumption of 3 servings of whole dairy product will positively modulate metabolic parameters vital to human health as a result of the milk fat's bioactive fatty acids

- Ensuring the public perception (increased appeal and acceptability) and sale of fat-containing dairy products
- Lead to revised dietary recommendations (e.g., Dietary Guidelines for Americans)
- Provide dairy industry with an opportunity to promote the role of milk fat as part of a healthy and balanced diet

Take Home Message

- Milk should be promoted for its significant contribution to our nutrient supply and it's benefits on human health!

- Milk fat is perceived as unhealthy but there is little or no evidence that milk has adverse health effects

- **Education of the public, nutritionists, dieticians, and physicians is essential!**