Metabolism and Health Effects of Lactose and Galactose

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Presented by
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Pretoria CNE
18 October 2017

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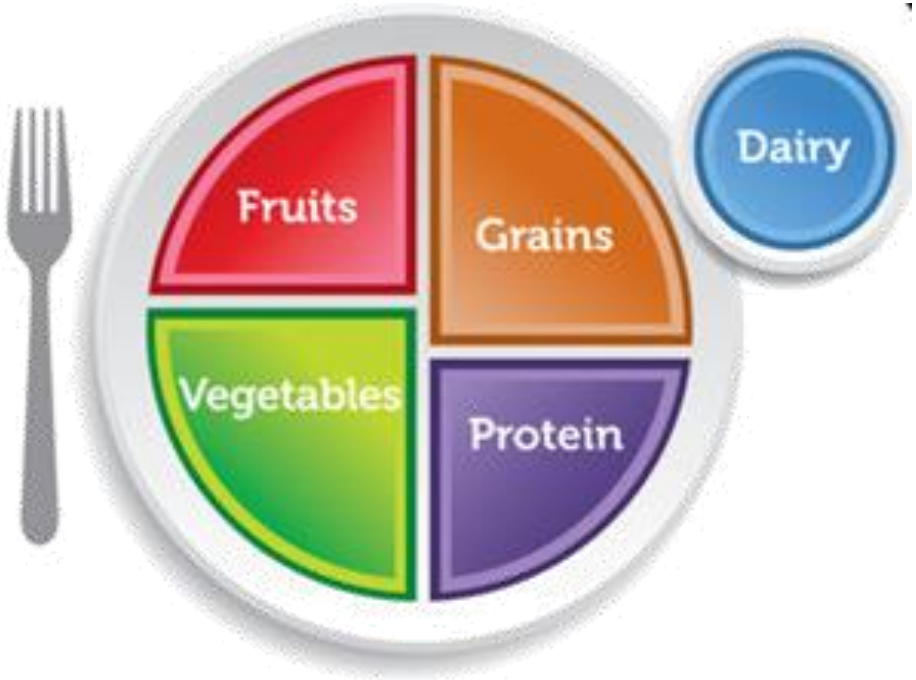
Introduction

Scientific evidence supports the essential role of milk and dairy products as part of a healthy eating pattern



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- Dairy foods are **excellent sources of** the **nutrients** calcium, magnesium, potassium, protein and carbohydrates
- Benefits of milk and other dairy foods for **bone and dental health** are well-known
- Dairy intake also linked to other health benefits
- Key role in **development** throughout life

Visioli and Strata, 2014; Hirahatake et al., 2014; Pereira, 2014; Keast et al., 2013; Prado and Dewey, 2014; Weaver, 2014; Rice et al., 2013

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BMJ 2014;349:g6015 doi: 10.1136/bmj.g6015 (Published 27 October 2014)

RESEARCH

Milk intake and risk of mortality and fractures in women and men: cohort studies

OPEN ACCESS

Karl Michaëlsson *professor*[1], Alicja Wolk *professor*[2], Sophie Langenskiöld *senior lecturer*[3], Samar Basu *professor*[3], Eva Warensjö Lemming *researcher*[1 4], Håkan Melhus *professor*[5], Liisa Byberg *associate professor*[1]

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Hypothesize that **galactose** from lactose in milk may induce:

- oxidative stress → chronic low grade inflammation
- a decreased immune response and
- neurodegeneration

Michaëlsson et al., 2014; Cui et al., 2006

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Criticisms

- Possibility of **reverse causation** (women who knew that they had osteoporosis may have consumed more milk)
- Multivariate **model** did **not adjust for osteoporosis** or bone mineral density
- **Large sex differences** not accounted for

- **Vit D status** may have impacted on fracture risk and all-cause mortality
- **Synthetic substances** used in milk production at the time that cohorts were recruited may have impacted on mortality

Michaëlsson et al., 2014; Labos and Brophy, 2014; Bonneux, 2014; Hill, 2014; Sundar, 2014

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Aim of presentation

- In view of the mentioned **limitations** and in the absence of evidence from **randomized controlled trials** (RCTs), the results of the Michaëlsson study need to be interpreted with caution

- Yet, the study has cast **doubt** on the health benefits of milk

- This presentation will aim to **evaluate the evidence** on the health effects of dairy, with special reference to **lactose and its metabolites**, which are naturally present in milk

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Content

Composition, digestion, absorption and metabolism of lactose

Lactose intolerance

Lactose as a prebiotic

Lactose in calcium absorption

Non-communicable diseases:

Type 2 Diabetes Mellitus

Hypertension

Dental caries

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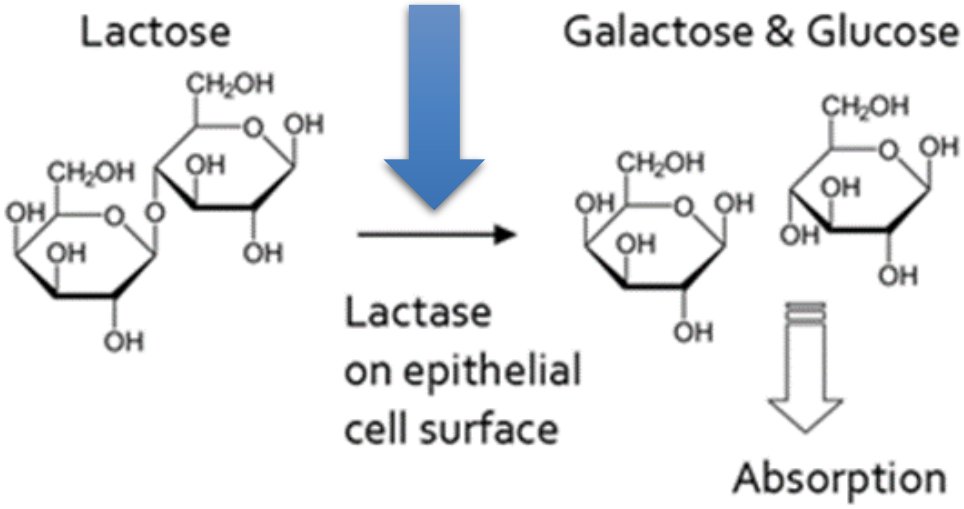
Composition, digestion, absorption and metabolism of lactose

- Lactose consists of **galactose bound to glucose**



- The enzyme **lactase** is needed to hydrolyse lactose to **glucose and galactose** to facilitate **absorption** and transport across the intestinal mucosa

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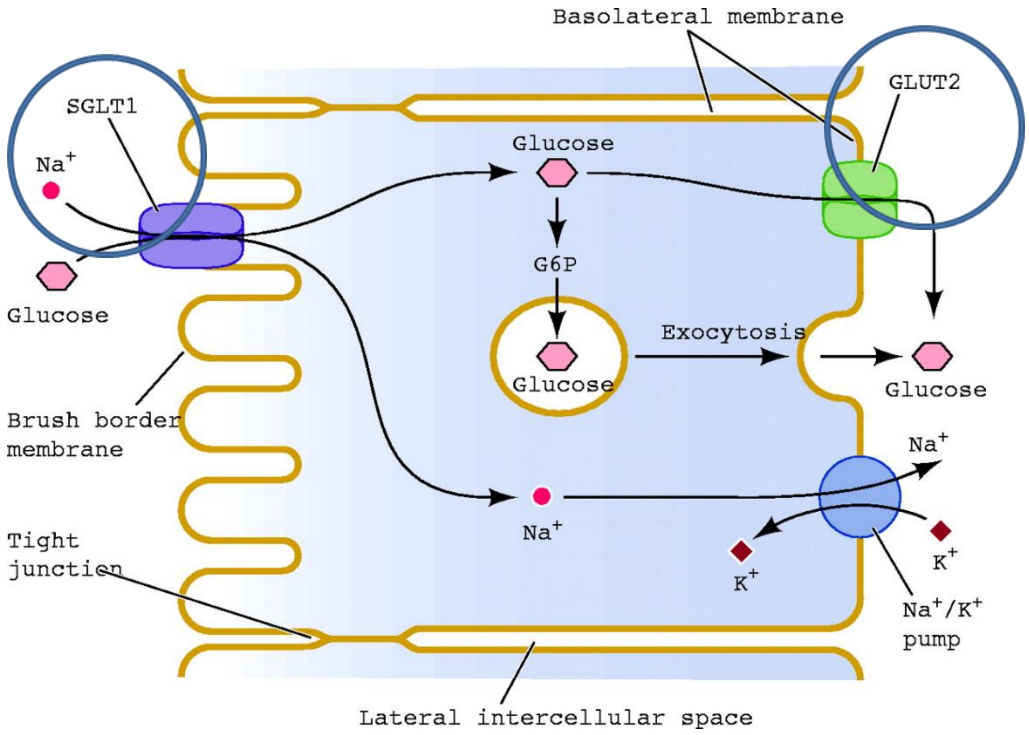
- Galactose and glucose are absorbed and **actively transported** from the intestinal lumen into the blood by the **sodium-dependent hexose transporter, SGLT1**

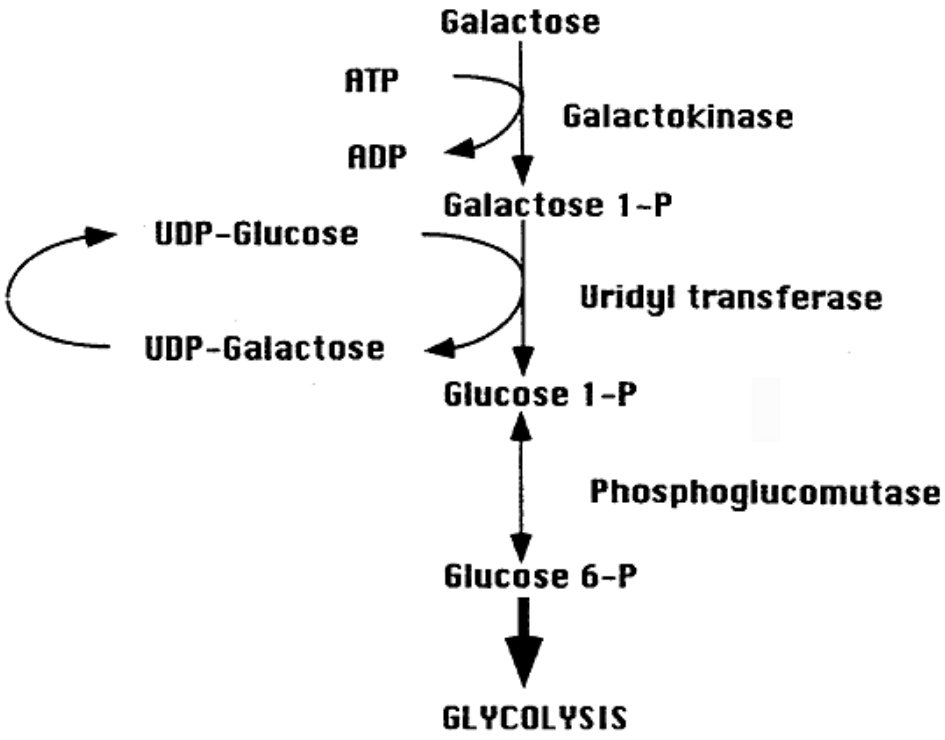


They are then **passively transported** from the blood into the liver by the GLUT-2 transporter

Deng et al., 2015; Coelho et al., 2015; Schaafsma, 2008

- Galactose is then **phosphorylated** in the **liver** and finally converted into glucose

- Glucose tends to pass through the liver and can be metabolised anywhere in the body as a **source of energy**



Deng et al., 2015; Coelho et al., 2015; Schaafsma, 2008

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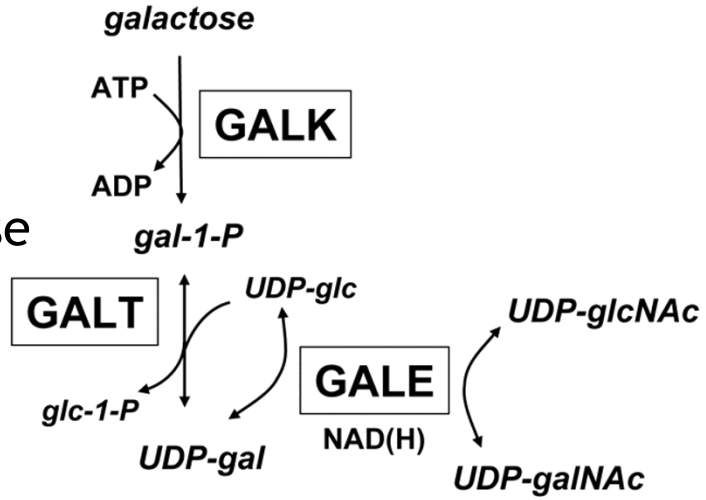
Galactose

- Galactose is metabolized to glucose by **3 enzymes** in the Leloir pathway, the main pathway of galactose metabolism

- These enzymes are:
  - galactokinase **(GALK)**
  - galactose-1 phosphate uridylyltransferase **(GALT)** and
  - UDP-galactose 4'-epimerase **(GALE)**



- Although this pathway occurs mostly in the liver, it is also active in cells in the **brain, lens of the eye and ovaries**

Coelho et al., 2015; Lukito et al., 2015

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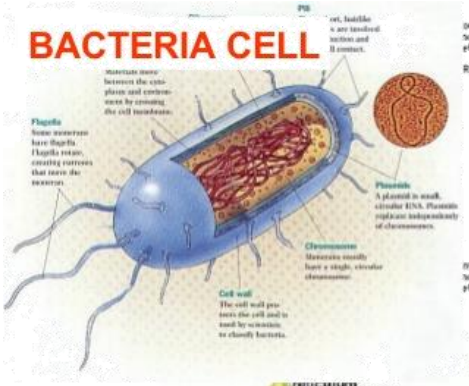
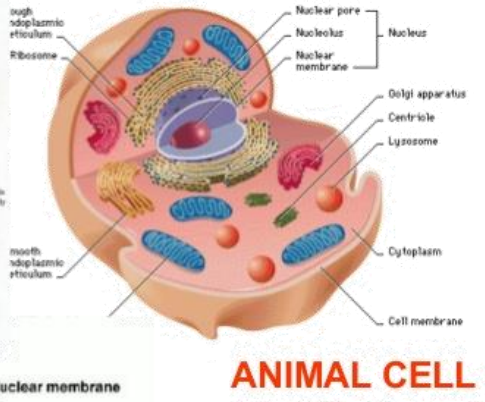
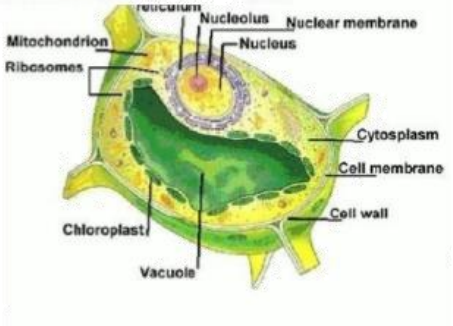
Galactose

- The presence of galactose in **bacteria, plants and animals** confirms its importance for living organisms





- It is found in lactose as well as in **complex carbohydrates**, including oligosaccharides and **polysaccharides**, glycoproteins and glycolipids

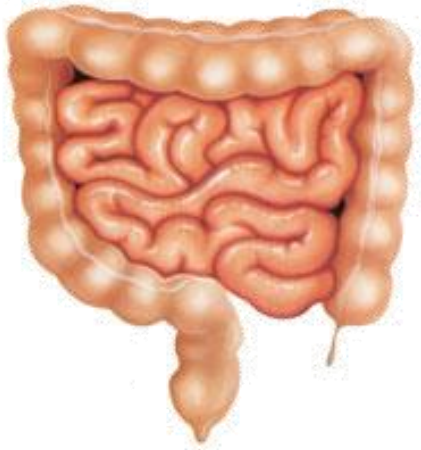


Coelho et al., 2015

Functions of Galactose

Apart from its importance in **energy production**:

- Referred to as **'brain sugar'** in lay terms owing to its role in supporting brain structure and development during the **neonatal period and early life**



- Important role in maintaining a **healthy GIT** - present in the raffinose-family oligosaccharides that stimulate growth of some intestinal microflora
- Display **anti-adhesive activity** - inhibit infections by enteric pathogens

Prado and Dewey, 2014; Schaafsma, 2008; Zivkovic and Barile, 2011

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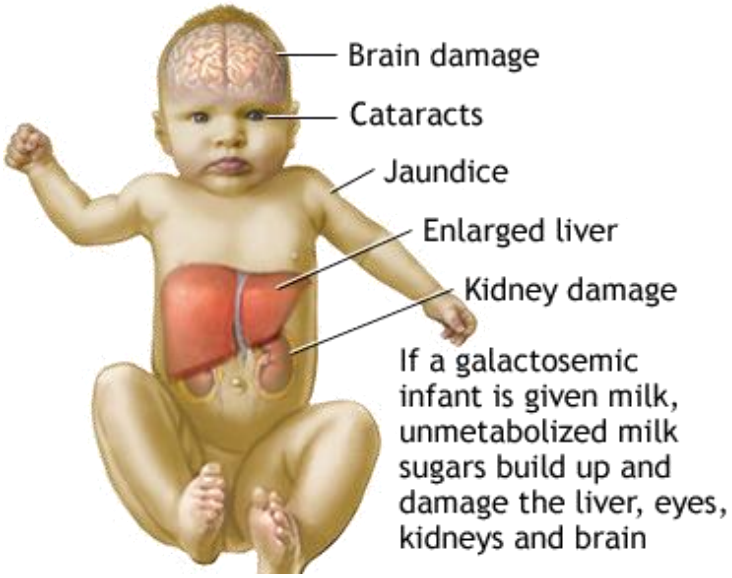
Galactosemia



- A congenital disorder involving one of the three enzymes in the Leloir pathway - classic **galactosemia** is due to a GALT deficiency
- Particularly serious during the **neonatal period** and affects a number of organs, including the **liver** and **brain**
- **Dietary restriction** of galactose resolves the symptoms of galactosemia, but
- Associated with severe **long-term complications** cognitive and fertility impairments, even in patients who follow a galactose-restricted diet rigorously

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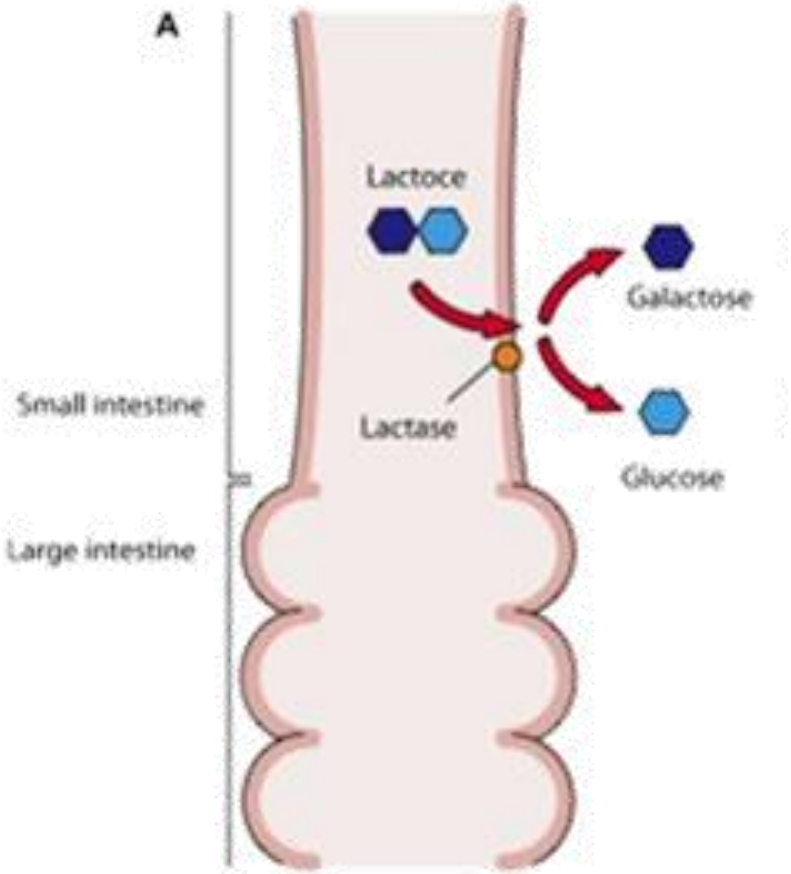
Lukito et al., 2015; Waisbren et al., 2012

Lactose intolerance



- Under normal conditions, **lactase** is produced in the intestinal mucosa of mammals
- Full-term newborn infants generally have sufficient lactase activity to **digest milk**

Deng et al., 2015; McSweeney and Fox, 2009; Vandenplas, 2015; Heaney, 2013; Mattar et al., 2012; Brown-Esters et al., 2012; Leonardi et al., 2012

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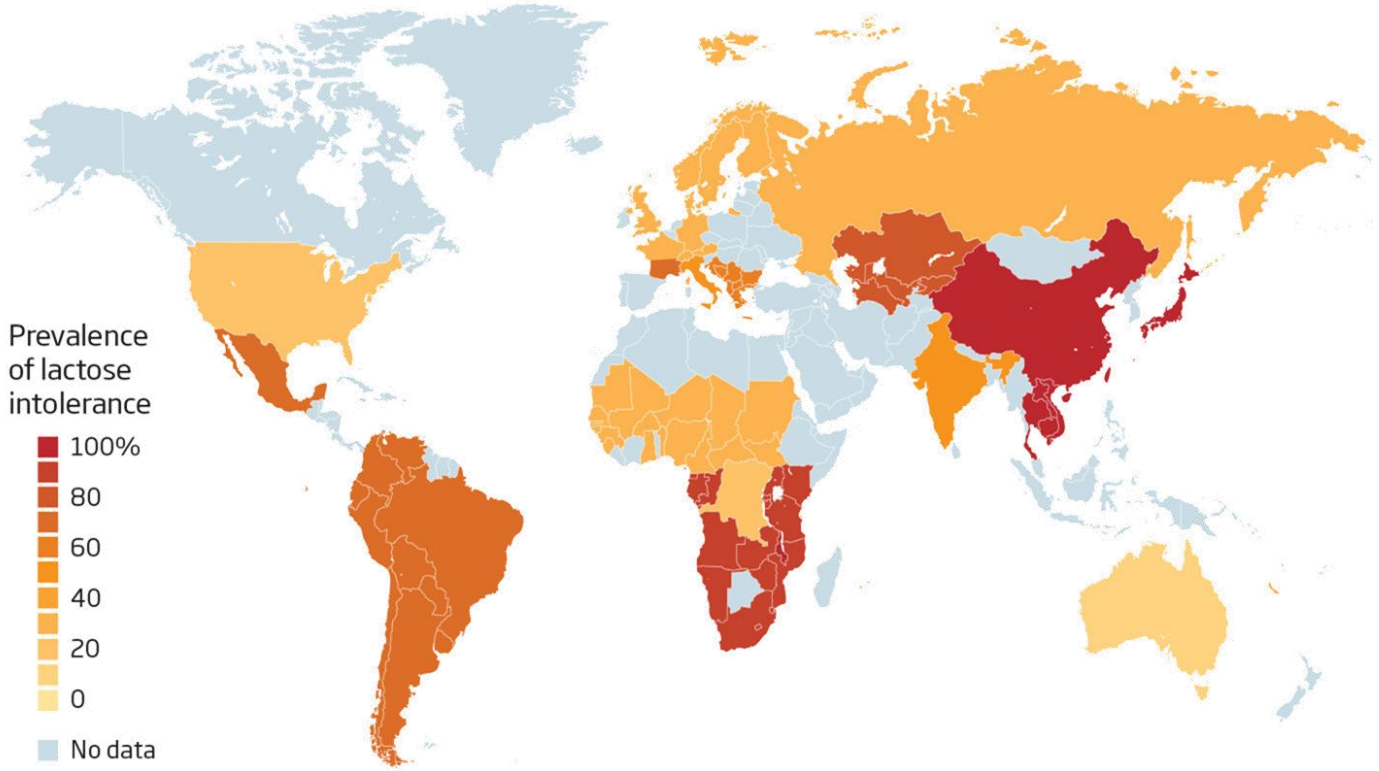
Lactose intolerance

- However, **lactase activity declines after weaning** in most humans (lactase non-persistence), especially those from East Asian and African heritage, resulting in lactose maldigestion



Deng et al., 2015; McSweeney and Fox, 2009; Vandenplas, 2015; Heaney, 2013; Mattar et al., 2012; Brown-Esters et al., 2012; Leonardi et al., 2012

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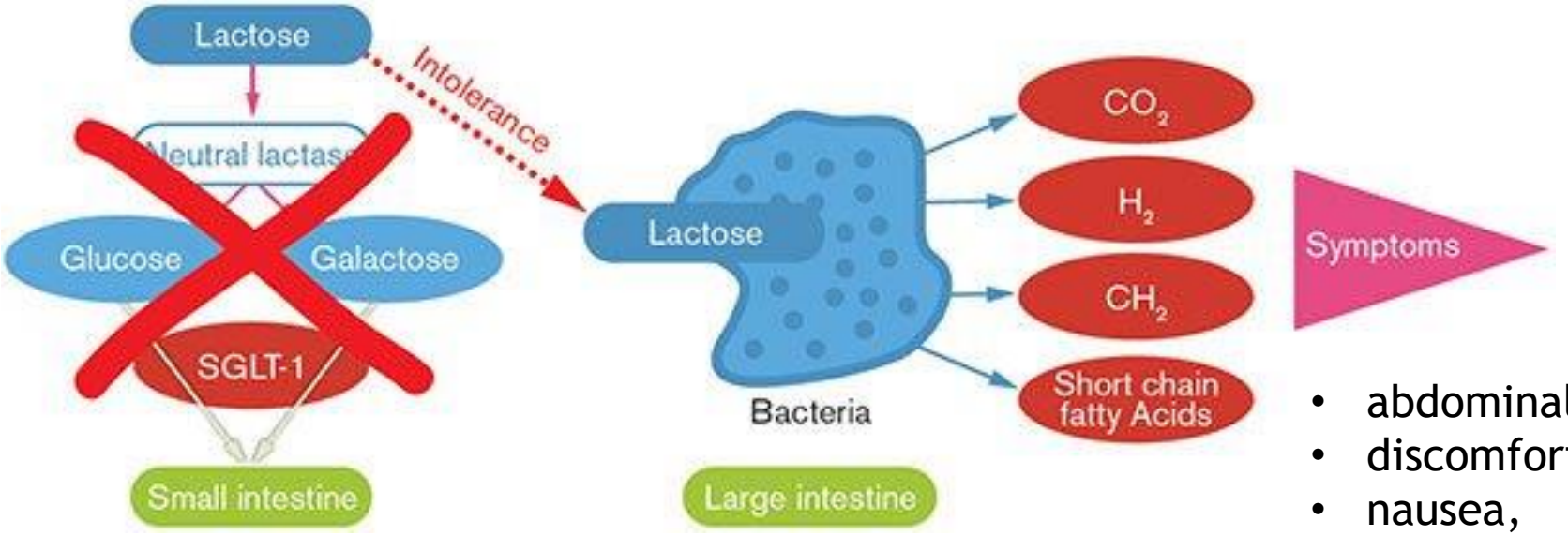
Lactose intolerance refers to the **digestive symptoms** that are associated with **lactose maldigestion**



- abdominal
- discomfort,
- nausea,
- cramps,
- bloating,
- flatulence,
- diarrhoea

Deng et al., 2015; McSweeney and Fox, 2009; Vandenplas, 2015; Heaney, 2013; Mattar et al., 2012; Brown-Esters et al., 2012; Leonardi et al., 2012

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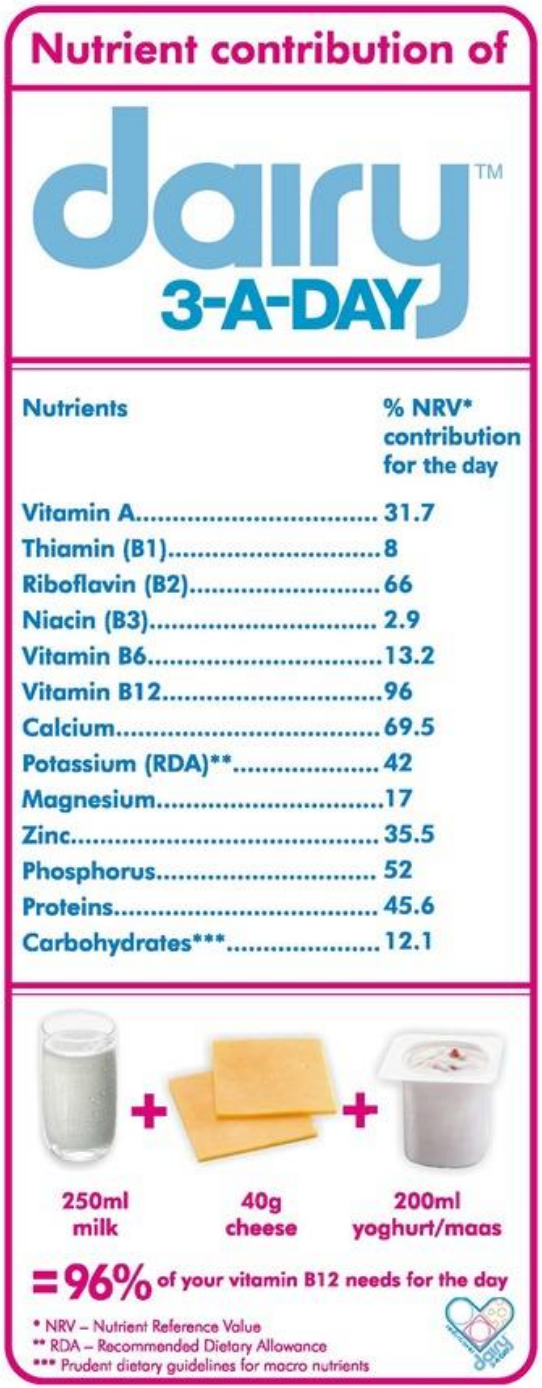

Lactose intolerance

Those who consider themselves lactose intolerant may decrease their dairy intake, resulting in compromised intake of the nutrients and other beneficial compounds in dairy

Bailey et al., 2013

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Strategies to improve lactose intolerance

- A **low lactose load** (<6 g present in half a serving of milk) is unlikely to cause symptoms

- Using **small amounts** of dairy at a time, or taking milk **with a meal**, **slows the release** of lactose into the intestine, which reduces the load to be digested - less discomfort

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Vandenplas, 2015; Heaney, 2013; Brown-Esters et al., 2012; Suchy et al., 2010

Strategies to improve lactose intolerance

- Dairy foods such as **cheese** (especially hard cheeses), active-culture **yoghurt** and fermented products such as **buttermilk** contain limited lactose and can be eaten without causing gastrointestinal discomfort

- These foods are fermented by **lactic acid bacteria**, which convert some of the lactose to lactic acid during production

Vandenplas, 2015; Heaney, 2013; Brown-Esters et al., 2012; Suchy et al., 2010

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Strategies to improve lactose intolerance

- Although more expensive, **reduced-lactose** or lactose-free milk is also available - this milk has many health benefits over dairy substitutes such as soy milk
- Taking a **lactase tablet** with milk improves digestion
- **Probiotics** that include lactase-containing organisms can help to relieve symptoms

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Vandenplas, 2015; Heaney, 2013; Brown-Esters et al., 2012; Suchy et al., 2010

Strategies to improve lactose intolerance

- **Tolerance** can be built up gradually over a period of time:
  - consuming lactose-containing foods encourages an intestinal flora population with active lactase
  - intake can be increased gradually by, for example, adding half a glass of milk to one meal on the first day, half a glass to two meals on the next day, etc.

- **Chocolate milk** is better tolerated than white (higher osmolality or energy content)

Vandenplas, 2015; Heaney, 2013; Brown-Esters et al., 2012; Suchy et al., 2010

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DO PEOPLE WITH LACTOSE INTOLERANCE NEED TO AVOID DAIRY?

D **D**rink milk with food.

A **A**dd natural cheeses to your diet, such as Cheddar, Colby and Swiss, which are low in lactose.

I **I**ntroduce dairy slowly. Gradually increase the amount.

R **R**educe it. Enjoy lactose-free milk and milk products.

Y **Y**ogurt with active cultures helps digest lactose.

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There may an evolusionary reason why only about **35%** of the human population can digest lactose beyond the age of about 7 / 8 years

Deng et al., 2015; McSweeney and Fox, 2009; Vandenplas, 2015; Heaney, 2013; Mattar et al., 2012; Brown-Esters et al., 2012; Leonardi et al., 2012

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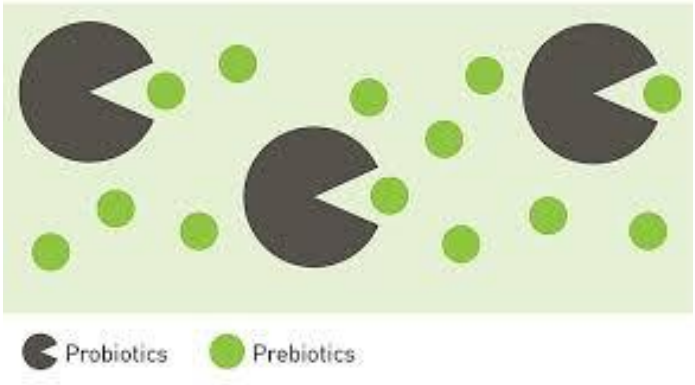
Effects of lactose as a prebiotic



- The recent emphasis on the structure and function of the human **microbiome** has focused attention on the potential role of probiotics and prebiotics in promoting health
- Prebiotics are non-digestible compounds that stimulate the **growth and activity** of the bacteria in the digestive system
- Lactose and oligosaccharides in milk are considered to be **bioactive ingredients** that may create a healthy microbiota owing to their bifidogenic effects

Petschow et al., 2013; Lukito et al., 2015; Visioli and Strata, 2014; Vandenplas, 2015; Hirahatake et al., 2014; Zivkovic and Barile, 2011

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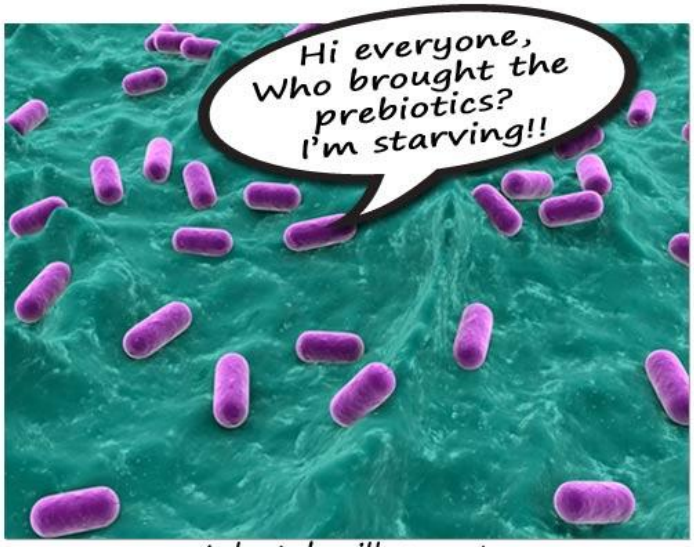
Effects of lactose as a prebiotic



A lactobacillus party

Lactose non-persistent persons

Lactose is not fully digested and thus proceeds to the colon where it exerts prebiotic effects

Lactase-persistent persons

Most lactose will be **digested** in the small intestine, but some may reach the large intestine and serve as a prebiotic for the colonic microbiota, including lactic acid bacteria

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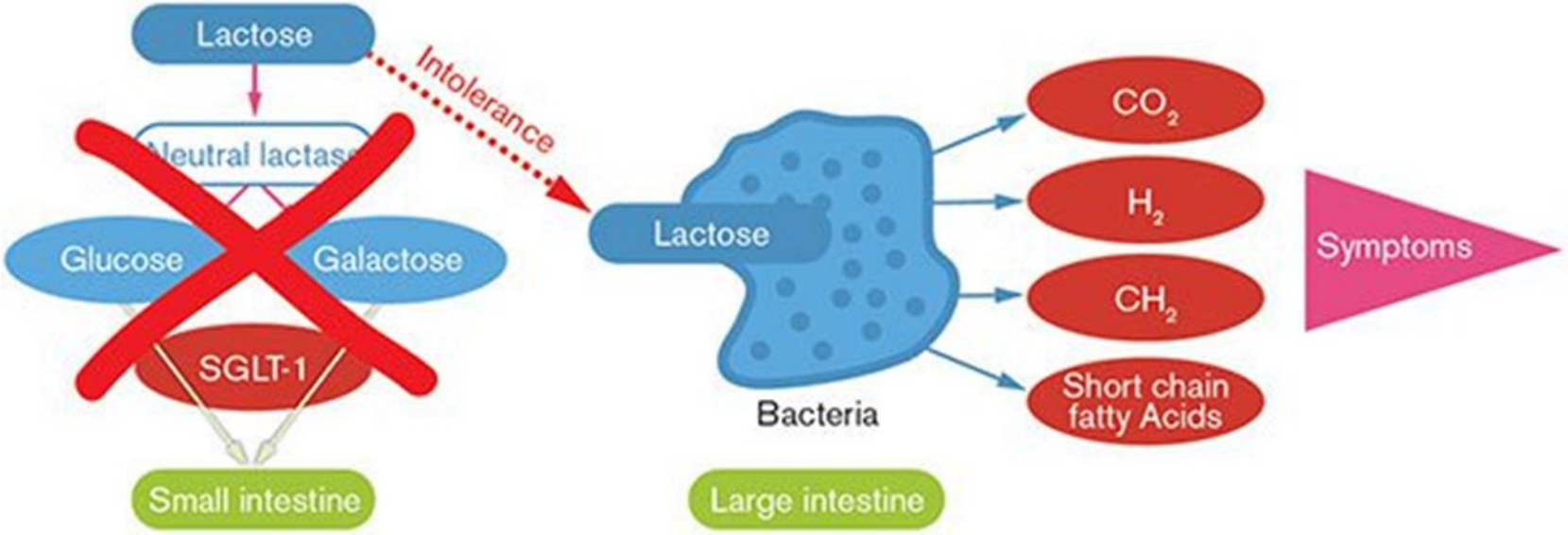
Lukito et al., 2015; Venema, 2012

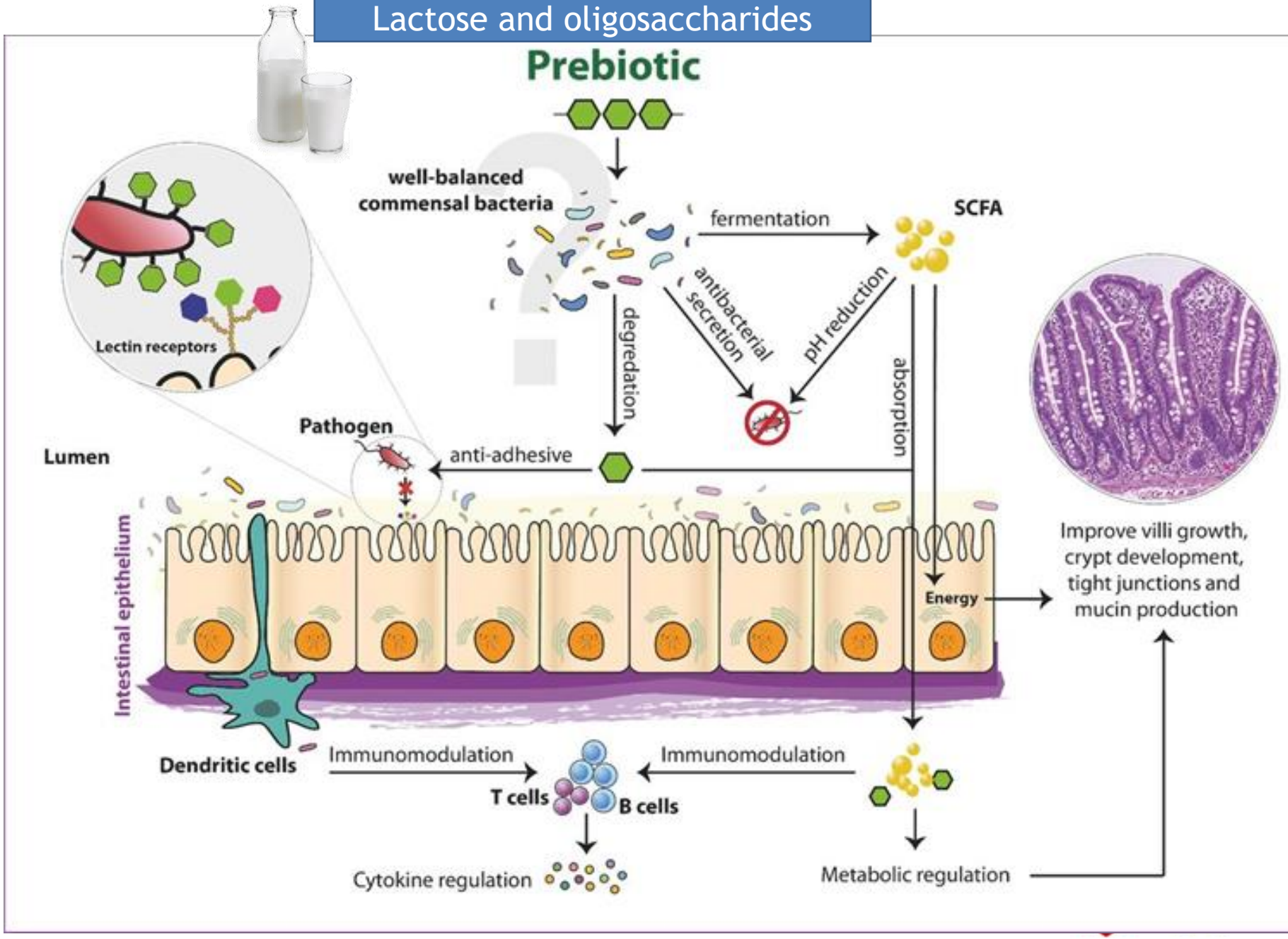
Effects of lactose as a prebiotic

The colonic microbiota **hydrolyse and ferment lactose** in the colon, producing metabolites such as **short-chain fatty acids** (primarily acetate, propionate and butyrate) and gases



Lukito et al., 2015; Venema, 2012

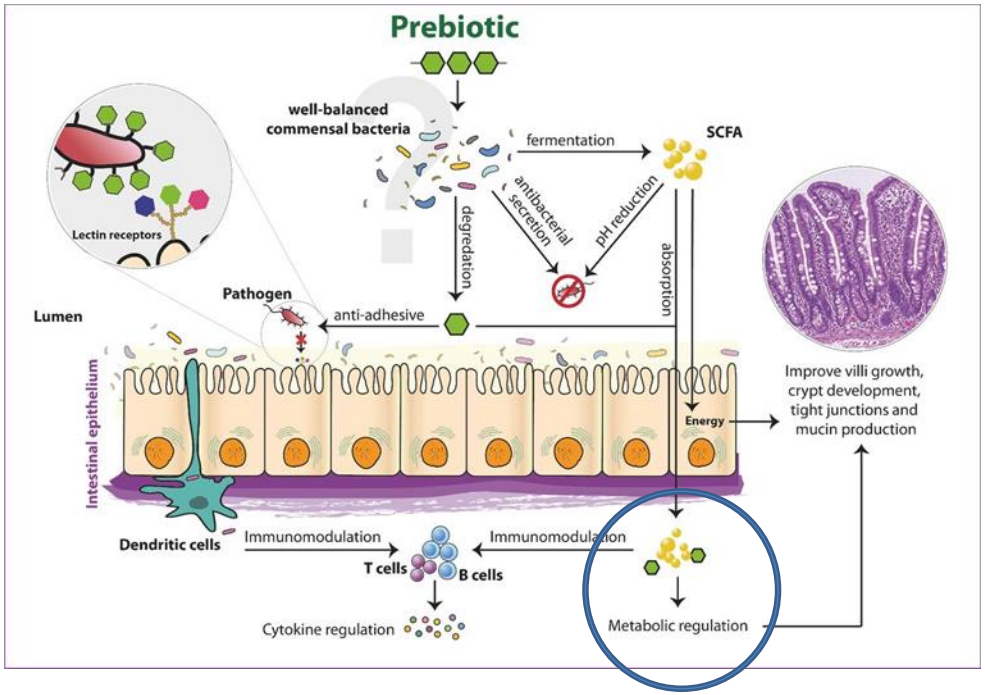
Lactose and oligosaccharides



Vandenplas, 2015; Vulevic et al., 2015; Eiwegger et al., 2004; Hickey, 2012; Flint et al., 2012; Zivkovic and Barile, 2011

Effects of lactose as a prebiotic

- Dairy prebiotics and probiotics may influence gut microbiota in such a way that **insulin sensitivity** and the action of the incretin hormone glucagon-like peptide (GLP-1) are positively affected



Vandenplas, 2015; Vulevic et al., 2015; Eiwegger et al., 2004; Hickey, 2012; Flint et al., 2012; Zivkovic and Barile, 2011

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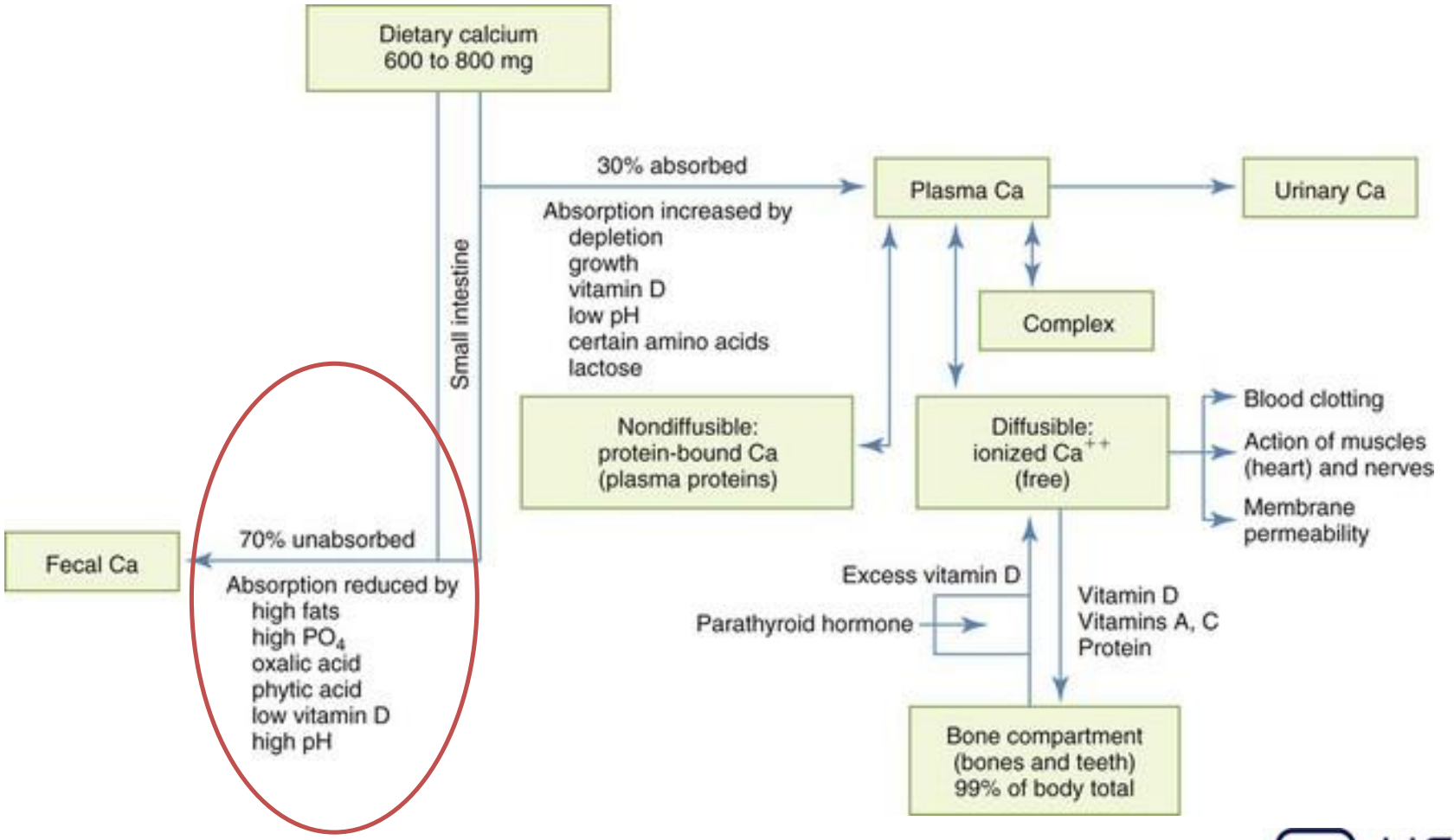
Effect of lactose on calcium absorption



Heaney and Nordin, 2002; Vandenplas, 2015; Kwak et al., 2012; Abrams et al., 2002

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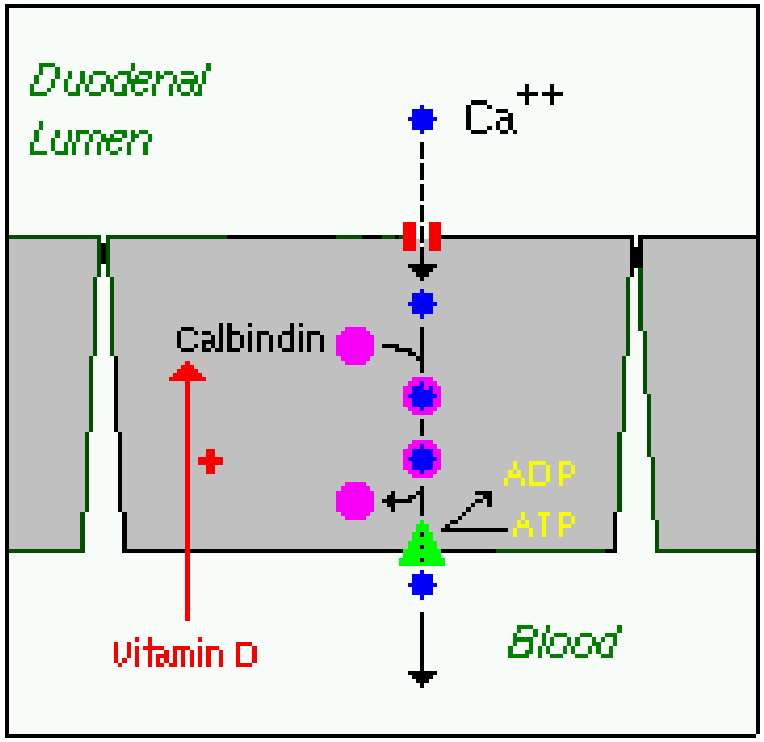
Effect of lactose on calcium absorption



- Net calcium absorption about **10-30%** of intake
- **Animal studies**: lactose has a positive effect on intestinal calcium absorption
- Effect in **humans** has not been confirmed (probably owing to potential confounding factors such as other dietary components that may affect calcium absorption)

Heaney and Nordin, 2002; Vandenplas, 2015; Kwak et al., 2012; Abrams et al., 2002

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Effect of lactose on calcium absorption

- Lactose does show enhanced absorption of calcium in humans compared with **other types** of non-absorbable **sugars** (such as mannitol, lactitol or corn starch)

- Absorption of calcium significantly higher in infants fed a lactose-containing formula than in those fed a **lactose-free formula** that contained corn maltodextrin and corn syrup solids

Heaney and Nordin, 2002; Vandenplas, 2015; Kwak et al., 2012; Abrams et al., 2002

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Effect of lactose on calcium absorption

The exact mechanism by which lactose enhances the absorption of calcium unclear:

- may be due to an effect on **intestinal alkaline phosphatase**
- increased **mineral solubility**
- enhanced **osmotic pressure** following fermentation

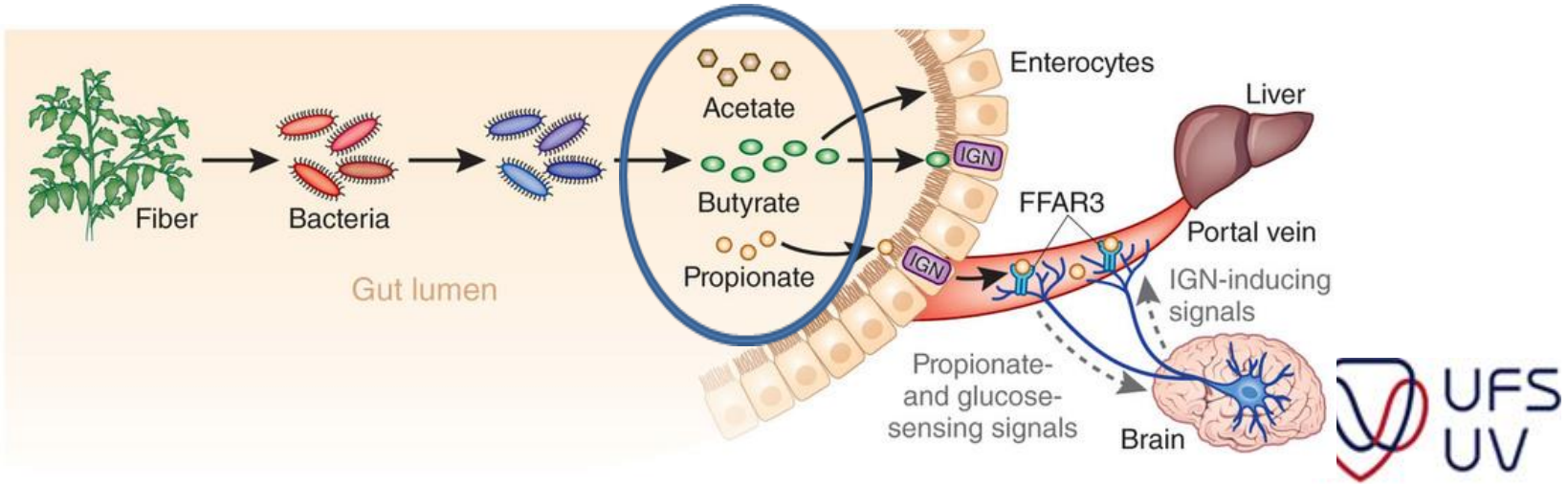
Kwak et al., 2012; Areco et al., 2015; Schaafsma, 2008

Effect of lactose on calcium absorption

In persons with lactase non-persistence, calcium absorption from dairy products is enhanced due to the prebiotic effect of lactose:

- sustaining the growth of **gut flora** such as bifidobacteria and lactobacilli

- encouraging the formation of **short-chain fatty acids** that promote the growth of lactic acid bacteria



Kwak et al., 2012

So, yes…there are apparent advantages to being lactose non-persistence after all…

Deng et al., 2015; McSweeney and Fox, 2009; Vandenplas, 2015; Heaney, 2013; Mattar et al., 2012; Brown-Esters et al., 2012; Leonardi et al., 2012

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Why are some people lactose non-persistence and others not?

(213910*T)

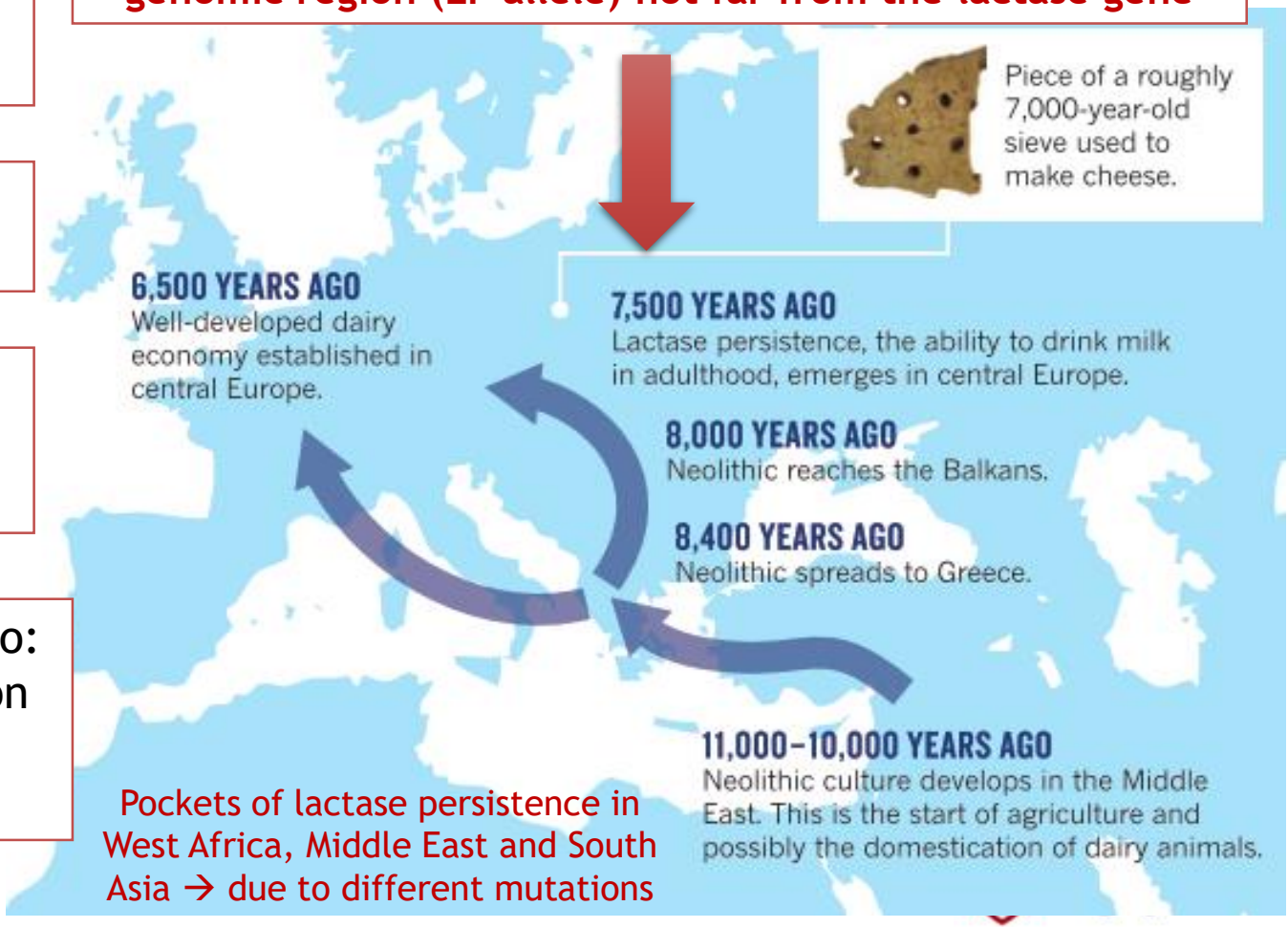
In Europe the DNA base cytosine changed to thymine in a genomic region (LP allele) not far from the lactase gene

Originally milk was not tolerated >7-8yrs

After the onset of cattle farming

Developed ways to tolerate milk by fermenting it

In Europe 7500 yrs ago: a single gene mutation emerged that caused lactose persistence



Pockets of lactase persistence in West Africa, Middle East and South Asia → due to different mutations

Curry, 2013, Nature, 500

Why did the mutation persist?

1. Opened up a new nutrient rich food source

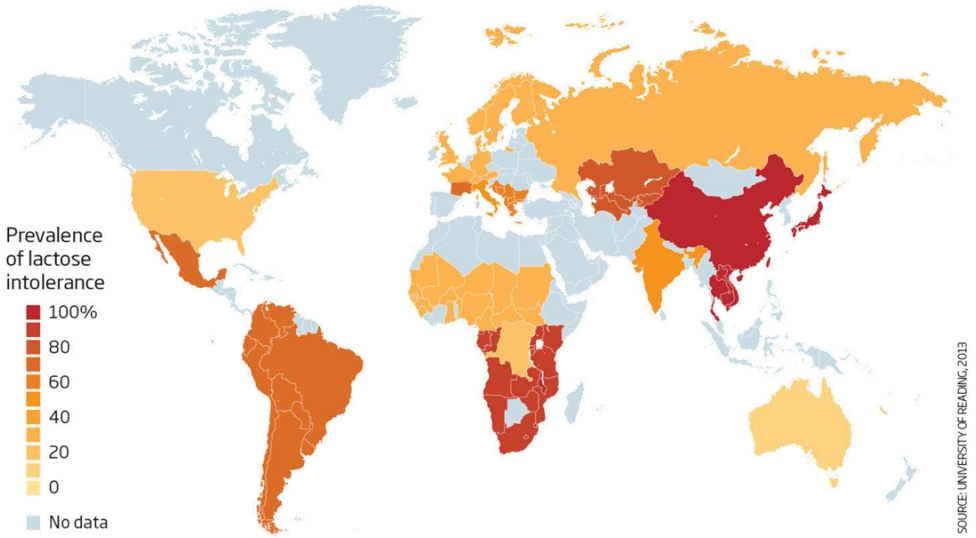
2. When the LP allele appeared, it offered a major selective advantage -> how?

Still debated….

-vit D?

- malaria?

In a 2004 study researchers estimated that people with the mutation would have produced up to 19% more fertile offspring than those who lacked it.



Compounded over several hundred generations, that advantage could help a population to take over a continent. But only if "the population has a supply of fresh milk and is dairying"

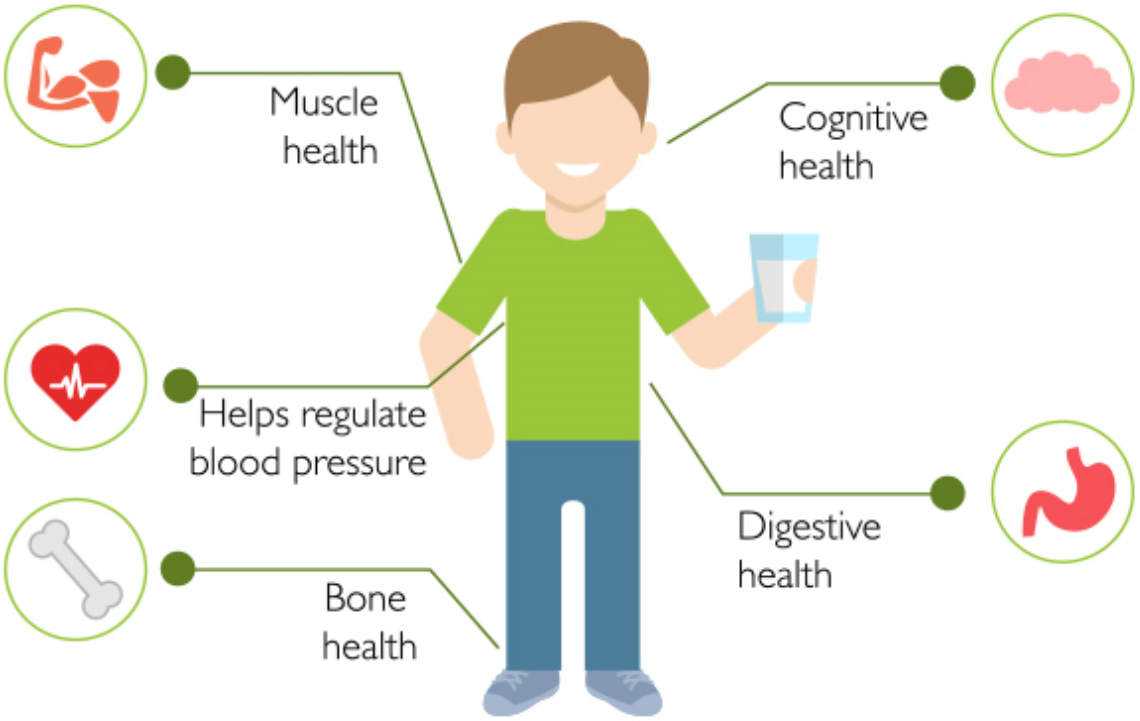
"It's **gene-culture co-evolution**. They feed off of each other."

Niche construction

Curry, 2013, Nature, 500

Laland, K. N., Olding-Smee, F. J. & Feldman, M. W. 1996 J. Evol. Biol. 9, 293–316.

A growing evidence base supports the inverse association between **dairy consumption** and **health outcomes**



Dairy : Chronic diseases of lifestyle?

- Studies often heterogeneous:
  - Various **study designs** have been applied, including observational studies (cross-sectional and longitudinal cohort studies), RCTs, systematic reviews and meta-analyses
  - Studies do not differentiate on the basis of **health status, weight, age or ethnic background**

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- Studies often heterogeneous (cont.):
  - Although **differences in nutrient composition** of dairy products may affect outcomes differently, some studies evaluated the effect of total dairy product intake, whereas others differentiated between low-fat dairy products, high-fat dairy products, yoghurt, cheese, and liquid versus solid foods
  - Other factors that may impact on health outcomes and which should ideally be adjusted for include **smoking, alcohol consumption** and other dietary confounders (such as calcium and total energy intake)

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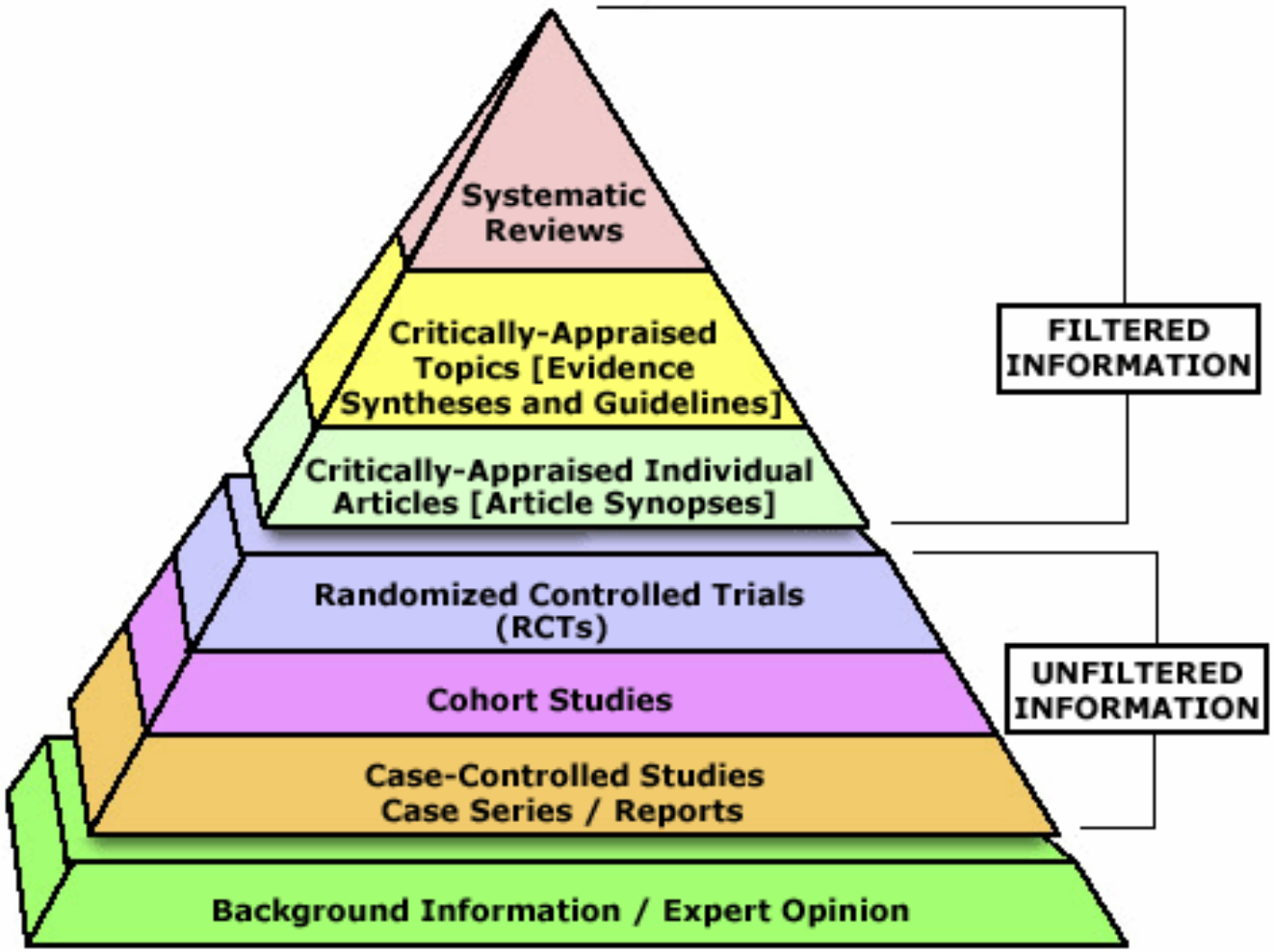
Systematic Reviews
Critically-Appraised Topics [Evidence Syntheses and Guidelines]
Critically-Appraised Individual Articles [Article Synopses]
Randomized Controlled Trials (RCTs)
Cohort Studies
Case-Controlled Studies
Case Series / Reports
Background Information / Expert Opinion
FILTERED INFORMATION
UNFILTERED INFORMATION

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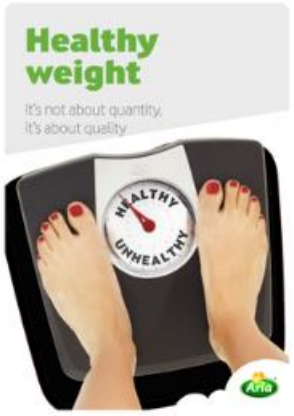
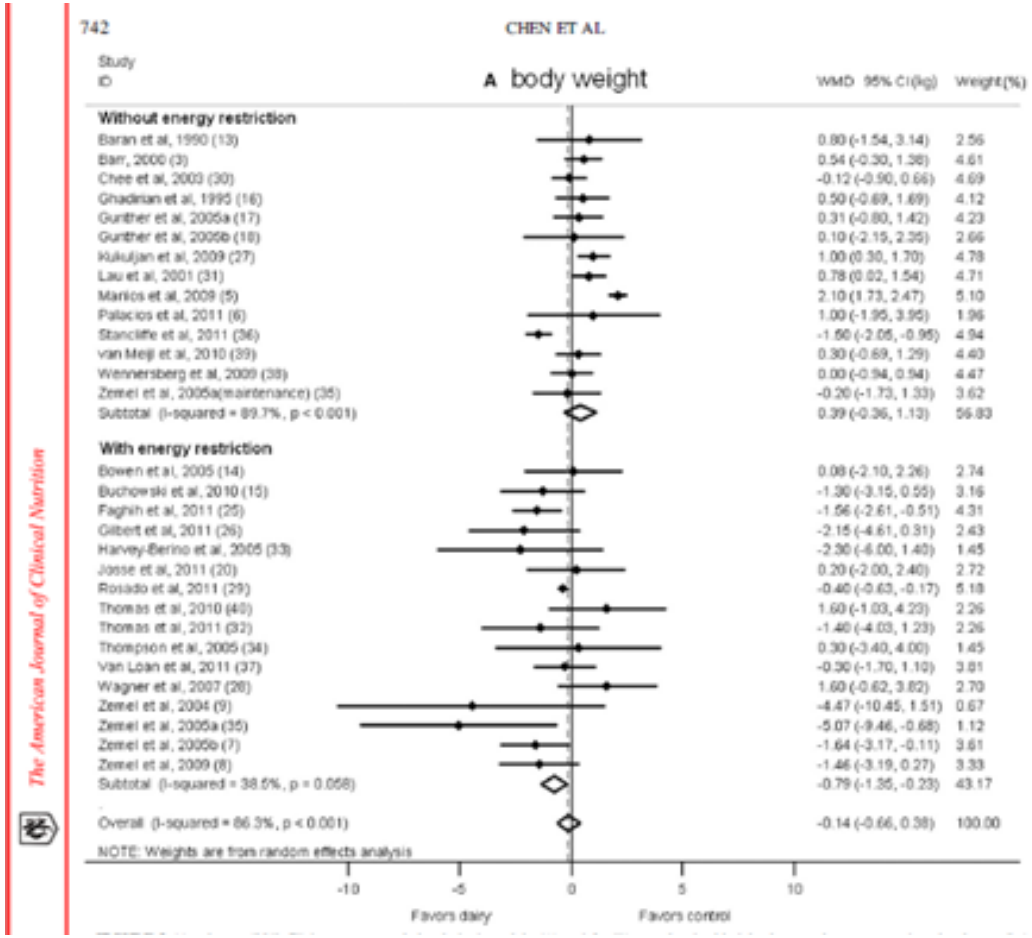
Overweight and obesity: Evidence



Chen et al. (2012): 27 RCTs, 2101 participants

- Confirmed that an energy-restricted diet that includes increased milk and dairy consumption lowered body weight and body fat in the short term

- However, in situations without energy restriction, inclusion of dairy was unlikely to impact on body weight



Overweight and obesity: Evidence

Kratz et al. (2013):
16 observational studies

- Relationship between dairy fat and high-fat dairy foods, obesity and cardio-metabolic disease

- In 11 of the 16 studies, high-fat dairy intake was inversely associated with measures of adiposity

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Overweight and obesity: Evidence

Abargouei et al. (2012):
14 RCTs, 883 participants

- Including dairy products in weight-loss diets, reduced fat mass and waist circumference and accelerated weight reduction, while increasing lean mass significantly more than conventional weight-loss diets

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Overweight and obesity: Evidence

Dror (2014):

36 cross-sectional, prospective cohort and intervention studies amongst pre-school children, school-age children and adolescents in developed countries

- In adolescents, dairy intake was inversely associated with adiposity, while the association was not significant in school-age or pre-school children

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Overweight and obesity: Evidence

Louie et al. (2011):

19 cohort studies (10 in children and adolescents and 9 in adults)

A beneficial effect was found in 8 studies, whereas 7 showed no effect, 1 reported an increased risk (amongst children) and 2 reported both a decreased and increased risk, depending on the type of dairy eaten

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Overweight and obesity: Evidence

Lu et al. (2016):

10 cohort studies (46 011 children and adolescents)

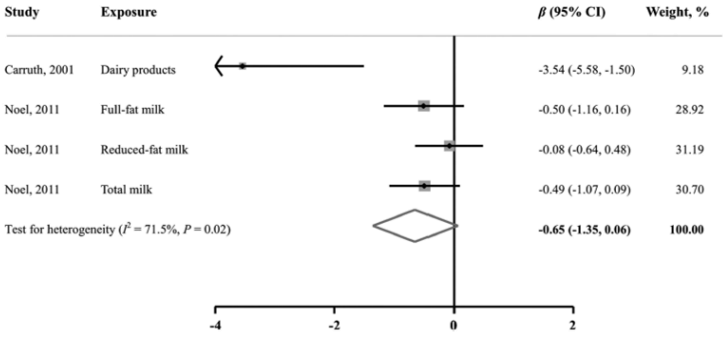

Figure 3. Multivariable-adjusted β-coefficients and 95% CIs of percentage body fat in relation to dairy consumption. The pooled estimate was obtained by using a random-effects model. The dots indicate the adjusted β-coefficient with 1 serving/day increment in dairy consumption. The size of the shaded square is proportional to the weight of each study. The horizontal lines represent 95% CIs. The diamond indicates the pooled β-coefficient. PBF indicates percentage body fat.

Dairy consumption was inversely associated with body fat and positively associated with an increased BMI, indicating that dairy products may promote lean body mass but decrease body fat and so increase BMI

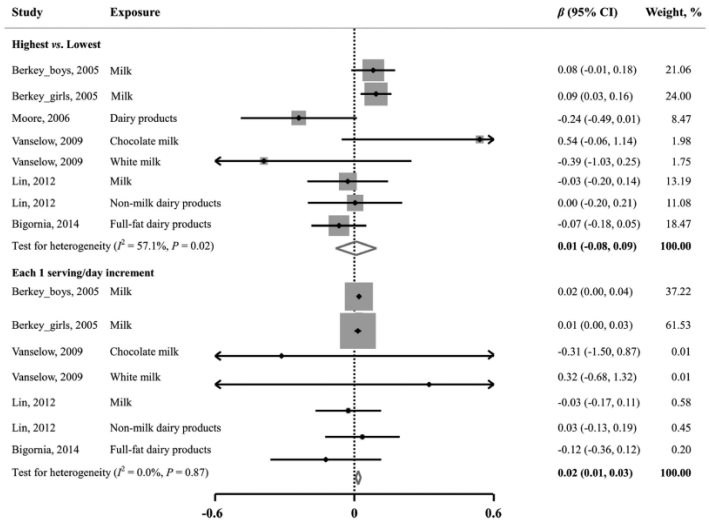

Figure 4. Multivariable-adjusted β-coefficients and 95% CIs of BMI gain in relation to dairy consumption. The pooled estimates were obtained by using a random-effects model. The dots indicate the adjusted ORs by comparing the highest with the lowest level of dairy consumption or each 1 serving/day increment in dairy consumption. The size of the shaded square is proportional to the weight of each study. The horizontal lines represent 95% CIs. The diamond indicates the pooled β-coefficient.

Overweight and obesity: Mechanisms

- A high calcium intake may lead to the calcium-mediated formation of **insoluble soaps**, which prevent fat absorption by binding bile acids
- Whey protein seems to have an important role in **muscle sparing** and lipid metabolism
- Dairy may induce **reduced lipogenesis** and **increased lipolysis**
- Lactose may influence the **bacterial composition** of the gut microbiota, influencing energy homeostasis and insulin sensitivity as well as fat storage and metabolism

Chen et al., 2012; Kratz et al. 2013; Zemel, 2009; Christensen et al., 2009; Weaver, 2014; Rice et al., 2013; Sanders, 2012; Sousa et al., 2012; Pal et al., 2010; Petschow et al., 2013; Velagapudi et al., 2010

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"The application of prebiotics and probiotics in manipulating the microbiota to improve lipid metabolism and insulin resistance is a **field of research** that may come to have an important role in addressing overweight and obesity"

Petschow et al.,2013

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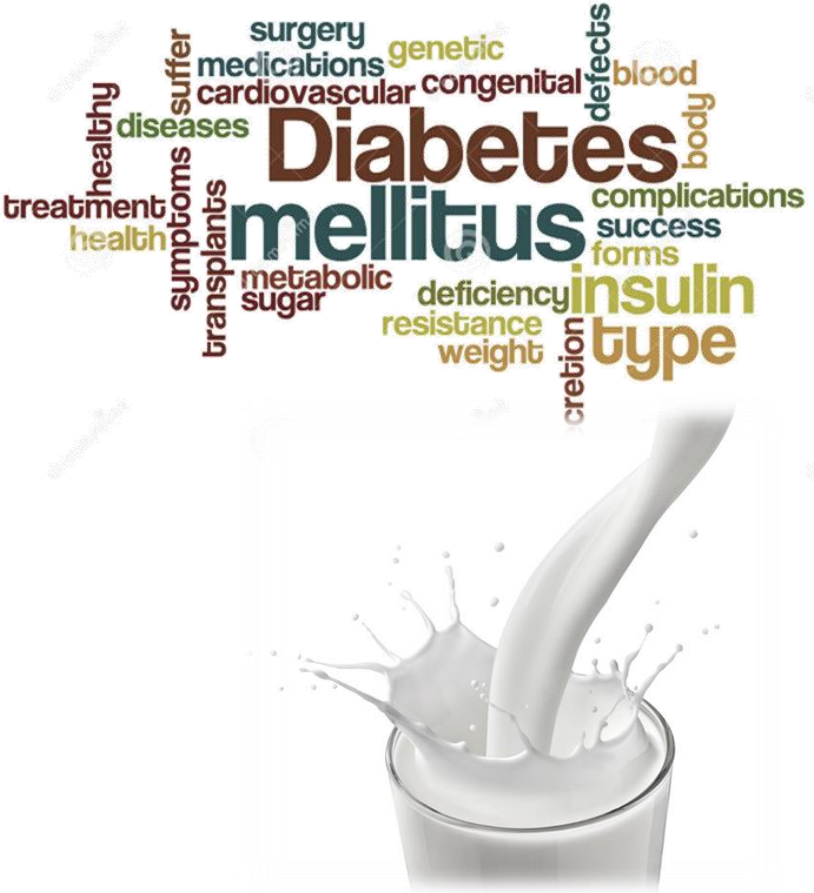
Type 2 Diabetes Mellitus: Evidence (6)

Elwood et al. (2):

4 prospective cohort studies

Milk or dairy consumption protected against T2DM

Each additional serving per day was significantly associated with a reduction of 4-9% in diabetes incidence



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Type 2 Diabetes Mellitus: Evidence

Pittas et al. (2007) cohort studies

- Compared the effect of high and low dairy intakes (3–5 servings per day vs 1.5 servings per day)
- Higher dairy intake was associated with a lower risk of diabetes

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Type 2 Diabetes Mellitus: Evidence

Kratz et al. (2013)

- Consumption of high-fat dairy products was inversely associated with T2DM
- Same association was not found for low-fat dairy

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Type 2 Diabetes Mellitus: Evidence

Tong et al. (2011): seven cohort studies (328 029 cases)

- Inverse association between yoghurt and milk consumption (especially **skimmed or semi-skimmed milk**) and type 2 diabetes, which seemed to be dose dependent

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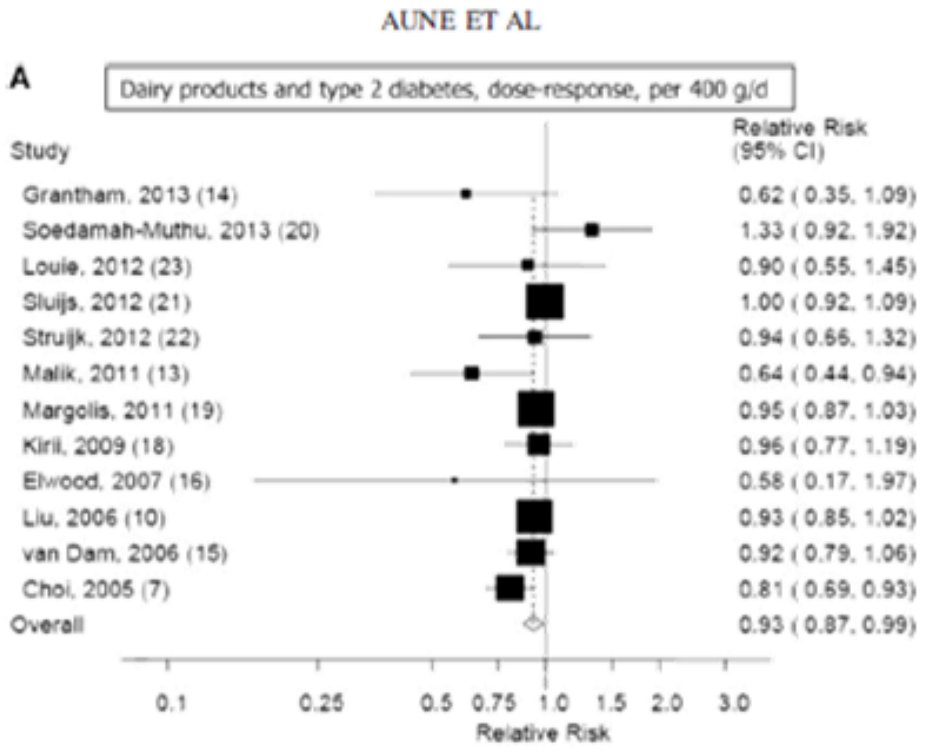
Type 2 Diabetes Mellitus: Evidence



Aune et al. (2013):
17 prospective cohort and case-control studies

- Significant inverse association between intakes of dairy products and the risk of type 2 diabetes

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Type 2 Diabetes Mellitus: Evidence

Gao et al. (2013):
14 studies

- To clarify the dose–response association of dairy intake and risk of T2DM

- Inverse linear association of consumption of all dairy products (13 studies), low-fat dairy products (8 studies), cheese (7 studies) and yoghurt (7 studies) and the risk of type 2 diabetes

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Type 2 Diabetes Mellitus: Mechanisms

- A beneficial effect of dairy on **metabolic and inflammation markers** relevant to T2DM and insulin resistance found in animal studies
- Dairy fat - **trans-palmitoleic acid** - may improve insulin secretion, triglyceridaemia and blood pressure
- Relatively **low glycaemic index** of milk assists in blood glucose control
- Lactose may have beneficial effects on the **gut microbiota** which may affect GLP-1 and gastric inhibitory polypeptide (GIP), both of which are affected in T2DM

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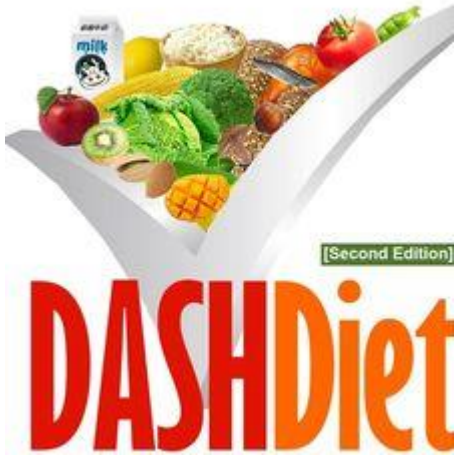
Hirahatake et al., 2014; Kalergis et al., 2013; Kratz et al., 2013; Mozaffarian et al., 2013; Sluijs et al., 2012; Gunnerud et al., 2012; Panwar et al., 2013

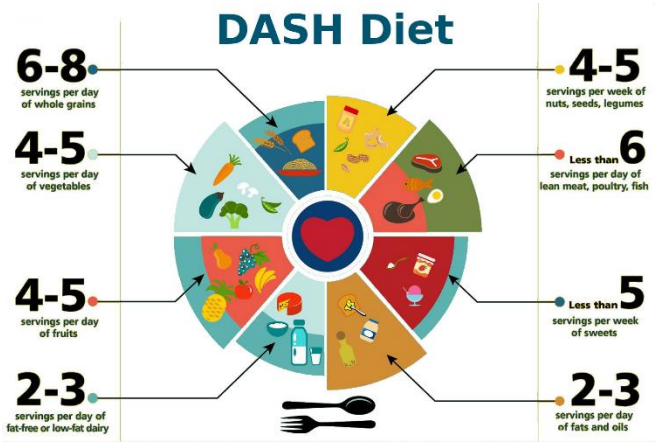
Hypertension: Evidence

Appel et al., 1997: Dietary Approaches to Stop Hypertension (DASH) trial



- A diet rich in fruit, vegetables and low-fat dairy, with reduced total and saturated-fat intake reduces blood pressure

- About **50% of the reduction in blood pressure** associated with the DASH diet ascribed to **dairy consumption**



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Hypertension: Evidence

McGrane et al. (2011): RCTs and cohort studies

- Significant inverse associations between intakes of total dairy, low-fat dairy and fluid dairy foods and hypertension, but none for high-fat dairy and cheese

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Hypertension: Evidence

Ralston et al. (2012):

5 cohort studies, 45 000 subjects of whom 11 500 had elevated blood pressure

- Significant inverse associations between intakes of total dairy, low-fat dairy and fluid dairy foods (milk and yoghurt) and blood pressure

- Fat-free and low-fat dairy products, especially milk, appear to have an even more significant lowering effect on blood pressure than other dairy products

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Hypertension: Evidence

Soedamah-Muthu et al. (2012):

dose-response meta-analysis of cohort studies, 57 256 subjects (of whom 15 367 were hypertensive)

Followed up for between 2 and 15 years

- Intakes of total dairy, low-fat dairy and milk were all linearly associated with a lower risk of hypertension

- Consumption of high-fat dairy, total fermented dairy, yoghurt and cheese not significantly associated with hypertension incidence

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Hypertension: Mechanisms

- Dairy products are low in sodium and rich in protein, minerals (calcium, magnesium, potassium and phosphorus), vitamins (riboflavin, folate, and vitamin D in fortified milk) and trace elements (iodine, selenium and zinc), which may contribute to a reduction in blood pressure **individually or in combination**

- Although sodium is the mineral with the most significant effect on blood pressure, **calcium and potassium** also play a role

McGrane et al., 2011; Kris-Etherton et al., 2009; Dickinson et al., 2006; Ralston et al., 2012; FitzGerald et al., 2004; Huth et al., 2006

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Hypertension: Mechanisms

Bioactive milk peptides such as **lactotripeptides** may also contribute to the protective effect of dairy on blood pressure

These compounds inhibit the action of **angiotensin 1-converting enzyme** (ACE), thereby preventing blood vessel constriction

The **prebiotics and probiotics** in dairy products may have a positive effect on body weight and thus potentially also on the comorbidities associated with overweight and obesity, of which hypertension is one

McGrane et al., 2011; Kris-Etherton et al., 2009; Dickinson et al., 2006; Ralston et al., 2012; FitzGerald et al., 2004; Huth et al., 2006

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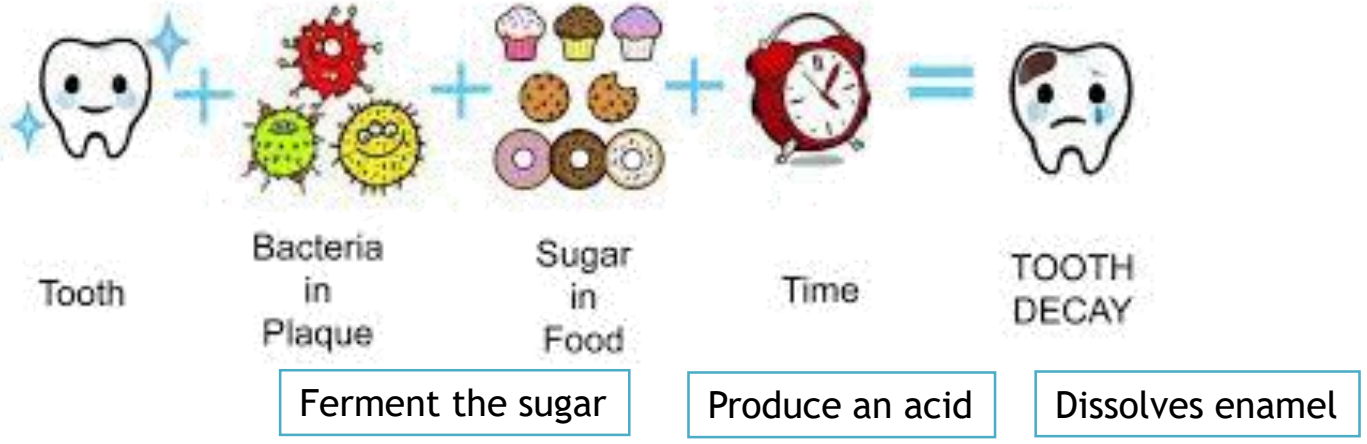
Dental Caries



Dietary sugars contribute to the development of dental caries

- However, this does not act in isolation:

3 factors are required for dental caries to develop:

- the presence of dietary carbohydrate (sugar)
- dental plaque bacteria and
- teeth that are susceptible to caries

Aimutis, 2012

Dental Caries

- Sweetening power of lactose is only **15%** that of sucrose - unlikely sweetener choice in processed foods
- Dairy products contain **proteins, fats, vitamins and minerals** (calcium and phosphorus), which protect against dental caries
- When replacing other sugars, such as **sucrose and fructose**, lactose has been shown to be the least cariogenic of all dietary sugars
- Milk further also does not increase **plaque acidity**

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Merritt, 2006; Shenkin et al., 2003; Molan, 2001

Dental Caries: Evidence

Dror and Allen, 2014:
11 observational studies

- Association between dairy intake and health outcomes in children and adolescents in developed countries

- All studies reported an inverse association between dairy intake and dental caries and some reported that the association was even stronger for yoghurt and cheese consumption

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Dental Caries: Evidence

Adegboye et al. (2012):

- Intake of calcium from dairy sources associated with a reduced risk of tooth loss, but the same association was not seen when calcium from non-dairy sources was consumed

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Dental Caries: Evidence

Levine (2001):

- Consumption of sweetened dairy foods, such as chocolate milk, does not increase the risk of dental caries and therefore dairy beverages are considered a healthier option than sweetened soft drinks

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Dental Caries: Mechanisms

- Eating **cheese** increases the concentration of calcium in saliva and plaque, which helps to protect tooth enamel

- **Bioactive peptides** in caseins protect against caries by preventing demineralization and inhibiting the attachment of bacteria to the teeth

- Probiotics in milk also result in **lower bacterial counts**, possibly because the composition of the salivary film changes and there is reduced adhesion of bacteria

Merritt et al., 2006; Kashket and DePaola, 2002; Aimutis, 2004; Stamatova and Meurman, 2009

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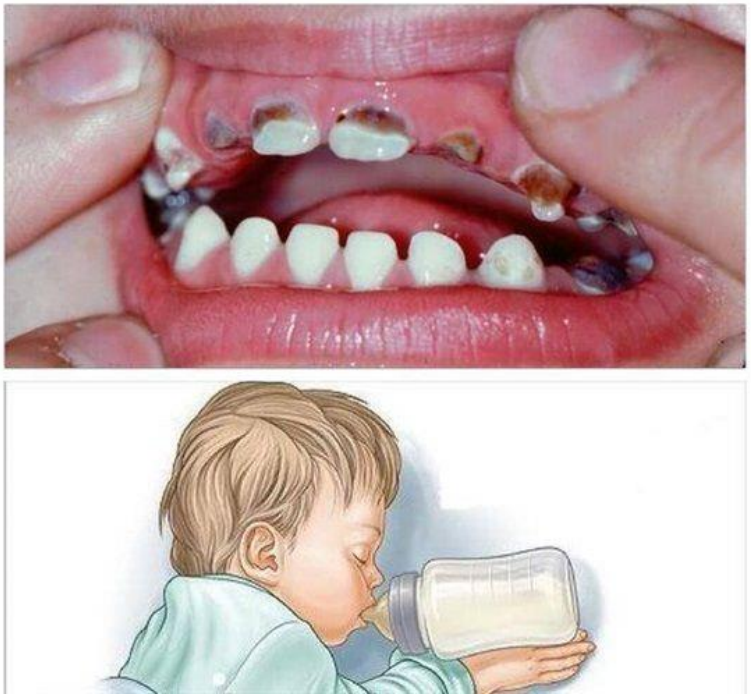
Dental Caries: Infant feeding

- Most infants are exposed to lactose during **breastfeeding or formula feeding** and in the presence of cariogenic bacteria, milk could potentially be cariogenic

- The reportedly higher cariogenecity of **human milk** (and some infant formulas) compared with **cow's milk** may be due to the comparatively higher lactose content and lower protein, calcium and phosphorus content in these milks

Koletzko et al., 2005

Dental Caries: Infant feeding



- When babies go to sleep with a **bottle**, milk may remain in the mouth for several hours, resulting in decreased salivary flow and extended exposure of dental plaque to fermentable carbohydrates

- Formulas that contain **other sweeteners**, such as high-fructose corn syrup or sucrose, are also more cariogenic than those containing only lactose

Koletzko et al., 2005

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Dental Caries: Prevention

- Importance of oral health in preventing development of caries
- **Different foods** can affect oral pH, plaque formation and salivary flow
- **Healthy eating** has a critical role in the growth, development and maintenance of oral tissues throughout life
- Intake of milk and dairy products is an essential component of healthy eating, and the calcium and bioactive components in dairy may have an important role in **preventing** dental caries and periodontitis

Aimutis, 2012; Merritt, 2006; Aimutis, 2004

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Conclusion

There is **extensive evidence** that moderate consumption of dairy, as part of a balanced diet, is beneficial to health!

Thank You!

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References

- Abargouei AS, Janghorban M, Salehi-Marzijarani M and Esmaillzadeh A. 2012. Effect of dairy consumption on weight and body composition in adults: a systematic review and meta-analysis of randomized controlled clinical trials. International Journal of Obesity, 36:1485–1493.
- Abrams SA, Griffin IJ, Davila PM. 2002. Calcium and zinc absorption from lactose-containing and lactose-free infant formulas. American Journal of Clinical Nutrition, 76:442–446.
- Adegboye AR, Twetman S, Christensen LB and Heitmann BL. 2012. Intake of dairy calcium and tooth loss among adult Danish men and women. Nutrition, 28:779–784.
- Ahmadi-Abhari S, Luben RN, Powell N, Bhaniani A, Chowdhury R, Wareham NJ, Forouhi NG and Khaw KT. 2013. Dietary intake of carbohydrates and risk of type 2 diabetes: the European Prospective Investigation into Cancer–Norfolk Study. British Journal of Nutrition, 23:1–11.
- Aimutis WR. 2004. Bioactive properties of milk proteins with particular focus on anticariogenesis. Journal of Nutrition, 134:989S–995S.
- Aimutis WR. 2012. Lactose cariogenicity with an emphasis on childhood dental caries. International Dairy Journal, 22:152–158.
- Amiri M, Diekmann L, von Köckritz-Blickwede M and Naim HY. 2015. The diverse forms of lactose intolerance and the putative linkage to several cancers. Nutrients, 7:7209–7230.

UFS UV

References

- Appel LJ, Moore TJ, Obarzanek E, Vollmer WM, Svetkey LP, Sacks FM, Bray GA, Vogt TM, Cutler JA, Windhauser MM, Lin P and Karanja N. 1997. A clinical trial of the effects of dietary patterns on blood pressure. New England Journal of Medicine, 336(16):1117–1124.
- Areco V, Rivoira MA, Rodriguez V, Marchionatti AM, Carpentieri A and Tolosa de Talamoni N. 2015. Dietary and pharmacological compounds altering intestinal calcium absorption in humans and animals. Nutrition Research Reviews, 28:83–99.
- Aune D, Lau R, Chan DS, Vieira R, Greenwood DC, Kampman E and Norat T. 2012. Dairy products and colorectal cancer risk: a systematic review and meta-analysis of cohort studies. Annals of Oncology, 23:37–45.
- Aune D, Norat T, Romundstad P and Vatten LJ. 2013. Dairy products and the risk of type 2 diabetes: a systematic review and dose-response meta-analysis of cohort studies. American Journal of Clinical Nutrition, 98:1066-1083.
- Bailey RK, Pozo Fileti C, Keith J, Tropez-Sims S, Price W and Allison-Ottey SD. 2013. Lactose intolerance and health disparities among African Americans and Hispanic Americans: an updated consensus statement. Journal of the National Medical Association, 105(2):112–127.
- Bonneux L. 2014. Unaccounted sex differences undermine association between milk intake and risk of mortality and fractures. British Medical Journal, 349:g7012.
- Brown-Esters O, Mc Namara P and Savaiano D. 2012. Dietary and biological factors influencing lactose intolerance. International Dairy Journal, 22:98–103.

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References

- Cederlund A, Kai-Larsen Y, Printz G, Yoshio H, Alvelius G, Lagercrantz H, Strömberg R, Jörnvall H, Gudmundsson GH and Agerberth B. 2013. Lactose in human breast milk an inducer of innate immunity with implications for a role in intestinal homeostasis. PLoS One, 8:e53876.
- Charlton KE, Steyn K, Levitt NS, Zulu JV, Jonathan D, Veldman FJ and Nel JH. 2005. Diet and blood pressure in South Africa: intake of foods containing sodium, potassium, calcium, and magnesium in three ethnic groups. Nutrition, 21:39–50.
- Chen M, Pan A, Malik VS and Hu FB. 2012. Effects of dairy intake on body weight and fat: a meta-analysis of randomized controlled trials. American Journal of Clinical Nutrition, 96:735–747.
- Chichlowski M, German JB, Lebrilla CB and Mills DA. 2011. The influence of milk oligosaccharides on microbiota of infants: opportunities for formulas. Annual Review of Food Science and Technology, 2:331–351.
- Christensen R, Lorenzen JK and Svith CR. 2009. Effect of calcium from dairy and dietary supplements on faecal fat excretion: a meta-analysis of randomized controlled trials. Obesity Reviews, 10:475–486.
- Coelho AI, Berry GT and Rubio-Gozalbo ME. 2015. Galactose metabolism and health. Current Opinion in Clinical Nutrition and Metabolic Care, 18:422–427.
- Cramer DW. 1989. Lactase persistence and milk consumption as determinants of ovarian cancer risk. American Journal of Epidemiology, 130:904–910.

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References

- Cui X, Zuo P, Zhang Q, Li X, Hu Y, Long J, Packer L and Liu J. 2006. Chronic systemic D-galactose exposure induces memory loss, neurodegeneration, and oxidative damage in mice: protective effects of R-alpha-lipoic acid. Journal of Neuroscience Research, 83:1584–1590.
- Daubioul C, Rousseau N, Demeure R, Gallez B, Taper H, Declerck B and Delzenne N. 2002. Dietary fructans, but not cellulose, decrease triglyceride accumulation in the liver of obese Zucker fa/fa rats. Journal of Nutrition, 132:967–973.
- Dauchet L, Kesse-Guyot E, Czernichow S, Bertrais S, Estaquio C, Peneau S, Vergnaud A, Chat-Yung S, Castetbon K, Deschamps V, Brindel P and Hercberg S. 2007. Dietary patterns and blood pressure change over 5-y follow-up in the SU.VI.MAX cohort. American Journal of Clinical Nutrition, 85:1650–1656.
- Décombaz J, Jentjens R, Ith M, Scheurer E, Buehler T, Jeukendrup A and Boesch C. 2011. Fructose and galactose enhance postexercise human liver glycogen synthesis. Medicine and Science in Sports and Exercise, 43:1964–1971.
- Deng Y, Misselwitz B, Ning D and Fox M. 2015. Lactose Intolerance in adults: biological mechanism and dietary management. Nutrients, 7:8020–8035.
- Dickinson HO, Nicolson DJ, Cook JV, Campbell F, Beyer FR and Mason J. 2006. Calcium supplementation for the management of primary hypertension in adults. Cochrane Database Systematic Review, 19(2):CD004639.

UFS UV

References

- Dong JY, Zhang L, He K and Qin LQ. 2011. Dairy consumption and risk of breast cancer: a meta-analysis of prospective cohort studies. Breast Cancer Research and Treatment, 127:23–31.
- Dror K. 2014. Dairy consumption and pre-school, school-age and adolescent obesity in developed countries: a systematic review and meta-analysis. Obesity Reviews, 15:516–527.
- Dror DK and Allen LH. 2014. Dairy product intake in children and adolescents in developed countries: trends, nutritional contribution, and a review of association with health outcomes. Nutrition Reviews, 72:68–81.
- Duthie SJ. 2011. Folate and cancer: how DNA damage, repair and methylation impact on colon carcinogenesis. Journal of Inherited Metabolic Disorders, 34:101–109.
- Eiwegger T, Stahl B, Schmitt J, Boehm G, Gerstmayr M, Pichler J, Dehlink E, Loibichler C, Urbanek R and Szepfalusi Z. 2004. Human milk-derived oligosaccharides and plant-derived oligosaccharides stimulate cytokine production of cord blood T-cells in vitro. Pediatric Research, 56:536–540.
- Elwood PC, Givens DI, Beswick AD, Fehily AM, Pickering JE and Gallacher J. 2008. The survival advantage of milk and dairy consumption: an overview of evidence from cohort studies of vascular diseases, diabetes and cancer. Journal of the American College of Nutrition, 27:723S–7234S.
- Emms T. 2005. Galactose Content of Foods, BIOSCREEN Specialist Medical Testing Laboratory. www.bioscreenmedical.com. Accessed on 3 May 2016.
- FitzGerald RJ, Murray BA and Walsh DJ. 2004. Hypotensive peptides from milk proteins. Journal of Nutrition, 134:980S–988S.

UFS UV

References

- Flint HJ, Scott KP, Louis P and Duncan SH. 2012.The role of the gut microbiota in nutrition and health. Nature Reviews Gastroenterology & Hepatology, 9(10):577–589.
- Gao D, Ning N, Wang C, Wang Y, Li Q, Meng Z, Liu Y and Li Q. 2013. Dairy products consumption and risk of type 2 diabetes: systematic review and dose-response meta-analysis. PLoS ONE, 8(9):e73965.
- Genkinger JM, Hunter DJ, Spiegelman D, Anderson KE, Arslan A, Beeson WL, Buring JE, Fraser GE, Freudenheim JL, Goldbohm RA, Hankinson SE, Jacobs Jr. DR, Koushik A, Lacey Jr. JV, Larsson SC, Leitzmann M, McCullough ML, Miller AB, Rodriguez C, Rohan TE, Schouten LJ, Shore R, Smit E, Wolk A, Zhang SM and Smith-Warner SA. 2006. Dairy products and ovarian cancer: a pooled analysis of 12 cohort studies. Cancer Epidemiology, Biomarkers & Prevention, 15(2):364–372.
- Goldfein KR and Slavin JL. 2015. Why sugar is added to food: food science 101. Comprehensive Reviews in Food Science and Food Safety, 14(5):644–656.
- Gopal PK and Gill HS. 2000. Oligosaccharides and glycoconjugates in bovine milk and colostrum. British Journal of Nutrition, 84(1):S69–S74.
- Guggenblichler JP, De Bettignies-Dutz A, Meissner S and Jurenitsch J. 1997. Acid oligosaccharides from natural sources block adherence of Escherichia coli on uropithelial cells. Pharmaceutical and Pharmacological Letters, 7:35–38.
- Gunnerud U, Holst JJ, Östman E and Björk I. 2012. The glycemic, insulinemic and plasma amino acid responses to equi-carbohydrate milk meals, a pilot-study of bovine and human milk. Nutrition Journal, 11:83.

UFS UV

References

- Hanover LM and White JS. 1993. Manufacturing, composition, and application of fructose. Journal of Clinical Nutrition, 58:724s–732s.
- Heaney RP. 2013. Dairy intake, dietary adequacy, and lactose intolerance. Advances in Nutrition, 4:151–156.
- Heaney RP and Nordin BEC. 2002. Calcium effects on phosphorus absorption: implications for the prevention and co-therapy of osteoporosis. Journal of the American College of Nutrition, 21:239–244.
- Hickey RM. 2012. The role of oligosaccharides from human milk and other sources in prevention of pathogen adhesion. International Dairy Journal, 22:141–146.
- Hill TR. 2014. Vitamin D status, bone fracture, and mortality. British Medical Journal, 349:g6995.
- Hirahatake KM, Slavin JL, Makic KC and Adams SH. 2014. Associations between dairy foods, diabetes, and metabolic health: potential mechanisms and future directions. Metabolism, 63:618–627.
- Huang LY, Wahlqvist ML, Huang YC and Lee MS. 2014. Optimal dairy intake is predicated on total, cardiovascular, and stroke mortalities in a Taiwanese cohort. Journal of the American College of Nutrition, 33:426–436.
- Huth PJ, DiRienzo DB and Miller GD. 2006. Major scientific advances with dairy foods in nutrition and health. Journal of Dairy Science, 89:1207–1221.
- Kalergis M, LeungYinko SSL and Nedelcu R. 2013. Dairy products and prevention of type 2 diabetes: implications for research and practice. Frontiers in Endocrinology, 4(90):1–6.

UFS UV

References

- Kashket S and DePaola DP. 2002. Cheese consumption and the development and progression of dental caries. Nutrition Reviews, 60:97–103.
- Keast DR, Fulgoni VL, Nicklas TA and O'Neil CE. 2013. Food sources of energy and nutrients among children in the United States: National Health and Nutrition Examination Survey 2003–2006. Nutrients, 5(1):283–301.
- Keith JN, Nicholls J, Reed A, Kafer K and Miller GD. 2011. The prevalence of self-reported lactose intolerance and the consumption of dairy foods among African American adults are less than expected. Journal of the National Medical Association, 103:36–45.
- Koletzko B, Baker S, Cleghorn G, Neto UF, Gopalan S, Hernell O, Hock QS, Jirapinyo P, Lonnerdal B, Pencharz P, Pzyrembel H, Ramirez-Mayans J, Shamir R, Turck D, Yamashiro Y and Zong-Yi D. 2005. Global standards for the composition of infant formula: recommendations of an ESPGHAN coordinated international expert group. Journal of Pediatric Gastroenterology and Nutrition, 41:584e599.
- Koralek DO, Bertone-Johnson ER, Leitzmann MF, Sturgeon SR, Lacey JV, Schairer Cand Schatzkin A. 2006. Relationship between calcium, lactose, vitamin D, and dairy products and ovarian cancer. Nutrition and Cancer, 56:22–30.
- Kratz M, Baars T and Guyenet S. 2013. The relationship between high-fat dairy consumption and obesity, cardiovascular, and metabolic disease. European Journal of Nutrition, 52:1–24.
- Kris-Etherton PM, Grieger JA, Hilpert KF and West SG. 2009. Milk products, dietary patterns and blood pressure management. Journal of the American College of Nutrition, 28(1):103S–119S.

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References

- Kuntz S, Kunz C and Rudloff S. 2009. Oligosaccharides from human milk induce growth arrest via G2/M by influencing growth-related cell cycle genes in intestinal epithelial cells. British Journal of Nutrition, 101:1306–1315. Kwak H, Lee W and Lee M. 2012. Revisiting lactose as an enhancer of calcium absorption. International Dairy Journal, 22:147e151.
- Labos C and Brophy J. 2014. Statistical problems with study on milk intake and mortality and fractures. British Medical Journal, 349:g6991.
- Lamprecht SA and Lipkin M. 2001. Cellular mechanisms of calcium and vitamin D in the inhibition of colorectal carcinogenesis. Annals of the New York Academy of Sciences, 952:73–87.
- Lee M, Wahlqvist ML and Peng C. 2015.Dairy foods and health in Asians: Taiwanese considerations. Asia Pacific Journal of Clinical Nutrition, 24(1):S14–S20.
- Lempert SM, Christensen LB, Froberg K, Raymond K and Heitmann BL. 2015. Association between dairy intake and caries among children and adolescents. Results from the Danish EYHS follow-up study. Caries Research, 49:251–258.
- Leonardi M, Gerbault P, Thomas M and Burger J. 2012. The evolution of lactase persistence in Europe. A synthesis of archaeological and genetic evidence. International Dairy Journal, 22:88–97.
- Levine RS. 2001. Milk, flavoured milk products and caries. British Dental Journal, 191:20.
- Li F, An SL, Zhou Y, Liang ZK, Jiao ZJ, Jing YM, Wan P, Shi XJ and Tan WL. 2011. Milk and dairy consumption and risk of bladder cancer: a meta-analysis. Urology, 78:1298–1305.
- Louie JC, Flood VM, Hector DJ, Rangan AM and Gill TP. 2011. Dairy consumption and overweight and obesity: a systematic review of prospective cohort studies. Obesity Reviews, 12:e582–592.

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References

- Lu L, Xun P, Wan Y, He K and Cai W. 2016. Long-term association between dairy consumption and risk of childhood obesity: a systematic review and meta-analysis of prospective cohort studies. European Journal of Clinical Nutrition, 70(4):414–423.
- Lukito W, Malik SG, Surono IS and Wahlqvist ML. 2015. From 'lactose intolerance' to 'lactose nutrition'. Asia Pacific Journal of Clinical Nutrition, 24(1):S1–S8.
- Mao QQ, Dai Y, Lin YW, Qin J, Xie LP and Zheng XY. 2011. Milk consumption and bladder cancer risk: a meta-analysis of published epidemiological studies. Nutrition and Cancer, 63:1263–1271.
- Mattar R, de Campos Mazo DF and Carrilho FJ. 2012. Lactose intolerance: diagnosis, genetic, and clinical factors. Clinical and Experimental Gastroenterology, 5:113–121.
- McGrane MM, Essery E, Obbagy J, Lyon J, MacNeil P, Spahn J and Van Horn L. 2011. Dairy consumption, blood pressure, and risk for hypertension: An evidence-based review of recent literature. Current Cardiovascular Risk Reports, 5(4):287–298.
- McSweeney PLH and Fox PF (eds.) 2009. Advanced Dairy Chemistry, Vol. 3: Lactose, Water, Salts and Vitamins, 3rd edn. New York: Springer.
- Merritt J, Qi F and Shi W. 2006. Milk helps build strong teeth and promotes oral health. Journal of the California Dental Association, 34:361–366.
- Michaëlsson K, Wolk A, Langenskiöld S, Basu S, Warensjö Lemming E, Melhus H and Byberg L. 2014. Milk intake and risk of mortality and fractures in women and men: cohort studies. British Medical Journal, 349:g6015.

UFS UV

References

- Missmer SA, Smith-Warner SA, Spiegelman D, Yaun SS, Adami HO, Beeson WL, van den Brandt PA, Fraser GE, Freudenheim JL, Goldbohm RA, Graham S, Kushi LH, Miller AB, Potter JD, Rohan TE, Speizer FE, Toniolo P, Willett WC, Wolk A, Zeleniuch-Jacquotte A and Hunter DJ. 2002. Meat and dairy food consumption and breast cancer: a pooled analysis of cohort studies. International Journal of Epidemiology, 31:78–85.
- Molan PC. 2001. The potential of honey to promote oral wellness. General Dentistry, 49:584e589.
- Moorman PG and Terry PD. 2004. Consumption of dairy products and the risk of breast cancer: a review of the literature. American Journal of Clinical Nutrition, 80:5–14.
- Moya M, Cortes E, Ballester MI, Vento M and Juste M. 1992. Short-term polycose substitution for lactose reduces calcium absorption in healthy term babies. Journal of Pediatric Gastroenterology and Nutrition, 14:57–61.
- Mozaffarian D, de Oliveira Otto MC, Lemaitre RN, Fretts AM, Hotamisligil G, Tsai MY, Siscovick DS and Nettleton JA. 2013. trans-Palmitoleic acid, other dairy fat biomarkers, and incident diabetes: the Multi-Ethnic Study of Atherosclerosis (MESA). American Journal of Clinical Nutrition, 97(4):854–861.
- Murphy N, Norat T, Ferrari P, Jenab M, Bueno-de-Mesquita B, Skeie G, Olsen A, Tjønneland A, Dahm CC, Overvad K, Boutron-Ruault MC, Clavel-Chapelon F, Nailler L, Kaaks R, Teucher B, Boeing H, Bergmann MM, Trichopoulou A, Lagiou P, Trichopoulos D, Palli D, Pala V, Tumino R, Vineis P, Panico S, Peeters PH, Dik VK, Weiderpass E, Lund E, Garcia JR, Zamora-Ros R, Pérez MJ, Dorronsoro M, Navarro C, Ardanaz E, Manjer J, Almquist M, Johansson I, Palmqvist R, Khaw KT, Wareham N, Key TJ, Crowe FL, Fedirko V, Gunter MJ and Riboli E. 2013. Consumption of dairy products and colorectal cancer in the European Prospective Investigation into Cancer and Nutrition (EPIC).. PLoS ONE, 8:e72715.

References

- Norat T and Riboli E. 2003. Dairy products and colorectal cancer: a review of possible mechanisms and epidemiological evidence. European Journal of Clinical Nutrition, 57:1–17.
- Pal S, Ellis V and Dhaliwal S. 2010. Effects of whey protein isolate on body composition, lipids, insulin and glucose in overweight and obese individuals. British Journal of Nutrition, 104:716–723.
- Panwar H, Rashmi HM, Batish VK and Grover S. 2013. Probiotics as potential biotherapeutics in the management of type 2 diabetes — prospects and perspectives. Diabetes/Metabolism Research and Reviews, 29(2):103–112.
- Park Y, Leitzmann MF, Subar AF, Hollenbeck A and Schatzkin A. 2009. Dairy food, calcium, and risk of cancer in the NIH-AARP Diet and Health Study. Archives of Internal Medicine, 169:391–401.
- Pereira PC. 2014. Milk nutritional composition and its role in human health. Nutrition, 30:619–627.
- Petschow B, Doré J, Hibberd P, Dinan T, Reid G, Blaser M, Cani PD, Degnan FH, Foster J, Gibson G, Hutton J, Klaenhammer TR, Ley R, Nieuwdorp M, Pot B, Relman D, Serazin A and Sanders ME. 2013. Probiotics, prebiotics, and the host microbiome: the science of translation. Annals of the New York Academy of Sciences, 1306:1–17.
- Pittas AG, Lau J, Hu FB and Dawson-Hughes B. 2007. The role of vitamin D and calcium in type 2 diabetes. A systematic review and meta-analysis. Journal of Clinical Endocrinology and Metabolism, 92: 2017–2029.

UFS UV

References

- Prado EL and Dewey KG. 2014. Nutrition and brain development in early life. Nutrition Reviews, 72:267–284.
- Ralston RA, Lee JH, Truby H, Palermo CE and Walker KZ. 2012. A systematic review and meta-analysis of elevated blood pressure and consumption of dairy foods. Journal of Human Hypertension, 26:3–13.
- Rautiainen S, Wang L, Lee I, Manson JE, Buring JE and Sesso HD. 2016. Dairy consumption in association with weight change and risk of becoming overweight or obese in middle-aged and older women: a prospective cohort study. American Journal of Clinical Nutrition, 103:979-88.
- Rice BH, Quann EE and Miller GD. 2013. Meeting and exceeding dairy recommendations: effects of dairy consumption on nutrient intakes and risk of chronic disease. Nutrition Reviews, 71:209–223.
- Rodriguez C, McCullough ML, Mondul AM, Jacobs EJ, Fakhrabadi-Shokoohi D, Giovannucci EL, Thun MJ and Calle EE. 2003. Calcium, dairy products, and risk of prostate cancer in a prospective cohort of United States men. Cancer Epidemiology, Biomarkers and Prevention, 12:597–603.
- Sanders TA. 2012. Role of dairy foods in weight management. American Journal of Clinical Nutrition, 96:687–688.
- Schaafsma G. 2008. Lactose and lactose derivatives as bioactive ingredients in human nutrition. International Dairy Journal, 18:458–465.
- Scrimshaw NS and Murray EB. 1988. The acceptability of milk and milk products in populations with a high prevalence of lactose intolerance. American Journal of Clinical Nutrition, 48:1080–1159.

UFS UV

References

- Shahar DR, Schwarzfuchs D, Fraser D, Vardi H, Thiery J, Fiedler GM, Bluher M, Stumvoll M, Stampfer MJ and Shai I. 2010. Dairy calcium intake, serum vitamin D, and successful weight loss. American Journal of Clinical Nutrition, 92:1017–1022.
- Shaw JH, Schweigert BS, McIntire JM, Elvehjem CA and Phillips PH. 1944. Dental caries in the cotton rat. I. Methods of study and preliminary nutritional experiments. Journal of Nutrition, 28:333–345.
- Shenkin JD, Heller KE, Warren JJ and Marshall TA. 2003. Soft drink consumption and caries risk in children and adolescents. General Dentistry, 51:30–36.
- Sluijs I, Forouhi NG, Beulens JW, van der Schouw YT, Agnoli C, Arriola L, Balkau B, Barricarte A, Boeing H, Bueno-de-Mesquita HB, Clavel-Chapelon F, Crowe FL, de Lauzon-Guillain B, Drogan D, Franks PW, Gavrila D, Gonzalez C, Halkjaer J, Kaaks R, Moskal A, Nilsson P, Overvad K, Palli D, Panico S, Quirós JR, Ricceri F, Rinaldi S, Rolandsson O, Sacerdote C, Sánchez MJ, Slimani N, Spijkerman AM, Teucher B, Tjønneland A, Tormo MJ, Tumino R, van der A DL, Sharp SJ, Langenberg C, Feskens EJ, Riboli E, Wareham NJ; InterAct Consortium. 2012. The amount and type of dairy product intake and incident type 2 diabetes: results from the EPIC-Interact study. American Journal of Clinical Nutrition, 96:382–390.
- Soedamah-Muthu SS, Ding EL, Al-Delaimy WK, Hu FB, Engberink MF, Willett WC and Geleijnse JM. 2011. Milk and dairy consumption and incidence of cardiovascular diseases and all-cause mortality: dose-response meta-analysis of prospective cohort studies. American Journal of Clinical Nutrition, 93:158–171.
- Soedamah-Muthu SS, Verberne LDM, Ding EL, Engberink MF and Geleijnse JM. 2012. Dairy consumption and incidence of hypertension: A dose-response meta-analysis of prospective cohort studies. Hypertension, 60:1131–1137.

UFS UV

References

- Soedamah-Muthu SS, Verberne LDM, Ding EL, Engberink MF and Geleijnse JM. 2012. Dairy consumption and incidence of hypertension: A dose-response meta-analysis of prospective cohort studies. Hypertension, 60:1131–1137.
- Sousa GT, Lira FS, Rosa JC, de Oliveira EP, Oyama LM, Santos RV and Pimentel GD. 2012. Dietary whey protein lessens several risk factors for metabolic diseases: a review. Lipids in Health and Disease, 11:67.
- Stamatova I and Meurman JH. 2009. Probiotics and periodontal disease. Periodontology, 51(1):141–151.
- Suchy FJ, Brannon PM, Carpenter TO, Fernandez JR, Gilsanz V, Gould JB, Hall K, Hui SL, Lupton J, Mennella J, Miller NJ, Osganian SK, Sellmeyer DE and Wolf MA. 2010. National Institutes of Health Consensus Conference: lactose intolerance and health. Annals of Internal Medicine, 152:792–796.
- Sundar S. 2014. Milk and mortality: the potential effects of modern milk production. British Medical Journal, 349:g7006.
- Szilagyi A, Nathwani U, Vinokuroff C, Correa JAA and Shrier I. 2006. The effect of lactose maldigestion on the relationship between dairy food intake and colorectal cancer: A systematic review. Nutrition and Cancer, 55:141–150.
- Tao N, DePeters EJ, German JB, Grimm R and Lebrilla CB. 2009. Variations in bovine milk oligosaccharides during early and middle lactation stages analyzed by high-performance liquid chromatography-chip/mass spectrometry. Journal of Dairy Science, 92:2991–3001.

UFS UV

References

- Tong X, Dong JY, Wu ZW, Li W and Qin LQ. 2011. Dairy consumption and risk of type 2 diabetes mellitus: a meta-analysis of cohort studies. European Journal of Clinical Nutrition, 65:1027–1031.
- United States Department of Agriculture (USDA). 2010. Report of the dietary guidelines advisory committee on the dietary guidelines for Americans 2010 to the Secretary of Health and Human Services and the Secretary of Agriculture. Washington, DC: USDA.
- Vandenplas Y. 2015. Lactose intolerance. Asia Pacific Journal of Clinical Nutrition, 24(1):S9–S13.
- Velagapudi VR, Hezaveh R, Reigstad CS, Gopalacharyulu P, Yetukuri L, Islam S, Felin J, Perkins R, Borén J, Oresic M and Bäckhed F. 2010. The gut microbiota modulates host energy and lipid metabolism in mice. Journal of Lipid Research, 51:1101–1112.
- Venema K. 2012. Intestinal fermentation of lactose and prebiotic lactose derivatives, including human milk oligosaccharides. International Dairy Journal, 22:123–140.
- Visioli F and Strata A. 2014. Milk, dairy products, and their functional effects in humans: a narrative review of recent evidence. Advances in Nutrition, 5:131–143.
- Vulevic J, Juric A, Walton GE, Claus SP, Tzortzis G, Toward RE and Gibson GR. 2015. Influence of galactooligosaccharide mixture (B-GOS) on gut microbiota, immune parameters and metabonomics in elderly persons. British Journal of Nutrition, 114:586–595.
- Wahlqvist ML. 2014. Ecosystem health disorders – changing perspectives in clinical medicine and nutrition. Asia Pacific Journal of Clinical Nutrition, 23:1–15.

UFS UV

References

- Waisbren SE, Potter NL, Gordon CM, Green RC, Greenstein P, Gubbels CS, Rubio-Gozalbo E, Schomer D, Welt C, Anastasoaie V, D'Anna K, Gentile J, Guo CY, Hecht L, Jackson R, Jansma BM, Li Y, Lip V, Miller DT, Murray M, Power L, Quin N, Rohr F, Shen Y, Skinder-Meredith A, Timmers I, Tunick R, Wessel A, Wu BL, Levy H, Elsas L and Berry GT. 2012. The adult galactosemic phenotype. Journal of Inherited Metabolic Disease, 35:279–286.
- Weaver CM. 2014. How sound is the science behind the dietary recommendations for dairy? American Journal of Clinical Nutrition, 99:1217S–1222S.
- Wilt TJ, Shaukat A, Shamliyan T, Taylor BC, MacDonald R, Tacklind J, Rutks I, Schwarzenberg SJ, Kane RL and Levitt M. 2010. Lactose intolerance and health. Evidence report/technology assessment (Full Report), 192:1–410.
- Wu Q, Cheung CKW and Shah NP. 2015. Towards galactose accumulation in dairy foods fermented by conventional starter cultures: Challenges and strategies. Trends in Food Science & Technology, 41:24–36.
- Zemel MB. 2009. Proposed role of calcium and dairy food components in weight management and metabolic health. The Physician & Sports Medicine, 2(37):1–12.
- Zivkovic AM and Barile D. 2011. Bovine milk as a source of functional oligosaccharides for improving human health. Advances in Nutrition, 2:284–289.
- Zong G, Sun Q, Yu D, Zhu J, Sun L, Ye X, Li H, Jin Q, Zheng H, Hu FB and Lin X. 2014. Dairy consumption, type 2 diabetes, and changes in cardiometabolic traits: a prospective cohort study of middle-aged and older Chinese in Beijing and Shanghai. Diabetes Care, 37:56–63.