



# Precision Nutrition

**Martin Kohlmeier, MD, PhD**

University of North Carolina at Chapel Hill

Department of Nutrition

and

UNC Nutrition Research Institute



UNC  
NUTRITION  
RESEARCH INSTITUTE

[mkohlmeier@unc.edu](mailto:mkohlmeier@unc.edu)



**We are all different**



**What is the most common genetic variation affecting many individual responses to nutrition and lifestyle?**



**What is the most common genetic variation affecting many individual responses to nutrition and lifestyle?**



**XX**  
**Female**

**XY**  
**Male**





## Food for thought

What is it?

What can it do?

Where did it start?

Where are we now?

What will happen next?

**PRECISION  
NUTRITION**

**USUAL  
NUTRITION**





1920s  
Subsistence  
Nutrition



Food fortification  
← RDA, Multivitamins



1970s  
Adequate  
Nutrition



Individualized  
← with Genetics



2020s  
Precision  
Nutrition

# **Foods, Genes and Cancer**



## Genotype-specific prevention of breast cancer

	MPO rs2333227 GG	MPO rs2333227 GA/AA
<u>Fruit/vegetable intake</u>		
Low ( $\leq 29$ servings/week)	Reference	Reference
High ( $> 29$ servings/week)	+5% ( n.s. )	<b>-24%</b> (p<0.03)
Genotype frequency	0.62	0.38



Ahn J et al., 2004  
Li Y et al., 2009



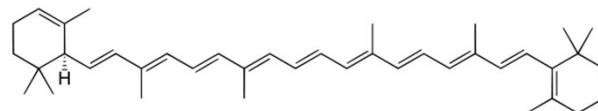


## Genotype-specific prevention of prostate cancer

	XRCC1 rs25487 AA/AG	XRCC1 rs25487 GG
<u>Lycopene intake</u>		
Low (< 567 µg/d)	Reference	Reference
Medium (~ 1448 µg/d)	-3% ( n.s. )	-41% ( n.s. )
High (>1773 µg/d)	-18% ( n.s. )	<b>-79%</b> (p<0.01)
Genotype frequency	0.43	0.57



**Good lycopene sources: tomato, water melon, guava**



Goodman M et al., 2006



## Genotype-specific prevention of prostate cancer

	PTGS2 rs5275 TT	PTGS2 rs5275 TC/CC
<u>Fatty cold-water fish</u>		
Never	Reference	Reference
At least once a week	+14% ( n.s. )	<b>-64%</b> (p<0.01)
Genotype frequency	0.40	0.60



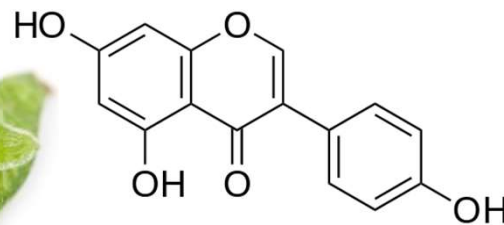
**Salmon, Arctic char,  
mackerel, herring, sardines**

Hedelin M et al., 2007



## Genotype-specific prevention of prostate cancer

	ESR2 rs2987983 TT	ESR2 rs2987983 TC/CC
<u>Soy intake</u>		
Low (< 0.005 mg Isoflavones/d)	Reference	Reference
High (> 17 mg Isoflavones/d)	<b>+40%</b> (p=0.1)	<b>-37%</b> (p<0.05)
Genotype frequency	0.58	0.42



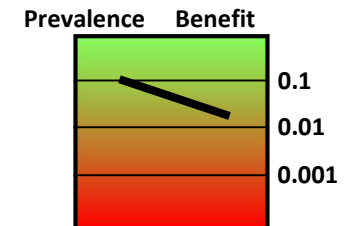
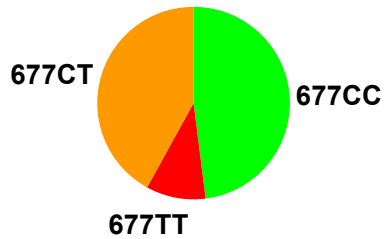
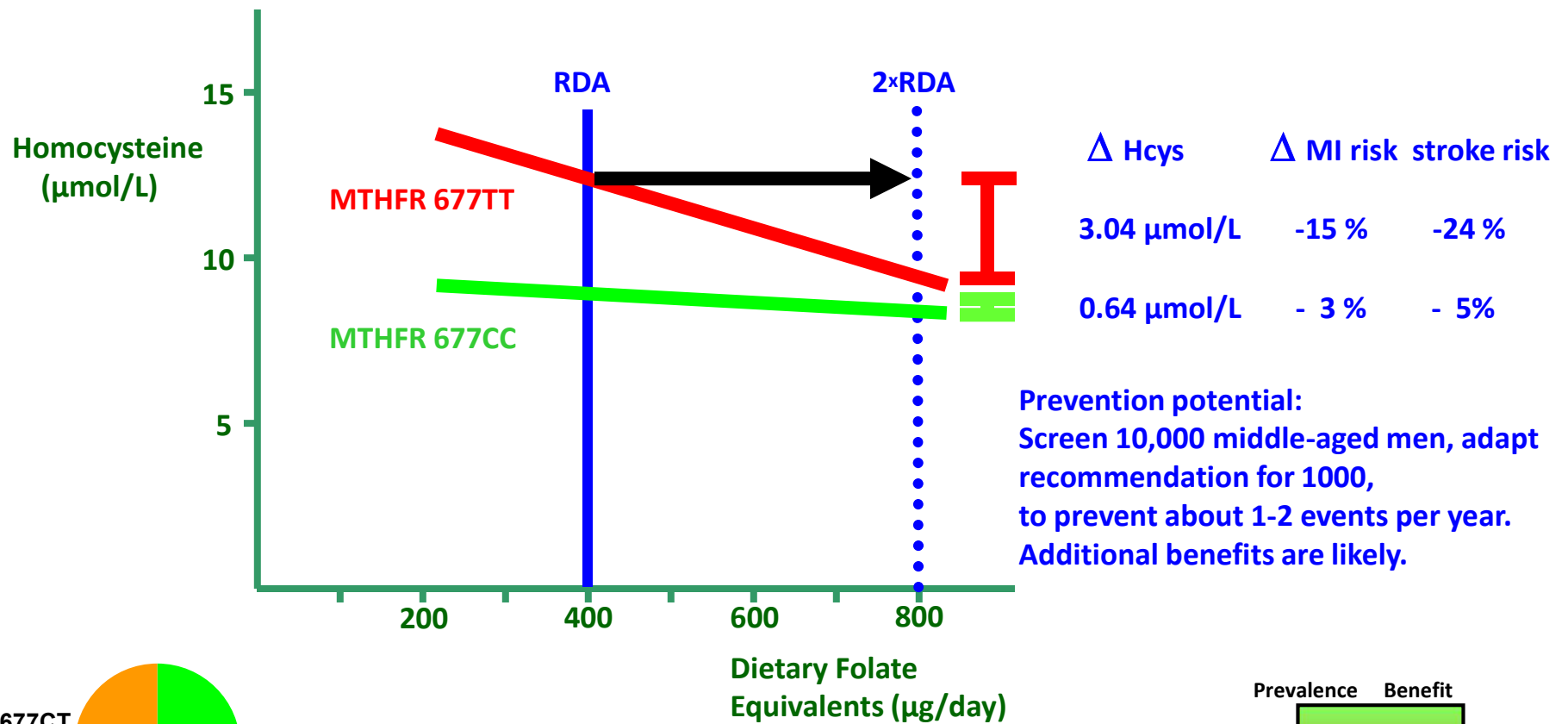
10 g Soy contain about 16 mg Isoflavones

Hedelin M et al., 2006

## **Individual nutrient needs**



# Case Study: Folate intake and homocysteine





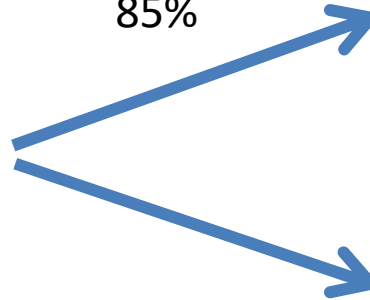
# Multivitamins



A typical group of women



DHFR +/+  
85%



DHFR del/del  
15%



Standard breast cancer risk



Breast cancer risk 52% higher



## Case Study: Folate intake and homocysteine

*What you want to do in practice:*

Individuals with two MTHFR 677 T copies (rs1801133 TT) should get at least 600  $\mu\text{g}$  dietary folate equivalents.

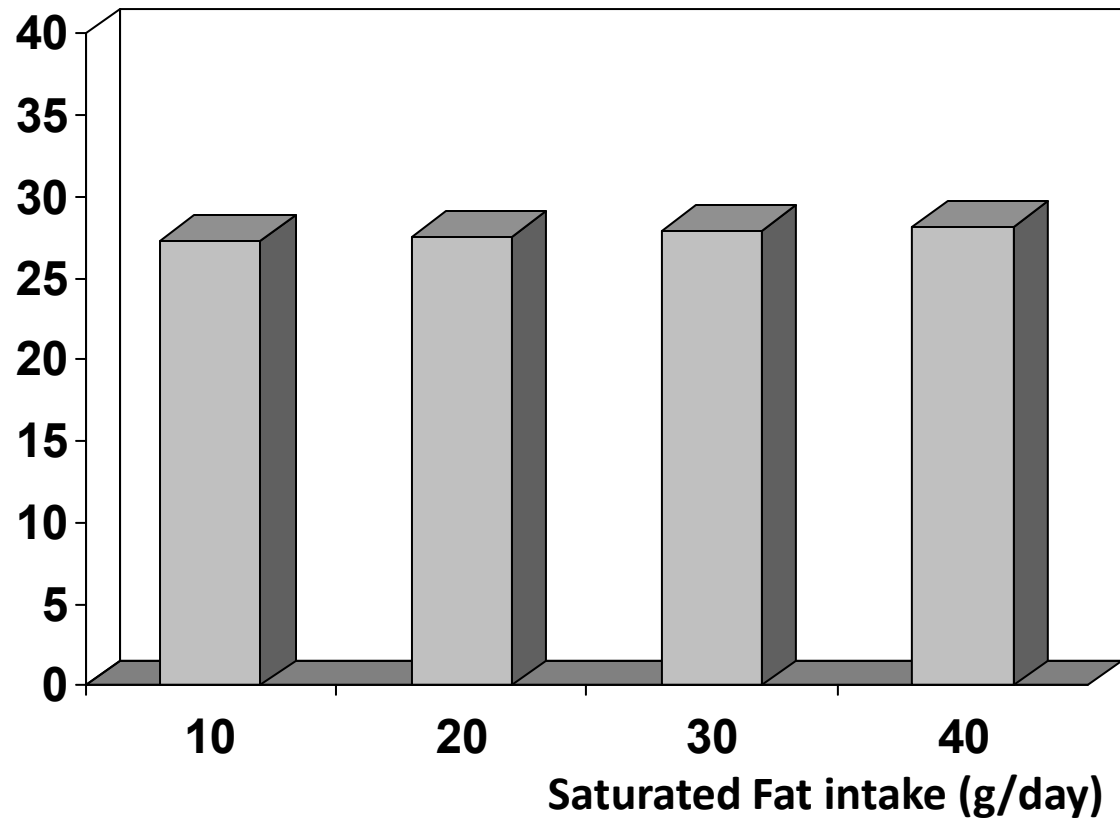
**Clinical utility  
of MTHFR allele testing  
to guide folate intake  
for lowering homocysteine  
is good**





## Case Study: Saturated fat and body weight

Body Mass Index  
(kg/m<sup>2</sup>)

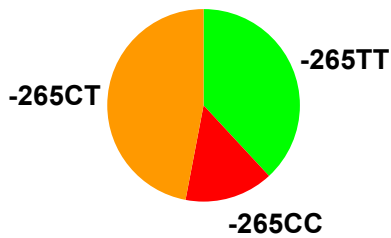
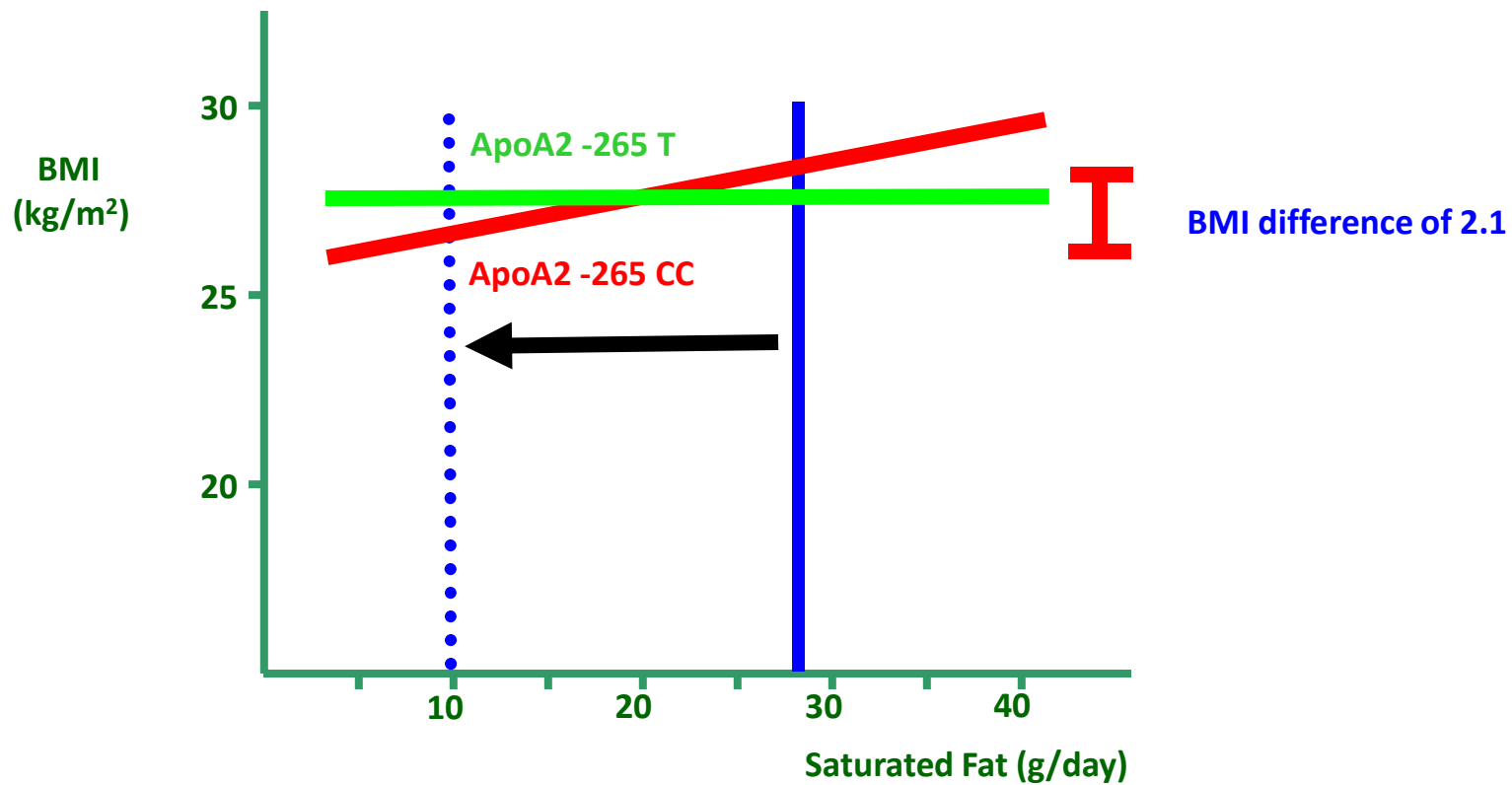


Based on data from Corella et al.  
Arch Int Med 2009;169:1897-1906





## Case Study: Saturated fat and body weight



Based on data from Corella et al.  
Arch Int Med 2009;169:1897-1906



## Case Study: Saturated fat and body weight

*What you want to do in practice:*

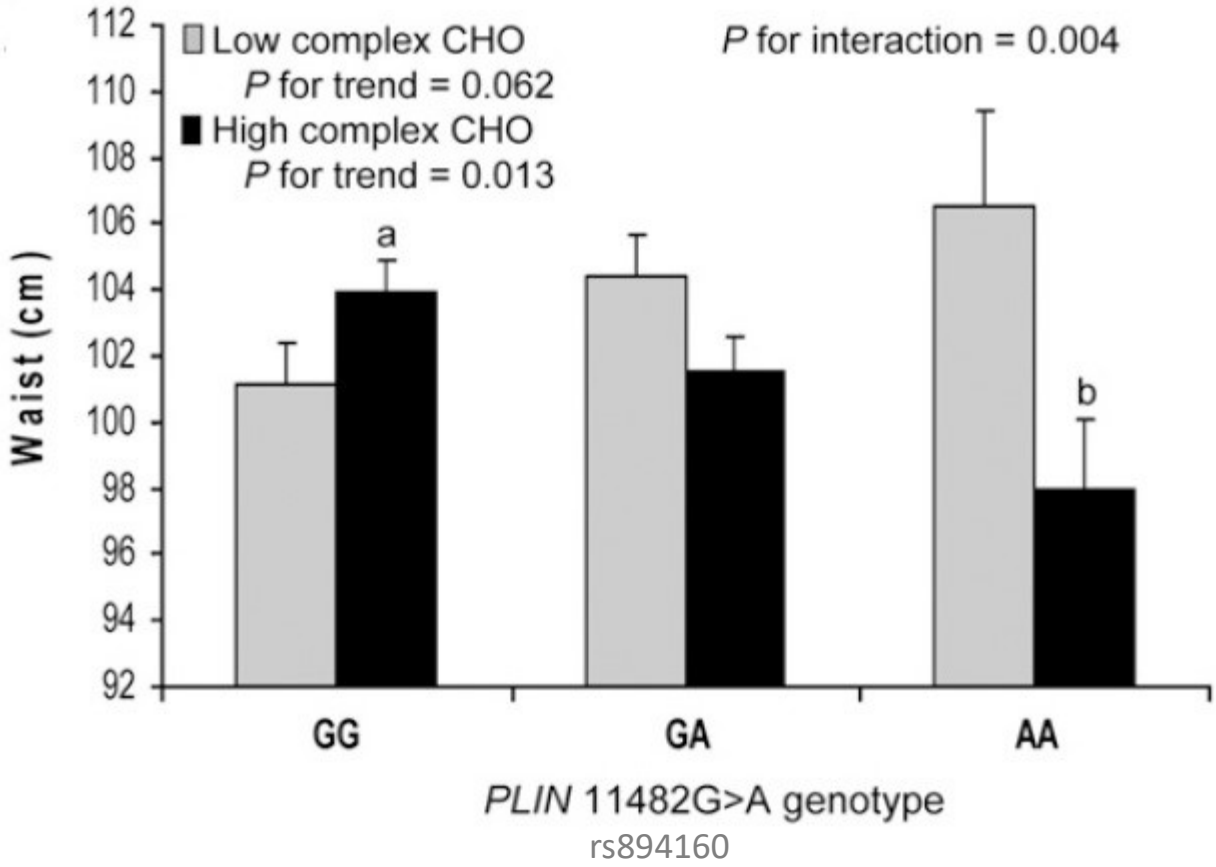
Carriers of two APOA2 alleles C (rs5082 CC) should limit their saturated fat intake to less than 12 g/day

**Clinical utility of  
APOA2 allele testing  
to guide saturated fat intake for  
limiting weight gain  
is good**





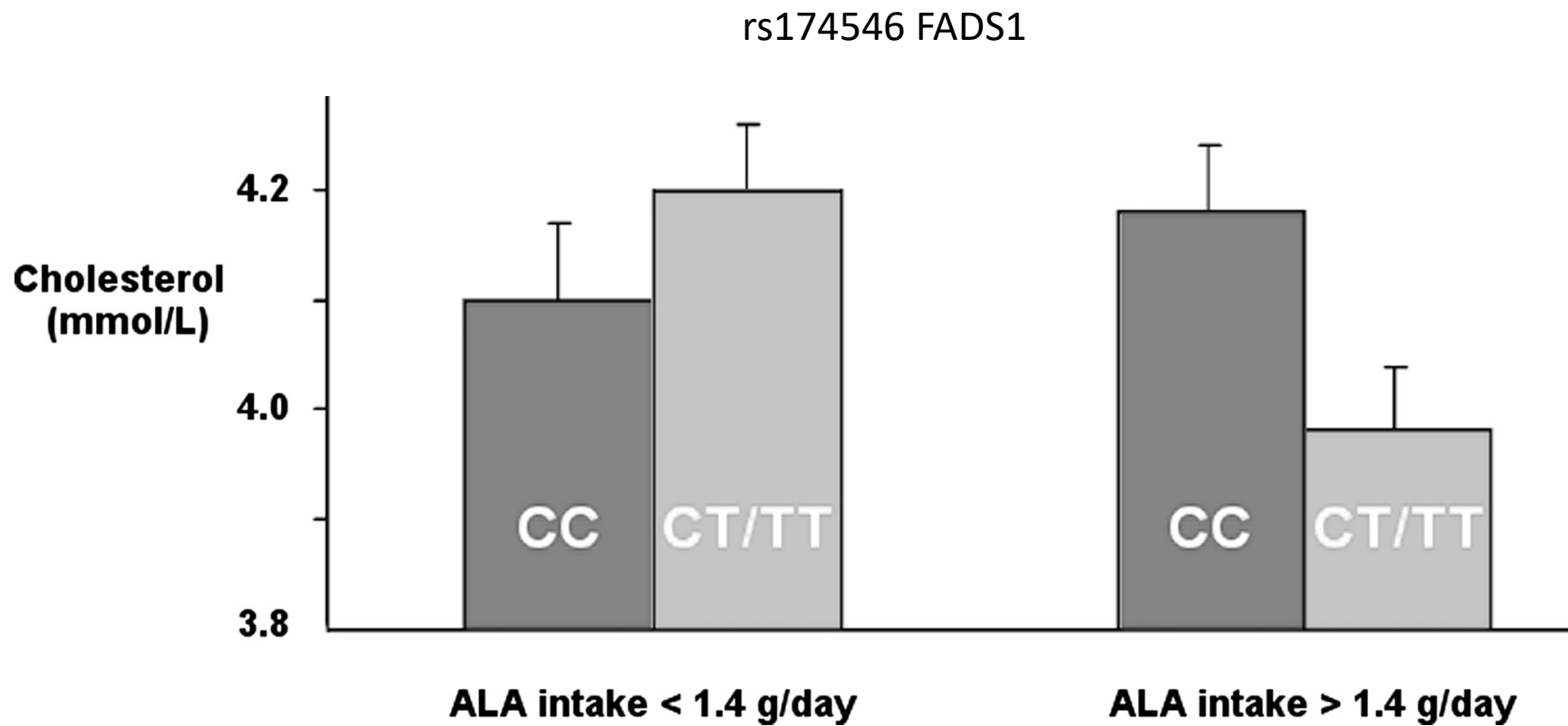
# Genotype-specific response to carbohydrate intake



Smith CE et al., 2008  
Smith CE et al., 2012



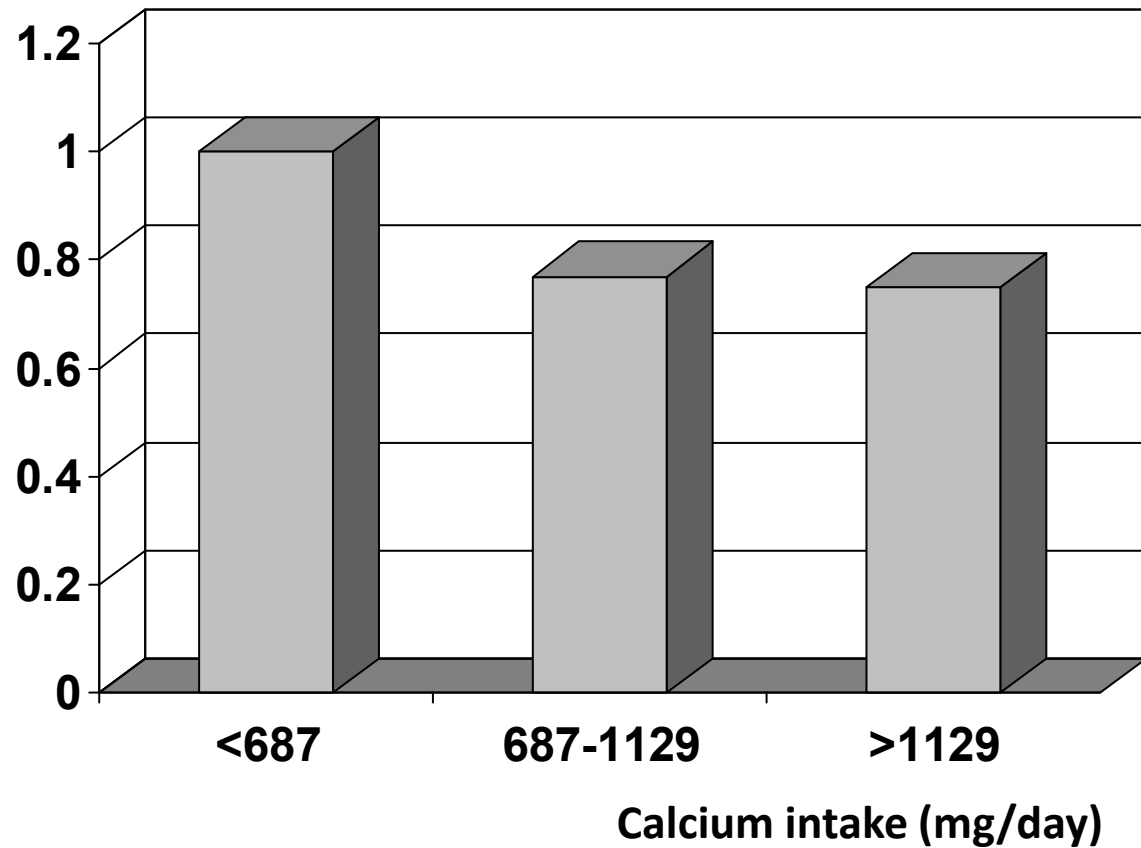
# Omega-3 Fats





## Case Study: Minerals and colorectal cancer

Odds Ratio  
colorectal  
cancer risk



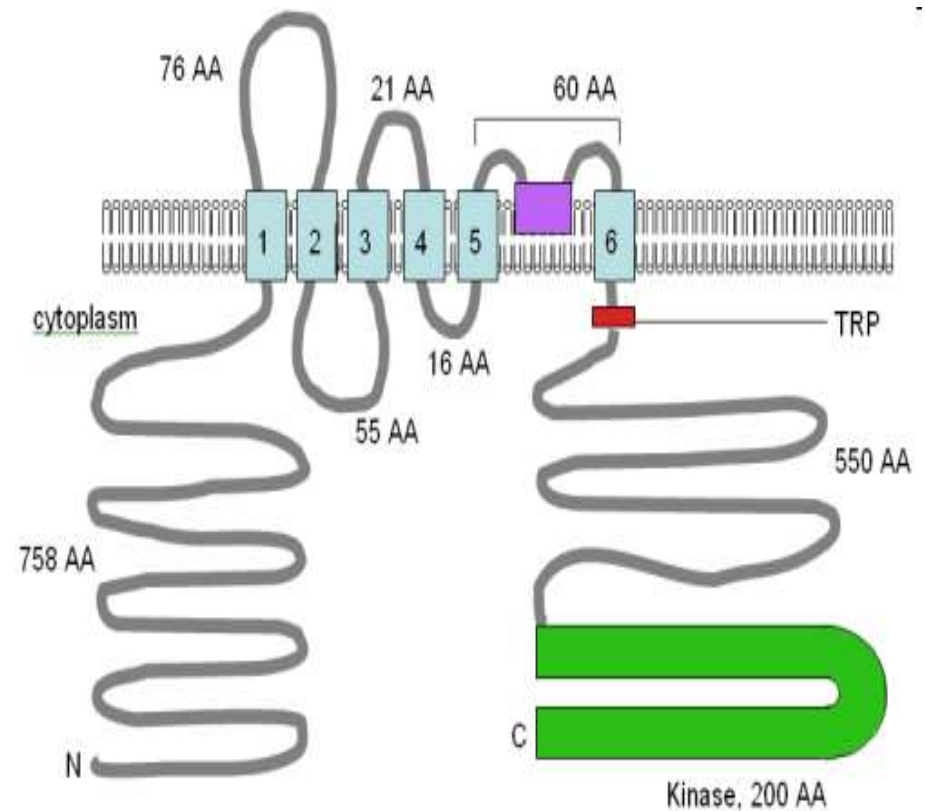
Based on data from Dai et al.  
AJCN 2007;86:743-751



## Case Study: Minerals and colorectal cancer

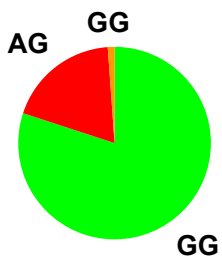
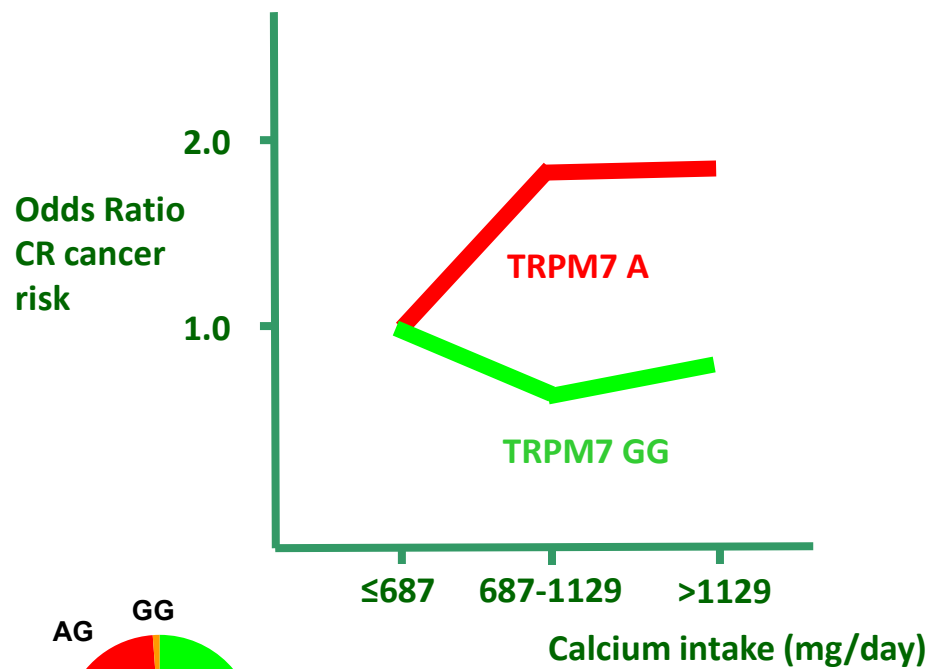
The transient receptor potential melastatin 7 (TRPM7) is an ion channel, through which calcium and magnesium enter cells.

A common genetic missense variant (1482Ile) alters the properties of the ion channel, predisposing carriers to magnesium deficiency.





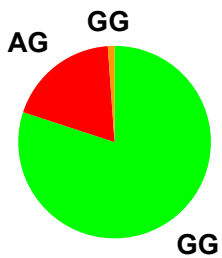
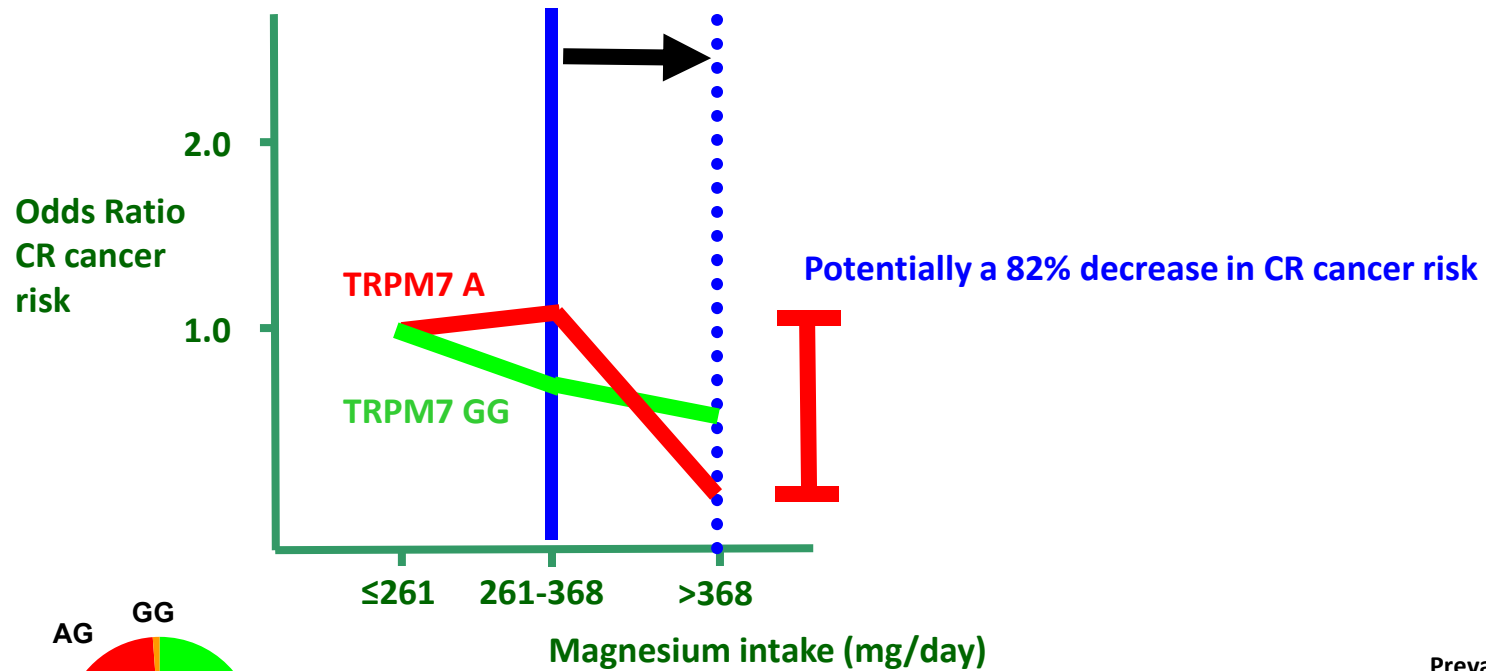
## Case Study: Minerals and colorectal cancer



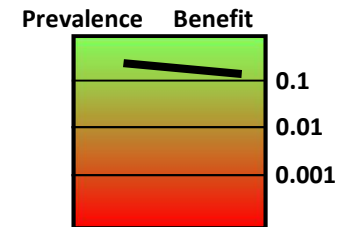
Based on data from Dai et al.  
AJCN 2007;86:743-751



# Case Study: Minerals and colorectal cancer



Based on data from Dai et al.  
AJCN 2007;86:743-751





## **Food preferences**

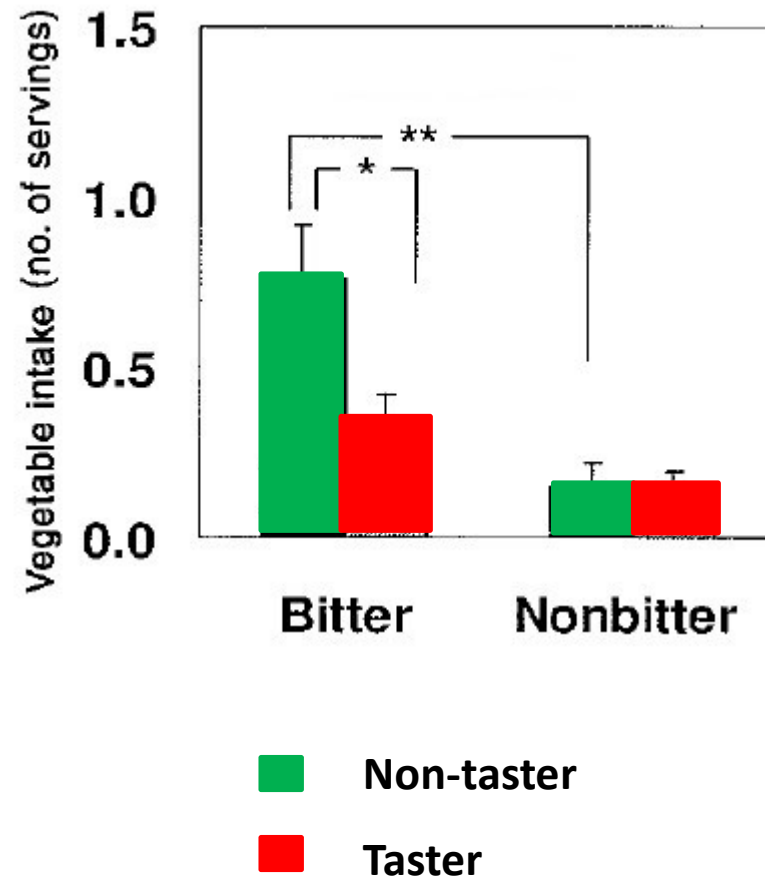
# Bitter taste (TAS2R38)

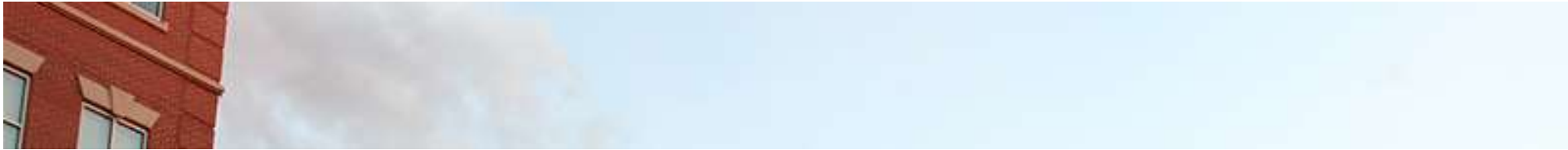


Carrots or Broccoli



6n-propylthiouracil (PROP)

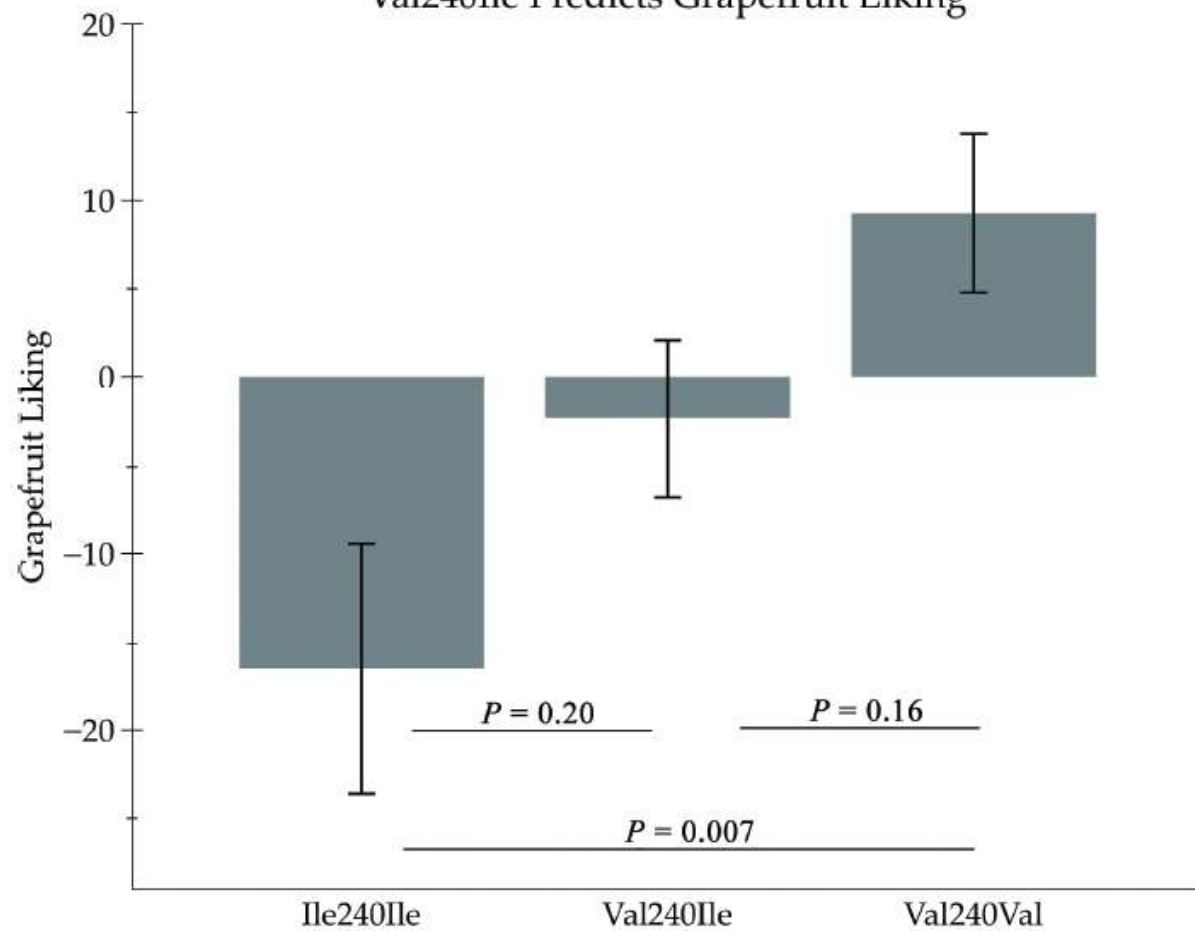




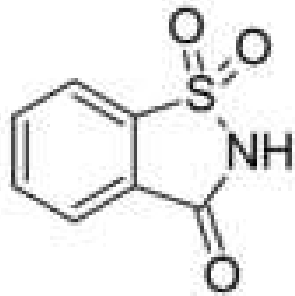
**TAS2R31**  
**rs10772423**



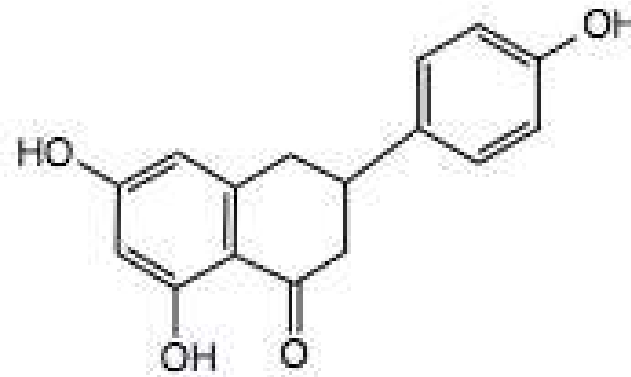
Val240Ile Predicts Grapefruit Liking



Hayes JE et al., 2015



**Saccharine**

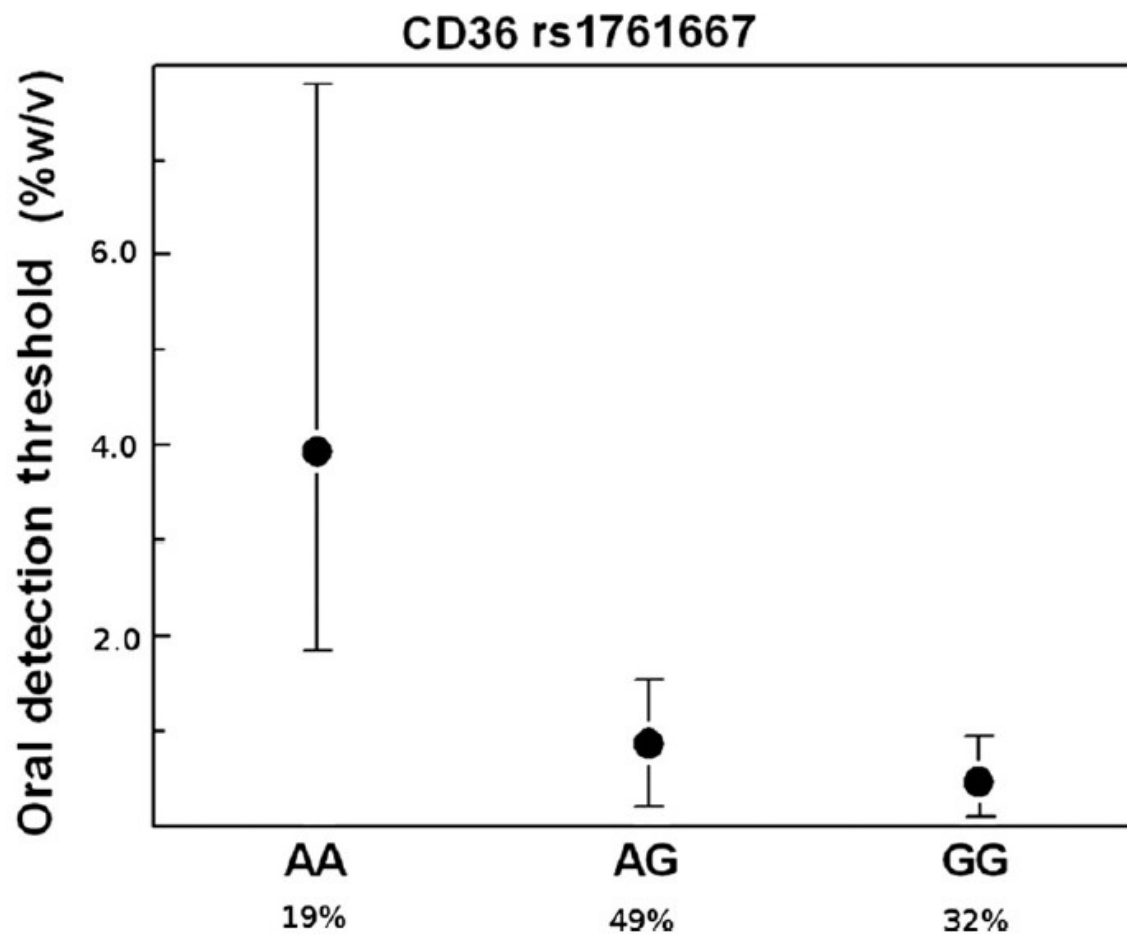


**Naringenin**





## Fat tasting



**Higher fat and total calorie consumption with less sensitive G allele**

## **Food intolerances**



# Alcohol





# Alcohol





# Alcohol



Before drinking

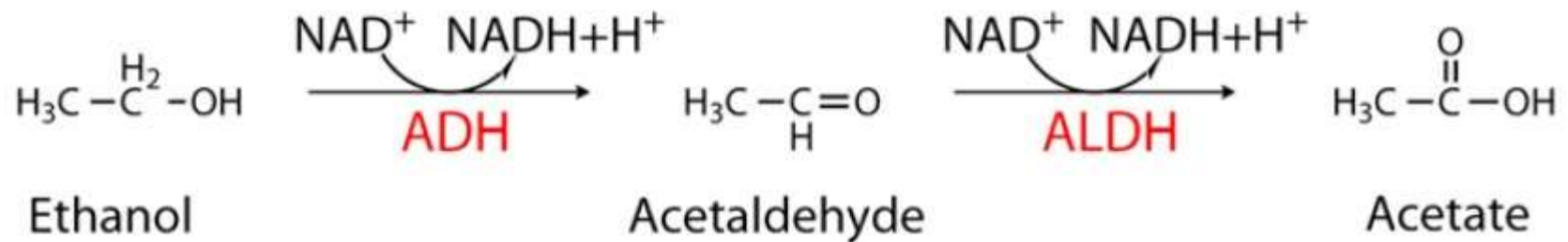
After drinking

Brooks PJ et al.,  
PLoS Med 2009

Many people with Asian heritage get red in the face and have other typical hangover signs right after drinking alcohol



# Alcohol



Drunkenness



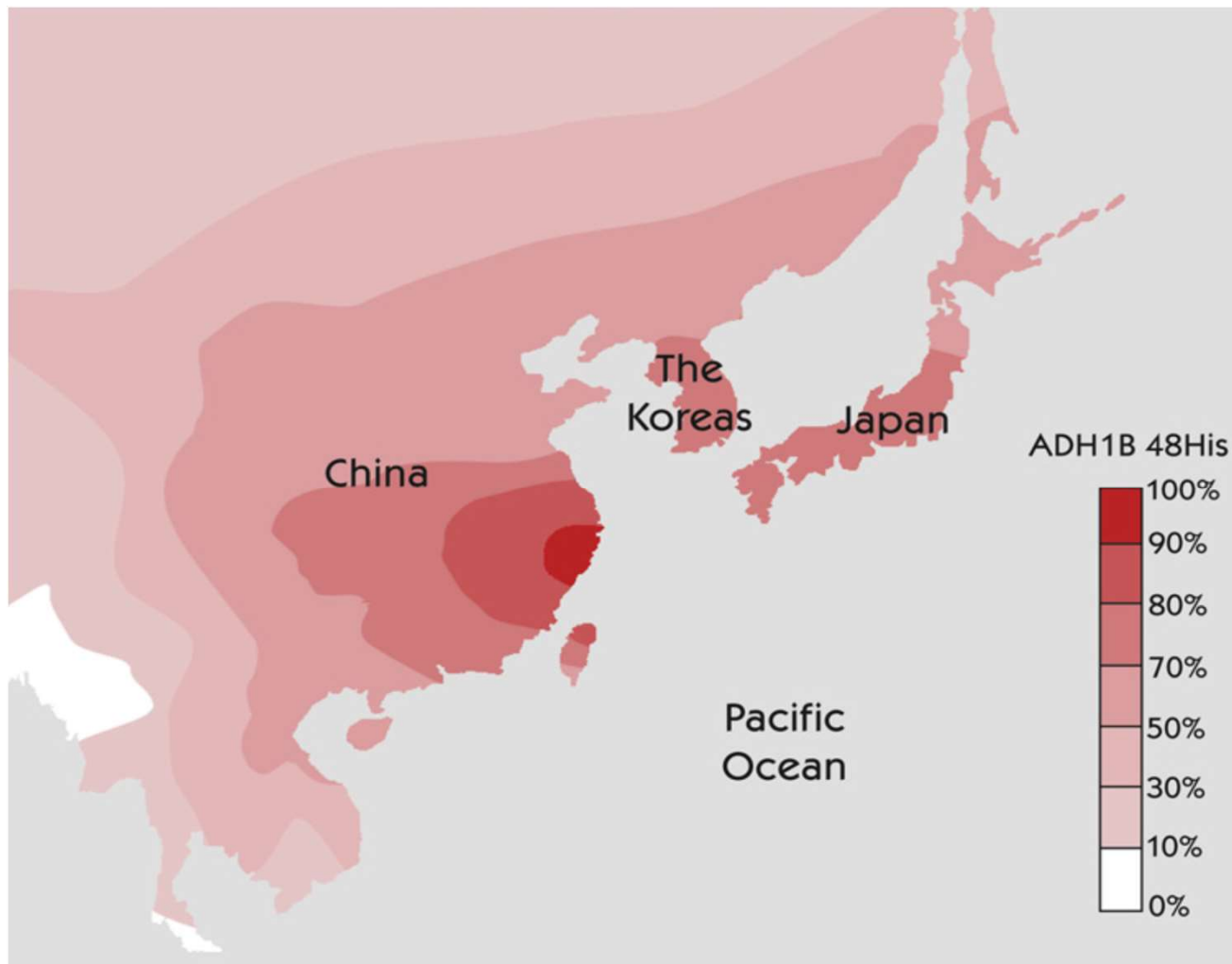
Hangover



Recovery



# Alcohol



Peng Y et al., BMC  
Evol Biol 2010

## What you can do



Learn about non-alcoholic drinks available in many bars and restaurants.



# Lactose

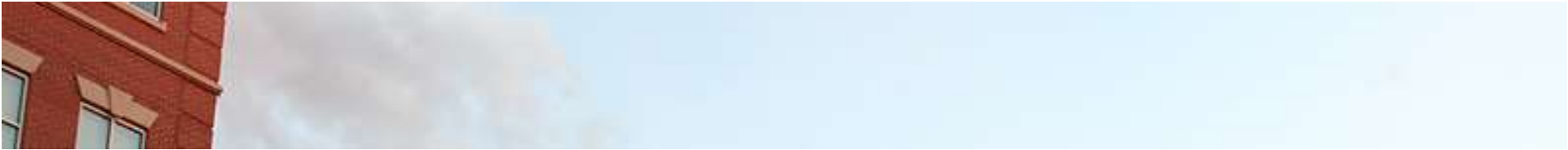


Fresh milk and many other dairy products contain large amounts of lactose.

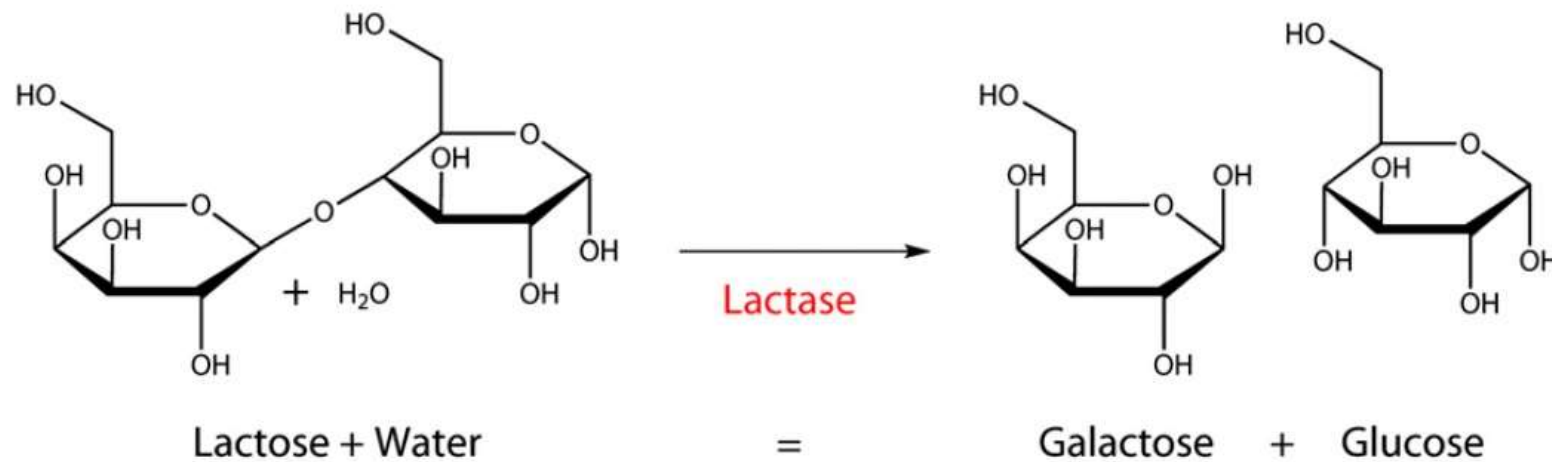


**Most adults cannot drink a lot of milk**





## Most adults cannot drink a lot of milk



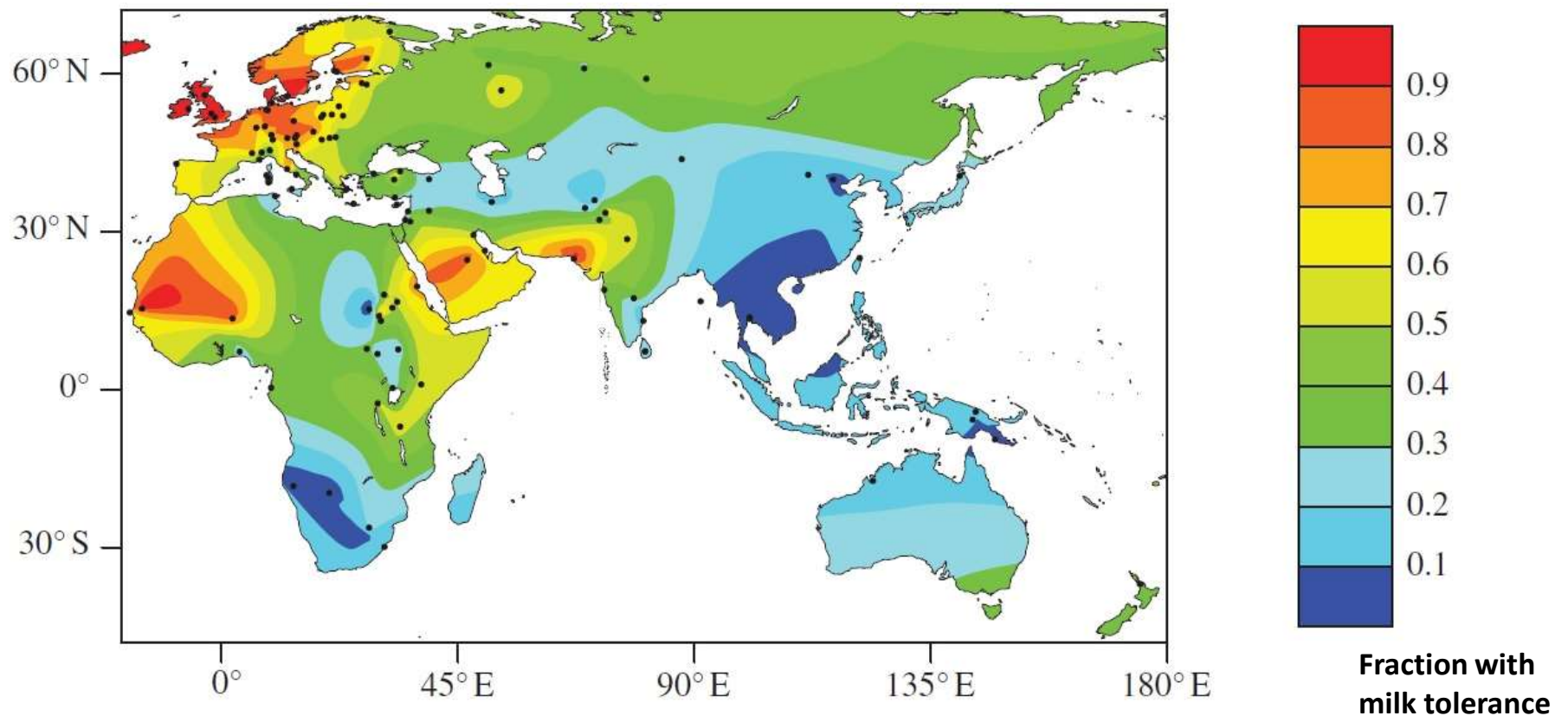
Not absorbed



Absorbed well



## Most adults cannot drink a lot of milk



Adults in a few regions of the world tolerate fresh milk well, but 70% of the world population respond with discomfort or illness.

Gerbault et al., Phil  
Trans Royal Soc 2011



## Milk provided a survival edge in some regions



**Xhosa in South Africa**  
LCT -14,010 C



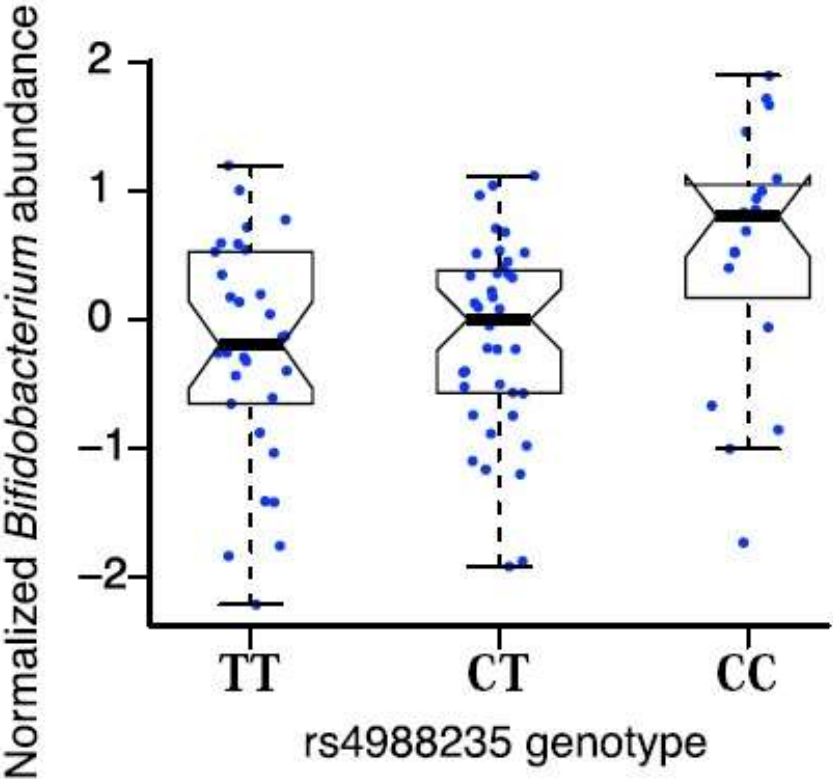
**Arabs in Oman**  
LCT -13,915 G



**Vikings on Atlantic Islands**  
LCT -13,910 T

Small changes in the lactase gene of these people sustain enzyme expression into adulthood. This adaptation helped them to consume lots of milk and survive in environments with otherwise sparse food supplies.

**Persistence-linked LCT allele -13910 T decreases abundance of *Bifidobacterium* genera in the small intestine**





## What you can do

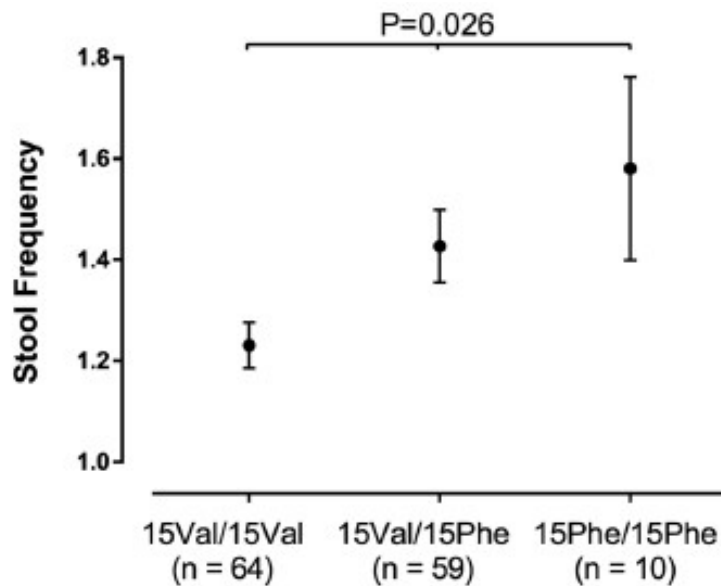


Learn which products are low enough in lactose for your safe consumption.



## Sugar

Carriers of the sucrase (SI) allele rs9290264 A have increased stool frequency and have an increased risk of irritable bowel syndrome (IBS), presumably due to incomplete sucrose digestion at high intakes.



Association of the 15Phe variant with IBS				
	CTRL	IBS		
	AF	AF	p Value	OR
Case-control	0.264	0.306	0.0030*	1.26
PopCol	0.29	0.417	0.045	1.89
Combined	0.268	0.309	0.0013*	1.27



# Gluten



Gluten comes from the main proteins in wheat, rye, barley and related grains.



# Gluten

**Celiac disease (CD) is an autoimmune condition triggered by gluten exposure in genetically susceptible individuals. About 1% of Americans have CD.**

**Symptoms are often unspecific and may include**

- **Abdominal cramps (in fewer than half of cases)**
- **Anemia due to intestinal blood loss**
- **Anxiety/depression**
- **Migraine headaches**
- **Itchy skin rash (dermatitis herpetiformis, less common)**

**Potential harmful health consequences include**

- **Lymphoma of the small intestines**
- **Nutritional deficiencies**
- **Osteoporosis**
- **Infertility**





# Gluten

## USUALLY CONTAIN GLUTEN

Barley  
Beer  
Bread  
Bulgur  
Cakes  
Cookies  
Farina  
Kamut  
Pasta  
Rye  
Semolina  
Spelt  
Triticale  
Wheat

**B**  
**e**  
**e**  
**r**

## OFTEN CONTAIN GLUTEN

Candies  
Corn chips  
French fries  
Gravy  
Imitation seafood  
Malt  
Matzo  
Oats  
Potato chips  
Processed meats  
Rice mixes  
Salad dressings  
Soup mixes  
Soy sauce

## USUALLY DO NOT CONTAIN GLUTEN

Amaranth  
Buckwheat  
Job's tears  
Legumes  
Maize (corn)  
Millet  
Potato  
Quinoa  
Rice  
Sorghum  
Tapioca  
Teff  
Wild rice



# Gluten

Individuals with celiac disease (CD) must carefully avoid all gluten.

Some people without CD may nonetheless benefit from avoiding gluten.

**The concern with gluten avoidance is lack of healthy foods and nutrients.**





# What you can do



Learn which products are gluten-free, carefully read the labels.



## Genes for tailoring individual nutrition decisions

IL6	ALOX5	GSTP1	XRCC1	OR2M7
UCP1	CETP	UGT1A1	MPO	CFTR
UCP3	FADS1	PON1	MTP	APOA2
FABP2	FADS2	ALPL	MnSOD	PLIN
LCT	OTC	SIRT1	CD36	CLOCK
ADH1B	GFOD2	ESR2	PAPOLG	TCF7L2
ALDH2	CYP4F2	HFE	TAS2R38	PNPLA3
CYP1A2	VDR	TMPRSS6	TAS2R50	FTO
ADORA2A	GC	SLC40A1	TAS1R3	MC4R
MTHFD1	FUT2	HAMP	TAS1R2	TFAP2B
PEMT	TCN2	NAT1	TAS2R3	FABP2
F2	HP	NAT2	TAS2R4	PPARG
F5	COX2	XPC	TAS2R5	ADRB2
AGT	MTHFR	TRPM7	TAS2R5	ADRB3
ADD1	DHFR	CUBN	TAS2R19	TNFA
GRK4	PTGS2	SLC23A1	[OR10A2]	IRS1
GSTM1	MGMT	SLC23A2	HLA-DQA1	AMY1
SEP15	CASR	PLA2G4A	HLA-DQB1	SLC30A3

**What can you do?**





## **What you can do**

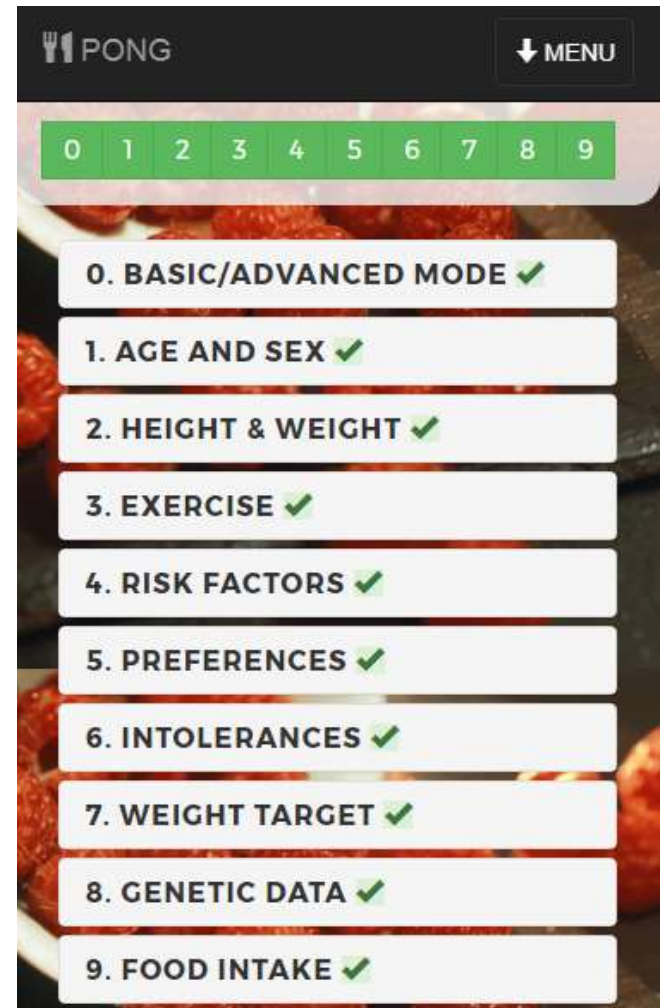
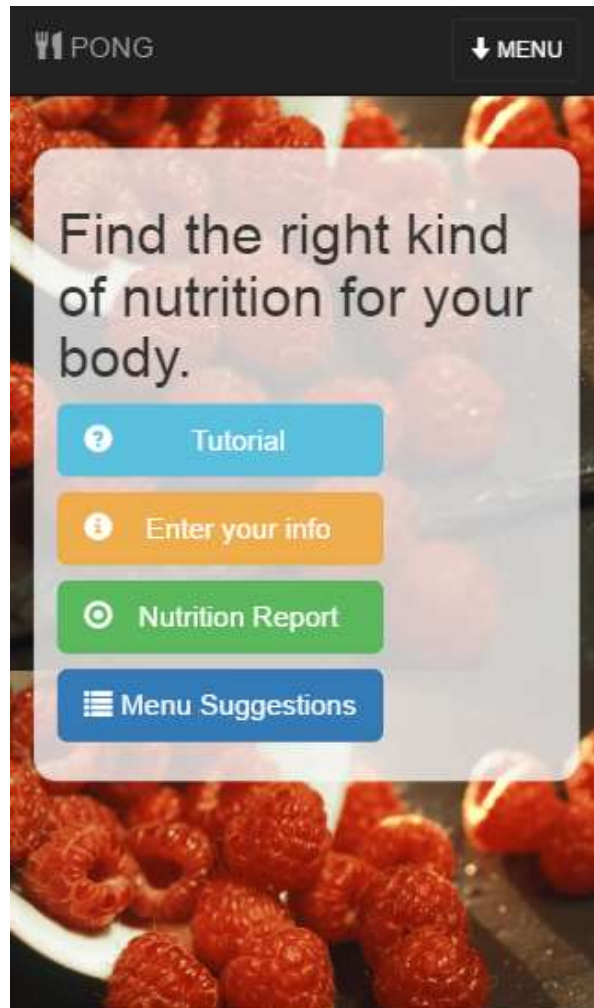
- work with a health care professional**
  - who provides guidance
  - without disclosing genetic information
  
- use an online meal planning tool that is**
  - self-administered
  - fully anonymized (double masking)



# Precision Online Nutrition Guidance

**Gluten-free**  
**Lactose-free**  
**Genotype-specific**

**Vegetarian**  
**Vegan**  
**Low-Carb**



1. BASIC INFORMATION ✓

2. HEIGHT & WEIGHT ?

3. EXERCISE ?

4. RISK FACTORS ?

5. PREFERENCES ?

6. INTOLERANCES ?

Food Intolerances/Allergies

Should gluten be avoided?

Should lactose be avoided?

SUBMIT

7. CALORIE TARGET ?

8. FOOD INTAKE ?

Personalized Nutrient Targets



Nutrient	Personalized
Calories	2364.0 kcal
Protein	56.0 g
Saturated Fat	< 26.0 g
Cholesterol	< 294.0 mg
Folate	392.0 µg
Added Folate	< 98.0 µg
Vitamin C	74.0 mg
Iron	11.0 mg
Sodium	< 2257.0 mg
Calcium	1275.0 mg
Magnesium	> 402.0 mg
Red Meat	< 98.0 g
Fruits/Veggies	> 589.0 g
Vitamin A	2943.0 IU
Preformed Vit. A	< 2943.0 IU
Beta-Carotene	> 1717.0 IU



## Nutritional Information



Rcp GF Homemade Gravy, 2 Tbsp

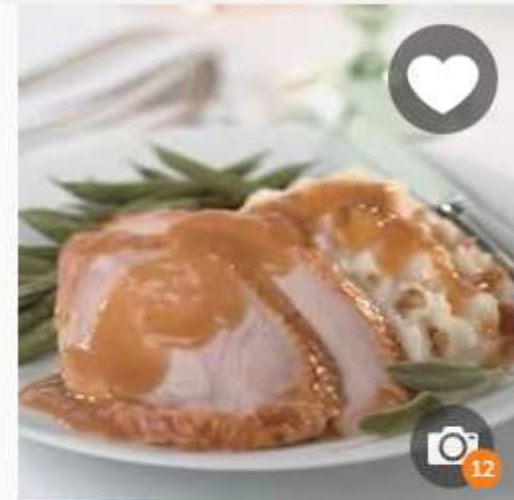
*the basics*

Nutrient	Value
Calories	22.0 kcal
Protein	0.3 g
Saturated Fat	0.8 g
Cholesterol	1.0 mg
Folate	0.0 µg
Added Folate	0.0 µg
Vitamin C	0.0 mg
Iron	0.1 mg
Sodium	227.0 mg
Calcium	2.0 mg
Magnesium	0.0 mg
Red Meat	0.0 g
Fruits/Veggies	0.0 g
Vitamin A	0.0 IU
Preformed Vit. A	0.0 IU

allrecipes!



Home > Recipes > Trusted Brands: Recipes and Tips



## Easy Gravy



111 made it | 62 reviews



7

Recipe by: ARGO®, KARO® and FLEIS...

"Cook up rich, velvety gravy with only four ingredients and in just 10 minutes."



Save





## **Key take-away concepts**

**We are all different people and therefore need different nutrition.**

**Many of us are at risk of harm, if we eat the wrong food.**

**The best way to eat what you need is to know yourself and to learn about the foods that suit you best.**

**Modern information tools can be very helpful for making healthy everyday food choices.**





**UNC Nutrition Research Institute at Kannapolis, NC, is housed in a 125,000-sf building featuring**

- state-of-the-art laboratory and research spaces
- clinical facilities
- a whole-room calorimeter for studies of energy metabolism



**UNC**  
NUTRITION  
RESEARCH INSTITUTE

[mkohlmeier@unc.edu](mailto:mkohlmeier@unc.edu)

# NUTRIGENETICS

APPLYING THE SCIENCE OF  
PERSONAL NUTRITION

MARTIN KOHLMEIER

