

# Do Our Genes Determine What We Should Eat?

**Ahmed El-Sohemy, PhD**

**Canada Research Chair in Nutrigenomics**

Department of Nutritional Sciences  
University of Toronto



# Faculty Disclosure

Commercial Interest	Nature of Relevant Financial Relationship (Include all those that apply)	
	What was received	For what role
<ul style="list-style-type: none"><li>Nutrigenomix, Inc.</li></ul>	<ul style="list-style-type: none"><li>Shares</li></ul>	<ul style="list-style-type: none"><li>Scientific Advisory Role</li></ul>

# Presentation Clinical Actions

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After participating in this presentation, clinicians should be better able to:

- Describe the benefits and limitations of genetic testing in clinical practice.

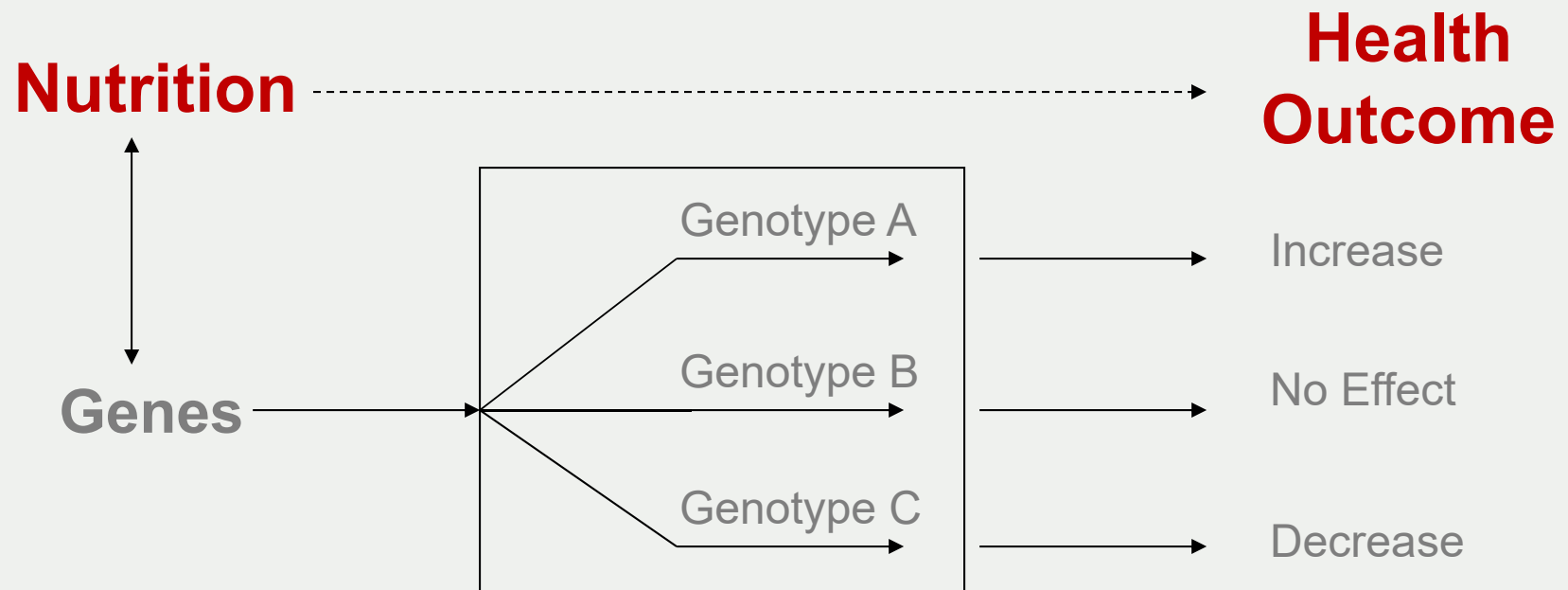
## Presentation Learning Objectives

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After participating in this presentation, learners should be better able to:

- Describe how genetic differences influence nutrient requirements.
- Learn how to use genetic information to personalize dietary recommendations.
- Describe the benefits and limitations of consumer genetic tests.

# Why bother with genetics/genomics?



***One size does not fit all***



MAY 27, 2013

TIME

# THE ANGELINA EFFECT

Angelina Jolie's double mastectomy puts genetic testing in the spotlight. What her choice reveals about calculating risk, cost and peace of mind

BY JEFFREY KLUGER & ALICE PARK



# Genetic Testing

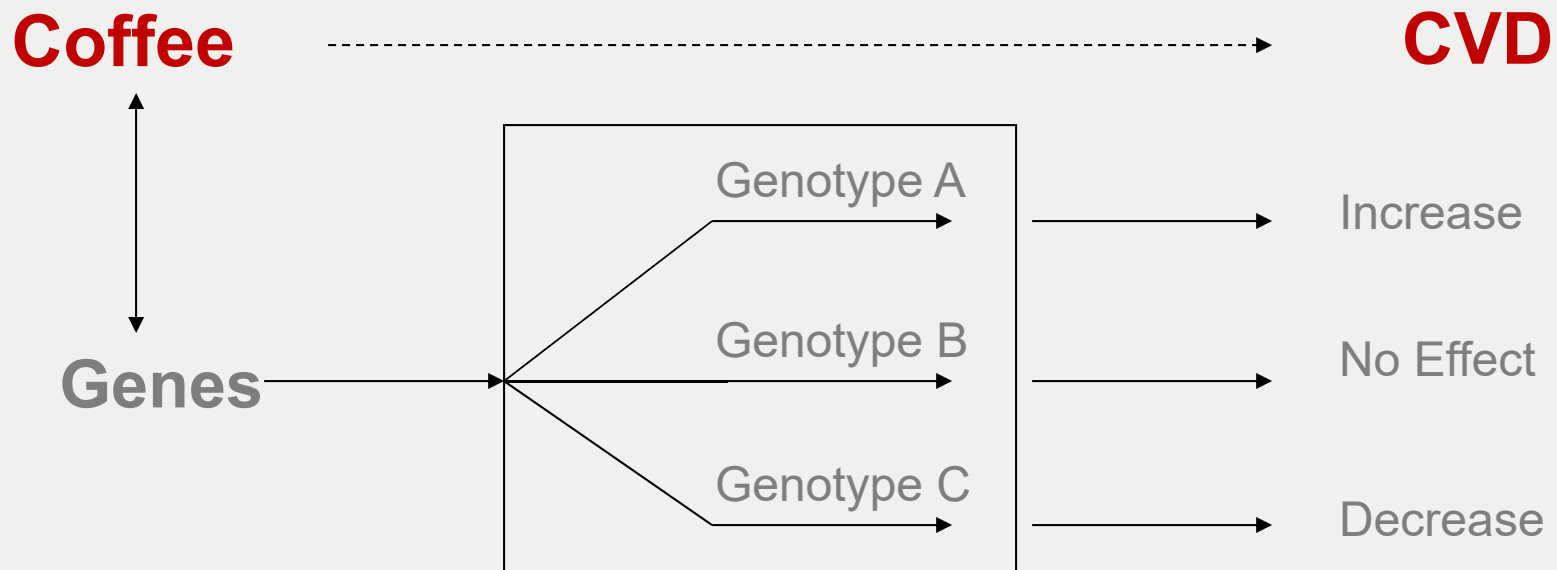
Disease Risk Genes

VS

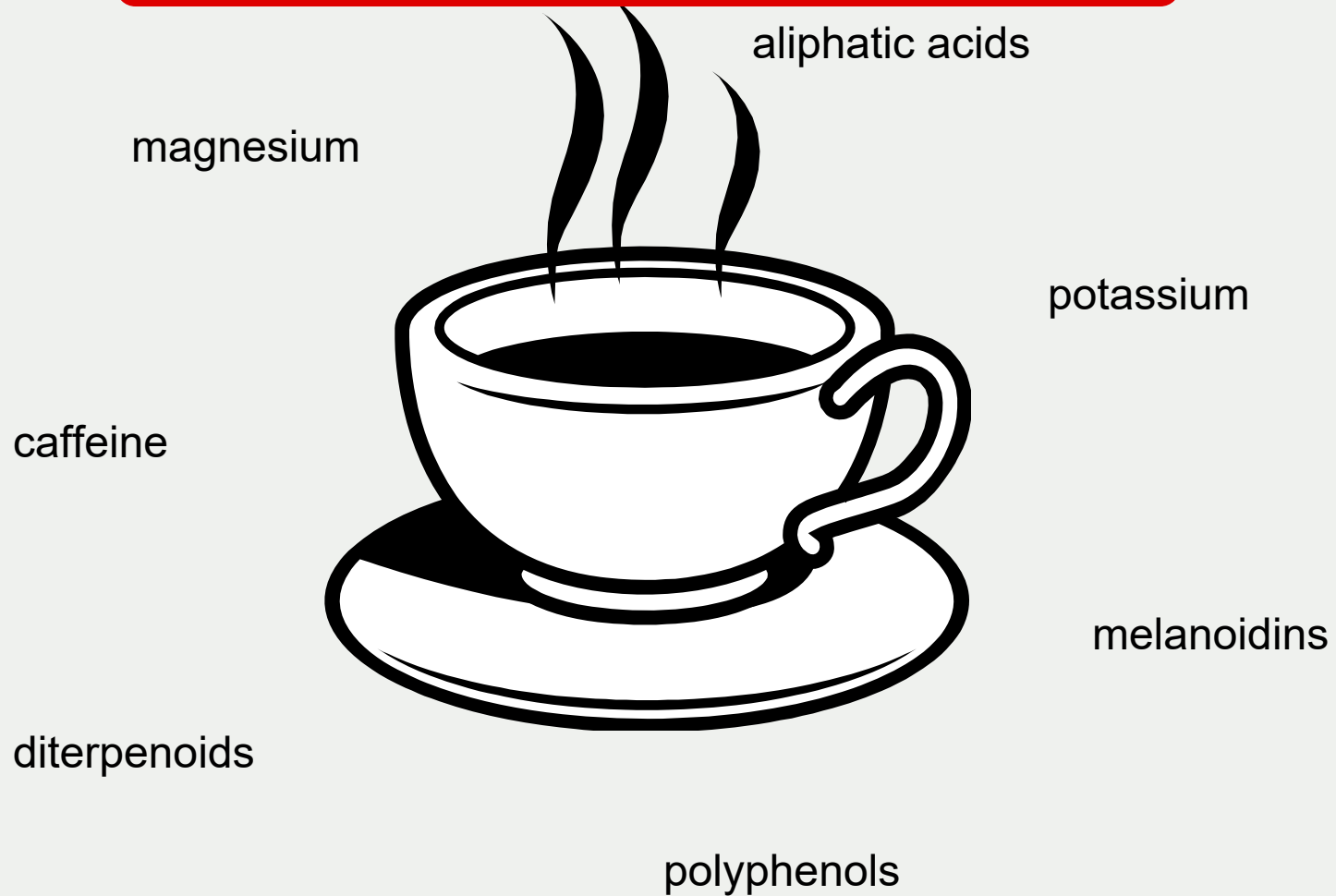
Modifier Genes



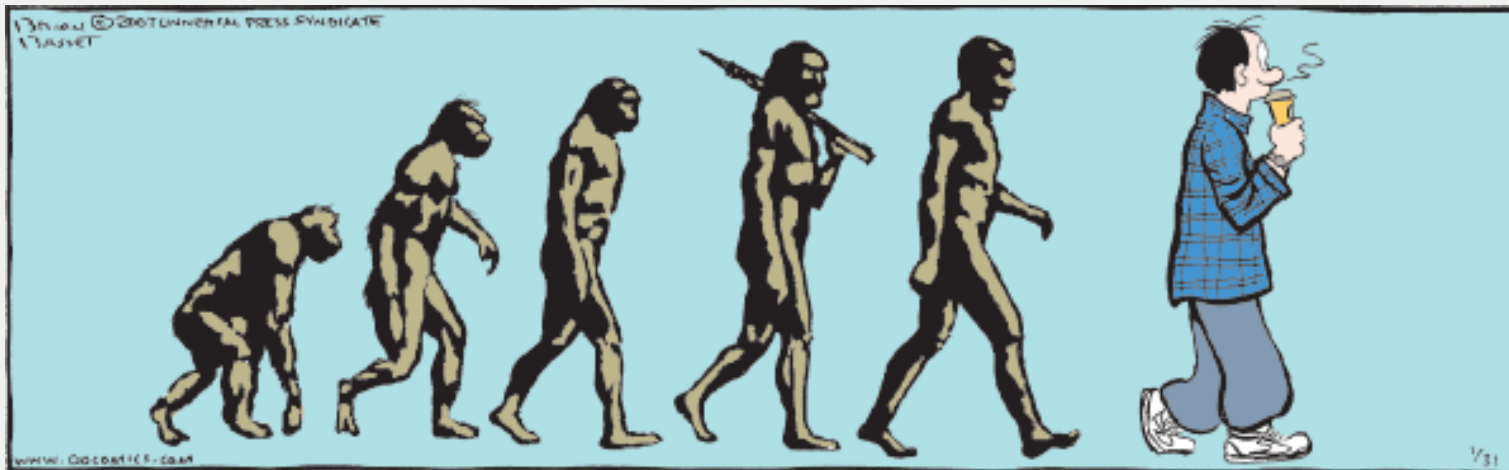
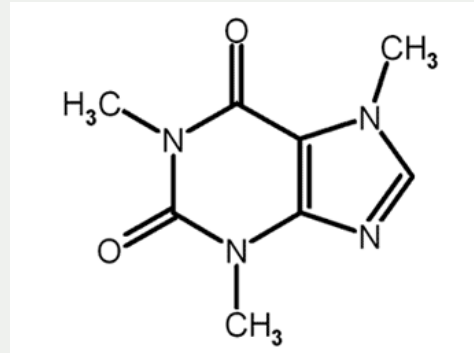
# Is Coffee associated with CVD?



# Bioactives in Coffee



# Caffeine (1,3,7-trimethylxanthine)







CAFFEINATED  
PEANUT BUTTER



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PROTEIN ELECTROLYTES CAFFEINE

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caffeine natur...  
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unpronounced...  
or instead of...  
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ALL NATU...

Natural Pean...  
Peanut Oil, N...  
Contains Pean...  
Caffeine 150mg  
Total Caffeine...  
+2 STR +1 ELEC...

Not recommen...  
women, or peop...  
pranks, or fan...

Manufactured...  
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CAFFEINATED  
PEANUT BUTTER



**STEEZM**  
PROTEIN ELECTROLYTES CAFFEINE

NET WT 8 OZ 228G

"The Legal Alternative"



"EXPLORER" PREMIERES ON NATIONAL GEOGRAPHIC CHANNEL, SUNDAY JAN. 9 AT 8 P.M. ET/PT

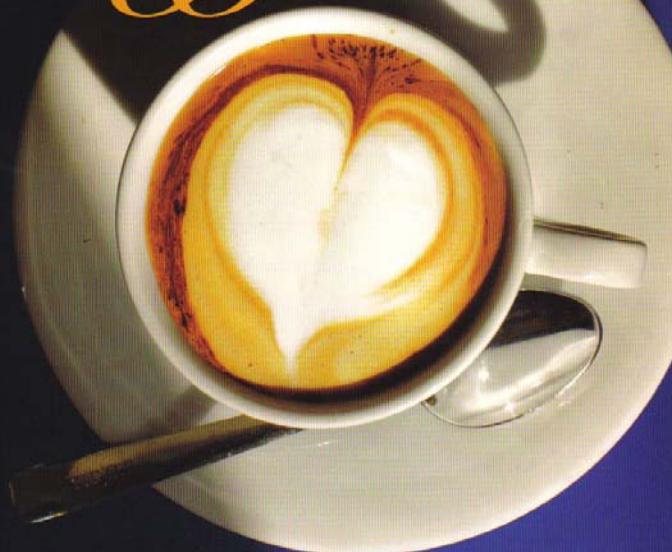
NATIONALGEOGRAPHIC.COM/MAGAZINE

JANUARY 2005

# NATIONAL GEOGRAPHIC

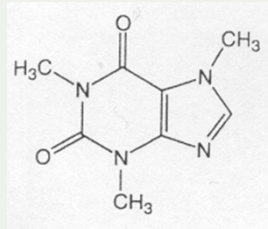
why we love

*caffeine*

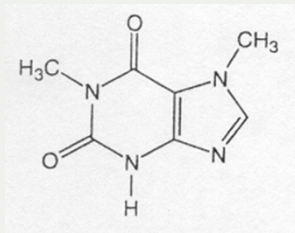


Growing Up Cheetah 34 Italy Before the Romans 52  
Morocco's Mountain Berbers 78 Yosemite—Grace Under Pressure 98  
ZipUSA: Hot Coffee, MS 118

# Caffeine



*CYP1A2*



## Paraxanthine

1,7-dimethyluric acid



1-methylxanthine



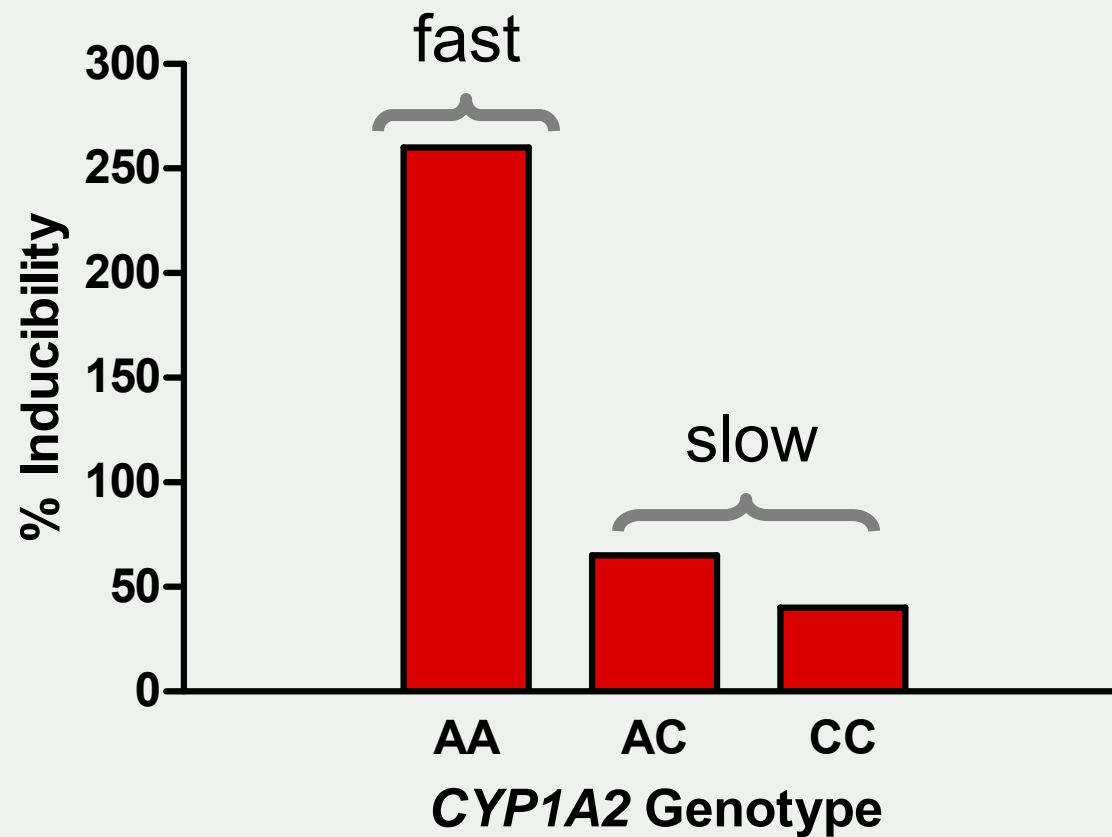
5-acetylamino-6-formylamino-3-methyluracil



1-methyluric acid



# Genetic Variation in CYP1A2 $-163 A \rightarrow C$



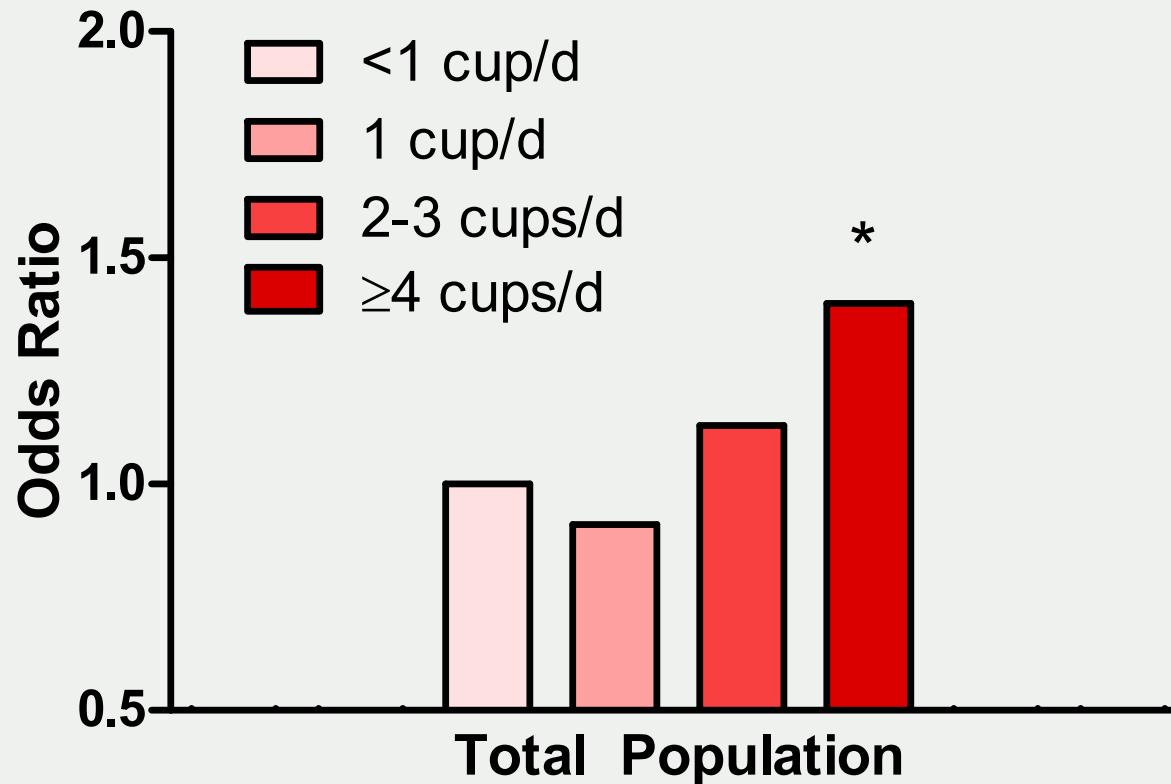


# Costa Rica Heart Study



- 2013 cases (myocardial infarction)
- 2013 population-based controls
  - matched (age, sex, area of residence)
- Data collection:
  - food frequency questionnaire
  - health and lifestyle questionnaire
  - fasting blood sample (DNA)

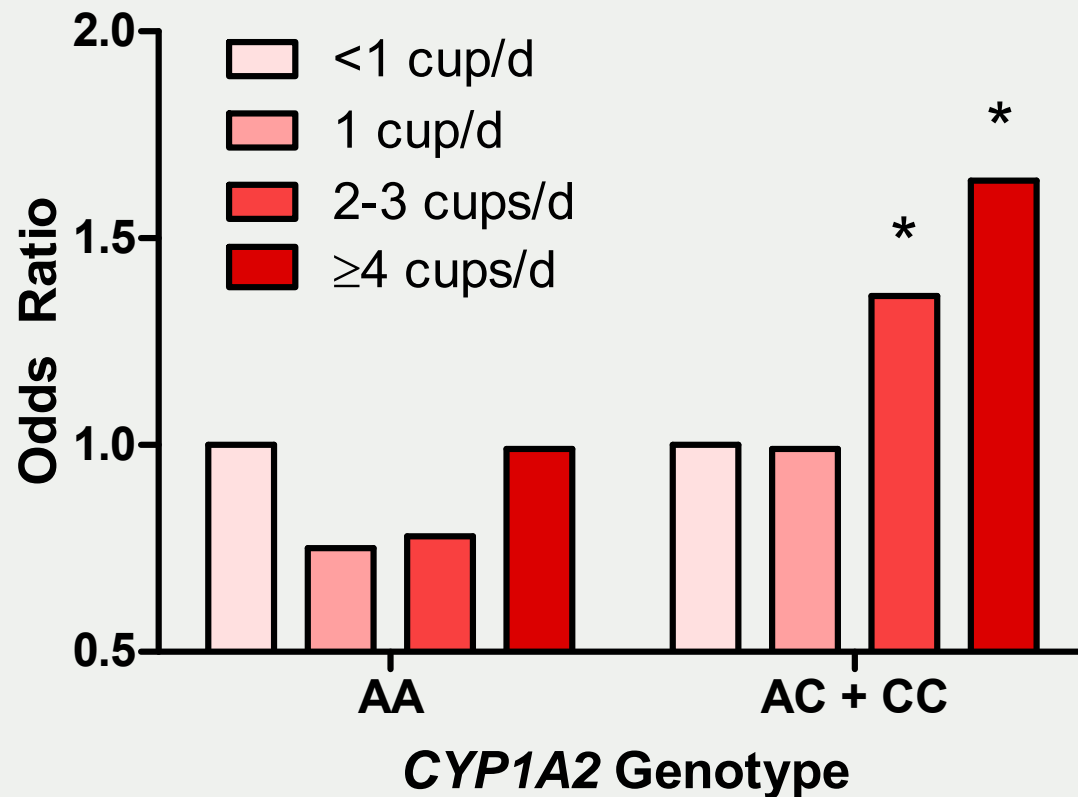
# Coffee Intake and Risk of Myocardial Infarction



\*  $P < 0.05$

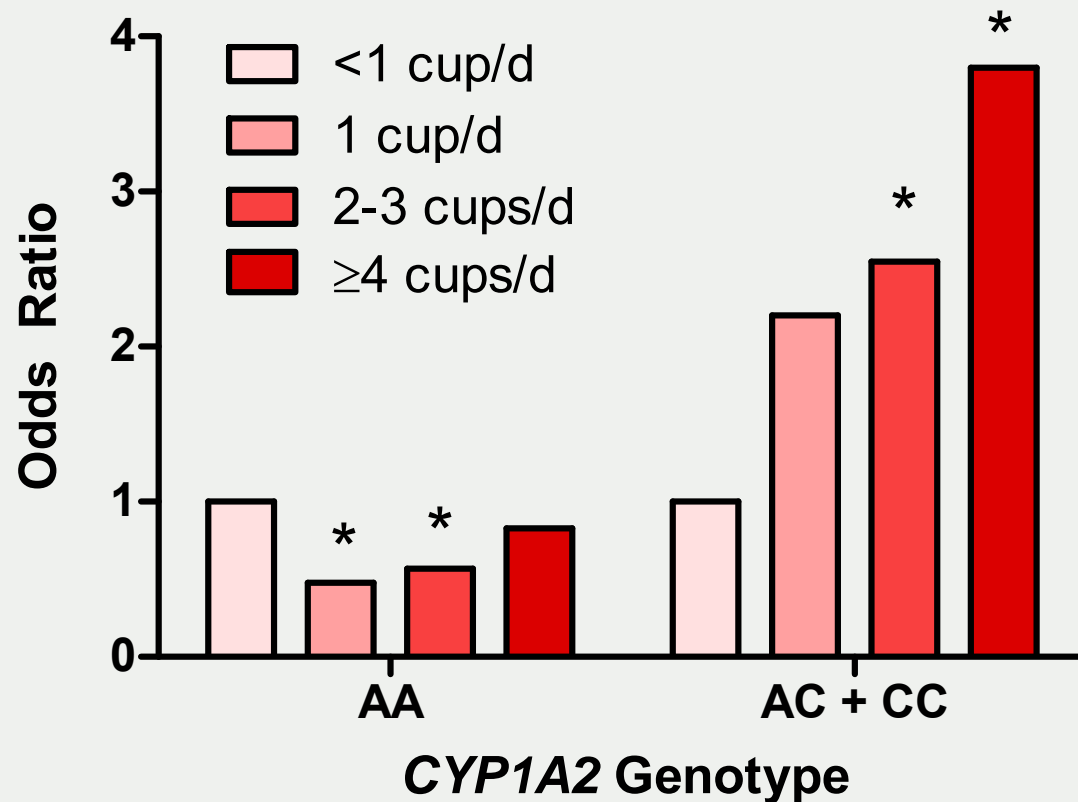
Cornelis *et al.*, JAMA 295: 1135-41, 2006

# Coffee Intake and Risk of Myocardial Infarction



\*  $P < 0.05$

# Coffee Intake and Risk of Myocardial Infarction



\* P<0.05

THE

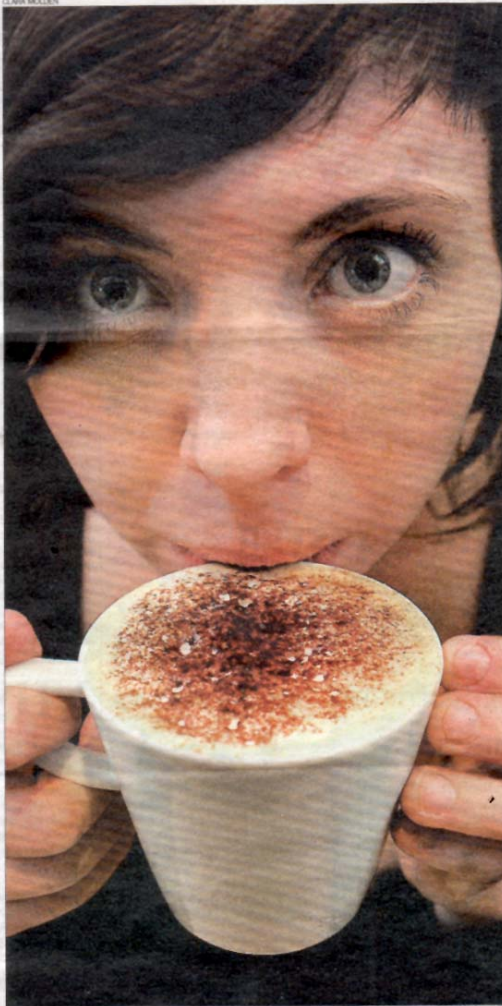


TIMES

60p

No. 68643 ■ WEDNESDAY MARCH 8 2006 ■ NEWSPAPER OF THE YEAR

## Why two cups of coffee can damage your heart



Coffee drinkers who consume four or more cups a day increase their chances of having a heart attack by more than 60 per cent if they carry a variant gene, newly published research suggests. The risk for those who drink two to three cups a day was shown to be 36 per cent higher than normal NEWS page 11

THE



TIMES

60p

No. 68643 ■ WEDNESDAY MARCH 8 2006 ■ NEWSPAPER OF THE YEAR

THE TIMES WEDNESDAY MARCH 8 2006

NEWS II

# Gene that could make your next coffee your last

New research suggests that some people cannot process caffeine as quickly as others and may therefore be more vulnerable to a heart attack, **Sam Lister** reports

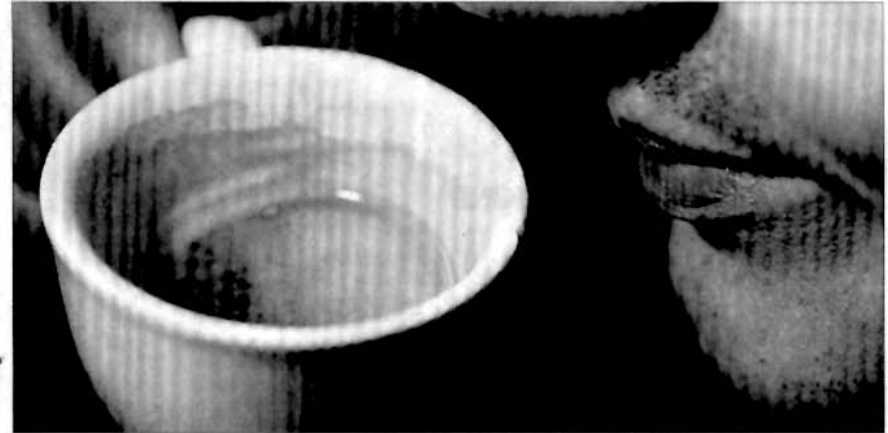
COFFEE drinkers who have more than three cups a day could significantly increase their chances of suffering a heart attack.

New research suggests that people who carry a particular variation of a gene cannot process caffeine as quickly as other people. Such individuals could be up to 64 per cent more likely to have a heart attack if they drink large amounts of coffee.

long be a source of controversy, with high amounts of caffeine long blamed for over-stimulating the nervous system. It contains diterpenes, said to be responsible for raising levels of a stress hormone called homocysteine, which can lead to strokes.

Pregnant women have been urged not to drink more than three cups of coffee a day in case it increases the chances of miscarriage or stillbirth.

HELEN ATKINSON



High amounts of caffeine can be dangerous, but some doctors suggest coffee also has benefits



Well

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## For Coffee Drinkers, the Buzz May Be in Your Genes



52



ANDREW SCRIVANI FOR THE NEW YORK TIMES

By ANAHAD O'CONNOR

JULY 12, 2016

Like most of my work, this article would not have been possible without coffee.



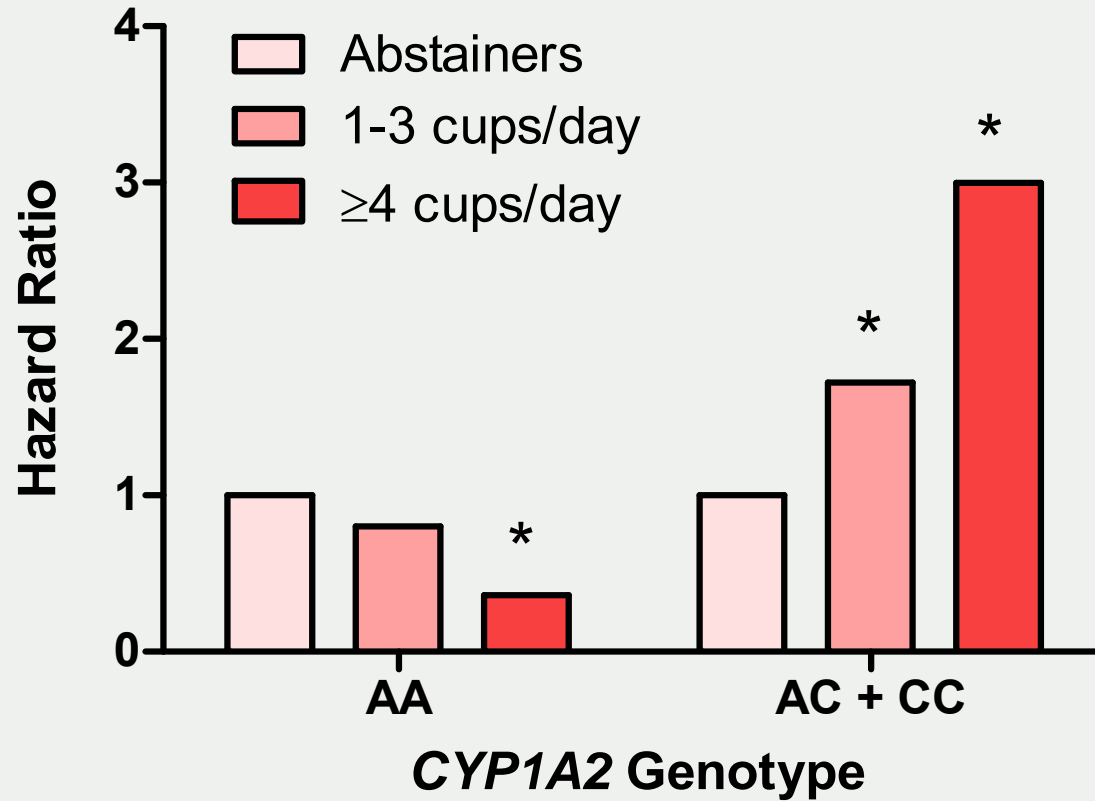


## **CYP1A2 genotype modifies the association between coffee intake and the risk of hypertension**

Paolo Palatini<sup>a</sup>, Giulio Ceolotto<sup>a</sup>, Fabio Ragazzo<sup>a</sup>, Francesca Dorigatti<sup>a</sup>,  
Francesca Saladini<sup>a</sup>, Italia Papparella<sup>a</sup>, Lucio Mos<sup>b</sup>, Giuseppe Zanata<sup>c</sup> and  
Massimo Santonastaso<sup>d</sup>

**Journal of Hypertension** 2009, 27:1594–1601

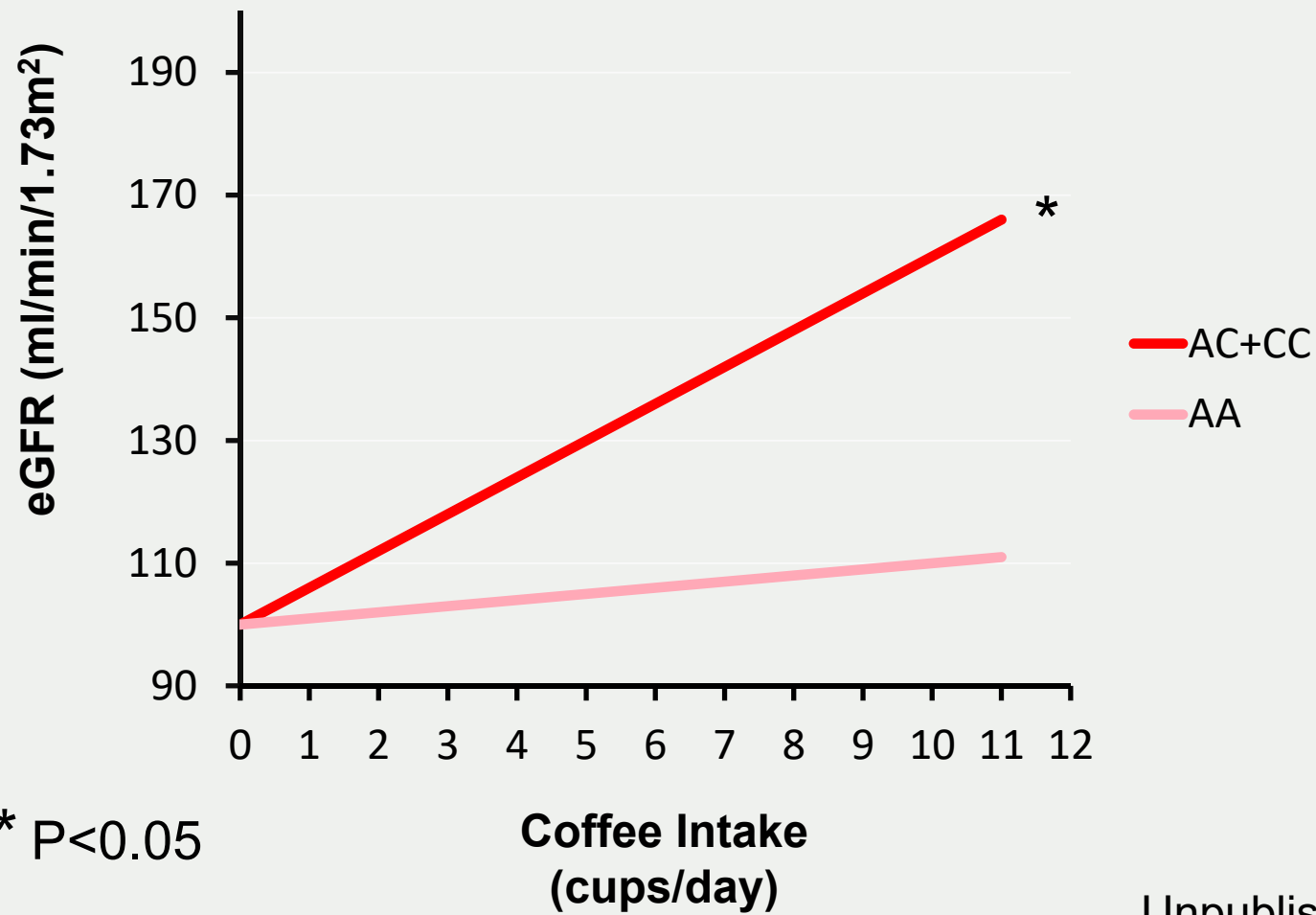
# Coffee Intake and Risk of Hypertension



\* P<0.05

Palatini *et al.*, J Hypertens 27: 1594-1601, 2009

## Daily Coffee Intake and eGFR



\* P<0.05

Unpublished Data

# Coffee Intake and Risk of Pre-Diabetes

Eur J Epidemiol (2015) 30:209–217

DOI 10.1007/s10654-015-9990-z

CARDIOVASCULAR DISEASE

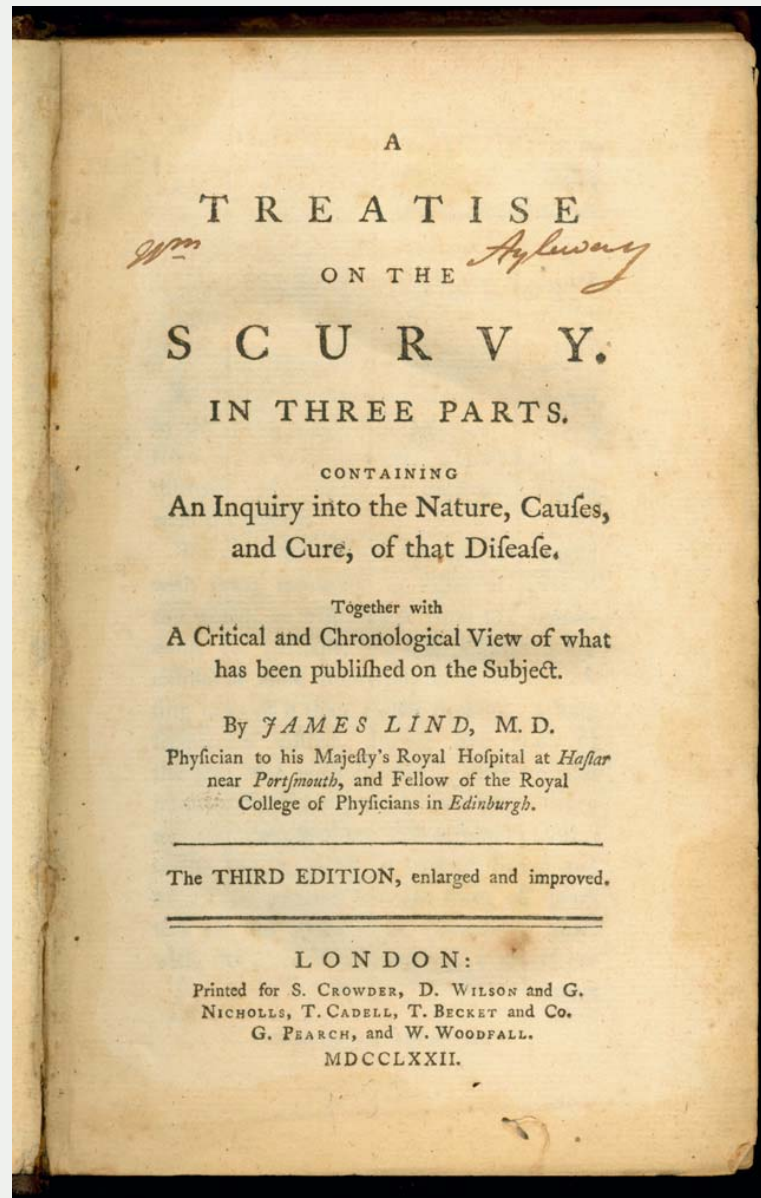
## **Association of coffee consumption and CYP1A2 polymorphism with risk of impaired fasting glucose in hypertensive patients**

**Paolo Palatini · Elisabetta Benetti · Lucio Mos ·  
Guido Garavelli · Adriano Mazzer ·  
Susanna Cozzio · Claudio Fania · Edoardo Casiglia**



# Micronutrient Genomics

# First Clinical Trial of Vitamin C



James Lind, 1772



American Journal of Epidemiology

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Vol. 170, No. 4

DOI: 10.1093/aje/kwp156

Advance Access publication July 13, 2009

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## Original Contribution

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# Vitamin C Deficiency in a Population of Young Canadian Adults

Leah Cahill, Paul N. Corey, and Ahmed El-Sohemy

*Initially submitted March 17, 2009; accepted for publication May 11, 2009.*

## Vitamin C Deficiency in Canadian Adults

<i>N</i> (%)	Serum Ascorbic Acid Concentration		
	Deficient ( $<11\mu\text{mol/L}$ )	Suboptimal ( $11\text{-}28\mu\text{mol/L}$ )	Adequate ( $>28\mu\text{mol/L}$ )
All subjects	133 (14)	325 (33)	521 (53)
Women	87 (13)	218 (31)	387 (56)
Men	46 (16)	107 (37)	134 (47)

Cahill et al Am J Epidemiol, 170: 464-471, 2009



## Serum Ascorbic Acid and Biomarkers of Disease

	Deficient ( $<11 \mu\text{mol/L}$ )	Suboptimal ( $11\text{-}28 \mu\text{mol/L}$ )	Adequate ( $>28 \mu\text{mol/L}$ )	<i>P</i>
BMI ( $\text{kg/m}^2$ )	$23.1 \pm 0.1^a$	$23.0 \pm 0.2^a$	$22.3 \pm 0.2^b$	0.007
Waist Circ. (cm)	$75.0 \pm 0.7^a$	$74.6 \pm 0.5^a$	$72.8 \pm 0.4^b$	0.003
Systolic Blood P.	$114.8 \pm 1.0$	$114.7 \pm 0.6$	$113.0 \pm 0.5$	0.06
Diastolic Blood P.	$70.2 \pm 0.7^a$	$69.6 \pm 0.4^a$	$68.2 \pm 0.4^b$	0.004
hs-CRP (mg/L)	$2.04 \pm 0.23^a$	$1.46 \pm 0.15^b$	$1.03 \pm 0.12^b$	0.0004
Insulin (pmol/L)	$54.3 \pm 3.1$	$47.8 \pm 2.0$	$48.0 \pm 1.6$	0.17
Total chol:HDL	$2.74 \pm 0.06$	$2.85 \pm 0.04$	$2.77 \pm 0.03$	0.22

Cahill et al Am J Epidemiol, 170: 464-471, 2009

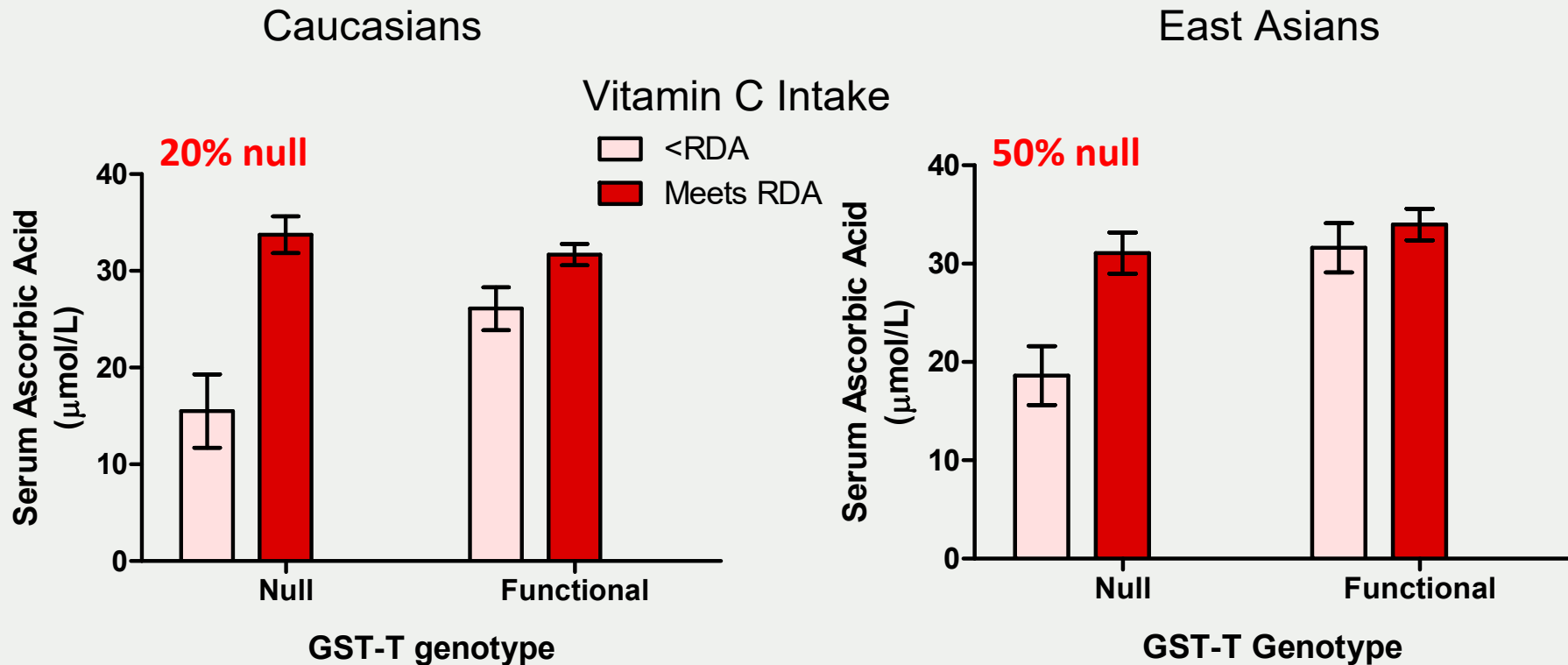
See corresponding editorial on page 1121.

## Functional genetic variants of glutathione S-transferase protect against serum ascorbic acid deficiency<sup>1-3</sup>

*Leah E Cahill, Bénédicte Fontaine-Bisson, and Ahmed El-Soheby*

*Am J Clin Nutr* 2009;90:1411-7.

# GST-T Genotype and Serum Ascorbic Acid Deficiency

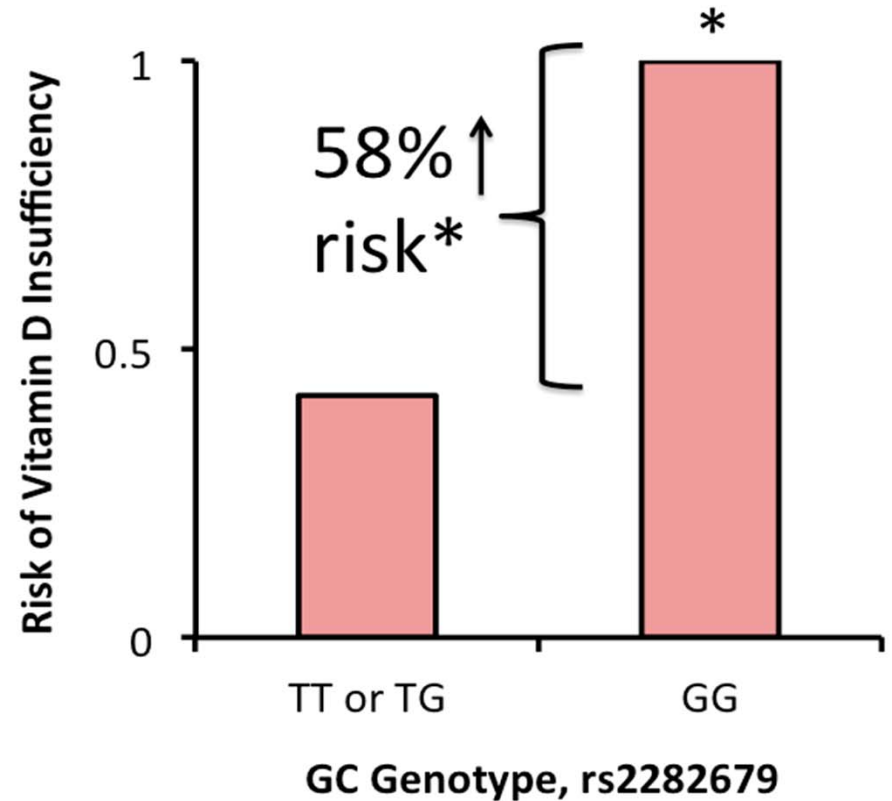
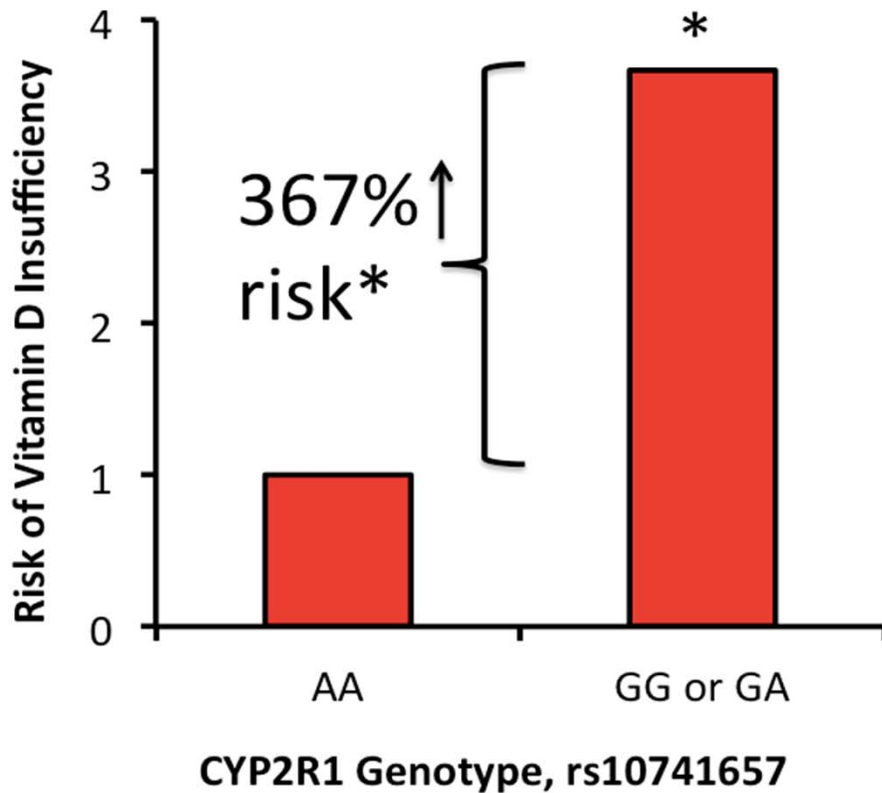


$P=0.001$  for diet-gene interaction

$P=0.02$  for diet-gene interaction

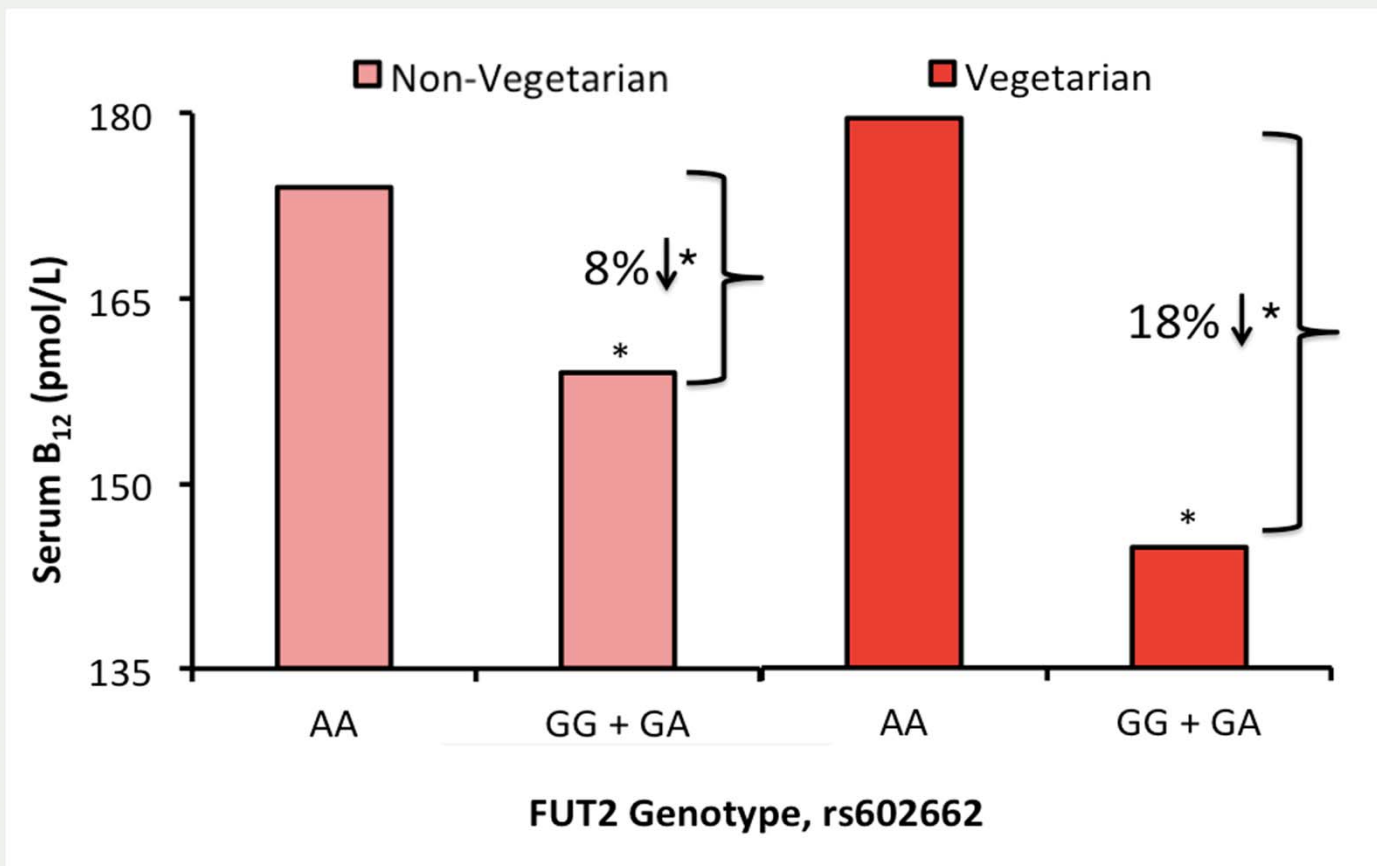
*Cahill et al, Am J Clin Nutr, 2009*

## Vitamin D insufficiency by CYP2R1 and GC genotype

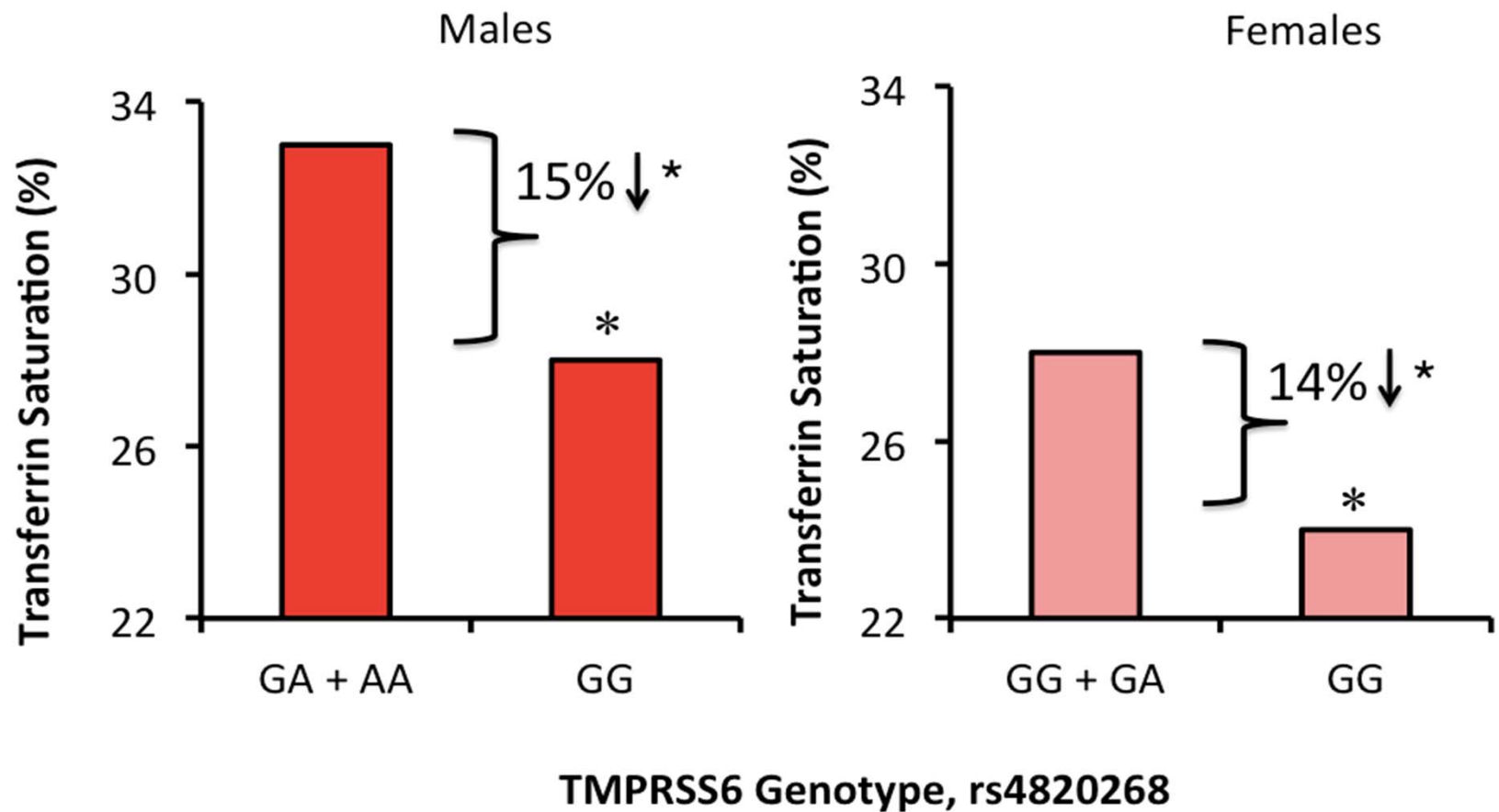


Adapted from Slater et al. J Pharm Pract. 2015:1-6.

## Serum vitamin B<sub>12</sub> (pmol/L) levels by FUT2 genotype

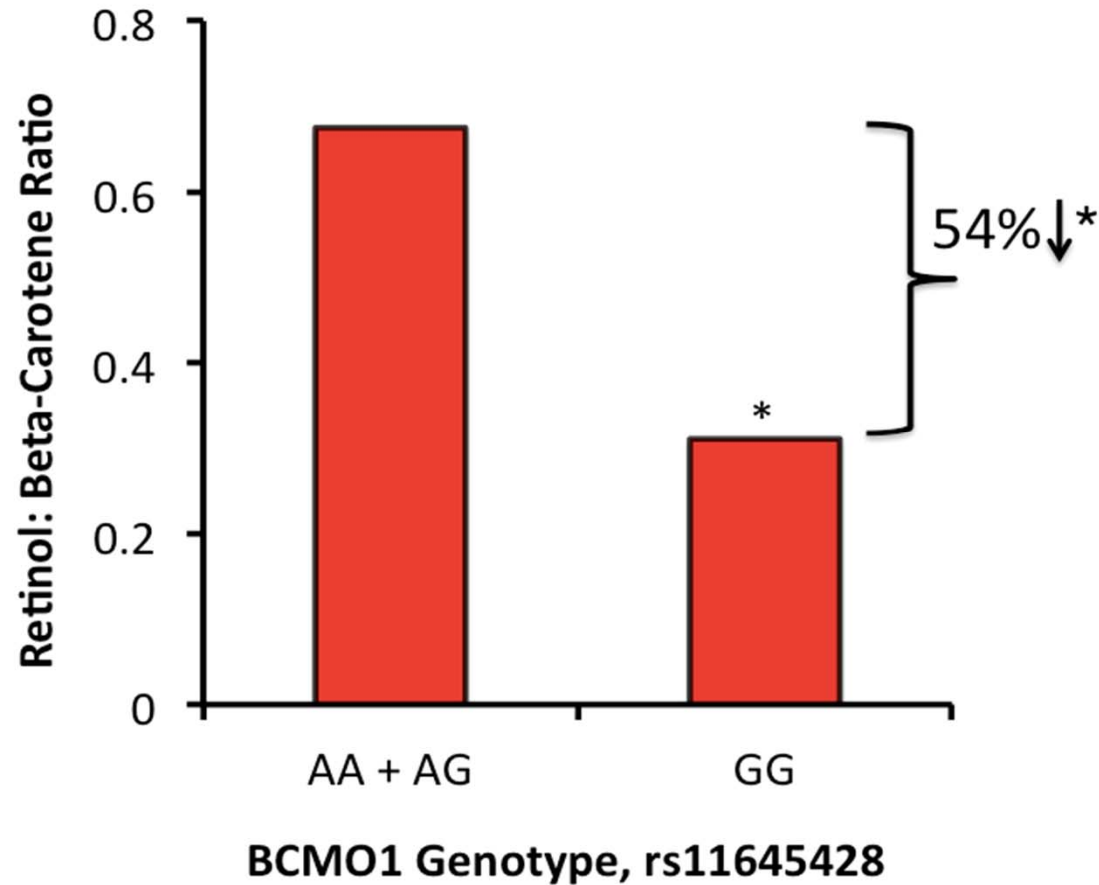


# Transferrin saturation (%) and TMPRSS6 genotype



Adapted from Benyamin et al. Nat Gen. 2009;41:1173-1175.

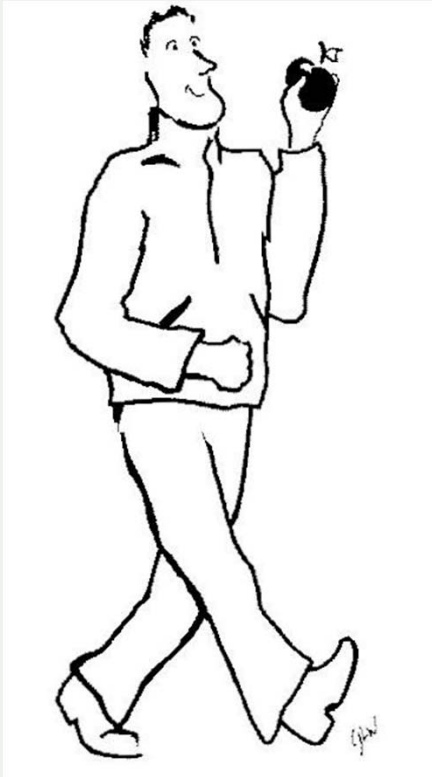
# Retinol:β-carotene ratio by BCMO1 genotype



Adapted from Lietz et al. J Nutr. 2011;142:161S-165S.

# Does genetic information influence behaviour?

*I have the gene,  
so I eat healthily.*



*I have the gene,  
so what can I do?*





## **A randomized trial of genetic information for personalized nutrition**

Daiva E. Nielsen · Ahmed El-Sohemy

- DNA-based dietary advice resulted in:
  - greater understanding of recommendations
  - greater interest in learning more
  - greater motivation to change eating habits

Genes Nutr (2012) 7:559–566  
DOI 10.1007/s12263-012-0290-x

RESEARCH PAPER

## A randomized trial of genetic information for personalized nutrition

Daiva E. Nielsen · Ahmed El-Soheemy

OPEN ACCESS Freely available online

 PLOS ONE

# Disclosure of Genetic Information and Change in Dietary Intake: A Randomized Controlled Trial

Daiva E. Nielsen, Ahmed El-Soheemy\*

Department of Nutritional Sciences, University of Toronto, 150 College St, Toronto, ON, M5S 3E2, Canada

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\*conditions apply



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**Labour MP who lives in £3million**

**Argentina passes law stating that all**

### Sections

- Alternative Therapies
- Blood, Heart and Circulation
  - › Blood Pressure
  - › Heart disease

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## Genetic testing for personalized nutrition leads to better outcomes

18/11/2014 08:50:00

## Genes really do hold the key to fitting into your jeans: Diets personalised to our genetic makeup are far more effective, study finds



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### Study Suggests Genetic Information May Lead to Behavioral Changes for Individuals with Sodium Sensitivity

Nov 14, 2014 | [a GenomeWeb staff reporter](#)

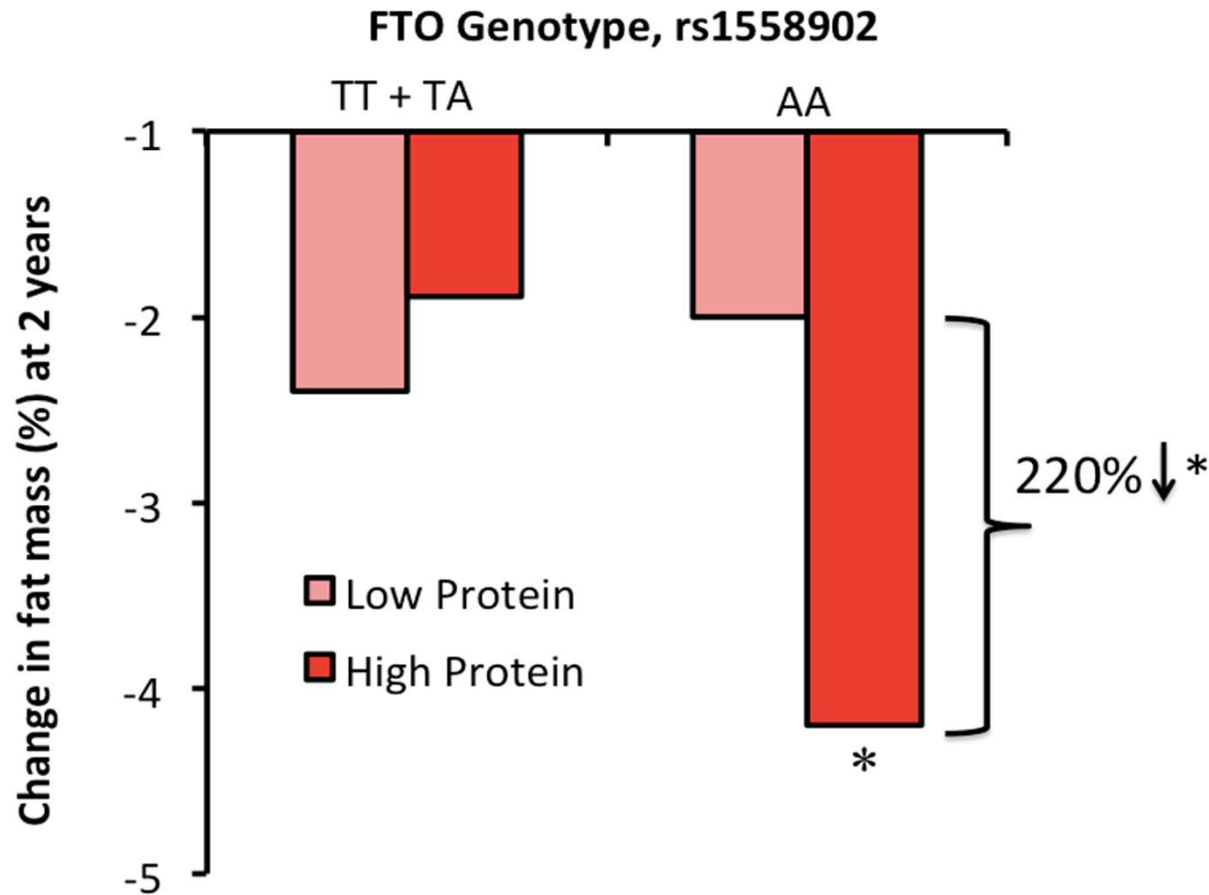
[HOME](#) > [PHYSICAL WELLNESS](#)

## DNA-Testing to Tailor Diets can be Effective, Study Reports

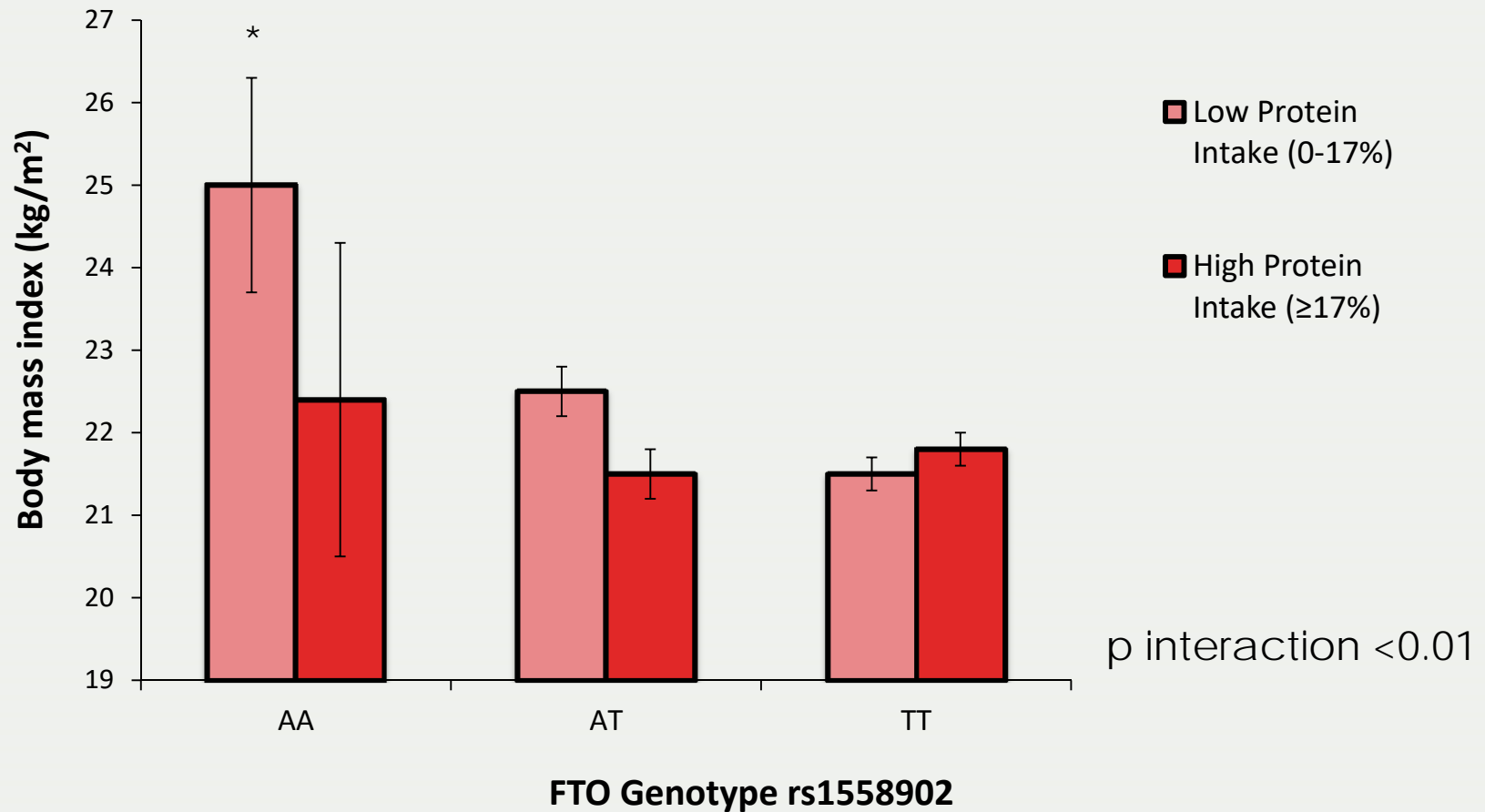
# Weight Management



# Loss of fat mass (%) after 2 years of low or high protein diet by FTO genotype

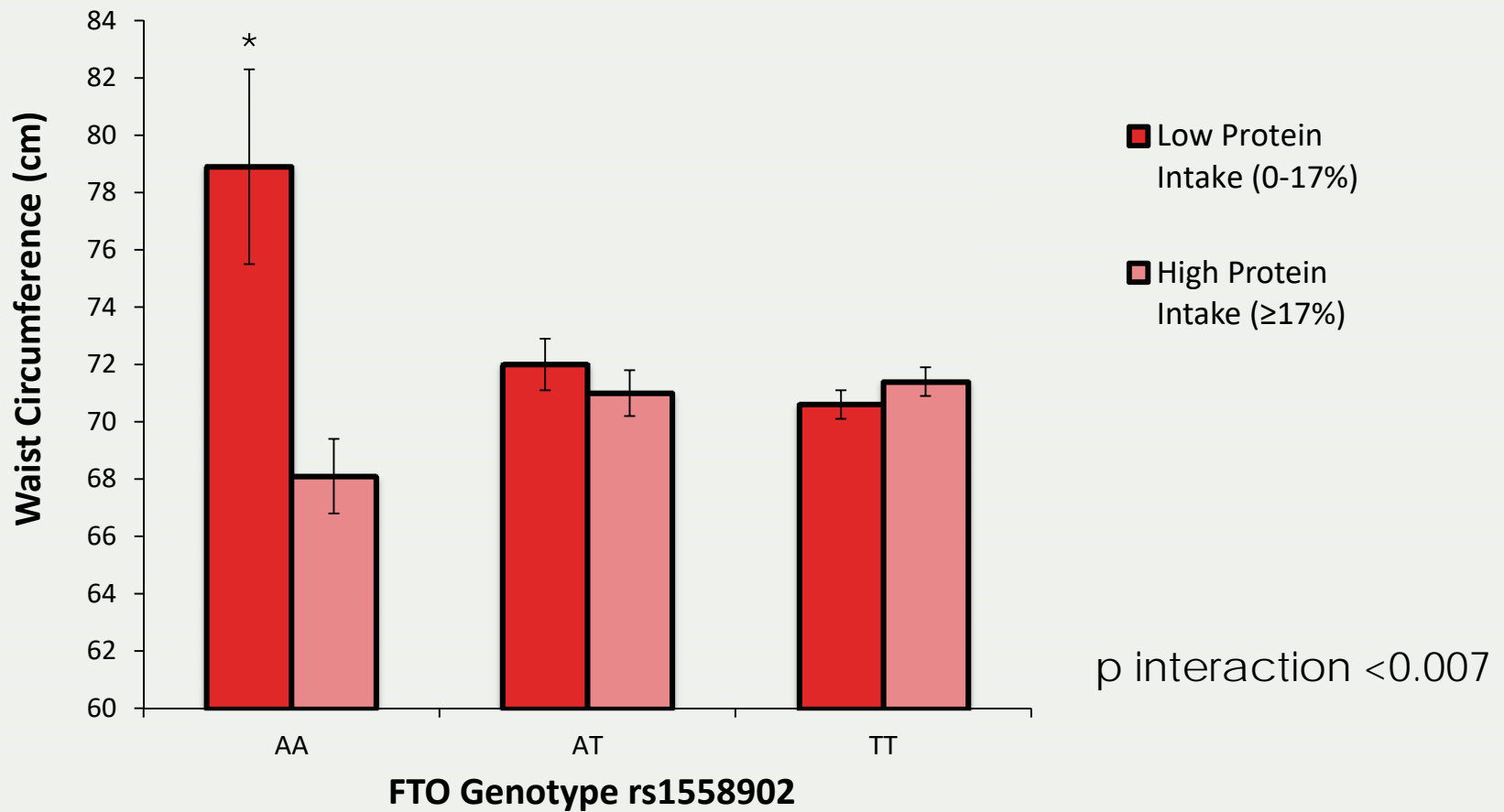


# Protein, FTO genotype and BMI in East Asians



Unpublished data

# Protein, FTO genotype and WC in East Asians



Unpublished data



What do the skeptics say?





## Position of the Academy of Nutrition and Dietetics: Nutritional Genomics

J Acad Nutr Diet. 2014;114:299-312.

- Outdated!

Applying nutritional genomics in clinical practice through the use of genetic testing requires that registered dietitian nutritionists understand, interpret, and communicate complex test results in which the actual risk of developing a disease may not be known.

## Keeping Pace with Innovations in Nutrition Care

Deborah Cohen, MHS, RD  
Practice Advisor & Policy Analyst

- College of Dietitians of Ontario

[www.collegeofdietitians.org](http://www.collegeofdietitians.org)

- Search: Nutrigenomics

# What do the skeptics say?

- Single SNPs are useless.
- People won't change their behaviors.
- It's the microbiome.

RESEARCH

Open Access



# Host genetic variation impacts microbiome composition across human body sites

Ran Blekhman<sup>1,2\*</sup>, Julia K. Goodrich<sup>3,4</sup>, Katherine Huang<sup>5</sup>, Qi Sun<sup>6</sup>, Robert Bukowski<sup>6</sup>, Jordana T. Bell<sup>7</sup>, Timothy D. Spector<sup>7</sup>, Alon Keinan<sup>8</sup>, Ruth E. Ley<sup>3,4</sup>, Dirk Gevers<sup>5,9</sup> and Andrew G. Clark<sup>3</sup>

Cell Host & Microbe

Resource

## Genetic Determinants of the Gut Microbiome in UK Twins

Julia K. Goodrich,<sup>1</sup> Emily R. Davenport,<sup>1</sup> Michelle Beaumont,<sup>2</sup> Matthew A. Jackson,<sup>2</sup> Rob Knight,<sup>3</sup> Carole Ober,<sup>4</sup> Tim D. Spector,<sup>2</sup> Jordana T. Bell,<sup>2</sup> Andrew G. Clark,<sup>1</sup> and Ruth E. Ley<sup>1,5,\*</sup>

<sup>1</sup>Department of Molecular Biology and Genetics, Cornell University, Ithaca, NY 14850, USA

<sup>2</sup>Department of Twin Research & Genetic Epidemiology, King's College London, London SE1 7EH, UK

<sup>3</sup>Departments of Pediatrics and Computer Science and Engineering, University of California San Diego, La Jolla, CA 92093, USA

<sup>4</sup>Department of Human Genetics, University of Chicago, Chicago, IL 60637, USA

<sup>5</sup>Department of Microbiome Science, Max Planck Institute for Developmental Biology, 72076 Tübingen, Germany

\*Correspondence: [rel222@cornell.edu](mailto:rel222@cornell.edu)

<http://dx.doi.org/10.1016/j.chom.2016.04.017>

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# Association of host genome with intestinal microbial composition in a large healthy cohort

Williams Turpin<sup>1,2</sup>, Osvaldo Espin-Garcia<sup>3,4</sup>, Wei Xu<sup>4</sup>, Mark S Silverberg<sup>1-3</sup>, David Kevans<sup>1,2</sup>, Michelle I Smith<sup>1,3</sup>, David S Guttman<sup>5,6</sup>, Anne Griffiths<sup>7</sup>, Remo Panaccione<sup>8</sup>, Anthony Otley<sup>9</sup>, Lizhen Xu<sup>4,10</sup>, Konstantin Shestopaloff<sup>4</sup>, Gabriel Moreno-Hagelsieb<sup>11</sup>, GEM Project Research Consortium<sup>12</sup>, Andrew D Paterson<sup>4,10,13</sup> & Kenneth Croitoru<sup>1-3</sup>

published online 3 October 2016;

# What do the skeptics say?

- Single SNPs are useless.
- People won't change their behaviors.
- It's the microbiome.
- We need to integrate all of the 'omics' technologies.
- We need more evidence. From RCTs.
- Results from genetic tests are too complex.
- Family history is more informative.
- Just follow recommendations for healthy eating.

# Is DNA-based Dietary Advice Ready for Prime Time? Yes

- Scientific evidence is robust (studies replicated)
- Independent of ethnic background
- Improved compliance (evidence from RCT)
- Information is actionable and “personalized”
- Increasing consumer awareness and demand
- Focus on wellness/prevention, not disease treatment

# Acknowledgements

Marilyn Cornelis

Bénédicte Fontaine-Bisson

Leah Cahill

Andrea Josse

Daiva Nielsen

Dennis Wang

Karen Eny

Bibiana Garcia-Bailo

Ilana Platt

Stephen Ozsungur

Joanne Brathwaite

Christine Asik

Cristina Cuda

Sara Mahdavi

Nanci Guest

Joseph Jamnik

Hyeon-Joo Lee

Susana Huang

Lindsay Stewart

Alejandra Navarro-Allende

Andre Dias

Laura Da Costa

Karina Fischer

Lilli Mauer

Erica Day-Tasevski

Ohood Alhabri

Alicia Jarosz

Riva Sorkin

Hannia Campos

Alaa Badawi

Tom Wolever

David Jenkins

Christoph Borchers

Andrew Paterson

Guang Sun

Steven Narod

Paolo Palatini

Greg Wells



# Acknowledgements

Advanced Foods and Materials Network Centres of Excellence



Natural Sciences and Engineering Research Council



Canadian Institutes of Health Research



Canada Research Chairs



Nutrigenomix Inc.



*Genotype*

**“Positive health requires a knowledge of man’s primary constitution and of the powers of various foods, both those natural to them and those resulting from human skill.”**

*Personalized Nutrition*

**- Hippocrates (480 BC)**