

# Role of Diet in Preventing Osteoporosis

What is enough and what is too little?

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# Women's Global Health Institute at Purdue



<http://www.purdue.edu/discoverypark/WGHI/>

*“Discovery with Delivery for Women’s Health Research”*

Connie M. Weaver, Ph.D.  
Director of the Women’s Global Health Institute  
Distinguished Professor of Nutrition Science

# Vision

To improve the health and quality of women worldwide through:

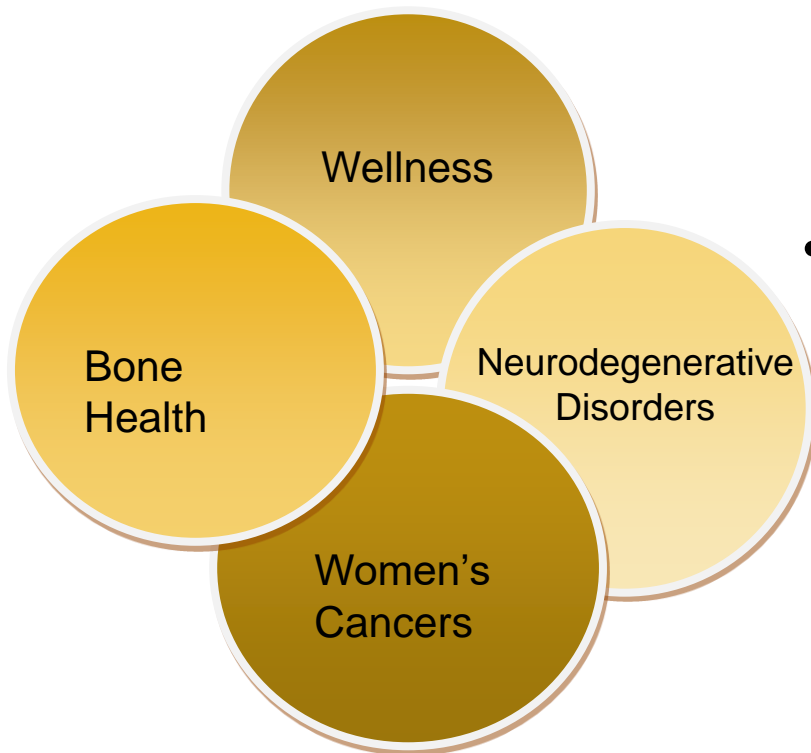
- Research
- Training future investigators





Women's Global Health Institute

- Focus on Wellness and disease **Prevention, early detection and effective interventions**



- Combine strong technology, engineering, natural and social sciences – a hub for interdisciplinary research
- Four research platforms
  - Bone Health
  - Women's Cancers
  - Neurodegenerative Disorders
  - Wellness

# 2017 WGHI Mildred Elizabeth Edmundson Research Pilot Grant Awards:



Women's Global Health Institute



**Sonak Pastakia**, Pharmacy Practice

*Proposal Title: "A Contextualized Community Based Approach for the Early Identification and Treatment of Breast and Cervical Cancer in Rural Western Kenya"*

*(in partnership with the Indiana CTSI):*



**Graham Cooks**, Chemistry

*Proposal Title: "ZIKV Diagnostic Approach in Human Semen by MRM-Profiling Mass Spectrometry"*



**Kathleen Hill Gallant**, Nutrition Science

*Proposal Title: "Effect of Ovariectomy on the Progression of Chronic Kidney Disease-Mineral Bone Disorder (CKD-MBD) in Rats"*



*WGHI Mildred Elizabeth Edmundson Research Pilot Grant Program is established by Bill and Diane Edmundson in 2012. To date, it has funded 10 pilot projects in women's health and generated more than \$4.6 million external funds*



Women's Global Health Institute

# 2017 WGHI Student Poster Award

## **Winner:**



**Farzaneh Atrian**, Basic Medical Sciences

*Poster title: "Enhancing the effect of anticancer drugs through modifications of nuclear morphology"*

*(This award helped supporting her presenting at Society of Toxicology annual meeting March 12-16, Baltimore, Maryland)*

## **Honorable Mention:**



**Tomasz Wilmanski**, Nutrition Science

*Poster title: "1,25-Dihydroxyvitamin D3 inhibits de novo fatty acid synthesis and metastatic capability of breast cancer cells"*



*Purdue alumnus Roberta Gleiter is the sponsor of the WGHI Student Travel award. Three Purdue students have received the award since 2016*



# Community Luncheon Series on Women's Health



Women's Global Health Institute



- Engage community
- Deliver new discoveries
- Address questions and concerns in women's health
- Two speakers:
  - Research
  - Clinical management

**PURDUE** HEALTH & HUMAN SCIENCES  
**Discovery Park**  
 PURDUE UNIVERSITY  
 DONALD R. PEDERSON CENTER FOR WOMEN'S HEALTH

Purdue University's Women's Global Health Institute & Indiana University's National Center for Excellence in Women's Health invite you to the Community Luncheon and Conversation

**NEURODEGENERATIVE DISORDERS**  
 Monday, November 6, 2017 • 11:30 AM  
 IUPUI Campus, Indianapolis, IN

Discuss neurodegenerative disorders with Drs. Jessica Huber and S. Elizabeth Zauber. Huber is a behavioral scientist and the inventor of "Spigette," a small wearable device to improve life quality of patients with Parkinson's disease. She also leads a research center on neurological diseases of aging. Zauber is a movement disorders specialist and seeing patients with Parkinson's disease.

**FEATURED SPEAKERS**

**Jessica Huber**  
 Professor and Dean's Fellow in the College of Health and Human Sciences, Purdue University

**Sarah Elizabeth Zauber**  
 Assistant Professor of Neurology at IU School of Medicine

\$15 per person  
**REGISTER AT:**  
<http://giving.purdue.edu/wh11-6>

Questions? Contact (765) 496-9316

**PURDUE UNIVERSITY**

- Neurodegenerative Disorders
- Co-host: IU National Center for Excellence of Women's Health
- Speakers:
  - Jessica Huber, PU
  - Sarah Elizabeth Zauber, IUSM

**WOMEN'S HEALTH COMMUNITY LUNCHEON SERIES**

Purdue University's Women's Global Health Institute & Indiana University's National Center for Excellence in Women's Health  
**INVITE YOU TO THE COMMUNITY LUNCHEON AND CONVERSATION ON OSTEOPOROSIS**

Monday, May 1, 2017 • 11:30 AM  
 \$15 per person  
 IUPUI Campus Center  
 420 University Blvd., Room #450 A, Indianapolis, IN  
 Questions? Contact (765) 496-9316  
**REGISTER AT:** [giving.purdue.edu/WHindy](http://giving.purdue.edu/WHindy)

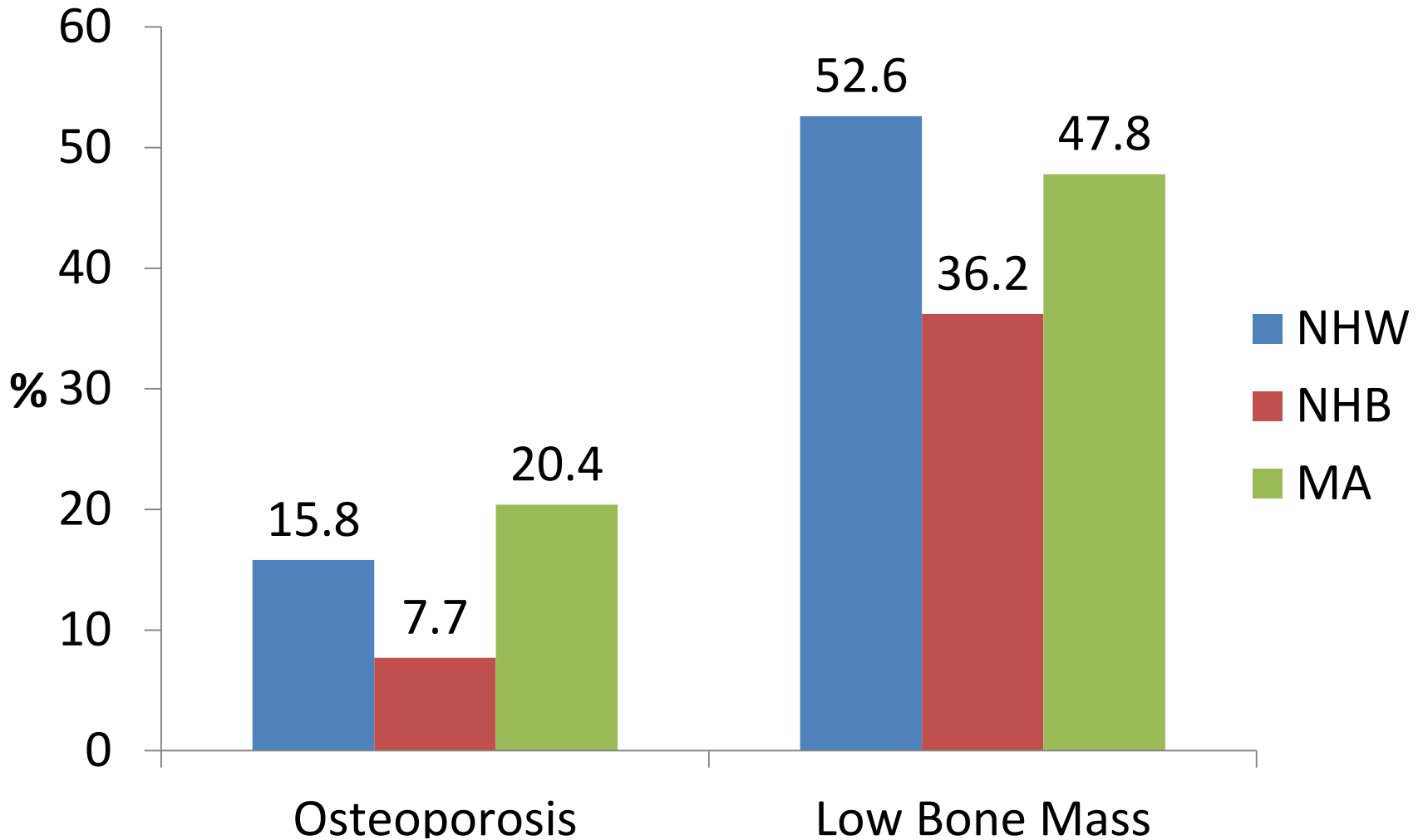
**Dr. Weaver** **Dr. DiMeglio**

Learn about preventing osteoporosis from Purdue's Distinguished Professor Dr. Connie Weaver and Dr. Linda Anne DiMeglio, Professor of Endocrinology/Diabetology at Indiana University School of Medicine. Dr. Weaver's research in bone health and nutrition defined national dietary guidelines. Dr. DiMeglio specializes in genetic bone disorders.

**SPONSORED BY:**  
 AMERICAN DAIRY FARMERS ASSOCIATION

- Osteoporosis Prevention
- Sponsor: American Dairy Association Indiana
- Speakers:
  - Connie Weaver, PU
  - Linda DiMeglio, IUSM

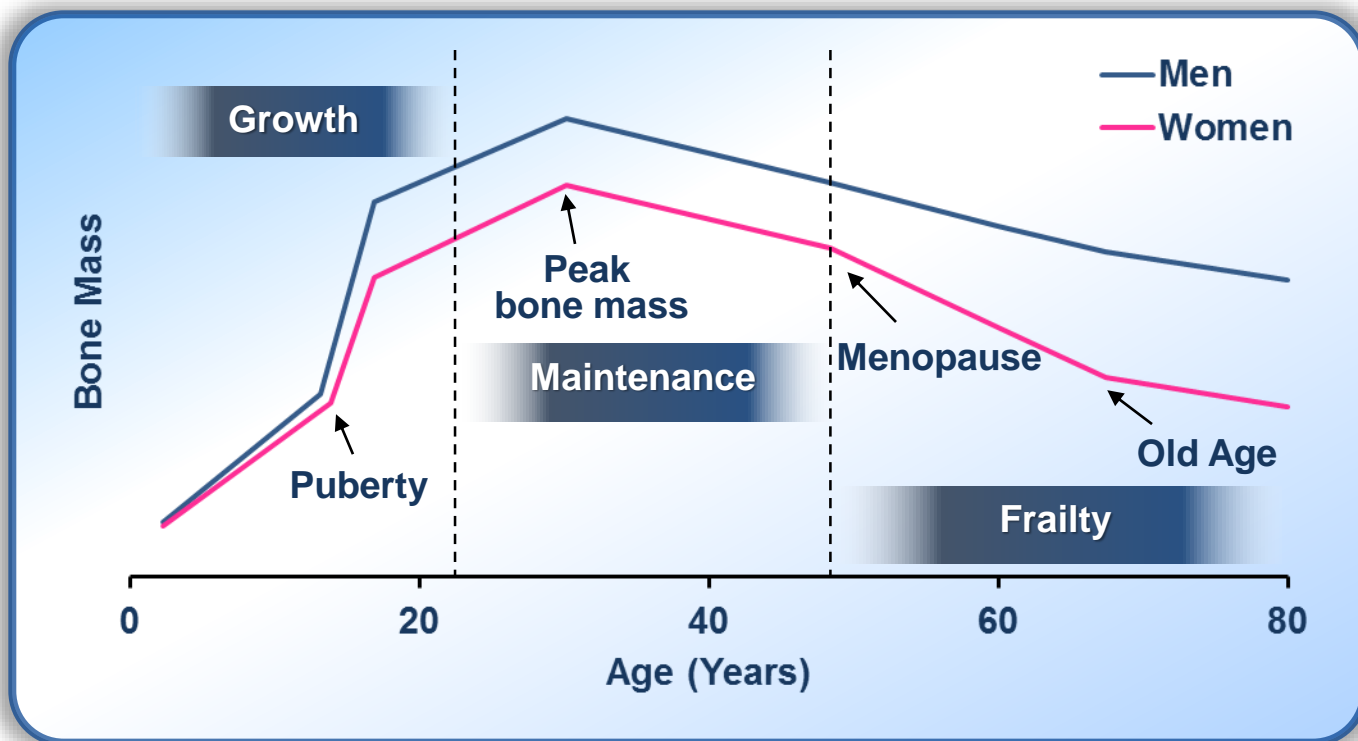
# Prevalence of Bone Health Categories: Females 50+ years, NHANES 2005-2010





# Bone Health: A Lifelong Concern

- Peak skeletal mass achieved by ages 20-30
- Adult skeleton remodeled and replaced every 10 years

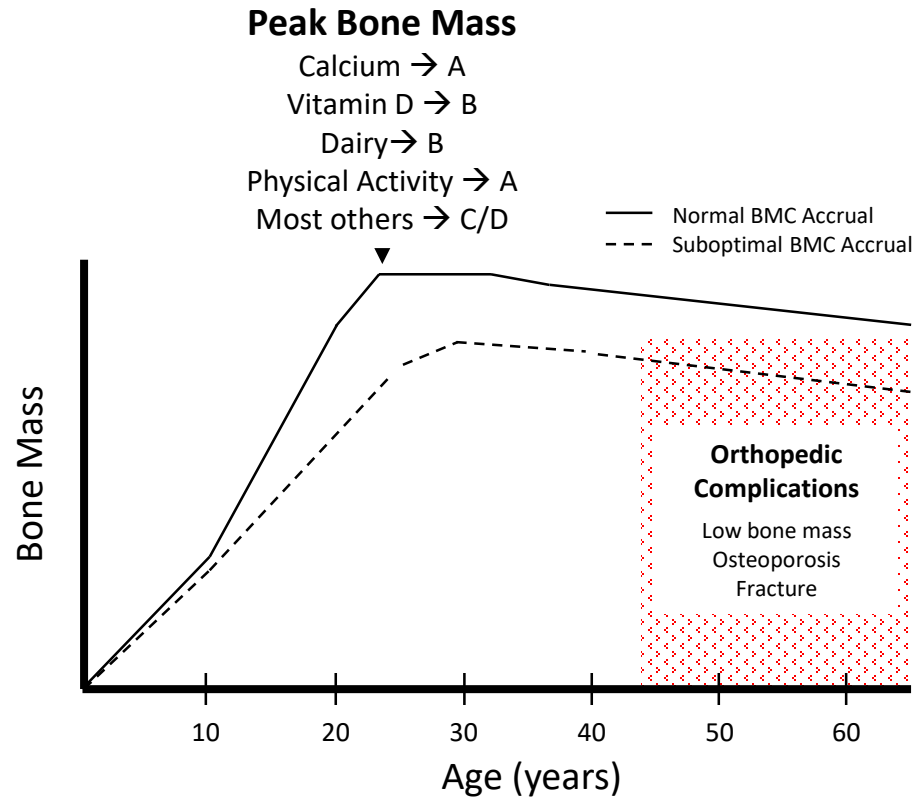


Strategies to prevent fracture are to build peak bone mass early in life and to reduce bone loss later in life

# Why is peak bone mass important?

- 30 to 50% of children have at least one fracture by the end of teenage years
- a 5–10% difference in PBM may result in a 25–50% difference in hip fracture rate later in life
- Estimated annual costs exceed \$131 billion for hip fractures worldwide.

# NOF Position on Lifestyle Factors and Peak Bone Mass

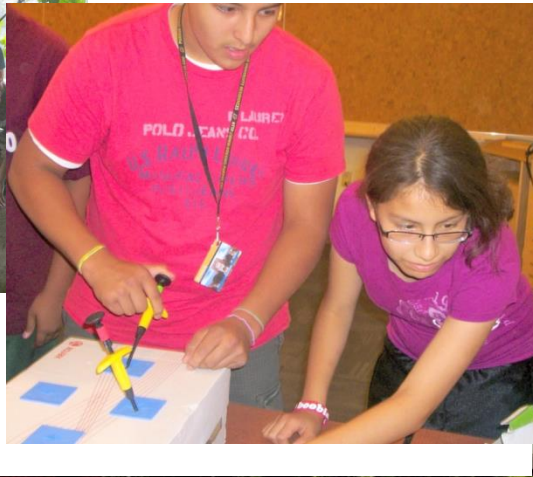


# Camp Calcium:11 metabolic studies in adolescents from 1990



**We have studied Whites, Blacks, Asians, and Hispanics; boys and girls.**

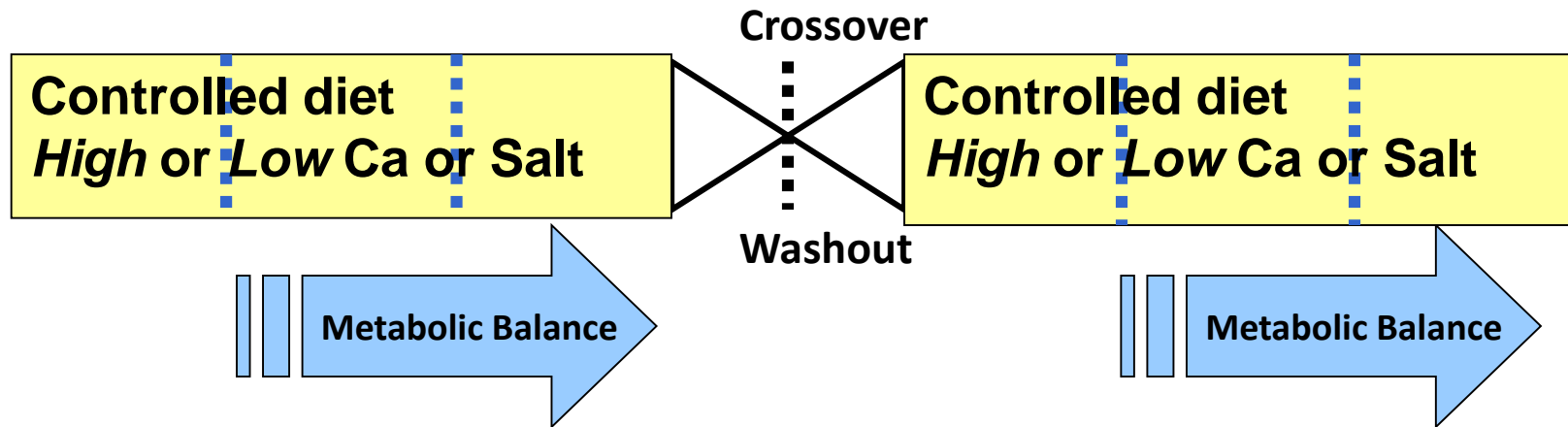




**We LOVE the fountain!**



# Study Design





Estimated bone gain from our model increasing Ca intake from 800 → 1300 mg/d:

10 % increase in peak bone mass, this could delay onset of *osteoporosis* by 13 years and decrease risk of *fracture* in postmenopausal women by 50 %.

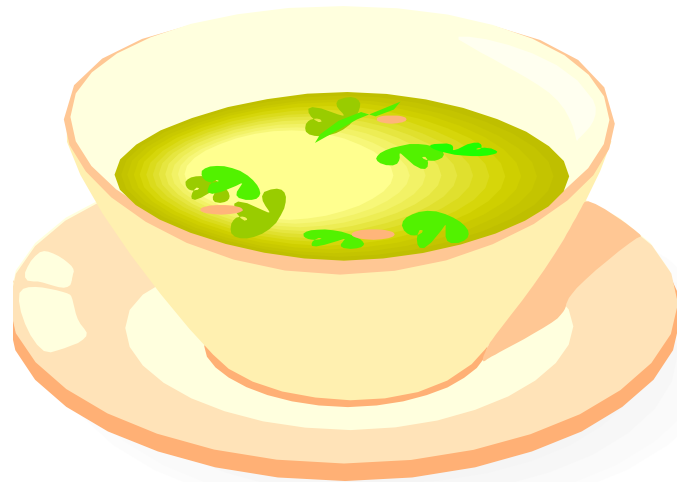
# Sodium Retention in Black and White Female Adolescents in Response to Salt Intake



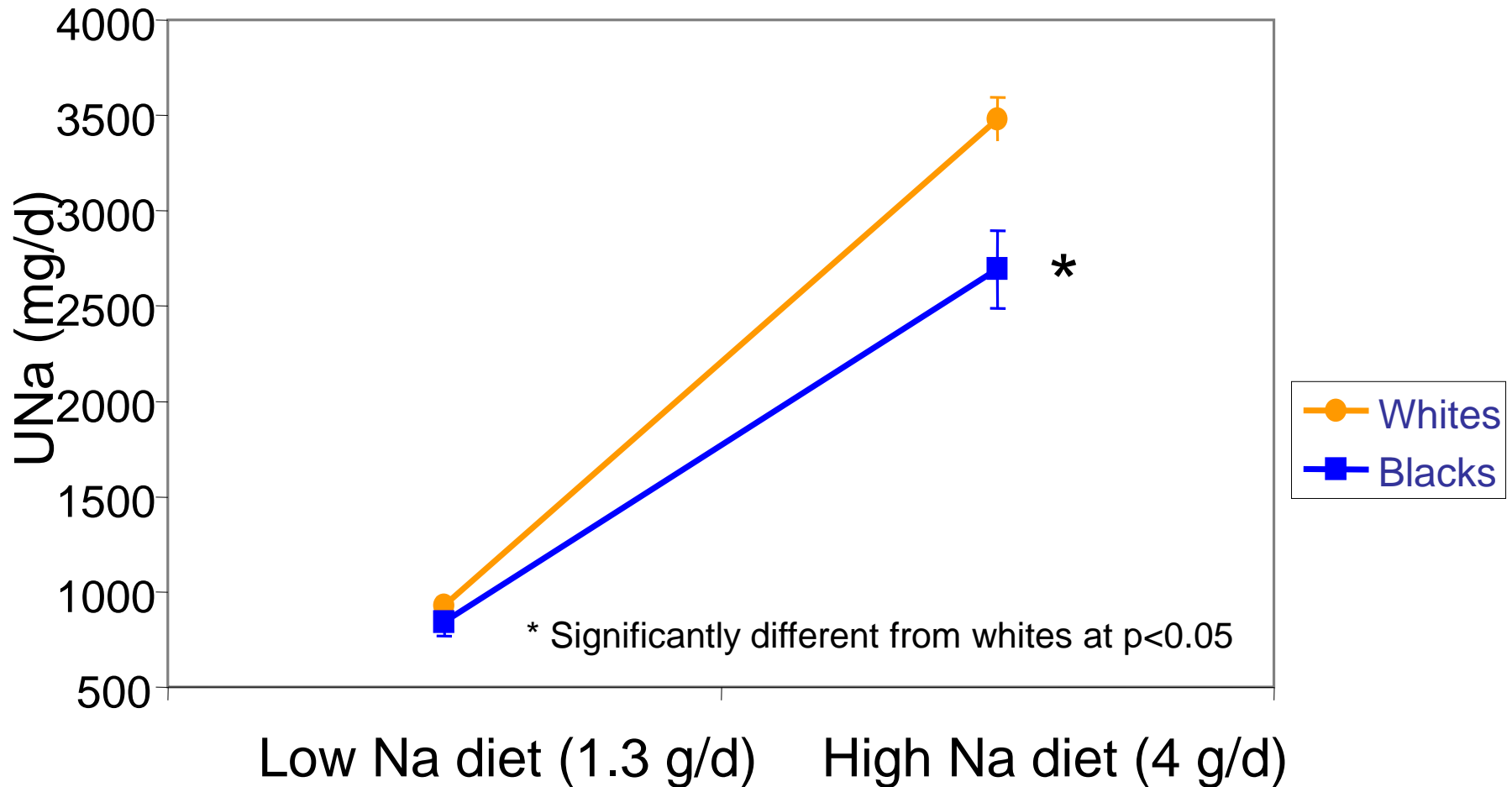
# Dietary salt varied



Low Na diet → 1.3 g/d  
High Na diet → 4 g/d

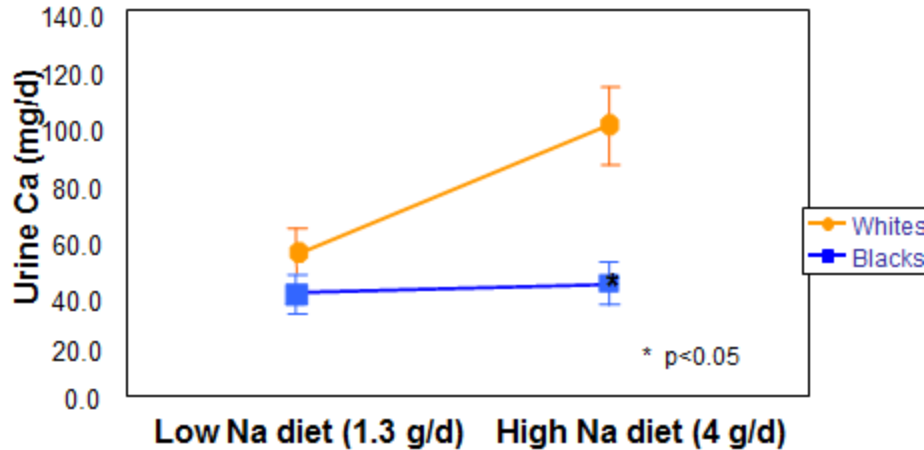


# Urinary sodium excretion (Mean $\pm$ SEM)

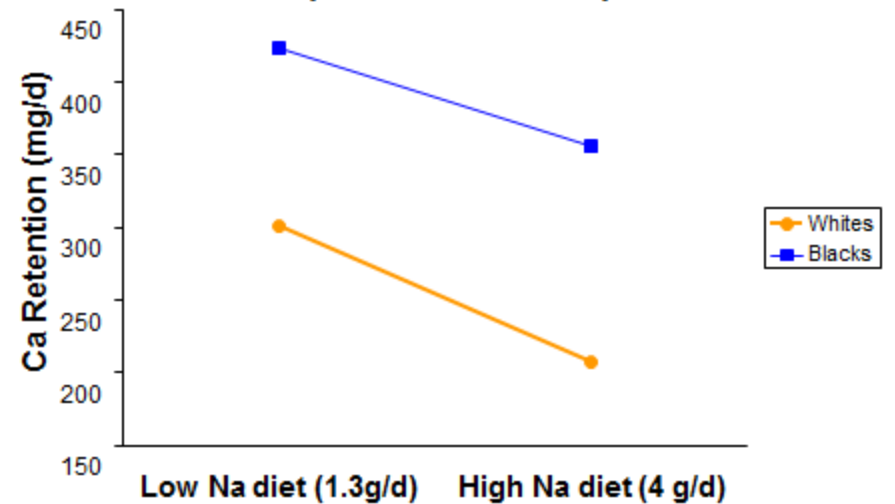


# Effects of Salt intake on Calcium Excretion and Balance in Black and White Adolescents

## Urinary calcium excretion (Mean $\pm$ SEM)



## Calcium retention (Mean $\pm$ SEM)



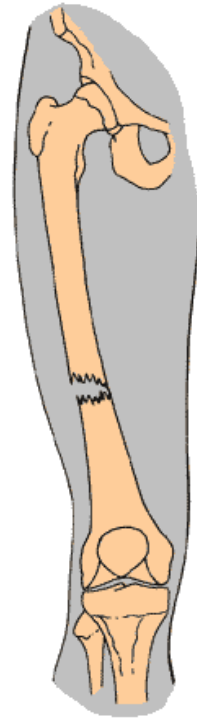
\*  $p < 0.05$  for diet and race

# Conclusions from Camp Calcium

- Calcium requirements for North America set at 1300 mg/d for adolescents based on Camp Calcium data.
- Dietary salt decreases Ca retention.
- Whites are more vulnerable to osteoporosis and blacks are more vulnerable to hypertension starting with differences in sodium and calcium metabolism in adolescence.
- Supplementing with vitamin D has no effect on calcium absorption in American children.



# Maximizing Bone Mineral Content Reduces Risk of Fracture



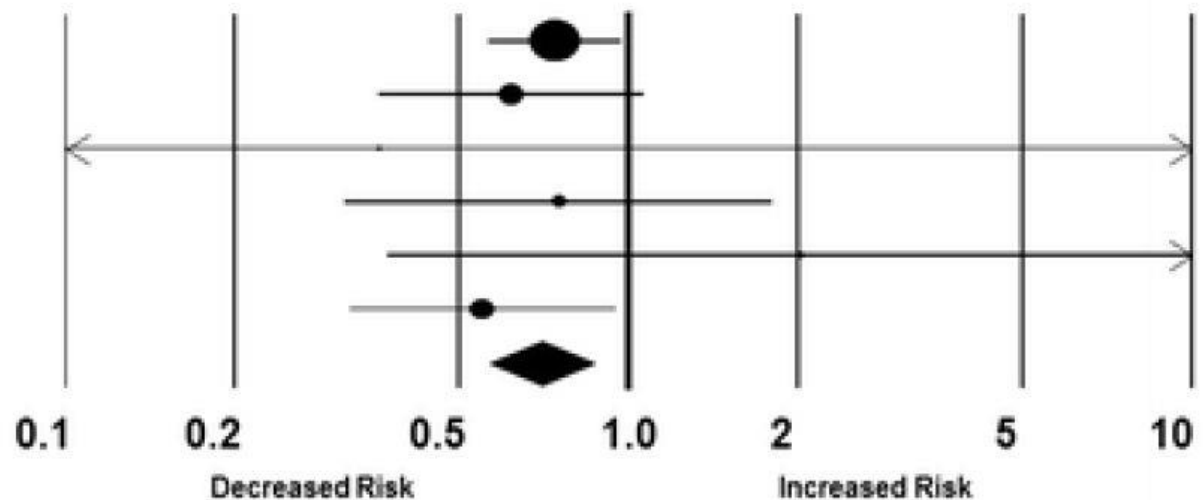
Calcium storage in  
bone is a functional  
reserve

# Meta analysis shows Calcium plus vitamin D reduces risk of hip fractures by 30%

**a** Study Name

Rate Ratio and 95% CI

Chapuy, 1992 [20]  
Chapuy, 2002 [21]  
Dawson-Hughes, 1997 [22]  
Porthouse, 2005 [23]  
Salovaara, 2010 [24]  
Prentice, 2013 [10]<sup>a</sup>  
SRRE = 0.70 (0.56–0.87)  
*P*-heterogeneity = 0.74  
*I*<sup>2</sup> = 0.00



# Are Calcium Supplements Safe?

BMJ

RESEARCH

Effect of calcium supplements on risk of myocardial infarction and cardiovascular events: meta-analysis

Mark J Bolland, senior research fellow,<sup>1</sup> Alison Avenell, clinical senior lecturer,<sup>2</sup> John A Baron, professor,<sup>3</sup> Andrew Grey, associate professor,<sup>1</sup> Graeme S MacLennan, senior research fellow,<sup>2</sup> Greg D Gamble, research fellow,<sup>1</sup> Ian R Reid, professor<sup>1</sup>



 CBS EVENING NEWS  
with SCOTT PELLEY

[FULL EPISODES](#) [ON THE ROAD](#) [THE TEAM](#) [ABOUT US](#)

July 29, 2010 8:56 PM

PRINT  TEXT 

## Calcium Supplements Linked to Heart Attacks

# Ossabaw Pig: Model for Soft Tissue Calcification

- Research Goal:
  - To examine the impact of high dietary calcium from supplement (calcium carbonate) or dairy (non-fat dry milk) on cardiovascular function, vascular calcification and the progression of coronary artery disease.
- Funding from Dairy Research Institute, Dairy Australia, Nestle, Fonterra, Kraft, Pharmavite



# Conclusions

6-month feeding of high calcium from calcium carbonate or dairy did not alter cardiovascular function, coronary artery disease burden or coronary artery calcification in Ossabaw miniature swine.

# Combined Effort to Elucidate Role of Calcium in Cardiovascular Disease

Calcium intake and CV disease risk:  
Updated systematic review and meta-analysis Tufts University

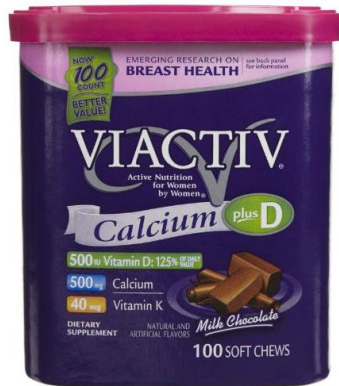
Position Statement :  
National Osteoporosis Foundation (NOF) and  
American Society for Preventive Cardiology (ASPC)



# Position Statement : NOF and ASPC

- B-level or “moderate” evidence that calcium w/ or w/o Vit D intake from food or supplements has no relationship (beneficial or detrimental) to the risk of CV and cerebrovascular disease incidence, mortality, and all-cause mortality in generally healthy adults.
- Calcium from food and supplements 2000-2500 mg/d [tolerable upper intake levels (UL) defined by National Academy of Medicine] should be considered safe from a CV standpoint

# Variety of Sources Provide Essential Nutrients



## Supplements

- Calcium
- Vitamin D

## Fortified Foods

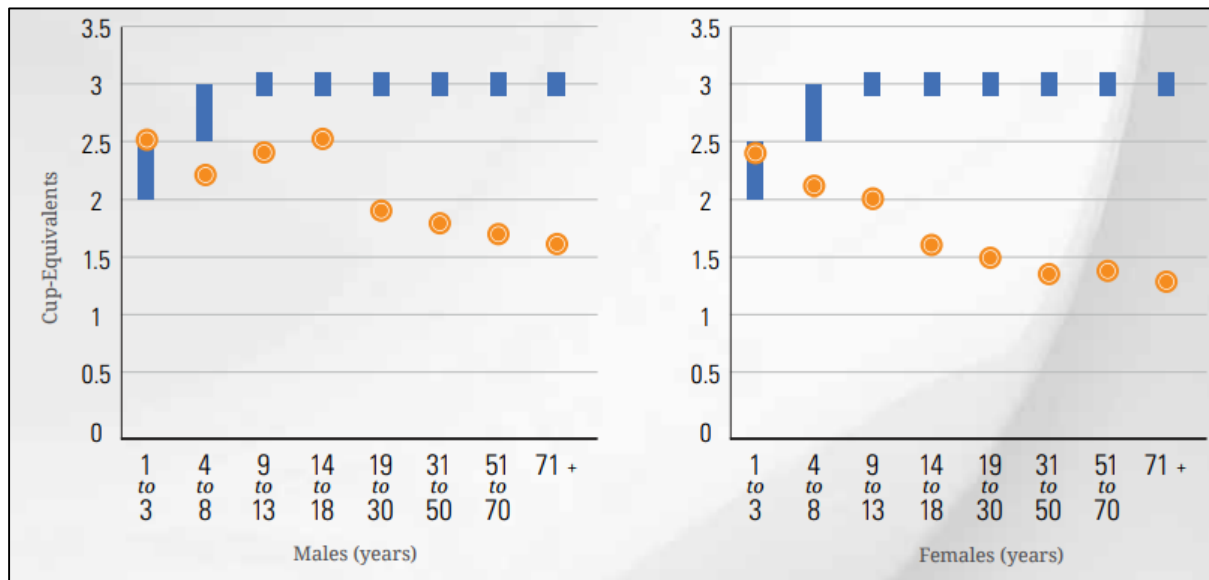
- Calcium
- Vitamin D
- Potassium

## Dairy Sources

- Calcium
- Vitamin D
- Magnesium
- Riboflavin
- Vitamin A
- Phosphorus
- Potassium

# Intake Compared to Recommendations:

Average dairy food group intakes by age-sex groups, compared to ranges of recommended intake



# Food sources of bioavailable calcium

<u>Food</u>	<u>Calcium Content Serving</u> (mg)	<u>Fractional Absorption</u> (%)	<u>Estimated Absorbable Ca/serving</u> (mg)	<u># Servings needed to = 1 c. milk</u>
Milk, yogurt	300	32.1	96.3	1.0
Beans, dried	50	15.6	7.8	12.3
Broccoli	35	61.3	21.5	4.5
Cabbage	79	52.7	41.6	2.3
Kale	47	58.8	27.6	3.5
Spinach	122	5.1	6.2	15.5
Tofu, calcium set	258	31.0	80.0	1.2

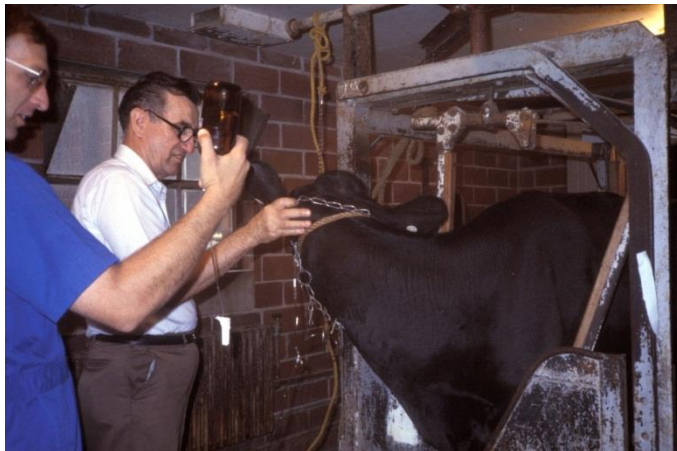
# Calcium absorption varies by lifestage



Calcium  
Absorption ~40%

Calcium  
Absorption ~30%

Calcium  
Absorption ~25%



Calcium  
Absorption ~80%

# Soluble Corn Fiber's Effect on Bone Health in Postmenopausal women

**Hypothesis:** SCF will increase bone calcium retention in a dose-dependent manner in postmenopausal women.

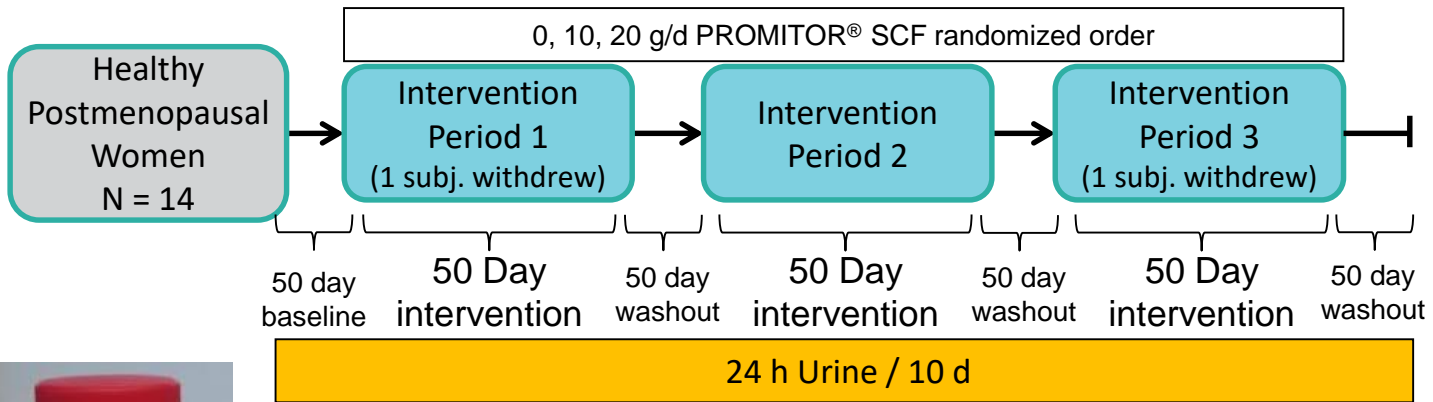
## Rapid Screening Method Accelerator Mass Spectrometry for Tracer Quantification

Measures  
atom level  
quantities  $^{14}\text{C}$ ,  
 $^{41}\text{Ca}$ ,  $^{129}\text{I}$ ,  $^{26}\text{Al}$ ,  
 $^{10}\text{Be}$

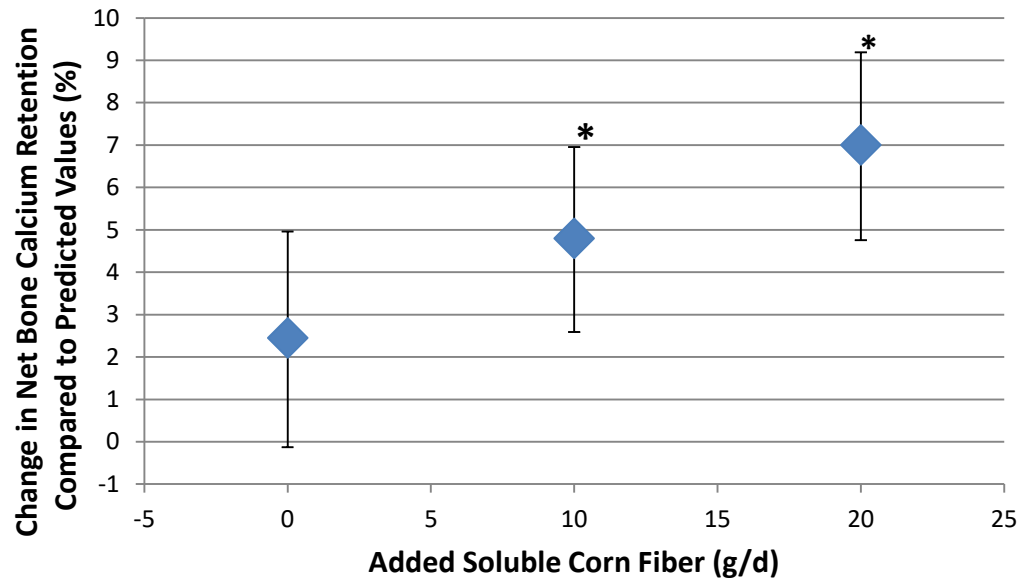




# STUDY: DESIGN



## Effect of Added Soluble Corn Fiber on Net Bone Calcium Retention in Postmenopausal Women (Mean $\pm$ 95% CI)



- Different from predicted values determined at baseline and recovery periods

SCF -

Weaver lab - 3 trials: 2 in adolescents and 1 in postmenopausal women



FDA Guidance -SCF meets dietary fiber definition for nutrient facts label based on Ca absorption and retention

1 year RCT in children  
Malaysia  
Winnie Chee, PI

RCT (NIH) in bariatric  
patients  
UCSF  
Anne Schafer, PI

SCF pathogenesis in  
T1D Mice  
Michigan State  
Laura McCabe, PI



# Berries and Bone Project – NCCIH

2014-2019

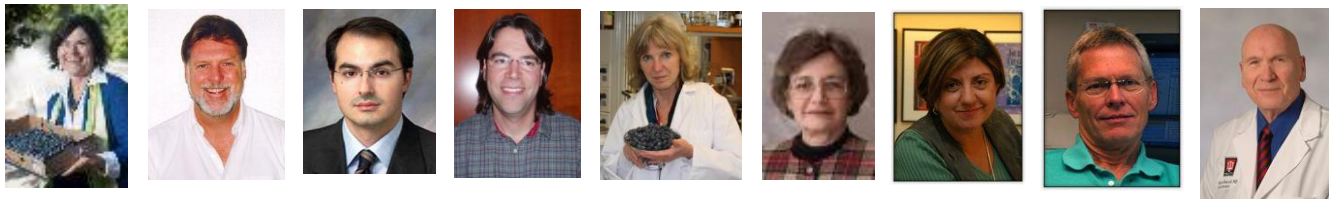
Connie Weaver, PI Nutrition

George McCabe, Co-PI Statistics

Mario Ferruzzi, Bruce Copper, Mary Ann Lila (NCSU), Elsa Janle  
– Berry procurement, bioactive analysis, and bioavailability

Teresita Bellido, David Burr (IUSM) – Cell Culture/Animal Studies

Munro Peacock (IUSM) – Clinical Investigator



# Methods

## $^{41}\text{Ca}$ technology

- Half-life of 100,000 years
- Dose – 50 nCi



J. Kalina Hodges

## Treatment

- Blueberry powder incorporated into 3 products
- Three dose levels
  - Low – 17.5 g (0.75 cup of blueberries)
  - Medium – 35 g (1.5 cups)
  - High – 70 g (3 cups)



# Overall Conclusions

- Building peak bone mass and reducing bone loss later in life are two strategies to reduce osteoporosis
- Increasing peak bone mass by 5-10% can reduce fracture risk substantially
- Lifestyle choices can modify both peak bone mass and bone loss
- Several of the essential nutrients important to bone are shortfall nutrients, i.e., calcium, vitamin D, magnesium



# Acknowledgements



## Funding:

- NIH
- Alliance for Potato Research & Education

## Weaver Lab:

- Dr. Connie Weaver
- Dr. Berdine Martin
- Pam Lachcik
- Kalina Hodges
- Andrea Lobene
- Maria Maiz
- Mike Stone
- Dennis Cladis
- Omer Sermet

## Collaborators:

### Purdue

- George McCabe
- Cindy Nakatsu

### IUSM

- Munro Peacock
- David Burr
- Teresita Bellido