Dietary Protein and Bone Health

Emphasis: Animal Protein

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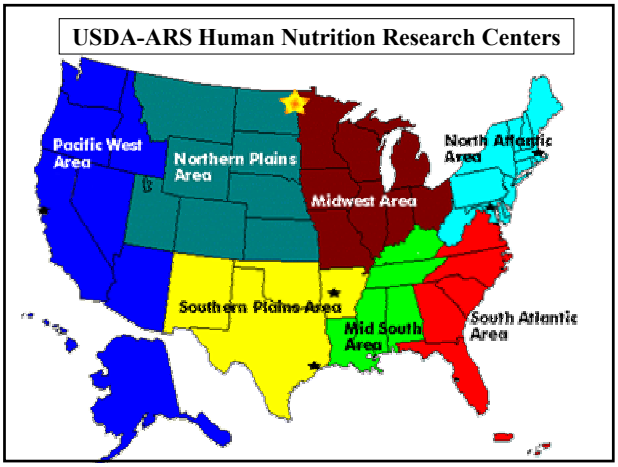
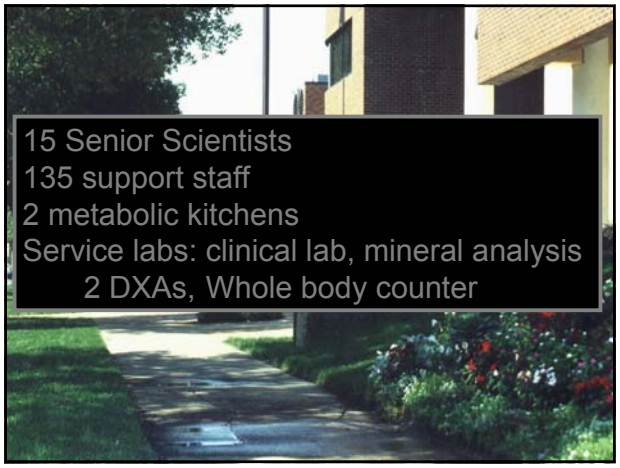
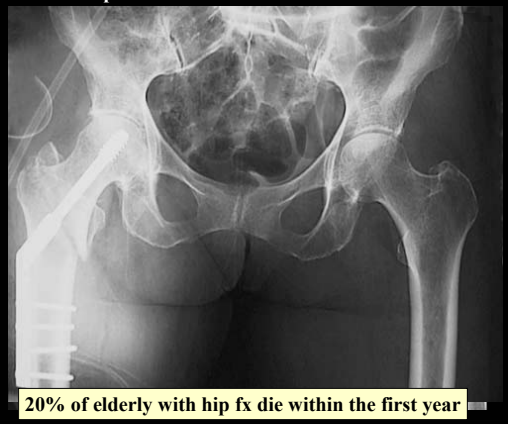




Osteoporosis affects 200 million worldwide



20% of elderly with hip fx die within the first year

Risk Factors for Osteoporosis

- Age
- Gender
- Genetics
- Sedentary life style
- Smoking
- Alcohol
- Low calcium / Vitamin D
- **High protein intake** (NIH Consensus Statement, 2000)

The Controversy

High protein diets are a risk for osteoporosis…

Especially if source is animal protein and calcium intake is low

The Evidence

- **Purified** sources of protein increased urinary calcium loss (Linkswiler et al 1970s)
- **common** sources of protein did not (Spencer et al,1978; Hunt, et al 1995)

Phosphorus Effect?

Observational Evidence

Feskanich et al (1996): Animal protein associated with increased risk of forearm fractures

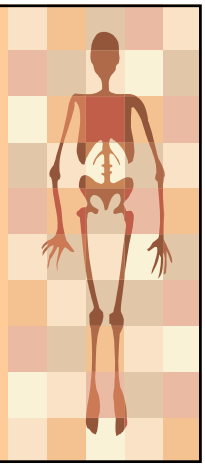
Munger et al (1999): Animal protein associated with reduced incidence of hip fractures

Hannan et al (2000): Lower total and animal protein intake associated with increased bone loss

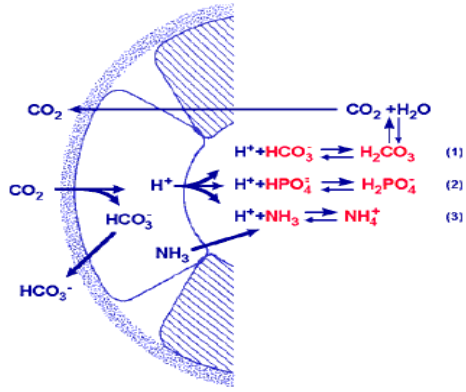
Wengreen et al (2004): Increased total protein intake associated with reduced hip fx in "younger" elderly

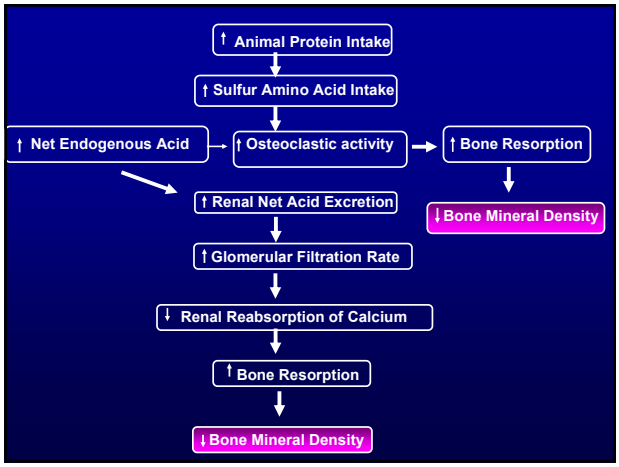
Bone

- **Composition:**
  - 70% mineral (40% **calcium**; 99% body Ca)
  - 25% organic (>90% **protein**)
  - 5-8% water
- **Function**
  - Structure, locomotion, hematopoesis, growth factors
  - **Acid-base balance**



Renal Mechanisms for Acid-Base Balance





Research Questions …

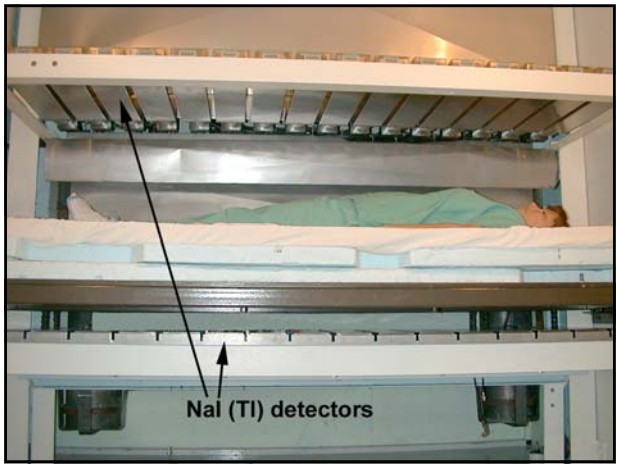
- ✓Does increased animal protein intake decrease calcium retention?
- ✓Does replacing animal protein with plant protein improve calcium retention?
- ✓Do dietary calcium and protein interact in a dose-dependent manner?

Design Considerations

• Purified	vs.	Common protein
• Equalized P	vs.	Variable P
• Urinary Ca	vs.	Ca retention
• Balance	vs.	Tracer methodology (absorption vs. retention)
• Short-term	vs.	Long-term feeding
• Few subjects	vs.	Statistical power

Protocol

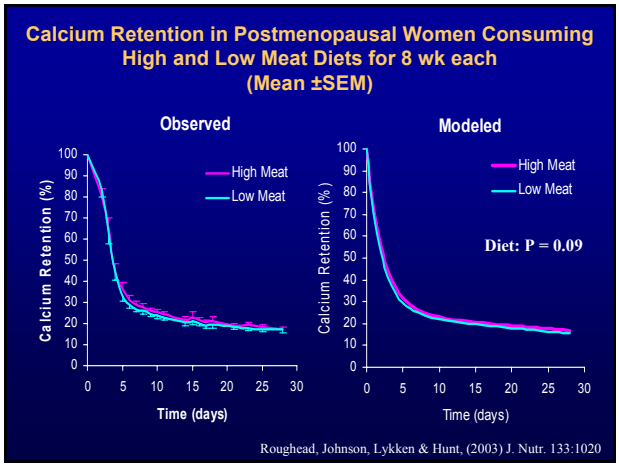
- Volunteers: - healthy post-menopausal women
- Design: - randomized crossover
- Diets: - weighed diets; 7-8 wk
- Calcium Retention:
  - wk 3-4: labeled entire 2-d menu with ^{47}Ca (constant specific activity)
  - whole body scintillation counting for 4 wk

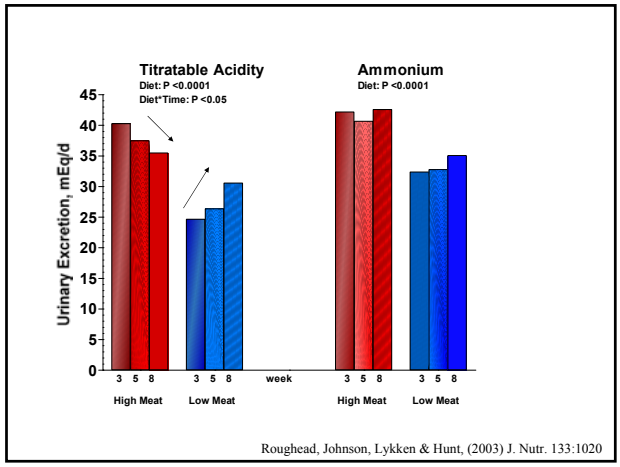


Diet Composition[1]

	Low Meat	High Meat
Meat (beef, chicken, turkey, pork), g	65	112
Protein, % of energy	12	20
g/kg bw	0.94	1.62
Fat, % of energy	30	31
Carbohydrate, % of energy	58	49
Calcium, mg	700 (594.2 ± 19.3)	698 (574.1 ± 18.4)
Phosphorus, mg	1214 (1218.2 ± 87.0)	1659 (1616.4 ± 104.1)
Potassium, mg	(2803 ± 339)	(2184 ± 290)

[1]Per 2200 Kcal. Data in parentheses are analyzed values (mean ± SD)





Diet did not Affect Biomarkers of Bone Metabolism

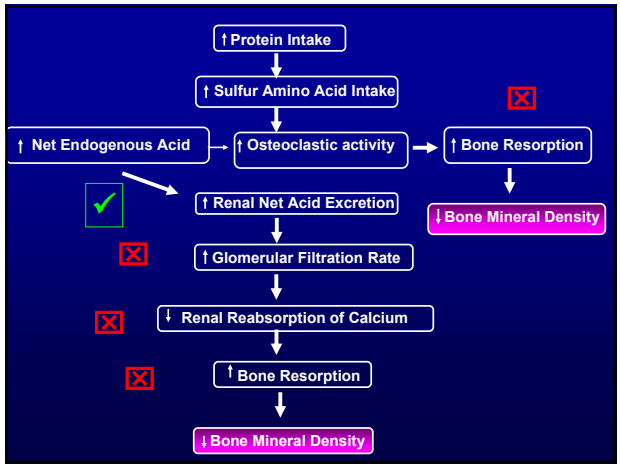
Blood:

- Tartarate-resistant acid phosphatase, Bone-specific alkaline phosphatase, Osteocalcin, 25-OH Vitamin D

Urine:

- Calcium, N-telopeptide

Roughead, Johnson, Lykken & Hunt, (2003) J. Nutr. 133:1020



Plant
vs.
Animal
Proteins?

Objectives

In healthy postmenopausal women, determine if daily substitution of 25 g of soy protein for meat protein

1) improves calcium retention
2) affects biomarkers of bone metabolism

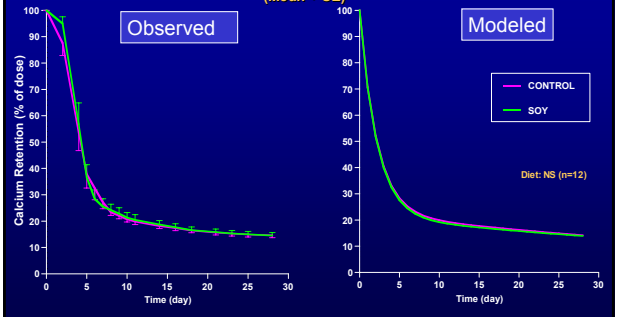
Diet Composition[1]

	CONTROL	SOY
Meat (beef, chicken, pork), g	170	55
Soy Protein Isolate, g*	---	30
Protein, % of energy	15	16
g/kg bw	**1.32**	**1.33**
Fat, % of energy	30	30
Carbohydrate, % of energy	55	55
Calcium, mg	690 (653 ± 40)	746 (740 ±27)
Phosphorus, mg	1505 (1563 ± 207)	1533 (1601 ± 178)
Phytate, mg	**1673**	**2150**

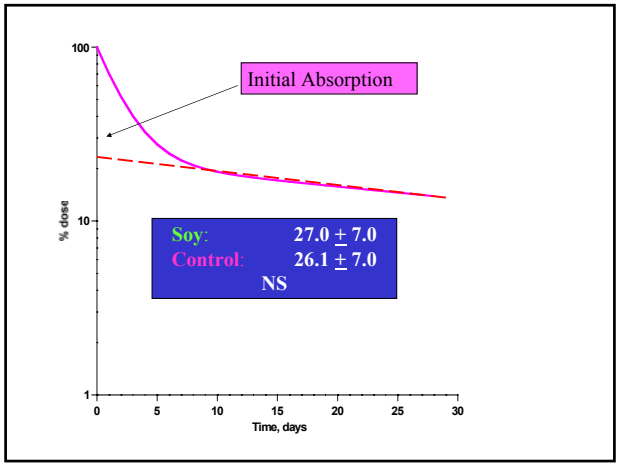
[1]Per 2200 Kcal. Data in parentheses are analyzed values (mean ± SD)

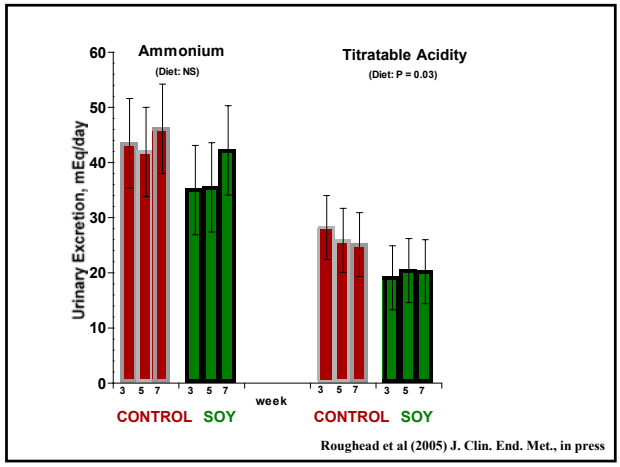
***Soy protein: 2.28 mg aglycone/g protein**

Consuming 25 g of Soy Protein Substituted for Meat Protein for 8 wk did not Affect Calcium Retention in Postmenopausal Women (Mean + SE)



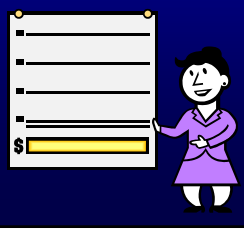
Roughead et al (2005) J. Clin. End. Met., in press





The bottom line…

No evidence of adverse effects from animal protein intake on calcium metabolism even when calcium intake is low



Controlled Diets
(HC:1500 mg/d or LC: 600 mg/d)

n=27

^{47}Ca

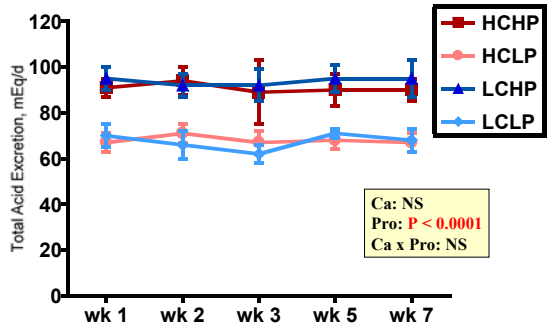
Whole body Counting (28 days)

0 1 2 3 5 7

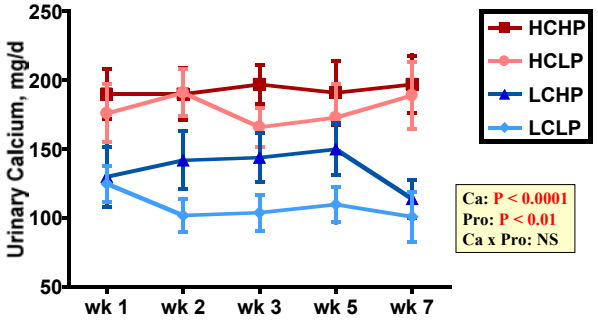
Blood Urine | Urine | Urine | Blood Urine | Urine | Blood Urine

Note: Participant consumed either a Low or High Protein diet for 7 weeks; after a 2-wk washout, consumed the alternate diet for 7 weeks.

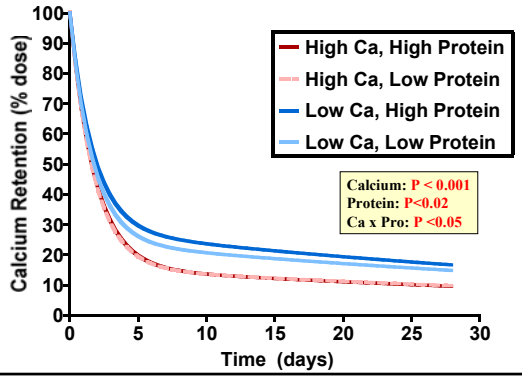
A high protein diet increased total renal acid excretion regardless of calcium intake



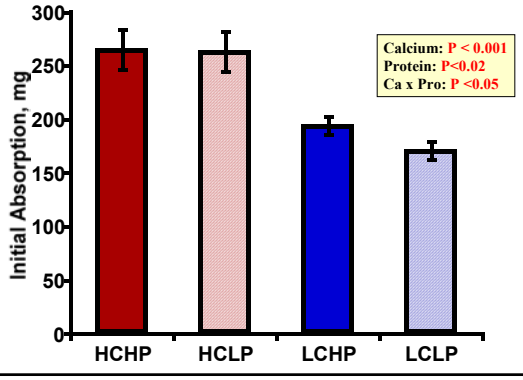
Both dietary calcium and protein independently influenced urinary calcium loss



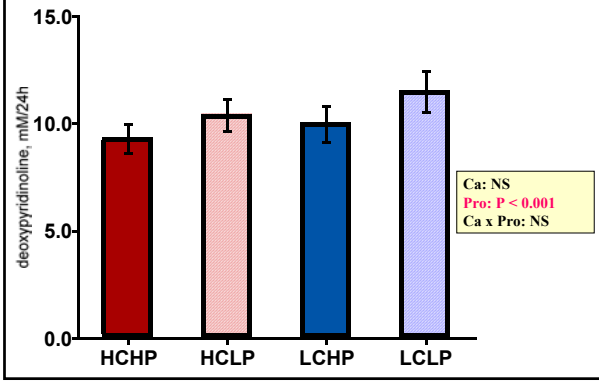
A high protein intake enhanced calcium retention from a low calcium diet



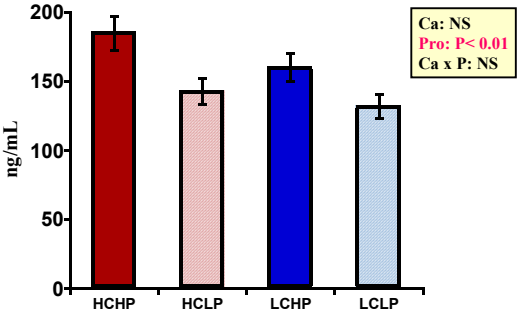
A high protein intake enhanced calcium bioavailability from a low calcium diet



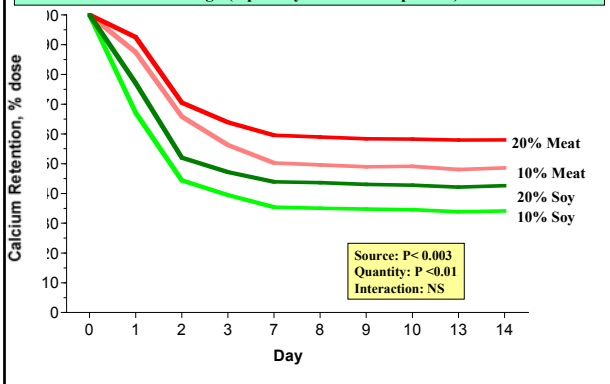
A high protein intake reduced bone resorption as indicated by urinary Dpd excretion

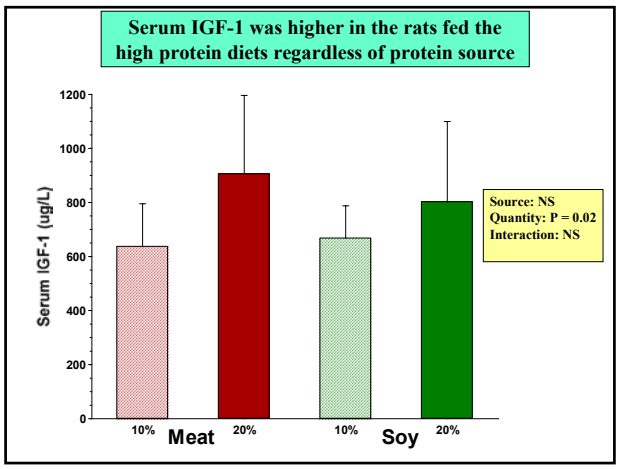


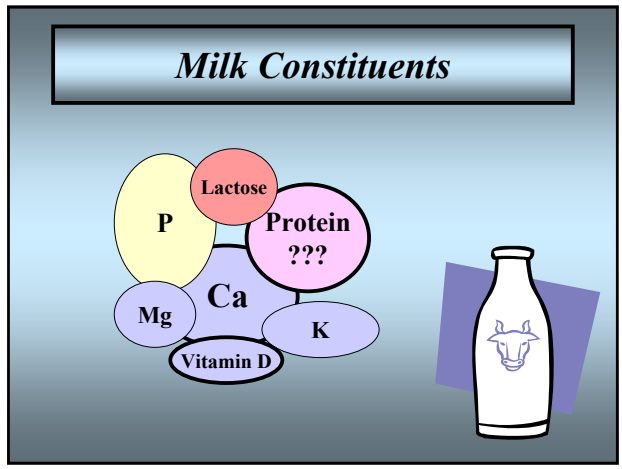
A high protein diet increased serum IGF-1 by ~27%, regardless of calcium intake



In ovx rats, the efficiency of calcium retention was highest when protein intake was high (especially from animal protein)





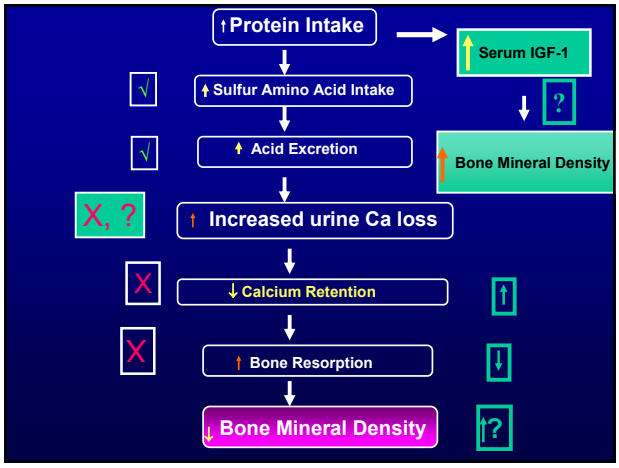


Dairy Protein and Bone?

- Isolated Casein and Lactalbumin have been shown to be calciuric
- Isolated Whey Protein may reduce bone resorption

Milk and Bone Health

- Milk supplementation, 12 mo: increased spine and total BMD in **young girls** (Chan, 1995)
- Milk supplementation, 18 mo: increased serum IGF-I and lumbar BMD and total BMC in **young girls** (Cadogan, 1997)
- Milk supplementation, 3 y: prevented vertebral bone loss in **pre-meneopausal women** (Baran, 1990)
- High Ca milk supplementation 24 mo: decreased bone loss in femoral neck, lumbar spine and total hip in **postmenopausal women** (Chee, 2003)
- Milk Supplementation 12 wk: increased serum IGF-I and decreased urinary N-telopeptides in **older men and women** (Heaney, 1999)



Future Directions

Carefully controlled feeding trials are needed to assess:

- **Effects of dairy proteins provided as food (milk, cheese, yogurt, etc) on calcium retention and bone health**
- **Effects of dairy proteins per se on calcium retention and bone health**

"*As we analyze a thing into its parts and properties, we tend to magnify these, to exaggerate their apparent independence and to hide from ourselves the essential integrity and individuality for the composite whole. We may study them apart but it is a concession to our weakness and the narrow outlook of our minds.*"

(*D'Arcy Thompson, 1942)*

Acknowledgments

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