OSU EXTENSION SERVICE | FAMILY & COMMUNITY HEALTH

BONE NUTRITION

Oregon State University

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ABOUT THE PRESENTER

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- Masters in Public Health Nutrition, Loma Linda University
- Registered Dietitian Nutritionist
- Certified Health Education Specialist and Wellness Coach
- Diplomate of the American College of Lifestyle Medicine, Certified in Diabetes Reversal
- Fellow of the Academy of Nutrition and Dietetics
- Chair of the Coos County Food & Nutrition Group

DISCLAIMER

- This presentation is designed to encourage the intake of whole plant foods
- A plant-based diet is well-documented to contribute to disease prevention
- Studies have found this dietary pattern is protective against osteoporosis
- Plant-based diets are endorsed by the USDA, American Heart Association, American Diabetes Association and the Academy of Nutrition and Dietetics

https://pubmed.ncbi.nlm.nih.gov/36856795/
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9879057/
https://pubmed.ncbi.nlm.nih.gov/32618637/

BONE NUTRITION

AGENDA

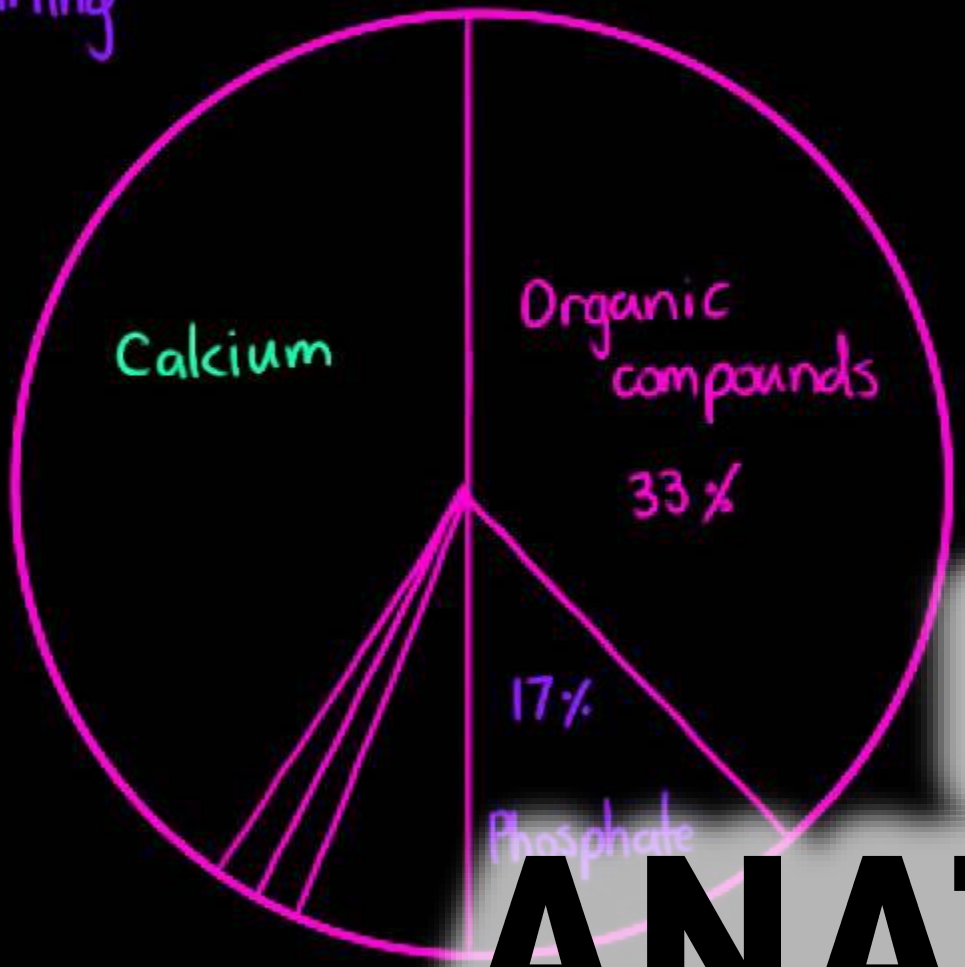
- Bone anatomy
- Bone function
- Nutrients for bones
- Best food sources
- Supplements
- Other healthy bone activities
- Review and best practices

Citations appear here

BONE NUTRITION

Bone composition

- All things composed of elements!
- Phosphate- phosphorus containing molecule.
  99% of body store!!
- mostly collagen and other molecules
- contains over 99% of body calc-

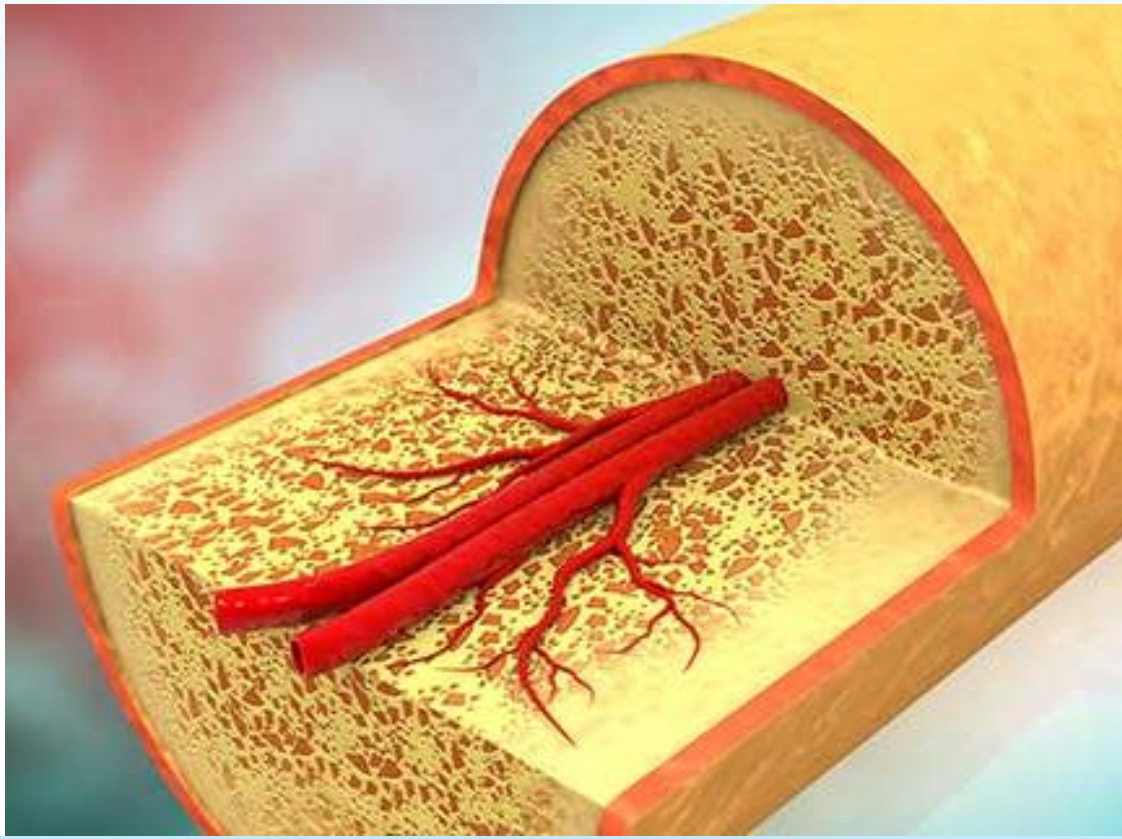


BONE ANATOMY

BONE ANATOMY

Bones are considered body organs because they contain:

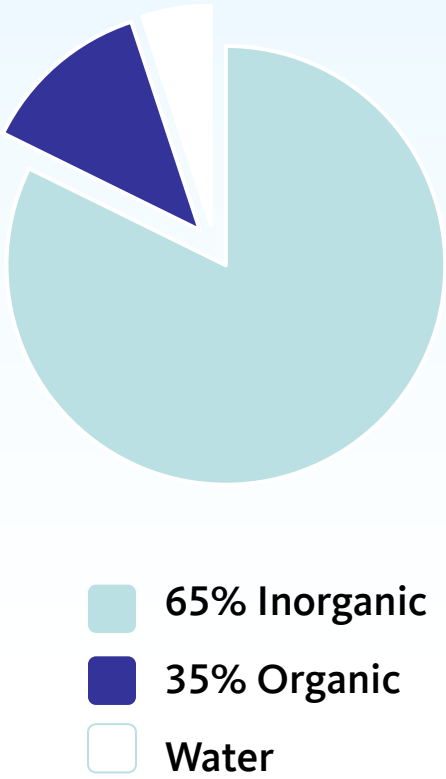
- Blood
- Connective tissue
- Nerves
- 3 types of bone tissue: compact bone, spongy bone and marrow



https://courses.lumenlearning.com/wm-biology2/chapter/structure-of-bones/

BONE ANATOMY

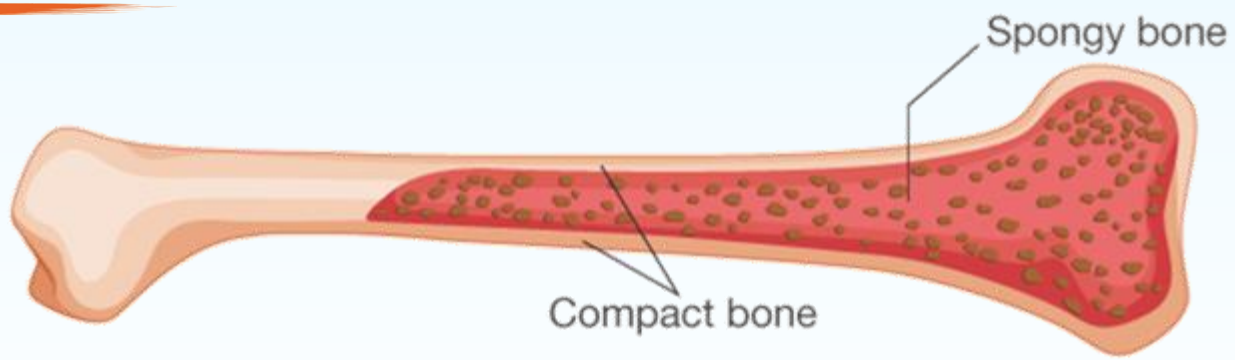
- Bones are ~35% protein, mostly collagen
- Minerals attach to collagen
- ~65% minerals including 99% of the body's calcium
- Other important minerals are phosphorus and magnesium
- Trace elements include boron, copper, iron, selenium and zinc
- Bones also contain water



https://pubmed.ncbi.nlm.nih.gov/30467628/
https://www.health.harvard.edu/staying-healthy/essential-nutrients-your-body-needs-for-building-bone

BONE ANATOMY

- Exterior bone is called compact or **cortical bone**
- Makes up 80% of bone
- Forms the external layer and protects interior
- Composed mainly of calcium phosphate

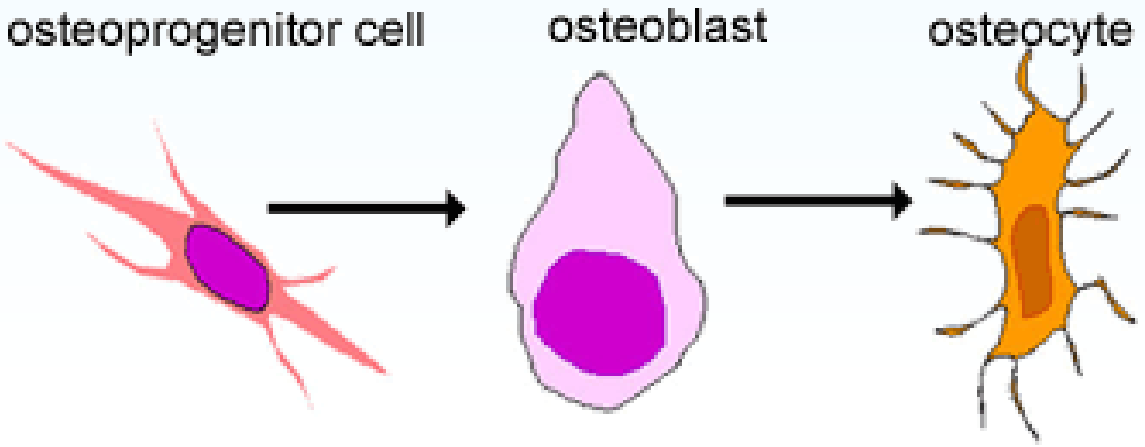


- **Spongy bone** or trabecular forms the interior
- Collagen gives the spongy interior a soft, flexible framework
- Makes up 20% of bone

https://lpi.oregonstate.edu/mic/health-disease/bone-health

BONE ANATOMY

- **Osteoblasts** form new bone
- **Osteoclasts** break down, absorb and remove old bone tissue
- **Osteocytes** maintain bone as living tissue and recycle mineral salts

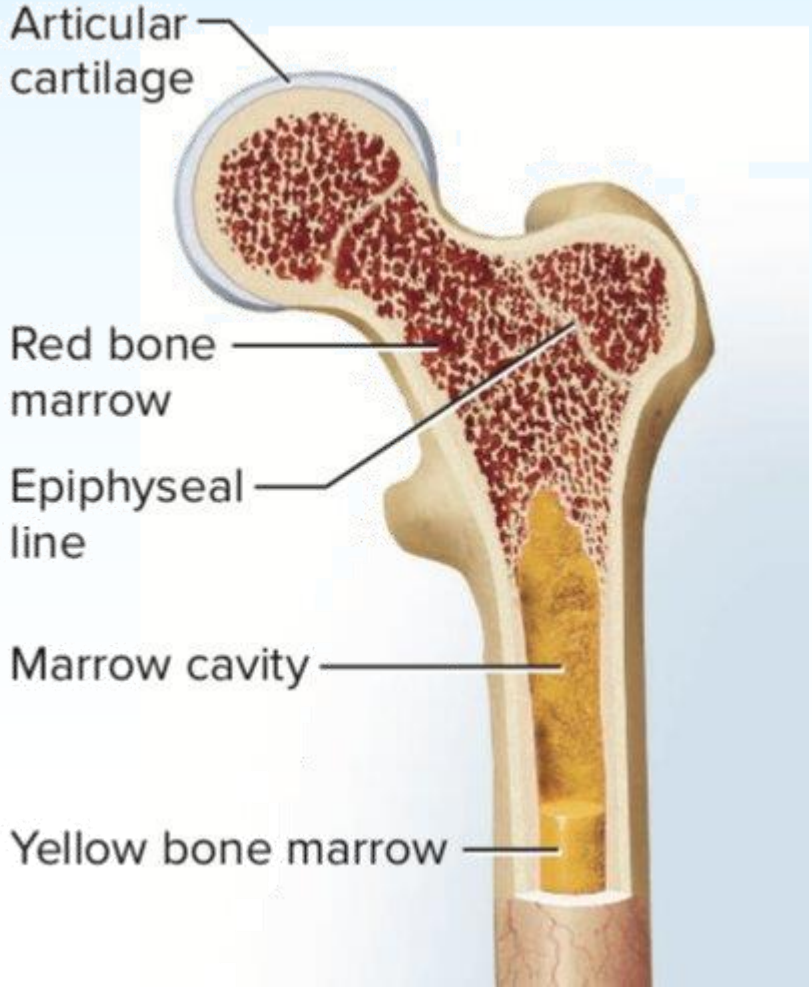


https://www.hopkinsmedicine.org/health/wellness-and-prevention/anatomy-of-the-bone

BONE ANATOMY

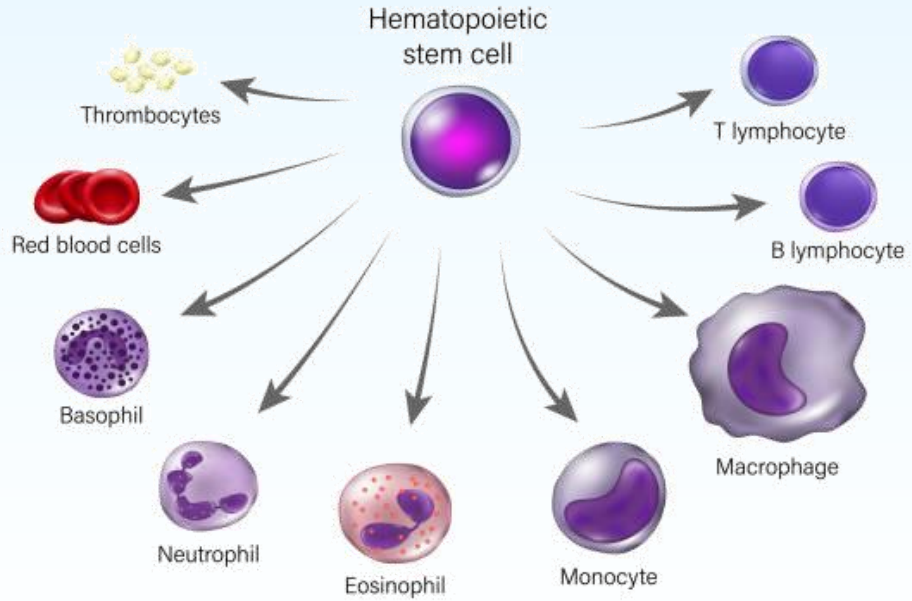
Bone marrow -2 types

- **Red** bone marrow contains stem cells to form red blood cells, white blood cells or platelets
- **Yellow** bone marrow is soft, fatty tissue that contains stem cells that can become cartilage, bone or fat cells
- Low bone marrow can be fatal



https://www.cancer.gov/publications/dictionaries/cancer-terms/def/bone-marrow

BONE ANATOMY



- **Hematopoietic cells** in the bone marrow produce:
  - ✓ Red blood cells contain hemoglobin which carries oxygen to the lungs and tissues
  - ✓ White blood cells are part of our immune system and fight off infection
  - ✓ Platelets clot blood in damaged blood vessels and initiate healing

https://www.hopkinsmedicine.org/health/wellness-and-prevention/anatomy-of-the-bone
https://www.hopkinsmedicine.org/health/conditions-and-diseases/what-are-platelets-and-why-are-they-important

BONE FUNCTION

BONE FUNCTION

- There are 206 bones in the body (not including teeth)
- Infants have 270, some later fuse
- Bones give the body structure and shape
- Protect organs, especially the heart
- Play a role in immune function

https://www.ncbi.nlm.nih.gov/books/NBK537199/

BONE NUTRITION

BONE FUNCTION

- Move the body through space
- Provide attachments for muscles and tendons
- Allow for lifting and carrying strength
- Facilitate breathing
- Store minerals and have a role in electrolyte homeostasis
  - ✓ Electrolyte imbalance is a factor in bone loss

https://www.ncbi.nlm.nih.gov/books/NBK537199/

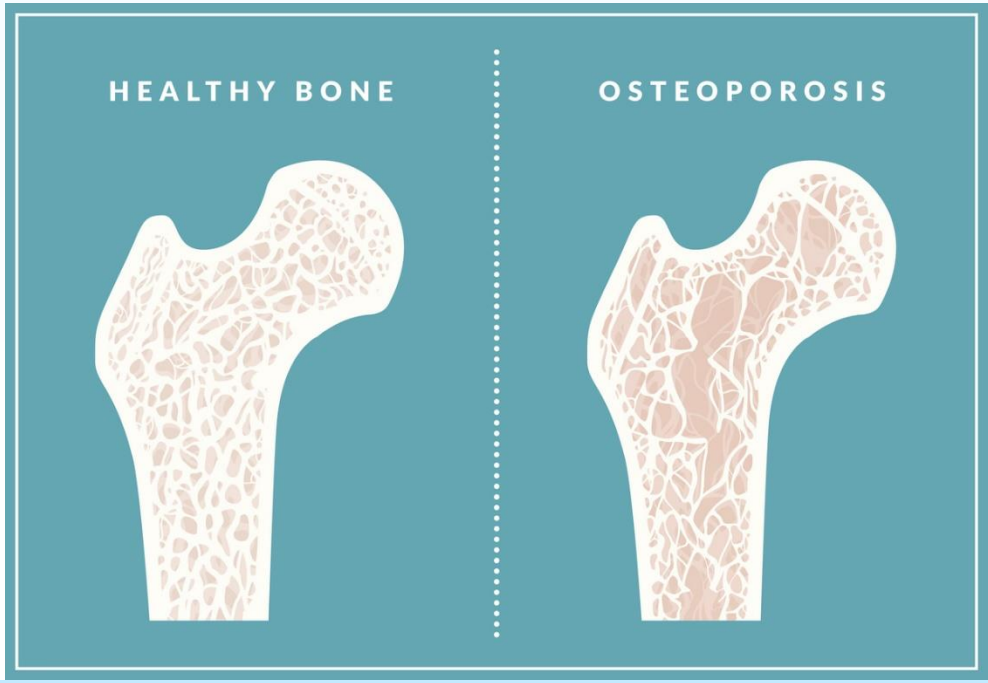
BONE FUNCTION

- Trabecular (spongy) bone has a faster rate of turnover than cortical bone
- 20-40% of peak bone mass is determined by lifestyle
- Bone mass peaks in our late teens, early 20's
- About age 24, bone reformation begins to slow and continues to slow as we age
- This is why it is important to maintain the bone we have

https://lpi.oregonstate.edu/mic/health-disease/bone-health

BONE FUNCTION

- Bone loss (osteopenia) progresses to osteoporosis
- Osteoporosis damages bone structure
- No symptoms
- Major cause of fractures in post-menopausal women and older men
- More common in white and Asian women
- Cancer medications and glucocorticoid steroids can increase bone loss



https://www.niams.nih.gov/health-topics/osteoporosis#:~:text=Osteoporosis%20is%20a%20bone%20disease,of%20fractures%20(broken%20bones)

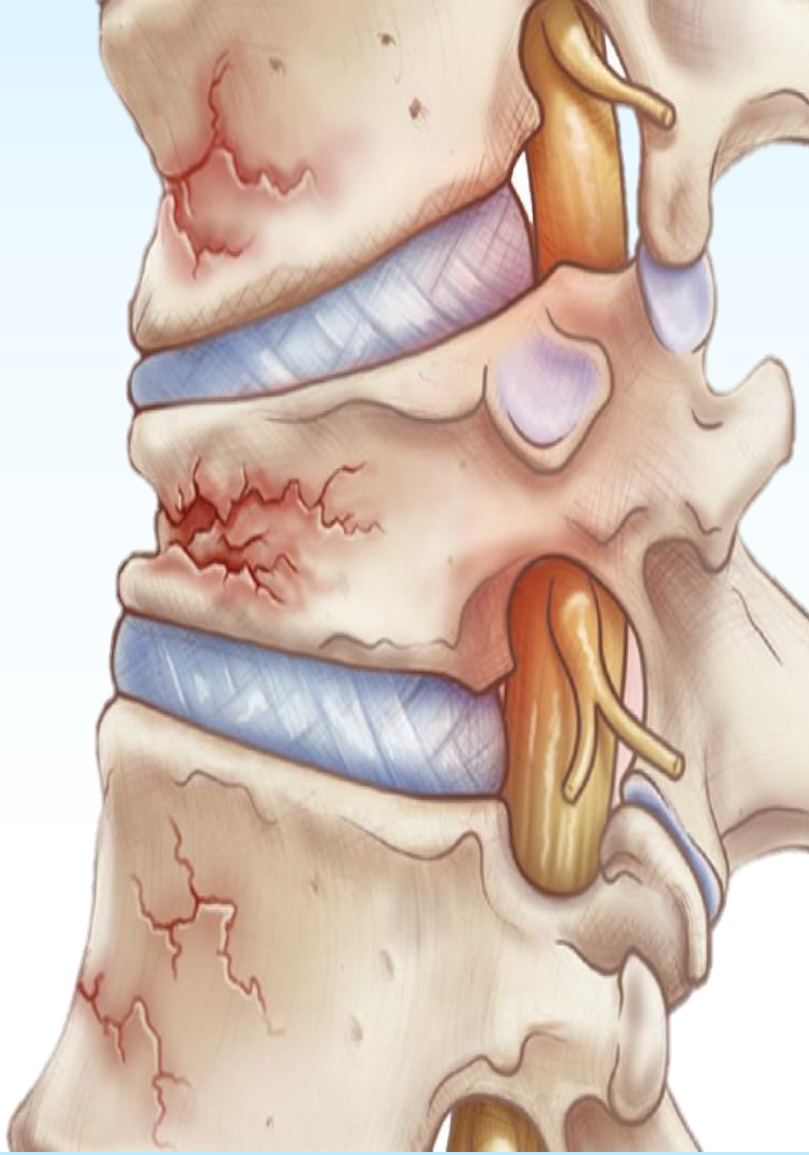
BONE NUTRITION

NUTRIENTS FOR BONES

Weak bones are a sign of

POOR NUTRITION

and can be prevented.



BONE
NUTRITION

NUTRIENTS FOR BONES

Important nutrients for bone health include:

- Calcium
- Phosphorus
- Fluoride
- Magnesium
- Sodium
- Potassium

- Vitamin D
- Vitamin K
- Vitamin A
- B6
- Folate
- B12

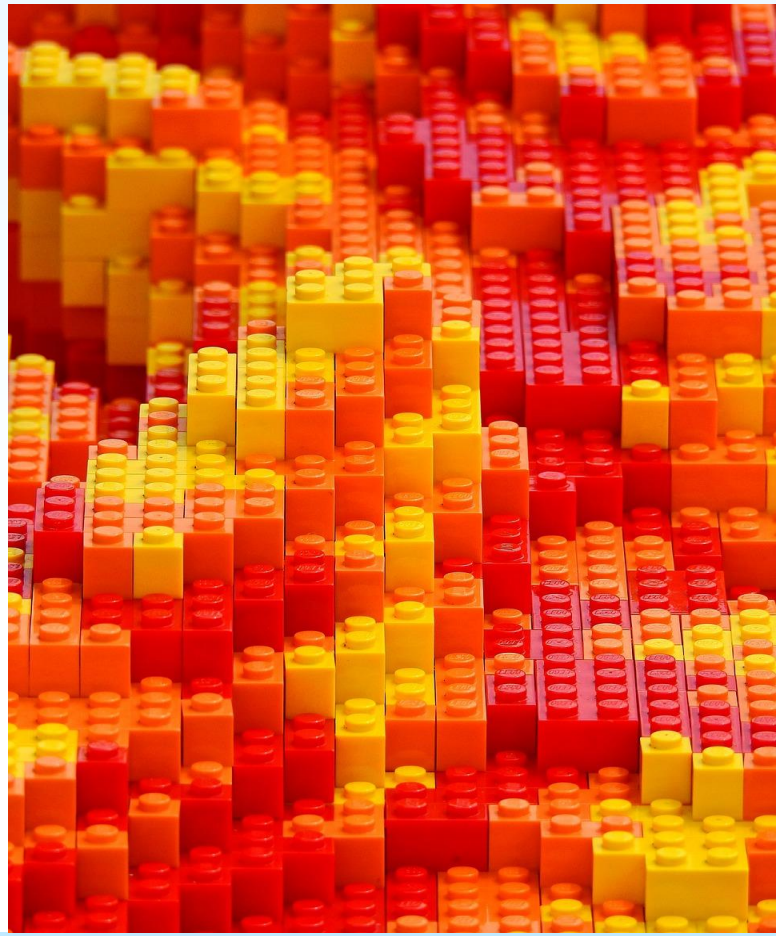
https://lpi.oregonstate.edu/mic/health-disease/bone-health

BONE NUTRITION

NUTRIENTS FOR BONES

CALCIUM

- Calcium is the major building block of bone
- 99% in bones and teeth
- 1% in blood and soft tissues is essential and must be maintained
- A drop in this 1% blood calcium could be the difference between life and death



https://lpi.oregonstate.edu/mic/health-disease/bone-health

BONE NUTRITION

NUTRIENTS FOR BONES

CALCIUM

1%

1% blood calcium is responsible for:

- Acid base balance of blood and soft tissues
- Nerve impulse transmission
- Stimulation of neurotransmitters
- Muscle contractions, including the heart
- Initiation of blood clotting
- Blood pressure maintenance
- Regulation of hormones and enzymes

https://lpi.oregonstate.edu/mic/health-disease/bone-health

BONE NUTRITION

NUTRIENTS FOR BONES

Low calcium in the blood causes the body to

steal calcium from the bones

https://lpi.oregonstate.edu/mic/health-disease/bone-health

NUTRIENTS FOR BONES

CALCIUM

- Our ability to absorb calcium diminishes with age
- **High sodium** intake increases calcium loss
- **High animal protein** intake increases calcium loss
- The Standard American Diet **(SAD)** is high in both animal protein and sodium
- 3 out of 4 women do not meet their minimum calcium need

https://lpi.oregonstate.edu/mic/health-disease/bone-health

BONE NUTRITION

NUTRIENTS FOR BONES

CALCIUM

Interesting facts:

- Less than **1/3** of the calcium we eat is absorbed by our digestive tract
- We can absorb only **~500 mg** of calcium at a time
- The more calcium in the food, the less we absorb

and visa versa

https://lpi.oregonstate.edu/mic/health-disease/bone-health

BONE NUTRITION

NUTRIENTS FOR BONES

OTHER MINERALS

- More than half of the mineral in bone is phosphorus combined with calcium
- 50-60% of the body's magnesium is found in the bones
- Other important minerals needed in trace amounts include fluoride, boron, copper and zinc

Bone-building nutrients
Calcium (Ca)
Phosphorus (P)
Magnesium (Mg)
Chromium (Cr)
Silica (Silicon-Si)
Zinc (Zn)
Manganese (Mn)
Copper (Cu)
Boron (B)
Potassium (K)
Strontium
Vitamin D
Vitamin C
Vitamin A
Vitamin B6
Folic acid/Folate (B9)
Vitamin B12
Vitamins K1 & K2
Fats
Protein

https://lpi.oregonstate.edu/mic/health-disease/bone-health
https://pubmed.ncbi.nlm.nih.gov/17092827/

BONE NUTRITION

NUTRIENTS FOR BONES

VITAMINS

- Either an excess of vitamin A (supplements) or deficiency can negatively impact bone
- B vitamins folate, B12 and B6 may help prevent fractures
- Vitamin C is important for collagen formation in the bone matrix
- Vitamin D controls the levels of calcium and phosphorus in the blood
- Vitamin K helps with calcium-binding in bone tissue

https://lpi.oregonstate.edu/mic/health-disease/bone-health

BONE NUTRITION


BEST FOOD SOURCES

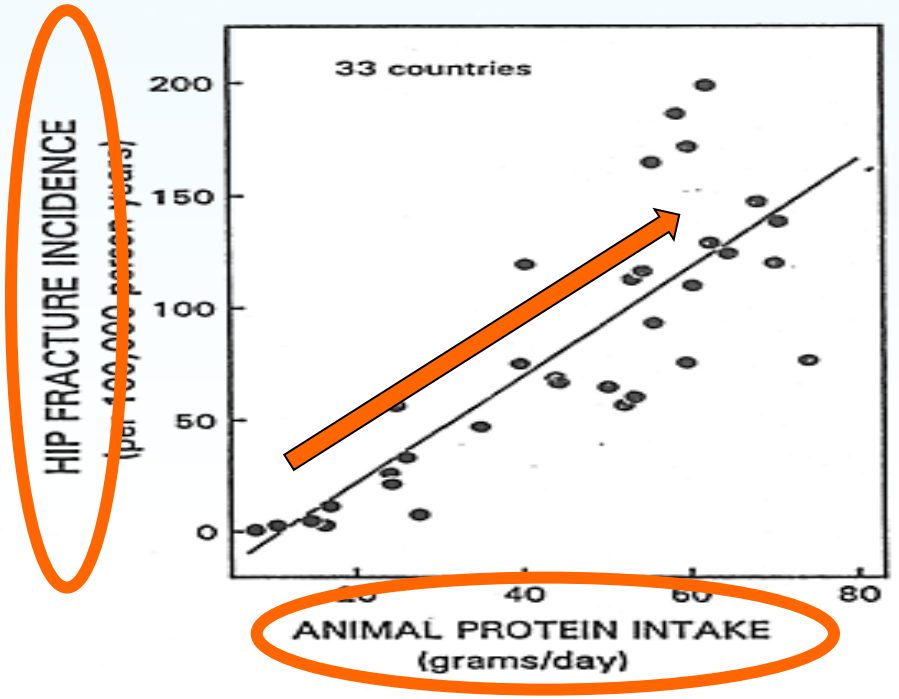
Choose Plant Foods First

- Focus on adequate protein, minerals and vitamins

BEST FOOD SOURCES

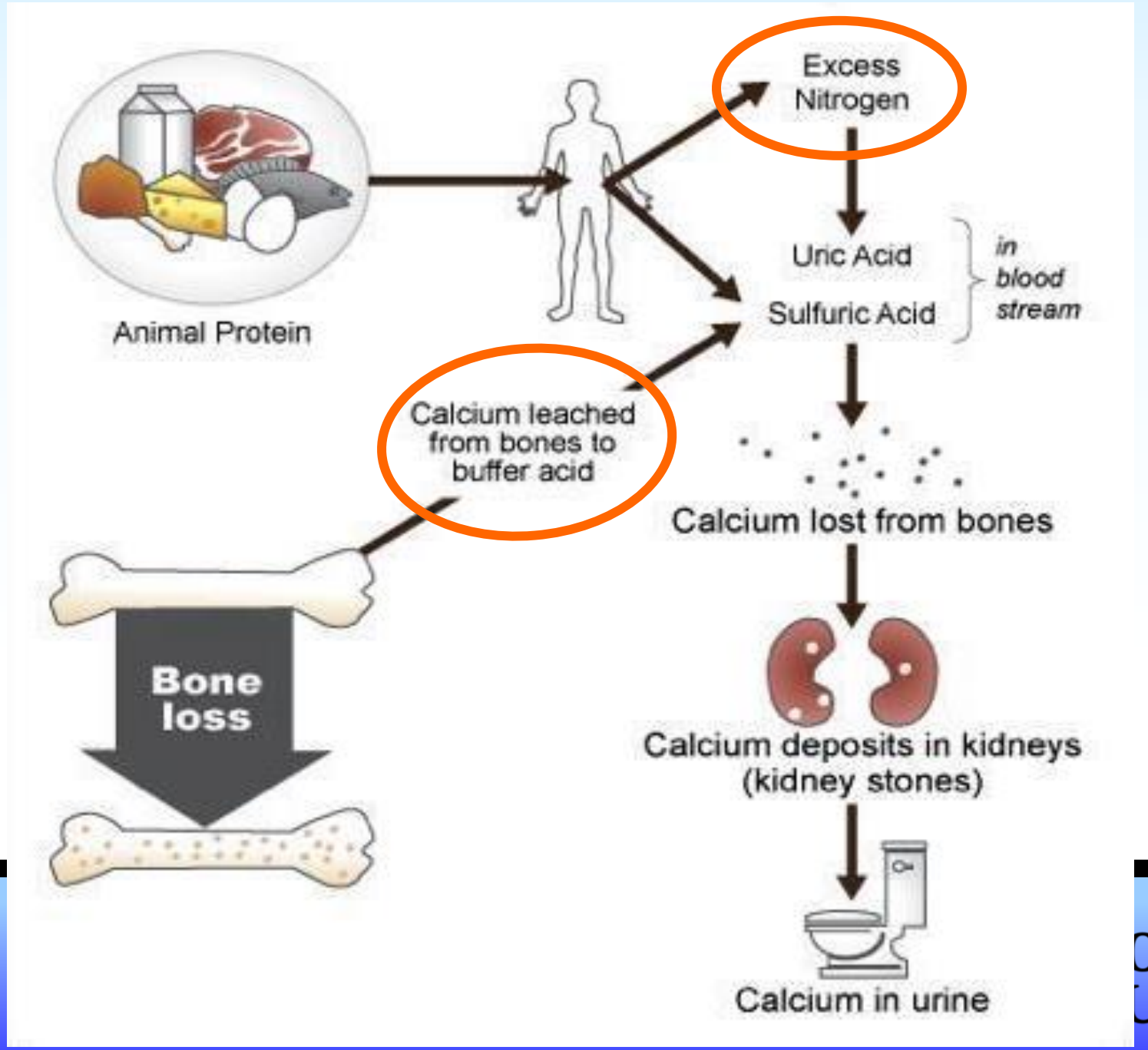
PROTEIN

- Adequate protein is essential for bone growth and bone preservation
- Protein requirement .83 g/pro/kg
- Higher protein (1.0-1.2g/kg) may be beneficial for seniors or those with osteopenia or osteoporosis
- Most adults require 45-55 g/day



https://www.osteoporosis.foundation/health-professionals/prevention/nutrition/protein-and-other-nutrients
https://www.researchgate.net/figure/Cross-cultural-relationship-N-33-countries-between-hip-fracture-incidence-in-women-aged_fig1_12290625

BONE NUTRITION



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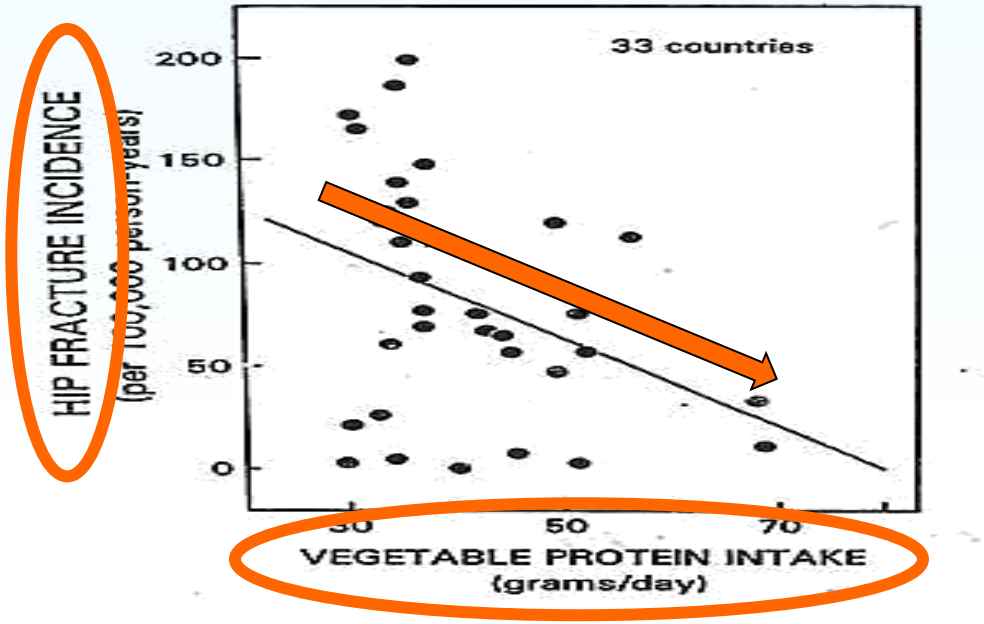
BEST FOOD SOURCES

PROTEIN

- High animal protein intake (SAD) can contribute to acidosis leaching calcium from the bone
- Vegetable sources of protein do not contribute to acidosis
- Prioritize plant sources of protein including legumes (beans, lentils), soya products, whole grains, nuts and seeds



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BONE NUTRITION

BEST FOOD SOURCES

DAIRY

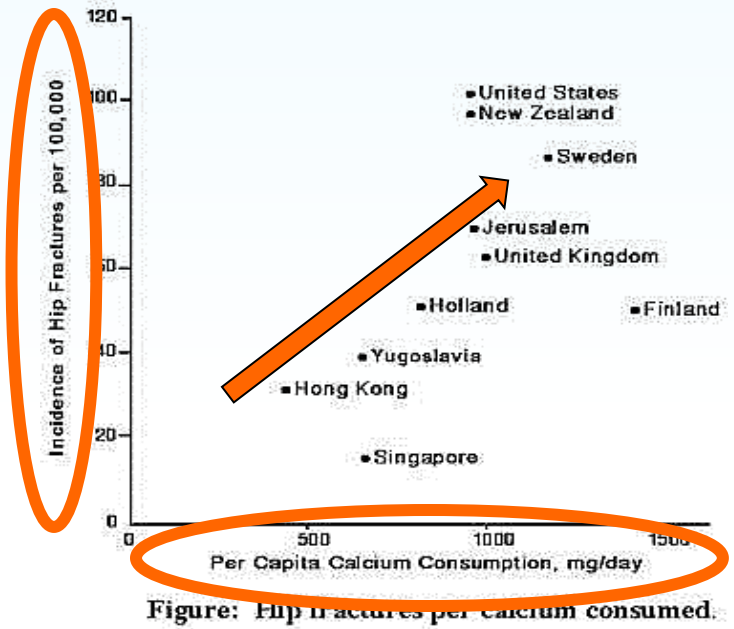


Figure: Hip fractures per calcium consumed.

- Dairy products are the top sources of calcium in the Standard American Diet (SAD)
- Also contain saturated fat and cholesterol
- Cheese is very high in sodium
- Dairy can cause cramping, bloating and diarrhea in 65% of the population who are lactose intolerant
- A 2020 Harvard study shows dairy may not contribute to bone health or prevent fractures

https://www.nejm.org/doi/full/10.1056/NEJMra1903547

BONE NUTRITION

BEST FOOD CHOICES

CALCIUM

- Fish with bones (sardines)
- Chia, poppy and sesame seeds, 2 Tbsp
- Almonds, white beans and edamame
- Greens including broccoli, kale and turnip greens, Brussels sprouts and green cabbage
- Dried figs (8) and oranges
- Fortified products like orange juice, soy milk, tofu

https://www.pcrm.org/good-nutrition/nutrition-information/health-concerns-about-dairy/calcium-and-strong-bones
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3662288/

BONE NUTRITION

BEST FOOD CHOICES

PHOSPHORUS

- Phosphorus is critical for bone health and remodeling
- Deficiency contributes to low red blood cell production
- Too much can contribute to kidney disease
- Excess phosphorous can be attributed to diets high in animal protein, dairy and cheese, soda and fast foods

- Excess phosphorous is unlikely with plant food sources
- Plant sources of phosphorous include whole grains, legumes, vegetables, nuts and seeds

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3461213/
https://ods.od.nih.gov/factsheets/Phosphorus-Consumer/

BONE NUTRITION

BEST FOOD CHOICES

MAGNESIUM

- Low levels can contribute to osteoporosis
- Grains include quinoa, millet, brown rice and wheat germ
- Vegetables include spinach, Swiss chard, sweet potatoes, artichoke hearts, legumes and tempeh
- Pumpkin seeds, flax seeds and nuts, especially Brazil nuts and cashews

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8313472/

BONE NUTRITION

BEST FOOD CHOICES

VITAMIN D

- Works with calcium to absorb and lay down bone
- Regulates 1% blood calcium level
- Enhances immunity
- We synthesizes vitamin D in skin exposed to direct sunlight

- Shitake mushrooms
- Cod liver oil and fatty fish (salmon, mackerel, sardines)
- Egg yolks
- Fortified cereals and juices

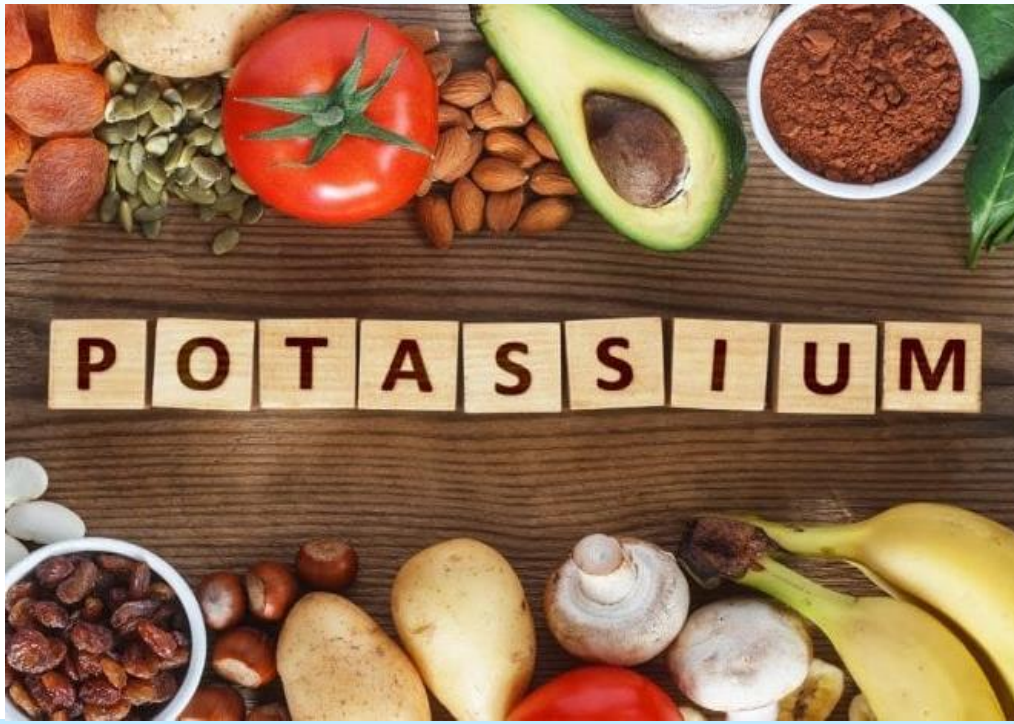
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8308383/

BONE NUTRITION

BEST FOOD CHOICES

POTASSIUM

- Works with sodium for fluid balance
- Alkalizes blood reducing calcium loss
- Cantaloupe, honeydew melon, plums, apricots, papayas, bananas, avocados
- Dark leafy greens, carrots, potatoes, tomatoes, beans
- Almonds and pistachios



https://www.hsph.harvard.edu/nutritionsource/potassium/

BEST FOOD CHOICES

VITAMIN K

- Needed for bone production
- Greens, kale, spinach, Swiss chard, parsley, dried herbs
- Cruciferous vegetables broccoli, cabbage, asparagus, Brussels sprouts
- Spices curry, cayenne, paprika, chili powder
- Soybeans, dried fruits, olive oil

https://www.hsph.harvard.edu/nutritionsource/vitamin-k/

BONE NUTRITION

BEST FOOD CHOICES

COPPER

- Needed for development of connective tissue of the trabecular and cortical bone
- Acts as antioxidant to remove free radicals in bone
- Important for post-menopausal women and elderly
- Menke's disease is malabsorption of copper that causes bone deformations

- Plant sources include whole grains, beans, nuts, potatoes and dark leafy greens

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8308383/

BONE NUTRITION

BEST FOOD CHOICES

ZINC

- Protects against bone loss
- Regulates bone homeostasis between osteoblasts and osteoclasts
- Facilitates healthy gene expression that protects bones
- Fish, seafood, nuts, seeds

https://ods.od.nih.gov/factsheets/Zinc-HealthProfessional/

SUPPLEMENTS

SUPPLEMENTS

CALCIUM

- Calcium carbonate (40% Ca)
- Calcium citrate (21% Ca)
- Calcium lactate (13% Ca)
- Calcium gluconate (9% Ca)
- 1250 mg deliver 500 mg Ca
- Ca needs vary by age

1 to 3 years	500 mg
4 to 8 years	800 mg
9 to 18 years	1,300 mg
19 to 49 years	1,000 mg
50+ years	1,200 mg

SUPPLEMENTS

CALCIUM

Consider taking a calcium supplement if you:

- Follow a vegan diet
- Avoid dairy or are lactose intolerant
- Consume a high-sodium diet
- Consume a high-animal-protein diet
- Take corticosteroids long-term

SUPPLEMENTS

VITAMIN D

- Direct exposure of skin to sunlight
- Best absorption when the sun's rays are strongest (9am to 3 pm)
- Expose hands, face and arms, 2-3 x/wk for 20-30 min each day
- Use less than 8 SPF sunscreen
- Not synthesized in cloudy weather, early am, late pm or during winter months

SUPPLEMENTS

VITAMIN D

- Under 50yrs should take 400-800 IU/d
- Over 50yrs 800-1000 IU/d
- Overweight, obese need more
- In Oregon, 1000-5000 IU/d is considered safe
- Speak to your primary care provider about possible medications that reduce absorption of vitamin D

SUPPLEMENTS

VITAMIN D

- Standard recommendations range from 1,000-5,000 IU/day for adults
- 1,000 IU = 25 mcg, 5,000 IU = 125 mcg
- Excess vitamin D (supplements) can accumulate and become toxic
- Upper limits for supplementation range from 40,000-50,000 IU/day for several months

SUPPLEMENTS

VITAMIN B12

- Low B12 decreases bone density and increases risk of fracture
- Found in animal foods (eggs, meat, fish) and fortified non-dairy milks, meat substitutes and cereals
- Those over age 50 and those on a plant-based diet should supplement
- Supplements should be sublingual or chewable

https://www.ars.usda.gov/news-events/news/research-news/2005/fight-osteoporosis-bone-up-on-b12/

BONE NUTRITION


OTHER HEALTHY
BONE ACTIVITIES

OTHER HEALTHY BONE ACTIVITIES

CARDIO EXERCISE

- You work your bones by doing activities that move the body against gravity
- Weight-bearing exercise makes bones stronger
- Walking, running, dancing, playing soccer, stair-climbing
- Work for bones means handling impact and weight

OTHER HEALTHY BONE ACTIVITIES

STRENGTH EXERCISE

Include strengthening exercises using:

- Free weights
- Weight machines
- Resistance bands
- Your own body weight

OTHER HEALTHY BONE ACTIVITIES

QUIT SMOKING

- Smoking weakens bones and increases risk of bone loss and fractures
- Nicotine and other chemicals are toxic to bone cells
- Smoking reduces calcium absorption
- Smoking makes exercise more difficult

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6304634/

OTHER HEALTHY BONE ACTIVITIES

LIMIT ALCOHOL

- Heavy drinking damages cells that form bone, reduces calcium absorption and increases excretion
- Obstructs vitamin D metabolism
- Reduces testosterone leading to bone demineralization
- May increase likelihood of smoking or being exposed to smoke

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6761900/

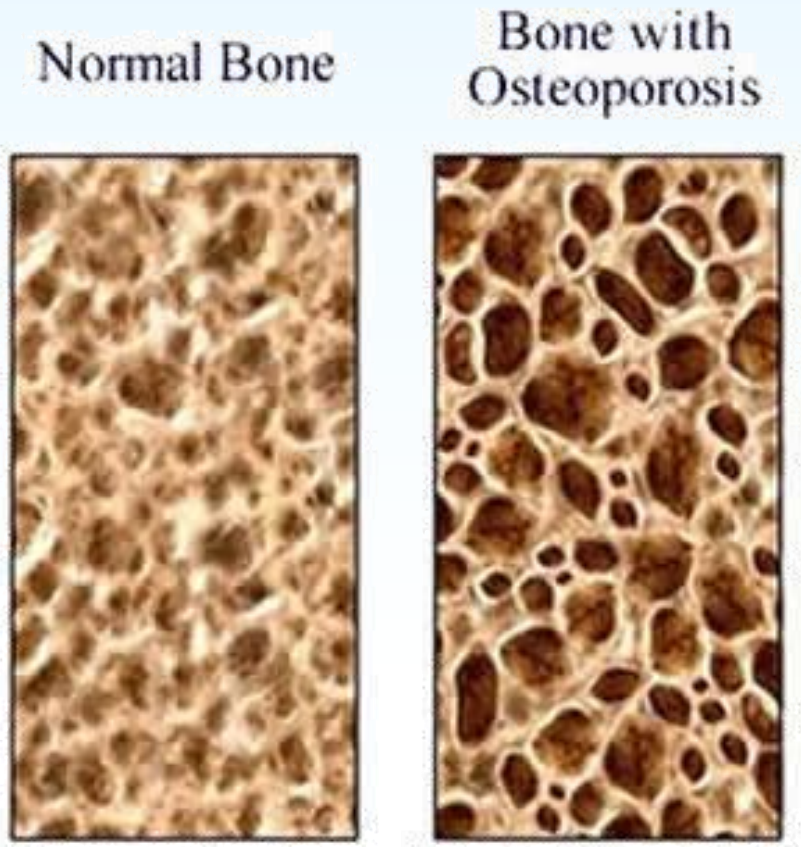
REVIEW

REVIEW

- Bones give the body shape and structure and protect organs
- Important part of immunity
- Store minerals and balance electrolytes
- Bone mass peaks in late teens to early 20’s and declines throughout the lifespan
- Calcium combined with phosphorus makes up the major portion of bone

REVIEW

- Although 99% of calcium is in our bones and teeth, the 1% in our blood is essential and a drop in that could be fatal
- The body pulls calcium from bones to maintain the 1% in the blood
- Many vitamins and minerals work to keep bones strong and healthy
- Consume these vitamins and minerals from whole foods and supplement if necessary



BEST PRACTICES

- Consume dark greens, white beans, fortified soy products, seeds, broccoli, almonds and blackstrap molasses for foods high in calcium
- Consume calcium-rich foods separately from iron-rich foods
- Include fresh mushrooms especially shitake for vitamin D
- Take a minimum of 800 IUs vitamin D/day

BEST PRACTICES

- Include foods containing phosphorus such as whole grains, legumes, vegetables, nuts, seeds
- Reduce intake of foods high in sodium such as cheese, canned foods and processed snacks
- Avoid overindulging in meat, cheese and sodas
- Consume a variety of plant foods for other bone-friendly nutrients like magnesium, copper and zinc and vitamins C, K, folate and B6

https://ods.od.nih.gov/factsheets/Phosphorus-Consumer/

BONE NUTRITION

BEST PRACTICES

- If taking calcium supplements, have only 500 mg at a time with meals
- Take 50 mcg/day of B12 supplement in sublingual or chewable form, especially if vegan or over age 50
- Get daily weight-bearing exercise and exposure to sunlight on face and arms
- Avoid alcohol and tobacco products

https://nutritionfacts.org/topics/vitamin-b12/

A plant-based diet can provide all the protein, vitamins and minerals that help maintain bone

without the risks associated with the Standard American Diet

high in excess animal protein and sodium which contribute to bone loss.

THANK YOU!

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https://extension.oregonstate.edu/coos/healthy-families-communities

Oregon State University
Extension Service
Coos County