Taurine: More Than Energy

Sarah Tauber, Michelle Zhu, Anna Zlatic, Grace Schmitz

What is taurine?

Taurine (2-aminoethanesulfonic acid) is a free form amino acid containing sulfur found within the body

It is known for:

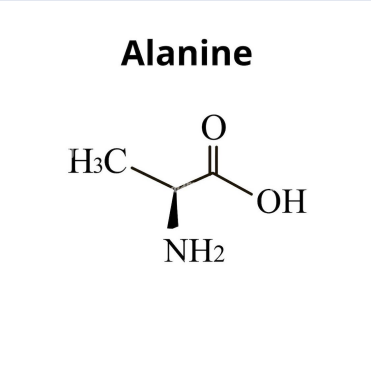
- Potentially reducing muscle inflammation and improving muscular strength
- Found in most animal sources (meat, fish, dairy)
- Common in energy drinks
- Can be found in powder or pill form
- Can be synthesized from other amino acids like cysteine or methionine

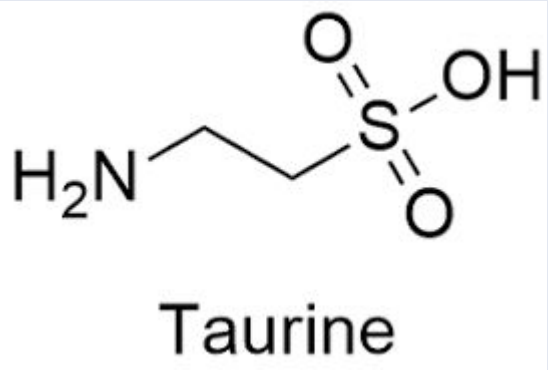
https://doi.org/10.1016/j.redox.2019.101223
https://doi.org/10.1007/978-3-319-15126-7_38

Continued

- Potential cardiac toxicity
- Observed safe limit: 3 g (in addition to normal dietary intake)
- Free form: does not participate in peptide bond formation like other amino acids
- Most abundant free-form amino acid in the tissues of mammals
- Produced by the pancreas

(https://doi.org/10.1016/j.yrtph.2008.01.004)



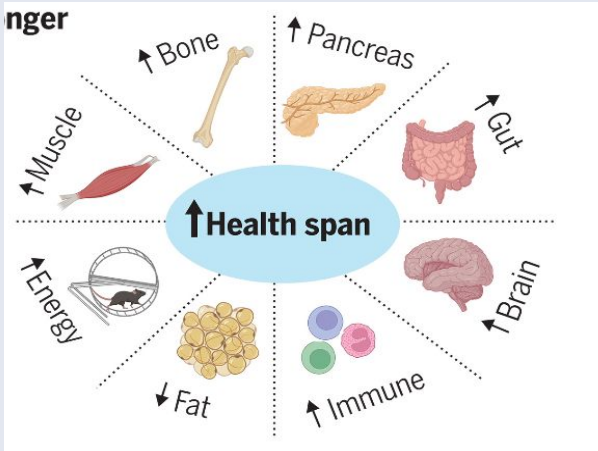


Taurine vs. another amino acid
- does not contain a carboxyl group

What does taurine do?

- Taurine has been found to help against oxidative stress from exercise
- Regulates energy metabolism, gene expression, and osmosis
- Plays an important role in mitochondrial efficiency
- Effects of taurine can be found in all body systems for different functions

(DOI: 10.1126/science.adi3025)



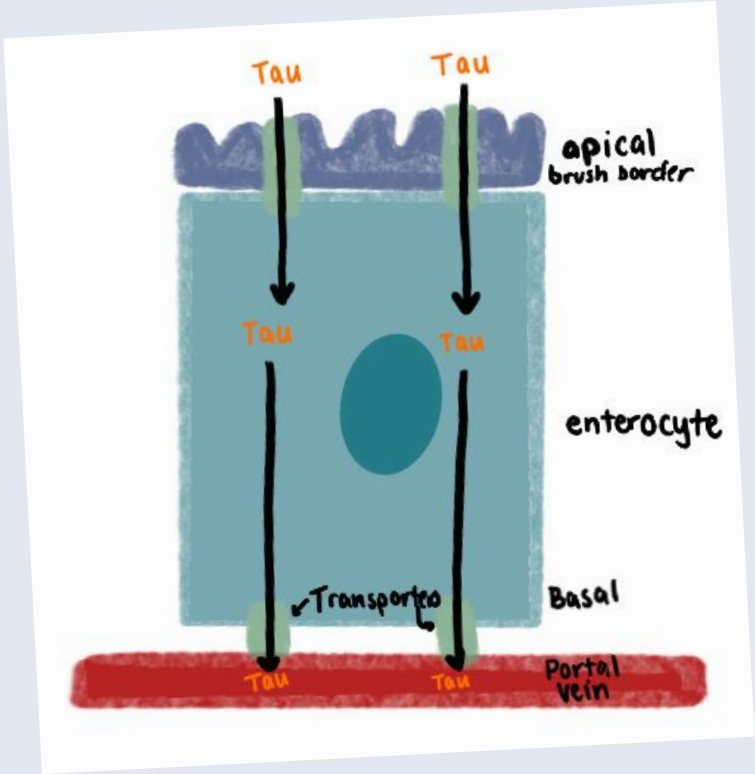
Taken from: /doi/10.1126/science.adi3025

Absorption of Taurine in Digestive Organs

Note: “TauT” = SLC6A6 transporter

- Dietary taurine is taken up across the apical side of the enterocyte through TauT
- Exits through the basal side into the small intestinal venule
- Transported in portal circulation in its free form to the liver to be combined with bile acids

(https://doi.org/10.1007/s00726-020-02823-6)



Effects on Digestive System

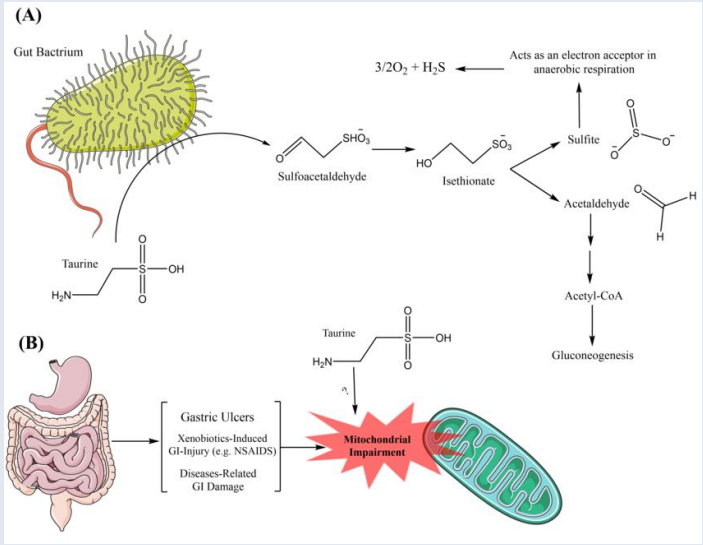
Maintains homeostasis and GI health through:

- Contribution to recovery of gut dysbiosis
  - Gut dysbiosis: microorganisms imbalance in the intestines
- Increases number and function of goblet cells for intestinal mucosal thickness

(PMC10135931)

- Increases bile acid synthesis and flow

(PMID: 26710098)



Taken from: DOI:10.2174/9789815124484123010011

Poll!

Taurine uptake through the apical side is through _____.

A. Passive Diffusion
B. Extra-Hepatic Tissues
C. Active Diffusion
D. Exocrine Tissue

Circulatory System

- Transported in the blood for uptake by other tissues
- Half life ranges from 0.7 - 1.4 hours
- Has many anti-inflammatory properties
    - Has been shown to reduce heart disease from certain studies
- Dilate blood vessels
    - Widens/relaxes muscular walls of blood vessels
    - Improves blood flow
    - Lowers blood pressure

(https://cdnsciencepub.com/doi/full/10.1139/cjpp-2019-0313)

(https://go.drugbank.com/drugs/DB01956)

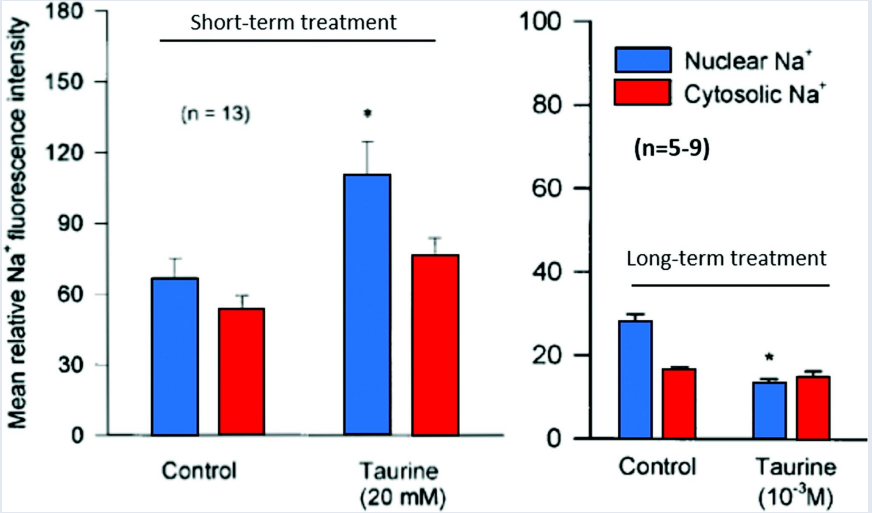
Circulatory System Continued

Most beneficial effects are suggested to be because of taurine's reactivity with oxygen

- This is still unknown for sure
- May need more research to know if it reduces effects of heart disease

Also shown to have a better short term effect than long term effect

(https://cdnsciencepub.com/doi/full/10.1139/cjpp-2019-0313)



Integumentary Functions

- Moderates inflammatory responses in skin
- Osmoregulation of epidermis

(PMID: 16676119)

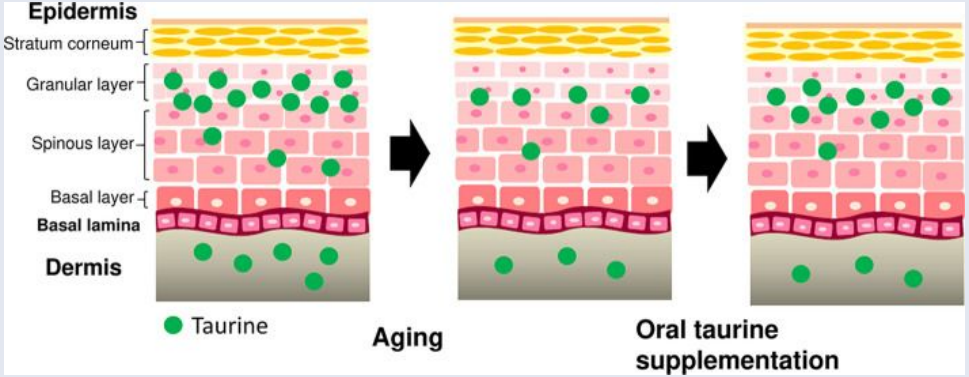
  - Leads to protection against UVB induced wrinkles

(https://doi.org/10.1016/j.biopha.2021.111898)

- Stabilizes keratinocyte integrity

(https://doi.org/10.1016/j.biopha.2021.111898)

- **Energy metabolism leading to lower adipose tissue** (PMID: 30251429)

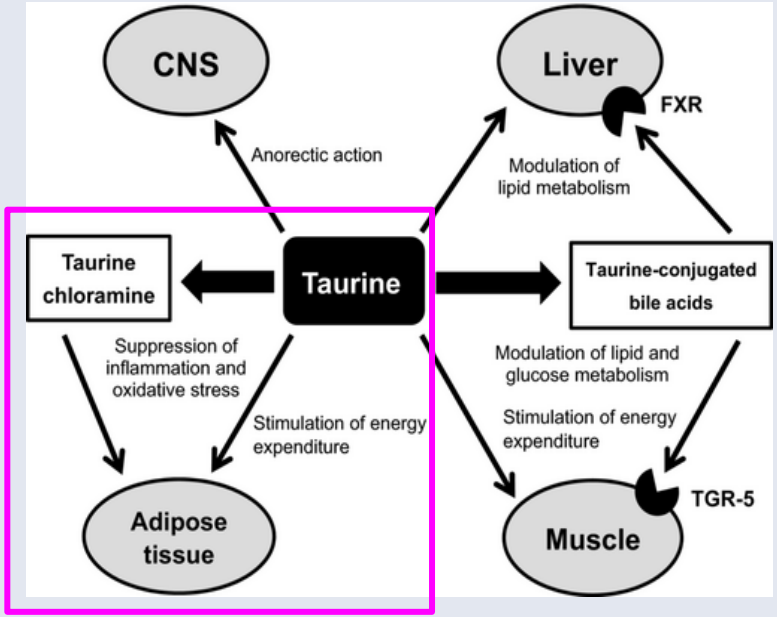


(taken from PMID: 16676119)

Metabolism and Adiposity

- Supplementation can increase **fat oxidation** up to 16% during exercise
- Increased **resting** energy expenditure in women with obesity
- Improves **lipolysis** in healthy individuals
- Stimulation of increased energy expenditure
- **Helps decrease adipose tissue**

(PMC8419774)



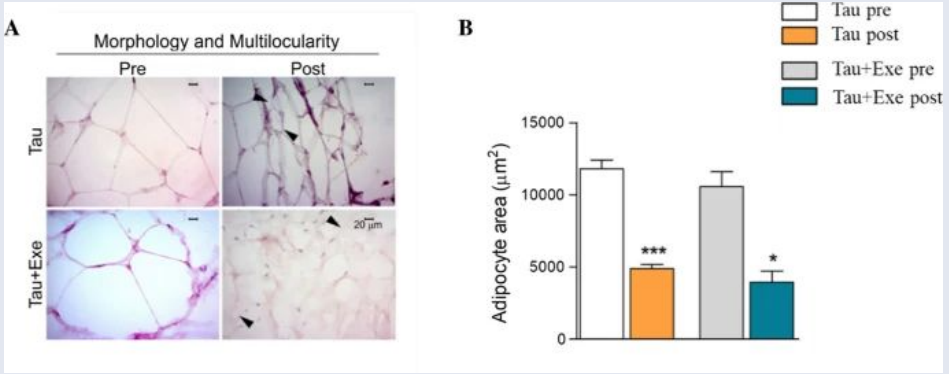
Taurine and Lipid Droplets

Lipid droplets decreased in size after taurine supplement.

- Pre-intervention: unilocular, large lipid droplets in the white adipose tissue
- Post-Intervention: both with exercise and without (+Tau) had more multilocular lipid droplets
    - Similar to beige adipocytes

(https://doi.org/10.1007/s00726-021-03041-4)

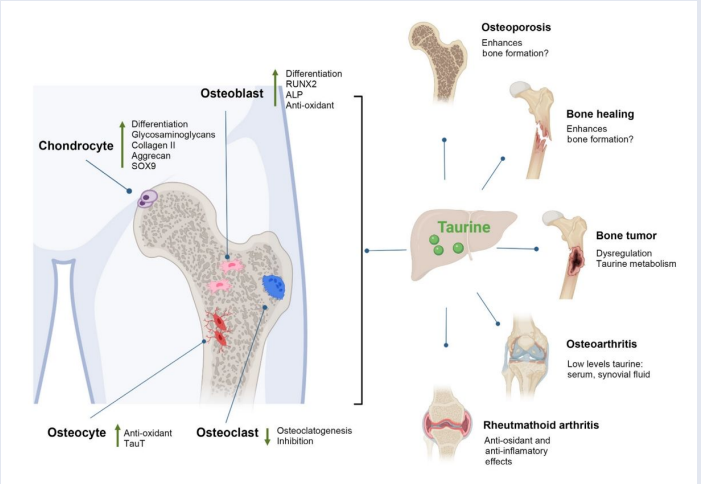
- Increased mobility with taurine treatment contributes to enhanced lipid consumption (PMC2994401)



(https://doi.org/10.1007/s00726-021-03041-4)

Taurine improves osteoporosis

- Metabolomic studies have shown that when giving women low levels of taurine was shown to “alleviate osteoporosis”.
- Taurine has been shown to have positive effects on osteogenesis by communicated with osteoblast which aid in bone growth.
- The increase in taurine in the diet has been shown to stimulate the osteoblast which are the cells that are involved in bone growth.

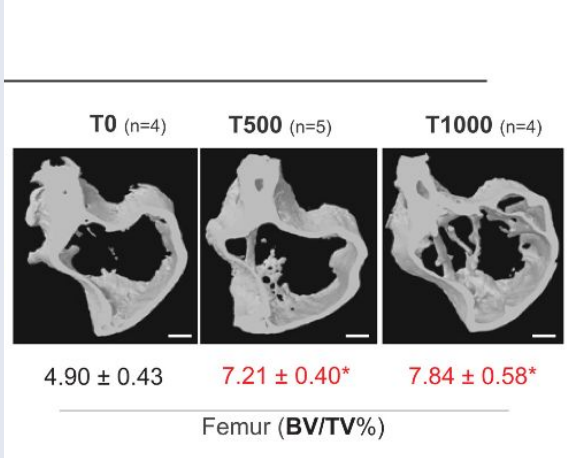


https://doi.org/10.3803/EnM.2022.1443

DOI: 10.1126/science.abn925

Taurine's effects on bone density

- A study done on mice showed that taurine increase bone mineral density (in the spine and femur) when a diet high in taurine is consumed.
- The study showed that when eating a diet high in taurine the bone mineral content increased by **4.5%** and the bone mineral density increased by **7.7%.**



https://doi.org/10.1007/978-0-387-75681-3_35

Taurine reduces muscle inflammation and improves strength

- Taurine may assist with regulating growth factor levels by increasing fat metabolism and lipolysis through exercise
- Has been tested on mice, findings show depletion of muscle taurine levels negatively alters force output and exercise performance
- Affects skeletal muscle contraction by decreasing oxidative stress

doi: 10.1186/s12970-021-00438-0

Taurines effects on DMD

DMD (duchenne muscular dystrophy) - a genetic muscular disorder of progressive muscular weakness, typically found in boys.

- There is altered regulation of taurine and its transporter in the muscles with DMD
- Life expectancy of person with DMD is to age 16-20, is severe
- Results found from mouse models that taurine supplements are beneficial to muscles in people with DMD, although it is not a treatment
- Can act as supportive therapy to DMD in combination with glucocorticoids(anti inflammatory medicine)

NCT02255552,25513,19502,26554
doi: 10.1016/j.redox.2016.08.016

So, to conclude, should you take taurine?

- If you’re not eating the foods that contain taurine (meat, fish, dairy products), then it is not a bad idea to take a taurine supplement.
- Even though there is added taurine in energy drinks, we do not advise taking the energy drink as the taurine supplement.

Reclast/Zoledronic Acid

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What is Reclast?

- A drug that is used to treat or prevent osteoporosis
- Reclast is administered by a medical professional through a 15 minute infusion once a year.
- It can be administered a second time seven days after the initial treatment if the calcium levels do not drop to normal levels.
- Is FDA approved (one of the only two infusions that are FDA approved)

(https://www.hopkinsarthritis.org/patient-corner/drug-information/zolendronic-acid-reclast/#:~:text=What%20is%20Zolendronic%20acid%20(Reclast,Thin)

Osteoporosis: bone disease that develops when bone mineral density and bone mass decrease

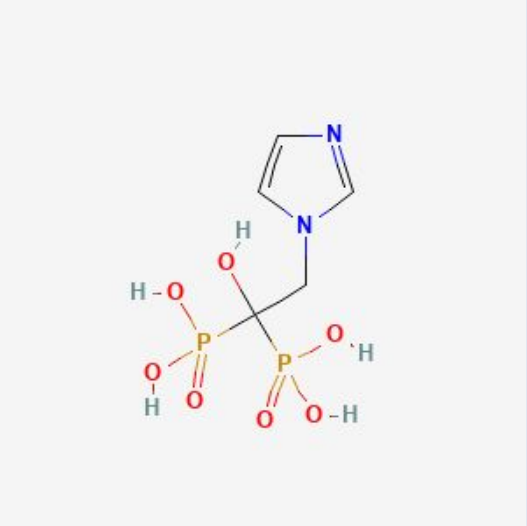
- Leads to a decrease in bone strength, which increases risk of fracture
- Affects women and men of all ages and ethnic groups
- Most common in postmenopausal, white and Asian women
- Risk for disease increases with age
- There are typically no symptoms until a bone is broken

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

How Does Reclast get Absorbed?

By injecting the medication directly into a person's bloodstream (intravenously) to bypass barriers to absorption

- Nitrogen containing bisphosphonate
- This slows bone resorption by osteoclasts and increases the rate of new bone growth
- Water soluble compound
- Is not a lipid



doi: 10.4184/asj.2016.10.4.787

What are Osteoclasts?

Osteoclasts: responsible for bone resorption

- Causes osteoporosis when balance is disrupted for any reason
- Bone resorption is the main issue for osteoporosis

Zoledronic acid targets osteoclasts!

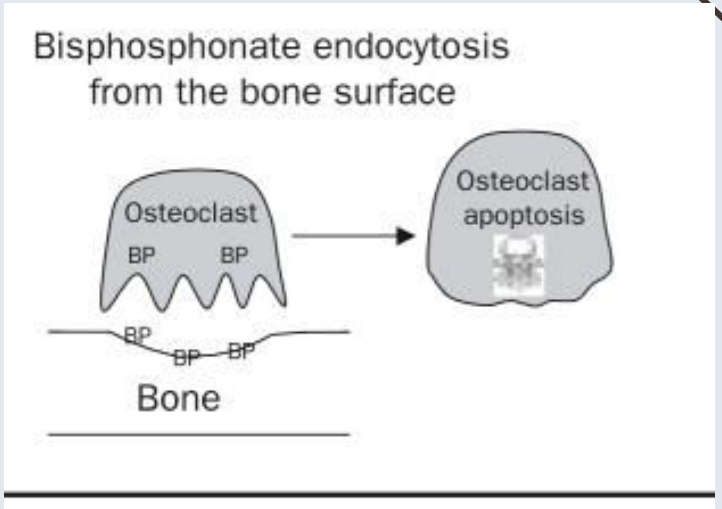
- Inhibits osteoclast differentiation
- Induces osteoclast apoptosis
- Result: **increases** bone density and **decreases** bone resorption

(https://doi.org/10.3389/fphar.2022.961941)

Mechanism of Action

1. Bisphosphonates bind to areas of bone surfaces containing many osteoclasts: Areas of high bone resorption
2. In the osteoclast, the drug will inhibit **farnesyl pyrophosphate synthase (FPPS)**
3. **Endocytosis** of zoledronic acid by the osteoclasts <u>inhibits</u> FPPS, and inhibits protein synthesis
4. Leads to apoptosis of osteoclast

(PMC2667901)



Taken from: PMC2667901

Farnesyl Pyrophosphate Synthase (FPPS): important key branch point **enzyme** for the mevalonate pathway

- Important for creating farnesyl pyrophosphate, an **intermediate** for key proteins for osteoclasts

(PMC4652608)

Poll!

What are osteoclasts responsible for?

A. Bone resorption

B. Bone stability

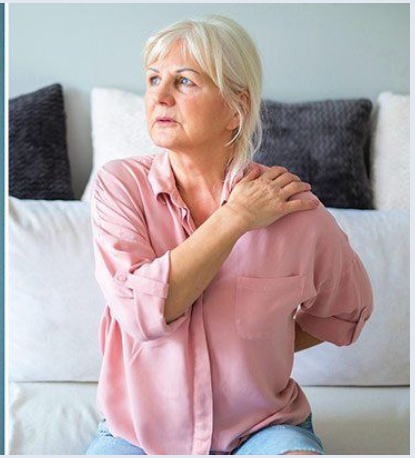
C. Bone formation

D. Both A and B

Side Effects from Reclast Infusion

- Muscle and joint pain
- Flu like symptoms
- Headache
- Nausea
- Hair loss
- Weight loss
- Numbness or tingling in mouth, fingers, or toes

These symptoms typically only last up to 48 hours after the initial infusion.



Conclusion

- Reclast is a drug given to help with osteoporosis
- It is a fifteen minute infusion given once a year
- It binds to osteoclasts, helping increase the rate of new bone growth
- We advise taking this drug if a person develops osteoporosis, as reclast is FDA approved and it is proven to help patients with osteoporosis