Dietary influence on cats urine composition

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Urine composition in cats

- Dietary factors affect urinary health in cats

  - Excretion
    - Phosphate, magnesium, nitrogen, oxalate
  - Effects on the acid base metabolism
    - pH
    - Solubility enhancers
  - Supersaturation → risk for uroliths

Incidence of lower urinary tract diseases

- Common problem in cats
- Especially middle-aged animals
- Male cats > female cats
- Male dogs > female dogs (excl. struvite)

Occurrence of urinary stones (USA)

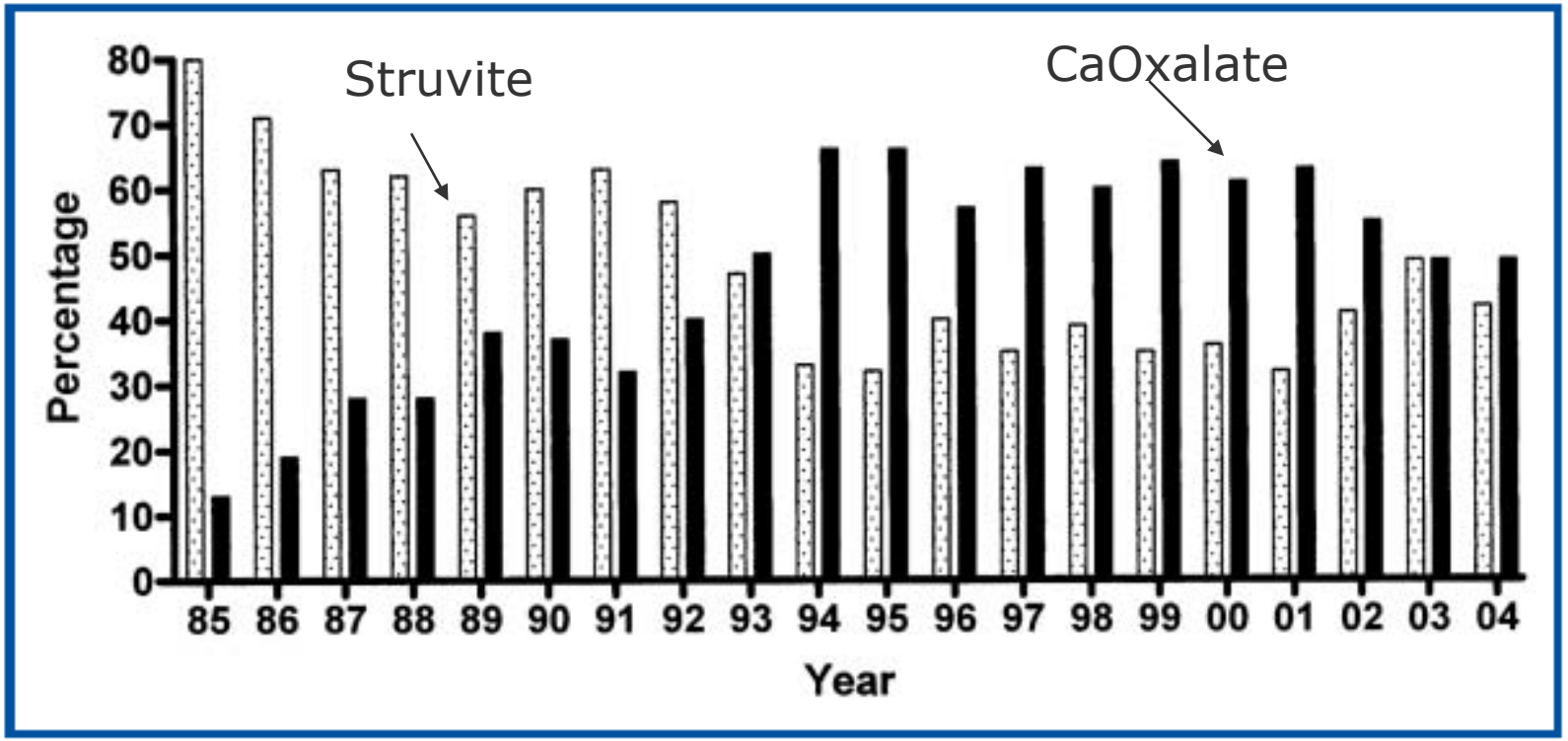


Figure 2—Percentage of calcium oxalate– (black bars) and struvite-containing (dotted bars) uroliths from the same cats as in Figure 1. Notice that the ratio of calcium oxalate–containing stones to struvite-containing stones increased significantly ($P < 0.001$) during the past 15 years.

Cannon et al., 2007

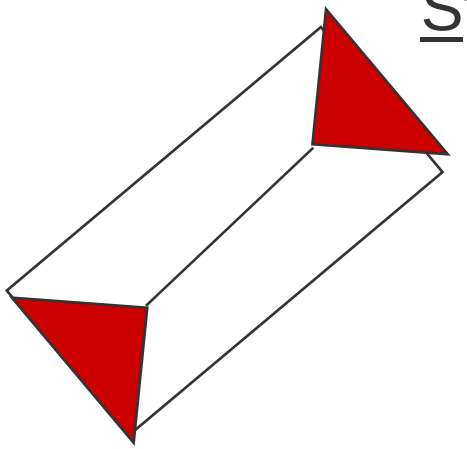
Pathogenesis

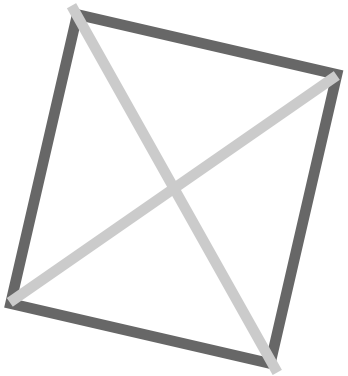
- Widely unclear
- Crystalluria
- Diet
  - Water
  - Minerals
- Obesity
- Stress
- Infections

Urolithiasis

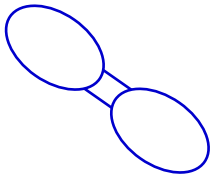
- Centrifuge fresh urine, investigate sediment by microscope (medium magnification) :

Struvite





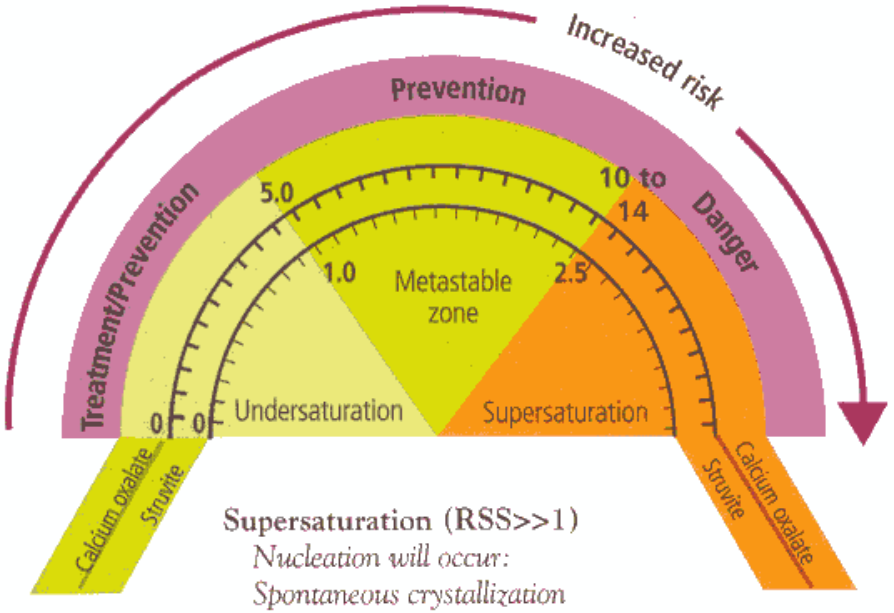
Calcium oxalate-dihydrate



Calcium oxalate-monohydrate

Urine pH

- Urine pH: Inhibition or promotion of crystallization
  - Alkaline → precipitation of struvite, Ca apatite
  - Neutral/acidic → precipitation of CaOx, cystine, urate
- Cave:
  - Postprandial: alkaline urine
  - Obstructions: acidic urine
- Determination of the urine pH
  - Measurement (test strips, pH-meter)
  - Calculation: Dietary Cation-Anion Balance (DCAB)



Supersaturation (RSS>>1)
Nucleation will occur:
Spontaneous crystallization
Rapid crystal growth and aggregation
Dissolution is not possible

Metastable zone (RSS>1)
Possible growth of preformed crystals
Heterogeneous nucleation may occur
Dissolution is not possible

Undersaturation (stable) (RSS<1)
No crystallization
Existing uroliths/crystals may dissolve

Source: Royal Canin

Relative Supersaturation, RSS

- Relative Supersaturation of the urine:
  - RSS < 1: Undersaturation (no new formation of uroliths; dissolution of existing crystals and uroliths is possible)
  - RSS 1-10 (dog) / 1-12 (cat) (CaOx) resp. 1-2.5 (struvite): Metastable zone (existing uroliths may grow; no new formation; no dissolution is possible)
  - RSS > 10 (dog) / > 12 (cat) (CaOx) resp. > 2.5 (struvite): Oversaturation (nucleation; new formation and growth of uroliths; no dissolution)

Stevenson and Rutgers, 2006

Genetic predispositions (Stevenson and Rutgers, 2006; Houston and Elliott, 2008)

- Struvite (magnesium ammonium phosphate hexahydrate):
  - Miniature schnauzer, bichon frise, shih tzu, toy poodle, lhasa apso, oriental shorthair, ragdoll, chartreux, foreign shorthair, DSH, DLH, DMH, himalayan, persian

- Calcium oxalate (calcium oxalate monohydrate (whewellite), calcium oxalate dihydrate (weddellite)):
  - Miniature schnauzer, lhasa apso, cairn terrier, yorkshire terrier, cocker spaniel, bichon frise, shih tzu, toy poodle, himalayan, persian, ragdoll, shorthair, havana brown, scottish fold, foreign shorthair, burmese, DSH

Genetic predispositions (Stevenson and Rutgers, 2006; Houston and Elliott, 2008)

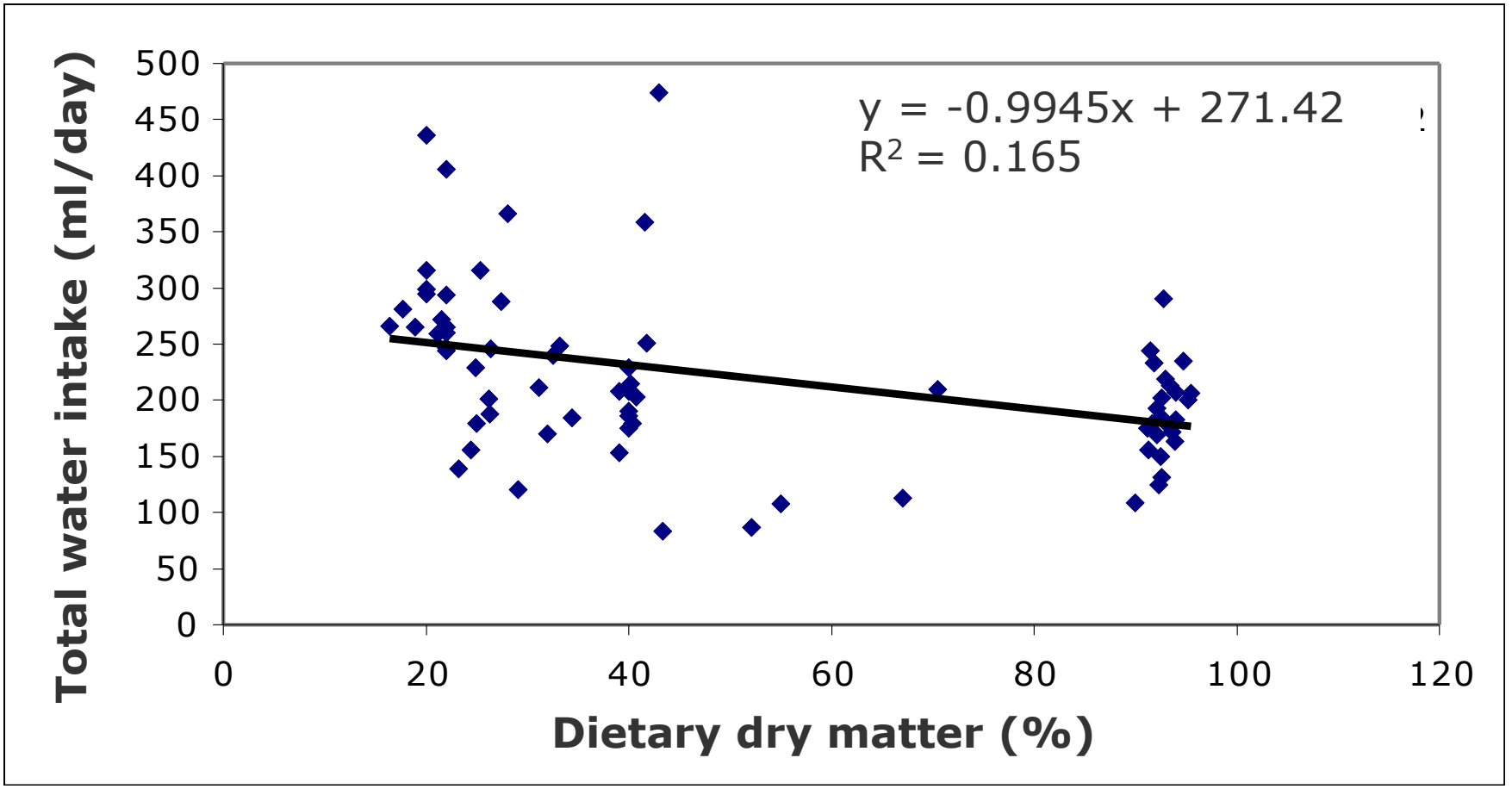
- Cystine:
  - English bulldog, dachshund, newfoundland, siamese, shorthair
- Urate:
  - Dalmatian, english bulldog, miniature schnauzer (PSS*), yorkshire terrier (PSS*), siamese, egyptian mau
- Calcium phosphate:
  - Yorkshire terrier
- Silicate:
  - German Shepherd, bobtail

*PSS: portosystemic shunt

- Water turnover and how we can modify it to decrease stone formation

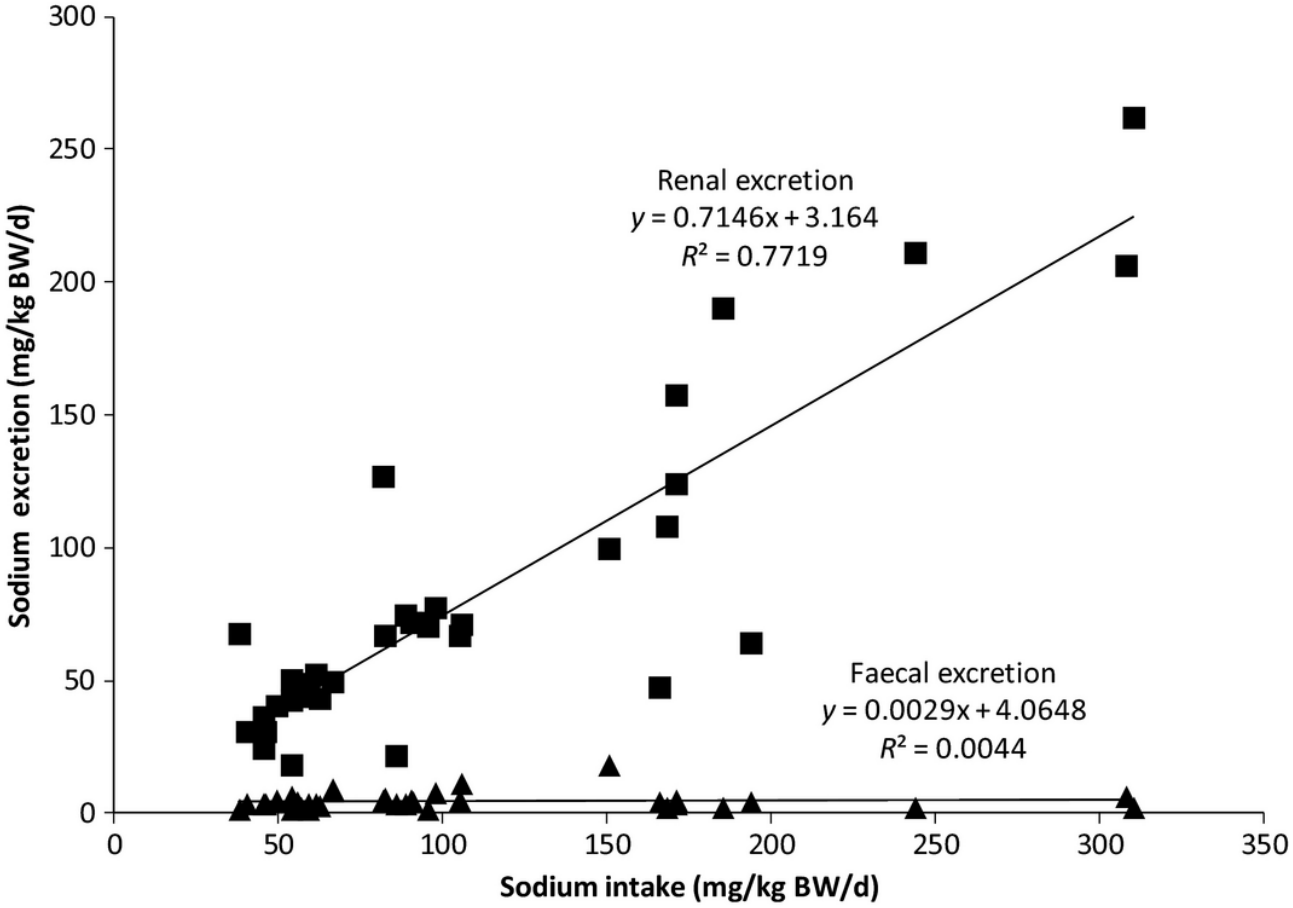
- Wet petfood – is it applicable as a treatment or preventive method for uroliths in dogs and cats?

Dietary dry matter and water intake of cats



Schulz, 2003

Sodium in feline nutrition



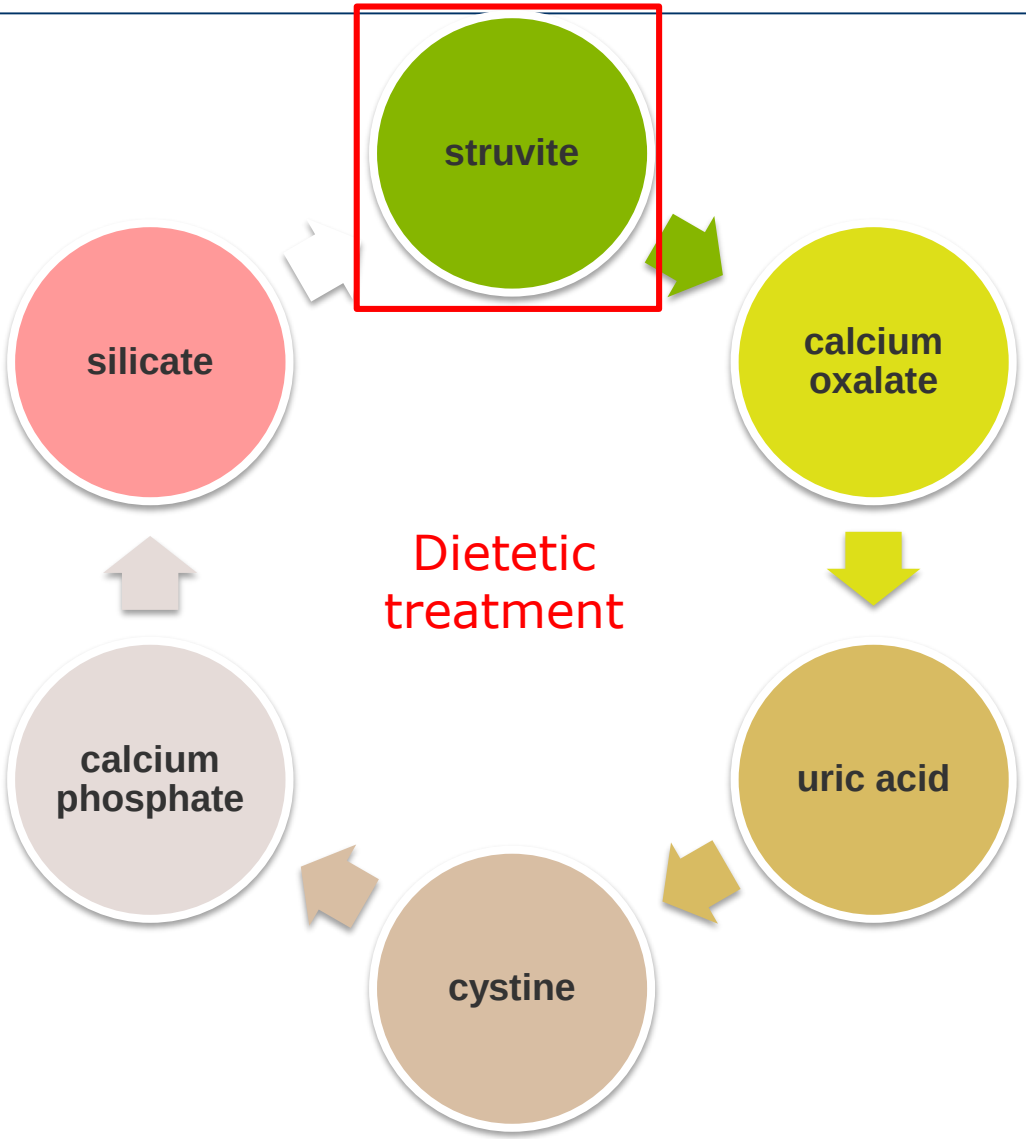
Journal of Animal Physiology and Animal Nutrition
23 AUG 2016 DOI: 10.1111/jpn.12548
http://onlinelibrary.wiley.com/doi/10.1111/jpn.12548/full#jpn12548-fig-0002

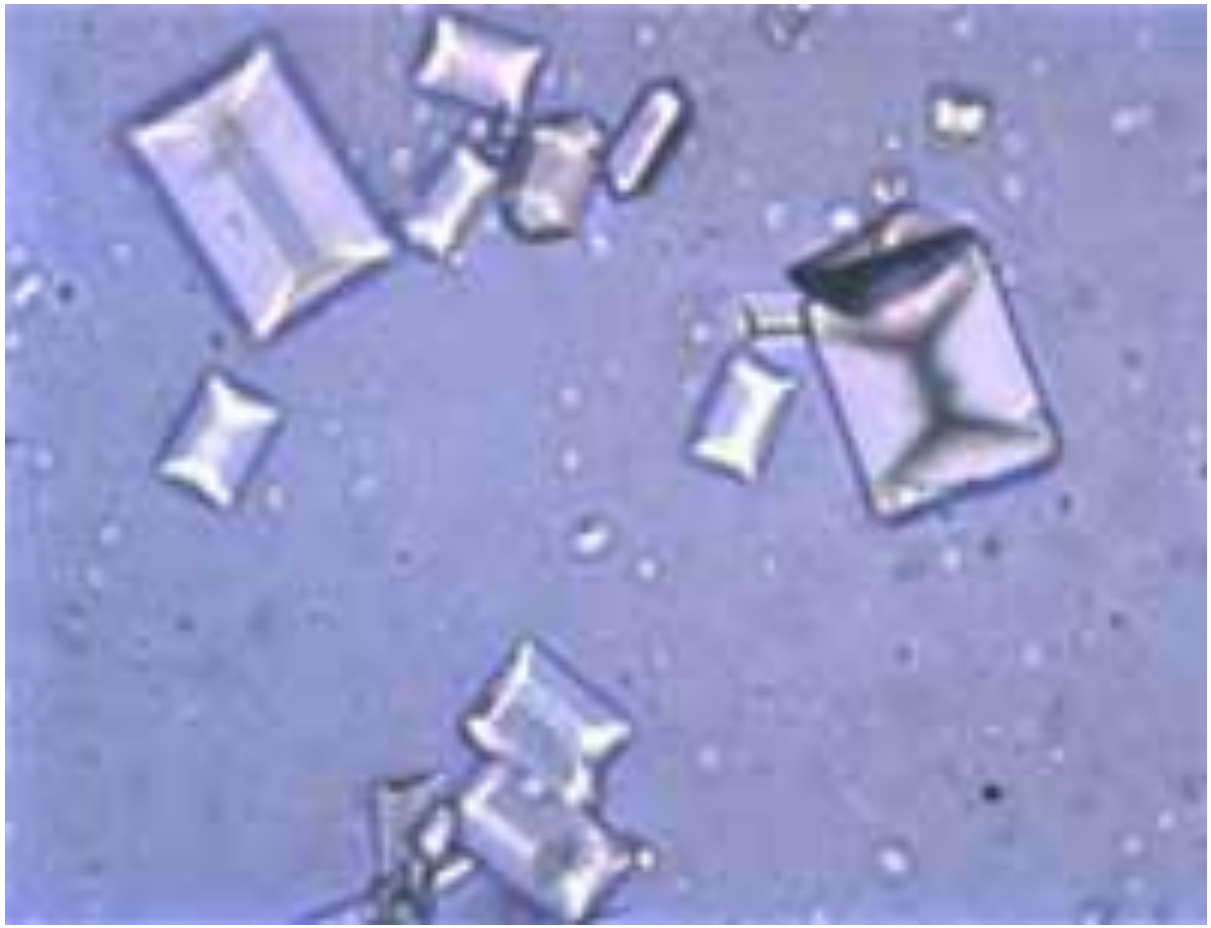
Nguyen et al. 2016

Increasing the urine volume

- Increasing the daily water intake

  - Canned diets or addition of water to dry exdruded diets
  - Fresh or old water (depending on preference)
  - Home-cooked diets: addition of meat broth
  - Drinking fountain
  - High-sodium diets (> 1 g/kg body weight/day; CAVE: animals with edema due to heart or liver diseases)
  - …


struvite
calcium oxalate
uric acid
cystine
calcium phosphate
silicate
Dietetic treatment

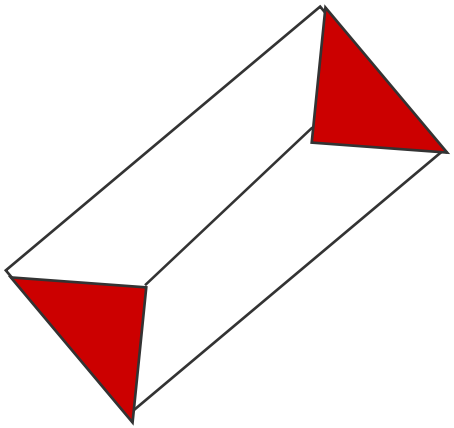


Struvite

- Risk factors:
  - Diets rich in magnesium, phosphorus and protein
  - Low water intake
  - Alkaline urine pH
  - Urinary tract infections (Urease-positive bacteria)
  - Breeds: Miniature schnauzer, bichon frise, shih tzu, toy poodle, lhasa apso, oriental shorthair, ragdoll, chartreux, foreign shorthair, DSH, DLH, DMH, himalayan, persian
  - Age (Dog: 2-8 years; varying data for the cat, ⌀1-7.2 years)
  - Sex: (80 % female dogs; varying data for the cat)
  - Obesity, inactivity (cat)

Struvite: dietetic treatment

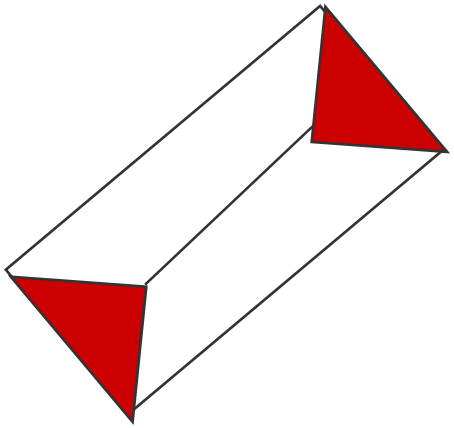
- Struvite (magnesium ammonium phosphate hexahydrate):
  - Urine pH: 6.6-6.8 (prevention) resp. 6.0-6.5 (therapy)
  - Reduction of dietary magnesium, protein, phosphorus
  - Water intake ↑
    - Canned diets > dry extruded diets
    - Urine specific gravity < 1.030



Struvite: dietetic treatment

- Avoidance of alkalizing dietary components (carbonates)

- Higher concentrations of dietary anions (sulphate/methionine, chloride)

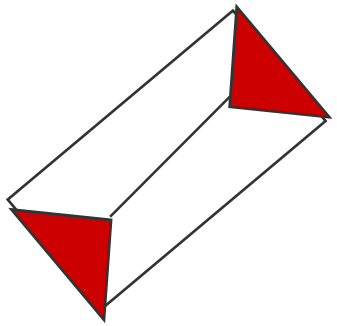


Struvite: dietetic treatment

- Acidification of the urine
  - Ammonium chloride 1 g/day (cat) resp.

    0.2 g/kg body weight (BW)/day (dog)
  - Methionine 1.5 g/day (cat) resp.

    0.2 g/kg BW/day (dog)



  - Urine pH should be measured several times a day

Food intake and urine pH

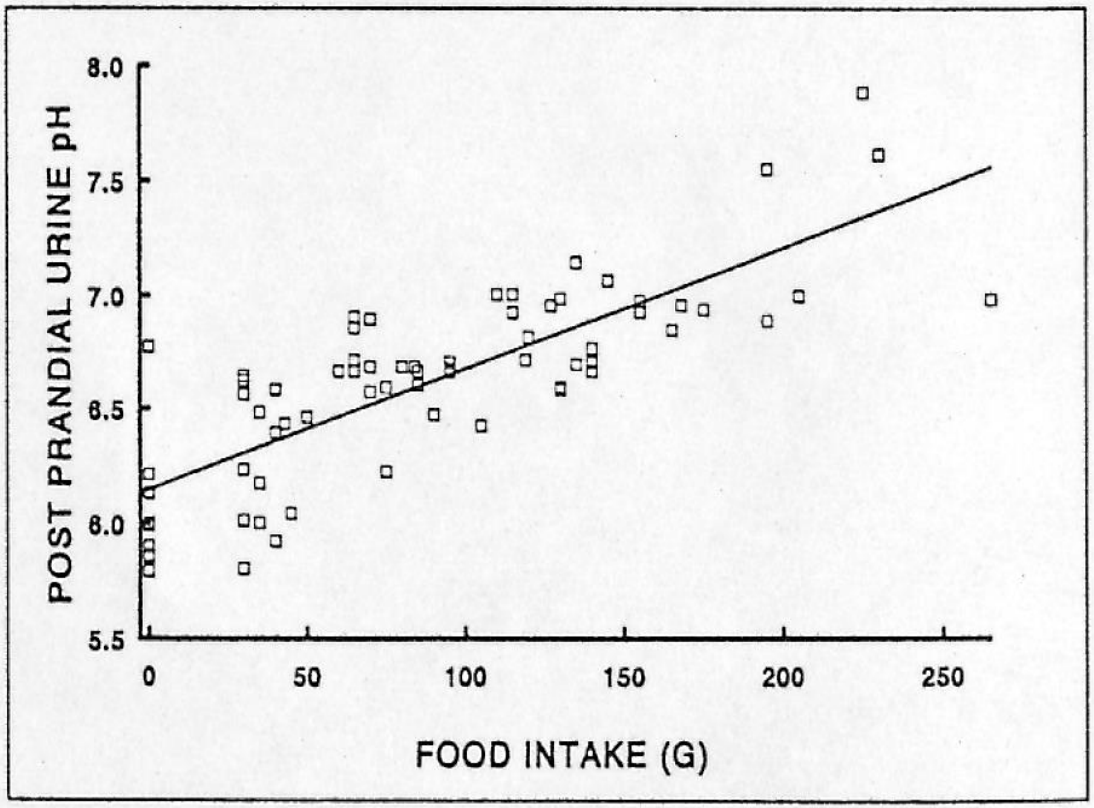


FIG 1. Effect of food intake on the post prandial urine pH of adult cats

FINKE and LITZENBERGER 1992

Struvite: Dietetic treatment (cat)

- Reduction of magnesium and phosphorus
  - Magnesium: 0.04-0.10 % in DM (prevention) resp. 0.04-0.06 % in DM (therapy)
  - Phosphorus: 0.5-0.9 % in DM (prevention) resp. 0.5-0.8 % in DM (therapy)

- Dietary protein should cover daily requirement
  - 30-45 % CP in DM (prevention and therapy)

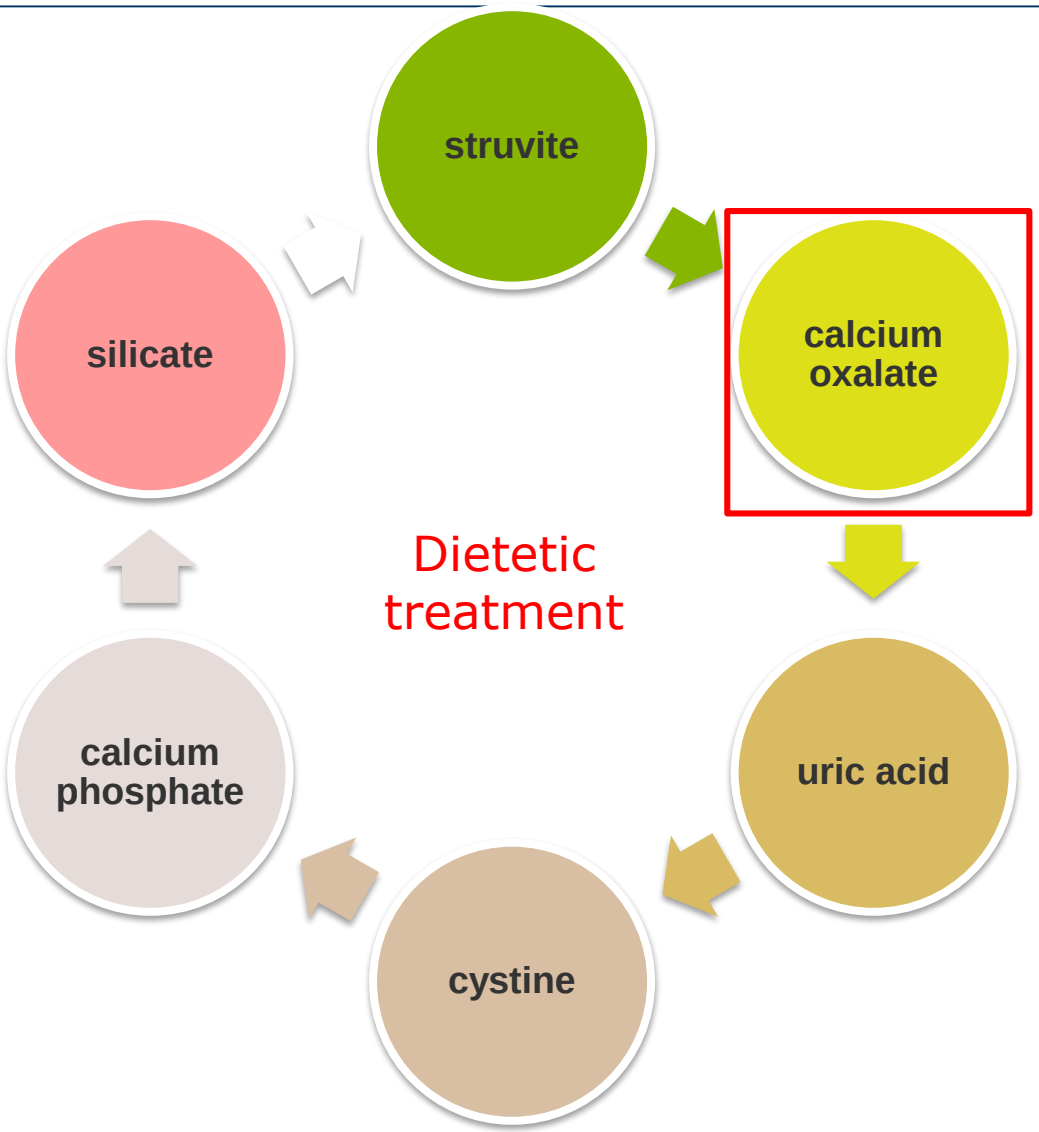


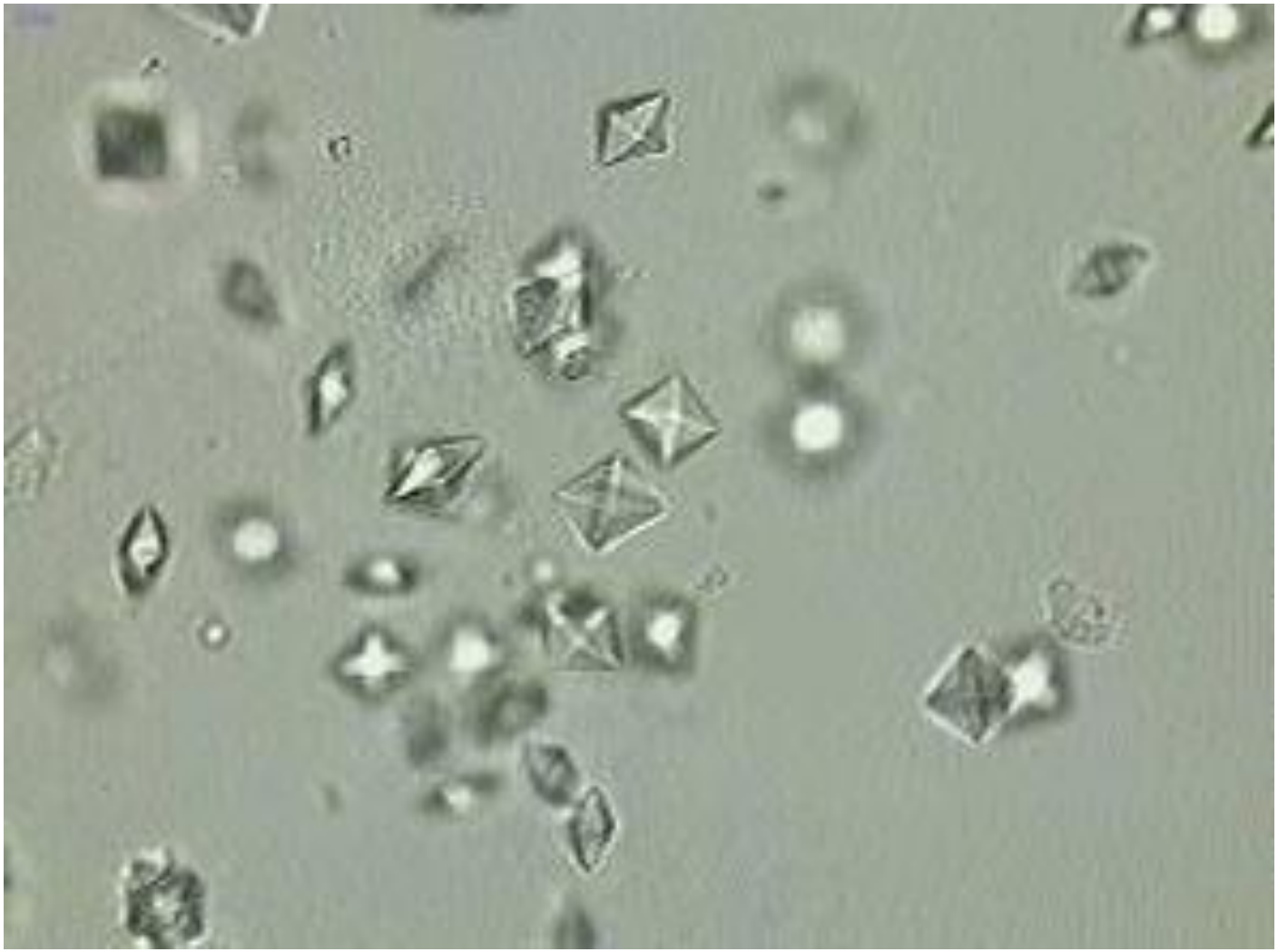
Source: http://www.ptotemtapsen.de

- Maine Coon, mc, 4 years, 8 kg body weight
- History:
  - 2.5 years ago: Cystitis and haematuria → struvite stones
  - Therapy: Infusions, antibiotics, commercial diet for dissolution and prevention
  - 6 months ago: new commercial diet for prevention of struvite stones → acceptance ↓
- Home-cooked diet requested

Case 1: Diet for the prevention of struvite stones (cat, 8 kg)

	Diet 1	Diet 2
Chicken breast	160 g	-
Liver (chicken)	5 g	-
Calf meat	-	150 g
Liver (calf)	-	5 g
Noodles (gross weight)	-	20 g
Rice (gross weight)	40 g	-
Lard	9 g	5 g
Carrots	10 g	
Calcium carbonate	0.3 g	
Vitamin and mineral supplement	2.5 g	
Iodized table salt	1 g	

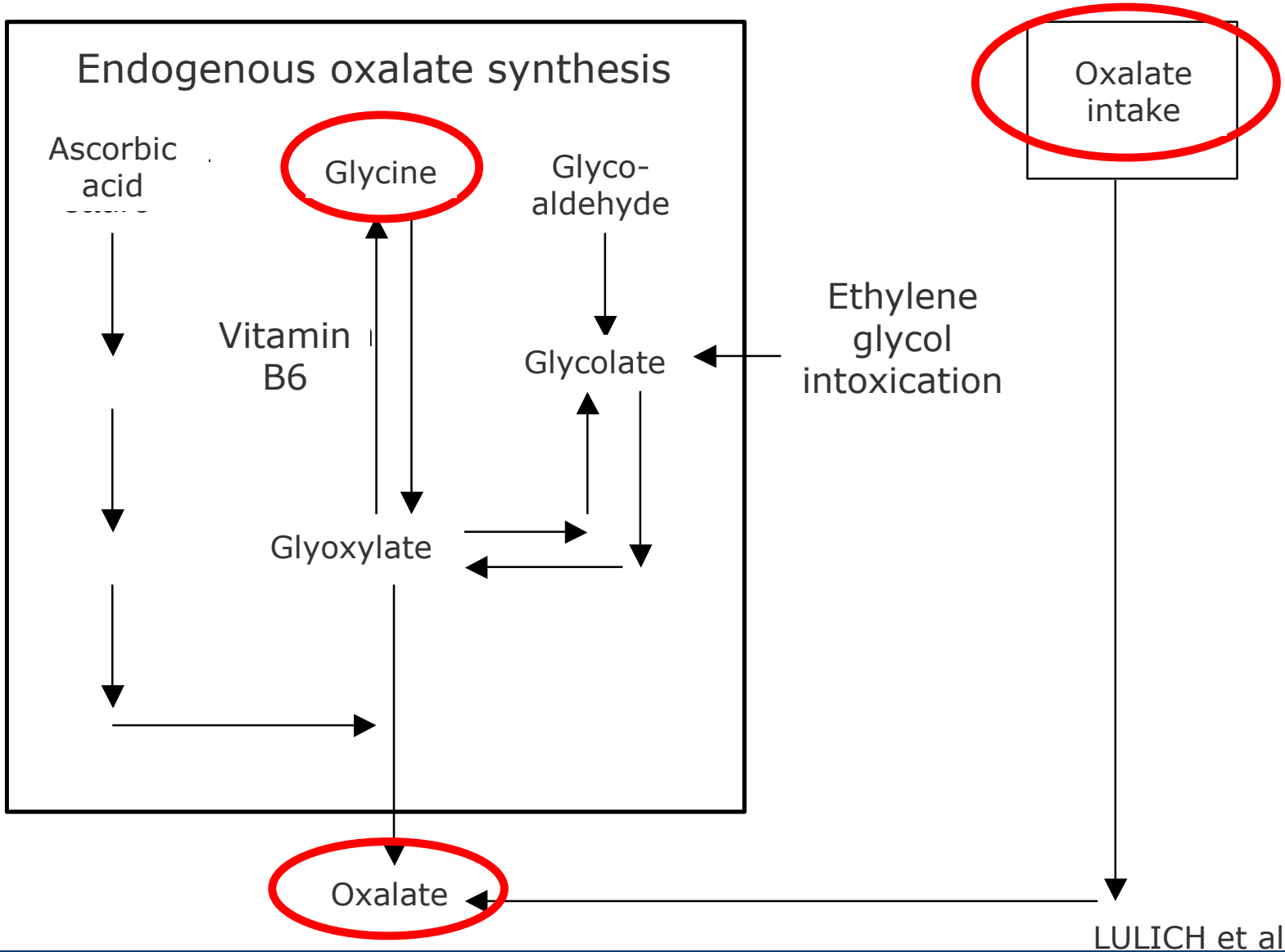

struvite
calcium oxalate
uric acid
cystine
calcium phosphate
silicate
Dietetic treatment



Calcium oxalate stones

- **Risk factors:**
  - High dietary Ca and oxalate concentrations; high dietary vitamin C concentrations (?); low water intake
  - Hypercalcaemia, hyperadrenocorticism, chron. metabolic acidosis
  - Breed: Himalayan, persian, ragdoll, shorthair, havana brown, scottish fold, foreign shorthair, burmese, DSH
  - Age cats, ⌀ 5-15 years
  - Sex: varying data for cats, mostly ♂ > ♀
  - Obesity, inactivity

Oxalate synthesis

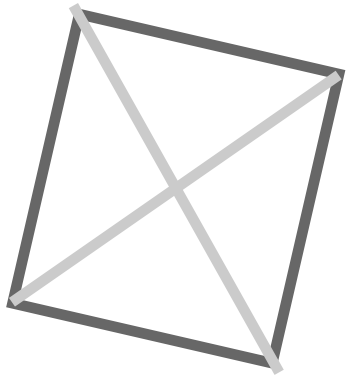


LULICH et al. 1999

Risk factor for calcium oxalate uroliths: metabolic acidosis

- Chronic metabolic acidosis
  - Release of calcium phosphate and calcium carbonate from bones (buffer for H^+ ions)
  - $Ca(HCO_3)_2 \xrightarrow{H^+} H_2CO_3 \longrightarrow CO_2 + H_2O$; $\rightarrow Ca^{++}$
  - $CaHPO_4 \xrightarrow{H^+} H_2PO_4$; $\rightarrow Ca^{++}$
  - Renal excretion of Ca

Dietary treatment of calcium oxalate uroliths



- Water intake ↑
- Avoidance of high dietary calcium and vitamin D concentrations
- Limitation of dietary ingredients rich in oxalate (vegetables)
- High protein quality
- Urine pH ~ neutral (6.8 – 7.2)
  - Addition of potassium citrate: 150 mg/kg BW/day (if necessary)

Calcium oxalate uroliths: Impact of dietary calcium

- Calcium concentration in the diet:
  - Recommendation in the past: Ca restriction in diseased/predisposed animals
  - Today: higher dietary Ca concentrations might be beneficial (complex between Ca and Ox in the intestine → renal Ca and Ox excretion ↓; Stevenson et al., 2004; Penniston et al., 2009)
  - Dietary Ca (12.2-27.0 g/kg DM and 6.23-24.3 g/kg DM) did not affect urinary Ca (Paßlack and Zentek, 2013; Paßlack et al., 2016) and Ox concentrations in cats (Paßlack and Zentek, 2013)

Calcium oxalate uroliths: Impact of dietary protein (1)

- Dietary protein concentration:
  - Humans: High protein intake is considered as a risk factor for calcium oxalate uroliths (Negri et al., 2013):
    - Theory: Oxidation of sulphur-containing amino acids → release of H^+ → „Acid load“ (Sabry et al., 1965)
    - Acidification: Renal calcium excretion ↑, urinary citrate ↓
    - But: Hypercalciuria was observed even when alkalizing substances were added to a high protein diet (Ceglia et al., 2009; Maalouf et al., 2011)

Calcium oxalate uroliths: Impact of dietary protein (2)

- Dietary protein concentration:
  - Dijcker et al. (2012): High protein concentration (45 g CP/MJ ME; basis: casein) in a diet for cats: Urinary oxalate ↓
  - Paßlack et al. (2014): High protein concentration (57 % CP in DM; basis: chicken meal) in a diet for cats:
    - Urine volume ↑
    - Urinary calcium ↑
    - Renal calcium and oxalate excretion ↑

Dietary treatment for the prevention of calcium oxalate uroliths



source: http://view.stern.de

- Cat, male, 4 years, 6 kg, overweight
- Case history:
  - July 2007: pollakisuria → homeopathic treatment, low magnesium diet
  - October 2007: Dysuria, stranguria →urethral obstruction; detection of calcium oxalate uroliths
  - Therapy: Infusions, catheter, lavage, commercial diet for the prevention of calcium oxalate stones

Dietary treatment for the prevention of calcium oxalate uroliths

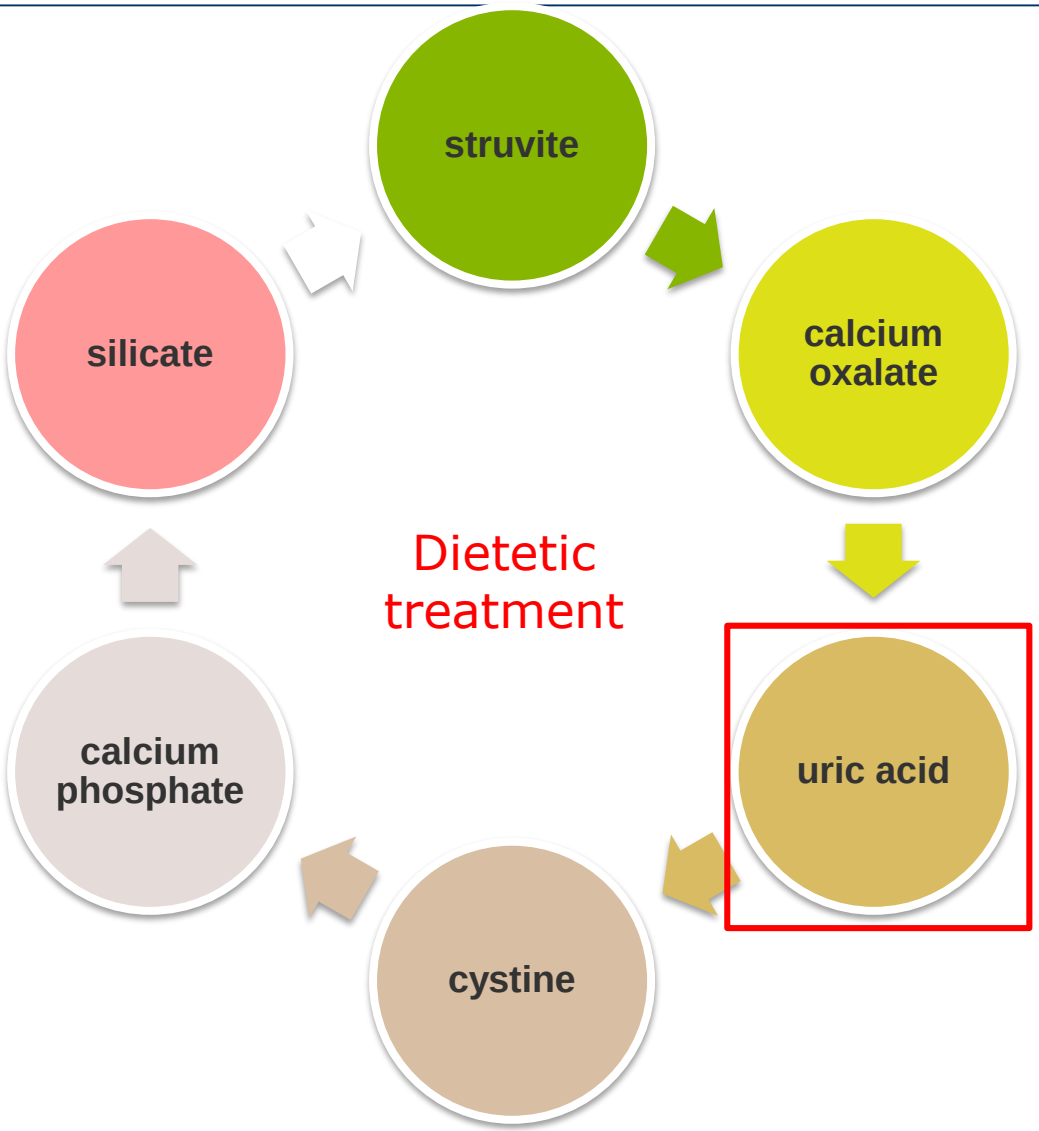
- Recommendation:
  - Commercial diet for the prevention of calcium oxalate stones
  - High water intake
  - Measurement of the urine pH
- Alternative: Home-cooked diet (target body weight of 5 kg):
  - 75 g sheepmeat + 5 g liver (sheep) + 30 g cottage cheese
  - 10 g noodles (gross weight)
  - 3 g lard
  - 1.8 g vitamin and mineral supplement + 0.5 g iodized table salt
  - 10 ml goat milk with water (1:4)

Dietary treatment for the prevention of calcium oxalate uroliths

- July 2008:
  - Optimum urine pH
  - No new formation of calcium oxalate stones
  - Body weight loss
  - Glossy coat
  - More active



Source: http://view.stern.de


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Dietetic treatment

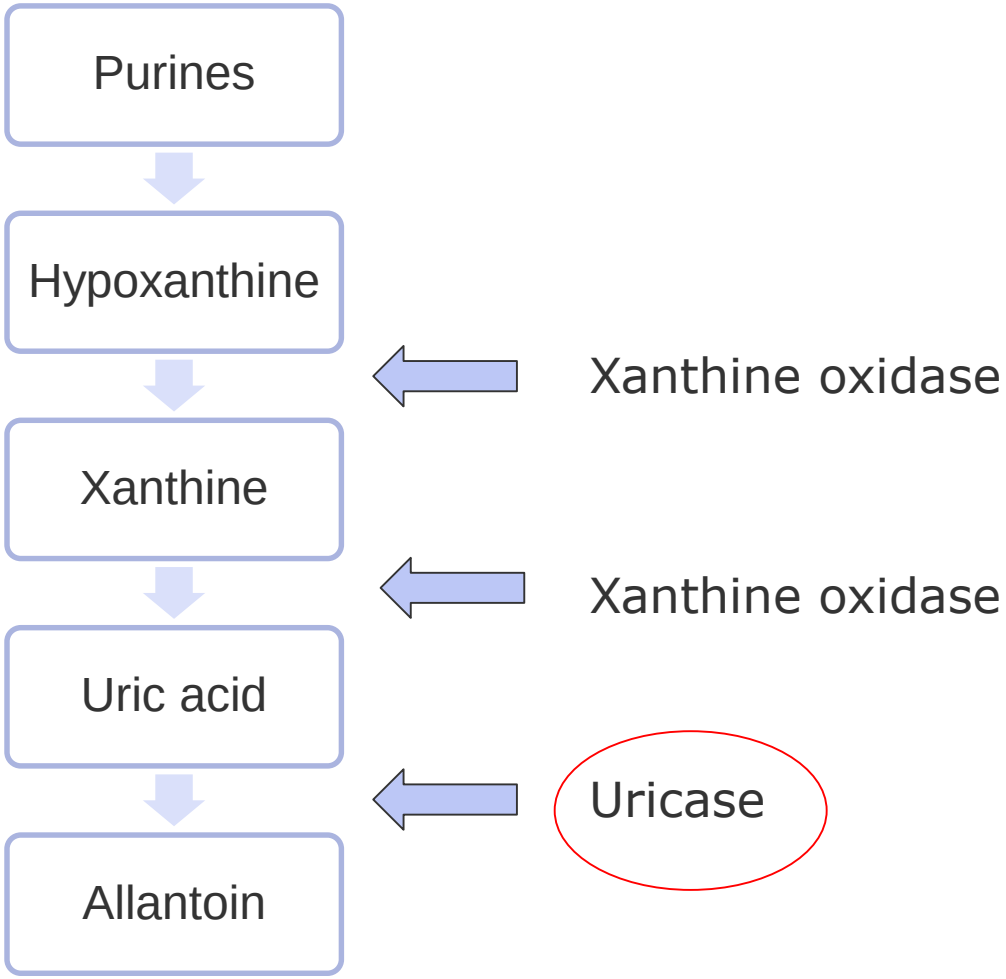
Uric acid stones

- Risk factors:
  - Purine-rich diets (innards)
  - Breed: Siamese, egyptian mau
  - Sex: Cat: ♂ = ♀ or ♂ > ♀
  - Age: varying data for cats: ⌀ 4.4-5.8 years
  - Liver disease, especially portosystemic shunt
  - Acidic urine (e.g. high protein diets)
  - Urinary tract infection (cat)
  - Low water intake

*PSS: portosystemic shunt

Uric acid stones

- Purine degradation

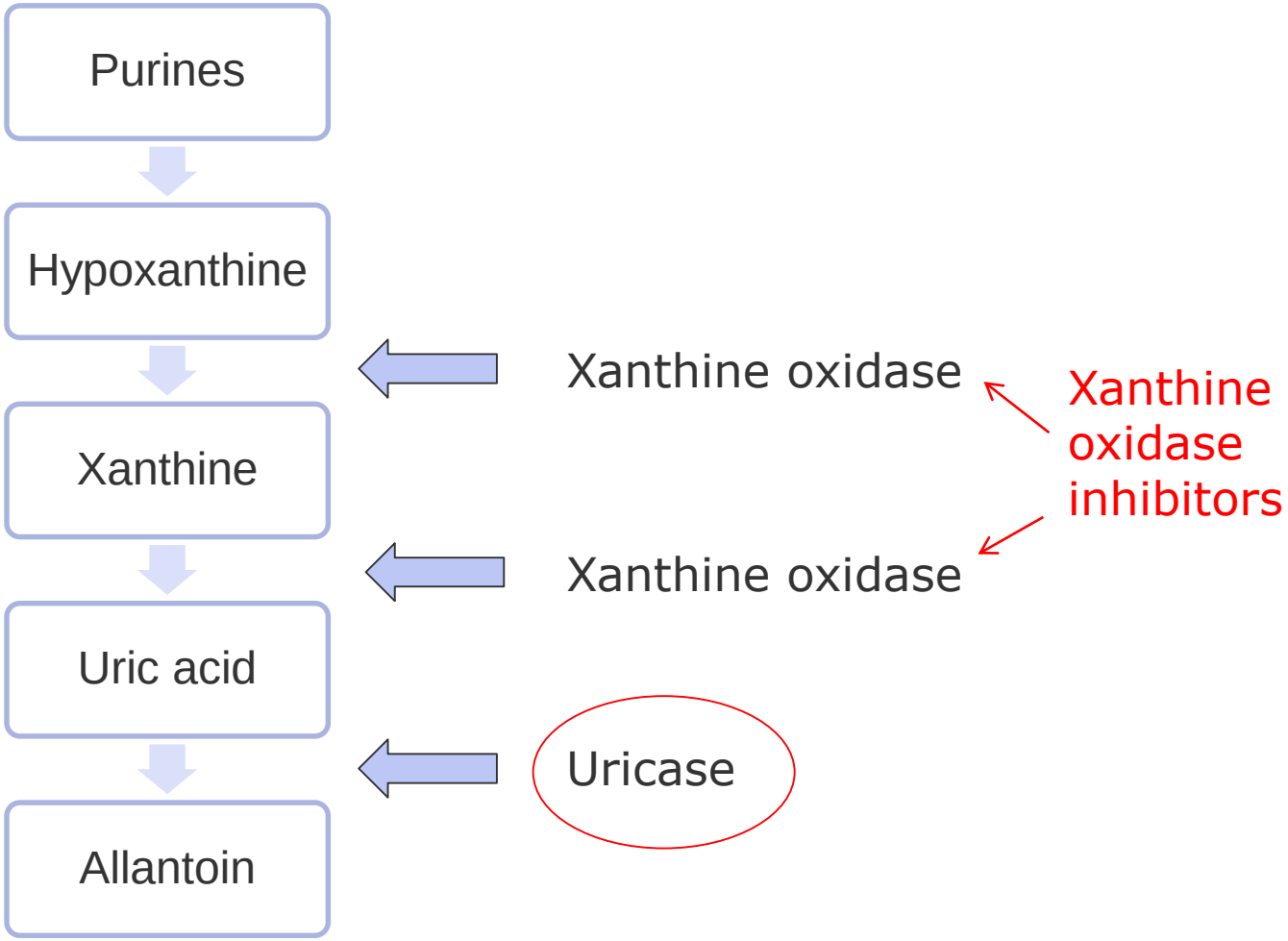


Uric acid stones

- Dietary treatment:
  - Restriction of purines (fish, innards)
  - Urine pH: 6.5-7.2
    - Potassium citrate (2x 50-150 mg/kg BW/day)
  - Increased water intake
  - Allopurinol (2x 15mg/kg BW/day; Osborne et al., 1996)

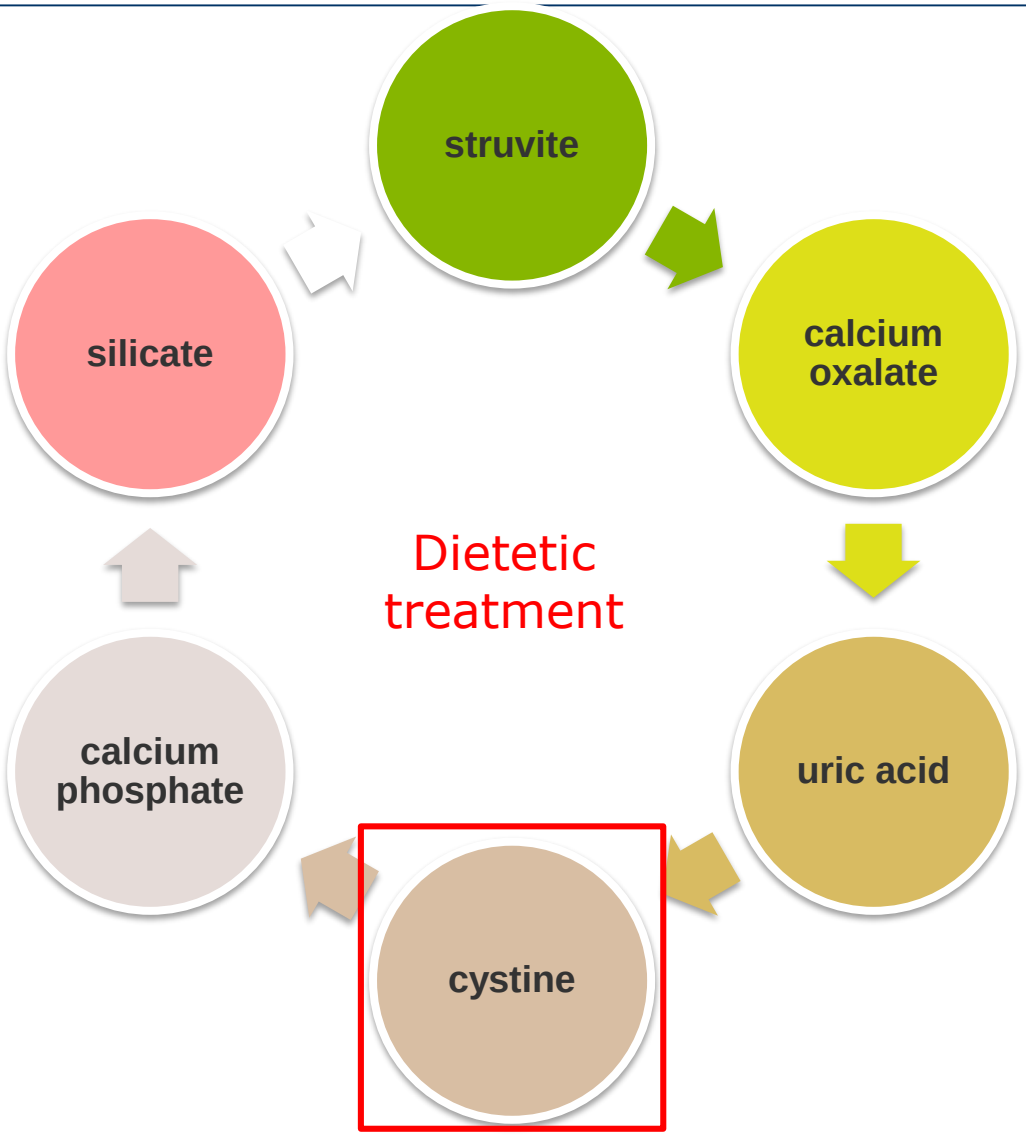
Uric acid stones

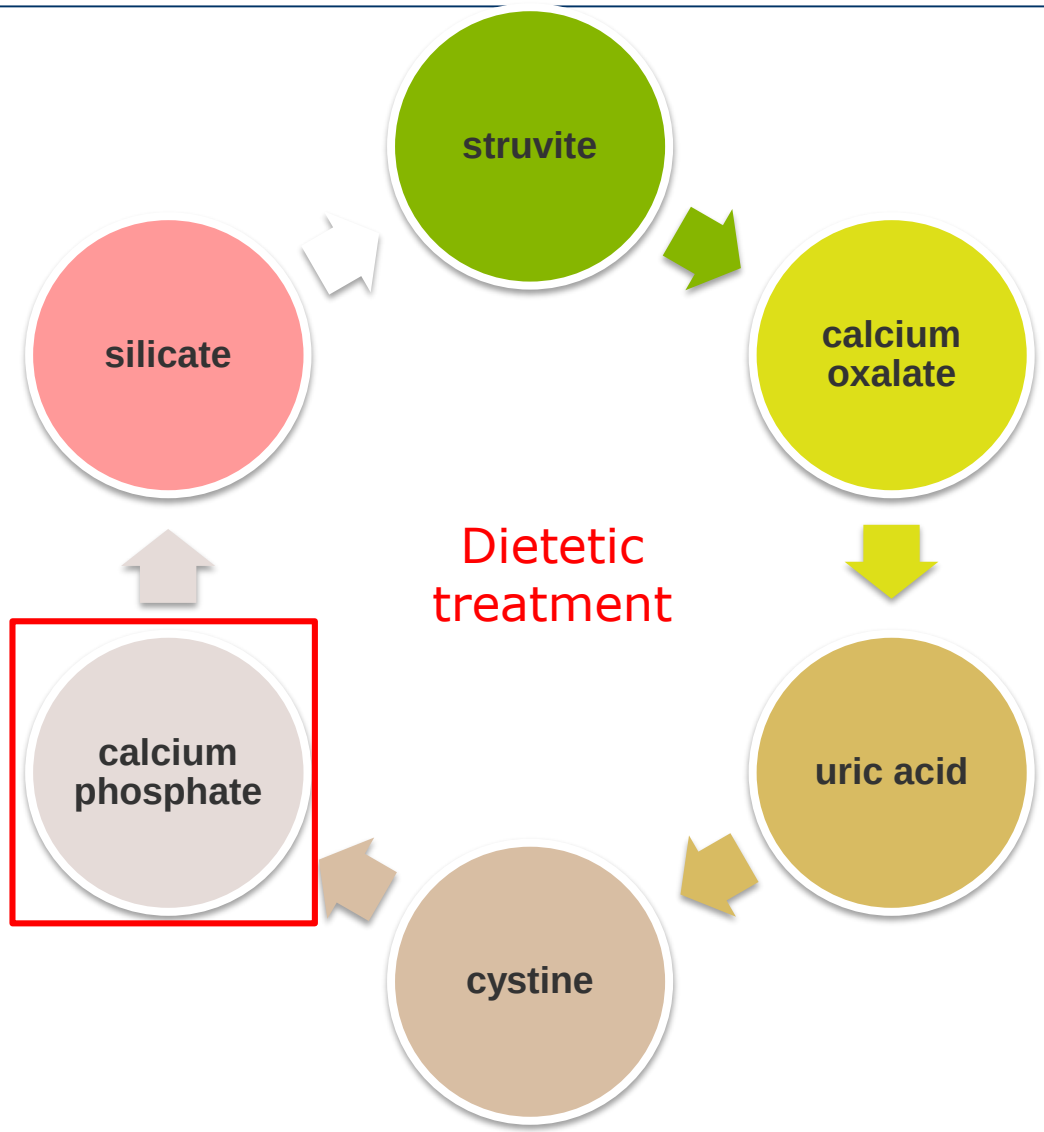
- Purine degradation



Xanthine oxidase inhibitors (uric acid stones)

- Allopurinol:
  - Side effects (humans): Exanthems, gastrointestinal disorders, haemolytic anaemia → infrequently described in dogs
  - Most common side effects in dogs: xanthine uroliths (→ diets with low purine concentrations still necessary)
  - Efficacy (and potential toxicity) not investigated in cats


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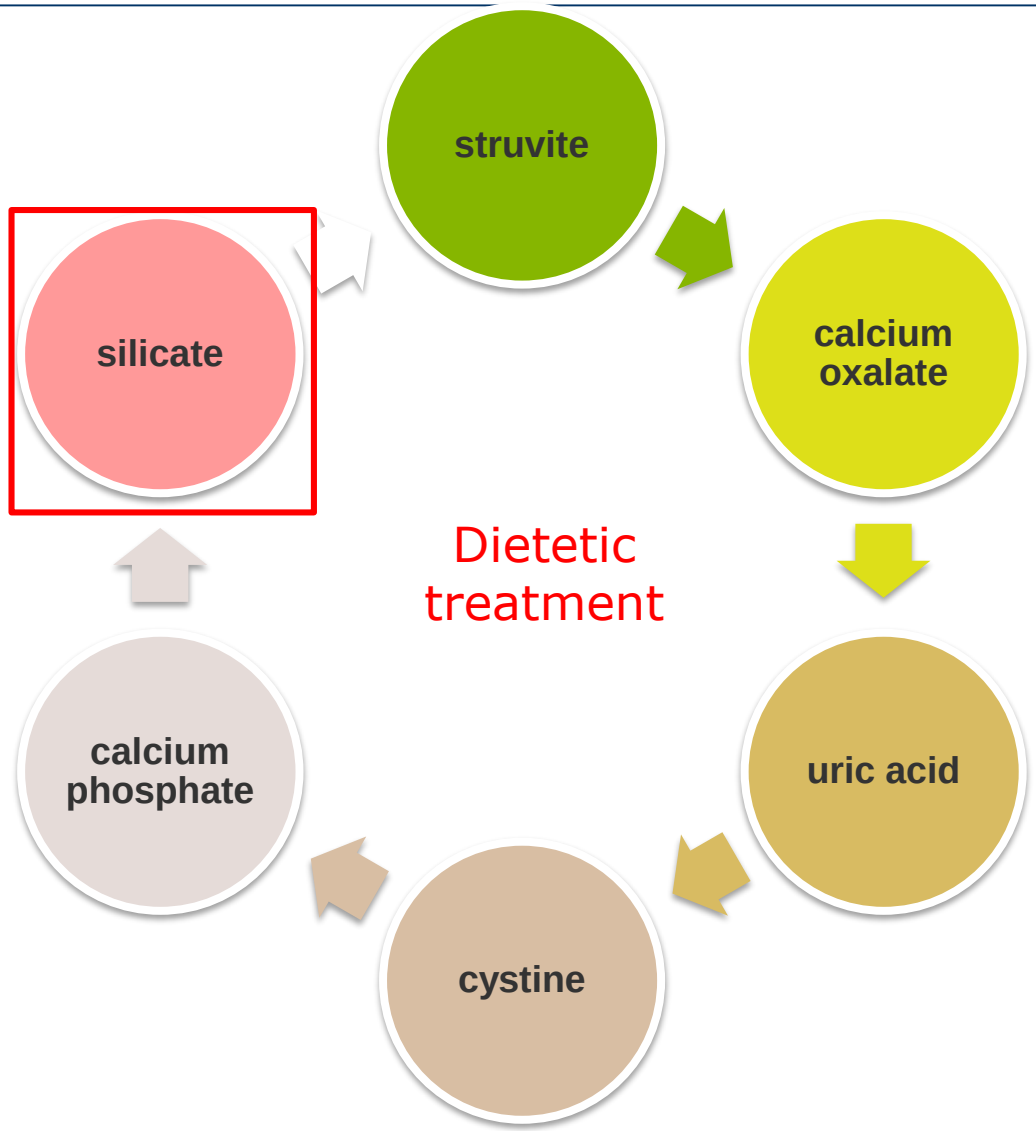
Calcium phosphate stones

- Risk factors/pathogenesis:
  - Breed: -
  - Sex: varying data
  - Age: ⌀ 7;1-8 years
  - Often associated with metabolic disorders (primary hyperparathyreoidism, other hypercalcaemic disorders, idiopathic hypercalciuria, renal tubular acidosis) and/or
  - Excessive calcium and phosphorus intake

Calcium phosphate stones

- Therapy:
  - In case of primary hyperparathyreoidism: parathyroidectomy → poss. dissolution of uroliths
  - Surgery

- Prevention:
  - Treatment of comorbidities that result in an increased renal calcium (and phosphate) excretion
  - Avoidance of an alkaline urine pH


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Summary

- Targeted dietary measures can prevent the formation of uroliths
  - In many cases (struvite) dissolution possible
- Limitations
  - Mixed concrements
  - Organic uroliths (tomcat)
  - Chronic cystitis/urinary tract infections, especially urease-positive bacteria
  - Genetic defects