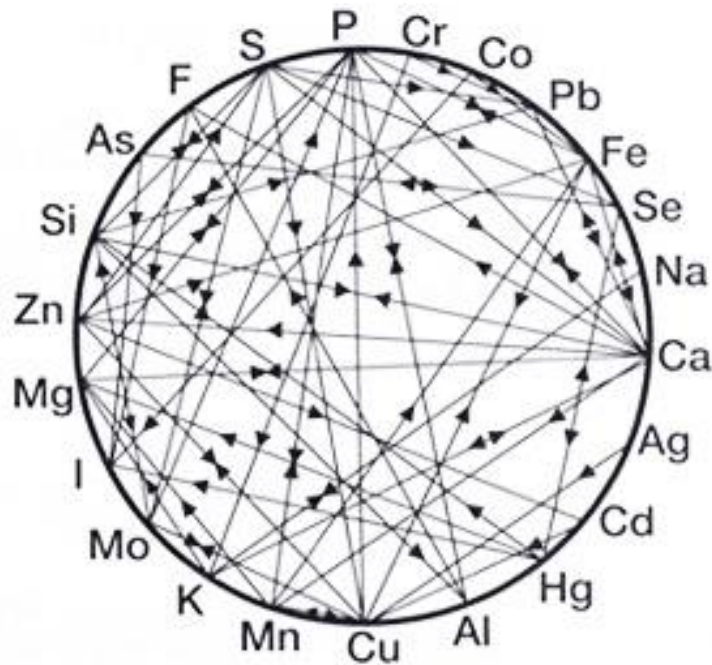


Vitamins and Trace Minerals



Cat Barr, PhD, DABT

Texas A&M Veterinary Medical Diagnostic Lab

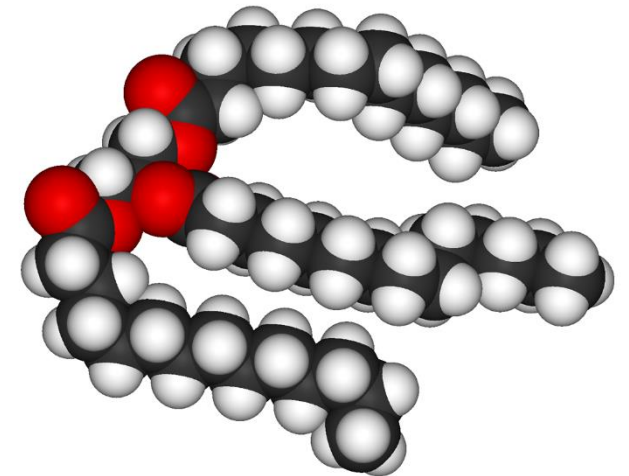
Amarillo Winter Meeting 2018

Fat Soluble Vitamins

A D E K

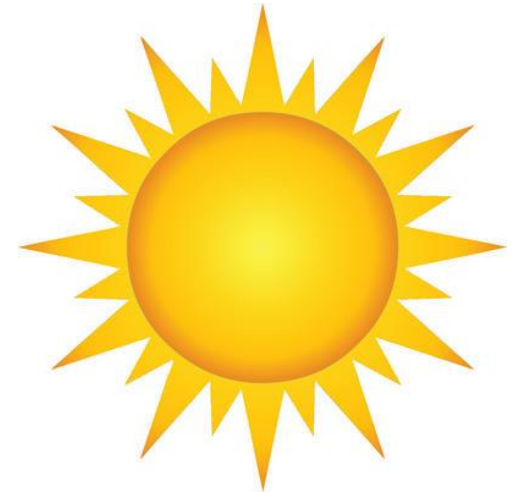


Are stored in the body
Can accumulate
Could potentially be toxic



Vitamin D

- Produced by the body when UV rays strike the skin
- Produced in sun-cured forages
- Supplementation rarely needed
- Converted by liver to 25-hydroxyvitamin D (calcidiol)
- Converted by kidney to active 1,25-dihydroxyvitamin D (calcitriol)
- Interacts with parathyroid hormone (PTH)
- Promotes calcium absorption, serum calcium homeostasis, bone remodeling
- Critical for inter- and intracellular communication
- Deficiency: rickets/osteomalacia (brittle bones)
- Toxicity: high blood calcium, loss of appetite, calcification of soft tissues



Vitamin K

- Present in green, leafy plants
 - Synthesized by ruminal/ intestinal bacteria
 - No need to supplement
 - Critical for normal blood clotting
 - Important to bone, cartilage, smooth muscle
-
- Deficiency rare
 - Toxicity not known
 - Testing not performed



Vitamin A

- Precursor β -carotene present in green forages – seasonal
- Grains contain very little, except some in yellow corn
- Degrades rapidly in the rumen when high concentrate present
- Sunlight and oxygen break it down, not much in hay
- Ensiling preserves β -carotene but makes it less bioavailable
- Stored in liver, but not more than 2-4 months' worth
- Serum levels not affected until liver stores almost gone
- Supplemental: all-*trans*-retinyl acetate, all-*trans*-retinyl palmitate

Vitamin A

- Component of visual purple required for dim light/night vision
- Component of visual pigments (rods & cones)
- Critical for maintenance of all epithelial tissues
- Required for bone development
- Protective against infection (particularly mastitis)
- Essential for normal growth and reproduction
- Barely crosses placenta – colostrum critical



Vitamin A

- Deficiency: reduced feed intake, rough hair coat, joint & brisket edema, lacrimation, xerophthalmia, improper bone growth, slow growth, increased incidence of infections, low conception rates, abortion, stillbirths, blind calves, abnormal semen
- Toxicity: rarely a problem in livestock
- Stored in liver, but not more than 2-4 months' worth
- Serum levels not affected until liver stores almost gone
- Liver biopsy or test livers of animals that die, stillbirths, abortions
 - run weekly at TVMDL-CS
 - protect from light and freeze before shipping for best results

Vitamin E

- Occurs naturally in green grass as α -tocopherol
- Degraded in hay
- Degraded by ruminal bacteria
- Destroyed by heat, oxygen, moisture, unsaturated fatty acids, trace minerals and high nitrate concentrations
- Level of supplementation needed varies with bovine diet
 - Difficult to formulate
 - Supplemental form all-*rac*- α -tocopheryl acetate
 - Depends on amounts of antioxidants, sulfur-containing amino acids, and selenium present
- Water-soluble supplements may increase levels rapidly for horses

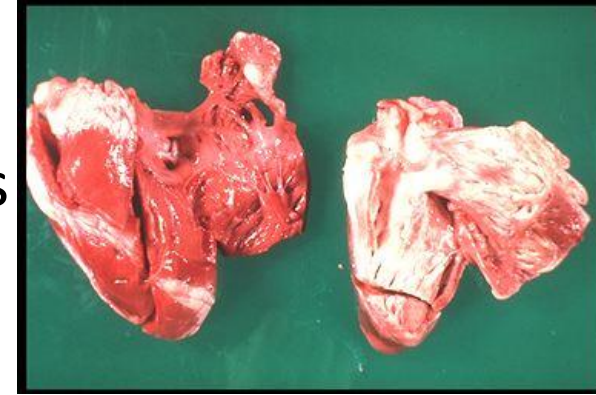
Vitamin E

- Lipid-soluble cellular antioxidant – membrane maintenance
- Arachidonic acid metabolism (prostaglandins)
- Free radical scavenger in the immune system
- Protects and facilitates uptake & storage of Vitamin A
- Functions closely linked with Selenium
- Maintains structural and functional integrity of
 - skeletal muscle
 - cardiac muscle
 - smooth muscle
 - peripheral vasculature



Vitamin E

- Present in many tissues, but not stored in high concentrations
 - Highest in liver and body fat
 - Barely crosses placenta – colostrum critical
- Deficiency: classically, white muscle disease; general muscular dystrophy, leg weakness, crossover walking, impaired suckling ability, heart failure, paralysis, hepatic necrosis
- Toxicity: Not known to occur, since large stores not maintained
- Serum levels not affected until liver stores almost gone
- Liver biopsy or test livers of animals that die, stillbirths, abortions
 - Run weekly at TVMDL-CS
 - Protect from heat, freeze before shipping if possible



Water Soluble Vitamins

Generated by ruminal microbes

- Biotin
- Folic acid
- Inositol
- Niacin (nicotinamide)
- Pantothenic acid
- Riboflavin (B2)
- Thiamine (B1)
- Cobalamine (B12)
- B vitamins in general

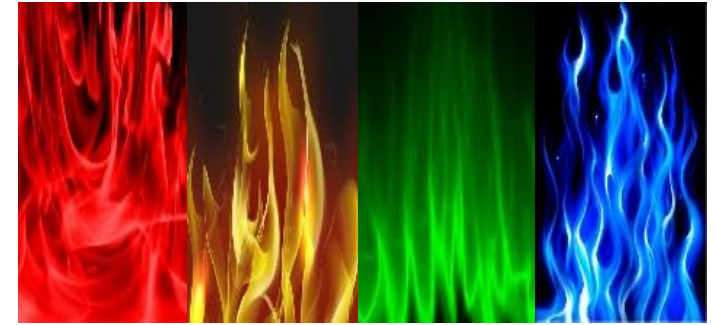
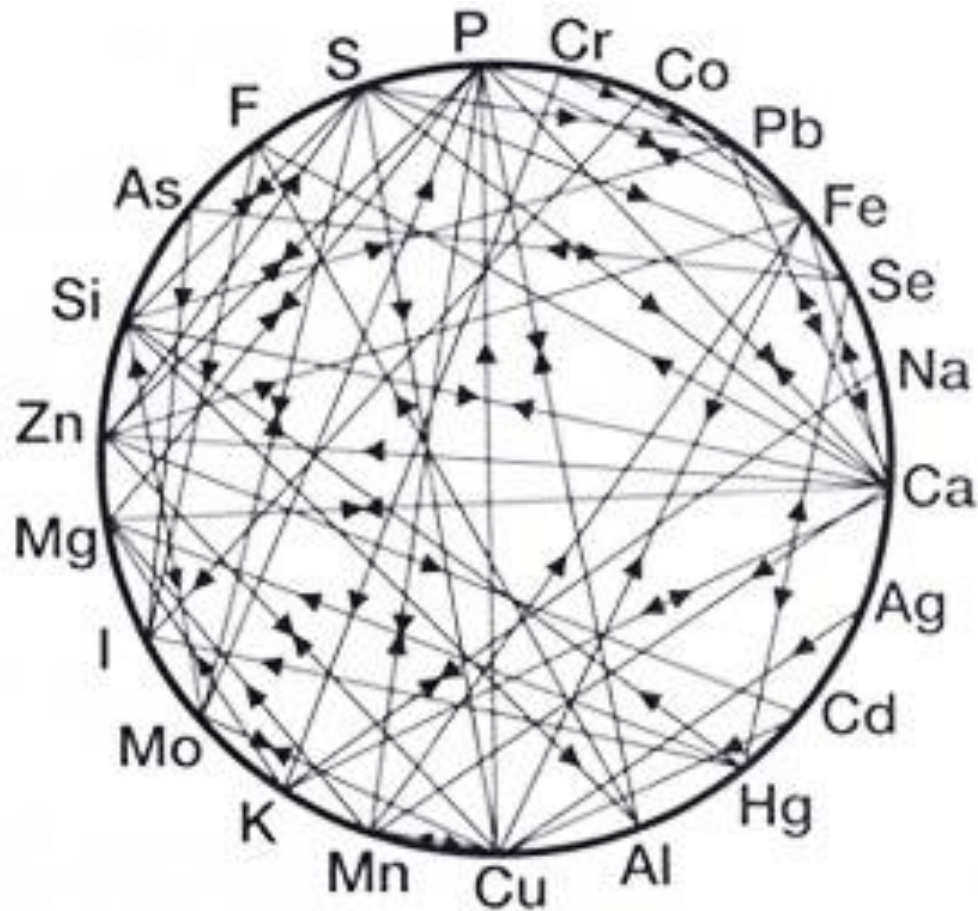
Vitamin C

- water soluble antioxidant
- synthesized by ruminants over 3 weeks old

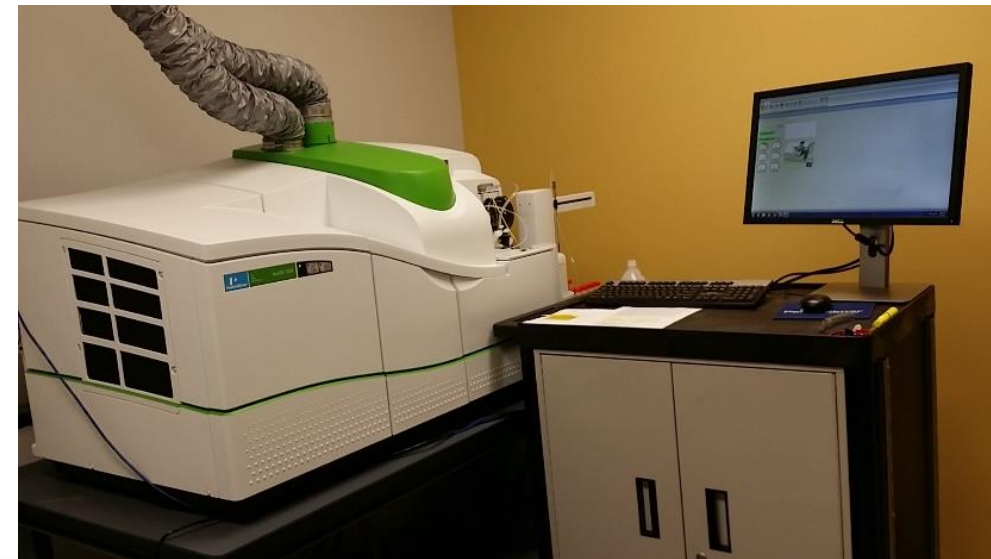
Choline

- required in g rather than mg amounts
- required in milk replacers
- degraded in rumen
- Deficiency: muscular weakness, fatty liver, renal hemorrhage

Trace minerals



ICP/MS



Chromium



- Component of glucose tolerance factor
- Increases immunity and growth rate in cattle
- Trivalent chromium, maximum tolerable level, bovine: 1000 mg/kg diet [hexavalent is the more toxic form]
- Dietary recommendations not yet set



Cobalt



- Vitamin B12 made by ruminal bacteria from dietary cobalt
- High concentrate diets reduce B12 production
- B12, with its attached cobalt, is stored in the liver
- Deficiency: Decreased appetite, failure to grow, weight loss, decreased resistance, fatty liver, anemia
- Toxicity: Unlikely unless mineral mixing error. Test liver cobalt.
- Liver and serum levels not tightly defined

Gathering data to develop better normal ranges in liver and serum



Copper



- From feedstuffs, incorporated into enzymes in tissues
 - Bone and connective tissue strength
 - Transporting iron for hemoglobin synthesis
 - Cellular antioxidation and phagocytic cell function
 - Melanin pigment
- Pre-ruminants absorb up to 60% of oral copper
- Adults absorb 1 - 5% (reduced more by dietary S, Mo, Fe)
- Stored in the liver



Copper Deficiency

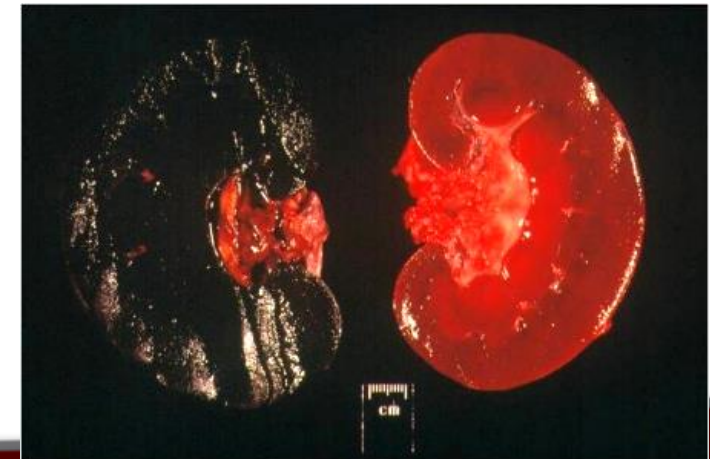
- Reduced growth
- Black-hair turns reddish
- Decreased reproductive efficiency
 - Delayed or depressed estrus
- Decreased disease resistance
- Cardiac failure
- Brittle bones





Copper Toxicity

- Accumulates in liver when over-supplemented
 - Sheep far more susceptible than cattle
- Stress-induced sudden release to circulation
- Intravascular hemolysis
 - Reduced oxygen to tissues
 - Hemoglobinuria
 - Renal dysfunction
- Molybdate compounds antidotal



Iodine

- From feedstuffs
- Critical component of thyroid hormones
 - Regulation of metabolism
 - Calcium homeostasis
- Secreted into milk – reasonable indicator of dietary status
- Deficiency: fetal death with normal cows; goiter in newborn calves
- Toxicity: 5 mg/kg dm too high; decreased milk production, excess nasal and ocular discharge, salivation, coughing

Iron



- From feedstuffs, incorporated into enzymes in tissues
 - Myoglobin and hemoglobin
 - Metabolic enzymes in liver and kidney
 - Required for cellular energy management
- Deficiency: anemia, decrease rate of gain, reduced immune response
- Toxicity: Interference with Cu, Zn; may deposit in tissues; oxidative stress; decreased gain
- Stored in the liver





Manganese



- From feedstuffs, incorporated into enzymes in tissues
 - Mucopolysaccharide production
 - Critical for bone and cartilage growth/maint
 - Important to immunity
- Deficiency: decreased growth, skeletal abnormalities, ataxia due to incomplete inner ear development
- Toxicity is unlikely: Feed intake and growth are depressed with diets > 1000 mg/kg
- Stored in the liver

Gathering data to develop better normal ranges in liver and serum

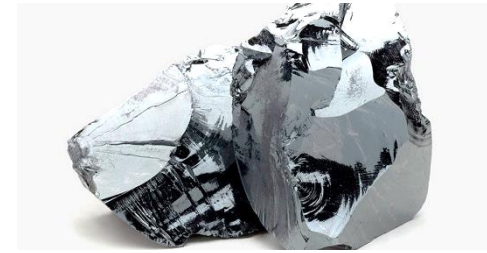
Molybdenum



- From feedstuffs, incorporated into enzymes in tissues
 - Important in several basic metabolic pathways
- Deficiency is difficult to reproduce, signs unclear; suggests supplementation is not necessary
- Toxicity: Directly antagonizes Cu absorption, clinical signs are due to Cu deficiency
- Stored in the liver

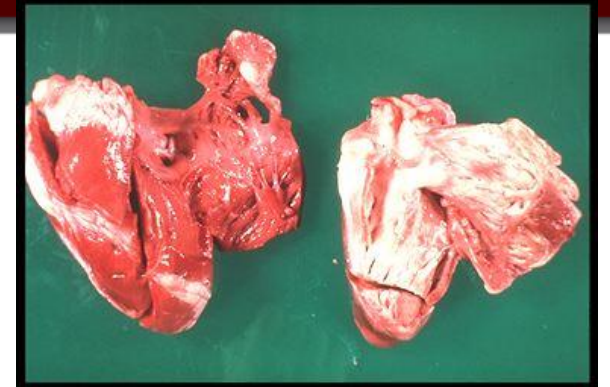
Gathering data to develop better normal ranges in liver and serum

Selenium



- From feedstuffs, incorporated into enzymes in tissues
 - Cellular antioxidant – part of glutathione peroxidase
 - Particularly in muscle and cartilage
 - Synergistic with Vitamin E
 - Critical to thyroid hormone metabolism
 - Important for prostaglandin metabolism
- Stored in the liver

Selenium



- Deficiency
 - Classically, white muscle disease
 - Leg weakness, stiffness, flexion of hock joints, muscle tremors, heart failure
 - Unthriftiness, diarrhea, fetal membrane retention, cystic ovaries, udder edema
- Toxicity: Sloughing hoofs, lameness, hair loss, emaciation (alkali disease, blind staggers – not)



Zinc



- Cofactor for many enzymes
 - Critical for immunity and metabolism
 - Needed for thyroid hormone binding
 - RNA synthesis & protein production
- Deficiency: decreased rate of gain, decreased testicular growth, hoof/horn weakness, parakeratosis, thymic dystrophy, lymphoid depletion; decreased cell-mediated immunity
- Toxicity: Suppression of copper uptake

Vitamin A, Vitamin E

Serum, off the clot

Liver

For Vitamin A – protect from light



Mineral Panels at TVMDL

Trace Minerals

Cobalt	Serum only
Copper	Serum & EDTA
Iron	Liver
Manganese	Feed
Molybdenum	
Selenium	
Zinc	

Heavy Metals

Arsenic	Serum & EDTA
Cadmium	EDTA only
Lead	Liver
Thallium	
Zinc	

Comprehensive Metal Panel =
Trace Minerals + Heavy Metals

Cat Barr, Diagnostic Toxicologist

TVMDL – College Station

483 Agronomy Road

acbarr@tvmdl.tamu.edu

digitaltoxicology@tvmdl.tamu.edu

Toll free 888-646-5623

Main 979-845-3414

Tox 979-845-1454