Classes of Nutrients Required

- Water
- Carbohydrates
- Lipids (Fats)
- Protein
- Minerals
- Vitamins
Water

- Cheapest, most abundant, most critical nutrient
- ~70% of wt of newborn; 45-60% at maturity

Functions

Water (cont.)

- Sources for animal
  - Drinking water
  - Water in feed
  - Metabolic water
Water (cont.)

- Dry matter *vs.* as-fed
  - Water content varies w/ ruminant & horse feeds
  - Swine and poultry usually “as-fed”
  - When using tables, **be aware of DM *vs.* as-fed**

- Determination of DM content

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Carbohydrates

- Account for
  - Main source of energy for animals
  - Primarily starches and cellulose
    - Also
    - Cell walls:
    - Cell contents:
    - Glucose
Carbohydrates

- Sugars/starches readily digested
- Fibrous feeds less well digested
- No requirement for CHO per se
  - Energy values expressed by several methods:

Lipids (Fat)

- Account for
- Insoluble in H₂O; soluble in organic solvents
- Because oil is valuable it is extracted from many oil seeds
  - Soybeans
  - Cottonseeds
  - Flax seeds (linseed)
  - Peanuts
Lipids (Fat) cont.

- Units of measure:
  - 
  - 
  - 
- 2.25X more energy than CHO or protein
  - 
  - 

Lipids (Fat) cont.

- Functions
  - 
  - 
  - 
    - Linoleic acid (C_{18:2 \omega-6})
    - Linolenic (C_{18:3 \omega-3})
    - Need only ~ 1 tablespoon of oil per day
  - 
  - 
  - 

EFA – Pg. 25
Kellems
Protein

Found in greatest amount of any nutrient, except water, in all living organisms
- Made up of amino acids
- Need a continuous supply in diet
- Most N in feeds is in protein
  - Why “crude” protein?

Protein (cont.)

- Protein terminology
  - True protein -
  - Nonprotein nitrogen (NPN) -
    - Made up of AA linked by peptide bonds
Protein (cont.)

- Animals require AA...not protein
  - Essential AA (also called *indispensable* AA)
    - Phenylalanine (PHE)
    - Valine (VAL)
    - Threonine (THR)
    - Tryptophan (TRY)
    - Isoleucine (ILE)
    - Methionine (MET)
    - Histidine (HIS)
    - Arginine (ARG)
    - Leucine (LEU)
    - Lysine (LYS)

Protein (cont.)

- Nonessential AA (also called *dispensable*)
  - Alanine (ALA)
  - Aspartic Acid (ASP)
  - Asparagine (ASN)
  - Cysteine (CYS)
  - Cystine (CYS-CYS)
  - Glutamic Acid (GLU)
  - Glutamine (GLN)
  - Glycine (GLY)
  - Proline (PRO)
  - Hydroxyproline (OH-PRO)
  - Serine (SER)
  - Tyrosine (TYR)
Protein (cont.)

- Requirements
  - Greater for young, rapid growing (as % of diet)
  - Monogastric animals require AA, not protein
  - Balance ruminant diets for protein
  - Exceptions...

Minerals

- Ash = total mineral content of plant or animal
- Minerals ~3-5% of animal body
  - Ca = approx. ½ of mineral content
  - P = approx. ¼
  - All other minerals = approx. ¼
Minerals (cont.)

Classification
- Macrominerals (major)
  - Ca, P, Na, Cl, Mg, K, S
  - Units of measure usually expressed in gm or as a % of diet or feed
- Microminerals (usually called “trace minerals”)
  - Co, Cu, F, I, Fe, Mn, Mo, Se, Zn
  - F and Se are toxic in excess amounts
  - Units of measure usually expressed in mg or μg or as a % of diet or feed

Minerals (cont.)

General functions
- Skeletal formation/maintenance
- Protein synthesis
- Oxygen transport
- Fluid balance & acid-base balance
- Cofactors in enzyme systems
Minerals (cont.)

- Some specific functions/Signs of deficiency
  - Ca
    - Bone and teeth formation; muscle contraction; blood clotting
    - Def: Rickets (young), osteoporosis (adults); tetany (intermittent muscle contractions); milk fever in dairy cattle (paturient paresis)
  - P
    - Bone and teeth formation; high-energy phosphate bonds
    - Def: Rickets, chewing on wood or boards (depraved appetite), eating soil (pica)

Minerals (cont.)

- Some specific functions/Signs of deficiency
  - Mg
    - Bone formation; enzyme cofactor for ATP formation and utilization
    - Def: hyperirritability and convulsions; loss of equilibrium; tetany
  - Fe
    - Cellular respiration (hemoglobin; myoglobin; cytochromes
    - Def: anemia
Minerals (cont.)

- Some specific functions/Signs of deficiency
  - Zn
    - Cofactor for enzyme systems
    - Def: Parakeratosis in swine (rough, thickened skin); poor hair development; slipping of wool
  - Co
    - Component of vitamin B\textsubscript{12} (also called cobalamin)
    - Def: Macrocytic anemia; Ruminants: severely reduced appetite and growth leading to death
  - I
    - Thyroxine formation (regulation of BMR)
    - Def: Goiter

Iodine

Simple goiter – enlarged thyroid gland due to I deficiency
Minerals (cont.)

- Some specific functions/Signs of deficiency
  - Se
    - Component of glutathione peroxidase which protects against cellular membrane damage; functions with vitamin E
    - Def: easily ruptured blood cells; nutritional muscular dystrophy (white muscle disease)
    - Excess: blind staggers; sloughing of hooves, tails
  - F
    - Bone formation; traces protects against teeth decay
    - Excess: defects in enamel; bone deformities

Minerals (cont.)

- Salt
  - Always should be available either free choice or incorporated into diet
    - Ruminants and horses - 0.5 to 1% of diet
    - Pigs and poultry - 0.25 to 0.5% of diet
  - Trace mineralized salt often used
    - TMS = 97% NaCl + Co, Cu, Fe, I, Mn, Zn & sometimes other minerals
Minerals (cont.)

- **Ca, P, and Vitamin D**
  - Try to keep the ratio of Ca to P (Ca:P) in the range of 2:1 to 1:1
  - Vitamin D is necessary for Ca absorption from intestines and bone deposition
  - Vit. D involved in renal reabsorption and bone deposition of P

Minerals (cont.)

- **General feeding guidelines** *(Know!)*
  - General rule-of-thumb
    - Grains tend to be low in Ca and adequate in P
    - Forages tend to be low in P and adequate in Ca
  - Phytic acid binds ~half the P in plants, and phytin-P is poorly utilized by nonruminants
    - Not a problem for ruminants because of rumen microorganisms
  - Fe needed for young pigs
Vitamins

- The name comes from “vital amines” which was shortened to “vitamines.”
  - “Vital” for life
  - Contain N
  - Vitamins A & C discovered….contained no N
    - Became “vitamins”
- Necessary for metabolic activity but do not become part of structural components of body

Vitamins (cont.)

- 4 fat-soluble vitamins
  - A, D, E, K
- 10 water-soluble vitamins
  - Thiamin, riboflavin, pantothenic acid, niacin, pyridoxine, biotin, folic acid, choline, B\textsubscript{12}
  - Vitamin C
- Monogastrics require a dietary source of all
- Ruminants: microorganisms synthesize Vitamin K, B vitamins & Vitamin C
Fat-soluble vitamins have “provitamins” (precursors)
- Chemically related substances that the body can convert to the active form of the vitamin
  - Carotene $\rightarrow$ Vitamin A
  - Cholecalciferol (animal) & ergocalciferol (plants) $\rightarrow$ Vitamin D
  - $\alpha$-Tocopherol $\rightarrow$ Vitamin E
  - Menadione $\rightarrow$ Vitamin K

No provitamins for the B-vitamins or Vit. C

Storage

Functions
- B-vitamins
  - Fat-soluble vitamins
Vitamins (cont.)

- Primary functions/Signs of deficiency
  - Vitamin A
    - Vision, epithelial tissue maintenance, bone formation
    - Def: Night blindness, xeropthalmia; abnormal bone growth
  - Vitamin D
    - Bone formation/maintenance of blood Ca concE
      - Ca absorption, P reabsorption (renal tubules)
    - Def: Rickets (growing youth); osteomalacia (adult rickets – softening of bones)

Vitamins (cont.)

- Primary functions/Signs of deficiency
  - Vitamin E
    - Antioxidant / Maintain membrane integrity
      - Protect Vitamin A, essential fatty acids, etc. from peroxidation
      - Membrane lipid bilayers are high in PUFA which are subject to oxidation. Vitamin E's function in maintaining membrane integrity might attribute to its prevention of the membrane damage
    - Def: nutritional muscular dystrophy
Vitamins (cont.)

- Primary functions/Signs of deficiency
  - Vitamin K
    - Prothrombin formation; blood clotting
    - Def: spontaneous hemorrhages; prolonged clotting time
  - Antivitamin (antagonists)
    - Sweetclover disease in cattle
      - Dr. Karl P. Link
      - Dicoumarol; warfarin

Vitamins (cont.)

- Primary functions/Signs of deficiency
  - Niacin
    - Coenzyme for oxidation/reduction reactions (energy metabolism)
      - NAD & NADP
    - Def: pellagra (pelle for skin; agra for sour); 1730
      - Rough skin; dermatitis; “black tongue” in dogs
      - Humans: 3D’s - dermatitis, diarrhea, dementia
      - Spread with the spread of the cultivation of corn
      - Epidemic in southern U.S. after Civil War
        - 1915 – 10,000 deaths
Pellagra

1937 – Discovery: caused by niacin deficiency
   - Dr. Conrad Elvehjem

Two problems with corn
   - Niacin is bound (Bound form called niacytin)
   - Corn is low in tryptophan (precursor for niacin synthesis)

Discovery was confusing
   - Caused by spoiled corn? Infectious?
   - Low protein diets also resulted in pellagra (no Tryp)
   - Milk prevented and cured pellagra (↓ niacin but ↑ Tryp)
   - Mexicans eat tortillas, but very little pellagra
     - Soak corn in lime water to make tortillas; lime frees niacin!

Vitamins (cont.)