Nutrition
The relationship of food and nutrients to health

Essential for normal development and overall health

Components
- Water
- Carbohydrates
- Protein
- Lipids
- Vitamins
- Minerals
Water
• For lubrication, nutrient transport and absorption and waste excretion
• Higher requirements in young animals
• Presentation

Carbohydrates
• Used for energy
  • Many readily available & easily metabolized
• Sugars, starches and fiber
  • Structural
  • Fiber
  • Nonstructural
    • Sugar and starch

Energy = 4.15 kcal/g of carbohydrate

Carbohydrates
• Fiber
  • Stimulates normal gut motility
  • Provides bulk to intestinal contents
  • Slows GI transit time
  • Stimulates growth of beneficial bacteria

• Beet pulp • Apple and tomato pomace • Peanut hulls • Citrus pulp • Oat, rice, or wheat bran • Cellulose
Protein

- Composed of amino acids
  - Essential
  - Non-essential
- Used to renew body’s nitrogenous components
  - Muscle, hair, hooves, antibodies . . .
- Plant protein ≠ Animal protein

Energy = 4.4 kcal/g of protein

Lipids

- Composed of fatty acids
  - Fats: Solid at room temperature
  - Oils: Liquid at room temperature
- Used for energy, cell membranes and hormones
- Facilitates absorption of fat soluble vitamins

Energy = 9.4 kcal/g of protein

Vitamins

- Organic compounds different from carbohydrates, proteins and lipids
- Used for enzymatic reactions, DNA synthesis, eye function, blood clotting . . .
  - Water soluble
    - B Vitamins
    - Vitamin C
  - Fat soluble
    - Vitamin A
    - Vitamin D
    - Vitamin E
    - Vitamin K
B Vitamins

- Essential for carbohydrate, amino acid and fatty acid synthesis and metabolism, enzyme function and nerve transmission
- Sources
  - Most natural foods contain B vitamins
  - Deficient foods
    - Many refined foods
    - Dead fish
- Requirements increase when metabolism increases
  - Fever, muscular activity, growth

Vitamin C

- Important for collagen synthesis; free radical scavenger and antioxidant
- Abundant in most fruits, vegetables and organ meat
- Most animals synthesize their own
  - Caves, primates, swallows do not

Vitamin A

- Important for vision, reproduction, immune health, feather pigmentation, growth and maintenance of epithelial cells throughout the body
- Forms
  - Provitamin = carotenoids
    - Green, orange, yellow plants and crustaceans
  - Active form = retinal
    - Liver, egg yolk, marine fish
- Some animals can convert carotenoids into retinal; others need to ingest the active form
Vitamin A
- Deficient foods
  - Seeds
  - Muscle meat
  - Unsupplemented insects
  - Some nectar formulations

Pesticide exposure can decrease vitamin A function.

Vitamin D
- Important for calcium, magnesium and phosphorous metabolism and balance
- Naturally occurring forms
  - D3 = Calcitriol
  - From animal sources – fish, egg yolks
  - D2 = Ergocalciferol
  - From plant sources – mushrooms
- Synthesized in some species
  - UV rays from sunlight act on a pre-cholesterol molecule in the skin

Vitamin E
- Antioxidant in cell membranes
- Sources
  - Leafy green vegetables
  - Seeds
  - Nuts
Vitamin K
• Important for effective blood clotting
• Sources
  • Leafy greens
  • Animal fats
  • Intestinal bacteria production

Minerals
• Inorganic nutrients
• Cannot be synthesized by the animal
• Used for enzymatic reactions, structural support (bones, teeth), acid-base balance, muscle and nerve function...
• Macronutrients
  • Required in the diet in percentage amounts
  • Calcium, phosphorous, magnesium, potassium, sodium, chloride and sulfur
• Micronutrients
  • “Trace” minerals, required in very small amounts
  • Many; including iron, zinc, copper, selenium

Calcium
• Important for structural integrity of bones and teeth, cell signaling, muscle and nerve function
• Sources
  • Bones
  • Milk
  • Leafy greens*
  • Oyster shell
• Deficient foods
  • Muscle and organ meat
  • Eggs
  • Meat trim

*Oxalate presence in some limits availability (e.g. spinach)
Phosphorous
- Structural rigidity of bones and teeth, cell membranes, energy (ATP), DNA/RNA
- Sources
  - Muscle and organ meat
  - Insects
  - Seafood

Recommend 2:1 Ca:P

Magnesium
- Essential for normal bone formation and enzyme function
- Sources
  - Green leafy vegetables
  - Nuts

Selenium
- Helps protect the body from oxidative damage
- Source
  - Soil in some regions of the country
Supplements

- Nutrient supplementation should be judicious
- Over-supplementing can be as dangerous as a deficiency
- Only implement in the face of a recognized deficiency or imbalance
- Balanced diet >> supplements

Kcal Calculation

Equation used to estimate the number of calories needed for maintenance of an individual animal based on species and age. Use as a starting point and adjust as needed based on the animal’s response.

Resting Energy Requirement (RER) = k x (weight in kg^0.75)

RER also known as Basal Energy Requirement (BER)

Metabolic Constant K Value

<table>
<thead>
<tr>
<th>Species</th>
<th>K Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birds</td>
<td></td>
</tr>
<tr>
<td>Juvenile passerine</td>
<td>280-420</td>
</tr>
<tr>
<td>Adult passerine</td>
<td>175</td>
</tr>
<tr>
<td>Juvenile non-passerine</td>
<td>156-234</td>
</tr>
<tr>
<td>Adult non-passerine</td>
<td>125</td>
</tr>
<tr>
<td>Mammals</td>
<td></td>
</tr>
<tr>
<td>Juvenile placental</td>
<td>140-270</td>
</tr>
<tr>
<td>Adult placental</td>
<td>70-90</td>
</tr>
<tr>
<td>Marsupial</td>
<td>48</td>
</tr>
<tr>
<td>Reptiles</td>
<td>32</td>
</tr>
</tbody>
</table>

3/22/2017
Kcal Calculation

Often need to adjust for additional energetic costs.

Daily Energy Requirement (DER) = required number of calories based on specific condition

*Still an estimate

- Cage rest = 1.25 × RER
- Post-op = 1.25 to 1.35 × RER
- Trauma = 1.35 to 1.5 × RER
- Neoplasia = 1.35 to 1.5 × RER
- Sepsis = 1.5 to 1.7 × RER

Diet Composition

- Natural history of the species
- Environment
- Age
- Season
- Breeding
- Molting
- Pre-existing conditions

Natural History - Birds

- Huge variation!
- Passerines:
  - More than 5,000 spp
  - Frugivores, carnivores, insectivores, granivores, omnivores
Natural History - Birds

- Raptors:
  - Carnivores
  - Whole prey
- Seabirds:
  - Piscivores
  > 3 species of fish/crustacean required
- Corvids:
  - Omnivores
- Woodpeckers:
  - Insectivores

Natural History - Birds

- Anseriformes (ducks, geese, swans):
  - Herbivorous, omnivorous, piscivorous
  - Commercial/game pellets available - not suitable for all species
- Galliformes (turkeys, quail, pheasants):
  - Herbivorous, omnivorous
  - Commercial diets often ok
  > May need insect supplementation

Natural History - Mammals

- Many commercial pet/zoo diets can be used alone or in addition to whole foods
  - High insect diets should be supplemented with calcium
Natural History - Mammals = Omnivore

Natural History - Mammals = Carnivore

Natural History - Mammals = Rodent
Natural History - Mammals

- Orphans
  - Appropriate formula at regular intervals
  - Lactose content of milk often varies widely between species
  - Domestic milk replacers can be suitable; specialized formulas exist
  - Artificial success often depends on having been with mother until a particular age
  - Immune development
    - Bursa of Fabricius
    - Colostrum

Natural History - Reptiles

- Carnivores – Snakes, snapping turtles
- Omnivores – Box turtles
- Herbivores – Iguanas

Some commercial diets exist; whole, natural foods often ideal

Natural History - Juveniles

Babies ≠ Small Adults

Generally require higher percentages of protein and fat
Diet Composition

- Food
  - Natural
  - Whole prey
    - Mice, rats, chicks, quail, fish
    - Insects/worms
  - Native Fruits and vegetables
  - Foliage
    - Grass, leaves
  - More likely to encourage self-feeding

Commercial Diets

- Wide variety of brands and formulations
- There is no rapid, reliable way to assess diet quality
- Nutrition profile
- Ingredients
  - Type, amount
  - Experience
  - Scientific literature
  - Company reputation and reviews

Commercial Diets

- Dry diets:
  - ~10% water
  - Most combined and cooked ~150 degrees
  - High temps makes starches easily digestible, destroys toxins and bacteria
- Canned diets:
  - ~75% water
- Raw diets:
  - No preservatives
Commercial Diets

- As fed vs dry matter
  - Converting dry as fed food to dry matter
    - Add 10%
    - 25% as-fed protein = 25% + 2.5% = 27.5% dry matter protein
  - Converting canned as fed food to dry matter
    - Multiply by 4
    - 6% as-fed protein = 6x4 = 24% dry matter protein

Commercial Diets

Product name that contains an ingredient indicates % in the product
- "Beef"
  - Beef ingredients ≥ 95% of total weight of all dry ingredients
- "Beef dinner/platter/entrée"
  - 25-95% of dry weight
- "With beef"
  - 3-24% of total product
- "Beef flavor"
  - Only enough for taste (≤ 3%)

Commercial Diets

- "Complete and balanced"
  - Indicates all nutrients in the correct levels currently known to be required for the species
Commercial Diets

- "Natural"
  - A food or ingredient derived solely from plant, animal, or mineral sources, either in its unprocessed state or not having been subject to a chemically synthetic process
- "Organic"
  - Currently, encompasses human foods; can only be used in pet foods if human standards are met; ≥ 95%
- "Made with organic"
  - 70-94%
- "Holistic"
  - Not legally defined or regulated by pet food regulations. Read: meaningless

Feeding guidelines:

GALORIE CONTENT: Nominally Energy: Calculated
4,015 kcal/kg
4.28 kcal/oz
1 cup = 4.28 oz (115g)

Nutritional Analysis:
- Protein
- Fat
- Fiber
- Calorie Content

Manufactured by: [Manufacturer Information]
Commercial Diets

• Ingredient list:
  • Listed in descending order of weight
    • A food ingredient may be listed first (e.g., chicken) but if it contains 75% moisture, it will contribute a much smaller percentage of total nutrients to the food dry matter.

• Careful of ingredients listed in different forms (flaked corn, ground corn, screened corn, kibbled corn)
  • May appear at the end because each form is in small amounts, but total overall corn amount may be significant

• “Ingredient splitting”
  • No reference to quality or grade of ingredient can be listed
  • Cannot evaluate a product solely based on the ingredient list.
Commercial Diets

- Meat:
  - Any combination of skeletal, striated muscle or muscle found in the tongue, diaphragm, heart, and esophagus with or without the overlying fat and the skin, sinew, nerves, and blood vessels that normally accompany muscle
  - Must be suitable for use in animal foods and therefore excludes feathers, heads, feet, and entrails.
  - Meat by-products vary in type and nutritional content:
    - Liver, kidney, and lung have excellent nutritional value.
    - Udder, bone, and connective tissue have poor nutrient availability
    - Do not include hair, horns, teeth, or hooves

- Guaranteed analysis:
  - Minimal amounts of crude protein and crude fat
  - Maximum amounts of crude fiber and water on an as-fed basis
  - MAY NOT REFLECT ACTUAL LEVELS
Commercial Diets

- Laboratory proximate analysis
  - Lists actual nutrient concentrations

**Example: Calculating guarantees from proximate analysis data**

<table>
<thead>
<tr>
<th>Batch</th>
<th>Crude Protein</th>
<th>Crude Fat</th>
<th>Crude Fiber</th>
<th>Moisture</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21</td>
<td>1.5</td>
<td>0.5</td>
<td>8</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>20.2</td>
<td>1.3</td>
<td>0.7</td>
<td>8.2</td>
<td>0.3</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>1.6</td>
<td>0.5</td>
<td>8.1</td>
<td>0.5</td>
</tr>
<tr>
<td>Average</td>
<td>20.0</td>
<td>1.56</td>
<td>0.65</td>
<td>8.2</td>
<td>0.35</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.85</td>
<td>0.56</td>
<td>0.19</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>Average +/- SD</td>
<td>20.95</td>
<td>1.55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weights</td>
<td>2.6</td>
<td>13</td>
<td>4.5</td>
<td>8.1</td>
<td>5.3</td>
</tr>
</tbody>
</table>

**Recommended Guarantees**
- Crude Protein: 20.95%
- Crude Fat: 1.55%
- Crude Fiber: 4.5%
- Moisture: 8.1%
- Ash: 5.3%

Commercial Diets

- Statement of nutritional adequacy:
  - Indicates how the food was tested
  - Lab analysis/formulation method does not address bioavailability
  - Feeding trials: preferred
  - For what lifestage it is intended
    - The Association of American Feed Control Officials (AAFCO) recognizes 4 life stages:
      - Growth
      - Maintenance
      - Gestation
      - Lactation
    - No approved profiles for geriatric, senior or weight loss
Regulation

- Current good manufacturing practices (CGMP's)
- Enforced by FDA for human products
- Inconsistent with animal products
  - Very few health claims permissible by FDA for animal products
- Third party verifications
  - Informed-choice.org – reprimands
  - National research council – minimum nutrient requirements

Better to rely on experience, as regulation is often unreliable

Take-Home Points

- Quality counts
  - Avoid spoiled or moldy foods
  - Commercial foods (>1 year for bagged or 6-12 mos for frozen)
  - Topping off uneaten food can lead to spoiling
- Some conditions are a direct result of dietary imbalances
  - Angel wing
  - Thiamine deficiency
  - Metabolic bone diseases
  - ...

Understand the natural history of the animal to determine nutrient requirements

- May extrapolate from companion animal when appropriate
- Whole foods are more natural
- Can be unbalanced without thorough information
- Can’t always rely on the animal to consume a balanced diet
- Commercial diets can be great substitutes when the animal is amenable to eating
- Label interpretation is just that – no hard and fast rule to assess quality
- Do your research!
Helpful Resources

- Merck Veterinary Manual
- http://petfood.aafco.org/
- https://lafeber.com/vet/
- http://www.zupreem.com/
- http://www.mazuri.com/

Helpful Resources

- http://www.oxbowanimalhealth.com/vets
- http://www.foxvalleynutrition.com/
- https://www.nal.usda.gov/fnic
- Nutrition Almanac