1. **My name is Vered Nograd I have been working with wildlife for 20 years now, 15 of which were strictly wildlife rehabilitation and the last 4 my "real job" is a tech at a small animal clinic…I work with a vet that is a wonderful person and allows me to bring anything I want and do whatever I need at the clinic…so I am pretty lucky that way. I chose to talk to you today, as I did few other times in past symposiums about nutrition because I strongly believe it is a critical part of rehabilitation and many times, especially when rearing young… the only one you need to provide.**

It has been said many times…. animals will get better in spite of what we do…that might be true for some things we do but never for nutrition

- Proper nutrition is a critical part of the rehabilitation process
    - Sometime the only one you need to provide
- Plays an important role in raising orphaned animals

In their natural environment wild species have little need for supplementary feeding as their free ranging habits enable them to pursue more nutritious grazing and therefore satisfy their nutritional requirements. But in case of wildlife rehabilitation/educational ambassadors their total feed requirements have to be met

- Aids in preventing the loss of lean body mass
    - Body mass less the fat

body composition is the percentages of fat bone and muscle – muscular tissue takes up less space in our body than fat tissue – you can have 2 animals at same weight but looking different because of different body composition. Lean body mass will be the mass minus the fat

- Essential to successful wound healing

Overcoming viral and bacterial diseases

If an animal is not provided with proper nutrition, their growth rate, reproduction rate, immunity, and well-being are all affected it will delay or altogether compromise healing of wounds or the ability to overcome diseases

2. There are 6 major classes of nutrients: **carbohydrates, fats, protein**, minerals, vitamin, and water

The purpose of digestion is to convert food into smaller nutrient molecules that can be absorbed across the wall of the digestive tract…The efficiency of digesting food depends on both the quality of the food and the digestive function of the consumer

- All living organisms
    - Need energy
        - Sustain life
        - Proper metabolic function
- The energy content of a diet is obtained from:
    - Proteins
    - Carbohydrates
    - Fats
- Those nutrients
    - Ingested
    - Digested
    - Absorbed

- Transported to cells
  - used to generate energy

Nutrition: the provision of all indispensable nutrients in adequate amounts to insure proper growth and maintenance of body functions… involves various chemical reactions and physiological transformations which convert foods into body tissues and activities…

involves ingestion, digestion and absorption of various nutrients

The **digestive system** is a group of organs that work together to convert food into energy and basic nutrients that feed the entire body; it's **the foundation of good health**. This amazing system includes a combination of nerves, **hormones**, bacteria, blood and the organs of the digestive system that work together to complete the intricate task of digesting the foods and liquids that we consume every day. Digestive system includes the **brain** The hypothalamus, which is involved in **metabolic processes**, stimulates appetite. When you eat, your brain decides how you will digest that food – it will respond with stress or ease, depending on the health of your organs and your state of mind.

3. Think of it as a puzzle. All the pieces of the puzzle must be present and in the proper order for the puzzle to be complete

   Balanced diet
   - Provides all required nutrients
   - In proper ratio

- Diet that does not contain enough energy components will not permit the animal's system to use the rest of the nutrients in the diet
- Missing one nutrient can affect the efficient digestion of the entire diet
- Surplus of a nutrient can cause the animal to avoid the diet altogether
- Surplus of certain nutrients can stop the absorption of another
  - Calcium/phosphorus

Vitamin C aids to protect against Vit A toxicity
Vitamin A is transported in the body through protein enzymes
Dietary fat and zinc needed for vit A absorption

- Balanced diet provides
  - Sufficient amounts of nutrients
    - More important than specific ingredients
- Animals will have unique adaptations
  - The manner in which they eat and digest will differ
  - The manner in which it is absorbed and utilized will be the same
- Trophic level
  - Who eats who…

An avian diet in the wild can be broken down by the species' "Trophic Level" (their position in the who-eats-who food chain). Their "Trophic Level" defines what their digestive system is <u>capable of processing</u> and <u>deriving nutrients</u> from.

Carnivore (C) (nutrients derived from flesh, bones and organs of other animals)

Piscivore (P) (nutrients derived from fish)

Herbivore (H) (nutrients derived from live plant material)

Omnivore (O) (herbivore and carnivore)

Insectivore (I) (nutrients derived from insects)

Vermivore (V) (nutrients derived from worms)

Granivore (G) (nutrients derived from grains and seeds)

Frugivore (F) (nutrients derived from fruits/berries)

Molluscivore (M) (nutrients derived from mollosks, crustaceans)

Nectivore (N) (nutrients derived from nectar)

- Diet needs to be
- Free of bacteria and toxins
    - Washing all fruits and vegetables
    - Reputable food source for fish and meat
    - Proper refrigerating
    - Proper thawing
        - Freezing food keeps most bacteria from multiplying
            - does not kill them
        - Temperature over 41 °F
            - bacteria will grow rapidly
            - All foods should be kept covered in containers that are rodent- and insect-proof to prevent contamination

1. **Thaw frozen food** in the refrigerator at a temperature at or below 41 °F. ….◊ Place packages of **frozen food** in a pan so that juices cannot drip on other **foods**…◊ Change the drip pan when liquid is visible in the pan. ◊ Allow adequate time for thawing. A small quantity of food may thaw in one day, while a large product such as a turkey may take several days.
   Freezing tends to break down tissues, making the food much more susceptible to bacterial invasion after thawing – feed within 24 hours
   To promote uniform thawing, the block of meat may be cut (sawed) or broken up while still frozen and the smaller portions thawed. If a large block of frozen meat is to be thawed, it is advisable to remove the outer, thawed meat as the block defrosts. This will help ensure thawing of the inner meat section, while keeping the outer meat section from thawing for a prolonged period of time

2. “Under potable running water at a temperature of 21 o C (70 o F) or below, with sufficient water velocity to agitate and float off loose particles into the overflow.” However, running water over thawing meat packages will increase nutrient loss, especially of water-soluble nutrients, and is therefore not recommended. Thawing in standing water is not recommended because of loss of nutrients and the possibility of increased microbial buildup.
uneaten food must be removed from an animal’s enclosure within 12 hours of placement, or sooner, depending on spoilage.
If the animals are fed outside in hot, humid, sunny weather, it is important to keep the meat cool until feeding time to avoid microbial buildup, nutrient loss, or contact by disease-spreading pests. Meat should be placed in the animal’s enclosure as close as possible to the time the animal will consume it.
All foods and possibly utensils should be kept covered in containers that are rodent- and insect-proof to prevent contamination

- avoid ultimate dependence on one particular food item
- offer a variety
    - If becomes unavailable it may be difficult to entice the animal to eat a new item
    - offering a variety of food items will help assure proper and complete nutrient profile in the diet
    - The amount of food consumed
        - Should be recorded
            - Quantity and type
        - Knowledge of food consumption
            - By all employees and volunteers
        - Knowledge of normal changes in health status
            - Age, time of year…
        - Obesity can lead to congestive heart failure, hepatic lipidosis and may predispose an animal to diabetes mellitus
- **The younger they are to be introduced to different foods the more readily they will except diversity in their diet**

the amount of food the animal consumes should be recorded to track significant changes in intake. The age, species, condition, and size of each animal should be considered when feeding. The rehabber must be able to recognize alterations from a normal state of health in order to adjust food intake. The quantity and type of food consumed by each animal should be documented and kept on record

Obesity is more common than inadequate nutrient intake…carnivores can rapidly become overweight when excess amounts of a high-quality diet are offered, particularly when activity is limited. In some birds (eg, ratites, waterfowl), rapid growth rates increase the incidence of leg and wing problems. Both adult and growing animals should be routinely weighed to monitor changes.

- Energy requirements for wild animals can be difficult to determine
    - Wide variations in nutritional and energy requirements
    - Species
        - Over 400 mammal and 800 bird species in north America

As each and every one of us knows there is a lack of information available on wildlife diets

- Physiological conditions
    - Age
        - Hatchlings and juveniles need extra protein
            - Insects (even if not insect's eaters as adults)
    - Size
        - Small birds will consume more food per body weight then a larger one
    - Sex

calcium for egg production

milk production

juveniles apparently incur the highest costs – while still growing…added mobility, thermoregulation, foraging and avoiding predation

hatchlings/babies need the building blocks of the new cells that protein provides

small animals spend more energy on all aspects of their survival compare to their larger counterparts simply because of their size – i.e. flight… the most expansive item on the energy budget – small birds would have to flap it's wings hundred more times than a large bird to reach the same distance

female – extra calcium at certain parts of the year

- Environmental conditions
  - Weather
    - Food higher in fat and carbohydrate
  - Season - breeding
    - food higher in protein and carbohydrates
    - migration
      - high in protein, fats and carbohydrates.

high ambient temperature requires increase need for water to cool off and hydration

The dietary changes that characterize the "nutrition transition" include both quantitative and qualitative changes in the diet. The adverse dietary changes include shifts in the structure of the diet towards a higher energy density diet with a greater role for fat and added sugars in foods, greater saturated fat intake

A physiological study of certain migrants has revealed that metabolic patterns usually change prior to migration, and fats accumulate in the body tissues. The whitethroat (*Sylvia communis*) weighs an average of 12 to 13 grams (about 0.4 ounce) during the breeding season, 16 to 19 grams (about 0.6 ounce) in the autumn, and 20 to 24 grams (about 0.8 ounce) in the winter. Food consumption increases with the autumn molt, reaching a peak at the beginning of the migration season. These fundamental physiological changes, chiefly under the control of thethyroid gland, are correlated with migratory activity. Such fluctuations are not observed in nonmigratory species.

Some birds radically change their diets just before their winter migrations, gorging themselves on antioxidant-rich berries to prepare for their long journeys, researchers have found.

"[The] results support the hypothesis that some migratory birds may actively select deeply-pigmented fruits as a signal for meals that are rich in antioxidants," researcher Navindra Seeram of the University of Rhode Island said. "These disease-fighting antioxidants may help the birds combat stress and inflammation that they experience during long flights."

"It has been known for some time, this phenomenon of birds switching to fruits in the fall," said study co-author Scott McWilliams, a bird researcher.

The phenomenon is particularly striking because sparrows, thrushes, warblers and other birds with beaks highly specialized for eating insects suddenly begin using them to pick berries instead. A single bird can consume up to three times its weight in berries per day -- the equivalent of a human being consuming more than 300 pounds-worth of food.

- Energy expended is lowest when the animal is inactive and under thermoneutral conditions
- Energy expanded is highest
  - during flight
    - Migratory flights
  - Foraging for food
    - Technique

Hover…flight feed…sit and wait…ground foraging…chasing prey items…. For example, the highest costs, for species which characteristically feed when flying, were 68 % greater than the DEE of 'sit and wait' species with their relatively low daily activity costs …kestrel, shuck will's widow

- Territory protection
  - Territorial animal uses 17% more energy defending their territory than non-territorial
- Laying eggs
- Feeding young

- Energy is measured in kilocalories
  - one Kcal equals 1000 calories
- Knowledge of energy requirements is needed to determine how much food is needed for a specific animal in a specific situation

- To survive, the amount of energy expended in finding food must be less than the amount of energy the food gives, so the bird will have enough leftover energy for sleeping and looking for mates (Brooke 128).
- Due to these variations of energy use, birds have different nutritional needs. Small birds may need to eat their weight in food every day because of their high BMR. For example, a Blue Tit weighs 11g, and it needs 1 kcal per gram of body weight each day in winter, which is about 300 small insects, about 10g in weight. Large birds, however, need relatively less food. A Kestrel that weighs 220g needs only 1/3 of a kcal per gram of body weight each day in winter, or about 120g of food (Brooke 134).

- **BER- basal energy requirement**
  - **Energy needed for healthy, awake, fasting animal in thermoneutral environment**
  - **Enough energy to maintain body function on a cellular level**
- **RER- resting energy requirement**
  - **Healthy animal at rest, thermoneutral conditions**
  - **Sufficient energy for digestion, absorption, and metabolism of food**
- **MER- maintenance energy requirement**
  - **Healthy, moderate active animal**
  - **BER plus energy for regulating body temperature and moderate activities**
- **DER – daily energy requirement**
  - **Healthy, normal activity for the species**
  - **Energy sufficient to maintain normal body weight**
  - **Energy needed for work, growth, lactation, and gestation**

- ***RER***
- **Placental animals**
  - **$70(\text{body weight in kg})^{0.75}$** **$70(BWkg)^{0.75}$**
- **Marsupial mammals**
  - **$49(\text{body weight in kg})^{0.75}$**
- **Reptiles**
  - **$10(\text{body weight in kg})^{0.75}$**
- **Passerine birds**
  - **$129(\text{body weight in kg})^{0.75}$**
- **Non-passerine birds**
  - **$78(\text{body weight in kg})^{0.75}$**
- **Seabirds**
  - **$90(\text{body weight in kg})^{0.75}$**

Standard equations for RER of different species have been developed by researchers, those equations estimate the RER of the specific animal and then are multiplied by an appropriate factor to find the DER – this result will tell you the number of Kcals needed to be fed per day

- **DER**
  - **For sick, anorectic, or wounded animals**
    - **1.5-2 x RER**
  - **Cells need extra energy in order to heal/generate**
- **Healthy young**
    - **4 X RER**
  - Extra energy for new tissue growth and proper development
- **sick orphans**
    - 5x RER
  - supply sufficient energy for new tissue growth and for fighting infections or healing injuries

Cells need extra energy to be able to perform the task of healing an injury or fighting an infection, however since a sick animal in captivity is usually inactive and in thermoneutral conditions - the DER is going to be below what might be expected under free ranging conditions – therefore it is safe to start the diet plan at RER and increase it gradually to DER for the specific situation.

- As the baby grows the DER decreases
  - **Healthy adult animal's DER should not be more then 2x RER**
- When reducing feeding and Kcal/day
  - Weigh babies on a daily basis
  - If losing weight
    - Put back to previous diet schedule and monitor closely for weight gain

As the animals grow the DER decreases – **healthy adult animal DER should not be more then 2x RER.**

- **Calculate the RER of the specific animal**
  - **Multiplied by an appropriate factor to find DER**
- **The result will present the daily amount of Kcals/day**
  - **Not the ml/day**
- **Each supplement will have a different amount of Kcals/ml**

- Squirrel weighing 70 g
  - convert weight to kilograms
    - 70g ÷1000g/kg = 0.07 kg
  - Calculate RER
    - $70\ (0.07)^{0.75}$ = 9.5 Kcal
  - Calculate DER
    - 4 x 9.5 = 38 Kcal/day
  - zoologic milk matrix – 33/40 + 30/55

        - 1.7 Kcal/ml
    - Calculate ml/day
        - 38 Kcal ÷ 1.7 Kcal/ml = 22.3 ml per day

Squirrel weighing 70g (healthy orphan) about 3 weeks old (eyes closed, noticeable hair but not on stomach and legs

- Next consideration
    - Stomach capacity
        - Most mammals' stomach volume is 5% of the total body weight
        - lagomorphs 10%
        - most birds' stomach volume is 3-5% of body weight
- Squirrel
    - 70 g x 5% (stomach volume) = 3.5 ml per feeding
- 22.3 ml (per day) divide by 3.5 ml (per feeding) = about 6 feedings per day over 12 hours

- http://wildliferehabber.com/
    - Online calculators
- Dosage Calculator
- Conversion Calculator
- kCal Calculator
- Milk Replacer Calculator
- Mammal Calculator
        - It is unrealistic to expect those equations to exactly calculate the specific energy of all species under all physiological conditions nor are they the only consideration in a sound diet plan

The site has a lot of non-working links but the online calculators are good

- ✓ **Life on earth is possible due to the presence of water**
- ✓ most abundant component of the animal body in all stages of development
    - ✓ The first and most important element of a sound diet
- ✓ Medium for all chemical reactions in the body
- ✓ Transfers
    - ✓ oxygen to body tissues
    - ✓ carbon dioxide from the tissues
- ✓ food carrier
- ✓ aids in digestion and absorption
- ✓ waste product removal

Feeding a correct and well balanced diet is essential to the animal's health and recovery however one can never overlook the most critical element for survival – WATER … organism absorb and secrets matter across a wet line

Water can become contaminated with chemicals, microbial organisms, high levels of minerals etc that could be detrimental to young animals, affecting their health and/or growth

Although animals can use a variety of mechanisms to conserve the water in their bodies, impaired regulation of water and solutes results in rapid death

The water content of the animal body varies with age. The newborn animal contains from 750 to 800 g/kg water but this falls to about 500 g/kg in the mature fat animal. It is vital to the life of the organism that the water content of the body be maintained: an animal will die more rapidly if deprived of water than if deprived of food. Water functions in the body as a solvent in which nutrients are transported about the body and in which waste products are excreted

- **Bloodstream**
  - **liquid for circulation**
- **tissue building and repair**
- **Allows cells to hold shape**
- **regulation of the body temperature**
- **Regulate pH (acidity or alkalinity) of body fluids**
- **Milk production**
- **Animals may lose nearly all the fat and half the protein of the body and survive, but a loss of about one-tenth of the water from the body can be fatal**
- **Excess moisture in food can dilute the nutrients and energy in a diet**

animals generally need about three pounds of water for every pound of solid feed they consume

Animals need a continuous supply of water for maximum efficiency. Because water functions as a lubricant in the transport of feed and aids in the excretion of waste products from the body, the intake must equal the output lost through urine, feces and evaporation.

- **Two water sources**
  - Ingested water
    - Free drinking water
    - Water in food
      - Some food will contain more water then other
        - Fruits vs. Seeds
  - Metabolic water
    - Water created through metabolism
- Migratory birds rely solely on metabolic water production while making non-stop flights
  - Mostly from fat
- In mammals water production through metabolism of protein approximately equals the amount excreted
- Humidity may be especially important to maintain hydration of many reptiles
  - Daily misting/soaking with warm water

In mammals, the water produced from metabolism of protein roughly equals the amount needed to excrete the urea which is a byproduct of the metabolism of protein. Birds, however, excrete uric acid and can have a net gain of water from the metabolism of protein

Check water dishes frequently – if it looks like you are not going to drink it – the animal will not drink it!

- **Change water and clean dishes twice a day**
- **Use broad bottom water bowels**
- **Do not place under branches**
- **Do not add supplement**

NUTRITIONAL SUPPLEMENTATION OF DRINKING WATER Supplementation of vitamins and minerals via the drinking water is not recommended. Water intake can vary inter- and intraspecifically and is influenced by environmental temperatures and diet. The high redox potentials of minerals, such as zinc, iron and copper, can destroy vitamins, and some vitamins are light-sensitive. It is impossible to standardize intake of vitamins via drinking water. Vitamin A and D toxicoses have been reported in macaws and conures being supplemented with liquid vitamins.7,67,78 Dehydration may result if the additives decrease water intake due to unpleasant taste or unfamiliar coloration.

- Most injured and orphaned animals will be in some state of dehydration and/or hypothermia
  - Must be corrected before feeding
- During the act of digesting food
  - fluid is pulled out from cells to aid in the process of digestion
  - If the animal is even mildly dehydrated
    - feeding will worsen the problem

- **Always give fluids wormed**
  - **Avoid/exacerbate hypothermia**
  - **Less painful**
- **Keep fluid bag**
  - **Fluid warmer**
  - **Heating pad**
- **Calculate % of dehydration (in decimal) X body weight in grams = amount of replacement for next 48-72 hours**
- **Daily Maintenance 50ml/kg/day**
  - **Young 135ml/kg/day**

fluids to be given SQ – since rehabbers get donations of various fluids it is wise to learn the difference between them and the routs to be used:

the best choice of fluid for SC administration is a balanced crystalloid that has the same osmolarity to the patient (approximately 300 mOsm/L). Fluids like 0.9% saline, Plasmalyte A, and Lactated Ringers Solution are all appropriate Fluids devoid of electrolytes (eg, 5% dextrose in water or D5W), hypotonic fluids, or hypertonic fluids are not appropriate, as inappropriate electrolyte shifts may occur. Likewise, dextrose should ideally not be given SC due to risk for SC cellulitis or dermal necrosis

- **2 kg Pelican is estimated to be 10% dehydrated**
- **0.10 x 2000 = 200mL**
- **200mL / 48 hours**
- **Maintenance = 50 mL/kg/day**
- **2 kg x 50 ml = 100mL**
- **100mL / 24 hours**
- **First day**
- **50% of deficit = 100ml**
- **100% maintenance = 100ml**
    - **200ml over first 24 hours**
- **Second and third day**
- **25% of deficit = 50ml**
- **100% of maintenance = 100ml**
    - **150 ml/day**
    - **1-2% body weight per injection site**

- **Dehydration**
    - **Mild**
        - **PO**
            - **Absorption slow**
    - **Moderate**
        - **SQ**
            - **Rapid administration – slow absorption**
                - **6-8 hours**
                - **10%-20% per injection site**
    - **Severe**
        - **IV**
            - **Large volume**
            - **Rapid absorption**
            - **Butterfly catheter**
                - **25 G ½ " needle – 3.5" tube**

Medial Metatarsal vain

Oral route; The absorption of fluids, electrolytes and foods from the stomach is slow. Obviously the oral route of delivery of fluids is contraindicated if the animal needs rapid fluid loading, such as in states of shock. Hypertonic solution, such as 50% dextrose should not be given orally, as the osmotic draw of these hypertonic

solutions will bring water into the stomach, causing gastric distension. (concentrations of 20-50% are used to treat hypoglycemia). Whenever the oral route of administration is used, there is always the danger of aspiration of fluid and food into the airways. SubCutaneouly The administration of fluids subcutaneously is a rapid, easy method of providing fluids. The absorption of fluids from the subcutaneous space is relatively slow, occurring over 6-8 hours. If the animal is severely dehydrated, blood is shunted away from the subcutaneous tissues to more vital structures, and absorption of fluids will be delayed even longer. Place about 10-20 ml/kg/hour per site. **IV**: large fluid volumes can be administered rapidly; 10 ml/kg/hour

LIPIDS

- Most energy dense component
  - Naturally selected
    - Mobilized in time of deficit
- highest gross energy
- Fat provides
  - 2.25 more calories of energy per unit then metabolized protein
    - 1gr of fat = 9 cal
    - 1gr of protein/carb = 4 cal
- Presented in all body tissues
  - cholesterol
    - Form the hormones that participate in growth and reproduction

Allow for intestinal absorption of fat soluble vitamins

A - D - E - K

Fats are the most energy-dense nutrient, and foods high in fat are often selected by wildlife. Fat is the principal form of energy storage in animals. Body fat stores are mobilized in times of energy deficits such as the migratory flights of birds and the hibernation or torpor bouts of mammals.

Some polyunsaturated fatty acids cannot be synthesized in the body and are therefore required in the diet. Essential fatty acids play important roles in a number of tissues such as the developing eyes and brain. Dietary changes that alter the fatty acid composition of tissues can affect annual patterns of migration and hibernation in wildlife.

All tissues contain small amounts of lipid because phospholipids are part of the membranes of both animals and plants. Lipid fractions in the skins of fruit act to waterproof tissues with coats of wax, and attract animals with colored carotenoids or aromatic essential oils. Lipid fractions in animals include cholesterol, which stiffens membranes and forms the steroid hormones that integrate development and reproduction. Cells contain droplets of lipid as energy depots in the muscle, liver and adipose tissue of animals and in the seeds and fruits of many plants. Foods that are rich in lipid are often selected by animals because lipids contain more gross energy (kilojoules per gram, kJ·g−1) than either carbohydrates or proteins (Chapter 1). Omnivores such as chickadees select oily seeds for their winter caches and rodents are routinely trapped with baits based on oily peanut butter. Carnivores also favor the fatty parts of their prey. Polar bears choose blubber over the muscles of seals (Stirling and McEwan 1975) and carnivorous marsupials choose the thorax and fat bodies over the legs of insects (Chen et al. 2004). Lipids are related to survival and reproduction of many animals because the energy from fat is used during winter fasts, cold spells, migration, incubation and lactation. Lipid stores in animals also contain contaminants that bio-accumulate at each trophic level, resulting in peak concentrations in apex predators such as eagles and polar bears (Moriarty 1999).

The lipid content of the animal body is variable and is related to age, the older animal containing a much greater proportion than the young animal. The lipid content of living plants is relatively low.

- **Fatty acid**
  - **Building blocks for all lipids**
    - **Saturated fat**
      - **synthesized by all animals**
    - **Unsaturated fat**
      - **'essential fatty acids'**
  - **Functions**
    - **Blood cells/vessel**
    - **Skin**
    - **Muscles**
    - **Development of brain and eyes**
    - **Inflammation reducing**
  - **Changes in amount stored**
    - **Will affect flight and thermoregulation**
      - **Migration…hibernation**

Lipids are greasy, water-insoluble organic compounds that are primary building blocks of animal cells

Essential PUFA participate in many functions of membranes in blood cells, blood vessels, skin, nerves and muscles. PUFA are particularly important during the development of brain and eyes among vertebrates; n-3 acids can comprise half the fatty acids of neural membranes (McKenzie 2005). Small changes in PUFA concentrations may alter the function of tissues. For instance, increasing proportions of n-6 acids in muscle are correlated with greater running speeds among species of mammals and with greater swimming speeds among individual Atlantic salmon (McKenzie 2005; Ruf et al. 2006). Changes in stores of fatty acids can affect their use as a fuel for flight in birds and for thermoregulation in mammals (Frank et al. 2004; Pierce et al. 2005).

Fatty acids are the building blocks for all lipids, especially those that constitute fat depots (triglycerides) and membranes (phospholipids). The smallest lipids are the water-soluble SCFA produced by fermentation of carbohydrates (Chapter 6). Fatty acids consist of a hydrocarbon chain that is poorly soluble in water. Increasing the length of the hydrocarbon chain decreases water solubility but increases the affinity for other fatty acids in membranes and fat (Fig. 7.1). Long chains of fatty acids readily associate to form oily droplets or micelles in the watery matrix of the digesta and within the adipose cells of fat depots

Fatty acids **without** double bonds between carbons are called saturated - synthesized by all animals Saturated fatty acids stack tightly to form a compact store of energy in fat depots.

Unsaturated fat – monounsaturated and polyunsaturated - Unsaturation increases the fluidity of lipids, especially at low temperatures; fatty acids in plants and ectothermic animals contain greater proportions of unsaturated fatty acids than those of birds and mammals - animals cannot produce the double bonds at C12 of linoleic acid –

Herbivorous animals consume foods that are quite different from their own tissues in contrast to carnivores, which digest materials that are similar to their own bodies

- **Flax seed/oil**
- **Fish**
- **Nuts**
  - **Butternuts, Walnuts, brazil nuts, cashews, hemp seeds and hazelnuts**
- **Vegetables**
  - **Broccoli, Spinach, Brussels sprout, kale, watercress**

All types of dietary fats contain lipids. Fat-soluble vitamins that are present in foods also contain lipids

Omega-6 unsaturated fat lipids are found in sunflower oil, safflower oil and soybean oil, while omega-3 unsaturated fat lipids are present in sardines, salmon, trout, anchovies, shellfish and canola oil.

Peanut butter – use on a log for woodpeckers

- Meat from grass-fed animals
- Liver from grass-fed animals (much higher amounts than muscle meats)
- Pasture-raised poultry meat
- Liver from pasture-raised poultry (much higher amounts than bird meat)
- Animal brain
- Small oily fish (anchovy, herring, sardines and mackerel)
- Large oily fish that eat small oily fish (bluefish, tuna, salmon, halibut, bass, and trout)—even farmed fish often contain omega-3's because of what they are fed.
- Fish liver oils, such as cod liver oil.
- Oysters

carbs

Basic source of energy

- Carbohydrates take the form of sugar and starch
- Provides immediate fuel for physical performance
  - Carbohydrates are an excellent source of immediate energy boost

- The only source of energy for the brain CNS and erythrocytes

The central nervous system and erythrocytes require glucose for energy, in contrast to muscles that can utilize substrates such as fatty acids. In the absence of adequate dietary carbohydrates, amino acids are shunted away from growth and production to be used for glucose

- **Sucrose, one of the predominant disaccharides of fruit sugars**
  - **easily digestible**
  - **However, some insectivorous passerines, such as thrushes, American robin, starlings, cedar waxwing, that feed on diets high in protein/fat and low in carbohydrate, lack the sucrose enzyme necessary for the digestion of these simple sugars. The differences in proportions of fruit mono- and disaccharides are important for species that lack the sucrase enzyme. Avoid feeding these birds fruits high in disaccharides such as mango, apricot, nectarine and peach…. Berries are high in monosaccharide**
  - **Chitin is a naturally occurring polysaccharide It is the principal polysaccharide of cell walls of the primary constituent of the exoskeletons of crustaceans and invertebrates**
  - **The digestion of chitin is considered low, but it still presents a useful energy source for some species starlings, raptors and a variety of seabirds it is low in chickens and absent in pigeons and doves**

protein

- **Proteins are part of every cell, tissue, and organ in the body**
- **Play crucial role in all biological processes**
- **Essential for growth, repair and maintaining healthy body tissues**
  - **Digestion of proteins is more efficient in nestlings than in adult**
- **Muscle contraction, immune protection, transmission of nerve impulse**
- **Provides structural support to skin and bones**
- **Source of energy**

In animals, muscle, skin, hair, feathers, wool and nails consist mainly of protein.

Protein requirements during egg production are influenced by clutch size/frequency and the protein composition of eggs

Dietary deficiencies of methionine result in dark, horizontal “stress lines” on feathers, while threefold excesses are correlated with soft, weak feathers and beak

Production of sheaths during molt can increase protein requirements 4 to 8% per day above maintenance requirements. The additional energy required for thermoregulation may increase food intake to provide sufficient protein for feather growth without increasing the proportion of protein in the diet

Molt and Stress Bars Molt results in increased protein needs. Feathers are enriched with cysteine and many of the nonessential amino acids. These amino acids are incorporated into the feather during its formation on a continual basis, while uptake from the GI tract occurs only after consumption of a meal. This means that when the protein levels in the blood stream dip, the growing feather ends up being malformed at that point. This translates to the visual manifestation of a stress bar.

Like proteins, nucleic acids are also nitrogen-containing compounds and they play a basic role in the synthesis of proteins in all living organisms. They also carry the genetic information of the living cell.

The dietary requirement for protein varies with age and physiological state, being highest

in hatchlings and females laying large clutches and lowest in adults at maintenance
Digestibility of proteins also varies, being more efficient in nestlings than adult
Protein requirements for growth are highest at hatch and decrease over time as growth rates slow. Altricial chicks have higher growth rates as they need to achieve independence at an earlier stage
t if the protein does not contain sufficient amounts of the amino acid
taurine. This is a dietary requirement for cats but not for dogs, and other mammalian insectivores have developed cardiomyopathy when maintained on dog foods, which may be attributed to the low taurine content of these foods.

- **Sources**
  - **Insects**
  - **Whole prey**
  - **Growing tips of leaves**
  - **Grains**
  - **Nuts**
  - **Seeds**
  - **Milk**
    - **Ideal proportions for greatest tissue synthesis**
      - **Species specific**
- The essential amino acids present in milk proteins are supplied in almost ideal proportions for maximum tissue synthesis – species specific
- Excess protein has been associated with overgrowth of beaks and nails

  - **Eggs**
    - **The perfect protein**
- **Raw egg white**
  - **Avidin**
    - **Renders biotin (B7) unavailable**
      - **Metabolism of fatty acids**
  - **Serpins**
    - **Inhibits trypcin action on protein**
      - **hydrolyses proteins**
- **Boiling the eggs**
  - **Destroys Avidin and trypcin inhibitor**
    - **Making protein available**

The proteins contained in eggs are so well proportioned in their amino acid composition that egg protein is considered to be a perfect protein

Raw egg white contains a protein known as avidin which renders the vitamin biotin unavailable to the body

Duck's egg white contains in addition, a substance which inhibits the action of trypsin on protein

Heating egg, as for instance, in the preparation of boiled egg, destroys both avidin and trypsin inhibitor. Cooking makes egg-protein easily available to the body

- Vitamins
    - Required in diet for proper body function
- Divided into 2 groups
- Fat soluble vitamins
    - A – healthy eyes, infection prevention
    - D - bone development
    - K- clotting
    - E- reproduction, muscle development
        - Stored in body fat and in the liver
- Water soluble vitamins
    - B complex- neurological system
    - C- teeth and bone, preventing infections
        - Are not stored in the body

It is important to maintain an appropriate balance with the fat-soluble vitamins as they all compete for sites of uptake. Dietary excess of one vitamin can diminish uptake and availability of another, despite adequate dietary intake.

Vitamins are fat soluble or water soluble. Watersoluble vitamins are dissolved in water, and fatsoluble vitamins are dissolved in fat. Fat-soluble vitamins include vitamins A, D, E, and K. Vitamin D is necessary for bone development, and it is produced in the animal's body. In order to produce vitamin D, the animal must be in sunlight for a portion of the day. Some of the main benefits of the other fat-soluble vitamins include blood clotting (vitamin K), reproduction and muscle development (vitamin E), healthy eyes, and preventing infection (vitamin A). Water-soluble vitamins include vitamin C and the B-complex. Vitamin C is needed for teeth and bone formation, and the prevention of infections.

Vitamins are present in plants and animals in minute amounts, and many of them are important as components of enzyme systems. An important difference between plants and animals is that, whereas the former can synthesise all the vitamins they require for metabolism, animals cannot, or have very limited powers of synthesis, and are dependent upon an external supply.

- Vitamin A (beta carotene)
    - Vision, reproduction, immunity, membrane integrity, growth, resistance to infections (sinuses) and the maintenance of epithelial cells
- Deficiencies/toxicity
    - Degeneration of eye structure
        - Prolong deficiency will result in blindness
    - Loss of membrane integrity

- Interfere with water retention
- Poor feathering – unkempt appearance
- Both deficiency and excess of dietary vitamin A suppress immune function
    - Insufficient antioxidants such as vitamin E in the feed may enhance lipid peroxidation during storage

- Vitamin A levels are stored in liver tissue of animals
    - Carnivores usually do not suffer vitamin A deficiency

This vitamin is important for the formation and maintenance of collagen, a protein that is widely distributed in the body. Collagen is the cementing material that holds the cells of the body together and is also necessary for the healing of wounds and fractures.

2. It is also essential for the formation of teeth and bones and for production and repair of tissues.

4. helps in easy absorption of iron from the gastro-intestinal tract by the reduction of ferric iron to ferrous iron.

Eye lesions in semiaquatic turtles (eg, box turtles) and some tortoises may be the result of low environmental humidity (or possibly upper respiratory tract disease) and not vitamin A deficiency. Conjunctivitis may respond better to supportive antibiotic therapy and higher humidity than to supplemental vitamin A

(loss appetite), hair loss, dry skin, enlarged spleen & liver, bone and joint pain, & jaundice - generally disappear when excess intake stopped

Clinical signs of vitamin A deficiency often resemble those of toxicity, and distinguishing between the two requires careful evaluation of dietary intake and other influencing factors

Deficiency symptoms of Vitamin A

night blindness, xeropthalmia (abnormal dryness of cornea and conjunctiva), poor growth, reproductive failures, reduced egg production, corneal dying, triangular gray spots on eye, cornea softening, corneal degeneration and blindness, impaired immunity, **hair follicles plugged with keratin forming white lumps**

- **Vitamin A levels in invertebrates are very low**
- Fish vertebral animals store large amounts of vitamin A in their liver and fatty tissue
    - Retinoids
        - Bio-available
- some fruits and vegetable can provide large quantities of vitamin A (carotenoids)
- Has to be converted to retinol
    - Orange fruits and vegetables
    - Apricots, cantaloupe, peaches
    - Dark green leafy vegetables
    - Carrots, squash, sweet potato, broccoli, and dandelion leaves

Retinoids vs. Carotenoids

The most important fact about vitamin A is the difference between retinoids and cartenoids. The vitamin A from animal sources is retinoids, also called retinol, while plant source vitamin A is carotenoids, such as beta carotene.

Animal sources of retinol is bio-available, which means the body can utilize it. The vitamin A from plant sources, in contrast, must first be converted to retinol to be useful in the body. This poses two big problems.

- Vitamin D "sunlight vitamin"
- calcium metabolism
- Normal mineralization of bone
- bone growth and remodeling
- Prevention of MBD
  - Naturally presented in very few food items
  - Fish such as salmon, and tuna, fish liver oils
- Excess vitamin D retards bone growth and causes calcification of soft tissue
- **Deficiency**
  - dietary inadequacy
  - prolonged indoor caging
    - Limited exposure to sunlight
  - physiological impairments
    - impaired absorption
      - absorption of vitamin D from the digestive tract is inadequate

Vitamin D has hormonal actions as it regulates calcium and phosphorus metabolism including bone mineralization and eggshell formation. Vitamin Deficient hens lay eggs with thin shells and develop osteomalacia with pathologic fractures. Vitamin D toxicity is associated with increased mobilization of calcium with soft tissue mineralization

-produced endogenously when ultraviolet rays from sunlight strike the skin and trigger vitamin D synthesis

-Vitamin D promotes calcium absorption in the gut and maintains adequate serum calcium and phosphate concentrations in the blood enabling normal mineralization of bone and to prevent hypocalcemic tetany (involuntary muscle movement) occurring w/ too little calcium in the blood - hypocalcaemia)

Vitamin K

- **Main biological role is blood clotting**
- **Stops bleeding through clot formation**
- **Vital to proper liver function**
- **body stores very little of it**
- **stores are rapidly depleted without regular dietary intake**
- **dietary source of vitamin K is generally green leafy vegetables**
    - **broccoli, peas, green beans**
- Hemophiliac animals

Vitamin K plays a major role in blood clotting factors and is involved in the synthesis of osteocalcin, with deficiencies resulting in increased bleeding times and toxicities resulting in kidney tubule degeneration

Vitamin K supplementation of armadillos has been recommended to help prevent hemorrhages: 5 mg of menadione sodium bisulfite/kg dry diet should be adequate.

- Vitamin E is an antioxidant
    - prevent chemicals in the body from damaging cells
- Animals with a vitamin E deficiency
    - Lack energy
    - Nervous system disorders (ataxia)
    - Vascular, and muscular disorders
    - Discoloration of body fat (orange or brownish yellow)
- high doses decrease absorption of vitamins A, D and K, resulting in reduced hepatic and egg yolk storage of vitamin A, impaired bone mineralization and coagulopathies
    - Studies of pelicans indicate that 500-10,500 IU vitamin E/kg result in decreased growth and coagulopathy
- Found in leafy green vegetables, walnuts, almonds, sunflower seeds, corn, vegetable oils

not very stable in storage

Vitamin E has been shown to be essential for the integrity and optimum function of reproductive, muscular, circulatory, nervous and immune systems in animals and humans

Vitamin E is perhaps the most studied nutrient related to the immune response (Meydani and Han, 2006). Evidence accumulated over the years and in many species indicates that vitamin E is an essential nutrient for the normal function of the immune system. Furthermore, studies suggest that beneficial effects of certain nutrients, such as vitamin E reducing disease risk, can be through their effects on the immune response.

Both vitamin E and selenium provide protection against toxicity of certain heavy metals (Whanger, 1981). Vitamin E is highly effective in reducing toxicity of silver, arsenic, nickel and lead, and shows slight effects against cadmium and mercury toxicity. Heavy metals produce oxidative damage to tissues, and thus vitamin E can exert a protective antioxidant effect. Vitamin E can be effective against other toxic substances. Mycotoxins must be detoxified by the cytochrome P-450 system, the activity of which appears related to vitamin E status

Vitamin E is one of the least toxic vitamins, however, high doses decrease absorption of vitamins A, D and K, resulting in reduced hepatic and egg yolk storage of vitamin A, impaired bone mineralization and coagulopathies

Vitamin E deficiencies are most common in captive wildlife fed fish diets, this despite the fact that fish are generally, a good source of vitamin E. Problems develop because:

- fish have high levels of polyunsaturated fats (which raises the requirements)
- fish are often frozen, and vitamin E activity decreases with storage, even if frozen
- fish are often eviscerated, even though viscera are important storage sites for vitamin E

VITAMIN C

- **Water soluble**
  - **Not stored in the body**
- **A cofactor in development and repair of all body tissues**
  - essential in the formation of collagen
  - Important in wound-healing
  - Reproduction and growth
- **Is obtained mainly from plant food sources**
  - **Orange, papaya, guava, ripe tomato, mango, strawberries, cantaloupe, watermelon, pears, kiwi, bananas**
  - **Dark leafy greens, green and red papers, snow peas, broccoli, sweet potatoes**
  - **Animals organs**

Vitamin C is concentrated in fresh fruits, green leafy vegetables and animal organs, with only small amounts in skeletal muscle

Excesses of vitamin C also can bind copper, resulting in growth deficiencies and increases in the incidence of aortic rupture and decreases in elastin content of the aorta if diets are also deficient in copper. It is important to minimize dietary vitamin C content for species that are susceptible to iron storage disease - Many frugivorous avian species kept in captivity develop iron storage disease (ISD) as indicated by high concentrations of hepatic iron and hemosiderin deposits in hepatocytes or phagocytes. In several susceptible species fed diets containing moderate levels of iron, ISD develops because of an inability to match rates of iron absorption to tissue needs.

Infections, trauma and neoplasia that trigger an acute phase response may exacerbate ISD in susceptible species and may be the primary cause in species that are normally resistant to ISD (i.e., those that are normally able to shut down intestinal iron absorption when iron stores are replete) myna birds and toucans are susceptible to iron storage disease

Grapes are high in iron

. Ascorbic acid also plays an important role in the normal metabolism of amino acids as tyrosine and in the function of the adrenal gland.

Sources

Fruits and vegetables are the main sources of ascorbic acid. Citrus fruits like limes, lemons, oranges, mosambis, grapes and tomatoes. Vitamin-C is also found in considerable amount in fresh mangoes, Papayas and other

fruits. Cauliflower, green leafy vegetables, raw cabbages, green chilies also supply Vitamin-C. Guavas and sprouted grams are valuable sources of Vitamin-C. Dry legumes contain small amount of Vitamin- C, which increases in manifold, approximately 7 times during germination. However animal foods do not contain much of Vitamin-C.

Daily Allowance

Since Ascorbic acid cannot be stored in the body, the requirement has to be met daily from the diet. The recommended daily allowance is 20 mg. to 40 mg. for children and 40 mg for an adult. An extra allowance is also recommended for nursing mother.

Deficiency

Deficiency of Vitamin-C makes the gums soft, tender that bleeds easily. If there are cuts and wounds, it takes a long time to heal. Jaws become swollen and tender. The body becomes susceptible to infection and disease. Premature signs of old age appear in the young. In case of acute deficiency, a disease, called as scurvy occurs. This is characterized by weakness, irritability, bleeding under the skin and in the joints bleeding gums, failure to heal or delay in the healing of wounds, anemia and weak bones.

B COMPLEX

- B complex consists of eight water soluble vitamins
- Enhance metabolism of carbohydrates and Proteins for available energy
- Boosts immune and nervous system
- Aids in cell growth, division and maintenance
- Important during breeding, molting, and rehabilitation process
    - Brewer's yeast is one of the best sources of the B vitamins
    - whole, unrefined grains (such as cracked and whole wheat, brown rice, rye, and wheat germ), leafy vegetables, peanuts (B1), raisins, oranges (B1, B9)), almonds, pecans, broccoli (B2), sunflower seeds, peanut butter (B3, B7), bananas (B7, B9)
- Excesses are passed out in urine

All flesh foods like meat and fish are good sources of B-complex vitamins. Pork, liver and other organ meats are excellent for their thiamine content; poultry is rich in niacin. Vitamin $B_{12,}$ which is contained only in foods of animal origin and not in plant foods, is supplied well by organ meats and muscle meats.

B12 injection should be included in botulism protocol. And for any other neurological condition

- competition for uptake - e.g. Amprolium in Coccidiostate
- Thiaminasis - there are chemicals in foods which break down Thiamine
- Deficiencies
- decreased appetite
- Incoordination
- moon gazing
- Seizures and death
- Response to Thiamine injections is rapid, often within minutes

The process of thawing fish in running water depletes them of water-soluble vitamins. Additionally, several fish species contain thiaminase, leading to thiamine (B_1) deficiency during the defrosting process.Supplementation of thiamine is recommended at 30–35 mg/kg fish, daily (Merck veterinary)

frozen fish are deficient in vitamin E. Clinical signs of vitamin E deficiency include weakness and inability to stand or hold the wings in normal posture. Severe generalized myopathy with muscle atrophy, degeneration and necrosis, and replacement with fibrous connective tissue can occur with chronic pronounced vitamin E deficiency. Supplementation with 100 IU vitamin E/kg fish has been proposed. However, oversupplementation (vitamin E at 500–10,500 IU/kg food) may result in decreased growth and coagulation disorders, possibly from creating vitamin K deficiency rather than directly from vitamin E toxicity.

- Vitamin Deficiencies
  - Abnormal bone growth
  - Decreased milk production
  - Decreased appetite
  - Diarrhea Digestive disorders
  - Increased susceptibility to infections
  - Alopecia
  - blood clotting
  - Poor coordination
  - Poor growth
  - Poor hair coat
  - Unthrifty appearance Weakness

Just to recap ….

- Calcium
  - Development of bones and muscles
  - Normal contractions of muscles
    - Heart
  - Blood coagulation
  - Egg formation (85% calcium)
- Calcium, phosphorus and vitamin D all connected
  - Poor calcium absorption is due to high phosphorus levels
  - Poor vitamin D absorption is due to low Calcium levels
- Calcium and Phosphorus must be balanced in diet (2:1)
  - Seeds are very high in phosphorus
  - When feeding whole vertebrate prey, it is not necessary to supplement with calcium
  - Feeding whole fish is imperative to maintain proper Ca:P ratio.

Whole prey fed to animals in captivity can differ from that available in the wild and may require supplementation. Feeding individual pieces of prey or eviscerated meat can contribute to nutrient

imbalances. Feeding high proportions of liver can result in hypervitaminosis A. Supplement meat-based diets with CaCO3, which has the highest ca content

Functions of minerals

1. They are the constituents of bone and teeth and required for their growth e.g. calcium and phosphorus.
2. They are the constituents of various body tissues e.g. iron, phosphorus.
3. They maintain electrolyte balance in body fluids e.g. sodium, potassium and chloride.
4. They maintain tone and functions of muscles e.g. sodium and calcium.
5. They stimulate digestive secretions.
6. They are necessary for growth.

Classification of minerals

1. Major minerals'. Calcium, phosphorus, sodium, potassium and magnesium.
2. Trace elements with known functions: iron, iodine, fluorine, zinc and copper.
3. Trace elements with no known functions, lead, mercury, barium and aluminum.

CALCIUM _____

It forms 1.5 to 2 per cent of body weight. An average adult body contains 1200 grams of calcium. Of this 98 per cent is present

in bones.

Functions

1. It is necessary for growth of bones and teeth.
2. It is required for the clotting of blood.
3. It regulates the contraction of muscles.
4. It is required for cardiac action and milk production.
5. It transforms light into electrical impulses in the retina.
6. It forms a component of several enzymes.

Sources

1. Milk and milk products like cheese, curd and butter milk. They are the best natural sources of calcium.
2. Green leafy vegetables like spinach.
3. Millets like ragi.

Deficiency:

Deficiency of calcium leads to osteomalacia. Also it leads to delayed blood clotting.

- Mealworms are deficient in calcium and high in phosphorus
- Raise and store in a nutritional media
- Bran, wheat germ, mixed grain baby cereal, bone meal powder, vitamins
- Feed mealworms everyday
    - Thin slices of apple, carrots, Greens
- What you feed your mealworms is the nutrition you are providing to the animal in your care

Invertebrates generally have poor Ca:P ratios. Crickets should be maintained on 80% poultry mash and 20% calcium carbonate. Water should be provided ad lib from produce (such as a slice of apple) or free water. If die-off of crickets occurs from constipation, restrict gut loading to 48 hours prior to feeding

INSECTS There are limited varieties of invertebrates for captive birds, with mealworms, earthworms and crickets forming the bulk of the available diet. Hard-bodied insects that contain up to 50% of their body weight

as chitin may be important sources of dietary fiber, as chitin is chemically similar to cellulose. Chitinase activity has been identified in starlings, raptors and a variety of seabirds. Vitamin E content of many insects is adequate, but vitamin A content is relatively low or undetectable, Insects (especially from colder climates) contain high levels of polyunsaturated fatty acids. Insects generally concentrate a number of carotenoids that may be important for pigmentation or antioxidant activity. Insects generally have poor Ca:P ratios

Muscle and organ meat, fruit, most grains and seeds, and most insects are poor sources of calcium, and excess consumption can result in calcium deficiency. Calcium gut-loading diets containing at least 12%–15% calcium should be fed to insects. Dusting with a balanced calcium-phosphorus powder is also a possibility; however, it is doubtful this can add enough calcium to the diet. Other sources of calcium include oyster shell, cuttle bone, and ground calcium carbonate tablets.

- Phosphorus
  - Growth
  - Maintenance of healthy system
  - Repair of bone tissues
  - Maintaining structure and function of bones
  - Aids in conversion of protein, fats, and carbohydrates into energy
- Found in peanut butter, almonds, broccoli, lima beans, and animal food items
- Check all food for proper ca/p ratio

In the animal body, about 80 percent of P is found in the skeleton Its major role is as a constituent of bones and teeth. The remainder is widely distributed throughout the body in combination with proteins and fats and as inorganic salts…Phosphorus must be balanced in the animal diet with adequate calcium (Ca) and vitamin D for growth, reproduction, gestation, and lactation….Adequate Ca and P nutrition depends on three factors: a sufficient supply of each nutrient, a suitable ratio between them, and the presence of vitamin D. These factors are interrelated. The desirable Ca:P ratio is often between 2:1 and 1:1

Earliest symptoms of P deficiency are decreased appetite, lowered blood P, reduced rate of gain, and “pica”, in which the animals have a craving for unusual foods such as wood or other materials. If severe deficiency occurs, there will be skeletal problems. Milk production decreases with P defi- ciency, and efficiency of feed utilization is depressed. Long-term P deficiency results in bone changes, lameness, and stiff joints

- Potassium
  - Regulates body fluids
  - Function of nervous system
  - Maintain normal contraction of muscles
  - Aids in carbohydrates metabolism
- Found in bananas, apricot, oranges, cantaloupe, squash, peanuts, and a verity of vegetables

Potassium is essential for life. Young animals will fail to grow and will die within a few days when the diet is extremely deficient in K. Potassium is the third most abundant mineral element in the animal body, surpassed only by calcium (Ca) and phosphorus (P). Potassium concentrations in cells exceed the concentration of sodium (Na) by 20 to 30 times. Outside the cell the reverse is true. Potassium comprises about 5 percent of the total mineral content of the body. Muscle contains most of the total K in the bodies of animals (Table 1). Potassium is contained almost entirely within the cells and is the most plentiful ion of the intracellular fluids. Potassium is found in every cell. It is present in tissues and cells only in ionic form (K^+).

Functions of Potassium… functions in the intracellular fluids the same as Na does in the extracellular fluids. The major functions of K in the human and animal body are to: • maintain water balance • maintain osmotic pressure • maintain acid-base balance • activate enzymes • help metabolize carbohydrates and proteins • regulate neuromuscular activity (along with Ca) • help regulate heartbeat

There are several causes of K deficiency: inadequate amounts of K in diet, K losses in digestive secretions caused by vomiting and diarrhea, high intake of Na, increased urination, and stress conditions. Potassium deficiency may commonly be manifested by depressed growth, muscular weakness, stiffness, decreased feed intake, intracellular acidosis, nervous disorders, reduced heart rate, and abnormal electrocardiograms. The first sign of K defi- ciency is reduced feed intake. Many of the other signs stem from reduced feed intake. Potassium must be supplied in the daily ration because it is a mobile nutrient and there are not any appreciable reserves.

Trace minerals

- **Copper is a part of several proteins, and enzymes**
  - **required for blood, bone, tissue and skin construction**
- **Cobalt, needed in very small amounts but very important**
  - **building block for Vitamin B 12**
- **Iodine**
  - **healthy thyroid function**
- **Zinc and magnesium**
  - **Protein synthesis (fusion)**
- **Selenium**
  - **Disease prevention, boosting of immune system**

- **It is unlikely that animals will suffer from deficiency of those trace minerals and supplementation is not usually needed unless a specific medical need arises**

- Mineral Deficiencies
  - Abnormal bone growth /MBD
  - Anemia
  - Decreased growth
  - Decreased milk production
  - Reduce food consumption
  - Dermal/alopecia
  - Lameness
  - Unthrifty appearance

- **Many factors of the animal's physical and physiological condition play an important role in the animal's system ability to use the nutrients you are providing**

- **Malnutrition**
  - inadequate intake of nutrients
- Animals can eat large amount of food
  - Unable to digest, absorb and/or convert food into energy
    - Parasites
    - Disease
      - Aspergillosis
      - Lead poisoning
    - Foreign body in GI
    - Food is insufficient in nutrients
      - Captivity (improper diet)
    - Stress
- A patient that consumes a sufficient amount of food
  - Not gaining weight
  - Losing weight
    - Further investigation into cause is necessary

starvation

- The animal is unable to acquire sufficient amount of food for an extended period of time
  - Injuries
  - Diseases
  - Environmental conditions

The terms malnutrition and starvation are used interchangeably, when in reality, there are specific definitions for each. Malnutrition is the inadequate intake of any of the required nutrients. This can even occur in an animal receiving large amounts of food, but is not able to ingest, digest, absorb, or utilize this food. Causes for this inability are injuries, poor teeth, parasitism, disease, foreign bodies in the digestive tract, tumors, or an increased motility of the digestive tract. Malnutrition can also occur if the food is inadequate in one or more of the required nutrients.
If an animal is not able to obtain food for an extended period of time either for the above reasons or due to an unavailability of food or insufficient energy intake, this is defined as starvation.

f an animal is forced into an inadequate plane of nutrition, there are many physiological changes as the animal attempts to satisfy its energy requirements. At the cellular level, catabolism (the breaking down in the body of complex chemical compounds into simpler ones) continues to supply the substances required for anabolism (the usage of nutritive matter and its conversion into living substance) and to continue vital functions. Reserve stores of nutrients contained in the individual are utilized to compensate for the lack of nutritional intake. Energy is generated from the utilization of proteins, fats, and carbohydrates. The most readily usable material, the carbohydrate glycogen, is utilized first. This is derived from glycogen stored in the liver and is exhausted within a few hours. This is followed by stored fat from the various subcutaneous deposits, around the kidney, and in the mesentery and omentum tissue. Fat deposits in the parenchymatous organs are utilized next. The last area of the body to lose its fat deposits is the marrow of the bones. The

final source of energy available is the protein comprising the cytoplasm of the cells. It is at this time that ketosis and an increase in nitrogen excretion may occur. Ketosis (a condition in which ketone substances appear in the blood and urine) is commonly seen in malnourished animals. This is because it is necessary for the animal to derive its energy from the stored fat and protein. After all the fat reserves have been exhausted, nitrogen excretion rises due to the protein catabolism which occurs just prior to death. The animal will eventually reach a point where the cells of the body are unable to perform the functions necessary for life. Death results from lack of sufficient blood glucose to provide the energy needs of the brain and hypoglycemic shock occurs.

- Probiotics
  - Encourage "good" bacteria in the gut
  - Barrier against pathogens
  - Digestive upset
    - Stress
      Weaning
      - Lactobacilli
  - Restoring desirable bacteria while on Abx
  - Competitive exclusion of bacteria
  - Boosts immune system

Probiotics

the inclusion of probiotics in foods is designed to encourage certain strains of bacteria in the gut at the expense of less desirable ones. A probiotic is defined as a live microbial food supplement that beneficially affects the host animal by improving the intestinal microbial balance. Although the digestive tract of all animals is sterile at birth, contact with the mother and the environment leads to the establishment of a varied microflora. The beneficial microorganisms produce enzymes which complement the digestive ability of the host and their presence provides a barrier against invading pathogens. Digestive upsets are common at times of stress (e.g. weaning), and feeding with desirable bacteria, such as Lactobacilli, in these situations is preferable to using antibiotics, which destroy the desirable bacteria as well as the harmful species.

It has been suggested that the desirable bacteria exert their effects in a number of ways:

- Adhesion to the digestive tract wall to prevent colonisation by pathogenic microorganisms. Detrimental bacteria, such as E. coli, need to become attached to the gut wall to exert their harmful effects. Attachment is achieved by means of hair-like structures, called fimbriae, on the bacterial surface. The fimbriae are made up of proteins, called lectins, which recognise and selectively combine with specific oligosaccharide receptor sites on the gut wall. Lactobacilli successfully compete for these attachment sites (Fig. 3.)

- Neutralisation of enterotoxins produced by pathogenic bacteria which cause fluid less. There is some evidence that live probiotic bacteria can neutralise these toxins but the active substance has not been identified.

- Bactericidal activity: Lactobacilli ferment lactose to lactic acid, thereby reducing the pH to a level that harmful bacteria cannot tolerate. Hydrogen peroxide is also produced, which inhibits the growth of Gram-negative bacteria. It has also been reported that lactic acid producing bacteria of the Streptococcus and Lactobacillus species produce antibiotics.

- Prevention of amine synthesis: coliform bacteria decarboxylate amino acids to produce amines, which irritate the gut, are toxic and are concurrent with the incidence of diarrhoea. If desirable bacteria prevent the coliforms proliferating then amine production will also be prevented.

- Enhanced immune competence: oral inoculation of young pigs with Lactobacilli has elevated serum protein and white blood cell counts. This may aid the development of the immune system by stimulation of the production of antibodies and increased phagocytic activity.

- Preparation of food
- Clean bowels every time you feed/water
- Wash fruits and vegetables before cutting
    - Bacteria can be found on the surface of fruits and vegetable
    - Once cut bacteria can multiply and spread to all food items in animal's dish
- Cut fruits and vegetables into appropriate size

Never add supplements to a commercially made formula

All food must be served in clean, sanitized receptacles. USDA stipulates that food receptacles, if used, must be accessible to all animals in the same primary enclosure and placed to minimize contamination. All feeding receptacles must be cleaned and sanitized after each use.

Equipment such as utensils, cutting boards, food containers, tables, gloves, and clothing can harbor pathogens and should be properly cleaned and sanitized daily …This should also apply to all meat preparation equipment for all animals. However, while regulations say a once a day cleaning is allowable, if the animals are fed more than once a day, one cleaning after each use is preferable

- Presentation of food
    - Important to learn the natural history and behavior of native species
    - Animals have divers foraging techniques
        - Need to present food to mimic natural feeding behavior
- Feeding smaller portions 3-4 times a day
    - Promotes healthy appetite
    - Mimics natural behavior

        Promotes psychological wellbeing

- Food intake
    - Amount consumed
        - Mainly when changing diets/amounts
- Do not forget the greens!!!
    - Many of the vitamins required by animals come directly from leafy green plants
    - The meats from animals that ate the leafy, green plants
    - fatty acids are manufactured by leafy green plants
        - Adds to presentation of diets
            - Chop on top of food

Food intake is a central concept in animal nutrition, but it is one of the most difficult parameters to measure in wildlife. Measurements of food intake must be made with the animals in steady state. The time to reach steady state when transferred to a new diet or environment depends on several factors, including the complexity of the digestive tract, and rates of feeding and digesta

Grit: GRIT is not needed for hook billed birds, it is only essential for doves, pigeons, foul and some soft bills. Regardless of your opinion on grit, always remove all grit from the cage of any sick bird (they may excessively eat it and impact their G.I. system).

In addition to the conventional domestic animal diets, there are several companies that offer non-domestic diets or supplements

tissues synthesized at one level of the trophic hierarchy are the food for the next level

herbivore animals consume food that is different than their own tissue while carnivores consume material which are similar to their own tissue

Feeding responses are studied at multiple scales of time and space to follow changes in the animal, its habitat and food supply. The rate at which animals can gain energy and nutrients is constrained by the relationship between food intake and food abundance. Decreases in food abundance reduce the absolute number of high-quality items available and shift selection to a broader range of foods that includes lower-quality items. Optimal foraging models predict the lowest investment of time or energy for the greatest benefit from a single behavior or method of foraging. Risk-sensitive foraging models solve for the best foraging behavior from a suite of responses with different probabilities of cost and benefit. The cost of foraging includes the time and energy to locate and capture each food item. The large diversity of structural adaptations used by animals during foraging reflects the strong selective pressure to minimize costs by maximizing the efficiency of finding and acquiring food

removal of unusable elements and waste products of metabolism

- essential nutrient: one that must be provided in the diet in order to insure adequate growth and maintenance, indispensable
- Nutrient categories: macro and micro
- macronutrients: protein, lipid, carbohydrate, etc.
- micronutrients: trace metals, vitamins
- important: molecular weight is not the basis, requirement level is
- proteins: g/kg vitamins: µg/kg

large requirement doesn't imply greater importance (example: B12 in some fish 0.4 µg/day