advantages

- Describe differences in bovine colostrum, transition milk, and whole milk
- Define failure of passive transfer (FPT) and how it is assessed in calves
- Describe assessment of colostrum quality
- Explain how much colostrum is fed to the average calf and how that volume is calculated
- Describe timing of colostrum feeding in ruminants
- Describe types and advantages / disadvantages of feeding raw colostrum, stored colostrum, colostrum replacement products, and heat-treated colostrum
- Describe changes in feeding for calves progressing through the three phases of calf development (pre-ruminant to transition to ruminant)
- Describe how feeding may vary in small ruminants based on time of the year
- Describe creep feeding
- Describe use of coccidiostats when feeding small ruminants
- Describe feeding systems for cattle and small ruminants
- Describe anatomy of the equine GI tract
- Explain ideal percentages of forage and other types of feed for horses
- Describe disease conditions associated with

improper nutrition / feeding of herbivores

Cattle, sheep, and goats are ruminants. Young that are still nursing do not function as ruminants as their rumen is still developing. Once weaned, all ruminants ferment food in the rumen and have unique nutritional needs.

Horses are not ruminants but still ferment food. They are hindgut fermenters, who ferment food in the cecum.

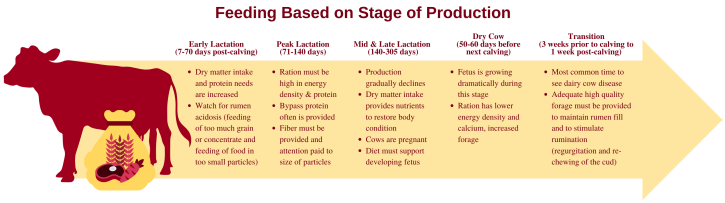
FEEDING DAIRY COWS

Cows, like all mammals, must give birth to make milk. They typically calve for the first time when 2 years old and have another calf every 13-14 months. Gestation length averages 280 days. They are not milked (dry) for 2 months at the end of pregnancy before the next calf is born. On average, cows have three calves before being replaced in the herd by their daughter (or the next cow's daughter). Cows are milked 2 or 3 times per day using milking machines that are cleaned and sanitized after each milking shift.

Cows are grazers. They are physiologically designed to consume large meals in a short amount of time. Meals are not chewed when consumed. Un-chewed feed is later

regurgitated and chewed so that particle size is reduced for further passage down the digestive tract.

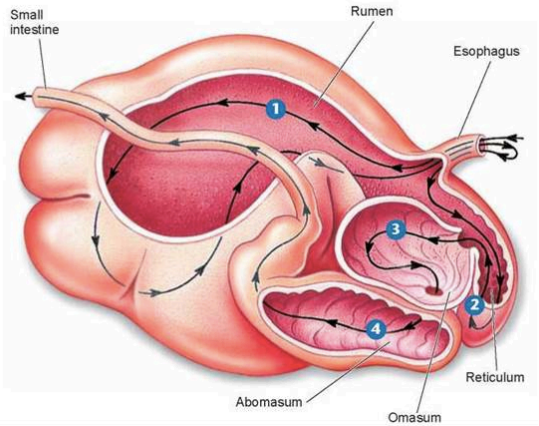
The cow has four stomach chambers. The reticulum is a specialized pouch of the rumen located adjacent to the heart but separated from it by the diaphragm. It has a honeycomb appearance. It empties primarily into the rumen (large pieces of ingesta) but also empties in the omasum (small pieces of ingesta). It also collects abnormal objects eaten by the cow and so is sometimes called "the hardware stomach." The rumen lies on the left side of the abdomen. It is lined with papillae to create a huge absorptive surface. It contains muscular pillars. Basically, it is a huge fermentation vat filled primarily with anaerobic bacteria. It is not functional at birth. It serves to store feed for regurgitation, to soak feed, to physically mix and break down feed, and to ferment fibrous feeds, sugars, and starches into volatile fatty acids (VFAs), which are absorbed by the papillae. It also is a source of protein production (some of the rumen micro-organisms synthesize proteins and vitamins), and generates heat (great in the winter, a source of heat stress in the summer). The omasum absorbs water and breaks down the ingesta into small particles by passage through many closely connected layers ("plies"). None of the first three compartments secrete digestive enzymes. The abomasum is a "true stomach" that secretes enzymes; it is a glandular stomach as is seen in monogastric animals like the dog and cat. It secretes hydrochloric acid, mucin, pepsinogen, rennin (which clots casein, or milk proteins), and lipase (which breaks down fats).



Cows have a more complex digestive system than monogastrics. The food cows eat first passes into the rumen, then is regurgitated and re-chewed, and then passes again into the rumen and on through the three other chambers. In the rumen, bacteria and protozoa break down the food into nutrients the cow can absorb. This allows cows to digest food that humans (or chickens or pigs) cannot digest. Most feed, about 70%, is digested in the rumen by bacteria, protozoa and fungi. Micro-organisms are substrate-specific, breaking down either fiber or starch, for example. Micro-organisms produce VFAs from digested feed; this is the cow's primary energy source. Micro-organisms also provide a significant source of protein to the cow (microbial protein).

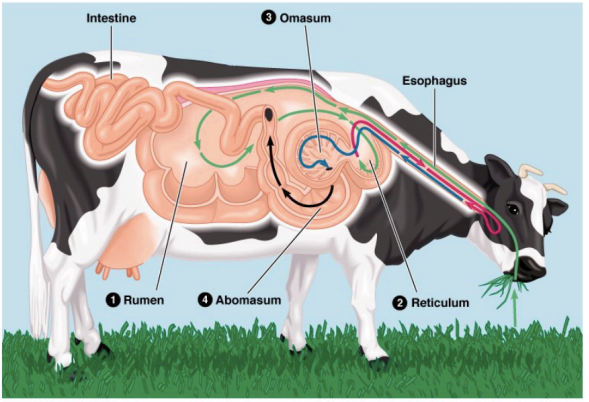
There is no oxygen in the rumen so when carbohydrates are broken down CO_2 and H_2O cannot be produced. The excess hydrogen is attached to carbon to make methane (CH_4), which is eructated (burped) or passed into manure. Fiber is broken down by rumen bacteria to create 2-carbon VFAs (acetate) and 4-carbon VFAs (butyrate) that are absorbed through the rumen wall. VFAs then go to the liver to be made into longer VFAs that contribute to milk fat. Starches and sugars are broken down to form 3-carbon VFAs (propionate) that are converted by the liver to glucose. Glucose plus galactose makes lactose – this is milk sugar and its production drives overall milk production.

Ruminant Digestion



"Four-chambered stomach of a ruminant", https://schoolbag.info/biology/living/209.html

1 = rumen, 2 = reticulum, 3 = omasum, 4 = abomasum



"Ruminant digestion in cattle", https://www.mun.ca/biology/scarr/Ruminant_Digestion.html

Name and describe the functions of the four chambers of the ruminant stomach.

The goals of feeding a milking cow are to maintain good cow health and reproduction, to support high milk production, to support good levels of milk components (3.7% fat, 3.2% protein in Holsteins) and to maintain adequate body condition. Cows are scored on a 1-5 scale with 1 being very thin and 5 being obese. Goals are a body condition score (BCS) of greater than 3 at calving, greater than 2.5 at peak lactation, and greater than 3.25 at dry off.

After calving, it is 3-6 weeks until peak lactation. Prior to and at the peak, it is hard for a cow physically to eat enough to keep up with metabolic needs of milk production. She will meet energy needs by mobilizing fat and, to a smaller extent, protein. More protein is provided to cows in early lactation. After peak lactation, energy needs will gradually decrease until she is dried off two months before her next calf is due.

Overall Nutrient Needs

- **Energy –** Carbohydrates and VFAs from rumen and fats
- **Protein –** Supplied by diet and microbial protein. Cows also get bypass protein, which passes the rumen and is taken up in the small intestine intact. This is needed to support milk production.
- **Fiber –** Physically necessary in rumen and needed to support acetate production and subsequent creation of butterfat in the milk
- **Fats**
- **Minerals**
- **Vitamins**

Adult cows are fed differently depending on their stage of production. These may or may not be different diets and instead may be different amounts of the same diet. Stages are early lactation (7-70 days post-calving), peak lactation (71-140 days), mid and late lactation (140-305 days), dry cow (50-60 days before next calving), and transition from

dry to lactation (3 weeks prior to calving and one week post-calving).

In early lactation there is a rapid increase in milk production. Cows cannot eat enough to take in sufficient energy to balance milk production. Dry matter intake is increased but is limiting as cows can only eat so much dry matter in a day. Protein needs are increased. A big concern in early lactation is rumen acidosis, a common condition where there is overproduction of lactic acid in the rumen with a decrease in production of the more valuable VFAs previously described. Causes of rumen acidosis include feeding of too much grain or concentrate and feeding of food in too small particles. Rumen acidosis is associated with lameness, low butterfat, weight loss, low production, poor reproduction, and eventual culling from the herd.

Describe formation in the rumen, absorption, and eventual use of volatile fatty acids (VFAs).

At peak milk production, intake again is limited by how much dry matter the cow can consume. The ration must be high in energy density, and high in protein; bypass protein often is provided. The cow may lose body condition due to inequality in energy out (milk production) versus energy in. Fiber must be provided and attention paid to size of particles introduced into the rumen to ensure normal rumen health.

At mid to late lactation, production gradually declines. Dry matter intake is associated with taking in enough nutrients to permit body condition to be restored. Cows are pregnant during this phase so the diet provided must support the developing fetus.

Cows are dried off (no longer milked) for about the last

two months of gestation. The fetus is growing dramatically during this stage. Cows receive a very different ration during this stage than they had as milking cows, with an increase in forage to prepare the rumen for the next lactation and feeding of a ration with lower energy density. The ration generally is low in calcium and is acidifying; this keeps calcium metabolism pathways operational to reduce chances of post-partum hypocalcemia.

The transition period is the time spanning from 2-3 weeks before calving to about 1 week after calving. This is a stressful time in the cycle as there is a big metabolic shift. This is the most common time to see dairy cow disease – for example, one study demonstrated that cows that ate less dry matter prior to calving were more likely to suffer from uterine infection (metritis) after calving. During this stage, adequate high quality forage must be provided to maintain rumen fill and to stimulate rumination (regurgitation and re-chewing of the cud). The diet is gradually shifted to that of the milking cow to give the rumen microflora time to adapt.

Common feeds are as those described in the Nutrition-Basics section of the course. Other miscellaneous feeds that may be added include bypass protein (fish meal, blood meal, dried brewer's grains, soybean meal) and bypass fat (Megalac™).

A total mixed ration (TMR) is composed of (1) a base vitamin and mineral mix, (2) an on-farm dry ingredient premix made up of protein mix (protein and concentrate: grain mix), and corn and other grains and byproducts or commodities as described in the Nutrition-Basics section of the course, and (3) forages. Advantages of a TMR is that each mouthful is the same so there is better assurance of a balanced diet delivered to the rumen micro-organisms; there is less chance of a given cow selectively eating or

avoiding a single type of feed; each individual cow can consume to her physical ability; and there is savings in labor and mechanization, especially in large operations.

Delivery of the diet includes such factors as order of mixing of components, processing (grinding, heating, extrusion, drying, etc.), and how the feed is provided to the cattle (amount, timing, delivery system, and removal of feed that is not consumed).

Cows may be fed in stanchion bars with feed provided as separate components or as a TMR; fed in freestall barns with bunk feeding, primarily of a TMR; or fed in a variety of other ways including forage in bunks, racks or pasture; feeding of concentrate in the milking parlor; feeding of concentrates in "computer feeders" ,and feeding mineral free choice as loose minerals or salt blocks.

Describe the production cycle of dairy cows. How old are they when they first calve? How long is a lactation? How often are cows milked?

FEEDING DAIRY CALVES

Care of the newborn calf includes:

- Monitoring the calving process and assisting if needed
- Removing the calf from the dam ASAP and drying it – The goal is to remove the calf from the dam within 30-60 minutes of birth to decrease exposure to pathogens.

- Disinfecting the navel (for example, 7% iodine dip) to prevent umbilical infection
- Feeding colostrum with the first feeding within 1-2 hours of birth
- Placing in calf housing and feeding a milk diet until weaned at approximately 8 weeks of age

The Five Cs of Successful Calf Rearing

Colostrum – Calories (nutrition) – Comfort – Cleanliness – Consistency

Colostrum

Colostrum is the first milk produced after calving. It contains elevated concentrations of immunoglobulins (primarily IgG and some IgM and IgA), and of proteins and fats – see table below for a comparison between colostrum (first milking after calving), transition milk (second and third milkings after calving), and whole milk (subsequent milk produced).

Comparison of Milks After Calving

	COLOSTRUM	TRANSITION MILK	WHOLE MILK
Total Solids(%)	23.9	14.1	12.9
Protein (%)	14.0	5.1	3.1
Fat (%)	6.7	3.9	3.7
Total Minerals (%)	1.11	0.87	0.74
IgG (mg/mL)	48.0	15.0	0.6

Colostrum is important because cows have an epitheliochorial (6-layer) or a synepitheliochorial (5-layer) placenta. Immunoglobulins cannot cross this placenta to the fetus so calves are born without circulating protective antibodies. Passive transfer is absorption of antibodies by the newborn calf across the gut into the circulation (IgG, IgA, and IgM). Colostral immunoglobulins protect the calf against diseases for the first few months, until the calf can produce its own immune response. Failure of passive transfer (FPT) is defined as concentration of IgG in calf

serum of less than 10 mg/mL when measured in blood drawn between 24 and 72 hours of age. In one study, 21% of United States dairy heifer calves had FPT. Benefits of having adequate passive transfer include reduced treatment and mortality rates in calves, improved growth rates and feed efficiency, decreased age at first calving, and increased first and second lactation milk production. Some of these parameters are not measured until cows are over 3 years of age so you can see that calf management has long-reaching effects.

The 5 Qs of a Successful Colostrum Management Program

Quality – Quantity – Quickness – sQueaky clean – Quantifying results

Describe nutrient differences in colostrum, transition milk, and whole milk in dairy cows.

Quality

Quality of colostrum is defined by amount of IgG within that colostrum. Feeding of colostrum that contains at least 50 mg/mL of IgG is associated with achieving > 10 mg/mL IgG in the calf's serum, or successful passive transfer.

Factors that Affect Colostrum Quality

FACTORS NOT UNDER MANAGEMENT'S CONTROL	FACTORS UNDER MANAGEMENT'S CONTROL
Breed – Colostrum quality is higher in colored breeds than in Holsteins	Dry cow nutrition
Parity – Colostrum quality is higher in older cows than in first calf heifers	Stress during dry period (heat stress, overcrowding)
Pre-partum leaking	Vaccination during dry period – may be stressful but also important for increasing antibodies
	Clinical mastitis (infection of the mammary glands – this milk must be discarded)
	Time to first milking – Optimally harvest colostrum within 1-2 hours of calving; beyond 6 hours, quality significantly declines
	Dry period length – Colostrum quality suffers if the dry period is less than 3 weeks in length

Colostrum quality is measured using a colostrometer or Brix refractometer. A colostrometer measures specific gravity. Its sensitivity is 75% and specificity is 87%. It is inexpensive, rapid, and simple to do but the instrument is fragile and the test must be performed at room temperature. The Brix refractometer measures total solids. Its sensitivity is 90.5% and specificity is 85%. It is more expensive but is rapid and simple and the test is not temperature-dependent.

Quantity

Often we do not have a clear idea of how much IgG is in the colostrum. Most people hedge their bets by giving a large enough volume to ensure that calves are receiving enough IgG. To achieve IgG of greater than 10 mg/mL in serum, calves must consume more than 100 gm of IgG in colostrum. If calves are fed 4 quarts of colostrum, this goal will be met 87% of the time. The current recommendation is to feed 10% of body weight at first feeding – for the average Holstein calf, which weighs 43 kg (90 lbs), that would be 3.8 liters (4 quarts).

Quickness

Quickness refers to time to first feeding. Calves are born with an open gut that is able to absorb large protein molecules intact, such as IgG. Gut closure begins soon after birth with progressive loss of ability to absorb IgG. Closure is complete by 24 hours of life. The goal is to feed colostrum within 1-2 hours of birth and certainly before 6 hours of life. Colostrum can be fed using either a nippled bottle or an esophageal tube. Veterinarians can teach producers how to safely tube feed calves by teaching them proper technique and stressing sanitation and management of the equipment. Options for providing colostrum include:

- Milking the cow and feeding the calf within 1-2

hours – preferred

- Feeding the calf colostrum that was previously collected from a different cow and stored (refrigerated or frozen)
- Feeding a commercial colostrum replacer product
- The calf suckling the dam – This is NOT preferred as it is associated with high FPT rates and increases exposure of the calf to pathogens.

sQueaky Clean

This refers to bacterial contamination. Colostrum is frequently an early source of microbial exposure. The goal is for colostrum to have a total plate count of fewer than 100,000 CFU/ml with total coliform count less than 10,000 CFU/ml. In one study, 82% of Wisconsin herds and 93% of Minnesota herds exceeded these amounts. If there are many bacteria in colostrum, this may prevent IgG absorption from the calf's GI tract and may directly cause disease. The three major sources of colostrum contamination are:

1. Infection from the mammary gland or fecal contamination of skin on the teats
    - This is best avoided by discarding milk from known diseased cows, not letting the calf suckle the dam, cleaning and sanitizing the udder before milk collection, and not pooling raw colostrum to be sure that colostrum containing bacteria from one cow does not adulterate good

colostrum from other cows.

2. Contaminated collection or storage equipment
    - This is best avoided by scrupulously cleaning equipment.
3. Bacterial proliferation in stored colostrum
    - This is avoided by feeding colostrum within 1-2 hours of collection, refrigerating it (use within 48 hours), or freezing it as soon as possible after collection.

Other techniques include feeding colostrum replacement products and heat-treating colostrum. Colostrum replacement products are powdered colostrum that is mixed with water. There is a minimum of 100 gm IgG per dose and cost is $25-30 / dose. It is a convenient, consistent source of IgG and controls disease transmission. One dose is equivalent to about 2 quarts of colostrum so most calves should receive at least two doses to try to avoid FPT. There is variation between products. Heat-treating is a relatively new technique. In one study, calves fed heat-treated colostrum were treated less and had less diarrhea (scours) than calves fed fresh colostrum.

Quantifying the Results

IgG in serum is not often measured. Total protein is more commonly measured; serum total protein of 5.0-5.2 gm/dL most accurately predicts serum IgG of 10 mg/mL. On-farm monitoring of passive transfer requires bleeding of about 12 clinically normal calves between 1 and 7 days old and measuring total protein with a refractometer. Goals are for 90% or more of the calves to have a total protein greater

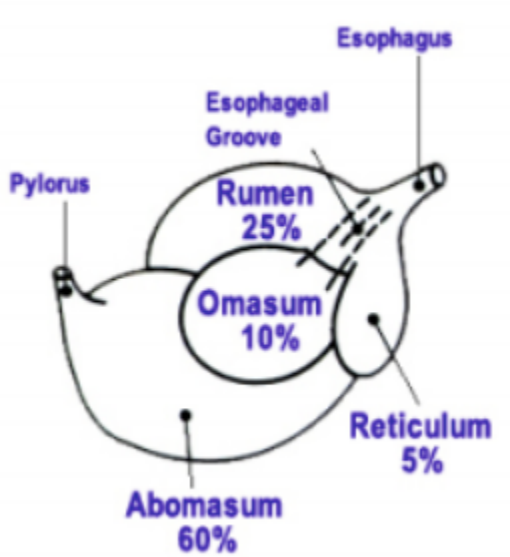
than 5 gm/dL or for 80% or more of the calves to have a total protein of 5.5 gm/dL. Higher is better!

Calories

Goals are for calves to double birth weight by 56 days of age (average daily gain (ADG) of 1.6-1.8 lb/day) and for calves to develop a functional rumen so the calf can be weaned off a milk diet and onto solid feed by 7-8 weeks of age.

Rumen Capacity as % of Total

The abomasum does not change in size as cows grow but the rumen changes dramatically in size and function.



AGE	ABOMASUM CAPACITY	RUMEN CAPACITY
1 week	60%	25%
3-4 months	20%	65%
Maturity	7-8%	80%

Phases of Calf Development

There are three phases of calf development: Pre-ruminant phase (birth to 3-4 weeks) – Transition phase (3-4 weeks to weaning) – Ruminant phase (weaning to 225 lbs and beyond)

Pre-Ruminant Phase (birth to 3-4 weeks of age)

Baby calves do not have a functional rumen. They cannot digest solid feed and have limited rumen fermentation capacity. The rumen has no absorptive papillae and the rumen wall is thin. The abomasum is the main compartment involved in digestion. Calves are dependent on a liquid diet (milk) as their major source of nutrients. Their diet consists of high-quality milk replacer, calf starter (pelleted grain), and water. Calves are fed whole milk or milk replacer in a volume of 2-3 quarts twice daily in summer and 3-4 quarts twice daily in winter, when more energy is needed for cold stress; some producers feed three times on cold winter days. Offer free choice starter grain after 3 days of age and offer free choice water after 3 days of age. Some producers like to offer a small amount of dry hay but this does not contribute to rumen development prior to weaning. Milk generally bypasses the rumen via the esophageal groove and empties directly into the abomasum. Esterase in the saliva begins fat digestion. Within the abomasum, milk clots within 10 minutes. Chymosin (rennin) acts on casein. The whey (liquid) fraction still includes many proteins, including antibodies. The milk clot is slowly digested by pepsin and HCl and is released to the intestines. Milk proteins but not vegetable proteins are best digested – look for this in milk replacers, as high-quality milk replacers will contain milk proteins, not soy or other vegetable-based proteins. In the small intestines, lactose is digested but starches and non-lactose

disaccharides such as sucrose are essentially not digested during this phase. Pancreatic protein enzymes (trypsin and chymotrypsin) increase gradually.

Options for liquid feed for calves include milk replacer (generally 20% crude protein and 20% fat), whole milk, and pasteurized nonsaleable milk (for example, waste or discard milk). Considerations include desired nutrient intake to meet health and growth targets, disease control, complexity of managing the feeding program, and cost-benefit analysis.

Milk Replacer Programs

Nutrient Levels (e.g. 20 : 20 = Crude protein % : Fat)

- Crude protein: 18-30%
- Fat: 15-20% (up to 25% for Jerseys)

Protein Sources

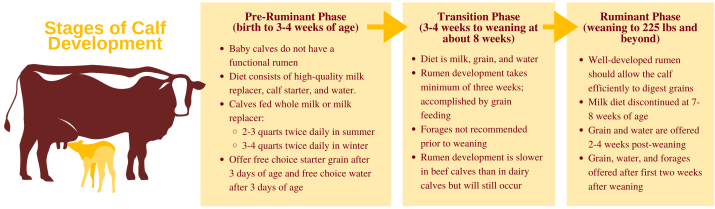
- All milk – Whey protein: best mixing, highly digestible, most expensive
- Alternative proteins:
  - Soy protein concentrate
  - Soluble wheat gluten
  - Plasma
  - Soy protein or modified soy flour isolate

- Egg protein

Fat Sources

- Lard – Probably the best and most economical
- Tallow – Can be less expensive at some times of the year
- Vegetable – Most expensive option today

Use of pasteurized non-saleable milk may be cost-effective. Pros include reduced pathogen transmission compared to raw milk, improved rate of gain compared to traditional milk replacer, improved calf health, improved economic efficiency, and use of a non-saleable product. Cons include cost of pasteurization and need for more intensive management and monitoring compared to conventional milk replacer programs.



Transition Phase (3-4 weeks to weaning at about 8 weeks)

The diet is milk, grain, and water. During this phase, the calf begins to develop a functional rumen capable of digesting dry feed. Rumen development takes a minimum of three weeks. Rumen development is accomplished by grain feeding to promote butyric and propionic acid production, lowering pH and increasing growth of microorganisms. This increases the size and muscularity of the rumen, and promotes development of papillae while the microflora is established. The rumen will not develop on a milk-only diet or on milk and forage. Grain feeding is required for development of the rumen in size and function. Forages are not recommended prior to weaning because microbes are not initially capable of fermenting forages, forage fermentation that may occur is associated with acetate production that does not stimulate rumen development, and forages fill the rumen and displace starter grains that would promote rumen development. Note that this is for dairy calves; beef calf management is described below.

Weaning Guidelines for Calves

Reduce stress by spreading out changes:

- Feed changes (weaning)
- Procedures: dehorning, vaccinations, tail docking
- Socialization/grouping, transport, environmental changes

Before weaning, calves should be:

- Eating starter for at least 3 weeks
- Consuming at least 2 lbs of starter per day for 3 consecutive days
- Receiving reduced milk diet by 50% in last week to increase starter intake

Move to groups after weaning:

- Keep in individual pen on same grain > 7 days after weaning
- Move to small groups initially (6-8 calves)
- Continue on same grain for 1-2 weeks after grouping
- Introduce forages after 3-4 weeks post-weaning

Ruminant Phase (weaning to 225 lbs and beyond)

After 3-4 weeks in the transition phase, a well-developed rumen should allow the calf efficiently to digest grains. A milk (liquid) diet is discontinued at 7-8 weeks of age. For 1-2 weeks post-weaning, grain and water are offered. After that, grain, water, and forages (for example, hay) are offered.

Describe differences in the pre-ruminant, transition, and ruminant diets of dairy calves.

General Considerations When Feeding Calves

Energy Status in Cold Weather

Strategies to improve energy status in cold weather include:

- Increase caloric intake:
    - Increase volume fed per feeding
    - Increase number of feedings per day
    - Add supplemental fat
    - Select liquid diet with increased energy density
- Decrease energy losses:
    - Keep calves dry
    - Prevent drafts
    - Use insulation: extra bedding (straw), calf jackets
    - Use supplementary heat if needed
    - Increase starter and water intake to promote rumen development
    - Avoid illness by health management

Starter Management

You want to encourage starter intake to promote rumen development. This is needed before weaning to onto a cheaper diet of dry feed (no milk).

Calves prefer:

- Textured starters (pellets with corn/oats and molasses)
- Avoiding fines, dust
- Fresh (no mold), palatable, free choice

For best results:

- 21-23% crude protein (dry matter basis)
- Molasses content 5-8%
- Begin offering at 3 days and replace daily
- Provide free-choice fresh water
- Put in clean buckets
- Put in mouth after milk feeding

Free-Choice Water

Free-choice water promotes rumen development by providing an aqueous environment for microbes because milk bypasses the rumen by running through the esophageal groove but water deposits directly in the rumen. Water also promotes greater intake of dry feed. Water is essential to maintain hydration status, especially during periods of heat stress and illness (diarrhea = scours). Provide free-choice fresh water beginning at 3 days old and replace twice daily. Clean and disinfect buckets regularly. In winter, offer warm water for 1 hour after each milk feeding, then dump it before it freezes. In summer, check water at mid-day. Some calves are in an accelerated milk

replacer program with high total solids – these calves absolutely must have free-choice water.

FEEDING BEEF CATTLE AND BEEF CALVES

What is fed to beef cattle varies widely. Beef cattle readily can use various rough feeds as are found on pasture and, in the United States, may be fed grain as well. As in other species and in dairy cattle, appropriate nutrition for beef cattle varies with life stage.

Breeding Cattle

Cows are bred to produce one calf per year. For the cows and bulls, grazed forage provides the bulk of the nutrition through the growing season. For the upper Midwest, this would typically be pasture from May through October, followed by grazing crop residue, primarily cornstalks, in November and December.

In addition to the grazed feed, beef cattle require supplemental vitamins and minerals for optimal health. These are delivered in the form of a loose mineral or a solid form. Solid products include a lick block, made from salt and minerals compressed into block form, or a lick tub, where vitamins and minerals are mixed with a protein source and molasses and cooked into a solid product that is delivered in a plastic or metal tub weighing 200 to 250 pounds. Supplemental vitamins and minerals are critical in grazing cattle to decrease the incidence of diseases such as pneumonia in the calves, as well as to prevent metabolic

dysfunctions such as grass tetany (magnesium deficiency) in the cows.

Good pasture management is key to allowing maximum production of forage and maintain plant health. While not our primary role as veterinarians, as the most referenced source of advice on animal husbandry for producers it is critical to have a basic concept of how to manage grazing pastures, as poor grazing leads to unthrifty livestock and opens the door to parasitic infection.

For pastures in the upper Midwest and the Northern Plains, grass species are livestock's primary food source. In order to thrive, grasses need to have enough leaf to collect sunlight that the plant can then use to create energy. If the grass is grazed too tightly to the ground, the lack of a leaf inhibits sunlight capture.

To keep grass healthy, animals should only begin to graze a pasture once the grass has achieved twice its minimum required height. For the cool-season pastures common to Minnesota and the eastern Dakotas, this would be roughly eight to twelve inches tall. Once grass has been grazed to half its original height, it is time to move the animals to a new pasture. This gives the grass in the first pasture time to recuperate and regrow before being grazed again. Because of the need to move animals to new pasture throughout the grazing season, having multiple pastures, having a pasture cross-fenced into multiple paddocks, or having personnel to move the animals daily is a requirement for good grazing. This program of moving animals when they have grazed half the plant height is termed rotational grazing, as the animals "rotate" from one location to another. Due to the inconsistency of the weather, movements are not predicated on the calendar, but rather when grass height dictates moving. If done properly,

the carrying capacity, meaning the number of animals the pasture can feed, will increase up to the level of doubling.

At the basic level, appropriate pasture management is critical to prevent malnutrition in livestock. Overgrazing early in the year can lead to a shortage later in the summer. Short pastures lead to poor body condition, lackluster reproductive performance and potentially weakened immune systems, allowing infectious disease to proliferate. Short pastures also open the door to increased parasite burdens, as was described in the chapter on parasite control. The life cycle of intestinal worms requires the larvae migrate up a blade of grass and be consumed livestock. This migration typically happens within the first two inches of grass height. Therefore, if pastures are rotated as recommended at 4-6" of grass height, the members of the herd or flock consume fewer parasites, decreasing parasite burdens in the gut.

During the winter in the upper Midwest, cows and bulls often need to have feed delivered to them, as nothing will be growing and most crop residues are depleted. As ruminants, beef cattle have the ability to use an impressive variety of feedstuffs. This includes, but is not limited to, forages such as grass hay, alfalfa hay, corn, or other crop silage; grains such as corn, oats, or milo; and byproducts such as those left over from the production of ethanol, high-fructose corn syrup, or soybean oil. Because of this variety, testing each type of feed to determine the quality and quantity of macro and micro nutrients is a necessity. These test results can be used by a ruminant nutritionist to provide a balanced ration to keep cows in good condition through the cold of the winter.

Feeding Beef Calves

Most calves are born in the early spring. This is done to match the most economical forage, grazed pasture, to

the time when cows are at peak lactation, the first 6-8 weeks after the calf is born. As lactation requires much energy, aligning calving so peak lactation occurs in late spring when grasses are most nutrient-dense is a common strategy.

Calving may occur at other times of the year for a variety of reasons. The most common is labor-related, as calving can be a labor-intensive process for the rancher. If spring is occupied by other endeavors, such as planting crops, calving may occur in the winter or in the early fall, when it doesn't overlap with farming.

Just like the dairy calf, the beef calf is born as a pre-ruminant. However, beef cattle are permitted to nurse from their dam, and unlike the managed process of rumen development that occurs with dairy calves, beef calves' rumens develop on their own, as they remain with the cow for several months. Beef calves develop their rumen through eating forages out of curiosity, taking small nibbles at a few weeks of age, and progressing to grazing more as they age. While cows' milk makes up the entirety of the calves' diet for the first few weeks after birth, it is gradually outpaced after that by grazed forage.

Weaning typically occurs in beef cattle around 6-7 months of age, usually in September, October or November. The reason for timing is once again cow-nutrition based—the process of nursing a calf takes energy from the cow and if she does not recover her body condition prior to winter, she will have difficulty during cold weather. By weaning a few months before winter, cows can store up body condition to have extra insulation for the incoming cold weather.

At weaning, calf diets start off forage-based, but must quickly progress to a supplement/forage blend. The reason for this transition is because calves' nutritional

requirements are higher for protein and energy than simple grass hay can provide. Supplements, such as grains, fill that gap, but if the conversion happens too quickly, the rumen pH can drop rapidly and lead to acidosis. Alternatively, if the change happens too slowly, calves robbed of necessary nutrition are more susceptible to health issues, predominantly pneumonia. At this critical juncture, it is essential for calf diets to be formulated by a nutritionist.

Once calves are comfortable eating their initial diet, the subsequent diet will be one that matches the ultimate destiny for each particular group of cattle. For calves destined for the breeding herd, the diet remains forage-based, with grains and/or byproducts supplemented at a low level to meet the calves' energy requirements. The goal is for both heifers and bulls to be sexually mature at or before 15 months of age, to allow for them to successfully produce calves when they are two years old.

For cattle destined for slaughter in the Midwest or the Great Plains, the diet is transitioned to a grain-predominant diet, or so called "grain-fed beef". It is important to not confuse grain-fed as grain-exclusive diets, as all cattle require some forage to keep their rumen functioning. For grain-fed cattle in the upper Midwest, approximately 10% of their diet is rough forage, such as grass hay, ground corn stalks or chopped straw. The rest of the diet typically consists of ground corn, corn silage and ethanol by-products. This is done for three reasons. First, grain-fed cattle are ready for slaughter much sooner than those fed forages alone. A grain-fed animal reaches the 1300-1500 lbs slaughter weight at 14-16 months of age, as compared to 20-24 months for forage-fed cattle. Second, in order to keep a steady supply of fresh beef coming to market, some cattle will need to be fattened during the winter. Stored forages do not have the energy necessary to fatten cattle

and without grain, the harsh winters of the central United States would inhibit cattle from fattening for a few months. This is why warmer climates, like Brazil or New Zealand, can provide fat, forage-fed beef year around. Lastly, the flavor profile of grain-fed cattle is preferred by many customers of beef both in the United States and abroad. This creates a lucrative market for grain-fed beef, causing the high-value cuts of US and Canadian beef to command a premium world-wide.

FEEDING SHEEP AND GOATS

Sheep are bred in the fall and lamb in the spring after a 147 day gestation. Important times to consider changes in nutrition are one month prior to breeding, in the first month after bred, in the last month of gestation, and in the first 45 days of lactation. Lambs are weaned at 60-120 days of age and go to market at about 5 months of age.

The production cycle of goats is similar. The typical dairy goat is bred in the fall while still lactating from her previous pregnancy. Gestation is 150 days. She is dried off for the last 60 days of her pregnancy and kids in the spring. Lactation is 305 days.

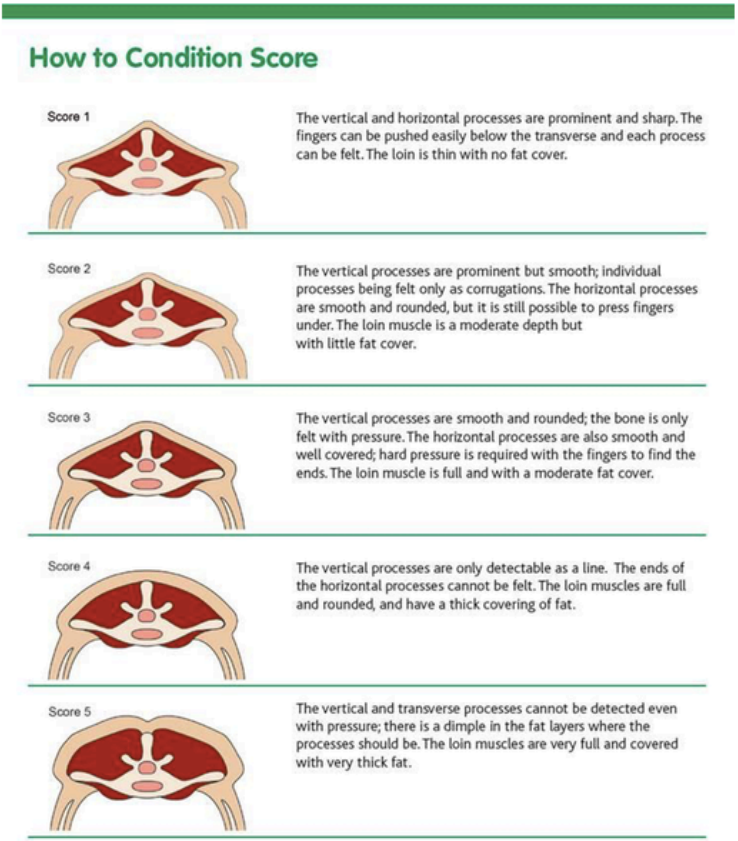
The information below refers to goats but is applicable to sheep as well; the complete document from which this is drawn is in the External Resources folder for this section.

The greatest asset of goats is the ability and tendency to use woody plants and weeds not typically consumed by other species of animals (cattle and sheep), converting them into a saleable product. Therefore, these plant species

can be inexpensive sources of nutrients and make for a very profitable goat enterprise. Goats typically consume a number of different plant species in any one day and can use some poisonous plants because they do not consume enough to be toxic. Similarly, goats are believed to have a relatively high ability to detoxify absorbed anti-nutritional factors. Goats are more resistant to bloating than other ruminants, and after a brief adaptation may graze alfalfa without bloating.

Body Condition Scoring

The adequacy of a nutritional program can be assessed by observing changes in body weight and condition of the animal. If animals lose weight, body condition will be reduced (animal is thinner), alerting an observant manager to a problem. Body condition is particularly responsive to energy and protein adequacy. Body condition scoring is a system of assigning a numerical score based on physical characteristics indicative of fatness. These include the amount of muscle and fat covering the spine in the loin area and ribs and fat pad at the sternum. Body condition scores range from 1 (very thin) to 5 (obese) in one-half score increments. Animals should achieve a certain body condition during specific periods of the production cycle. For example, animals should have a body condition of at least 2.5 but no more than 4.0 at the beginning of the breeding season. Prior to entering the winter a minimum score of 3.0 is desirable. Also, if body condition score is 4.5 or greater, pregnancy toxemia prior to kidding is likely, as also is the case with a score of 2.0 or less.



"Condition scoring of ewes", https://www.farmhealthonline.com/wp-content/uploads/2015/12/AHDB-Ewe-Condition-Handout-2015.pdf

Nutrients must be provided using feedstuffs such as pasture, hay, concentrate, and minerals. For most goats throughout much of the year, nutrient requirements can be met by available pasture, a mineral supplement, and water. During times of limited forage availability or quality such as winter, or feeding poor quality hay or stockpiled forage, a supplement will be needed to supply deficient nutrients. The level of supplemental feeding should be adjusted with

changes in animal requirements, such as increased needs of late pregnancy. Sometimes it may be preferable to put an animal in a lot and feed a complete diet or one high in concentrate such as with dairy goats.

There may be periods when nutrient requirements cannot be met, resulting in loss of body weight. This is acceptable at certain times in the production cycle if body condition is sufficient for the animal to draw upon body reserves and maintain the desired production level. An example would be weight loss during early lactation because sufficient nutrients cannot be consumed. However if the doe is in poor body condition, is a growing yearling, or has severe weight loss during this time, milk production will be depressed. During a drought, it may be acceptable for open or early pregnant animals that are not lactating to lose weight. During late pregnancy, inadequate nutrition can have adverse effects on pregnancy outcome and subsequent lactation. Severe undernutrition can cause abortion, reduced livability of the kid(s), and reduced milk production, and can adversely affect maternal behavior.

Feeding Different Classes of Goats

Feeding Bucks

Mature bucks can obtain most of their nutrients from pasture. However, yearling and 2 year old bucks have greater nutrient requirements since they are still growing. Bucks need to be in good body condition (BCS greater than 3) before the breeding season because feed intake may be relatively low during that time, with loss of body weight. Thus, body condition should be evaluated 3 months before the breeding season. Decisions can then be made on the supplemental nutrition needed for the buck to achieve the

desired BCS. Whenever bucks cannot meet nutritional needs from pasture, supplementation is necessary. Under most conditions, whole shelled corn or sweet feed at 0.25 to 0.5% of body weight will be adequate (0.5 to 1 lb of feed for a 200 lb buck). Feeding bucks high levels of grain (greater than 1.5% of body weight) for a long period of time makes them prone to urinary calculi. The levels of grain recommended above are safe for bucks. When pasture is scarce, bucks can be fed medium quality hay free-choice.

Feeding Does Throughout their Life Cycle

The four production periods of does are dry nonpregnant, pregnant, late gestation, and lactating. Does that are open (nonpregnant) or in the early stage of pregnancy (< 95 days) have fairly low nutrient requirements. For open does, the goal is to gain a little weight to be in good condition for breeding. A medium quality pasture, such as in late summer, or a medium quality hay is sufficient to prepare for breeding and the early stage of pregnancy. However, adequate quantities of feed are necessary. Flushing refers to the practice of providing extra nutrition to does approximately 2 weeks prior to breeding and for a variable portion of the breeding period (e.g., 1-2 weeks) to increase the number of ovulations and have a greater proportion of twins and triplets. This is widely advocated with sheep producers and Angora goat producers. Producers have extrapolated the practice to meat goats. However, several controlled studies with Spanish goats in reasonable body condition (BCS 2.5 – 3.5) have shown no response in kidding or conception rate of meat goats to flushing with extra protein, energy, or both. The practice may have utility for meat goats in poor body condition, but there does not appear to be justification for flushing does in acceptable body condition.

Winter Feeding of Does

Early to mid-winter is a time when does should be in early pregnancy. The goal of a wintering program is to economically provide the necessary nutrients to maintain a reasonable body condition, lose no weight, and keep them warm. In general, most wintering programs consist of both forage and supplement components. The forage component can consist of hay, stockpiled forage, or a cheap byproduct roughage feed. The supplement usually contains energy, protein, and often vitamins and minerals, although these may be provided separately as a mineral mix. Commonly used supplements include whole shelled corn (inexpensive source of energy), range cubes (inexpensive source of energy and protein), sweet feed, protein blocks, molasses blocks or tubs, and liquid feed. Stockpiled forage is forage that is

Dry/Nonpregnant

- Fairly low nutrient requirements
- Goal is to gain a little weight to be in good condition for breeding
- Medium quality pasture or medium quality hay is sufficient
- Adequate quantities of feed are necessary

Pregnant

- Early to mid-winter
- Goal is to maintain body condition & keep them warm
- Feed forage and supplement components
- Forage can consist of hay, stockpiled forage, or cheap byproduct roughage
- Supplement usually contains energy, protein, and vitamins and minerals

- Supplements include whole shelled corn, range cubes, sweet feed, protein & molasses blocks or tubs, & liquid feed

Late Gestation

- Energy requirements increase
- Feed intake may be reduced in the last 4 to 6 weeks of gestation
- Will need a more nutrient dense diet & exercise

Lactating

- Doe has very high nutrient requirements
- Nutrient requirements decline as stage of lactation advances
- Can consume nearly enough nutrients if an abundant supply of high quality pasture is available

grown during the summer or fall upon which animals are not allowed to graze, reserving it for the winter months. In drier areas, the forage is well preserved, but in a more humid climate quality declines rapidly, making the practice less satisfactory. Stockpiled forage is a very inexpensive forage source since it does not have to be mechanically harvested (baling forage doubles the cost of forage). Animals harvest stockpiled forage by grazing, which also decreases cost. Animals make much more efficient use of stockpiled forage when strip grazed (using temporary electric fence to limit animal access to an area containing a 1 to 3 day supply of forage) to minimize trampling. Fescue is used in many temperate regions for stockpiling and retains its quality well into late winter even in humid areas. Most recommendations for stockpiling fescue include late summer fertilization, clipping, and deferred grazing. Warm season grasses such as native range and Bermuda grass can be stockpiled. The amount of deterioration is dependent on grass species and rain.

Feeding Does in Late Gestation

Energy requirements increase dramatically in late pregnancy. Doelings require more supplementation than mature does, as the doelings are still growing. Feed intake may be reduced in the last 4 to 6 weeks of gestation by the growing kids that reduce available abdominal space. Pregnancy toxemia is a metabolic disease usually caused by animals being too fat (body condition score greater than 4) prior to kidding, although very thin animals (body condition score less than 2) are subject to the disease also. It is caused by a high demand for nutrients by the growing fetus in late pregnancy that is not being met (excess fat in the body and the growing fetus limit room in the stomach for food, reducing intake of the diet). This unmet nutrient demand causes a rapid breakdown of fat reserves, forming

ketone bodies at high levels which are toxic. Treatments include administration of propylene glycol, large doses of B vitamins, glucose given intravenously, and possibly C-section. Prevention of the disease is far easier and more effective than treatment. Simply monitor animal body condition and adjust nutrition, especially energy, to manipulate body condition. Do NOT sharply reduce feed in late gestation as this may cause pregnancy toxemia. Also, pregnant goats in the last third of pregnancy will need a more nutrient dense diet (higher quality) due to fetal growth and reduced intake because of reduced stomach capacity. Exercise will help. Does can be encouraged to exercise by separating hay, feed and water at a substantial distance, forcing them to walk more.

Feeding the Lactating Doe

The lactating doe has very high nutrient requirements. During lactation, the doe can consume nearly enough nutrients if an abundant supply of high quality pasture is available, such as in spring or early summer. However, does will likely lose some bodyweight due to the high demands of peak lactation (weeks 3 to 8 of lactation) and an inability to consume an adequate quantity of feed. Kidding should take place when there is an adequate supply of high quality pasture. If there is not adequate pasture, supplemental feed will be required. Inadequate nutrition will decrease body condition, reduce milk production, reduce kid weaning weight, and increase kid mortality. When feeding high levels of grain, the animal should go through an adjustment period of two to three weeks during which time the grain portion of the diet is gradually increased to prevent digestion and other problems from occurring. Feeding a dairy ration and hay to a doe during late gestation and the lactating period will cost approximately $30 per animal. Utilizing available pasture

as a feed source is a much cheaper alternative. Kids are usually weaned at about 12 weeks of age. Milk production of the doe begins to decrease after the 6th week of lactation and is quite low by the 12th week. Nutrient requirements decline as stage of lactation advances, enabling the doe to maintain body condition or even increase it on pasture alone. Kids may be creep fed while nursing to increase growth rate of the kids and reduce nutrient demands on the doe for milk production.

Creep Feeding

Creep feeding is a method of providing feed for the kids only. This is accomplished by fencing around a feeder and using a creep gate that has holes about 5 inch wide by 1 ft high. These holes are small enough so that kids can enter the feeder, but adults are excluded because they are too big to go through the hole. Creep feeding will provide extra growth for the kids and train them to eat feed, facilitating weaning. A commercial creep feed with at least 16% crude protein that is medicated with a coccidiostat should be used. It requires about 6 lbs of feed to produce 1 lb of animal gain. The more rapid growth from creep feeding may be beneficial for producing show prospects. An alternative to grain-based creep feeds that is used in the beef cattle industry is to creep graze calves, using a creep gate that allows calves access to ungrazed high quality pasture. This may have application for goats using high quality pastures (crabgrass or sudangrass that is planted for the kids). In rotational grazing of cattle, the calves are often allowed to creep graze the next pasture before cows so that they have relatively high nutrient intake. Those pastures often have less parasites and disease organisms because of the time since last grazing.

Describe creep feeding in goats.

Effect of Kidding Season on Nutrient Requirements

Nutrient requirements of does change dramatically with stage of production. Requirements increase dramatically the last 6 weeks of gestation due to increasing fetal growth and remain high in early lactation. During the month prior to kidding and for the following 3 months (assuming weaning at 12 weeks of age), the doe will consume nearly as much nutrients as in the remaining 8 months of the production cycle. Thus, during that time it makes sense to supply nutrients from an inexpensive source, typically pasture. The cost of providing the same nutrients as hay is more than twice that of pasture, and supplying through purchased feeds may be four to five times greater than for pasture. Kidding should be planned for a time when pasture is rapidly growing. This period corresponds to late spring for pastures comprised of warm season forages such as Bermuda grass or native range, browse, and forbs, but could be either fall or early spring for cool season grasses such as ryegrass, wheat, orchard grass, and fescue. Cool season grasses usually produce less forage per acre than warm season forages, but generally are higher in energy and protein. Rapidly growing pasture is high in protein and energy. A major consideration in determining the date to kid is level of forage production at that time. However, there are other considerations in selecting kidding date, such as parasites and market opportunities. Some markets provide a substantial price premium from kidding at a

specific time of the year, such as producing prospect show wethers or registered animals. However, it may take a considerable market premium to cover the cost of purchased feed, so general reliance on pastures and forages is best.

Artificial Raising of Kids

Sometimes it is necessary to bottle feed young kids due to death of the mother or the mother refusing to take them. It may be avoided by crossfostering kids onto another doe. If a bottle-raised kid is with other kids and does, they may learn to 'steal' sufficient milk to raise themselves. Kids can be raised on cow milk replacer, goat milk replacer (expensive) or, if none is available, cow milk from the store may be used. It is very important that kids receive colostrum within 12 hours of birth. After 12 hours, antibodies absorption decreases. Colostrum may be milked from another doe that recently kidded. Colostrum contains antibodies that strengthen the immune system for the first months of life. A kid should be fed one ounce of colostrum per lb of weight (average birthweight 7 lbs, therefore, 7 ounces of colostrum) at each of three feedings in the first 24 hours. If the kid is too weak to nurse, it is appropriate to provide the colostrum via stomach tube. This does take some practice, but obtaining colostrum is critically important to kid survival. Initially kids can be fed using a baby bottle or a nipple such as the Pritchard teat which fits on a plastic soda bottle. Kids can be bottle fed twice a day, although three times a day the first 4 to 6 weeks of life may increase growth rate. Kids are very susceptible to bloating and other gastrointestinal problems from milk replacers that contain a high level of lactose due to use of dried

whey in their formulation. Reduced lactose milk replacers will reduce bloating problems. A calf starter feed (with a coccidiostat such as Rumensin or Deccox, sometimes called medicated) and high quality hay should be made available the second week of life. Deccox can be used in the milk from week 2-6 to prevent coccidiosis. After 4 weeks of life, kids can be limit fed milk at one pint in the morning and also in the afternoon. This will stimulate consumption of starter feed and facilitate weaning. Kids can be weaned after 8 weeks of age if they are consuming 2 ounces of starter per day and weigh two and a half times their birth weight (about 18 lbs). Weaning shock can be reduced by going to once daily milk feeding for several days to encourage consumption of the starter.

Note: *Remember that any time you're talking about medicated feed, under new legislation, a Veterinary Feed Directive is required – see the Drug Management chapter to learn more about veterinary feed directives.*

Considerations in Ration Formulation

Rations should be balanced not only for protein and energy, but calcium and phosphorus contents should be calculated, macrominerals supplemented, and a trace mineralized salt used to provide microminerals. A vitamin premix should be used to provide at least vitamin A and E. If the diet is being fed at high levels to bucks or wethers, there is risk of urinary calculi. To prevent urinary calculi, the ration should be formulated with a minimum of phosphorus, over twice as much calcium as phosphorus, and a urine acidifier such as ammonium chloride at 0.5-1.0% of the diet. Salt can also be included in the diet, such as at 1%, to reduce incidence of urinary calculi. If the ration is being fed at high levels,

sufficient fiber should be included in the diet to prevent acidosis. Dried brewers yeast and probiotics are often used in rations fed to animals at high levels to help prevent them from going off feed. Feeds may have a coccidiostat included in the formulation to prevent coccidiosis. There are a number of coccidiostats, but Food and Drug Administration approved drugs commonly used include Deccox and Rumensin. Since goats are very susceptible to coccidiosis when stressed, such as at weaning or shipping, many starters and show feeds contain coccidiostats and have the term 'medicated' on the feed tag. Management considerations to reduce coccidiosis incidence include sanitation, cleanliness, and dry housing.

Feeding Systems

There are many methods of feeding goats. Feeds should be offered in such a way to minimize mold growth or fecal contamination that reduces intake. Mineral mixes must remain dry and should be replenished at 2 week intervals to avoid caking. Feed troughs should be designed to facilitate removal of feces and leftover feed. Troughs generally require a bar running above the length of the trough to keep goats from defecating in them. Self feeders can be used for feeds containing sufficient roughage for use as a complete feed or for feed that has a built-in intake limiter. For large range operations, feeds such as whole shelled corn or range pellets or cubes are often fed on the ground. The feeding area is moved each day to have clean ground upon which to feed. Round hay bales should be fed in a rack off the ground. Feeding round hay bales on the ground results in hay wastage and leaves a mess that is difficult to clean. Hay can be fed in a manger or hay feeder with keyhole slots,

but horns may cause problems preventing access to feed. For large operations, unrolling round bales on the ground works well.

FEEDING HORSES

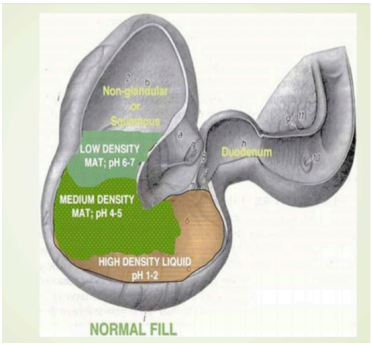
Horses are social animals with an established hierarchy. Wild horses are nomadic, following the food, and don't defend a set territory. They are herbivores with a forage-based diet. They are grazers or trickle feeders, designed to eat numerous small meals throughout the day. They tend to feed more heavily at dawn and dusk.

Horse Anatomy

Horses have hypsodont teeth that erupt over the life of the horse. Horses prehend with their tongue and incisors, moving the bolus to the back of the mouth where it is ground by the cheek teeth (premolars and molars). Side-to-side chewing motion maximizes grinding. Differences in tooth wear are noted between forage and concentrate-based diets. Intense mastication by the cheek teeth leads to reduction in particle size and stimulates production of saliva, which is 99% water and serves primarily as a lubricant. There are virtually no digestive enzymes in equine saliva but it does provide buffering of gastric contents. Saliva secretion increases with increased dry matter (DM) intake (i.e. forage requires more chewing than

concentrates and is associated with larger volume of saliva). Careful chewers will reduce particle size of ingested feeds to 1-2 mm, which allows for more complete exposure of feeds to enzymatic digestion in the small intestine.

The esophagus is 1.2-1.5 meters (4-5 ft) long from the pharynx to the cardia of the stomach with upper and lower esophageal sphincters. It is lined with stratified squamous epithelium and has no secretory function. The sequence of motility follows – food enters pharynx, upper esophageal sphincter relaxes, peristalsis, distal movement of bolus, lower esophageal sphincter relaxes, bolus enters stomach – total transit time is 4-10 seconds.



"Horse digestive tract", https://slideplayer.com/slide/6123276/

Stomach volume is 8-15 L (about 8% of the total GI tract). The proximal half is non-glandular, and the distal half is glandular. The fundic mucosa produces HCl (continuous, highly influenced by type of feed), and the pyloric mucosa produces gastrin. The gastric bacterial population contributes to digestion of non-structural carbohydrates – this population is pH dependent and produces lactic acid and VFAs. Gastric emptying time for water is 30-90 minutes, for high-fiber / low-starch diets about 90 minutes, and for low-fiber / high-starch diets 2-4 hours; meal size also affects rate of gastric emptying. Little absorption of nutrients occurs here.

The small intestine is 25 meters (82 ft) long – passage of foodstuffs occurs at a rate of 6-90 cm/min. This is the major site of enzymatic digestion and absorption of nutrients such as glucose, amino acids, fatty acids, fat-soluble vitamins, calcium, phosphorus, magnesium, and water. The small intestine is the only site of calcium absorption in the equine GI tract.

The hindgut is made up of the cecum, large (ascending) colon, small colon, and the rectum. This is the major site of microbial fermentation and fluid absorption – horses are hindgut fermenters. The hindgut processes plant components that do not get broken down in the small intestine. A huge resident microbial population is responsible for digestion of fibrous matter and includes bacteria, fungi, and protozoa. VFAs, fructans (complex sugars), nitrogen, sodium, chloride, and water are absorbed. Simple sugars (glucose, fructose), amino acids, fatty acids, and fat soluble vitamins are not absorbed in the hindgut. The small colon is responsible for desiccation and formation of fecal balls.

Nutrient Requirements of Horses

- **Water –** Requirement is 30-60 ml/kg/day in adults (4-8 gallons or 15-30 L). Requirements fluctuate with ambient temperature, exercise, pregnancy, lactation, etc. Water may be consumed with diet when on pasture (40-60% water). A goal is to maximize water consumption. Horses can be very finicky about temperature of water, bucket, location, etc.
- **Energy –** Horses eat to meet their energy needs. Need is heavily influenced by life stage, body

condition, and ambient temperature. The most useful term for practical purposes is digestible energy (DE) = gross energy minus energy lost in feces – Maintenance DE (Mcal/day) = 1.4 + (0.03 x BW in kg) for horses 600 kg or less (1 Mcal = 1000 kcal).

- **Carbohydrates –** The principle source of energy in equine diets and come from forages and grains. Some are hydrolyzed to simple sugars in the small intestine, leading to absorption of glucose into the bloodstream, and some undergo bacterial fermentation in the hindgut. More energy is derived from those broken down in the small intestine than from those metabolized in the hindgut. There are no established maximum or minimum requirements for carbohydrates.
- **Protein –** A source of energy and is the major component of most tissues in the body. It is obtained from feed and is digested and absorbed primarily in the small intestine. Quality of the protein affects its digestibility and therefore the amount that must be fed. Digestion of protein is initiated in the stomach through the actions of HCl and pepsinogen and is completed in the small intestine. Undigested protein is absorbed as nitrogen in the cecum. Essential (also called indispensable) amino acids cannot be synthesized and must be obtained in the diet. Dispensable amino acids can be synthesized. For conditionally indispensable amino acids, pathways exist but at times the body cannot make them in sufficient quantities. The essential

amino acids in horses are lysine, methionine, threonine, isoleucine, leucine, valine, phenylalanine, tryptophan, histidine, arginine – Lysine is the first limiting amino acid in equine diets (first one to be used up and therefore prevent further protein synthesis), followed by threonine and methionine.

- **Lipids –** A source of energy absorbed in the small intestine as fatty acids; fats are highly digestible and are required for absorption of fat-soluble vitamins (A, D, E, K). Essential fatty acids (FAs) must be supplied in the diet and include linoleic (0.5% of DM) and alpha-linoleic acids. Omega FAs – omega 6 = linoleic, gamma-linoleic and arachidonic acids – these are potent inflammatory mediators from soy, corn, sunflower, and safflower oils. Omega 3 = alpha-linoleic, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) – these are less potent inflammatory mediators from flaxseed oil or fish oil. Forage diets (fresh forage and hay) are naturally higher in omega 3 FAs. Cereal grains, soybean meal, rice bran, and vegetable oils are higher in omega 6 FAs. Dietary recommendations for horses are still under investigation. Supplementation is aimed at inflammation and immune function – flaxseed and fish oil often are used. Benefits of fat supplementation are increased energy density for weight gain and replacing carbohydrates as sources of calories. Palatability is the major factor in how much fat you can supplement. Fats must be added gradually to the diet. Oxidation also is an issue. Vitamin E supplementation is

suggested when adding fat to the diet.

- **Vitamins and Minerals –** Vitamin requirements are set based on daily DM intake. For fat-soluble vitamins, toxicities are rare and deficiencies are more common. There are high concentrations in fresh forage. In dried forage (hay), vitamin A, D, and E levels decrease rapidly. Supplementation is recommended for horses not on pasture. Water-soluble ("natural") vitamin E is more bioavailable than are synthetic forms. Water-soluble vitamins are thiamin and riboflavin. Macrominerals that are required in the diet include calcium, phosphorus, sodium, chloride, magnesium, and potassium. Calcium absorption is estimated at 50% and is variable depending on the source. Vitamin D plays a smaller role in Ca:P homeostasis in horses than in other species. Phosphorus absorption varies widely, averaging 33%. Ca:P ratio more important than absolute numbers; ideal is a ratio of 1.5:1 to 2:1. High calcium can negatively impact phosphorus absorption and vice versa. Microminerals that are required in the diet include copper, zinc, iron, selenium, manganese, cobalt, and iodine. Dietary toxicity can be seen if microminerals are fed in excess. Selenium should be a maximum of 0.5 mg/kg DM intake. Selenium deficient soils exist in different parts of the United States, so having an understanding of local growing conditions (and/or a hay analysis) is key to making good decisions about supplementation. The maximum tolerable concentration is 2 mg/kg DM; selenium toxicity is a clinical concern.

Types of Horse Feed

Forage

The stems, leaves and stalks of plants – pasture = fresh forage, hay = dried forage. Horses should consume at least 70% of their diets (ideally 80-100%) in forage. No forage is 100% complete so some vitamins/mineral supplementation will be required. Minimum requirement = 1% of BW in forage daily (ideally 1.5-2%). Type of forage available varies with region and time of year. Cool season grasses = orchard grass, Kentucky bluegrass, timothy, ryegrass, bromegrass, tall fescue. Warm season grasses = Bermuda grass, teff. Legumes = alfalfa and clover.

Concentrates

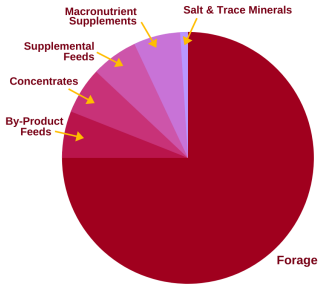
Cereal grains such as corn, oats, barley, wheat, rye, and millet. These are highly digestible with a high concentration of soluble carbohydrates. They are usually processed by cracking, grinding, steaming, and flaking. Many have an inverted Ca:P ratio. Grain should be limited to less than 30% of the overall diet. Concentrates can be used to supplement calories, vitamins, and minerals lacking in forage.

Supplemental Feeds

These may be added to forage. These may be pelleted, and may be cereal grains, and supplemental protein or vitamins/minerals, for example Purina Ultium. Ration balancers are very concentrated sources of vitamins and minerals designed to be fed with either grass forage or alfalfa forage, for example Nutrena Empower Grass Balancer. Complete feeds are designed to be fed as the sole source of nutrition in the absence of forage. These are forage-based and often are pelleted and softened by the addition of water, for example, Purina Equine Senior.

By-Product Feeds

These are as in other species and include beet pulp, wheat bran, and rice bran.



Macronutrient Supplements

Protein may be added to improve quality of forage and to aid in building muscle, hair and hooves. Owners can use as a protein supplement, a complete feed, or alfalfa (forage or pellets). Don't use human supplements; equine-specific supplements often are soy or whey-based. Other examples are soybean meal, fish meal, meat and bone meal, cottonseed, and linseed. Fats may be plant or animal based. Examples are rice bran, fish oils, and flax. Fat supplements have variable palatability and digestibility. Essential fatty acids vary between oils – omega 3 flax>soy> canola>sunflower> corn. Flax oil has an omega 3:omega 6 ratio of 4.2. Corn oil has an omega 3:omega 6 ratio of 0.2. Feed supplemental vitamin E when feeding > ½ c oil/day (1000-2000 IU vitamin E/cup of oil). Limit flax to ½ cup oil or 1 pound of flaxseed per day.

Salt and Trace Minerals

Salt should be provided free choice. Salt blocks may contain iodine. Loose salt may be added to the bucket to encourage water consumption (1-3 tsp BID). Trace mineral blocks are okay if only one horse has access but it is hard to guarantee adequate consumption. Trace mineral blocks are not necessary if the diet is complete. Many vitamin and mineral mixes are available and again are not necessary if the diet is complete.

Discuss forage as a component of the equine diet.

Ideal Feeding Practices

Feed horses like horses – Horses are designed to eat for up to 18 hours per day. Their cycle is eat – drink – sleep – repeat. Horses selectively graze areas where they have not defecated and remove the tops of plants that are actively growing. Continuous grazing maximizes saliva production, and decreases risk of gastric ulcers, colic, and vices. Horses on 24 hour turn-out will consume about 2 to 2.5% of their body weight /day in dry matter. If pasture is limited, they will actually consume more per hour. It is ideal to:

- Monitor the horse's body weight
    - When estimating, consistency is key. Have the same person do the measurements each time, use consistent landmarks, and take digital photos.
- Monitor the horse's Body Condition Scoring (BCS)
    - Monitor as in other species. A BCS of 5 on 9-point scale is ideal. Evaluate the horse from all angles and do a hands-on evaluation as well. Key areas to evaluate are the neck, shoulder, barrel (ribs), and tailhead. A

horse with BCS less than 4 needs more calories and a horse with BCS greater than 6 needs fewer calories.

Humans may mess up horses' body weight and condition by:

- Limiting access to feed – Horses will eat 2-3% of their body weight daily. Forage must be available. 80-100% of their diet should be forage. Horses should go no more than 2-3 hours without forage intake. Forage can be fresh or dried.
- Overfeeding – Not all horses will self-regulate, especially when turnout is restricted. Compensating for decreased turnout with free choice hay may work but must be monitored.
- Overfeeding concentrates, supplements, treats – Cereal grains are very high in non-structural carbohydrates, are not tolerated by all horses, and are not needed by all horses, leading to disease (obesity, equine metabolic syndrome, and laminitis).
- Underfeeding supplemental feeds – Feeding a concentrate at less than label recommendations can lead to nutrient deficiencies. If forage is fed solely in the form of hay, vitamins A and E will need to be supplemented.

Consequences of poor feeding practices include obesity, poor performance, starvation, insulin resistance, colic, gastric ulcers, and laminitis.

List your five (5) take-home points – What are things you want to remember from this chapter as you progress through the curriculum and into your career?

EXTRA RESOURCES

- Monitoring the horse's body weight: https://www.youtube.com/watch?v=IVVQcTgynDc
- Monitoring the horse's body condition scoring (BCS): https://ker.com/wp-content/uploads/body-condition-score-chart.pdf
- Goat nutrition: https://pressbooks.umn.edu/app/uploads/sites/7/2019/08/Goat-nutrition-for-health.pdf

12.

Nutrition: Omnivores and Carnivores

Learning Objectives

- Define common terms and parameters in swine production
- Describe phase feeding in pigs
- Define feed budgets in pigs
- Describe rationale behind split-sex feeding in swine
- Describe required nutrients for feeding of swine, dogs, and cats
- Describe common feed ingredients used in swine feeds
- Explain economic impacts of food wastage in swine
- Compare natural feeding behaviors of dogs and cats
- Determine food dosage for the dog
- Describe body condition scoring in swine and dogs

- Describe feeding during gestation / lactation in sows, bitches, and queens
- Explain unique aspects of weaning, and feeding puppies and kittens post-weaning
- Discuss pros and cons of homemade and raw diets in dogs and cats, and vegetarian diets in cats
- Describe unique anatomy and physiology of the cat as an obligate carnivore

Swine and dogs are omnivores. Cats are true carnivores.

FEEDING SWINE

Pig Terminology Used In This Chapter

Boar	Intact male pig
Barrow	Castrated male pig
Gilt	Young female pig not having produced her first litter
Sow	Older female pig having produced at least one litter
Pig	Younger swine (less than about 120 lbs)
Hog	Older swine (more than 120 lbs)
Weaner	Young pig (18-60 days of age)
Early-Weaned Pig	Pig weaned at less than 21 days of age
Litter	Multiple pigs born from same pregnancy
Gestation	115 days of pregnancy
Lactation	18-25 days after birth where sows nurse baby pigs
Grow-Finish	Production phase from 60-260 lbs body weight
Wean-to-Finish	Production phase from 10-260 lbs body weight
Nursery	Production phase from weaning to 60 lbs body weight
Feeder Pigs	40-60 lb pigs sold for feeding to market weight

Market Hogs	Hogs weighing 240-280 lbs, ready for slaughter

Production Phases of the Breeding Herd

Male Reproduction – Boar

Female Reproduction – Gilt development / pre-breeding to breeding to gestation to farrowing / lactation to weaning to rebreeding to gestation, etc.

Growing Pigs to Market – Nursing pigs (nursing off the sow, eating creep feed) with three phases (phase I 12-15 lb body weight, II 15-25, III 25-50) to grow-finish in four phases (phase I 5-100, II 10-150, III 150-200, IV 200-250) to market

Pork Production Measures for Growing Pigs

ADFI	Average daily feed intake
ADG	Average daily gain = average amount of weight gained daily
F/G or G/F	Feed conversion = feed efficiency
% carcass lean	Ratio of lean:fat
Lbs lean gain/day	Lbs of lean body weight gained daily
Lean gain efficiency	Lbs feed per lbs lean body weight gained

Pork Production Measures for Breeding Herd

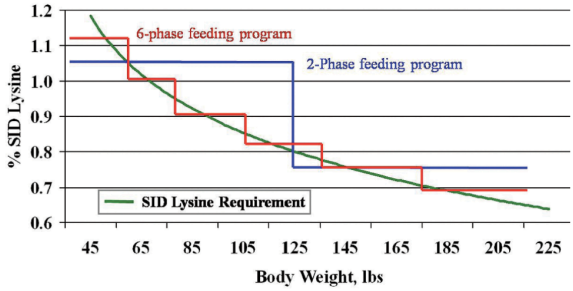
NPD = non-productive sow days	Time that sows are not pregnant or lactating – goal is fewer than 50 NPD/female/year
Litter size	Number of piglets in the litter
Litter weaning weights	Weights of piglets at weaning – this is a reflection of milking ability of the sow
Wean-estrus interval	Days from weaning to re-breeding – goal is 4-7 days
Farrowing rate	Percentage of females mated that farrow – goal is 85+%
Litters / sow / year	Goal is greater than 2.2

Phase Feeding

Pigs are commonly phase fed. This is a system of separating pigs by weight and feeding specific diets to those groups of pigs. The value of this is demonstrated in the graph below. The curved line shows daily lysine requirement. The stepped lines show either a 6-phase feeding program or a 2-phase feeding program. Note how pigs in these groups (or phases) are occasionally underfed and occasionally overfed as they grow. The goal of phase feeding is to minimize the amount of over- and

underfeeding. There is increasing economic advantage in increasing number of phases (and therefore, number of group of pigs and number of diets provided) in pig production.

Phase Feeding Swine



"Swine nutrient recommendations and feeding management", http://porkgateway.org/resource/growing-finishing-swine-nutrient-recommendations-and-feeding-management/

What is phase feeding in pigs? Describe its importance for pig health and to help producers meet production goals.

Feed Budgets

It is essential to get the right feed to the right pig for the right amount of time. An example is shown below,

demonstrating how amount of food provided varies with phase (grower phases I-III and finisher I-III) and with body weight of those pigs.

Feed Budgets by Phase

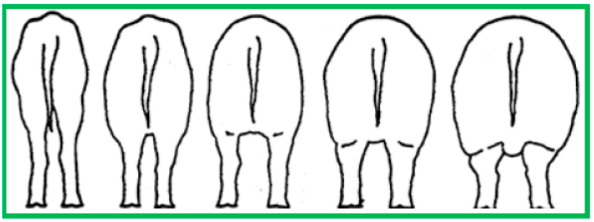
PHASE	G1	G2	G3	F1	F2	F3
BW (LBS)	60-80	80-110	110-140	140-180	180-220	220-250
AMT OF FEED (LBS)	46	76	84	123	137	193

Split-Sex Feeding

Sometimes specific diets must be provided by sex. As an example, gilts have higher amino acid requirements and have a 5% greater lean growth potential than barrows. Gilts consume less than barrows so different diets must be provided for gilts and barrows when they reach about 80 lbs body weight. Another example is the change in diet required of sows as they go through their reproductive cycle. Assessment of body condition score (see image

below) allows one to watch how sow weight varies and to feed to try to keep as consistent a body weight as possible. Generally, the sow is heavy until the time of farrowing and lactation, when she loses a lot of weight from giving birth and from milk production. It is difficult for sows to eat enough during lactation to gain weight and it is wise to keep a record of how much they eat (average daily feed intake) to plan for future pregnancies. Sows regain body condition after they wean piglets and generally are at a higher weight at the time of the next pregnancy, and then the cycle starts again.

Swine Body Condition Score Assessment



SCORE	LAST RIB BACK FAT DEPTH	CONDITION	BODY SHAPE
1	<15	Emaciated	Hips, spine prominent to the eye
2	15-18	Thin	Hips, spine easily felt without pressure
3	18-20	Ideal	Hips, spine felt only with firm pressure
4	20-23	Fat	Hips, spine cannot be felt
5	>23	Overweight	Hips, spine heavily covered

—"Swine nutrition guide", https://prairieswine.com/rsc/swine-nutrition-guide-2/

Nutrition Goals

Nutrition goals in commercial pork production include the following: Maximizing net profit / pig space by minimizing cost of inputs (feed is 65% of the total cost of production; providing good nutrition to improve productivity, which reduces facility and labor costs/cwt* pork produced); supporting and maintaining high health; minimizing nutrient excretion and odor emissions; and ensuring pre-harvest food safety. * = *hundredweight*

Factors affecting feed cost/cwt pork produced are:

- Factors altering cost/ton of complete feed (cost of feed manufacturing and quality control, cost of service for commercial products, cost of feed delivery, profit margin of manufacturer)
- Factors affecting the rate of gain of body weight per lb of feed (diet digestibility, diet nutrient levels relative to requirements, feed wastage). Attention to proper nutrition and proper feeding of a correct diet supports pig health and economics for the producer.

Understanding Nutrient Requirements

Animals require amounts of nutrients per day, not % of nutrients in the diet. A key concept is that feed intake times nutrient concentration equals the amount of nutrient consumed per day. For example, let's say a lactating sow is consuming 4.5 kg (which is 4500 gm) of feed per day and that the feed she is consuming contains 1.0% lysine. Her daily lysine requirement is 50 gm lysine/day. Is this diet adequate to meet her needs? Using the calculation above,

feed intake (4500 gm/day) times nutrient concentration (0.01) yields a total consumption per day of 4.5 gm. This is deficient. This could be corrected by giving her more to eat of her current diet or by offering a diet that is higher in lysine.

Nutrient requirements vary with production phase due to genetics, gender, health, and housing conditions.

- **Energy** – Generally provided as starch (carbohydrates) and fat.
- **Amino Acids** – The ten essential amino acids (required in the diet) are lysine (first limiting), methionine (2nd limiting), threonine (3rd limiting), tryptophan (4th limiting), histidine, arginine, leucine, isoleucine, valine, and phenylalanine. "Limiting" refers to the composition in feed ingredients – lysine is the first amino acid to be inadequate in a corn-based diet, because there is limited lysine in corn.
- **Macrominerals –** Those supplemented are calcium, phosphorus, sodium, and chloride. Trace minerals supplemented are iron, copper, zinc, iodine, manganese, and selenium. Vitamins supplemented are the fat-soluble vitamins (A, D, E, K) and some water-soluble vitamins (riboflavin, niacin, pantothenic acid, choline, folic acid, biotin, B12).
- **Water** – Attention must be paid to water quality, quantity, and availability – Water is used for metabolism and to regulate body temperature, and it is a constituent of body tissues.

Feed Ingredients = Nutrient Sources

Most swine diets in the United States are comprised of corn (primary energy source), soybean meal (primary amino acid source), monocalcium phosphate (primary P source), limestone (primary Ca source), and a vitamin and trace mineral premix. Depending on cost and availability, other ingredients are partial substitutes for corn and soybean meal. Corn substitutes are barley, wheat, sorghum, and dried distillers grains with solubles (a mix of corn, rice and other grains that is a byproduct of distilling for brewing or creation of ethanol). Soybean meal substitutes are meat and bone meal, dried distillers grains with solubles, and synthetic amino acids. Nursery diets include lactose, dried whey, spray dried porcine plasma, fish meal, spray dried blood meal, and supranutritional levels of copper and zinc.

Feed Manufacturing

Grain is ground using a roller mill or hammermill – reduced particle size = increased nutrient digestibility. Average particle size should be 700-800 microns. Ingredients are mixed to ensure uniform dispersion in a complete feed. Most diets are fed in meal form. Nursery diets are fed in pellet or crumble form – these are complex diets with multiple ingredients.

Life-Cycle Feeding for Swine

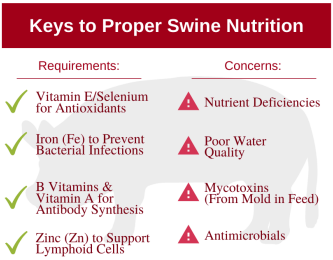
Pigs are provided ad libitum access to feed (all they can eat, feed available continuously) in all phases except pre-breeding, breeding, and gestation. Sows are fed limited

amounts (4-8 lbs/day) to control body weight gain and body condition.

Typical Ranges in Daily Feed Consumption Levels for Swine

STAGE	AMOUNT (LBS/DAY)
Pre-Breeding	4-8
Breeding	4-6
Gestation	4-6
Lactation	8-20
Weaning-Rebreeding	4-8
Nursery Phase I (12-15 lbs BW)	0 – 0.5
Nursery Phase II (15-25 lbs BW)	0.5-1.5
Nursery Phase III (25-50 lbs BW)	1.5-2.5
Grow-Finish Phase I (50-100 lbs BW)	2.5-3.5
Grow-Finish Phase II (100-150 lbs BW)	3.5-4.5
Grow-Finish Phase III (150-200 lbs BW)	4.5-5.5
Grow-Finish Phase IV (200-250 lbs BW)	5.5-.65

Feeder Design and Feeder Management



Feeder space and design is important to minimize chances of pigs fouling the feed with feces and to minimize feed wastage. Feed wastage can be as high as 20% due to inadequate design and/or management. In a study of grow-finish pigs, 5% feed wastage increased feed cost / pig by more than $2 and 20% wastage increased it by more than $8.

Nutrition and Health Conditions

Proper nutrition supports the immune system (Vit E / selenium are anti-oxidants, Vit A – antibody synthesis, Fe (too high or too low) – increased susceptibility to bacterial infections, Zn – role in lymphoid cells, B vitamins – deficiency reduces antibody synthesis). Concerns include nutrient deficiencies and toxicities – water quality – mycotoxins (toxins due to molds in feed = aflatoxin, doexynivalenol [DON], zearalenone, fumonisin), and antimicrobials (antibiotics, growth promoting levels of Cu and Zn).

DOGS

Feeding and Hunting

Dogs must be fed by life stage. Dietary goals include good quality of life, maximum longevity, optimization of performance, and disease prevention. For example, obesity is the number 1 nutritional disease in dogs and cats and is present in 12-40% of animals. It is associated with health risks (musculoskeletal disease, cardiovascular disease, cancer, diabetes mellitus, reduced immunocompetence), and with decreased life span. Other conditions associated with nutrition in dogs are dental disease and urolithiasis.

Wild dogs live in hierarchical groups. They hunt in packs and the dominant dog(s) eat first. They consume large meals (up to 16% of their body weight in a single meal). Dogs retain the "social value" of food. Their behavior is influenced by breeding, selection, and interaction with humans.

Nutrients

A nutrient is any food constituent that helps support life. Essential (also called indispensable) nutrients are those that the body cannot synthesize and that are needed at all life stages. Conditionally essential (conditionally indispensable) nutrients are those that are required only

during certain physiologic or pathologic conditions. Nonessential (dispensable) nutrients are those that can be synthesized by the body.

Canine Feeding Behavior

Dogs are omnivores. They eat 1-3 meals/day and feed during daylight. They are glutton feeders (built to eat large volumes of food infrequently) and recognize the social value of food (food is a resource to guard).

Free Choice Feeding = ad libitum or ad lib

- Advantages: less labor and knowledge required, better share for non-dominant dogs
- Disadvantages: increased risk for obesity, skeletal disease, less knowledge about intake by each animal, for dry/semi-moist foods only

Food Restricted or Meal Feeding

- Advantages: best control and knowledge of intake, best control of body weight, reduced risk of obesity and skeletal disease, facilitates house training
- Disadvantages: labor-intensive, need to calculate food

Determination of food dosage is the basis for nutritional management and is a basic skill in nutritional therapy. We must calculate food dosage recognizing that dogs may be fed a complete and balanced diet, supplements, and treats.

Energy Requirements

Resting energy requirement (RER) is the energy used by an adult at rest in a thermoneutral environment. This level does not support activity, growth, or reproduction and is a function of metabolic body size. RER (kcal/day) = 70(BW in kg)$^{0.75}$ or 30(BW in kg)+70 – use latter if body weight is between 2 and 46 kg. Canine maintenance energy requirement (MER) = 1-1.8 x RER and varies by intact status and life stage. These are averages; needs for specific individuals may be considerably higher or lower.

Canine Maintenance Energy Requirement

TYPE OF DOG	MER (value x RER)
Intact adult	1.8
Neutered healthy adult	1.6
Adult prone to obesity	1.4
Geriatric animal	1.4
Adult needing to lose weight	1.0 (note that this would be RER at ideal weight)

Daily energy requirement (DER) is affected by breed, neuter status, age, activity, environment and so may be higher than MER – for example, daily energy requirement for dogs doing light work equals 2 x RER, for those doing moderate work equals 3 x RER, and for those doing heavy work equals 4-8 x RER. Animals that are late in pregnancy and are lactating have increased nutrient requirements. Animals that have been spayed or castrated have decreased energy requirements.

Your client has a 5-year-old castrated male Australian Shepherd that is exercised daily but still seems "fat" in the owner's perception in the winter. The dog is being fed a weight loss diet that contains 310 kcal/cup and gets 1.5 cups twice daily. You examine him; his BCS is 5 on a 1-9 scale. He currently weighs 46 lbs. Is he getting too much food? Show your calculations.

Food Dosage Determination

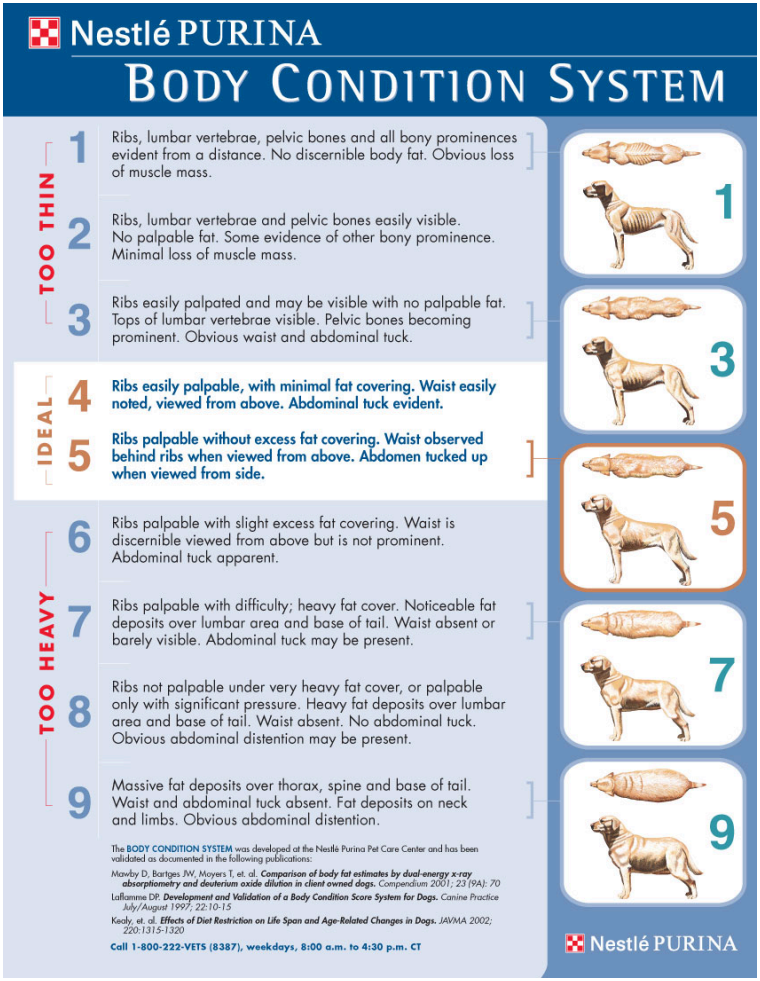
Calorie content is not required on pet food labels so to determine number of calories per cup, you may need to check the website or call the pet food company.

1. Estimate RER as described as above
2. Factor RER if necessary to get estimated maintenance energy requirement (MER) or daily energy requirement (DER)
3. Select specific food, determine energy density
4. Energy requirement divided by energy density = food dosage

Because individual animal needs vary, body condition scoring is important to determine if the amount of food calculated is ideal for a given animal. New ideal BCS = 4-5

on a 9-point scale – see chart below. This was defined by the Purina lifespan study – 48 Labrador retriever puppies were paired by weight and sex, with one member of the pair fed 25% less than the other. Dietary restriction resulted in lower prevalence and severity of osteoarthritis. The age when 50% of dogs were first treated for chronic conditions was 2.1 years later in restricted-fed dogs and the restricted-fed dogs had a 15% longer median lifespan and were considerably healthier than their free-fed littermates.

As an example of food dosage calculation and nutritional assessment, Ms. Gray owns a 5-year-old spayed female Beagle. The dog weighs 26 pounds and has a body condition score of 5/9. You collect a diet history and find that Ms. Gray is feeding 1.5 cups of food/day of a food that has 350 kcal/cup. No other food or treats are given. She wants to know if this is enough food. – First, calculate RER. Body weight is 26 pounds (11.8 kg). RER = 30(BW in kg)+70 = (30)(11.8)+70 = 424 kcal/day. She is a neutered healthy adult so her MER = 1.6 x RER = 678 kcal/day. She currently is eating 525 kcal/day (1.5 cups x 350 kcal/cup). Her body condition score is fine so this appears to be a good amount of food for her for right now. The owner should watch body condition and if the dog appears to be getting thin, she certainly could be getting more food, up to about 2 cups per day (678 / 350 = 1.9).



"Dog body condition scores", https://aspengrovevet.com/body-condition-system/

Specific Versus All-Purpose Diets

Specific purpose diets are produced to feed dogs for specific life stages or specific activities. Examples include diets for growth, lactation, adults at maintenance, athletes

/ performance, and geriatric animals. Breed-specific diets exist. Veterinarians can prescribe diets to specifically treat disease, for example, highly digestible diets for intestinal disorders and diets with unique proteins for dogs that are allergic to common pet food ingredients.

Feeding Specific Types of Dogs

Gestation and Lactation

For the first 6 weeks of gestation, MER = 1.8 x RER and for the last 3 weeks of gestation, MER = 3 x RER. During lactation (the equivalent of heavy work), MER = 4-8 x RER with ad lib feeding. During lactation, carbohydrate is conditionally essential so the recommended diet has 20% of calories as carbohydrate.

Nursing Pups

Puppies that are nursing should gain 2-4 g/kg adult weight/day. Offer solid food (growth / lactation diet) at 3-4 weeks of age and wean off the dam at 6-7 weeks. Feed growing pups to have a slim figure (ideal BCS of 4-5) to promote normal hip development. Overconsumption of food after weaning (excess energy and calcium) is associated with development skeletal diseases such as hip dysplasia, osteochondrosis, panosteitis, angular limb defects, and other bone and cartilage dysplasias. Genetics and environmental factors also increase risk. Feeding recommendation for growth at < 4 months of age = 3 x RER, from 4-12 months of age = 2 x RER, and at greater than 12 months of age = 1.6 x RER. Feed the right diet (protein 25-35% DMB, calcium 0.9-1.5% DMB, energy 3.4-4.2 ME/g/DMB – feed the diet right – calculate starting point – evaluate every 2 weeks – adjust to maintain lean body condition.

Trends in Canine Nutrition

Home-Prepared Diets

Owners may wish to prepare diets at home because they equate nutrition with nurturing their pets, they want control over quality of ingredients (natural, preservative-free, color-free, organic), or to meet specific health goals for their pet. In 2020, survey data from over 3600 pet owners in the United States, Canada, Australia, New Zealand, and the United Kingdom described about 2/3 of dogs and 1/2 of cats receiving some homemade food at least some of the time, with more than half of dogs and at least half of cats sometimes getting raw diets.

Raw Diets

Three common names in the raw diet conversation for dogs are Billinghurst BARF, Schultz, and Volhard. All claim that no extra knowledge is required by owners to feed this diet. They all are based on raw meat, bones, and some vegetables and are intended not to be complete and balanced but to achieve nutritional balance over time. An increasing number of commercial raw preparations are available. Some are formulated to meet AAFCO nutrient profiles and may be complete and balanced in each meal. They are usually very highly digestible, with high quality ingredients, high water content that helps with satiety and weight control, and provide a sense of nurturing. However, there is no scientific evidence that raw diets provide superior nutrition, they may have nutritional excesses or deficits, vitamin A and D have the potential to be excessive if offal is used as an ingredient, and calcium is a nutrient of concern especially

in growing large breed puppies. Other concerns include the possibility of bones in the diet fracturing teeth and perforating intestines. Nutritional problems take years to manifest into clinical disease and people who choose to create a raw food diet or any homemade diet are encouraged to work with a veterinary nutritionist. Raw diets also pose safety concerns for the very young and very old (animals and humans) due to concerns about bacterial and parasitic contamination; studies suggest that 3-50% of adult dogs fed raw food diets may be asymptomatic shedders of Salmonella into the environment. In one study of dog owners feeding raw food diets, confirmed transmission of Salmonella from the pets to the people was 0.2%, with very young, very old, pregnant, and immunosuppressed people at greatest risk. Finally, it is valuable to help clients understand that some things they provide for their pets are uncooked and pose a risk of bacterial spread. This includes rawhides and pig ears provided as treats.

Grain-free diets

Grain-free diets contain a high proportion of peas, lentils, other legumes, and other ingredients including potatoes. The rationale is that dogs would not eat a significant amount of grain in the wild. In 2018, the FDA warned pet owners of a possible link between eating foods labeled as grain-free and development of a heart condition called dilated cardiomyopathy. Cause-and-effect of this association has not been defined.

CATS

Feeding and Hunting Behavior

Cats are obligate carnivores. Their molars are vertically oriented and they have almost no lateral jaw motion. Their molars are not intended for grinding, as in omnivores and herbivores. They lack salivary amylase, and have a simple stomach and short intestinal tract.

Five traits of a cat are nocturnal (crepuscular), predators, territorial, solitary, and maternal.

Cats are exceptional hunters. In cats, hunting behavior is independent from feeding behavior, and they are solitary hunters and eaters, with no concept of the social value of food. Cats are constantly attuned to hunting, with hearing very acute when hunting at night and vision (motion) very acute when hunting during the day. Cats prefer to eat 10-20 small meals/day and in the wild, would spend 6-8 hours daily stalking prey. The average rat carcass provides about 5.7 kcal/gm of energy. How much cats eat is dependent on how much energy they get from it, not on the bulk of food eaten. Cats have specific preferences for temperature, odor, and physical form of food. Wild cats maintain body weight and fitness. House cats lose the ability to regulate energy intake due to readily available food and lack of physical activity. Best tips for cat owners are to feed smaller, more frequent meals throughout the day; provide food puzzles or other feeders that foster hunting behavior, feed individual

cats separately in multi-cat households, and feed from an elevated location that is away from noise and visual threats.

What is normal feeding behavior for dogs? For cats?

Food Selection

Food selection is highly variable in dogs and cats and is based on senses (odor, temperature, mouth feel) and on past experience. Neophobia (disliking new things) is important in veterinary patients, who may choose not to try a new food. Milk composition is affected by maternal diet so pups and kittens may develop preferences at a very early age. Aversion to new foods is greater in cats than in dogs.

Nutrition and Energy Requirements

- **Water –** the most important nutrient. Age affects thirst, total body water, and water balance (intake versus loss). Domestic cat breeds are descendants of wild desert cats and so will concentrate urine significantly before they drink more water. They are not driven by thirst. In the wild they will get some water from their prey (1.5 – 2 mL / gm of prey eaten).
- **Energy** – In general, their daily energy requirement (DER) = 1.2 x RER
- **Protein** – Cats are missing some key enzymes

and other enzymes are not adaptive (that is, they do not upregulate or downregulate relative to the presence of substrate). This contributes to their high protein requirement. For example, they require arginine to synthesize ornithine and citruline in the gastrointestinal tract as part of the urea cycle. A single meal devoid of arginine will lead to excess ammonia in the blood stream (hyperammonemia). Another example is taurine. Taurine is present in most animal tissues and can be synthesized from cysteine and methionine. Cats lack the enzymes necessary to consistently synthesize taurine and lose it through the gastrointestinal tract as it binds bile acids. In general, cats require protein as 19% of the diet – food animal tissue should be listed within the first two ingredients on a dry food and within the first three ingredients for a canned food.

Feeding adult cats – Atkins-type diet for cats = high protein and fat, low carbohydrate – The natural feline diet is 7% carbohydrate (DMB) so this kind of diet is well suited for cats.

- **Lipids** – Consume up to about 65% of the diet without negative effects. Cats require linoleic acid (like dogs) but also require arachidonic acid.
- **Low Carbohydrates** – Cats lack sucrose taste buds, their small intestine has low sucrase and lactase activity, they have non-adaptive sugar transporters that do not upregulate with a high carbohydrate diet, they lack salivary amylase, and their pancreatic amylase concentration is

only 5% that of dogs. Carbohydrates can be up to 30% of the diet.

- **Vitamins and Minerals**– Cats have some unique vitamin requirements – Key vitamins required in high amounts or preformed are vitamins A and D, and niacin. Vitamin K may be required in the diet during long-term antibiotic therapy. Mineral requirements are similar to that in dogs. Calcium and phosphorus deficiency is the most common deficiency reported, especially in those cats who are on all meat diets. The sodium requirement in cats is three times that in dogs.

Regarding nutrients in feed, define essential (indispensible), conditionally essential (indispensable), and nonessential (dispensable). What are examples of essential nutrients in swine? In dogs? In cats?

Feeding Specific Types of Cats

Gestation and Early Lactation

Queens have an increased requirement for energy, protein, fat, calcium and phosphorus, soluble carbohydrates, taurine and copper. Unlike in bitches, who need a change in diet to one with increased energy at mid-gestation, queens should gain weight gradually throughout pregnancy and so should be changed to a growth / lactation diet as soon as it is known that they are pregnant. At the end of lactation, when kittens are weaning, the queen should have a gradual reduction in energy provided as

follows: the day prior = little / no food, weaning day ¼ DER, next day ½ DER, next day ¾ DER, 3rd day full DER.

Kittens

See chart below as a reference. Kittens should gain 50-100 g/wk. Feed a growth/lactation diet beginning at 3 weeks of age, wean kittens at 8-10 weeks of age, and then free choice or meal feed three times daily.

Key Nutritional Factors in Finding the Ideal Kitten Diet

Energy	4.0-5.0 Kcal/g
Protein	35-50% DM
Fat	18-35% DM
Carbohydrate	10% DM
Crude Fiber	<5% DM
Calcium	0.8-1.6% DM
Ca:P ratio	(1.1-1.5):1
Potassium	0.6-1.2% DM
Magnesium	0.08-0.15% DM

Neutered Adult Cats

Cats that have been spayed or castrated have decreased RER associated with a 25% reduction in DER, increased food intake, and decreased insulin sensitivity. Because cats naturally eat many small meals, it can be difficult to decrease calories and maintain body condition without exercising cats. Options for ways to increase exercise in cats can be found through the Indoor Pet Initiative and Purrfect Fence.

Current Trends

Raw Diets

Concerns are as in the dog. Feeding "human grade" tuna is a concern because that tuna is high in polyunsaturated fatty acids and is associated with vitamin E deficiency, steatitis (fatty inflammation), vitamin K antagonism, loss of B vitamins when the fish is cooked, excess in minerals (for example magnesium), and possible fixation on specific foods.

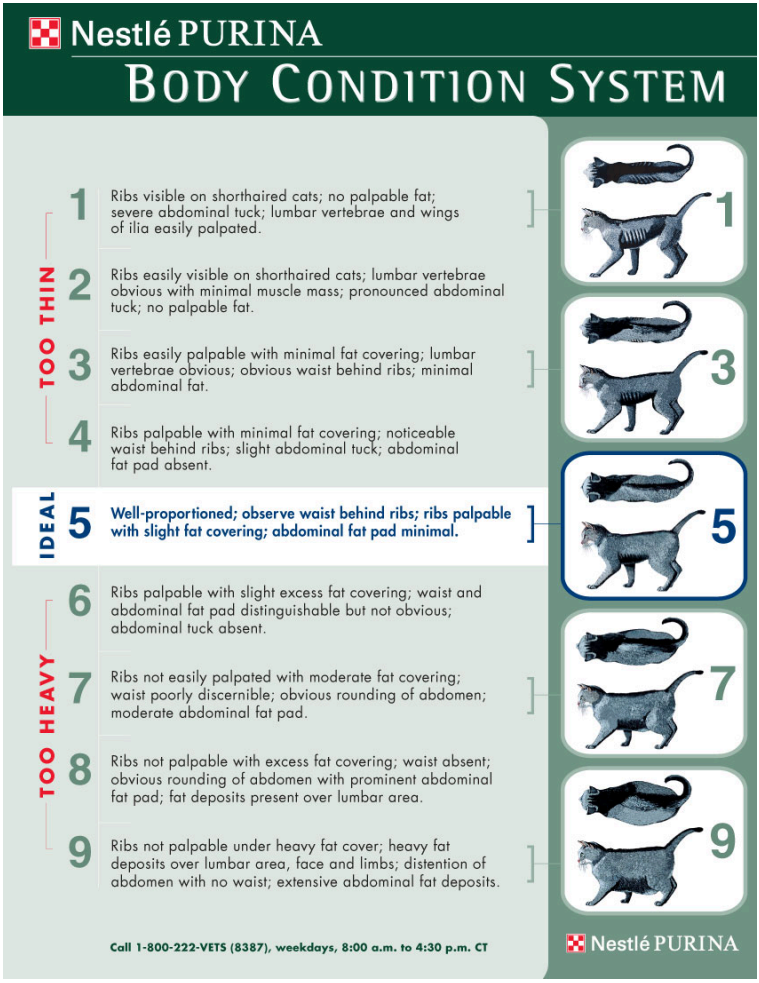
Vegetarian Diets

In cats, feeding of vegetarian diets is associated with inadequate protein / amino acids (taurine, arginine) and arachidonic acid, and alterations in other nutrients (vitamin A, B12, niacin, calcium, iron, zinc, copper).

Homemade Diets

Feeding of homemade diets may be associated with problems especially if they contain all meat or very high protein, deficient calcium, excess phosphorus, excesses of vitamins A and D toxic to the liver, and deficient microminerals. Thiamin may be deficient in raw fish diets. Homemade diets can be made safely and be complete and

balanced but involve cost and effort. Consultation with a veterinary nutritionist is recommended.



"Cat body condition scores", https://aspengrovevet.com/body-condition-system/

List your five (5) take-home points – What are things you want to remember from this chapter as you progress through the curriculum and into your career?

EXTRA RESOURCES

- Ways to increase indoor exercise in cats: https://indoorpet.osu.edu/home
- To keep cats safe during outdoor exercise: https://www.purrfectfence.com/

13.

Biosecurity

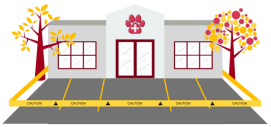
Learning Objectives

- Define bioexclusion and biocontainment
- Define what is meant by a reportable disease and identify whether a given disease is reportable in the state of Minnesota
- Define open versus closed herds
- List and explain a variety of risks of disease introduction and movement through a facility
- Describe appropriate use of disinfectants
- Create a list of best practices regarding control of biosecurity by management of visitors to a facility
- Describe common practices in food animal and companion animal facilities to mitigate risk of disease introduction and movement

BIOEXCLUSION AND BIOCONTAINMENT

Biosecurity is split out by some into bioexclusion, also called external biosecurity (preventing disease from entering a facility) and biocontainment, also called internal biosecurity (managing a disease once it is on the premises). Biosecurity in general is a concern for populations of animals and the facilities where they are housed. If the disease of concern is a zoonotic disease, precautions to protect those who work in those facilities or otherwise interact with those animals also are in order.

Bioexclusion
(keeping disease out in the first place)



Biocontainment
(managing disease once it's present)

The concepts of biosecurity are presented here to help you see the continuum of infection control in veterinary medicine. We often concentrate on infection control in the hospital (wearing gloves or other personal protective equipment, using foot baths in the large animal hospital to prevent spread of disease by traffic through the facility, properly using isolation facilities). For many veterinarians, that is the full scope of their responsibility in addressing biosecurity. For others, including everyone who works with groups of animals, whether that be a herd of cattle or a group of cats in a rescue facility, knowledge of principles of biosecurity can

prevent disease from being introduced or spreading in a facility and is a cornerstone of preventive care for those animals.

Concepts of biosecurity are of concern for any disease-causing organism. Some organisms and diseases rise to a higher level of concern and oversight. These reportable diseases are those that we are required by law to report to the state Board of Animal Health so appropriate biosecurity measures may be enforced to prevent widespread disease with subsequent economic consequences and the potential for loss of human and animal life. The list of reportable diseases in Minnesota, the timing of reporting, and the type of testing to be performed are updated constantly.

Define "biocontainment" and "bioexclusion". Give an example of each.

FOOD ANIMAL FACILITIES

Much of the information in this section is from the following website: http://www.omafra.gov.on.ca/english/livestock/vet/facts/04-003.htm

Biosecurity at the farm level can be defined as the management practices enabling producers to prevent the movement of disease-causing agents onto and off of

agricultural operations. This includes environmental contamination. Biosecurity therefore involves many aspects of farm management, such as disease control and prevention (e.g. closed herd, vaccinations), nutrient management, and visitor control. Closed herds are those defined as having no new animal introduction into the established herd; either all animals move as a cohort, leaving the facilities empty for a while (all in-all out), and/or all replacement animals are born on the farm (a process called internal multiplication). Keeping the herd closed is extremely difficult for a producer, so most choose to introduce new animals into the herd after they undergo testing and quarantine before introduction. Although controlling and limiting the movement of livestock is recognized as the most important biosecurity measure for most diseases, many important hazards can be carried on contaminated clothing, boots, equipment, and vehicles.

Biosecurity has become a major concern to the agriculture industry as a result of foreign and emerging disease issues, the globalization of agriculture, and increasing public concerns over food safety. Individual farms are less isolated and inputs are entering the farms of today from further away, often from other countries. Issues such as bovine spongiform encephalopathy, foot and mouth disease, avian influenza and Newcastle disease have brought world concerns closer to the local farm level.

Practices do not have to be cumbersome, confusing or expensive, but a small investment in time and money can yield big benefits for the farmer, the industry, and for the consumer through improved food quality and safety.

Disease Spread Risks

What are the chances of introducing disease? The single biggest risk factor in disease is purely mathematical in that the higher number of animals in any facility or on any one

site, the greater the chances of disease spread. Other risk factors include:

- Direct contact between animals on the farm and newly purchased animals
- Mechanical spread by animal transporters
- Mechanical spread on contaminated farm equipment, boots, clothing, and contractors cables and tools
- Movement of birds, mice, rats, flies, dogs, cats, and wildlife
- Airborne spread in aerosols or dust / dirt, affected by the herd location, wind, animal density, and neighbors
- Contamination of feed, water, and bedding
- Contamination of the environment on farm – moving animals from diseased pen or hospital leads to dirty passages and yards
- Biting insects

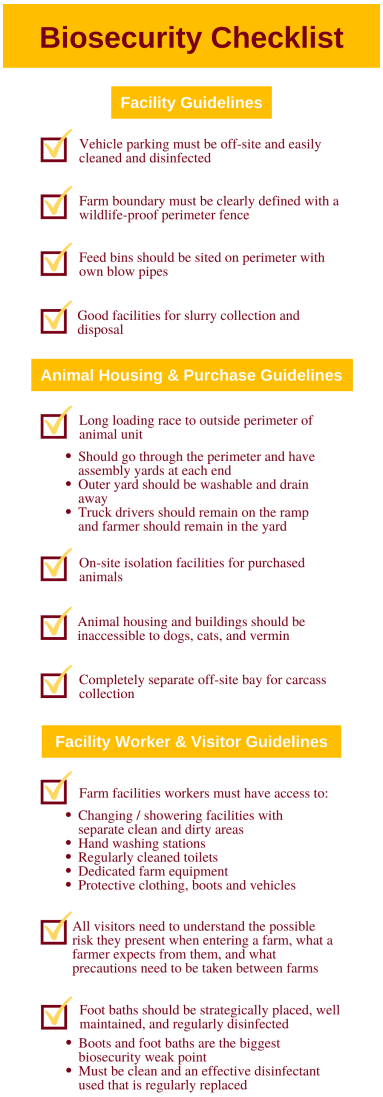
Mechanical Transmission

Infection present in feces, saliva, nasal secretions, blood, milk, or semen may be mechanically transmitted between animals on a variety of inanimate objects (fomites). The body fluid is not the fomite. If you sneeze on your cell phone, the cell phone is the fomite. The time that these fomites remain infectious depends on the resistance of the organism, the temperature, amount of sunlight, dryness, and level of disinfection.

Guidelines for Buying Breeding Stock and Minimizing Risks

If you have any doubts about the health of breeding stock, don't buy those animals! Health is worth far more than genetics. Producers should work with veterinarians to make sure the veterinarian completes all necessary health assessments and testing. The buyer should only work with sellers who are completely open about the health status of the animals. Isolate incoming animals for at least 3-4 weeks and if possible limit the number of intakes of live animals. Guidelines for buying breeding stock include:

- Know the disease status of both the recipient and source herds.
- Consider the location of both herds and the surrounding disease risks.



- Recognize the limitations of recipient herd biosecurity.
- Select an appropriate single source for replacements.
- Check and test disease status including history and past and present customers.

Guidelines for Isolation Units

No matter how reliable the health status of the herd of origin is, it is important that incoming animals undergo a period of isolation for at least 3-4 weeks. The biosecurity of the quarantine unit ideally should be better than that of the home unit, preferably be on another site and managed by different staff or at least have dedicated boots clothing and equipment. There should be no slurry or drainage crossovers and an all in-all out policy in place with thorough cleaning and disinfection between batches. Regular clinical and veterinary inspections / tests should be carried out with all diseases and deaths being investigated.

Checklist of Physical Biosecurity Measures

- Strategically placed, well maintained disinfectant footbaths
- Off-site vehicle parking, easily cleaned and disinfected
- Defined farm boundary and wildlife-proof perimeter fence
- Changing / showering facilities with separate clean and dirty areas
- Hand washing and regularly cleaned toilets
- Dedicated farm equipment, for example,

protective clothing, boots and vehicles

- Long loading ramp to outside perimeter of animal unit
- Completely separate off-site bay for carcass collection
- On-site isolation facilities for purchased animals
- Feed bins sited on perimeter with own blow pipes
- Bird and vermin proof buildings
- Good facilities for slurry collection and disposal

Livestock Loading and Unloading

Animal loading areas are always a weakness. The race is often not long enough, or far enough away from the buildings. It should go through the perimeter and have an assembly yard at each end with the outer yard washable and draining away from the unit. Truck drivers should not come into the unit, they should remain on the ramp and likewise, the farmer should not go onto the truck.

Disinfection and Disinfectants

Disinfection is targeted at reducing disease spread from contaminated boots, buildings, yards, equipment and vehicles. Disinfection will not work without proper cleaning and removal of all organic matter. It is vital to dry and rest buildings before final disinfection and equally vital that all surfaces are saturated. The drying and resting of buildings for 3-4 days before final disinfection improves efficacy to over 99%. The sequence for cleaning a building looks like this – (1) soak all surfaces with water – (2) powerwash to remove the bulk of the organic matter – (3) use detergent to break down what's left – (4) powerwash again – (5) let the building dry – (6) apply disinfectant.

In any operation, boots and foot baths are the biggest weaknesses! Clean boots are vital and every farm should have them for staff and visitors alike. Remind everyone to be biosecurity conscious and to reduce transmission between buildings, hospital pens, and birthing pens. Foot baths must be clean and an effective disinfectant used that is regularly replaced. Remember that the boots must also be cleaned of organic matter; use of footbaths alone will not disinfect boots adequately. The ideal disinfectant has the following characteristics:

- Proven broad spectrum activity and efficacy
- Fast acting to rapidly kill very infectious agents
- Active in the presence of organic matter
- Stable after dilution, especially in footbaths
- Safe for environment, animals and people
- Non-corrosive and suitable for a range of surfaces, for example, porous and other applications
- Easy to store, move and dispose of
- Cost effective – do not judge by smell

Truck Wash and Disinfection

As mentioned earlier, trucks can and do bring infection onto a farm. They are often washed at the factory or rendering plant and contaminated equipment, hoses, and boots are put onto the truck. Wheels and wheel arches are a big risk. Ideally an off-site washing stand is required at the truck driver's home base.

Vermin Control

Animal housing should be inaccessible to dogs, cats,

and vermin. Control of birds and insects is vital to prevent spread of disease.

Biosecurity for Workers and Visitors

Staff training and their vigilant attitude is the best defense. How often do they have explained to them the importance of changing clothes and boots and doing the biosecurity disciplines? Do you have standard operating procedures (SOPs), which are agreed ways of doing each task? Simply written, these should improve staff members' understanding of why certain procedures are in place.

All visitors need to understand the possible risk they present when entering a farm, what a farmer expects from them, and what precautions need to be taken between farms that are visited. This applies to anyone entering or leaving the premises who may be visiting other livestock operations, and not just those of the same species or commodity type. The list includes:

- neighbors and friends;
- agribusiness and service representatives;
- veterinarians;
- municipal/regulatory personnel, inspectors;
- dead stock collectors / renderers;
- custom manure/biosolids haulers and applicators.

Visitors can unknowingly bring harmful agents onto a farm via contaminated clothing and footwear, equipment, or vehicles. Equipment used to repair buildings and machinery, to treat or handle animals, and to carry out testing or procedures are all potential sources of contamination. The risk is increased with visitors who

regularly go from farm to farm as part of their employment or routine. Such individuals, businesses, and organizations are encouraged to develop and follow a biosecurity plan. All visitors, farm owners, and their employees have a shared responsibility in biosecurity. Visitors need to be aware of that farm's level of biosecurity and need to follow their recommendations. Visitors must be prepared to accept all reasonable directives from the farmer when visiting his or her operation. In many swine operations, for example, showering in and out of facilities is a requirement.

Farmers and their employees also have a responsibility to prevent hazards from leaving the premises. Wear clean clothing and footwear when leaving the farm, particularly if visiting other farms, feed supply agencies, veterinary facilities, or auction markets.

All visitors should make an appointment so that both parties can make best use of their time. The visitor should ask the farm operator about his or her biosecurity protocol and any special measures that must be taken.

Assessing Visitor Risk and Controlling Access

Risk assessment is a method of determining the likelihood and severity of the risk posed by a visitor. By identifying key risk factors, appropriate procedures and protocols can be determined.

Guidelines for Visitor Risk Assessment

	LOW RISK	MODERATE RISK	HIGH RISK
Number of farm visits per day	No other farm contact	One or occasionally more than one farm per day	Routinely visits many farms or auctions
Protective Clothing	Wears sanitized shoes or boots. One pair of clean coveralls per site	Wears sanitized shoes or boots – If clean, may not change coveralls	Does not wear clean or protective clothing
Animal Ownership	Does not own and/or care for livestock	Owns and/or cares for a different species	Owns and/or cares for a similar species and production type
Contact with animals	No animal contact	Minimal or no direct contact – exposure to housing facilities	Regular direct contact with animals
Biosecurity knowledge	Understands and promotes biosecurity for industry	Aware of basic biosecurity principles but is not an advocate	Little appreciation or understanding of biosecurity principles

Foreign travel	Does not travel out of the country	Limited travel outside of the country without animal contact	Travel to foreign countries with animal contact in those countries

Biosecurity Guidelines for Visitor Control

- Provide a farm gate sign indicating biosecurity levels in effect on the farm. Place restricted entry notices on the doors to animal facilities.
- Keep service vehicles as far away from the animal facilities as is feasible. Designate a parking area for vehicles entering the farm, away from traffic areas used by farm vehicles and away from feed and manure. Visitors' vehicles should be visibly clean of manure and organic matter.
- Establish one area of the farm for visitors to enter if required. All visitors should go directly to the entry point. Consider installing a bell or alarm system for visitors to indicate their arrival.
- Keep a visitor log or record of the names, dates, and vehicles that visit.
- Determine if, when and what types of farms

have been visited prior to your farm. As a precaution, 48 hours may be required between visits (1 week for foreign visitors).

- Restrict access to animal facilities to essential visitors only. Keep visitors out of animal pens and feed alleys, and do not allow direct contact with animals if not essential.
- Insist on clean clothing and/or supply clean boots and clothing at your farm.
- Do not allow foods of animal origin to be brought onto the premises.
- Provide a container or plastic bag for collecting dirty clothing or disposable items used by visitors.
- Ask visitors to wash their hands prior to leaving the premises, especially if in contact with animals. If hosting tours, provide hand washing facilities or disinfectant hand gel. If food is to be served, do this away from the animal facilities and after hand washing.
- Provide a footbath and a container of an appropriate disinfectant solution with a scrub brush at the entrance to each facility. Maintain these with daily cleaning, remove accumulated organic matter, and replenish disinfectant regularly. Footbaths alone are not an effective means of disinfecting footwear.
- Ensure all equipment used by visitors has been thoroughly cleaned and disinfected and stored appropriately before being used on your premises. Also clean and disinfect all borrowed

equipment and tools prior to use on your farm and before returning them.

Proper use of disinfectants is a critical component of biosecurity. Use all disinfectants according to product recommendations.

Some facilities use ultraviolet (UV) germicidal chambers to decrease number of pathogens on objects that could introduce disease into farms. Recent work by Dr. Torremorrel and Summer Scholar Katelyn Rieland from the University of Minnesota College of Veterinary Medicine has verified that use of these products reduces risk of introducing pathogens but does not guarantee it. Guidelines that should be followed when using products such as these include frequently cleaning the chambers and replacing the UV bulbs, and rotating objects for optimal exposure to UV light.

Manure and its Concerns

Many important diseases can be transmitted by manure, either directly or indirectly, via contaminated clothing and equipment. The pathogens responsible can be classified into four major types:

- bacterial (e.g., *Salmonella*, *E. coli*, Johne's disease, tuberculosis);
- viral (e.g., hog cholera, foot and mouth disease, bovine viral diarrhea);
- protozoal (e.g., coccidiosis, cryptosporidiosis);
- parasitic (e.g., ascariasis, sarcocystosis).

Fungal diseases, such as aspergillosis, are less likely to be shed in manure, but may be present in contaminated bedding and litter.

As production costs increase, more producers are contracting professional manure handlers and haulers. However, there is a risk of disease being introduced by hiring custom labor. Improper sanitation procedures between farms can potentially spread a number of diseases. Ensure manure management equipment is properly maintained and cleaned, especially if being used at several farm sites. Wash all exterior surfaces of manure handling equipment; check that they are visibly free of organic matter before arriving on a farm.

Summary for Food Animal Facilities

Biosecurity is an essential component of many on-farm food safety programs and provides:

- greater consumer acceptability of the quality and safety of the food supply;
- healthy animals that are more productive;
- improved animal welfare and well-being;
- improved efficiency and profitability for the farmer.

Whether it is the relatively controlled environment of a poultry production facility, or the more open pasture of a beef or dairy operation, biosecurity is critical. Over the past decade, food safety, public health and animal health have gained greater importance throughout the world. Quality assurance and HACCP (Hazard Analysis Critical Control Points) programs originate at the primary production level – the farm – with biosecurity planning a key role for the entire food production chain.

Because hazards and risks vary among species and types of operations, what works for one farm may not be appropriate or effective for another. Each farm needs to

develop a specific, documented biosecurity plan in consultation with their veterinarian. Visitor control as presented in this information is just one component of the complete biosecurity plan.

The fundamentals of developing a biosecurity plan are:

- Identify possible risk factors.
- Identify critical control points for your operation.
- Set limits or standards for your farm.
- Set up a monitoring schedule and procedures.
- Keep effective records.

Explain as you would to a new employee how to optimally disinfect a building.

COMPANION ANIMAL FACILITIES

Horses

General principles of biosecurity apply although facilities that house horses often are less stringent than facilities that house food animals unless a disease outbreak has occurred.

This is a good thing for us to watch for when we visit equine facilities as we can help them improve biosecurity and prevent disease outbreaks. Attention should be paid to likelihood of new animals introducing disease into an established group of horses. Some vaccinations also are more likely to be recommended for horses that have greater exposure to groups of horses, for example at shows or sales barns. In any horse facility that has animals that are not healthy, it is wise to always care for the healthy animals first, including young animals, and then care for those that are ill, so there is less risk of the person who provides daily care transmitting disease through fomites. Foot baths are a good measure to try to minimize disease movement within and between buildings.

Most medical facilities for horses will have a dedicated area for isolation of horses with potentially contagious disease. This is not true at all locations that board or otherwise house horses and it is valuable to help owners recognize when there is a serious risk to biosecurity. General guidelines for immediate admission of horses to an isolation unit as they enter a medical facility include:

- Any 2 of the following 3 signs – diarrhea, fever, neutropenia (low white blood cell number)
- A primary complaint of diarrhea that is not obviously physiologic
- A positive diagnosis of a known contagious / zoonotic disease
- Fever greater than 102°F accompanied by any 2 of the following signs – cough, nasal discharge, lymphopenia (low number of lymphocytes)
- Clinical signs suspicious of equine herpesvirus 1 (neurologic signs)

Clients should be made well aware of the list above, so they know to contact their veterinarian immediately if any of these signs occur, both for the sake of the affected animals and for other animals in the facility.

Dogs and Cats

As with equine facilities, often facilities that house large numbers of dogs and cats do not have stringent biosecurity protocols unless a disease outbreak occurs. Boarding kennels usually require some sort of verification of health of animals before they are allowed to enter but these often are superficial and not based in science. For example, most boarding facilities require that dogs and cats be vaccinated for specific diseases before entry, but will permit those vaccinations to have been given the day before, such that animals are brought to the facility well before any immune response could have been generated.

Most biosecurity protocols that are published for animals are for humane societies and small animal clinics, where there is great likelihood of mixing of healthy and diseased animal populations. Policies to minimize introduction and spread of disease in these facilities, as generated by the American Animal Hospital Association, include:

- Having separate entrances for animals with possible infectious disease and having signs to direct people to those entrances appropriately
- Requiring staff to wear appropriate personal

protective equipment

- Posting and following very specific cleaning and disinfecting measures
- Using specific examination rooms or housing areas for animals with infectious disease, perhaps even disease-specific (a set of runs only used for dogs with suspected parvovirus, for example)
- Having dedicated staff for infectious disease patients who do not interact with healthy animals in the facility
- Training all staff and faculty in biosecurity protocols
- Developing a surveillance program to ensure that breaks in protocols are identified and that disease outbreaks are caught early

List your five (5) take-home points – What are things you want to remember from this chapter as you progress through the curriculum and into your career?

EXTRA RESOURCES

- List of reportable animal diseases in Minnesota: https://www.bah.state.mn.us/reportable-diseases/
- Animal facility information: http://www.omafra.gov.on.ca/english/livestock/vet/facts/04-003.htm

14.

Backyard Poultry / Caged Birds / Fish / Reptiles / Amphibians

Learning Objectives

- Describe unique internal and external anatomy of birds, amphibians, and reptiles
- Describe diseases against we vaccinate chickens
- Describe principles of disease control in chickens
- Describe common parasites of chickens and their control
- Describe housing considerations for chickens, caged birds, reptiles, and amphibians
- Briefly describe normal behaviors of birds, reptiles, and amphibians
- Briefly describe nutritional requirements of birds, reptiles, and amphibians

Information in this and the next two sections (Mammals

I and Mammals II / Marsupials) is not inclusive of all disease conditions or common concerns in these species and instead will focus on relevant aspects of housing, vaccination / diseases, parasite control, behavior, dentistry, biosecurity, and nutrition. The information about poultry is about backyard chicken flocks and not all of this information is appropriate for large-scale poultry production operations.

BACKYARD POULTRY

Unique Anatomy – External

"Rooster and hen external anatomy", https://mrandmrscoletti.wordpress.com/category/uncategorized/

Unique Anatomy – Internal

The respiratory tract of birds is dissimilar to that of mammals in that they have no diaphragm. Air is pulled in and forced out by movement of the rib cage and keel. Chickens have a trachea that bifurcates into two lungs. The syrinx (voice box) is located at the bifurcation. From the

lungs, air moves into large air sacs. This video explains breathing in birds.

The gastrointestinal tract begins at the beak. The tongue has barbs that help direct food into the esophagus. Birds do not swallow; movement of the tongue forces food into the upper esophagus. The crop lies midway along the esophagus. It is a place where food can be stored and moistened; no digestion takes place in the crop. From the lower esophagus, food moves through the proventriculus (glandular stomach) into the ventriculus or gizzard (muscular stomach) where it is physically broken down. Food then moves into the small intestine where enzymatic digestion takes place and nutrients are absorbed. Paired ceca lie at the junction of the small and large intestines. Not all ingesta pass into the ceca, which primarily function to break down dietary fiber. The short large intestine is attached to the cloaca, which is a common chamber for the gastrointestinal, excretory, and reproductive tracts.

The excretory tract consists of paired, trilobed kidneys that lie posterior to the lungs and bilateral ureters that empty directly into the cloaca. There is no urinary bladder. Metabolic wastes (urates) are deposited onto the feces before being expelled.

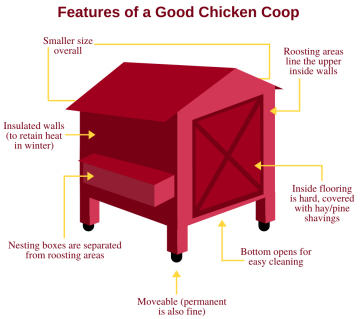
The reproductive tract in chickens is unilateral. The left ovary and oviduct are functional and the right ovary and oviduct regress. The left oviduct is made up of the infundibulum, which catches the yolk as it released from the ovary; the magnum, which secretes albumen; the isthmus, which secretes the inner shell membranes; the shell gland, which secretes the calcium carbonate shell; and the vagina, which secretes the outer cuticle of the shell and any pigments, and directs the egg for laying (oviposition). Birds begin laying eggs at about 6 months of age and lay until about 3 years of age. It takes 23-26 hours for an egg

to form and be layed. Chickens will lay a clutch of 3-8 eggs and then take a day or so off before beginning laying of another clutch. Roosters need not be present for hens to lay eggs.

Housing

Local ordinances determine whether or not people can keep chickens, especially in urban areas, and may place restrictions on gender of birds (no roosters, for example) or total number of birds. It is the client's responsibility to investigate and follow these ordinances.

Most backyard chicken flocks are small. Single chickens are lonely and if you have only two chickens, they are likely to fight. For that reason, a minimum of three chickens works well for most people.



You do not want the coop to be too palatial; a smaller, insulated space will retain heat better in the winter. You should provide about 2-5 square feet per bird in the coop and 8-10 square feet per bird for outside enclosures. Chickens should be provided with indoor housing where they can nest and roost. The chicken coop should contain nesting boxes that are separate from roosting areas and are not directly below roosting areas, so they do not become soiled with droppings. You should have at least one nest box for every 3-4 birds. Birds will roost at the highest point available to them. Coops can be

permanent, on a concrete or wood base, or can be movable and placed on grass or pasture. Hard flooring should be covered with clean, dry straw or pine shavings. Protection from predators includes protection from owls and hawks; a covered, fenced area is recommended for birds given access to the outside. The coop should be well ventilated to permit enough air flow to decrease moisture and thereby minimize odor of ammonia from droppings. Keeping bedding clean and dry also will help control insects. Keeping feed securely stored, ideally in closed containers, will help control rodents.

Chickens are sensitive to daylength. Chickens require about 12-14 hours of light daily to continue laying; with decreasing daylength, they layer fewer eggs and eventually molt, which will stop egg laying temporarily. Nest boxes should be checked for eggs 1-2 times daily.

Droppings must be regularly cleaned out of the coop. Disposal or management of waste is dependent on local ordinances. Uncomposted chicken droppings cannot be used directly as fertilizer as the high nitrogen content will burn plants.

Fresh water must be available at all times and in winter, care must be taken that water does not freeze.

Clients who keep chickens in cold environments may wish to insulate the coop; a student from the class of 2019 informed me that chickens in Minnesota can freeze off their combs if it gets too cold in the coop. A student from the class of 2022 tells me this can be minimized by applying petroleum jelly to the wattles and comb. Some owners provide heat lamps. Use of electricity in a coop may be controlled by local municipalities.