Unique Anatomic and Physiologic features

- **Digestive System**
  - 4 compartments
  - Main source of energy is Volatile Fatty Acid (VFA) as opposed to glucose
  - Eruption of large amounts of CO₂ and Methane
- **Hemal Nodes**
  - BUN is not a good indicator of renal function due to GI production of urea nitrogen
  - ALT cannot be used to evaluate liver disease in goats
  - Small RBCs (especially sheep)
  - Chromosome number?
    - Goats 54
    - Sheep and Cattle 60

Reproductive Characteristics

- **Ruminants**
  - Seasonal Polyestrous
  - Gestation lengths (days)?
    - Sheep 147-150
    - Goats 145-155
    - Cattle 270-292
  - Placentation?
    - Epitheliochorial, cotyledonary
What are the nodules?

Normal caruncles

Uterus

Cotyledon: the fetal side of the placenta
Caruncle: the maternal side of the placenta
Placentome: a cotyledon and caruncle together

Bovine

- Order: Artiodactyla (even-toed ungulates)
- Family: Bovidae
- Genus species: Bos taurus, Bos indicus
- Female: Cow/Heifer
- Male: Bull/Steer
- Young: Calf
- Semmental (Bos taurus)
- Brahman (Bos indicus)

Bovine Research Use

- Cardiac Transplantation
- Cardiac prosthetics- stents, valves
- Reproductive research
  - Artificial insemination
  - Embryo transfer
  - Genetic engineering

Bovine Infectious Disease Model

- Trichomonas fetus
  - Bovine trichomoniasis
  - Animal model for human Trichomonas vaginalis

Caprine

- Genus and species: Capra hircus
- Order: Artiodactyla
- Family: Bovidae
- Male: Buck (billy)
- Castrated Male: Wether
- Female: Doe (nanny)
- Young: Kid

Disease Model?

Leukocyte adhesion deficiency syndrome
Hereditary ornithine aciduria
Inherited Cardiomyopathies

Breed?: Holstein

Breed: Toggenburg
Breed: Saanen

Location of scent glands:
Behind horn bud

Breed?
La Mancha

Polled trait:
- Absence of horns
- Dominant allele, linked to a recessive trait for a sterile intersex phenotype
- Females that are homozygous for the dominant polled trait also have the recessive trait for intersex phenotype and are infertile

Model for which disease?
Beta mannosidosis -
- Autosomal recessive, lysosomal storage disease
- Accumulation of mannose (oligosaccharides) due to lack of lysosomal hydroxylase enzyme
- Results in a neurologic disorder, paucity of white matter, myelin and neuronal vacuolation

Breed: Nubian

Model for what disease:
Myotonia congenita
- "Thomson’s Disease"  "Fainting Goats"

Autosomal dominant trait
- Transient spasms of skeletal muscles brought about by visual, tactile or auditory stimuli
- Caused by mutation in a gene responsible for down regulating electrical excitation in the muscles

What research technique is being demonstrated in this image?
Goat plasmapheresis

- Tissue from a goat
  - Uterus
  - Pathology
    - Hydrometra
  - Condition
    - Pseudopregnancy

- May occur in mated or non-mated does
- Distention of abdomen- appear pregnant
- May "deliver" large volumes of cloudy fluid
- Persistent Corpus Luteum
- Can be treated with prostaglandins
Sheep

**Genus and species:** Ovis aries

- **Male:** Ram
- **Castrated male:** Wether
- **Female:** Ewe
- **Young:** Lamb

**Location of Sebaceous Glands?**
Below eye and between toes

**Breed:** Suffolk

- Pruritis
- Nervous
- Excitable
- Tremors

**Tissue from a sheep**

**Intestinal adenocarcinoma**

- Occur in aged, unthrifty sheep
- 100% in the small intestine
- Proposed as a model for human intestinal adenocarcinoma

**Diagnosis:** Scrapie

- Neuron - large cytoplasmic vacuoles (spongiform)
- Medulla oblongata, pons and midbrain
- Prion disease
- Transmissible spongiform encephalopathy
- Genetic component
  - Suffolk are susceptible
  - Targets are resistant
- Specific codon genes identified
  - 171 - genes Q, R or H
  - 136 - genes A or V
  - R and A confer resistance

**What procedure is being performed?**

Collection of the third eyelid lymphoid tissue to detect Scrapie

- Immunohistochemical detection of PrP which accumulates in the lymphatic tissue of the inner eyelid of sheep
- Test is positive one year before clinical signs develop (Vet Forum; June 1998; April 98, New Scientist)

Research complication in sheep/goats
- Infection associated with chronic catheterization
- More often present clinically silent
- In comparison to the organisms colonizing catheter tips in humans and nonhuman primates, the catheters in these sheep were colonized by gram negative bacteria
Other Spongiform Encephalopathies

Scrapie - sheep and goats
Bovine Spongiform Encephalopathy - bovine
Transmissible Mink Encephalopathy - mink
Chronic Wasting Disease of deer and elk
Feline spongiform encephalopathy
Kuru - human
Cruetzfeld-Jakob Disease - human
Gerstmann-Straussler – human

Submandibular edema with abscesses, draining tracts and granulomas.

Diagnosis:
- "Wooden tongue"
- Actinobacillus lignieresii
- Gram negative rod
- Goats - not affected
- Sheep – lip
- Cattle – tongue

Rule out:
- "Lumpy Jaw"
- Arcanobacterium pyogenes, A. bovis
- Gram positive rod/coccobacillus
- Affects bone
- Rare in sheep and goats

Diagnosis:
- Contagious ecthyma (Orf, sore mouth)
- Parapoxvirus
- Primary lesions on lips and mouth
- Usually seen in animals < 1yr
- High morbidity/Low mortality

Rule out:
- Other vesicular/ulcerative diseases of sheep and goats

Blue tongue
- orbivirus
- Cyanosis, ulcers of the dental pad, gingiva and tongue, chorioretinitis, conjunctivitis, coronitis

Foot and Mouth Disease
- picornavirus
- Vesicles around the mouth, hooves and teats

Ulcerative dermatosis
- poxvirus
- Ulcers of face, genitals and feet

Foot and Mouth Disease
- orbivirus
- Vesicles on the oral mucus membranes, teats, interdigital spaces

Other vesicular/ulcerative diseases of sheep and goats

Contagious ecthyma
- Zoonotic disease
- Human-to-human transmission can occur
- Handlers should wear PPE
- Disinfect clippers, ear taggers etc. between infected animals
- Commercial vaccine available, but should be used with caution, may induce lesions in handlers
- Do not vaccinate herds that are already free of the disease

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- Do not vaccinate herds that are already free of the disease
Diagnosis: Haemonchus Haemonchus Haemonchus

*Haemonchus contortus*
“barbor pole worm”

Clinical signs-
- Pallor, severe anemia
- Submandibular edema (“bottlejaw”): hypoproteinemia
- Weight loss, diarrhea
- Unthriftiness, decreased milk production, poor wool coat

Pathogenesis
- Direct life cycle
  - Ingestion of larvae from eggs passed in feces
  - Hypobiotic (arrested) larvae may exist in host
  - “spring rise” - large number of larvae passed from periparturient ewes onto pasture
  - Blood meals from mucosa of abomasum

Treatment Control
- Anthelmintics
  - Severe resistance has developed!
  - Facility sanitation and pasture management and rotation
  - Susceptible to freezing and dry conditions

Diagnosis: Nodule worm
*Oesophagostomum columbianum*
*Oesophagostomum venulosum*

Diagnosis: Goiter- enlarged thyroid gland
- Congenital Goiter
  - Merino sheep
- Nutritional Goiter
  - Due to iodine deficiency
  - Consumption of goitrogenic plants (soybeans, rape, kale, cabbage and turnips)
Clinical exam

Blood smear (Wright Geimsa)
Describe the RBC morphologic changes:
- Polychromasia (Hb)
- Poikilocytosis (shape)
- Anisocytosis (size)
Describe arrows:
- Heinz body (curved arrow)
- Howell Jolly body (straight arrow)

Necropsy

Presumptive Diagnosis: Copper Toxicosis
- Icterus/hemolysis
- Enlarged black/brown liver/spleen
- "Gun-barrel" black kidneys
- Hematuria/hemoglobinuria

Copper Toxicity
Pathogenesis:
- Sheep store Cu readily
  - Single toxic dose range = 20-100 mg/kg (vs 220-880 mg/kg in cattle)
  - Cu released from liver is directly toxic to RBC membranes
Cause:
- Sheep fed improperly balanced rations or cattle diets
  - Feed low in molybdenum, zinc or calcium
  - Phytophagenous sources- subterranean clover
  - Merino sheep may be more susceptible to this cause than other breeds
Treatment:
- D-penicillamine, Mb. thiosulfate, tetramethylthiomolybdate
Model for Wilson’s disease

- Human genetic defect in copper transporting p-type ATPase
- Northern Ronaldsay Sheep

Other well known animal model (rodent) for Wilson’s disease?

Long Evans Cinnamon (LEC) Rat

Diagnosis

Lymphosarcoma – Bovine Leukemia Virus

- B lymphocyte associated retro-virus
- Common Sites
  - Retroorbital
  - Abomasum
  - Uterus
- Goats seroconvert but do not develop clinical disease
  - Sheep can be infected both naturally and experimentally
Diagnosis

- **Bovine Viral Diarrhea Virus**
  - Flaviviridae, pestivirus
  - Disease primarily of cattle
  - Very similar virus and disease in sheep called “Border” disease
  - Clinical signs: subclinical, fever, anorexia, oral erosions, diarrhea, congenital abnormalities, reduced fertility, abortions, contributing factor to pneumonia
  - Persistent infection
    - Animals infected in utero, become immuno tolerant to the virus
    - Usually do not survive to maturity, show signs of mucosal disease
    - Important source for infection of other animals, as they shed large amount of virus, even through the skin
  - Vaccination should be integrated into herd health programs

Clinical signs:
- Dysentery, anorexia, stiffness, inability to stand
- Other lambs found dead
- Creatinine Kinase (CK) and aspartate aminotransferase (AST) elevated

Presumptive diagnosis?

- **White Muscle Disease**
  - *Bacillus anthracis*
  - Septicemia, hyperthermia, anorexia, depression and acute death with bloody discharges from the nostrils, mouth, anus, and vulva
  - Necropsy
    - Incomplete rigor mortis, dark uncoagulated blood protruding from all body orifices, splenomegaly
    - Reportable
    - Report to state officials
    - Botulism threat
    - Zoonotic

- **Lungworms**
  - *Dictyocaulus filaria*
  - *Protostrongylus rufescens*
  - *Muellarius capillaris*

  Less common in goats

Pathogenesis
- Vitamin E and/or Selenium deficiency
- Lack of one or both results in oxidative stress and loss of membrane integrity
- Cardiac form - neonates
- Skeletal form - young

Reportable
- Report to state officials
- Botulism threat
- Zoonotic

Tissue from a lamb

- Dysentery, anorexia, stiffness, inability to stand
- Other lambs found dead
- Creatinine Kinase (CK) and aspartate aminotransferase (AST) elevated

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Tissue from a sheep

- Dysentery, anorexia, stiffness, inability to stand
- Other lambs found dead
- Creatinine Kinase (CK) and aspartate aminotransferase (AST) elevated

Presumptive diagnosis?

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Reportable
- Report to state officials
- Botulism threat
- Zoonotic
Tissue from a goat

Brain

Clinical Signs
- Abortion
- CNS signs

Cold enrichment (20°C) beneficial in culturing the organism

Diagnosis?
Listeria monocytogenes

Most likely diagnosis?

Corynebacterium pseudotuberculosis
- Disseminated superficial abscesses of lymph nodes
- Very common
- Gram + coccobacillus
- Thick caseous exudate
- ELISA available

Goat small intestine

Presumptive diagnosis?
Coccidiosis
(Eimeria ninakohlyakimovae, E. arloingi, E. christenseni)

Necropsy Findings:
GI may appear congested, hemorrhagic, or ulcerated and have scattered pale, yellow to white mucosal plaques

- Common in young animals
- Often associated with stress or intensive housing conditions, or weaning
- 11 Eimeria species in sheep, 9 in goats

Brain from a ruminant with CNS disease

Diagnosis?
Rabies
(Lyssavirus-genus)
(Rhabdovirus-family)

Histology
- Negri bodies in the cytoplasm of the neuron
- Confirmation made by fluorescent antibody stain of the brain

Zoonotic!
Reportable!

Frontal sinus of a sheep

Clinical Presentation
Name the Parasite

Oestrus ovis
Nasal bot fly - larva

Clinical Exam – fetlock of a goat
- Pruritus, scales, crusts and hyperkeratosis

Diagnosis?
Chorioptes bovis
- Affects lower legs and scrotum
- Usually occurs in cooler months
- Ruminant mites have been eradicated or are very rare in the US
- Sarcoptes and Psorergates infections are reportable!

Scabies in sheep:
Psoroptes ovis, Sarcoptes scabiei, Psorergates ovis, Chorioptes ovis

Rule outs?
- Psoroptes ovis (common scabies) - woolly areas
- Psoroptes scabiei (ears - rare)
- Sarcoptes scabiei (head scabies)

Parasite found on sheep with pruritis, and chronic dermatitis of the neck, sides, abdomen and rump

Diagnosis?
Sheep keds (Melophagus ovinus)
- Wingless, flat, brown, bloodsucking fly
- Can transmit which virus?
- Bluetongue

Brain from aborted goat fetus
- Moderate gliosis, non-suppurative encephalitis, perivascular mononuclear infiltrates
**Diagnosis?**

*Neospora caninum*

- Widespread worldwide
- Abortion is the only clinical sign in adults
- Young may show weakness or CNS signs
- More common in bovine, but may be seen in sheep and goats
- Immunohistochemical staining specific for the organism (immunoperoxidase)

**Definitive host?**

Dog

**Rule outs?**

Toxoplasma sp. (smaller)

---

**Diagnosis?**

*Mycobacterium paratuberculosis*

"Johne’s Disease"

- Non-sporing, fastidious, acid-fast, gram-positive rod

**Diagnostic tests?**

- Fecal culture: 8-12 weeks
- Serology: ELISA (most reliable), AGID or CF
- Acid-fast organisms on rectal biopsy smears

- Chronic carriers exist
- Most likely route of infection via ingestion
- Vertical transmission reported
- Organisms inhabit macrophages of host

---

**Tissue from a sheep**

unthriftiness, weight loss and intermittent diarrhea

---

**Name three potentially zoonotic organisms associated with abortion and/or lambing in sheep:**

- *Coxiella burnetii* - Q fever
- *Brucella melitensis*
- *Campylobacter fetus* subspecies *intestinalis*

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**Histopathology**

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**Q fever**

- *Coxiella burnetii*
- Gram-negative coccobacillus-like bacteria, similar to rickettsial organisms
- Found in milk, urine and feces of infected animals
- Placenta and fetus are particularly dangerous source of infection for people
- Transmission via inhalation of aerosolized particles
- Likely to be asymptomatic in sheep
- Causes flu-like symptoms in people
- Can be treated with appropriate antibiotics
Goat with stiffness, lameness and swelling of the carpal joints

**Diagnosis:**
- Caprine Arthritis Encephalitis Virus (CAEV)

**Genus and family of the virus?**
- Lentivirus, Retroviridae
  - Progressive arthritis or interstitial pneumonia in animals > 6 months
  - Encephalitis in younger animals
  - Prevalent in the US
  - No treatment exists
  - Diagnostic tests: AGID, ELISA
  - Test and Cull

*Same viral genus/family as Ovine Progressive Pneumonia (Maedi/Visna)*

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**Catheterization of Intestinal Loops in Ruminants Does Not Adversely Affect Loop Function**

This recent publication using sheep evaluated the feasibility of using catheterized intestinal loops for studying host response to various treatments with the small intestine. The study concluded that:
- a. The catheters were patent for more than 40 days
- b. Treatments (bacteria) administered into the loops remained localized with the loops
- c. Neither the surgical procedure to place the catheters or the catheters themselves had any long term behavioral or health effects on the sheep
- d. All of the above
- e. None of the above

---

**Evaluation of an Inhouse Rapid ELISA Test for Detection of Giardia in Domestic Sheep (Ovis aries)**

This recent publication evaluated whether a commercially available rapid ELISA test used for Giardia detection in dogs and cats could be used in sheep. The study concluded that the rapid ELISA test exhibited what percentage of sensitivity for sheep giardiasis?
- a. 0%
- b. 68%
- c. 88%
- d. 100%

---

**Surgical Approaches to Vascular Access for Large-Caliber Devices in Preclinical Research Models**

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---

**Morphometric Comparison of the Lumbar Cancellous Bone of Sheep, Deer, and Humans**

In this recent publication the feasibility of using deer and sheep as animal models for the human spine was studied. This image depicts:
- a. Sampling methods to be used to collect binary images from same sized areas of interest for each species
- b. Morphologic differences in the vertebral bodies of each species
- c. CT scan images of each vertebrae

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**Barnes-Type Dehorner**
THANK YOU!

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Next Presentation…