Overview: Principles of Immunology and Vaccination

James A. Roth, DVM, PhD, DACVM
College of Veterinary Medicine
Iowa State University
Ames, Iowa USA

Topic Areas
- Basic immunology: Protection from infectious agents and neoplasia
- Systemic vs mucosal immunity
- Immunity in the neonate
- Immune mediated diseases
- Comparative immunology
- Principles of vaccine safety and efficacy

Native Defense Mechanisms
- Protects naïve animal
- Protects immediately
- Not antigen specific
- Activated by "PAMPs"

Acquired Defense Mechanisms
- Develop after antigen exposure
- Require several days to weeks
- Antigen specific
- Memory and tolerance
- Activate native defense mechanisms
Native Defense Mechanisms

- Barriers to infection
  - Skin
  - Mucus
  - Normal flora
  - Acid in stomach
  - Antimicrobial peptides – defensins

Acquired Defense Mechanisms

- Antibodies
- Cell mediated immunity
  - T-Helper Cells (Cytokines)
  - Cytotoxic T cells
  - Gamma Delta T cells

Native Defense Mechanisms

- Phagocytic cells
  - Neutrophils
  - Macrophages
Native Defense Mechanisms

- Complement system
  - 20-30 serum proteins
  - Enzyme cascade system
  - Very rapidly induced
  - Multiple mechanisms for controlling microbial infection

Native Defense Mechanisms

- Native defense cytokines
  - Macrophage and dendritic cell derived in response to PAMPs
  - Pro-inflammatory cytokines
    - Fever, lethargy, loss of appetite
  - Chemokines
  - Interferons

Native Defense Mechanisms

- Natural killer (NK) cells
  - A type of lymphocyte, not antigen specific
  - Kill some virus infected and tumor cells
  - Recognize and kill cells that do not express normal proteins
Acquired Defense Mechanisms

- **Humoral immunity/Antibody**
  - B cells/plasma cells
  - IgM, IgG, IgA, IgE

- **Cell Mediated Immunity (CMI)**
  - T cells – alpha/beta TCR
    - CD4+: Th1, Th2, Th17, Treg
    - CD8+: Cytotoxic T cells (CTLs)
  - T cells – gamma/delta TCR

Antigen Recognition

- Antibodies recognize a small portion of a molecule (epitope)
- Very specific ~ $10^9$ different epitopes
- B cells recognize intact antigens
- TH and CTLs recognize only peptides processed and presented on major histocompatibility complex molecules (MHC)
- Gamma Delta T cells recognize cell surface molecules

Immunologic Memory

- Anamnestic or memory response
  - Faster than primary response
  - Antigen specific clones of B lymphocytes have expanded and matured
    - Higher titer of antibody
    - Antibody can bind more tightly
    - Antibody class has switched
  - T helper and T cytotoxic clones have expanded, matured, and are circulating
Tolerance

- Acquired immune system does not attack self molecules
  - Antigens present during lymphocyte maturation are tolerated
  - Antigens not present during lymphocyte maturation are attacked
  - Tolerance can break down resulting in autoimmune diseases

Immune System Dysfunction

- Hypersensitivity reactions
- Allergies
- Autoimmune disease
- Immunodeficiency