THE UNIVERSITY OF MELBOURNE

FACULTY OF VETERINARY & AGRICULTURAL SCIENCES

VETS30029 / VETS90121

Subject Guide

Veterinary Bioscience: Cells to Systems

Veterinary Bioscience: Cells to Systems

VETS30029 / VETS90121 - Semester 1, 2023

Introduction

Welcome to the Cells to Systems unit of the Veterinary Bioscience, VETS 90121 and VETS 30029 courses. Whilst there are different subject codes for the graduate (DVM, VETS 90121) and undergraduate (BSc3, VETS 30029) subjects, all lectures, practical classes, seminars and case studies in these two subjects are co-taught.

This unit introduces some fundamental concepts in each of the disciplines that underpin the integrated study of Veterinary Bioscience in particular, the disciplines of **anatomy** (form and physical relationships at the micro and macro levels), **physiology** (function at the levels of the cell, organ, system and animal), **pathology** (the mechanisms of disease) and **pharmacology** (using drugs to modify function for the treatment of disease). In all other units of Veterinary Bioscience, elements of these disciplines are combined so that we can consider structure, function, diseases processes and their management, for a particular organ or body system. **Cells to Systems provides the strong foundation in the basic disciplines, on which an integrated understanding of system function can be built**.

Each week of the Cells to Systems module has a general theme such as “basic cell types” or cell communication”. This enables the course to introduce the disciplines of bioscience, in the key areas of function and dysfunction in body systems, while maintaining a coherent narrative. Having themes will also enable a weekly routine to develop, which will culminate in a practical class or case study at the end of each week. These **case studies and practical classes** are an important addition to the lectures, as they have been devised to illustrate the importance of the acquired knowledge of fundamental principles and hone your problem-solving and technical skills. Students will work through these classes in small groups, with a moderated summary session at the end.

This booklet provides a summary of all learning activities in the Cells to Systems unit. A weekly overview lists the topics that will be covered in lectures and practical classes and highlights the intended learning outcomes across the **five learning domains: the scientific basis of clinical practice, clinical skill acquisition, personal and professional development, animal ethics and welfare, and population health and biosecurity.** The outline summaries for each lecture allow you to preview the content and identify the intended learning outcomes, keywords and recommended reading lists. You should prepare for each week by reading these short summaries in advance. Other learning materials, such as detailed lecture notes and lecture power-point presentations, will be made available to you prior to delivery via the LMS platform. A separate manual that covers the practical classes of this module will be provided to you at the start of the subject.

The assessment components and weightings for BSc 3 and DVM 1 students undertaking the Cells to Systems subject/module are provided on the Learning Management System.

Intended Learning Outcomes for Cells to Systems

- Explain how the structural and functional organisation of the cells, tissues, organs and body systems enable maintenance of homeostasis
- Communicate anatomical and microscopic features of animal tissues using scientific terminology
- Explain how homeostasis is maintained through normal hormonal, electrical and pharmacological communication
- Describe the major components of the immune system and the clinical manifestations of an activated immune response
- Apply the principles of common inflammatory and non-inflammatory pathological processes to explain the clinical features of disease
- Interpret data acquired from clinical cases, and apply understanding of the cellular and system structure and function in order to analyse and interpret clinical problems

Your feedback on this module will be very much appreciated by the Faculty (and will be actively sought during Semester 1). If you have any queries regarding components of this unit, please do not hesitate to contact me or the other staff members who are contributing to its delivery.

I hope that you find this subject intellectually stimulating and enjoyable at the same time.

Dr Smitha Rose Georgy BVSc MVSc PhD MANZCVS Diplomate ACVP

Subject Coordinator (s.georgy@unimelb.edu.au)

Senior Lecturer in Veterinary Pathology

Veterinary Bioscience: Cells to Systems

Theme One: Homeostasis and Basic Cell Types

Veterinary Bioscience: From cells to systems provides an introduction to the approach and language of each of the major disciplines that make up the integrated studies of the body systems. In the first lecture, we will provide an overview of the subject, and introduce the principles of homeostasis and body systems.

We commence our study of animal structure by examining structures at a microscopic level- this is the discipline of histology. In order to make sense of what we see down a microscope we need to understand how the tissue has been preserved and processed for examination. We also need to appreciate the distinctive structural and functional characteristics of the major tissue types of the body - with a particular focus on connective and epithelial tissues.

Lectures

1. Introduction to the course and homeostasis	• Homeostasis- ensuring cell survival. • Cell types and body systems • Functions of cells
2. Connective tissues	• How are tissues prepared for microscopic examination? • Tissue types of the body • What is connective tissue? • Cells and extracellular matrix
3. Epithelium	• Identification and classification of epithelial tissues as they relate to function.
4. Histology of muscle and nerve cells	• Histologic features of different muscle tissue and nervous tissue

Practical class

1. Microscopic anatomy	Identification of major tissue types in a range of tissue specimens	Room 331, LTB, Werribee

Outcomes

Clinical Skills

- Correctly identify and describe basic cell types in mammalian tissues.

Scientific Basis of Clinical Practice

- Describe homeostasis in terms of the key components that promote cell survival and normal function.
- Describe the basic cell types in mammalian tissues and explain how their structure relates to their function.

Veterinary Bioscience: Cells to Systems

Lecture 1 Introduction to Cells to Systems

Lecturer: Dr Laura Dooley

Laura graduated as a veterinarian from the University of Melbourne in 2007. She worked in small animal private practice in Australia and the UK for 7 years. She completed her PhD thesis about the anti-inflammatory effects of stem cells at the University of Melbourne 2014. She is a Senior Lecturer in Veterinary Biosciences, and has a special interest in collaborative learning, student wellbeing and mentoring. Laura's research interests are in veterinary education.

Email: laura.dooley@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture, you should be able to:

- Describe the basic structure of a cell and understand the function of the major cell components
- Describe the relationship between cells, tissues, organs and body systems in terms of their anatomical structure and physiological functions
- Explain the general concept of homeostasis and the principles of positive and negative feedback in physiological systems

Keywords

- Cells, tissues, organs, body systems, homeostasis, negative feedback, positive feedback

Lecture Overview

This lecture sets the scene for the subject *Cells to Systems*. It will introduce in general terms how the animal body is organised, from the cellular level through to the whole organism. These levels are:

- Cells – the basic units of life
- Tissues - groups of cells with similar structure and function
- Organs – structures comprised of two or more tissues that are organised to perform a function
- Body systems – groups of organs that perform related functions
- Organism – body systems organised together to create a fully functional body

Body systems function together to maintain a relatively stable internal environment, a concept called *homeostasis.* Homeostatic mechanisms enable the body to maintain a dynamic steady state in the internal environment.

Further Reading

Any general physiology textbook will include this introductory material.

Hall JE: *Guyton and Hall Textbook of Medical Physiology*, Elsevier, 2021.Ebook. Chapters 1&2.

Klein BG: *Cunningham's textbook of veterinary physiology*. Elsevier, 2020. Available in BioMed and Werribee libraries.

Veterinary Bioscience: Cells to Systems

Lecture 2 Connective Tissues

Lecturer: Dr Smitha Georgy BVSc MVSc PhD MANZCVS Diplomate ACVP

Smitha Georgy is a veterinary graduate from Kerala Agricultural University, India, and undertook PhD from The University of Melbourne. She briefly worked in mixed animal practice in Kerala before moving to Australia. Smitha then worked as a research scientist in the Department of Medicine, Monash University. In 2015, she completed the National Veterinary Examination and started small animal practice in Melbourne. She started her career as an anatomic pathologist in 2018 when she joined the Melbourne University as a lecturer. She became a diplomate of the American College of Veterinary Pathologists in 2021. Her research interests are in epithelial cancers affecting the skin, oral cavity, and oesophagus, and is an author of several research publications.

Email: s.georgy@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture you should be able to:

- Explain how the basic tissue types combine to form body systems
- Explain the basic structure of connective tissues
- Identify the cells and extracellular material found in connective tissues

Keywords

- Histology, preparation artefact, eosinophilic, basophilic, connective tissue, fibre, fibroblast, fibrocyte, macrophage, adipocyte, mast cell, plasma cell.

Lecture Overview

All tissues in the animal body are composed of different combinations of four different tissue types, connective tissue, epithelial tissue, muscular tissue and nervous tissue. In this lecture, a general introduction to histology (the study of microscopic anatomy) will be provided, including an overview of tissue preparation techniques and guidance on interpretation of histological images. The histology of connective tissues will be examined, including a discussion of the different types of cells and extracellular material found in different forms of connective tissue.

Further Reading

Jennings Ryan, 2017, Veterinary Histology

Eurall, JA. Frappier BL. 2006. *Dellman's Textbook of Veterinary Histology*, 6th Edition, Blackwell Publishing.

Bacha WJ. Bacha LM. *Color Atlas of Veterinary Histology*, 2nd Edition, Blackwell Publishing. Chapter 1, 3.

Veterinary Bioscience: Cells to Systems

Lecture 3 Epithelium

Lecturer: Dr Smitha Georgy

Email: s.georgy@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture you should be able to:

- Explain the system for classifying epithelial tissues
- Provide examples of different types of epithelia
- Identify the different types of epithelia

Keywords

- Epithelium, squamous, cuboidal, columnar, simple, stratified, exocrine gland, endocrine gland.

Lecture Overview

Epithelia are tissues consisting of closely apposed cells without intervening intercellular substances. Epithelial tissues cover all free surfaces of the body and also line the large internal body cavities. They are separated by a basement membrane from underlying connective tissues. In this lecture, the microscopic appearance and classification of epithelial cells will be examined.

Further Reading

Jennings Ryan, 2017, Veterinary Histology

Eurall, JA. Frappier BL . *Dellman's Textbook of Veterinary Histology*, 6th Edition. Blackwell Publishing. Chapter 2.

Bacha WJ. Bacha LM. *Color Atlas of Veterinary Histology*, 2nd Edition, Blackwell Publishing. Chapter 2.

Veterinary Bioscience: Cells to Systems

Lecture 5 - Histology of Muscle and Nerve Cells

Lecturer: Dr Babatunde (Tunde) Ayodele

Tunde Ayodele is a veterinary graduate and works as a research fellow in the Melbourne Veterinary School where his research focuses on equine limb injury prevention. His research interest is in the physiology and pathology of the musculoskeletal system.

Email: awodeleb@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture, you should be able to:

- Define and identify different types of muscle tissue based on their histological features
- Describe the main types of nervous tissues and identify defining cell types

Keywords

- Skeletal muscle, cardiac muscle, smooth muscle, peripheral nerve, central nervous system, neuron, astrocyte, glia.

Lecture Overview

Motion, as a reaction of multicellular organisms to changes in the internal and external environment, is mediated by muscle cells and controlled by nerve cells. In this lecture we will examine the microscopic anatomy of skeletal, smooth and cardiac muscle cells, and how their structure reflects their function.

Further Reading

Jo Ann Eurell, Brian L. Frappier. Dellmann's Textbook of Veterinary Histology. Wiley-Blackwell; 2006. **Chapters 5 and 6.**

Bacha LM, Bacha Jr. WJ, Bacha lJ, Bacha dM. Color Atlas of Veterinary Histology. Hoboken: John Wiley & Sons, 2012. **Chapters 8 and 9.**

Jennings Ryan, 2017, Veterinary Histology

Veterinary Bioscience: Cells to Systems

Theme Two: Language and the Body Plan

This theme introduces you to gross anatomy. Anatomy is the study of structure as it relates to function, as well as position of structures and their relationship to one another. Anatomy uses a special language to describe this - a language you will need to learn in order to communicate with colleagues. This week you will be introduced to the language of anatomy, and also to the overall body plan of mammals.

Lectures

5. The language of anatomy	• Position terms • Planes • Prefixes • Body structures
6. The skeleton	• Body regions • The limbs • Bones of the trunk: vertebrae, ribs and sternum • The skull and mandible • Joints: where bones meet • Describing features on bones • Special bones
7. The Body Plan	• Generalised body systems • Systems with restricted range • Identifying specific structures

Practical class

2. Osteology	Examination and identification of the bones of the skeleton	Dry Lab 1 and OBLA, Building 125, Parkville

Outcomes

Personal and Professional Development

- Describe the structure, position and relationship of mammalian structures using precise and appropriate anatomical terms (N)

Scientific Basis of Clinical Practice

- Identify and describe the position, relationship, form and appearance of animal structures and features.
- Describe the major body regions of mammals and the arrangement of the skeleton
- Recognise bones of different parts of the skeleton, and use correct anatomical terms to describe features on bones.

Veterinary Bioscience: Cells to Systems

Theme 2 – Anatomy: The body and skeleton

Lecture 5: The Language of Anatomy

Lecturer: Dr Janine Hofmann

Janine is a Lecturer in Veterinary Anatomy at the University of Melbourne. Janine graduated from The University of Melbourne before working in small animal practice for 10 years. She rejoined the university to undertake a PhD in veterinary microbiology, in addition to teaching within the disciplines of veterinary anatomy and physiology.

Email: hofmann.j@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture, you should be able to:

- Describe the position, relationships, form, and appearance of important animal structures and features
- Apply correct terminology for normal and novel structures in a meaningful way

Keywords

- Position terms: left/right; medial/lateral; ventral/dorsal; cranial/caudal/rostral; palmar/plantar; superficial/deep; proximal/distal; axial/appendicular; axial/abaxial.
- Planes: median; sagittal; transverse; dorsal.
- Movement terms: flexion/extension/hyperextension, adduct/abduct, supinate/pronate.
- Prefixes: epi; peri; endo; dia; meta; infra; sub; supra, ante, anti, ab; ad; hypo; hyper.
- Tissues: bones, joints, cartilage, muscles, ligaments, tendons, nerves, veins, skin.

Lecture Overview

To facilitate meaningful, unambiguous communication, anatomy has standardised names or all the structures of the body, and many parts within these structures, as well as description terms for position and relationships. In this lecture, we introduce the basic terminology and look at how anatomical names and terms are used to communicate complex 3D positions and relationships in a clear and precise manner.

Further Reading

Nomina Anatomica Veterinaria – available online at http://www.wava-amav.org/wava-documents.html

Studdart, Gay & Hinchcliff. *Saunders Comprehensive Veterinary Dictionary*. Elsevier, Missouri. Available as a downloadable e-book through the library.

Singh. *Dyce, Sack & Wensing's Textbook of Veterinary Anatomy* (any edition). Elsevier, Missouri.

König & Liebich. *Veterinary Anatomy of Domestic Mammals* (any edition).

Hermanson, de Lahunta & Evans. *Miller and Evans' Anatomy of the Dog* (any edition). Elsevier.

Veterinary Bioscience: Cells to Systems

Theme 2 – Anatomy: The body and skeleton

Lecture 6: The Skeleton

Lecturer: Dr Janine Hofmann

Email: hofmann.j@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture, you should be able to:

- Describe the position, relationships, form, and appearance of the major bones of the quadruped skeleton
- Identify the major bones in novel animals

Keywords

- Axial skeleton: skull, mandible, hyoid, vertebral column (cervical, thoracic, lumbar, sacral, caudal vertebrae), thoracic skeleton (thoracic vertebrae, ribs, sternum).
- Appendicular skeleton: bones of the forelimb and hindlimb
- Bones of the forelimb: pectoral girdle (scapula, clavicle, coracoid), humerus, radius and ulna, carpal bones, metacarpal bones, digits (phalanges).
- Bones of the hindlimb: pelvic girdle (ilium, ischium, pubis, acetabulum), femur, tibia and fibula, tarsal bones, metatarsal bones, digits (phalanges).
- Features on bones: process, tuberosity, epicondyle; fossa, foramen, fissure, canal, duct, condyle, articular facet.
- Specialised bones: sesamoids, splanchnic bones, pneumatic bones.

Lecture Overview

The skeleton serves to support the body and provide its basic shape, as well as anchor the leverage system used for locomotion and provide protection to delicate structures.

Skeletal bones may be palpated or vizualised from the surface of the animal or identified on a radiograph. Thus, they offer consistent and accessible landmarks for the description of many other structures and for the location of internal organs or clinically relevant structures. The basic quadruped skeleton has been adapted in numerous ways to allow for flight, fast running, swimming, digging, and many other ways of life. This lecture introduces the bones that may be present and how to identify which bones are present in any animal skeleton.

Further Reading

Studdart, Gay & Hinchcliff. Saunders Comprehensive Veterinary Dictionary. Elsevier, Missouri.

available as a downloadable e-book through the library.

Singh. Dyce, Sack & Wensing's Textbook of Veterinary Anatomy (any edition).

available as an e-book through the library.

König & Liebich. Veterinary Anatomy of Domestic Mammals (any edition).

Hermanson, de Lahunta & Evans. Miller and Evans' Anatomy of the Dog (any edition). Elsevier.

available as a downloadable e-book through the library.

Hildebrand. Analysis of Vertebral Structure (any edition).

vet-Anatomy, the interactive atlas of veterinary anatomy by IMAIOS.

available through the University Library: http://cat.lib.unimelb.edu.au/record=e1002019~S30

Coulson & Lewis. An Atlas of Interpretative Radiographic Anatomy of the Dog & Cat.

Veterinary Bioscience: Cells to Systems

Theme 2 – Anatomy: The body and skeleton

Lecture 7: The Body Plan

Lecturer: Dr Janine Hofmann

Email: hofmann.j@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture, you should be able to:

- Identify regions of the body by their anatomical name in domestic and novel species
- Describe the position and relationships of the major systems in relation to the major bones of the quadruped skeleton and in relation to each other
- Identify major structures of the major systems by their anatomical name and relative position
- Find selected structures from a written description and/or their anatomical name

Keywords

- Body regions: pectoral limb, pelvic limb, head, neck, thorax, abdomen, pelvis.
- Body cavities: thoracic/abdominal/pelvic
- Relationships of generalised body systems (musculoskeletal, cardiovascular, lymphatic, nervous, integument) and body systems with a restricted range (respiratory, digestive, urinary, reproductive, endocrine).
- Specific structures/organs: heart, aorta, carotid artery, jugular vein, cranial vena cava, caudal vena cava, portal vein, brain, spinal cord, spleen, trachea, lungs, diaphragm, tongue, teeth, oesophagus, liver, stomach, intestines, kidneys, bladder, male and female reproductive tract.

Lecture Overview

The organs and structures of the body can be categorised into ten body systems based on a common function, and often a similar structure and origin. Each system can be studied individually, called a systematic approach, which provides insight into the normal physiology of the system, as well as the disease processes that affect it. The systematic approach does not illustrate the relationships between structures within different systems in the same body region or provide approaches to specific structures in the living animal. To understand these relationships and approaches, the ability to identify a structure's location in relation to other structures within the same system and with structures from other systems is needed.

This lecture provides an overview of the relative positions and extent of the different body systems and highlights the important structures.

Further Reading

Hermanson, de Lahunta & Evans. Miller and Evans' Anatomy of the Dog (any edition). Elsevier.

available as an e-book through the library.

Evans & de Lahunta. Guide to the Dissection of the Dog (any edition).

Goody. Dog Anatomy, A pictorial approach to canine structure (2nd edition).

Singh. Dyce, Sack & Wensing's Textbook of Veterinary Anatomy (any edition).

available as an e-book through the library.

König & Liebich. Veterinary Anatomy of Domestic Mammals (any edition).

vet-Anatomy, the interactive atlas of veterinary anatomy by IMAIOS.

available through the University Library: http://cat.lib.unimelb.edu.au/record=e1002019~S30

Veterinary Bioscience: Cells to Systems

Theme Three: Cell structure and transport of molecules around the body

This theme commences with consideration of the functional organisation of cells. Each cell is a discrete entity with its own complexity of functions. It must function though within the environment shared by all the cells around it. This shared environment is called the internal environment of the animal. It consists of connected fluid compartments separated by semipermeable membranes. Cell survival and effective cellular function depend on the constancy of the internal environment, as well as on the capacity of the cells to regulate movement of substances across their membranes. The cardiovascular system and lymphatic system are integral to maintenance of the internal environment through delivery of molecules to and removal of molecules from the environment of cells. The third lecture will commence the discussion of the cellular composition of blood, with a focus on the formation and function of the red blood cell.

Lectures

8. Transport of molecules around the body	• Organization of the cardiovascular system. Transport of molecules across capillaries. Structure and function of the lymphatic system. • What comprises the cardiovascular system and what does it do? • Composition of fluid compartments • What is the lymphatic system and what does it do?
9. Functional organization of the cell	• What are the essential functions of the cell? • What molecules are in the cell membrane and what are their functions? • How do cells regulate the movement of substances across their membranes? • How do cells communicate with the environment in which they are located?
10. Blood cell formation and function	• Cellular and non-cellular composition of blood. • Role of blood in homeostasis. • Identification of blood cells. • Blood cell turnover and response to infection

Practical classes

3. Haematology	Examination of blood smears and identification of leukocytes from different animal species	LTB 331 Werribee

Outcomes

Scientific Basis of Clinical Practice

- Describe homeostasis in terms of the key components that promote cell survival and normal function
- Describe the basic cell and tissue types, and explain how their structure relates to their function
- Describe the essential functions of the cell
- Explain the roles of the cardiovascular and lymphatic systems in homeostasis.
- List the cellular and non cellular components of blood
- Describe the blood leukocytes

Personal and Professional Development
Work effectively in a group to enhance shared understanding of biological principles

Clinical Skills

- Consider the approach taken to addressing a clinical presentation, and clinical diagnostic reasoning

Veterinary Bioscience: Cells to Systems

Lecture 8 Transport of molecules around the body

Lecturer: Dr Laura Dooley

Email: laura.dooley@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture, you should be able to:

- Describe the organization of the cardiovascular and lymphatic systems and their role in fluid homeostasis
- Describe the major body fluid compartments and the composition of intracellular and extracellular body fluid
- Explain how water and solutes traverse the capillary wall, using Fick's equation and Starling's hypothesis
- Explain the mechanisms underlying disruptions to fluid homeostasis including oedema and lymphoedema

Keywords

- Fluid compartments, intracellular, extracellular, blood circulation, capillaries, lymphatics, diffusion, Starling's forces, oedema, lymphoedema.

Lecture Overview

This lecture describes the distribution of water across body compartments; with two thirds contained within the intracellular fluid, and the remaining one third in the extracellular compartment (plasma and interstitial fluid). The fluid in the intracellular and extracellular compartments have very different compositions, because the cell membrane creates a selective barrier. This lecture will also describe how water and solutes cross capillary walls, controlling the distribution of fluid within the body. An overview of the cardiovascular and lymphatic systems and their role in maintaining fluid homeostasis is also covered.

Further Reading

Hall JE: *Guyton and Hall Textbook of Medical Physiology*, Elsevier, 2021.Ebook. Chapters 1&2.

Klein BG: *Cunningham's textbook of veterinary physiology*. Elsevier, 2020. Available in BioMed and Werribee libraries.

Veterinary Bioscience: Cells to Systems

Lecture 9 Cell membrane structure and function: movement of molecules across cell membranes

Lecturer: Dr Laura Dooley

Email: laura.dooley@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture, you should be able to:

- Describe the composition of the cell membrane and explain how the distribution of phospholipids and proteins influences the membrane permeability to ions, hydrophilic and hydrophobic compounds, and cell-cell communication
- Describe how cells regulate the movement of substances across their membranes and the role of diffusion, facilitated diffusion, and primary and secondary active transport mechanisms
- Explain how energy from the Na+ and K+ electrochemical gradients across the plasma membrane are maintained and can be used to drive the movement of other solutes

Keywords

- Plasma membrane, cytoskeleton, integral and peripheral proteins, osmosis, phospholipids, ion channels, diffusion, facilitated diffusion, primary active transport, secondary active transport.

Lecture Overview

This lecture describes the structure and function of the cellular membrane, which forms the barrier to the intracellular environment. The distribution of phospholipids and proteins within the membrane influences the permeability of the membrane to different molecules. In addition to controlling the entry of molecules and the exit of secretory and waste products, the cell membrane also maintains differences in ion concentrations across the intracellular and extracellular compartments. This lecture will discuss the mechanisms underlying the control of movement of substances across the cell membrane, including the role of both passive and active mechanisms.

Further Reading

Hall JE: *Guyton and Hall Textbook of Medical Physiology*, Elsevier, 2021.Ebook. Chapters 1&2.

Klein BG: *Cunningham's textbook of veterinary physiology*. Elsevier, 2020. Available in BioMed and Werribee libraries.

Veterinary Bioscience: Cells to Systems

Lecture 10 The role of blood and blood cells in homeostasis

Lecturer: Astrid Oscos Snowball MVZ (Hons), MVM (Hons), DVSC (ClinPath)

Astrid is a graduate of the University of Guadalajara, Mexico (2007), and serves as a Lecturer in Clinical Pathology here at the University of Melbourne. After veterinary school, she completed a Master's in Veterinary Clinical Pathology in 2011, followed by a Doctor of Veterinary Science degree (research + residency) in Clinical Pathology at the Ontario Veterinary College, University of Guelph, Canada, in 2017. She joined the faculty at Melbourne in October of 2018 and is currently pursuing Board Certification in Clinical Pathology.

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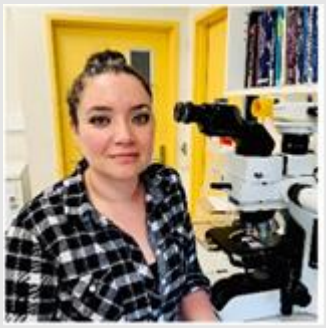

Intended Learning Outcomes

At the end of this lecture, you should be able to:

- Describe the components of blood (cells, ions, proteins, platelets), giving their normal values.
- Describe the main functions of blood in the homeostasis of the body.
- Identify the cells in the blood and their species variations.
- Discuss the normal balance of blood cell turnover and how this enables an animal to respond to infection.

Keywords

- Haematocrit, haemoglobin, erythrocyte, platelet, anaemia, neutrophil, monocyte, eosinophil, lymphocyte, basophil, protein.

Lecture Overview

Blood is a specialized bodily fluid with essential functions, including the transportation of respiratory gases, nutrients and waste products, chemical messengers, and cells. In this lecture, we will examine the formed and unformed components of blood and their role in homeostasis, paying particular attention to the function of leukocytes.

Further Reading

https://eclinpath.com/

Hall JE: Guyton and Hall Textbook of Medical Physiology, 14th Ed. Elsevier, 2021. UoM ebook
https://www.clinicalkey.com.au/#!/browse/book/3-s2.0-C20170004883

Latimer KS. Duncan & Prasse's Veterinary Laboratory Medicine. Clinical Pathology. 5th Ed 2011. UoM ebook
https://ebookcentral.proquest.com/lib/unimelb/detail.action?docID=821970

Harvey JW. Veterinary hematology: a diagnostic guide and color atlas**.** Elsevier/Saunders, 2012. UoM ebook
https://www.sciencedirect.com/book/9781437701739/veterinary-hematology

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Theme Four: Cell communication (chemical and electrical)

This theme examines the mechanism by which cells receive and translate chemical messages. Chemical communication can take many forms, such as the communication between a nerve cell and a muscle, that results in contraction of the muscle, or the communication that takes place between neighbouring cells in a tissue. Cells also communicate with one another by release of specific chemical signals that are recognised by specific receptors on the cell surface of other cells. Hormones are chemicals released by cells that signal to other cells distant from their site of release. Hormones are produced in a range of organs and tissues and have a number of different chemical structures. Factors that control hormone secretion will be discussed in the context of the biological function of the principle hormones.

This theme expands on cell communication and explores the mechanism by which cells receive and translate electrical messages. The first lecture describes the structure of nerve and muscle cells. We will then be asking questions such as how are messages conducted along nerves, how are messages communicated from one nerve to another and between nerves and effector organs such as muscles?

Lectures

11. Principles of cell communication	• Communication by direct contact- chemical and electrical communication • Communication that uses cell surface receptors • Signalling molecules in cell to cell communication
12. Endocrine system and signalling pathways I	• General structure of hormones. • Principles of hormone function. • Control of hormone secretion
13. Endocrine system and signalling pathways II	• Molecular mechanisms of cell signalling • Structure of different receptor type • Second messengers
14. Endocrine system and signalling pathways III	• Molecular mechanisms of cell signalling • Intracellular hormone receptors • Factors that influence speed of signal transmission •
15. Nerve conduction 1: the neuron, resting membrane potentials, and action potentials	• Functional arrangement of the nerve cell membrane • Differences in ion concentrations across the nerve cell membrane • Ionic basis of the action potential • Propagation of the action potential
16. Nerve conduction 2: the synapse and graded potentials	• Communication between nerve cells • The structure of the synapse • The role of neurotransmitters • Receptors on post synaptic membranes • Excitatory and inhibitory synapses
17. Neuromuscular communication 1: skeletal muscle contraction and its molecular mechanism	• The structure of the neuromuscular junction • Neuromuscular junctions in smooth and skeletal muscle • The mechanism of contraction in skeletal muscle • Control of skeletal muscle contraction- muscle twitch, summation and tetanus • Mechanisms for grading the strength of contractile response in skeletal muscle • Introduce how neurons initiate contraction of the different muscle types

	• Discuss how neuronal input influences the strength of contraction • Introduction to the molecular mechanics of skeletal muscle contraction
18. Neuromuscular communication 2**:** contraction of smooth muscle and skeletal muscle	• The mechanics of muscle contraction- sliding filament theory and the power stroke • The role of calcium in contraction of smooth and skeletal muscle • Energy cycling in active muscle • Grading the contractile response- recruitment of motor units, summation and tetanus • Excitation-contraction coupling in smooth muscle
19. Reflex arc**:** spinal reflex control of skeletal muscle contraction	• The different types of lower motor neurons that contribute to reflex arcs • The structure and function of intra- and extrafusal muscle fibres • The structure and function of muscle spindles and golgi tendon organs • How a reflex arc works

Outcomes

Clinical Skills

- Apply physiological principles and clinical reasoning to explain an animal's presenting signs.

Scientific Basis of Clinical Practice

- Describe the ways in which cells communicate with one another
- Describe the role of the major hormones in regulating organ function
- Describe the site of origin and structural features of the major classes of hormones
- Explain how hormone secretion is regulated, and the factors that determine duration of hormone effect
- Describe the major types of cell surface receptors and the mechanisms by which signals alter cell function

Veterinary Bioscience: Cells to Systems

Lecture 11 Principles of cell communication

Lecturer: Dr Laura Dooley

Email: laura.dooley@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture you should be able to:

- Define the terms autocrine, paracrine, endocrine and synaptic signalling and explain why these different types of signalling processes exist
- Describe the anatomical and functional arrangement of the Hypothalamo-Pituitary axis and how this axis regulates the release of pituitary hormones
- List the hormones produced by the anterior and posterior pituitary and describe their main functions

Keywords

- Autocrine, paracrine, endocrine, hormones, neurocrine, signal transduction, gap junctions, ligands, hypothalamus, pituitary

Lecture Overview

This lecture explains how the ability of cells to communicate with each other is critical for the coordination of their diverse activities within the body. This communication between cells is largely achieved by through extracellular chemical messengers, which may act locally or travel to more distant sites. This lecture will define types of intercellular communication mechanisms, including autocrine, paracrine, endocrine and synaptic signalling, and give examples of where these mechanisms are employed across diverse body functions. This lecture will also more specifically examine the role of the hypothalamo-pituitary axis in controlling the release of pituitary hormones, which are involved in regulating a wide variety of bodily processes, including control of metabolic and reproductive functions.

Further Reading

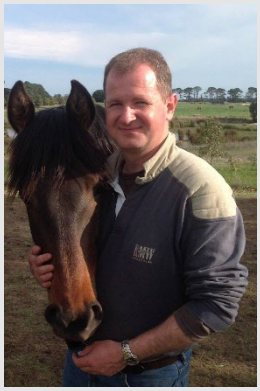
Hall JE: *Guyton and Hall Textbook of Medical Physiology*, Elsevier, 2021.Ebook. Chapters 1&2.

Klein BG: *Cunningham's textbook of veterinary physiology*. Elsevier, 2020. Available in BioMed and Werribee libraries.

Veterinary Bioscience: Cells to Systems

Lecture 12 Endocrine system and signaling pathways 1

Lecturer: Prof Simon Bailey



After time spent in mixed veterinary practice in the UK, Simon undertook a PhD at the Royal Veterinary College, London, on equine serotonin receptors and laminitis. He then continued in research at the RVC, working in the fields of equine laminitis and inflammatory cell signalling. Simon then worked as a research scientist at the Heart and Lung Research Institute at the Ohio State University Medical Center, Columbus, Ohio, where he worked on adrenoreceptors and cell signalling mechanisms in vascular smooth muscle cells. He then returned to the Royal Veterinary College as a lecturer and moved to the University of Melbourne in 2007. He is currently Professor of Pre-clinical Veterinary Sciences, and conducts research on inflammatory diseases, pharmacology and endocrinology in various species including horses.

Email: bais@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture you should be able to:

- Describe the main signal transduction pathways involved in cell signalling
- Explain through the use of examples how a G protein signal transduction pathway is regulated
- Describe how bacterial toxins such as cholera toxin are able interfere with heterotrimeric G protein signalling

Keywords

- cAMP, nicotinic receptors , G-proteins, ligand gated ion channels, hormone response elements.

Lecture Overview

The ability of cells or tissues to respond to a particular hormone or signalling molecule (ligand) is governed exclusively by the presence of specific receptor molecules either upon plasma membranes or within responsive cells. In this lecture we examine how the initial message is converted by signal transduction into a cellular response.

Further Reading

Boron WF and Boulpaep EL: Medical Physiology, 3rd Ed. Elsevier, 2017.

Tortora, G. Principles of Anatomy and Physiology 2nd Ed. Wiley, 2018.

Greenstein B and Wood D. *The endocrine system at a glance* 2nd ed Blackwell Publishing 2006.

Veterinary Bioscience: Cells to Systems

Lectures 13 and 14 Endocrine system and signalling pathways II and III

Lecturer: Prof Simon Bailey

Email: bais@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture you should be able to:

- Describe how different types of G proteins (Gs, Gi ,Gq, Gt signalling) can be linked to different intracellular signalling pathways
- Describe signalling transduction pathways for kinase-linked receptors and be able to give examples
- Discuss the mechanism of nuclear receptor activation
- For each of the structural hormone groups, describe how and where the hormone is produced, its main biological function, and the hormone's secretion is regulated
- Describe using specific hormone examples, how negative and positive feedback process work
- Explain using examples, how certain diseases can interfere with the production or effect of a hormone

Keywords

- G-proteins, tyrosine kinase, thyroid hormones, glucocorticoids.
- Peptide hormones, amine hormones, steroid hormones, eicosanoids, positive feedback, negative feedback

Lecture Overview

In lecture 13 we continue our examination of how hormone signals are converted by signal transduction into a cellular response, looking at different types of G-proteins, kinase-linked receptors and nuclear receptors.

Hormones are classified into four main groups - peptides (eg insulin), amines (e.g. catecholamines and thyroid hormones), steroids (eg cortisol) and eicosanoids (eg prostaglandin). In lecture 14 we will look at some examples of each and examine how they are regulated.

Further Reading

Boron WF and Boulpaep EL. Medical Physiology, 3rd Ed. Elsevier, 2017.

Tortora, G. Principles of Anatomy and Physiology 2nd Ed. Wiley, 2018.

Voet ,D. Fundamentals of Biochemistry: Life at the Molecular level 5th Ed. 2016.

Veterinary Bioscience: Cells to Systems

Lecture 15 - Nerve Conduction 1:
The Neuron, Resting Membrane Potentials, and Action Potentials

Lecturer: Dr Babatunde Ayodele

Email: awodeleb@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture, you should be able to:

- Understand the ionic basis of resting membrane potential.
- Understand the ionic basis for action potential.
- Describe how action potential can be generated and propagated along nerve fibres.
- Understand how threshold and refractory period relate to neuron functions.

Keywords

- Neurons, ion channels, resting membrane potential, action potential, threshold, refractory period.

Lecture Overview

This lecture will introduce the key concepts involved in neuronal functions. The main focus will centre on how neurons transmit messages along their specialised membrane. The lecture will define the resting membrane potential and then detail how this feature of the neuronal membrane transiently changes during an action potential. An action potential is a self-propagating change in resting membrane potential that occurs across the axon membrane. This allows information to be transmitted along the neuronal membrane. Also in this lecture, the importance of maintaining different ion concentrations in the extracellular fluid (ECF) and the intracellular fluid (ICF), on each side of the nerve cell membrane, and the differences in permeability of the nerve cell membrane to different type of chemical ions will be discussed. The major chemical ions driving action potential are potassium and sodium. The roles of their ion channels in propagating action potentials will also be examined.

Further Reading

Sherwood L. *Animal Physiology, From genes to Organisms*, 2nd Edition, p103-

Sherwood L. *Human Physiology, From cells to Systems* 9th Ed. Chapter 3&4.

Stryer, L. *Biochemistry*. Chapter 37, pp 949-957. Chapter 39, pp 1011-1027.

Stephens, C.F. *The Neuron*. Scientific American 241: 48-59. (Copies available in the Library).

Nicholls et al., *From neuron to Brain*, Sinauer associates Inc, 2001

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Lecture 16 - Nerve Conduction 2: The Synapse and Graded Potentials

Lecturer: Dr Babatunde Ayodele

Email: awodeleb@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture, you should be able to:

- Explain how communication between nerves and effector tissue is achieved.
- Describe the functional significance of synapses.
- Explain the importance of excitatory and inhibitory synapses.
- Describe the properties and functions of neurotransmitters and their receptors.

Keywords

- Synapse, neurotransmitter, excitatory synapse, inhibitory synapse, excitatory postsynaptic potential, inhibitory postsynaptic potential, graded potential.

Lecture Overview

This lecture will discuss how neurons communicate messages between themselves and other organs. In particular it will discuss the roles of the various synapses in the body and the specialized array of chemical messengers known as neurotransmitters.

Further Reading

Sherwood, *Animal Physiology, From genes to Organisms*, p103-

Sherwood L. *Human Physiology, From cells to Systems* 9th Ed. Chapter 4.

Stryer, L. *Biochemistry*. Chapter 37, pp 949-957. Chapter 39, pp 1011-1027.

Stephens, C.F. *The Neuron*. Scientific American 241: 48-59. (Copies available in the Library).

Nicholls et al., *From neuron to Brain*, Sinauer associates Inc, 2001

Squire et al., *Fundamental neuroscience*, academic press 2003.

Veterinary Bioscience: Cells to Systems

Lecture 17 - Neuromuscular Communication 1: Skeletal Muscle Contraction and Its Molecular Mechanism

Lecturer: Dr Babatunde Ayodele

Email: awodeleb@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture you should be able to:

- Describe the neuromuscular junction
- Describe motor units and their recruitment for varying strengths of contraction
- Explain the sliding filament mechanism of muscle contraction and the role Ca++ plays in contracting smooth and skeletal muscle
- Explain how cross bridge power strokes bring about shortening of muscle fibres and the utilisation of ATP during cross bridge power strokes
- Describe the levels of organization of skeletal muscle and the differences in skeletal muscle fibre types

Keywords

- Motor neuron, neuromuscular junction, skeletal muscle, contraction, sliding filament, motor units, twitch, summation, tetanus.

Lecture Overview

This lecture will introduce how neurons communicate the message that initiate contraction of the different muscle types. It will then discuss the molecular mechanism orchestrating the contraction of skeletal muscle and how neuronal input, Calcium ion and Adenosine Triphosphate (ATP) influences the strength of contraction of skeletal muscle.

Further Reading

Sherwood L. *Human Physiology, From cells to Systems* 9th Ed. Chapter 8.

Rhoades, *Medical Physiology, Principles for Clinical Medicine*, 3rd Ed. p140-

Squire et al., *Fundamental neuroscience*, Academic press 2003

Berne & Levy, *Physiology* 6th Ed p233-

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Lecture 18 - Neuromuscular Communication 2: Contraction of Smooth and Cardiac Muscle

Lecturer: Dr Babatunde Ayodele

Email: awodeleb@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture you should be able to:

- Describe differences between neuron connections between skeletal muscle, cardiac muscle and smooth muscle
- Describe the various control mechanisms of smooth muscle contraction

Keywords

- Twitch, summation, tetanus, sliding filament.

Lecture Overview

This lecture will introduce the molecular mechanism of cardiac and smooth muscle contraction. It will discuss some of the factors that influence the strength of contraction of smooth muscles particularly the roles of neuronal input, Ca++ and ATP. It will also look at the control of muscle contraction.

Further Reading

Latash, *Neurophysical basis of movement, Human kinetics* 1998

Sherwood L. *Human Physiology, From cells to Systems* 9th Ed. Chapter 8.

Rhoades, *Medical Physiology, Principles for Clinical Medicine*, 3rd Ed. p140-

Squire et al., *Fundamental neuroscience*, Academic press 2003

Berne & Levy, *Physiology* 6th Ed p233- , 268-

Sherwood, *Animal Physiology, From genes to Organisms*, p315- , p348-

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Lecture 19 - Reflex Arc: Spinal Reflex Control of Skeletal Muscle Contraction

Lecturer: Dr Babatunde Ayodele

Email: awodeleb@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture you should be able to:

- Describe the different types of lower motor neurons that contribute to reflex arcs.
- Describe the structure and function of intra- and extrafusal muscle fibres
- Describe the structure and function of muscle spindles and Golgi tendon organs
- Explain how a reflex arc works

Keywords

- Reflex arc, Intra- and extra-fusal muscle fibres, interneurons, Gamma and alpha fibres, Golgi tendon organs, Muscle spindles.

Lecture Overview

The nervous system functions to allow animals to stand upright against gravity, move in a purposeful manner, and integrate incoming information from the outside world to allow planned interactions with the environment. In this lecture we will examine how the components of the reflex arc allow an upright posture to be maintained in the face of gravity.

Further Reading

Sherwood, *Animal Physiology, From Genes to Organisms*.

Sherwood L. *Human Physiology, From cells to Systems* 9th Ed. Chapter 8.

Veterinary Bioscience: Cells to Systems

Theme Five: Host defences against injury

This theme begins with a particular focus on white blood cells, and their range of functions. In particular the role of white blood cells in defence against infection will be explored. The second lecture will be your introduction to pathology- with explanation of the events in acute inflammation and the characteristics of inflammatory lesions. The third lecture continues the study of inflammatory processes and their consequences.

Lectures

20. Functions of the innate immune system **21**.Functions of the adaptive immune system	• Innate immunity • Recognition of pathogens • Function of white blood cells • Acquired immunity
22. Acute inflammation	• Characteristics of inflammatory lesions • Events in acute inflammation • Mediators of inflammation
23. Chronic inflammation and healing	• Causes and types of chronic inflammation • Processes of tissue healing • Factors that alter healing

Case study

Case study 1	Fridge Cat	CLSGO4, Parkville

Practical class

4. Pathology of inflammation	Gross pathology wet specimens, histopathology	LTB 410 and 331 Werribee

Outcomes

Clinical Skills

- Describe, in both lay terms and the appropriate medical terms, the gross and histological appearance of lesions involving tissue inflammation and/or wound repair and understand the biological processes involved in development of the lesions.
- Apply your theoretical knowledge to interpret the gross and histological appearance of lesions in terms of the most likely underlying disease process, the possible cause or causes, and the potential consequences

Scientific Basis of Clinical Practice

- Describe the function of the innate and adaptive immune systems
- Describe the sequence of biological events and mediators of acute inflammation
- Explain the processes that occur at each stage of inflammation
- Describe the characteristics of inflammatory lesions
- Explain the process of tissue healing and factors that influence its progression

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Lectures 20 Function of the innate immune system

Lecturer: Dr Jenni Bauquier

Jenni graduated from Murdoch University, then moved to the USA to do an internship in equine private practice then residency in large animal internal medicine at the University of Pennsylvania. She then joined the University of Melbourne, undertaking a PhD in equine systemic inflammation and working as an equine internal medicine specialist in the U-Vet Equine Centre, and is now a senior lecturer in Veterinary Biosciences. Her primary research interests are systemic inflammation and sepsis in horses.

Email: jennifer.bauquier@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture, you should be able to:

- Describe the role of the innate immune system
- Describe the different types of innate cells found in blood and tissues
- Explain how cells of the innate immune system are able to recognise and eliminate pathogens

Keywords

- Haematopoietic, innate immunity, monocytes, macrophages, dendritic cells, neutrophils, eosinophils, basophils, mast cells pattern recognition receptors, pathogen associated molecular patterns.

Lecture Overview

The primary function of the white blood cells (and the immune system) is to protect the body against disease by identifying and eliminating pathogens. The innate immune system is not specific for a particular pathogen but rather is specific for a “group” of pathogens that share similar structural features. In this lecture we will examine how the innate immune system enables a very rapid response to infection.

Further Reading

Weiss D & Warddrop K. Schalm’s Veterinary Haematology, 6th ed. Wiley Publishing. 2010.

Abbas A, Cellular and Molecular Immunology 9th edition Elsevier 2017.

Tizard I. Veterinary Immunology 10th edition Elsevier press 2017.

Lecture 21 Function of the adaptive immune system

Lecturer: Dr Jenni Bauquier

Email: jennifer.bauquier@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture, you should be able to:

- Describe the role of the adaptive immune system
- Describe how B lymphocytes and T lymphocytes both recognise and respond to pathogens
- Explain how the adaptive and innate immune systems work in conjunction to eliminate infections

Keywords

- Lymphoid, T and B lymphocytes, antibodies, cytokines, immune memory.

Lecture Overview

The adaptive immune system is specific for particular pathogens and works in conjunction with the innate immune system. In this lecture we will examine how the adaptive immune system enables the development of memory responses to infections.

Further Reading

Weiss D & Warddrop K. Schalm's Veterinary Haematology, 6th ed. Wiley Publishing. 2010.

Abbas A, Cellular and Molecular Immunology 9th edition Elsevier 2017.

Tizard I. Veterinary Immunology 10th edition Elsevier press 2017.

Veterinary Bioscience: Cells to Systems

Lecture 22 Acute Inflammation

Lecturer: Dr Yuchi Chen, Lecturer in Veterinary Anatomic Pathology

Yuchi received his Bachelor's and Master's degrees in Veterinary Medicine in China, then completed 1.5 years of training in Clinical Pathology in a commercial veterinary laboratory in Germany. After that, he dived into the business world and spent six years for LABOKLIN in China in a multitasking role, including consulting veterinarian, clinical pathologist, lecturer, company manager, etc. He then moved to Australia with his family to explore a different possibility of life. He undertook PhD study on secondary photosensitisation in livestock at Charles Sturt University in 2016 and started to work as a tutor at the University of Melbourne in 2019. He attained Membership of the Australian and New Zealand College of Veterinary Scientists in Veterinary Pathobiology in 2021 and secured his PhD degree in 2022. Yuchi has authored and co-authored 39 articles and one book chapter, and he is passionate about teaching. He believes that it is essential to know what you should know, it is crucial to understand why it is known this way, and this is the Way.

Email: yuchi.chen@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture, you should be able to:

- List and explain the pathophysiology of the five cardinal signs of acute inflammation
- Demonstrate an understanding of the major processes of acute inflammation
- List the main types of inflammatory mediators involved in inflammation
- Describe the different types of acute inflammation and exudation

Keywords

- Inflammation; autacoids; prostaglandins; cytokines; leukocytes; serous inflammation; suppurative inflammation; fibrinous inflammation; exudation; abscessation.

Lecture Overview

Inflammation is the body's response to injurious agents, including physical and microbial insults. The acute (early) stages of inflammation are largely a reflection of alterations in blood flow and vascular permeability, as well as migration and activation of leukocytes. This lecture will examine the pathophysiology and biochemical signaling involved in the development of acute inflammation, as well as the different presentations and effects of acute inflammation on the host. Students should be familiar with basic cell types such as the various classes of leukocyte and their function prior to attending this lecture.

Further Reading

MR Ackermann, Inflammation and Healing. In: *Pathologic Basis of Veterinary Disease*, Ed: MD McGavin. Elsevier Saunders, Philadelphia, USA. 6th edition (2017).

V Kumar, AK Abbas, JC Aster, Inflammation and repair. In: *Robbins Basic Pathology*, Elsevier Saunders, Philadelphia, USA , 10th edition (2018).

Veterinary Bioscience: Cells to Systems

Lecture 23 Chronic inflammation and repair

Lecturer: Dr Yuchi Chen, Lecturer in Veterinary Anatomic Pathology
Email: yuchi.chen@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture you should be able to:

- Describe the different types of chronic inflammation and their basic gross/macroscopic and histological features
- Describe the different types of chronic inflammation and their basic gross/macroscopic and histological features
- Explain the differences between tissue regeneration and repair and describe the steps involved and factors that influence their development

Keywords

- Inflammation, granulomatous inflammation, pyogranulomatous inflammation, lymphoplasmacytic inflammation, eosinophilic inflammation, macrophage, healing, regeneration, repair, granulation tissue, angiogenesis, fibroblast, fibroplasia, scar formation, primary intention healing, secondary intention healing, cytokines.

Lecture Overview

Chronic inflammation occurs when an acute response is not able to resolve a tissue insult. Chronic inflammation is characterised by changes in the inflammatory cell population, with increasing dominance of cells such as macrophages, lymphocytes and plasma cells, as well as ongoing tissue destruction and, eventually, attempts at repair. In this lecture we will examine the gross and histological features of chronic inflammation. We will also examine how healing occurs either through regeneration of the tissue from residual viable cells, and/or through replacement by fibrous scar tissue.

Further Reading

MR Ackermann, Inflammation and Healing. In: *Pathologic Basis of Veterinary Disease*, Ed: MD McGavin. Elsevier Saunders, Philadelphia, USA. 6th edition (2017).
V Kumar, AK Abbas, JC Aster, Inflammation and repair. In: *Robbins Basic Pathology*, Elsevier Saunders, Philadelphia, USA , 10th edition (2018).

Veterinary Bioscience: Cells to Systems

Theme Six: Cellular Responses to Injury

This theme is about how the body responds to injury. The cellular processes of cell and tissue injury and death will be explained. In both lectures and practical class, the language of pathology will be introduced, in the context of terms used to describe inflammation, degeneration and cell death.

Lectures

24. Cell and tissue degeneration	• Causes of cell injury • Sublethal versus lethal injury • Cellular responses to sublethal injury: hydropic degeneration, fatty degeneration, intra-cellular accumulation of glycogen, proteins and ceroid-lipofuscin • Extra-cellular accumulations: amyloidosis, fibrinoid change
25. Lethal Cell Injury - Necrosis and Apoptosis	• Irreversible cell injury and cell death (necrosis) • Oncotic necrosis versus apoptosis • Types of necrosis: coagulative, caseation, liquefactive, fat necrosis and gangrene • Consequences of necrosis • Dystrophic mineralisation

Practical class

5. Pathology of cell degeneration and necrosis	Gross pathology wet specimens Histopathology tutorial	LTB 410 and 331 Werribee

Outcomes

Clinical Skills

- Describe in both lay terms and the appropriate medical terms the gross and histological appearance of lesions involving cell degeneration, tissue degeneration and cell necrosis
- Apply your theoretical knowledge to interpret the gross and histological appearance of lesions in terms of the most likely underlying disease process, the possible cause or causes, and the potential consequences
- Construct a morphological diagnosis to describe concisely and accurately gross and histological lesions of cell degeneration, tissue degeneration and cell necrosis

Scientific Basis of Clinical Practice

- Describe the range of responses of cells and tissues to sublethal and lethal injury.
- Describe the processes, types and consequences of necrosis.
- Describe the characteristics of inflammatory lesions.

Lecture 24 Cell and Tissue Degeneration

Lecturer: Dr Yuchi Chen, Lecturer in Veterinary Anatomic Pathology

Email: yuchi.chen@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture you should be able to:

- Utilizing appropriate terminology, describe the gross and microscopic features of the various degenerative processes affecting cells and the extra-cellular components of tissues
- Outline the causes of the degenerative changes displayed by cells and extra-cellular components of tissues and the mechanisms by which they manifest these

Keywords

- Acute cell swelling, cloudy swelling, hydropic degeneration, fatty degeneration, fatty change, lipidosis, glycogen storage, amyloid, amyloidosis, fibrinoid change, collagen flame figures.

Lecture Overview

Cell injury can be induced by a wide range of causes such as physical trauma, noxious chemicals, oxygen deprivation, infectious agents, nutritional deficiency or excess, metabolic disturbance, immunological attack or genetic mutation. The injury may be lethal or sublethal to the cell involved. This lecture focuses on sublethal cell injury (also known as cell degeneration) and on degenerative processes that involve extra-cellular components of tissues.

The most common expression of sublethal cell injury is acute cell swelling (also referred to as cloudy swelling or, if severe, hydropic degeneration). This change is characterised by an increase in cell size and volume due to sodium and water influx, and thus essentially represents intra-cellular oedema. It can be associated with variable distension and degeneration of intra-cellular organelles and, if severe, may progress to cell death.

Alternative expressions of sublethal cell injury include the intra-cellular accumulation of lipids, glycogen or proteins, or cell shrinkage (atrophy). The gross and microscopic appearance of intra-cellular lipid, glycogen and protein accumulation and the mechanisms responsible will be discussed, using common veterinary examples to illustrate.

In some forms of tissue injury, the degenerative process may be centred on the extra-cellular components of the tissue. Examples of such changes include deposition of amyloid (an insoluble fibrillar glycoprotein), fibrinoid change involving the walls of damaged blood vessels and surrounding connective tissues, and collagen flame figures typically seen in areas of eosinophilic inflammation. The histological appearance of these changes and the circumstances in which they develop in domestic animals will be reviewed.

Further Reading

MA Miller and JF Zachary. Mechanisms and Morphology of Cellular Injury, Adaptation and Death. In: *Pathologic Basis of Veterinary Disease*. 6th ed. Ed. JF Zachary. Mosby Elsevier, St Louis, USA (2017), pp. 8-32 (emphasis on pp. 8-13 and 25-33).

Veterinary Bioscience: Cells to Systems

Lecture 25 Lethal Cell Injury - Necrosis and Apoptosis

Lecturer: Dr Yuchi Chen, Lecturer in Veterinary Anatomic Pathology

Email: yuchi.chen@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture you should be able to:

- Utilizing appropriate terminology, describe the gross and microscopic features of the various forms of irreversible cell injury
- Outline the causal factors involved in irreversible cell injury and the mechanisms by which they lead to cell death
- Outline the key differences between necrosis and apoptosis
- Define dystrophic mineralization, explain how it differs from metastatic mineralization, and describe its typical gross and histological appearance

Keywords

- necrosis, apoptosis, programmed cell death, oncosis, oncotic necrosis, ante mortem autolysis, heterolysis, coagulative necrosis, gangrene, liquefactive necrosis, caseation necrosis, fat necrosis, dystrophic mineralisation, metastatic mineralisation.

Lecture Overview

Irreversible cell injury resulting in cell death is often caused by hypoxia or ischaemia and/or by significant damage to cell membranes. In most circumstances, the affected cells undergo oncotic necrosis, a process of progressive cellular degradation that takes place within still living tissues. Oncotic necrosis (or oncosis) is mediated by proteolytic enzymes released by the dead cell themselves (ante-mortem autolysis) and/or by leukocytes that infiltrate the damaged tissue (heterolysis).
In contrast to oncotic necrosis, some cells die via the process of apoptosis. In apoptosis, affected cells shrink, the nuclear chromatin condenses and the cytoplasm fragments, with the debris being rapidly phagocytosed by adjacent cells (especially macrophages). This form of cell death usually affects individual cells or small groups of cells and is therefore not usually discernible with the naked eye. Apoptosis can be a normal (physiological) feature of embryogenesis and of tissue involution (for example, during involution of mammary parenchyma post-lactation, or during regression of the thymus at puberty). Apoptosis can also be a feature of tissue injury induced by radiation, toxins, drugs, viruses or cytotoxic T-lymphocytes and may also be observed within tumours.

In this lecture, we will focus on the intra-cellular events that follow lethal cellular oxygen deprivation or substantial damage to cell membranes, review the characteristic histological and gross features of oncotic necrosis, and outline the potential consequences of such necrosis.

There are certain distinctive patterns of oncotic necrosis that are of diagnostic value because they provide clues to the possible cause or causes. These patterns include coagulative necrosis, gangrene (gangrenous necrosis), liquefactive necrosis, caseation necrosis, and fat necrosis. The characteristic features of each pattern and the circumstances in which they develop in animals will be discussed.

Tissues in which oncotic necrosis has occurred may also undergo dystrophic mineralisation. In this process, minerals (particularly calcium salts) may accumulate intra-cellularly or be deposited in the extra-cellular matrix. The mechanisms

responsible for such mineral deposition will be reviewed briefly and the typical gross and microscopic appearance illustrated. The definition of dystrophic mineralisation will also be compared with that of metastatic mineralisation.

Further Reading

MA Miller and JF Zachary. Mechanisms and Morphology of Cellular Injury, Adaptation and Death. In: *Pathologic Basis of Veterinary Disease*. 6th ed. Ed. JF Zachary. Mosby Elsevier, St Louis, USA (2017), pp. 8-32 (emphasis on pp. 13-21 and 33-35).

Veterinary Bioscience: Cells to Systems

Theme Seven: Growth, Development and Differentiation

In the past weeks we have looked at normal cell and organ structure and function, including overviews of the body plan and basic cell types, homeostasis and communication between cells and between organs, and how drugs can be used to modify these communication pathways. We now turn our attention to growth and development by firstly considering the normal development of the embryo and the major organ systems. We will subsequently go on to consider the ways in which cellular differentiation can be perturbed in disease processes. We commence our discussion of disorders of growth with examination of congenital disorders and then move on to acquired disorders of growth.

Lectures

26. Normal embryogenesis 1	• Fertilisation • Cleavage, hatching of the blastocyst • Gastrulation
27. Normal embryogenesis 2	• Formation of extraembryonic membranes • Formation of the basic body plan and embryo folding • Formation of the major organ systems from the three germ layers (ecto-, meso-, endoderm)
28. Disorders of tissue mass and cell differentiation 1	• Congenital disorders: Dysplasia, Hypoplasia, Agenesis, Aplasia, Atresia • Acquired disorders: atrophy, ageing
29. Disorders of tissue mass and cell differentiation 2	• Acquired disorders: hypertrophy, hyperplasia, metaplasia, dysplasia and anaplasia

Practical classes

6. Disorders of tissue mass	Wet specimens and histopathology autotutorial	LTB 410 and 331 Werribee

Outcomes

Scientific Basis of Clinical Practice

- Explain fertilisation and the normal developmental stages of the embryo after fertilisation and deduct their clinical relevance
- Explain the basic layout of the extra-embryonic membranes in order to infer their function
- Evaluate the basic processes in which the three germ layers contribute to the formation of the major organ system
- Discuss the transformation from flat embryonic disc to 3-dimensional embryo

Veterinary Bioscience: Cells to Systems

Lectures 26 and 27 Normal Embryogenesis I and II

Lecturer: Dr. Christina Marth

Dr Christina Marth is a lecturer in Veterinary Biosciences in the Faculty of Veterinary and Agricultural Sciences at The University of Melbourne. Christina completed a PhD exploring how innate immune factors influence the way horses respond to breeding and the ability of healthy horses to clear all traces of inflammation from their uterus efficiently. Prior to coming to the University of Melbourne, Christina has completed a veterinary degree at the University of Veterinary Medicine in Hannover, Germany. Her research interests are in the immunology, microbiology and physiology of reproductive processes, particularly during breeding and pregnancy.

Email: christina.marth@unimelb.edu.au

Intended Learning Outcomes

At the end of this lecture you should be able to:

- Explain fertilisation and the normal developmental stages of the embryo after fertilisation in order to understand their clinical relevance
- Describe the origin and basic function of the extra-embryonic membranes in order to understand their relationship with the developing embryo and the surrounding uterus
- Describe the basic processes in which the three germ layers contribute to the formation of the major organ system in order to explain tissue structures and organ locations in the final body plan
- Explain the embryonic body folding in order to outline the transformation from flat embryonic disc to 3-dimensional embryo

Keywords

- Embryogenesis, fertilization, cleavage, hatching of blastocyst, gastrulation, extra-embryonic membranes.
- Body plan formation, ectoderm, mesoderm, endoderm, embryonic folding, pharyngeal arches

Lecture Overview

After fertilisation, the zygote needs to develop from a clump of cells, the morula, to a conceptus that comprises both a 3-dimensional embryo and the extra-embryonic/ fetal membranes that connect it to the uterus from where it is supported with oxygen and nutrients. In lecture 31, we will explore the details of these processes.

In lecture 32, we will explore how the three tissue layers formed during gastrulation (ectoderm, mesoderm, endoderm) contribute to the final body formation and how the folding of the embryo allows for the primitive gut to form ventrally and for the neural tube to form dorsally. We will also investigate the pharyngeal arches and how they contribute to many structures of the head and neck once the fetus is fully developed.

Further Reading

McGeady TA., Quinn PJ., Fitzpatrick ES., Ryan MT. *Veterinary Embryology*. Blackwell Publishing. Second edition, 2017.

Noden DM., De Lahunta A. Williams and Wilkins. *The embryology of domestic animals: Developmental mechanisms and malformations*. Waverley Press. 1985.

Senger PL. *Pathways to Pregnancy and Parturition*. Current Conceptions Inc. Third edition, 2012.

Veterinary Bioscience: Cells to Systems

Lecture 28 Disorders of Tissue Mass and Cell Differentiation 1

Lecturer: A/Professor Jenny Charles

As a veterinary graduate of the University of Sydney, Jenny Charles undertook specialist training in veterinary anatomic pathology at the University of Melbourneand the University of Guelph. She also worked in the United Kingdom on the clinical diagnosis and eradication of bovine spongiform encephalopathy before returning to Australia. She is a Diplomate of the American College of Veterinary Pathologists and previously served as a member of the international WSAVA multi-disciplinary team responsible for refining diagnostic criteria for hepatobiliarydisorders of dogs and cats. Jenny's research interests include disorders of the liver, pancreas, and cardiovascular and reproductive systems of domestic animals, diseases of New World camelids, causes of wastage in the horse racing industry, and applied aspects of clinical pathology

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Intended Learning Outcomes

At the end of this lecture you should be able to:

- Use appropriate terminology to describe congenital lesions characterised by deficits of tissue mass or disorderly tissue development
- Describe the characteristic gross and microscopic features of atrophy
- Explain the factors that contribute to cell and tissue atrophy

Keywords

- Congenital, agenesis, aplasia, hypoplasia, dysplasia, atresia, atrophy, ceroid lipofuscin, ageing, abiotrophy.

Lecture Overview

Many disorders of veterinary importance involve abnormalities of cell and tissue growth and/or differentiation. These conditions may result in excess tissue mass, a deficit of tissue, or an abnormal pattern of tissue growth. Some of these conditions manifest at birth (as congenital malformations) whereas others are acquired later. In this lecture we will examine developmental disorders of tissue mass, using a range of veterinary examples: agenesis, aplasia, hypoplasia, dysplasia and atresia. The concept of cell and tissue atrophy (a decrease in cell size or tissue mass after normal growth has been achieved) will then be discussed, including the gross, microscopic and ultrastructural appearance of atrophic tissues and the causal mechanisms responsible for atrophy. Pertinent veterinary examples of both physiological and pathological atrophy of tissues will be presented, including the mechanisms that contribute to atrophy of tissues and organs during the process of ageing.

Further Reading

RK Myers and MD McGavin. Cellular and tissue responses to injury. In: *Pathologic Basis of Veterinary Disease*. 4th ed. Ed. MD McGavin and JF Zachary. Mosby Elsevier, St Louis, USA (2007), pp. 3-62 (emphasis on pp. 36-38, 52, and 59-61).

Veterinary Bioscience: Cells to Systems

Lecture 29 Disorders of Tissue Mass and Cell Differentiation 2

Lecturer: A/Professor Jenny Charles

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Intended Learning Outcomes

At the end of this lecture you should be able to:

- Use appropriate terminology to describe acquired lesions characterised by excess tissue mass or altered tissue differentiation
- Explain the factors that promote tissue hypertrophy, hyperplasia, metaplasia and/or dysplasia
- Explain the potential consequences of these processes

Keywords

- Hypertrophy, hyperplasia, metaplasia, squamous metaplasia, glandular metaplasia, acquired dysplasia, anaplasia, neoplasia, pre-neoplastic.

Lecture Overview

An increase in mass is a common adaptive response of tissues to an increase in work load, hormonal stimulation or functional demands. The increase in tissue mass is reversible and may reflect an increase in the size of the component cells (hypertrophy) or an increase in the number of component cells (hyperplasia), or a combination of both processes. Pertinent veterinary examples will be utilised to illustrate these processes in health and disease, their triggers and the potential consequences.
Tissues that are chronically irritated may undergo metaplasia, an adaptive response in which cellular differentiation is altered to result in transformation of the original cell type to a related but less vulnerable type. Metaplasia may permit cell survival in a hostile environment but is often associated with the loss of specialised functions, particularly in affected epithelium. Examples of squamous and glandular metaplasia of epithelium and of metaplasia within connective tissues will be provided.
Metaplasia is usually a reversible process that is often accompanied by orderly hyperplasia of the affected cells. However, the process can become disorderly, a phenomenon known as acquired dysplasia. Although acquired dysplasia is essentially a reversible process, it often progresses to tumour formation (neoplasia). Failure or loss of differentiation (anaplasia) is a microscopic feature of malignant tumours.

Further Reading

RK Myers and MD McGavin. Cellular and tissue responses to injury. In: *Pathologic Basis of Veterinary Disease*. 4th ed. Ed. MD McGavin and JF Zachary. Mosby Elsevier, St Louis, USA (2007), pp. 3-62 (emphasis on pp. 32-36).

Veterinary Bioscience: Cells to Systems

Theme Eight: Disorders of Growth and Neoplasia

The focus of this theme is on pathological processes. In this week of semester we explore the nature, causes and effects of neoplasia. We find answers to questions such as "what is neoplasia?" and "How does it affect the host?"

Lectures

30. Neoplasia 1: the body's own cells in revolution	• Definition of neoplasia • Benign versus malignant neoplasia • Epithelial, round cell and mesenchymal tumours - characteristic microscopic features and nomenclature • Effects of neoplasia in the body
31. Neoplasia 2: Why does neoplasia develop?	• Define the hallmarks of neoplasia • Explain the role of regulatory genes in the cell cycle and in carcinogenesis • Describe important causes of cancer • Understand how neoplastic cells invade and metastasize

Case study

Case study II The gagging Dog

Practical classes

7. Neoplasia	Wet specimens and histopathology autotutorial	LTB 410 and 331 Werribee

Outcomes this week

Clinical Skills

- Use appropriate vocabulary to describe lesions in a range of pathological specimen
- Apply knowledge of pathological processes to identify and predict behaviour and consequences of diseases of tissue mass and neoplasia

Scientific Basis of Clinical Practice

- Explain what is meant by the terms aplasia, dysplasia, hypoplasia, agenesis and atresia
- Explain what is meant by the terms hypertrophy, hyperplasia, metaplasia, dysplasia and anaplasia
- Explain the causes and pathogenesis of neoplasia, and define terminology related neoplastic disease

Lecture 30 Neoplasia 1: the body's own cells in revolution

Lecturer: Dr Panayiotis (Panos) Loukopoulos DVM, PGDipVSt, PhD (Comparative and Veterinary Oncology)

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Dr Loukopoulos is a Senior Lecturer in veterinary anatomic pathology. His research focuses on diagnostic pathology and the study of neoplasia. He graduated as a veterinarian from Aristotle University (Greece), took the wrong path for a short time (anaesthesia studies), but quickly made an uneventful recovery with a PhD on the pathology of bone tumours at the University of Queensland. He joined the University of Melbourne in 2018, following postdoctoral work on human cancer genomics at the National Cancer Center in Tokyo, work as a diagnostic pathologist at UC Davis and a number of years as an academic in Europe and elsewhere in Australia.

Intended Learning Outcomes

At the end of this lecture you should be able to:

- Define common terminology associated with neoplasia and apply naming conventions to types of neoplasia
- Explain the concept of benign and malignant forms of neoplasia and describe the features associated with each form
- Predict effects of neoplasia in the body based on the knowledge of typical biological behaviours

Keywords

- Neoplasia, tumour, neoplasm, benign, malignant, epithelial, mesenchymal, round cell, carcinoma, sarcoma, cytology, paraneoplastic syndrome.

Lecture Overview

Neoplasia is a major category of disease and is caused by irreversible, persistent and unregulated proliferation of the body's own cells. In this first lecture on neoplasia, we will define the terminology associated with neoplastic disease, examine its characteristic features and discuss its effects on the body.

Further Reading

V Kumar, AK Abbas, JC Aster, Neoplasia. In: *Robbins Basic Pathology*, Elsevier Saunders, Philadelphia, USA , 10th edition (2018).

KM Newkirk, EM Brannick, DF Kusewitt, Neoplasia and Tumor Biology. In: *Pathologic Basis of Veterinary Disease*, Ed: MD McGavin. Elsevier Saunders, Philadelphia, USA. 6th edition (2017).

Veterinary Bioscience: Cells to Systems

Lecture 31 Neoplasia 2: Why does neoplasia develop?

Lecturer: Dr Panayiotis (Panos) Loukopoulos DVM, PGDipVSt, PhD (Comparative and Veterinary Oncology)

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Intended Learning Outcomes

At the end of this lecture you should be able to:

- List the hallmarks of neoplastic cells and explain their role in the progression of neoplastic disease
- Explain how mutations in specific types of genes result in neoplastic transformation
- List common causes of neoplasia and explain how they may induce neoplastic transformation
- Explain how neoplastic cells invade and metastasise

Keywords

- Oncogene, tumour suppressor gene, carcinogen, angiogenesis, growth factors, invasion, metastasis.

Lecture Overview

Following from our first lecture on neoplasia, this lecture will examine how neoplasia develops, the adaptations neoplastic cells acquire to survive and continue proliferating, and some of the causes of neoplasia.

Further Reading

V Kumar, AK Abbas, JC Aster, Neoplasia. In: *Robbins Basic Pathology*, Elsevier Saunders, Philadelphia, USA , 10th edition (2018).

KM Newkirk, EM Brannick, DF Kusewitt, Neoplasia and Tumor Biology. In: *Pathologic Basis of Veterinary Disease*, Ed: MD McGavin. Elsevier Saunders, Philadelphia, USA. 6th edition (2017).

Veterinary Bioscience: Cells to Systems

Theme Nine: Receptor Pharmacology

Now that we have discussed cell communication in some detail- electrical and communication between cells, receptor biology and intracellular signalling, we will turn our attention to the ways in which chemicals can be used to modulate communication between cells. This is the discipline of pharmacology. We will introduce this discipline using as our examples the classes of drugs that affect the autonomic nervous system and the neuromuscular junction, and also some of the autacoids that are important in regulating organ function. We will also introduce some important features of drug action – agonism, antagonism and the dose-response curve.

Lectures

32. Pharmacodynamic principles of drug action	• Cellular communication • Receptors • Drug targets • Agonists/antagonists • Dose-response curves
33. Introduction to the peripheral nervous system - somatic and autonomic nervous systems	• Compare and contrast the different nervous systems in the body. • Organisation of the autonomic nervous system • Role of the autonomic nervous system • Receptors and transmitters in the ANS
34. Introduction to pharmacology: Using drugs to modify the sympathetic nervous system	• Where do drugs act? • Mechanisms of drug action, • Selectivity potency and efficacy, • The dose response curve • Chemical transmission in the sympathetic nervous system • Adrenergic receptors • Intracellular signalling • Presynaptic receptors • Adrenaline and noradrenaline • Drugs that modulate the actions of the sympathetic nervous system and their uses
35. Using drugs to modify the parasympathetic nervous system	• Chemical transmission in the parasympathetic and somatic nervous systems • Synthesis, release and degradation of acetylcholine (ACh) • Cholinergic receptors • Drugs that modulate the actions of the parasympathetic nervous system and their uses •
36. Autacoids: diverse regulators and therapeutic targets	• Histamine and antihistamines • Eicosanoids: products of phospholipid metabolism • Autacoid peptides: Bradykinin

Case Study

Case study III	Lame dog interactive PDF case study

Practical classes

8. Neuromuscular transmission	Using drugs as tools to understand neurotransmission

Outcomes

Scientific Basis of Clinical Practice

- Explain the role of the nervous system in regulating organ function and maintaining a constant internal environment
- Describe the organization of the different components of the nervous system- somatic, autonomic and enteric and its role in regulating body functions
- Describe the two divisions of the autonomic nervous system, and list the transmitters, receptor and effectors in each division
- Explain how drugs can be used to modulate signalling between cells
- Understand the interaction of agonists and antagonists with receptors, and explain the significance of the dose response curve
- Describe the classes of drugs used to modify sympathetic nervous system function
- Describe the classes of drugs used to modify parasympathetic nervous system function
- Describe the classes of drugs used to modify somatic nervous system function
- Explain the role of autacoids in local cell to cell communication and how this communication can be modulated using drugs

Clinical Skills

- Consider the approach taken to addressing a clinical presentation, and clinical diagnostic reasoning

Personal and Professional Development

- Work effectively in a group to enhance shared understanding of biological principles

Veterinary Bioscience: Cells to Systems

Lecture 32 Pharmacodynamic principles of drug action

Lecturer: Associate Professor James Ziogas

James is Deputy Head of the Dept. of Pharmacology where his research group examines the actions of drugs in the cardiovascular system. He is a Melbourne graduate and has worked in Oxford, Tucson, and Freiburg. In his series of lectures, he will introduce you to the key concepts in pharmacology and discuss chemical transmission in the autonomic nervous system. He will discuss how neurotransmitters act to regulate cell, tissue and organ function. In so doing, opportunities for drug modulation at various sites will be focused upon and examples of clinically utilized drugs will be given. These concepts will be reinforced and built upon in your later studies.

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Intended Learning Outcomes

At the end of this lecture you should be able to:

- Describe how drugs can influence the function of cell, tissues and organs (Pharmacodynamics)
- Describe processes by which the body may influence the actions of a drug (Pharmacokinetics)
- Describe the importance of the concentration-response curve in characterising the action of drugs

Keywords

- Pharmacodynamics, Pharmacokinetics, Receptor, Agonist, Antagonist, Selectivity.

Lecture Overview

Introduction to Pharmacology

Drugs are chemicals that affect physiological function in specific ways. Veterinarians prescribing drugs have to ask themselves a number of questions- Where does the drug act? How much should be given and how often should it be given? Are there any long-term consequences of giving it? The answers to these questions are the domain of the pharmacologist. In this lecture, we will Identify drug targets and look at the mechanism of action and of toxicity of drugs. We will also look at how we quantify their activity, potency, effectiveness and how long drugs persist in the body.

Veterinary Bioscience: Cells to Systems

Lecture 33 Introduction to the peripheral nervous system – autonomic and somatic nervous systems

Lecturer: Associate Professor James Ziogas

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Intended Learning Outcomes

At the end of this lecture you should be able to:

- Describe the basic anatomy of the Peripheral NS (efferent), the Autonomic nervous System (ANS) and its Parasympathetic and Sympathetic divisions
- Describe the major neurotransmitters and receptors involved in chemical transmission within the ANS and somatic NS
- List examples of agonists and antagonists that have selective activity at adrenoceptors

Keywords

- Adrenergic, Adrenoceptors, Cholinergic, Muscarinic receptor, Neurotransmitter, Nicotinic receptor, Parasympathetic, Postganglionic, Postsynaptic, Preganglionic, Presynaptic, Somatic.

Lecture Overview

Chemical transmission in the peripheral nervous system

The organization and function of the peripheral autonomic and somatic nervous systems will be reviewed from a pharmacological perspective. We will consider how drugs were integral in developing our understanding of the operation of the peripheral nervous system and how this understanding can lead to rational use of therapeutic agents that target specific aspects of chemical signalling in the autonomic and somatic nervous systems. We will also look at the role of the principal neurotransmitters, acetylcholine and noradrenaline in the peripheral nervous system, and how the magnitude of the signalling response depends on their synthesis, release, reuptake and metabolism. Each of these processes may be manipulated with drugs and will be discussed in subsequent lectures.

Further Reading

Rang HP, Dale MM, Ritter JM & Flower RJ. (2012) Pharmacology. (6th ed). Churchill Livingstone, Edinburgh. Chapters 12 -14.

Katzung BG. (2007) Basic and Clinical Pharmacology. (10th ed). Appleton Lange. Chapter 6-10

Riviere JE and Papich MG (2008). Veterinary Pharmacology and Therapeutics. 9th edition. Wiley-Blackwell. Chapters 5 & 6.

Hsu WH (2008). *Handbook of Veterinary Pharmacology*.1st edition. Blackwell. Chapter 2

Veterinary Bioscience: Cells to Systems

Lecture 34 Using drugs to modify sympathetic nervous system function

Lecturer: Associate Professor James Ziogas

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Intended Learning Outcomes

At the end of this lecture you should be able to:

- Describe the synthesis, storage, uptake and metabolism of the major natural catecholamines and how certain drugs are able to modulate sympathetic NS activity through alteration of these processes
- Describe, in a more detailed way, how adrenoceptors are divided into subtypes and the pharmacological basis for this division and how they are responsible for the major physiological roles of the sympathetic NS and circulating adrenaline
- Describe the basic signal transduction mechanisms that adrenoceptors employ to produce their functional effects
- Describe the therapeutic utility of agonists and antagonists that have selective activity for different neurotransmitters, and of drugs that affect their synthesis, storage, release and inactivation

Keywords

- Adrenergic, Adrenoceptors, Agonist, Antagonist, Catecholamines, Neurotransmitter, Postsynaptic, Preganglionic, Presynaptic, Selectivity.

Lecture Overview

Chemical transmission in the Sympathetic nervous system

In the sympathetic nervous system, the neurotransmitter at neuro-effector junctions is noradrenaline. In this lecture we will look at the localisation and subtypes of receptors in the sympathetic system, and introduce a number of clinically significant drugs that act on adrenoceptors, either as agonists or as antagonists, or that affect release, re-uptake or degradation of the neurotransmitter.

Further Reading

Rang HP, Dale MM, Ritter JM & Flower RJ. (2012) *Pharmacology*. (6th ed). Churchill Livingstone, Edinburgh. Chapters 12-14.

Katzung BG. (2007) *Basic and Clinical Pharmacology*. (10th ed). Appleton Lange. Chapter 6-10

Riviere JE and Papich MG (2008). *Veterinary Pharmacology and Therapeutics*. 9th edition. Wiley-Blackwell. Chapters 5 & 6.

Hsu WH (2008). *Handbook of Veterinary Pharmacology*.1st edition. Blackwell. Chapter 2

Veterinary Bioscience: Cells to Systems

Lecture 35 – Using drugs to modify the parasympathetic nervous system

Lecturer: Dr Graham Mackay

Graham is a Senior Lecturer in the Dept. of Biochemistry & Pharmacology where his research group examines mechanisms and treatments of allergic disease. He studied in the UK and has worked in London, New Mexico and Queensland. In his series of lectures, he aims to examine the importance of peripheral neurotransmitters and local mediators to the control of cell, tissue and organ function. In so doing, opportunities for drug modulation at various sites will be focused upon and examples of clinically utilized drugs given. These concepts will be reinforced and built upon in your later studies.

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Intended Learning Outcomes

At the end of this lecture you should be able to:

- Describe the synthesis, storage, release and inactivation of acetylcholine (ACh) and how certain drugs are able to modulate cholinergic NS activity through alteration of the above processes
- Describe how ACh receptors are divided into subtypes and the pharmacological basis for this division and explain the functional difference between muscarinic and nicotinic receptors
- Give examples of agonists and antagonists that have selective activity at ACh receptors
- Describe the basic signal transduction mechanisms that ACh receptors employ to produce their functional effects

Keywords

- Acetylcholinesterase, Adrenergic, Adrenoceptors, Agonist, Antagonist, Anticholinesterase, Atropine, Cholinergic, Muscarinic receptor, Neuromuscular Junction, Neurotransmitter, Nicotinic receptor, Organophosphate, Parasympathetic, Postganglionic, Postsynaptic, Preganglionic, Presynaptic, Selectivity, Somatic.

Lecture Overview

The parasympathetic division of the autonomic nervous system (ANS) promotes anabolic functions, (the *rest and repose* phase). Dominant parasympathetic tone results in decreased heart rate, increased gut activity, constriction of pupils, increased glandular secretion and constriction of bronchi, (summarised in the acronym *SLUD*). All these effects on target organs can be mimicked by application of the neurotransmitter acetylcholine (ACh). In this lecture we will examine the function of the cholinergic system and the drugs that can be used to modulate it. The accompanying practical class will focus more on the role and pharmacological regulation of ACh within the somatic nervous system.

Further Reading

Rang & Dale's Pharmacology (2020). (9th ed). Elsevier. Chapters 13, 14. This textbook is also available electronically at The University of Melbourne via ClinicalKey (will need login): https://www.clinicalkey.com.au/#!/browse/book/3-s2.0-C2016004202X

Basic and Clinical Pharmacology by Katzung and Vanderah (ed). 15th edition, 2021, Lange (McGraw-Hill). Chapters 6-8. This textbook is also available electronically at The University of Melbourne (will need login): https://accessmedicine.mhmedical.com/Book.aspx?bookid=2988#250593850

Riviere JE and Papich MG (2018). *Veterinary Pharmacology and Therapeutics*. 10th edition. John Wiley and Sons. Chapters 6, 8.
Hsu WH (2008). *Handbook of Veterinary Pharmacology*.1st edition. Blackwell. Chapter 2

Veterinary Bioscience: Cells to Systems

Lecture 36 – Autacoids: diverse regulators and therapeutic targets

Lecturer: Dr Graham Mackay

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Intended Learning Outcomes

At the end of this lecture you should be able to:

- Describe what an 'autacoid' is and give examples of agents that belong to this category
- Describe the synthesis, storage and biological effects of histamine and bradykinin (including their receptors) and the clinical uses of histamine receptor antagonists (H_1 antihistamines and H_2 receptor antagonists)
- Describe how eicosanoids are generated with particular emphasis upon the key roles played by the enzymes PLA2, cyclooxygenase and lipoxygenase and explain how prostaglandins and leukotrienes produce their biological effects and their major actions in the body
- Describe how commonly used non-steroidal anti-inflammatory drugs (NSAIDs) and steroidal anti-inflammatory drugs (glucocorticoids) interfere with the production of eicosanoids (and additional pathways)
    - *(NB: This lecture is to be integrated with content from your earlier lectures on inflammation)*

Keywords

- Aspirin, Arachidonic Acid, Bradykinin, Cyclooxygenase, COX1, COX2, Eicosanoid, Glucocorticoid, Histamine, Leukotriene, Lipoxygenase, NSAID, Phospholipase A_2, Prostaglandin, Prostanoid, Leukotriene, Thromboxane.

Lecture Overview

Hormones are released from endocrine cells and travel in the blood to mediate an effect at a target cell that may be at some distance from the source of the hormone. By contrast, signalling compounds called 'autacoids' are released locally from their cell of origin, and generally act only locally. This is because they are often quite labile and are broken down close to their site of release. Autacoids are usually low molecular weight substances that can be considered as defence mediators and are important therapeutic targets. They modulate functions such as smooth muscle tone, glandular secretion, permeability of airways and blood vessels, and sensory functions such as pain and itch. You will have already been introduced to a number of autacoid mediator's in your earlier lectures on inflammation and in this lecture, we will examine their formation and function in greater detail.

Further Reading

Rang & Dale's Pharmacology (2020). (9th ed). Elsevier. Chapters 18, 19, 27, 34. This textbook is also available electronically at The University of Melbourne via ClinicalKey (will need login): https://www.clinicalkey.com.au/#!/browse/book/3-s2.0-C2016004202X

Basic and Clinical Pharmacology by Katzung and Vanderah (ed). 15th edition, 2021, Lange (McGraw-Hill). Chapters 16-18, 36, 39, This textbook is also available electronically at The University of Melbourne (will need login): https://accessmedicine.mhmedical.com/Book.aspx?bookid=2988#250593850

Riviere JE and Papich MG (2018). Veterinary Pharmacology and Therapeutics. 10th edition. John Wiley and Sons. Chapters 19, 20, 29.

Hsu WH (2008). *Handbook of Veterinary Pharmacology*.1st edition. Blackwell. Chapters 3, 7, 12.