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REVIEW OF VETERINARY SCIENCE

FOR COMPETITIVE EXAMINATIONS

VETERINARY MEDICAL OFFICER
ASRB-ICAR-NET
ICAR-JRF/SRF
IAS/PCS

REVIEW OF VETERINARY SCIENCE

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Chapter-1

Veterinary Science- An Introduction

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- World Organization for Animal Health (formerly **OIE**- Office International des Epizooties) was established on **25th January 1924 - HQ- Paris**
- IVRI (Indian Veterinary Research Institute) was established in **1889** and earlier known as Imperial Veterinary Research Institute
- ICAR (Indian Council of Agriculture Research) was established on **29th July 1929** and earlier known as Imperial Council of Agriculture Research)
- World Health Organization was established on 7th April, 1948- HQ: Geneva, Switzerland
- Veterinary Council of India (VCI) was established in 1984 and governed by Veterinary Council Act, 1984
- TANUVAS (Tamil Nadu veterinary and Animal Sciences University) was **first veterinary university** established in 1989
- The first veterinary school in world was established in 1761 in Lyon, France by Claude Bourgelat

Animal Division of ICAR has 6 National research centre	
National Research Centre on Pig	Guwahati
National Research Centre on Mithoon	Medziphema (Nagaland)
National Research Centre on Camel	Bikaner
National Research Centre on Equine	Hisar
National Research Centre on Yak	Dirang (Arunachal Pradesh)
National Research Centre on Meat	Hyderabad
Animal Division of ICAR has 8 Central/National Research Institute	
Central Institute for Research on Goat	Makhdoom (Mathura)
Central Sheep and wool research Institute	Avikanagar (Rajasthan)
Central Institute for Research on Buffaloes	Hisar
Central Avian Research Institute	Izzatnagar
Central Institute for Research on Cattle	Meerut
National Institute of Animal Nutrition and Physiology	Bengaluru
National Institute of Veterinary Epidemiology and Disease Informatics	Bengaluru
National Institute of High Security Animal Diseases	Bhopal

Other Institute	Location
Directorate on Foot and Mouth disease	**Mukteshwar (Nainital)**
National Bureau of Animal Genetic Resource	**Karnal, Haryana**
National Bureau of Fish Genetic Resource	**Lucknow**
National Bureau of Plant Genetic Resource	**New Delhi**
National Institute of Animal Health	**Baghpat (UP)**
National Institute of Occupational Diseases	**Ahmedabad**
All India Institute of Hygiene and Public Health	**Kolkata**
Central Leprosy Training and Research Institute	**Chengalpattu (Tamil Nadu)**
LRS National Institute of Tuberculosis and Respiratory Diseases	**New Delhi**
National Institute of Virology	**Pune**
National Institute of Pathology	**New Delhi**
National Institute for Research in Tuberculosis	**Chennai**
National Tuberculosis Institute	**Bengaluru**
National Institute of Communicable Diseases	**New Delhi**
National Institute of Cholera and Enteric diseases	**Kolkata**
Indian Institute of Toxicology	**Lucknow**
Central Institute of Fisheries Education	**Mumbai**
Central Marine Fisheries Research Institute	**Cochin**
Central Inland Fisheries Research Institute	**Barrackpore (Kolkatta)**
Central Drug Research Institute	**Lucknow**
National Dairy Research Institute	**Karnal, Haryana**
Indian Veterinary Research Institute	**Bareilly**

Important Days	
World Leprosy Day	**30 January**
World Cancer Day	**4 February**
National Deworming day	**10 February**
World Wildlife day 3/3	**3 March**
World Forest Day	**21 March**
World Water Day	**22 March**
World Tuberculosis Day	**24 March**
World Health Day	**7 April**
World Malaria Day	**25 April**
World Veterinary day	**Last Saturday of April**
World Immunization weak	**Last week of April**
World Biodiversity Day	**22 May**
World Milk Day 1 June	**1 June**
World Environment Day	**5 June**
National Higher Education Day	**6 June**
World Blood Donar Day	**14 June**
International Yoga Day	**21 June**
National Doctor's Day	**1 July**
World Zoonosis Day	**6 July**
World Population Day	**11 July**
World Hepatitis Day	**28 July**
World Literacy Day	**8 September**
World Rabies Day	**28 September**
World Animal Welfare Day	**4 October**
World Wildlife Day	**6 October**
World Mental Health Day	**10 October**
World Polio Day United Nations Day	**24 October**
National Bird Day	**12 November**
National Milk Day 26/11	**26 November**
World AIDS Day	**1 December**
National Pollution Control Day	**2 December**
World Disability Day	**3 December**
Human Rights Day	**10 December**
UNICEF Day	**11 December**
Good Governance Day	**25 December**

Important year	
1867	Phenol 1st disinfectant and antiseptic used by Lister
1878	Avian Influenza in Italy
1880	Fowl cholera by Louis Pasteur
1881	Blue Tongue is 1st reported by Hutcheon in Africa **In 1964 in Maharashtra (India) by Sapre**
1886	Leptospirosis by Adolf Weil Commercial pasteurisation of milk started
1892	FMD in cattle caused by virus discovered by Loeffler & Frosch
1905	John Disease
1928	Ranikhet disease by Edward
1929	Lumpy skin disease first recognised in Zambia
1930	Marble spleen disease turkey
1942	PPR in West Africa (**In 1989 in Tamil Nadu**)
1945	Duck Plague in New York
1947	**Infectious Canine Hepatitis by Rubarth**
1963	Inclusion Body Hepatitis in USA
1965	Master Degree started in VPH in Pantnagar
1969	Infectious bronchitis in India
1973	Chlamydiosis in India from sheep and goat
1986	BSE first time reported in Great Britain
1987	**Equine influenza outbreak in India** **Equine infectious anemia is reported in India** **First ETT project started by NDDB**
1988	Hydropericardium in Pakistan (In 1994 in India)
1960-61	African Horse sickness outbreak in India **India got OIE AHS free status in 2007**
1962	Swine fever outbreak in India
1990	First animal born (Pratham-buffalo calf) through IVF in India in NDRI
5 July, 1996	Dolly (Finish Dorset Sheep)- First cloned mammal born at Roslin Institute, Scotland using somatic cell nuclear transfer technology by Ian Wilmut
2001-02	Trypanosomiasis outbreak in India
2002-03	FMD outbreak in India
2006	**Avian Influenza outbreak in India**
2006-07	Sheep and goat outbreak in India
2007-08	Blue tongue outbreak in India
2009-10	Black quarter outbreak in India
2009	Massive Swine flu outbreak in Mexico
6 Feb, 2009	World first cloned buffalo calf (Samrupa) born in NDRI
6 June, 2009	World second cloned buffalo calf (Garima) born in NDRI
2011	Babesiosis outbreak in India
June, 2013	**First outbreak of PPRS diseases in pig was reported in Mizoram in India**

Chapter-2

Animal Welfare and Acts

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SECTION	INDIAN PENAL CODE
44	Word 'Injury'
47	Word 'Animal'
51	Word 'Oath'
52	Nothing is said to be done or believed in 'good faith'
53	Punishments
80	Nothing is an offence which is done by accident/misfortune
81	Act likely to cause harm, but done without criminal intent, and to prevent other harm
172	Not present in court after receiving summon (Summon-fine)
173	Preventing service of Summon or other proceedings
178	Refusing oath or affirmation when duly required by public servant to make it
192	False entry in record
193	False evidence in proceeding of court
197	Issue/sign any certificate/false certification
204	Destroy any document
269	Done by negligence to spread infectious disease
270	Done by intention to spread infectious disease
271	Not following quarantine rule- 6-month prison+ Rs. 1000 fine
272	Adulteration of any food or drink-6-month prison+ Rs. 1000 fine
273	Sale of unfit food/drink- 6-month prison + Rs. 1000 fine
274	Adulteration of medicinal item for sale- 6-month prison + Rs. 1000 fine
275	Sale of adulterated medicine- 6-month prison + Rs. 1000 fine
289.	Disobey any order with any animal in his possession- 6-month prison+ Rs. 1000 fine
304	Negligently causing death of any person
377	Bestiality – 10-year prison + Rs. 10000 fine
420	Fraudulent cheating of altered animals- 7 year prison (C Bishoping)
428 & 429	Mischief, killing, poisoning, maiming- 2 year
430	Decrease of water supply to animals

Type of court	
Civil court Civil court deals with civil cases i.e. all cases other than criminal cases. Eg. Housing disputes, bankruptcy, debt, consumer problems, divorce etc.	**Criminal Court: 4 type-** 1. The Supreme Court 2. The High Court 3. The Session Court 4. The Magistrate Court (3 type) • Chief Judicial magistrate • First Class Judicial magistrate • Second Class Judicial magistrate

- Indian Penal Code (1860), 1860
- Criminal Procedure Code (1973)
- Indian Evidence Act, 1872
- Summons: A summons is legal document issued by a court containing an order to appear before a judge or magistrate on a particular day, time and place for the purpose of giving evidence
- Evidence is of two type: Oral evidence and Documentary evidence
- Record of Evidence:
  - Oath
  - Direct examination
  - Cross-examination
  - Re-examination
  - Questions by the Judge
- Term **'Injury'** means any illegal harm to a person, in body, mind, reputation or property
- Term **'animal'** means any living creature, other than a human being
- **Bishoping-** is a method of making animals to look younger. This is punishable under IPC section 420
- **Phooka (Doom dev/ Cow blowing)-** it includes any process of introducing air or any substance into femal organ of a milch animal with the object of drawing off from the animal any secretion of milk. This is punishable under Prevention of Cruelty to Animals Act, 1960

Animal welfare Act & Rules	
The Prevention of Cruelty to Animals **Act**	**1960**
The Prevention of cruelty to Animals (licensing of farriers) **Rules**	**1965**
The Prevention of cruelty to Draught & Pack Animals **Rules**	**1965**
The Wildlife (Protection) **Act**	**1972**
The Performing Animal Rules 1973	**1973**
The Prevention of cruelty to Animals (Application of Fine) **Rules**	**1978**
The Prevention of cruelty to Animals (Registration of Cattle Premises) **Rules**	**1978**
The Transport of Animals **Rules**	**1978**
The Breeding of and Experiment on Animal (Control & Supervision) **Rules**	**1998 (amended in 2001 & 2006)**
The Performing Animals (Registration) **Rules**	**2001**
The transport of Animals on Foot Rules	**2001**
The Slaughter House Rules	**2001**
Animal Birth Control (Dog) Rules	**2001**
Dog Breeding and Marketing Rules	**2017**
Pet Shop Rules	**2018**
Egg Laying Hens Rules	**2019**

Animal Welfare Organization	
International	**National**
RSPCA- Royal Society for prevention of cruelty to animals, **1824** **HQ**- Southwater, United Kingdom	**Bombay Natural History Society (BNHS), 1883** **HQ- Mumbai**
Blue Cross, 1897 **HQ**- Oxfordshire, England (UK)	National Institute of Animal Welfare Ballabhgarh, Haryana
PETA- People for the Ethical Treatment of Animals, **1980** HQ- Virginia, USA	**(BCI)** Blue Cross of India, 1959, Chennai
	Jeevashram Foudation, 1990, New Delhi
WPA-World Animal Protection (Formerly: The World Society for the Protection of Animals- WSPA), **1981** **HQ**- London	**CUPA**- Compassion Unlimited Plus Action, 1991 Bangalore
(WSAVA) World Small Animal Veterinary Association, 1959	Wildlife Trust of India (WTI), 1998 HQ- Noida, Uttar Pradesh
PAWS- Performing Animal Welfare Society, **1984, HQ**- California, USA	**PETA, India**- Mumbai, 2000
MFA- Mercy for Animals, **1999** **HQ**- California, USA	**PAWS**- Pet Animal Welfare Society, 1998, New Delhi
Animal Welfare Board of India Established in 1962 under section 4 of the Prevention of Cruelty to Animals Act, 1960 HQ- Ballabhgarh, Haryana The board consist of 28 members and the tenure is 3 years for board members	
CPCSEA (The Committee for the Purpose and Supervision of Experiments on Animals) This committee is constituted in 1964 under the Prevention of Cruelty to Animals Act, 1960	
Central Zoo Authority (CZA), New Delhi Established in 1992 under section 38A of the Wildlife Protection Act, 1960	
Wildlife Institute of India (WII), 1982, Dehradun, Uttarakhand	
National Board for Wildlife (NBWL) Established in 2003 under section 5A of the Wildlife Protection Act, 1960 It has replaced the Indian Board for Wildlife, 1952 The board consist of 47 members	

Acts/Rules/Order related to animals	
Glanders and farcy Act	1899
The Dourine's Act	1910
AGMARK Act	1937 (amended in 1986)
The Drug and Cosmetic Act	1940
The Drug and Cosmetic **Rules**	1945
The Prevention of Food Adulteration Act	1954
The Prevention of Food Adulteration **Rules**	1955
The Essential Commodities Act	1955
The Indian Veterinary Council Act	1984
APEDA Act	1985
The Consumer Protection Act	1986
Meat Food Product Order (MFPO)	1973
Milk and Milk Products Order (MMPO)	1992
Food safety and Standards Act	2006
The Prevention and Control of Infectious and Contagious Disease in Animal Act	2009

3 R Principle of Biomedical Research

3 R Principle was fiven by **WMS Russel and RL Burch** for use of animals in biomedical research as guiding principles for ethical use of animals in experimentation-

- **Replacement** of animals by insentient materials (use of tissue culture and organoid models)
- **Reduction** in number of animals used to obtain given information
- **Refinement** of procedures actually used to minimise distress imposed on animals

Note: Recently 4R is added which denotes Rehabilitation

Common offences against animals

Maiming: making an animal useless by violence viz. bone fracture, joints dislocation, injury to udder, introducing blunt object into vagina or rectum etc.

Malicious poisoning: The criminal or unlawful killing of animals by administering certain toxin or poisonous agents.

Doping: The administration of illegal substances for the purpose of increasing speed, stamina, courage of the animals.

Bestiality: This is an unnatural sexual activity in which a person has sex with an animal. This is punishable under section-377 with imprisonment for life or fine or both.

Chapter-3

Veterinary Bacteriology

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Father of Bacteriology: Leuwenhoek / Robert koch
Father of Microbiology: Louis Pasteur

Gram positive bacteria (exotoxin)	Gram negative bacteria (endotoxin)
Cell wall is thick and single layered	Cell wall is thin walled but double layered
Cell wall is smooth and rigid	Cell wall is wavy & elastic
Lipid and lipoprotein content is low in cell wall	Lipid and lipoprotein content is high in cell wall
Peptidoglycan layer is thick and multi-layered	Peptidoglycan layer is thin and single-layered
Basal body has one pair of ring (2 ring)	Basal body has two pair of ring (4 ring)
Baer's junction absent	-Bayer's junction- present
Absence of outer membrane	Presence of outer membrane
Periplasmic space-absent	Periplasmic space present
No porin channel	Porin channel present
Lysozyme destroy the gram positive bacteria Protoplast-	Cannot destroy the bacteria Spheroplast-
Greater amount of peptidoglycan	Lesser amount of peptidoglycan
Techoic acid present in cell wall (act as surface antigen)	Absent
Mainly produce exotoxins	Mainly produce endotoxin
Pili- absent	Present on some bacteria
More susceptible to anionic detergents	Less susceptible to anionic detergents
Resistance to drying is high	Low
Sensitive to penicillin	Less sensitive to penicillin
Complement lysis (MAC)- Resistant	Sensitive

Exotoxin	Endotoxin
Heat labile	Heat stable
Made of protein (regulated by genes of plasmid)	Made of lipopolysaccharide
Highly toxic	Weakly toxic
Highly specific for particular tissue	Non-specific in action
Mostly in gram positive but also in gram negative	Located at outer membrane of gram negative bacteria
Excreted or secreted by microorganism	Liberated when the bacteria disintegrated
Converted into harmless toxoid by formaldehyde	Cannot be converted into any harmless substance
Don't produce fever in host	Often produce fever

Highly immunogenic (stimulate production of neutralizing antibody i.e. antitoxin)	Poor immunogenic

Structural component of bacterial cells

Structure	Chemical composition	Details
Capsule	Usually polysaccharide; polypeptide in *Bacillus anthracis*	Often associated with virulence; interferes with phagocytosis
Cell wall	Peptidoglycan and teichoic acid in Gram-positive bacteria. Lipopolysaccharide (LPS), protein, phospholipid and peptidoglycan in Gram-negative bacteria	Peptidoglycan is responsible for shape of organism. LPS is responsible for endotoxic effects. Porins (protein structures) – regulate the passage of small molecules through the phospholipid layer
Cell membrane	Phospholipid bilayer	Selectively permeable involved in active transport of nutrients, respiration, excretion and chemoreception
Flagella	Made of protein called flagellin	provide motility

On the basis of arrangement of flagella, bacteria are classified as:

- **Monotrichous** bacteria- single flagella at one end. Eg. *Vibrio cholera*
- **Lophotrichous** bacteria- multiple flagella at same place. Eg. *Helicobacter pylori*
- **Peritrichous** bacteria- multiple flagella at different places. Eg. *E. coli*
- **Amphitrichous** bacteria- one flagella on each of two opposite ends. Eg. *Alcaligens faecalis*

Note: Most Bacillus spp. are motile by peritrichous flagella except **B. anthracis**

Pili	Made of Protein called pilin	Thin, straight, thread-like structures present on many Gram-negative bacteria. Mediate attachment to host cells. Specialized pili are involved in conjugation termed as sex pilli
Chromosome	DNA	Single circular structure with no nuclear membrane
Ribosome	RNA and protein	Involved in protein synthesis
Storage granules or inclusions	Variable chemical composition	Present in some bacterial cells; may be composed of polyphosphate (volutin or metachromatic granules), poly-β-hydroxybutyrate (reserve energy source), glycogen

Bacteria with capsule

Capsule is demonstrated by:
India Ink staining
Maneval's capsule stain
Quellung reaction

- *Klebsiella spp.*
- *Campylobacter spp.*
- *Pasteurella spp.*
- *Haemophilus spp.*
- *Yersinia spp.*
- *Bacillus spp.*
- *Treponema*
- *Salmonella spp.*
- *Streptococcus pyogenes*
- *S. agalactiae*
- *Staphylococcus aureus*
- *S. epidermidis*
- Some strains of *E. coli*

Motile Bacteria

Type of motility:
Swimming motility-
Swarming motility- *Proteus mirabilis*
Twitching motility
Tumbling motility- *Listeria spp.*
Gliding motility

- *E. coli*
- *Campylobacter spp.*
- *Salmonella spp.*
- *Proteus mirabilis*
- *Klebsiella spp*
- *Leptospira interrogans*
- *Vibrio cholerae*
- *Pseudomonas aeruginosa*
- *Burkholdria pseudomallei*
- *Borrelia burgdoferi*
- *Bordetella bronchiseptica*

Spore (endospore): stained by: His-copper method, Schaeffer-Fulton method, Moeller method, Dorner method, Butt-Bonynge-Joyce method.

Cragie Tube method used for determining bacterial motility

. capsule stain - India ink, maneval capsule stain, His method, mut method, -ve stain
endospore stain - His copper method, schaffer fulton method, moller method, Dorner method, But - Bonnge Joyce method.

Bacteria	Media
Mycobacteria	Lowenstein-Jensen Media
Corynaebacterium	Loeffler's Serum agar
Campylobacter	Thiol medium
Pseudomonas	Cadmium sulphate agar
Leptospira	EMJH (Ellinghausen-McCullough-Johnson-Harris) media with 0.21% rabbit serum, 5-fluorouracil and fatty acids
Listeria	PALCAM (Polymixin, Acriglavin, LiCl, Aesculin, Mannitol)
E.coli	EMB agar
Shigella/ Salmonella	Deoxychocolate citrate agar, Brillant Green Agar
Haemophillus	Blood agar, Chocolate agar (X & V factor)
Brucella	Serum dextrose agar
Vibrio	Thiosulphate citrate bile sucrose agar
Staphylococcus	Mannitol salt agar Tellurite glycerine agar SM-110 or Chapman Stone media Baird Parker Medium
Streptococcus	Edward medium
Clostridium	Robertson cooked media
Bacillus anthracis	PELT Polymixin EDTA Lysozyme Thallus acetated added to blood heart infusion agar
Mycoplasma	Heart infusion peptone broth

Physical methods for sterilizing equipment or fluids	
Moist heat (autoclaving) employing steam under pressure to generate 121^0 C for 15 minutes or 115^0 C for 45 minutes	for sterilizing culture media, laboratory items and surgical equipment. Prions are not inactivated by this treatment
Dry heat in a hot-air oven at 160^0 C for 1-2 hours	for sterilizing metal, glass and other solid materials. Unsuitable for rubber and plastics
Incineration at 1,000^0 C	for destruction of infected carcasses and other contaminated material
Flaming	for sterilizing inoculating loops in the naked flame of a Bunsen burner
Gamma irradiation (Ionizing ray)	Ionizing rays used for sterilizing disposable plastic laboratory and surgical equipment. Unsuitable for glass and metal equipment
Ultraviolet (UV) light (Nonionizing ray)	Non-ionizing rays with poor penetration. Used in biosafety cabinets
Membrane filtration	Used for removing bacteria from heat-sensitive fluids such as serum and tissue culture media. Pore size of filter should be 0.22 µm or less
D-value time in which 90% of bacterial population is killed at a given temperature	

moist heat - Dry heat
121°c - 15 min 160°c 1-2 hr
115°c - 45 min

Growth of bacteria

Bacterial colonies follow 4 phases of growth namely lag, log, stationary and death phase and growth is depicted on Growth Curve

Phase	Characteristics
Lag phase	Adaptation period. Cells are metabolically active, increase only in cells size, synthesis of enzyme and RNA occurs
Log (exponential phase)	There is increase in cell number in logarithmic manner (doubling of population)
Stationary phase	Bacterial population remains constant (number of new cells produced is equal to number of cells dying Sporulation process start
Death/ Decline phase	Bacterial death: number of cells dying are greater than number of new cells produced

Mechanisms which assist bacterial survival in the host	
O antigen polysaccharide chain	Length of polysaccharide chain hinders binding of the membrane attack complex of complement to the outer membrane of many Gram-negative bacteria
Capsule production	Antiphagocytic role in many bacteria
M protein (microcapsule) production	Antiphagocytic activity in *Streptococcus equi*
Production of Fc-binding proteins	Staphylococci and streptococci produce proteins which bind to the Fc region of IgG and prevent interaction with the Fc receptor on membranes of phagocytes
Production of leukotoxins	Cytolysis of phagocytes by toxins produced by *Mannheimia haemolytica*, Actinobacillus species and other pathogenic bacteria
Interference with phagosome–lysosome fusion	Allows the survival of pathogenic mycobacteria within phagocytes
Escape from phagosomes	Survival mechanism used by *Listeria monocytogenes* and Rickettsiae
Resistance to oxidative damage	Allows survival of *Salmonella spp.* and *Brucella spp.* within phagocytes
Antigenic mimicry of host antigens	Adaptation of surface antigens by *Mycoplasma* species to avoid recognition by the immune system
Antigenic variation of surface antigens	Mycoplasma species and *Borrellia spp.* can partially evade detection by the host's immune response
Coagulase production	Conversion of fibrinogen to fibrin by *Staphylococcus aureus* can isolate site of infection from effective immune responses

Bacteria

Taxonomic classification scheme of bacteria identified using Bergey's manual

- Mendosicutes- Methanogens/Archaebacteria
- Firmicutes- Gram positive bacteria
- Gracillicutes- Gram negative bacteria
- Tenericutes (Mollicutes)- Mycoplasma spp.

Bacteria	Characteristics, Disease, Diagnosis
Phylum: Firmicutes; Order: Bacillales	
Genera- *Staphylococcus spp., Listeria Spp., Bacillus spp.*	
Staphylococcus spp.	

- Pathogenic *Staphyococcus spp.* produce golden yellow pigment and are coagulase positive (*S. aureus, S. hyicus, S. pseudointermedius*)
- Protein A is surface antigen present on S. aureus
- Cell division occurs along multiple axis & form cluster or bunch of grapes
- Toxin: Haemolytic toxin, Lethal toxin, Leucotoxin, Enterotoxin (Heat stable-food poisoning), Epidermolytic toxin
- Enzyme: Coagulase, Staphylokinase, Hyaluronidase, Phosphatase

S. aureus	Mastitis in C/B/S/G Botryomycosis **Poultry:** Bumble foot (Subdermal abscess), Gangrenous Dermatitis, Arthritis & Tenosynovitis, Spondylitis & osteomyelitis
S. hyicus	Greesy Pig Disease (Exudative epidermatitis)
S. pseudointermedius	Canine pyodermatosis

Listeria spp. PALCAM

- Typical gram + bacteria, motile at 25°C with tumbling motility, Head over heels motility
- Grow on non-enriched media with wide range of temperature
- Diagnosed by Anton's test
- Cold enrichment is required for isolation when sample is collected from brain

Listeria monocytogenes	Listeriosis (Circling disease/ Silage disease)

Bacillus anthracis- Anthrax

- The first pathogenic bacterium to be seen under microscope
- The first bacterium shown to be the cause of a disease
- The first bacterium to be isolated in pure culture and shown to possess spores
- The first bacterium used for the preparation of attenuated vaccine by Louis Pasteur
- Capsule is made up of D-glutamyl polypeptide
- Chain of bacilli presents Bamboo Stick appearance/ Box car bacillus/ Linked rail carriages

Diagnosed by isolation and identification
Ascoli's precipitation test
Mc Faydean's reaction
Growth on nutrient agar plate: Frosted glass appearance/Lock matted hair/ Medusa Head/ Judge's wing/ Women curly hair type
Growth on gelatin swab: Inverted Fir tree appearance
String of pearls reaction on solid medium containing penicillin
Mucoid or Smooth colony on PLET agar medium (Selective medium)

Bacillus anthracis	**Anthrax**

Phylum: Firmicutes; Order: Lactobacillales (Lactic acid bacteria)

Genera: *Streptococcus spp., Enterococcus spp., Leuconostoc spp.,*

Streptococci spp.

- Lancefield classification: classify streptococcus bacteria on the basis of presence or absence of antigenic carbohydrate on cell surface
- They are catalase negative by which they are distinguished from staphylococci
- They are fastidious bacteria requiring enriched medium, such as blood or serum agar for their growth.
- Cell division occurs along single axis & form chains or pairs

- Streptococci possess a protein on their surface termed as Protein M (prevent from phagocytosis)

Three types on basis of haemolysis on blood agar

1. Alpha-hemolytic streptococci
2. Beta-hemolytic streptococci
3. Gamma-hemolytic streptococci

- Toxin: Streptolysin, Streptokinase (Fibrinolysin), Deoxyribonuclease (Streptodornase), Hyaluronidase (Spreading factor)

Diagnosed by: CAMP test (Christin Atkinson Munch Peterson) and Hotis test mainly for *S. agalactiae*, Bacitracin susceptibility, Bile Solubility test (mainly for *S. pneumoniae*), Optochin test,

Species	Lancefield group	Hosts	Disease
S. pyogenes	**A**	Man	Scarlet fever (due to erythrogenic toxin)
S. agalactiae	**B**	Cattle, sheep, goat, dog	Chronic mastitis
S. dysgalactiae	**C**	Cattle, lamb	Acute mastitis
S. equi	**C**	Horse	Strangles
S. zooepidemicus	**C**	Horse, cattle, lambs, pigs, poultry	Urogenital infection in Horse Avian Streptococcosis
S. suis	**D**	Pig	Streptococcal arthritis & Meningitis
S. canis	**G**	Canine	Urogenital infection
S. porcinus	**E**	Swine	Cervical lymphadenitis (Cervical abscess/Swine Strangle/ Jowl Abscess)

Phylum: Firmicutes; Order: Erysipelotrichales

Genera: *Erysipelothrix spp.*

Isolates with acute infections form smooth colonies while isolates from chronically infected animals form rough colonies

Bottle brush type growth on gelatin & **Pipe Cleaner type growth** on TSI (Triple Sugar Iron media)

Erysepalothrix rhusiopathiae	Erysepalas (Diamond Skin disease)

Phylum: Firmicutes; Order: Clostridiales

Genera: Clostridium spp.

Clostridium spp.

- All *Clostridia spp.* are motile except Cl. perfringens (non motile)
- All *Clostridia spp.* sub- terminal spore **except *Cl. tetani* (Tennis racket shape/Drumstick shape)**
- All *Clostridia spp.* are non-capsular except *Cl. perfringens* (capsule)
- Non-invasive (proteolytic) Clostridia turns meat black- Eg. *Cl. tetani* & *Cl. botulinum* while Invasive (Sacchrolytic) Clostria turns meat pink- other Clostridia spp.

Neurotoxic clostridia	***C. tetani; C. botulinum* (A-Z)**
Histotoxic clostridia	***C. chauvoei; C. septicum; C. novyi type A; C. novyi type B C. perfringens type A; C. sordellii; C. haemolyticum***

Enteropathogenic and enterotoximia producing clostridia	***C. perfringens*** **(type A-E); *C. colinum*** ***C. difficile*** ***C. spiroforme***
Atypical clostridia	***C. pilliforme***
C. tetani	Produce exotoxin: tetanospasmin, tetanolysin, Causes Tetanus (Horse is most susceptible)
C. chauvoei ***(Typical Clostridium)*** ***Pear shaped spore*** ★ Black Quarter (Black leg/Symptomatic Anthrax/ Emphysematous Necrotizing Myositis) **(not in horse & pig)**	Produces 5 toxins: • **C. chauvoei cytotoxin A (CctA- oxygen stable-haemolytic)-main toxin** α, β, γ, δ, neuraminidase • Beta toxin (DNAase) • Gamma-toxin (Hyaluronidase) • Delta-toxin (oxygen labile haemolysin) • Neuraminidase/Sialidase(NanA)
C. septicum (citron-shaped) ★ Closely resemble with *C. chauvoei* in morphology	Alpha toxin is main virulence factor Braxy in Sheep Atraumatic Gas Gangrene & traumatic malignant oedema in cattle buffalo sheep goat **Horse pig**
Clostridium perfringens **type A** **Produces alpha toxin**	Gas Gangrene traumatic infections, avian & canine necrotic enteritis, Colitis X in horses
Clostridium perfringens **type B** Produces Alpha, beta, epsilon, Iota toxin	Lamb dysentery, Foal enterotoxaemia,
Clostridium perfringens **type C** Produces alpha & beta toxin	Struck (adult sheep), goat enterotoxaemia, piglet enterotoxaemia
Clostridium perfringens **type D** Produces alpha & epsilon toxin	Classical Enterotoxaemia (Overeating disease/Pulpy kidney disease) in **sheep**, goat, cattle
Clostridium perfringens **type E** **Produces alpha & Iota**	Enterotoxaemia — Epsilon, iota → ↑ vascular permeability, Tissue necrosis.
Note: calf enterotoxaemia is caused by type B & C *Clostridium perfringens* Alpha toxin (phospholipase C)- necrotic & haemolytic factor Epsilon & Iota toxin is produced as **Proto-toxin** & converted to toxin by proteolytic enzyme such as trypsin mainly involved in increasing vascular permeability and tissue necrosis	
C. difficile	Pseudomembranous Colitis (C. difficile enterotoxaemia)
C. novyi **type A** Produces alpha, gamma, delta, epsilon toxin	Alpha toxin is oedomatous & necrotizing factor Big Head disease in Rams ★★
C. novyi **type B** Produces alpha, beta, zeta toxin	Infectious Necrotic Hepatitis/Black disease ★★★
C. novyi **type C** Produce gamma toxin	Almost non-pathogenic
C. haemolyticum ***Produce beta toxin***	Beta toxin (phospholipase C) is necrotic & haemolytic factor **Bacillary Haemoglobinuria (Red water)**
C. colinum	**Quail Disease** (Ulcerative Enteritis)
C. botulinum **type A**	Botulism in human, birds
C. botulinum **type B**	Botulism in cattle, horse, birds
C. botulinum **type C1**	Botulism in most animal (cattle, horse, chicken, duck,)

C. botulinum type D	Botulism in cattle (main)
C. botulinum type E	Human and fishes
C. botulinum type F	Human
C. botulinum type G	Human
Note: Bone chewing form of botulism is known as Bulbar paralysis/Lamsiekte/Loin disease **Botulism** is rapid fatal motor flaccid paralysis, sign usually appear after 3-7 days after ingestion but sheep does not show typical flaccid paralysis Birds, paralysis of wing, neck, legs with protrusion of nictitating membrane	
C. piliformae	Tyzzer's disease in rodents

Phylum: Actinomycetota; Order: Actinomycetales

Actinomycetales, is an order of phylum Actinobacteria, are diverse group of Gram-positive and anaerobic bacteria which tend to grow slow and produce branching filaments.
The actinomycetales are also known as Higher Bacteria because they induced lesions which are similar to those produced by fungi and known as ray fungus
Eg. **Actinomyces, Nocardia, Dermatophillus, Rhodococcus, Corynaebacterium, Mycobacterium**

Actinomyces bovis	**Lumpy Jaw**: The swelling becomes painful with fistulous tracts, discharging exudate containing 'sulphur granules' with characteristic club colonies.
Actinomyces viscosus	Affect dog
Actinomyces hordeovulneris	Affect dog
Nocardia asteroids Acid fast organism	Main virulent factor is superoxide dismutase Culture have an odour of wet dirt Bovine farcy (Tropical actinomycosis)
Rhodococcus equi (earlier *C. equi*)	Suppurative bronchopneumonia of foal
Dermatophilus congolensis Tram track appearance	Strawberry foot rot/ Cutaneous actinomycosis/ Mycotic dermatitis/ Cutaneous Streptothricosis/ Lumpy wool of Sheep

Corynaebacterium spp.

- Gram staining shows bacteria in short chains or clumps resembling characteristic Chinese letters
- Most of the bacteria have 2–3 granules at the swollen ends known as **metachromatic granules or Babe Ernest's granules or volutin granules or polar bodies** which are the accumulation of polymerized phosphates and are responsible for the beaded appearance of the bacteria
- The granules can be demonstrated by special stain such as Albert stain, Neisser stain, and Ponder stain

Corynebacterium bovis	Pyelonephritis and mastitis in cattle
Arcanobacterium pyogenes (earlier - C. pyogenes)	Summer mastitis
C. pseudotuberculosis (C. ovis/ Preisz Nocard bacillus)	Caseous lymphadenitis in sheep & goat Ulcerative lymphangitis in horses
C. renale	Contagious Bovine Pyelonephritis (Bacillary pyelonephritis) Ulcerative Balanoposthitis (Pizzle rot) in sheep & goat
C. kutscheri	Pseudotuberculosis in rat and mice

Mycobacterium spp.

The cell wall of Mycobacterium is typical as that of Gram-positive having unique cytoplasmic membrane, surrounded by a thick peptidoglycan and a layer of highly antigenic mycolic acid. It is thick and lipid rich.

Herold med - M. paratb. ? Stone brink med - M. bovis

Component of cell wall:

- Cord factor (trehalose 6,6 Dimycolate): responsible for granuloma (tubercle) formation
- LAM (lipoarabinomannan): similar to endotoxin of Gram – ve bacteria & inhibit activation of macrophage
- *M. tuberculosis* heat shock protein: role in autoimmune reactions
- Complement: opsonise organism & facilitate its uptake by macrophages

The examples of solid media are: egg-containing media (Lowenstein–Jensen-LJ medium, Petragnani and Dorset egg medium), blood-containing media (Tarshis medium), serum-combining media (Loeffler's serum slope), potato-based media (Pawlowsky medium).

Note: LJ medium without starch is most widely used

- Glycerol increases growth rate of M. tuberculosis & M. avium while sodium pyruvate increases growth rate of *M. bovis*
- Stone Brinks medium only used for *M. bovis*

Glycerol - ↑ growth M. tuberculosis, M. avium

sod. pyruvate - ↑ M. bovis

Mycobacterium tuberculosis complex include 4 species:

- *M. tuberculosis*
- *M. bovis*
- *Mycobacterium africanum*
- *Mycobacterium microti*

M. tuberculosis (C/B serpentine cords)	Tuberculosis in Human. Monkey, dogs, Guinea pig
M. bovis	Tuberculosis in C/B/S/G/Horse/Pig/rabbit/Guinea pig (not birds)
M. avium C/B Bundle of faggots)	Tuberculosis in Birds & pig
M. paratuberculosis	Herold's medium is used for growth of *M. paratuberculosis* Johne's disease/Paratuberculosis/Chronic bacillary dysentery
M. micoti (Vole bacillus)	Very similar to *M. tuberculosis* (used in vaccine development)
M. lepraemurium	Rat leprosy and Feline leprosy
M. marinum (atypical mycobacterium)	Infect fishes and amphibians (no true tubercle formation)

Phylum: Proteobacteria

This is a major phylum of Gram negative bacteria

Class	Genera
Alphaproteobacteria	Brucella, Rickettsia, Bartonella
Betaproteobacteria	Bordetella, Burkolderia
Gammaproteobacteria	Enterobacteriacae members, Hemophillus, Vibrio, Pseudomonas, Yersinia, Moraxella
Epsilonproteobacteria	Campylobacter, Helicobacter

Family: Enterobacteriaceae (Oxidase -ve)

- Non-spore forming, non-acid fast, and moderately sized Gram-negative bacilli
- They are motile by peritrichous flagella or non-motile without any flagella
- Lactose-fermenting bacteria (Escherichia, Klebsiella, Enterobacter, Citrobacter etc.) or non-lactose fermenting bacteria (Salmonella, Shigella, Proteus, etc.)
- Oxidase negative
- **Proteus spp. is urease positive**
- Ferment glucose and reduce nitrate to nitrite
- Mucoid colonies are typical of Klebsiella and Enterobacter species

Escherichia coli

Minor protein components are attached at tip of pilli that determine to which host cells bacteria will get attached

Diens phenomenon – Proteus.
Diens stain – mycoplasma

- Type 1 protein: bind with mannose and cause urinary tract infection
- Type P protein: bind with galactose & cause pyelonephritis
- Type S protein: bind with sialic acid & cause meningitis

Fimbrial antigen causing infection:

- K-99: calf
- K-88 & K-99: pig

Calf scour/White scour
Honeymoon cystitis
Diagnosed by: Rabbit ileal loop test, Congo-red binding test, Skin permeability Biken test

Enterotoxigenic *E. coli* (ETEC)	Produces 2 toxin heat stable (ST) & Heat labile (LT) Action of heat stable is of fast onset & short duration Commonest colibacillosis in domestic animals Post weaning diarrhoea in piglets Traveler's diarrhoea in humans
Shiga toxin producing *E. coli* (STEC)/ Enterohaemorrhagic E. coli (EHEC)/ Verocytotoxic E. coli (VTEC)	Most common is ***E. coli* O157:H7** **Oedema disease of Swine** (Enterotoxemic colibacillosis/ Gut oedema/ Bowel oedema)- oedema in submucosa of stomach and coiled portion of colon (mesocolon)
Enteropathogenic *E. coli* (EPEC)	
Enteroaggressive *E. coli* (EAEC)	
Enteroinvasive *E. coli* (EIEC)	
Diffusely adherent *E. coli* (DAEC)	

Salmonella spp.

- Classification is done by Kauffmann White Scheme which is based on H & O antigen
- Tetrathionate broth (enrichment media) favour growth of Salmonella
- Salmonella spp. have T4 secretory system (T4SS)

Salmonella typhimurium	HB/C/B/S/G
S. Dublin	Paratyphoid in animals
S. enteritidis	Paratyphoid in animals
S. arizonae	Paracolon infection
S. pullorum	Pullorum disease (Bacillary white diarrhoea)
S. gallinarum	Fowl typhoid
S. anayam	Keel disease

Yersinia spp.

also shows bipolar staining

Yersinia pestis	Plague (Black death) in human
Yersinia enterocolitica	Has similar antigen like *Brucella spp.* Pneumonia & dysentery
Yersinia pseudotuberculosis	Avian pseudotuberculosis Bovine lymphangitis

Proteus spp.

- *Proteus spp.* gives urease positive test, H2S positive and PPA reaction
- Shows Swarming phenomenon & Diens phenomenon
- Gives Weil-Felix reaction (*Proteus vulgaris*)
- Causes urinary tract infection

Klebsiella pneumoniae

- Also known as **Fried Lander's bacilli** & **Prominent capsule** is distinguishing feature
- Causes mastitis & metritis in domestic animals

Actinobacillus- Morse code appearance.

S.aureus, Haemophilus – Satelite phenomenon.

• Causes severe pneumonia and middle ear infection in monkey	
Order: Pseudomonadales: Family: Pseudomonadaceae	
Pseudomonas aeruginosa	Culture gives characteristic fruity smell Fleece rot in sheep
Pseudomonas alcaligens	Used for bioremediation
Order: Pseudomonadales: Family: Moraxellaceae	
Moraxella bovis	Infectious Bovine Keratojunctivitis/ Pink eye/ New Forest Disease
Moraxella anatipestifer (earlier Pasteurella anatipestifer)	New Duck Disease/Duck Septicaemia/ Infectious Serositis of Duck
Order: Burkholdriales: Family: Burkholderiaceae	
Burkholderia mallei	Glanders
Burkholderia pseudomallei	Meliodosis (Glanders like disease) in man & animals (mainly disease of rodents, monkey, rabbit)
Order: Burkholdriales: Family: Alcaligenaceae	
Bordetella bronchiseptica	Kennel cough (dog) Atropic rhinitis (pig)- co-infected with *Pasteurella multocida*
B. avium	Turkey coryza (Bordetellosis)
Taylorella equigenitalis	Contagious Equine Metritis
Family: Pasteurellaceae (Oxidase +ve)	
Gram negative bacteria with absence of flagella (Non-motile) Oxidase test positive (Negative by Enterobacteriacae) Live as commensals in mucosal surfaces of mammals and birds especially in upper respiratory tract Morse code appearance is characteristics of *Actinobacillus spp.* Satellitism phenomenon is shown by Hemophilus spp. and S. aureus ***Actinobaciilus spp., Pasteurella Spp., Haemophilus spp., Mannheimia spp., Bibersteinia spp.,***	
Actinobaciilus lignieresii	Wooden tongue/Timber tongue
A. equuli	Naval ill or joint ill of foal/ foal septicaemia/ Sleepy foal disease)
A. suis	Septicaemia in swine
A. pleuropneumoniae (earlier Haemophillus pleuropneumoniae)	Porcine Contagious Pleuropneumonia
A. seminis	Epididymitis & Chronic pyogranulomatous inflammation in Rams (similar to *Brucella ovis*)
Pasteurella spp.	
***Pasteurella multocida* type A**	Avian Cholera (Fowl cholera)
***Pasteurella multocida* type B**	Haemorrhagic septicaemia
***Pasteurella multocida* type D**	Atrophic rhinitis in pig with Bordetella bronchosepica
***Pasteurella multocida* type E**	
***Pasteurella multocida* type F**	
Mannheimia spp.	
Mannheimia haemolytica	Produces haemolysis on blood agar Shipping fever
Bibersteinia spp	
Bibersteinia trehalosi	Systemic pasteurellosis in sheep less than 2 months
Hemophilus spp.	
Hemophilus parasuis	Glasser's disease
Hemophilus somnus	Infectious Thrombo-Embolic Meningoencephalitis of cattle

Histophilus somni (H. agni/ H. ovis, H. somnus)	Haemophilus septicaemia in lamb Part of Respiratory disease complex in bovines
Haemophilus paragallinarum (New name: ***Avibacterium paragallinarum***)	Infectious coryza in birds
Family: Campylobacteraceae; *Campylobacter spp.* (Curved bacteria)	
Curved shape/ S-shaped/ Comma- shaped/ Sea gull shaped with **Darting mortility** - hence termed as Twisted bacteria	
C. foetus	**Campylobacteriosis** (Abortion in mid gestation in cattle, sheep)
C. veneralis	Early embryonic death
C. jejuni, C. coli, C. laridis	Avian campylobacteriosis
Phylum: Proteobacteria; Order: Rickettsiales; Family: Rickettsiacae	
Genus: Rickettsia- non- motile, non-spore forming, gram negative, intracellular bacteria ★	
Rickettsia rickettsii	Rocky spotted mountain fever (transmitted by ticks)
Rickettsia akari	Rickettsial pox (transmitted by mites)
Rickettsia prowazekki	Epidemic typhus (transmitted by louse)
Rickettsia typhi	Endemic typhus (Murine typhus) (transmitted by flea)
Genus: Orientia	
Orientia tsutsugamushi (Earlier: ***R. tsutsugamushi***)	Scrub typhus (transmitted by mites)
Phylum: Proteobacteria; Order: Rickettsiales; Family: Ehrlichiaceae	
Ehrlichia canis	Canine Ehrlichiosis Transmitted by Rhipicephalus sanguineus (brown dog tick)
Canine Ehrlichiosis: Characterized by leukopenia, thrombocytopenia, anaemia and increases level of gamma globulin in serum. Three intracellular forms of E. canis are found-initial bodies; **morula or mulberry bodies;** elementary bodies	
Ehrlichia ruminatum (Earlier: *Cowdria ruminatum*)	Heart water disease (Cowdriosis/ Nintas/ Ehrlichiosis) Transmitted by Amblyomma spp. (tick)
Ehrlichia ondiri (***Cytoecetes ondiri***)	**Bovine Petecchial fever (Ondiri disease)** characterized by high fluctuating fever, **Poached egg eye,** leukopenia (neutropenia)
Genus- Neorickettsia: reside in cytoplasmic vacuoles within monocytes & macrophages of dog, horse	
Neorickettsia risticii (Earlier: *E. risticii*)	Potomac Horse Fever (Equine neorickettsiosis/ Equine monocytic Ehrlichiosis)
Neorickettsia helminthoeca	Salmon Poisoning Disease in dog & other canids (Canine neorickettsiosis)
Anaplasma marginale	Anaplasmosis in cattle & buffalo characterized by anisocytosis, poikilocytosis, punctate basophilia
Anaplasma phagocytophilum (Earlier: *E. phagocytophilum*)	**Tick-borne fever** (Pasture fever/ Grazing Fever/ Bovine & Ovine Ehrlichiosis)- resides in neutrophils **Equine Granulocytic Anaplasmosis**
Phylum: Proteobacteria; Order: Legionellales; Family: Coxiellaceae	
Coxiella burnetii	Intracellular parasite of phagolysosome & causes Q- Fever
Phylum: Proteobacteria; Order: Hyphomicrobiales; Family: Bartonellaceae	

Spirochaetes - Dark Field microscopy.

B. suis - inhibited by basic fuschin.
Brucella spp - — Thionine.

Bartonella Quintana ***(earlier: Rochalimeae Quintana*** or ***Rickettsia quintana)***	Trench Fever (5 day fever/ Shin bone fever/ His Werner disease) (transmitted by louse)
Bartonella hensalae	Cat scratch disease

Phylum: Proteobacteria; Order: Hyphomicrobiales; Family: Brucellaceae

Brucella spp.

Intracellular organism & require CO_2 for growth, best grow on liver extract
Growth is inhibited by thionine but of *B. suis* is inhibited by basic fuschin
Serum Tube Agglutination Test (STAT)- agglutination at 1:40 (80 IU) and above is positive for bovine (except breeding bulls) and other animals including HB
Agglutination at 1:20 (40 IU) is positive for breeding bulls, sheep, goat
Coombs test, CARD test, Rivanol precipitation test, Mercaptoethanol agglutination test, Abortus Bang Ring Test **(ABRT)**, Rose Bengal Plate Test **(RBPT)**

Brucella abortus	Brucellosis
B. ovis	Sheep & Goat
B. meletensis	Sheep & Goat
B. canis	Canine
B. neotome	Rodents

Phylum: Spirochaetes; Order: Spirochaetales Cork-screw shape cell anaerobic

- Characterised by Gram –ve, anaerobic bacteria, Double membrane, mostly have helically coiled (cork-screw shaped) cells, seen with help of Dark Field microscopy
- Peptidoglycan layer is associated with cytoplasmic membrane rather than outer membrane
- They have hooked ends and two periplasmic flagella known as Axial filaments or endoflagella
- Dinger's ring/disc- opaque ring just below surface of semisolid EMJH media in tube

Leptospira spp.	Leptospirosis in C/B/S/G/dog/cat Microscopic Agglutination Test (MAT)
Borrelia anserina	**Fowl Spirochaetosis** (Transmitted by *Argus persicus*)
Borrelia burgdoferi	**Lyme disease** (Transmitted by *Ixodes spp.*)
Borrelia recurrentis	Relapsing fever in humans (louse born)
Treponema hyodysentriae	Swine dysentery/ **Porcine ulcerative spirochaetosis** C/B strawberry coloured faeces, mainly affect piglets
Treponema paraluiscuniculi	Rabbit syphilis (venereal spirochaetosis)
Serpulina hyodysentriae	Avian **Intestinal Spirochaetosis** (C/B mild diarrhoea)

Phylum: Chlamydiae; Family: Chlamydiaceae; *Chlamydia spp.* (E elementary body)

Chlamydia exists as an Elementary body-EB (rigid cell wall similar to bacterial spore, metabolically inert, able to infect new host but cannot replicate) transform into Reticulate Body (not able to infect new host but can replicate)
Diagnosis: Isolation & Identification- reliable method LCL - Basophilic intracytoplasmic body.
By staining: Giemsa (dark purple), Casteneda (Blue), Macchiavello & Giemenez (Red)
Basophilic intracytoplasmic bodies are found in infected cells termed as **LCL bodies (Levinthal-Coles-Lillie)**

Chlamydia psittaci	Sporadic bovine encephalomyelitis Enzootic bovine/ovine abortion Seminal vasculitis syndrome Follicular Conjunctivitis of sheep (Pink eye/Snow blindness)

Phylum Fusobacteria; Order: Fusobacteriales	
Obligate anaerobic, Gram negative bacteria	
Fusobacterium necrophorum	Foot rot (Infectious pododermatitis/Necrobacillosis)
Streptobacillus moniliformis	Haverhill fever (Epidemic Arthritic Erythema)
Phylum: Tenericutes; Class: Mollicutes	
Mycoplasma Spp. PPLO like org.	
Lack cell wall, can survive without oxygen, often referred as PPLO (pleuro-pneumonia like organisms) and colonies look like Fried egg appearance **P 1 antigen** is primary virulence factor of mycoplasma Colonies studied by **Diene's stain** (alcoholic solution of Methylene blue)	
★ ***Mycoplasma mycoides* var. *mycoides***	Contagious Bovine Pleuro-Pneumonia (CBPP)
★ ***Mycoplasma mycoides* var. *caprae***	Contagious Caprine Pleuro-Pneumonia (CCPP)
Mycoplasma agalactiae	Contagious agalactia of sheep
M. hyosynoviae & M. hyorhinis	Polyarthritis & Polyserositis
M. hyorhinis	Atrophic rhinitis
M. hyopneumoniae	Enzootic pneumonia of pigs
★ ***M. bovis***	Bovine mycoplasmal mastitis Bovine Mycoplasmal arthritis
M. bovigenitalium	Bovine Granular Veneral Disease (Granular Vulvo-vaginitis)
★★ ***Mycoplasma gallicepticum***	Chronic Respiratory Disease (CRD)
★ ***Mycoplasma synoviae***	Infectious synovitis
★ ***Mycoplasma gallisepticum*** (Turkey) ***Mycoplasma imitans*** (Duck/goose)	Infectious Sinusitis
★★★ ***Mycoplasma haemofelis*** (Earlier: Haemobartonella felis)	**Feline Infectious anaemia (Feline haemobartonellosis)** Characterized by haemolytic anemia, macrocytosis, anisocytosis, reticulocytosis
Phylum: Bacteroidetes; Order: Flavobacteriales	
Gram negative, rod shaped bacteria	
Ornithobacterium rhinotracheale	Respiratory infections in poultry
Capnocytophaga canimorsus	Normal inhabitant of dog mouth
Riemerella anatipestifer (earlier: Pasteurella anatipestifer)	Duck septicaemia (New Duck Disease/Duck Pasteurellosis)

Chapter-4

Veterinary Virology and Mycology

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Virus

- Name virus was given by Pasteur
- WM Stanley crystallized viruses and crystals composed of proteins
- The protein coat of virus is termed as capsid (made up of capsomeres which are held together by non-covalent bonds)
- Baltimore classification used to classify viruses based on pattern of messenger RNA synthesis
- Viruses are named by International Committee on Taxonomy of Viruses (ICTV)

Classification of Viruses

RNA viruses

Family	Genetic material	Nucleocapsid Symmetry	Envelope	Remark
Nidovirales: order of viruses having positive sense ssRNA and are enveloped, include Coronaviridae and Arteriviridae				
Coronaviridae	ssRNA (+ sense)	Helical or Doughnut shaped	Enveloped	Largest RNA virus
Two subfamily: Coronavirinae (helical shaped nucleocapsid); Torovirinae (doughnut shaped)				
Arteriviridae	ssRNA (+ sense)	Icosahedral	Enveloped	
Mononegavirales- order of negative sense RNA viruses having non-segmented genome and include Rhabdoviridae, Paramyxoviridae, Bornaviridae				
Rhabdoviridae	ssRNA (- sense)	Helical symmetry (Bullet shaped)	Enveloped	Bullet shaped virions
Paramyxoviridae	ssRNA (- sense)	Pleomorphic	Enveloped	Herring bone nucleocapsid
Bornaviridae	ssRNA (- sense)	Helical symmetry	Enveloped	
Articulavirales: order of negative sense RNA viruses having segmented genome and include Orthomyxoviridae				
Orthomyxoviridae (segmented genome)	ssRNA (- sense) 6-8 segments	Pleomorphic	Enveloped	
Bunyaviridae	ssRNA (- sense)	Spherical	Enveloped	
Togaviridae	ssRNA (+ sense)	Spherical	Enveloped	
Arenaviridae (bisegmented)	ssRNA (ambisense)	Pleomorphic (Spherical)	Enveloped	Contains sand like particle
Retroviridae	ssRNA	Icosahedral	Enveloped	
Reoviridae	**dsRNA**	Icosahedral	Non-enveloped	
Picornaviridae	ssRNA	Icosahedral	Non-enveloped	

Astroviruses	ssRNA	Icosahedral	Non-enveloped	Star shaped surface structure
Caliciviridae	ssRNA	Icosahedral	Non-enveloped	Cup-like depression on surface
DNA viruses				
Herpesviridae	dsDNA	Icosahedral	Enveloped	
Poxviridae	dsDNA	Complex	Enveloped	Brick shape genome
Asfaviridae	dsDNA	Icosahedral	Enveloped	Haemadsorption property
Papovaviridae	dsDNA	Icosahedral	Non-enveloped	Skew arrangement
Adenoviridae	dsDNA	Icosahedral	Non-enveloped	Fibrils are present
Circoviridae	**ssDNA (circular)**	Icosahedral	Non-enveloped	Rolling circle replication
Parvoviridae	**ssDNA**	Icosahedral	Non-enveloped	Rolling hair pin replication
Annelloviridae	**ssDNA (- sense) (circular)**	Icosahedral	Non-enveloped	

- Enveloped viruses are sensitive to ether and chloroform while resistant to lipid solvents
- Envelop of some viruses contains spike called peplomer
- Most enveloped viruses are inactivated at pH: 5-6
- Most enveloped viruses are characterized by Icosahedral symmetry
- At end of replication enveloped viruses are released by **budding** while non-enveloped viruses by **lysis**
- Reassortment is feature of viruses having segmented genome
- Viral proteins (structural, non-structural, regulatory and accessory proteins)
- Matrix protein: form of structural protein which links envelop and nucleocapsid and also involved in budding process, present in Rhabdoviridae, Orthomyxoviridae, Paramyxovoridae,
- In Herpesviruses, matrix protein is termed as tegument
- Nonstructural proteins of virus are expressed in infected cells
- Negative ssRNA viruses replicate in cytoplasm except Orthomyxoviridae and Bornaviridae (replicate in nucleus)
- Cytopathic effect (CPE)- structural changes in host cells resulting from viral infection
  - Syncytia formation: fusion of cells-
  - Rounding of infected cells
  - Inclusion bodies

Viruses of veterinary importance

Paramyxoviridae

Fusion proteins and attachment proteins appear as Spikes on the virion surface
Require neutral pH for fusogenic activity

Genus & characteristics	Disease
Morbillivirus (have only haemagglutinin)	• Canine Distemper • Rinderpest • PPR • Measles (human)
Orthoavulavirus	Ranikhet disease
Avian pneumovirus	• Turkey Rhinotracheitis (Turkey coryza)

	• Swollen head syndrome of chicken
Paramyxovirus	Mumps (Human), Parainfluenza-1, 2, 3, 4
Orthomyxoviridae	
Orthomyxovirus	Swine influenza (Swine flu) Avian influenza (Bird flu) Equine flu
Influenza virus is classified into A,B, C based in nucleoprotein and matrix protein	
Poxviridae	
Lateral bodies are present	
Orthopoxvirus	Cow pox/ Buffalo/Horse/ Camel/ Monkey/ Rabbit/ Mouse pox
Capripoxvirus	Sheep/Goat pox
Suipox virus	Swine pox
Parapoxvirus	• Bovine pustular stomatitis • Contagious Pustular dermatitis (orf) • Pseudocow pox (Milker nodules/Paravaccinia)
Leporipoxvirus	• Myxomatosis (Big head disease of rabbit) • Shope fibroma of rabbit
Avipoxvirus	Fowl pox
Neethling virus	Lumpy Skin Disease (LSD)
Parvoviridae	
Canine parvovirus-2 (CPV-2)	Canine parvovirus infection
Feline parvovirus (Feline panleukopenia virus)	• Feline parvo/ panleukopenia/Feline Infectious enteritis • Cerebellar hypoplasia, retinal dysplasia & optic neuropathy in kittens
Porcine parvovirus	Infertility, maceration, foetal death
Circoviridae	
Smallest known animal viruses with rolling circle replication	
Porcine circovirus-2 (PCV-2)	Post-weaning Multisystemic wasting syndrome in pig
Adenoviridae	
Aviadenovirus	• Inclusion Body Hepatitis (Hepatomyeloporetic disease) • Egg Drop Syndrome • Litchi Disease (Hydropericardium syndrome/Leechi disease- Aviadenovirus 4) • Turkey Haemorrhagic Enteritis • Pheasant Marble Spleen Disease • Quail Bronchitis
Mastadenovirus	Infectious Canine Hepatitis (Canine adenovirus 1/ CAV-1/ Canine mastadenovirus A)
Asfarviridae	
Asfivirus	African Swine Fever
Birnaviridae	
dsRNA (linear, bi-segmented)	
Avibirnavirus	Infectious Bursal Disease (Gumboro Disease) in birds
Aquabirnavirus	Infectious Pancreatic Necrosis in salmonid fish
Coronaviridae	
Genome is characterized by large club or petal shaped surface projections termed as peplomers or spikes (typically look like solar corona in electron microscopy)	
Alphacoronavirus	**Alphacoronavirus 1 (species)** • Porcine Epidemic Diarrhoea

	• Transmissible Gastroenteritis of pig (TGE) • Feline Infectious Peritonitis • Canine coronavirus infection
Betacoronavirus	**Porcine haemagglutinating Encephalomyelitis (Vomiting & wasting Disease/ Coronaviral Encephalomyelitis)**
Gammacoronavirus	• Avian Infectious Bronchitis (IB) • Turkey Blue comb Disease (Mud Fever/ Coronaviral Enteritis of Turkey/ Transmissible enteritis)
Flaviviridae	
Pestivirus	• Bovine Viral Diarrhoea/Mucosal Disease (Pestivirus A, B) • Classical Swine Fever (Pestivirus C) • Border Disease (Pestivirus D)
Flavivirus	• Japanese Encephalitis • Kyasanur Forest Disease • Louping ill • West Nile disease • Yellow fever • Zika virus infection
Herpesviridae Capsid is surrounded by another layer of protein termed as integument Name is derived from 'herpein' means 'to creep'-spreading cutaneous lesions	
Subfamily: Alphaherpesvirinae	
Gallid alphaherpesvirus 1- GHV-1	Infectious laryngotracheitis (ILT)
Gallid alphaherpesvirus 2- GHV-2	Marek's Disease
Bovine alphaherpes virus 1 (BHV-1)	Infectious Bovine Rhinotracheitis (IBR)
Bovine alphaherpes virus 2 (BHV-2)	Bovine mammilitis & pseudolumpy skin disease
Canid alphaherpesvirus 1 (CHV-1)	Haemorrhagic disease in puppy & abortion in adult
Equine alphaherpesvirus 1 (EHV-1)	Abortion & respiratory disease
Equine alphaherpesvirus 3 (EHV-3)	Equine coital exanthema
Equine alphaherpesvirus 4 (EHV-4)	Rhinopneumonitis
Feline alphaherpesvirus 1 (FeHV-1)	Feline viral rhinotracheitis
Suid alphaherpesvirus 1 (SuHV-1)	Pseudorabies (Aujeszky's disease)
Subfamily: Betaherpesvirinae	
Elephantid betaherpesvirus/ Elephant endotheliotropic herpesvirus 1 (EEHV-1)	Fatal haemorrhagic disease in Asian elephants
Suid betaherpesvirus 2 (SuHV-2) (Pig cytomegalovirus)	Inclusion Body Rhinitis (Cytomegalic Inclusion Disease)
Subfamily: Gammaherpesvirinae	
Human gammaherpesvirus 4 (HGV-4)	Epstein-Barr (Burkitt lymphoma) in human, old world monkey, new world monkey
Alcelapine gammaherpesvirus 1 (AHV-1) Ovine gammaherpesvirus 2 (OvHV-2)	Bovine Malignant Catarrhal Fever (Snotsiekte) in cattle buffalo, deer, antelope
Equine betaherpesvirus 2 (EHV-2) (earlier Equine cytomegalovirus)	

Equine betaherpesvirus 5 (EHV-5)	Equine multinodular pulmonary fibrosis
Rhabdoviridae	
Produces five protein- L (RNA dependent RNA polymerase), G (glycoprotein- makes peplomer), N (nucleoprotein), P (viral polymerase) and M (matrix protein)	
Subfamily: Alpharhabdovirinae	
Genus: Ephemovirus	Bovine Ephemeral Fever (three-day sickness) Transmitted by: Culicoides (biting midges)
Genus: Lyssavirus (agglutinate goose RBC)	Rabies
Genus: Vesiculovirus Species: Indiana vesiculovirus New Jersey vesiculovirus	Vesicular Stomatitis
Picornaviridae	
Genus: Apthovirus	Foot & Mouth disease
• Apthovirus can be cultivated in BHK-21 cell line, Guineapigs, suckling mice • Virus is inactivated by 2-4% sodium carbonate (Na_2CO_3), 2% NaOH • Virus can be stored at 4 ^{0}C	
Genus: Enterovirus	Swine vesicular Disease
Genus: Tremovirus	Avian Ecephalomyelitis/ Epidemic tremor
Genus: Teschovirus	Porcine enteroviral encephalomyelitis/ Teschen Disease/ Talfan Disease
Genus: Cardiovirus	Viral Encephalomyocarditis of pig
Genus: Avihepatovirus	Turkey Viral Hepatitis Duck Viral hepatitis (DHAV-1)
Retroviridae	
Alpharetrovirus	• Avian leucosis • Rous sarcoma virus
Betaretrovirus	• Jaagsiekte (Pulmonary Adenocarcinoma of sheep) • Mouse Mammary Tumour
Deltaretrovirus	Bovine leukemia
Gammaretrovirus	• Feline leukemia • Murine leukemia • Reticuloendotheliosis in birds
Lentivirus	• Caprine arthritis encephalitis (CAE) • Equine Infectious Anaemia (EIA) • Feline Immunodeficiency • Bovine Immunodeficiency • Visna-maedi • Simian Immunodeficiency
Reoviridae	
'Reo' means Respiratory Enteric Orphan	
Avian orthoreovirus 10 segmented genome	Arthritis and tenosynovitis in poultry
Orbivirus (Doughnut shaped capsomere) 10 segmented genome	African Horse Sickness Blue tongue Epizootic Haemorrhagic Disease (wild ruminants) Equine Encephalosis
Rotavirus (11 segmented genome)	Gastroenteritis in animals
• Rotavirus is classified into seven groups (A-G) on basis of epitopes in VP 6 protein	

- Rotavirus is characterized by wheel like appearance when observed by electron microscope with triple layer capsid
- Every segmented genome codes for one protein except segment 11 which code for 2 proteins

Togaviridae	
Alphavirus	Equine Encephalomyelitis Salmon Pancreas Disease
Arteriviridae	
Alphaarterivirus	Equine Viral Arteritis (EVA)
Betaarterivirus (Betaarterivirus suid 1 & 2)	Porcine Reproductive Respiratory Syndrome (PRRS) or Blue Ear Pig Disease/Mystery Swine Disease
Deltaarterivirus	Simian haemorrhagic Fever
Caliciviridae	
Lagovirus	Rabbit Haemorrhagic Disease
Vesivirus	Feline Calcivirus Vesicular Exanthema of Swine
Astroviridae	
Genus: Avastrovirus Species: Avastrovirus 2	Baby Chick Nephropathy (Avian Nephritis)
Anelloviridae	
Gyrovirus	Chicken Infectious Anaemia
Pappillomaviridae	
Papillomavirus	• Warts (papilloma and fibropapilloma) of skin, teat and alimentary tract • Equine sarcoid (skin tumour) • Genital papilloma in pig • Cuatneous and oral papilloma in rabbit
Polyomaviridae	
Simian vacuolating virus (SV 40)	Tumour in monkey

Fungi and Fungal diseases

- The structure of fungi composed of long thread like structures termed as hyphae and collection of hyphae is known as mycelium
- **Candida albicans** is termed as Dimorphic fungi (grows as both yeast and filamentous cells)

Reproduction in fungi is by 3 methods:

- Vegetative reproduction (fragmentation, fission, budding)
- Asexual reproduction with help of asexual spores (conidia/Sporangiospores/zoospores)
- Sexual reproduction: with help of sexual spores (basidiospores, oospores, ascospores)

Animal Fungi is divided into 2 major phylum:

Ascomycota	Basidiomycota (Higher fungi)
Branched and septate mycelium Asexual spores: conidia Sexual spores: ascospores Eg. • Aspergillus • Claviceps • Microsporum, Trichophyton, Epidermophyton • Candida • Coccidioides • Histoplasma • Sporothrix • Fusarium • Penicillium • Stachybotrys • Pithomyces	Mainly Parasitic on plants Asexual spores absent Sexual organs absent • Cryptococcus

Fungal Diseases	
Aspergillosis *Aspergillus fumigatus*	Characterized by granulomatous and cavity lesions in lungs Abortion in dairy animals (3-7 month)
Candidiasis ***Candida albicans*** (Germ tube test)	Common in suckling piglet Formation of pseudomembrane on tongue, gum, buccal cavity which is known as Thrush Systemic form also occur in cattle leading to gastroenteritis
Coccidioidomycosis *Coccidioides immitis* Barrel shaped arthrospore	Granulomatous lesions in lungs Most common in dogs
Cryptococcosis (Torulosis) *Cryptococcus neoformans*	Common in dog & monkey Affected organs are central nervous system & lung characterised by cystic lesion in brain & very minimal cellular reaction
Histoplasmosis (Darling Disease/Cave Disease) *Histoplasma capsulatum*	Most common in dog characterized by disseminated granuloma formation in lungs, splenomegaly, hepatomegaly, lymphadenopathy, nasopharyngeal and GIT ulceration
Epizootic Lymphangitis (Pseudoglander) Histoplasma farcinosum	Chronic disease (I/P- 90 days) of equids characterized by suppurative lymphangitis, lymphadenitis, **granulomatous skin lesion**, pneumonia
Sporotrichosis (Red Gardner disease) ***Sporothrix schenckii***	Most common in **horse, dog, cat** Suppurative granuloma or nodule formation on skin and subcutaneous tissue Pus reveal characteristic **Cigar shaped bodies**
Dermatophytosis (Ringworm/ Trichophytosis/ Tinea infection) Superficial infection affecting hair, nail, skin **Microsporum spp.-** infect **hair mainly** characterized by **spindle or boat shaped conidia** **Epidermophyton spp.**- infect **skin mainly** characterized by **peat shaped conidia** **Trichophyton spp.-** infect **hair, nail, skin mainly** characterized by **cylindrical conidia**	
Trichophyton verrucosum	Cattle, buffalo, sheep, goat
Trichophyton equinum ***Microsporum gypseum***	Horse
Microsporum canis ***Microsporum gypseum***	Dog, cat

Mycotoxicosis	
Aflatoxicosis Toxin: B1, B2, G1, G2 B1- is most prevalent & most toxic *Aspergillus flavus* *Aspergillus parasiticus*	**Acute aflatoxicosis:** Hepatic necrosis (Centrilobular necrosis- cattle, pig, dog; periportal necrosis- cat) Oedema and haemorrhage in wall of gall bladder **Chronic aflatoxicosis:** more common form characterized by bile duct proliferation at periphery of hepatic lobules (peri-portal cirrhosis) & megalocytic hepatocytes
Ochratoxicosis (Mouldy nephrosis/ Swine nephropathy/ Citrinin toxicity)	Toxin of ***Aspergillus ochraceous & Penicillium viridicatum*** are mainly responsible characterized by tubular necrosis of kidney
Vulvovaginits mycotoxicosis Zearalenone (F-2 toxin-oesterogenic)	***Fusarium graminearum & Fusarium roseum*** Hyperplasia of uterus, vagina & mammary gland
Trichothecene toxicity	Trichothecene: group of chemically related mycotoxins **T-2 toxin (mouldy corn poisoning in cattle-** haemorrhage); DAS (diacetoxyscipenol); DON (deoxynivalenol); Satratoxin (Stachybotrys chartarum)
Mouldy corn poisoning in horse & pig (Fumonisin toxicosis)	*Fusarium moniliforme* (*F. verticilliodes*) & *F. proliferatum* Equine leucoencephalomalacia Porcine pulmonary oedema
Facial eczema in cattle & Sheep **Toxin: Sporidesmin**	***Pithomyces chartarum*** Perilobular fibrosis and atrophy of hepatocytes Spongy vacuolation of brain
Nervous ergotism	***Claviceps paspalli***
Neurotoxicosis in cattle	*Penicillium patalum* *Aspergillus clavatus*
Lupinosis/Phomopsis	Phomopsin (Phomopsis leptostromiformis) affect liver & nervous system
Dallis grass poisoning (Dallis grass staggers)	***Claviceps paspalli*** (affect horse & cattle mainly) Diarrhoea, staggering gait, muscle tremors, falling
Perennial rye grass staggers **Toxin: Tremorigens (neurotoxin)**	Neotyphodium lolii & Penicillium spp.
Note: 4-Ipomeanol (toxin by Fusarium spp.) causes Atypical interstitial pneumonia in cattle	

Chapter- 5

Veterinary Immunology

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- **Immunity** can be defined as complex biological system to prevent the invasion of harmful microorganisms into the body
- The cells, tissues, structures and secretions which confers immunity to infectious agents are known as Immune system
- **Innate immunity** can be defined as immunity which is present since birth and persists lifelong. Eg. Skin, mucous coating of epithelium lining the gastrointestinal tract, respiratory tract, urogenital tract, acid in stomach, saliva in mouth, tears from eyes, natural killer cells, granulocytes etc.
- **Acquired (adaptive) immunity** can be defined as immunity which is acquired/developed in response to antigen. It is highly pathogen specific and its response is slow as compared to innate immunity

Adaptive immunity			
Active immunity		**Passive immunity**	
Natural active immunity- Developed with recovery from disease (clinical or subclinical)	**Artificial active immunity-** As a result of vaccination	**Natural passive immunity-** Result of colostrum uptake	**Artificial passive immunity-** Oral or injection of antiserum to new-born animals

- **Primary lymphoid organs:** Bone marrow, Thymus, Bursa of fabricus (birds). All lymphocytes originate from stem cells in bone marrow. Differentiation of B lymphocytes take place in Bone marrow (BM) in mammals and Bursa of fabricus in birds. Differentiation of T lymphocytes take place in thymus. BM also act as secondary lymphoid organ
- **Secondary lymphoid organs:** Lymph nodes, spleen, peyer's patches, tonsils and diffused lymphoid tissue (Bronchial associated lymphoid tissue- BALT in respiratory tract and Mucosal Associated Lymphoid tissue- MALT in digestive tract). These organs provide environment for proliferation and maturation of lymphocytes and also for filtering and trapping antigens. They also provide sites for interaction of lymphocytes with antigens.
- Cells of Immune system: Macrophages, monocytes, neutrophils, dendritic cells and most important Lymphocytes
- Macrophages are involved in phagocytosis, production of various cytokines and are also act as antigen presenting cell.
- **Antigen Presenting Cells (APC):** are cells that process and present antigens in conjunction with MHC II for recognition by T lymphocytes. Eg. Macrophages, dendritic cells and B cells.
- **Dendritic cells:** are antigen presenting cells present in lining of nose, lungs, stomach, intestine, heart and in lymphoid tissues. In skin, these cells are known as Langerhans cells.
- Lymphocytes: are of 3 types- B lymphocytes, T lymphocytes and natural Killer cells

- **Natural Killer (NK) cells:** also known as large granular lymphocytes and lymphocytes of innate immune system. These cells do not express antigen specific receptors and are mainly involved in killing of tumour cells and virus infected cells as these cells express less MHC-I molecules.

B-cells	T-cells
• Maturation take place in bone marrow	• Maturation take place in thymus
• Life span- short	• Long
• B-cells take part in humoral immunity	• T-cells take part in cell mediated immunity
• Activated form of B Cells- Plasma cells & memory cells	• Activated form of T-cells- Helper T cells and Cytotoxic T cells
• Plasma cells secrete antibodies	• Activated T cells secrete cytokines
• Have BCR receptor B cell receptor complex consist of membrane bound immunoglobulin and signalling subunit Ig alpha and beta proteins	• Have TCR receptor T-cell receptor complex consist of TCR alpha and beta peptide, CD3 proteins and 2 zeta chains
• Have surface antigen	• Do not have surface antigen
• Recognize antigens on surface of the invading bacteria and viruses	• Recognize antigens on outside of the infected cells
• Defend against bacteria and viruses in the blood stream or lymph (extracellular microbes)	• Defend against pathogens that enter the cells in body (intracellular microbes)
• 15-20 % of blood lymphocytes are B cells	• Up to 80 % of blood lymphocytes are T cells
Function: B- cell on antigenic stimulation are converted to plasma cells which secretes antibodies that are involved in lysis of antigen with the help of complement or help in phagocytosis of antigen by neutrophils/ macrophages	**Function:** Antigens are processed with the help of antigen presenting cells (APC) and MHC molecules, processed antigen are brought to Cytotoxic T cells with the help of cytokines released by Helper T cell and lysis of infected cells take place with the help of macrophages and natural killer cells
• CD molecules present on B cells are: CD-19, CD-20, CD-21, CD-40	• Present on T-cells are CD-3, CD-4, CD-8, CD-28, CD-154
• Memory cells protected from apoptosis by Bcl_2 gene • Naïve cells: B or T cells not exposed to antigen earlier • Cytotoxic T cells mediate apoptosis by: ➢ Perforin or Granzyme apoptosis pathway ➢ CD95 pathway • Lymphocyte proliferation assay used to measure T cell or B cell response in vitro to specific antigens • B-cell mitogen: Lipopolysaccharide • T-cell mitogen: Phytohaemagglutinin (PHA), Concanavalin A (ConA) • B & T cell mitogen: Pokeweed mitogen (PWM)	

IMMUNOGLOBULINS (Antibodies)					
Type	**IgG**	**IgA**	**IgM**	**IgE**	**IgD**
%	80%	10-13%	5-8%	1-2 %	1%
Mol. weight	1.5 lac	1.6 lac	9 lac	1.9 lac	1.8 lac
Physical state	Monomer	Monomer/ **Dimer (Secretory Ig A)**	Monomer **/Pentamer**	Monomer	Monomer
No. of antigen binding sites	2	4	10	2	2
Antigenic Determinant	Gamma	Alpha	Meu	Delta	Epsilon
Hinge region	Present	present	**Absent**	Present	Present
J- chain	Absent	**present**	**present**	Absent	Absent
Function	Neutralization, agglutination, Complement activation, **opsonisation,** ADCC	Neutralization, agglutination and trapping of pathogens in mucous. It cannot act as opsonin.	Neutralization, agglutination, Complement activation, Monomer form act as B cell receptor	Involved in immediate hypersensitivity reaction and defence against parasitic infection	Act as B cell receptor
Occurrence	Found in blood, lymph and intestine	Present in almost all body secretions (saliva, tears, milk, bronchial secretions, vaginal secretions etc.)	Found in blood and lymph	Found on mast cells and basophils	Found in blood and lymph
	Only antibody that crosses placenta. Main antibody in secondary immune response		First antibody produced by foetus. First antibody produced in primary immune response		
Fixes Complement	**Yes**	No	**Yes**	No	No

- Soluble B cell receptors are also termed as antibodies
- **Paratope:** antigen binding site on antibody
- **Class switching (Isotype switching/ Class switch recombination):** is a process whereby an activated B cell changes its antibody production from IgM to either IgG, IgA or IgE depending on requirements
- Hinge region of antibody is rich in protein
- Hypervariable regions on variable portion of antibodies are termed as hotspots
- Portion of antibody recognise antigen is Fab
- Blocking antibody: prevents other antibodies from combining with specific antigen
- Monoclonal antibody (magic antibody)- are man-made antibodies made by cloning using hybridoma technology
- Surface Plasmon Resonance (SPR)- method used to know antibody affinity for an antigen

Cytokines

Cytokines are small proteins released by cells and control growth and activity of cells that are involved in immune and inflammatory responses of body. They are of different types:

Lymphokines	secreted by lymphocytes
Monokines	secreted by monocytes and macrophages
Interferons (IFNs) • Are host specific • low mol. weight	soluble glycoproteins produced and released mainly from cells in response to virus infection. Types: • Type I interferons: Alpha-interferons: produced by leukocytes and Beta-interferons: produced by fibroblasts. • Type II interferons (**Gamma-interferons/Immune IFN**): released by cytotoxic T cells and type 1 helper cells.
Interleukins (IL)	group of proteins that act as cytokines i.e. mediate communication between cells and regulate cell growth, differentiation and stimulate immune responses. Eg. IL-1 to IL-15.
Colony Stimulating factor (CSFs)	cytokines that stimulate the production of blood cells. Eg. Granulocyte-CSF (G-CSF), Macrophage- CSF (M-CSF), Granulocyte Macrophge-CSF (GM-CSF) etc.

Function of cytokines:

- Cytokines mediate innate immunity
- Regulate growth, activation and differentiation of lymphocytes (eg. IL-2, IL-4 favours while IL-10 antagonistic effect)
- Recruit inflammatory cells to site of inflammation (eg. IL-2)
- Stimulate production of blood cells (eg. Colony stimulating factor)
- Help in class switching of antibodies (eg. IL-4) and increase in antibody production by B lymphocytes
- Regulate function of macrophages (Gamma interferon activates macrophages while IL-10 prevents the activation of macrophages)

Major Histocompatibility Complex (MHC)

MHC are proteins present on cell surface and are mainly involved in presenting antigen to T lymphocytes for recognition. They are mainly of 2 types:

MHC class I	MHC class II
• MHC I are present on all nucleated cells, virus infected cells • Has 3 extracellular domain (Peptide binding groove is closed at both ends) • MHC class I present endogenous antigen that originate from cytoplasm to Cytotoxic CD8+ T Cells and ultimately destruction of antigen take place	• MHC II are present on antigen presenting cells (dendritic cells, macrophages and B cell) • Has two extracellular domain • MHC class II present exogenous antigen that originate extracellularly from foreign bodies such as bacteria to Helper CD4+ T cells for recognition and stimulate B cells to produce antibodies and attract immune cells for destruction of antigen

Complex System (Complement cascade)

- Complement system consists of small proteins circulating in blood in inactive forms and are synthesized by liver
- C3a & C5a are potent anaphylatoxins
- Guinea pig serum is rich in complement
- Discovered by **Jules Bordett**

They are activated by 2 major pathways:

Classical pathway (occurs rapidly)	**Alternative pathway** (occurs slowly)
This is initiated by fixation of C1 to antigen-antibody complexes C3 convertase: C4bC2a	This is initiated by non-immunological stimuli such as microbial surfaces, complex polysaccharides or aggregated IgA C3 convertase: C3bBb
Both pathways converge into a common terminal and produces pore like Membrane Attack Complex-C5b9 (MAC) that causes pore like holes in cell membrane of invading bacteria causing swelling which ultimately leads to bacterial death	
Function of complement system: • Activation of inflammation process • Opsonisation of pathogens for phagocytosis, clearance or destruction • Direct killing of target cells by lysis • Agglutination: causes clustering and binding of pathogens	

Hypersensitivity Reactions		
Type	**Pathogenesis**	**Example**
Type I hypersensitivity (Immediate hypersensitivity)	Binding of Specific allergen to the IgE induces degranulation of mast cells	Anaphylaxis, Asthma, Allergy
Type II hypersensitivity (Antibody Mediated Cytotoxic hypersensitivity/ Tissue specific reactions)	IgG or IgM binds to cellular antigen leading to complement activation and cell lysis. IgG can also mediate ADCC with cytotoxic T cell, natural killer cells.	Auto-immune haemolytic anaemia, Blood Transfusion reactions, Erythroblastosis foetalis in humans, Good Pasture Syndrome
Type III hypersensitivity (Immune Complex mediated hypersensitivity)	Antigen-antibody complexes are deposited in tissues. Subsequently complement activation provide inflammatory mediators and recruit neutrophils. Enzymes released from neutrophils damage tissue	Arthus Reaction (local reactions), Serum sickness (systemic reaction), Blue eye, Glomerulonephritis, vasculitis
Type IV hypersensitivity (Cell mediated/ Delayed Hypersensitivity)	Antigen stimulated type 1 helper T cells (Th 1) that releases cytokines which produces inflammation and tissue damage	Tuberculosis, Contact dermatitis, transplant rejection
Type V hypersensitivity (Stimulatory hypersensitivity)	Antibodies are produced with property of stimulating specific cell targets	Grave disease

Difference between live (attenuated) vaccine and killed vaccine (BR Singh, 2009)

Live (Attenuated) vaccine	Killed vaccine
Duration of immunity is long	Short
No requirement of adjuvant	Requirement of adjuvant
More potent than killed vaccine	Less potent
Oral dosing- good immunity	No or poor immunity
Should not be administer in immunodeficiency diseases	Administered
Usually single dose required	Multiple or booster dose is required

Cross protection from related strains-Yes	Rare
Cost of the vaccine- less	More
Potential for use in multivalent combination- less	Good
Stability and maintenance- poor and difficult (Mandatory refrigeration required)	Good and easy (Can be stored without refrigeration)
• *B. abortus* strain-19 vaccine • *B. abortus* strain RB51 vaccine • Coccivac • Swine fever vaccine • Anthra spore vaccine	• *B. abortus* strain 45/20 vaccine • Salk polio vaccine • Tetanus toxoid • Rabies vaccine

- Term vaccine and vaccination was coined by Edward Jenner
- The first vaccine was developed by Louis Pasteur
- Virulence enhancement of an organism is termed as exaltation
- Adjuvants are substances administered with vaccine to enhance immunogenicity of vaccine. Eg. Freund's complete adjuvant-FCA (water-in-oil emulsion), Freund's incomplete adjuvant (FIA), aluminium salts- aluminium hydroxides etc
- Bacterial ghost (BG) are empty cell **envelops of bacteria** and are potent activator of cells involved in immunity. They also act as vehicle for antigen delivery

Common Vaccine	Strain/Remarks
Haemorrhagic septicemia	P-52
Black Quarter	S-49
PPR	Sunyri
Swine Fever	Hudson
Bruvax (Indian Immunologicals)- Brucellosis	Strain-19 ($4* 10^{10}$ organism in each dose)
Toxovax (Toxoplasmosis)	S-48 (Tachyzoits from sheep)
Pyrodol MASP (Babesiosis)	Micro Aerophillus Stationary Phase
Tick-Gard (Australia)	Bm-86 antigen for *Boophillus microplus*
GAVAC (Cuba & South America)	
Raksha Vac-T (Theileriosis)	$2* 10^6$ schizont infected lymphoblast
Marek Disease	HVT-FC 126 & SB-1
Cocci vac 8	Oocyst from 8 precocious lines of Coccidia
Myiasis vaccine (Lucila)	PM-44, 48, 95 (PM-peritrophic membrane)
Dictol	Dictyocaulosis in cattle

Chapter-6

Veterinary Helminthology

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- The word 'parasite' is derived from the Greek word and means 'besides food" (Para-beside, sitos - food).
- Erratic or aberrant or ectopic parasites are present in locations that are not their usual site
- Parasites with a narrow host range are referred to as Stenoxenous parasites
- parasites with a wide host range are known as Euryxenous parasites
- Transport host: host which transfer only non-developing phase of parasite to another host
- Protelean parasite: parasite which is parasitic in its larval stage
- Paedogenesis: reproduction by larval or young form of parasites
- SNOAPAD- Standard Nomenclature of Animal Parasitic Diseases

Class: Trematoda (Flukes)

- Characterized by composite eggs
- Life cycle: egg- miracidium (infects 1st intermediate host) -sporocyst- redia- cercaria- metacercaria
- **Redia stage is absent** in Dicrocoeliidae, Schistosmatidae, Prosthogonimidae
- Paedogenesis: common in trematodes

Family- Fasciolidae

Species	Synonym/ Host	Disease/ lesions/ remark
Fasciola hepatica (Gymnocephalous cercaria)	Common liver fluke/Sheep liver fluke I.H- Water Snail (*Lymnae truncatula*) Apical cone is very prominent Found in Semi-temperate region	Acute fascioliosis (fluke > 1000)- common in sheep Chronic fascioliosis (200+)- hyperplastic cholangitis, hepatic fibrosis **(Clay Pipe stem liver)**, sub-mandibular oedema **(Bottle Jaw)** Egg- Golden yellow colour (not distinct operculum) MM3 coprotest is done
Fasciola gigantica	I.H- Snail (*Lymnae auricularia*) Apical cone is not prominent Found in tropical region	
Fascioloides magna		
Fasciolopsis buski (pig and man)	Water chest nut I.H- Snail (*Helicorbis coenosus*)	

Family- Dicrocoeliidae

Redia stage absent
Two intermediate host
1. **Land snail**
2. Ants

Dicrocoelium dendriticum (Lancet fluke/ Blade fluke/ Needle fluke)	Forms slimeball (clumps of cercaria)	Xiphoid cercaria (cercaria vitrina)- long tail
Eurytrema pancreatum	Pancreatic liver fluke	

Family- Ophisthorchidae

Two intermediate host
1. **Water snail**
2. Fish

Ophisthorchis caninus (O. noverca)	Liver fluke of dog Y-shaped excretory organ	Cholangitis/ Cholangiocarcinoma/ Cirrhosis of liver
Ophisthorchis tenuicolis (O. felineus)	Liver fluke of cat	
Clonorchis sinensis	Chinese liver fluke	

Family- Paramphistomatidae

- Also known as **Plug feeder or stomach flukes** and disease caused by them is knowns as **Amphistomiasis/ pitto/ Gillar/Bissi**
- Larval forms are infective
- Characterized by presence of pharyngeal pouch

Paramphistomum cervi		Persistent foetid diarrhoea (duodenitis), abdominal pain Egg- transparent (colourless) with presence of distinct operculum
Cotylophoron cotylophorum		
Gastrothylax crumenifer		
Gigantocotylle explanatum	Biliary amphistomosis	
Gastrodiscus aegyptus		
Gastrodiscus secundus		
Gastrodiscoides hominis	Colon of pig, monkey	
Pseudodiscus collinsi	Colon of equine	

Family-Schistosomatidae (Blood Fluke)

- Redia stage absent
- Male have gynaecophoric canal in which female lives
- Cercaria stage (fercocercus cercaria- bifurcated tail) is infective
- Actinobody formation
- Concommitant immunity develops

Schistosoma nasalis (I/H- Indoplanorbis exustus-water snail)	Nasal vein of ruminant and horses	Nasal Schistosomiasis (Nasal granuloma/ Sunsuna/ Snoring disease)
Schistosoma indicum (I/H- Indoplanorbis exustus)	Portal and mesenteric vein of cattle	Hepato-intestinal Schistosomiasis
Schistosoma spindale (I/H- Indoplanorbis exustus)	Mesenteric vein of ruminant and dog	
Schistosoma incognitum (I/H- Lymnae luteola)	Mesenteric vein of pig and dog	
Schistosoma haematobium	In urinary bladder	Urinary Schistosomiasis
Ornithobilhazia bomfordi	Mesenteric vein of ruminant	
Bivitellobilharzia nairi	Mesenteric vein of elephant	

Cercarial dermatitis/Swimmer's itch/ Swamp itch/Collector's itch- **in humans**

Family-Paragonimidae (Lung fluke)

Two intermediate host
1. snail
2. **Crab/cray fish**

Paragonimus westermani (Microcercus cercaria-short tail) Rossette shape uterus	Lung of dog, cat, pig	Causes metaplasia and result into Hazel-Nut like cyst formation in lungs Clinical manifestation and X-ray picture overlap pulmonary tuberculosis
Family-Prosthogonimidae		
• Redia stage absent Two intermediate host • Water snail • Nymphal stage of dragon flies		
Prosthogonimus ovatus (*P. indicus*)		Penguin like movement in birds (Laying of leathery eggs)

Class: TAPEWORM (Eucestoda)

Larval stage is termed as **Bladder worm (cyst/metacestode stage)** which is infective to direct host
The head (scolex) is provided with suckers and rostellum which may be armed (hooks) or unrmed (no hooks)
Body is segmented (segments are termed as strobila- strobilia consists of proglottids)
Release of gravid proglottids is termed as apolysis
Cestodes eggs are non-operculated except cotyloda members

Family: Davaineidea (Tapeworm of poultry)

Rostellum and sucker bear one or more row of hooks

Species	D.H	I.H	Disease/lesions/remark
Davainea proglotina Hammer shaped hooks Egg capsule contains 1 egg	Poultry	Arthropods	**Dwarf or smallest or most pathogenic tapeworm of poultry** Causes Haemorrhagic enteritis
Rallietina tetragona Egg capsule contains 6-12 eggs Oval suckers	Poultry	Arthropods	**Largest tapeworm of poultry**
Rallietina echinobothridia Egg capsule contains 6-12 eggs Circular suckers	Poultry	Arthropods	(Nodular Tapeworm of Poultry) Causes Nodular taenosis **Windows** in gravid segment
Rallietina cesticellus Hooks absent Egg capsule contains 1 egg	Poultry	Arthropods	
Cotugnia digonopora Egg capsule contains 1 egg Cup like suckers	Poultry	Arthropods	Have two sets of reproductive organ hence known as **Double Pored Tapeworm of Poultry**
Family: Dilepididea			
Dipylidium caninum Egg capsule contains 1 egg Rose thorn shaped hooks Gravid segment resemble Cucumber seed	Dog	Flea or Louse **Flea-** Ctenocephalides canis/ C. felis **Louse-** Trichodectus canis	Commonest tapeworm of dog Known as Double Pored Tapeworm of Dog Larval stage is cysticercoid Uterus contain many capsule Ovary and vitelline gland look like Bunches of grapes
Choanotaenia infundibulum	Poultry	Musca domestica & Beetles	

Amoebotaenia sphenoides *Amoebotaenia cuneata* Bottle shaped rostellum	Poultry	Earthworm	Uterus is sac like Triangular tapeworm of poultry
Family: Anoplocephalidae			
Rostellum and hooks absent			
Anoplocephala perfoliata Dwarf or Lappet tapeworm of horse	Horse	Oribatid mites	Causes depressed ulcerative lesions Larval stage- cysticercoid
Anoplocephala magna	Horse	Oribatid mites	**Largest tapeworm of horse** Larval stage- cysticercoid
Moniezia benedeni **(Sheep tapeworm)** Gravid segment looks like Cooked Rice Grains Inter-proglottidal gland (multi-layered) present in form of ring	Ruminants	Grasshopper	Egg contains triangular pyriform apparatus Have two sets of reproductive organ hence known as **Double pored tapeworm of Ruminants**
Moniezia expansa	Ruminants	Grasshopper	Inter-proglottidal gland (unilayered) present in form of band Egg contains rectangular or square pyriform apparatus
Stilesia hepatica	Ruminants		**Bile duct tapeworm** Uterus- Dumble shaped
Avitellina centripunctata	Ruminants	Psocids	Uterus- sac like
Thysanosoma actinoids	Ruminants	Psocids	**Fringed tapeworm**
Thysaniezia giardia (Helictometra)	Ruminants		Irregular appearance Lateral testes
Gravid uterus is replaced by paruterine organ in Avitellina, Stilesia, and Thysanosoma spp. and these species are also characterized by absence of vitelline gland			
Family: Taenidae			
Scolex bears two rows of hooks			
Taenia saginata **(hookless taenia)** **Motile gravid segment**	Man	Cattle Site- muscles	Larval tapeworm- Cysticercus bovis
Taenia solium (Auto-infection also occurs)	Man	Pig Site- muscles	Larval tapeworm- Cysticercus cellulosae
Taenia multiceps	Dog	Sheep Site- CNS	Larval tapeworm- Coenurus cerebralis – causes Gid/sturdy/staggers/ warbling (Pressure atrophy)
Taenia hydatigena	Dog	Sheep Site- peritoneal cavity	Larval tapeworm- Cysticercus tenuicolis Hepatic cysticercosa
Taenia ovis	Dog	Sheep Site- muscles	Larval tapeworm- Cysticercus ovis
Taenia pisiformis	Dog	Rabbit Site- peritoneal cavity	Larval tapeworm- Cysticercus pisiformis
Taenia serialis	Dog	Rabbit Site- Connective tissue	Larval tapeworm- Cysticercus serialis
Taenia taeniformis	Cat	Rodents Site- liver	Larval tapeworm- Cysticercus fasciolaris (strobilocercus)

Echinococcus granulosus	*Echinococcus multilocularis*
• Smallest and commonest dog tapeworm • Larval tapeworm- unilocular Hydatid cyst • Longer penultimate segment • Arc 5 antigen present • **Ovary- Kidney shaped** • Direct host- Man • Intermediate host- Mammals (Lung & Liver) • Strain is highly host specific ➢ **Cattle- G5 & Buffalo- G3** ➢ **Sheep- G2 & Horse-G4** ➢ **Pig-G7 & Camel-G6** ➢ **Cervids-G8 & G10** • Sheep strain is involved in human infection	• Larval tapeworm- multilocular Hydatid cyst • Smaller Antepenultimate segment • Metastasis common • Direct host- Dog, fox • Intermediate host-Rodents, man (Liver)

Family: Mesocestoididea (Cyclophyllidean)			
Characterized by presence of sucker, branching of uterus, absence of uterine pore and non-operculated eggs			
Mesocestoides lineatum • Suckers have no hooks • Ovary and vitellaria- bilobed • Par-uterine organ	Dog	Two intermediate host 1. Arthropods (mites) 2. Mammals	Larval tapeworm in arthropods- Cysticercoid Larval tapeworm in mammals- Tetrathyridium
Family: Diphyllidea (Pseudophyllidean)			
• Characterized by presence of bothridia, absence of branching of uterus, presence of uterine pore and operculated eggs • Ciliated embryo knowns as Coracidium			
Diphyllobothridium latum (Fish tapeworm) Rossete shaped uterus	Dog, cat, pig, man (fish eating mammals)	Two intermediate host- 1st – Cyclops 2nd – Fresh water fish	Larval tapeworm in cyclops- Procercoid Larval tapeworm in Fresh water fish- Plerocercoid (causes ligulosis in fishes)
Spirometra mansoni Spiralled shaped uterus Mid-ventral uterine pore	Cat, dog	Two intermediate host- 1st – Cyclops 2nd – Water snails	**Broad fish tapeworm** Larval tapeworm in cyclops- Procercoid Larval tapeworm in Fresh water fish- Plerocercoid larva known as Sparganum (causes sparaganosis)

Phylum: Nematoda (roundworms)	
Order- Ascarididae	
Family	**Genus**
Ascarididae	Ascaris, Parascaris Toxascaris Toxocara
Oxyuridae	Oxyuris Enterobius Skrjabinema
Order- Rhabditida	
Rhabditidae	Rhabditida

Strongyloididae	Strongyloides
Order- Strongylida	
Strongylidae	Strongylus Triodontophorus Chabertia Oesophagostomum
Stephanuridae	Stephanurus
Syngamidae	Syngamus; Mommomanogamus
Ancylostomatoidae	Ancylostoma Uncinaria Gaigeria Bunostomum
Trichostrongylidae	Trichostrongylus Cooperia; Paracooperia Nematodirus Haemonchus Mecistocirrus Marshallia Ostertagia
Protostrongylidae	Protostrongylus; Metastrongylus Muellerius
Dictyocaulidae	Dictyocaulus
Order- Spirurida	
Spiruridae	Habronema
Thelazidae	Thelazia Tetramere Oxyspirura Spirocerca Gongylonema
Gnathostomatidae	Gnathostoma
Filaridae	Dirofilaria; Parafilaria Elaephora
Setaridae	Setaria
Stephanofilaridae	Stephanofilaria
Onchocercidae	Onchocerca
Dracunculidae	Dracunculus
Order- Enoplida	
Trichuroidae	Trichinella; Trichuris
Capillaridae	Capillaria
Dioctyophymidae	Dioctophyma

Nematodes

- Mainly direct life cycle
- Bursa (present in male) in family members of Metastrongylidae. Strongylidae and Trichostrongylidae and members known as bursate nematode
- Infective stage is L_3 larva (in most nematodes), L_2 larva (Ascarididae) and L_1 larva (in Trichuris, Trichinella and Capillaria)
- Hypobiosis- arrested development of juvenile helminths in direct host

Family: Ascarididae

Species	Characteristics/Lesions/Diseases
Ascaris suum	Found in small intestine of pig Symptoms similar to Thumps and Piglet anaemia

		Milk spot/White spot on liver
Parascaris equorum		Found in small intestine of equine Causes **Summer Cold** in Europe
Toxascaris leonine		Found in small intestine of Dog, cat, fox Arrow Headed worm of dog and cat
Toxocara vitulorum ***(Neoascaris vitulorum)***		Found in small intestine of Cattle, buffalo, sheep, goat Causes mortality in new borne calves often get infected through transcolostral/Transmammary route Mud coloured smelling faeces with steatorrhoea
Toxocara canis Paratenic host- Mice		Found in small intestine of Dog, fox Prenatal infection of pup through placenta is very common during 8th week of gestation
Toxocara cati Paratenic host- Rat		Arrow Headed worm of cat
Oxyuris equi (hour-glass shaped oesophagus and pin shaped spicules)		Found in large intestine of equines Rat tailed condition with anal pruritis Horse pinworm/False whipworm
Enterobius vermicularis		Human pin worm/seat worm
Skrjabnema ovis		Pinworm of sheep
Heterakis gallinarum		Caecal worm of poultry In egg of this nematode, protozoa- Histomonas meleagridis is found Causes- Nodular Typhlitis
Ascaridia galli		Found in small intestine Largest nematode of poultry Causes haemorrhagic enteritis
Family- Rhabditidae		
Rhabditis bovis		Bovine parasitic ootitis
Family- Strongyloididae		
Strongyloides papillosus		Thread worm of ruminants
Strongyloides westeri		Small intestine of Horse pig zebra
Strongyloides stercoralis (larva- currens larva)		Dog, fox, cat, man Auto infection and hyper infection is possible
Strongyloides cati		Small intestine of cat
Strongyloides ransomi		Small intestine of pig
Strongyloides avium		Small intestine of poultry
Family- Stronylidae (Palisade worm/Strongyles)		
Strongylus spp. known as Red worms and follow diapause phenamenon Anthelmintic resistance against benzimidazole is reported on small stronyles of equine. Anthelmintic resistance is detected by FECRT- faecal egg count reduction testing Large strongyles of equines are termed as Sclerotomes		
Strongylus vulgaris **(Blood worms)**	**(Palisade worm)** **Equines**	Large intestine and in aorta 2 ear shaped dorsal teeth Most pathogenic & smallest among strongylids Thrombosis and aneurysm in aorta
Strongylus equinus		Large intestine One large bifid dorsal teeth Haemorrhagic nodules
Strongylus edentates		Large intestine Teeth are absent
Triodontophorus spp.		Haemorrhagic ulcer
Oesophagostmum spp. known as Nodular worm and causes Pimply gut or Knotty gut (Formation of Suppurative nodule in intestinal wall)		

Oesophagostmum radiatum	Colon of cattle and buffalo
Oesophagostmum columbianum	Colon of sheep and goat
Oesophagostmum aspersum	Large intestine of sheep and goat
Oesophagostmum multifoliatum (O. indicum)	
Oesophagostmum venulosum	Colon of Sheep goat camel deer Only species of Oesophagostomum which doesn't causes nodule formation
Chabertia ovina	Sheep goat cattle
Family- Stephanuridae	
Stephanuru ntatus Earthworm act as transport host as well as paratenic host	Stout worm or Kidney worm of swine Found in pairs within cyst Posterior paralysis Stiffness of leg due to pre-crural nodules Nodule on skin
Family- Syngamidae	
Syngamous trachea (Y-shaped) Chicken also act as transport host	Gapeworm/Redworm/Forked worm of poultry Present in trachea and causes nodule formation which lead to gaping movement in birds
Family- Ancylostomatoidae	
• Rodents & cockroaches act as transport host • Ancylostomosis is characterized by tarry coloured faeces and papery white mucus membrane	
Ancylostoma caninum	Hookworm of dog Small intestine of dog 3 pair teeth in buccal capsule
Ancylostoma braziliense	Small intestine of dog and cat 2 pair teeth in buccal capsule
Ancylostoma tubaeforme	Small intestine of dog
Uncinaria stenocephala	Hook worm of dog and cat in North America
Bunostomum phlebotomum	Hookworm of ruminants (mainly cattle)
Bunostomum trigonocephalum	Hookworm of ruminants (mainly sheep and goat) Sub-ventral lancets & cutting plates
Family- Trichostrongylidae (Gastro-intestinal nematodes)	
Trichostrongyles of small intestine	
Trichostrongylus colubriformis	**Bankrupt worm/ Black Scour worm** Cattle sheep goat camel Calves shows typical ringworm like lesions (raised plaques) due to adult worm Formation of tunnel beneath skin Protein losing gastroenteropathy-hypoalbuminemia Abnormality in mineral metabolism (Ca & P) Arrested bone growth and osteoporosis
Trichostrongylus axei	**Abomasum** of bovines, sheep, goat
Cooperia punctate, Cooperia pectinata	Cattle & buffalo
Cooperia curtcei	Sheep Goat Pathogenesis similar to Trichostrongylus spp.
Paracooperia nodulosa	Buffalo calves
Nematodirus filicolis	Cattle, sheep goat Infection is conducive for formation of Cl. Welchii toxins resulting in pulpy kidney disease
Nematodirus spathiger	Long worm of Ruminants Spicules spoon shaped

Stomach worm of ruminants	
Haemonchus spp. – Blood sucking abomasal nematodes of sheep goat cattle Also known as Wire worm or Twisted worm or Barber's pole worm	
Haemonchus contortus	Sheep and goat Vulval flaps present
Haemonchus placei	Cattle
Haemonchus longisteps	Camel
Mecistocirrus digitatus Morphology similar to H. contortus but vulval flaps absent	Cattle buffalo sheep goat pig Bursa-Pincer shaped Oedema of submandibular region Dry and scanty faeces
Marshallia marshalli	Sheep goat
Ostertagia ostertagi Brown stomach colony worm of cattle	Ostertagiasis causes changes in gastric glands of the abomasum & result in protein indigestion Moracco leather appearance od abomasal mucosa Type 1 Ostertagiasis in calves: Morbidity is high Type 2 Ostertagiasis in yearlings: Mortility is high
Ostertagia leptospicularis	Cattle
Ostertagia circumcincta	Sheep goat
Family- Dictyocaulidae (Lungworms having direct lifecycle)	
Dictyocaulus viviparous Milky white in colour In lungs, they give appearance of Lumps of Broken Thread	Lungworm of cattle Boat or sock shaped spicules Causes parasitic catarrhal bronchitis (Husk/Hoose/Verminous pneumonia/Fog fever syndrome/Dictyocaulosis) Pilobolus fungus help in transmission of larva of lungworms
Dictyocaulus filaria	Lungworm of sheep goat
Dictyocaulus arnfieldii	Lungworm of equines
Family- Protostrongyloidae (Lungworms having indirect lifecycle)	
Metastrongylus elongates (M. apri)	Lungworm of Pig Intermediate host- Earthworm Lesions are similar to tuberculous nodule
Filaroids asleri	Lungworm of Dog
Anafilaroids rostratus	Lungworm of Cat
Protostrongylus rufescens	Lungworm of Sheep and goat
Muellerius capillaris	Commonest Lungworm of Sheep
Angiostrongylus cantonensis	Lungworm of rat Zoonotic importance- causes Eosinophilic meningitis in humans
Family- Spiruridae	
Habronema spp. commonly known as Stomach Worm of Equine When larva of Habronema spp. deposited on broken skin, they causes **Summer sore or Granular dermatitis or Cutaneous habronemiasis or Bursati**	
Habronema megastoma (Drashia megastoma)	Rarely free in stomach Tumour of stomach wall Intermediate host: Musca domestica & Stomoxys calcitran (Stable fly)
Habronema microstoma (H. majus)	Free in stomach Intermediate host: Stomoxys calcitran
Habronema muscae	Free in stomach Intermediate host: Musca domestica

Family- Thelazidae		
Thelaria rhodesii (T. bubalis)	**Eyeworm**	conjunctival sac and lacrimal duct of cattle
Thelaria lacrymalis		aqueous humour and lacrimal duct of horse
Thelaria callipeda		Found under nictating membrane of dog
Oxyspirura mansoni		**Eyeworm of bird** nictating membrane of fowl and turkey
Tetrameres mohtedai		Commonest nematode found among desifowl
Spirocerca lupi (C/B 2 lips) (Dog oesophageal worm) Egg is smallest in nematodes and gelatin capsule shaped		Intermediate host: Beetles Paratenic host: Garden lizard Spirally coiled worm and pink in colour Causes osteosarcoma in oesophagus
Gongylonema pulchurum (Gullet worm) C/B bosses		Found in oesophagus of cattle sheep goat pig
Gongylonema verrucosum		Found in rumen of cattle sheep goat deer zebra
Gongylonema ingluvicola		Crop of fowl
Family- Gnathostomatidae		
Gnathostoma spinigerum Eggs are ornamental C/B baloonets		Found in stomach of dog and cat Intermediate host: cyclops and fresh water fishes Causes yellow mosaic marking on liver during migration
Family- Filaridae		
• Members are viviparous and Larval stages are termed as microfilaria		
Dirofilaria immitis Heart worm of dog (Found in right ventricle, pulmonary artery and posterior vena cava in dog) Diagnosed by Knott test		Intermediate host/vector- mosquito (Aedes/Culex/Anopheles) Causes post venal caval syndrome In man produces typical coin like lesions in X-ray
Dirofilaria repens		Subcutaneous tissue of dog and cat
Parafilaria bovicola (I/H- House fly)		Causes **Bleeding Sore** (Haemorrhagic nodules in skin) in cattle and buffalo in summer
Parafilaria multipappilosa Found in subcutaneous tissue and intramuscular tissue in equines		Intermediate host- Haematobia spp. (H. atripalpis) Causes **Summer Bleeding or Haemorrhagic filariasis or parasitis dermatorrhagia or verminous haemorrhagic dermatitis**
Elaephora poeli		Aorta of cattle and buffalo
Elaephora Schneider		Common carotid and internal maxillary arteries of sheep, deer
Family- Setaridae		
Commonly found in peritoneal cavity of ungulates		
Setaria labitopappilosa		Found in cattle Sheep
Setaria digitata Found in cattle buffalo sheep goat horse Intermediate host- Mosquitoes (Aedes, Culex, Anopheles)		Causes cerebrospinal nematodiasis or lumbar paralysis or Filariosis of Central Nervous System in Sheep and goat Causes Necrotising encephalomyelitis (malacia) also known as KUMRI/Equine paraplegia
Setaria equine Found in equines		Intermediate host- Mosquitoes (Aedes, Culex, Anopheles) Causes Ocular Setariasis
Family- Stephanofilaridae		
Stephanofilaria assamensis		Causes hump sore or chronic dermatitis or Verminous cascade or DUM-DIM in Indian cattle
Stephanofilaria zaheeri		Causes Ear sore in Indian Buffaloes

Stephanofilaria andamani	Found in elephant
Family- Onchocercidae	
Onchocerca gutturosa Vector- Simulium (black fly)	Cattle (connective tissue of ligamentum nuchae)
Onchocerca armillata	Found in aorta of Cattle buffalo sheep goat and causes Aneurysm and Atheroma of aorta.
Onchocerca gibsoni (vector- Cullicoides)	Brisket and external surface of hindlimbs of Cattle Produce Worm Nest or Worm Nodule- A swelling in brisket or neck or flank region of cattle containing worms of Onchocerca spp.
Onchocerca cervicalis (O. reticulata) Tendon of foot and suspensory ligament of fetlock Vector- Cullicoides nubeculosus	Causes- **Poll-evil and fistulous wither with Brucella abortus and Actinomyces spp. termed as Dermatitis/ Summer Mange/ Knootle/ Microfilariae Pityriasis/ Protein Rash/ Lichen Tropicus**
Onchocerca linealis	Pectoral muscle of Cattle
Onchocerca fascilata	Subcutaneous tissue of camel
Onchocerca volvulus	Humans (vector-Black fly)
Onchocerca lupi	Canine and feline Ocular onchocerciasis
Brugia pahangi	Domestic cats and wild animals
Family- Dracunculide	
Dracunculus medinensis	Guinea worm/ Serpent worm/ Fire worm Man dog horse cattle
Family- Trichuroidae	
Trichinella spiralis (Autoheteroxenous parasite) Pig act as direst host as well as intermediate host	Adult live in small intestine of man, pig, rat and other animals while larva live in striated muscle cell known as Nurse cell Spicules are absent
Family- Trichuridae	
Trichuris means Hair tail. Trichuris spp. known as **Whip worm** and present in caecum and colon, egg is barrel shaped with plug at both end. Stichosome is present.	
Trichuris ovis	Cattle buffalo sheep goat camel
Trichuris discolor	Cattle buffalo sheep goat camel
Trichuris vulvis	Dog
Trichuris trichura (T. suis)	Pig
Family- Capillaridae	
Capillaria bilobata	Cattle goat
Capillaria annulata	Crop and proventriculus of fowl egg is barrel shaped (colourless) with truncated plug
Capillaria columbae	Fowl
Family- Dioctophymidae	
Dioctophyma renale Found in kidney usually in right kidney Geohelminth 1st intermediate host- Leech 2nd intermediate host-Fish	• Giant kidney worm of dog • Blood red coloured worms • egg is barrel shaped • Single spicule nematode of dog • Kidney looks like Bag of water

Chapter-7

Veterinary Entomology and Acarology

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PHYLUM- ARTHROPODA 2 Class of Veterinary importance	
INSECTA: It has 5 order 1. DIPTERA **(Mosquitoes, Midges, Gnats & Flies)** 2. SIPHONOPTERA (APHANIPTERA) **(Fleas)** 3. MALLOPHAGA **(Biting lice)** 4. SIPHUNCULATA (ANOPLURA) **(Sucking lice)** 5. HEMIPTERA **(Bugs)**	**ARACHNIDA** It has one order: ACARINA having 2 suborder 1. IXODOIDEA (has 2 sub family) **A. Argasidae (Soft ticks)** **B. Ixodidae (Hard ticks)** 2. SARCOPTIFORMEA

- Nymph is only seen in hemimetabolus (Incomplete metamorphosis) condition and found in life cycle of Lice, Bugs, ticks and mites. Nymph never enters in pupal stage.
- Pupa Stage: characteristics of holometabolus (complete metamorphosis) condition and found in life cycle of flies, fleas

Order: DIPTERA

Family: Culicidae (Mosquitoes)

Pupa - tumbler
Larva - Wriggler

Genera/ Species	**Characteristics**	**Lesions/Disease/Remark**
Anopheles spp.	Egg with floats (winged) Breeding place-running water	Spotted wings
Aedes spp. (Tiger/Forest mosquito)	Egg without floats Breeding place-water in cans	Abdomen has black & white rings
Culex spp. (Nuisance mosquito)	Breeding place-stagnant water Eggs are layed in group and are of cigar shaped	Better flier Transmit avian malaria and JE, West Nile virus
Family: Ceratopogonidae (Biting midges/No-see-ums)		
Culicoides spp.	Minute (very small) in size	Transmit Blue tongue, African Horse sickness, Bovine ephemeral fever
Family: Psychodidae (Sandflies)		
Phlebotomus spp.	They resemble mosquitoes but are hairy and active at night	Eggs have black eye spot V-shaped wings
Family: Simulidae		
Simulium spp (Buffalo gnats/ Black fly/Turkey gnats/White socks)	Hump backed dark colour wing veination, Active at sunset Boiling water with mass emergence appearance	Beaded Antenaa like horns Obtectate pupa Male and female both suck blood

Family: Glossinidae		
Glossina spp. (Tsetse fly/Tiktik fly)	Cleaver shaped discal cells	Transmit African trypanosomiasis
Family: Tabanidae		
Tabanus spp. (horse fly/Marsh fly/Breeze fly/Green heads) Larva is carnivorus and has Grabers organ (respiration)	Inactive at night (Obtectate pupa) Biting & sponging mouth Hexagonal shaped discal cells **Eggs- cigar shaped and stratified**	Vector of Surra and EIA Pupa has ear shaped spiracles & caudal aster on terminal abdominal segment
Chrysops spp. (deer fly)	Dark band across wings	
Haematopota spp.	Mottled/ speckled wings	
Family: Gastrophilidae		
Larva fund in dung and known as Stomach bots and possess spine Adult have vestigeal mouth, hence cannot feed and live to deposit egg		
Gastrophillus intestinalis (horse bot fly)	Deposit egg on hair of forelegs mainly	Bean shaped posterior spiracle in larva
Gastrophillus nasalis	Deposit egg under jaw in inter mandibular jaw	
Family: Oestridae (Warble fly, nasal bot fly)		
Larva of warble fly is called Grub		
Oestrus ovis (Sheep nasal bot fly)		Causes False Gid (erosion of frontal bone)
Hypoderma spp. (warble fly of sheep, goat, cattle) • Causes Butcher's Jelly or Licked beef in cattle • Warble: oedomatous swelling on back of neck region		
H. lineatum (cattle)	Found in India Deposit egg on hair of hoof mainly	Produce buzzing sound
H. bovis (cattle)		
H.crossi (goat)		
Family: Muscidae (House fly & stable fly)		
M. nebulo	Common bazaar fly	
M. vicina	House dwelling fly	
M. crassirostris	True biting fly (Attack cattle)	
M. conducens	I/H of *Stephanofilaria assamensis*	
M. planiceps	I/H of *Stephanofilaria zaheeri*	
Haematophagus spp.	Blood sucker	
Haematobia sanguisugens	Blood sucker	
Siphona exigua (Lyperosia exigua)	Blood sucker	
Stomoxys spp. (Stable fly) • Both sex suck blood • While sitting proboscis project like a Bayonet (Baton- like: bladed weapon such as knife) • Presence of 6 round spot on abdomen is characteristic feature • Prefer horse manure for breeding		
Stomoxys calcitran	Stable fly/Barn fly/Biting house fly/Dog fly/Power Mower fly	
Family: Calliphoridae (Blow flies) • They are of metallic colour, do not suck blood and their larva feed on pre-existing wound • Larva known as maggots		
Calliphora spp.	Blue bottle fly	
Lucila spp.	(Green bottle fly)	
Chrysomia spp. (Screw worm fly)		

Family: Sarcophagidae (Flesh flies)		
Sarcophaga spp. (Flesh Fly)	They have chequered abdomen and lay larva on wounds or near natural orifices, decaying flesh	

Family: Hippoboscidae (tick or louse flies)

- They have dorsoventrally flattened and have tough leathery texture
- Both male and female suck blood
- They produced fully formed larva which almost immediately turn into pupae
- Hippobosca has powerful claws on legs

Hippobosca maculate	Horse	
H. capensis	Dog	
H camelina	Camel	
Melophagus ovinus (Sheep tick fly/Sheep ked)		
Pseudolynchus canarensis (P maura)	Young nestling pigeon	Transmit protozoa- Haemoproteus columbae

Order: Siphonoptera (Aphaniptera)-FLEAS

- Wingless insect- laterally compressed bodies characterized by presence of pygidium and sensilium
- Both sex suck blood- not host specific

Ctenocephalides canis	Dog	
C felis	Cat	Miliary dermatitis
C felis orientalis	Commonest flea Cat/dog/cattle/goat	
Echidnophaga gallinacean	Stick tight flea of fowl	Telescoped thorax
Xenopsylla cheopsis	Transmit plague	

Order: Mallophaga (Biting lice)	Order: Siphonculata (Anoplura-sucking lice)
Mouth part- biting + chewing type	Piercing + sucking
Host specific	Rigid host specific (often organ specific)
Trichodectus canis- (I/H of Dipyllidium caninum)	***Haematopinus eurysternus***- Tail switch louse of cattle *H. asini*- horse *H suis*- pig
Heterodoxus spinigerum (dog)	*Haematopinus tuberculatus*- buffalo
Damalina (Bovicola) bovis – cattle	*Linognathuss vituli*- calves
Damalina equi (horse)/ Damalina ovis (sheep)/ *Damalina capra* (goat)	*L. pedalis*- sheep
Haematomyzus elephantis- elephant	*L. stenopsis*- goat
Felicola subrostratus	***L. setosus***- dog
Poultry Lice	*Solenoptes capillatus*- cattle/buffalo
Eomenacanthus stramineus- body louse	
Gonoides gigas- large body louse	
Menopon gallinae- shaft louse	
Cuclogaster heterographus- head louse	
Lipeurus caponis- wing louse	
Lipeurus tropicalis- tropical wing louse	
Goniocotes gallinae- fluff louse	
Anaticola crossicornis- Duck	
Columbicola columbae- pigeons	

Order: Hemiptera (Bugs)

- Wings absent- piercing and sucking type mouth
- Member of sub family Triatomiae suck blood of man and animal on thin skin of lips and are vector of Chagas disease.

Cimex hemipterus	Most common in India	
Cimex lectularius	Cosmopolitan bed bug	

Order: Acarina (Ticks & Mites)

- Body divided into two parts- anterior (Gnathostoma//capitulum) having mouth (piercing and sucking) and posterior part (idiosoma) having leg, gut and sex organs

Sub-Order: ixodoidea (ticks)- it has two family- Argasidae (soft tick) and Ixodidae (hard tick)

- Haller's organ (sensory organ) present at terminal segment of first pair of legs of ticks
- Gene's organ in female provide waxy coating on eggs

Argasidae (soft tick)	Ixodidae (hard tick)
	Mostly parasitic on mammals but less non-specific- dorsally have scutum- mating take place while feeding on host- life cycle has 4 stages- egg- hexapod larvae (seed tick)- octapod nymph- imago (adult)
***Argas persicus*- common fowl tick**- 2 nymph stage- nocturnal	*Boophilus microplus*- cattle tick- **one host tick**
***Ornitodorus savignyi* (Sand tampans)- common soft tick**- 4 nymph stage	*Hyalomma anatolicum*- cattle/buffalo- **2 host tick**- transmit Theileriasis
Ornitodorus papillipes (O. crossi)- cattle/dog/sheep	*Haemophysalis spinigera*- transmit KFD *Haemophysalis bispinosa*- **3 host tick**
***Otonius megnini*- Spinose ear tick**- cattle/sheep/horses- larva and nymph are parasite of external ear	*Rhipicephalus sanguineus*- Brown dog tick (3 host tick) *Rhipicephalus bursa & R. evartsi*- **2 host tick** **R.appendiculatus- 3 host tick**
	Dermacentor auratus- domestic and wild animals
	Ixodes spp.- **3 host tick (tick paralysis)**
	Amblyomma- Bont tick

Class- Arachnida
Order: Acarina; Sub-order: Sarcoptiformes (Mites)

Mites are much smaller than ticks and are characteriszed by absence of cheliceral digits on hypostome and haller's organs (which are present in ticks).

Family	Genus and species
Sarcoptidae	*Sarcoptes scabei, Notoedrus cati, Cnemidocoptes mutans, C. gallinae*
Psoroptidae	*Psorptes ovis, Chorioptes bovis, Otodectus cynotis*
Cytoditidae	*Cytodites nudus*
Myobitidae	*Psorergates ovis, Springophillus bipectinatus*
Cheyletidae	*Cheyletiella parasitivorax* (rabbit) *C.blakei* (Cat-walking dandruff)
Epiderdermobidae	*Epidermoptes spp., Dermatophagoides spp., Rivoltasia spp.*
Trombiculidae **(larva k/a Harvest mite/Chiggers mite)**	***Trombicula deliensis*- only larva is parasitic- transmit scrub typhus**
Demodicidae (follicular mange mites)	*Demodex canis* (stumpy legs), *Demodex bovis, D. caprae, D. ovis, D. phylloides*

Dermanyssidae (Gamosid mites)	*Dermanyssus gallinae, Ornithonyssus bursa, Pneumonyssus caninum*
• Burrowing mites-larger (Sarcoptes, Notoedrus, Demodex, Cnemidocoptes) and non-burrowing mites (Chorioptes, Otodectes, Psoroptes, Dermanyssus) • Nodoedrus cati is characterized by presence of dorsally situated anus and thumb print like appearance (dorsally) • Otodectic mange (otoacariosis) in ears of dog and cat is caused by Otodectus cynotis- highly contagious	
Animal	**Affected by mange**
Cattle	**Psoroptic mange** by Chorioptes bovis causes itchy leg
Sheep	**Psoroptic mange** (Sheep scab)- by *Psoroptes ovis*- host specific
Goat	Sarcoptic mange- commonest and most severe Psoroptic mange- ear mange
Buffalo	Sarcoptic mange
Horse	Sarcoptic mange
Dog	**Demodectic mange and Sarcoptic mange** Demodectic mange- **not contagious-** mainly in young dog- 2 forms occur- **1. Squamous/scaly form-Red mange** 2. Pustular form Sarcoptic mange- **contagious-** lesion first appear around eyes and head
Cat (highly contagious)	Sarcoptic mange caused by *Notoedrus cati*
Pig	Sarcoptic mange
Camel	Sarcoptic mange
Rabbit	**Psoroptes** spp. and Notoedrus spp.
Poultry mites	
Cnemidocoptes mutans	Causes scaly leg
Cnemidocoptes gallinae	Causes depluming itch
Dermanyssus gallinae	K/a Red mite of poultry/ Roost mite
Ornithonyssus bursa	Typical fowl mite/ feather mite
Cytodites nudus	Air-sac mite
Class- Pentostomida	
Lingatula serrata	Tongue worm- dog/sheep/goat Nymphs produce pharyngitis k/a Halzoon disease
Phylum- Annelida	
Order- Hirudinea (Leeches)	
***Hirudinaria granulosa* (*Poecilobdella granulosa*)**	Fresh water leech k/a paddy field leech or medicinal leech Commonly attack buffalo during wallowing
***Haemodipsa spp.*- only one genus in India**	Land Leeches- smaller in size

Chapter-8

Veterinary Protozoology

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Protozoology

Genera/ Species	Characteristics	Lesions/Disease/Remark
Family: Trypanosomatidae		
• Trypanosoma spp. are extracellular except *T. cruzi* & *T. theleri* • Transmitted by Tabanus mainly except *T. cruzi* • Pathogenesis (progressive anaemia- intravascular coagulation- haemodilution) • **Earlier test used to diagnose surra** • Mercuric chloride test (camel), Formol gel test (camel), Stilbamide test (bovine), Thymol turbidity test- these test detect only a rise in globulin level	**Diagnosis** Thick & thin blood smear Haematocrit centrifugation technique (Woo's technique) CFT, CATT (card Agglutination trypanosomosis test-for specific antibodies), LAT (Latex agglutination test- for circulating antigen), PCR **OIE** recommends use of Ab-ELISA & CATT for declaring a surra free status of a geographical area or herd.	
Trypanosoma evansi	1st pathogenic tryps discovered in India by Griffith Evans in 1880 in camel	Surra or Tibersa in India Deleban in Algeria Murrina in Panama Guifar in Islam country
Trypanosoma equinum		Malde cadaras in equine
Trypanosoma equiperdum		Dourine or Equine syphilis or breeding paralysis or Veneral trypanosomiasis
Trypanosoma theileri	Largest trypanosome	Occult trypanosome
Trypanosoma rhodensi		Sleeping sickness in humans
Trypanosoma gambiense		Sleeping sickness in humans
Trypanosoma cruzi	Transmitted by Triatoma bug	Chagas disease in humans
Trypanosoma congolense	Shortest trypanosome Transmitted by *Glossina spp.*	Nagana disease in cattle
Trypanosoma vivax		Nagana disease in cattle
Trypanosoma lewisi		Trypanosomiasis in mice
Leishmania spp.		
• Multiply in macrophages • LD bodies- are amastigotes which are seen in vertebrate host • PKDL- multiple nodule infiltration without ulceration		
Leishmania donovani	Transmitted by *Phlebotamus argentipus*	Kala-azar/ Visceral leishmaniasis/ black fever/ Dum dum fever/ Death

		sickness/ Tropical spleenomegaly
Leishmania tropica	Transmitted by *Phlebotamus sergentii*	Oriental Sore/ Delhi boil/ Cutaneous leishmaniasis
Leishmania major		
Family: Hexamitidae		
Hexamita meleagridis	Infectious Catarrhal Enteritis	characterized by foamy watery diarrhoea
Giardia lamblia	Wizened-Monkey appearance in faeces	Chronic diarrhoea
Family: Monocercomonadidae		
Histomonas meleagridis No flagella	Found in caeca and liver of turkey/chicken Transmitted by Hetarakis gallinarum (caecal worm of poultry)	Black Head Disease/ Histomoniasis/ Infectious Enterohepatitis characterized by typhlitis, hepatitis & yellow coloured faeces
Family: Trichomonadidae		
Tritrichomonas foetus (inhabitant of preputial cavity) Capitulum is present	Bovine trichomoniasis/ Bovine trichomonad abortion (Abortion in 1st trimester) Causes Post-coital pyometra (potato-soup like pus in uterus)	Trichomonas cultured in- • CPLM • BGPS • Diamond medium
Trichomonas gallinae	Upper GIT More common in pigeon	Yellow buttons/ Pendulous crop (thick necrotic mass in oesophagus, crop and proventriculus)
Tetratrichomonas gallinarum	Lower GIT	
Family: Entamoebidae		
Entamoeba histolytica		Amoebiasis/ amoebic dysentery/ Hepatic amoebic abscess characterized by Inverted flask shaped ulcers

Subclass: Coccidia

Divided into two groups

1. Intestinal coccidian- Eimeria, Isospora, Cryptosporidium
2. Extra-intestinal (tissue dwelling) coccidian- Toxoplasma, Neospora, Sarcocystis

Order: Eucoccidiorida; Family: Eimeridae

- Intracellular parasite of epithelial cell of vertebrate host. Sporozoits are usually comma shaped or banana shaped with central nucleus.
- **Unsporulated oocyst** in faeces of affected birds
- Generally, 2 generation schizonts are formed.
- Schizogony occur in cytoplasm of epithelial cell except Eimeria albamensis (intanuclear)

Eimeria ahsata	Most pathogenic in sheep	
Eimeria ovina	One generation schizonts are formed	
Eimeria zuernii	Most pathogenic in cattle Schizont pathogenic effect	Winter coccidiosis/ Red dysentery in calves
Eimeria bovis	Largest coccidian of cattle Gamontt pathogenic effect	
Eimeria deblieki	Most pathogenic in pig	
Eimeria scabia		
Eimeria tenella	Chick of 4 weeks highly susceptible	Caecal coccidiosis (bloody diarrhoea)

Eimeria necatrix	Intestinal coccidiosis (characterized by ballooning of intestine and mucoid faeces)	
Eimeria brunetti		Rectal coccidiosis (bloody diarrhoea)
Eimeria truncata		Renal coccidiosis
Eimeria acervulina	4 generation schizonts are formed	
Eimeria mewati	4 generation schizonts are formed	
Eimeria maxima	Largest oocyst among birds	
Eimeria precox		
Eimeria stedai	Found in liver of rabbit	Hepatic coccidiosis
Eimeria residua & E. magna	Found in intestine of rabbit	
Order: Eucoccidiorida; Family: Cryptosporidae		
Cryptosporidium parvum (auto-infection occurs)	Neonatal calves, lambs, pups, kitten Zoonotic	Kenyan acid fast staining Zehil-Neelson staining for Cryptosporidium oocyst
Order: Eucoccidiorida; Family: Sarcocystidae Genus: Sarcocystis, Toxoplasma, Neospora		

Genus: Sarcocystis

Characterized by Isosporan type oocyst **(sporulated oocyst)** and are infective to intermediate host from the moment they shed (unlike other coccidian oocyst) in faeces.
In I/H, they multiply by endodyogeny in muscles and form **sarcocyst** containing bradyzoits. Bradyzoits (banana/crescent/sickle shaped cystozoits inside sarcocyst) similar to coccidian merozoits infectious to direct host when they feed on raw meat.

Sarcocystis cruzi (S. bovicanis)	Direct host: canine Intermediate host: bovine	Dalmony disease/ Meischner's tubule/ Tail switch/ Cooked rice grain
Sarcocystis hirsuti (S. bovifelis)	Direct host: feline Intermediate host: bovine	
Sarcocystis tenella (S. ovifelis)	Direct host: feline Intermediate host: ovine	
Sarcocystis meisheriana	Intermediate host: swine	
Sarcocystis neurona		Equine protozoal myeloencephalitis

Genus: Toxoplasma

- In definitive host (cat), parasite multiplies by schizogony, endodyogeny, endopolygeny, gametogony and form isosporan type oocyst **(unsporulated)** are infective to intermediate host. In I/H, they multiply by endodyogeny in different tissue and form **Thin-walled** tissue cyst containing 4 bradyzoits (slow growing)
- Toxoplasma is characterized by gliding motion

Toxoplasma gondii	D/H- cat I/H- all warm blooded animals	**Causes abortion**

Genus: Neospora

In I/H, they multiply by endodyogeny in different tissue and form **Thick-walled** tissue cyst.

Neospora caninum		Neuromuscular disorder in dog, Spontaneous massive abortion in farm animals
Order: Eucoccidiorida; Family: Hepatozoidae		
Hepatozoon canis	Infection occurs by ingestion of ticks	
Order Haemosporida; Family: Plasmodiidae		
Plasmodium gallinarum	Bird	Transmitted by **Culex spp.**
Plasmodium bubalis	Buffalo	

Plasmodium vivax		
Order Haemosporida; Family: Haemoproteidae		
Haemoproteus columbae	Domestic and wild birds Characterized by Halter shaped gametocytes and cytomeres	Pseudomalaria
Order Haemosporida; Family: Leucocytozoidae		
Leucocytozoon simondii	Duck	
Leucocytozoon smithi	Turkey	
Leucocytozoon caulleryi	Chicken	

Order: Piroplasmida; Family: Babesiidae

- Babesia spp. found in RBC as ring/pear/cigar/spindle shape
- In gut of ticks (vector), schizonts converted into cigar shaped organism known as Vermicules (merozoits).
- Babesia bigemina- only found in India- Ray bodies present- Inverse Age resistance-
- Preimmunity (infectious immunity/Active immunity) developed
- Babesiosis in cattle is characterized by haemoglobinuria, high fever, anaemia while in equines, it is characterized by Biliary fever
- Maltese cross formation is seen in RBC in infection with *B. equi* and *B. cati*
- Signet ring in RBC is characteristics of *B. gibsoni*

Species	Small form Babesia spp.	Large form Babesia spp.
Cattle	*B. bovis, B. divergens*	*B.bigemina, B. major*
Horse	*B.equi*	*B.cabali*
Dog	*B.gibsoni, B. comrade*	*B.canis, B.vogeli, B.rossi*
Sheep/Goat	*B.ovis*	*B.motasi*

Order: piroplasmida; Family: Theileriidae		
Found in lymphocyte and erythrocyte- multiply asexually by schizogony in lymphocyte & binary fission in erythrocyte in **vertebrate host** – signet ring stage is present in RBCs		
Theileria annulata Organism appears in lymphocytes of lymphnode and spleen as macroschizonts known as **Koch Blue's body**	Common in India Vector: **Rhipicephalous appendiculatus** Trans-stadial transmission Cell and humoral immunity both involved	It causes Bovine tropical theileriosis characterized by punched out ulcers in abomasum, swelling of prescapular lymph nodes and parotid gland OIE recommends IFAT (indirect fluorescence antibody test) for international trade.
Theileria parva	Vector: Hyalloma anatolicum	East coast fever
Theileria hirci	Sheep and goat	
Theileria ovis	Sheep and goat	
Theileria lawrenci		Corridor's disease
PHYLUM: Ciliophora; Family: Balantiididae		
Balantidium coli	Common in pig	Balantidiasis (Zoonotic disease)

Specific test in Protozoology	
Mercuric chloride test Formol gel test Stilbamide test Thymol turbidity test	Trypanosomiasis
Montenegro Skin test	Leishmaniosis
Tricin test	Trichomoniasis in cattle

Sabin-Feldman dye test Torch test	Toxoplasmosis
Kinyoun's acid fast staining	*Crytosporidium spp.*
Diamond's medium	For culture of Trichomonas spp.

Vectors and diseases transmitted by them

Vectors	Transmitted disease
Boophilus microplus	Babesiosis
Tabanus	Trypanosomiasis
Sand fly (Phlebotomus)	Kala azar, Sand fly fever, Oraya fever
Cullicoides	*Onchocerca gibsoni*, Leucocytozoon, Blue tongue, African horse sickness, Bovine ephemeral fever, fowl malaria, Akabane disease, Epizootic haemorrhagic disease, Queensland itch
Tse-tse fly	Sleeping sickness of Africa
Black fly	Onchocercosis (Riverblindness)
Aedes mosquito	Chickenguniya, Rift valley fever, Dengue, Yellow fever
Anopheles mosquito	Malaria
Culex	Avian malaria
Culex tritaeniorhyncus	Japanese encephalitis
Culex quinquefasciatus (*Culex fatigans*)	Filariasis
Trombiculid mite	Scrub typhus, Rickettsial pox
Louse	Epidemic typhus, Trench fever
Hard tick	Tularemia, Tick encephalitis, Kyassanur forest disease, Congo fever
Soft tick	Q-fever, Relapsing Fever
Rat flea (Xenopsylla)	Plague, Endemic typhus, Chiggerosis
Reduvid bug (kissing or Assassin bug)	Sleeping sickness of America (Chagas Disease)
Haematopinus suis (Pig louse)	Swine pox

Note: The most common mode of transmission of parasite is **Ingestion** followed by Skin penetration, contact, predation, intranasal, coitus, transplacental and transcolostral route

Chapter-9

General Veterinary Pathology

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- Hyperplasia- increase in size of tissue with increase in number of cells (eg. Wart)
- Hypertrophy- increase in size of tissue with increase in size of cells
- Metaplasia- conversion of one type of tissue (cell) into another type in same germinal layer
- Atrophy- decrease in size of organ/tissue after its full development
- Dysplasia (atypical hyperplasia)- change in shape, size and orientation of cell within organ/tissue
- Renal epithelial cells don't develop hyperplasia
- Degeneration- change in tissue itself
- Infiltration- abnormal deposits in tissue

Type of Degeneration

Cellular swelling

- The most common disturbances of cell metabolism and first reaction of a cell to injury occurs as a result of failure of sodium pump in cells.
- **Earlier it was known as Cloudy swelling, parenchymatous swelling, albuminous degeneration**
- Most common cause is bacterial toxins
- Cytoplasm of cell become granular giving Ground glass appearance and hazy cytoplasm due to swelling of endoplasmic reticulum and mitochondria.
- Granules are soluble in acetic acid but not in lipid solvents such as chloroform.
- Par-boiled (swollen) appearance of organ.

Note: Eosinophilic intracytoplasmic composed of intermediate filaments.

Hydropic degeneration (Vacuolar degeneration)- Etiology is similar to cellular swelling but more severe	• Hydropic fluid stain pink with eosin due to protein content • Observed in vesicular exanthema, pox, neoplasm of cervi, blister on skin
Mucous or mucinous degeneration In response to mild irritant	• Mucin (glycoprotein) is produced by columnar or cuboidal epithelial cell (subcellular level by mitochondria) • Mucin stain **Blue with Alcian blue, haematoxylin** and **Red with thionine, mucicarmine, PAS,**
Mucoid or myxomatous degeneration In response to mild irritant	• Mucin like glycoprotein (stain blue with haematoxylin) normally produced in foetus but abnormal in adult • Observed in myxoma, myxosarcoma, myxoedema

Hyaline change or degeneration

Structural elements of cells are replaced by hyaline (which is a substance with glassy appearance composed of protein)
Tissue gives a homogenous, glassy and translucent look
Stained pink with H & E

Keratohyaline

Observed in-

- Calluses
- Wart (papilloma)
- Epithelial pearls (cell nests) in squamous cell carcinoma
- Hyperkeratosis

Cellular hyaline

Observed in-

- prostate gland as Corpora amylacea (starch bodies)
- Brain sand
- Alveoli after pneumonia
- Mammary gland of cow dried off too quickly

Connective tissue hyaline (Permanent changes)

Observed in-

- Old scars
- Degenerating stroma of tumour and lymph node
- Draining areas of chronic inflammation

Renal glomeruli in chronic nephritis
Intima and media of blood vessels in arteriosclerosis

Amyloidosis

- Most common in spleen, liver, kidney of dog and horse
- Common in horse used for antitoxin production
- Amyloidosis is prominent lesion in spleen of chicken having tuberculosis
- Isolated deposition of amyloid in a neoplastic form in heart called Amyloidoma

Deposition of amyloid (composed of protein-made of non-branching fibrils of indefinite length- fibrils have characteristics pattern known as Beta pleated sheet structure) in the interstitial tissues only
Amyloidosis is related with hypergammaglobulinemia

Main form of amyloid protein

1. AL (amyloid light chain) derived from plasma cells and contain immunoglobin light chains
2. AA (amyloid associated)- non-immunoglobulin protein synthesized by liver- derived from SAA (serum amyloid associated) protein- deposited in chronic inflammatory diseases

Type of amyloidosis

- Primary amyloidosis
- Secondary amyloidosis- due to SAA protein. Observed in TB, rheumatoid arthritis, chronic suppurative osteomyelitis

Amyloidosis in spleen

Doughnut spleen- circular spleen with hole in middle
Sago spleen- focal amyloid degeneration
Bacon spleen- Diffuse amyloid degeneration

Amyloid staining

Congored stain- **PINK/RED**
Iodine- **Yellow red (Mahogony brown**
H & E- **PINK**
Van Gieson technique- **YELLOW**
Methyl violet, methyl green, crystal violet, thionin- **RED**

Fibrinoid degeneration- deposition of homogenous material resembling fibrin occurs in tissues like connective tissue or blood vessels. Eg. Occurs in collagen disease

Common biochemical mechanisms involved in cell injury

1. **ATP depletion and decreased ATP synthesis-** are common results of both ischaemic and toxic injury
2. **Lack of oxygen or generation of oxygen derived free radicals**
3. **Loss of calcium homeostasis**
4. **Defects in membrane permeability**
5. **Mitochondrial damage-** mitochondria are almost always involved in most types of injury

Irreversible injury: swelling of mitochondria, swelling of lysosomes and extensive damage to plasma membrane
Cell membrane damage is central factor in pathogenesis of irreversible cell injury

1. Progressive loss of membrane phospholipids
2. Mitochondrial dysfunction
3. Cytoskeleton abnormalities
4. Toxic oxygen radicals

Free radical induced cell injury:

- Free radicals are chemical species that have a single unpaired electron in the outer orbital
- Oxygen derived free radicals are most important in cell injury which are produced during normal metabolic processes in reduction-oxidation (redox) reactions.

Radicals are produced by oxidative enzymes:

- Mitochondria- P-450, b 5 oxidases
- ER- P-450, b 5 oxidases
- Plasma membrane- NADPH oxidase
- Cytosol- Xanthine oxidase, transition metals (Fe, Cu)
- Lysosomes- Myeloperoxidase, NO synthase

Free-radicals

1. **Superoxide (O_2^-):** rapid burst of superoxide production occurs in activated neutrophils during inflammation. They are inactivated by Superoxide dismutases (SOD). Mn-SOD present in mitochondria and Cu-Zn-SOD in cytosol.
2. **H_2O_2:** peroxisome contain enzymes for both production and degradation of H_2O_2.
3. **OH^-:** produced in Fenton reaction and in hydrolysis of water by ionizing radiation (X-rays, Gamma rays). OH^- are the most reactive in inducing cell damage.
4. **Singlet oxygen**
5. **Nitric oxide-** is a soluble free radical gas produced by endothelial cell, macrophages, neurons and other cell types.

Mechanism of cell injury by free radicals-

1. **Lipid peroxidation of membranes-** double bonds are vulnerable to attack by free radicals. Autocatalytic chain develops known as propagation.
2. **Cross-linking of proteins-** by formation of di-sulphide bonds in labile amino-acids (Methionine, histidine, cysteine and lysine).
3. **DNA fragmentation-** free-radicals react with thymine in nuclear and mitochondrial damage.

Heat shock proteins/ Stress potein

Play important role in protein folding and in protein kinesis (transport of proteins into various intracellular organelles like ER, golgi bodies).

HSP handle the damaged proteins in two ways-

1. By re-folding (repairing) the damaged proteins
2. When re-folding is not successful, permanently damaged proteins are bound to ubiquitin HSP molecule and make protein as target for intracellular degradation by proteasomes

Intracellular accumulations

Fatty changes Etiology: • Inadequate amount of oxygen • Hepatotoxins • Metabolic diseases • Lipotrophic factor- Choline	Any abnormal accumulation of neutral fat (triglycerides) within parenchymal cells of liver Fatty liver colour: Cattle- yellow, Horse-Orange, Cat- White Fat droplets are small and numerous in phosphorous poisoning but large in diabetes Microscopically, heart look like **Thrush-breast heart/ Tigroid appearance/ Speckled appearance/ Tabby cat heart**
Protein Accumulation	Russel bodies (eosinophilic inclusions)- are found in plasma cells. Ultra-structurally, they are cisternae of endoplasmic reticulum
Glycogen infiltration Mostly occurred in liver and kidney To demonstrate glycogen, tissues must be obtained immediately after death and fixed in absolute alcohol	• Glycogen is best preserved in non-aqueous fixative • Glycogen staining- • Iodine- reddish brown • Best carmine and PAS- bright red

Cholesterol and cholesteryl esters-	Macrophages laden with lipids known as Foam cell. Macrophages laden with Cholesterol accumulate in skin and produces tumorous masses known as xanthomas	
Endogenous pigmentation		
Melanin	• **Albinism-** absence of melanin but melanocytes present, occur as result of deficiency of tyrosinase enzyme • **Vitilago-** partial or complete loss of melanocytes • **Leukoderma-** local loss of melanin pigment • **Acanthosis nigricans-** Increased amount of melanin within the skin, frequently reported in dog	
Lipochrome Lipochrome= complex of lipid and protein Important marker that cell has suffered from free radical injury	• Lipofuschin represent indigestible residue of autophagic vacuole (residual bodies) formed during aging or atrophy give **Brown Discolouration to tissues (Brown Atrophy)** • Prominent in liver and heart of aging patient, severe malnutrition and cancer cachexia	
Derivatives of haemoglobin		
Hemosiderin: Large aggregate of ferritin micelles It is identified by Prussian Blue reaction (use of potassium ferrocyanide)	• Local accumulation- eg. Bruises, scar • Systemic accumulation- haemochromatosis in diabetes mellitus and liver fibrosis • Lungs- Brown induration of lungs • Macrophages laden with hemosiderin k/a **Heart Failure cells**	
Porphyrins: These pigments normally present in haemoglobin, myoglobin and cytochromes	A brown or black pigmentation of the bones called **osteohaemochromatosis** is observed in **cattle and pigs**	
Bilirubin in blood	Leads to jaundice	
Prehepatic/Hemolytic jaundice: Characterized by increased **unconjugated bilirubin** in blood and diagnosed by **Indirect Vandenbergh Test** • Bilirubin in urine: **absent**	**Hepatic/toxic Jaundice:** Characterized by increased **both unconjugated and conjugated bilirubin** in blood and diagnosed by **Biphasic Vandenbergh Test** • Bilirubin in urine: **present**	**Post-hepatic/Obstructive Jaundice (Cholestasis):** Characterized by increased **conjugated bilirubin** in blood and diagnosed by **Direct Vandenbergh Test** Bilirubin in urine: **present**
Exogenous pigmentation		
Most common exogenous pigment is carbon or coal dust; harmful particle size: 1 -5 micron		
Anthracosis (Carbon)	• Lung show peppered appearance • Carbon is mild irritating causes slight fibrosis	
Siderosis (Iron)	Iron is mild irritating causes slight fibrosis	
Silicosis (Silicon)	• Most harmful and predisposes lungs to tuberculosis • Silica dust is powerful irritant	
Note: Plumbism (Lead & H2S); Chalicosis (Calcium carbonate); Asbestosis (asbestos)		

Haemorrhage Escape of blood without break (diapedesis) and with break (rhexis) in blood vessels	• **Petechiae:** Pin-point haemorrhage not larger than 1-2 mm (mainly associated with capillaries) • **Ecchymoses:** haemorrhage of size 1-2 cm • **Suffusion:** Diffuse, flat, irregular haemorrhage • **Hematoma:** accumulation of blood in abnormal cavity • **Purpura** (skin haemorrhage/blood spot) • **Apoplexy-** haemorrhage in brain
Oedema Fluid in interstitial tissue spaces or body cavities	• Peritoneal cavity- **Hydroperitoneum/ Ascites** • Pericardium- **Hydropericardium** • Tunica vaginalis of testes – **hydrocoel**

Oedematous fluid stain pink with Eosin fluid	• Ventricles of brain- **Hydrocephalous** • Generalised oedema (swelling of subcutaneous tissue)- **Anasarca**

Thrombosis

- Formation of thromi is termed as thrombosis
- Thrombi is a blood clot formed insitu with in vascular system and also known as intravital intravascular clot
- Calcified thrombus in vein is termed as phlebolith
- Platelet play a central role in thrombosis
- Arterial thrombi are more common in animals
- Red thrombi- composed of platelet, fibrin, RBC & WBC & found in veins
- White thrombi- mainly composed of platelets and found in arteries
- Mixed thrombi- most common type

Antithrombotic properties	Pro-thrombotic factors	Predisposing factor for thrombosis (Virchow Triad)
• Antiplatelet effect- prostacyclin & NO • Anti-coagulative property- thrombodulin & heparin like molecules • Fibrinolytic property- Tissue plasminogen activator	• Vonwillebrand factor • Thromboplastin (thrombokinase) • Inhibition of plasminogen activator	• Endothelial injury • Stasis of blood flow • Blood hypercoagulability

Emboli

- Most emboli are derived from thrombi
- Emboli mostly occurs in arteries in animals
- Multiple long bone fractures result into fat embolism
- Caisson's disease is characterized by air embolism (mainly nitrogen-N_2 is involved)
- Lung, liver & kidney are the frequent organs in which metastasis of emboli occurs
- Paradoxical embolism occur in patent foramen ovale/congenital inter-auricular or interventricular defect

Infarction

- It is defined as localized area of ischaemic necrosis caused mainly by occlusion of arterial supply
- The most common shaped of infarct is wedge shaped
- Pale (white) infarction- Most common type of infarction & occur in solid organ (heart & Kidney) caused by occlusion of arteries, characterised by WEDGE shape and depressed surface
- Red (haemorrhagic) infarction- Occur in spongy organ (lung & spleen) characterised by bulging surface
- Thrombi & emboli are common cause of infarction
- Infarction of lung is not common in animals
- Infarction of brain is seen mainly in dogs

Pathological calcification

- Abnormal deposition of calcium in tissues other than bone is termed as pathological calcification
- Calcium is stained in tissues by Vonkossa's Silver Nitrate stain (BLACK)
- Manschester wasting disease is characterized by deposition of calcium in arteries, heart muscles, lungs and kidney

Dystrophic/Local calcification	Metastatic/ General calcification
• Deposition of calcium occurs in dead or dying tissues characterized by: **normal serum calcium level, normal calcium metabolism** and white chalky deposition with in tissues **(reversible)** • Occurs in tubercles in tuberculosis, old abscess, advanced atherosclerosis, parasitic lesions, necrotic renal tubules, infarcted area	Deposition of calcium mainly in soft tissues like stomach, kidney, lungs caused **by increased serum calcium level, abnormal calcium metabolism,** hyperparathyroidism, Vitamin D intoxication and renal failure characterized by white chalky deposition in tissues **(Irreversible)**

Necrosis

Coagulative necrosis	Liquifactive necrosis	Caseous necrosis
Most common type of necrosis C/B protein degeneration	C/B dominant enzymatic digestion and transformation of tissue into liquid mass	Transformation of tissue into granular mass resembling cheese
loss of cellular details	loss of cellular details	Loss of cellular details
Architectural details of cells persists	Architectural details of cells also lost	Architectural details of cells also lost
Eg. Infarct- classical example (except infarction of brain) Muscular dystrophy, necrobacillosis,	Eg. Abscess & suppurative infection, hypoxic death of cell Infarction of brain, Cyanide poisoning	Tubercles of Tuberculosis Nodules of oesophagostomiasis Caseous lymphadenitis

Gangrene

- Dry gangrene sets in faster than moist gangrene
- Freeze burn (frost bite) leads to gangrene by causing thrombi and blocking blood vessels

Dry gangrene	Moist/Wet gangrene	Gas gangrene
Occurs when coagulative necrosis is dominant Mostly occurs on extremities	occurs when liquefactive necrosis is dominant Mainly occurs in internal organs (intestine & lungs)	Characterized by invasion by *Cl. chauvoei, Cl. septicum, Cl. novyi*

Common Post-mortem changes

- Pallor mortis-commonly seen in primates-1st stage of death
- Algor mortis- coolness after death-2nd stage of death
- Rigor mortis- stiffness of muscles-3rd stage of death
- Livor mortis-discolouration of carcass-4th stage of death
- Post mortem blood clotting- indicate slow death of animals
- Hypostatic congestion
- Pseudomelanosis (imbibition of blood and bile)
- Putrefaction and autolysis- depend on temperature
- Post mortem emphysema- accumulation of gases (mainly H_2S) in organs/tissues
- Post mortem displacement/looping

Cardinal signs of Inflammation

1. **Redness (L. Rubor)**- result of hyperemia
2. **Swelling (L. Tumor)**- result of hyperemia & exudate
3. **Heat (L. Calor)**- result of increased blood flow
4. **Pain (L. Dolar)**- result of pressure, stretching, serotonin, kinin, prostaglandin, K^+, acetylcholine
5. **Loss of function (L. function-laesa)**

Note: 1st four was given by Cornelius Celsus & 5th was given by Rudolph Virchow

Chemical mediators of inflammation

Cells derived chemical mediators		Plasma derived chemical mediators	
Preformed	**Newly synthesized**	**Hageman factor**	**Complement system**
• Vasoactive amines (Histamine & 5-HT) • Lysosomal enzymes	• Prostaglandins • Leukotrienes • Platelet Activating factor • Activated oxygen species • Nitric oxide • Cytokines	• Kinin System (bradykinin) • Coagulation system • Fibrinolysis system	• C3a • C5a • C5b9

- Chemical mediators mainly act on venules
- Nitric oxide is also known as endothelium derived relaxation factor and is a potent vasodilator
- Histamine is secreted by mast cell, basophil, platelets while serotonin is secreted by platelets
- Lysosomal enzymes are mainly secreted by neutrophils
- Leukotrienes are 1000 times more potent than histamine
- Leukotriene C4 (LT C4), LT D4, LT E4 are vasoconstrictor while Lipoxin A4 and Lipoxin B4 are vasodilator
- LT C4, LT D4, LT E4 are known as Slow Reacting Substances of anaphylaxis (SRS-A)
- Thromoxane A2 (TXA2) is vasocontrictor while Prostacyclin (PGI2) is vasodilator
- Cytokines are mainly proteins which are involved in cell signalling and stimulate cell movement to sites of infection, inflammation and trauma. They are secreted by many cells including lymphocytes, macrophages, mast cells, fibroblast, endothelial cells, granulocytes etc.
- Cytokines which are involved in inflammation is IL-1 & TNF (Tumour Necrosis Factor)
- Chemokines, are small cytokines (8-10 kilo Dalton), induce chemotaxis in nearby cells
- CXC chemokines are chemotactic for neutrophils while CC chemokines are chemotactic for monocytes
- Kinins are highly vasoactive whereas complements are both vasoactive and chemotactive
- Bradykinin is nonapeptide and the action of bradykinin is short-lived, and act like histamine
- C3b is involved in phagocytosis while C5a is involved in chemotaxis

Vascular changes in inflammation

- Vascular changes of inflammation first reported by **Julius Cohnheim**
- Changes in blood vessels characterized by momentry constriction and vasodilation
- Changes in rate flow characterized by increased vascular permeability, slowing of circulation and stasis
- Change in blood stream
- Exudation of plasma
- Emigration of leukocytes
- Diapedesis of erythrocytes

Cellular changes in inflammation

Characterized by accumulation of white blood cells at site of infection or injury

- Margination- leukocytes accumulation at periphery of vessels
- Rolling- loose sticking of leukocyte to endothelium
- Adhesion- firm sticking of leukocytes to endothelium (leukocytes attachment are termed as pavementing)
- Emigration (diapedesis/transmigration)- WBCs come out of blood vessels
- Phagocytosis with the help of IgG, C3b and collectins

Cells of Inflammation

Cells of acute inflammation
(Neutrophil, Eosinophil, basophil)

Cells of chronic inflammation
(Macrophages, Lymphocytes, plasma cells, Giant cells)

Neutrophils

- Characterized by multilobed nucleus
- Neutrophil contain primary (Azurophil) granules and secondary (specific)
- Defining characteristic of azurophil granules is presence of myeloperoxidase (MPO) enzyme

Eosinophils

Characterized by Bi-lobed nucleus
Secondary (specific granules) contain major basic protein, eosinophilic cationic protein, eosinophil peroxidase

Monocytes (tissue macrophages)

- Characterized by Kidney shaped nucleus
- Monocytes in tissues transform into large phagocytic cells called macrophages

Lymphocytes

Characterized by Condensed round nucleus
Lymphocytes is of three types:

- T-lymphocytes
- B-lymphocytes
- NK-cells

Plasma cells

Characterized by cart wheel shaped nucleus
They are larger than lymphocytes and possess more cytoplasm having complex endoplasmic reticulum and never go under mitosis

Note: **Monocytes** are termed as **Macrophage** of Metchnikoff while **neutrophils** are termed as **Microphage** of Metchnikoff

Giant cells

Giant cells are formed by fusion of various cells mainly macrophages, epitheloid cells etc.- observed in chronic inflammation

- **Langhans giant cells-** Characterized by Horse-shaped nucleus- observed in TB, ParaTB, Actinomycosis, Actinobacillosis
- **Touton giant cells-** characterized by ring of nuclei at periphery- observed in xanthoma, fat necrosis
- **Reed-Sternberg cells (Popcorn cells)-** derived from B-lymphocytes and characterized by owl's eye appearance of nucleus and eosinophilic nucleolus
- **Foreign body giant cell-** characterized by overlapping nucleus- observed in tissues exposed to foreign substances

Types of inflammation

Serous inflammation **Cause:** moderately severe irritant	• Main constituent of exudate is plasma (not serum) • 1st stage in many inflammatory process characterized by frosted glass or shaggy appearance to the smooth surface • Exudate stain pink with eosin
Catarrhal inflammation **Cause:** Mild irritant	• Main constituent of exudate is mucus • Occurs in mucous membranes & characterized enlargement of secretory epithelial cells • Mucus stain blue with haematoxylin
Fibrinous inflammation **Cause:** very severe irritant	• Main constituent of exudate is fibrin • Characterized by fibrin deposition in pericardial cavity, pleural space, and results in formation of pseudo-membrane (croupous membrane) & diphtheritic membrane.
Suppurative/Purulent inflammation	• Main constituent of exudate is pus • Pus is viscous liquid consist mostly of dead, dying neutrophils and bacteria, cellular debris and fluid leaked from blood vessels
Granulomatous inflammation	• Characterized by granuloma formation • Granuloma is a focal and compact aggregation of epitheloid cells. • Epitheloid cells are activated macrophages assumed epithelial cell like appearance and become flat, large and eosinophilic

Difference between exudate and transudate

Exudate	Transudate
• Formed due to increased permeability of membrane • Origin- acute inflammation • Exudate is characterized by high protein content (more than 4%), high enzyme content, high cell count. • Thick, creamy with tissue fragment • Mostly acidic in nature (except pus)	• Formed due to increased hydrostatic pressure and decreased osmotic pressure • Cardiac/renal failure, cirrhosis, nephrotic syndrome • Transudate is characterized by low protein content (less than 3%), low enzyme content, low cell count • Thin, watery (no tissue fragments) • Alkaline in nature

Systemic effects of inflammation

Systemic effect of inflammation is termed as Acute-Phase reactions

1. Fever	Bacteria, virus, protozoa etc.
2. Other acute phase reactions	Increased sleep, decreased appetite, increased degradation of skeletol muscle protein, synthesis of acute phase proteins by liver
3. Changes in peripheral blood leukocytes	Extreme blood leukocytes is termed as Leukemoid Reaction (as this is similar to WBCs count in leukemia)

Acute phase proteins (APPs)

Acute phase proteins are plasma proteins synthesized by liver whose concentration increases or decreases rapidly during inflammation in response to inflammatory cytokines (IL-1, Il-6, TNF alpha) & play role in mediating fever, leucocytosis, increased cortisol, decreased thyroxine, decreased serum iron etc.

Acute phase proteins whose concentration increases by 25% are termed as **positive APPs** while whose concentration decreases by 25% are termed as **negative APPs**

Major proteins	CRP- C-Reactive Protein SAA- Serum Amyloid A SAP- Serum Amyloid P
Protease inhibitor	Alpha-1-acid glycoprotein (AGP) Alpha-1-antitrypsin Alpha-1-antichymotrypsin Alpha-2-antiplasmin
Metal binding protein	Haptoglobin Haemopexin Ceruloplasmin
Complement components	C3, C4
Clotting factors	Fibrinogen, Vonwillebrand factor
Negative acute phase proteins	Albumin Pre-albumin Transferrin Adiponectin Retinol binding protein

Species	Major acute phase proteins (APPs)
Cattle/Buffalo	**Haptoglobin, SAA**, AGP
Sheep & goat	**Haptoglobin, SAA**
Horse	**SAA**, haptoglobin
Dog	**CRP, SAA**, Haptoglobin, AGP, Ceruloplasmin
Pig	**CRP** Haptoglobin Ceruloplasmin
Mice	SAA
Rat	Alpha-2-macroglobulin

Chapter- 10

Special Veterinary Pathology

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Disease & Etiology	Characteristics symptoms & lesions	Diagnosis & remark
Foot and mouth disease (Apthous fever/ Khurkut/ Aftosa) **Apthovirus of picornaviridae family**	• **Inhalation-** is main mode of transmission • Vesicle formation in oral mucosa (stratum spinosum layer) and foot of cloven footed animal • Fever, drooling of saliva and lameness • In dead calves, heart gives **Tigroid appearance** due to necrotizing myocarditis • Muscle fibre having hyaline degeneration	Competitive ELISA Animal inoculation test- Guinea pig Pig- amplifier host CFT is used for virus serotyping
Vesicular stomatitis (PseudoFMD/ Malde Yerbe) **Vesiculovirus of Rhabdoviridae**	**Sporadic aptha/ Estomatitis/ Sore nose/ Sore mouth** • Vesicle formation in oral mucosa • Transmitted through insect	Animal inoculation test- Guinea pig Dear- amplifier host
Vesicular exanthema Calcivirus	• Occurs only in pig • Vesicle formation in snout, lips, nostril, tongue, tongue, feet and mammary gland	
Rinderpest (Cattle plague/ Bovine typhus/ Bulkandi) **Morbilivirus of paramyxoviridae family**	• **Inhalation-** is main route of infection • Erosive stomatitis and haemorrhagic enteritis • Mucus membrane of lips, gums and tongue have small eruptions resembling Bran-like deposits • Virus has affinity to lymphoid tissue (leucopenia) and alimentary tract • Haemorrhage in intestine leads to Zebra markings mainly in caecum and colon	Eradicated from India in 1995 **CFT-** confirmatory test Intracytoplasmic and intranuclear eosinophilic inclusion bodies
Malignant Catarrhal fever/ Gangrenous coryza/ Snotsiekte/ Epitheliosis **Herpes virus**	• Catarrhal and mucopurulent conjunctivitis • Ulcer on oral mucosa, intestine • Panopthalmitis • Enlargement of superficial lymph nodes • Cooked up appearance of brain	No inclusion bodies formation Cattle-dead end host
Bovine Viral Diarrhoea (BVD)/ Mucosal Disease (MD) **Pestivirus of Togaviridae**	• Virus is transmitted by direct contact and by transplacental route to foetus • Ulcer in oral mucosa, oesophagus, abomasum, intestine characterized by high rise of temperature and diarrhoea • Hypoplasia of cerebellum	BVD (acute) & MD (chronic) are clinically dissimilar

Infectious bovine Rhinotracheitis (IBR) Necrotic rhinitis/ Red nose/ vesicular venereal disease/ Coital exanthema/ vesicular vaginitis **Bovine herpes virus**	• Characterized by respiratory disease (bronchopneumonia), encephalitis in calves • Third trimester abortion and mastitis in cows • Presence of intra-nuclear inclusion bodies in affected cells • Site of latency (lifelong latency)- sciatic ganglia in genital disease & trigeminal ganglia in respiratory disease • IBR Virus may survive up to 1 year in Frozen semen	• Advance post-mortem autolysis in foetus in intrauterine death • Sandwitch Indirect ELISA is gold standard test
Ephemeral [illegible]r Dragon Boat Disease/ Bovine Epizootic fever/ Cattle Dengue/ Stiff Sickness **Vesiculovirus of Rhabdoviridae**	• Also known as Three-day sickness • Characterized by biphasic to polyphasic fever, serous nasal discharge, shivering, pulmonary emphysema, stiffness and lameness • Polyserositis, focal necrosis of skeletol muscles • Generalized oedema pf lymph nodes & lungs	• Arthropod borne disease • Diagnosis is mainly on basis of sign and symptoms
Rotavirus infection/ White scour/ milk scour/ three weak scour /Neonatal calf diarrhoea **Rotavirus (ds RNA)**	• In pig K/a **Porcine Rotaviral enteritis** • Acute gastroenteritis (yellowish watery diarrhoea) • Rota virus is most important cause of calf diarrhoea	Immunoperoxidase test
Corona virus infection	• Acute haemorrhagic gastroenteritis (diarrhoea with blood) • Emerging disease in canine	Immunoperoxidase test
Bovine Leukemia Leucosis/ Bovine lymphoma/ Bovine lymphosarcoma/ malignanat lymphoma **Oncornavirus**	Characterized by increased number of immature lymphocytes Occur in 3 form • Juvenile-less than 6 month • Thymic- 0.5 – 2 years • Cutaneous- older animals	Horizontal transmission
Bovine Immunodeficiency Lentivirus	• Characterized by lymphopenia, lymphocytic subcutaneous nodules, pododermatitis, abomasitis	Vertical transmission
Blue Tongue Sore Muzzle/ Sore Mouth of Sheep/ Dancing Disease/ Catarrhal Fever of Sheep **Orbivirus (ds RNA)**	• Biological vector: Culicoides • Mechanical vector: Sheep ked • Affect haemopoietic tissue and vascular endothelium • Congestion, oedema, cyanosis of tongue, endothelial cell damage, arteritis and pink lesion above coronet	Haemorrhage at base of pulmonary artery & aorta **(pathognomic lesion)**
Contagious Ecthyma/ Orf/ **Pox viridae**	Thistle Disease/ Scaby Mouth/ Infectious Labial Dermatitis/ Contagious Pustular Dermatitis Scabby and pustular lesions on muzzle and lips	
Jaagsiekte/ Ovine Pulmonary Carcinoma or Adenomatosis/ Driving Sickness **Type-D oncovirus**	• Proliferative pulmonary lesions along with metastasis • Adenomatosis of alveoli • Metaplasia of alveolar epithelium to cuboidal or columnar epithelium (adenomatosis) • Cells of tripier are also seen	Neoplastic (tumor) and malignant disease **Wheel Barrow test**

Maedi/Visna (Ovine Progressive Pneumonia/ Chronic Viral Encephalomyelitis/ Thin Ewe Syndrome) **Lentivirus**	• characterized by progressive interstitial pneumonia, lymphadenitis and progressive demyelination in CNS • Lung size increases up to 2-5 times	Non-neoplastic disease
Peste De Petits Ruminants (PPR) (Goat Catarrhal Fever/**Goat Plague**/ Stomatitis-pneumoenteritis complex/KATA) **Morbillivirus**	• Inhalation (main route) • 4 months -2 year goats are mostly susceptible • Incubation period-: 4-5 days • Characterized by interstitial pneumonia, erosive stomatitis and enteritis • **Zebra marking in rectum (pathognomic lesion)** • Case fatality rate: 55-85%	Interstitial pneumonia is absent in Rinderpest Multinucleated giant cell formation Intranuclear & intracytoplasmic inclusion bodies are found in affected cells
Louping Ill (Trembling ill/ Ovine encephalomyelitis) Flavivirus	• Characterized by leaping gait (jumping or bounding gait) • By Ixodes ricinus	
Rift Valley Fever Phlebovirus of Bunyaviridae	• Heavy mortality in young ones and abortion in pregnant animals • Transmitted by Culicine mosquitoes • Fever and muscle pain	Mainly affect sheep & cattle Ist reported in 1912 from Kenya
Akabane Disease (Runt Muscle Disease) Othobunya virus of Bunyaviridae	• Disease of foetus without systemic lesions C/B Congenital arthrogryposis hydranencephaly syndrome • Absence of dam seeking reflex	Mainly affect cattle Transmitted by Culex & Aedes
Nairobi Sheep Disease Orthonairovirus (Ganjam Virus) of Nairoviridae	• Most pathogenic virus infection of sheep and goat in Eastern Africa • Transmitted by hard tick (*Rhipicephalus appendiculatus & Amblyomma variegatum*) • Fever, diarrhoea, rapid respiration, premature abortion	Mainly affect sheep & goat
Classical Swine Fever/ Hog Cholera/ Swine Plague Pestivirus High morbidity & High mortality	• Ingestion (main route) • Characterized by widespread haemorrhage in visceral organs (Subcapsular haemorrhage on kidney and lymphnode, thrombosis of small & medium sized arteries) • **Pathognomic lesion: Button ulcers** at ileo-caecal junction (due to infarction) & **Turkey appearance of kidney** (Due to petechial haemorrhage)	Highest lesion is found in kidney Taylor Iodine Reduction Test Robert Amylase Test Nitric Acid Test
Transmissible Gastroenteritis of Pig Corona virus	Gastroenteritis (vomiting & diarrhoea with almost 100% mortality)	
Pseudorabies/ Mad Itch/ Aujesky's Disease/ Infectious Bulbar Paralysis **Herpes Virus**	• Direct contact (main route) • Disease of swine mainly but also occurs in cattle, sheep, goat, dog, cat • Characterized by itching, convulsion, non-purulent encephalitis • Intense inflammation of paravertebral ganglion, dorsal root ganglioneuritis	ELISA-recommended test Itching is absent in pig and goat Pig also act as reservoir host
Equine Influenza	Bronchopneumonia (dry persistant cough)	

(Equine flu/ Equine Distemper/ Pink Eye/ Stable Pneumonia/ Equine Typhoid fever) **Orthomyxovirus (H_3N_8)**	Mild fever	
Equine Infectious Anemia (Equine malarial fever/ Equine AIDS/ Equine Swamp Fever) **Lentivirus**	• Anemia (Normocytic Normochromic anemia) • Oedema of ventral wall of abdomen • Large quantities of hemosiderin deposition on liver & kidney • Spleenomegaly (Raspberry appearance) • Hepatomegaly	RBC count drop to 4 million per cubic mm **Coggin's test (AGID, Agar Gel Immunodiffusion Test)** is confirmatory test
Equine encephalomyelitis **Arbovirus**	Virulence of Strain: Venezuelon > Eastern > Western strain High fever, circling movements, neurophagia, perivascular cuffing Intranuclear inclusion bodies (Joest bodies) in neurons	Indirect immunoflorescent assay
Equine Viral Arteritis **(Pink Eye)** **Arterivirus**	• Inhalation (main route), ingestion, venereal • Ventral oedema (oedema of limbs- very common, palpebral oedema, anasarca) • Vascular damage to small arteries (severe damage to arteries of caecum & colon) • Enteritis (diarrhoea) • Rhinopneumonitis	Intranuclear inclusion bodies
African Horse Sickness (Equine Plague) **Orbivirus**	Occurs in 3 forms: 1. **Acute pulmonary form/Dunkop form- most common form-** frothy nasal discharge, pulmonary oedema, paroxysmal cough 2. **Sub-**acute cardiac form/ DIKKOP form- S/C oedema in head region- extensive swelling of supraorbital fossa, lips, eyelids 3. **Mixed form/ Horse sickness fever-** most common form in mule, donkey, zebra	Vector borne disease Vector- Cullicoides
Rabies (Hydrophobia/Lyssa/ madness/ Tollwat/ Rage/ Pisalne/ Lerage **Lyssa Virus of Rhabdoviridae**	• Non suppurative encephalitis • Intracytoplasmic inclusion bodies are formed in nerve cells are K/a **Negri Bodies (Carnivores- Hippocampal lobe; other animals- Purkinje fibres of cerebellum)** • Lymphocyte, plasma cells, glial cells proliferate and replace neurons and form **Babe's nodules** (mainly collection of micoglia) • Dog- Furius form & dumb form • Cat- furious form mainly • Rabbit- Dumb form mainly • Horse- colic • Cattle- Bellowing	FAT- Fluorescent Antibody Test (impression smear from brain) Demonstration of Negri Bodies Hable's Mouse Inoculation test Corneal Smear test
Infectious Canine Hepatitis (ICH) **(Rubarth Disease)** **Canine Adenovirus-1**	• Saddle curve fever and bleeding time increases • **focal** hepatic necrosis mainly in peri-portal region, chronic kidney lesions and corneal	Recovered dogs shed virus in urine for 6 months Intra-nuclear inclusion bodies in hepatocytes

Virus has affinity for parenchymal and kupffer cells of liver and endothelial cells	clouding **(Blue eye),** oedema of spleen, lymphnode and thymus • Haemorhages mainly of stomach and serosal surfaces • **Oedomatous and thickened gall bladder (pathognomic lesions)**	Bleeding time is more prolonged in ICH than CD CAV-2 is used in vaccine
Canine Distemper (Hard pad disease/ Carre's Disease/ Canine Influenza/Old Dog Encephalitis) **Morbillivirus**	• **Inhalation** (main route) • Biphasic fever, muco-purulent nasal discharge, temporal twitching, convulsion • Hyperkeratinisation of foot pad (Hard Pad) • Vesicle and pustules on abdominal skin • Thymus Atrophy is consistent finding • **Nut-meg liver (chronic venous congestion)** • Intra-nuclear and intracytoplasmic inclusion bodies formed in infected cells	Virus has affinity for myelinated portion of brain and spinal cord Perivascular cuffing of lymphocytes in old dog encephalitis Gemistocytic astrocytes are found Panleukopenia occurs
Canine Parvoviral Infection **Canine Parvovirus-2 (CPV-2)**	Occurs in 2 forms: 1. **Myocarditis form:** myocardial necrosis- 2-8 week of age- C/B by bilateral systolic murmur 2. **Enteric form:** Acute gastroenteritis (vomiting & Diarrhoea), hepatitis- greater than 6 weeks	Dobermann & Labra are at higher risk Basophilic intra-nuclear inclusion bodies (inclusion body myocarditis) **but absent in Feline Parvo**
Feline parvo infection (Feline panleucopenia/ Feline Distemper/ Feline Ataxia) **Parvovirus**	**Fadding Kitten Syndrome/ Feline enteritis/ Agranulocytosis/Cat plague** • Virus is present in all secretion and excretion of affected animals • Acute gastroenteritis (vomiting & Diarrhoea) • Cerebellar hypoplasia • Biphasic fever • Lesions occur in GIT & lymphoid organ	Vaccine failure occur very frequently due to interference by maternal antibody
Feline Infectious Peritonitis Corona Virus	Effusive (wet) & Non-effusive (dry) fibrinous peritonitis	Progressive fatal disease of cat of all age
Feline Leukemia (Feline lymphoma/ Lymphosarcoma/ **Oncornavirus**	Account 30% of all feline tumours Transmitted by nasal & salivary secretions C/B malignant lymphoma, lymphocytosis Thymic lymphoma- young cat Alimentary/Multicentric lymphoma- old cat	No lesions in brain
Pox	Cow pox (vaccinia) Sheep pox (sheep most susceptible to pox with highest mortality)- two form (malignant-lambs & Benign) Horse pox-two form- Leg form (Jenner Horse pox) & Buccal form	Pock lesions on hairless skin Goat pox-similar to sheep pox
Lumpy Skin Disease **Capri-pox virus**	Charcaterized by fever and nodular lesions on skin; restricted to African countries; recently outbreak occur in India also; African buffaloes reservoir host; first time discovered in Zambia (1929)	

Bacterial Diseases

Disease & Etiology	Characteristics symptoms & lesions	Diagnosis & remark
Brucellosis (Bang's Disease/ Gastric Fever/ Bruce Septicemia/ Malta Fever) ***B. abortus*** ***B. ovis*** ***B. meletensis* (S/G)** ***B. canis***	• Transmitted by **ingestion (main route)** • Bacteria has affinity to erythritol sugar which is abundant in placenta & foetus • C/B abortion in late gestation • Granuloma formation in genital organs, joints & foetal liver (**Granuloma is not present in all cases except in *B. Suis*)** • Horse- poll-evil & fistulus wither (associated with Actinomycosis) • In birds, lesions found in GIT & bone • Boar brucellosis- cervical lymph node enlargement	Rose Bengal Plate test Abortus Bang Ring Test (ABRT)-herd screening Rivanol/ Mercaptoethanol test Card test Complement Fixation Test (differentiate vaccinated & non-vaccinated animals)
Tuberculosis-TB (Pearly Disease/ Pthisis/ Consumption) ***M. tuberculosis* (Dog)** ***M. bovis* (Cattle & Horse)** ***M. avium* (birds, pig & horse)** Rabbit- *M. bovis*	• Tubercle formation in any organ except skeletal muscles (mainly in lung, spleen, lymph node) • Hacking cough, low grade fever, wasting (weakness) • Primary tuberculosis complex known as **Ghon's focus** • Horse-shoe shaped giant cells formation in tubercles • Generalized form of TB termed as **Miliary nodules** • **Pig** (*M. bovis*- caseous lesions; *M. avium*- tumour like lesions) • Bronchopneumonia is common in Sheep & Goat	**Stormont test (double intradermal test)** Avian TB- lesions are more in spleen, liver, intestine and less frequent in lungs, **no calcification of tubercle lesions** TB mastitis occur in 1% cattle **Horse:** Alimentary infection is common & spleen is highly affected organ, caesation & calcification of tubercle is rare
Paratuberculosis **(Johne's Disease/ Chronic bacillary dysentry)** M. paratuberculosis	• Emaciation, chronic intermittent diarrhoea (no foul smell), granulomatous enteritis, chronic lymphadenitis, submandibular oedema • **Thickening (Corrugation) of intestine: pathognomic lesion** • **no corrugation in sheep** • **Ileum is highly corrugated** • Caseative necrosis and calcification in sheep & goat (absent in cattle)	**Smear examination** (ileo-caecal valve is commonest site for detection of organism) **Johnin test** **Spoligo test** **Rectal pinch Biopsy test**
Pseudotuberculosis (caseous lymphadenitis) ***Corynaebacterium pseudotuberculosis* (*C. ovis*)**	• Abscess & granulomatous lesions in lymph node • No giant cell formation • Thick green pus is discharged	Onion-like concentrated mass on cut of lesion
Yersiniosis ***Yersinia tuberculosis***	Also known as Bovine lymphangitis • Necrotic hepatitis; Arteritis; Abortion	
Nocardiosis ***Nocardia asteroids***	**Bovine nocardiosis/Bovine Farcy** Photophobia, oedomatous swelling of eye, corneal ulcer, mastitis, lymphangitis, pneumonia, lymphadenitis **Canine nocardiosis:** lung is commonly affected	Isolation on SDA agar

Haemorrhagic Septicemia (HS) (Pasteurellosis/ Ghatsurp/ Barbone) ***Pasteurella multocida* type B:2** C/B/S/G/P	• Transmitted by ingestion (main route) • High fever, dyspnoea (ghar-ghar sound on respiration), oedematous swelling in brisket region, wide spread haemorrhage in visceral organ (no change in spleen) • Fibrinous bronchopneumonia • **Marbling appearance of lungs** (highly congested & consolidated) • **Sub-serous haemorrhage in endocardium** is almost a pathognomic lesion	Pasteurella survive longer in long bones **Rabbit: Haemorrhagic tracheitis- pathognomic lesion**
Pneumonic pasteurellosis of cattle (Shipping fever)	• Pasteurella haemolytica type A:1 • Pasteurella multocida type A:2 • Classical fibrous (lobar) pneumonia	
Pasteurellosis of Sheep & Goat	• Pasteurella haemolytica type A (pneumonic & septicemic) • Pasteurella haemolytica type T (Systemic)	
Anthrax (Spleenic fever/ Charbon/ Siberian plague/ Tarka disease/ malignant pustule/ Hide-porter disease) ***Bacillus anthracis*** Bacterial exotoxin has 3 components: Oedema factor Lethal Factor Protective antigen	• **Ist discovered bacterial disease** • Sudden death, tary coloured blood from natural openings, absence of rigor mortis, wide spread haemorrhage & odema • Spleenomegaly (10-15 times) • Death is due to apoplexy, asphyxia & toxemia • Horse- Acute form- bloody diarrhoea, severe colic & swelling on throat • Pig- chronic form- swelling on throat & neck, cervical lymph node enlargement • Dog- gastroenteritis	Algerian sheep is resistant Diagnosis: Ascoli's test Mc faydean's reaction Blood smear In non-ruminants, diagnosed by oedema smear onl
Black Quarter (Black Leg/ Symptomatic anthrax/ Farrya/ Felon) ***Cl. chauvei***	• Transmission by contaminated soil but in sheep by wound • Accumulation of sero-sanguinous fluid in thigh muscles leading to crepitating sound • Black colour of muscles is due to iron sulphide • **Mural thrombosis in heart (pathognomic lesion)**	Smear of affected muscle
Braxy (Bradshot) ***Cl. septicum***	• Ingestion of frozen grass • Mainly occur in winter and affect lambs • Necrotic and haemorrhagic abomasitis • Malignant oedema	
Enterotoxemia (Pulpy Kidney Disease/ Monday Morning Sickness in Goat/Overeating disease) ***Cl. perfringes* type D**	• **Most killer disease in goat** • Lesions develop due to epsilon toxin • Gastro-enteritis, pulpy kidneys, endocardial haemorrhage • Glycosuria & hyperglycemia	Mouse neutralization test
Tetanus ***Cl. tetani***	• I/P- 1-2 weeks • Spasmodic contraction of muscles	Mainly disease of horse & sheep

	• Muscles stiffness & immobilization (Wooden Horse appearance) • Toxin inhibit release of GABA and glycine resulting into spastic paralysis	Early rigor mortis in PM examination
Black Disease (Infectious Necrotic hepatitis) **Cl. novyi**	Black discoluration of skin Necrotic hepatitis	
Botulism **Cl. botulinum**	Ingestion of preformed toxin Flaccid Paralysis & sudden death	Hypoglyemia & glycosuria albuminuria
Colibacillosis (White diarrhoea/ Calf scour) ***E. coli*** **Calf: K 99** **Pig: K 88 & K 99**	Commonest bacterial disease of new born farm animals Enteritis (white diarrhoea), swelling of lymph node & payer's patches, pneumonia, endocardial haemorrhage	Isolation & identification
Salmonellosis (paratyphoid) **S. typhimurium** **S. dublin** **S. cholaraesuis (pig)** **S. typhi (human)**	C/B by 3 syndromes: 1. Septicaemia: occurs in new born 2. Acute enteritis- Adult animals 3. Subacute or chronic- **Pig** • Small foci of necrosis in liver known as **paratyphoid nodules** (consist of small aggegates of reticulo-endothelial cells- histiocytes & macrophages) • **Fibrinoid necrosis** of vessel walls & hyaline material deposition in glomerular capillaries (septicaemic form) • **Prolonged Ulcerative Proctit[illegible] S. typhimurium)-** mainly in Pig- C/B rectal stricture	**Generalized Shwartzman Reaction-** observed in pig: disseminated vascular thrombosis, bilateral cortical necrosis of kidneys
Campylobacteriosis (Vibriosis)	Abortion between 5th & 6th month (Sheep- at end of gestation)	
Listeriosis **(Circling disease)** *Listeria monocytogenes* Surface protein of organism (internalins) bind with E cadherin on host epithelial cells	• Transmitted by Ingestion (main route) • High fever, circling movement, **abortion** • **Encephalitis:** presence of micro-abscess in brain **(Pathognomic lesion)**, lymphocytic leptomeningitis • **Septicaemia (Systemic infection)-** common in mono-gastric animal C/B focal necrosis of liver	**Anton's test**
Leptospirosis (Weil's Disease/ Stutgart Disease/ Infectious Jaundice/ Haemoglobinuria/ Canine Typhus/ Canicola fever/ Mud Fever/ Seven-day fever/ Swine Handler Disease/ Sugar cane worker Disease/ Rice field	Canine leptospirosis Acute (Septicaemic) stage: Separation (individualisation) of **liver cells** Sub-acute stage: focal lesions in **kidney parenchyma** are concentrated at inner margin of cortex Bovine/Ovine leptospirosis- self-limiting disease Acute (Septicaemic) stage: centrilobular necrosis of liver	High leucocytic count is more indicative of Leptospirosis than CD

worker Disease/ Rat Scratch Yellow Fever) ***Leptospira canicola*** ***L. icterohaemorrhagiae*** ***L. hardjo***	Sub-acute stage (Nephritic form): focal lesions in **kidney parenchyma** are scattered throughout cortex **(Interstitial nephritis)**	

Actinomycosis (Cattle)
(Lumpy Jaw)

- Caused by Actinomyces bovis (gram + ve) - affects hard bone
- Suppurative rarefying osteomyelitis of mandible
- Miliary nodules in lungs
- Presence of large, hard, sulphur granules in exudate

Actinobacillosis (cattle)
(Wooden tongue/ Timber tongue)

- Caused by Actinobacillus ligneressie (Gram –ve) - affects soft tissue like tongue
- Granulomatous lesions in tongue, lymph node- fibrosis of tongue (wooden tongue)
- Presence of small granules in thick creamy pus

Strangle
(Equine Distemper, purulent lymphadenitis)

- *Streptococcus equi* (Gram +ve)
- Abscess in pharyngeal & maxillary lymphnode, suppurative pneumonia
- Metastatic abscess occurs in lung, liver, kidney (Chronic form/ Bastard strangle)
- Caesation and calcification of abdominal lymph node (Strangle in Burros)
- Thick & creamy nasal discharge
- The most common sequel to strangles is bronchopneumonia, laryngeal hemiplegia (roaring), facial paralysis, purpura haemorrhagica

Glanders
(Farcy, Pacin, Carn)

- *Burkholdria mallei* (Gram –ve)
- Ulcerative nodules in nasal passage, miliary nodules in lungs- bronchopneumonia, lymphangitis & lymphadenitis
- Punched out ulcer in lungs
- Lung-lesions are of tubercle like
- Cutaneous form is known as Farcy- ulcer on legs mainly
- Oily nasal discharge
- Acute form (septicaemia) common in mule & donkey
- Chronic form (bacteremia)- horse
- **Diagnosed by Mallein test**

Necrobacillosis (Foot Rot/ Infectious Pododermatitis) ***Fusobacterium necrophorum***	• Foot rot, necrosis of liver, enteritis • **In calf k/a Calf Diphtheria** C/B· diptheric membrane over oral mucosa, necrotic stomatitis, laryngitis, pharyngitis • **Pig- Bull nose** • Complicated by *Dichelobacter nodosus* in sheep	Cattle, sheep, goat (goat-highest incidence)
Swine Erysepalas (Diamond Skin Disease) ***Erysepalothrix rusiopathie***	Acute (Septicaemic) form- Diamond shape lesions on skin due to blood vessel damage Chronic form- Non-suppurative vegetative endocarditis & polyarthritis	
Botryomycosis (Staphylococcosis) ***S. aureus***	Pyogranulomatous lesions (nodules) in udder, jaw, shoulder region Yellow pus discharge	White granules are seen in lesions termed as SPLENDORE-HOEPPLI material
Dermatophillosis *Dermatophillus congolensis*	Strawberry foot rot/ Cutaneous actinomycosis/ Mycotic dermatitis/ Cutaneous Streptothricosis/ Lumpy wool of Sheep	

Mycoplasmal Diseases

Contagious Bovine Pleuro-Pneumonia (CBPP-lung plague/ lung sickness/ Brahmaputra valley disease)

- By Mycoplasma mycoides var. mycoides
- Diffuse lobar pneumonic lesions
- Marbling of lungs prominent: Separation of lobule into distinct compartment by thickened interlobular septa
- Sequestration- prominent feature

Contagious Caprine Pleuro-Pneumonia (CCPP)

- By Mycoplasma mycoides var. caprae
- Focal pneumonic lesions
- Marbling of lungs less prominent
- Pericarditis is noticed frequently

Mycoplasma agalactiae	Contagious agalactia of sheep
M. hyosynoviae & M. hyorhinis	Polyarthritis & Polyserositis
M. hyopneumoniae	Enzootic pneumonia of pigs
M. bovis	Bovine mycoplasmal mastitis Bovine Mycoplasmal arthritis
M. bovigenitalium	Bovine Granular Veneral Disease (Granular Vulvo-vaginitis)

Diseases with multifactorial etiology

Mastitis

Etiology: various bacteria, viruses, fungi, Mycoplasma and other organisms are involved
Staphylococcus aureus
Streptococcus dysgalactiae (Acute mastitis)
Streptococcus agalactiae (Chronic mastitis)
Streptococcus uberis
Sporadic mastitis- *Pseudomonas aeruginosa* and *E. coli*
Fungal agent- *Candida spp.* and *Aspergillus spp.*
Diagnostic tests: Strip cup test

- **White side test:** based on increased leukocyte content of milk
- **California Mastitis test**: based on increased leukocyte content and increased pH of milk
- Bromothymol blue test & Bromocresol purple test
- Chloride test
- **Hotis Miller test**: for Streptococcus agalactiae
- Catalase test
- Sodium lauryl sulphate test

Summer mastitis: by Corynaebacterium pyogenes (in heifers and dry cows)
Cold Mastitis: by Leptospira spp.

Cat flu (Feline Upper respiratory tract disease)

Etiology: Feline Herpes virus (Feline viral rhinotracheitis-cat common cold)
Feline calcivirus
Bordetella bronchseptica (cat kennel cough)
Chlamydia felis

Kennel cough (Canine infectious tracheobronchitis)

Etiology: *Bordetella bronchseptica*
Canine parainfluenza virus
Canine Adenovirus 2 (CAV-2)
Canine influenza virus

Note: Atropic rhinitis in pig caused by Pasteurella multocida but Necrotic rhinitis (Bull nose) in pig is caused by Fusobacterium necrophorum

Chapter-11

Pathology of Poultry Diseases

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Viral Diseases of Poultry

Disease	Characteristics findings	Diagnosis & remark
Infectious Bursal Disease (Gumboro disease/ Infectious Bursitis/ Avian Nephrosis) **Birna virus** Virus interfere with blood clotting mechanism	• **3-6 week** birds mostly affected • C/B classical spike mortality • Initially swelling in Bursa of fabricus then atrophy occurs • Deposition of urates in kidney & ureter **Pathognomic lesions:** 1. haemaorrhage at junction of proventriculus & gizzard 2. Paint brush haemorrhage in breast & thigh muscle	**No Vertical transmission** Immunosuppressive disease (mainly affect B lymphocytes but also affect T cells) Virus isolation is rarely used GD is common sequel to IBD
Infectious bronchitis **Corona virus** (Serotypes: Massachussets & Connecticut- **affect respiratory tract** T, Gray, Holte- **affect kidney** 793B- affect muscles)	• Cheesy exudate in bronchi • Deposition of urates in kidney • Interstitial nephritis • Effect on **egg quality & egg production** • WATERY WHITES (albumen loses its viscosity in eggs- thin & watery yolk) • Birds known as BLIND LAYERS	**No Vertical transmission** Dwarfing & curling of embryo take place in 10 day embryonated egg
Marek's Disease (MD) (Fowl paralysis/ Range paralysis/ Avian Reticulitis/ Skin leucosis/ Neural leucosis/ Grey eye/ Pearl eye) **Herpes virus** **3-6 month** mostly susceptible	Inhalation (primary route of transmission) • **Classical Form/ Neural leucosis-** Split leg stance (sport man posture) & enlargement of peripheral nerves mainly sciatic nerves (2-3 times) • **Visceral form:** lymphoma in gonads and other visceral organ characterized by pleomorphic lymphoid cells • **Occular form/ Grey eye/ Pearl eye:** anterior uveitis or iridocyclitis • **Cutaneous form/ Skin leucosis:** Nodular lesions at base of feathers	**No Vertical transmission** Mainly affect T cells (also affect B cells) **MATSA (Marek Associated T cell Surface Antigen)** is demonstrated in T cells
Avian Leucosis **Type C Retrovirus** Tumorous growth of bursa of fabricus is seen only in LL not in MD	C/B tumorous growth of lymphocytes in liver spleen lungs & other visceral organs Avian leucosis complex includes: • **Lymphoid leucosis (LL)/ Big liver disease/ Visceral lymphoma:** C/B	**Both** vertical & Horizontal transmission take place Affect B cells

	Moracco leather appearance of liver or cherry red liver Large lymphocytes & lymphoblast • **Erythroblastosis/ Leukemia** • **Myeloblastosis/ Myeloid leucosis** • **Osteopetrosis:** Thick leg Disease/ Marble bone Disease	Lymphoblast have B-cell marker & carry surface IgM only COFAL test RIFT test
Ranikhet Disease (RD) (New Castle Disease/ Pseudofowl plague/ Doyle's Disease/ Avian Distemper/ Avian Pest/ Black eye) **Morbilli virus** **3 strain:** Velogenic strain Mesogenic strain Lentogenic strain	5 forms are reported- • **Doyle's form/ Asiatic form/ Velogenic viscerotropic form:** most virulent form- **greenish stained diarrhoea**, pin-point haemorrhage at tip of proventriculus, caecum • **Beach (Pneumoencephalitic) form:** respiratory symptoms, late paralysis • **Beaudett's form (acute respiratory form) :** by Mesogenic strain • **Hitchner form:** by Lentogenic strain- mild respiratory infection • **Asympyomatic enteric form:** no clinical sign	Diagnosis by **HI** test RD is more severe than IB & Loss in egg production is also more in RD than IB
Avian Influenza **(Fowl Plague/ Bird flu)** **Orthomyxovirus** **(H5N1 strain)**	• Faeco-oral (ingestion)- main route • Oedema of face, cyanosis of comb & wattle, respiratory distress, convulsion • Serofibrinous pericarditis, air sacculitis, pneumonic lesions, caseous exudate in upper respiratory tract	**No Vertical transmission** Duck act as reservoir & carrier
Infectious Laryngotracheitis (ILT) Avian Diphtheria **Herpes Virus**	• Latent infection occurs (Trigeminal ganglion is main site of virus latency) • Hand pump like appearance of birds • Conjunctivitis is common ocular lesions **Per-acute form:** haemorrhagic tracheitis **Acute form:** dyspnoea & diptheric exudate	**No Vertical transmission** Intranuclear inclusion bodies in infected cells
Duck Viral Enteritis **(Duck plague)** **Anatid alphaherpesvirus 1**	Sudden death & high mortality (old duck) Mutiple tissue haemorrhage Free blood in body cavities & lumen of gut Necrosis of GI mucosa & liver Paint brush haemorrhage on heart Diphtheritic lesions in oesophagus	**No Vertical transmission**
Avian Encephalomyelitis (Epidemic tremor/ New England Disease/ Blue Eye) **Tremovirus** (Picornaviridae)	C/B lesions in CNS & pancreas Aggregation of lymphocytic foci in proventriculus, gizzard & pancreas Central chromatolysis of neurons in nucleus of brain stem	**Both** vertical & Horizontal (ingestion) transmission take place Peripheral chromatolysis in RD
Baby chick nephropathy (Avian nephritis)	**Avastrovirus 2 (Astroviridae)** Deposition of urate crystal (chalk like) in kidneys, on surface of peritoneum, liver & heart	
Fowl pox	**Contact:** main mode of transmission	Elementary bodies are known as Borrel bodies

(Avian pox/ Contagious epithelioma) **Pox virus** Sometime vector: Culex and Aedes are involved in transmission	**Cutaneous form/ dry form:** pock lesion on featherless part of body- only papules- no vesicle formation **Diptheric form/ Wet pox:** diptheric membrane lining the upper digestive & respiratory system	**Inclusion bodies are known as Bollinger bodies**
Inclusion body Hepatitis (Hepato-myeloporetic disease)	**Adenovirus** • Mainly seen in broilers (3-7 week) • Haemorrhage in liver and muscles	**Both** vertical & Horizontal transmission Intra-nuclear inclusion bodies are seen
Hydropericardium Hepatitis syndrome (Leechi Disease/ Angara Disease)	**Fowl Adenovirus-4 (FAV-4)** • Watery straw coloured fluid in pericardial sac • Hepatitis & atrophy of lymphoid organ	**Both** vertical & Horizontal transmission Intra-nuclear inclusion bodies are seen
Egg Drop Syndrome (EDS-76) **Adenovirus**	• 35-40% drop in egg production • Bird looks healthy • Thin & soft shelled eggs but not mis-shapen	Both **vertical (main)** & Horizontal transmission
Chicken Infectious Anemia (CIA) (Anemia Dermatitis Syndrome/ Panmyelophthisis- wasting away of bone marrow) **Gyrovirus (ss circular DNA) of Anelloviridae**	• Aplastic anaemia & generalized lymphoid atrophy (atrophy of bone marrow, thymus, spleen, bursa of fabricus) • Haemopoietic cells are replaced by adipose tissue • Affect T cells in thymic cortex	Both vertical & Horizontal transmission
Avian Stunting Syndrome (Helicopter Disease/ Malabsorption syndrome / **Pale Bird syndrome/ Runting- Stunting syndrome)**	**Disease is of viral origin but virus is not confirmed (Reovirus, Enteroviruses- mostly suspected)** • Stunted growth and lack of pigmentation • Disease of growing broilers • Atrophy of pancreas, thymus, bursa • Thread like Pancreas is pathognomic • Chickens are known as Yellow Heads	

Bacterial Diseases of Poultry		
Disease	**Characteristics findings**	**Diagnosis & remark**
Colibacillosis ***E. coli***	Commonest disease of poultry • **Colisepticemia:** Sero-fibrinous pericarditis **(pathognomic)**, perihepatitis, peritoniotis, • Presence of pseudomembrane over visceral organs • **Coligranuloma/Hjarre's Disease:** presence of yellow hard nodular granuloma in intestine, liver, mesentry • **Omphalitis/Mushy Chick Disease/ Yolk sac infection**: thin, watery coagulated unabsorbed yolk	

	• **Egg peritonitis** • **Air sacculitis**	
Pullorum Disease (Bacillary White Diarhhoea) ***S. pullorum***	• Chicks below 3 weeks affected • C/B dead in shell chick, **Whitish viscous diarrhoea**, Peritonitis & unabsorbed yolk • Small white necrotic foci on liver, lungs and Focal interstitial nephritis in kidney • In adult- mis-shapened & pedunculated ovary	Both vertical (main) & Horizontal transmission
Fowl Typhoid ***S. gallinarum***	• Affect grower & adult birds • **Liver- Bronze colour (pathognomic)** • Catarrhal enteritis (yellowish diarrhoea) • Turkey: White plaques in intestine	Both vertical & Horizontal (main) transmission
Salmonellosis/ Paratyphoid infection ***S. enteritidis***	• Organisms are confined to intestine mainly caecum (**Typhlitis** is most constant finding) • Diarrhoea with pasting feathers around vent & conjunctivitis	Both vertical & Horizontal transmission
Arizonosis ***S. arizonae***	Acute septicemic disease of young turkey C/B typhlitis	
Fowl Cholera (Avian haemorrhagic Septicemia/ Avian Pasteurellosis)	• **Peracute & Acute form:** multiple pin point necrotic foci in liver • **Aub-acute form:** pneumonia, oedema of lung, perihepatitis • **Chronic form:** caseous arthritis of the hock & foot joint	Turkey is more susceptible than chicken Bipolar staining of Bone marrow impression
Infectious Coryza (Fowl Coryza/ Roup) ***Haemophillus paragallinarum***	C/B swelling of face (facial oedema), comb, wattle, Ocular & nasal discharge	
Turkey coryza ***Bordetella avium***	Upper respiratory tract infection C/B rhinotracheitis	
Avian Tuberculosis ***M. avium***	• Transmitted by Ingestion (main route) • Granuloma (tubercle) formation in liver, intestine, spleen, bone marrow • Spleen gives knobby appearance • Tubercle in bone marrow (pathognomic) • Atrophy of sternal muscles (keel bone becomes prominent)	Chicken: Lung lesions rarely found waterfowl (duck): lung lesions are commonly found
Ornithosis (Chlamydiasis/ Psittacosis/ Parrot Fever) ***Chlamydia psittaci***	Transmitted by Inhalation (main route) • Watery greenish diarrhoea, marked wasting of pectoral muscles • Serofibrinous pericarditis, airsacculitis, enteritis, enlarged liver & spleen • Basophilic intracytoplasmic bodies are found in infected cells termed as **LCL bodies (Levinthal, Coles and Lillie)**	Turkey> Duck> Pigeon> chicken

Spirochaetosis (Tick fever/ Tick paralysis) ***Borrelia anserina***	Greenish diarrhoea, Mottling of Spleen & liver **Pathognomic lesions** • Mottled Spleen: 5-6 times enlarged • Haemorrhage at junction of proventriculus & ventriculus	Transmitted by *Argus persicus*
Campylobacter infection	***C. jejuni***- commonest spp. found in poultry Necrotic hepatitis, catarrhal enteritis	
Necrotic Enteritis	***Clostridium perfringes type A, C*** Necrotic patches in intestine Dark coloured diarrhoea	Commonly occur after coccidiosis
Gangrenous dermatitis (GD) (Necrotic dermatitis/ Gangrenous Cellulitis/ Avian malignant Oedema)	Multifactorial etiology: *Cl. septicum* *Cl. perfringes* type A *Staphylococcus aureus*	
Chronic Respiratory Disease ***Mycoplasma gallicepticum***	• Affect lower respiratory tract • C/B thickened cloudy air sacculitis with caseous plug on lung, air sac, fibrinous pericarditis, perihepatitis • Beaded (pearl) appearance of air sac	Serum Agglutination test- Standard screening test
Infectious synovitis ***Mycoplasma synoviae***	Cheesy material in synovial sac of foot & hock joint	
Infectious Sinusitis	Turkey: *Mycoplasma gallisepticum* Duck/goose: *Mycoplasma immitans*	

Important Fungal Diseases of Poultry	
Disease	**Characteristics findings**
Aspergillosis ***Aspergillus fumigatus*** ***Aspergillus flavus***	**Brooder pneumonia/ Mycotic pneumonia** • Affect lower respiratory tract • White or grey multiple granulomatous nodule in lungs and saucer shaped lesion in lungs with thickening of air sac • Presence of fungal growth in lungs & air sac
Favus *Trichophyton megnini* (earlier *T. gallinae)*	**White comb Disease** Deposition of thin white flour like material on comb giving Honey Comb like appearance
Candidiasis *Candida albican*	**Thrush/Crop Mycosis/Sour crop/Mycosis of digestive tract** Diphtheric membrane in crop & oesophagus giving Turkish Towel like appearance of crop & oesophagus **(pathognomic)**
Mycotoxicosis	
Aflatoxicosis **Toxin of *A. flavus*** (B1, B2, G1, G2)	• Young duck is 10 time more susceptible than chicken • Multifocal haemorrhage in liver with yellowish discoloration • Peri-portal hepatic **necrosis** • pericellular **cirrhosis** (chronic aflatoxicosis)
Ochratoxicosis ***Aspergillus ochraceous*** ***Penicillium veridicatum*** Young duck is more susceptible than chicken	• More lethal than aflatoxicosis but less occurrence • Acute ochratoxicosis: Acute tubular necrosis & urate deposition on visceral organ (visceral gout) • Subacute ochratoxicosis: hyperplasia of tubular epithelium & fatty change in liver, increase in glycogen content of muscles

Ulcerative Stomatitis	T-2 toxin
Prolapse of cloaca	Fusarium toxin

Parasites of Poultry	
Trematodes of poultry	
Prosthogonimus ovatus (P. indicus)	Penguin like movement in birds Laying of leathery eggs
Cestodes (tapeworm) of poultry	
Davainea proglotina	Dwarf or smallest or most pathogenic tapeworm of poultry
Rallietina tetragona	Largest tapeworm of poultry
Rallietina echinobothridia	Nodular tapeworm of poultry
Cotugnia digonopora	Double Pored Tapeworm of Poultry
Amoebotaenia cuneate	Triangular tapeworm of poultry
Nematodes of poultry	
Heterakis gallinarum	Caecal worm of poultry
Ascaridia galli	Largest nematode of poultry
Syngamous trachea (Y-shaped)	Gapeworm/Redworm/Forked worm of poultry
Oxyspirura mansoni	Eyeworm of poultry
Tetrameres mohtedai	Commonest nematode found among desifowl
Flies of Poultry	
Pseudolynchus canarensis (P. maura)	Young nestling pigeon
Flea of Poultry	
Echidnophaga gallinacea	Stick tight flea of fowl
Poultry lice	
Eomenacanthus stramineus	body louse
Gonoides gigas	large body louse
Menopon gallinae	shaft louse
Cuclogaster heterographus	head louse
Lipeurus caponis	wing louse
Lipeurus tropicalis	tropical wing louse
Goniocotes gallinae	fluff louse
Anaticola crossicornis	Duck
Ticks of Poultry	
Argas persicus	Common fowl tick
Mites of Poultry	
Cnemidocoptes mutans	Causes scaly leg
Cnemidocoptes gallinae	Causes depluming itch
Dermanyssus gallinae	Red mite of poultry/ Roost mite
Ornithonyssus bursa	Typical fowl mite/ feather mite
Cytodites nudus	Air-sac mite
Protozoa of Poultry	
Coccidiosis	
Eimeria tenella	Caecal coccidiosis (haemorrhagic typhlitis)
Eimeria necatrix	Intestinal coccidiosis (C/B ballooning of Intestine & Salt & pepper appearance)

Eimeria brunetti	Rectal coccidiosis (Bloody diarrhoea)
Histomoniasis (Black Head Disease/ Infectious enterohepatitis)	***Histomonas meleagridis*** Sulphur coloured faeces & black discoloration of head Necrotic foci in liver termed as Saucer-shaped lesions (pathognomic), necrotic ulcer in caecum
Hexamitiasis	*Hexamita meleagridis* (C/B diarrhoea)
Avian malaria	*Plasmodium gallinaceum & P. juxtanucleare*

Blue-comb disease

- Disease of poultry with multifactorial etiology
- Also known as Pullet disease/Avian monocytosis/New wheat disease/X-disease/Summer disease/Mud-fever of turkey/contagious indigestion
- Mainly characterized by white spots on liver and chalkiness of pancreas

Chapter- 12

Laboratory and Wild Animal Diseases

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Disease	characteristics
Diseases of rat & mice	
Tyzzer's Disease (Fat Rat Syndrome)	***Clostridium piliformae*** • Ingestion- main mode of transmission • Necrotic lesions on liver • Megaloileitis and haemorrhagic enteritis is most important lesion characterized by profuse watery diarrhoea
Haverhill fever (Rat bite Fever/ Epidemic Arthritic erythema)	***Streptobacillus moniliformis*** Swollen joints (Arthritis), oedema of extremities & tail
Murine respiratory mycoplasmosis (Chronic respiratory disease)	***Mycoplasma pulmonis***
Rolling disease	***Mycoplasma neurolyticum***
Transmissible murine colonic hyperplasia	***Citrobacter freundii***
Wasp waist (contracted abdomen)	***Clostridium botulinum***
Seropurulent conjunctivitis	***Chlamydia caviae***
Pasteurella infection	***Pasteurella pneumotropica***
Pseudotuberculosis	***Corynaebacterium kutscheri***
Wet tail (Proliferative ileitis/ regional enteritis/ Proliferative enteropathy/ Transmissible ileal hyperplasia)	It is a disease of hamster mainly, having multifactorial etiology namely: • ***Lawsonia intracellularis*** (Proliferative enteropathy) • ***E. coli*** • ***Campylobacter jejuni*** (Proliferative ileitis) Characterized by severe diarrhoea, wet tail matted with faeces Stress is predisposing factor
Mouse Typhoid (Salmonellosis)	*Salmonella typhimurium & S. enteritidis*
Epidemic Mouse Septicaemia	***Erysipelothrix muriseptica***
Salivary gland tumour	**Polyoma virus**
Epizootic diarrhoea (infantile diarrhoea)	**Rota virus** Characterized by yellow watery diarrhoea, dried perianal faecal plug, gaseous distention of intestine

Ectromelia (Mouse pox)	**Ectromelia virus**
Sialodacryoadenitis	**Corona virus**
Lymphocytic Choriomeningitis (LCM)	**Arena virus** Characterized by proteinuria, aseptic meningitis & lameness of hind legs
Mouse Hepatitis Virus infection	**Murine coronavirus**
Gongylonema neoplastica	**Stomach tumor**
Note: Mammary fibroadenoma is most common tumour in rat Chromodacryorrhoea is known as Red Tears in rat Mange & neoplasm are common in hamster Ring tail in rat is caused by high temperature and low humidity	
Diseases of Guinea pig	
Cervical lymphadenitis (Lump)	**Streptococcus zooepidemicus**
Sendai virus pneumonia	**Sendai virus (Murine respovirus/ Murine parainfluenza virus type 1)**
Note: Guinea pig is extremely susceptible to pneumonia & septicaemia caused by Bordetella bronchisepticum	
Diseases of Rabbit	
Tyzzer's Disease	***Clostridium piliformae*** • Ingestion- main mode of transmission • Necrotic lesions on liver • Megaloileitis and haemorrhagic enteritis is most important lesion characterized by profuse watery diarrhoea
Haemorrhagic septicaemia (Snuffles)	***Pasteurella multocida*** Characterized by haemorrhagic tracheitis, pneumonia, rhinitis, ootitis media or interna (wry neck/head tilt), conjunctivitis, dacrcystitis (weepy eye), subcutaneous and visceral abscess,
Tularemia (rabbit fever)	***Francisella tularensis***
Mastitis **(Blue bag/ Blue breast)**	***Staphylococcus spp.***
Mucoid enteritis (enterotoxaemia)	***Clostridium spiroformae*** (iota toxin) Characterized by typhlitis
Arthritis	Actinobacillus capsulatum
Pseudotuberculosis	Yersinia pseudotuberculosis
Tuberculosis	Mycobacterium tuberculosis
Rabbit syphilis (Vent Disease)	Treponema paraluiscuniculi
Floppy Rabbit Syndrome	Encephalitozoon cuniculi C/B hypokalemia, hypocalcemia
Myxomatosis (big head)	Myxoma virus (Poxviridae)
Shope fibroma	Shope fibroma virus (Poxviridae)
Oral papillomatosis	Oral papilloma virus (wart like growth om back of tongue)
Cutaneous papillomatosis	Shope papilloma virus (Cotton tail papilloma virus)

	Characterized by wart formation (hyperplasia of stratum spinosum)
Myxomatosis (Big head)	Myxovirus
Viral Haemorrhagic Disease	Calcivirus Characterised by hepatitis
Ringworm	Trichophyton mentagrophytes
Ulcerative pododermatitis (sore hocks)	
Hutch burn/Urine burn	
Moon eye	**Blue eye/ Bupthalmia/ Infantile Glaucoma**

Note:

- Corneal ulceration is most common opthalmic disease
- Adenocarcinoma of uterus is most common tumour
- Ring worm in guinea pig & rabbit- Trichophyton mentagrophytes
- Suppurative condition is not seen commonly in rabbit because serum is rich in antienzyme and poor in leucocytes

Parasites of laboratory animals

Klosiella muris infestation	**Nephritis**
Eimeria caviae	**Coccidiosis (colon) in guinea pig**
Hetarakis spumosa (nematode)	**Caecum & colon of rat and mice**
Polyplax serrata	Common lice of mice
Gyropus ovalis Gliricola porcelli	Lice of Guinea pig
Hymenolapis nana **Hymenolepis diminuta**	Tapeworm of rat & mice
Psoroptes cuniculi	Otocariasis in rabbit
Oxyuris ambigua	Pinworm of rabbit
Eimeria steidae	**Liver coccidiosis in rabbit**
Haemodipsus ventricosus	Lice of rabbit

Diseases of wild animals

Elephants

- Foot & Mouth disease
- **Elephant Endotheliotropic Herpes virus infection:** caused by Elephantid betaherpesvirus/ **Elephant endotheliotropic herpesvirus 1 (EEHV-1),** occurs mainly in Asian elephants, characterized by cyanosis of tongue, oral & intestinal ulcers, extensive serosal & cardiac haemorrhages, lymphoid nodules in lungs, skin and vestibule
- Tetanus: common in captive elephants
- Trypanosomiasis: Surra like camel
- Pasteurellosis: symptoms similar to anthrax
- Fibrolipoma
- Pododermatitis: causative agent- E. coli, Pseudomonas spp., Streptococcus spp.,
- Intussusception
- Enteritis
- Chronic metritis
- Dropsy
- Elephant pox: severe conjunctivitis lead to corneal opacity

- Streptococcus, Staphylococcus, Corynaebacterium infection: colic like disorder & corneal opacity
- Long-time persistent wound common in elephants
- Cutaneous filariasis is caused by *Indofilaria pattabhiramani*
- Flea & tick infestation is more common in elephant than other wild animals
- Elephant tick- *Amblyomma tholloni*
- Elephant louse- *Haematomyzus elephantis*
- Fascioliasis (Asian elephants)- *F. hepatica* & *F. jacksoni*
- Fascioliasis (African elephants)- *Protofasciola robusta*
- Trypanosomiasis- Thut (Asian elephants)- *Trypanosoma evansi*
- Trypanosomiasis- Thut (African elephants)- *T. congolense, T. vivax, T. brucei*

Other Wild Animals

- Bunny hopping gait and cow hocked stance occurs in deer in copper deficiency
- *Klebsiella pneuminae*- severe pneumonia and middle ear infection in monkey
- **Chronic Wasting Disease-** of mule deer, white tailed deer, elk, mouse characterized by transmissible spongiform encephalopathy caused by **Prions** protein
- **Epizootic Haemorrhagic disease of** white tailed deer, antelope characterized by extensive haemorrhage of skin and clinical signs are similar to Blue tongue disease in small ruminants. Etiology- **Orbivirus**
- **Capture Myopathy (overstraining disease/ Excertional rhabdomyolysis)** of hooved mammals & birds: non- infectious disease caused by capture struggle & stress characterized by muscle rupture, muscle stiffness, shock & death
- **Mucosal & cutaneous ulcerative syndrome in black rhinoceros** caused by transportation stress, sudden climate change, stress & advance pregnancy
- Peracute Mortality Syndrome in Giraffe **characterized by serous atrophy of fat body reserves and pancreatic degeneration**
- **Periarticular hyperostosis in Lemur:** unknown etiology, characterized by distention of joint capsule, joint pain, stiff gait
- **Haemochromatosis in lemur:** etiology- excess intake of iron & ascorbic acid characterized by haemochromatosis & diffuse, chronic necrosis in liver & diffused oedema in brain
- Chytridiomycosis in amphibians
- **White nose syndrome** in bats
- **Devil facial tumour disease** in Tasmanian devils
- **Septicaemic Cutaneous Ulcerative Disease (SCUD)** of reptiles: Etiology- **Citrobacter freundii**
- **Shell rot of aquatic turtles & tortoises-** caused by **Benekia chitonovora** & characterized by unpleasant discharge and smell from affected area, soft areas under the shell
- **Athesmia foxi-** trematode of bile duct of monkey
- *Ophionyssus natricis*- blood sucking mite of captive snake

Chapter- 13

Toxicopathology

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Poisoning/Toxicity	Features	Diagnosis/Treatment
Lead poisoning • Most common in dog and cattle • Cross placenta and blood brain barrier	• Basophilic stippling • Horse- roaring • Birds- paresis of wings/wing drop condition • Blue line at tooth (plumbism) as a result of lead sulphide	Potassium Iodine test DOC- Calcium disodium EDTA
Mercury Poisoning **More common in bovine and feline** Inorganic mercury is more toxic than organic Inorganic mercury- Gastroenteritis and renal disease Organic- CNS disease	• Inorganic Hg –slow absorption from GIT & excreted in urine • Organic Hg- fast absorption from GIT & excreted in faeces • All Hg forms crosses placenta • Perforation in intestine	
Arsenic poisoning • Order: Arsine> Trivalent> pentavalent> organic arsenic • Cross Placenta but not blood brain barrier • Effect glycolysis, TCA, inhibit pyruvate dehydrogenase	• Swine assume Dog sitting posture • GIT mucosa- Brick red colour • Haemorrhagic gastroenteritis • (Rice water diarrhoea) • Preserved carcass is feature of post mortem • Mee's line across nails	Marsh test DOC: • BAL (Dimercaprol) • Sodium arsenite • Acetylcysteine
Copper poisoning Sheep more susceptible than cattle • Damage liver and lowers concentration of glutathione • Genetic defect in Bedlington terrier	• Haemolytic crisis in ruminants • Haemoglobinuria • Deep green colour faeces • Port wine colour urine • Bluish black kidney/Gun metal kidney • Spleen-black berry jam like • Kayser-Fleischer (KF) rings in eyes	DOC: • Ammonium molybdate • D-penicillamine

Molybednum poisoning (Teart/Spectacle disease) cattle more susceptible than Sheep	Persistent scouring/scouring diarrhoea (Peat scour) Pacing disease Sway back disease	DOC- Copper sulphate
Selenium poisoning: Toxicity order- Selenate (Se+6)> Selenite (Se+4)> Selenide (Se+2) Replace sulphur in aminoacids Rapidly absorbed in small intestine	• All forms converted to Se^{+4} • Acute/subacute- Blind staggers • Chronic- Alkali disease/Long Rocker shaped hoof/ Rooted to one spot stance	Selenium toxicity in Ireland known as **Dog Murrain** Obligate plant- 100-1000ppm Facultative- 25-100 ppm Non-accumulator- 1-25ppm
Phosphorous poisoning Phossy Jaw Bran disease in horse	• Garlic like odour in breath and vomitus • Vomitus Glow • Fatty infiltration in hepatocytes	
Nitrate and nitrite poisoning Highest susceptibility: Swine>Cattle>Sheep	• Death due to failure of cellular respiration and hypotensive crisis • Chocolate brown colour blood on Post mortem	Diphenyl amine blue test Starch Iodine test DOC: 1% Methylene blue (in excess causes Heinz body anaemia)
Salt poisoning (pig and poultry- most susceptible)	• Haggard appearance • Water deprivation syndrome • Eosinophilic meningoencephalitis in pig • Cerebral oedema on PM	Laminar loss of cortical neurons is pathognomic lesions in pig
Fluoride poisoning	Black discoloration of teeth Exostosis of long bone Aplastic anemia	
Carbon monoxide poisoning	Cherry red colour blood due to carboxyhaemoglobin Compensatory myocardial hypertrophy occurs	
Cyanide/Cynogenic plant poisoning Toxic principle: Bitter almond & wild cherry- Amygdalin Linseed & Welvet grass- Linamarin Sorghum- Dhurrin Lotus- Lotastralin	• cattle more susceptible than Sheep • Bright cherry red colored unclotted blood • Bitter almond smell on opening mouth • Histotoxic anoxia occurs	Picrate test (Sodium paper picrate test/Henrici test) DOC: Sodium thiosulphate and sodium nitrate in 3:1 ratio
Abrus poisoning (Rosary peg/ Lectin/ Sui-Needle poisoning)	• Vomition, • Diarrhoea	DOC: antiabrin serum

Toxic principle: Abrin	• Hemolytic anemia	
Ricinus poisoning (Castor/Palma Christi poisoning) Toxic principle: Ricin 1 & Ricin 2- resemble bacterial exotoxin	• Horse most susceptible • Inhibit 60 S RNA (protein synthesis)	DOC: antiricin serum
Lantana poisoning (Beach disease/Malde Palaya/ Bunch beri/ Wild sage poisoning) Toxic principle: Pentacyclic triterpines (Eg. Lantadenes- Lantadene A is more toxic)	• Hepatotoxicity • Secondary photosensitization	
Parthenium poisoning (Congress grass) Toxic principle:Parthenin (Sesquitorpene lactone)	• Contact dermatitis • Primary photosensitization	
Ipomea poisoning (Morning glory) Toxic principle: resin (Scomonin)	• Lower dose- diarrhoea • High dose- purgation • Toxic dose- salivation, mydriasis, ataxia	
Dhatura poisoning (Jimson weed/Thorn apple)	Cat and bird- more toxic Death due to respiratory/cardiac failure	
Nerium/Thevatia poisoning (Kaner poisoning)	Toxic principle: Nerioside, Oleoandroside Inhibit Na-k-ATPase enzyme	DOC: Atropine sulphate
Strychnos poisoning Dog and cat- more susceptible	• Mode of action is similar to tetanus toxoid • Inhibit glycine in CNS • Saw horse posture	
Braken fern & Horse tail poisoning Sheep: bright blindness	• Thiamine deficiency • Ruminants- Bone marrow depletion (Aplastic anemia) • Bovine enzootic haematuria	DOC: DL-Batyl alcohol
Oxalate poisoning	• Monogastric, pregnant, lactating animal more susceptible • Hypocalcinemia	DOC: Lime water
Sweet clover poisoning Toxic substance- Dicumarol (Vitamin K antagonist)	• Characterised by massive haemorrhages, hematoma in muscles and joints	DOC: Vitamin K
Onion toxicity	Characterized by Haemolytic anaemia, jaundice, methaemoglobinemia and Heinz body formation,	
Rodenticide poisoning		

ANTU Selective poison for rat	• Ruminant resistant • Pulmonary oedema (animal drowns in its own fluid)	Work best on full stomach
Zinc phosphide (Mad Dog Running)	• Most potent & commonly used rodentcide • Cardiac arrest and pulmonary oedema	Dead fish odour in stomach content Work best on empty stomach
Red squill (Safe rodenticide)	Cardiac failure	
Warfarin	• Blood does not clot • Pigs are most susceptible	DOC: Phytonadione
Toxins		
Zearalenone	Porcine vulvo-vaginitis syndrome in swine	
Ergotism	Respiratory failure	
Black widow Spider bite (*Latrodectus tredecimguttatus*)	Toxin principle: alpha latrotoxin-similar to botulinum toxin- 10 times more toxin than rattle snake venom	Other toxic spider: Browb recluse spider Holo spider
Toad toxin	Contain cardiac glycoside and neurotoxin (bufotoxin)	
Fish poisoning	• Tetradotoxin by Puffer fish • Saxitoxin	Both are neurotoxin but tetradotoxin is more toxic
Ant venom	Formic acid (potent cytotoxin)	
Cantharidine poisoning	Mainly occurs in horses when they ingest alpha alpha hay contaminated with **dead blister beetle** and characterized by diaphragmatic flutter	
Miscellaneous poisoning		
Ethylene glycol poisoning	Mainly reported in dog and cat characterized by nephrocalcinosis, polyuria, polydipsia, vomiting and formation of calcium oxalate crystals in PCT of kidney DOC- Ethanol or Fomepizole (4-methylpyrazole)	
Atenolol toxicity	Characterized by bradycardia, hypotension and vacuolation of Brunner's gland	
Haemotoxic snake	Viper & Rattle snake	
Neurotoxic snake	• Cobra (alpha-bungarotoxin- similar action like d-tubacurarine) • Krait	
• Venomous snake: Elapines (Cobra, Mamba, Coral snakes); Viperine (True viper- Russel viper; Pit viper-Rattle snake) • Poisonous snake is characterized by triangular shaped head, elliptical pupil and single row of sub-caudal plate (anal plates) • Dose rate of antivenom @ 1 unit/70 kg b.wt. in large animals and 5 units in small animals		
Thallium poisoning (Thallium- perfect poison)	Characterized by Burning feet syndrome and triad syndrome- gastroenteritis, polyneuropathy, alopecia Antidote- Gentian violet	
Silo fillers disease	Toxicity of NO_2 gas characterized by atypical interstitial pneumonia	
H_2S & Disulfiram poisoning	Rotten egg smell from stomach contents	
Potassium chlorate poisoning	Characterized by haemoglobinuria	

Insecticides poisoning			
Organophosphorus compound	**Organocarbamates**	**Organochlorine**	**Pyretheroids**
-Irreversible inhibition of acetylcholinesterase -Bind only to esteratic site Eg. Tabum, Serin, Coumophos, Diazinone Chlorpyrifos DOC: • Atropine sulphate • 2- PAM (Pyridine Aldoxime Methiodide) • DAM (Diacetyl mono-oxime)	-Reversible inhibition of acetylcholinesterase -Bind to anionic and esteratic site Eg. Carbaryl (Sevin), Propoxus (Baygon) DOC: Atropine sulphate	**-Diphenyl aliphatic agent** eg. DDT, Methoxychlor, Perthane, Dicofol **-Cyclodiene agent** eg. Aldrin, Dieldrin, Endrin, Endosulphan, Chlordane Heptochlor **Hexachlorocyclohexane agent** Lindane (BHC), Mirex, Kepone, Paradichlorobenzene	**Type-I** (do not have alpha cyno moiety) **Eg.** Allethrin, Permethrin, Cismethrin **Type-II** (have alpha cyno moiety) **Eg.** Deltamethrin, Cypermethrin, Fenvalerate, Fluvalinate, Flumethrin
• Flumethrin- Fish, cat, rat are mostly susceptible for flumethrin poisoning • Chlorpyrifos poisoning is characterized by neurodegenerative changes which includes neuronal vacuolation, neuronal breakdown and replacement by satellite cells and Nodules of Nageotte formation • Lindane poisoning is common in Cat and Dog			

Quantity of samples required to diagnose toxicity	
Samples	**Quantity**
Feed/fodder	2 kg (for mycotoxin)
Stomach/Ruminal contents	500 gm
Fat tissues/Faeces/Vomits	250 gm
Liver/Kidney	100 gm
Hair	10 gm
Bile	100 ml
Urine	50 ml
Blood/serum	10 ml
Water	500 ml
Brain	Half
Eye/Ocular fluid	Whole eye

Chapter- 14

Veterinary Public Health

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- Health is a state of physical, mental and social well-being in which disease and infirmity are absent (WHO).
- Public Health: The science and art of preventing disease, prolonging life and promoting health and efficiency through organized community measures such as control of infection, sanitation, health education, health services and legislation, etc. (Winslow, 1851)
- Father of Public health- **Cholera**
- Veterinary Public Health- is a multidisciplinary approach that focuses on application of veterinary science to protect and improve physical, mental and social well-being of humans
- **Father of Veterinary Public health- J.H. Steele**
- Illness- Subjective state of the person who feels aware of not being well.
- Hygiene- set of practices performed for the preservation of health
- **All India Institute of Hygiene and Public Health is located at Kolkata, West Bengal**
- 'The Sanitary Condition of the Labouring Population' was published by **Edwin Chadwick** in 1842.
- 1st Public Health Act was passed in United Kingdom in 1848.
- Publication of the Health Belief Model (HBM) in 1958 by **Rosenstock and Kegels**
- Since both in importance and in time health precedes the disease, so, we ought to consider first how health may be preserved and then how one may best cure the disease- by **Galen.**
- Ist International sanitary conference in 1851- Paris
- WHO declared TB a global public health emergency-1993
- Nothing on earth is more International than disease- **Paul Russel**
- The President of USA having polio before 1945- **Franklin Roosevelt**
- Father of epidemiology or father of modern epidemiology- **John Snow**
- **Father of Veterinary epidemiology- Schwabe**
- **John Last** defined epidemiology
- The concept of Public Health in India started after 1858 when there was heavy mortality and morbidity among European troops in India due to malaria and other preventable diseases.
- Milk- it is wholesome, fresh, clear, lacteal secretion obtained from complete milking of healthy udder 15 days before & 5 days after parturition
- Wholesome milk- milk having minimum bacterial load and free from antibiotic residue
- Food safety- is a systemic preventive approach describing handling, preparation & storage of food in ways that prevent food borne illness
- Good manufacturing Practices (GMP)- production & testing practices that helps to ensure a quality product.

Germicidal activity in milk	
Immunoglobulins	IgA & IgG provide passive immunity, neutralizes toxin, prevent adhesion of bacteria and act as opsonin
Leukocytes	Present in small quantity
Complement	Present in small quantity
Bifidus factor	Present in human milk. These factors are oligosaccharides that enhance growth of desire bacteria Bifidobacterium spp.
Lactoferrin	Iron protein inhibit multiplication of bacteria Content is more in human milk
Lysozyme	Concentration is more in human milk than bovines
Lacto-peroxidase thiocyanate H2O2 system	Concentration is more in bovine milk than human milk

- V-globulin is major protein in colostrum
- Lactenin (bacteriostatic) is also a spermicidal factor present in milk

Classification of dairy bacteria b/o temperature

Psychotrophic Optimum Temperature (OT)- 7^0 C Temp. range: 15-20^0 C	**Mesophilic** (OT)- 37^0 C Temp. range: 20-40^0 C	**Thermophilic** (OT)- 55^0 C Temp. range: 40-85^0 C	**Thermoduric** (OT)- 63-64^0 C Temp. range: 35-37^0 C
• *Pseudomonas spp.* • *Alkaligenes spp.*	• *S. aureus* • *E. coli*	• *Streptococcus thermophilus.* • *Bacillus stearothermophilus,*	Survive at pasteurization temperature • ***Micrococcus varians***

Serratia marcescens produces red pigment known as 'prodigiosin'
Clostridium perfringenes: Causes "bovine mastitis' in cattle and causes 'neurological disorders' in humans. It produces profuse gas and breaks the coagulum of milk causing "Stormy fermentation"
Clostridium tyrobutyricum: Causes 'late blowing condition' in Cheeses
Clostridium butyricum; Causes 'late blowing condition' in Cheeses after 1-2 months of manufacture
Clostridium sporogenes : Develops rancidity of emmental cheese

Source of contamination of milk on farm	Production of hygienic milk
• Contamination during collection • Contamination by milkers • Contamination from environment • Equipment contamination • Contamination during processing & transport • Contamination of raw milk in chilling centre • Contamination by tankers • Contamination during pasteurization • Contamination during packing	Cleaning & sanitization of dairy equipments & utensils Milker's hygiene Methods of milking: most hygienic method of milking in dairy animals is **Full hand milking** (Dry full hand is best) Teat should be washed with cloth dipped in KMnO4 or bleaching powder Hygienic milking practices Adopting clean-in-place (CIP) method

DMC (Direct Microscopic count) in milk	SPC (Standard Plate Count) in milk
Less than 5 lac- Good 5-40 lac- Fair 40-200 lac-Poor Greater than 200 lac- Very poor	Upto 2 lac- Very good milk 2-10 lac- Good milk 10-50 lac- Fair Greater than- Poor

Milk-borne pathogens		
Bacteria	**Virus**	**Fungi**
Bacillus cereus	Poliomyelitis virus	*Penicillium spp.*
Clostridium perfringens	Coxa sakie	*Aspergillus spp.*
Botulism (*Brucella spp.*)	Infectious hepatitis A	*Rhizopus spp.*
Q- Fever	Tick borne encephalitis virus	*Geotrichum candidum*
Brucellosis	Foot & Mouth virus	*Cladosporium spp.*
Tuberculosis	Cow pox & pseudopox virus	
Alcaligenes spp.	Bacteriophages	
Streptobacillus moniliformis		
Bacillus anthracis		
Streptococcus spp.		

Spoilages in milk and milk products	
Natural souring / curdling (lactic acid production)	*Streptococcus lactis, S. cremoris* *Lactobacillus casei, L. acidophilus, L. bulgaricus.*
Ropiness or Sliminess	*Alcaligenes viscolactis* – **Most common** *Bacillus cereus, B. subtlis, B. circulans* *Streptococcus lactis, Lactobacillus casei, L. bulgaricus*
Frothiness/ Gassiness/ Bulging of cans	*Candida pseudotropicalis, E. coli* *Clostridium butyricum, Cl. sporogenes*
Lipolysis	Psychrotrophs – *P. fragi, P. fluorescens, Achramobacter lipolyticum, A. viscolactis, S. marcescens. Flavobacterium and Acinatobacter spp.*
Proteolysis	Psychrotropic – *P. fluorescens, P. fragi, P. putrifaciens, P. putida, P. aeruginosa, Achromobacter spp., Acinitobacter spp., Aeromonas,* Thermoduric – *Bacillus subtlis, B. cereus, B. stearothermophilus*
Sweet Curdling	Aerobic spore formers – *B. cereus, B. subtlis, B. mycoides* Psychrotropic spore formers – *B. lichiniformis, B. albolactis* Non spore forming rods – *Proteus spp., Escherichia* Cocci – *Str. Liquifaciens*
Bitty cream or broken cream	*B. cereus*
Early blowing of cheese	*E. coli*
Late blowing of cheese	*Clostridium spp.*
Colour change in Milk	
Yellow milk	*Pseudomonas synxantha, Flavobacterium*
Blue milk	*Pseudomonas synciani*
Brown milk	*Pseudomonas putrifacians*
Green milk	*Pseudomonas aeruginosa, P.fluorescenss*
Red milk	*Serratia, Micrococcus, Yeast (Rhodutorula glutinis)*
Flavour change in Milk	
Bitter flavour	Proteolysis
Medicinal flavour	*E. aerogenes*
Musty odour	*Streptococcus lactis*
Fruity odour	*Pseudomonas fregi*
Phenolic/carbolic odour	*Bacillus circulens*
Bitter odour	Psychotropic and thermoduric bacteria
Fishy odour	*Aeromonas hydrophila*
Potato-like odour	*Pseudomonas mucidolense*
Malty flavour	*S. lactis var maltigens, Lactobacillus maltaromicus*
Unclean flavour	Most of the psychrotrophic bacteria

Milk borne poisoning		
Milk borne infection	**Milk borne intoxication**	**Milk borne toxi-infection**
Viable organisms are involved	Ingestion of preformed toxins	
Salmonella poisoning (Salmonellosis)	Staphylococcal poisoning	B. cereus poisoning (emetic toxin and diarrhoeal toxin)
Bacillary dysentery (Shigellosis)	Botulism	
Streptococcal infection	E. coli poisoning	Cl. perfringens poisoning
Tuberculosis, Brucellosis Diphtheria, Q-fever	Aflatoxicosis	
Poliomyelitis, Coxasackie infection, Infectious hepatitis		

- Ingestion of toxins already synthesized in the food (pre-formed) is called food intoxication
- Ingestion of viable pathogenic organisms along with the food leads to their lodgement and establishment in organs is called food infection.
- Brucellosis is classical example of milk borne disease
- Botulism is characterized by double vision and respiratory failure
- B. cereus poisoning is characterized by vomition and fried rice syndrome

Species	Different Constituents Of Milk (Approx. Value in %)				
	Water	**Fat**	**Protein**	**Lactose**	**Ash**
Cow	86.6	4.6	3.4	4.9	0.7
Buffalo	84.2	6.6	3.9	5.2	0.8
Mare	**89.1**	7.6	2.7	6.1	0.5
Sheep	79.4	**8.6**	**6.7**	4.3	**1**
Goat	86.5	4.5	3.5	4.7	0.8
Human	87.7	3.6	1.8	**6.8**	0.1

Type of milk	SNF (Solid Non Fat-%)	Milk Fat (%)
Skim Milk	8.7	< 0.5
Double Toned Milk	**9**	1.5
Tonned Milk	8.5	3.5
Buffalo Milk	**9**	**6**
Cow Milk	8.5	3.5
Standard Milk	8.5	4.5

Pasteurization Methods	
High Temperature-Short time (Flash) pasteurization (HTST)- most common methods	72^0C (161^0F) for 15 seconds
Low temperature-Long time (Batch or Holding) pasteurization	63^0C (145^0F) for 30 minutes
Stassanization	74^0C for 7 seconds
Ultra high temperature pasteurization (UHT)	130 - 135^0C for fraction of second
Ultra pasteurization or Uperization	150^0C for fraction of second

- UHT milk can be stored up to 20-25 days at room temperature
- Freshly prepared UHT milk has cooked and cabbage flavour

Chemicals required to detect adulterants in milk	
Chemicals	**Adulterants**
Iodine	Starch
Barfoed's reagent and Phosphomolybdic acid	Glucose

24% trichloroacetic acid, 2% NaOH, 2% NaOcl, 5% phenol	Urea
Resorchinol	Cane sugar
2% NaOH, 2% NaOcl, 5% phenol	Ammonium sulphate
Name of specific tests	
Resorchinol test	Adulteration of canes sugar in milk
Phosphatase test	Inadequacy of pasteurization
Iodine solution test	Starch adulteration in milk
Dimethyl amino benzaldehyde reagent	Urea in milk
Bromo cresol purple solution	Detergent in milk
Delvokit test	Presence of antibiotic and sulphur residue in milk
Mercuric nitrate test	Adulteration of gelatin in milk
Diphenyl amine sulphuric acid test	Adulteration of water in milk
Baudin test	Adulteration of desi ghee with dalda/ Vanaspati/hydrogenated oil/Sesame oil
Phytosterol acetate test	Adulteration of ghee with vegetable oil
Halphen's test	Cotton seed oil in ghee

Meat Hygiene and Public health

Ways of hygienic meat production	Conditions during transport of animals
• Proper transportation of animals includes adequate space, Food & water, ventilation • Sanitary and clean procedures of slaughtering • Humane methods of slaughter • Clean procedures of processing and packaging to stop entry of pathogens • Transportation of meat to consumers in clean condition & proper temperature	• Loss of weight • Transportation stress: pig and poultry-most susceptible • Mortality • Dehydration & shrinkage • Change in meat quality (DFD in cattle & PSE in pigs) • Bruising (mainly of hip region) • Shipping fever or transit fever • Transit tetany • Salmonellosis • Bloat
• Bilirubin test with help of Fouchet's reagent (trichloroacetic acid & Fecl3) is done to detect bruise in meat sample • Torrymeter is used to detect spoilage in meat	

Sources of contamination of meat	Ways to reduce contamination
• **Hides & hair, stomach & gut contents**: major source of bacteriological contamination • Water: source of pathogens • Physical contact with structures: mainly in booth dressing • Movement from dirty to clean part • Unhygienic drainage system • contamination by workers, utensils & equipments, knife, saws & hock cutters • cleaning chemicals	• Cleaning & sanitization of equipments & utensils, different rooms of abbatoir • workers hygiene • Teat should be washed with cloth dipped in KMno4 or bleaching powder • Hygienic processing & packaging practices • **Bunging:** technique used for sealing the rectum • **Rodding:** oesophagus (weasand) in cattle is sealed by an elastrator ring • Proper Scalding & Singeing: in pig & poultry

Abnormal condition of meat	
PSE (Pale Soft Exudate)/ Watery pork	Developed in pork meat due to short term stress developed during transportation characterized by low pH, high temperature, high lactic acid and low water holding capacity pH of PSE meat: 5.2 – 5.4 (Normal pork pH: 5.6- 5.8)
DFD (Dark Firm Dry)	Developed in beef & carabeef meat due to long term stress developed during transportation characterized by high pH, low temperature, low lactic acid and high water holding capacity
Black spot	*Cladosporium herbarium*
White spot	*Sporotrichum cryosporidium, Sporotrichum carnis*
Green spot	*Penicillium spp.*
Phosphorescence	*Pseudomonas fluorescence*
Sulphur stinker spoilage	*Clostridium nigrificans*
Whiskers	*Thamnidium spp., Mucor Spp., Rhizopus Spp.*
Methods of differentiation of meat of different animals	
Physical & Anatomical method	colour, texture, odour of meat Colour consistency & distribution of fat on the basis of the dentition, number of bones, presence or absence of a specific structure on bones Refractive Index
Chemical method	Value of, Iodine Value, Glycogen content, Linoleic acid, Carotene content, Myoglobin content, direct probe mass spectrometry
Biological method	Histological method (fibre length), SDS-PAGE, FAT, Agar gel precipitation test, DAS-ELISA, PCR, Gene probes

- The length of radius in sheep is 1.25 times of metacarpal but 2 times in goat
- 3rd trochanter absent in horse femur & Acromian process is absent in horse scapula
- Nutrient foramen: present on **medial surface** of horse humerus whereas on **posterior surface** of cattle humerus
- **Length of muscle fibre: Pig** > Buffalo > Sheep > Goat > Poultry
- **Horse-** Iodine No (70-85); Glycogen content; Myoglobin content (0.7%); Refractive Index (53.5); Linoleic content (1-2%) **is highest in horse meat**
- Intramuscular fat content is **highest in mutton** (13%) followed by pork (4.4%), Chevon (3.6%), beef (2.6%) and lowest in carabeef (1%)
- **Odour:** Chevon (goaty odour); Pork (urine); Mutton (ammonical odour); Veal (sweetish odour)
- Deposition of subcutaneous fat is characteristic of pork & poultry while kidney fat is abundant in chevon
- Feathering: a characteristic phenomenon of fat distribution in intercoastal muscles in mutton
- DAS-ELISA- most suitable type of ELISA for detecting adultered meat
- Falsification-mixing of meat of different animals

Chapter-15

Epidemiology and Zoonosis

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- Epidemiology: The study of disease in population and factors that determine the occurrence of disease.
- Father of epidemiology/Modern Epidemiology: **John Snow.** His contribution in the form of study on cholera causation is well known to all
- Components of epidemiology: disease frequency (ratio, rate and proportion), disease distribution (with respect to time, place and person) and determinants (causes or risk factors) of diseases.
- Predisposing factor: make animal more susceptible for a disease
- Precipitating factors: initiate disease
- Perpetuating factors: maintain disease once established
- **Basic (broad) types** of epidemiology- descriptive and analytical
- The study of time, place and person distribution of disease is known as Descriptive epidemiology and is first step in disease investigation
- Analytical epidemiology- this involves analysis of observation using suitable diagnostic and statistical tests
- **Theoretical epidemiology-** disease representation using mathematical models that simulate natural pattern of disease occurrence
- Shoe-leather epidemiology or **field epidemiology**-personal investigation of disease at field level
- **Landscape**/Horizontal epidemiology/Ecology- study of disease in relation to ecosystem
- The epidemiological triads are- host, agent and environment that determine the onset of disease in population
- The occurrence of disease can be measured by incidence and prevalence.
- **Sporadic-** The pattern of occurrence of disease is irregular or scattered.
- **Endemic-**The pattern of occurrence of diseases in a single area over and over again.
- **Epidemic-** The occurrence of disease clearly in excess of expected number in a community.
- **Pandemic-** The occurrence of a disease involving multiple nations
- Direct Standardization-age specific health related event rates in study population are applied to the reference population.
- Indirect standardization- age specific rates in reference population are applied to the study population.
- Interruption of transmission of disease from a large geographic area is called as **Elimination**
- In an epidemic, first case to occur in community is known as **primary case** and first case to come to notice of an investigator is known as **index case.**
- A graph of time distribution of cases is termed as **Epidemic Curve.**
- Stages of epidemic curve
  - Period of accrescence
  - Culmination point

➢ Period of decrescence

- **Propagated epidemic**, the epidemic continues for more than one incubation period
- **Point source epidemic:** all cases occur in single incubation period of the disease, all cases occur abruptly and simultaneously and the epidemic curve rises and falls rapidly
- **Secular trends** describe progressive changes occurring over a long period of time.
- Seasonal variation of a disease is assessed by comparing the incidence of disease.
- Point prevalence overestimates the disease with low mortality.
- If prevalence is very low as compared to incidence, it indicates that disease is very fatal and easily curable.
- 'Yield' is the amount of previously unrecognised disease that is diagnosed as a result of screening effects.
- The validity of a screening test is based on sensitivity and specificity
- The specificity of a screening test is the ability to correctly identify true negative.
- The sensitivity of a screening test is the ability to correctly identify true positive.
- Screening is useful if screening time is much less than **lead time.**
- Time period between detection by screening test and standard diagnostic test is known as lead time or **Lead time** refers to time between first possible point of detection and usual time of diagnosis.
- Secondary Attack rate is measure of communicability.
- **Serial Interval-** time between onset of primary and secondary case.
- **Generation time-** time between receipt of infection and maximum infectivity.
- **Latent period-** time between disease initiation and detection
- **Extrinsic incubation period-**period between infection and availability of an infectious agent in an arthropod vector
- Nested case control study is a type of cohort study used only if a disease is new and rare, and diagnostic test is expensive. This study avoid problem related to temporal association.
- Berkesonian bias occurs as a result of different rates of admission to hospital for different diseases.
- In the iceberg phenomenon of disease, the submerged portion of the iceberg represents inapparent cases and physicians sees only tip of the iceberg

Determinants/factors of diseases		
Host determinants	**Agent Determinants**	**Environmental determinants**
• Genotype • Age • Sex • Breed & Species	• Virulence & Pathogenicity • Gradient of inection • Outcome of disease • Microbial colonization of host	• Location • Climate (macroclimate & Microclimate) • Husbandry practices
• Infection gradient includes Clinical infection, Sub-clinical and inaaparent infection • Microbial colonisation includes opportunistic pathogens, Exogenous and endogenous pathogens • Sex determinants includes Genetic determinants (sex limited, sex-linked & sex influenced); occupational determinants; Hormonal determinants; social &ethnological determinants • Outcome of disease includes carrier (incubatory & convalescent carrier) • Husbandry practices includes housing, management, diet etc.		

Methods of epidemiological investigation/Observational study				
Cohort Study	**Case Control Study**	**Cross Sectional Study**	**Ecological Study**	**RCT**
Used for rare risk factor	Used for rare diseases	Used for chronic diseases		Used to prove causation/testing different interventions
Synonyms: Prospective study Exposure to outcome study Risk factor to disease study Cause to effect study Incidence study Follow up study	Synonyms: Backward or Retrospective study Disease to risk factor study Outcome to exposure study Cause to effect study Case reference study	Synonyms: Snap shot study Prevalence study Simplest form of an observational study.	Synonyms: Co-relational study	Types of RCT: Parallel group study Cross-over study Cluster study Factorial study
Start with individuals exposed to risk factor	Start with disease	It is more useful in chronic cases.		
Measure of association- **Relative Risk** **Attributable Risk** **Population Attributable Risk**	Measure of association- **Odds Ratio or Cross-product Ratio**	All cases are seen at one point of time Follow up is not a necessary feature	Study are made at the population or group level rather than individual level.	
Major bias are-selection bias, Observer bias, Hawthrone bias and Attrition bias	Major bias are-Recall bias, selection bias and Berkensonian bias	It does not give much information about natural history of disease		Use of random table is recommended as randomization eliminates selection bias

Survey and its types	
It is data gathering non-experimental investigation conducted mostly under field condition on target population.	
Two type on the basis of frequency:	
Cross sectional survey: survey conducted only once at particular point of time	Longitudinal survey; survey conducted repeatidly
Diagnostic survey (Screening): Types	
1. Mass screening: survey conducted on total population 2. Strategic screening: survey conducted on diseased population 3. Prescriptive screening: survey conducted in early pathogenesis stage	

Sampling (2 TYPES)	
Random (Probability) Sampling	**Non-Random Sampling**
Type of random sampling: 1. Simple- most commonly used	Type of non-random sampling: 1. Convenience (Accidental or Haphazard sampling) 2. Quota (similar to Stratified sampling) 3. Chain (Snow ball or Referral sampling)
2. Systematic	
3. Stratified ✓ By forming strata (group)- each group is homogenous in characteristics	
4. Multistage	
5. Cluster (take less time and less expensive)	
Sampling fraction: ratio of sample size to population size Sampling frame: list of all items in study population Cluster: smaller group in population	

Surveillance	
the continuous investigation of given population to detect the occurrence of a disease for control purpose which may involve testing of part of population.	
Steps involved in surveillance cycle	**Type of surveillance**
• Data collection • Data collation • Data analysis • Data interpretation • Formulation of recommendation • Dissemination of recommendation	• Active • Passive • Serological • Sentinel • Target • Scanning
Monitoring- It is the routine collection of the information in the disease productivity and other characteristics possibly related to them in population.	

Steps in investigation of an epidemic in sequence:

1. Determine existence of an epidemic
2. Confirm the diagnosis
3. Define and count the cases
4. Propose measures for control and prevention

Correct step in sampling design

1. Type of universe
2. Sampling unit
3. Sample size
4. Sampling procedure

Classification of data/Variables	
Based on **source-** • **Primary data** (obtained by researcher itself by interviews or questionnaire) • **Secondary data** (collected from other sources like hospital records, books etc.)	Based on **nature-** • Numerical data (Quantitative) – ➢ Discrete data ➢ Continuous data • Categorical data (Qualitative) ➢ Nominal data ➢ Ordinal data

- Geometric mean is commonly used measure in demography because population growth is exponential
- Standard deviation of sampling distribution of any statistics is called standard error
- Central Limit Theorem- As the number of samples gets larger then samples are considered to be approximately normally distributed
- Degree of freedom is the number of independent members in the sample
- Scale of measurement are Nominal scale, Ordinal scale, Interval scale and Ratio scale
- Data-The facts that are collected and analysed for epidemiological studies known as data
- Data base- It is a structured collection of data
- Information- Data that have been processed and organised

The data can be represented in numerical, graphical and mathematical way

- Tables are used in numerical presentation. It is simplest method of displaying numerical data
- Different graphs are used in graphical presentation
- Measure of central tendency and measure of dispersion are used in mathematical presentation.
- Measure of central tendency- arithmetic mean, median and mode.
- In a left sided skewed curve, the mean is smaller than median.
- In right sided skewed distribution the mean is greater than the median.
- In symmetrical distribution, mean and median are same.
- Measure of dispersion are- Range, Variance, Standard deviation, Semi-interquartile range, coefficient of Variation, Standard error etc.

Graphical representation of data

- **Bar chart**- used to display those data whose count comprise of whole numbers. If the bars touch each other, it is known as histogram.
- **Line chart**-simplest and most frequently used graph for displaying epidemiological data. Time distribution in outbreaks of diseases is best described by line chart.
- Pie chart (Sector diagram)
- Doughnut chart & Shewhart chart
- Box and Whisker chart
- **Spot map**- John Snow used spot map to describe cholera. It is often used to show geographical distribution of frequency.
- Pictogram
- Histogram- It is described as the bars are joined together.
- Frequency polygon & Frequency curve
- Ogive- A graph of the cumulative relative frequency distribution is called ogive.
- Scatter diagram

Classification of Zoonoses on basis of reservoir		
Anthropozoonoses Diseases transmitted from animal (lower vertebrate) to man. Eg. Rabies, Anthrax, Brucellosis, Leptospirosis	**Zooanthropozoonoses** Diseases transmitted from man to animal (lower vertebrate). Eg. Amoebosis, Diphtheria, Tuberculosis	**Amphizoonoses** Diseases transmitted from man to animal (lower vertebrate) and vice-versa, Eg. Staphylococcosis, Streptococcosis, Salmonellosis
Vector borne Zoonoses (Biological)		
Developmental Only development of causative eagent take place in vector. Eg. Dirofilaria immitis in mosquito	**Propagative** Only multiplication of causative agent take place in vector. Eg. Plague, Yellow fever	**Cyclo-propagative** Both development & multiplication of causative agent take place. Eg. T. cruzi in bugs

CLASSIFICATION OF ZOONOSES (On basis of maintenance cycle in nature/Mode of transmission)			
Direct Zoonoses Require single vertebrate species for completion of life cycle Eg. Rabies, Brucellosis, Anthrax, leprosy, Trichinosis	**Cyclozoonoses** Require more than one vertebrate species for completion of life cycle. 2 types: **Type-1** (Obligatory cyclozoonoses) Eg. Taeniasis **Type-2** (Non-obligatory cyclozoonoses) Eg. Hydatid diseases	**Metazoonoses** Require both vertebrate and invertebrate species for completion of life cycle. 4 types: **Type-I** (One vertebrate and one invertebrate species are involved) Eg. Yellow fever, JE **Type-II** (One vertebrate and two invertebrate species are involved). Eg. Paragonimiasis **Type-III** (Two vertebrate and one invertebrate species are involved). Eg. Clonorcchiasis, EEE **Type-IV** (It represents trans-ovarian transmission). Eg. Tick borne encephalitis, KFD	**Saprozoonoses** Require inanimate reservoir in addition to vertebrate and invertebrate species for completion of life cycle. 3 types: **Type-I** Saproamphixenoses Eg. Histoplasmosis (Propagative) **Type-II** Saproanthropozoonoses Eg. Cutaneous larva migrans (Develeopmental) **Type-III** Saprometaanthropozoonoses Eg. Fascioliasis (Cyclo-propagative)

Methods employed for disease prevention and control:

- Mass immunization
- Vector control & Reservoir control
- Early diagnosis
- Health education
- Epidemiological diagnosis
- Environmental hygiene
- Quarantine: longest incubation period of disease

Zoonotic diseases	
Zoonotic diseases	**Characterisitics**
Q-fever (Query/Balkan Influenza/Abattoir fever/ Nine-Mile fever/Queensland fever/ Pneumorickettosis/Burnett's rickettosis)	Frontal headache, chest pain, fever, chills, hepatomegaly, spleenomegaly
Rabies	Man act as accidental host
Brucellosis (Cyprus fever/ Gibraltar fever/ Undulant fever)	Acute- fever Chronic- arthritis
Japanese encephalitis (I/P- 14 days) Horse & man- encephalitis & Pig- sporadic abortion Human, cattle, horse- Dead end host	Vector- Mosquitoes (Main vector- Culex tritaeniorhyncus) Pig- Amplifier Host Resevoir- Pig & Birds
Kyassanur Forest disease (Monkey Disease) Encephalitis (animals); Haemorrhage (man) Cattle & man- accidental host	Vector- Haemophysalis spinigera (Hard tick) Monkey- Amplifier host Reservoir- rat, squirrel, birds
Yellow fever (Black vomit, American plaque)	Vector- Aedes

Viral Haemorrhagic fever due to Hanta virus	Two major syndrome: Haemorrhagic and Renal Failure Syndrome (HRFS) Respiratory distress
Lymphocytic Choriomeningitis **(LCM)**	Caused by Arena Virus
Monkey pox	Mainly seen in Africa
Leptospirosis (Flood fever/ Mud fever/ Swamp fever/ seven day fever of Japan/ Weil's disease)	
Erysipeloid	(Rose disease/ Pork Finger disease/ Fish Finger disease)
Haverhill fever/Rat bite fever/ Epidemic arthritic Erythema	*Streptobacillus miniliformes*
Lyme disease (Erythema Chronicum Migrans/ Lyme arthritis)	Transmitted by hard ticks (Ixodes spp.) Borellia burgdoferri- culture by Kelly's medium
Dengue (Breakbone fever)	Transmitted by *Aedes aegypti* Symptoms- diaphoresis and ecchymoses
Quintan fever (5 day fever/ Trench Fever)	Caused by *Bartonella quintana* (New name: *Rickettsia quintana*)
Vagabond fever/Bilious typhoid/Relapsing fever	*Borrelia recurrentalis*
Chikangunya	Transmitted by Mosquitoes Caused by alpha-viruses of Togaviridae
Anthrax	3 form in human being- • Cutaneous (most common form) • Pulmonary • Intestinal
Plaque	**3 form-** Bubonic, Septicemic, Pneumonic
Glanders	(Equine Nasal Phthisis/ Farcy/ Malleus)
Tularemia (Deer fly fever/ Rabbit fever/Ohara's fever)	
Histoplasma/Darling disease/Cave disease	*Histoplasma capsulatum*
White More's disease/Meliodosis	*Burkholderia pseudomallei*
Clonorchiasis	*Cholangiocarcinoma*
Anisakiasis/Hering worm disease	*Anisakis simplex*
Diphyllobothriasis/Jewish House wife disease	*Diphyllobothrium latum*

Biosafety Level (BSL)			
BSL-1	**BSL-2**	**BSL-3**	**BSL-4**
Work with Minimum potential hazard agents • *Bacillus subtilis* • ICH virus • *E. coli*	Work with Moderate potential hazard agents Agents are not transmitted by air borne route • *Bacillus anthracis* • *Brucella spp.* • *Clostridium botulinum* • *Salmonella spp.*	Work with agents may be transmitted by air borne route • *M. tuberculosis* • *Salmonella typhi* • *Yellow fever* • *Tularemia* • *Q-fever*	Work with dangerous and exotic microbes Agents transmitted by air borne route for which vaccine is not available • Ebola virus • Lassa fever virus • Marburg virus • Haemorrhagic fever virus

Chapter-16

Environmental Hygiene

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- **Ecosystem:** It is the structural and functional unit of ecology where living organism interact with their environment
- **Biotope-** an area of uniform environmental conditions acting as living place for particular plant and animals
- **Biocoenosis (biotic community)-** interation (collection) of living organism in a habitat (biotope)
- **Biome-** It is a **large** well differentiated and climatically uniform geographical region. Many ecosystems join together to form a biome.
- **Ecology-** Study of plant or animal in relation to their habit and habitat. Ecology is also known as Bionomics or natural history.
- **Ecological climax-** When plant, animal, microbes, soil and macroclimate have evolved to a stable balanced relationship than an ecological climax has occurred.
- **Ecological interface-** It is a junction of two ecosystems. Infectious diseases can be transmitted across interface.
- **Ecological mosaics-** It is a modified patch of vegetation created by man with in a biome that has reached a climax.
- Network of interconnected food chain is termed as **Food web while** position occupied by an organism in food chain is termed as their **trophic level**
- Graphical representation of food or energy relationship between organisms at each trophic level is termed as **Ecological pyramid**
- **Germ cloud-** aggregation of large number of microbes in atmosphere
- Environmental (Protection) Act, 1986; Air (Prevention and Control of pollution) Act, 1981
- Water (Prevention and Control of pollution) Act, 1974
- After secondary treatment of sewage waste, the solid waste is termed as **Effluent**
- Coliforms must be absent in any 100 ml sample of water
- Dry weather flow rate is defined as sewage flow in 24 hours through sewage system
- Presumptive coliform test (Multiple Tube Method): It is a screening test for coliforms in drinking water & used for bacteriological surveillance of water samples
- Emporiatrics deals with the health of-**Travellers**
- Environmental manipulation which enables genes to express themselves readily is known as **Euthenics**
- Best way to dispose e-waste is **Recycling**
- Nalgonda Technique is used in **Endemic fluorosis**
- The characteristics of the waste suitable for incineration are low heating volume, content of non-combustible fines below 20% & moisture content below 50%
- Waste water from kitchen is called **Sullage**
- The type of Pneumoconiosis that cotton dust causes is known as **Byssinosis;** Bagassosis-Cane sugar fibres; Argyrosis- Silver dust
- Strength of sewage is expressed in terms of Suspended particles, Chemical oxygen demand and Biological oxygen demand
- Arrange the following disasters in chronological order of their occurrence-
  - Bombing on Hiroshima and Nagasaki

- Bhopal Gas Tragedy
- Chernobyl Disaster
- Fukushima Disaster

- International laboratory for monitoring and studying air pollution is located at **Nagpur**
- **Disinfection:** killing of infectious agents outside the body by direct exposure to chemicals or physical agents
- **Sterilization:** The process of destroying all forms of life including spores
- Orthotoluidine test determines **Both free and combined chlorine**

Water related disease	
Water borne diseases	Cholera, Typhoid
Water washed diseases- due to improper sanitation and hygiene	Scabies, Worm infestation
Water based diseases- transmitted through an aquatic invertebrate	Schistosomiasis, Guinea worm, Paragonimiasis, Clonorchiasis
Water related vector borne disease- transmitted by insect which depend on water for their propagation	Malaria, Filaria

- Naegleriasis (amoebic meningoencephalitis)- vaused by Naegleria fowleri (brain eating amoeba)- infection occurs when water containing Naegleria is inhaled mostly during swimming
- Recent faecal pollution of water is indicated by Streptococcus spp.
- Remote faecal pollution of water is indicated by Clostridium spp.
- Iron bacteria that clogs iron pipes- Gallionella spp.
- Free and saline ammonia in water indicate sewage contamination of recent origin

Element	**Maximum limit in water/litre**
Mercury	0.001 mg
Lead	0.01 mg
Arsenic	0.05 mg
Fluoride	1.5 mg
Nitrate	50 mg
Radioactive substance	
Alpha particle	0.5 Beq
Beta particle	1.0 Beq
Lead indicator in water- *Stuckenia pectinate* (sago pond weed/fennel pond weed)	

Radiation	**Penetrating power in tissues**
Alpha-particle	Up to 0.05 mm
Beta-particle	Up to 4 mm
X-rays	Up to 30 cm
Gamma rays	50 M

- Ultraviolet B-rays causes: mutation, snow blindness cataract, various type of skin cancer
- Radiation sickness is Immediate somatic effect of ionizing radiation
- Non-ionizing radiation- UV rays, Infrared rays, Micro wave, Radiowaves

Decibel (dB)	**Conditions**
25	Bedroom
Up to 30 (WHO- 30)	Hospital ward
20-30	Whispering

40	Living room
60	Normal conversation/ normal speech/ restaurant
Up to 85	Maximum tolerable limit of ear
90	Shouting/ auditory fatigue
100	Permanent exposure lead to hear loss
120	Discomfort to ear
130	Pain ear
160	Sudden exposure may lead to breakdown of ear drum

Methods of water purification		
1. Small scale purification	**2. Large scale purification**	**3. Chemical sterilization**
• Boiling • Storage • Distillation • Domestic filters • Chemicals like alum, bleaching powder, lime iodine etc.	• Storage • Filtration (Slow sand filter and Rapid sand filter)	• Ozonisation • Chlorination • Super chlorination • Chlormine
• Best method of large scale purification is chlorination • Chlorine demand of water is measured using Horrock's apparatus • Point at which free chlorine begins to appear in water is termed as Break point • Retention period of chlorine is 60 minute and excess chlorine is removed by aluminium sulphate • The size of sand in Rapid Sand Filter is **0.4 – 0.7 mm** • The optimum storage of river water should be **10 to 14 days** in large scale purification • Zoogleal layer: **growth of algae diatoms, plankton and bacteria** ➢ It is known as Heart of slow sand filter ➢ Also known as Schmutzdecke/ Biological layer/ Vital layer ➢ It is mainly composed of algae having dirty and gelatinous nature • Rapid sand filter is cleaned by back washing while slow sand filter is cleaned by scrapping • Permutit- complex of sodium with aluminium and silicates • Berkefeld filter- water filter made of diatomaceous earth • Ceramic microfilters (Katadyn): have microporous layer impregnated with silver; simple and easy to use, disinfect water immediately; size of pore- 0.2 micron • Pasteur Chamberland filter- porcelain water filter		

Method of sewage treatment	
Physical method (primary treatment)	**Biological treatment (secondary treatment)**
Removal of small and large floating suspended solids from sewage through filtration and sedimentation process. Settled solids are termed as **primary sludge** and supernatant forms termed as **effluent**	Primary effluent is passed into aeration tanks agitated mechanically and air is pumped into it which leads to growth of useful microbes (bacteria and fungus-flocs) then effluent is passed into settling tanks where flocks settled down and termed as activated sludge Activated sludge is again pumped into anaerobic sludge digesters which leads to growth of anaerobic bacteria (kills aerobic bacteria and leads to production of biogas- methane & CO_2) Now water is released into lakes, river, ocean
• Screens and grit chamber	• Contact beds and trickling filters

• Sedimentation tank	• Humus tanks
• Skimming tank	• Activated sludge treatment

WHO Regional HQ	Location
1. Africa	Brazzaville, Republic of Congo
2. Western Pacific	Manilla, Phillipines
3. Eastern Mediterranean	Cairo, Egypt
4. South East Asia	New Delhi, India
5. Europe	Copenhagen, Denmark
6. America	Washington, DC, USA

Disaster Management

The United Nations defines disaster as "the occurrence of sudden or major misfortune which disrupts the basic fabric and normal functioning of the society or community".

The Disaster Management Act, 2005 defines disaster as "a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area".

Types of Disaster (Campbell & Knowles, 2011)**:**

- **Slow onset:** e.g. unusually harsh winters, drought
- **Rapid onset:** e.g. earthquakes, tsunamis, hurricanes, floods
- **Complex emergency:** conflict / war

Types of disaster			
Water and climate disasters	**Geological disasters**	**Major Accidents**	**Biological related disasters**
• Floods • Cyclones • Tornadoes • Snow • Cloud burst • Avalanches • Hurricane • Tsunami • Hailstorm • Heat wave • cold wave • Droughts • Thunder • Lightning	• Landslides • Mudflows • Earthquakes • Dam failures • Dam bursts	• Forest fires • Electrical disasters and fires • Urban fires • Mine flooding • Village fire • Oil spills • Major building collapse • Serial bomb blasts • Festival related disasters • Nuclear disaster	• Biological disasters • Epidemics • Pest attacks • Cattle epidemics • Food poisoning

Disaster Response cycle

Mitigation: The impact of disasters can be reduced before they strike, by building certain defences and implementing appropriate policies. Mitigation can be the most cost-effective intervention of all. Measures to ensure that emergencies are prevented, or their effects made less severe.

Preparedness: Arrangements to ensure that all the resources and services which may be needed to cope with the effects of a disaster can be rapidly mobilised and deployed such as-

- National warning systems
- Vaccination programmes
- Shelters
- Evacuation methods
- Storage of food and water
- Identification
- Clinic preparedness plans

Response: Actions taken in anticipation of, during and immediately after impact to ensure that the effects are minimised and people are given immediate relief and support such as-

- Static and mobile clinics
- Search and rescue operations
- Provision of emergency food
- Temporary shelters

Recovery: Actions are taken to restore the pre-disaster status quo and social structure.

Formation of triage **Triage-** A method of identifying victims of disaster on the basis life threatening injuries and likelihood of their survival with prompt medical treatment.		
Colour	**Priority**	**Treatment**
Red	Immediate	·No delay; Require major surgery
Yellow	Urgent	Can delay up to 1-2 hour but require major surgery
Green	Delayed	Minor surgery required
Black	Deceased	No care needed

Bio-Medical Waste (Management and Handling) Rules, 2018			
Category	**Type of waste**	**Bag used**	**Treatment options**
Red	Recyclable contaminated waste (IV bottle, IV tube, urinary catheter, syringe, gloves, blood bag, plastic dropper, IV Cannula, extension tube, ET tube etc.)	Red- Non chlorinated plastic bag	• Autoclave • Microwave • Incineration
Yellow	• Human and animal anatomical waste • Expired medicine • Chemical Waste (disinfectant, formalin solution, aspirated body fluids etc.) • Solid waste (contaminated cotton swab, dressing pad etc.) • Discarded linen and bedding • Microbiological and biotechnology waste	Yellow-Non chlorinated plastic bag	• Incineration • Plasma pyrolysis • Deep burial at PHC
Blue	• Infected broken glass and bottle • Glass slides • Mannitol injection bottle • Vials	Puncture proof containers	• Autoclave • Chemical • Shredding • Landfills
White	Waste sharps including metals (Scalpels, blade, razor, syringe with fixed needle etc.)	Puncture proof containers	• Autoclave • Chemical • Shredding • Landfills

Chapter- 17

Veterinary Pharmacology

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- Father of pharmacology: J.J. Abel
- Father of Modern Pharmacology- Rudolf Buchheim
- Father of modern veterinary pharmacology- Meyer Jones
- Father of Indian pharmacology- Ram Nath Chopra
- Pharmacognosy- study of source of drug
- Posology-study of drug dosage
- Prodrug- active metabolite of inactive drug
- Placebo is also known as sham treatment by giving inert inactive substances
- Pharmacy- collection, compounding and dispensing of drugs
- Affinity-bonding strength between receptors and drugs
- Potency- Dose of drug to produce effective response. It depends on efficacy and affinity of drug. It is non-absolute expression
- Efficacy- it is maximum response a drug can produce. It is an absolute expression
- Dose is inversely proportional to potency
- Agonist possess both affinity and efficacy
- Antagonist lack efficacy
- Dose- response curve: Hyperbola
- Log- Dose-Response curve: Sigmoid
- Desensitization- Failure of an animal to respond at normal therapeutic dose. Down regulation of receptor. This is important for development of tolerance.
- Tolerance- Decrease in response on repeated administration of drugs
- Super-sensitization- Up-regulation of receptor
- Sensitization- Reverse tolerance
- Tolerance- Gradual decrease in response on repeated administration of drug.
- Dale- coined the term receptor
- Albumin is plasma carrier protein for acidic drugs while alpha-acid glycoprotein for basic drugs
- Basic drugs are ionized to greater extent in an acidic medium
- low ionization and high lipid solubility promotes absorption of drugs
- Enterohepatic circulation of drugs increases duration of action of drugs
- Passive diffusion involves crossing of drugs across cell membrane from high concentration to lower concentration (followed by majority of drugs)
- Idiosyncrasy- atypical abnormal reaction of body to drugs
- First pass effect is also termed as pre-systemic metabolism of drug

Clinical trials

Phase	Done on	Remark
1	Healthy human volunteers	Maximum tolerable drug given
2.	Diseased volunteers (patient)	Maximum drug fail at this phase
3.	Diseased volunteers (patient)	Comparison with existing drug is done
4.	Diseased volunteers (patient)	To know rare and long term side effect Post marketing surveillance is done

- Recently Phase zero is added for pharmacodynamics and pharmacokinetic study
- Pre-clinical trials are done on animals

Type of receptors

Receptors are chemical structure mainly made of glycoproteins that recognize, bind and receive signals (drugs)

Ligand-gated ion channels (Inotropic receptors)- produce fastest action	**Enzymatic receptor (tyrosine kinase-coupled receptor)**	**G-protein coupled receptor (metabotropic receptor/7-transmembrane spanning receptors)**	**Steroid receptor (nuclear receptors)**
• Nicotinic acetylcholine receptors • Glutamate receptors	• Insulin receptor	• Muscarinic acetylcholine receptors • Adrenergic receptors	• Thyroid hormone receptors • Steroid hormones receptor

Receptor for steroid hormone are always present inside cells

Different type of secondary messenger produced during hormone action and receptor stimulation-

- **cAMP-cyclic adenosine monophosphate** (Alpha1, Beta1 & Beta2 adrenergic receptor stimulation)
- **cGMP-Cyclic guanosine monophosphate**
- **DAG-Diacyl glycerol** (M1 receptor stimulation)
- **PIP_2-Phosphotidal inositol biphosphate**
- **IP_3-Inositol triphosphate** (M1 receptor stimulation)

Biotransformation of drugs

Biotransformation is a process through which drugs or harmful chemical substances are transformed in such a way so that they can be excreted from body

This process mainly take place in liver in which hydrophobic molecules transformed into hydrophilic molecules

Phase I Biotransformation reaction	**Phase II Biotransformation reaction**
• Reduction • Oxidation • Cyclization • Hydrolysis • Decyclization	**Microsomal conjugation** • Glucuronide conjugation **Non-microsomal conjugation** • Acetylation • Methylation • Sulphate conjugation • Glycine conjugation • Glutathione conjugation

SYMPATHOMIMETIC (ADRENERGIC) DRUGS

On the basis of action

Direct acting (2 type)

Indirect acting
- ✓ Amphetamine
- ✓ Tyramine

Mixed acting
- ✓ Ephedrine
- ✓ Mephentermine
- ✓ Metaraminol

1. Alpha agonist (2 type)

1.1. Non-selective
- ✓ Epinephrine
- ✓ Norepinephrine

1.2. Selective (2 type)

1.2.1. Alpha1 agonist
- ✓ Phenylephrine
- ✓ Methoxamine

1.2.2. Alpha 2 agonist
- ✓ Xylazine
- ✓ Clonidine
- ✓ Guanfacine
- ✓ Detomidine
- ✓ Medetomidine
- ✓ Romifidine

2. Beta agonist (2 type)

2.1. Non-selective
- ✓ Isoproterenol
- ✓ Epinephrine

2.2. Selective (2 type)

2.2.1. Beta 1 agonist
- ✓ Dobutamidine

2.2.2. Beta 2 agonist
- ✓ Terbutaline
- ✓ Salbutamol
- ✓ Metaproterenol
- ✓ Ritodrine
- ✓ Orciprenaline

SYMPATHOMIMETIC (ADRENERGIC) DRUGS

On the basis of chemical structure

Catecholamine
- ✓ Epinephrine
- ✓ Norepinephrine
- ✓ Dopamine
- ✓ Isoproterenol

Non-catecholamine
- ✓ Ephedrine
- ✓ Amphetamine
- ✓ Methamphetamine
- ✓ Metaraminol
- ✓ Tyramine

SYMPATHOLYTIC (ANTI-ADRENERGIC) DRUGS

Adrenergic receptor antagonist (3 type)

Drug inhibiting norepinephrine synthesis
- ✓ Methyldopa
- ✓ Carbidopa
- ✓ Alphamethyl tyrosine

Drug inhibiting norepinephrine storage
- ✓ Reserpine

Drug inhibiting norepinephrine release
- ✓ Bretylium
- ✓ Guanethidine
- ✓ Guanadrel

3. Alpha receptor antagonist (2 type)

3.1. Non-selective
- ✓ Phenoxybenzamine
- ✓ Phenotolamine
- ✓ Tolazoline
- ✓ Dibenamine

3.2. Selective (2 type)

3.2.1. Alpha1 antagonist
- ✓ Prazosin
- ✓ Terazosin
- ✓ Trimazosin
- ✓ Doxazosin

3.2.2. Alpha 2 antagonist
- ✓ Yohimbine
- ✓ Atipamezole
- ✓ Idazoxam

4. Beta agonist (2 type)

4.1. Non-selective
- ✓ Propranolol
- ✓ Nadolol
- ✓ Timolol
- ✓ Pindalol
- ✓ Cartelol

4.2. Selective (2 type)

4.2.1. Beta 1 antagonist
- ✓ Metoprotol
- ✓ Atenolol
- ✓ Practolol
- ✓ Esmolol
- ✓ Labetolol

4.2.2. Beta 2 antagonist
- ✓ Butoxamine
- ✓ Alpha-methyl propranolol

5. Alpha and beta antagonist
- ✓ Labetalol
- ✓ Medroxalol
- ✓ Bucindolol

Parasympathomimetic drugs (Cholinergic/Muscarinic agent)

Direct acting anticholinesterase (2 type)- A & B		Indirect acting anticholinesterase (2 type)-C & D	
A. Choline esters	**B.** Natural alkaloid	**C.** Irreversible anticholinesterase agent (2 type)- **E & F**	**D.** Reversible anticholinesterase agent
• Acetylcholine • Methacgoline • Bethanechol • Carbachol	• Muscarine • Pilocarpine (liquid alkaloid) • Arecoline • Nicotine		• Neostigmine • Physostigmine • Pyridostigmine • Edrophonium • Demecarium • Ambenonium
	E. Organophosphorus compound • Malathion • Parathion • Tabum • Sarin • Diisopropylphosphorofluorodate		**F.** Carbamate • Carbaryl (Sevin) • Propoxur (Baygon)

Note:
Carbachol used in ruminal atony and impaction of intestine
Physostigmine- topical application in glaucoma
Neostigmine- Snake bite and for mysthenia gravis
Tabum and serine are known as Nerve gas

Para-sympatholytic drugs (Anti-cholinergic/Anti-muscarinic agent/Anti-spasmodic/Spasmolytic/Atropine-like drugs/Relaxants)

Natural	**Synthetic**			
	Structural analogue to atropine		**Structurally non-related to atropine**	
	Tertiary ammonium compound	**Quarternary ammonium compound**	**Tertiary amine**	**Quarternary am**
• Atropine (DL-hyoscyomine) • Scopolamine (L-hyoscine)	• Homatropine (mydriatic agent)	• Atropine methyl nitrate • Homatropine methyl bromide • Ipratropium • Tiotropium	• Pirenzepine • Dicyclomine • Cyclopentolate • Oxyphencycli--mine • Tropicamide	• Methanthelin • Propantheline • Isopropamide • Glycopyrrolat

Para-sympatholytic drugs (On the basis of action)

Non-selective muscarinic receptor antagonist	**Selective antagonist**			
	M_1 antagonist	**M_2 antagonist**	**M_3 antagonist**	**M_4 antagonist**
• Atropine (DL-hyoscyomine) • Scopolamine (L-hyoscine) • Homatropine	• Pirenzepine • Telenzepine • Trihexyphn--ydyl	• Methoctramine • Gallamine	• Hexahydrosilo defenidol	• Himbacine

Drugs acting on digestive system

Salivary stimulants/Sialics/Sialagogues	Salivary inhibitors
Direct acting- Carbachol, Arecaline Indirect acting- Nux vomica	Anticholinergics- Atropine Antihistaminics- Diphenyhydramine Neuroleptics- Thioridazine

Drugs stimulate gastric secretion

Gastrin analogue- pentagastrin
Histamine analogue- Histamine, Betazole
Neostigmine, Bethanechol

Drugs inhibit gastric secretion

H2 antagonist	Proton pump inhibitor	Prostaglandin analogues
• Ranitidine • Cimetidine • Fomatidine	• Omeprazole • Pentaprazole • Lansoprazole	• Misoprostol

Antacids
(acid neutralizing drug)

Systemic antacids	Non-systemic antacids
• Sodiumbicarbonate (side effect- rebound acidity) • Sodium citrate • Sodium acetate	• Aluminium salts ✓ Aluminium hydroxide (Side effect-constipation) ✓ Aluminium magnesium silicate ✓ Aluminium phosphate • Magnesium salts ✓ Magnesium hydroxide (side effect- diarrhoea) ✓ Magnesium oxide • Calcium carbonate (Side effect- rebound acidity and constipation)

- Ulcer healing drugs- Carbenoxolone, Gefaruate
- Ulcer protective drugs (cytoprotective drugs)- Sucralfate, tripotassium dicitratobismuthate

Prokinetic drugs

These drugs increases GIT motility by increasing frequency and strength of contractions but no change in rhythm

Dopamine (D2 antagonist)	Serotonin antagonist	Antibiotics	Histamine (H2) antagonist
Metaclopramide Domperidone Bromopride	Cisopride	Erythromycin	Ranitidine

Antiemetics

Locally acting antiemetics	Centrally acting anti-emetics
• Demulcents- kaolin, pectin • Gastric antacids- magnesium hydroxide, aluminium hydroxide • Anticholinergics- Glycopyrronium, Methoscopolamine • Prokinetics- Domperidone, Cisapride	• H_1 antagonist- Meclozine, cyclizine, promethazine • D2 (dopamine) antagonist- phenothiazine derivatives, Butyrophenones, Benzamides (Metaclopramide) • 5-HT3 antagonist- ondansetron, Granisetron, Cyproheptadine

Cholegogues- Causes contraction of gall bladder. Eg .Ceruletide
Choleretics- Increases secretion of bile by hepatocytes

Drug acting on respiratory system

Expectorants	Antitussives
Make mucus thin making it easier to expel	Used to suppress cough
• Stimulant expectorants ➢ Direct acting- Guaifenesin (most commonly used) & Guaicol ➢ Indirect acting- KI, NH4Cl ➢ Reflex acting- Balsam of tolu • Mucolytic expectorants- Bromhexine, Dembrexine, Acetylcystein • Inhalent expectorants- Benzoin	• Locally acting Antitussives ➢ Demulcents- honey, glycerine ➢ Bronchodilators- theophylline, ephedrine ➢ Expectorants- Bromhexine ➢ Mucosal anaesthetics- Benzonatate • Centrally acting Antitussives ➢ Non-opioids- Dextromethorphan (most commonly used), Pholcodine ➢ Opioids- Codeine, Morphine, Butorphenol

Bronchodilators

These drugs make breathing easier by relaxing muscles surrounding airways ultimately result into widening of bronchi

Selective B_2 agonist (adrenergics)	Xanthine derivatives	Anticholinergics	Leukotrienes antagonist
• Salbutamol • Terbutaline • Salmeterol	• Theophylline • Aminophylline	• Atropine • Glycopyrronium • Ipratropium	• Monteleukast • Zafirlukast

Analeptics (Respiratory stimulants)

Specific respiratory stimulants	Non-specific respiratory stimulants
• Doxapram • Nikethamide • Bemegride	• Opioid antagonist- Naloxone • Gases- CO_2, Ammonia • Xanthine derivatives- Aminophylline • Alpha-antagonist- Yohimbine

Decongestants- are drugs which help to relieve congested or blocked nose. Eg. Oxymetazoline, Phenylephrine, Pseudoephrine

Drugs acting on urinary system

Diuretics (Water pills)

These drugs increase production and flow of urine (diuresis) and also termed as Water Pills

High efficacy diuretics	Medium efficacy diuretics	Low efficacy diuretics
• **Loop diuretics** ➢ Frusemide ➢ Bumetanide ➢ Ethacrynic acid • **Mercurials (not in use now)** ➢ Mersalyl ➢ Calomel	• **Thiazides (act on DCT)** ➢ Chlorothiazides ➢ Hydrochlorothiazides ➢ Polythiazides • Xanthine diuretics (cardiac diuretics) ➢ Theophylline ➢ Caffeine	• **Osmotic diuretics (PCT)-** mannitol (only I/V), sorbitol, glycerine, isosorbide (oral) • **Carbonic anhydrase inhibitors-** Acetazolamide (rarely used) • **Potassium sparing diuretics** ➢ Aldosterone antagonists- Spiranolactone (oral) ➢ Direct acting- Triamterene, Amiloride, Benzamil

Diuretics act on ascending loop of Henle	**Frusemide** **Ethacrynic acid**
Diuretics act on distal tubules	**Thiazides & osmotic diuretics**
Diuretics act on collecting tubules	**Triamterene** **Amiloride**
Inhibitor of sodium potassium chloride symport	**Loop diuretics**

- Frusemide is most commonly used diuretics in veterinary medicine given at dose rate of 1 mg/kg body weight
- Diuretics like frusemide enhances toxicity of aminoglycosides as well as cardiac glycosides

Drugs acting on reproductive system

Ecbolics/Uterotonics/Myometrial stimulants These drugs increase uterine contraction	**Tocolytics** Inhibit uterine contraction
• Oxytocin • PGF_2 alpha • Ergot alkaloids- Ergometrine, Ergonovine • B_2 antagonist- Butoxamine	• Beta2 agonist- Salbutamol, Ixosuprine, Terbutaline, Clenbuterol • Oxytocin antagonist- Atobisan • Ca-channel blocker- Diltiazem, Nifedipine

Antiarrhythmic drugs

These drugs help to correct abnormal rhythm of heart (arrhythmia)

Class I (sodium channel blockers)	**Class II (Beta adrenergic blockers)**	**Class III (Potassium channel blockers)**	**Class IV (Calcium channel blockers)**
Class I_A (moderate potency) Quinidine Procainamide Disopyramide **Class I_B** (Lowest potency) Lidocaine Phenytoin Aprindine Mexiletine **Class I_C** (Most potent) Encainide Flecainide Propegenone Morizicine	Atenolol Ismolol Propranol **Sotalol** Timolol Bisoprolol	Amiodarone Dronedarone Bretylium Nifekalant Bunaftine **Sotalol**	**Diphenylalkylamines groups** Verapamil Gallopamil **Benzothiazepine groups** Diltiazem Clentiazem **Dihydropyridine group** Nifedipine Amlodipine

Adverse effect of common antiarrhythmic agent- Quinidine (Cinchonism-temporary deafness), Procainamide (Gangiionic blockade/Lupus like syndrome), Disopyramide (Dryness of mouth), Propranol (bronchospasm), Amiodarone (photsensitization/pulmonary toxicity), Verapamil (hypotension)

Vasodilators

Direct acting vasodilators	**Indirect acting vasodilators**
• Calcium channel blockers • Potassium channel blocker • Nitrates (Amyl nitrate, glyceryl trinitrate-nitroglycerine)	• ACE inhibitor- Angiotensin Convertin Enzyme inhibitor (Captopril, Enlapril) • Angiotensin II antagonist (Losartan) • Renin inhibitor (Enalkiren)-Not in use

Antihypertensive drugs

These drugs reduce increased blood pressure

Alpha and beta adrenergic blocker- Labetalol	**Alpha adrenergic blocker-** Tolazoline,	**Beta adrenergic blocker-**	**Calcium channel blocker** Described above	**Centrally acting Sympathomimetics** Clonidine

	Phentolamine, Prazosin	Metoprolol, Atenolol		

Sources of Cardiac glycosides	
Digitalis purpurea	Digitoxin
Digitalis lanata	Digoxin (most used cardiac glycosides)
Thevatia nerifolia	Thevatin
Strophanthus gratus	Ouabain (Strophanthin-G) most potent cardiac glycosides
Urginea maritima	Proscillaridin-A
Bufo vulgaris	Bufotoxin

Central Nervous System (CNS) Stimulants		
Cortical stimulants (Psychostimulants)	**Medullary stimulants (analeptics)**	**Spinal stimulants (convulsants)**
• Amphetamine • Theophylline, Theobromine • Caffeine, Nicotine • Cocaine • Piracetam	• Bemegride • Doxapram • Nikethamide	• Strychnine • Picrotoxin

NSAIDs

NSAIDs- Non steroid anti-infammatory drugs
These drugs reduces pain, inflammation, fever and also prevent blood clots (antithrombosis)

Classification of NSAIDs (on basis of chemical structure)

Para-aminophenol derivatives Acetaminophen	**Heteroaryl acetic acid** Diclofenac, Ketorolac	**Arylpropionic acid** Ibuprofen, Ketoprofen, Naproxen
Salicylic acid derivatives Aspirin (acetyl salicylate)	**Enolic acid derivatives** Oxicams (Piroxicam, Meloxicam) Pyrazolones (Phenylbutazone)	**Anthranilic acids** Mefenemic acid Tolfenamic acid
Aminonicotinic acids Flunixin		

Classification of NSAIDs (on basis of inhibition of COX enzyme)

Non selective COX inhibitors Acetaminophen, Flunixin, Aspirin, Ibuprofen, Piroxicam, Ketorolac, Phenyl betazone	**Selective COX-2 inhibitors** Coxibs (Cefocoxib, Etoricoxib)	**Preferential (semi-selective) COX-2 inhibitor** Nimesulide, Diclofenac, Meloxicam

Glucocorticoids		
Short acting	**Intermediate acting**	**Long acting**
• Cortisone • Hydrocortisone	• Prednisolone • Triamcinolone • Methylprednisolone (Depomedrol) • Isoflupredone	• Dexamethasone • Betamethsone • Flumethasone

Chapter-18

Veterinary Chemotherapy

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Antibiotics based on mode of action	
Bacteriostatics	**Bactericidals**
Tetracyclins	Penicillins
Spectinomycin	Cephalosporins
Sulphonamides	Fluoroquinolones
Macrolides	Glycopeptides
Chloramphenicols	Monobactums
Trimethoprim	Carbapenems
Lincosamide	Polymix is
Tylosin	Nitrofurans
Tiamulin	Novobiocin
Ethambutol	Isoniazid
Fusidic acid	Rifampicin
Linezolid	Vancomycin, Bacitracin

Narrow spectrum and broad spectrum antibiotics	
Narrow spectrum	**Broad spectrum**
Penicillin-G	Ampicillin
Streptomycin	Carbenicillin
Erythromycin	Clhloramphenicol
Lincomycin	Tetracyclins
Vancomycin	Cephalosporins
Polymixin-B	Sulphonamides

Classification based on chemical structure	
Diaminopyrimidines	Trimethoprim
Nitrobenzene derivatives	Chloramphenicol
Polypeptides	Polymixin B, Colistin, Bacitracin
Glycopeptides	Vancomycin
Nicotinic acid derivatives	Isoniazid, Pyrizinamide
Polyene antibiotics	Nystatin, Amphotericin-B

Classification based on mechanism of action	
Mechanism	**Antibiotics**
Inhibition of bacterial cell wall synthesis	Penicillin, Cephalosporins, Vancomycin, Bacitracin Cycloserine

Increase of cell membrane permeability (Leakage from cell membrane)	Polymixins, Colistin Miconazole Amphotericin Nystatin	
Inhibition of protein synthesis	Irreversible binding with 50-S ribosome unit	Chloramphenicol
	Reversible binding with 50-S ribosome unit	Macrolides Lincosamides
	Irreversible binding with 30-S ribosome unit	Aminoglycosides (Gentamycin)
	Reversible binding with 30-S ribosome unit	Tetracyclins
Inhibition of nucleic acid synthesis	Interference in synth[illegible]s of nucleotide	Flurouracil Mercaptopurine Flucytosine
	Alteration of base pairing	[illegible]idine, Chloroquin [illegible]tiviral drugs
	Inhibition of DNA Polymerase	Acyclovir, Cytarabin
	Inhibition of RNA Polymerase	Rifampin, Rifamycin
	Inhibition of DNA gyrase	Quinolones
	Direct effect on DNA	Alkylating agents
Inhibition of folic acid synthesis	Competitive inhibition mechanism	Sulphonamides
	Sequential blockage	Trimethoprim and sulpha drugs combination
Interference with microtubules and microfilaments	Griseofulvin Colchicine	

Sulphonamides		
Topical	**Gut acting/Enteric**	**Systemic**
Sulphacetamide (ophthalmic)	Sulphaquanidine	Sulphadiamidine (Sulphamethazine)
Sodium Sulphacetamide	Phthalylsulphathiazole	Sulphadiazine
Mafenide	Succinyl sulphathiazole	Sulphamerazine
	Sulfasalazine	Sulphapyridine

Sulphonamides **On the basis of duration of action**		
Short acting	**Intermediate acting**	**Long acting**
sulphathiazole	Sulphasimazole	Sulphadiamidine (Sulphamethazine)
Sulphasomidine	sulphamethaxazole	Sulphamerazine
Sulphadiazine		Sulphamethoxypyridazine
Sulphamerazine		Sulphaethoxypyridazine

- Sulphonamides are derivative of para-aminobenzene sulphonamides, they interfere with utilisation of **PABA** by bacteria by competitively inhibiting the **enzyme dihydrofolate synthase.**
- **Sequential blockage-** Sulphonamides when used with trimethoprim, it potentiates the action of sulphonamide through preventive formation of tetrahydrofolic acid from dihydrofolate by inhibiting dihydrofolate reductase. This phenomenon is called Sequential blockage. The common combination is Sulphadiazine or sulphadoxine with trimethoprim in ratio of 5:1 (Synergistic action).
- Sulphonamides should not be given with procaine penicillin
- Sulphadiamidine is also used as feed additive in swine

- Urine is the main source of excretion of Sulphonamides
- Calcium and antacids inhibit absorption of sulphonamides
- **Triple sulpha-** Sulphamerazine+ sulphapyridine+ sulphadiazine
- Toxicity of Sulphonamides- Nephrotoxicity characterized by crystalluria, haematuria and obstruction of renal tubules.

Beta-lactam antibiotics		
Penicillins		Cephalosporins
Beta-lactamase sensitive	**Beta lactamase resistant**	
Narrow spectrum • Penicillin G • Penicillin-V • Phenethicillin	• Cloxacillin • Dicloxacillin • Oxacillin • Nafcillin • Fluclocillin • Methicillin	**First generation** • Cephaprin • Cefazolin • Cephalothin • Cephradine • Cephaloridine • Cephalexin
Broad spectrum • Amoxicillin • Ampicillin • Bacampicillin		**Second generation** • Cefachlor • Cefamandole • Ceforonide • Cefuroxime • Cefoxitin • Ceftiofur
Extended spectrum /Antipseudomonal penicillins • Aziocillin • Carbenicillin • Mezlocillin • Piperacillin • Ticarcillin		**Third generation** • Cefotaxime • Cefoperazone • Ceftizoxime • Ceftazimidine • Ceftriaxone • Cefmenoxine • Cefsulodin • Cefixime • Ceftazidimine
		Fourth generation • Cefepime, cefpirome
		Fifth generation • Ceftaroline • ceftobiprole

- One unit of penicillin is defined as amount of antibacterial activity present in 0.6 microgram of pure crystalline sodium salt of penicillin G.
- 1 mg of penicillin is equivalent to 1667 unit of Penicillin G sodium **or** 1595 unit of Penicillin G potassium
- Repository penicillins- are poorly absorbed over a period of 5-7 days following a single I/m injection such as benzathine Penicillin G and Procaine penicillin in oil.
- Beta-lactamase inhibitors (Suicidal inhibition)- Clavulonic acid and sulbactum potentiates action of penicillinase sensitive penicillins by irreversible inhibition of Beta lactamase. Amoxycillin (10mg/kg B.wt) + potassium clavunate 2.5 mg/kg B.wt)- synergistic action
- Probenecid prolongs blood levels of penicillins
- Cephalosporins follow urinary excretion but Cefoperazone, Ceftriazone, cefoxitin, cefamaxdole has Biliary excretion
- Cefamandole causes bleeding and Disulfiram like effect with methylthiotetrazole (MTT)
- Cephaloridine produce direct renal toxicity at therapeutic dose.

Aminoglycosides

- Streptomycin
- Neomycin
- Framycetin
- Amikacin
- Gentamicin @ 5 mg/kg B.wt
- Tobramycin
- Netilmycin
- Kanamycin

- Efficacy: Gentamicin=Tobramycin > amikacin > Neomycin= kanamycin
- **Aminoglycosides has poor oral bioavailability so given parenteral only**
- Aminoglycosides has **Biphasic mode of killing**-initial rapid killing followed by late slow killing
- Bacteria develop cross resistance to all Aminoglycosides
- Aminoglycosides are contraindicated in pregnant animal as they cross placenta leading to foetal damage
- Aminoglycosides potentiate neuromuscular blockage caused by skeletal muscles relaxants
- Neomycin increases urinary excretion of calcium hence contraindicated in milk fever
- Gentamicin- used in respiratory tract, urinary tract and soft tissue infection
- Aminoglycosides (toxicity)
  - ✓ Ototoxicity
  - ✓ Nephrotoxicity
  - ✓ Enlargement of blind spot
- Neomycin is highly nephrotoxic and oto-toxic

Tetracyclins

Short acting (less than 8 hour)	Intermediate acting (8-16 hour)	Long acting (> 16 hour)
Chlortetracyclin (I/V only)	Demeclocycline	Doxycycline
Oxytetracyclin	Methacycline	Minocycline
Tetracyclin	Demethylchlortetracycline	

- Tetracyclins are antibiotics with Blanket activity
- Tetracyclins should not be used during pregnancy, lactation and in children
- Tetracyclins/Chloramphenicols should not be used with immunization schedule as they cause immunosuppression
- Doxycycline used for prophylaxis of infection with chloroquin resistant strain of Plasmodium falciparum
- Nocardiosis- Minocyclin & Ehrlichiosis- Doxyxycline
- Cat shows drug fever reaction
- Oxytetracyclin dose rate:
  - Cow, sheep, pig @ 5-10 mg/Kg B.wt
  - Calf, lamb, foal, piglet @ 10-20 mg/Kg B.wt
  - Horse @ 3-5 mg/Kg B.wt
  - Dog & Cat @ 7 mg/Kg B.wt

Macrolides and Lincosamides

Macrolides

Old Macrolides	New macrolides
• Erythromycin (hepatotoxic)	• Rozithromycin
• Oleandomycin	• Clarithromycin
• Troleandomycin	• Azithromycin

- Erythromycin- DOC to treat and prevent diarrhoea and abortion caused by Campylobacter jejuni, ***Rhodococcus equi*** pneumonia in foal
- Clarithromycin- DOC for Mycobacterium avium complex
- Adverse reaction of erythromycin:

- ✓ I/M injection- Pain
- ✓ I/V injection- Thrombophlebitis
- ✓ Causes colitis in horse and rabbit

Lincosamides

- Lincomycin
- Clindamycin (used in Staphylococcal mastitis)

- Lincosamides and macrolides has similar antimicrobial property
- Lincomycin- absorption affected by recent feeding but not with clindamycin
- Lincosamides are contraindicated in Horses
- Cross resitance between macrolides, lincosamides and streptogramin B (MLSBr)

Chloramphenicols

- It prolongs the action of many drugs like barbiturates, NSAIDs and coumarins
- It antagonise the action of macrolides and clindamycin
- Contraindicated in Cat
- Not effective in urinary infection because large portion of it excreted in urine
- Toxicity:
  - ✓ Large dose- Reversible bone marrow suppression
  - ✓ Small dose- irreversible bone marrow depression

Polypeptide antibiotics

Polymixins: Two type: Polymixin B Polymixin E (colistin)	Obtained from Bacillus polymyxa Active against Gram –ve bacteria
Bacitracin	Obtained from Bacillus subtilis Active against Gram +ve bacteria (topical infection)
Vancomycin	Obtained from *Streptococcus orientalis*
Teicoplanin	
Dalbavancin	

Fluoroquinolones

1st generation	2nd generation	3rd generation	4th generation
Nalidixic acid Oxalinic acid Cinoxacin Flumequine	**Norfloxacin** **Ciprofloxcin** Ofloxacin **Enrofloxacin** **Danofloxacin** Kenoxacin Difloxacin	Peflofloxacin Marbofloxacin Sarfloxacin Levofloxacin	Gatifloxacin Moxifloxacin Premafloxacin Sparfloxacin

- They are excreted via urine and bile
- Fluoroquinolones inhibit activity of DNA gyrase and control supercoiling of DNA
- Dose rate: **Enrofloxacin**
  - ✓ Ruminants @ 2.5-5 mg/Kg B.wt I/M or S/C
  - ✓ Pig @ 2.5-5 mg/Kg B.wt I/M
  - ✓ Dog & cat @ 2.5-5 mg/Kg B.wt Oral (BID) or I/M (once)
- Toxicity: Arthropathic toxicity: Dog and horse are highly susceptible
- Fluoroquinolones are antagonist to nitrofurans, chloramphenicols and rifampin
- Additive effect of fluoroquinolones with Beta-lactums, aminoglycosides and macrolides.

Anti-tuberculosis drugs

First line of drug	Second line of drug
• Rifampin • Isoniazid • Pyrizinamide • Ethambutol (bacteriostatic) • Streptomycin	• Para-aminosalicylic acid (PAS) • Ethiomide • Cycloserine • Kanamycin • Amikacin • Capreomycin

- Prolong use of Isoniazid results in neurotoxicity due to deficiency of pyridoxine
- Rifampin imparts orange colour to saliva, sputum, tears and sweet
- Capreomycin causes renal damage and injury to 8th cranial nerve leading to deafness and ataxia
- Rifampin is potent inducer of hepatic microsomal enzyme system

Miscellaneous anti-microbials

1. Ionophores
   - Mainly for **feed efficiency** and **anti-coccidial activity**
   - Horse is most susceptible to toxicity
   - Relative toxicity:
   - Maduromycin > Monensin > Narasin > Laslocid> Salinomycin
2. Novobiocin
3. Vancomycin
4. Virginamycin

Antiviral agents

Pyrimidine antagonist	Purine antagonist	Reverse transcriptase inhibitor	Prevent entry
Trifluridine Idoxuridine	Vidarabine	Acyclovir Ribavin Zidovudin	Amantidine Ritonovir Tamiflu

- Amantidine- Inhibit M2 protein ion channels
- Ritonavir- used in HIV trearment
- Tamiflu-act by inhibiting neuraminidase (used in treatment of Swine flu)

Antineoplastic drugs

Alkylating agents (cycle non-specific drugs) Eg. **Nitrogen mustard** • Cyclophophamide • Chlorambucil	**Antimetabolites** **Pyrimidine antagonist** • 5-flurouracil • Cytarabine **Purine antagonist** • 6 Mercaptopurine • Fludarubine **Folic acid antagonist** • Methotrexate	**Vinca alkaloids (mitotic inhibitors)** • Vincristine • Vinblastin	**Antineoplastic antibiotics** • Bleomycin • Doxorubicin

Platinum complexes

- Cisplatin- causes pulmonary toxicity and nephrotoxicity
- Oxaliplatin
- Carboplatin

- 5-flurouracil is neurotoxic in cat
- Bleomycin causes pulmonary toxicity
- Cyclophosphamide causes haemorrhagic cystitis

Common drugs used in parasitology (ICAR Handbook of Animal Husbandry, 2016) (on basis of action on helminths)	
GABA agonist (flaccid paralysis)	Macrocyclic lactones (Ivermectin, Milbemycin)
Spastic paralysis (Cholinergic agonist)	Pyrimidines (Pyrentel, Oxantel) Imidathiazoles (Levamisole)
Spastic paralysis (Cholinesterase inhibitor)	Organophosphorus insecticides (Dichlorvos)
Flaccid paralysis (Muscle hyperpolarization)	Piperazine
Inhibition of oxidative phosphorylation	Salicylanilides (Oxyclozanide, Closantel)
Inhibitor of tubulin polymerization	Probenzimidazole (Febentel)
Inhibitor of glycolysis	Clorsulon, Thiacetarsamide
Tegument disruption (spastic paralysis)	Praziquantel

- Drug effective on trematodes-
  - Triclabendazole-fascioliasis (DOC-10-12mg/kg B. wt), effective for all stages of flukes
  - Oxyclozanide (DOC for amphistomes-10 mg/kg)- effective for mature flukes
  - Praziquantel (Schistosomiasis)
  - Nasal Schistosomiasis-Potassium antimony tartarate (Tartar emetic)
  - Rafoxanide (all stages- 7.5 mg/kg); Clorsulon (all stages-7mg/kg)
  - Carbontetrachloride (CCl_4)
- Drug effective on cestodes-
  - Praziquantel
  - Fenbendazole (5-10 mg/kg in farm animals)
- Drug effective on nematodes-
  - Pyrantel
  - Piperazine (Ascarids & eye worm)
  - Thiabendazole (Strogylus)
  - Diethylcarbamazine citrate and Ivermectin (Heartworm)

Diseases/Infection/Infestation	Drug of choice
Surra (Trypanosomiasis)	Quinapyramine sulphate (Therapeutic drug) @4.5mg/kg Quinapyramine chloride (Prophylactic drug)
Leishmania	Potassium antimony tartarate (Tartar emetic) Lithium antimony thiomalate Stibophen Pentostan (Pentavalent antimonials)-main drug of choice
Babesiosis	Diminazine aceturate@ 3.5 mg/kg
Theileriosis	Buparvaquone@2.5 mg/kg
Cattle coccidiosis	Sulphonamides
Poultry coccidiosis	Amprolium

Ectoparasiticides	
Agrochemicals (insecticides)	Permethrin, cypermethrin, propoxus, coumophos, diazinone, fenvalerate, lindane, aldrin, endosulphan, chlordane
Formamides	Amitraz
Macroyclic lactones	Ivermectin, doramectin
Neonicitinoids	Imidocloprid
Phenylpyrazoles	Fipronil
Insect growth regulators	Cyromazine
Insect development inhibitor	Diflubenzurone
Antichitin agent	Lufenuron (Fleas)

Chapter- 19 Veterinary Medicine

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- Veterinary medicine- deals with diagnosis, treatment, prevention and general study of diseases of animals.
- Clinical Veterinary medicine also k/a Bed side medicine/ Internal medicine/ Curative medicine.
- Disease- Any deviation from normal, physical or physiological condition
- Father of medicine: Hippocrates
- Father of veterinary Medicine: Renatius Vegatius

Species	Site of pulse rate	Site of blood collection	Site of CSF collection	Type of respiration
Cattle/Buffalo	Coccygeal artery, Maxillary artery, Facial artery	Jugular vein, ear vein	Lumbo-sacral/1st, 2nd coccygeal region	Abdominal
Sheep/Goat	Femoral artery	Jugular vein, ear vein	Sub-occipital/ Lumbo-sacral region	Abdominal
Dog/Cat	Femoral artery	Recurrent tarsal vein, cephalic vein	Cisterna magna (atlanto-occipital joint)	Thoracic (Costal)
Horse	External maxillary artery	Jugular vein	Sub-occipital/Lumbo-sacral region	Costo-abdominal

Methods of close physical examination	
Palpation	Method to touch any body parts in which direct hands are used (direct palpation) or probes are used (indirect palpation)
Percussion	Body surface is struck in such a way that vibration is produced and emit audible sounds. It is done with help of finger tips (immediate percussion) or with pleximeter and hammer (mediate percussion)
Auscultation	Listening to internal sounds of body. It is usually done with help of stethoscope for heart sounds, breath sounds and bowel sounds
William's method of auscultation	Auscultation of reticulum and palpation of rumen, mainly done to diagnose TRP
Succussion	It involves shaking of body to detect presence of fluid and air in a body cavity and simultaneously auscultation is done
Ballotment	Method for feeling a floating object in body in which a push is given to move organ away and then allow it to rebound on finger tips (palpation and percussion

Classification of disease	
On the basis of clinical manifestation	**On basis of spread of disease**
Peracute: few hours to 4 hours- very severe- short duration	**Sporadic disease:** Occur infrequently and irregularly
Acute: 3-14 days- sudden onset	**Endemic disease:** prevalent in a particular region, location or population
Sub-acute: 2-4 weeks- slow onset	**Epidemic disease:** affects large number of population in many parts of a country
Chronic: > 4 weeks- slow onset- longer duration	Pandemic disease: occurs across countries or continents

Classification of symptoms	
Subjective symptoms	Importance in human medicine
Objective	Importance in veterinary medicine
Pathognomic	Indicator symptoms of a particular disease
Direct/idiopathic	Spontaneous in nature
Indirect/Sympathetic	Confined to disease of remote organs
Pre-monitory/Pre-cursory	Indicate warning of a disease
Periodical/ remittent	Appear and disappear
Typical	Characteristic of disease
Atypical	Irregular

Type of diagnosis	
The art of recognition and determination of nature of disease is termed as diagnosis	
Snap-shot diagnosis	At a glance
Direct/physical diagnosis	Involve auscultation, palpation, percussion
Exclusion diagnosis	Method of elimination
Tentative/ presumptive	Preliminary diagnosis as per animal owner narration
Symptomatic diagnosis	Diagnosis on basis of symptoms
Confirmatory diagnosis	Diagnosis on basis of laboratory tests
Differential diagnosis	List of diseases which may be responsible for ongoing symptoms

Treatment	
Symptomatic treatment	Etiology is unknown
Pallitative	Used in incurable diseases
Rational therapy	Scientific method
Empirical treatment	Trial and error method (experience based)

Condition and aetiology	characteristics	Diagnosis/treatment
Hyperthermia (Heat stroke/Over-heating) High environmental temperature, prolong muscular exertion, high humidity	Metabolic rate is increased by 40-50% - blood NPN increases- fall in blood pressure(vasodilation)- pulse is rapid but weak- death due to respiratory and circulatory failure	Multiple organ failure- increased level of ALT, AST, LDH & CPK in serum **Treatment:** Shadow, cold water, Fans, electrolyte in drinking water

Hypothermia Excessive cold air exposure or insufficient heat production in body	Bradycardia- collapse of major veins- lack of saliva-hypoglycaemia death due to respiratory and circulatory failure Neonatal hypothermia is commonly seen in piglets	Cold extremities Treatment: passive re-warming, infusion of warmed I/V fluid
Toxaemia Antigenic toxin (exotoxin/ endotoxin) Metabolic toxin	Petechial haemorrhage are seen under conjunctiva and mouth mucosa	There is fall in blood sugar
Septicemia	Invasion of pathogenic bacteria in systemic circulation	Septicaemia is common cause of morbidity and mortality in new born
Fever **(Hyperthermia + Toxemia)**	Stages of fever: 1. Stage of increment or chill 2. Stage of fastigium/period of constant temperature 3. Stage of decrement/ defervescence	

Types of fever	Characteristics
Simple fever	Temperature does not touch normal limit in 24 hours and variation of temperature does not exceed 2^0 F in 24 hours
Remittent fever	Temperature does not touch normal limit in 24 hours and variation pf temperature more than 2^0 F in 24 hours
Intermittent fever	High temperature- then normal- again high temperature (eg. Biphagic fever)
Atypical/ Irregular fever	Temperature fluctuation does not follow a definite pattern. Mostly observed in veterinary cases
Transient	Temperature subsides within 24 hours
Continuous fever	Temperature does not touch base line and remains above normal
Periodic fever	Comes in a periodic pattern
Sthenic fever	High Temperature with strong bounding pulse
Asthenic fever	High temperature with weak and quick pulse

SHOCK (peripheral circulatory failure)

Shock is a life threatening condition occurs when body organs are not getting sufficient blood flow (hypoperfusion) as a result of peripheral circulatory failure

DEHYDRATION

Skin tenting	PVC	Degree of dehydration (%)
2-4 second	50%	6-8%
5-10 second	55%	8-10%
20-40 second	60%	10-12%

Skin tenting is not a good diagnostic feature in case of horse

Digestive system

Stomatitis

Simple stomatitis (Catarrhal stomatitis)	Mild inflammation
Papular stomatitis (Stomatitis follicularis)	Observed in bovine papular stomatitis and Orf
Vesicular stomatitis (Stomatitis aptha)	Characterized by vesicles formation (observed in FMD)

Proliferative Stomatitis	Observed in Bovine Papular Stomatitis
Fibrinous Stomatitis	Characterized by pseudomembrane formation (fibrinous exudate)
Phelegmonous stomatitis (Stomatitis erysepelatosa)	Connective tissue is involved
Ulcerative Stomatitis	Ulcer formation
Necrotic Stomatitis (Diptheroid Stomatitis)	Calf diphtheria (*Fusobacterium necrophorum*)
Granulomatous Stomatitis (trench mouth)	Also known as Vincent's gingivitis Caused by *Borellia vincentii* & *Fusobacterium spp.*
Mycotic stomatitis (Muzzle disease/thrush)	Causative agent is fungi
Gangrenous Stomatitis (Noma/cancrum oris)	Gangrene setup in mouth and mouth becomes dry (in other stomatitis, there is excessive salivation)

Pharyngitis		
Pharyngitis	Coughing, painful swallowing Regurgitation through nostrils	Bilateral nasal discharge is consistent finding

Bloat/ Ruminal tympany/ hoven/ Meteorism	
Primary tympany (Frothy bloat)	**Secondary tympany (free gas bloat)**
Dietary in origin **Etiology:** Excessive intake of green plants, leguminous plants, cereal fodders, lush green pasture, soluble carbohydrates(sugar, molasses), less intake of fibrous food	Failure of eructation of gases **Etiology:** Oesophageal choke and stenosis Pressure on oesophageal wall from outside Vagus indigestion, DH, TRP, mediastinal lymph node enlargement

INDIGESTION			
Simple indigestion	**Alkaline indigestion**	**Acidic indigestion/ acute carbohydrate engorgement/ ruminal acidosis/ Founder/ Impaction**	**Vagus indigestion (Hoflunds syndrome)**
History of sudden changes in quantity or quality of ration Etiology: excess feeding, excess protein intake, prolong use of oral antibiotics Common in stall fed/hand fed animals Fall in volatile fatty acids Dehydration- absent	Etiology: protein rich diet, intake of decomposed oil cakes, placenta Increase in number of large sized protozoa	Characterized by presence of gram positive bacteria and absence of ruminal activity and protozoa. Treatment of choice: 5% sodium bicarbonate	Characterized by bradycardia, recurrent tympany, hypochloremia, hypokalemia, metabolic acidosis, constipation **Diagnosed by atropine test** **Papple- shaped abdomen (Pear shaped on right side and Apple shaped on left side)**

Abomasal displacement

Common in high yielding heavily fed dairy cows
Etiology: anatomical predisposition (abomasum loosely suspended by greater and lesser omantum), pregnancy, heavy feeding, abomasal ulceration, vagal nerve paralysis, ketosis
Temperature, pulse and respiration are in normal range.
Ketonuria is a constant finding with metabolic alkalosis, hypochloremia, hypokalemia and haemconcentration
Paracentesis of abomasal fluid- absence of protozoa with pH of 2

LDA- Left-sided abomasal displacement	**RDA- Right-sided abomasal displacement**
Abomasum is trapped betwwen rumen and left abdominal wall	Abomasum displaced into craniodorsal right abdominal wall
More common	Less common
LIPTAK test: Auscultation in area below a line from the centre of the left paralumber fossa just	

behind the elbow reveals a high pitch sound known as **Splashing/Tinkling/Peeble in well sound**		
Gastritis/ Abomasitis in ruminants/ dyspepsia		
Granulomatous gastritis	Histoplasma capsulatum	
Emphysematous gastritis	Clostridium perfringens	
Hypertrophic gastritis	Habronema spp. & Trichostrongyles in horses	
Etiology:	Vomition, abdominal pain, praying posture- hallmarks of gastritis Healed ulcer have star-like appearance	Nothing per-os
Enteritis/malabsorption/Enteropathy		
Etiology: infectious agents, nutritional deficiency mainly copper	Diarrhoea- hallmark of entritis	

Small intestinal (bowel) diarrhoea	**Large intestinal (bowel) diarrhoea**
Frequency- normal to slight increased	Very Frequent
Faecal output- large volume	Small Volume
Tenesmus- absent	Present
Dyschezia- absent	Present With Rectal Disease
Mucus in faeces- absent	Present
Haematochezia- absent	Present
Melena- present	Absent

RESPIRATORY DISEASES

Rhinitis

- Serous rhinitis
- Catarrhal rhinitis
- Purulent rhinitis
- Fibrinous rhinitis
- Granulomatous rhinitis

Pulmonary congestion & oedema	**Pneumonia**	**Pleurisy (Pleuritis)**	**Pulmonary emphysema**
• No fever, no pain, no toximia • Absence of frictional sound • Forced expiration absent • Increased vesicular murmurs • Percussion- normal sound in congestion and dull sound in pulmonary oedema	• Dry and moist rales • Cough, dyspnoea • High rise of temperature • Localized respiratory sound	• Toximia- present • Dry pleurisy- Pain • Moist pleurisy- dyspnoea • Pleural friction sound and dull areas on acoustic percussion of thorax because of pleural effusion	• No fever and toximia • Expiratory dyspnoea or double expiration • Formation of groove anterior to flank in horses called heaves • Leads to hypertrophy of right ventricle • Tympanic sound on percussion
Hydrothorax/Hemothorax	Sudden development, no systemic involvement, no fever, no sign of toxaemia, absence of pleural rub and pain Aspirated fluid- transudate in hydrothorax and bloody in hemothorax		
Pneumothorax	Unilateral in all animals except horse		

	Presence of forced inspiration, inspiratory dyspnoea, No adventitious sound on auscultation, bulging of affected side of chest
Laryngitis	Bacterial- mucopurulent discharge Viral- serous discharge Dog usually suffer from chronic laryngitis
Bronchitis	Frequent dry cough, moist rales,

Note:

- Foul smell from nasal cavity is termed as ozaena
- Atelectasis- collapse of alveoli due to failure of alveoli to inflate
- Bronchiectasis- permanent dilation of bronchi- honey comb like appearance of lungs in radiography
- Pulse is brief, small and hard- Wiry pulse
- Pulse is small, weak and prolonged- Thready pulse
- Hyperpnoea: increased rate of respiration with increased or decreased depth of respiration
- **Polypnoea:** increased rate of respiration with decreased depth of respiration
- **Cheyne stroke respiration:** gradual decrease in depth of respiration (cardiac and renal diseases)
- **Biot's respiration-** Alternating hyperpnoea and apnoea (Meningitis and encephalitis)
- **Kussmaul's respiration (Air hunger)-** forceful and regular respiration but expiration unaffected (Uremia and diabetic ketoacidosis)
- Continous abnormal lung sounds are termed as wheezes while discontinous abnormal lung sounds are termed as crackles
- **Hic**-cough: short jerky inspiration as a result of stimulation of phrenic nerve
- **Stridor-** high pitched abnormal inspiratory sound audible without stethoscope

Pneumonia

Bronchopneumonia

Most common pneumonia in animals characterized by cranio-ventral (antero-ventral) consolidation of lungs and texture of lungs becomes firmer and harder than normal.

Two types: Suppurative and fibrinous bronchopneumonia

4 stages of pneumonia- mainly observed in lobar pneumonia

1. Congestion
2. Red hepatisation
3. Grey hepatisation-macrophages start to form
4. Resolution- large number of macrophages present

Suppurative (lobular) bronchopneumonia	**Fibrinous (lobar) bronchopneumonia**
Causes: *Pasteurella multocida* *Streptococcus spp.* & *E. coli* *Bordetella bronchiseptica* Observed in diseases viz. Calf pneumonia Haemorrhagic septicaemia, Porcine Enzootic Pneumonia	Causes: *Pasteurella haemolytica* Infection is related to one lobe of a lung

Interstitial pneumonia

Characterized by inflammation of alveolar septa, presence of hyaline membrane and foetalization of lungs

Cells of tripier is seen in interstitial pneumonia

Acute interstitial pneumonia	**Chronic interstitial pneumonia**
Characterize by hyperplasia of type II pneumocytes to replace lost type I pneumocytes	Alveolar fibrosis occurs, seen in ovine progressive pneumonia, silicosis

Verminous pneumonia: pneumonia caused by parasites

Drenching pneumonia: pneumonia occurs as a result of faulty drenching

Granulomatous pneumonia: pneumonia characterized by formation of granuloma

Diseases of urinary system

Cystitis Etiology: **Mainly by bacteria (*E. coli*)**	Inflammation of wall of urinary bladder Mainly occur in DOG and CAT (incidence is more in female) Frequent and painful urination Large number of pus cells, WBC, RBC, bacteria voided through urine	Antibiotic for 7-14 days Irrigation of bladder with acriflavin Use of acidifier
Uraemia/ Azotaemia **Etiology: mainly bilateral urolithiasis**	Elevation of NPN compounds in blood Vomition (dog), evil smelling skin, urine odour from breath and body discharge Black oral ulcer in dog	Metabolic acidosis
Amyloidosis	Glomeruli are the most common site for deposition of amyloid in domestic animals characterized by proteinuria and uraemia	
Tubular necrosis **Etiology:** Ischaemia & nephrotoxin	Acute tubular degeneration and necrosis is termed as nephrosis characterized by uremia, oligouria or anuria Tubulorrhectic necrosis- basement membrane is involved Nephrotoxin lesions are similar to ischaemic lesion but nephrotoxin never damage tubular basement membrane	PCT epithelium is most susceptible for tubular nephrosis
Glomerulonephritis	Polyuria, polydipsia, puffy eyelids, dry skin coat, vomiting, panting in dogs, muscle wastage, oedema, Nephrotic syndrome, nephritic syndrome **Nephrotic syndrome:** characterized by oedema, increase protein in blood, decreases protein in blood and increased fat in blood **Nephritic syndrome:** characterized by blood in urine and decrease in amount of urine	proteinuria, hyperphosphatemia, hypoproteinemia, hypercholesterolemia, hyperglobinemia

Type of Glomerulo--nephritis	**Proliferative glomerulonephritis** Characterized by increase number of cells in glomerulus and presents nephritic syndrome	**Membranous glomerulonephritis** Characterized by thickening of glomerular basement membrane	**Membrano-proliferative glomerulonephritis** Characterized by thickening of basement membrane & increase number of cells in glomerulus
Proteinuria	Present	**Highly present**	Present
Azotaemia	**Trace**	**Trace**	Highly present
Polyuria	Present	Present	Highly present
Polydipsia	Present	Present	Highly present
Weak muscle	Present	Present	Present
oedema	**Absent**	Present	Present

Interstitial nephritis		
Interstitial nephritis (Tubulo-interstitial nephritis) Etiology: **Bacteria-** E. coli, Leptospira spp. **Virus-** Adenovirus (ICH), Herpes virus (MCF),	Very common in DOGS • Space between kidney tubules gets swollen or inflammed • Polyuria, polydipsia, pain on palpation of lumber region • Reddish brown scum on teeth, gum and tongue • Arching of back	Uremia

Sheep pox, Equine Viral arteritis, PRRS **Parasite-** Dioctophyema renale Toxin- lead, Arsenic, Sulphonamide, mercury	• Temperature at initial stage • Diffuse lesions occur in canine leptospirosis • Multifocal lesions occur in E. coli, ICH, MCF, Porcine Leptospirosis and characterised by **white spotted kidney**	
Pyelonephritis		
Pyelonephritis Etiology: Cattle: Corynaebacterium renale Pig: Corynaebacterium suis	Mainly found in CATTLE Suppurative inflammation of renal parenchyma and pelvis Polyuria with strangurea Thick purulent evil smelling urinary discharge Rectal examination- thick elastic fluctuating cord corresponding dilated ureter on both side	Common in female & usually bilateral
Renal amyloidosis	Amyloid deposition around mesangial part of glomerular tuft characterized by severe proteinuria	
Urolithiasis		
Urolithiasis Etiology: Vitamin A deficiency Excess of vitamin D Bacterial infection	Crystal deposition in any part of urinary tract More common in male calf and dog (incidence is more in male) Vomition in dog and cat, haematuria, uraemia, Urinary Incontinence Rupture of bladder	Diet low in concentrate and high in roughage & High intake of estrogenous plants are pre-disposing factors
Uroliths (calculi)	• **Phosphate uroliths** (sand like granules- found as multiple stone): most common form of calculi in dog and cats • Magnesium ammonium phosphate (struvite) is commonest form of phosphate calculi in dog and cats • **Silicate uroliths** are common in herbivores • **Oxalate uroliths:** occur as single stone in bladder • **Uric acid uroliths** (radiolucent): common in Dalmatian dog • **Cystine uroliths** (inflection induced): very common in cat	
Renal failure		
Renal failure	Kidneys are not able to maintain their normal function Acute renal failure- mostly reversible and characterized by enlarged kidney Chronic renal failure- irreversible and characterized by small firm nodular kidney	Hyperproteinemia, decreased Hb level, Hypocalcemia, serum level of creatinine, phosphorous, potassium is increased

Notes:

- Dog and pig usually suffer from renal parasitic infestation
- Acidic urine has bacteriostatic effect and it also does not allow crystal formation.
- **Nephrosis-** Degenerative changes mainly affecting renal tubules
- **Nephrotic syndrome-** excess excretion of protein in urine causing hypoalbuminemia
- **Hydronephrosis-** cyst like distention of calyces and pelvis, of ureter with non-infective urine
- Proliferative GN- is the commonest form of GN which lead to renal failure
- Heavy protein diet makes urine acidic
- Nephroblastoma (Embryonal Nephroma or Wilm's tumour) is common in pig & poultry
- Normal urine protein and creatinine ratio is less than 1
- Hematuria: presence of blood in urine

Abnormal colour of urine	Cause/Drug
Red	Phenothiazine, Phenopthaline, Azosulamine
Pink	Congenital porphyria
Greenish	Acriflavin

Diseases of cardiovascular system	
Congenital heart diseases	1. Valve narrowing (stenosis) 2. Valve malformations (dysplasia) 3. Abnormal opening between heart chambers (septal defects) 4. Patent ductus arteriosus: persistent arterial connection between aorta and pulmonary artery- murmur felt throughout body wall like Washing machine churning (Blue baby syndrome C/B caudal cynosis) 5. Patent foramen ovale 6. **Tetralogy of fallot:** include 4 abnormality **(A) Pulmonary stenosis** **(B) Ventricular septal defects** **(C) Right ventricular hypertrophy** **(D) Over-riding aorta (dextro-position of aorta)** **Ventricular septal defects-** common in cat Most common congenital abnormality in horse Heritable in miniature swine Lead to left sided congestive heart failure If resistance increases, then blood start shunting from right to left **(Eisenmenger's complex)**
Conditions in which hypertrophy of right ventricles occurs	Left to right shunting defect Corpulmonale & corbovicum Heaves & Brisket disease Patent foramen ovale & congenital stenosis in dogs Dirofilariasis Acute heart failure
Murmur (adventitious sound)	Abnormal cardiac sound produced by circulatory sequence through valve or abnormal openings 2 type of murmur- **Functional murmur:** produced with in heart without any structural alterations in the valve **Organic murmur-** produced by structural alterations in the valve Murmur of valve stenosis- Harsh and whirring Murmur of incomplete closure – Softer and hissing
Corpulmonale	Hypertrophy of heart (mainly right ventricle) following the stasis of pulmonary circulation
Cardiac temponade	Increased amount of blood in pericardial sac resulting from acute compression of heart or blood clot completely enclosing heart Characterised by engorged jugular vein, peripheral cyanosis, pulse paradoxus and shock
Pericardial rub (Bruits)	Frictional sound produced within pericardium (similar to pleurisy)
Cardiac arrhythmia	Any deviation from normal cardiac rate and rhythm and si mainly observed in myocardial affections Transient arrhythmia common in foals
Pericarditis	Inflammation of pericardium and pericardial sac Arching of back due to pain, respiration is shallow and abdominal Auscultation- muffled heart sound

	Diminished amplitude of QRS complex **Fibrinous pericarditis:** most common type of pericarditis (also known as Bread & Butter pericarditis)-shaggy heart **Traumatic pericarditis:** characterized by cor-rugosum (wrinkled or corrugated heart) or shaggy heart (having rough surface) **Uric acid pericarditis-** fine-frost appearance of heart **Fatty changes in heart** results into Thrush breast heart or tigroid heart
Myocarditis Inflammation of heart muscle (mainly middle layer of heart wall)	Haemorrhagic myocarditis- Black Quarter Lymphocytic mycocarditis- Parvo infection Necrotizing myocarditis- toxoplasmosis
Endocarditis **Etiology:** Cattle- tricuspid valve and right sided heart enlargement	Horse- mostly mitral valve Dog- mostly aortic valve Affect lining of heart as well as valves within it Sign: PUO, pain in joints and limbs, systolic murmur, arrhythmia Vegetative endocarditis is noticed in Swine erysepalas
Endocardiosis (degenerative valve disease)	Most common cardiac disease in animals Dog- mitral valve involvement Horse- mitral and aortic valve involvement Cat- uncommon
Valvular diseases Etiology: Acute or chronic endocarditis Tearing of chordae tendinae	Characterised by murmurs DOG/HORSE/PIG- common cause is bacterial endocarditis Aged dog- Atrio-ventricular valvular regurgitation or involvement of mitral valve is noticed
Canine cardiomyopathy	2 form- **Dilated form (DCM-Dilated cardiomyopathy):** most common- occur in large breed dogs- characterized by abdominal swelling, exercise intolerance, cachexia, lethargy **Hypertrophic form:** sudden death- left sided heart failure is observed
Disseminated Intravascular coagulation (DIC)/ Coagulopathy/ Conjumptive coagulopathy	Defined as systemic activation of blood coagulation characterized by formation of blood clot in small blood vessels throughout of the body
Generalized vascular degenerative diseases	**Arterioscerosis-** hardening, thickening and loss of elasticity of walls of arteries **Atherosclerosis-** type of arteriosclerosis **Medial Arterial calcification (MAC-Monckeberg arteriosclerosis)-** stiffening of elastic (medial) layer of arterial wall **Intimal Arterial Calcification:** is associated with atherosclerosis characterized by lipid accumulation, fibrosis & focal plaques development
Acute heart failure **Etiology:** Severe tachycardia or bradycardia, drug, poison, shock, electrocushion, lightening	Suddenly heart stop functioning and characterized by loss of consciousness, falling with or without convulsion, severe paleness of visible mucosa, either complete recovery or death. Heart sound absent, absence of pulse Respiratory distress is prominent manifestation Acute dilatation of heart mostly of right ventricle

Congestive (chronic) heart failure (2 type) Etiology: Valvular disease, myocardial disease, pericardial disease, hypertension, congenital causes	Failure of cardiac output to meet the body requirement with excess retention of sodium and fluid, characterized by increased heart rate, venous congestion and engorgement of superficial vein. Pulmonary circulation implies left sided heart failure Systemic circulation implies right sided heart failure

Left sided heart failure Causes pulmonary venous congestion	**Right sided heart failure** Causes systemic venous congestion
• Sign: cough (very common), hemoptyxis, cyanosis, paroxysmal dyspnoea • PM lesions- pulmonary congestion and pulmonary oedema, brown induration of lungs • Microscopic examination- **heart failure cells (macrophages laden with haemosiderin)** are seen	• **Positive hepatojugular reflex is diagnostic feature** • Hepatic and spleenic enlargement • hydrothorax, hydropericardium, Pear-shaped abdomen • Horse- oedema more in pectoral region between frontalis, epistaxis • Auscultation of heart- Gallop rhythm over mitral area, Apical impulse, systolic murmur • Microscopic examination of liver: **Nutmeg** appearance characterized by increased lobular pattern of liver

Note:

- Dog and cat do not suffer from myocardial infarction due to adequate amount of vitamin C and Collateral circulation
- Petechia and eccchymoses- hallmark of thrombocytopenia and thrombocytopathy
- Generalized oedema occur in pericarditis, myocarditis, endocarditis
- Digitalis contraindicated in ventricular tachycardia
- Water hammer pulse- observed in valvular defect of aortic insufficiency
- Heart Block- Impairment of conduction through conducting tissue of heart
- Thrombangitis obliterans (Buerger's disease)- chronic inflammation of artery
- Aneurysm- localized dilatation or outpouching of thin and weak portion of vessels

Electrocardiogram (ECG)

- **P-wave: represent depolarisation of atria (atrial systole)**
- **QRS- wave: represent depolarisation of ventricle (ventricle systole)**
- **T-wave: represent repolarisation of ventricle (ventricular diastole)**

Abnormalities in ECG	
Narrower ECG	Tachycardia
Wider ECG	Bradycardia
Irregular ECG	Arrythemia
Higher P-wave	Atrial hypertrophy
Higher QRS-wave	Ventricular hypertrophy
Only P-wave (No QRS wave)	Atrio-ventricular block (AV block)
Wider QRS	Slow depolarisation of ventricle
Elevated T-wave	Myocardial infarction (Heart attack)
Depressed T-wave	Cardiac muscle hypoxia or ischemia

Diseases of integumentary system	
Pityriasis	Excess bran like deposit on skin surface Etiology: **primary pityriais:** deficiency of Vitamin A, B2, niacin, unsaturated fatty acids **Secondary pityriasis:** excess desquamation of epithelial cell by flea, louse, mites
Acanthosis (hyperplasia)	Increase in number of cells in epidermis mostly in stratum spinosum
Hyperkeratosis (Vitamin A deficiency)	Excess accumulation of keratinized epithelial cells leads to thickening of skin **(stratum corneum)** with or without loss of hair Skin is dry, scaly and fissured in a Grid- like pattern Cells **do not have nuclei** and Characterized by hypergranulosis
Acanthosis nigricans	Is a skin disorder in which there is dark, thick, velvety skin in body folds and creases i.e. thickening of skin increase in skin creases characterized by hyperkeratosis, hyperpigmentation and lichenification
Acantholysis	Loss of cohesion between keratinocytes due to breakdown of intercellular bridges through immune destruction or due to neutrophilic enzymatic destruction
Parakeratosis Zinc deficiency	Imperfect keratinization of epithelium characterized by **persistent nucleus** in **stratum corneum** characterized by hypogranulosis Mainly observed in pig and cattle
Pachyderma	Thickening of skin affecting all layers including subcutaneous tissue
Impetigo (puppy pyoderma/ milk rashes)	Non-pruritic superficial bacterial infection affection non-hairy part of skin
Urticaria (Nettle rash/ Hives)	Transient oedematous skin characterized by wheal like flat top eruption on skin surface. If lesion affect S/C tissue, termed as Angioneurotic oedema
Vesicles	Fluid filled cavity (blister) within or under epidermis (less than 5mm in diameter)
Bulla	Fluid filled cavity (blister) more than 1 cm in diameter
Pustule (microabscess)	Vesicles filled with inflammatory cells
Carbuncle	Cluster of boils situated close to each other opening to skin through several pores
Wheal	Circumscribed raised lesions caused by dermal oedema
Eczema	Defined as inflammatory reaction of epidermis to certain exogenous/ endogenous substance against which cell is sensitized
Pruritis	Deep physiological itching sensation produced by mild stimulation of epidermal layer characterized by scratching, biting, rubbing of skin Allergic pruritus diagnosed by Patch test
Spongiosis	Spongiosis is **intercellular** oedema (abnormal accumulation of fluid) in epidermis
Ballooning	**Intracellular oedema** of epidemis & epithelial structures of adenexa characterized by reticular degeneration, hydropic or vacuoler degenerartion
Folliculitis	Inflammation of hair follicle
Hidradenitis	Inflammation of apocrine gland (sweat gland)
Photosensitization	Sensitization of skin to UV radiation of sunlight with presence of photodynamic agent in the skin Phylloerythrin accumulation in dermal tissue General sign, skin lesions, systemic sign, Nervous sign Diagnosed by plasma Phylloerythrin levels Primary photosensitization- observed in Parthenium toxicity

	Secondary photosensitization- observed in *Lanatana camara* toxicity
Seborrhoea (Dandruff)	Hypersecretion of sebum with increased scale formation **Seborrhoea sicca-** excessive scale and dryness of skin (German Shephard & Dobermann) **Seborrhoea oleosa-** excessive greesyness in skin along with scale (Pig and greesy heal of horse) **Flexural Seborrhoea-** excessive secretion of sebum in skin between udder and groin region and medial surface of thigh in cow
Vitiligo	Patchy depigmentation of skin with premature graying of local hair Common in cattle and horse Genetic in Arabian horse and HF cattle
Malassezia dermatitis	Frequent in dogs by fungus Malassezia pachydermatitis characterized by lichenification, hyperpigmentation, pruritis, papule, erythema

Diseases of nervous system			
Focal disease of brain Abscess Tumor Gid/sturdy	**Diffuse disease of brain** Cerebral hypoxia Cerebral oedema Brain swelling, hydrocephalous Encephalomalacia Traumatic injury	**Disease of meninges** Meningitis Epilepsy Psychosis	**Disease of spinal cord** Spinal cord compression, myelitis, myelomalacia, traumatic injury

Important cells of nervous system	
Astrocytes	Most numerous type of cells in CNS & similar to fibroblast Hypertrophied astrocytes are termed as **Reactive astrocytes** Astrocytes are termed as **Gemistocytes** in prolonged degenerative conditions Do not take H & E stain
Micoglia	Microglia originate from monocytes & are the first cell to react in CNS injury Inactive stage of microglia is termed as Ramified microglia or resting cells Active microglia is termed as Rod cells or reactive cells
Gitter cells	Lipid laden macrophages having foamy appearance & seen in Canine Distemper & Listeriosis
Oligodendrocytes	Cells with few branches located in white and grey matter mainly associated with formation and maintenance of myelin sheath Do not take H & E stain

Important terms	
Satellitosis	Accumulation of neuroglial cells around neurons in CNS often followed by neuronophagia
Tremors	Continuous repetitive twitching of skeletol muscles
Fibrillation	Isolated contraction of various muscles fibres
Spasm	Involuntary contraction of group of muscles
Tics	Spasmodic twitching movement may get much longer interval than in tremor
Mania	Excessive response
frenzy	Stage of violent mental agitation
Schiff-Sherrington syndrome	Noticed in dogs mainly and characterized by hypertonic paralysis of forelimbs (forelimb extension) as a result of thoracolumbar spinal cord injury
Tetany	Tonic symmetrical muscular contraction accompanied by hyperexcitability, twitching and sweating

Myoclonus	Intermittent tetanic contraction of skeletol muscles which result in entire body being rigid for several seconds followed by relaxation
Convulsion	Rapidly alternating violent contraction and relaxation of muscles or spasm affecting the whole body known as convulsion Tonic Convulsion- result from stimulation of sub-cortical ganglions Clonic Convulsion- result from stimulation of cerebral cortex
Narcolepsy	Excessive sleep disorder
Catalepsy	Muscular rigidity and fixing of posture
Psycholepsy	Feeling of hopelessness and lethargy as a result of sudden mood change
Ataxia	Incoordinated movement of limbs
Hypermetria	Increased range of movement
Hypometria	Decreased range of movement
Dysmetria	Include both hypermetria and hypometria
Coma	First stage of unconsciousness or terminal point of apathy or depression
Horner's syndrome	Interruption of nerve supply to eye and facial muscles characterized by constricted pupil, partial ptosis and loss of hemifacial sweating
Psychosis/ neurosis	Disturbed nerve function without any histological evidence
Syncope/ fainting	Transient loss of consciousness due to ischaemia or less supply of oxygen to brain

Epilepsy
(According to etiology)

Idiopathic epilepsy Cause cannot be determined	**Symptomatic/ secondary epilepsy** Cause is known

(According to fits)

Focal epilepsy	**General epilepsy**
1. Temporal lobe or pshycomotor epilepsy 2. Jacksonian epilepsy 3. Myoclonic epilepsy 4. Akinetic epilepsy	1. Grandmal/ Major epilepsy (1-3 minute) 2. Petitmal/ Minor epilepsy (10-30 seconds) 3. Status epilepticus

Hydrocephalous	Increase in volume of CSF, common in large ruminants and dog **Normotensive hydrocephalous-** associated with ischemia, inflammation, injury **Hypertensive hydrocephalous-** associated with obstruction of CSF flow, may be congenital or acquired- Congenital hydrocephalous resembles with Vitamin A deficiency in new born (No distortion of cranium in Vitamin A deficiency)
Hydranencephaly	Cavity formation in white matter of cerebral hemisphere
Porencephaly	Cleft in wall of cerebral hemisphere
Syringomyelia	Formation of tubular cavity in spinal cord not lined by ependymal
Concussion	Diffuse brain injury
Contusion	Focal brain injury
Encephalitis	Sign of involuntary movement followed by loss of nervous functions Pathogenesis involve- perivascular cuffing, gliosis, neuronal satellitosis, neuronophagia Fever is common in encephalitis but not present in Rabies, Scrapie, BSE
Encephalomalacia	Degenerative disease of brain characterized by softening of brain Etiology: Deficiency of vitamin B1, Vitamin E, copper, vitamin A Mouldy corn with Fusarium moniliformes
Brain abscess	Occur in young farm animals Hematogenous infection is common Local spread via peripheral nerves in case of Listeriosis
Brain tumor	Primary neoplasia is more common in dog over 3 years of age Boxer breed is more susceptible

	Paradoxical vestibular syndrome- circling away from lesion sides Horner's syndrome Right/ left visual field of both eyes affected
Meningitis (Cerebral and spinal meningitis)	Increased intracranial pressure due to defect of drainage of CSF Blindness is common in cerebral meningitis

Disease of peripheral nervous system

Paralysis — Dearrangement of neurological control over the peripheral organs

Paralysis- classification

Symptomatic based	**Lesion based**	**Position based**	**Clinical basis**
1. **Spastic paralysis-** contractile stage 2. **Flaccid paralysis–** relaxation stage	1. **Upper motor neuron paralysis-** lead to spastic paraplegia 2. **lower motor neuron paralysis-** lead to flaccid paraplegia	1. **infranuclear paralysis-** associated with lower part of motor pathway 2. **Supranuclear paralysis-** associated with upper part of motor pathway	1. **Monoplegia-** few or more nerves are affected 2. **Diplegia-** both side of body affected 3. **Hemiplegia-**one side along posterior/anterior part of limb 4. **Quadriplegia-** all 4 legs affected 5. **Paraplegia-** paralysis of hindquarter **Paraplegia in extension-** only pyramidal tract is involved **Paraplegia in flexion-** pyramidal and extrapyramidal tract is involved

Notes:

- Caloric test- to assess the vestibular nerve while Oculo-cardiac reflex- to assess the vagus nerve
- Neuritis- inflammation of peripheral nerves
- Calcification is more common in meninges
- Bierbeck granules are present in dendritic cells
- Cells most sensitive to ischaemia- Cortical neurons

Disease of musculo-skeleton system

Myopathy	Non-inflammatory hyaline degeneration of skeletal muscles **Primary myopathy (Muscular dystrophy)-** generally inherited and characterized by progressive degeneration of skeletal muscles **Secondary myopathy-** result due to ischemia **On the basis of clinical findings** • **Nutritional myopathy-** 2 forms 1. Cardiac form- young calves and foals- sudden onset 2. Skeleton form- older calves and foals- slower onset • **Excertional rhabdomyolysis** • **Neurogenic muscular atrophy** **PM findings- FISH FLESH LIKE appearance of skeletal muscle**
Myositis	Inflammation of muscle fibres
Osteomyelitis	Inflammation of osseus as well as myeloid tissue of bone Epiphyseal osteomyelitis – most common in calves under 3 months of age caused by Salmonella spp. Dog/Cat- Staphylococcus spp.

	Clinical pathology- **Necrotic Sequestrum,** new bone formation, losss of bone density
Osteodystrophy It includes: 1. Rickets 2. Osteomalacia 3. Osteodystrofibrosa 4. Osteoporosis 5. Congenital defects (complete- Achondroplasia and incomplete- chondrodystrophy)	General term for those diseases of bone in which there is failure of normal bone development or abnormal metabolism of bone which is already mature
Barlow disease	Developmental disease of **young giant breed dogs** characterized by hypertrophic osteodystrophy and also known as **skeletal scurvy or canine scurvy**
Arthropathy (Osteoarthropathy/ Degenerative Joint Disease)	Non-inflammatory lesion of articular surface of joints **Primary arthropathy-** due to normal aging process **Secondary arthropathy-** injury or congenital defects Cattle- stifle joint commonly affected followed by hock joint
Arthritis & Synovitis	Inflammation of articular surface and synovial membrane **Polymethylmethacrylate beads-** used in treatment of chronic arthritis

Disease of neonates/Postnatal disease/ calf hood disease		
Early post-natal disease Occurs within 48 hours of birth Non-infectious and metabolic	**Delay post-natal disease** 2-7 days of age Due to failure of passive transfer of colustrum	**Late post-natal disease** 7-28 days of age
Hypoglycemia (Baby pig disease in swine)	Colibacillosis	Septicemic disease
Hypothermia	Joint ill/Navel ill (calves, lambs, foals)	Enteric disease
Neonatal rickets	Salmonellosis	Respiratory disease
Goiter	Rota virus infection	Cryptosporidiosis
Crooked calf disease	Corona virus infection	White muscle disease
		Ascariasis
Note: **Neonatal isoerythrolysis (haemolytic anemia)-** very common in Foals, pup, kitten **Neonatal maladjustment syndrome/Dummy foals/Barkers/Wanders-** common in foals		

Chapter- 20

Metabolic and deficiency diseases

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Disease	Characteristic findings	Diagnosis & Remarks
Milk fever **(Paturient paresis/ calving Paralysis/ Parturient Apoplexy)** **Etiology: Hypocalcemia** Cations (Na & K) rich diet favours milk fever Jersey cow & Jaffarabadi buffalo is highly susceptible	Occurs within 48 hours after parturition & between 3rd to 7th calving mainly Characterized by 3 stages: 1. Stage of excitement- tetany & hyperaesthesia 2. Stage of Sternal Recumbency- S- shaped head, pupillary & rectal reflex lost- subnormal temperature 3. Stage of Lateral Recumbency- subnormal temperature, inaudible heart sound	Increase in CPK & AST levels Sulkowich test for calcium in urine Treatment of choice **25 % calciumborogluconate** NH_4Cl- prevent milk fever
Downer Cow Syndrome (Post Parturient recumbency) **Unknown etiology** Occurs after 2-3 days of calving	• Holstein Friesian is most susceptible • Characterized by prolong recumbency (Frog-like posture/Creeper cow) and Ischemic myopathy • Death is due to myocarditis & decubital ulcer Urination normal but urine has excess protein & ketone bodies	Low level of Ca, P, Mg, K Increase in CPK & ALT levels
Eclampsia in bitches **(Milk fever in bitch/ Post parturient tetany/ Peurperal tetany/ Lactational tetany)** **Etiology: hypocalcemia and hypoglycemia**	• Occurs 2-4 weeks after whelping • Restricted to small breeds • C/B opisthotonus condition, tonoclonic convulsion, head & tail upward, swollen vulva & mammary gland, bitch cry & restlessness • Temperature is above normal	Treatment of choice **10 % calciumborogluconate**
Eclampsia in mare **(Lactational tetany of mare/ Transit Tetany)** **Etiology: Hypocalcemia**	• Occurs at about 10th day of foaling or 1-2 days after weaning or after prolong exercise or transport • Thumping sound of diaphragm	• High producing & hard working-more susceptible
Hypomagnesemic tetany (Lactational tetany/ Grass tetany/ Grass Staggers/ Wheat Pasture poisoning)	Xylidil Blue dye test & AKZ paper test **Cattle. Sheep, goat** Twitching of muscles & ears, hyperaesthesia, champing of jaws Normal Mg level: 1.5-3 mg/dL In deficiency: 0.5 mg/dL	Increase in CPK & AST serum levels Treatment of choice **25 % calciumborogluconate & 5 % Magnesium hypophosphate**
Hypomagnesemic tetany in calves (Whole milk tetany)	2-4 month calves more susceptible Shaking of head, stamping of feet, involuntary urination & defaecation	

Peri-parturient Haemoglobinuria (PPH) (Nutritional Haemoglobinuria/ Red Water/ Lahu Mutna **Etiology: Hypophosphaetemia**	Occurs after 2-4 weeks of parturition & between 3rd to 6th lactation Molybednum & oxalate toxicity, feeding of cruciferous plants predisposes to PPH C/B history of parturition & red colour urine Death due to anemic anoxia	Normal P level: 4-8 mg/dL In PPH: 0.5-3 mg/dl RBCs have Heinz bodies
Bovine Ketosis (Acetonemia/ Hypoglycemia) **Guarnesy cow** is most susceptible	**Rothera test (ketone bodies in urine)** **It occurs in 2 forms:** 1. **Wasting form (Digestive form)**- loss of body weight, ketone odour from mouth & milk 2. **Nervous from- due to hypoglycemia** aimless movement, crossing of legs, staggering gait	Treatment of choice **50 % Dextrose** (replacement therapy) **Dexamethasone** (Hormonal therapy) **Cysteamine** (precursor of CoA)
Pregnancy toxaemia/Ketosis (Ovine Ketosis/ Twinning disease/ Kidding Sickness/ Antepartum paralysis) **Nervous sign is due to Iso-propyl alcohal**	Occurs during last 2 week of pregnancy C/B progressive neurological dysfunction (**Star Gazing Posture,** circling movement, convulsion, champing of jaws, grinding of teeth, twitching of muscles, cog wheel type clonic contraction of cervical muscles), diarrhoea **High Plasma cortisol is characteristic feature**	• **Rothera test (ketone bodies in urine)** Treatment of choice **5 % Dextrose** Concentration of glucose in CSF is more accurate than blood glucose for diagnosis
Pregnancy toxaemia in cattle (Fat cow syndrome/ Fatty liver in cattle/ Hepatic lipidosis)	Occurs after 30-60 days of parturition Emerging disease with challenge feeding	**Liver biopsy** Treatment of choice • **Choline chloride** • **Vitamin B12**
Azoturia (Paralytic Myoglobinuria/ Monday Morning Sickness/ Tying Up Myositis/ Cording Up/ Black Water/ Exertional Rhabdomyolysis)	• Exact etiology unknown • Deficiency of Vitamin E & Selenium- predisposing factor • C/B myoglobinuria (Dark brown urine) & Muscular degeneration (Quadriceps femoris & gluteal muscles are hard & board-like resulting into lameness) • Death is due to muscle degeneration and renal failure	Serum CPK & AST level increases CPL level is highest in skeletal and cardiac muscle degeneration
Neonatal Hypoglycemia (Baby Pig disease/3 Day pig disease) Also occur in foal and Calves	Occurs due to low calorie intake & increased catabolism Baby pig cannot utilise sucrose and starch except lactose C/B cold clammy skin, pallor & erected hair, nervous sign is more common in piglet	Blood glucose level is less than 50 mg/dl

Vitamin	Deficiency	Remark
Vitamin A (Retinol) Esterified form- present in fish oil &	Night blindness (Earliest sign but not in pig- shaggy appearance of skin in pig) Xeropthalmia (dry eye) Bitot Spot (small plaques of keratin debris)	**Anti-infectious vitamin** **Anti-rachitic factor** Stored in liver on retinol ester form

can pass through placenta but alcoholic form-present in green grass	Keratomalacia Papilloedema- accumulation of fluid in optic canal Nutritional Roup Penguin like squat Stone formation-uroliths (male) Vaginal cornification (infertility)	Transport form-retinol **Dioxygenase & retinol reductase** convert beta-carotene into Vitamin A
Vitamin B_1 (Thiamine) Active form- thiamine pyrophosphate	Pyruvate and lactate ratio increased Polioencephalomalacia (cerebro-cortical necrosis) Star-Gazing condition Beri-beri or peripheral neuritis Wernicke's encephalopathy syndrome Acute Cardiac dilatation (Pig) Chastek paralysis in foxes & mink	**Energy releasing vitamin** Act as co-factor in pentose phosphate pathway
Vitamin B_2 (Riboflavin)	**Poultry:** Curled toe paralysis Clubbed down condition Dead-in-shell Demyelinating peripheral neuropathy	Aflatoxin is antagonistic to Riboflavin
Vitamin B_3 (Niacin) Glucogenic and antilipolytic vitamin	**Pig & dog**: Pellagra (Dermatitis, Diarrhoea, Dementia, Death -4D) **Chondrodystrophy or perosis (Poultry)**	Maize is deficient in niacin, tryptophan & pantothenic acid
Vitamin B_5 (Pantothenic acid)	Chick anti-dermatitis factor Act as precursor of cholesterol Goose Stepping gait in pig	Involved in Two-carbon metabolism
Vitamin B_6 (Pyridoxine)	Dermatitis-Acrodyna (peculiar feature) and neurological disorder- paddling in chicken Microcytic anaemia in pig Haemosiderosis of spleen, liver & bone marrow Rat Pellagra	**Eluate factor**
Vitamin B_7 (Biotin) Anti-egg white injury factor	**Pig:** Kangaroo Sitting Posture Red tongue **Poutry:** Parrot Beak in turkey Fatty Liver Kidney Syndrome (FLKS)/ Pink Disease Chondrodystrophy (slipped tendon or perosis)	Aflatoxin is antagonistic to biotin Act as co-factor for pyruvate carboxylase & Acetyl Co. A carboxylase
Vitamin B_9 (Folic acid/ Vitamin M)	Macrocytic Megaloblastic anaemia Chondrodystrophy (slipped tendon or perosis)	Involved in single carbon metabolism
Vitamin B_{12} (Cyanocobalamine)	Megaloblastic anaemia or pernicious anaemia	Animal protein factor
Choline (Lipotrophic factor)	Fatty liver in new born calves & pigs **Poultry: Chondrodystrophy or perosis**	Colustrum is excellent source of choline
Vitamin C (Ascorbic acid/ Hexuronic acid) Anti-oxidant Stored in adrenal & pituitary gland	Man, Guinea pig, primate, bat, bulbul lack L-glunolactone enzyme required for Vitamin C synthesis Scurvy (Bleeding gums) **Poutry:** Battery sickness- paralysis & atrophy of striated muscles	Main function is hydroxylation of proline & lysine Aminoacids
Vitamin D (Ergocalciferol-D2 Cholecalciferol-D3) Vitamin D2 is poorly utilized by poultry	Synthesis occur in liver in mammals & in kidney in birds Active form of vitamin D: **1,25 dihydroxyvitamin D** Rickets- young	Alpha-1- globulin (Vitamin D binding protein)

	Osteomalacia- adult	
Vitamin E (Tocopherol) Anti-sterility factor, **Anti-oxidant**	White Muscle Disease Stiff Lamb Disease- suckling lambs **Pig:** Dietary hepatic necrosis (Hepatosis dietetica) & Mulberry heart disease Poultry: Encephalomalacia (Crazy Chick Disease) Exudative diathesis Nutritional muscular dystrophy	**Vitamin A sparer but selenium act as Vitamin E sparer** **Pig & Cat:** Yellow fat disease or Steatitis
Vitamin K	Poor blood clotting (Blood diathesis/ Bleeding tendency)	Haemorrhagic syndrome
Micro-organism can synthesize water soluble vitamins, provitamin A (beta carotene) & Vitamin K2 Vitamin B12 can only be synthesized by micro-organism neither by plant or animal Expired CO_2 is major route of elimination of excess Vitamin C in Guinea pig		

Minerals	Deficiency	Remark
Calcium	High level of phosphorous & magnesium interfere with calcium absorption Ricket-young; Osteomalacia- adult Poultry- cage layer fatigue	Calcium is absorbed in small intestine
Phosphorus	Ricket-young; Osteomalacia- adult Pica (allotriophagy) Lamsiekte (Lame sickness)/ Styfsiekte/ Creeps/Peg leg	Cotton seed & Wheat bran has excess phosphorus
➢ **Osteomalacia: also known as Pegleg/ Creeper/ Bog lame/ Milk leg/ Milk lameness** C/B osteoporosis, weakness & deformity		
Magnesium	Grass tetany (grass staggers/wheat poisoning) Magnesium is absorbed in rumen	Kidney is organ of Mg homeostasis
Manganese Involve in synthesis of chondroitin sulphate, mucopolysaccharide, glycoprotein etc.	Swine- enlarged hocks **Poultry:** Chondrodystrophy (slipped tendon or perosis) Parrot beak in chicken embryo	Rice bran has excess manganese
Copper	Microcytic & hypochromic anaemia **Cattle:** Falling disease (myocardial degeneration & cavity lesions in cerebral white matter Spectacle disease- loss of pigment from coloured hair especially around eyes Salt sickness **Sheep:** Steely wool/Stringy wool Enzootic ataxia (Swayback Disease)- weakness of hind limbs	High molybdenum, zinc, cadmium & sulphate caused copper deficiency
Cobalt Copper is essential for maintenance of normal rumen flora	Normocytic & Normochromic anaemia **Wasting Disease (Enzootic marasmus or Pine)** **Hill Sickness** **Grand Traverse Disease** Coast Disease Bush Sickness White Liver Disease	**Methyl Malonic acid (MMA)** in plasma & FIGLU (Formimino glutamic acid) in urine- level increases in Co deficiency
Zinc	Parakeratosis in pig Crooked legs in swine	Antagonist effect of calcium

	Lowers immunity	Storage in bones
Iron	Microcytic & hypochromic anaemia Piglet anaemia (C/B pneumonia & enteritis)	
	Thumps	
Salt (Nacl)	Pecking behaviour & Cannibalism in poultry	
Iodine	Goiter Young- Cretinism Old- Myxoedema Waddling gait in pig	Deficiency is also related with high calcium intake

➢ Selenium deficiency is similar to Vitamin E deficiency

Minerals	Toxicity	Remark
Selenium	Acute toxicity: Blind Staggers- cattle Chronic toxicity: Alkaline Disease- horse (Bob tail disease- falling hair on mane & tail), Long Rocker Shaped hoof	Excess selenium replaces sulphur in amino acids
Molybednum	Teartness (persistent diarrhoea)	
Fluorine	Mottling of teeth Bones become shorter, thicker, heavier- osteomalacia- osteoporosis (Shifting Lameness)	
Salt poisoning	Pig- catarrhal gastroenteritis & eosinophilic meningoencephalitis Poultry- diarrhoea, convulsion, visceral gout	

Common Hormonal disorder	
Hypothyroidism	Characterized by rat tail appearance, myxoedema (due to hyaluronic acid), hyperkeratosis, bilateral symmetrical alopecia (non-pruritic), neurological sign and symptoms
Hyperadrenocorticism/ Cushing syndrome(cortisol level-high)	Characterized by thin soft skin with scales (sand paper like appearance, pot-bellied appearance, polyuria, polydipsia, bilateral symmetrical alopecia (non-pruritic)
Hypoadrenocorticism/Addison's Disease (cortisol level-low)	Characterized by lethargyness, diarrhoea, vomition, anorexia
Diabetes mellitus	
Type 1 diabetes mellitus	Juvenile diabetes or Insulin dependent diabetes meliitus (IDDM) and characterized by weight loss, frequent urination, increased thirst, increased hunger
Type 2 diabetes mellitus	Non-insulin dependent diabetes mellitus (NIDDM) Characterized by hyperglycemia, glycosuria, weight loss, frequent urination (polyuria), increased thirst (polydipsia), increased hunger(polyphagia), deposition of amyloid (mainly in cats), hepatomegaly, cataract (in dogs) Renal threshold for glucose in dogs- 180 mg/dl Cats: 280 mg/dl Diagnosis: persistent hyperglycemia, glucosuria, glycosylated haemoglobin estimation, serum fructosamine estimation Treatment : Lente insulin in dog while Basal insulin (slow acting insulin) in cat
Diabetes insipidus	
• Hormonal disorder caused by low level of Anti-diuretic hormone (ADH)/ Vasopressin • Characterized by polyuria, polydipsia and diagnosed by water deprivation test	

Chapter-21

Veterinary General Surgery

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- Father of surgery- Sushruta
- Father of veterinary radiology- Richard Eberlein
- Major surgery- Duration is more than 30-45 minutes and involve risk on the life of patient
- Minor surgery- Duration is less than 30-45 minutes
- Radical/extirpative surgery- removal of diseases part
- Explorative surgery- for confirmatory diagnosis
- Elective surgery- can be postponed
- Cryosurgery
  - ✓ Liquid nitrogen (-196 ^{0}C)
  - ✓ Liquid N_2O- (-80 ^{0}C)
  - ✓ Gas N_2O- (-70 ^{0}C)
- Principles of modern surgery was first given by Halsted

Wound	
On the basis of extent of injury	**On the basis of time involved**
Close wound	1. Clean wound/ surgical wound/ incised wound- **0 hour wound**
Abrasion wound	2. Contaminated wound- **less than 6-8 hours old**
Contusion wound	3. Infected wound/ open wound- **more than 6-8 hours old**
Haematoma	
Open wound	
Lacerated wound-Wound margin zig-zag	
Penetrating wound	
Avulsion wound- Substantial tissue lost from body	
Punctured wound- Deep and prone to anaerobic infection	
Gunshot wound	
Virulent wound	
Granulating wound- tendency to heal	
Ulcerative wound- No tendency to heal	

- Contusion wound: by compression or blow of blunt Weapon
- Proud flesh/Exuberant granulation-excessive growth of granulation tissue and blood vessels during healing process.
- Keloid: abnormal proliferation of scar tissue at the site of injury, seen in horse mainly
- Haematoma: collection of blood in an abnormal cavity
- Contractures- excess of contraction seen after serious burns and interfere with joint movements

- Cicatrix-final stage of wound healing

Abscess	Cyst	Tumor	Hematoma	Hernia
circumscribed collections of purulent material (pus) in a cavity	a closed sac having a distinct inner lining of secreting membrane	Abnormal growth of cells	Abnormal collection of blood outside of blood vessel	Abnormal protrusion from one anatomic space to another
Acute development (2-4 days)	Very slow development	Slow development & non-inflammatory origin	Immediate after injury	May be congenital/ if acquired then immediate after injury
Painful and, firm at periphery and soft at centre	Painless	Benign- painless Malignant- painful	Painful and doughy on palpation	Painless
On puncture- pus obtained	Straw colour fluid	Blood or nothing	Blood	Never punctured Diagnosed by hernia sac, hernia ring and its content

- Collection of pus in normal cavity is termed as empyema
- Collection of pus in abnormal cavity is termed as abscess
- The Syme's knife is used to open abscess
- Abscess involving sebaceous gland is termed as acne
- Abscess involving hair follicle is termed as boil while Group of boils is termed as Furuncle
- Maturation of abscess is done by Iodine ointment
- Group of small boils is termed as carbuncle
- Improper treatment of an abscess is termed as antibioma and characterized by fibrosis and inspissated pus
- Fistula is an abnormal inflammatory tubular tract between two anatomic spaces or a pathway that leads from an internal cavity or organ to the surface of body while Sinus is defined as abnormal inflammatory tubular tract that originates or end in one opening
- Common organism isolated from cat abscess is Pasteurella spp.

Type of abscess	Type of ulcer	Burn and its degree	Type of hernia
Type of abscess **Acute Abscess** (Hot abscess) **Chronic Abscess** (Cold abscess) **Dry abscess** Have inspissated pus **Shirt-stud abscess/ collar button abscesss** Two abscess connected by narrow channel **Broodies abscess** Chronic and semi-purulent over tibial head	**Phagidenic ulcer-** Pathogenic bacteria **Decubital ulcer/Bed sore/ Ischemic ulcers** Continuous pressure over bony prominence **Indolent ulcer-** Chronic & painless characterized by excessive granulation tissue **Indurant ulcer-** Thick and indurative edges	**1st degree burn-** only epidermis affected **2nd degree burn-** vesicle/bulla formation occurs **3rd degree burn-** epidermis, dermis and its component affected **4th degree burn-** Subcutaneous tissue & muscles involved	**Enterocoele-** intestine **Epiplocoele-** mesentry/omentum **Oscheocoele-** scrotum **Bubonocoele-** Inguinal ring **Hysterocoele-** uterus **Vesiculocoele-** bladder **Omphalocoele-** umblicle **Enteroepiplocoele-** intestine & omentum

- Burn: injury caused by dry heat
- Scald: injury caused by moist heat
- Frost bite- injury caused by extreme cold
- **Perineal hernia:** occurs in old uncastrated male dogs
- **Omphalocoele:** common in foals, pigs, calves and pups. Umbilical hernia is more common in females
- **Ventral or lateral adnominal hernia**: common in horse, goat and cattle, hernia through any part of the abdominal wall other than a natural orifice.
- **Diaphragmatic hernia in bovines:** In cattle and buffaloes, reticulum is the common herniating organ. It occurs due to weakening of the diaphragm in TRP, increased intra-abdominal pressure during pregnancy and parturition characterized by recurrent tympany
- **Gut tie in bullocks is lso known as pelvic hernia or Peritoneal hernia)**
- **Inguinal hernia** (Bubonocele)- Protrusion of an abdominal organ through the inguinal canal is called inguinal hernia
- **Hiatal hernia:** type of diaphragmatic hernia in which cardiac part of the stomach pass through the oesophageal hiatus of the diaphragm
- Sun stroke (heat stroke) is common in dog and horses, heat cramps are common in draft horses and heat exhaustion is common in draft horses, cattle and swine.
- Bier's hyperemia is a method of treatment for septic inflammatory lesions

Shock (peripheral circulatory failure)

- Shock is a life threatening condition occurs when body organs are not getting sufficient blood flow (hypoperfusion) as a result of peripheral circulatory failure
- Haemorrhagic shock develops when loss of blood is more than 25 % and it is treated by whole blood administration
- Metabolic change which occur very frequently is hypoxia
- Adrenaline is recommended only in anaphylactic shock @ 0.1-0.2 mg/kg IV
- Fluid of choice in burn shock is plasma

Suture material

Absorbable (2 type)		Non-absorbable (3 type)		
Natural	**Synthetic**	**Organic**	**Inorganic**	**Synthetic**
Catgut obtained from submucosa of small intestine of a sheep or Serosal layer of bovine intestine	**Polyglycolic acid (Dexon)**	**Cotton** Less tissue reaction than silk	**Gold, silver**	• **Nylon** • Obtained from hexamethylene diamine and adipic acid- closed as triple knot • **Terelene** • Polymerized caprolactum **(Vetafil)**- highly reactive • **Surgilene** • **Polyester fibre (Terylene/Dacron)** • **Polybutester (Novafil)** • **Polypropylene (Prolene)** • **Polyethylene**
Cargile membrane obtained from bovine caecum	**Polyglactin 910 (Vicryl)** glycolic acid and lactic acid in the ratio of 9:1.	**Silk** Obtained from cocoon of silk worm	**Copper, tantalum**	
Kangaroo tendon obtained from tendon of tail of kangaroo	**Polydiaxanone (PDS)** polymer of paradioxanone	**Linen**	**Aluminium**	
Fascia lata obtained from bovine fascia lata	**Polyglyconate (Maxon)**	**Umblical tape**	Vitallium (Stainless steel) Minimal reactive	

		used to tie the umblical cord of new born		(Ticron)
Amniotic membrane	**Polyglecaprone (Monocryl)**	**Dermal suture**		
Collagen prepared from bovine flexor tendon filament				

- Plain Catgut (Type A): Absorbed in about 5 days
- Mild chromic catgut (Type B): Absorbed in about 10 days
- Medium Chromic (Type C): Absorbed in about 20 days- most commonly used
- Extra Chromic (Type D): Absorbed in about 40 days
- **The catgut is available in sizes:**
  7/0 (Finest) < 6/0 < 5/0 < 4/0 < 3/0 < 2/0 < 1/0 < 1 < 2 < **3 (Thickest)**
- Swaged on needles are intended for single use
- Least thrombogenic suture material is polypropylene
- Needle with longitudinal grooves are termed as Ribbed needles

Type of suture	
Appositional suture (for skin, muscles and oesophageal wound)	Eg. Simple continuous, Simple interrupted Lock stitch subcuticular suture and pin suture
Inversion Suture (for hollow organ having serous outer coat) Inversion sutures are effective in preventing leakage	Eg. **Lambert suture** (suture passes through serous and muscular layers but not the mucosal layer) **Czerny suture** (double row of lambert's suture) **Jobert's suture:** It is just like lambert's suture but it penetrates all the layers **Cushing suture:** similar to Lambert's suture but suture line is parallel to the line of incision, whereas it is perpendicular in lambert's suture. It also penetrates the layers except mucous layer. **Connel suture:** It is just Cushing suture but it penetrates all the layers- (abomasal wound)
Eversion suture	used to suture cut end of the vessels
Relaxation suture	Eg. Quill suture, Button suture, Mattress suture Near and far suture Tension suture
Purse String suture (Tobacco pouch suture)	Used to narrow lumen of a hollow organ

- Parker-ker suture technique: ist layer Lambert and 2nd layer Cushing-used to close stump
- Chinese finger trap technique- for fixing thoracostomy tube to thoracic wall

Suture technique	
Interrupted pattern	**Continuous pattern**
Simple (Eg. For skin)	**Simple (Furrier suture)**
Interrupted cruciate/ Cross mattress Eg. Amputated tail and digits	**Lock stitch suture/ Glover's suture/ Blanket suture/ Ford interlocking suture** (Skeletol muscles, diaphragm, oesophagus)
Horizontal mattress	**Schmieden's suture**

Eg. Tail gangrene	(intestinal obstruction)
Vertical mattress Eg. Teat fistula	**Running suture** (speedy closure of long incision)
Quill suture Eg. Prolapse of vagina and uterus	**Purse String suture** (rectal prolapse)
Gambee suture/ Crushing Suture (Intestine anastomosis)	**Connel, cushing, Lambert, Parker-ker suture**
	Shoe-maker stitch/ Cobbler's suture
	Guard suture/ Modified cushing

Suture pattern for special purpose

Condition	Suture pattern	Suture Material
Tenorrhaphy/ Tenostomosis/ Tendon repair-	• Locking loop/ Kessler pattern • Bunnell Mayer's technique	
Herniorrhaphy/ hernia ring repair	Vest over pant/ Overlapping suture/ Mayo mattress	Vetafil
Blood vessels repair	Simple continuous	Polypropylene
Urinary bladder repair	Bell suture	Synthetic absorbable
Vaginal prolapse	Shoe-lace; Buhner suture; Modified quill suture	Umbilical tape
Rectal prolapse	Purse string suture	Silk, nylon

STERILIZATION

Physical sterilization				Chemical sterilization
Thermal		Filtration	Radiation	Ethyl alcohol (70%)
				Isopropyl alcohol (90%)
Steam sterilization	Dry heat sterilization	sterilize heat labile solutions	X-rays, Ionizing radiation, Beta rays	Formaldehyde (40% formalin)
				Beta-propiolactone
Autoclave (121 ^{0}C for 15 min at 15 lbs pressure)- most commonly used method. Surgical instrument are sterilized by this method	Eg. Hot air oven (160 ^{0}C for 60 minutes) suitable for oils, powders, glass surgicals			Ethylene oxide: Sharp edged instruments- Scalpel blades, hypodermic needles

Anaesthesia stages (4 stages)

- **Stage I**/Stage of Voluntary excitement/ Stage of Analgesia & amnesia
- **Stage II**/Stage of involuntary excitement/ Stage of delirium/ Stage of un-inhibited action
- **Stage II**/Stage of surgical anaesthesia: is divided into 4 planes-
  - Plane I: light surgical anaesthesia- eye ball fixed and loss of palpebral reflex
  - Plane II: moderate surgical anaesthesia- loss of corneal and laryngeal reflex
  - Plane III: Deep surgical anaesthesia-pupil dilate and loss of light reflex
  - Plane IV: Excessive surgical anaesthesia- intercoastal paralysis, shallow abdominal breathing
- **StageIV**/Stage of medullary paralysis/ death/ Overdose stage- characterized by fish eye appearance (dilatation of pupil)

- Methoxyflurane, halothane, barbiturates **by pass II stage**
- Alpha-chlorase, Isoflurane, Enflurane **by pass II & III stage**
- Ketamine, N2O, Trichloroethylene **by pass III & IV stage**
- pedal reflex is abolished in stage III anaesthesia.
- PALPEBRAL REFLEX is abolished in the light plane of anaesthesia in dogs
- Palpebral reflex & corneal reflex, Laryngeal reflex is not abolished during ketamine anaesthesia
- Absence of corneal reflex indicates deep plane of anaesthesia in horses
- Dogs under light plane of anaesthesia yawn when the mouth is opened.
- Swallowing reflex is protected in ketamine anaesthesia.
- Anal reflex is abolished in the middle of III stage of anaesthesia in dogs and cats
- Atropine induces pupillary dilatation and narcotics induce constriction in dogs.
- In horses under halothane anaesthesia nystagmus is common during light plane of anaesthesia and it is centrally placed at the surgical plane of anaesthesia.
- Hearing sense is the last sense to disappear during induction and the first sense to reappear during recovery.

Classification of Pre-anaesthetics (4 type)

Anticholinergics	**Tranquilizers (2 type)**		**Sedatives (2 type)**		**Neuroleptics (Tranquilizer + Analgesic)**
Atropine sulphate	Major tranquilizer Minor tranquilizer **(Benzodiazopene eg. Diazepam)**		**Opioids**	**Non-opioids**	Fentanyl citrate + Droperidol **(INNOVAR-VET)**
Glycopyrrolate	**Major tranquilizer (2 type)**		Morphine	**Xylazine**	Atropine sulphate + Methadone + Promazine **(Lytic cocktail)**
Scopolamine	**Phenothiazine derivatives**	**Butyrophenone derivatives**	Codeine	Romifidine	Etorphine + Acepromazine **(Immovilon large animal)**
	Acepromazine	**Droperidol**	Meperidine	Medetomidine	Etorphine + Methotrimeprazine **(Immovilon Small animal)**
	Chlorpromazine	Haloperidol	Fentanyl	Dexmedetomid-ine	
	Triflupromazine	**Azoperone**	**Etorphine**	Detomidine	
	methotrimeprazine	Lenperone			
	Promethazine				

Important points

Atropine sulphate	• prevent bradycardia (main function), Reduces secretion, • Dose rate: Dog and horse @ 0.02 – 0.05 mg/kg (I/M or S/C) • Cat @ 0.02 – 0.1 mg/kg (S/C or IV)

	• Large dose of atropine may cause dilatation of cutaneous vessels (Atropine flush) • Antidote: Neostigmine or Physostigmine
Glycopyrrolate	Does not cross blood brain barrier It cannot control excessive salivation Dose rate- dog @ 0.01 mg/kg B.wt
Diazepam (Solvent- Polypropylene glycol)	Ideal drug for cardiovascular compromised patient as it binds with GABA receptors Excellent for patient of CNS disorder Contraindicated in glaucoma Dose rate: Dog: 0.1 – 0.5 mg/kg I/V ;0.3 – 0.5 mg/kg I/M Cat: 0.05 – 0.4 mg/kg I/V; 0.3 – 1.0 mg/kg I/M **Antidote: Flumazenil**
Xylazine	• Sedative effect last for 1-2 hour and analgesic effect for 15-20 minutes • Induces hyperglycaemia in dog and cats & Bradycardia and regurgitation in ruminants • Induces A-V block • Bradycardia, decreased cardiac output, hypotension and increase in central venous pressure are seen • Contraindicated in branchycephalic breeds, older dogs and in intestinal obstruction **Antagonist: Yohimbine, 4-Aminopyridine** Dose rate of Xylazine- Dog: 0.5 -1 mg/kg B.wt. (I/V); 1-2 mg/kg (I/M) Cat: 1-2 mg/kg (I/M) Bovine: one-tenth of dog (0.05-0.1 mg/kg- I/V) Horse: 1.1 mg/kg (I/V)
Fentanyl	250 time more potent than morphine and 500 time more than meperidine
Carfentanyl	11000-18000 times more potent than morphine & named as **Superfentanyl**
Etorphine Hcl (M-99)	Used for restraining wild animals & 1000 times more potent than morphine **Antagonist: Nalorphine, Diprenorphine**
Medetomidine	10 time more potent than Xylazine & 6 time more than detomidine **Antagonist: Idozoxan, Doxapram, Tolazoline**

- Acepromazine causes hypotension in normal doses
- Acepromazine, Diazepam, Isoflurane passes placental barrier
- Routine use of atropine in horse is avoided as it causes colic
- Priapism- permanent penile protrusion may occur after administration of phenothiazine derivatives
- Phenothiazine derivatives can be used as anti-motion sickness drug
- Phenothiazine derivatives should not be used before slaughter of feed lot cattle
- Use of catecholamines is contraindicated in animals pre-treated with phenothiazine or butyrophenone derivatives as it causes hypotension
- Phenothiazines is contraindicated in animals undergoing epidural, spinal or segmental anaesthesia.
- Azoperone is widely used in pigs for control and transportation
- Diazepam is used as an effective appetite stimulant in dogs and cats at dose of 0.05-0.40 mg/kg Oral or I/M.
- Chloral hydrate is used as a reliable sedative hypnotic in cattle and horses
- Morphine causes maniacal excitement in cat

General anaesthesia (2 type)	
Inhalant anaesthesia	**Injectable anaesthesia**
Eg. Volatile and Gaseous anesthesia	Eg. Barbiturates, dissociative anaesthesia, Imidazole derivatives, Alkyl phenol derivatives, Steroids,

Inhalant anaesthesia	
Volatile anaesthesia	**Gaseous anaesthesia**
Ether (Concentration: 3.5 % - 4.5% & MAC- 1.92%)	N_2O
Methoxyflurane (Concentration: 0.4 % - 1 %)	Cyclopropane
Enflurane	CO2
Sevoflurane (Halogenated ether)	Ethylene
Halothane (Induction dose: 2-4% & Surgical: 0.8-1.2%) MAC in dog: 0.86%	
Isoflurane (Fluorinated ether)	
Desflurane- least potent inhalant anaesthetics	

Isoflurane (pungent odour)	• It is non-inflammable and does not react with metal, rubber or soda lime. • It donot decomposes, if exposed to ultra violet light • It does not require any preservative • it is recommended in patients with cardiac diseases (least cardiotoxic effects), liver diseases, head injuries.

- Ether is stored in sealed metal container coated with copper
- Depth of anaesthesia is better controlled with gaseous anaesthetics
- Methoxyflurane potentiate the action of curariform drugs. It is not used in renal diseases.
- Halothane is 4 time more potent than diethyl ether. Salivary mucous and bronchial secretion is absent during anaesthesia. In liquid, it is stabilized by 0.1% thymol and stored in colour glass bottle. Halothane is preferred over Methoxyflurane in equines. Halothane is teratogenic and mutagenic.
- Sevoflurane should be used in precision vapouriser and out of circuit vapourizer
- **Order of potency**
  Methoxyflurane (0.23%) > Chloroform (0.77%) > Halothane (1.20%) > Ether (3%)
- Low blood gas partition coefficient determines rapid induction and recovery of inhalant anaesthetics
- Malignant hyperthermia: severe reaction to certain drugs used for anaesthesia (volatile anaesthetic gases or depolarising muscle relaxants- succinyl choline) and is characterized by high body temperature, rapid heart rate. It is treated by dantrolene @ 2.5-10mg/kg B.wt (IV)

Injectable anaesthesia					
Barbiturates (Poor analgesics)	**Dissociative anaesthesia**	**Imidazole derivatives**	**Alkyl phenol derivatives**	**Steroids**	**Miscellaneous agent**
Ultra-short acting: 0.5 hr Thiopental Methohexitone Thiamylal **Short acting:** Secobarbital Pentobarbital (Nembutal)	Ketamine	**Metomidate** (mainly used in pigs and birds)	Propofol	Althesin (saffon)	Chloral hydrate
	Phencyclidine	Etomidate			Chloral hydrate + MgSO4 (Dank's formulation)
	Tiletamine				Chloral hydrate + MgSO4 + Pentobarbital Na (Equithesin)

Intermediate acting: 4-8 hr Hexobarbital Long acting: Phenobarbital (Luminal)					

	Important points
Thiopental 1-5%- dog/cat 5-10%- cattle/Horse	• Most popular in barbiturates. Contraindicated in neonate felines • Dose: 10-15 mg/kg (I/V) with pre-anaesthetics • It should not be injected S/C or I/M • It should be stored at 4-6 ^{0}C in refrigerator • Crosses blood brain barrier • Provide sufficient muscle relaxation for minor surgery • Donot cause prolong decrease in gastro-intestinal motility • Recovery is due to distribution
Pentobarbital	• Dose: Dogs & cats 20 - 30 mg/kg without premedication & 10 - 20 mg/kg with premedication. For continuous infusion an initial loading dose of 2- 5 mg/kg is given followed by 1-2 mg/kg/hr. • Preparation containing 240 mg/ml of pentobarbital is used for euthanasia of animals at the rate of 48 mg/kg (1 ml/5kg) & this solution is often used to castrate large boars
Phenobarbital	• Starting anticonvulsant dose rate @ 2-4 mg/kg oral BID
Ketamine	• **Wide margin of safety** • **Metabolism in liver** • **poor muscle relaxants,** produce catalepsy, inhibitor of GABA, contraindicated in epilepsy, induces copious salivation and lacrimation, induces hyperglycaemia. Classical stress leukogram; leucocytosis with lymphopenia and neutrophilia can be observed following ketamine administration. • Persistence of reflexes like swallowing, pharyngeal, palpebral and corneal • Contraindicated in patients with increased intracranial pressure and not recommended for intraocular surgery • Tiletamine is 2-3 times potent than ketamine. • Dose: Dog: 2.5-10 mg/kg (I/M or I/V) • Cat: 5-20 mg/kg (I/M or I/V) • Equine: 2.2 mg/kg (I/V) • Pig: 6 mg/kg (I/V) • **Antidote: Physostigmine & mixture of Yohimbine + 4-aminopyridine**
Propofol	**Chemically: (2-6 diisoprophylphenol)** • Propofol induce rapid loss of unconsciousness in 20 to 40 seconds after I/V administration due to its lipophilic nature. • Propofol does not affect hepatic and renal function • It crosses the blood-brain barrier • It is a safe anaesthetic in brachycephalic breeds of dogs. • Dose: Dog and cat: 5-6 mg/kg I/V • Continuous infusion rate: 0.22-0.44 mg/kg/hour (I/V)
Saffan	Combination of alphaxalone and alphadolone is marketed as Saffan (in veterinary) and Althesin (in human).

Local anaesthetics (LA)		
Potency & duration	**Local anaesthetics & duration of Action**	**Derivative (Ester/ Amide)**
Low potency; short duration	Chlorprocaine (30-60 minute) Procaine (60-90 minute)	Ester- derived from benzoic acid and biotransformation by hydrolysis
Intermediate potency & duration	Lidocaine (90-120 minute) Proparacaine (120-240 minute) Mepivacaine (120-240 minute)	Amide- derived from aniline and biotransformation by liver microsomal enzymes
High potency; long duration	Etidocaine (180-600 minute) Tetracaine (180-600 minute) Bupivacaine (180-600 minute) (most potent)	Ester
Lidocaine	• combined with thiopentone due to its dysrhythmic property and protective action on myocardium • The convulsive dose is 15 mg/kg in cat • Goat is extremely sensitive to lidocaine (The total dose should never be exceeded 10 mg/kg in any route) • Lignocaine 4% and proxymethacaine 5% used as topical anaesthetics for eye, also used to lubricate catheters and endotracheal tubes	
• For quick absorption and action of LA, a vasoconstrictor (Adrenaline) is added and for distribution/ diffusion, Hyaluronidase is added. • Renal excretion is main route of LA • Mepivacaine is only used in equines • Retrograde-regional anaesthesia is contraindicated in equines • Cocaine is obtained from the leaves of *Erythroxylon coca* • Bier block (Intravenous Regional (local) Anesthesia-IVRA)- safe and cost effective method to provide short term anesthesia and analgesia during extremity surgery • Toxicity of local anaesthetics can be treated by short or ultrashort acting barbiturates		

Muscle relaxants		
Depolarising agent/ Non-competitive agent/ Pachycurare Rapid action but not reversed	**Non-Depolarising agent/ Competitive agent** Slow action but reversed by anticholinesterase	**Miscellaneous agent**
Decamethonium	d-tubocurarine	Baclofen
Suxamethonium (Succinyl choline)	Ropacuranium	Guafensin
	Gallamine	Miphenesin
	Atracurium	Dantrolene
• All muscle relaxants produce their effect on neuromuscular junction but Mephenesin & Guafenesin act upon synapses in spinal cord • Muscle relaxants have narrow margin of safety, do not cross placental barrier and do not have analgesic property • **Doxapram test:** Injection of 2mg/kg of doxapram in apneatic patient evokes marked respiratory response indicate that cause of apnoea is central depression and caused by general anaesthesia while there is no marked respiratory response will indicate that cause of apnoea is peripheral neuromuscular blockade and caused by muscle relaxant		

NERVE BLOCK

Nerve block	Purpose
Cornual nerve block	To desensitize the horn
➢ Amputation of horn is goat is done by blocking cornual nerve and infratrochlear nerve	
Infra orbital nerve block	To desensitize skin of lip, face of the side up to level of foramen Removal of polyp and extraction of teeth
Supra orbital nerve block	For surgical affection **above the upper eyelid** Dogs do not have supra orbital foramen.
Mandibular nerve block	For surgical affection of mandible, incisor, molar teeth, suturing wounds of lower lip
Auriculopalpebral nerve block	For surgical affection of **eyelids** and normal eye examination
Retro-bulbar nerve block	For surgical affection of **eye ball**, nictitating membrane
Paravertebral nerve block	For laparotomy, rumenotomy, caesarean section, TRP
Internal pudendal nerve block	For surgical affections of **penis**
Radial nerve block	Reduction of fractures and dislocation below the elbow joint
Brachial plexus nerve block	Surgical affections & amputation of digits and limbs
Proximal Paravertebral nerve block	Also known as Farquharson/Hall/Cambridge technique Site: L1, L2 & L3 Desensitize: T13, L1 and L2 spinal nerves
Distal paravertebral nerve block (Magda method)	Also known as Cakala or Cornell method Site: L1, L2 & L4 Desensitize T13, L1 and L2 spinal nerves

Epidural anaesthesia

Bovine: Sacro-coccygeal junction, between I & II coccygeal vertebrae
Equine: Between I & II coccygeal vertebrae
Canine, swine, sheep, goat: Lumbosacral space

Anterior epidural anaesthesia	Caudal epidural anaesthesia
Gastrotomy, cystotomy, affections of mammary gland, caesarean section, enterotomy, phimosis, nephrotomy, castration	Atresia ani, Atresia recti, Perineal fistula, Anal tumor, Prevention of straining, prolapsed rectum, vagina, uterus

Radiography

- X-rays are electromagnetic radiation of extremely short wavelength and high frequency used to produce images of internal tissues, bones, and organs on film or digital media.
- Substances through which X-rays can pass are termed as radiotransparent while through which X-rays can't pass are termed as radiopaque
- Cathode: consists of tungsten filament which act as source of electrons. Tungsten is preferred because of its high melting point (3370 ^{0}C) and high atomic number
- A printed X-ray picture is termed as Skiagram.
- Father of veterinary radiology- R. Eberlein
- X-rays were discovered by Roentgen in 1895
- Detail is the degree of definitions of an object on a radiograph.
- Radiographic density is determined by the amount of light absorbed by an exposed x-ray film and is a measure of the degree of blackness of the film.
- Contrast is the difference between blacks, grays and whites
- Collimator is used to decide field of radiation
- Bucky invented grid is used when thickness of part is more than 10 cm
- Scattering of X-rays from tube is prevented by lead outer cover
- R. Eberlin was the first to use radiotherapy in veterinary practice for localised solid neoplasm that cannot be excised. In animals, it is usually in 10-12 fractions of a radiation dose of 4-5 Gy each time, usually three times per week.

- Methods: Teletherapy: The radiation source is kept at a distance from the lesion
- Brachytherapy: It is the therapeutic use of radioisotope either within the interstitium or on the surface of a neoplasm

Factors affecting radiograph:

- **Kilovoltage or kilovoltage potential (kV or kVp):**
  - Quality of x-rays produced depend on kilovoltage.
  - High kVp produces X-rays of shorter wavelength with higher penetration power
  - Wavelength of X-rays is inversely proportional to kilovoltage and penetration power
  - **Miliampere (mA)**: mA is directly proportional to square of FFD
- **Exposure time**
- **Focal film distance (FFD)**- recommended is 90-100 cm
- **Part film distance (generally constant)**
- **Thickness of tissue**

Characteristics images

- **Osteosarcoma:** Fir tree/Moth eaten/Sun burst appearance/Spiculated hair-on-end appearance/onion peel appearance
- **Intussusceptions:**
  - Sausage shaped mass with increased density.
  - Thin layer of gas outlining the layers of intussusceptions
  - Barium enema- 'coiled watch spring' pattern
- Double bubble appearance: GDV in dogs

Solutions used for processing X-ray film

Developer	Rinser	Fixer
Reducing agent- Hydroquinone or metol Activator- Sodium carbonate Restrainer- Potassium bromide Preservative-Sodium sulphite Solvent-water	Glacial acetic acid & water	Fixing agent- sodium or ammonium thiosulphate Acidifier- Acetic acid or sulphuric acid Hardner-Ammonium chloride or Ammonium sulphide Preservative-Sodium sulphite Solvent -water

Ultrasonography

- Sound waves of frequencies greater than audible to the human ear i.e greater than 20- 20,000 Hz. is called Ultrasound waves. Diagnostic ultrasound uses frequencies between 1 to 10 MHz
- Dog- 3-3.5 MHz frequencies mainly used
- When elements are located at the end of the probe they are called end fire transducers and they are used in abdominal and cardiac scanning
- Side fire transducers are used for intra-cavity scanning like large animal reproductive scanning

Doppler ultrasonography

Doppler ultrasound: Reflected sound waves are used to observe how blood flows through a blood vessel. Four Doppler modes are used in ultrasonography namely Continuous wave Doppler, Pulsed wave Doppler, Colour Doppler and Power Doppler

- **Bedside/continuous wave Doppler:** This type uses the change in pitch of the sound waves to provide information about blood flow through a blood vessel.
- **Duplex Doppler:** converts the Doppler sounds into a graph that gives information about the speed and direction of blood flow through the blood vessel
- **Colour Doppler:** converts the Doppler sounds into colours that are overlaid on the image of the blood vessel
- **Power Doppler** (special type of colour Doppler) is used to evaluate blood flow through vessels within solid organs.

Digital radiography: It involves translating x-ray energy into an electric signal that is in turn converted to digital data (numbers) and X-ray image is available for viewing almost immediately after exposure.

Computed tomography: Very thin beam of x-ray passes through body in a cross-sectional manner

Magnetic Resonance Imaging (MRI): MRI uses hydrogen atoms to generate an image. Hydrogen is universally distributed in the body, principally in water molecules (no ionizing radiations are used)

Scintigraphy: used in **Nuclear medicine:** radioisotopes (radiopharmaceuticals) are taken internally, and the emitted radiation is captured by external detectors (gamma cameras) to form two dimensional images.Most widely used radioisotope is Technetium-99m.

CONTRAST RADIOGRAPHY

<table>
<tr><th colspan="6">Positive Contrast Radiography-high atomic weight (radiopaque)</th><th rowspan="2">Negative Contrast Radiography (Radiolucent) Low atomic weight</th></tr>
<tr><td>Barium sulphate</td><td colspan="2">Water soluble iodine preparation LOCM- Low Osmolar Contrast Media (FOR ANGIOGRAPHY)</td><td colspan="2">Cholecystopaques</td><td>Viscous & oily preparation- used to demonstrate bronchial tree and the uterus</td></tr>
<tr><td>(6-12 mg/kg-given orally and X-ray . taken after sometime)</td><td>Ionic preparation</td><td>Non-ionic preparation</td><td>Oral</td><td>I/V</td><td>Viscous- Propyledene
Oily- Iodinized ion & Iophindylate</td><td rowspan="5">CO_2
O_2
N_2O
Atmospheric air
Indications:
• Orthography
• Fasciography
• Pneumoperi -toneography
• Pneumo- -cystography</td></tr>
<tr><td>Oesophagus & stomach-immediately</td><td>Meglumine iothalmate (Conray-280)</td><td>Metrizamide (Amipaque)</td><td>Sodium iopadate</td><td>Meglumine</td><td rowspan="4">Indication-
Lymphangiography
Dacrocystorhinography
Hysterosalpingography
Myography</td></tr>
<tr><td>Reticulum-after 30 minute</td><td>Sodium iothalmate (Conray-420)</td><td>Iopamidol (Niopam)</td><td>Iopanoic acid</td><td>Ioglycamate</td></tr>
<tr><td>Colon- 3 hour</td><td>Meglumine diatrizoate (Urografin-150)</td><td>Iohexol (Omnipaque)</td><td></td><td>Iotroxate</td></tr>
<tr><td>Rectum- 5 hour</td><td>Sodium diatrizoate (Urografin-370)</td><td></td><td></td><td></td></tr>
</table>

Chapter-22

Regional Surgery and Lameness

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Important operation/test and purpose	
Operation name	**Purpose**
Cotton ball test	used to access eye sight in dogs
Vinsot's operation	Amputation of penis to remove diseases part
Grid iron technique	Separation of muscles/ for removal of ovary
Hyovertebrotomy White House technique	Empyema of guttural pouch
Hellers' myotomy	Stricture of lower oesophageal sphincter
Staphylectomy	Resection of posterior soft palate to open airway mainly in brachycephalic dogs
Zepp's operation (Lateral/Vertical ear canal Resection)	Ootitis externa
Lateral Bulla osteotomy with Total ear canal ablation & myringotomy	Ootitis media
Boccar's operation	Stringhalt
Perrier's operation	Quittor
Ascheim operation	Bowed tendon
Formstone operation	Ottorhoea
Flexor tendon tenotomy	Knuckling
Cherry's operation	Broken knee or open knee
Campbells' test	Assess integrity of collateral ligament of elbow in dogs
Paatsama's operation	Rupture of anterior cruciate ligament
Hemilaminectomy	Intervertebral disc protrusion
Forssell's operation	Recto-vaginal fistula
Omentalization/Marsupialization	Pyometra
Vander Kay's operation	Chronic gastric tympany in ox
Vennerhalm's operation	Removal of integument of penis
Moussu's method & Gold's method	Teat fistula
Hugs teat tumor extractor	Teat tumor/polyp
Stenson operation/Hudson operation	Stricture or blocked teat by Hudson teat spiral instrument
Litchy teat knife	To enlarge teat canal/remove growth inside canal
Larson teat tube	Maintain milk flow for sore, injuredand hard-to-milk teats
Teat slitter	Used for closed tear surgery
Smith operation	Contracted hoof
Hobday's operation	Roaring in horse (paralysis of left recurrent laryngeal nerve)
Cunean tenectomy	Bone spavin
Mule's operation	Prevention of blow fly strike
Whipple's operation	Vaginal prolapse in bitch
Caslick operation	Pneumovagina in horse (vaginal wind sucking)
Colopexy	Recurrent rectal prolapse
Enteroplication	Intussusception

Staphylorraphy & Uranoplasty	Cleft palate
Utrecht method	Left flank omentopexy
Internal obturator flap technique	Perineal hernia
Neoureterostomy	Intramural ectopic ureters
Ureteroneocystostomy	Extraluminal ectopic ureters

Oesophageal obstruction- cattle (cervical region-trumpet shape); Horse (Thoracic region -Funnel shape); Canines (at thoracic inlet)

Ventral midline celiotomy: Pyloromyotomy, Pyloroplasty, Billroth I (Gastroduodenostomy) & Billroth II (Gastrojejunostomy) for pyloric stenosis

- **Pyloromyotomy** Eg. Fredet-Ramstedt pyloromyotomy
- **Pyloroplasty:** Heineke-Mikulicz pyloroplasty (transverse pyloroplasty), Y-U Advancement Pyloroplasty
- **Billroth I**-removal of the pylorus (pylorectomy) & attachment of the stomach to the duodenum (gastroduodenostomy)
- **Billroth II-** attachment of the jejunum to the stomach (gastrojejunostomy) after a partial gastrectomy (including pylorectomy)

Incision	Condition
Triangular shape incision	Phimosis
Front occiput incision	Poll evil
Criss cross incision	Atresia ani
Circumscribe incision	Preputial prolapse
Multi stab incision	Rupture of urethra
Semilunar incision	Diaphragmatic hernia
Skin incision for laparotomy (Site)	
• **Flank incision**	
✓ **Right flank incision**	Intestinal obstruction, Nephrotomy
• **Left flank incision**	
✓ **Parallel to last rib**	Traumatic reticulitis
✓ **Mid lower flank**	Abomasopexy
✓ **Post flank**	For surgical correction of urinary bladder
• **Paramedian incision**	
✓ **Cranial paramedian**	
✓ **Lateral caudal paramedian**	Caesarean section
Post xiphoid incision	Diaphragmatic hernia **(Shape- semilunar incision)**

Gastric dialatation and volvulus: Enlargement of stomach associated with rotation on its mesenteric axis and treated by Belt Loop Gastropexy

Pyloric stenosis –muscular hypertrophy of the pylorus and characterized by vomiting. Two type-

- **Chronic antral mucosal hypertrophy**
- **Chronic hypertrophic pyloric gastropathy:** Most commonly seen in brachycephalic breeds (Boxers, Bulldogs, & Boston terriers)

Intussusception or Invagination of the bowel: telescoping of proximal intestinal segment (intussusceptum) into the lumen of the distal segment (intussucipiens)

Uroabdomen (Uroperitoneum): accumulation of urine in the peritoneal cavity due to rupture of bladder

Cystorrhaphy: Cushing followed by Lembert suture

Cystotomy in cattle: Site-Pre-pubic site along linea alba- young animals

- **Oblique flank incision**

Indications of urethrotomy: used to remove urethral calculi
Bull: Post scrotal site, Ischial site & Ventral approach.
Horse: The median line of perineal region below the level of ischial arch.
Sheep & goat: The urethral calculi in rams and wethers are mostly lodged in the urethral process or in the sigmoid flexure.
Operation technique in dog: Pre-scrotal urethrotomy & Perineal urethrotomy

Castration

Cattle, sheep and goats are usually castrated by the closed method using Burdizzo castrator
Castration of horses is performed under general anaesthesia by the open-covered method.
Techniques:

- Closed method: Parietal layer of tunica vaginalis is never opened before trans-fixation ligature.
- Open method: Parietal layer of tunica vaginalis is incised before emasculation of spermatic cord.
- Half closed

Surgical affection of eye

Cherry eye	Congenital disorder of nictating membrane, common in Napolian mastiff
Pannus	Ingrowth of blood vessels into cornea
Chemosis	Extreme oedomatous condition of conjunctiva
Immatropia	Correct image formation at retina
Hypermetropia	Farsightedness- image formation beyond retina
Aquous flare	Turbidity of aquous humor increases by increased protein level and cells
Cataract	Complete or partial opacity of lens
Anopthalmia	Complete absence of eye ball
Cryptopthamia	Incomplete development of eye ball
Cyclopia	Only one eye is present on mid-line of head
Chalazion	**Tarsal cyst:** pea size distension of tarsal gland
Hordeolum	**Stye:** Inflammation of hair follicle of the eye lashes
Dacroadenitis	Inflammation of lacrymal gland
Dacrocystitis	Inflammation of lacrimal sac
Entropian	Elliptical piece of skin from lower eyelid
Ectropian	V-Y plasty- Removal of triangular piece from lower eye
Distichiasis	Double eyelashes
Trichiasis	Eye lashes are slightly inverted irritating the cornea and conjunctiva
Ptosis	Dropping of upper eyelid as a result of auriculopalpebral nerve paralysis
Coloboma	Failure of closure of embryonic ocular cleft (cleft in iris)
Lagopthalmus	Incomplete closure of eye-lid
Staphyloma	Abnormal protrusion of uveal tissue through weak point in the eye ball mainly as a result of corneal ulcer
Buphthalamus	Bulging of eye ball due to excessive fluid in anterior chamber
Exopthalamus	**Proptosis:** Abnormal protrusion of eye ball
Endopthalamus	Pig eye: Abnormal retraction of eye ball into the orbit
Hyphema	Haemorrhage in anterior chamber
Hypopion	Pus in anterior chamber
Hydropthalamus	Bulging of eye ball associated with increased amount of aquous humor
Megalopthalamus	Congenital Bulging of eye ball without increase in amount of aquous humor
Keratoglobus	Protrusion of cornea into a globular enlargement
Keratoconus	Protrusion of cornea into a conical enlargement
Strabismus	Squint: abnormal deviation of portion of eye ball
Nystagmus	Involuntary movement of eye ball
Glaucoma	Increase in intra-ocular pressure

Trachoma	Small follicular enlargement on conjunctiva
Epiphora	Excessive flow of tear
Symblepheron	Bulbar conjunctiva is adherent to palpebral conjunctiva
Ankyloblepheron	Adhesion of eyelid
Pterygium	Growth of conjunctiva toward cornea
Dermoid cyst	Teratoma: Skin & hair growth at limbus
Horner syndrome	Set of ocular sign due to sympathetic deinnervation
Panopthalmia	Accumulation of septic pus in eye ball
Chemosis	Extensive oedema of conjunctiva
Anterior synechia	Attachment of the iris to the cornea is called anterior synechia.
Posterior synechia	Attachment of the iris to the lens is called posterior synechia.

- Opacity of lens (3 type):
  - ✓ Nebula- least dense opacity
  - ✓ Macula- Moderate dense opacity
  - ✓ Leucoma- complete dense opacity (Milky white)
- Enucleation- eye ball is removed
- Extirpation- eyeball + orbital fat + extra ocular muscle is removed
- Bridge type, Apron Type and Key hole type keratoplasty is used in treatment of corneal ulcer
- Luxation of lens- displacement of lens from normal position
- Senile cataract is common in veterinary practice
- Posterior rectus or Retractor oculi- absent in man
- Periodic opthalmia/ moon blindness/ Recurrent opthalmia: Periodic ophthalamia of horses is characterized initially by repeated attacks of iridocyclitis.

- **Smooth tongue:** The horny papillae on the dorsum of the tongue will be either small or absent. Condition is more common in Brown Swiss and Holstien Fresien
- Quidding: horse appear similar to camel (nostril constricted in muzzle region)
- Gangrene of tongue is common sequel of canine distemper
- Most common salivary gland tumour is adenocarcinoma
- **Atheroma/cyst:** sebaceous cyst that mostly occurs in the false nostril in the horse
- **Ranula-** salivary cyst mostly occurs in dogs, forms in mouth under tongue involving sublingual salivary gland
- **Guttural pouch tympany**: accumulation of air in guttural pouch characterized by an external swelling in the parotid region. Common in young foals and usually unilateral
- **Guttural pouch empyema:** accumulation of pus in guttural pouch, characterised by nasal diascharge, painful distention in the parotid region, swelling of the submaxillary lymphatic glands, a rattling noise in the pouch during exercise. Inspissation of the material occur in chronic infection, forming masses termed as chondroids
- **Dental tartar:** brown or yellow deposit accumulation in the teeth, very common in dogs and cats. It predisposes to gingivitis and alveolar periostitis.
- **Alveolar periostitis:** Inflammation of the alveolar periosteum. Ttwo types-
- Chronic ossifying alveolar periostitis: common in horses and cattle.
- Purulent alveolar periostitis: commonly in carnivores
- Overlapping Molars are also termed as Shears mouth
- **Wave-formed mouth:** Tables of the teeth are irregular, mainly 4th cheek teeth is affected
- **Parrot Mouth/Brachygnathism:** upper jaw is much longer than lower jaw, the upper incisors overhang the lower ones, common in Dachshund and Collies
- **Hypognathism (prognathism / pig mouth / sow mouth):** lower jaw is longer than upper jaw, common in brachycephalic breeds

- **Dental fistula**: root of a tooth opens outside. Alveolar periostitis and caries of the tooth are the main causes. Dental fistula mainly affects 4th upper cheek tooth in dog as a result of alveolar periostitis commonly known as **pus in the antrum**
- **Odontoma:** tumour composed of tooth tissue originating from odontoblast
- **Ameloblastoma/Adamantinoma**: arising from odontogenic epithelial remnants
- **Pollevil:** necrosis of ligamentum nuchae and dorsal arch of the atlas characterized by painful and lobulated Inflammatory swelling, purulent discharge, Head is kept abnormally high due to pain
- **Yoke gall and saddle gall:** Localized acute inflammation of the skin and subcutis on the neck due to injury caused by friction (rubbing) of the yoke in cattle or saddle in horses.
- **Sit fast:** dry gangrene caused by the presence of collar on top of neck of horse

Classification of Fracture

On basis of connectivity with environment

Simple fracture (closed fracture) No wound on skin	**compound fracture (open fracture)** Communication with an open wound on skin

On basis of extent of fracture line

Incomplete fracture	Complete fracture
• **Green stick fracture-** bone is broken like bent green stick, seen in young animals • **Fissured fracture-** fissure extend through bone • **Deferred fracture-** separation of fragments occur after a period • **Splintered fracture-** splinter of bone is separated from main bone	• **Single fracture-** bone is broken in one place only • **Double fracture-** two fracture in same bone • **Multiple/Comminuted fracture-** bone is broken into more than 2 pieces. • **Avulsion fracture-** a part of bone is torned away due to high force

On basis of direction of fracture

Transverse fracture Fracture line is at right angle to axis of bone	**Longitudinal fracture** Fracture in longitudinal direction	**Oblique fracture** Fracture line oblique (faster healing)	**Spiral fracture** Spiral fracture line

On basis of relationship between fragments

Torsion fracture Fragments are twisted and separated	**Impacted fracture** Fragments are driven into another fracture	**Dentate fracture** Fragments are toothed & interlocked	**Riding/overriding fracture** Fragments lie side by side	**Distracted fracture** Fragments are separated by muscular pull

Miscellaneous fracture

- ***Compression fracture-*** by compression force resulting into reduced size of bone
- ***Depressed fracture-*** fragment is depressed below the surface in skull fracture
- ***Colle's fracture-*** fracture of distal end of radius
- ***Pathological fracture-*** weakening of bone by disease resulting in fracture
- ***Montegial fracture-*** fracture in olecranon process of ulna

Methods of fixation of fracture

External fixation	Internal fixation
• **Splints-** used in fracture of lower long bone. Eg. Modified Thomas splint Modified coaptation splint • **Cast:**	• Intramedullary pinning • Wiring • Bone screws (cortical screws are more stronger than cancellous screws) • Trans fixation

✓ **POP**- most commonly used casting material is Plaster of Paris (chemical: CuSO4. 0.5 H2O) ✓ **Fibre glass**- resistant to water, radiolucent but expensive	• Tension band wiring (used for distracted fracture) • Bone plating & Screwing

- Intramedullary pinning- for long bones; method of insertion of IMP
1. Retrograde pinning- pin is inserted through fracture site; most commonly used method in animals
2. Normograde pinning- pin is inserted through upper or lower end of bone
- In sheep, goat, dog, calf- single pin is used while in adult ruminants- multiple pin is used and termed as Stack pinning
- Wiring- used for mandibular fracture while Tension band wiring- for avulsion fracture
- Bone plating and screwing- used to unite broken ends
- DCP is used for diaphyseal fracture

Lameness

Luxation	Displacement of articular surface
Sprain	Injury to ligament
Strain	Injury to tendon
Gonitis	Inflammation of stiffle joint
Laminitis (founder)	Inflammation of sensitive laminae of foot- more common in **fore-foot**
Coxitis	Inflammation of hip joint
Sweeny (shoulder slip)	Paralysis of pre-scapular nerve
Bicipital bursitis	Inflammation of bicipital bursa
Omarthritis	Arthritis of shoulder joint
Carpitis (Popped knee)	Inflammation of carpal joint
Sore shin (buck shin)	Periostitis on anterior aspect of metacarpus or metatarsus of horse
Splints	Typical example of periostitis Exostosis on the splint bones i.e. small metacarpals or small metatarsals
Jack splint (bump)	Large exostosis on the metacarpal bone
Windpuff (Wind gall)	Synovial swelling due to poor nutrition- No lameness
Osselets	New bone formation on distal extremity of metacarpal and proximal extremity of Ist phalanx
Ring bone (phalangeal exostosis)	New bone growth of I, II, III phalanx True ring bone: exostosis at interphalangeal joints False ring bone: exostosis on shaft of phalangeal bone
Side bone	Ossification of collateral cartilage of digital joint (Coffin joint)
Quittor	Purulent Inflammation of collateral cartilage of digital joint (Coffin joint)
Buttress foot (Pyramidal disease)	Inflammation and exostosis of extensor process of III phalanx Normal U-shape of foot changes to V-shape, **more in hindfeet**
Canker	Chronic hypertrophic, moist, dermatitis involving foot characterized by foul smelling exudates- **more common in hind feet**
Seedy toe	Separation of sensitive and insensitive lamina after chronic laminitis
Sand crack	Cracks/fissure on hoof
Thrush	Chronic degenerative condition of frog characterized by black necrotic foetid odour material in lateral sulci of foot
Corn (Bruised sole or bruised frog)	Involvement of **sensitive** and insensitive tissue at angle of wall and bar of hoof due to presence of shoe
Pedal osteitis	Inflammation of III phalanx
Navicular disease (podotrochlosis or podotrochlitis)	Chronic ostitis of navicular bone & bursa characterized by screwing of fore limb while turning- common in light horses- most common cause of chronic forelimb lameness in horses Posterior digital nerve block-used to diagnose navicular disease
Crural paralysis	Femoral nerve paralysis

Bog spavin	Chronic distention of joint capsule of hock joint characterized by swelling	
Bone spavin	Chronic arthritis of hock joint	
Curb	Inflammation of planter ligament over the fibular tarsal bone	
Bucked knee (Goat knee)	Also known as knee sprung or Over in knees Forward deviation of carpal joint	**Abnormal conformation of forelimbs**
Calf knee (Sheep knee)	Backward deviation of carpal joint	
Knocked knee	**(knee narrow/carpus valgus)** Medial deviation of carpal joint	
Bow leg	**(Bandy legged/Carpus varus)** Lateral deviation of carpal joint	
Toe-in	**(Pigeon toed)** lead to paddling	
Toe-out	**(Splay footed)** lead to plaiting	
Thoroughpin	Tenosynovitis of tarsal sheath	
String halt/Springhalt (equine reflex hypertonia)	Involuntary exaggerated upward hyperflexion of one or both of the hind limbs but mostly unilateral- Treated by: peroneal tenotomy (Boccar's operation)	

- Rupture of achilles tendon result in dropped hock
- Rupture of suspensory ligament result in **Broken Down condition in horse**
- Paralysis of pectoral nerve result in outward bowing of limb and inward rotation of digit
- Capped elbow is also termed as shoe boil/hygroma of elbow/olecranon bursitis
- Radial nerve paralysis is common in cattle and horse which is characterized by dropped elbow condition and animal stand with help of knee and fetlock joint
- **Upward fixation of patella:** Impaired patellar function is characterized by jerky movements during flexion to complete immobilization of joints. Since the animal fixes its limb in extension while the patella glides up over the trochlea to its maximum height on the articular surface, this condition called as recurrent or permanent upward fixation of patella
- **Syndactyly (mule foot):** Fusion of digits to a single hoof
- **Polydactyly (polymelia):** Increase in normal number of digit
- **Beak claw: congenital defect** in which dorsal wall of hoof is concave from coronet to toe and the weight bearing borders of the walls are convex from heel to toe. **It is not curable.**
- **Corkscrew claw:** this is an **inherited defect** in which an abnormal hoof with the lesion primarily in the lateral especially of the hindlimb, the horn of which takes the form of a coarse medially turning spiral. Rotation towards axial plane.
- **Scissor feet (crossed toes, slipper foot, straddle claw):** Extensive overgrowth of both claws of a foot with overlapping **seen in chronic laminitis**
- **Inter digital hyperplasia (inter digital fibroma, keloid, papilloma, corn, wart, limax, tylom, bone cyst):** A variable excess of epidermal and hypodermal tissue occupying part or all of the inter digital space especially dorsal. common in HF & Hereford

Cruciate ligament rupture

- Cranial cruciate ligament rupture is more common diagnosed by Drawer sign and tibial compression test. Old dogs of small breeds mainly affected.
- Treated by Extra-articular technique (Pearson technique-capsular imbrication; De Angel's technique- lateral retinacular imbrications) and Intra-articular techniques (Paatsama technique-fasci lata; DickensonNurmaker technique; Deulan technique-Patellar tendon; Arnoczky/Over top technique)

Hip dysplasia: common in large breed dogs

Abnormal development of coxofemoral joint (ball and socket do not fit or develop properly) characterized by joint laxity (positive Ortolani sign), Barlow sign, Barden sign, bunny hopping gait and subsequent degenerative joint disease. Type:

- Cox-magna: head and neck of femur is broad
- Coxa-plana (Legg-Calve-Perthe's disease): flat articular surface
- Coxa valga: angle between head and neck of femur and its shaft increases (knocked knee)
- Coxa vara: angle between head and neck of femur and its shaft decreases (bow leg)

Chapter- 23

Veterinary Gynaecology and Obstetrics

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FEMALE REPRODUCTIVE TRACT

Mesodermal origin- Oviduct, uterus, cervix and cranial vagina
Endodermal origin- germ cells, caudal vagina, vulva, vestibule, urethra and associated gland

Species	Cow	Sheep/goat	Mare	Bitch	Sow
Comparison of reproductive tract					
Oviduct length	25cm	15-20cm	20-30cm		15-30cm
Uterus type	**Bicornuate**	**Bicornuate**	**Bipartite (T-shape)**	**Bicornuate (V-shaped)**	**Bicornuate**
Endometrium	**caruncles**	**caruncles**	**Longitudinal fold**	**absent**	**Longitudinal fold**
Hymen	Ill defined	Well developed	Well developed		Ill defined

- Bitch and queen-uterus lies in abdominal cavity
- Horn length highest in sow
- Body length of uterus and ovary weight is highest in mare

More functional	Right	Right	Left		Left
Comparison of ovary					
Shape	**Almond**	**Almond**	**Kidney**	**Oval/Berry**	**Berry**
Weight(gm)	5-10gm	3-4gm	70-100gm		3-5gm
Mature graffian follicle	1-2	1-4	1-2		10-25
Follicle diameter	12-20mm	5-10mm	25-70mm		8-12mm
Egg diameter(u)	120-160	140-185	120-180		120-170
Corpus luteum shape	**Spheroid**	**Spheroid**	**Pear/ Cauliflower**		**Spheroid**

- Ovary is divided into cortex and medulla but not in mare
- Size of buffalo ovaries are generally smaller than cattle
- Size of sheep and goat ovary is approx. half of cattle ovary

Site of deposition	Mid cervix	cervix	Uterus	cervix	Uterus
Artificial Insemination					
Insemination volume	0.2-1ml	0.005-0.2ml	20-50ml	1.5ml	30-50ml
Insemination time	8-16 hour after onset of estrus	10-24 hour after onset of estrus	Every 2nd day during estrus	10-12 days after onset of pro-estrus	12-30 hour after onset of estrus

- Shape of pelvic cavity:
  - **Elliptical-** Cow, ewe, sow
  - **Round-** Mare
  - **Oval-** Bitch
- Cattle- caruncle arranged in 4 rows
- Fornix vagina: anterior vagina develops into pouch around cervix (Fornix absent in sow and prominent in mare)
- Cervix is screw shape in sow and have annular folds
- Cervical star is found in pregnant mare & cervical canal is more open than other animals
- Cervix in ruminants has annular rings- cattle (3-4 rings & more prominent); buffalo (2 rings)
- Vagina in cattle is more contractile and flaccid than buffalo

Type of uterus:

- **Bipartite:** Uterine septum separate short two horn and uterine body is prominent. Eg. **mare, cat**
- **Bicornuate:** Uterine horns are folded and they are much long in comparison to small uterine body. Eg. **Ruminants, Bitch, sow and birds**
- **Simplex: Higher primates (Human and chimpanzee)** characterized by pear shaped uterine body and absence of uterine horns
- **Duplex: Marsupials, Rodents, Lagomorphs (Rabbit), Guinea pig** characterized by 2 cervical canal & 2 horns

REPRODUCTIVE HORMONES

Organ	Hormones	Functions
Hypothalamus	GnRH (HL: 7-8 minutes	Stimulate release of FSH and LH
	TRH	Stimulate release of TSH and prolactin
	PIF	(prolactin inhibiting factor) Inhibit prolactin release
	Oxytoxin	Stimulate uterine contraction, participate in sperm and egg transport, milk let down
Anterior pituitary	FSH AA-210	Stimulate follicular growth, estrogen secretion Stimulate spermatogenesis (upto 2° spermatocytes) & also act on sertoli cells which result into release of ABP & inhibin Regulate spermiogenesis
	LH (HL-30 minutes) AA- 207	Stimulate ovulation, corpus luteum formation Act on Leydig cells & stimulate secretion of testosterone, estrogen and androgen
	Prolactin	Promote lactation, stimulate corpus luteum formation and progesterone secretion in some species (sheep), promote maternal behaviour, promote tissue and bone growth **Luteotropic in dog, sow, mice, rat**
Placenta	hCG (AA-236)	Maintain corpus luteum of pregnancy in primate
	PMSG (AA-245)	Stimulate formation of accessory corpus luteum in mare
	Protein B	Produced by binucleated cells of trophoblastic ectoderm Help in pregnancy diagnosis
Gonads	Estrogen	Promote female sex behaviour, stimulate secondary sex characters, growth of reproductive tract, Uterine contractions, **mammary duct growth**, Stimulate calcium uptake in bone, control gonadotrophin release by negative feedback **Luteolytic action in cow and sheep but luteotropic in sow**
	Progesterone (HL: 22-35 minutes)	Act synergistic with estrogen in promoting estrus behaviour and preparing reproductive tract for implantation, stimulate **mammary alveolar growth**, control gonadotrophin secretion

		Growth of glandular system of uterus
	Testosterone	Develop and maintain accessory sex glands, stimulate secondary sex characters, sexual behaviour, spermatogenesis Maturation of secondary spermatocytes Testosterone has negative feedback on GnRH, FSH, LH
Uterus	Inhibin	Inhibit FSH release Inhibin is also secreted by sertoli cells having same function
	Relaxin	Dilate cervix
	PGF_2alpha (prostaglandins)	Causes uterine contraction and luteolytic
	• Prostaglandins in secreted by seminal vesicle in male	
Sertoli cells	Production of estrogen, androgen, Androgen Binding protein (ABP), Anti-mullerian hormone	
Pineal gland	Melatonin	Antigonadotrophin hormone
Pheromones (Known as ectohormones)		Ram effect & Boar effect: Pheromones are present in fleece of Ram & in prepuce of Boar & have effect like estrus synchronisation, induction of estrus & seduce sexual response in female

- eCG has LH like activity in mare but has FSH like activity in other species.
- High level of estrogen is found in stallion urine mainly due to estrogen produced by interstitial cell and sertoli cell of testes
- Inhibin has negative feedback on FSH but not on LH
- Testosterone is 16 times more active than androstenedione in bulls

Oestrus cycle

Duration of oestrus cycle varies as per species
Progesterone is organizer of oestrus cycle

Follicular phase		Luteal phase	
Proestrus	**Estrus**	**Metestrus**	**Diestrus**
rise in estrogen produced by developing follicles	Period of sexual receptivity & mating Estrogen is the main hormone for estrus behaviour (sign and symptoms)	It is period from ovulation and formation of corpus luteum	It is longest phase identified by fully functional corpus luteum and high level of progesterone

Symptoms of estrus	
Cows	Clear stringy mucoid discharge hanging from vulva, Oedematous vulva, Standing to be mounted by other cows (most peculiar symptom), bellowing, frequent urination, reduced feed intake, drop in milk yield, tail raising
Buffaloes	Temporary teat engorgement, Similar to cows but not pronounced.
Bitch	Elevate perineum toward male, vulva is soft and flaccid, vaginal discharge is straw coloured or pink
Cat	Lordosis, more vocal than normal (calling), urine spraying, attention seeking behaviour, rolling on floor, treading
Mare	Winking of clitoris, Raising of tail to one side, Oedematous vulva, mucoid discharge, foal heat, split heat
Pig	Grunting and standing immobile with erect ears for long time (immobilization reflex), champing of jaws, lordosis
Sheep and goat	Tail wagging from side and up and down, Oedematous vulva, Clear mucus discharge from vagina, frequent bleating, clear sign is visible in ewe in presence of ram.

- Bitch shows external evidence of Proestrus with vulval oedema, hyperemia and sanguinous vulval discharge, termed as **Proestrus bleeding**
- **Metestrus bleeding** is noticed in some bovines due to estrogen withdrawl

Methods of heat detection	
Sign and symptom of estrus	Described above
Heat detector animals	Animals known as teaser animals (vasectomised bulls)
Heat mount detectors	Tail paint (simplest), paint sticks
Pedometers	Pedometers are sensor placed on front leg of animal (highly efficient and accurate method)
Hormonal estimation	Progesterone (P_4) estimation in milk

- Before puberty, follicular growth is intraovarian
- **Polyestrous**
  - ➢ Seasonal polyestrous- Mare, Doe, ewe, camel
    - ✓ Long day breeders: mare
    - ✓ Short day breeders: doe and ewe
  - ➢ Non-seasonal polyestrous- Cow, sow
- **Monoestrous-** wild animals and bitch
- **Split estrous-** occur in winter, animal shows behavioural estrus twice in which 1st estrus is non-ovulatory and 2nd estrus is ovulatory
- **Mid- cycle estrus-** Animal having fully developed corpus luteum co-existing with palpable ovarian follicle and showing heat symptoms
- Cows with pyomera do not have estrous cycle but with hydrometra have cycle
- Amniotic plagues are absent in pig
- When E_2 level reaches threshold value, they exert positive feedback upon surge centre.
- P_4 release gives negative feedback upon Episodic or tonic centre for less release of gonadotropin (FSH and LH)
- Predominant antibody in follicular fluid is IgG
- Ovulated ovum is secondary oocyte (N) in most species but in mare & bitch, ovum is primary oocyte (2N)
- Tonic centre is controlled by negative feedback of estrogen & progesterone but surge centre is controlled by positive feedback of pre-ovulatory surge of estrogen
- Preovulatory luteinisation of follicle occurs in bitch
- Oogonial mitosis is completed after birth in sow

Oestrus Cycle			
Species	**Duration**	**Estrus length (heat)**	**Time of ovulation**
Cattle/Buffalo	20-21 days	12-24 hour	10-15 hour after end of estrus
Sheep	16-17 days	24-36 hour	12 -14 hour before end of estrus
Goat	17-21 days	30-40 hour	12 -14 hour before end of estrus
Mare	20-23 days	2-4 day	1-2 day before end of estrus
Sow	19-20 days	2-3 day	30-40 hour after onset (mid-estrus)
Bitch	6-7 month	8-10 day	1-2 day after onset of estrus

FERTILISATION			
Species	**Fertile life of ovum**	**Sperm**	**Duration of fertilisation**
Cattle/Buffalo	1 day (12-24 hour)	1-2 day	1 day
Sheep	1 day	1-2 day	15-20 hour
Goat	1 day	1-2 day	15-20 hour
Mare	6-8 hour	3-5 day	
Sow	8- 12 hour	1-3 day	12-15 hour

METHODS OF PREGNANCY DIAGNOSIS

Days	Diagnosis
Rectal Method	
21-25 days	Fully developed corpus luteum on one ovary-80% accuracy
30-35days	Asymmetry of horns (Dorsal bulging-cattle; Ventral bulging- mare) Foetal fluid fluctuation
30-45 days	Amniotic vesicle
40-90 days	Slipping of foetal membrane (Double slipping)
65-80 days	Palpation of cotyledons- 100% accuracy
80-120 days	Fremitus/thrill/Whirr in middle uterine artery
Immunological method	
3-6 days	EPF (Early pregnancy factor) but in sheep 6-24 hour after fertilization Done by Rosette Inhibition test
22- 24 days	P_4 in milk as well as in blood; 80% accuracy in pregnant animals 100% accuracy in non- pregnant animals
After 25 days	PSPB (pregnancy Specific Protein B)
After 30 days	bovine Pregnancy Associated Glycoprotein- bPAG Pregnancy Serum Protein (PSP-60)
40-80 days	PMSG in blood (A-Z test in mare)
105 days	Estrone sulphate
150-300 days	Estrogen in urine (Cuboni test in mare)
Ultrasonography	
Cattle	Non-echogenic area (black)- 12-15 days Heart beat- 22-24 days of pregnancy
Horse	Heart beat- 22 days
Small ruminants	Placentome: 26-28 days of pregnancy

- Pseudopregnancy occurs in bitch (due to prolactin) and cat (due to progesterone)
- Corpus luteum is also known as yellow body
- Caruncles- cow (75-110-convex type); sheep/goat (80-90- concave type)

Type of placenta

On the basis of maternal tissue lost at birth time	On the basis of villi distribution	On the basis of histology	Animals
Non-deciduate	**Cotyledonary**	Syndesmochorial	**Ruminants**
Non-deciduate	**Diffuse**	Epitheliochorial	**Mare, sow, camel**
Deciduate	**Zonary**	Endotheliochorial	**Canine and felines**
Deciduate	**Discoidal**	haemochorial	**Human, monkey, rodents**

- Implantation in ruminants is superficial & Non-invasive while in rodent, primate, pig is Invasive (with the help of proteolytic action)
- Fixation of embryo in mare is termed as gestational sac at about 16 days
- Maternal Recognition of pregnancy(MRP) is responsible for implantation
  - Cattle- 16-17 day due to bovine interferon tau
  - Sheep/goat- 12-14 day due to ovine interferon tau
  - Mare- 14-16 day due to transuterine migration of conceptus
  - Swine- 10-12 day due to estrogen
- 4-cell stage embryo is transported from site of fertilization to uterus in sow
- Hippomanes or allantoic calculi are found in allantoic fluid
- Corpus luteum is present in all animals except Mare and Ewe
- Endometrial cups are unique features of equine placenta which secrete PMSG

- Glucose is major metabolic fuel for foetus
- Uteroverdin (derivative of Biliverdin) is present in placenta of bitch which is responsible for post-partum greenish discharge (lochia)
- Sometime blood on placenta appear as dry, amber coloured, inspissated granules form which are termed as Uterine sand

Parturition

Foetus decide day of birth and dam decide time of birth

Species	Ist stage (dilation)	2nd (expulsion)	3rd stage (expulsion of placenta)
Cattle/ Buffalo	2-6 day	**0.5 -1 hour**	6-12 hour
Sheep/goat	2-6 day	1-2 hour	1-8 hour
Mare	1-4 day	0.2- 0.5 hour	1-3 hour
Sow	2-12 day	2-3 hour	1-4 hour

- Foetal cortisol act on placenta to induce 17alpha hydroxylase which convert progesterone to estrogen to help in parturition
- Failure of cervical dilation in sheep is termed as Ring womb
- Lochia or secundus or 2nd cleanising is post-partum uterine discharge
- Feathering: is technique to assist bitch to stimulate stronger contraction during whelping
- **Abortion:** expulsion of live or dead foetus before gestation period. Abortion is considered only after 42 days of pregnancy tp 260 day (cattle) & 300 day (buffalo)
- **Still birth:** expulsion of dead foetus at full gestation
- Multiparous animals: animals who is having 2nd or more pregnancy
- Uniparous animals: bearing first offspring
- Pluriparous animals: giving birth more than one off-springs
- Placentome: maternal caruncles and foetal cotyledons

Puerperium

1. Involution of uterus
   - **Cow**- Primipara (8-10 days)
     Pleuripara (42-45 days)
   - Mare- 32 days
   - Bitch- 4-5 week
   - Ewe/Sow- 30 days
2. Restoration of endometrium
   - Ruminants- 4-5 weeks
   - Mare and sow- 2-3 weeks
   - Bitch- 12 week
3. Return of heat/Ovarian rebound
   - Cow- 50 days
   - Buffalo-4-7 months
   - Mare- 6-12 day (Foal heat- breeding mostly done in this period)
   - Bitch-150 days
   - Sow- 3-5 days
   - Ewe- 180 days

- Uterine involution is rapid in primipara while ovarian rebound is delayed in primipara
- Ovarian rebound is time interval from calving to 1st estrus (heat)
- Local uterine immunity is better developed in mare than any other species

Fertility parameter

- Economical method- based on calving interval
- Biological method based on calving rate- it is better than other method as it considers number of insemination
- Calving interval- it should not be more than 12 or 13 months
- Culling rate – it should not be more than 5%

Cause of dystocia

Maternal causes

Defect related to forces (expulsive defect)

Uterine causes

1. Primary and secondary inertia
2. Rupture of uterus
3. Uterine torsion

Primary inertia:

Myometrium defect-

- Intrinsic weakness
- Overstretching
- Toxic degeneration
- Fatty infiltration
- Senility
- Diabetes
- Systemic illness
- Herditary causes

Chemical deficiency-

- Hormonal causes (estrogen, progesterone, oxytocin)
- Calcium deficiency

Premature birth

Environmental disturbances

Abdominal causes

- Age, debility
- Herniation of uterus
- Diaphragmatic rupture
- Perforated trachea

Defect related to birth canal

Inadequate pelvis

- Immature
- Fracture
- Breed susceptibility
- Diet
- Development
- Diseases

Insufficient dilation

- Uterine torsion
- Cervical inertia
- Fibrosis of cervix
- Congenital defect in vagina and vulva
- Fibrosis in vagina and vulva
- Prolapse of vagina
- Vaginal abscess
- Vaginal neoplasm

Foetal causes

Oversize foetus

- Breed predisposition
- Prolonged gestation
- Monster
- Ascites
- Anasarca
- Hydrocephalous

Wrong presentation, posture, position

- Transverse presentation
- Vertical presentation
- Ventral and lateral position
- Posture
  - ✓ Limb flexion
  - ✓ Head flexion
  - ✓ Hock flexion
  - ✓ Hip flexion

Foetal death

Cause of dystocia in animals

Ruminants	Foeto-maternal disproportion
Mare	Lateral deviation of head
Sow and bitch	Primary uterine inertia

Presentation, position and posture of foetus		
Presentation Relationship between longitudinal axis of dam with longitudinal axis of foetus and parts present towards birth canal (3 type)	**Position** Relationship between vertebral column of foetus with four quadrants of pelvic inlet of dam	**Posture** Relationship between movable appendages of foetus with its own body
1. Longitudinal presentation (normal): -longitudinal axis of dam is parallel to longitudinal axis of vertebral column of foetus **Anterior longitudinal presentation-** Forelimbs and head are present toward birth canal **Posterior longitudinal presentation-** Both hind limbs are present towards birth canal	8 position in anterior presentation and 8 position in posterior presentation There are 2 position in vertical position	Forelimb flexion Hind limb flexion Flexion of head & neck ➢ Upward ➢ Downward ➢ lateral
2. Transverse presentation (abnormal): 3 type Longitudinal axis of foetus forms a right angle with long axis of dam in transverse plane		
3. Vertical Presentation (abnormal): 3 type Longitudinal axis of foetus forms right angle with long axis of dam in vertical plane		

Some typical posture are:	
Breech presentation	Posterior presentation; dorso-sacral position; bilateral hip flexion posture
Dog sitting position in foal	Oblique ventro-vertical presentation; Dorso-sacral position; Dog sitting posture (Bilateral hip flexion)
Vertex (Poll/ But) posture of foal	Anterior presentation; Dorso-sacral position; downward displacement of head and poll is directed into pelvic inlet (Bilateral shoulder flexion)
Nape posture in foal	Same as vertex posture but degree of downward displacement of head is more
Breast head posture in foal	Same as vertex posture but degree of downward displacement of head is more than vertex and nape posture
Foot nape posture in foal (bilateral)	Anterior presentation; Dorso-sacral position; upward deviation of both forelimbs

Obstetrical operation			
1. Mutation	**2. Forced extraction**	**3. Foetotomy or embryotomy**	**4. Caessarian/ Laprohysterotomy**
For correction of presentation, posture and position **A. Repulsion (Retropulsion)** Pushing foetus into uterus from birth canal to make adequate space for correction of **position and posture** **B. Rotation** Turning of foetus on its long axis to bring the foetus into dorso-sacral **position** **C. Version** Rotation of foetus on its transverse axis into an anterior or posterior longitudinal **presentation** **D. Extension and adjustment of foetal extremity-** correction of head, neck and limbs of foetus	It is withdrawal of foetus from dam using outside force or traction	It is never practised in pig and small animals (dog, cat) **Percutaneous foetotomy-** new and quick method in which Thygeson's foetotome is used. Removal of parts of foetus along with skin to reduce foetus size. **Subcutaneous foetotomy:** removal of decorticated limb (skinless limb) to reduce size of foetus	Site for laparotomy: Left or right flank Ventro-lateral Ventral or mid line linea alba Paramedian

Reproductive disorders	
Cervico-vaginal prolapse	• Common in pleuripara in advance gestation • Common in Gir and Hereford breed of cattle • In bitch occur during proestrus mainly in brachycephalic breeds (Boxer and bull dog) **Treatment:** Unilateral pudendal neurectomy Mencher's method (Vaginopexy) Farquharson's technique Guard and Frank technique Caslick's operation (Vulvoplasty)
Uterine torsion	• Right side and post cervical is most common • Common in buffalo, not common in mare • Gravid and non-gravid horn is involved in unipara while one horn in multipara
Uterine prolapse	(Casting of withers/Casting of calf bed/eversion of uterus)
Hydroallantois (10 fold increase in fluid)	• Shape of abdomen- round and tense • Rapid enlargement of abdomen within 5-20 days • Less malformed foetus (considered normal) • **Bloated bull frog like calf** • Placentome hypertrophy with reduced number • Fluid- Watery, clear, Amber, transudate
Hydroamnion (Hydoutreri)	• Shape of abdomen- pyriform or pear shaped but not tense • Slow enlargement of abdomen over weeks or months • Placenta, allantois, chorion, and placentome is normal • Fluid- Clear, colourless, mucoid (viscous) with good prognosis

Hydrocephalous	Slow enlargement of abdomen Dummy or Bawler's calves
Pyometra	Always associated with retained corpus luteum usually develop secondary to mucometra. Two type: 1. Post-partum pyometra (Open pyometra) 2. Post-service/Coital pyometra (Close pyometra):Seen in Trichomonas infection characterized by **Potato soup like pus**
Retention of placenta	Term used when placenta is not expelled out within 12-24 hours post -partum Advance Treatment: Collegenase therapy- Collegenase (2 lakh unit) from *Clostridium hemolyticum* + 40 mg cacl2 + 40 mg NaHCO3 + 1 litre saline in retained umbilical cord
Puerperal metritis	Occurs early post-mortem (within 3 weeks) Uterus is abnormally large with foetid watery brown discharge
Perimetritis	Inflammation of serosal layer of uterus
Parametritis	Inflammation of adjacent structure (broad ligament) of uterus
Sclerotic uterus	Inflammation of all three layers resulting into fibrosis
Adenomyosis	Presence of nests of endometrium within the myometrium
Endometriosis	Presence of endometrial glands outside the uterus
Endometritis	• Inflammation of endometrium of uterus • Endometritis does not affect general health of animal • Metabolic disorder increases endometritis by 10 times
Ovarian hypoplasia	• Due to defect in single recessive autosomal gene characterized by shrunken and shrivelled ovaries • More common than ovarian agenesis • Oocyte or follicle are absent resulting into **Streak Gonad**
Ovarian neoplasia	Most common is Granulosa cell tumour & fibroma
Tumefaction	Normal swelling of vulva during oestrus
Hermaphrodism	Very common in goats
CTVT	Also known as sticker tumor/Infectious sarcoma arises from histiocytes Both sex affected but more common in young female of 1-6 year of age Neoplastic cells have 59 chromosomes instead of 78 Cytological smear gives round cells with cytoplasmic vacuolation

Cystic ovarian Degeneration

- Characterized by large one or more anovulatory follicle, greater than 2.5 cm in diameter, present in one or both ovaries persist for at least 10 days in absence of corpus luteum with abnormal estrus behaviour. More common in cattle than buffalo
- Common in winter & in closely confined animal having high protein diet

Follicular cyst	Luteal cyst	Cystic corpora lutea
• Single or multiple • thin walled • Low progesterone • High estrogen Sign: • Nymphomania • Sterility hump • Adrenavirlism (Steer like appearance) • Mucometra and hydrometra- typical swiss cheese appearance	• Single • thick walled • high progesterone • low estrogen Sign: • prolonged anoestrus • rough & dry hair coat • progressive emaciation Treatment **PGF 2 alpha**	Due to non-pathological corpus luteum

Mummification	Maceration
• Cervix is tightly closed • Absence of air & bacterial contamination • Prognosis is good • More common in swine • Hematinic mummification- cattle • Papyraceous mummification- other animals	• Cervix is opened • Bacterial contamination present with foetal emphysema • Prognosis is poor

Anestrus

False anestrus Anestrus **with** functional corpus luteum	True anestrus Anestrus **without** functional corpus luteum
It may be due to:	Low plane of nutrition is most common cause
1. Pregnancy CL persist	Congenital & hereditary cause: Ovarian agenesis & hypoplasia, Free-martin
2. Pathological condition in which CL persist • Pyometra, Mucometra, Hydrometra • Foetal mummification • Foetal maceration	**Physiological true anestrus** • Prepubertal anestrus • Gestational anestrus • Post-partum anestrus • Lactational anestrus
3. Silent estrus (Subestrus / Quite ovulation)	**Pathological true anestrus** • Anovulatory anestrus-I (small follicle) • Anovulatory anestrus-II (atretic follicle) • Anovulatory anestrus-III (No ovulation) • Anovulatory anestrus-IV (no regression of CL)
4. Managemental error (missed estrus) Treatment: PGF_2 alpha	Treatment: GnRH, Buserelin, Lugol's iodine, CIDR, PRID, Uterio-ovarian massage

Note: **type of corpus luteum**

- Corpus luteum spurium-Cyclic CL
- Corpus luteum verum- Pregnancy CL
- Corpus luteum albicans-Regressing CL
- Corpus luteum haemorrhagicum-Freshly formed CL

Chapter-24

Veterinary Andrology

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- SRY protein (testes determining factor)- initiate male sex determination
- Gonadal ridge is visible in bovine embryo at about 28-29 days of age and differentiated into testes at about 45 days

	Bull	Stallion	Dog	Boar	Ram/Buck
Length of penis	100cm	90cm	8-10cm	55cm	35cm
Type of penis	Fibroelastic	Vasculomuscular	Os-penis	Fibroelastic	Fibroelastic
Glans penis	Pointed	Urethral process	Bulbus glandis and Longa glandis	Absent	Urethral process
Orientation of testis	Vertical	Horizontal	Oblique Cat-Vertical	Oblique	Vertical
Weight of testis	**300gm**	250gm	-	150gm	250gm
Sigmoid flexure	Present	**Absent**	**Absent**	Present	Present
Mediastinum testis	Present	**Absent**	Present	Present	Present
Ejaculate volume	4-15 ml (6 ml)	30-250 ml (80ml)	10 ml (1.25-12 ml) Cat- 0.04 ml	**25-500ml (250ml)**	0.5-2ml (1ml)
Sperm concentration (million per ml)	300-2500 (1200)	30-600 (150)	-	25-1000 (200)	**1500-4000 (2500)**
Time lapse for ejaculation	1 second Short copulator	30-60 second Intermediate copulator	**5-25min Sustained copulator**	**5-25min Sustained copulator**	1 second Short copulator
Motile sperm(%)	40-70	40-75		50-80	**60-80**
pH	6.4-7.8 (6.8) acidic	7.0-7.8 (7.4) Alkaline	6.7 Cat-7.4	7.0-7.8 (6.8) alkaline	6.2-7.0 (6.8) acidic
Seminal vesicle	Lobulated	Non- Lobulated (pyriform like)	-	Lobulated	Lobulated
Rate of dilution of semen	100-105 times	2 times		4 times	9 times
Preferred diluent	Egg yolk citrate	Glucose gelatin		Egg yolk glucose bicarbonate	Egg yolk glucose citrate

Time lapse for ejaculation is defined as average interval of time from contact of glans penis with vulva to ejaculation

Male puberty:	Female puberty
• Bull- 12-18 month • Buffalo- 24-30 month • Stallion- 18 month • Dog- 18 month • Boar- 6-7 month • Ram – 7-8 month	• Dairy cattle- 10-12 month • Buffalo & zebu cattle- 18-24 month • Mare- 16-24 month • Sow- 4-8 month • Sheep & goat- 7-10 month

Penis

- Fibrous/Musculo-fibrous/fibroelastic- presence of large number of connective tissue. eg. Bovine, porcine, ovine, caprine
- Vascular/Musculo-cavernosus- presence of large number of erectile tissue along with vascular sinuses. Eg. Equine, canine, feline

Os-penis also known as os-priapi or baculum (also present in most non-human primates)
Urethral sinus diverticulum for smegma (bean) in stallion only
Stallion- Preputial ring is present which causes sucking noise when gelding or stallion trots.
Intra-preputial urination is characteristics of ruminants and swine only.

Cowper's gland (bulbourethral glands)

- **secrete Nacl in stallion & Sialoprotein in boar**
- Bull- single duct from each gland
- Stallion- 7-8 ducts from each gland
- Boar- single duct from each gland
- Is highly developed in boar
- **Absent in dog but present in cat**

Prostate Gland

- Ring shaped gland characterized by alkaline secretion
- Totally external in stallion

Testicular descent

- Bull- 106 days of gestation (105-120 days)
- Stallion- at or near birth
- Dog- 3-4 days post-natal (5 days)
- Ram/Buck/Boar- 70 days of gestation

High flankers- testes reaches the inguinal canal but not descend into the scrotum
Sigmoid flexure:

- Pre-scrotal- boar
- Post-scrotal- Bull, ram
- Absent- Stallion, dog, cat

- Retractor penis muscles control sigmoid flexure
- Spermatic cord is more long in swine
- Animal having intra-abdominal testes known as testchondras
- Consistency of testes- turgid
- Testicular appendix is seen in stallion and ram
- Blood testes barrier includes sertoli cells and peritubular or myoid cells

Length of epididymis	Function of epididymis
Bull-30 meter Stallion- 20 meter Boar- 50 meter	• Storage & maturation of sperms • Concentration • Secretion- ➢ Sialic acid in large quantity (decapacitating factor) ➢ GPC ➢ Acyl cartine- useful in lipid transport & source of energy

Cauda epididymis (principle storage organ)- store about 75% of total epididymal spermatozoa
Physiological anabiosis: epididymal fluid keep spermatozoa immotile & reduces metabolic activity
Epididymis behave like kidney by virtue of its embryonic characteristics

Inguinal canal

Small- short external inguinal ring- Bull, boar, dog

Large- large external inguinal ring- Stallion

Sperm remain alive in epididymis for 60 days

After completion of spermiogenesis, most of excess cytoplasm cast off resulting into residual cytoplasmic mass termed as **Residual Body of Regaud**

Mediastinum testes and rete testes are absent in stallion

Time require to complete a cycle of spermatogenesis:

- Bull- 13.5 days (Approx.- 14 days)
- Stallion-12.2 days (Approx.- 12 days)
- Dog-
- Boar-8.3 days (Approx.- 9 days)
- Ram-10.1 days (Approx.- 10 days)

Spermatogenesis comprised of 4-5 cycle of seminiferous epithelium

Total days required for spermatogenesis:

- Bull, Ram, Dog- 60-70 days
- Stallion-40-45 days
- Boar- 50-60- days

Sperm:

- Pattern of fibril- middle piece (9+9+2) and tail (9+2)
- Source of fructose- seminal vesicle
- Fragile part- neck
- Source of energy in female genital tract- GPC
- Velocity in female genital tract- 3mm/second
- Bull spermatozoa resemble a tadpole
- Buck spermatozoa is quite susceptible to cold shock

Buck semen- presence of egg coagulating enzyme (phospholipase A) prevents the storage at 5^0C in yolk containing diluents

Double rig (cryptorchid)- both testicles retained in the abdomen

Static ejaculation is a unique phenomenon in buffalo

Citric acid present only in seminal vesicle secretion of stallion

Lactenin: Spermicidal factor present in milk

Colliculus seminalis prevents urination during ejaculation

Pulsation at base of penis is noticed during ejaculation in stallion

Stallion ampullae secrete ergothineine

Seminal vesicle

- Contribute 55-60% of total semen volumeand secretion has fructose, prostaglandins, citric acid, riboflavin, vitamin C etc.
- Buck secretion has inositol & ergothioneine
- Boar secretion has lysolecithin

Seminal Plasma

- Specific gravity of seminal plasma is 1.030 and sperm is 1.075
- Seminal plasma- pH- about 6 with high osmotic pressure (300 mili osmol)
- Seminal plasma contains high sodium than potassium while sperm contain high potassium than sodium
- Major carbohydrate and lipid in seminal plasma is fructose and phospholipid respectively

Causes of male infertility

Impotentia coeundi Reduced or complete lack of sexual desire and ability to copulate	Impotentia generandi Inability or reduce ability to fertilize	
	With apparently normal semen	**With apparently abnormal semen**
➢ Hereditary ➢ Nutrition ➢ Lack of libido ➢ Age ➢ Managemental causes ➢ Psychogenic causes ➢ Weather ➢ Hormonal disturbances ➢ Hernia ➢ Premature or failure of erection ➢ Urinary calculi ➢ Diseases of joints, muscles, nerve, bone, ligaments etc. ➢ Diseases of penis and prepuce ✓ Phimosis & Paraphimosis ✓ Phallocampsis/Diphallus ✓ Priapism ✓ Epispadias & Hypospadias ✓ Balanoposthitis ✓ Pizzle rot ✓ Rupture/Prolapse/Adhesions ✓ Tumour ✓ Persistent penile frenulum	➢ **Inherited sperm defects** ✓ Knobbed sperm ✓ Diadem effect ✓ Enzymatic disturbances ✓ Chromosomal defects ➢ **Infectious diseases**	➢ Cryptorchidism (rigs/originals-horse) (High flankers-bulls) ➢ Imperfect testicular descent ➢ Testicular hypoplasia ➢ Testicular degeneration ➢ Testicular fibrosis ➢ Testicular neoplasm ➢ Epididymitis ➢ Inguinal hernia ➢ Segmental aplasia ➢ Pathology of accessory gland ➢ spermiostasis ➢ Congenital defects ➢ Inbreeding ➢ Intersexes ➢ Scrotal torsion ➢ Orchitis ➢ Testicular calcification

Male reproductive disorder

Rainbow penis	Ventral deviation of penis
Cork-screw penis	Lateral deviation of penis
Schirrous cord	Chronic inflammation of spermatic cord
Cryptorchidism	Usually unilateral & common in dog & horse
Hypoplasia	Unilateral hypoplasia is more common; small scrotum; testes feels flabby, ejaculates few or no sperms; libido & coitus remain unaffected
Testicular degeneration (atrophy)- reversible	Vacuolation of the sertoli cells is more pronounced in degeneration than hypoplasia, fibrosis and calcification of testes

Testicular tumour

Interstitial cell tumour	Seminoma	Sertoli cell tumor
Most common No endocrine disturbances	Most malignant of all testicular tumour	Most common in cryptorchid testes with endocrine disturbances like gynaecomastia

METHODS OF SEMEN COLLECTION

BULLS	• Vaginal method (Spoon or Sponge method)- simplest and earliest method • Ampullary Massage method

	• Electro-ejaculator method- helps to collect the semen from bull that are not able to mount. This method was first described by Gunns in 1936 in ram. • Artificial Vagina (AV) method- most widely used method for semen collection
STALLION	• Vaginal method (Spoon or Sponge method) • Collection of tail end sample • Condom or Breeder's bag method • Artificial Vagina (AV) method- most widely used method for semen collection
DOGS	• Digital pressure and massage method • Artificial Vagina (AV) method- most widely used method for semen collection
BOARS	• Gloved hand method • Electro-ejaculator method- helps to collect the semen from boar that are not able to mount • Artificial Vagina (AV) method- most widely used method for semen collection
RAMS & BUCKS	• Vaginal method (Spoon or Sponge method) • Electro-ejaculator method • Artificial Vagina (AV) method- most widely used method for semen collection
• Pressure of AV is more important than temperature in boar and stallion • Temperature of AV in bull (40-42^{0}C) and in boar & Stallion (45-50^{0}C) • Coolidge effect: sexual receptivity of male increases when many females in herd becomes receptive	

Semen evaluation		
Macroscopic semen evaluation	Volume	Highest Volume is ejaculated by boar
	Colour	Depends upon concentration of spermatozoa in semen Yellow colour of semen is normal in some bulls due to riboflavin content which is secreted by ampulla or seminal vesicles.
	Consistency	Depends upon concentration of spermatozoa in semen
	Specific gravity/Density	Positive correlation between specific gravity and sperm cell concentration
	Gross motility (Grading: 0 – 5)	Semen with good motility will show wavy or swirling motion of sperm by naked eye
Microscopic semen evaluation	Sperm concentration	Estimation of sperm concentration is done by: • Haemocytometer method- old but most accurate method • Cell volume method- use of centrifuge machine • Calorimeter- faster than other methods • Computer assisted semen analyser- most advanced but costly method
	Motility of spermatozoa • Mass motility • Individual motility	Individual motility is most common and used tool to estimate semen quality Circular movement indicate cold shock to sperms Good semen sample should have an initial motility of 70%
	Live and dead count	**By Eosin and Nigrosin staining** Unstained sperm-live Pink stained- Dead Partial stained- Dead Fresh and frozen semen should have 80% and 50% live sperms, respectively
	Morphological abnormality • Acrosome integrity	**Acrosome integrity** It is evaluated by **Giemsa stain-** • Normal acrosome

	• Sperm abnormality	• Partially and completely lost acrosome • Ruffled or Wrinkled acrosome • knobbed acrosome • Diadem effect (Necklace/nuclear pouch formation) • Detached galea capitis • Apical notch or ridge ✓ Fresh semen should have 80% acrosome integrity while frozen semen should have minimum 65% intact acrosome ✓ Knobbed acrosome and diadem effect should not exceed 5%.

Sperm abnormality (should not exceed 20%)

Defect in head	Defect in neck	Defect in mid piece	Defect in tail
• Macrocephalic & Microcephalic head • Pear shaped & Tapering head • Round short head • Lost acrosome • Loose head • **Knobbed acrosome** • **Diadem effect** • Double head	• Swollen neck • Broken neck • Teratoid	• Coiled mid piece • Kinked/bent mid piece • Broken mid piece • Bowed & abaxial mid piece • Cork screw defect • Proximal & Distal droplet	• Coiled tail • Terminally coiled tail • Broken tail • Stump tail • Double tail • **Dag effect** (tail is coiled over mid piece)

Biochemical evaluation of semen	Hydrogen ion concentration (pH)	When bulls are used extensively, the pH will be alkaline. Excellent quality: 6.4 – 6.5
	Respiration co-efficient (Oxygen utilization test)	Volume of CO_2 produced by sperms per unit of time by the volume of O_2 consumed in same unit of time
	Fructolytic index	It is the amount of fructose utilised by 10^9 sperms in one hour at 37°C (related to metabolic activity) Mean value: 1.5 – 2 mg/ 10^9 sperms
	Resazurin reduction test	1 minute- good sample Used to measure metabolic activity of sperms
	Methylene blue reduction test	Used to measure metabolic activity of sperms 3-5 minute- good; 9 minute- average More than 9 minute- discarded
	Hypo-osmotic swelling Test	Measure of cryosurvival of sperms Fresh semen must have minimum of 70% sperms showing tail curling (Swollen sperm)
	Hyaluronidase test	Presence of hyaluranidase in extracellular fluid indicate acrosomal damage
	Alkaline and acid phosphatase test	Presence of these enzymes indicate functional state of accessory sex glands
	Millovanov's resistance test (R-value)	It is used to know the ability of sperm to withstand the action of 1 % NaCl solution

Post-thaw evaluation of semen

- Post-thaw motility
- Post-thaw acrosomal integrity
- Post-thaw acrosomal enzyme release
- Post-thaw incubation survival or viability at 37°C

Components of semen extender/diluents (5)				
Buffer	**Fructose**	**Glycerol**	**Egg yolk**	**Antibiotics**
The most common buffer- Tris buffer	Act as Energy source	Act as cryo-protective agent	Protect lipoprotein sheath of sperm against cold shock	Penicillin G and Dihydrostreptomycin Penicillin@ 500-1000 IU/ml

Diluents for liquid and frozen semen	
Liquid semen	**Frozen semen**
• Tris buffer • Sodium citrate egg yolk diluent • Reconstituted skim milk diluent	• Tris buffer • Sodium citrate egg yolk diluent • Reconstituted skim milk diluent

Preservation of semen		
At room temperature (18-25^0 C)	At refrigerator temperature (4-6^0 C)	At ultralow temperature (-79 to -196^0 C)
• Illini variable temperature (IVT) diluent • Cornell University Extender (CUE) • Millovanov's method (Carbonate-phosphate method) • Coconut milk extender • Caprogen • MG32 extender	• Egg yolk phosphate extender • Egg yolk citrate extender • Caprogen • Egg yolk glucose bicarbonate extender (Kampschmidt) • D2 dilutor & D5 dilutor • Glycine dilutor • Milk dilutor • Citric acid whey • Tris yolk extender	• Tris egg yolk glycerol diluent (universal diluent) • Sodium citrate extender • Milk extender • Lactose egg yolk extender

Packaging methods of frozen semen			
Ampoule method	**Pellet method**	**Tupol method**	**Straw technique**
Semen is placed in glass ampoules, sealed, frozen and preserved in solid carbon dioxide or in liquid nitrogen. Sperm loss (25 %)	Semen is rapidly frozen as small pellets and freezing is done with solid carbon dioxide Extender does not contain buffers	Packaging by using polythene tubes named as Tupol for freezing in liquid nitrogen	Straws are made of polyvinyl chloride (Sperm loss 5%)

Straw method			
Type of straw	**Length**	**Diameter**	**Volume**
French medium	133 mm (13.3 cm)	2.8 mm	0.5 ml
French mini	133 mm (13.3 cm)	2.0 mm	0.25 ml
German straw	65 mm (6.5 cm)	2.8 mm	0.25 ml

MOET (Mutiple Ovulation Embryo Transfer Technology)

Animal is admistered with FSH for superovulation (6-8 eggs) then mated with elite bull or AI, the fertilised eggs (8-32 cell stages-embryo) are collected non surgically by 3 way Foley catheter with help of flushing media (Phosphate buffer saline) and transferred to surrogate mothers

First Embryo Transfer Technology Project was initiated by National Dairy Development Board (NDDB) in 1987 & established ET lab at Sabarmati Ashram Gaushala, Bidaj (Gujarat)

- All filling & sealing process operated at 20-22^0 C
- First semen bank is established at NDRI, Bengaluru
- First AI in cattle in India was done in 1939 at Dairy Farm, Mysore by Sampat Kumaran
- First AI in bitch by Spallanzani (1780) and in cattle by Evanov

Chapter-25

Veterinary Osteology and Arthrology

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Bone

Bone is a connective tissue having hard matrix, specialized cells, mineral salts and collagen fibres.

Cells of bone

- **Osteoprogenitor cells:** are stem cells that divide to produce osteoblasts
- **Osteoblasts:** are the main cells responsible for bone formation and synthesize inorganic part of intracellular matrix and collagen fibres and ultimately differentiated into osteocytes
- **Osteocytes:** are mature cells and cannot divide and control mineral and calcium content
- **Osteoclasts:** are known as multinucleated bone eating cells responsible for remodelling of bones, breakdown of old bone tissue.

Classification of bones

- **Long bones:** are longer than they are wide and characterized by a long shaft (diaphysis) and two ends (epiphysis). Eg- femur, humerus
- **Aborted long bones:** long bones that do not develop completely. Eg. Ulna of horse and small metacarpals of horse
- **Short bones:** absence of diaphysis. Eg. Carpal bones
- **Flat bones:** are bones with flattened and broad surface. Eg. Scapula, ilium, ischium, pubis
- **Irregular bone:** has shape that does not confirm to above 3 types. Eg. Vertebral bones
- **Sutural (Wormian) bones:** small flat irregular shaped present at suture joints of skull
- **Sesamoid bones:** small flat bones similar to sesame seed. Eg. Patella

Structure of bone

- **Peristoeum:** is a membrane which covers outer surface of bone and made up of two distinct layer- outer fibrous layer (provide structural integrity) and inner cellular layer (possess osteogenic potential).
  Periosteum is not present on sesamoid bone and those areas where bone is covered by cartilage and where tendons and ligaments are attached to bones
- **Compact bone (Cortical bone) tissue:** Forms hard external layer of all bones and protect medullary cavity or bone marrow and characterized by haversian system (osteons). Each osteon consists of lamellae (layer of compact matrix) surrounding haversian canal. Haversian canal contains blood vessels and nerve fibres and run parallel to long axis of bone.
- **Spongy (cancellous) bone tissue:** Forms inner layer of all bones and characterized by absence of osteons and presence of trabeculae in which red bone marrow is present.
- **Endosteum:** is a vascular membrane that lines the medullary cavity
- **Bone marrow:** are spongy tissue that fills medullary cavity and contains stem cells They are of two types: Red bone marrow (contain hemopoeitic stem cells that develop into RBCs, WBCs and platelets.) and yellow bone marrow (contain mesenchymal stem cells that develop into fat, cartilage and bone).

Number of bones in domestic animals and fowl					
Region	**Cattle**	**Horse**	**Dog**	**Pig**	**Fowl**
Vertebral Column	51	57	53	52	41
Ribs	26	36	26	30	14
Sternum	1	1	1	1	1
Fore Limb	48	40	88	80	28
Hind Limb	48	40	90	80	42
Skull	34	34	34	30	40
Visceral Bone	2	0	1	1	2
Total	**210**	**208**	**293**	**274**	**168**

Bones of skull			
Facial bones		**Cranial bones**	
Paired facial bones	**Single facial bones**	**Paired cranial bones**	**Single cranial bones**
• Turbinate (nasal conchae) • Pterygoid • Nasal • Palatine • Premaxilla • Maxilla • Malar (zygomatic bone) • lacrimal	Vomar	• Temporal • Frontal • Parietal • Interparietal	• Ethmoid bone: C/B by presence of crista galli and cribriform plate • Sphenoid • Occipital
Premaxilla	Is C/B presence of palatine process and palatine fissure		
Maxilla	Largest bone among facial bones and characterized by presence of facial tuberosity, alveolar sockets, osseus lacrimal canal, infraorbital foramen, sphenopalatine foramen, maxillary foramen and posterior palatine foramen		
Temporal bones	Divided into 2 parts: Squamous temporal and Petrous temporal Petrous temporal is hardest bone of body and give space to whole internal ear		
Sphenoid bone	C/B presence of Pituitary fossa, foramen ovale, foramen orbitorotandum and optic foramen		
Occipital bone	C/B of condyles, foramen magnum, paramastoid process, condyloid fossa, condyloid foramen, hypoglossal foramen, mastoid foramen and external occipital protuberance		
Mandible			
Mandible	C/B presence of mental foramen, condylar process, coronoid process, mandibular notch, mandibular foramen, lingual groove (for lingual nerve) and faint notch		
Hyoid bone			
Hyoid bone	C/B presence of transverse body, thyroid cornua, small cornua and styloid (great cornua)		

Paranasal sinuses

Paranasal sinuses are air filled spaces located within skull that connect to nasal cavity

- Frontal sinus- largest in ox
- Maxillary sinus- largest in horse
- Palatine sinus
- Ethmoid sinus
- Sphenoid sinus

Forelimb

Cattle	Horse	Dog	Pig	Fowl
	Acromian process is **absent** in scapula	Coracoid process is **absent** in scapula	Glenoid notch absent	Sword shaped
Supratrochlear foramen **absent** in humerus	Supratrochlear foramen **absent**	Supratrochlear foramen **PRESENT**		
Nutrient foramen present on **posterior surface** of humerus	Nutrient foramen present on **medial surface** of humerus	Nutrient foramen present on **posterior surface** of humerus		
Interosseous space is **absent** in ulna	Styloid process **absent** and Interosseous space is **present** in ulna	Interosseous space is **absent** in ulna Olecranon process is grooved Radius and ulna are not fused in dog		
Carpals- 6	**7**	**7** (Radius and intermediate carpals are fused)	**8**	**2**
Metacarpals- 2 (1 small + 1 large) **Large metacarpal is known as Cannon bone**	3 (2 small + 1 large) **Small metacarpal is known as Splint bone**	5	4	3
Digits- 2 2nd& 5th digit is rudimentary, known as Dew Claws	1	5	3	-
Sesamoid-6 (4 proximal + 2 distal)	**3** (2 proximal + 1 distal) Shuttle shaped distal sesamoid	**14** (14 proximal + 0 distal) Distal sesamoid (navicular bone) is absent Dorsal sesamoid (5) present	-	-

Scapula is characterized by 2 surfaces, 3 borders and 3 angles
Metacromion process is present in rabbit scapula
Carpals of ox: Radial carpal (Scaphoid); Ulnar (Cuneiform) carpal ;Intermediate (semilunar) carpal; Accessory (pisiform) carpal; 2nd & 3rd fused carpal (Os magnus) and 4th carpal (Unciform)

Sternum (Breast bone)	• Consists of Sternebrae • Ox and horse has 7 sternebrae while dog have 8 sternebrae and pig has 6 sternenrae • **Sternum of Horse is boat shaped**
Clavicle (Beauty bone/ Collar bone)	• Absent in ox and horse • Rudimentary in dog and cat • Found in pig and rabbit in form of thin band • **Clavicles (paired) are well developed in fowl** and characterized by fusion into V shaped structure termed as **Wish Bone (Furculum)** in which **hypocleidium** is present. The furcula connects shoulder joints with keel of sternum.
Coracoid bone	Are paired bones present in fowl and connect with sternum, scapula, humerus and furcula.

Hindlimb				
Cattle	**Horse**	**Dog**	**Pig**	**Fowl**
-	Fovea capitis is notched and **third trochanter** is present in **femur**	-	-	-
Patella- Triangular	Quadrilateral	Sesamoid bone at posterior aspect known as **fabella**	-	Triangular
Tibia & Fibula- Fibula rudimentary	Fibula rudimentary Anterior tuberosity of tibia is grooved	Tibia and fibula is of equal length	-	Tibiotarsus is **longest bone in fowl**
Tarsal- 5	6	7	7	
Metatarsal- 2	3	5	4	Tarso-metatarsal is known as **Spur of fowl**

- Acetabulum of ox and horse is made large and deep by cotyloid ligament
- Acetabulum is a cotyloid cavity formed by **ilium, ishium and pubis**
- Obturator foramen is formed by **ischium and pubis**
- Lesser ischiatic notch is **absent** in Horse
- Pronation and supination is found in dog only
- **External angle of ilium is termed as tuber coxae and form Point of Hip**
- Ischial tuberosity is trifid in ox and form pin bone
- Cnemial crest is part of tibiotarsus
- Third trochanter is also present in femur of rabbit
- **Fibular tarsal (calcaneous) bone** is characterised by presence of **tuber calcis and sustentaculum tali**

Vertebrae					
	Cattle	**Horse**	**Dog**	**Pig**	**Fowl**
Cervical	7	7	7	7	14
Thoracic	13	18	13	14-15	7
Lumbar	6	6	7	6-7	L+S=14
Sacral	5	5	3	4	
Coccygeal	18-20	15-20	20-23	20-23	6-7
Total	49-51	51-57	50-53	51-56	41-42
Atlas vertebrae	C/B presence of alar foramen, fovea dentis and fossa atlantis				
Axis vertebrae	C/B presence of odontoid process				

- Fundamental part of a vertebrae is its body
- Atlas, axis and 6th cervical vertebrae- termed as **atypical** cervical vertebrae
- Foramen transversarium is present in cervical vertebrae but absent in 7th cervical vertebrae
- 6th cervical vertebrae is known as vertebrae prominence
- Cervical process of 6th cervical vertebrae is trifid in horse
- **Thoracic vertebrae** are characterized by long supraspinous process, well developed dorsal spine and cylindrical body
- **Lumbar vertebrae** are characterized by long transverse process
- Lumbar and sacral vertebrae are fused to form **synsacrum in fowl**
- Few caudal vertebrae fused to form a bont projection termed as **pygostyle in fowl**
- In Coccygeal vertebrae-neural arch open dorsally in horse only
- Chevron bone present in coccygeal vertebrae of dog only

- The largest foramen is foramen magnum through which spinal cord passes
- Thoracic vertebrae- Withers and back
- Lumber vertebrae- loin region
- Sacral vertebrae- croup region

Ribs					
Animal	**Cattle**	**Horse**	**Dog**	**Pig**	**Fowl**
Ribs	**26 (13 pairs)**	**36 (18 pairs)**	**26 (13 pairs)**	**30 (15 pairs)**	**14 (7 pairs)**
Sternal ribs	First 8 pairs	First 8 pairs	First 9 pairs	First 7 pairs	-
Asternal ribs	Last 5 pairs	Last 10 pairs	Last 4 pairs	Last 8 pairs	-
Floating ribs			Last pair of ribs	Last pairs of ribs	

- Sternal ribs- connected to sternum directly by their own costal cartilages
- Asternal ribs (false ribs)- indirectly connected to sternum by cartilage of rib in front to form the costal arch
- Floating ribs- are not connected with the sternum directly or indirectly
- 6th rib is widest and 11th rib is longest in horse

Arthrology

Types of joints		
On the basis of structure involved	**On the basis of movement**	**On the basis of axes**
Synovial joints Bones are not joined directly, synovial cavity is involved	**Diarthrosis** (freely movable joints- synovial joints)	**Uniaxial joints** Back and forth along a single axis. Eg.- hinge joints
Fibrous joints Bones are joined with dense connective tissue	**Synarthrosis** (immovable joints- mostly fibrous joints)	**Biaxial joints-** move along two axes. Eg- Ellipsoidal joint and saddle joint
Cartilaginous joints Bones are joined by cartilage **2 type:** **Primary (synchondrosis)-** Hyaline cartilage directly involved **Secondary (Symphysis)-** hyaline cartilage cover bone but fibrocartilage connects them	**Amphiarthrosis** (Slightly movable- mostly cartilaginous joints)	**Polyaxial joints** Move through all axes.eg- ball and socket joints

Types of synovial joints	
Ball and socket joints (enarthrosis)	Eg. Shoulder joint, hip joint, joint between incus and stapes
Hinge joint (ginglymus)	Movement is one direction is allowed Eg. Elbow joint, knee joint,
Saddle joint	Interphalangeal joints in dogs
Ellipsoidal (condylar) joint	Eg. Atlanto-occipital joint; Temporo-mandibular joint; Fetlock joint
Pivotal joint (Trochoid/ rotatory)	Rotatory movement around a single axis Eg, Atlanto-axial joint
Type of Fibrous joints	
Suture joints	Skull joints

Gomphosis	Teeth in alveoli
Schindylesis (Wedge and groove joint)	Crest (sharp edge) of one bone fits into groove (cleft) of another bone. Eg- Vomar and sphenoid bone
Syndesmosis	Two adjacent (parallel) bones are joined by a strong membrane or ligaments. Eg.-- Radius and ulna along its length; tibia and fibula; joint between metacarpal bones
	Type of cartilaginous joints
Synchondrosis (Primary) joint	Bones are joined together by hyaline cartilage Eg. Occipito-sphenoid joint
Symphysis (Secondary) joint	Fibro-cartilaginous joint between two bones Eg. Pelvic symphysis; Vertebrae connected by intervertebral discs; mandibular symphysis

Various joints of body	
Joints of skull	**Joints of Vertebral column**
• Temporo-mandibular joint • Temporo-hyoid joint • Proximal and Distal intercornual joint • Mandibular symphysis • Basi cornual joint	• Inter central articulation • Inter neural articulation • Atlanto-axial articulation • Atlanto-occiptal articulation
Joint of thorax	
• Costo-vertebral joint • (Costo-central and Costo-tranverse) • Chondro-sternal articulation • Costo-chondral articulation	
Joints of forelimb	**Joints of hindlimb**
1. **Shoulder joint** (only capsular ligament is involved) 2. **Elbow joint** (comprises of 2 articulations) • Radioulnar articulation • Humero-radial articulation 3. **Carpel (Knee) joint:** 3 articulations • Radioulnar carpal articulation • Intercarpal articulation • Carpometacarpal articulation 4. **Fetlock (Metacarpal-phalangeal) joint** Superior sesamoidean (Suspensory ligament) is involved 5. **Pastern (Proximal interphalangeal) joint** 6. **Coffin (Distal interphalangeal) joint**	1. **Sacro-iliac articulation** 2. **Pelvic symphysis** 3. **Hip-joint** 4. **Stifle joint:** 2 articulations • Femoro-patellar articulation • Femoro-tibila articulation 5. **Hock joint** • Tibiotarsal articulation • Intertarsal articulation • Tarsometatarsal articulation 6. **Fetlock (Metacarpal-phalangeal) joint** Superior sesamoidean (Suspensory ligament) is involved 7. **Pastern (Proximal interphalangeal) joint** 8. **Coffin (Distal interphalangeal) joint**
Check ligament (Accessory ligament of femur) is present in hip joint of horse	

Type of Muscles			
Function	**Skeletal muscles (voluntary muscles)**	**Smooth muscles (involuntary muscles)**	**Cardiac muscles (involuntary)**
Shape	Cylindrical	Fusiform/Spindle	Short Cylindrical
Striations	Present	Absent	Present
Nucleus	Multinucleated (peripheral located)	Uninucleated (centrally located)	Uninucleated
Branching	No Branching	No Branching	Branching

Cell to Cell Connection	No	By Fusion of Plasma Membrane	Through Intercalated disc
Contraction	Rapid	Slow	Quick
Occurrence	Lymph, Trunk	Stomach, Intestine, Urinary Bladder & Genital Tract	Heart

Classification of Voluntary muscles

On the basis of force of action		On the basis of colour	
Spurt muscles	**Shunt muscles**	**Red muscles**	**White muscles**
• This muscle has its distal attachment near the joint • Provide force during movement • Eg. brachialis	• This muscle has its proximal attachment near the joint • Are good stablizer • Eg. Flexor carpi radialis	• Also known as Slow twitch muscles • Rich in myoglobin and mitochondria • Less endoplasmic reticulum • Deep seated • Contraction is for long time	• Also known as fast twitch muscles • Less content of myoglobin and mitochondria • Abundant ER • superficial • Contraction is strong but short lived

On the basis of direction of muscles fibres			
Parallel muscles	**Pennate muscles**	**Spiral muscles**	**Cruciate muscles**
Fibres are parallel to force generating axis	Fibres are oblique to force generating axis and tendon runs along length muscles	Fibres are arranged in spiral manner	Fibres are arranged in X-shaped configuration
Eg. Biceps brachi		Eg. Brachialis	Eg. Massater

Type of parallel muscles	
Fusiform parallel muscles: spindle shaped **Eg.** Biceps brachi	**Non-fusiform parallel muscles:** more rectangular with a constant diameter

Type of pennate muscles		
Unipennate muscles Muscle fibres run on same side of tendon and giving look of **half of a feather** eg. Peroneus tertius	**Bipennate muscles** Muscle fibres run on either side of tendon Eg. Rectus femoris Gastrocnemius muscle	**Multipennate muscles** Muscle fibres lie side by side of tendon Eg. Deltoid

Muscles on the basis of supporting nature		
Agonistic muscles	**Antagonistic muscles**	**Synergistic muscles**

Origin & Insertion of muscles

Origin: proximal fleshy and fixed end
Insertion: distal fibrous narrow flat end is insertion of muscles
When insertion is in form of fibrous band, it is termed as **tendon** while insertion in form of thin sheet is termed as **aponeurosis**

Important muscles in domestic animals

Muscles of forelimb

Muscles of shoulder girdle	Medial aspect of shoulder	Lateral aspect of shoulder
Trapezius (triangular muscle)	Subscapular (adduction of limb)	Deltoideus **(V-shaped muscles)**
Brachicephalicus	Teres major	Teres minor
Serratus ventralis **(fan-shaped muscles)**	Coracobrachialis	Supraspinatous

Deep pectoral (largest muscle of body in birds)		Infraspinatous
Muscles of arm	**Flexor of forearm and manus**	**Extensor of forearm & manus**
Brachialis (flexion of elbow)	Lateral and medial interosseous (suspensory ligament)- absent in ox but present in horse	Extensor carpi radialis & obliquus
Biceps brachii (flex elbow joint)	Lumbaricales (absent in ox but present in horse)	Common digital extensor
Triceps brachii	Flexor carpi radialis and ulnaris	Medial & lateral digital extensor
Tensor fascia antibrachii (extend the elbow)	Deep digital flexor	
Muscles of hindlimb		
Muscles of anterior aspect of thigh	**Muscles of lateral aspect of thigh**	**Medial aspect of thigh**
• **Quadriceps femoris** (extension of stifle joint) Cover anterior, lateral and medial surface of femur	• Superficial gluteus (present in horse and dog)	Superficial layer: • Sartorius and Gracialis
	• Tensor fascia lata • Semitendinous	Middle layer: Pectineous Semimembranous
• Articular genu	• **Biceps femoris** (extension of hip & abduction of limb)	Deep layer: • **Quadratus femoris** • Obturatus & Gemellus
Muscles for opening jaw	**Muscles for closing jaw**	**Muscles of mastication (temporo-maxillary region)**
• Ospito-mandibularis • Sterno-mandibularis • Digastricus • Zygomaticus (Ribbon shaped muscles)	• Pterygoideusmedialis • Massater • Temporalis (well developed in carnivores)	Pterygoideus medialis Pterygoideus lateralis Masseter Temporalis Digastricus (raise tongue)
Muscles of lips & cheek	**Muscles of abdomen**	**Muscles of tail**
• Levator labii inferioris (Incisivus mandibularis) Elevate lower lip • Buccinator (main cheek muscles)	• Oblique abdominis externus- Poupart's ligament present • Oblique abdominis internus (gavard muscle) • Tranverse abdominis- Thin and innermost muscle of abdomen • Rectus abdominis- Insertion of this muscle is known as Pre-pubic tendon	• Sacro-coccygeus dorsalis medialis- **extend tail** • Sacro-coccygeus dorsalis lateralis- **extend tail** • Sacro-coccygeus ventralis dorsalis & Sacro-coccygeus ventralis lateralis- **flexion and lateral movement of tail** • Intertransversal caudae- **lateral flexion of tail**

Note: Stay apparatus in horse is made by: Gastrocnemius muscle & Peroneus tertius muscle

Chapter-26

Veterinary Splanchnology and Aesthesiology

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Splanchnology: anatomical study of digestive system, respiratory system and urogenital system
Aesthesiology: study of sense organs

Digestive system	
Mouth	C/B presence of muzzle (planum nasolabiale), frenum labii inferioris, papilla salivalis (opening of parotid duct), Hard palate (presence of transverse ridges), papilla incisive, soft palate (presence of palatopharyngeal arch- posterior pillar; palatoglossal arch- anterior pillar), frenum linguae, sublingual caruncle
Tongue	C/B presence of dorsum linguae, torus linguae, lingual fossa, various papillae, lingual tonsils

Papillae of tongue	
Taste buds present (gustatory)	**Taste buds absent (mechanical)**
• Fungiform papillae • Foliate papillae (absent in ruminants) • Circumvallate papillae (largest)- only 2 in horse and 7 in dog	• Conical papillae • Filiform papillae • Lenticular papillae

Salivary glands		
Parotid gland **Largest in all animals except dog**	**Mandibular gland** **(largest in dog)**	**Sublingual gland**
Capsulated	Non-capsulated	capsulated
Stenson's duct open at Papilla salivalis	Wharton's duct open at carancula sublingualis	
Serous (watery secretion)	Mixed (serous + mucous)	Mixed (serous + mucous) Mainly mucous
Shape- V shape in horse Triangular in ox, dog & pig Rectangular in sheep & goat		
In dog, one more salivary gland is present known as **Zygomatic salivary gland** open opposite to last upper molar		

Oesophagus	Abdominal part of oesophagus is absent in cattle
Peritoneum	Serous membrane that lines the abdominal cavity
Epiploic foramen	Also known as Foramen of winslow: passage between greater sac (peritoneal cavity) and lesser sac (omental bursa)
Stomach of ruminants (4 parts)	
Rumen	C/B presence of rumen papillae and extend from 7th intercostal space to pelvic inlet
Reticulum (smallest in bovine)	C/B honey comb like structure and extend from 6th to 8th rib

Omasum (smallest in sheep)	Also known as Psalterium C/B presence of crescent shaped fold (laminae) and extend from 7th to 11th rib
Abomasum	Also known as rennet or true stomach or glandular stomach C/B presence of glands and extend from xiphoid cartilage to ventral part of 10th rib
Note: Rumen, reticulum and omasum is made up of keratinized stratified squamous epithelium while abomasum is made up of simple columnar epithelium	
Stomach of non- ruminants	
Horse	C/B presence of **saccus cecus** (at entrance of oesophagus) and **Margoplicatus** (a ridge which separates glandular and non-glandular part of stomach
Dog	Stomach is fully glandular in dog
Pig	C/B presence of **torus pyloricus**
Fowl	Stomach is divided into 2 part: proventricular (glandular part) and ventricular or muscular part (known as Gizzard)

Cells of gastric glands		
Oxyntic (parietal cells) Secrete HCl and intrinsic factor	Chief (Peptic/Zymogen) cells Secrete enzymes (pepsinogen)	Argentaffin cells Secrete hormone (gastrin)

Intestine					
Small intestine			**Large intestine**		
Duodenum	Jejunum	Ileum	Caecum	Colon	Rectum
Duodenum	C/B presence of duodenal glands in submucosa known as Brunner's gland Bile duct and pancreatic duct open separately into duodenum In sheep and goat, bile duct and pancreatic duct join together and open into duodenum Hepatic and pancreatic duct open into duodenum in a pouch structure termed as Ampulla of Vater (Hepatopancreatic ampulla)				
Jejunum	Longest part of intestine **Meckel's diverticulum (remnant of yolk sac) in fowl** present at mid portion of jejunum				
Ileum	C/B presence of Peyer's patches, goblet cells, villi, microvilli, enterocytes, lacteals, **Crypt of Lieberkuhn** Terminal part of lieum is dilated and known as **Sacculus rotundus in rabbit**				
Caecum	Comma shaped in equines Terminal part is known as **Vermiform appendix in rabbit** Fowl caecum is C/B **caecal tonsil**				
Colon	Wall of colon has bands (teniae coli) and sacculation in horse and pig				
Rectum	Rectum of **dog has Anal glands (anal sacs)** which are paired and secrete scent having offensive smell				
Note: from oesophagus to anus, wall is composed of 4 layers namely serous layer, muscular layer, submucosal layer and mucosal layer					

Histology of pancreas	
Exocrine part	**Endocrine part**
Consist of pancreatic acini which secrete pancreatic juice	Consist of islets of Langerhans (have 3 cells) • Alpha cells- secrete glucagon • Beta cells- secrete insulin • Delta cells- somatostatin

Differential diagnosis in digestive system

Cattle	Horse	Dog	Pig	Fowl
Hard palate ridges: 15-19	18	8-10	20. Rabbit- 15	Soft palate absent
Dental pad- present	Absent	Absent	absent	-
Muzzle- keratinous	Non-keratinous (Philtrum is present	-	-	-
Papilla salivalis situated at 5th cheek tooth	Papilla salivalis situated at 3rd cheek tooth	Papilla salivalis situated at 3rd cheek tooth	-	-
Torus linguae- present	ABSENT	Lyssa is present	absent	-
Teeth	Canine teeth is absent or vestigial	Well developed	Well developed	-
Teeth	Lophodont	Secodont	Bunodont	-
Formula: 0033/4133	**3133/3133**	**3142/3143**	**3143/3143**	**absent**
Shape of stomach-	J-shape	Pyriform shape	Human embryo shape	Spindle shape
Shape of pancreas- Quadrilateral	Triangular	V-shape	triangular	Long lobulated
Shape of spleen- Elliptical Goat- Oyster shell shaped	Triangular/Scythe shaped	Human foot print shape/ Sock shaped	Rabbit- spatula shaped	Round/ globular shape
Liver Lobe- 4	**3**	**5**	**5**	**2**
Liver Ligament- 5	**6** (Extra left lateral ligament)	**4**	**4**	**2**
Carancula sublingualis present behind 3rd incisor tooth	Carancula sublingualis present opposite to canine tooth	Carancula sublingualis present opposite to 1st cheek tooth	-	-
Foliate papillae- absent	Present	present	-	-
Circumvallate papillae no:- 10-16	2	7	-	-

Interlobular connective tissue is well developed in liver of pig
Papilla salivalis- a large papilla where there is opening of stenson's duct (parotid gland duct)
Caranculasublingualis (Barb)- structure on which mandibular gland opens (Wharton's duct open)
Round ligament of liver is known as ligamentum teres (absent in dog)
Spleen of horse, dog, pig- Stoarge type while in ruminants and cat- Non-storage type

Urinary System

Cattle	Horse	Dog	Pig
	Right kidney		
Location: ventral to last rib to 3rd LTP (lumbar transverse process)	Ventral to last 3 ribs to 1st LTP	Opposite to 1st three LTP	Below last four lumbar vertebrae
Hilus is situated on ventral surface	Hilus is situated on ventral surface	Hilus is situated on ventral surface	
Position- fix.	Fix	**variable**	

Shape: Bean shaped	**Heart shaped**	Bean shaped	Bean shaped
Left kidney			
Location: suspended by peritoneal fold below 3rd to 4th LTP	Not suspended- fix ventral to last rib to 3rd LTP	Ventral to 2nd , 3rd & 4th lumbar vertebrae	Below last four lumbar vertebrae
Hilus is situated on dorsal surface	Hilus is situated on ventral surface	Hilus is situated on ventral surface	
Position: **variable** according to stomach	**Fix**	**variable**	
Shape: Bean shaped	Bean shaped	Bean shaped	Bean shaped
Kidney lobulation and number of pyramids			
Lobulated (18-22) Number of lobes is equal to number of lobes	Non-lobulated **Renal Crest (area cribrosa)** is present instead of pyramid	Non-lobulated Only one pyramid is present (unipyramidal) Calyx minor- absent	Non-lobulated but number of pyramids are present
Goat- Non-lobulated (Only one pyramid is present-unipyramidal); Calyx minor- absent **Sheep-** Renal crest is present instead of pyramid			
Bladder is kept in position by 2 ligament namely Ventral ligament and lateral ligament (Round ligament- remnants of umbilical artery)			

Respiratory System

Cartilage of Larynx

Unpaired	Paired
• Cricoid- signet ring shaped • Thyroid- largest • Epiglottis- oblanceolate leaf shaped	• Arytenoid-pyramidal shaped • Corniculate- Horn shaped • Cuneiform- Bar shaped

Cattle	Horse	Dog	Pig
Cartilge Larynx- 4 type (total 5) Corniculate and cuneiform absent	Similar to man	Similar to man	
Fowl: Total 4 (Pre-cricoid, cricoid and 2 arytenoid)			
Lung: apical bronchus present in right lung and absent in left lung	Apical bronchus is absent	Apical bronchus is present in right lobe	
Right lung has 4 lobe and left lung has 3 lobe	Right lung has 4 lobe and left lung has 3 lobe	Right lung has 4 lobe and left lung has 3 lobe	Right lung has 4 lobe and left lung has **2 lobe**
Note: Cardiac impression is more deep in right lung but more wide in left lung			
Pleural sacs			
Do not communicate	communicate	communicate	
Air sac of fowl: there are **9 air sacs** (2 cervical; 2 cranial/anterior thoracic; 2 caudal/posterior thoracic; 2 abdominal; **1 clavicular**) to keep the body light Syrinx (vocal organ of birds) is situated at bifurcation of trachea Nutritional blood supply to lungs: bronchial artery Functional blood supply to lungs: pulmonary artery			

Male Genital System

	Bull	Stallion	Dog	Boar	Ram/Buck
Type of penis	Fibroelastic	Vasculomuscular	ospenis	Fibroelastic	Fibroelastic
Glans penis	Pointed	Urethral process **Urethral sinus** **Corona glandis** Present	Bulbus glandis and Longa glandis	Absent	Urethral process
Orientation of testis	Vertical	Horizontal	Oblique Cat-Vertical	Oblique	Vertical
Mediastinum testis	Present	**Absent**	Present	Present	Present
Sigmoid flexure	Present	**Absent**	**Absent**	Present	Present
Seminal vesicle	Lobulated	Non- Lobulated (pyriform like)	**Absent**	Lobulated	Lobulated
Cowpers gland	Present	Present	**Absent**	Present	Present

- **Preputial diverticulum is present in pig** above orifice of prepuce
- Colliculus seminalis (verumontanum): small elongated eminence at wall of urethra

Female Genital System

Species	Cow	Sheep/goat	Mare	Bitch	Sow
Comparison of reproductive tract					
Uterus type	Bicornuate	Bicornuate	Bipartite (T-shape)	Bicornuate (V-shaped)	Bicornuate
Endometrium	Caruncles	Caruncles	Longitudinal fold	absent	Longitudinal fold

Bitch and queen-uterus lies in abdominal cavity
Horn length highest in sow

Comparison of ovary					
More functional	Right	Right	Left		Left
Shape	Almond	Almond (bean) **Ovulation fossa**	Kidney	Oval **Ovarian bursa**	Berry

Ovary is divided into cortex and medulla but not in mare
Shape of pelvic cavity:

- **Elliptical-** Cow, ewe, sow
- **Round-** Mare
- **Oval-** Bitch
- Fornix absent in sow and prominent in mare
- Cervix is screw shape in sow and have annular folds
- **Suburethral diverticulum is present in cow** but absent in mare
- Retia ovarii is located in the medulla of ovary
- Primary follicles are evenly distributed in ruminants and sow and occur in cluster in bitch
- Graffian or tertiary follicles are characterized by presence of a central cavity (antrum) and Callexner bodies

Mammary gland

It is compound tubulo-alveolar gland of ectodermal origin and is modified sweat gland of apocrine type
The mammary gland is characterized by structure (from inner to outer): lobule-alveoli- alveolar duct-milk cistern (gland cistern/milk sinus)-teat cistern (teat sinus)- lactiferous duct (streak canal/teat canal)- opening of teat canal is termed as galactophore

The alveoli and duct system is characterized by presence of myo-epithelial or basket cells
Rosette of Furstenberg: longitudinal folds in lactiferous ducts
Tubercles of Montgomery are modified sebaceous gland surrounding base of teat during pregnancy and their secretions protect teat during suckling
Lactogenesis: initiation of milk secretion
Galactopoiesis: maintenance of milk secretion

Cow	4 mammary gland; only one lactiferous duct for each teat
Sheep/ goat	2 mammary gland; only one lactiferous duct for each teat
Mare	2 mammary gland; two lactiferous duct for each teat
Sow	10-12 mammary gland arranged in 5-6 pairs; two lactiferous duct for each teat
Bitch & cat	10 mammary gland arranged in 5 pairs (2 pair thoracic, 2 pair abdominal, 1 pair inguinal); multiple lactiferous duct for each teat; Lactiferous sinus is absent

Endocrine System

Pituitary gland

It is situated in the sella turcica of sphenoid bone and enclosed by diaphragm sellae and connected with the 3rd ventricle of the brain. It has two lobes: anterior lobe and posterior lobe
Rathke's pouch is a diverticulum from the embryonic buccal cavity from which the anterior lobe of pituitary gland develops

Anterior lobe (Adenohypophysis)	**Posterior lobe (Neurohypophysis)**
Has 3 important regions: 1. **Pars anterior (pars distalis):** characterized by presence of 3 type of cells b/o staining property • Acidophilic cells: secrete GH and prolactin • Basophilic cells: secrete FSH, TSH, LH, ACTH • Chromophobic cells 2. **Pars tuberalis** 3. **Pars Intermedia:** has basophilic cells which secrete MSH	**Pars nervosa** is main part of posterior lobe and is characterized by presence of herring bodies (nerve terminals), pitvicytes (glial cells)

Thyroid gland

- Thyroid is a bilobed structure connected by isthmus and located on cranial part of trachea
- Thyroid is endodermal in origin and composed of 2 cells namely (follicular cells- secrete thyroxine hormone) and parafollicular cells (secrete calcitonin hormone)
- **Colloid and C cells** are found in Thyroid gland

Parathyroid gland

- Parathyroid gland is small glandular structure and are 4 in number (two cranial and two caudal)
- They are located near thyroid gland and characterized by presence of **chief cells** which secrete paratharmone hormone (PTH) and **oxyphil cells** (oxyntic cells)
- **Only one pair in horse, pig, poultry**

Pineal gland (epiphysis cerebri/conarium)

- Pineal gland is characterized by presence of pinealocytes (secrete melatonin hormone)
- Ependymocytes are present in fowl
- Ependymocytes and hypendymocytes are present in Pineal Gland
- Brain sand (corpora arenacea) is not found in domestic animals and birds

Adrenal gland

Adrenal glands are 2 in number and divided into 2 part: adrenal cortex and adrenal medulla
Right gland is V shaped while left one is C shaped in cattle
Sheep, goat- both adrenals are bean shaped

Adrenal cortex	**Adrenal medulla**
Origin: mesodermal and divided in to 3 zones: • **Zona glomerulosa (arcuata)** –outer layer secretes mineralocorticoids (aldosterone)	Origin: ectodermal (from neural crest) & characterized by presence of **chromaffin cells (pheochromocytes)** which are modified post

• **Zona fasciculata (foamy appearance)**- middle layer- secrete glucocorticoids (cortisol) and sex steroids-DHEA • **Zona reticulate**	ganglionic sympathetic nerve fibres and secrete **adrenaline and nor-adrenaline hormone**

Skin

Skin is largest organ of body and consists of epidermis and dermis
Epidermis is characterised by 3 type of cells namely squamous cells, basal cells and melanocytes
Dermis layer (corium) characterised by blood vessels, lymph vessels, hair follicles, sweat gland, sebaceous glands, fibroblast, collagen bundles, nerve fibres
The epidermis has 5 layer: inside outward

Stratum basale (stratum germinativum)	Innermost layer C/B presence of **basal cells** (multiply and produce new cells), **melanocytes** and **Merkel cells** (tactile cells having neuroectodermal origin). This layer give wavy appearance in histological sections
Stratum spinosum (squamous cell layer)	Thickest layer of skin C/B presence of squamous cell or prickle cells (**keratinocytes**-produce keratin) and **Langerhans cells** (role in immune system)
Stratum granulosum	Cells of this layer contain keratohyaline granules
Stratum lucidum	Thinnest layer (absent in thin skin) and cells of this layer has eleidin
Stratum corneum	Outermost layer C/B dead keratinocytes

Dermis has two layer namely papillary layer (superficial) and reticular layer (dep layer)

EAR

External ear

Pinna is C/B 3 cartilage:
- Annular cartilage
- Conchal cartilage
- Annular cartilage

External auditory meatus (canal): tube like structure that connects pinna to middle ear
Tympanic membrane **(ear drum):** membrane separate external and middle ear and composed of connective tissue covered with skin outside and mucus membrane inside

Middle ear (tympanic cavity)

Three bones are present in each ear
- Malleus (hammer shaped)
- Incus (anvil shaped)
- Stapes (Stirrup shaped): attached to oval window

Middle ear is connected to inner ear by 2 window:
- Oval window (vestibular window/ fenestra ovalis)
- Round window (cochlear window/fenestra rotundus)

Ventrally this cavity is connected to nasopharynx through Eustachian tube

Internal ear: has 2 parts

- Bony (osseus) labyrinth: present around membranous labyrinth
- Membranous labyrinth: highly coiled structure having cavity filled with endolymph (similar to ICF-intracellular fluid)
- Space between bony labyrinth and membranous labyrinth is filled with perilymph (similar to CSF-cerebrospinal fluid)
- **Phalangeal cells (Dieter's cell)** found in inner ear and support hair cells
- **Hensen's cells. Claudius cells and Boettcher cells** are found in organ of corti

Bony labyrinth (has 3 parts)	Membranous labyrinth
• **Vestibule** • **Cochlea (spiral/coiled canal):** basilar membrane divide canal into scala vestibule (ends at oval window) and scala tympani (ends at round window) and are connected by helicotrema Apex of cochlea is termed as **cupola**	Otolith organ (**Utricle & saccule**): utricle is larger than saccule and has projecting ridge termed as macula Utricle is ballon like structure filled with endolymph

Space within cochlea is termed as scala media • **3 Semicircular canals:** terminal part of canals are swollen and termed as ampulla having sensory structure- crista ampullaris (has hair cells)	**Organ of corti (hearing organ):** situated on basilar membrane and C/B presence of **Hair cells** (auditory receptor), tectorial membrane (above haircells), spiral ganglion and Reissner's membrane
Vestibular apparatus of ear **(balancing organ):** consist of semicircular canals & otolith organ	

EYE

Eye ball (consists of 3 coats)

Fibrous coat (mesodermal origin)	Vascular coat (mesodermal origin)	Nervous coat (ectodermal origin)
Outermost layer	**Middle layer (uvea)**	**Innermost layer (retina)**
It is divided into 2 parts: • **Sclera (whites of eye):** C/B presence of suprachoroid lamina, scleral spur • **Cornea:** transparent layer C/B presence of Bowman's membrane, substantia propria, Decemet's membrane Junction of cornea & sclera is termed as corneo-scleral junction (limbus) Canal of Sclemn (sclera-venous sinus) is present at limbus	Divided into 3 parts: • **Choroid:** tapetum is present in this layer • **Ciliary body:** C/B presence of ciliary process and ciliary muscles • **Iris:** gives colour to eye 7 C/B presence of central aperture termed as pupil	Retina is C/B presence of ora serrata, macula lutea (yellow spot), fovea centralis (depressed area on mucula lutea) Histologically retina is composed of 10 layers in which Bruch's membrane, **Muller cells** (glial cells-present in outer external layer), **amacrine cells** & horizontal cells (present in outer plexiform layer) and most important **rod and cone cells (modified neurons)** Rod cells has pigment Rhodopsin (responsible for night vision) Cone cells has pigment Iodopsin (responsible day light vision)

Lens	Biconvex, transparent and connected to ciliary muscles by suspensory ligament (Zonula of Zinn)
Aqueous humour	It is secreted by ciliary body and occupies anterior and posterior chamber of eye (space in front of iris and lens). It resembles blood plasma in composition
Vitreous humour	Viscous fluid between lens and retina and viscosity is due to vitrin protein and hylaocytes and coverd by hyaloid mebrane. Hyaloid canal is present in vitreous humour in embryonic life
Blind spot	Situated at posterior side of eye ball from which optic nerves arises
Pecten	Vascular network present at blind spot only in fowl
Nicitating membrane	Also known as third eyelid, present at medial angle of eye. Harderian's gland is situated near nicitationg membrane
Nerve supply to eye	Superior oblique muscles by trochlear (4^{th}) cranial nerve Posterior and external rectus by Abducent (6^{th}) cranial nerve Rest muscles by 3^{rd} cranial nerve
Two operation related to eye ball	Enucleation: eyeball is removed Extirpation- eye ball, extraocular muscles and orbital fat is removed

Chapter-27

Veterinary Angiology and Neurology

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Circulatory system

Artery	Vein
Blood vessels carrying blood away from heart are known as arteries	Blood vessels carrying blood toward heart are known as veins
They carry oxygenated blood except pulmonary artery	They carry deoxygenated blood except pulmonary vein
Generally Deep seated	Generally Superficial
Lumen of artery is narrow	Lumen of vein is wider
Wall of artery is thick	Wall of vein is thin
They do not have valve	They have valve to prevent backflow of blood as pressure of blood is lesser in vein

The wall of artery or vein is composed of 3 layer:

- Tunica adventitia or tunica externa
- Tunica media
- Tunica intima

Heart

Heart is enclosed in pericardium (membrane or sac that surrounds heart) having parietal and visceral layer

The heart wall is composed of 3 layers:

- **Epicardium (visceral layer of pericardium):** space between parietal and visceral layer is filled with pericardial fluid which protect hear from any shock, jerks and keep heart in its position.
- **Myocardium:** muscular layer composed of cardiac muscles
- **Endocardium:**

Heart consist of 4 chamber

Left atrium	• Receive oxygenated blood from 4 pulmonary veins, pectinate muscles are less in number • The left atrioventricular opening is guarded by **bicuspid valve**
Left ventricle	• Thickest of all 4 chambers Chordae tendineae are muscular thread like structure running between bicuspid and tricuspid valve to papillary muscles • The apex of heart is made by left ventricle only • Trabeculae carneae (column carneae/ meaty ridges/papillary muscles) are muscular columns project from **inner surface of right and left ventricle of heart** • **Moderator band** (septomarginal trabecula-very prominent is sheep)-muscular band extend from anterior papillary muscle to ventricular septum • **Aorta (largest artery in body) originate from left ventricle and guarded by semilunar valves**

Right atrium	• It is smaller than left atrium and characterized by presence of **Sinu-Atrial node (SA node), atrioventricular node (AV node),** coronary sinus (coronary veins opens at coronary sinus- opening is guarded by **Thebesian valve**), fossa ovalis and musculi pectinati/ pectinate muscles (parallel muscular ridges in wall of atrium)
Right ventricle	• The right atrioventricular opening is guarded by **tricuspid valve (mitral valves)** • Pulmonary artery originates from conus arteriosus of right ventricle and guarded by semilunar valve • Chordae tendineae, column carneae are similar to left ventricle

Location of heart in domestic animals and fowl				
Cattle	**Horse**	**Dog**	**Pig**	**Fowl**
3rd to 6th intercostal space	2nd to 6th ICS	3rd to 6th ICS		Cranial part of thoracoabdominal cavity

Working of heart

The wave of contraction starting from **SA node** (PACE MAKER) spread to entire wall of atrium and received by **AV node** (PACE SETTER) through special muscle bundle (bundle of Bachmann, bundle of Wenchback and bundle of Thoral) and then transmitted to **Bundle of His** and again transmitted to **Purkinje fibres** (located in inner wall of ventricles) that enables heart to contract in coordinated fashion.

Distribution of blood to organs via artery (Arterial system)

Aorta emerge from left ventricle having oxygenated blood and bifurcate at level of 4th rib into ascending aorta (brachiocephalic trunk) and descending aorta.

Ascending aorta (brachiocephalic trunk)

Brachiocephalic trunk detaches left axillary artery (subclavian artery), right axillary artery and continues as common carotid artery and then again divide into right and left common carotid artery and at level of larynx again divide into external and internal carotid artery

Internal carotid artery	**External carotid artery**
Enters into cranial cavity	Continues as facial artery, lingual artery, lacrimal artery, corneal artery and maxillary artery

Left axillary artery (subclavian artery) while running in thorax termed as intrathoracic artery and leave as extrathoracic (axillary) artery

• **intrathoracic artery:** it detaches as intercostal artery • vertebral artery	**Extra-thoracic (axillary) artery:** it detaches as • Subscapular artery • Brachial artery • Common interosseous artery • Radial artery • Ulnar artery

Descending aorta

It continues as thoracic aorta and abdominal aorta

Thoracic aorta: it detaches as

- Bronchial artery
- Oesophageal artery
- Intercostal artery
- Phrenic artery

Abdominal aorta: it detaches as

Celiac artery: it detaches as • Splenic artery • Right and left ruminal artery • Omaso-abomasal artery (left gastric)	• Renal artery • Cranial mesenteric artery • Left and right testicular or ovarian artery

• Hepatic artery: it detaches as ➢ Pancreatic artery ➢ Cystic artery ➢ Right and left hepatic artery ➢ Gastro-duodenal artery	• Lumbar artery • Caudal mesenteric artery

At last abdominal aorta divide into 2 external and **2 internal iliac arteries** and **continues as median sacral artery**
Median sacral artery (ABSENT IN HORSE)
External iliac artery: continue as Femoral artery-Popliteal artery (below stifle joint)-Cranial tibial artery-Dorsal pedal artery in succeeding order

External iliac artery (to hindlimb): continue as	**Internal iliac artery**
• Deep circumflex iliac artery • Deep femoral artery: it detaches as ➢ Median circumflex femoral artery ➢ Pudendo-epigastric artery: it detaches as ✓ External pudendal artery: to scrotum, prepuce in male and mammary gland in female ✓ Posterior pudendal artery • Lateral circumflex femoral artery • Saphenous artery • Caudal femoral artery • Popliteal artery • Cranial tibial artery • Dorsal pedal artery • Dorsal metatarsal artery • Dorsal common digital artery	• Umbilical artery: to urater, bladder, uterus (as middle uterine artery), vasa deferens • Cranial and caudal gluteal artery • Urogenital artery: to urethra, seminal vesicle, uterus (caudal uterine artery) • Obturator artery • Internal pudendal artery: penis, rectum, vagina, vestibule, vulva

Collection of blood from organs via vein (Venous system)

Internal jugular vein collect blood from cranial cavity while external jugular vein collect blood from superficial aspect of head and neck and join together to form cranial vena cava
Cranial and caudal mesenteric vein, and right and left ruminal vein to form portal vein (contain digested nutrients) which ultimately enter into liver join with hepatic vein to open into caudal vena cava.
Vena azygous- large unpaired vein receive blood from dorsal wall of left side of thoracic and abdominal region and open independently to heart

Pampiniform plexus

The coiling of testicular vein over testicular artery is termed pampiniform plexus. It befins in scrotum with veins arising from mediastinum testes. It helps to regulate temperature of testes by acting as heat exchange mechanism.

Lymphatic system

- Lymphatic system consists of lymphatic vessels, lymph nodes, lymph and act as filter against microbes, toxins and other waste material.
- The thymus, spleen and tonsils are also part of lymphatic system
- Lymphatic vessels are similar to veins and capillaries but have more valves than veins
- Lymphatic vessels are connected to lymph nodes where the lymph is filtered

- Lymph is colourless and clear fluid made up of white blood cells mainly lymphocytes and macrophages
- Lymph capillaries take up lymph and flow slowly through lymph vessel and finally conveyed to venous system and on the way, lymph is filtered through spleen thymus and lymph nodes
- **Cisterna chyli (receptaculum chyli):** is a sac like structure located at the origin of thoracic duct. It is reservoir of lymph and formed by union of lumbar and gastrointestinal lymphatic trunks.
- Thoracic duct: is main and largest lymphatic vessel and collect lymph from all body parts except right side of head, neck, thorax and right forelimb and conveyed lymph to venous system

Lymph Node

- Lymph nodes are small, round or bean shaped cluster of cells located in many parts of body
- Lymph nodes are covered by fibrous capsule and divided into lobules or nodules
- Each lobule is marked by outer cortex (centre of inactivated B cells) followed by paracortex and inner most medulla layer (having germinal centre-centre of activated B cells)
- T cells are also found in inter-follicular zone of lymph node

Thymus

- Thymus is bilobed lobular organ derived from 3rd pharyngeal pouch with central isthmus
- Each lobule consists of follicle which is divided into cortex and medulla.
- The cortex is composed of mature T lymphocytes while medulla has different cells- reticular cells termed as **Hassall's corpuscles**, secretary epithelial cells, **Kulchitsky cells** and fewer T lymphocytes

Spleen

- Spleen is surrounded by dense connective tissue capsule. Trabeculae subdivide organ.
- The spleen is mainly composed of white pulp, red pulp and marginal zone (between red pulp and white pulp- devoid of sinusoids)
- White pulp: Lymphoid nodules along with dense lymphoid tissue surrounding central arterioles called periarterial lymphatic sheath (PALS)
- Red pulp: consist of sinusoids and cord of Billroth (splenic cords)
- **Spleen of horse, dog, pig- Storage type while in ruminants and cat- Non-storage type**
- **Accessory spleen is found in fowl**

Nervous system

Central Nervous System		**Peripheral Nervous System**		
Brain	Spinal cord	Cranial nerve	Spinal nerve	Autonomic nervous system

Brain

Forebrain (Prosencephalon)		**Midbrain (Mesencephalon)**	**Hindbrain (Rhombencephalon)**	
Telecephlon: Cerebrum Olfactory lobe	**Diencephalon:** Pituitary gland Pineal body Thalami	Crura cerebri (cerebral peduncle) Optic lobe Corpora quadrigemina	**Metencephlon:** Cerebellum (arbor vitae) Pons varolli	**Myelencephalon** Medulla oblongata
Cerebrum	Largest and most developed part of brain and made of two cerebral hemispheres connected by **corpus callosum** (corpus callosum has **genu**- anterior part and **splenium**- posterior part) Surface of brain has elevation **(gyri)** and depression **(sulci)**			

	Basal nucleus (basal ganglia)-bundle of grey nerve fibre but present in white matter region and consist of Corpora strata, amygdala and claustrum
Corpora Quadrigemina	Also known as colliculi and are 4 in number (2 superior and 2 inferior)
Crura cerebri	Has 2 nerve tract that connect forebrain to hindbrain and C/B presence of structure like substantia niagra, crus cerebri and reed nucleus
Cerebellum	Also k/a Arbor vitae (Tree of life) and C/B presence of mossy fibres, climbing fibres, nucleus fastigii, nucleus dentatus, nucleus globosus, nucleus emboliformis, corpus restiforme, brachium conjuntivum, brachium pontis The cerebellar cortex has various cells namely: golgi cells, granule cells, Purkinje cells, basket cells, stellate cells, molecular cells.
Medulla oblongata	C/B presence of structure like restiform body, Olivary body, corpus trapezoidum

Blood supply to Brain

Blood to brain is supplied by:

- **Rete mirabile cerebri** (vascular network made by branches of vertebral artery, occipital artery and maxillary artery)
- **Circle of Willis (circular arteriosus):** anastomosis of arteries (anterior cerebral artery and basilar artery) at base of brain

Grey matter and white matter of brain

Grey matter: neuron without myelin sheath are termed as non-myelinated or non-medullated fibres form grey matter of CNS	**White matter:** neuron with myelin sheath are termed as myelinated or medullated fibres form white matter of CNS 3 types: • Projection fibres (corona radiata) • Association fibres • Commissural fibres (corpus callosum)

Spinal cord

Tubular structure extends from medulla oblongata to middle of sacrum.
Conus medularis: Last part of spinal cord
Filum terminale: extension of piamater from conus medularis to first coccygeal vertebrae
Cauda equine (pony tail): structure composed of filum terminale and few spinal nerves

Grey matter of spinal cord	White matter of spinal cord
• Grey matter is centrally located and ventricles continue as central canal (lined by ependymal cells) in grey matter • Grey matter give shape of butterfly or H in its cross section view • The grey commissures divide grey mater into dorsal horn (motor nerve cells), ventral horn (sensory nerve cells) and lateral horn (autonomic nerve cells)	The white matter composed of modulated nerve fibre which are arranged in 3 columns (funiculi/tracts) • Sensory or ascending tracts • Motor or descending tracts • Intersegmental tracts

Meninges

Space between duramater and peripheral bone is epidural space (absent in brain but present in spinal cord)

Duramater	Arachnoid mater	Piamater
Outer tough fibrous layer made of inelastic collagen fibre Part of duramater divides brain into compartments: • **Falx cerebri:** differentaiate both cerebral hemisphere	• Middle and vascular layer • Space B/W piamater & subarachnoid space is termed as	• Innermost and most vascular • **Tela choroidea** is thin membrane formed by piamater and ependymal layer of 4th ventricle

• **Falx cerebelli:** differentaiate both cerebellar hemisphere • **Tentorium cerebelli:** differentaiate both cerebrum & cerebellum Space B/W duramater & subarachnoid space is termed as subdural space	subarachnoid space (filled with CSF)	• Blood capillaries form **choroid plexus (plica choroidea)** having secretary nature and produce CSF **Denticulate ligament:** extension of piamater that anchor spinal cord to duramater

Ventricles of brain

Cavity of brain is termed as ventricles and continue as central canal in spinal cord

2 lateral ventricles (paracoel) One in each cerebral hemisphere and separated from each other by **septum pellucidum** These 2 connect with 3rd ventricle and with each other by **Foramen of monro (interventricular septum)**	**3rd Ventricle** (Diocoel) and **4th Ventricle** (metacoel) by **Aqueduct of Sylvius (Iter/ cerebral aqueduct)** 4th ventricle is connected to sub arachnoid space by **Foramen of Luschka and Foramen of Magendie**

Structure of Neuron (Nerve cell)

The structural and functional unit of nervous system is termed as neuron

Cell body (cyton/ soma/perikaryon)	• Cytoplasm (axoplasm) of cell body has characteristics basophilic Nissl's granules (tigroid or chromatophilic substances having ribosomes and rough endoplasmic reticulm), neurofibril, large nucleus but centrioles are absent • Neurofibril is present in all part of neurons and maintain cytoskeleton • Axon hillock is present in cell body from which axon arises
Dendrites	Are processes which convey impulse toward cell body
Axon (fibres)	• Are processes which convey impulse away from cell body • Terminal part of axon is termed as presynaptic knob • Some axon is surrounded by discontinuous myelin sheath (myelin sheath is formed by **Schwann cells in PNS** (peripheral nervous system) and by **oligodendrocytes in CNS** (central nervous system) • The gap between myelin sheath is termed as Node of Ranvier • Myelin sheath is made of sphingolipid (lipid and protein) • **Endoneurium (Endoneurial sheath or tube/ Henle's sheath/Key Retzius):** layer of connective tissue around myelin sheath in PNS • Neurilemma: outermost layer of Schwann cell present below endoneurium

Tract: collection of nerve fibre in CNS
Nerve: collection of nerve fibre in PNS
Ganglia: group of cell body in PNS
Nucleus: group of cell body in CNS

Neuroglia

Non-neuronal cells in central nervous system that form supporting structure for neurons and provide them with insulation, nutrition, also form blood brain barrier.

Neuroglia of CNS	Neuroglia of PNS
• **Microglia** (mesodermal origin): phagocytic in nature • **Astrocytes:** star shaped cells- has role in nutrition and blood brain barrier and C/B large number of protoplasmic process	• **Schwann cells** (neurolemmocytes): form myelin sheath in PNS • Satellite glial cells

• **Oligodendrocytes:** form myelin sheath in CNS	• Ependymal cells

Cranial nerves

Cranial nerve (12 pair)	Origin	Nature
1. Olfactory nerve	Forebrain	Sensory
2. Optic nerve	Forebrain	Sensory
3. Occulomotor nerve	Forebrain	Motor
4. Trochlear nerve **(thinnest and smallest)**	Forebrain	Motor
5. Trigeminal nerve: **(largest cranial nerve)** C/B **Gasserian or semilunar ganglion** 3 nerve branches: • Opthalmic nerve (sensory) • Maxillary nerve (sensory)- largest among 3 • Mandibular nerve (mixed)	Midbrain	Mixed
6. Abducens nerve	Midbrain	Motor
7. Facial nerve (C/B **Geniculate ganglion)**	Midbrain	Mixed
8. Auditory nerve (Acoustic/ Vestibulo-cochlear nerve) C/B **spiral and vestibular ganglion**	Midbrain	Sensory
9. Glossopharyngeal nerve **(C/B proximal & distal ganglion)**	Hindbrain	Mixed
10. Vagus nerve/ Pneumogastric nerve **(longest nerve) C/B Jugular ganglion**	Hindbrain	Mixed
11. Spinal accessory Nerve	Hindbrain	Motor
12. Hypoglossal nerve	Hindbrain	Motor

3 nerve branches of trigeminal nerve

Opthalmic nerve (sensory) It detaches as	**Maxillary nerve (sensory)** It detaches as	**Mandibular nerve (mixed)** It detaches as:
• Zygomaticotemporal nerve • Corneal nerve • Lacrimal nerve • Frontal nerve • Ethmoid nerve • Infratrochlear nerve	• Zygomaticofacial nerve • Anterior & posterior palatine	• Pterygoid nerve • Buccal nerve • Masseteric nerve • Superficial temporal • Lingual nerve

Nerve branches of vagus nerve

Cervical branches	Thoracic branches
• Auricular nerve • Pharyngeal nerve • Oesophageal nerve • Aortic nerve	• Recurrent laryngeal nerve • Cardiac nerve • Pulmonary nerve

Spinal nerves

	Cattle	Horse	Dog	Pig	Fowl
Cervical	8	8	8	8	15
Thoracic	13	18	13	15	7
Lumbar	6	6	7	6-7	L+S=14
Sacral	5	5	3	4	
Coccygeal	5	5	4	5	
Total	**37 pair**	**42 pair**	**35 pair**	**39 pairs**	**36 pairs**

Spinal nerves

- Spinal nerves are always paired and always will be of mixed (sensory as well as motor) nature and connected to spinal cord
- They originate by 2 root (dorsal and ventral root) and unite to form common nerve trunk which will again divide into dorsal ramus and ventral ramus (largest and thickest)
- The dorsal root is connected to dorsal horn of spinal cord and is sensory in function while ventral root is connected to ventral horn and is motor in function
- Spinal nerves form various plexus

Brachial plexus

Formed by 6th, 7th & 8th cervical and 1st, 2nd thoracic spinal nerves

Nerves of brachial plexus are:

- Lateral (external) thoracic nerve
- Thoraco-dorsal nerve
- Pectoral nerve
- Long thoracic nerve
- Subscapular nerve
- Suprascapular nerve
- Axillary nerve
- Teres major nerve
- Musculocutaneous nerve
- Radial nerve: **largest nerve in brachial plexus**
- Ulnar nerve
- Median nerve

Lumbosacral plexus

Formed by 4th, 5th, 6th lumbar and 1st 2nd sacral spinal nerves

Nerves of lumbar plexus are:

- Lateral cutaneous nerve
- Femoral nerve
- Obturator nerve
- Internal saphenous nerve
- Obturator nerve

Nerves of lumber plexus are:

- Cranial gluteal nerve
- Ischiatic nerve (**largest nerve in body**): detaches as
  - External saphenous (caudal cutaneous) nerve
  - External popliteal (Peroneal) nerve
  - Tibial nerve
- Pudendal nerve: detaches as
  - Pelvic nerve
  - Proximal & distal cutaneous nerve
  - Deep perineal nerve

Autonomic Nervous System

ANS is component of peripheral nervous system which regulates mainly involuntary physiological processes like heart rate, blood pressure, respiration, digestion and sexual activities and nerve fibre is divided into 2 parts:

- **Pre-ganglionic motor nerve fibres:** shorter in SNS and longer in PSNS. They are always medullated and terminate into autonomic ganglia (relay centre) close to CNS and form 1st synapses (always secrete acetylcholine)
- **Post-ganglionic motor nerve fibres:** longer in SNS and shorter in PSNS. They are always non-medullated and terminate into viscera and form 2nd synapses (secrete Nor-adrenaline in SNS and Acetyl choline in PSNS)

Sympathetic nervous system (SNS)	Parasympathetic nervous system (PSNS)
Ganglion in SNS: • Sympathetic ganglion • Coeliac ganglion • Superior mesenteric ganglion • Inferior mesenteric ganglion	Ganglion in PSNS: • Otic ganglion • Pterygo palatine ganglion • Sub-mandibular ganglion • Ciliary ganglion
Thoraco-lumbar in origin	Craniosacral in origin (cranial nerves and sacral spinal nerves)
Prepares body for emergency or stressful situations	Work during ordinary situation
Pupil- dilate	Constrict
Ciliary muscle- relax	Contract
Trachea, brochi- dilate	Normal

Penis- ejaculation	Erection
Urinary bladder muscle- relax	Contract
Urinary bladder-trigone- contract	Relax

Chapter-28

Developmental Anatomy

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- Embryology is the study of formation and development of an embryo and foetus
- Von Baer is the father of modern embryology
- Teratology- study of birth defects (congenital abnormalities and abnormal formations) and teratogens

Type of eggs			
On the basis of yolk distribution		**On basis of yolk content**	
Egg	**Species**	**Egg**	**Species**
Isolecithal	Human, marsupials	**Microlecithal**	Mammals
Centrolecithal	Insects	**Mesolecithal**	Amphibians
Telolecithal	Amphibians, fishes, birds and reptiles	**Megalecithal**	Reptiles and birds

Type of cleavage	
Holoblastic equal	Mammals, amphioxus
Holoblastic unequal	Amphibians and lower fishes
Meroblastic equal	Reptiles, birds and higher fishes
Meroblastic superficial	Insects
Cell division without growth is called Cleavage Cleavage is inversely proportional to amount of yolk	

Implantation time	
Cattle	17-35 days
Horse	17-36 days
Dog	14-18 days
Pig	12-16 days
Rabbit	7-8 days
Implantation in ruminants is superficial & Non-invasive while in rodent, primate, pig is Invasive (with the help of proteolytic action)	

Type of placenta			
On the basis of maternal tissue lost at birth time	**On the basis of villi distribution**	**On the basis of histology**	**Animals**
Non-deciduate	**Cotyledonary**	Syndesmochorial	**Ruminants**
Non-deciduate	**Diffuse**	Epitheliochorial	**Mare, sow, camel**

Deciduate	**Zonary**	Endotheliochorial	**Canine and felines**
Deciduate	**Discoidal**	haemochorial	**Human, monkey, rodents**

- Haemotroph is the nutrient source for embryo from maternal blood and the histotroph is the nutrient source for embryo from maternal tissue
- Foetal membrane
  - Yolk sac
  - Amnion
  - Chorion
  - Allantois

Stages of prenatal life		
Period of ovum	**Period of embryo**	**Period of foetus**
Fertilization to 2 weeks	3rd week to 8th week (2 month)	From 3rd month to end of gestation

Differentiation of inner cell mass (embryoblast/Embryonic knob)			
Epiblast (embryonic disc/germ disc)			**Hypoblast**
Surface layer of epiblast form ectoderm	Caudal part form mesoderm	Middle part form primitive streak (Hensen's node/ presumptive notochord)- appearance of blastopore (primitive pit)- notochord canal- notochordal plate- definitive notochord- vertebral column	Hypoblast form endoderm

Fate of germ cells		
Ectoderm	**Mesoderm**	**Endoderm**
Skin- epidermis	Dermis	-
Teeth- Enamel	Dentine	-
Hoof, hair, horn, nail	Connective tissue	-
External & Internal ear		Middle ear, Eustachian tube
Mouth tongue palate	Spleen	Digestive system, liver, pancreas
Sweat gland Sebaceous gland Salivary gland Mammary gland	Skeletal system Blood vessels Lymphatic system Cardiovascular system	germ cells, caudal vagina, vulva, vestibule, urethra and associated gland
Nervous system	Uro-genital system	Urinary bladder
Eyes- lens, retina, iris muscles, conjunctiva	Sclera, choroid, cornea	
Pituitary gland		Thyroid gland Parathyroid gland

Foetal circulation

- Through foramen ovale maximum blood passes from right atrium to the left atrium
- Left Umbilical vein joins the portal vein, hepatic vein and finally opens into the abdominal vena cava through ductus venosus
- In foetal circulation the blood from right ventricle goes into the descending aorta through Ductus arteriosus
- Ductus arteriosus becomes occluded at birth and in adult it persists as ligamentum arteriosum

Pronephric kidney	Mesonephric kidney	Metanephric kidney
Some fishes	Most of the fishes and amphibians	Reptiles birds and mammals

- After cleavage, Morula is formed having 16- 32 cells with mulberry appearance
- Teratology is the study of abnormalities resulting from extrinsic and intrinsic factors.
- Blastula has blastocoels cavity
- **Gastrula** has archenteron cavity and the opening of archenteron is blastopore
- Gastrulation in **mammal is by delamination** and **in chick by involution**
- Meckel's cartilage gives rise to the malleus and incus and Reichert's cartilage forms stapes of middle ear
- Membranous labyrinth is derived from the otocyst
- **Adrenal medulla** develops from neural crest cells and cortex develops from mesoderm
- Urachus connects future urinary bladder with the large allantoic cavity
- Nucleus pulposus is remnant of notochord present in intervertebral disc
- Umbilical cord consists of 2 umbilival arteries, 1 umbilical artery, duct of yolk sac and distal part of allantoic diverticulum. Umbilical cord is surrounded by Wharton's jelly
- Umbilical vein transform into ligamentum teres of liver
- Apodia-absence of posterior limbs
- Amelia-absence of limbs
- Agnathia-absence of lower jaw
- Abrachia-absence of forelimb
- Rachischisis- cleft spine
- Schistorrhachis-cleft in lower vertebral column (spina bifida)

Differentiation of pharyngeal pouch	
1st pharyngeal pouch	Form Eustachian tube, tympanic cavity of middle ear
2nd pouch	Palatine, tonsil
3rd, 4th & 5th pouch	Form parathyroid, thyroid, thymus, tongue

Primordium	
Primordium: is an organ or tissue in its earliest recognizable stage of development	
Primordium	**Developed organ/tissue**
Tuberculum impair	Tongue
Septum transversum	Diaphragm

Epithelium	Occurrence
Simple squamous epithelium	**Mesothelium**: pleura, pericardium and peritoneum. **Endothelium**: lining of heart, blood and lymph and vessels. **Mesenchyma**: lining of subdural and subarachnoid space and anterior chamber of eye. The thin limb of Henle's loop in the kidney Inner surface of tympanic membrane and of membranes of labyrinth of ear
Simple cuboidal	Choroid plexus, germinal epithelium, ducts of glands, collecting ducts of kidney, lining of thyroid follicle, ciliary body of eye
Simple columnar	Glandular mucosa of stomach, small and large intestine, gall bladder, bulbourethral gland and oviduct.
Stratified squamous	Keratinized skin and lip, tongue, oesophagus of ruminants and horse, reticulum, omasum, rumen and cornea.

Stratified cuboidal	Excretory duct of salivary gland, pancreas
Stratified columnar	Distal urethra, conjunctiva, lacrimal sac and duct.
Pseudostratified columnar	Nasal cavity, nasopharynx, trachea with cilia, large bronchioles, epididymis and ductus deference.
Transitional (urothelium)	Excretory passage of urinary system (renal pelvis, calices, ureter, urinary bladder and urethra
Sensory epithelium	Retina, olfactory epithelium, taste bus and internal ear.

Dominant X-linked diseases	Recessive X-linked	Autosomal dominant	Autosomal recessive
Vitamin D resistant rickets (X-linked hypophosphatemia)	• Haemophilia A & B • Colourblindness • Duchenn & Becker muscular dystrophy • X-linked Ichthyosis • X-linked agammaglobulinemia • Glucose-6-phosphate dehydrogenase deficiency (Favism)	• Myotonic dystrophy • Familial hypercholesterimia • Von Willebrand disease • Hereditary sphercytosis • Marfan syndrome • ABO blood group	• Sickle cell anemia • Phenylketonuria • Lysosomal storage disease

Monster (malformed foetus)		
Anterior twinning	**Posterior twinning**	**Complete twinning**
• Dicephalous • Diprosopus • Ischiopagus • Pyopagus	• Dipygus • Cephalothoracopagus • Craniopagus	• Thoracopagus • Rachipagus • Prosopothoracopagus

Chapter-29

Veterinary Laboratory Diagnosis

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Type of microscopes	
Optical/Light microscope	**Electron microscope**
Two basic types: 1. **Simple microscope** (only one convex lens is used) 2. **Compound microscope** (More than one lens are used) **Alternatives** • Phase contrast microscope (for colourless and transparent samples) • Inverted microscope • Dark field microscope • Confocal microscope • Polarized microscope (isotropic samples) • Stereo microscope/ Dissecting microscope (give 3D view of samples) • Fluorescent microscope (uses UV light)	Lens is made up of magnetic coils (magnetic lens) • **Transmission Electron microscope-TEM** (traditional) Gives 2D view of samples • **Scanning Electron microscope-SEM** ➢ Use of secondary electrons ➢ Gives 3D view of samples but lower magnification than TEM **Scanning probe microscope:** use of probe for study of magnetic property of samples, nanoparticles study
Electron microscopy	
Preparation of tissue follows 5 main steps: fixation-dehydartion-embedding-sectioning-staining Fixation of tissues: by 2.5 % glutaraldehyde and Osmium tetraoxide Dehydration by use of ethanol or acetone Embedding by use of raisin termed as Raisinoid Staining- Uranyl acetate and lead citrate Magnification up to 10 lakh times	

Type of Microtomes	
Rotatory microtome	Most widely used microtome; tissue moves along stationary knife Knife is fixed in vertical position
Sledge/ sliding microtome	for cutting large blocks of paraffin and resin embedded tissue including whole organs
Cryostat (Cryotome/ freezing microtome)	For cutting frozen tissue Advantage- tissue require less preparation
Ultra-microtome	For cutting very thin sections (between 40 & 100 nm for TEM)
Rocking/Vibrating microtome (Vibratome)	Sections are cut by moving horizontal handle forward and backward

Common stain and their use	
Substance/Bacteria	**Stain**
Collagen fibre	Masson's trichome stain & Van Gieson trichome stain
Reticulin fibre	Silver nitrate stain
Melanin pigment	Fontana-Masson stain
Iron	Gomori's iron stain & Pearl's stain
Calcium	Vonkassa silver nitrate stain
Fat/lipids	Oil Red O, Sudan Black B, Osmium tetra oxide
Amyloid	Congo red, Methyl violet, Methyl green, Thionin, Crystal violet
Cytoplasmic granules	Luna's mast cell stain & Gomori's chromaffin stain
Metachromatic granules	Albert stain, Neisorr' stain, Ponder's stain
Glycogen	Best Carmine, PAS, Iodine
Negri bodies	Seller's stain, Triple shor stain, Parson stain
Uric acid crystals	De Gelentha Carmine stain
Bile pigment	Svain's stain
Mucin	Haematoxylin, Thionin, Mucicarmine, PAS, Alcian blue
Supravital staining	
It is a method of staining living cells that has been removed from body to study vital process The common supravital stain are- New Methylene Blue, Brilliant Cresyl Blue, Crystal violet (gentian violet), Methyl violet, Hoecht stain (DNA), Nile blue	
Immature RBC	**New Methylene Blue, Brilliant Cresyl Blue**

Type of media	
Basal media	These media do not require any additional nutrients, mainly used for growth of non-fastidious bacteria. eg. Nutrient agar, Nutrient broth, peptone water
Enriched media	Basal media is enriched by blood, serum or egg Eg. Blood agar, Chocolate agar (heated blood agar) Lowenstein-Jensen media
Enrichment media	Selenite broth, Tetrathionate broth Alkaline peptone water
Differential media (indicator media)	One indicator (dye or metallic substances) is used Eg. McConkey Lactose agar, Blood agar, TCBS agar, XLD agar (Samonella and Shigella)
Selective media	Media favour growth of particular organism by inhibiting growth of undesirable organism
Transport media	Cary Blair media (*Campylobacter spp.*)

Media on the basis of consistency		
Solid media Solid media is most commonly used media. Agar is commonly used as solidifying agent Mainly used to identify and characterize bacterial colony morphology Agar concentration: **1- 2.5 %**	**Semi-solid media** Agar concentration (0.5 % or less) Mainly used for determine bacterial motility • Stuart's media • Amies media	**Liquid media (broth)** Used for growing large number of bacteria • Nutrient broth • Selenite broth • Tetrathionate broth
Nutrient agar	Peptone+ beef/yeast extracts+2.5% agar+ NaCl	
Nutrient broth	Peptone+ beef/yeast extracts + NaCl	
Blood agar	General nutrients+5% sheep or horse blood Used as enriched as well as differential media	
McConkey Lactose agar	Peptone+lactose+bile salt+ NaCl+Neutral Red+Crystal violet+agar Crystal violet inhibit growth of Gram positive bacteria Used as selective as well as differential media	
Mueller-Hinton agar	Casein hydrosylate+ beef extracts+ Starch+agar+ NaCl	

	Used for antibiotic susceptibility testing
Lowenstein Jensen media	Malachite green+egg+glycerol+potato starch+L-Asparagine Glycerol promote growth of Mycobacterium tuberculosis Malachite green inhibit growth of other organism

Staining methods for bacteria	
Gram stain	Widely used for the routine staining of bacteria in smears. Gram-positive bacteria are stained blue by the crystal violet which is retained in their cell walls despite decolourization. In contrast, Gram-negative bacteria, which do not retain the crystal violet, are counterstained red
Giemsa	Useful for demonstrating *Dermatophilus congolensis,* Rickettsiae *spp.* and Borrelia *spp.*, which stain blue
Dilute carbol fuchsin	Especially useful for recognizing Campylobacter species and Fusobacterium species, which stain red
Polychrome methylene blue	Used for the identification of *Bacillus anthracis* in blood smears. The organisms stain blue with distinctive pink capsules
Ziehl–Neelsen stain	Hot concentrated carbol fuchsin which penetrates mycobacterial cell walls is retained after acid-alcohol decolourization. The red staining bacteria are described as acid-fast or Ziehl–Neelsen positive
Modified Ziehl–Neelsen stain	Unlike the Ziehl–Neelsen stain, this method employs dilute carbol fuchsin with decolourization by 0.5% acetic acid for 15 seconds. Eg- *Nocardia spp. Brucella spp.*

	Gram's staining	**Acid-fast staining**
Primary stain	Crystal violet	Carbol fuschin
Mordent	Iodine	Heat
Decolourizer	Acid alcohol	Acid alcohol
Counterstain	Saffranin	Methylene blue/Malachite green

Biochemical tests

IMViC tests

Group of 4 biochemical test namely Indole test, Methyl red test, Voges-Proskauer test and Citrate test and represented by IMViC pattern

Organism	**IMViC pattern**
E.coli/Shigella	+ + - -
Pasteurella multocida	+ - - -
Listeria/Klebsiella	- + + -
Salmonella/Proteus	- + - +
Streptococcus/Staphylococcus	- + + +

Other commonly used biochemical tests are:

- Catalase test
- Oxidase test
- Urease test
- Triple Sugar Iron (TSI) test
- Hippurate hydrolysis test
- Gelatin hydrolysis test
- Esculin hydrolysis test

Note:
- Brucella and Proteus gives Urease test positive but Salmonella is negative for Urease test
- Members of Enterobacteriacae family are Oxidase negative while member of Pasteurellaceae are oxidase positive

Binding tests		
Primary binding test (marker techniques)	**Secondary binding test**	**Tertiary binding test**
Binding of antigen and antibody is measure directly with help of labels like radioisotopes, fluorescent dyes or enzymes • IFA • Immunoperoxidase test • ELISA • RIA • Western blotting	Invitro measurement of antigen antibody interaction • Agglutination tests • Precipitation tests • HI • AGID • CFT • Serum neutralization test	Invivo tests • Neutralization assay

Immunoassays
- Counting immunoassay (CIA)
- Radio immunoassay (RIA)
- Chemiluminescence immunoassay (CLIA)
- Enzyme linked immunosorbent assay (ELISA) or Enzyme immunoassays (EIA)
- Fluoro immunoassay (FIA)

Type of ELISA	
Direct ELISA	ELISA plate is coated with antigen and conjugated antibody is added, then substrate is added (only one antibody is used hence less specific)
Indirect ELISA	ELISA plate is coated with antigen and unconjugated primary antibody is added; then conjugated antibody is added followed by substrate addition; used to measure endogenous antibodies
Sandwitch ELISA	Most commonly used ELISA with highest sensitivity and specificity; ELISA plate is coated with capture antibody and antigen is sand-witched between two antibodies
Competitive ELISA	Done to detect antigen concentration, too small molecules or hormones in sample; ELISA plate is coated with capture antibody: **conjugated antigen is used**

Cell culture	
Primary Cell culture	**Secondary cell culture (cell line)**
• Contain cells which are directly obtained from host tissue • Don't undergo cell proliferation • limited life span • Cannot be maintained by passaging • Little bit difficult • act as in-vivo model • Cells are heterogenous	• Cells obtained from primary cell culture • Undergo cell proliferation • Indefinite life span • Can be maintained by passaging • Easy to maintain • Act as in-vitro model • Cells are homogenous • Eg. HeLa cells, BAE-1, MRC-5, BHK21

Faecal examination (Microscopic method)		
Direct wet mount	**Concentration method**	
	Sedimentation method (For all type of parasitic eggs)	**Floatation method (mainly for nematode eggs)**

		Willi's methods (no centrifugation)	Lane's method (centrifugal floatation method)
Quantitative egg count technique			
• Stoll's dilution egg count technique • Mac-Master method			
Faecal culture			
• Watch glass or petridish method • Baermann's technique: mainly for non-migratory larva • Harada Mori method			

Chemical examination of urine	
Protein	Heller's ring test, Biuret test, Sulphosalicylic acid test
Glucose	Benedict's test
Bile pigment	Gmelin test & Pouchet test
Bile salts	Hay's sulphur flower test
Ketone bodies	Rothera test
Blood	Benzedine test
Characteristics shape of some uroliths/calculi in urine	
Dumbbell shape	Monohydrate form of clcium oxalate
Square shape	Dihydrate form of clcium oxalate
Hexagonal shape	Cystine calculi
Coffin lids	Struvite calculi (magnesium ammonium phosphate calculi/infectious/urease stone/triple phosphate stone)

Anticoagulants	
Anticoagulant	**purpose**
EDTA (1 mg/ml)	It preserves cellular morphology so it is used in routine haematology Excess EDTA lead to shrinkage of RBC, WBC and decreased PVC
Sodium citrate (1 mg/ml)	Blood transfusion
Sodium fluoride (10 mg/ml)	Glucose estimation
Sodium oxalate (2 mg/ml)	Prothrombin time
Heparin (0.1 mg/ml)	Arterial blood gas analysis

Hb estimation	**Total RBC count**	**WBC estimation**
Sahli's haemoglobinometer	Haemocytometer method	Haemocytometer method
Diluting fluid- N/10 HCl	Normal saline Hayem's saline Grower's solution	Turk's fluid N/10 HCL
ESR estimation: Wintrobe tube method and Westergren method **Platelet estimation:** Rees & Ecker diluting fluid **PCV estimation:** Wintrobe tube method		

Differential Leukocyte Count (DLC)	
Neutrophils	Multi-lobed nucleus Number increases in bacterial infection or inflammatory diseases
Lymphocytes	Condensed round nucleus

	Number increases in viral infection, after vaccination, leukemia, radiation therapy
Eosinophils	Bi-lobed nucleus Number increases in allergic reaction, parasitic infestation
Basophils	S shaped or dumb-bell shaped nucleus Number increases in chronic inflammation, allergy
Monocytes	Kidney shaped nucleus Number increases in all kind of infection and inflammatory diseases

Left Shift

Degenerative left shift: When absolute band cells (immature neutrophils) are greater than absolute mature neutrophil. It indicates severe inflammation usually due to bacterial infection, common in cattle in acute inflammation like mastitis, metritis etc.

Regenerative left shift: When absolute band cells are less than absolute mature neutrophil.

RBCs pathology

Anaemia

Anaemia is a condition in which number of red blood cells or haemoglobin concentration is lower than normal

Classification based on size of RBCs and amount of haemoglobin in each cell	
Normocytic normochromic anaemia	Seen in aplastic anaemia, haemorrhagic anaemia, chronic inflammation, Dyserythropoeisis, Hypothyroidism
Microcytic normochromic anaemia	Ionizing radiation
Microcytic hypochromic anaemia	Iron deficiency anaemia, Ancylostomiasis, Lead poisoning
Macrocytic hypochromic anaemia	Folic acid deficiency, Vitamin B12 deficiency, Cobalt deficiency

Classification based on response by bone marrow	
Regenerative anaemia	**Non-regenerative anaemia**
Bone marrow respond by increasing production of new red blood cells	Bone marrow does not respond adequately
Eg. Anaemia due to infection, toxicosis, trauma, immune system defect, haemorrhage, haemolysis	Eg. Anaemia caused by decrease in hormone production(erythropoietin), bone marrow abnormality, nutritional deficiency, kidney diseases
Measured by Reticulocyte Index	By Bone marrow examination
Blood picture is characterized by macrocytosis (increased MCV), nucleated RBCs i.e. immature erythrocytes stains blue (polychromasia), decreased MCHC	Blood picture is characterized by microcytosis (decreased MCV), normal MCHC
Reticulocyte Index No. of reticulocytes as the percentage of number of total RBCs	**Interpretation:** Less than 1: non-regenerative anaemia Between 2 & 3: haemorrhagic anaemia More than 3: haemolytic anaemia

Abnormalities in RBCs	
Poikilocytosis	**Change in shape of RBC**
Anisocytosis	**Change in size of RBC**
Leptocytes (Wafer cells/Target cells/Pessary cell/Annulocytes)	Are thin and flat erythrocytes with an increase in cell area, but no changes in cell volume. The wall is thrown into folds with haemoglobin at periphery

Spherocytes	Relatively smaller spherical RBCs which stain bright red and show no central pallor area. e.g. Hereditary spherocytosis, Haemolytic anaemias
Schistocytes	Are red cell fragments (fragmented RBCs)
Keratocyte	Half-moon shape/Helmet shape RBCs with spicules
Burr cells (Echinocyte)	Cells with one or more spiny projection (spikes) along its periphery.
Cigar cell/Pencil cell	pencil or cigar shaped RBCs
Drepanocyte (sickle cell/Meniscocyte)	Elongate crescent shaped RBCs with pointed ends
Acanthocytes (Thorny red cells/ Spur cells)	Are spherocytes with pseudopodia (spikes)
Heinz bodies (Heinz-Ehrlich bodies.	Are irregular round retractile bodies (denatured haemoglobin) Found in Glucose-6-phosphate dehydrogenase deficiency and thiosulphate poisoning
Howell-Jolly bodies	The nuclear remnants remain in the cytoplasm and appear as dark purple bodies
Pappenheimer bodies	RBCs are characterized by basophilic inclusions (iron aggregates)
Cabot ring	Bluish granules (thread like) which are nuclear remanant in RBC Eg. in lead poisoning
Basophilic stipling (Punctate basophilia)	RBCs are characterized by cytoplasmic basophilic granules (RNA/ribosomes) which is indicative of disturbed erythropoiesis It is noticed in anaplasmosis, Haemonchosis, Lead poisoning, heavy metal poisoning
Polychromasia (Polychromatophilic cells	Young RBCs (immature) recently released from bone marrow, larger than normal RBCs and are bluish in colour It is noticed in hemolysis, blood loss, bone marrow infiltration

Liver function test

- Vandenbergh test
- Icteric Index
- Glucose tolerance test
- Amino-acid tolerance test
- Protein estimation
  - Total protein
  - Total albumin and globulin
  - Prothrombin time
  - Turbidity or flocculation test
    - ✓ Thymol turbidity test
    - ✓ Zinc sulphate turbidity test
- Excretory function test
  - Bromosulphthlein clearance test
  - Indocyanin green test
  - Hippuric acid synthesis test
- Serum enzyme level
  - AST
  - ALT
  - ALP
  - GGT
- Liver biopsy
- Ultrasonography

Kidney function test

- GFR
- Creatinine clearance test
- Urine osmolality test
- Urine protein test
- Blood urine nitrogen
- Water deprivation test
- Volhard's concentration test

Pancreas function test

- Serum amylase
- Serum lipase
- Fat absorption
- Pancreatic chymotrypsin activity
- Pancreo-lauryl test
- Lundh test
- Secretin test
- Serum trypsin like immunoreactivity

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