Animal Science

Veterinary Anatomy and Physiology

Grade 9

Government of Nepal
Ministry of Education, Science and Technology
Curriculum Development Centre
Sanothimi, Bhaktapur
Phone : 5639122/6634373/6635046/6630088
Website- https://www.moecdc.gov.np
Email- info@moecdc.gov.np

Technical and Vocational Stream
Learning Resource Material

Veterinary Anatomy and Physiology

(Grade 9)

Animal Science

Government of Nepal
Ministry of Education, Science and Technology
Curriculum Development Centre
Sanothimi, Bhaktapur

Publisher: Government of Nepal
Ministry of Education, Science and Technology
Curriculum Development Centre
Sanothimi, Bhaktapur

Layout by Santosh Dahal

Preface

The curriculum and curricular materials have been developed and revised on a regular basis with the aim of making education objective-oriented, practical, relevant and job oriented. It is necessary to instill the feelings of nationalism, national integrity and democratic spirit in students and equip them with morality, discipline, self-reliance, creativity and thoughtfulness. It is essential to develop linguistic and mathematical skills, knowledge of science, information and communication technology, environment, health and population and life skills in students. It is also necessary to bring the feeling of preserving and promoting arts and aesthetics, humanistic norms, values and ideals. It has become the need of the present time to make them aware of respect for ethnicity, gender, disabilities, languages, religions, cultures, regional diversity, human rights and social values to make them capable of playing the role of responsible citizens with applied technical and vocational knowledge and skills. This learning resource material for Animal Science has been developed in line with the Secondary Level Animal Science Curriculum with an aim to facilitate the students in their study and learning on the subject by incorporating the recommendations and feedback obtained from various schools, workshops, seminars and interaction programs attended by teachers, students and parents.

In bringing out the learning resource material in this form, the contribution of the Director General of CDC Mr. Yubaraj Paudel and members of the subject committee Dr. Manraj Kolakshpati, Madhukumari Tiwari, Lavdev Bhatta is highly acknowledged. The learning resource material is written by Dr. Ganesh Gautam Dr. Shibalal Bhandari and Dr. Asis Mahat the subject matter of the materials, was edited by Mr. Badrinath Timsina and Mr. Khilanath Dhamala and language was edited by Mr. Narendra Raj Bogati. CDC extends sincere thanks to all those who have contributed to developing this material in this form.

This learning resource material contains a wide coverage of subject matters and sample exercises which will help the learners to achieve the competencies and learning outcomes set in the curriculum. Each chapter in the material clearly and concisely deals with the subject matters required for the accomplishment of the learning outcomes. The Curriculum Development Centre always welcomes constructive feedback for the betterment of the material.

2082 BS

Ministry of Education, Science and Technology
Curriculum Development Centre

Table of Content

Unit	Content	Page
1.	Introduction to Anatomy	1
2.	Splanchnology	11
3.	Introduction to Physiology	50
4.	Digestive System	56
5.	Reproductive System	62

Guidelines to Teachers

A. Facilitation Methods

The goal of this course is to combine the theoretical and practical aspects of the contents needed for the subject. The nature of contents included in this course demands the use of practical or learner focused facilitation processes. Therefore, the practical side of the facilitation process has been focused much. The instructor is expected to design and conduct a variety of practical methods, strategies or techniques which encourage students engage in the process of reflection, sharing, collaboration, exploration and innovation new ideas or learning. For this, the following teaching methods, strategies or techniques are suggested to adopt as per the course content nature and context.

Brainstorming

Brainstorming is a technique of teaching which is creative thinking process. In this technique, students freely speak or share their ideas on a given topic. The instructor does not judge students' ideas as being right or wrong, but rather encourages them to think and speak creatively and innovatively. In brainstorming time, the instructor expects students to generate their tentative and rough ideas on a given topic which are not judgmental. It is, therefore, brainstorming is free-wheeling, non-judgmental and unstructured in nature. Students or participants are encouraged to freely express their ideas throughout the brainstorming time. Whiteboard and other visual aids can be used to help organize the ideas as they are developed. Following the brainstorming session, concepts are examined and ranked in order of importance, opening the door for more development and execution. Brainstorming is an effective technique for problem-solving, invention, and decision-making because it taps into the group's combined knowledge and creative ideas.

Demonstration

Demonstration is a practical method of teaching in which the instructor shows

or demonstrates the actions, materials, or processes. While demonstrating something the students in the class see, observe, discuss and share ideas on a given topic. Most importantly, abstract and complicated concepts can be presented into visible form through demonstration. Visualization bridges the gap between abstract ideas and concrete manifestations by utilizing the innate human ability to think visually. This enables students to make better decisions, develop their creative potential, and obtain deeper insights across a variety of subject areas.

Peer Discussion

Peer conversation is a cooperative process where students converse with their peers to exchange viewpoints, share ideas, and jointly investigate subjects that are relevant or of mutual interest. Peer discussion is an effective teaching strategy used in the classroom to encourage critical thinking, active learning, and knowledge development. Peer discussions encourage students to express their ideas clearly, listen to opposing points of view, and participate in debate or dialogue, all of which contribute to a deeper comprehension and memory of the course material. Peer discussions also help participants develop critical communication and teamwork skills by teaching them how to effectively articulate their views, persuasively defend their positions, and constructively respond to criticism.

Peer conversation is essential for professional growth and community building outside of the classroom because it allows practitioners to share best practices, work together, and solve problems as a group. In addition to expanding their knowledge horizon and deepening their understanding, peer discussions help students build lasting relationships and a feeling of community within their peer networks.

Group Work

Group work is a technique of teaching where more than two students or participants work together to complete a task, solve a problem or discuss on a

given topic collaboratively. Group work is also a cooperative working process where students join and share their perspectives, abilities, and knowledge to take on challenging job or project. Group work in academic contexts promotes active learning, peer teaching, and the development of collaboration and communication skills. Group work helps individuals to do more together than they might individually do or achieve.

Gallery Walk

Gallery walk is a critical thinking strategy. It creates interactive learning environment in the classroom. It offers participants or students a structured way to observe exhibition or presentation and also provides opportunity to share ideas. It promotes peer-to-peer or group-to-group engagement by encouraging participants to observe, evaluate and comment on each other's work or ideas. Students who engage in this process improve their communication and critical thinking abilities in addition to their comprehension of the subject matter, which leads to a deeper and more sophisticated investigation of the subjects at hand.

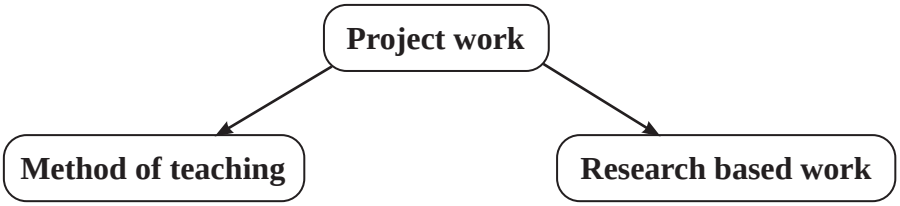
Interaction

The dynamic sharing of ideas, knowledge, and experiences between people or things is referred to as interaction, and it frequently takes place in social, academic, or professional settings. It includes a broad range of activities such as dialogue, collaboration or team work, negotiation, problem solving, etc. Mutual understanding, knowledge sharing, and interpersonal relationships are all facilitated by effective interaction. Interaction is essential for building relationships, encouraging learning, and stimulating creativity in both in-person and virtual contexts. Students can broaden their viewpoints, hone their abilities, and jointly achieve solutions to difficult problems by actively interacting with others.

Project Work

Project work is a special kind of work that consists of a problematic situation which requires systematic investigation to explore innovative ideas and solutions.

Project work can be used in two senses. First, it is a method of teaching in regular class. The next is: it is a research work that requires planned investigation to explore something new. This concept can be presented in the following figure.



Project work entails individuals or teams working together to achieve particular educational objectives. It consists of a number of organized tasks, activities, and deliverables. The end product is important for project work. Generally, project work will be carried out in three stages. They are:

- Planning
- Investigation
- Reporting

B. Instructional Materials

Instructional materials are the tools and resources that teachers use to help students. These resources/materials engage students, strengthen learning, and improve conceptual comprehension while supporting the educational goals of a course or program. Different learning styles and preferences can be accommodated by the variety of instructional resources available. Here are a few examples of typical educational resource types:

- Daily used materials
- Related Pictures
- Reference books
- **Slides and Presentation:** PowerPoint slides, keynote presentations, or other visual aids that help convey information in a visually appealing and organized manner.
- **Audiovisual Materials:** Videos, animations, podcasts, and other multimedia resources that bring concepts to life and cater to auditory and visual learners.

- **Online Resources:** Websites, online articles, e-books, and other web-based materials that can be accessed for further reading and research.

Maps, Charts, and Graphs: Visual representations that help learners understand relationships, patterns, and trends in different subjects.

Real-life Examples and Case Studies: Stories, examples, or case studies that illustrate the practical application of theoretical concepts and principles.

C. Assessment

Formative Test

Classroom discussions: Engage students in discussions to assess their understanding of concepts.

Quizzes and polls: Use short quizzes or polls to check comprehension during or after a lesson.

Homework exercises: Assign tasks that provide ongoing feedback on individual progress.

Peer review: Have students review and provide feedback on each other's work.

Summative Test

Exams: Conduct comprehensive exams at the end of a unit or semester.

Final projects: Assign projects that demonstrate overall understanding of the subject.

Peer Assessment

Group projects: Evaluate individual contributions within a group project.

Peer feedback forms: Provide structured forms for students to assess their peers.

Classroom presentations: Have students assess each other's presentations.

Objective Test

Multiple-choice tests: Use multiple-choice questions to assess knowledge.

True/False questions: Assess factual understanding with true/false questions.

Matching exercises: Evaluate associations between concepts or terms.

Portfolio Assessment

Compilation of work: Collect and assess a variety of student work samples.

Reflection statements: Ask students to write reflective statements about their work.

Showcase events: Organize events where students present their portfolios to peers or instructors.

Observational Assessment

Classroom observations: Observe students' behavior and engagement during class.

Performance observations: Assess practical skills through direct observation.

Field trips: Evaluate students' ability to apply knowledge in real-world settings.

Introduction to Anatomy

Unit 1

1.1 Introduction and Terms Used in Veterinary Anatomy

Anatomy is the branch of biology and medicine that studies the structure of living organisms. It involves the identification and description of body parts, their organization, and relationships at both macroscopic and microscopic levels. Anatomy provides a foundational understanding of how organisms are built and how their structures function together.

Branches of Anatomy

Anatomy is broadly divided into several branches, each focusing on different aspects of structural biology:

1. **Gross Anatomy**
   - Study of structures visible to the naked eye.
   - Can be further divided into:
     - Systemic Anatomy: Study of specific organ systems (e.g., skeletal, muscular, or cardiovascular systems).
     - Regional Anatomy: Study of all structures in a specific area of the body (e.g., the thorax, abdomen).
     - Surface Anatomy: Study of external body features and their relationship to deeper structures.
2. Microscopic Anatomy (Histology)
   - Study of tissues and cells using a microscope.
   - Includes the examination of organs at a cellular level.
3. Developmental Anatomy (Embryology)
   - Study of the development of an organism from fertilization to birth.
   - Focuses on changes in structure during the prenatal period.

4. Comparative Anatomy
    - Comparison of anatomical structures in different species.
    - Helps understand evolutionary relationships.
5. Radiological Anatomy
    - Study of anatomy using imaging techniques like X-rays, CT scans, MRI, and ultrasounds.
    - Useful in clinical diagnostics and treatment.
6. Functional Anatomy
    - Study of anatomical structures with emphasis on their functions and mechanical roles.
7. Pathological Anatomy
    - Study of diseased or abnormal structures.
    - Focuses on understanding changes due to disease or injury.
8. Topographic Anatomy
    - Study of anatomical landmarks in relation to surface features, important in surgery.
9. Clinical Anatomy
    - Application of anatomical knowledge in clinical practice for diagnosis, treatment, and surgical procedures.
10. Artistic Anatomy
    - Study of human anatomy for use in art, focusing on proportions and body structures for accurate representation.
    - Terms used in Veterinary Anatomy

      The position, orientation, planes, and structures of animal bodies are all described using particular words in veterinary anatomy. For veterinarians, researchers, and other animal care specialists to communicate effectively, these terminology are essential. Here is a summary of important terms:

Directional Terms

- Cranial: Towards the head.
- **Caudal**: Towards the tail.

- **Rostral**: Towards the nose (used for head structures).
- **Dorsal**: Towards the back or spine.
- **Ventral**: Towards the belly or underside.
- **Proximal**: Closer to the body or point of attachment (used for limbs and tail).
- **Distal**: Farther from the body or point of attachment (used for limbs and tail).
- **Medial**: Towards the midline of the body.
- **Lateral**: Away from the midline of the body.
- **Superficial**: Closer to the surface of the body.
- **Deep**: Further away from the surface of the body.
- **Palmar**: Pertaining to the underside of the forelimb (similar to the palm of the hand in humans).
- **Plantar**: Pertaining to the underside of the hind limb (similar to the sole of the foot in humans).

Anatomical Planes

- **Median Plane**: Divides the body into equal left and right halves.
- **Sagittal Plane**: Divides the body into left and right parts (parallel to the median plane).
- **Transverse Plane**: Divides the body into cranial (head) and caudal (tail) parts.
- **Dorsal Plane**: Divides the body into dorsal (upper) and ventral (lower) parts.

Terms Related to Movement

- **Flexion**: Bending a joint, decreasing the angle between two body parts.
- **Extension**: Straightening a joint, increasing the angle between two body parts.
- **Abduction**: Movement away from the midline of the body.
- **Adduction**: Movement toward the midline of the body.
- **Rotation:** Circular movement of a part around its axis.
- **Supination**: Turning the limb or paw so that the palmar or plantar surface

faces upward.

- **Pronation**: Turning the limb or paw so that the palmar or plantar surface faces downward.

Terms for Teeth and Mouth

- **Mesial**: Surface of the tooth facing the midline of the dental arch.
- **Distal**: Surface of the tooth away from the midline of the dental arch.
- **Lingual**: Surface of the tooth facing the tongue.
- **Buccal**: Surface of the tooth facing the cheek.
- **Occlusal**: Chewing surface of the teeth.

Terms Specific to Veterinary Anatomy

- **Axial**: Closer to the axis of the limb (used for digits).
- **Abaxial**: Away from the axis of the limb.
- **Cervical**: Pertaining to the neck.
- **Thoracic**: Pertaining to the chest.
- **Lumbar**: Pertaining to the lower back.
- **Sacral**: Pertaining to the sacrum region.
- **Coccygeal**: Pertaining to the tail region.
- **Perineal**: Pertaining to the area between the anus and the genital organs.

Common Terminologies in Bone

1. **Long Bones**: Bones longer than they are wide, typically found in limbs (e.g., femur, humerus).
2. **Short Bones**: Cube-shaped bones, providing stability and support (e.g., carpal and tarsal bones).
3. **Flat Bones**: Thin and broad bones that provide protection (e.g., skull, scapula).
4. **Irregular Bones**: Bones with complex shapes (e.g., vertebrae, pelvis).
5. **Sesamoid Bones**: Small, round bones embedded in tendons (e.g., patella).

6. **Pneumatic Bones**: Bones containing air spaces (e.g., sinuses in the skull of birds)

Bone Features and Landmarks

1. **Articular Surface:** The smooth area of a bone where it forms a joint with another bone.
2. **Condyle:** A rounded articular surface, often found at the end of bones (e.g., femoral condyles).
3. **Head:** The rounded, proximal end of a bone, often involved in forming joints (e.g., femoral head).
4. **Facet:** A small, flat articular surface (e.g., facets of vertebrae).
5. **Fossa:** A shallow depression or cavity in a bone (e.g., olecranon fossa of the humerus).
6. **Foramen:** A hole or opening in a bone allowing the passage of nerves or blood vessels (e.g., foramen magnum in the skull).
7. **Canal:** A tunnel-like passageway through a bone (e.g., optic canal in the skull).
8. **Meatus:** A canal-like structure (e.g., external auditory meatus of the skull).
9. **Process:** A projection or outgrowth of bone (e.g., spinous process of vertebrae).
10. **Tubercle:** A small, rounded projection on a bone (e.g., greater tubercle of the humerus).
11. **Tuberosity:** A larger, roughened projection where muscles attach (e.g., ischial tuberosity of the pelvis).
12. **Trochanter:** A large, blunt projection on a bone, specific to the femur (e.g., greater trochanter).
13. **Crest:** A prominent ridge or border on a bone (e.g., iliac crest of the pelvis).
14. **Line:** A less prominent ridge than a crest (e.g., linea aspera on the femur).
15. **Spine:** A sharp, slender projection (e.g., spine of the scapula).

16. **Epicondyle:** A projection above a condyle, often a site for muscle attachment (e.g., medial epicondyle of the humerus).
17. **Groove:** A narrow, elongated depression for nerves, tendons, or vessels (e.g., radial groove).
18. **Notch:** A deep indentation or depression (e.g., sciatic notch of the pelvis).

Specific Bones and Regions

- **Axial Skeleton:** Bones along the body's central axis.
  - **Skull:** Protects the brain and supports sensory structures.
  - **Mandible:** Lower jawbone.
  - **Vertebrae:** Bones of the spine.
    - **Cervical Vertebrae:** Neck region.
    - **Thoracic Vertebrae:** Chest region.
    - **Lumbar Vertebrae:** Lower back.
    - **Sacral Vertebrae:** Pelvic region (fused to form the sacrum).
    - **Coccygeal Vertebrae:** Tail region.
    - **Ribs:** Protect thoracic organs.
    - **Sternum:** Breastbone.
- **Appendicular Skeleton:** Bones of the limbs.

  Scapula: Shoulder blade.

  Humerus: Upper forelimb bone.

  Radius and Ulna: Forelimb bones.

  Carpals: Wrist bones.

  Metacarpals: Bones of the forefoot.

  Phalanges: Toe bones.

  Pelvis: Hip bones.

  Femur: Thigh bone.

  Tibia and Fibula: Lower hind limb bones.

Tarsals: Ankle bones.

Metatarsals: Bones of the hind foot.

Bone-Related Terms in Veterinary Context

1. **Periosteum:** The outer membrane covering bones, providing nourishment and attachment for tendons.
2. **Endosteum:** The inner lining of the bone's medullary cavity.
3. **Medullary Cavity:** The hollow center of long bones containing bone marrow.
4. **Bone Marrow:** Tissue within bones that produces blood cells.
5. **Cortex:** The dense, outer layer of bone (compact bone).
6. **Cancellous Bone:** The spongy, porous inner part of bone.
7. **Epiphysis:** The ends of long bones.
8. **Diaphysis:** The shaft of a long bone.
9. **Metaphysis:** The region between the diaphysis and epiphysis, containing the growth plate in young animals.
10. **Growth Plate (Epiphyseal Plate):** The cartilage area where bone growth occurs in young animals.
11. **Ossification:** The process of bone formation.
12. **Articulation:** A joint or junction between two bones.

Bone Diseases and Conditions

1. **Fracture:** A break in a bone.
2. **Osteoarthritis:** Degeneration of joint cartilage and bone.
3. **Osteomyelitis:** Inflammation of bone caused by infection.
4. **Osteosarcoma:** Bone cancer.
5. **Rickets:** Bone deformities caused by vitamin D deficiency.
6. **Luxation:** Dislocation of a joint.

Exercise

Choose the correct answer from the given alternatives.

1. Which branch of the veterinary anatomy focuses on the study of the structure and relationships of body parts visible to the naked eye?
   a. Histology
   b. Gross Anatomy
   c. Developmental Anatomy
   d. Comparative Anatomy

2. What does comparative anatomy study in the context of veterinary science?
   a. Microscopic structures of animal tissues
   b. Structural differences and similarities between species
   c. Functional aspects of organs and systems
   d. The development of embryos

3. Which branch of the veterinary anatomy involves the microscopic study of cells and tissues?
   a. Embryology
   b. Systemic Anatomy
   c. istology
   d. Regional Anatomy

4. Which branch of veterinary anatomy focuses on the study of the structural changes during the development of an embryo?
   a. Embryology
   b. Pathological Anatomy
   c. Topographic Anatomy
   d.Gross Anatomy

5. Which of the following branches of veterinary anatomy focuses on the study of bones?
   a. Myology
   b. Neurology
   c. Osteology
   d. Arthrology

6. The branch of anatomy that examines joints and articulations is known as...
   a. Arthrolog
   b. Osteology
   c. Myology
   d. Splanchnology

7. Which branch of the veterinary anatomy deals with the study of internal organs?

a. Splanchnology
b. Myology
c. Neurology
d. Arthrology

8. What does myology study in veterinary anatomy?

a. Bones and joints
b. Muscles and their functions
c. Nervous system structures
d. Circulatory system

9. Which branch of anatomy is primarily focused on the nervous system?

a. Angiology
b. Neurology
c. Myology
d. Splanchnology

10. Which of the following system studies Angiology?

a. Digestive system
b. Nervous system
c. Circulatory system
d. Reproductive system

11. Which branch of anatomy involves the study of the external features of the body that are visible and palpable?

a. Topographic Anatomy
b. Surface Anatomy
c. Systemic Anatomy
d. Developmental Anatomy

12. What is the longest bone in the skeletal system of cattle?

a. Radius
b. Femur
c. Humerus
d Tibia

13. What is the shortest bone in the skeletal system of cattle?

a Stapes
b. Navicular bone
c. Patella
d. Metacarpal II

14. In largest sesamoid bone in animal is .....

a. Navicular bone
b. Patella
c. Scapula
d. Calcaneus

15. Which of the following visceral bones is unique to pigs?
    a. Os cordis
    b. Os rostri
    c. Os penis
    d. Os carpi

16. Which of the following visceral bones is absent in pigs but present in dogs?
    a. Os rostri
    b. Os cordis
    c. Os penis
    d. Keel

17. In which species is the os cordis most prominently developed?
    a. Dogs
    b. Pigs
    c. Poultry
    d. Cattle

18. Which plane divides the body into left and right halves?
    a. Coronal Plane
    b. Transverse Plane
    c. Sagittal Plane
    d. Oblique Plane

19. What type of bone is the sternum classified as?
    a. Long bone
    b. Flat bone
    c. Irregular bone
    d. Short bone

20. Which plane divides an animal's body into dorsal and ventral parts?
    a. Sagittal Plane
    b. Transverse Plane
    c. Median Plane
    d. Frontal Plane

Write short answer to the following questions.

1. Define anatomy. Explain the different branches of anatomy.
2. Define the following terms:
    a. Caudal b. Ventral c. Cranial d. Medial e. Lateral

Project work

1. Select three farm animals (e.g., cow, goat, pig) and identify the major external body parts of each. Compare the external body parts of the animals and discuss their similarities and differences in terms of size, shape, and function.

Splanchnology

Unit 2

2.1 Introduction to Splanchnology

Splanchnology is a branch of anatomy that deals with the study of the viscera or internal organs. These organs are primarily located within the body cavities, including the thoracic, abdominal, and pelvic cavities, and they are associated with essential body systems such as the digestive, respiratory, urinary, reproductive, and endocrine systems.

Scope of Splanchnology

Splanchnology encompasses the anatomy, structure, function, and organization of visceral organs. It is divided into several subdivisions based on the systems it focuses on,

1. Digestive System
   - Includes organs responsible for digestion and nutrient absorption, such as the mouth, esophagus, stomach, intestines, liver, pancreas, and associated glands.
2. Respiratory System
   - Covers organs involved in gas exchange, such as the nose, pharynx, larynx, trachea, bronchi, and lungs.
3. Urinary System
   - Involves structures for waste elimination and fluid balance, including the kidneys, ureters, urinary bladder, and urethra.
4. Reproductive System
   - Focuses on organs associated with reproduction, including the testes, epididymis, vas deferens, ovaries, uterus, and vagina.

5. Endocrine System

- Includes glands that secrete hormones regulating various body functions, such as the thyroid, adrenal glands, pancreas, and pituitary gland.

Importance of Splanchnology

1. Understanding Organ Functionality: It provides insight into how individual organs work and contribute to overall body function.
2. Clinical Applications: It is essential for diagnosing and treating diseases affecting visceral organs.
3. Surgical Relevance: Vital for veterinarians performing surgeries on internal organs.
4. Comparative Anatomy: Highlights similarities and differences in organ structures across animal species.

2.2 Study of Digestive System of Farm Animals

2.2.1 Ruminant digestive system

The ruminant digestive system is highly specialized for breaking down fibrous plant material like grasses and hay through fermentation. It has a unique four-chambered stomach and a symbiotic relationship with microbes that aids digestion. Below is a detailed explanation of the ruminant digestive system, with its anatomical parts and their functions.

1. Mouth

- Anatomy
  - No upper incisors; instead, a dental pad is present.
  - Molars grind feed.
  - Salivary glands produce large amounts of saliva (100–150 liters/day in cattle).
- Function
  - Chewing reduces particle size for easier digestion.
  - Saliva contains bicarbonate and phosphate buffers to maintain the rumen pH.

- Initiates the process of feed breakdown.

2. Esophagus

- Anatomy
  - A muscular tube connecting the mouth to the stomach.
- Function
  - Moves feed from the mouth to the stomach via **peristalsis**.
  - Facilitates **regurgitation** (cud chewing) and **remastication** to further break down feed.

3. Stomach (Four Compartments)

a. Rumen

- Anatomy
  - The largest compartment, occupying the left side of the abdomen.
  - Lined with papillae that increase surface area for absorption.
- Function:
  - Acts as a fermentation vat, housing billions of microbes (bacteria, protozoa, fungi).
  - Microbes digest complex carbohydrates (e.g., cellulose) into volatile fatty acids (VFAs), such as acetate, propionate, and butyrate, which are absorbed as energy sources.
  - Produces gases (methane, carbon dioxide) released through **eructation** (burping).

b. Reticulum

- Anatomy
  - Located next to the rumen, with a honeycomb-like lining.
  - Often considered part of the rumen-reticulum complex.
- Function
  - Filters and traps large, dense feed particles and foreign objects (e.g., nails, wire).

- Works with the rumen to mix feed and microbes.
- Participates in regurgitation for cud chewing.

c. Omasum

- Anatomy
  - A spherical organ with multiple leaf-like folds, increasing surface area.
- Function
  - Absorbs water and reduces feed particle size.
  - Extracts nutrients such as volatile fatty acids from digesta.

d. Abomasum (True Stomach)

- Anatomy
  - Glandular, similar to a mono-gastric stomach.
- Function
  - Secretes gastric juices, including hydrochloric acid and enzymes like pepsin.
  - Breaks down proteins and kills microbes from the rumen, making them available as a protein source for the ruminant.

4. Small Intestine

- Anatomy
  - A long, coiled tube divided into the **duodenum**, **jejunum**, and **ileum**.
- Function
  - Enzymes from the pancreas and bile from the liver help digest carbohydrates, proteins, and fats.
  - The small intestine absorbs nutrients (amino acids, glucose, fatty acids, vitamins, and minerals) through villi and microvilli.

5. Large Intestine

- Anatomy

- Includes the cecum, colon, and rectum.

- Function
  - Absorbs water and electrolytes.
  - Performs limited microbial fermentation to digest remaining fiber.
  - Forms and expels feces.

Accessory Organs

a. Liver

- Function
  - Produces bile, stored in the gallbladder, to emulsify fats.
  - Processes absorbed nutrients for metabolism.

b. Pancreas

- Function
  - Produces digestive enzymes (lipase, amylase, proteases) and bicarbonate.

c. Gallbladder

- Function
  - Stores bile and releases it into the duodenum.

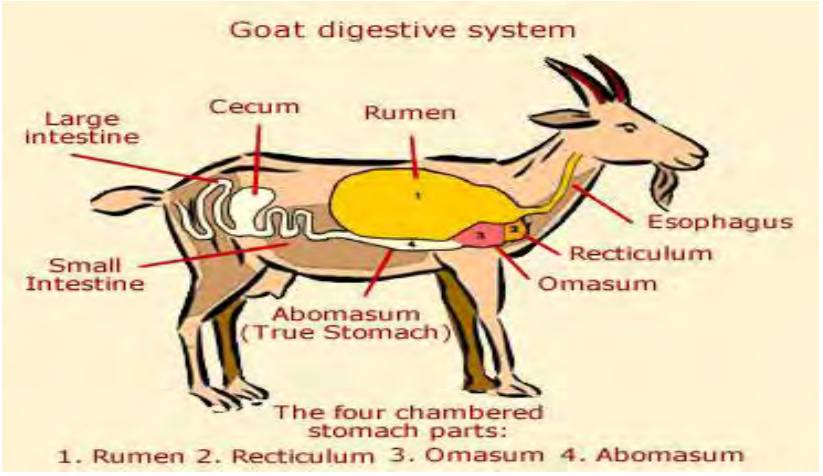


Fig 1: Digestive system of Goat

Source: https://thekebun.wordpress.com/wp content/ uploads/ 2008/10/digest system1 .jpg

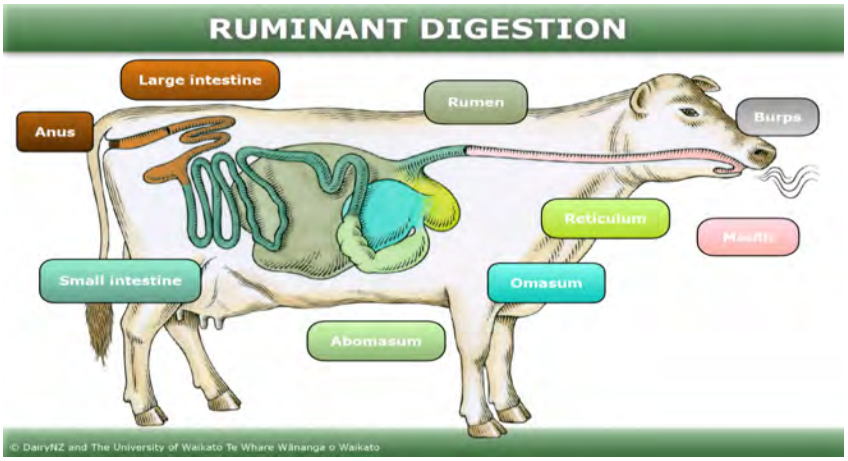


Fig 2: Digestive system of cattle

Source: https://www.sciencelearn.org.nz/images/4590-the-amazing-3d-cow

2.2.2 Digestive System of Mono-gastric Animals

The digestive system of monogastric animals (e.g., pigs, poultry, and horses) consists of a single-chambered stomach and is specialized for enzymatic digestion. While pigs and poultry are classic monogastrics, horses have a modified hindgut for fermentation, making them hindgut fermenters. Here's a detailed breakdown of their digestive anatomy and functions.

1. Pig (True Mono-gastric)

Anatomy and Function

Mouth

- **Anatomy:** Teeth, tongue, and salivary glands.
- **Function**
  - **Teeth:** Chew and grind feed into smaller particles (mechanical digestion).
  - **Saliva:** Contains enzymes like amylase to begin carbohydrate digestion and lubricates the feed.

Esophagus

- **Anatomy:** A muscular tube connecting the mouth to the stomach.

- Function
    - Transports feed to the stomach through peristalsis (wave-like muscle contractions).

Stomach

- **Anatomy:** A single-chambered organ with regions secreting gastric juices.
- **Function:**
    - **Chemical digestion:** Gastric glands secrete hydrochloric acid and enzymes like pepsin to break down proteins.
    - Mixes feed to form chyme, a semi-liquid material.

Small Intestine

- **Anatomy:** Divided into three sections: duodenum, jejunum, and ileum.
- **Function**
    - **Duodenum:** Receives bile (from the liver) and pancreatic enzymes for fat, carbohydrate, and protein digestion.
    - **Jejunum and Ileum:** Main site for nutrient absorption via villi and microvilli.

Large Intestine

- **Anatomy:** Comprises the cecum, colon, and rectum.
- **Function:**
    - Absorbs water and minerals.
    - Ferments undigested material, producing volatile fatty acids (limited in pigs).
    - Forms and stores feces for excretion.

Accessory Organs

- **Liver:** Produces bile to emulsify fats.
- **Pancreas:** Produces digestive enzymes (amylase, lipase, proteases) and bicarbonate.

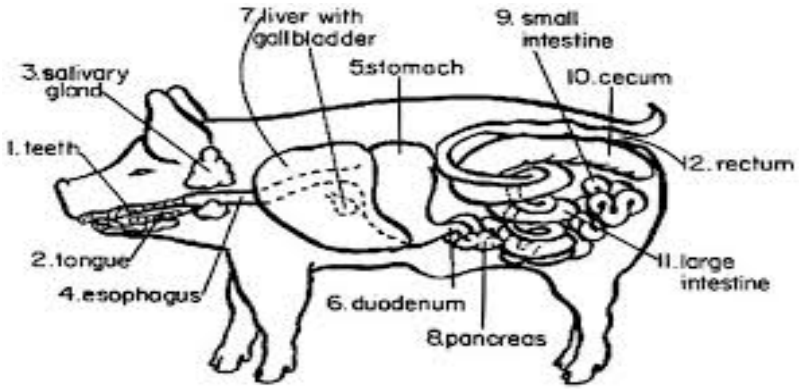


Fig 3: Digestive system of pig

Source:https://encryptedtbn0.gstatic.com/images?q=tbn:ANd9GcTRvo_LJ6xwXsRecbyD1XRQLa7J452MxElKmQ&s

2. Poultry (Modified Mono-gastric)

Anatomy and Function

Beak and Mouth

- **Anatomy:** No teeth; hard beak.
- **Function**
  - Picks up and swallows feed without chewing.
  - Saliva moistens the feed and begins minimal digestion.

Esophagus and Crop

- **Anatomy**
  - **Esophagus:** Tube connecting the mouth to the crop.
  - **Crop:** An enlarged sac in the esophagus.
- **Function**
  - Temporary storage of feed in the crop.
  - Softens feed and initiates slight fermentation.

Proventriculus (Glandular Stomach)

- **Anatomy:** Glandular portion of the stomach.
- **Function**
  - Secretes digestive enzymes and hydrochloric acid.
  - Begins chemical digestion.

Gizzard (Ventriculus)

- **Anatomy:** Muscular organ with a tough lining.
- **Function**
  - Grinds feed into smaller particles with the help of ingested grit or stones (mechanical digestion).

Small Intestine

- **Anatomy:** Includes the duodenum, jejunum, and ileum.
- **Function**
  - Receives bile and pancreatic enzymes to digest fats, carbohydrates, and proteins.
  - Absorbs nutrients through the intestinal walls.

Ceca (Plural of Cecum)

- **Anatomy:** Two blind pouches at the junction of the small and large intestine.
- **Function**
  - Perform minor microbial fermentation of fibrous material.

Large Intestine

- **Anatomy:** Short colon and cloaca.
- **Function**
  - Absorbs water and minerals.
  - Forms and excretes feces and uric acid through the cloaca.

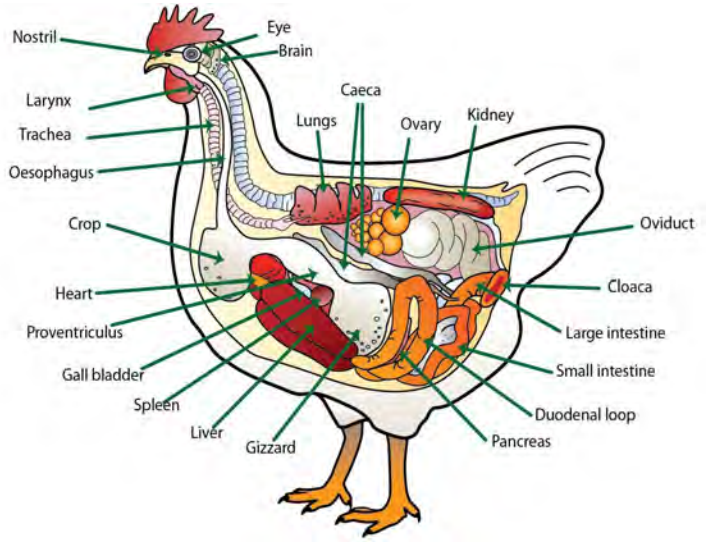


Fig 4: Digestive system of poultry

Source: https://www.poultryhub.org/content/uploads/2012/07/Anatomy-of-the-chicken-with-text-e1591660865528.jpg

3. Horse (Hindgut Fermenter)

Anatomy and Function

Mouth

- **Anatomy:** Teeth, tongue, and salivary glands.
- **Function**
  - **Teeth:** Chew and grind fibrous feed thoroughly.
  - **Saliva:** Lubricates feed and provides some enzymatic digestion.

Esophagus

- **Anatomy:** A muscular tube leading to the stomach.
- **Function**
  - Moves feed to the stomach via peristalsis.
  - Horses cannot regurgitate due to the esophageal sphincter.

Stomach

- **Anatomy:** Small, single-chambered (about 10% of the digestive tract).
- **Function**
  - Secretes acids and enzymes to digest proteins.
  - Limited storage capacity; horses require frequent feeding.

Small Intestine

- **Anatomy:** Composed of the duodenum, jejunum, and ileum.
- **Function**
  - Primary site for enzymatic digestion and nutrient absorption.
  - Bile is continuously secreted (horses lack a gallbladder).

Cecum

- **Anatomy:** A large, blind-ended sac (part of the large intestine).
- **Function**
  - Houses microbes for fermenting fibrous feed (cellulose and hemicellulose).
  - Produces volatile fatty acids (VFAs), absorbed as an energy source.
  - Synthesizes some vitamins (e.g., B-complex).

Colon

- **Anatomy:** Divided into the large colon and small colon.
- **Function**
  - Continues microbial fermentation.
  - Absorbs water and VFAs.

Rectum

- **Anatomy:** Final segment of the large intestine.
- **Function**
  - Forms and expels feces.

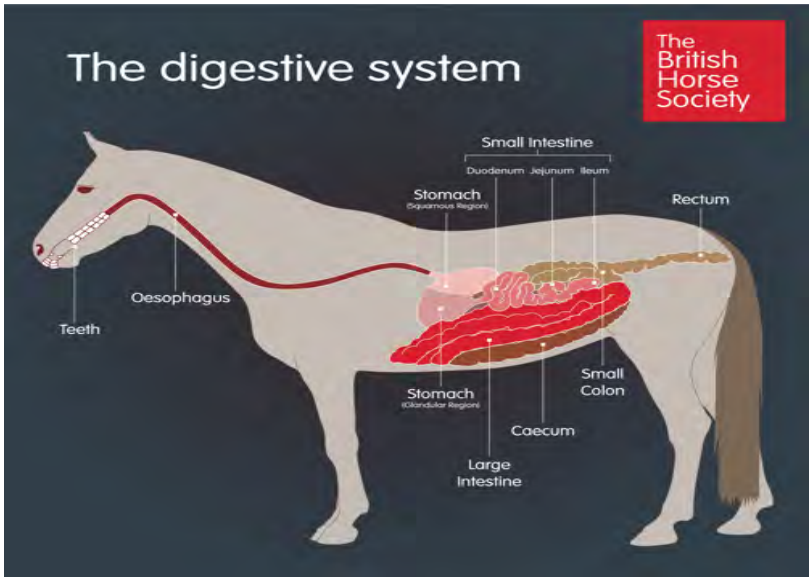


Fig 5: Digestive system of Horse

Source: https://www.bhs.org.uk/media/jl0nwewp/bw24-0152_digestive-system-diagram-v5.jpg?rmode=max&width=500&height=500

Key Comparisons of Mono-gastric Systems

Feature	Pig	Poultry	Horse
Teeth	Present, for chewing	Absent, uses beak	Present, for thorough grinding
Stomach	Single chamber, enzymatic	Proventriculus + gizzard	Single chamber, small
Cecum	Small, limited function	Paired, minor fermentation	Large, major fermentation
Fermentation Site	Minimal	Ceca	Cecum and colon (hindgut)

2.3 Study of Respiratory System of Farm Animals

The respiratory system of farm animals is crucial for oxygen intake, carbon dioxide elimination, and maintaining homeostasis. It also plays roles in thermoregulation

and vocalization. Below is a detailed explanation of the anatomy and functions of the respiratory system in farm animals such as cattle, sheep, pigs, poultry, and horses.

Anatomy of the Respiratory System

The respiratory system can be divided into two main parts:

1. **Upper Respiratory Tract**
    - **Nostrils (Nares)**
        - **Anatomy:** External openings of the nose.
        - **Function:** Allow air to enter and leave the respiratory system. Filter large particles using nasal hairs.
    - **Nasal Cavity**
        - **Anatomy:** Lined with mucous membranes and cilia.
        - **Function**
            - Warms, humidifies, and filters air.
            - Detects odors via olfactory receptors.
    - **Pharynx (Throat)**
        - **Anatomy:** A common passage for air and food.
        - **Function:** Directs air to the larynx and food to the esophagus.
    - **Larynx (Voice Box)**
        - **Anatomy:** Cartilaginous structure containing the vocal cords.
        - **Function**
            - Regulates airflow into the trachea.
            - Produces sound for communication.
2. **Lower Respiratory Tract**
    - **Trachea (Windpipe)**

- **Anatomy:** A tube supported by cartilaginous rings.
- **Function**
  - Provides a passage for air to move to the lungs.
  - Filters particles using mucus and cilia.

- **Bronchi**
  - **Anatomy:** The trachea branches into right and left bronchi, which enter the lungs.
  - **Function:** Conduct air into smaller airways (bronchioles).

- **Bronchioles**
  - **Anatomy:** Small, branching airways lacking cartilage.
  - **Function:** Direct airflow to the alveoli.

- **Alveoli**
  - **Anatomy:** Tiny, thin-walled air sacs surrounded by capillaries.
  - **Function**
    - Primary site of gas exchange.
    - Oxygen diffuses into the blood, and carbon dioxide diffuses out.

- **Lungs**
  - **Anatomy:** Large, spongy organs occupying most of the thoracic cavity.
  - **Function:** Contain bronchi, bronchioles, and alveoli for air distribution and gas exchange.

- **Diaphragm**
  - **Anatomy:** A dome-shaped muscle beneath the lungs.
  - **Function**
    - Contracts to enlarge the thoracic cavity during inspiration.
    - Relaxes to aid expiration.

Functions of the Respiratory System

1. Gas Exchange

- Oxygen is inhaled and diffused into the bloodstream via the alveoli.
- Carbon dioxide, a waste product of metabolism, is exhaled.

2. Thermoregulation

- Animals regulate body temperature by panting (e.g., in dogs, poultry) or through heat exchange in the nasal passages.

3. Vocalization

- The larynx produces sound as air passes over the vocal cords.

4. Acid-Base Balance

- The respiratory system regulates blood pH by controlling carbon dioxide levels, which affect the bicarbonate buffer system.

5. Filtration and Defense

- The nasal cavity, trachea, and bronchi filter dust and pathogens using mucus and cilia.
- Macrophages in the alveoli defend against infections.

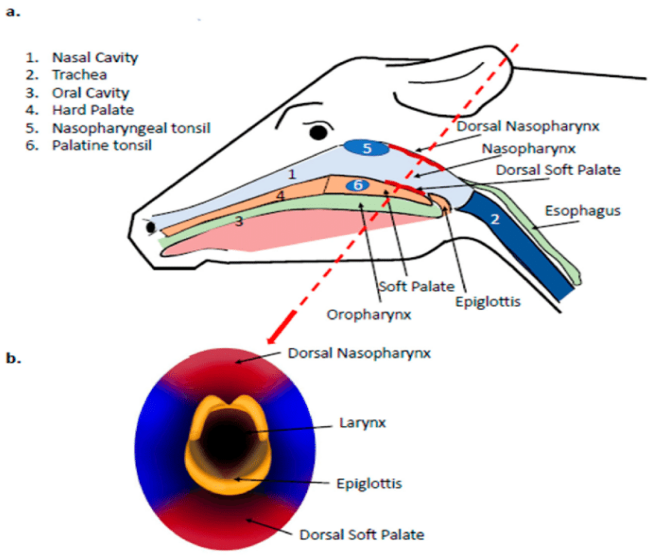


Fig 6: Upper respiratory system of cattle

Source:https://www.researchgate.net/publication/339574264/figure/fig2/AS:863725502337024@1582939615172/Anatomy-of-the-bovine-upper-respiratory-tract-relevant-to-FMDV-infection-a-The-bovine.png

Species-Specific Respiratory Features

1. Cattle and Sheep

- Large nasal cavities and sinuses are adapted for air humidification and filtering.
- Prone to respiratory diseases like pneumonia due to environmental stress or overcrowding.

2. Pigs

- Relatively small lung capacity compared to body size.
- Susceptible to respiratory diseases like swine influenza and porcine respiratory disease complex (PRDC).

3. Poultry

- Unique respiratory anatomy:
  - Air Sacs: Thin-walled structures connected to the lungs that act as reservoirs for air.
  - Lungs: Rigid and do not expand; air flows through them in a unidirectional manner for efficient gas exchange.
  - Function: Allows continuous airflow through the lungs, even during exhalation.

4. Horses

- Large nasal passages adapted for high oxygen intake during intense physical activity.
- Obligate nasal breathers, meaning they breathe only through their nostrils.

Breathing Mechanism

1. Inspiration (Inhalation)

- Diaphragm contracts and moves downward, enlarging the thoracic cavity.
- Air is drawn into the lungs due to lower pressure inside the thoracic cavity.

2. Expiration (Exhalation)

- Diaphragm relaxes, and the thoracic cavity decreases in size.
- Air is pushed out of the lungs due to higher internal pressure.

2.4 Study of Urinary System of Farm Animals

The urinary system of farm animals is essential for maintaining fluid balance, excreting waste products, and regulating electrolytes and blood pH. This system filters blood to produce urine, which removes metabolic waste products like urea and creatinine. Below is a detailed study of the urinary system's anatomy and functions in farm animals, including cattle, horses, pigs, and poultry.

Anatomy of the Urinary System

The urinary system consists of the following main structures:

1. Kidneys

- Anatomy
  - Paired, bean-shaped organs (except in cattle, where they are lobulated).
  - Located in the abdominal cavity, dorsal to the peritoneum (retroperitoneal).
  - Renal structure
    - **Cortex:** Outer region containing glomeruli and parts of the nephron.
    - **Medulla:** Inner region with renal pyramids and tubules.
    - **Renal pelvis:** Funnel-shaped area where urine collects before entering the ureter.
- Function
  - Filters blood through the nephron to remove waste products, excess ions, and water.
  - Regulates electrolyte balance, blood pressure, and blood pH.
  - Produces hormones such as erythropoietin (stimulates red blood cell production) and renin (regulates blood pressure).

2. Ureters

- Anatomy
  - Thin, muscular tubes that extend from each kidney to the urinary bladder.
  - Lined with transitional epithelium to accommodate urine flow.
  - Function
  - Transport urine from the renal pelvis of the kidney to the urinary bladder via peristaltic contractions.

3. Urinary Bladder

- Anatomy
  - A hollow, muscular organ located in the pelvic cavity.
  - Lined with transitional epithelium and surrounded by smooth muscle (detrusor muscle).
  - Function
  - Temporarily stores urine until excretion.
  - Expels urine during micturition (urination) through contraction of the detrusor muscle and relaxation of the sphincter.

4. Urethra

- Anatomy
  - A tube leading from the bladder to the external environment.
  - Male animals: Longer, serving both urinary and reproductive functions.
  - Female animals: Shorter, used solely for urination.
  - Function
  - Conveys urine from the bladder to the outside.
  - In males, also transports semen during reproduction.

Functions of the Urinary System

1. Excretion of Waste Products

- Removes nitrogenous wastes like urea, uric acid, and creatinine from the blood.

2. Water and Electrolyte Balance

- Regulates levels of sodium, potassium, calcium, and chloride to maintain homeostasis.

3. Acid-Base Regulation

- Maintains blood pH by excreting hydrogen ions and reabsorbing bicarbonate.

4. Blood Pressure Regulation

- Produces renin, which helps regulate blood pressure through the renin-angiotensin-aldosterone system.

5. Hormone Production

- Secretes erythropoietin to stimulate red blood cell production.
- Activates vitamin D for calcium metabolism.

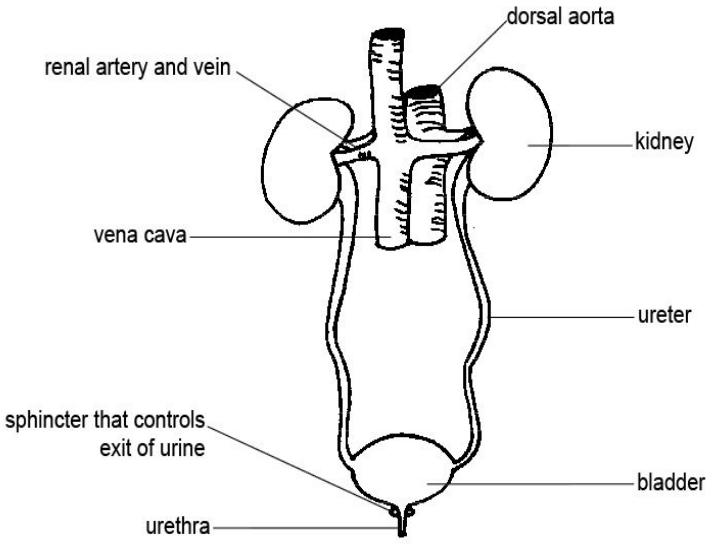


Fig 7: Male urinary system of cattle
Source:https://upload.wikimedia.org/wikipedia/commons/5/5f/Anatomy_and_physiology_of_animals_Urinary_system.jpg

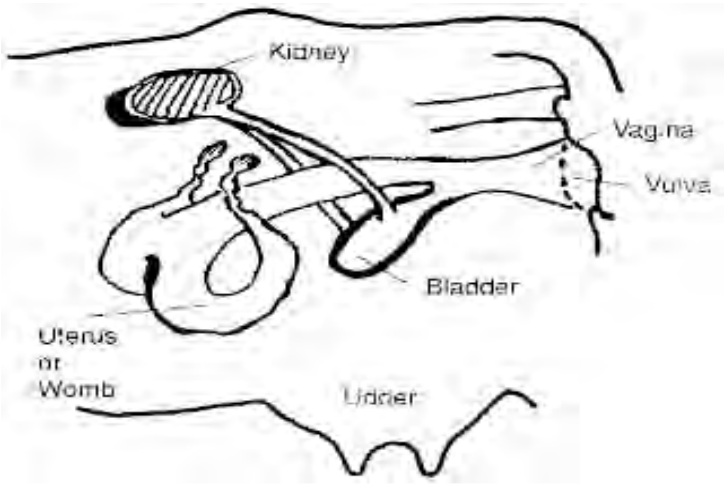


Fig 8: Female urinary system of cattle

Source:https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.drvet.in%2F2019%2F05%2Fveterinary-anatomy-online-urinary-system

Species-Specific Features

1. Cattle

- **Kidneys:**
  - o Lobulated structure, with each lobe functioning independently.
  - o Adapted for high water and electrolyte excretion due to their grazing diet.
    - Urine Characteristics
  - o Typically alkaline due to their herbivorous diet.

2. Horses

- **Kidneys**
  - Smooth and bean-shaped in the left kidney; the right kidney is heart-shaped.
  - Highly efficient at conserving water, making their urine highly concentrated.
  - Urine Characteristics

- Cloudy due to the presence of mucus and calcium carbonate crystals.
- Yellowish in color.

3. Pigs

- **Kidneys**
  - Similar to those of humans, with a smooth, bean-shaped structure.
  - Adapted for omnivorous diets.
  - Urine Characteristics
  - Variable pH depending on diet, but generally neutral to slightly acidic.

4. Poultry

- **Kidneys**
  - Divided into three lobes on each side, located close to the backbone.
  - Lack a renal pelvis and produce both urine and urates (uric acid).
  - Ureters
  - Directly transport waste from the kidneys to the cloaca (no urinary bladder).
  - Urine Characteristics
  - Excreted as a semisolid mixture of uric acid (white paste) and feces through the cloaca.

2.5 Study of Reproductive System of Farm Animals

2.5.1 Study of Male Reproductive System

The male reproductive system consists of the following main parts:

1. Testes
2. Epididymis
3. Ductus Deferens (Vas Deferens)
4. Accessory Sex Glands
    - Seminal vesicles (Vesicular glands)
    - Prostate gland
    - Bulbourethral glands (Cowper's glands)

5. Penis and Prepuce

Anatomical Details and Species-Specific Features

Structure	Cattle	Goat/Sheep	Pig	Horse	Poultry
1. Testes	- Oval, located in the scrotum, pendulous. - Size and weight depend on breed.	- Small, oval, and pendulous. - Similar to cattle but smaller.	- Large and caudally positioned. - Non-pendulous.	- Large, oval, horizontally positioned. - Located high in the inguinal region.	- Internal testes located near the kidneys. - No scrotum.
2. Epididymis	- Long, coiled tube on the testis. - Divided into the head, body, and tail. - Tail is the storage site for sperm.	- Similar to cattle. - Tail faces backward for sperm storage.	- Large and prominent. - Tail positioned dorsally near the anus.	- Elongated and tightly coiled. - Efficient sperm storage and maturation.	- Short and straight, connects to the vas deferens.
3. Vas Deferens	- Transports sperm from epididymis to urethra. - Joins the urethra near the accessory glands.	- Similar to cattle in function and structure.	- Thick-walled and short. - Transports sperm efficiently.	- Long and tortuous. - Merges into the ejaculatory duct.	- Transports sperm to the cloaca. - Lacks a urethra.

4. Accessory Glands	a) Seminal Vesicles: Paired, lobulated glands. b) Prostate Gland: Compact and well-developed. c) Bulbourethral Glands: Small, paired glands. - Glands contribute fluid to semen.	- Similar to cattle but smaller glands. - Secretion is less voluminous.	a) Seminal Vesicles: Large and lobulated. b) Prostate Gland: Small and disseminated. c) Bulbourethral Glands: Large and long, producing a gelatinous plug.	a) Seminal Vesicles: Elongated and lobulated. b) Prostate Gland: Prominent and bi-lobed. c) Bulbourethral Glands: Moderate in size.	- No accessory glands. - Sperm is produced without seminal fluid. - Cloaca receives sperm directly.
5. Penis	- Fibroelastic type with a sigmoid flexure. - Retracts into the sheath. - Tip is rounded with a urethral process.	Fibroelastic type with a sigmoid flexure. - Urethral process is elongated (longer in sheep).	- Fibroelastic type with a sigmoid flexure. - Spiral-shaped tip for effective insemination.	Musculocavernous type. - Enlarges significantly during erection. - Blunt and rounded tip (glans penis).	- No true penis. - Has a papilla in the cloaca that serves as the copulatory organ.

6. prepuce	- Protective sheath enclosing the penis. - Pendulous and extends during mating.	Similar to cattle, slightly smaller.	Prominent and thick sheath. - Extends during mating.	Thin and pliable sheath. - Protects the musculocavernous penis.	Absent, as there is no external penis.

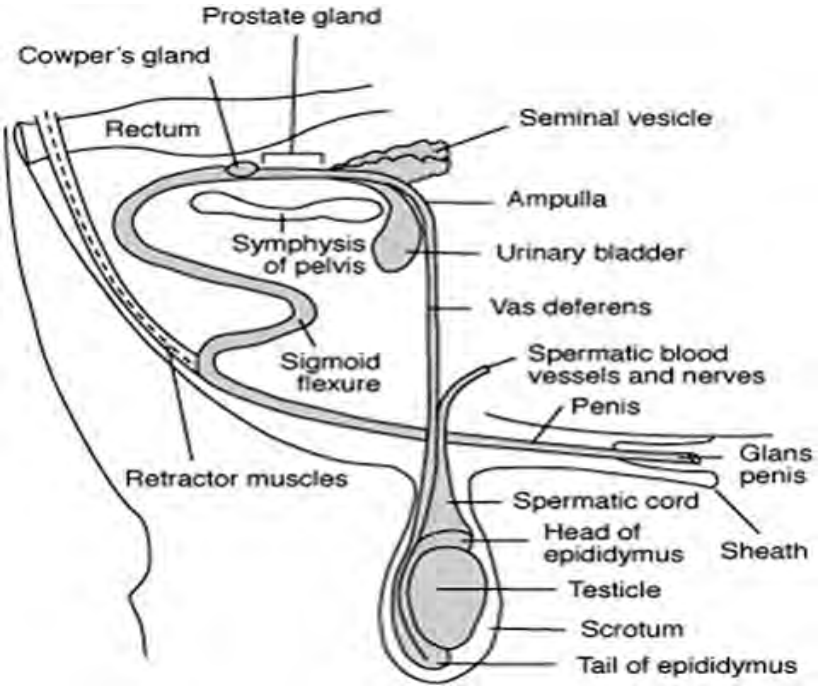


Fig 9: Male reproductive system of cattle

Source: https://www.groupe-esa.com/ladmec/bricks_modules/brick03/res/ZBOB303.jpg

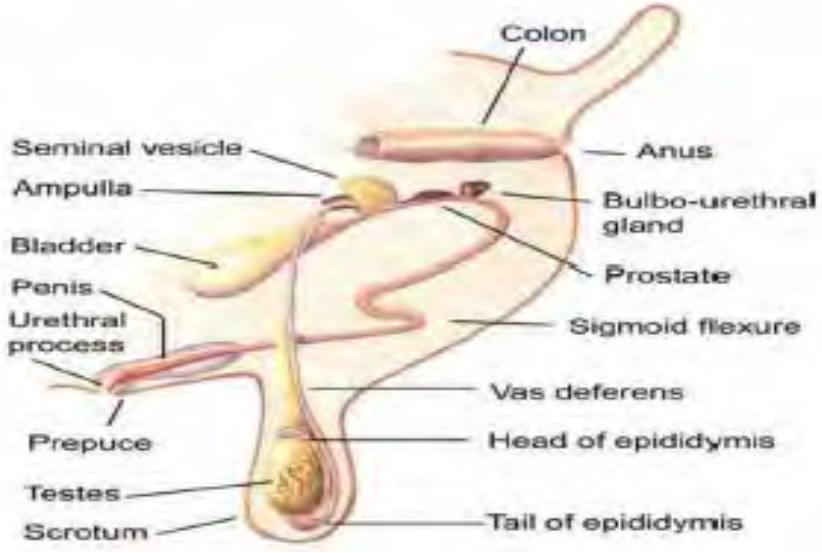


Fig 10: Male reproductive system of cattle

Source: https://static.vikaspedia.in/media/images_en/agriculture/livestock/sheep-and-goat-farming/maletest.jpg

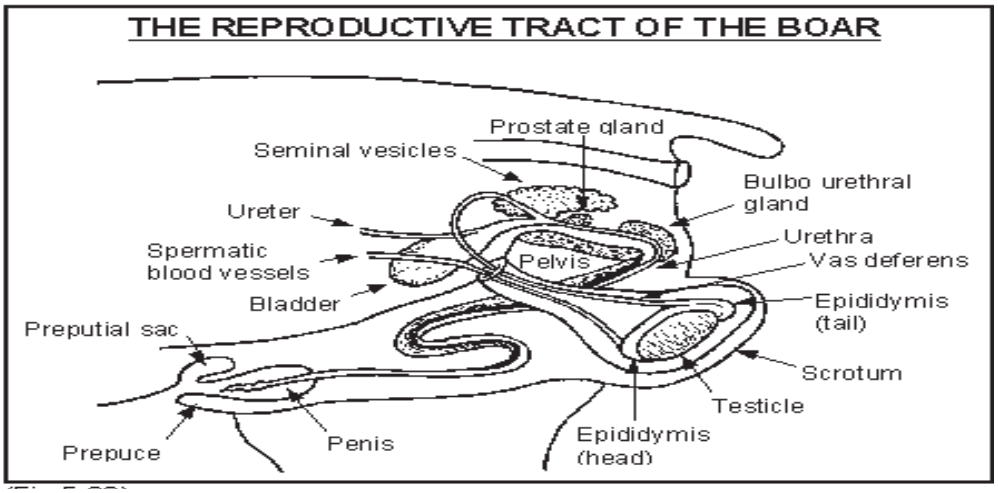


Fig 11: Male reproductive system of pig

Source: https://cdn.globalagmedia.com/pig/legacy/files/pighealth/Fig.5-32.gif

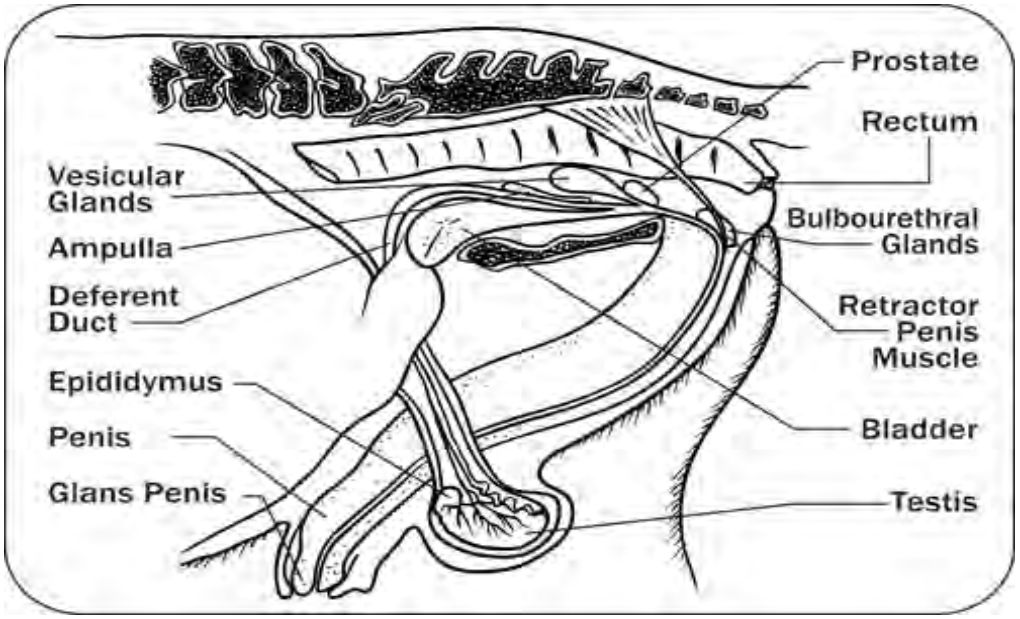


Fig 12: Male reproductive system of Horse

Source: https://www.ontario.ca/files/2022-05/omafra-anatomy-physiology-and-reproduction-in-the-stallion-en-3-500x351.jpg

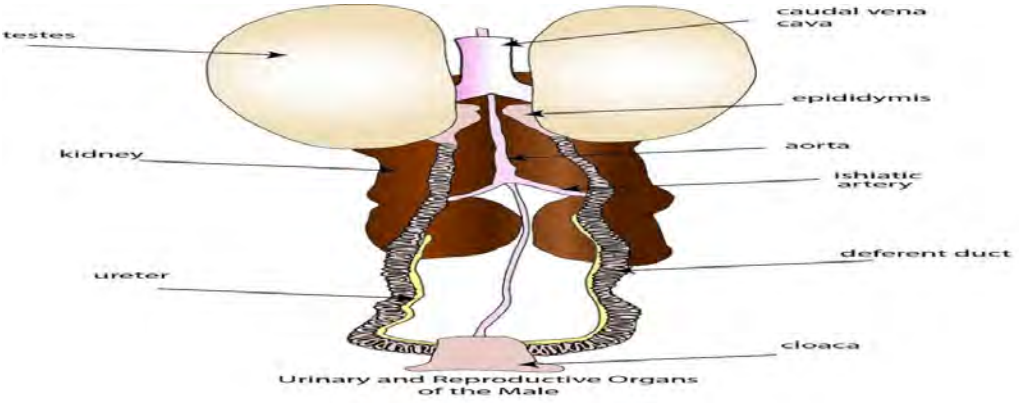


Fig 13: Female reproductive system of Poultry

Source:https://www.poultryhub.org/content/uploads/2012/04/male_urinary_genital_system1-843x1024.jpg

2.5.2 Study of Female Reproductive System

The Female Reproductive System Consists of Following Organs

- **Ovaries**
  - Produce eggs (ova) and secrete hormones (estrogen and progesterone).
  - Oviducts (Fallopian Tubes)
  - Facilitate the transport of ova and sperm, and are the site of fertilization.
- **Uterus**
  - Provides an environment for embryonic and fetal development.
- **Cervix**
  - Acts as a gateway between the uterus and vagina, with roles in sperm transport and pregnancy maintenance.
- **Vagina**
  - Functions as the copulatory organ and the birth canal.
- **Vulva**
  - o External genitalia that serve as the entrance to the reproductive tract.

Anatomy and Species-Specific Features

Structure	Cattle	Goat/Sheep	Pig	Horse	Poultry
1. Ovaries	- Oval and small, 2–3 cm in diameter. - Follicles and corpus luteum (CL) are prominent.	- Smaller than in cattle, but similar in shape and function.	- Small, irregularly shaped due to multiple follicles (litter-bearing species).	- Large and bean-shaped. - Prominent ovulation fossa for egg release.	- Cluster of developing follicles in the ovary. - Only the left ovary is functional.
2. Oviduct	- Coiled, about 25–30 cm long. - Site of fertilization in the ampulla.	- Similar to cattle but smaller in size.	- Long and coiled. - Specialized to accommodate multiple eggs.	- Long and straight with a distinct infundibulum to capture the egg.	- Oviduct is divided into infundibulum, magnum, isthmus, uterus, and vagina.
3. Uterus	- Bicornuate (two uterine horns). - Long horns, short body. - Suitable for single births.	- Similar to cattle but smaller horns. - Adapted for single or twin pregnancies.	- Bicornuate with very long horns to accommodate litters. - Short uterine body.	- Bicornuate with large uterine body. - Short horns due to single births.	- Shell gland (uterus) adds the shell to the egg. - No horns; egg passes quickly through.

4. Cervix	- Thick, muscular, with annular folds. - Acts as a barrier during pregnancy.	- Similar to cattle but smaller. - Multiple annular folds.	Long and interdigitated. - Spiral shape locks the boar's penis during mating.	- Short and muscular. - Relaxed during estrus and tightly closed during pregnancy.	- No true cervix. - Vagina and cloaca serve as the pathway for egg expulsion.
5. Vagina	- Muscular and elastic. - Functions as the copulatory organ and birth canal.	- Similar to cattle but proportionally shorter.	Long and capacious to accommodate large volumes of semen.	- Long and muscular. - Functions as a copulatory organ and the birth canal.	- Short passage from the uterus to the cloaca. - Egg passes through here.
6. Vulva	- External opening with distinct labia. - Swells during estrus.	- Similar to cattle. - Slightly smaller in size	- Large and prominent. - Reddening indicates estrus.	- Large and softens during estrus. - Becomes prominent before foaling.	- No distinct vulva. - Egg passes through the cloaca to the exterior.

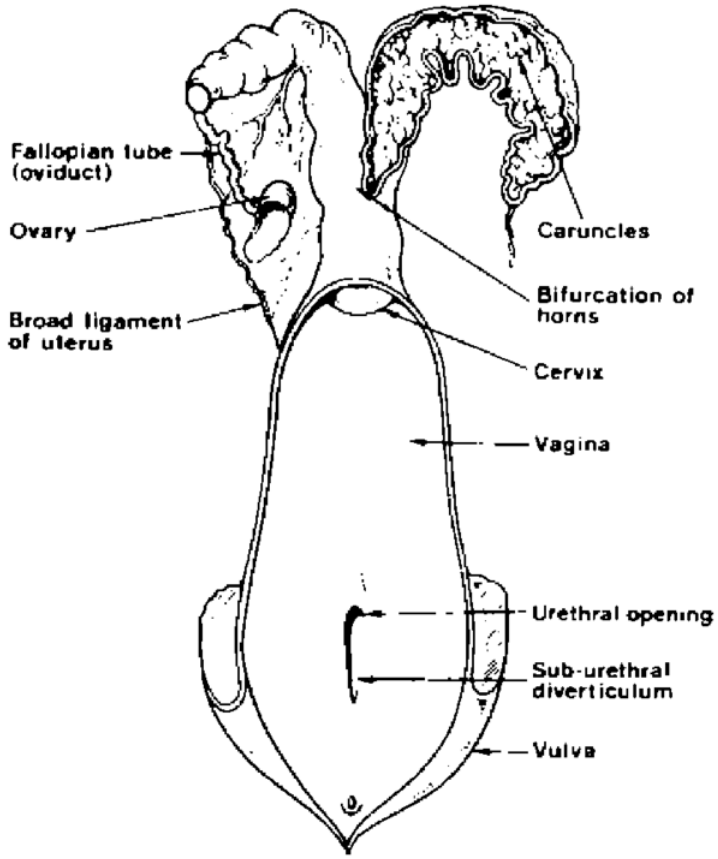


Fig 14: Female reproductive system of cattle

Source: https://www.researchgate.net/publication/316285755_Reproduction_in_Cattle

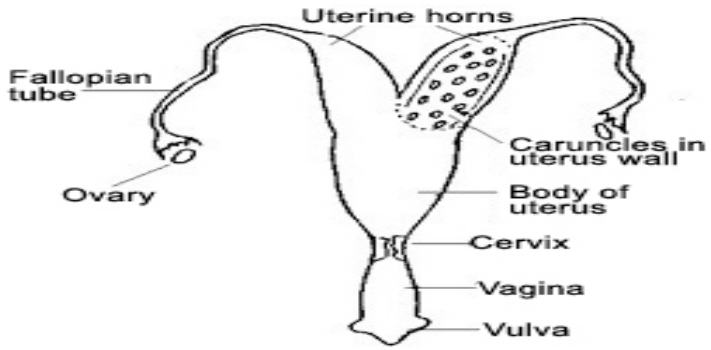


Fig 15: Female reproductive system of sheep

Source: https://www2.zoetis.com.au/content/_assets/Microsite-Images/Livestock-Solution-Testing/Sheep-images/OptimiseEweHealth/anatomy_imgs_1.jpg

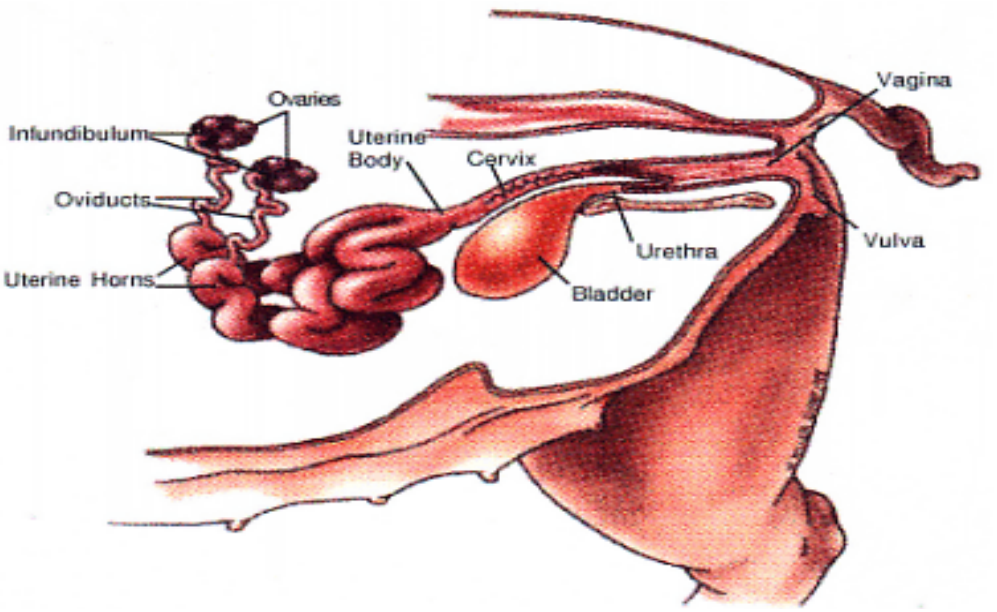


Fig 16: Female reproductive system of pig

Source: https://www.ansc.purdue.edu/pork-archive/pubs/SowAnatomy.gif

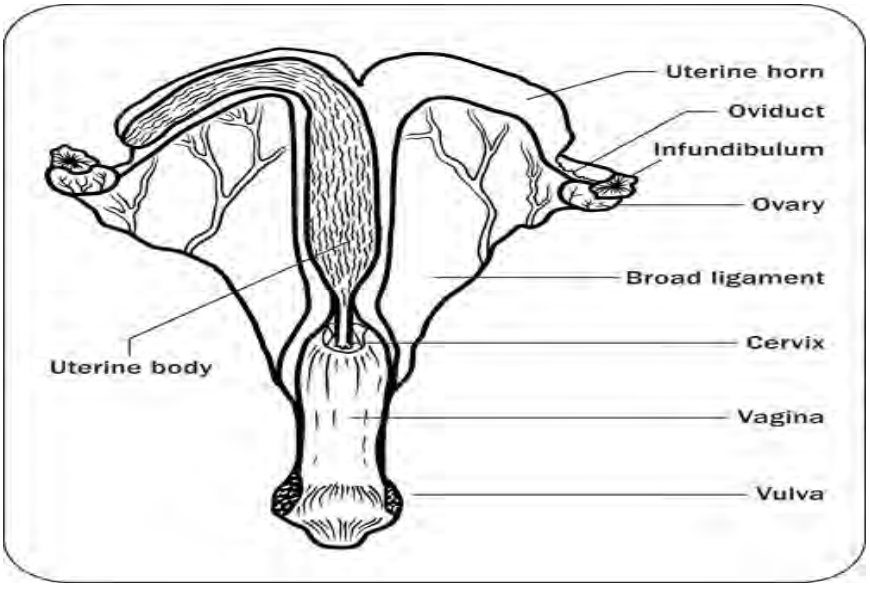


Fig 17: Female reproductive system of Horse

Source: https://www.ontario.ca/files/2022-05/omafra-anatomy-physiology-and-reproduction-in-the-mare-en-3-500x518.jpg

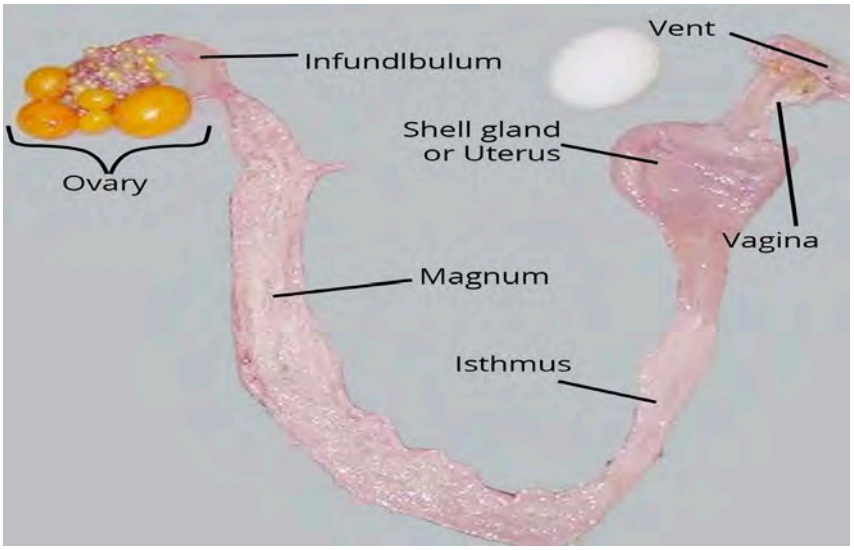


Fig 18: Female reproductive system of Poultry

Source:https://images.squarespacecdn.com/content/v1/5f87b82c3640400719116914/d009f885-81f3-4bc7-87ad-91927cad4259/fig+1.jpg

Exercise

Choose the correct answer from the given alternatives.

1. What is the primary focus of veterinary splanchnology?

   a. Study of bones and joints b. Study of internal organs

   c. Study of muscles and tendons d. Study of the skeletal system

2. Which of the following organs is not typically studied in veterinary splanchnology?

   a. Heart b. Lungs

   c. Kidney d. Femur

3. Which of the following animals is a ruminant and has a four-chambered stomach?

   a. Pig b. Sheep c. Poultry d. Dog

4. Which stomach compartment in cattle is primarily responsible for fermentation of fibrous plant material?

   a. Reticulum b. Omasum

   c. Abomasum d. Rumen

5. In which of the following animals does the gizzard function as the main site of mechanical digestion?

   a. Cattle b. Pig c. Poultry d. Sheep

6. Which of the following animal has a simple stomach (monogastric) for digestion?

   a. Cattle b. Sheep c. Goat d. Pig

7. The small intestine is the primary site of nutrient absorption in which of the following species?

   a. Cattle b. Sheep c. Goat d. All of the above

8. Which organ in cattle is responsible for absorption of water and electrolytes in the digestive system?

a. Abomasum
b. Omasum
c. Cecum
d. Rumen

9. What part of the degestive system functions as the proventriculus in poultry?

a. Mechanical digestion
b. Chemical digestion (secretes gastric juices)
c. Nutrient absorption
d. Food storage

10. Which organ in pigs secretes digestive enzymes and neutralizes stomach acid?

a. Liver
b. Pancreas
c. Small intestine
d. Cecum

11. In which of the animal, the rumen most developed, responsible for fermenting plant material?

a. Pig
b. Sheep
c. Goat
d. Cattle

12. What is the primary function of the crop in poultry?

a. Digestion of proteins
b. Storage and softening of food
c. Absorption of nutrients
d. Breakdown of fats

13. The large intestine in pigs primarily functions as .....

a. Absorb nutrients
b. Absorb water and form feces
c. Break down proteins
d. Store food

14. Which stomach compartment in ruminants is known as the "true stomach"?

a. Rumen b. Reticulum

c. Omasum d. Abomasum

15. The gizzard poultry helps in .....

a. Secretion of digestive enzymes

b. Breaking down food with muscular contractions

c. Absorbing nutrients

d. Storing food

16. In poultry, Where does the majority of nutrient absorption occurs?

a. Crop b. Gizzard

c. Small intestine d. Large intestine

17. Which of the following animals has a respiratory system that lacks a diaphragm?

a. Cattle b. Sheep c. Goat d. Poultry

18. Which of the following is the primary organ for gas exchange in cattle, sheep, and goats?

a. Trachea b. Lungs c. Bronchi d. Nasal cavity

19. Which structure in the urinary system is responsible for storing urine in the mammals?

a. Kidneys b. Urethra c. Ureters d. Bladder

20. Which organ is responsible for producing ova (eggs) in female farm animals?

a. Uterus b. Ovary c. Oviduct c. Cervix

21. Which of the following is not part of the male reproductive system in farm animals?

a. Epididymis b. Ampulla c. Follicle d. Vas deferens

22. Which structure in male farm animals produces the majority of seminal fluid?

a. Testicles
b. Prostate gland
c. Seminal vesicles
d. Bulbourethral glands

23. What is the function of the testicles in male farm animals?

a. Production of testosterone and sperm
b. Storage of sperm
c. Secretion of seminal fluid
d. Transportation of sperm

24. What is the function of the epididymis in male farm animals?

a. Production of sperm
b. Storage and maturation of sperm
c. Secretion of testosterone
d. Transport of semen

25. In female farm animals, the ovary is responsible for.....

a. Storage of eggs
b. Production of eggs and hormones
c. Transport of fertilized eggs
d. Formation of the placenta

26. Which structure in poultry is responsible for the formation of egg white (albumen)?

a. Infundibulum
b. Magnum
c. Isthmus
d. Shell gland

27. What is the function of the shell gland in the poultry?

a. Deposition of egg white
b. Secretion of the eggshell
c. Capturing the yolk
d. Storage of sperm

28. Which species has only one functional ovary in the female reproductive system?

a. Sheep
b. Cattle
c. Poultry
d. Goat

Write short answer to the following questions.

1. Define splanchnology.
2. List the names of digestive organs of cattle and write their functions.
3. Describe briefly the respiratory system of ruminants.
4. Enlist the organs of male urinary system and explain them briefly.
5. Draw a labeled diagram of female urinary system of cattle.
6. Describe the male reproductive system of ruminants.
7. Write in short about female reproductive system of pig.
8. Describe the male reproductive system of poultry.
9. List the name of female reproductive organs of poultry and explain them briefly.
10. Compare the digestive system of ruminants and mono-gastric animals.

Write long answer to the following questions.

1. Describe the digestive system of ruminants with a labelled diagram.
2. Draw a diagram of digestive system of mono-gastric animal. Explain about digestive system of pig.
3. Describe the anatomy and function of the male reproductive system in cattle.
4. Describe the female reproductive system of cattle with a labeled diagram.

Project work

1. Choose one farm animal (e.g., cow, sheep, and goat) and describe its digestive system. Identify the major organs involved in the digestive process (e.g., mouth, stomach, small intestine, large intestine, liver, etc.). Explain how the digestive system of this animal is adapted to its diet (e.g., herbivore, omnivore, ruminant). How do the processes of digestion and absorption work in this animal, and how is the system important for its overall health and productivity?"

2. Examine the respiratory system of a selected farm animal (e.g., cow, pig, chicken). Identify and describe the key organs involved in respiration (e.g., nose, trachea, lungs, and bronchi). Explain how the respiratory system functions in this animal.
3. Draw a labelled diagram of urinary system of male and female animals farm and describe the main components of the system (e.g., kidneys, ureters, bladder, and urethra) and their functions.
4. Select a farm animal (e.g., cow, goat, pig, horse) and describe its reproductive system. Identify the key reproductive organs (e.g., ovaries, uterus, testes, and penis) and explain their roles in reproduction.

Unit 3 Introduction to Physiology

1.1 Introduction to Veterinary Physiology

Veterinary physiology is a branch of veterinary science that deals with the study of the normal functioning of animals' bodies. It focuses on how animals' organ systems work, both individually and together, to maintain homeostasis (a stable internal environment). Veterinary physiology integrates knowledge from various biological sciences, including anatomy, biochemistry, pharmacology, and pathology, to understand how animals' bodies respond to various internal and external stimuli.

Veterinary physiology is a fundamental discipline for veterinarians as it helps in diagnosing and treating diseases, understanding animal health and performance, and ensuring the proper functioning of physiological processes in both domestic and wild animals. The knowledge gained through veterinary physiology aids in improving animal care, nutrition, breeding, and management, making it crucial for veterinary practice, research, and animal husbandry.

Definition of Veterinary Physiology

Veterinary Physiology refers to the study of the normal biological functions of animals. Particularly, in relation to their structure, metabolic processes, organ systems, and responses to stimuli. It includes understanding how various systems—such as the cardiovascular, respiratory, nervous, digestive, and musculoskeletal systems—function in healthy animals and how they adapt to environmental and physiological changes.

In essence, veterinary physiology is the science of how the body of an animal functions under normal conditions, as well as how it responds to diseases, treatments, and various environmental conditions.

Terms used in Veterinary Physiology

Homeostasis

- The maintenance of a stable internal environment in an organism despite changes in external conditions. It is critical for the proper functioning of organs and systems.

Metabolism

- The sum of all biochemical reactions in an animal's body, including both anabolic (building) and catabolic (breaking down) processes.

Physiology

- The scientific study of the functions and mechanisms in a living organism.

Anatomy

- The study of the structure and organization of the body and its organs, often paired with physiology for a complete understanding.

Neurophysiology

- The branch of physiology that studies the nervous system, including how neurons transmit signals and how the nervous system controls and regulates various body functions.

Cardiovascular Physiology

- The study of the heart, blood vessels, and the circulation of blood, including blood flow, heart rate, and the regulation of blood pressure.

Respiratory Physiology

- The study of the respiratory system, including the mechanics of breathing, gas exchange, oxygen transport, and the regulation of respiratory rate.

Gastrointestinal Physiology

- The study of the digestive system, focusing on how food is broken down, nutrients are absorbed, and waste is eliminated.

Endocrinology

- The study of hormones and the endocrine system, focusing on how hormones regulate bodily functions such as growth, metabolism, and reproduction.

Renal Physiology

- The study of kidney function, including the filtration of blood, urine production, and the regulation of electrolytes and water balance.

Musculoskeletal Physiology

- The study of muscles and bones, including how muscles contract, how the skeleton supports the body, and how both systems enable movement.

Reproductive Physiology

- The study of the reproductive systems in animals, including the processes of gametogenesis (sperm and egg formation), fertilization, pregnancy, and birth.

Immuno-physiology

- The study of the immune system and how the body defends itself against pathogens, including mechanisms of immunity and inflammation.

Thermoregulation

- The process by which animals maintain their body temperature within a certain range, including behavioral and physiological adaptations to temperature changes.

Acid-Base Balance

- The maintenance of the pH of body fluids within a narrow range, essential for proper cellular function and overall health.

Electrophysiology

- The study of the electrical properties of cells, tissues, and organs, including the study of nerve impulses, muscle contractions, and cardiac rhythms.

Autonomic Nervous System (ANS)

- The part of the nervous system that controls involuntary bodily functions, such

as heart rate, digestion, and respiratory rate. It consists of the sympathetic and parasympathetic systems.

Sympathetic Nervous System (SNS)

- Part of the autonomic nervous system that prepares the body for "fight or flight" responses, such as increased heart rate and blood pressure.

Parasympathetic Nervous System (PNS)

- Part of the autonomic nervous system responsible for "rest and digest" activities, such as lowering heart rate and promoting digestion.

Action Potential

- A temporary change in the electrical potential across the membrane of a cell, particularly nerve or muscle cells, that allows for the transmission of signals.

Hemostasis

- The process of stopping bleeding or hemorrhage, which involves the blood vessels, platelets, and clotting factors.

Circulatory Shock

- A condition where there is insufficient blood flow to tissues, leading to inadequate oxygen delivery and potential organ failure.

Excretion

- The process by which waste products are removed from the body, primarily by the kidneys, liver, and digestive system.

Osmoregulation

- The process by which animals maintain the balance of water and electrolytes (such as sodium, potassium, etc.) in their bodies.

Reflex Arc

- The neural pathway that controls a reflex action, such as a quick response to a stimulus (e.g., withdrawal of a limb from a painful stimulus).

Exercise

Choose the correct answer from the given alternatives.

1. What is the primary focus of veterinary physiology?
   a. Treatment of animal diseases
   b. Study of functions and mechanisms in animal bodies
   c. Understanding animal anatomy
   d. Classification of animal species

2. Which of the following is NOT a major system studied in veterinary physiology?
   a. Nervous system
   b. Musculoskeletal system
   c. Integumentary system
   d. Evolutionary system

3. Homeostasis refers to.....
   a. The process of reproduction in animals
   b. Maintenance of a stable internal environment
   c. The adaptation of animals to their environment
   d. Breakdown of complex molecules in the body

4. Which branch of physiology studies the function of hormones in animals?
   a. Neurophysiology
   b. Endocrinology
   c. Cardiovascular physiology
   d. Reproductive physiology

5. The term 'metabolism' refers to.....
   a. The production of red blood cells
   b. The sum of all chemical reactions in the body
   c. The function of muscles during exercise
   d. The mechanism of nerve transmission

6. Which physiological system is primarily responsible for gas exchange?

   a. Digestive system
   b. Nervous system
   c. Respiratory system
   d. Urinary system

7. Which term describes the process of breaking down food into smaller molecules for absorption?

   a. Anabolism
   b. Catabolism
   c. Digestion
   d. Homeostasis

8. What does 'hypoxia' mean in veterinary physiology?

   a. Low oxygen levels in the tissues
   b. Excess oxygen in the blood
   c. High carbon dioxide levels in the body
   d. Increase in blood pressure

9. What does the term 'hyperkalemia' mean?

   a. Low levels of potassium in the blood
   b. High levels of potassium in the blood
   c. Excess calcium in the blood
   d. Dehydration due to lack of water

10. What does 'thermoregulation' mean in physiology?

    a. Regulation of blood pressure
    b. Maintenance of body temperature within a normal range
    c. Control of hormone secretion
    d. Adjustment of heart rate during exercise

Write short answer to the following questions.

1. Define veterinary physiology.
2. Write short notes on veterinary physiology.

Write long answer to the following questions.

1. Define any five terms used in veterinary physiology.

Unit 4

Digestive System

4.1 Physiology of Digestion in Ruminants, Non-ruminants, and Birds

A. Ruminants

Ruminants (e.g., cattle, sheep, and goat) have a specialized digestive system to process fibrous plant materials efficiently. Their digestion is characterized by foregut fermentation.

1. Digestive Tract Features

- Mouth: Chewing and salivation (buffering with bicarbonates).
- Esophagus: Bidirectional movement (allows regurgitation and re-chewing of cud).
- Stomach: Four compartments:
    1. Rumen: Largest compartment; site of microbial fermentation (producing volatile fatty acids like acetate, propionate, and butyrate).
    2. Reticulum: Honeycomb structure; facilitates regurgitation and trapping of foreign materials.
    3. Omasum: Absorbs water and nutrients; reduces particle size.
    4. Abomasum: True stomach; secretes enzymes (pepsin and hydrochloric acid) for protein digestion.
        - Small Intestine: Absorption of digested nutrients (amino acids, glucose, and fatty acids).
        - Large Intestine: Microbial fermentation and water absorption.

2. Microbial Digestion

- Rumen microbes (bacteria, protozoa, fungi) break down cellulose and hemicellulose into volatile fatty acids.
- Microbial protein synthesis occurs, which is digested in the abomasum.

B. Non-Ruminants

Non-ruminants (e.g., pigs, humans, horses) lack a complex foregut fermentation system and rely primarily on enzymatic digestion.

1. Digestive Tract Features

- Mouth: Saliva contains amylase for carbohydrate digestion.
- Stomach: Acidic environment (pH ~2) for protein denaturation and enzymatic digestion (pepsin activity).
- Small Intestine
  - Main site of digestion and nutrient absorption.
  - Enzymes from the pancreas and bile from the liver aid in fat emulsification and digestion.
- Large Intestine: Fermentation of undigested material, water absorption, and feces formation.

2. Hindgut Fermentation (in species like horses)

- Fermentation occurs in the cecum and colon, producing volatile fatty acids absorbed for energy.

C. Birds

Birds (e.g., chickens, ducks) have a unique digestive system adapted for their high metabolic rate and lack of teeth.

1. Digestive Tract Features

- Beak and Crop
  - Beak: No chewing; food is picked and swallowed.
  - Crop: Temporary storage pouch; moistens and softens food.

- Proventriculus
  - Glandular stomach; secretes enzymes and hydrochloric acid.
- Gizzard (Ventriculus)
  - Muscular stomach; grinds food with the help of ingested grit.
- Small Intestine
  - Primary site for nutrient absorption.
- Ceca
  - Paired structures for microbial fermentation of fibrous material.
- Large Intestine
  - Short; water absorption and feces formation.
- Cloaca
  - Common exit for digestive, urinary, and reproductive tracts.

2. Rapid Digestion

- Adaptation for flight requires efficient and quick processing of food.

Exercise

Choose the correct answer from the given alternatives.

1. Which of the following is the largest compartment of the ruminant stomach?

   a. Rumen
   b. Reticulum
   c. Omasum
   d. Abomasum

2. What is the primary function of the rumen?

   a. Absorption of water and nutrients
   b. Fermentation of fibrous plant material
   c. Acidic digestion of proteins
   d. Production of bile

3. Which part of the ruminant stomach is referred to as the "true stomach"?

   a. Rumen
   b. Reticulum
   c. Omasum
   d. Abomasum

4. What is the function of the omasum in ruminants?

   a. Mixing and fermentation
   b. Absorption of water and minerals
   c. Storage of feed
   d. Production of volatile fatty acids (VFAs)

5. The reticulum in ruminants is also known as .....

   a. Honeycomb
   b. Book stomach
   c. Paunch
   d. Glandular stomach

6. What is the primary end-product of microbial fermentation in the rumen?

   a. Glucose
   b. Volatile fatty acids (VFAs)
   c. Amino acids
   d. Lactose

7. Which volatile fatty acid is the primary energy source for ruminants?

a. Acetate b. Propionate

c. Butyrate d. Lactate

8. The process of regurgitation, re-mastication, re-salivation, and re-swallowing in ruminants is called.....

a. Rumination b. Fermentation

c. Digestion d. Peristalsis

9. Which of the following is the primary site of nutrient absorption in mono-gastric animals?

a. Stomach b. Large intestine

c. Small intestine d. Esophagus

10. In mono-gastric animals, which enzyme begins the digestion of carbohydrates in the mouth?

a. Lipase b. Amylase

c. Pepsin d. Trypsin

11. The stomach of mono-gastric animals secretes hydrochloric acid (HCl) to..

a. Neutralize food pH

b. Break down fats

c. Denature proteins and activate enzymes

d. Absorb nutrients

12. Which of the following structures prevents food from entering the trachea during swallowing?

a. Esophagus b. Pharynx

c. Epiglottis d. Larynx

13. Which segment of the small intestine receives bile and pancreatic secretions?

a. Ileum b. Jejunum

c. Cecum d. Duodenum

14. What is the end product of carbohydrate digestion in the small intestine?

a. Polysaccharides b. Disaccharides

c. Monosaccharides d. Glycogen

15. Which enzyme is responsible for initiating protein digestion in the stomach?

a. Lipase b. Amylase c. Pepsin d. Trypsin

Write short answer to the following questions.

1. Explain the physiology of digestion in ruminants.
2. Compare the digestive physiology of ruminants and simple stomached animals.

Write long answer to the following questions.

1. How does digestion in ruminants differ from digestion in mono-gastric animals? Describe the digestive process in mono-gastric animals.
2. Explain the physiology of digestion in poultry with functions of the digestive organs.

Project work

1. Compare the physiology of digestion in ruminant and mono-gastric animals. Choose one animal from each category (e.g., cow for ruminant and pig for mono-gastric) and describe their digestive systems. Highlight the key differences in the structure and function of the stomach, intestines, and other digestive organs.

Unit 5

Reproductive System

5.1 Physiology of Reproduction of Different Species of Animals and Birds, Gametogenesis, Sexual Cycle, Ovulation, Fertilization, Implantation, Pregnancy and Parturition

5.1.1 Physiology of Reproduction of Different Species of Animals and Birds

The physiology of reproduction varies significantly between mammals and birds due to differences in anatomy, reproductive strategies, and adaptations for survival. The detailed outline is given below.

A. Mammals

Mammals include both polyestrous (e.g., cattle, pigs) and seasonally polyestrous (e.g., sheep, horses) species, with internal fertilization and live births (viviparous).

1. Reproductive Anatomy

- **Males**
  - **Testes:** Spermatogenesis and testosterone production.
  - Accessory glands (prostate, seminal vesicles): Secrete fluids for sperm transport.
  - **Penis:** Organ for copulation and semen delivery.
- **Females**
  - **Ovaries:** Follicle development, ovulation, and hormone secretion (estrogen, progesterone).
  - **Oviducts (Fallopian tubes):** Site of fertilization.
  - **Uterus:** Site of embryo implantation and development.
  - **Cervix and Vagina:** Birth canal and copulation.

2. Reproductive Processes

- **Estrous Cycle**
  - Divided into proestrus, estrus, metestrus, and diestrus phases.
  - Hormonal regulation by the hypothalamus-pituitary-gonadal axis (GnRH, LH, FSH, estrogen, and progesterone).
- **Gestation**
  - Duration varies by species (e.g., 9 months in cattle, 3 months in pigs).
  - Placenta develops for nutrient and gas exchange.
- **Parturition**
  - Triggered by hormonal changes (decline in progesterone, increase in oxytocin and prostaglandins).
- **Lactation**
  - Mammary glands produce milk under the influence of prolactin and oxytocin.

B. Birds

Birds have unique reproductive physiology due to their oviparous nature (egg-laying) and adaptations for flight.

1. Reproductive Anatomy

- **Males**
  - **Testes:** Produce sperm and testosterone; located within the body cavity (temperature-tolerant).
  - **Vas deferens:** Transport sperm to the cloaca.
  - **Cloaca:** Common exit for reproductive, digestive, and urinary tracts.
- **Females**
  - Single functional ovary (left side in most species).
  - Oviduct: Divided into five regions:

1. **Infundibulum:** Captures the ovum; site of fertilization.
2. **Magnum:** Secretes egg white (albumen).
3. **Isthmus:** Adds shell membranes.
4. **Uterus (Shell gland):** Deposits calcium carbonate for the eggshell.
5. **Vagina:** Stores sperm and lays eggs.
    - **Cloaca:** Passage for laying eggs.

2. Reproductive Processes

- **Oogenesis and Ovulation**
    - o Ovum develops in the ovary and is released into the oviduct.
    - o Birds lay eggs regularly (e.g., daily in chickens) due to their continuous reproductive cycle.
- **Fertilization**
    - o Occurs in the infundibulum shortly after ovulation.
- **Egg Development**
    - o Eggs are encased in shells and laid externally.
    - o Incubation (e.g., by the parent) provides optimal temperature for embryonic development.
- **Hatching**
    - o Chick breaks the shell using an egg tooth; growth continues outside the mother's body.

Species-Specific Highlights

Ruminants (e.g., Cattle, Sheep, Goats)

- Polyestrous cycles.
- Seasonal breeding common in sheep.
- Placenta type: Cotyledonary (ruminants).

Pigs

- Non-seasonal breeders with large litter sizes.
- Diffuse placental attachment.

Horses

- Seasonal breeders (long-day photoperiod).
- Gestation: ~11 months.
- Diffuse placenta.

Chickens

- Continuous laying cycle regulated by photoperiod.
- Ovulation occurs ~24 hours after the previous egg is laid.
- No external genitalia; cloacal kiss for mating.

5.1.2 Gametogenesis

Gametogenesis is the biological process in which specialized sex cells, or gametes (sperm and eggs), are produced through meiosis and differentiation in animals. The process is essential for sexual reproduction and occurs in the gonads (testes in males and ovaries in females). There are two main types of gametogenesis:

1. Spermatogenesis (Formation of Sperm in Males)

Stages of Spermatogenesis

Spermatogenesis occurs in the seminiferous tubules of the testes and involves the transformation of diploid germ cells into haploid sperm cells. It can be divided into three main phases:

1. Mitotic Phase (Spermatogonia Proliferation)

- Spermatogonia (diploid, 2n) divide by mitosis to maintain a pool of stem cells and produce primary spermatocytes.
- Type A spermatogonia: Stem cell pool.
- Type B spermatogonia: Proliferate to form primary spermatocytes.

2. Meiotic Phase

- Primary Spermatocytes (2n): Undergo meiosis I, reducing the chromosome

number by half and forming secondary spermatocytes (haploid, n).

- Secondary Spermatocytes (n): Undergo meiosis II to produce spermatids (haploid, n).

3. Spermiogenesis (Spermatid Differentiation)

- Spermatids undergo morphological changes to become mature spermatozoa:
  - Formation of the acrosome (contains enzymes for penetrating the egg).
  - Condensation of the nucleus.
  - Development of the flagellum for motility.
  - Shedding of excess cytoplasm.

Key Hormonal Regulation in Spermatogenesis

- GnRH (Gonadotropin-Releasing Hormone): Stimulates the release of FSH and LH from the anterior pituitary.
- FSH (Follicle-Stimulating Hormone): Stimulates Sertoli cells to support spermatogenesis.

2. Oogenesis (Formation of Eggs in Females)

Stages of Oogenesis

Oogenesis occurs in the ovaries and involves the formation of haploid ova (eggs) from diploid germ cells. Unlike spermatogenesis, oogenesis begins in the fetal stage and is completed after fertilization.

1. Mitotic Phase (Fetal Development)

- Oogonia (diploid, 2n) divide by mitosis during fetal development, forming primary oocytes.
- Primary oocytes enter prophase I of meiosis and become arrested (dormant) until puberty.

2. Meiotic Phase

- At puberty, hormonal stimulation resumes meiosis:

- Primary Oocytes (2n): Complete meiosis I during each menstrual/ estrous cycle, producing a secondary oocyte (haploid, n) and a polar body (non-functional).
- Secondary Oocyte (n): Begins meiosis II but arrests at metaphase II until fertilization.

3. Fertilization and Completion of Meiosis

- If fertilization occurs, the secondary oocyte completes meiosis II, forming a mature ovum and a second polar body.

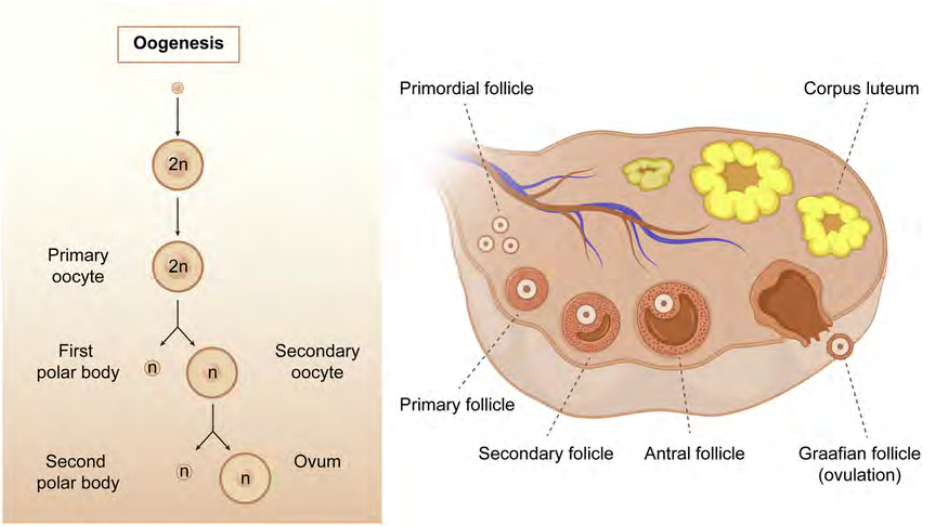


Fig 20: Oogenesis

Source:https://www.researchgate.net/publication/372929799/figure/fig3/AS:11431281258620735@1720122333887/The-process-of-oogenesis-Oogenesis-starts-with-a-transformation-of-the-oogonia-into-the.tif

Key Hormonal Regulation in Oogenesis

- GnRH: Stimulates FSH and LH release.
- FSH: Stimulates follicular growth and maturation in the ovary.
- LH: Triggers ovulation and the formation of the corpus luteum, which secretes progesterone to prepare the uterus for implantation.

5.1.3 Sexual cycle

The sexual cycle refers to the recurring physiological and behavioral changes in female animals that prepare them for reproduction. It is regulated by the hypothalamic-pituitary-gonadal (HPG) axis and involves hormonal, ovarian, and uterine changes. Below is a comparison of the sexual cycles in ruminants and non-ruminants.

1. Ruminants

Ruminants, such as cattle, sheep, and goats, exhibit a polyestrous cycle (recurring cycles throughout the year) or are seasonally polyestrous (cycling during specific seasons). Their cycle consists of distinct phases. As describe below.

Estrous Cycle Phases (Ruminants)

The cycle is divided into four phases:

1. Proestrus

- Transition period before estrus.
- Follicular growth is stimulated by FSH.
- Estrogen levels increase, causing uterine changes and behavioral signs of heat.
- Lasts ~2–3 days in cattle.

2. Estrus

- Period of sexual receptivity (standing heat).
- Dominant follicle ovulates under the influence of LH surge.
- High estrogen levels trigger behavioral signs (mounting, bellowing, vulvar swelling).
- Lasts ~18 hours in cattle, ~30–36 hours in sheep.

3. Metestrus

- Post-ovulation phase.
- Formation of the corpus luteum (CL), which secretes progesterone.

- Progesterone prepares the uterus for pregnancy.
- Metestrus bleeding (in cattle) may occur due to vascular changes.

4. Diestrus

- Longest phase; period of functional CL.
- High progesterone levels maintain uterine environment for pregnancy.
- If no pregnancy occurs, PGF2 (prostaglandin) from the uterus causes luteolysis, and the cycle restarts.

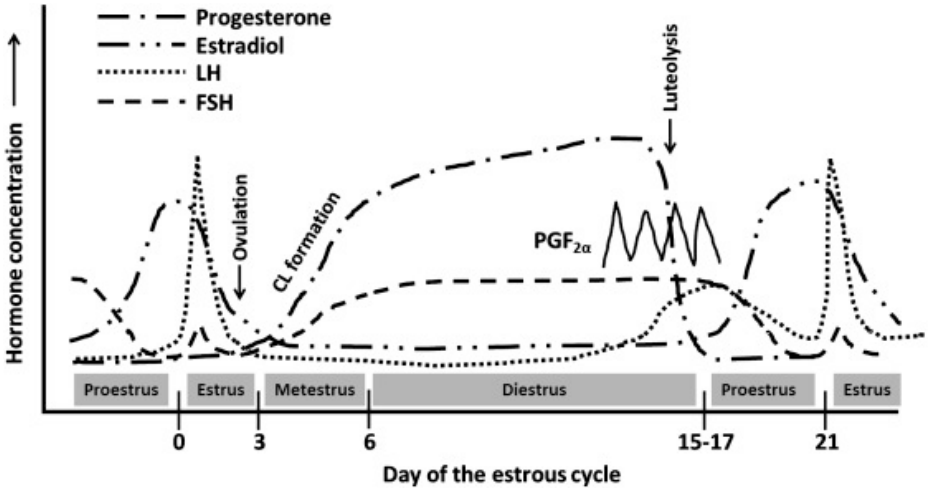


Fig 21: Phases of estrous cycle in cattle

Source: https://ars.els-cdn.com/content/image/3-s2.0-B9780128096338205207-f20520-02-9780128118993.jpg

Cycle Length and Seasonality

- Cattle: Polyestrous; cycle length ~21 days.
- Sheep/Goats: Seasonally polyestrous; cycle length ~17 days in sheep, 21 days in goats.
- Buffaloes: Polyestrous but affected by seasonality (more pronounced in tropical climates).

Key Hormones in Ruminants

- GnRH: Stimulates FSH and LH release.

- FSH: Promotes follicle growth.
- LH: Induces ovulation.
- Estrogen: Prepares reproductive tract and induces estrous behavior.
- Progesterone: Maintains pregnancy or suppresses estrus during diestrus.

2. Non-Ruminants

Non-ruminants, such as pigs, horses, and small mammals, have variations in their sexual cycles based on their species, reproductive strategy, and environmental factors.

Estrous Cycle Phases (Non-Ruminants)

The phases are similar to ruminants but with species-specific differences in duration and characteristics:

1. Proestrus

- Follicular growth and increasing estrogen levels.
- Behavioral changes begin (e.g., restlessness in mares).

2. Estrus

- Sexual receptivity occurs.
- Ovulation timing differs:
  - In pigs, ovulation occurs near the end of estrus.
  - In mares, ovulation occurs 1–2 days before the end of estrus.

3. Metestrus

- Corpus luteum formation and initial progesterone secretion.
- Short or absent in some species (e.g., horses).

4. Diestrus

- Corpus luteum dominance and high progesterone levels.
- Ends with luteolysis if no pregnancy occurs.

Cycle Length and Seasonality

- Pigs (Sows): Polyestrous; cycle length ~21 days.
- Horses (Mares): Seasonally polyestrous; long-day breeders. Cycle length ~21 days.
- Dogs: Monoestrous; cycles occur every 6–12 months.
- Cats: Seasonally polyestrous; induced ovulators (ovulation triggered by mating).

Key Hormones in Non-Ruminants

- Similar hormonal roles as ruminants, with variations:
- In horses, estrogen levels during estrus are lower compared to ruminants, and progesterone levels rise more gradually.
- In pigs, ovulation rates are high due to litter-bearing nature.

5.1.4 Ovulation

Ovulation is the physiological process in which a mature ovarian follicle ruptures, releasing an ovum (egg) into the oviduct for potential fertilization. It is a critical event in the reproductive cycle of mammals and birds and is regulated by a complex interaction of hormones.

1. Process of Ovulation

Ovulation is the culmination of follicular development during the estrous or menstrual cycle. It involves the following steps:

A. Follicular Development

1. **Recruitment:** Small follicles begin to grow under the influence of FSH (Follicle-Stimulating Hormone).
2. **Selection:** A dominant follicle is selected for further development; others regress (atresia).
3. **Growth and Maturation:** The dominant follicle grows and secretes increasing levels of estrogen, which stimulates changes in the reproductive tract.

B. Hormonal Surge

1. **Estrogen Peak:** High estrogen levels from the mature follicle trigger a surge of GnRH (Gonadotropin-Releasing Hormone) from the hypothalamus.
2. **LH Surge:** GnRH stimulates a large release of LH (Luteinizing Hormone) from the anterior pituitary, which is the key trigger for ovulation.

C. Follicular Rupture

1. **Enzymatic Activity:** LH induces enzymes like collagenase to weaken the follicular wall.
2. **Follicle Rupture:** The follicle bursts, releasing the ovum and follicular fluid into the peritoneal cavity, where it is captured by the fimbriae of the oviduct.

2. Regulation of Ovulation

- Hormones Involved
- FSH: Promotes follicular development.
- LH: Triggers ovulation and corpus luteum formation.
- Estrogen: Prepares the reproductive tract and regulates the LH surge.
- Progesterone: Inhibits further follicular development and prepares the uterus for implantation.
- Feedback Mechanism
- Rising estrogen levels provide positive feedback to the hypothalamus and pituitary to induce the LH surge.
- After ovulation, progesterone from the corpus luteum exerts negative feedback, suppressing further cycles.

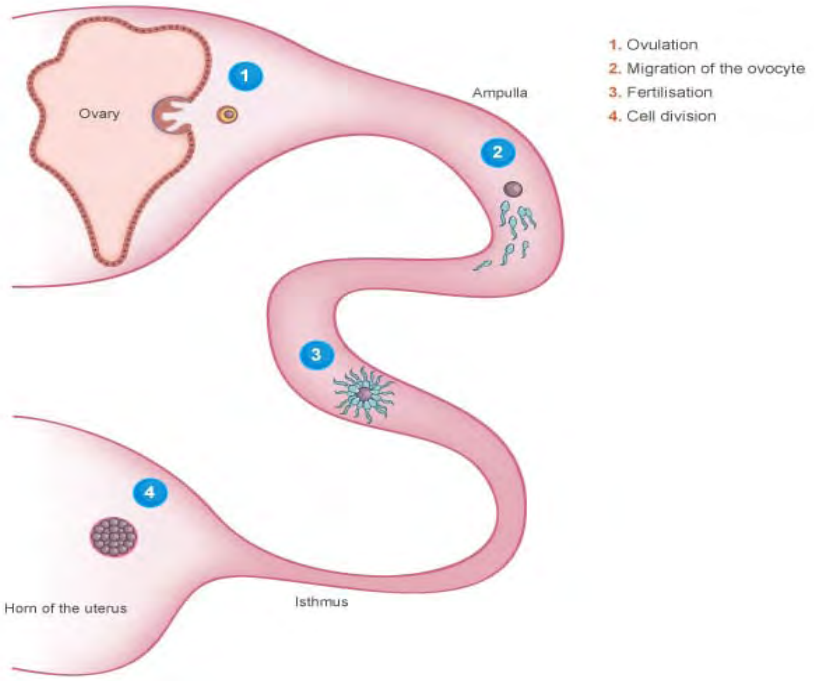


Fig 22: Ovulation

Source:https://product.cdn.cevaws.com/var/storage/images/media/reprodaction/images/22_fertilisation-oviduct/64162-1-eng-GB/22_fertilisation-oviduct.jpg

3. Types of Ovulation

A. Spontaneous Ovulation (Most Mammals)

- Ovulation occurs at regular intervals, regardless of mating.
- Examples: Humans, cattle, sheep, pigs, dogs.

B. Induced Ovulation (Certain Species)

- Ovulation is triggered by copulation or external stimulation.
- Mechanism: Mating causes sensory signals that lead to a GnRH surge and subsequent LH release.
- Examples: Cats, rabbits, camels.

5.1.5 Fertilization

Fertilization is the process by which a male gamete (sperm) and a female gamete

(egg or ovum) unite to form a diploid zygote, marking the beginning of a new organism. This process occurs in the female reproductive tract in most mammals and involves several critical steps.

1. Steps of Fertilization

A. Sperm Transport

1. Sperm Migration

- After ejaculation, sperm travel through the female reproductive tract (vagina, cervix, uterus, oviduct).
- The motility of sperm and contractions of the female reproductive tract aid their movement.

2. Capacitation

- Sperm undergo biochemical changes in the female reproductive tract that increase their ability to fertilize an egg.
- The glycoprotein coat is removed from the sperm's head, allowing for better binding to the egg.

B. Egg Transport

- The ovum is released from the ovary during ovulation and is captured by the fimbriae of the oviduct.
- It travels down the oviduct toward the site of fertilization.

C. Sperm-Egg Binding

1. Recognition and Binding

- Sperm bind to the zona pellucida (outer glycoprotein layer of the egg) via species-specific receptors.

2. Acrosome Reaction

- The acrosome (a cap-like structure on the sperm head) releases enzymes (e.g., hyaluronidase) that digest the zona pellucida, allowing sperm to penetrate the egg.

D. Fusion of Gametes

1. Plasma Membrane Fusion

- The sperm and egg membranes fuse, allowing the sperm nucleus to enter the egg cytoplasm.

2. Cortical Reaction

- The egg releases cortical granules that harden the zona pellucida, preventing polyspermy (fertilization by multiple sperm).

E. Completion of Meiosis in the Egg

- The secondary oocyte, arrested in metaphase II, completes meiosis upon sperm entry, forming a haploid ovum and a second polar body.

F. Formation of the Zygote

1. Pronuclei Formation

- The sperm and egg nuclei (pronuclei) swell and migrate toward each other.

2. Syngamy

- The pronuclei fuse, restoring the diploid chromosome number (2n), forming a zygote.

2. Types of Fertilization

A. Internal Fertilization

- Fertilization occurs inside the female reproductive tract.
- Found in most mammals, birds, reptiles, and some fish.
- Provides a protected environment for gamete fusion.

B. External Fertilization

- Fertilization occurs outside the body, often in aquatic environments.
- Found in amphibians, most fish, and some invertebrates.
- Requires the simultaneous release of eggs and sperm into water.

5.1.6 Implantation

Implantation is the process in which the developing embryo (blastocyst) attaches to and embeds itself into the lining of the uterus (endometrium) to establish a connection for nutrient exchange and further development. This is a critical step in pregnancy and involves a series of coordinated cellular and molecular events.

1. Stages of Implantation

A. Preparation of the Uterus

1. Endometrial Changes

- Under the influence of estrogen and progesterone, the endometrium undergoes decidualization, characterized by:
  - o Thickening of the endometrial lining.
  - o Increased vascularization and glandular activity.
  - o Production of glycogen and other nutrients to nourish the embryo.

2. Receptive Window

- The endometrium becomes receptive to implantation during the implantation window, typically 6–10 days after ovulation in most mammals.

B. Blastocyst Development

1. Hatching

- The blastocyst sheds its surrounding zona pellucida (a glycoprotein layer) to prepare for attachment.

2. Trophoblast Differentiation

- The outer cells of the blastocyst, known as trophoblasts, differentiate into:
  - o Cytotrophoblasts: Inner layer.
  - o Syncytiotrophoblasts: Outer layer that invades the endometrium.

C. Apposition

- The blastocyst loosely aligns with the endometrial surface, typically at a site of high vascularization.

D. Adhesion

- Molecules like integrins, cadherins, and selectins mediate firm attachment of the blastocyst to the endometrial cells.

E. Invasion

1. Trophoblast Invasion

- Syncytiotrophoblasts secrete enzymes (e.g., metalloproteinases) that degrade the extracellular matrix, allowing the embryo to penetrate the endometrial lining.

2. Endometrial Response

- The maternal immune system is modulated to tolerate the semi-foreign embryo.
- Spiral arteries are remodeled to establish blood flow to the developing placenta.

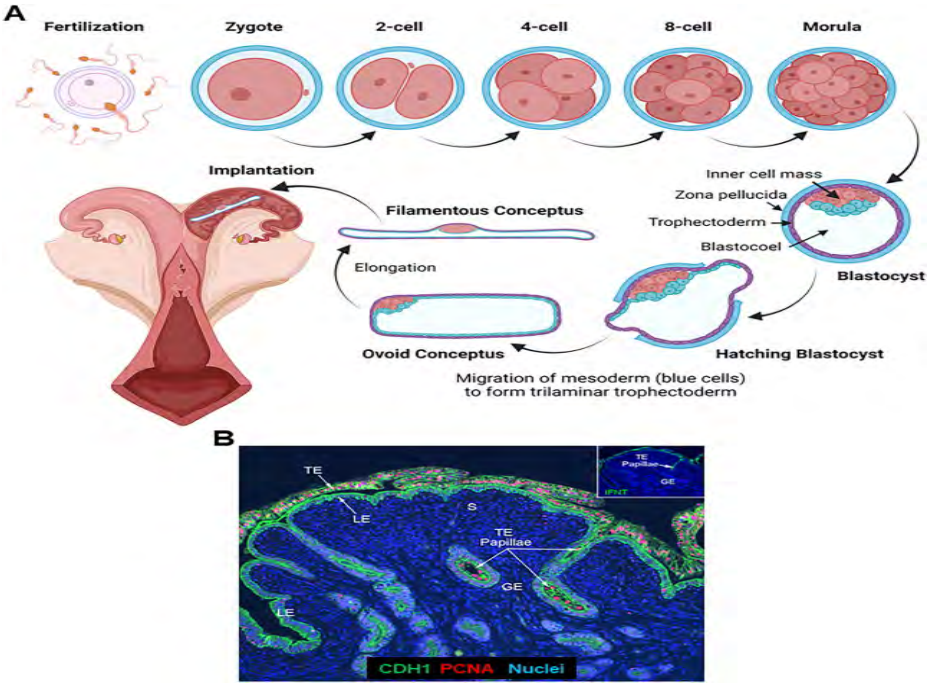


Fig 23: Implantation and placentation in ruminants

Source: https://ars.els-cdn.com/content/image/1-s2.0-S1751731123000927-gr1.jpg

2. Types of Implantation

The manner of implantation varies across species:

Type	Description	Examples
Superficial	The blastocyst attaches and remains on the uterine surface.	Pigs, cows, horses
Eccentric	The blastocyst partially embeds into the uterine wall.	Rodents
Interstitial	The blastocyst fully embeds within the uterine wall.	Humans, primates

5.1.7 Pregnancy

Pregnancy, also known as gestation, is the physiological state during which a

fertilized ovum develops into an embryo and then into a fetus, supported by the maternal system. It ends with parturition (birth). The process involves a series of complex hormonal, anatomical, and physiological adaptations in the mother.

1. Stages of Pregnancy

Pregnancy is generally divided into three stages:

A. Early Pregnancy (Embryonic Stage)

1. Fertilization to Implantation

- The zygote undergoes cleavage to form a morula and then a blastocyst.
- The blastocyst implants into the uterine wall.

2. Embryonic Development

- The embryo differentiates into three germ layers: ectoderm, mesoderm, and endoderm.
- Vital structures such as the placenta begin to form.

B. Mid-Pregnancy (Fetal Stage)

1. Organogenesis

- Major organs develop and begin functioning.

2. Rapid Growth

- The fetus grows in size and weight, and secondary structures, like hair and nails, begin to develop.

C. Late Pregnancy

- Final maturation of the fetus occurs.
- The fetus accumulates fat reserves, and its lungs mature for breathing post-birth.

2. Maternal Adaptations during Pregnancy

Pregnancy induces significant changes in the maternal body to support fetal

development:

A. Hormonal Changes

1. Progesterone

- Maintains the uterine lining, prevents contractions, and supports placental development.

2. Estrogen

- Promotes uterine growth and blood supply.

3. Relaxin

- Loosens pelvic ligaments and softens the cervix in preparation for birth.

4. Human Chorionic Gonadotropin (hCG)

- Sustains the corpus luteum in early pregnancy (in humans and primates).

B. Cardiovascular System

- Blood volume increases by 30–50% to supply the placenta.
- Cardiac output and heart rate increase.

C. Respiratory System

- Tidal volume increases to meet higher oxygen demands.

D. Metabolic Changes

- Basal metabolic rate rises.
- Increased glucose and fat mobilization for fetal energy demands.

5.1.8 Parturition

Parturition is the process by which the fetus and placenta are expelled from the uterus at the end of pregnancy. It marks the culmination of gestation and the beginning of a new phase for both the mother and offspring. This process is highly regulated by hormonal, physiological, and physical factors.

1. Stages of Parturition

Parturition occurs in three main stages:

A. Stage I: Preparation for Delivery

1. Cervical Dilatation

- The cervix softens (ripens), thins (effaces), and begins to dilate under the influence of hormones like relaxin and estrogen.

2. Uterine Contractions

- Weak, irregular contractions (Braxton Hicks in humans) transition into stronger, coordinated uterine contractions.

3. Fetal Positioning

- The fetus aligns into the birth position (anterior presentation is common in most mammals).

4. Signs

- Restlessness, nesting behavior, isolation, tail raising, or colicky symptoms in some species.

B. Stage II: Delivery of the Fetus

1. Expulsion

- Strong uterine contractions, aided by abdominal straining, expel the fetus through the birth canal.

2. Rupture of Membranes

- The amnion and chorion rupture, releasing amniotic and allantoic fluids ("breaking of water").

3. Timing

- This stage is the shortest and most critical. Prolonged labor can lead to complications.

4. Signs

- Visible emergence of the fetal parts, active straining by the mother.

C. Stage III: Delivery of the Placenta

1. Placental Expulsion

- Uterine contractions continue to expel the placenta and any remaining membranes.

2. Involution

- The uterus begins to return to its non-pregnant size and condition (uterine involution).

3. Signs

- Discharge of lochia (postpartum uterine fluid).

2. Hormonal Regulation of Parturition

Parturition is initiated by a cascade of hormonal signals involving the fetus and the mother:

A. Fetal Hormones

1. Cortisol

- Secreted by the fetal adrenal glands.
- Triggers the conversion of progesterone to estrogen in the placenta, initiating parturition.

B. Maternal Hormones

1. Estrogen

- Increases uterine sensitivity to oxytocin.
- Stimulates the production of prostaglandins.

2. Progesterone

- Levels decline before parturition, reducing uterine quiescence.

3. **Prostaglandins (PGF2α)**
   - Induce luteolysis (corpus luteum regression) in species where the corpus luteum maintains pregnancy.
   - Stimulate uterine contractions.
4. **Oxytocin**
   - Released from the posterior pituitary in response to uterine and cervical stretching (Ferguson reflex).
   - Enhances the strength and frequency of uterine contractions.
5. **Relaxin**
   - Loosens the pelvic ligaments and softens the cervix.

3. Species-Specific Features

Species	Gestation Period	Duration of Stage II	Unique Characteristics
Cattle	~ 280 days	30 minutes–2 hours	Calves typically delivered in anterior presentation.
Horse	~ 340 days	15–30 minutes	Rapid delivery; prolonged labor is an emergency.
Sheep	~150 days	1–2 hours	Twin births are common; assistance may be needed for mal-presentations.
Pig	~ 114 days	1–4 hours (for litter)	Sequential delivery of piglets; stillbirths may occur.
Dog	~ 63 days	6–12 hours (for litter)	Puppies delivered with placentas; maternal care begins immediately.
Cat	~ 63 days	4–8 hours (for litter) 4–8 hours (for litter)	Similar to dogs; kittens born with placentas.

Human	~ 280 days	20–50 minutes 20–50 minutes	Active management often involves monitoring fetal distress.

Exercise

Choose the correct answer from the given alternatives.

1. The estrous cycle in cows lasts for approximately.....

   a. 14 days b. 21 days

   c. 28 days d. 30 days

2. Which phase of the estrous cycle is characterized by high progesterone levels?

   a. Proestrus b. Estrus

   c. Metestrus d. Diestrus

3. Spermatogenesis occurs in which part of the testis?

   a. Epididymis b. Seminiferous tubules

   c. Vas deferens d. Leydig cells

4. The main function of Leydig cells during spermatogenesis is to.....

   a. Secrete testosterone b. Nourish sperm cells

   c. Store sperm d. Facilitate sperm transport

5. Which hormone stimulates Sertoli cells to support spermatogenesis?

   a. Luteinizing hormone (LH)

   b. Follicle-stimulating hormone (FSH)

   c. Testosterone

   d. Prolactin

6. The process of releasing a mature oocyte from the ovary is called.....

   a. Spermiation b. Ovulation

   c. Fertilization d. Implantation

7. Which of the following hormones is required for both spermatogenesis and oogenesis?

a. Oxytocin

b. Prostaglandin

c. Follicle-stimulating hormone (FSH)

d. Progesterone

8. During each estrous cycle? How many oocytes are typically ovulated in cattle?

a. 1 b. 2 c. 3 d. 4

9. Which phase of the estrous cycle is characterized by behavioral signs of heat?

a. Proestrus b. Estrus

c. Metestrus d. Diestrus

10. The hormone that peaks during estrus and causes the outward signs of heat is...

a. Progesterone b. Estrogen

c. Luteinizing hormone (LH) d. Prostaglandin F2α

11. Which phase of the estrous cycle, does the Ovulation typically occurs cattle?

a. Estrus b. Metestrus

c. Diestrus d. Proestrus

12. Which hormone is responsible for maintaining the corpus luteum during the diestrus phase?

a. Estrogen b. Luteinizing hormone (LH)

c. Progesterone d. Follicle-stimulating hormone (FSH)

13. What is the average length of the estrous cycle in buffalo?

a. 18 days b. 21 days

c. 25 days d. 28 days

14. In sheep, the estrous cycle typically lasts.....

a. 17 days b. 21 days

c. 24 days d. 28 days

15. In goats, the duration of estrus (heat) lasts approximately.....

a. 12–24 hours b. 24–48 hours

c. 36–72 hours d. 48–96 hours

16. The estrous cycle of pigs (sows) lasts for.....

a. 17 days b. 21 days

c. 24 days d. 28 days

17. Mares (horses) are considered as .....

a. Polyestrous b. Seasonal polyestrous

c. Monoestrous d. Aseasonal breeders

18. The phase of the estrous cycle dominated by the corpus luteum and progesterone is.....

a. Proestrus b. Estrus

c. Metestrus d. Diestrus

19. In cattle, the follicular phase includes.....

a. Estrus and metestrus b. Proestrus and estrus

c. Metestrus and diestrus d. Diestrus and proestrus

20. During the estrous cycle, prostaglandin F2α causes.....

a. Ovulation

b. Follicular development

c. Regression of the corpus luteum

d. Behavioral signs of heat

21. Silent estrus (absence of visible heat signs) is most common in.....

a. Sheep
b. Goats
c. Buffalo
d. Pigs

22. The best time for artificial insemination in cattle is.....

a. At the onset of estrus
b. Midway through estrus
c. 8–12 hours after the end of estrus
d. 12–18 hours after the onset of estrus

23. Which species has the shortest estrus duration?

a. Cattle
b. Buffalo
c. Sheep
d. Goats

24. Which species exhibits the longest estrus duration?

a. Buffalo
b. Horse
c. Goat
d. Pig

25. Where does fertilization typically occur in most farm animals?

a. Ovary
b. Fallopian tube
c. Uterus
d. Cervix

26. What hormone is crucial for maintaining pregnancy in farm animals?

a. Estrogen
b. Progesterone
c. Oxytocin
d. Prostaglandin

27. which part of the reproductive system, does the embryo attaches during implantation?

a. Uterus
b. Cervix
c. Ovarian follicle
d. All of the above

28. What is the average duration of pregnancy (gestation period) in sheep?

a. 114 days b. 150 days

c. 280 days d. 340 days

29. What is the average duration of pregnancy in pig?

a. 114 days b. 150 days

c. 280 days d. 63 days

30. What is the average duration of pregnancy in buffalo?

a. 114 days b. 340 days

c. 280 days d. 310 days

31. What is the average duration of pregnancy in horse?

a. 114 days b.. 340 days

c. 280 days d. 310 days

32. What is the role of the placenta during pregnancy?

a. Nutrient and gas exchange b. Waste elimination

c Hormone production d. All of the above

33. Which stage of parturition involves the expulsion of the fetus?

a. Stage 1 b. Stage 2

c. Stage 3 d. Postpartum

34. What is the primary hormone responsible for initiating parturition?

a. Progesterone b. Estrogen

c. Oxytocin d. Cortisol

35. Which species has the longest gestation period among common farm animals?

a. Pig b. Goat

c. Horse d. Buffalo

36. What is the duration of the expulsion of the placenta (Stage 3 of parturition) in cattle after birth?

a. 1 hour
b. 2-4 hours
c. 6-8 hours
d. 12-24 hours

37. Which of the following is a common sign of impending parturition in cattle?

a. Udder enlargement and milk secretion
b. Swollen vulva and mucus discharge
c. Restlessness and decreased appetite
d. All of the above

38. What is the average duration of the second stage of labor in goats and sheep (delivery of the fetus)?

a. 15-30 minutes
b. 1-2 hours
c. 3-4 hours
d. 6-8 hours

Write short answer to the following questions.

1. Write the name of any two male reproductive hormones. Illustrate the process of spermatogenesis.
2. Write the name of female reproductive hormones. Illustrate the process of oogenesis.
3. Define ovulation and fertilization.
4. Define implantation, pregnancy and parturition.
5. Explain the stages of parturition in cattle.
6. Write the gestation period of cattle, buffalo, sheep, goat and pig.
7. Write the estrous length of cattle, buffalo, horse, goat and pig.

Write long answer to the following questions.

1. Explain the different phases of estrous cycle.

2. Describe the process of spermatogenesis and oogenesis.

3. Define parturition. Which hormones are involved in the process of parturition? Explain stages of parturition.

Project work

1. Choose one male and one female farm animal (e.g., cow, sheep, goat, pig) and describe the structure and function of their reproductive organs. Explain the reproductive cycles of the selected animals, including hormonal regulation, the process of ovulation, fertilization, and pregnancy.

References

https://ars.els-cdn.com/content/image/1-s2.0-S1751731123000927-gr1.jpg

https://ars.els-cdn.com/content/image/3-s2.0-B9780128096338205207-f20520-02-9780128118993.jpg

https://cdn.globalagmedia.com/pig/legacy/files/pighealth/Fig.5-32.gif

https://encryptedtbn0.gstatic.com/images?q=tbn:ANd9GcTRvo_LJ6xwXsRecbyD1XRQLa7J452MxElKmQ&s

https://images.squarespacecdn.com/content/v1/5f87b82c3640400719116914/d009f885-81f3-4bc7-87ad-91927cad4259/fig+1.jpg

https://product.cdn.cevaws.com/var/storage/images/media/reprodaction/images/22_fertilisation-oviduct/64162-1-eng-GB/22_fertilisation-oviduct.jpg

https://static.vikaspedia.in/media/images_en/agriculture/livestock/sheep-and-goat-farming/maletest.jpg

https://thekebun.wordpress.com/wp content/ uploads/ 2008/10/digest system1 .jpg https://upload.wikimedia.org/wikipedia/commons/5/5f/Anatomy_and_physiology_of_animals_Urinary_system.jpg

https://www.ansc.purdue.edu/pork-archive/pubs/SowAnatomy.gif

https://www.bhs.org.uk/media/jl0nwewp/bw24-0152_digestive-system-diagram-v5.jpg?rmode=max&width=500&height=500

https://www.ck12.org//flx/show/THUMB_POSTCARD/image/user%3A6e25eba59f01/spermatogenesis.jpg

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.drvet.in%2F2019%2F05%2Fveterinary-anatomy-online-urinary system.html&psig= AOvVaw2JWf1uEFCaCvHbYRt5CLUn&ust= 1732426596818000&source= images

https://www.groupe-esa.com/ladmec/bricks_modules/brick03/res/ZBOB303.jpg

https://www.ontario.ca/files/2022-05/omafra-anatomy-physiology-and-reproduction-in-the-mare-en-3-500x518.jpg

https://www.ontario.ca/files/2022-05/omafra-anatomy-physiology-and-reproduction-in-the-stallion-en-3-500x351.jpg

https://www.poultryhub.org/content/uploads/2012/07/Anatomy-of-the-chicken-with-text-e1591660865528.jpg

https://www.poultryhub.org/content/uploads/2012/04/male_urinary_genital_system1-843x1024.jpg

https://www.researchgate.net/publication/339574264/figure/fig2/AS:863725502337024@1582939615172/Anatomy-of-the-bovine-upper-respiratory-tract-relevant-to-FMDV-infection-a-The-bovine.png

https://www.researchgate.net/publication/316285755_Reproduction_in_Cattle

https://www.researchgate.net/publication/372929799/figure/fig3/AS:11431281258620735@1720122333887/The-process-of-oogenesis-Oogenesis-starts-with-a-transformation-of-the-oogonia-into-the.tif

https://www.sciencelearn.org.nz/images/4590-the-amazing-3d-cow

https://www2.zoetis.com.au/content/_assets/Microsite-Images/Livestock-Solution-Testing/Sheep-images/OptimiseEweHealth/anatomy_imgs_1.jpg

Stenfeldt, C., & Arzt, J. (2020). The carrier conundrum; a review of recent advances and persistent gaps regarding the carrier state of foot-and-mouth disease virus. Pathogens, 9(3), 167.