Chapter 7: Structural Organisation in Animals

Comprehensive Study Notes

Class 11 Biology - NCERT Based

EXAM SPRINT - Complete Coverage for NEET and Board Examinations

Introduction

Multicellular animals exhibit complex organization where different groups of cells work together in a coordinated manner. Unlike unicellular organisms where a single cell performs all functions, multicellular animals have specialized cells organized into tissues, organs, and organ systems that demonstrate division of labor.

Key Concept: All complex animals consist of only four basic types of tissues that organize to form organs, which further combine to form organ systems.

7.1 ORGAN AND ORGAN SYSTEM

Organizational Hierarchy

The structural organization in multicellular animals follows a specific hierarchy:

Cell → Tissue → Organ → Organ System → Organism

Tissue Organization

- **Definition**: A group of similar cells along with intercellular substances performing a specific function
- **Four Basic Tissue Types**: Epithelial, Connective, Muscular, and Neural
- **Example**: Human heart contains all four tissue types working together

Organ Formation

- **Structure**: Made of one or more types of tissues
- **Function**: Specialized for specific physiological activities
- **Examples**: Stomach, lung, heart, kidney

Organ System

- **Definition**: Two or more organs performing a common function through physical and/or chemical interaction
- **Examples**: Digestive system, respiratory system, circulatory system
- **Coordination**: Ensures efficient functioning of millions of cells

Evolutionary Trend

- **Pattern**: Complexity in organ and organ systems shows discernible evolutionary progression
- **Significance**: Reflects evolutionary relationships and adaptations
- **Study Focus**: Morphology (external features) and anatomy (internal structure)

7.2 FROGS

Classification and Habitat

- **Scientific Name**: *Rana tigrina* (most common Indian species)
- **Class**: Amphibia
- **Phylum**: Chordata
- **Habitat**: Dual life - both land and freshwater environments

Physiological Characteristics

Temperature Regulation

- **Type**: Poikilothermic (cold-blooded)
- **Feature**: Body temperature varies with environmental temperature
- **Adaptation**: Behavioral thermoregulation

Protective Mechanisms

Camouflage (Mimicry):

- **Ability**: Color change for protection from enemies
- **Mechanism**: Chromatophores in skin
- **Function**: Protective coloration

Seasonal Adaptations:

- **Summer Sleep**: Aestivation during extreme heat
- **Winter Sleep**: Hibernation during cold periods
- **Behavior**: Deep burrow shelter for protection

7.2.1 MORPHOLOGY

Skin Characteristics

- **Texture**: Smooth and slippery due to mucus secretion
- **Condition**: Always maintained in moist state
- **Water Absorption**: Never drinks water; absorbs through skin
- **Coloration**:
  - Dorsal side: Olive green with dark irregular spots
  - Ventral side: Uniformly pale yellow

Body Organization

Body Regions

- **Primary Divisions**: Head and trunk only
- **Absent Features**: Neck and tail

Sensory Structures

Head Region:

- **Nostrils**: Paired, above mouth
- **Eyes**: Bulged with protective nictitating membrane
- **Tympanum**: Membranous ear on either side of eyes
- **Function**: Sound signal reception

Locomotory Structures

Forelimbs:

- **Digits**: Four
- **Function**: Swimming, walking, support

Hind Limbs:

- **Digits**: Five
- **Characteristics**: Larger and more muscular than forelimbs
- **Webbed Feet**: Adaptation for swimming
- **Functions**: Swimming, walking, leaping, burrowing

Sexual Dimorphism

Male Characteristics:

- **Vocal Sacs**: Sound-producing organs
- **Copulatory Pad**: On first digit of forelimbs
- **Function**: Mating adaptations

Female Characteristics:

- **Absence**: No vocal sacs or copulatory pads
- **Size**: Generally larger than males

7.2.2 ANATOMY

Body Cavity Organization

The coelomic cavity accommodates multiple organ systems with well-developed structures and coordinated functions.

7.2.2.1 DIGESTIVE SYSTEM

System Components

- **Alimentary Canal**: Digestive tract
- **Digestive Glands**: Liver and pancreas

Structural Features

Alimentary Canal

Pathway: Mouth → Buccal cavity → Pharynx → Oesophagus → Stomach → Intestine → Rectum → Cloaca

Adaptations:

- **Length**: Short alimentary canal
- **Reason**: Carnivorous diet requires shorter intestine
- **Efficiency**: Rapid digestion of protein-rich food

Specialized Structures

Feeding Mechanism:

- **Tongue**: Bilobed, muscular
- **Function**: Food capture
- **Attachment**: Fixed at front, free at back

Storage and Processing:

- **Stomach**: Muscular, expandable
- **Intestine**: Absorption surface with villi and microvilli
- **Rectum**: Waste consolidation
- **Cloaca**: Common exit chamber

Digestive Glands

Liver

- **Product**: Bile secretion
- **Storage**: Gall bladder
- **Function**: Fat emulsification

Pancreas

- **Product**: Pancreatic juice
- **Enzymes**: Digestive enzymes for carbohydrates and proteins
- **Delivery**: Through common bile duct to duodenum

Digestive Process

Gastric Phase

- **Secretions**: HCl and gastric juices from stomach walls
- **Product**: Partially digested food (chyme)
- **Function**: Protein breakdown initiation

Intestinal Phase

- **Location**: Duodenum (first part of small intestine)
- **Secretions**: Bile and pancreatic juice
- **Functions**:
  - Bile: Fat emulsification
  - Pancreatic juice: Carbohydrate and protein digestion

Absorption

- **Surface**: Villi and microvilli in intestinal wall
- **Function**: Nutrient absorption into bloodstream
- **Efficiency**: Maximized surface area for absorption

Elimination

- **Process**: Undigested waste moves to rectum
- **Exit**: Through cloaca to exterior

7.2.2.2 RESPIRATORY SYSTEM

Dual Respiratory Adaptation

Frogs demonstrate remarkable respiratory flexibility with different mechanisms for aquatic and terrestrial environments.

Aquatic Respiration

Cutaneous Respiration:

- **Organ**: Skin acts as respiratory surface
- **Mechanism**: Dissolved oxygen exchange through diffusion
- **Requirement**: Moist skin condition
- **Efficiency**: Adequate for underwater oxygen needs

Terrestrial Respiration

Multiple Organ System:

- **Primary**: Pulmonary respiration (lungs)
- **Secondary**: Buccal cavity respiration
- **Supplementary**: Cutaneous respiration

Pulmonary System:

- **Structure**: Pair of elongated, pink, sac-like lungs
- **Location**: Upper trunk region (thorax)
- **Pathway**: Nostrils → Buccal cavity → Lungs
- **Mechanism**: Positive pressure breathing

Specialized Conditions

During Dormancy:

- **Aestivation and Hibernation**: Gaseous exchange primarily through skin
- **Advantage**: Reduced metabolic oxygen requirements

7.2.2.3 CIRCULATORY SYSTEM

System Types

Dual Vascular Organization:

- **Blood Vascular System**: Heart, blood vessels, blood
- **Lymphatic System**: Lymph, lymph channels, lymph nodes

Heart Structure and Function

Anatomical Features

- **Type**: Muscular, three-chambered
- **Chambers**: Two atria (left and right) + one ventricle
- **Location**: Upper body cavity
- **Protection**: Surrounded by pericardium membrane

Associated Structures

Sinus Venosus:

- **Shape**: Triangular
- **Connection**: Joins right atrium
- **Function**: Receives blood from major veins (vena cava)

Conus Arteriosus:

- **Structure**: Sac-like chamber
- **Position**: Ventral side of heart
- **Function**: Blood distribution from ventricle

Blood Vessel Organization

Arterial System

- **Function**: Carries blood from heart to body parts
- **Structure**: Thick-walled, muscular vessels
- **Pressure**: High pressure system

Venous System

- **Function**: Collects blood from body parts to heart
- **Structure**: Thin-walled vessels with valves
- **Pressure**: Low pressure system

Specialized Portal Systems

Hepatic Portal System:

- **Connection**: Between liver and intestine
- **Function**: Direct nutrient transport from intestine to liver
- **Advantage**: Immediate processing of absorbed nutrients

Renal Portal System:

- **Connection**: Between kidney and lower body parts
- **Function**: Enhanced filtration efficiency
- **Advantage**: Direct waste removal from posterior regions

Blood Composition

Plasma

- **Component**: Liquid matrix of blood
- **Contents**: Water, proteins, nutrients, hormones, waste products
- **Function**: Transport medium

Cellular Components

Red Blood Cells (Erythrocytes):

- **Structure**: Nucleated cells
- **Pigment**: Haemoglobin (red-colored)
- **Function**: Oxygen and carbon dioxide transport
- **Note**: Unlike mammalian RBCs, frog RBCs retain nucleus

White Blood Cells (Leucocytes):

- **Function**: Immune defense
- **Types**: Various types for different immune functions
- **Mobility**: Can move through tissues

Platelets:

- **Function**: Blood clotting
- **Size**: Small cellular fragments

Lymphatic System

Composition:

- **Lymph**: Clear fluid lacking some proteins and RBCs
- **Difference from Blood**: Reduced protein content, no RBCs
- **Function**: Tissue fluid drainage, immune function

Circulation Process

Mechanism: Muscular heart pumping action **Transport Functions**:

- **Nutrients**: From digestive system to tissues
- **Gases**: Oxygen and carbon dioxide transport
- **Water**: Fluid balance maintenance
- **Wastes**: Removal from tissues

7.2.2.4 EXCRETORY SYSTEM

System Components

- **Kidneys**: Paired, primary excretory organs
- **Ureters**: Transport ducts
- **Urinary Bladder**: Storage organ
- **Cloaca**: Common discharge chamber

Kidney Structure and Function

Anatomical Features

- **Appearance**: Compact, dark red, bean-shaped
- **Location**: Posterior body cavity, both sides of vertebral column
- **Size**: Relatively large for body size

Functional Units

- **Nephrons**: Structural and functional units
- **Alternative Name**: Uriniferous tubules
- **Number**: Several per kidney
- **Function**: Filtration, reabsorption, secretion

Duct System Organization

Male Reproductive System Integration

- **Ureters**: Dual function as urinogenital ducts
- **Connection**: Direct opening into cloaca
- **Advantage**: Shared pathway for urine and sperm

Female System Separation

- **Ureters**: Separate from reproductive system
- **Oviducts**: Independent opening into cloaca
- **Advantage**: Separate control of excretory and reproductive functions

Storage and Elimination

Urinary Bladder

- **Structure**: Thin-walled, expandable
- **Location**: Ventral to rectum
- **Connection**: Opens into cloaca
- **Function**: Temporary urine storage

Excretory Product

- **Primary Waste**: Urea
- **Classification**: Ureotelic animal
- **Advantage**: Less toxic than ammonia, requires less water for elimination

Excretory Process

Filtration: Blood waste separation in kidneys **Transport**: Waste carried by blood to kidneys **Elimination**: Processed waste excreted through cloaca

7.2.2.5 CONTROL AND COORDINATION SYSTEM

Dual Control Mechanism

The frog exhibits highly evolved coordination through both chemical and electrical signaling systems.

Neural System Organization

Central Nervous System:

- **Brain**: Enclosed in cranium (brain box)
- **Spinal Cord**: Continuation of brain through vertebral column
- **Protection**: Bony encasement for both components

Peripheral Nervous System:

- **Cranial Nerves**: Ten pairs arising from brain
- **Spinal Nerves**: Arising from spinal cord segments
- **Function**: Connect CNS to body parts

Autonomic Nervous System:

- **Sympathetic Division**: Emergency responses

- **Parasympathetic Division**: Rest and digest functions
- **Coordination**: Involuntary organ function control

Brain Organization

Regional Specialization

Forebrain Components:

- **Olfactory Lobes**: Smell processing
- **Cerebral Hemispheres**: Paired, higher brain functions
- **Diencephalon**: Unpaired, coordination center

Midbrain:

- **Optic Lobes**: Paired, visual processing centers
- **Function**: Visual reflex coordination

Hindbrain:

- **Cerebellum**: Balance and coordination
- **Medulla Oblongata**: Vital functions control
- **Continuation**: Extends into spinal cord through foramen magnum

Endocrine System

Gland Distribution:

- **Pituitary**: Master gland
- **Thyroid**: Metabolism control
- **Parathyroid**: Calcium regulation

- **Thymus**: Immune system development
- **Pineal Body**: Biological rhythms
- **Pancreatic Islets**: Blood sugar regulation
- **Adrenals**: Stress response
- **Gonads**: Reproductive hormones

Coordination: Chemical messengers (hormones) for long-term regulation

Sensory System Organization

Specialized Sense Organs

Touch: Sensory papillae (cellular aggregations) **Taste**: Taste buds (chemical detection) **Smell**: Nasal epithelium (chemical detection) **Vision**: Eyes (well-organized structures) **Hearing**: Tympanum with internal ears (well-organized)

Visual System

Eye Structure:

- **Type**: Simple eyes (single unit per eye)
- **Location**: Orbits in skull
- **Shape**: Paired spherical structures
- **Function**: Light detection and image formation

Auditory System

External Ear: Absent **Tympanum**: Visible externally **Internal Ear**: Complex structure **Functions**:

- **Hearing**: Sound detection and processing
- **Balance**: Equilibrium maintenance

7.2.2.6 REPRODUCTIVE SYSTEM

Sexual Organization

Frogs exhibit distinct male and female reproductive systems with clear sexual dimorphism and specialized reproductive strategies.

Male Reproductive System

Primary Organs

Testes:

- **Number**: Paired
- **Shape**: Yellowish, ovoid
- **Location**: Adhered to upper kidney region
- **Attachment**: Suspended by mesorchium (double fold of peritoneum)
- **Function**: Sperm and hormone production

Duct System

Vasa Efferentia:

- **Number**: 10-12 tubules per testis
- **Origin**: Arise from testes
- **Path**: Enter kidneys on corresponding side
- **Connection**: Open into Bidder's canal

Urinogenital Duct:

- **Formation**: Continuation from Bidder's canal
- **Exit**: Emerges from kidneys

- **Termination**: Opens into cloaca
- **Function**: Combined passage for urine and sperm

Female Reproductive System

Primary Organs

Ovaries:

- **Number**: Paired
- **Location**: Near kidneys
- **Connection**: No functional connection with kidneys (unlike males)
- **Function**: Egg and hormone production

Duct System

Oviducts:

- **Number**: Paired
- **Origin**: Arising from ovaries
- **Termination**: Open separately into cloaca
- **Function**: Egg transport and modification

Reproductive Process

Reproductive Capacity

Female Fertility:

- **Egg Production**: 2500-3000 ova per breeding season
- **Timing**: Seasonal breeding

- **Environment**: Aquatic breeding sites

Fertilization and Development

Fertilization Type: External **Environment**: Takes place in water **Development Pattern**: Indirect with metamorphosis **Larval Stage**: Tadpole

Metamorphosis

Process: Tadpole undergoes complete transformation **Changes**: Anatomical and physiological restructuring **Result**: Adult frog formation **Duration**: Species and environment dependent

Cloaca Function

Structure: Small, median chamber **Multiple Functions**:

- **Digestive**: Fecal matter passage
- **Excretory**: Urine passage
- **Reproductive**: Gamete passage (sperm in males, eggs in females)
- **Efficiency**: Single external opening for multiple systems

ECOLOGICAL AND ECONOMIC IMPORTANCE

Environmental Benefits

Pest Control

- **Diet**: Insectivorous feeding habits
- **Impact**: Natural pest population control
- **Agriculture**: Crop protection through insect consumption
- **Ecosystem**: Maintains insect population balance

Ecological Balance

Food Chain Position:

- **Primary Consumers**: Feed on insects and small invertebrates
- **Secondary Consumers**: Prey for birds, snakes, and mammals
- **Link Function**: Important connector in food webs

Ecosystem Services:

- **Nutrient Cycling**: Transfer of nutrients between aquatic and terrestrial systems
- **Indicator Species**: Environmental health indicators
- **Biodiversity**: Contribute to ecosystem diversity

Human Utilization

Food Resource

Regional Consumption:

- **Muscular Legs**: Used as food in some countries
- **Nutritional Value**: High protein content
- **Cultural Significance**: Traditional food in certain cultures

Research Applications

- **Biological Research**: Model organism for various studies
- **Medical Research**: Physiological and developmental studies
- **Educational**: Laboratory specimens for anatomy study

SUMMARY OF KEY FEATURES

Structural Organization

- **Tissue Integration**: Four basic tissue types organize into functional organs
- **System Coordination**: Multiple organ systems work in harmony
- **Division of Labor**: Specialized functions enhance survival efficiency

Adaptive Features

- **Dual Habitat**: Successful land and water adaptation
- **Respiratory Flexibility**: Multiple respiratory mechanisms
- **Sensory Integration**: Well-developed sensory systems
- **Reproductive Strategy**: High reproductive output with metamorphic development

Evolutionary Significance

- **Transitional Form**: Bridge between aquatic and terrestrial vertebrates
- **Amphibian Characteristics**: Demonstrates key amphibian adaptations
- **Model Organism**: Representative of amphibian class features

EXAM-ORIENTED KEY POINTS

High-Yield Topics for NEET

Morphological Features

1. **Body Divisions**: Head and trunk (no neck or tail)
2. **Sensory Structures**: Tympanum, nictitating membrane, nostrils
3. **Sexual Dimorphism**: Vocal sacs and copulatory pads in males
4. **Locomotory Adaptations**: Webbed feet, muscular hind limbs

Anatomical Systems

1. **Digestive System**: Short alimentary canal, bilobed tongue, cloaca
2. **Respiratory System**: Cutaneous, pulmonary, and buccal respiration
3. **Circulatory System**: Three-chambered heart, dual portal systems
4. **Excretory System**: Ureotelic, nephrons, urinogenital ducts

Physiological Adaptations

1. **Temperature Regulation**: Poikilothermic with behavioral adaptations
2. **Water Balance**: Skin absorption, no drinking behavior
3. **Seasonal Adaptations**: Aestivation and hibernation
4. **Reproductive Strategy**: External fertilization, metamorphic development

Common NEET Question Patterns

Identification Questions

- Recognize frog structures from diagrams
- Identify system components and their functions
- Match adaptations with environmental requirements

Comparative Questions

- Compare amphibian features with other vertebrate classes
- Contrast aquatic and terrestrial adaptations
- Analyze evolutionary advantages of amphibian characteristics

Function-Based Questions

- Explain physiological processes
- Describe system interactions
- Analyze adaptive significance

Memory Aids and Mnemonics

Body Systems

"**D**igesting **R**ats **C**auses **N**ausea, **E**specially **R**aw"

- **D**igestive
- **R**espiratory
- **C**irculatory
- **N**ervous
- **E**xcretory
- **R**eproductive

Heart Chambers

"**T**wo **A**tria, **O**ne **V**entricle"

- **T**hree-chambered heart
- **A**tria (2)
- **O**ne ventricle
- **V**entricular mixing

Respiratory Types

"**C**ute **P**uppies **B**ark"

- **C**utaneous

- **P**ulmonary
- **B**uccal

Practice Questions for NEET

Multiple Choice Questions

1. **The number of chambers in frog heart is:** a) Two b) Three c) Four d) Five
2. **Skin of frog is used for:** a) Protection only b) Respiration only c) Both respiration and protection d) Camouflage only
3. **Frogs are called ureotelic because they excrete:** a) Ammonia b) Uric acid c) Urea d) Creatinine
4. **The larval stage of frog is called:** a) Caterpillar b) Maggot c) Tadpole d) Pupa
5. **Vocal sacs are present in:** a) Male frogs only b) Female frogs only c) Both male and female d) Neither male nor female

Short Answer Questions

1. **Explain the dual respiratory mechanism in frogs.**
2. **Describe the significance of three-chambered heart in amphibians.**
3. **What are the advantages of external fertilization in frogs?**
4. **Explain the role of cloaca in frog physiology.**
5. **Describe the adaptive features of frog for amphibian life.**

Long Answer Questions

1. **Describe the complete digestive system of frog with labeled diagram.**
2. **Explain the circulatory system of frog highlighting the portal systems.**
3. **Compare and contrast the male and female reproductive systems of frog.**

EXAM SPRINT - Master frog anatomy through systematic study of morphological features, anatomical systems, physiological adaptations, and evolutionary significance. Focus on system integration, adaptive features, and comparative analysis for comprehensive NEET preparation.

Source: NCERT Biology Class 11, Chapter 7 - Complete coverage for NEET and Board examination success