Tikrit University
College of Veterinary Medicine

Anatomy of poultry

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The skeletal system:- Characterized by:

1- Compact, coherent and fused.

2- It is extremely lightweight but strong enough to withstand the stresses of taking off, flying, and landing.

3-Birds have many bones that are hollow with criss-crossing struts or trusses for structural strength.

Respiratory air sacs often form air pockets within the semi-hollow bones of the bird's skeleton. Some bones of the avian species are considered **pneumatic** as a result of diverticula's from the air sacs. The bones connected with respiratory system are (the skull, the humerus, the clavicle, the keel, the lumber and sacral vertebrae.

One key adaptation is the fusing of bones into single ossifications, and elongation,

Especially in lumber and sacral region, Birds are the only vertebrate animals to have a fused collar bone or a **keeled sternum** or breastbone. The keel of the sternum serves as an attachment site for the muscles used for flight.

The skull consists of five major bones: the frontal (top of head), parietal (back of head), premaxillary and nasal (top beak), and the mandible (bottom beak).

The vertebral column is divided into: **vertebral formula** is:

C13, T7, L+S14 & C5 = 39

Atlas (first vertebrae)

Axis (second vertebrae)

The cervical vertebrae (13-16)

The thoracic vertebrae (5)

The lumbar vertebrae (6)

The fused caudal vertebrae (4)

The coccygeal vertebrae (**pygostyle**)

The vertebrae of the neck and tail are movable but the body of the chicken has only one movable vertebra along its length. The body vertebrae are fused into rigid structures that give the body sufficient strength to support wings.

uncinate processes projecting backward over the outer surface of the next rib and connected to it by a ligament, thus adding strength to the thoracic cavity (uncinate = hooked or bent).

The modifications of bones include:

1. Pneumatic bones where the air sacs of the respiratory system connect with the cavity of some of the long bones.
2. Fusion of some vertebral sections to provide the rigidity required for flight.
3. The sternum provides a large surface area for the strong attachment of the main muscles of flight.
4. The size of the head has been reduced significantly when compared to other species. A large head would be a hindrance when flying.
5. The neck is quite long in most species to enable the bird to:
    - Protect the delicate tissues of the brain from too much jarring when landing. The flexibility of the neck acts as a shock absorber.
    - Aid in the reaching of food located on the ground - the rigid body makes this simple activity more difficult without this modification.
    - Aid in the adjustment of the Centre of gravity needed when the bird changes from the upright position of walking or perching to the more horizontal position of flight.
6. The long tail of many other animals has been reduced to a very short section of fused bones called the pygostyle.
7. The ribs have been modified by the inclusion of the uncinate process - this gives strength to the rib cage.

The wing skeleton may be divided into:

1. The shoulder girdle:
    - Scapula
    - Coracoid
    - Clavicle
2. The free part:
    - The arm - or humerus.
    - The forearm - radius and ulna.
    - The manus or hand - carpus, metacarpus and digits.

The shoulder consists of the scapula (shoulder blade), coracoid , and clavicle (upper arm). The humerus joins the radius and ulna (forearm) to form the elbow. The

carpus and metacarpus form the "wrist" and "hand" of the bird and the digits (fingers) are fused together. The bones in the wing are extremely light so that the bird can fly more easily.

Clavicle: The clavicle or collarbone is thin, rod-like and slightly bent. Its upper or dorsal end is connected with the coracoid bone. The other end is joined to that of the other wing to form the “wish-bone”. The combined clavicles form a bone called the furcula that is capable of acting like a spring and aiding in forming a firm basis of support for the wing.

The leg

The significant features of the skeleton of this limb are:

1. The hipbone is firmly fixed to the vertebral column
2. There is no ventral union between the two hipbones
3. There is no independent tarsus

The skeleton of the hind limb or leg is structured as follows:

1. The pelvic girdle or hip bones:
    - Ileum
    - Ischium
    - Pubis or pin bones
2. The free part:
    - Femur or thighbone
    - Tibia and fibia
    - Pes or foot - tarsus, metatarsus and digits or toes

The upper leg consists of the femur. At the knee joint, the femur connects to the tibiotarsus (shin) and fibula (side of lower leg). The tarsometatarsus forms the upper part of the foot, digits make up the toes.

The side of the chest is formed by the ribs, which meet at the sternum (mid-line of the chest).The first and second ribs are not connect. There are 7 pairs of ribs in chicken and pigeon, 9 pairs in duke and geese.

The hips consist of the pelvis which includes three major bones: Illium (top of the hip), Ischium (sides of hip), and Pubis (front of the hip). These are fused into one

(the innominate bone). Innominate bones are evolutionary significant in that they allow birds to lay eggs.

The medullary bones are: the femur, shin, pelvic, keel, ulna, toes, scapula, and ribs.

Medullary Bone:

This bone fills the marrow cavity with fine interlacing spicules of bone which provide a source of calcium for egg shell formation when Ca intake is low. This bone is not normally found in males or in non – laying hens. Pullets, when maturing, begin to deposit medullary bone about 10 days prior to formation of the first egg.

About 40% of the total skeletal Ca is lost by hens after laying 6 eggs when they receive a diet containing a very low amount of Ca.

Muscular system

Muscular tissue is the principle contractile organ of the body. It is responsible for nearly all movement in higher animals. Chickens and turkeys contain both red and white muscles. The red muscle contains more myo-globulin, an iron-containing, oxygen- carrying compound, than does white muscle.

There are 3 types of muscles:

Skeletal muscles: responsible for most voluntary movement and makes up most of the human protein consumption (the breast, thigh, and leg muscles).

Cardiac muscles: Involuntary muscles(cardiac).

Smooth muscles: which are found in blood vessels, intestine, and other organs not under voluntary control.

Respiratory system

Consist of:

Nasal cavities

Upper larynx

Trachea

Lower larynx (syrinx)

Bronchi

Lungs

Air sacs

Air enters through nasal cavities then pharynx→upper larynx → trachea → lower larynx which located under the trachea which is the sound-producing vocal organ of birds, the upper larynx serves only to modulate the voice. The syrinx is essentially the same in both male and female, the hen does not crow because she lacks the physiological incentive to do so. The trachea divides after syrinx into 2 short bronchi every one enters one lung, then divides into primary, secondary, tertiary broncules → air capillaries then O_2 & CO_2 gases exchange occurs between air capillaries and surrounded blood capillaries.

Air sacs

Are very delicate, thin- walled structures that are difficult to recognize when they collapse. Sacs attaches lungs and some with pneumatic bones of the body. Changes in pressure within the air sacs that cause air to into and out of the lungs. In expiration, contraction of abdominal muscles and movement of keel bone to the top and bend the ribs to the interior causes air sacs contraction then the air get out. In inspiration, the air return to the air sacs by relaxation and dilatation of abdominal muscles, movement of keel bone down, and bend the ribs to the exterior. The air sacs consist of:

Single interclavicular sac, located at the base of the neck, between the wish bones (clavicle).

Pairs of the cervical sacs, located at the beginning of the thoracic cavity.

Pairs of the anterior thoracic sacs, located at the middle of the thoracic cavity.

Pairs of the posterior thoracic sacs, at the beginning of the abdominal cavity.

Pairs of the great abdominal sacs, at the abdominal cavity (the largest sac).

Respiration and temperature regulation in chickens

Heat loss from the body may be as:

Sensible heat : that can be measured in a calorimeter, sensible heat losses, by radiation, convection and conduction of heat from body surfaces, make up the major heat losses from the body at environmental temperatures 80°F (26° C). The comb and wattles have a large role in the sensible heat losses.

Latent heat: is the heat required for evaporation of water which occurs primarily in the respiratory passages. Rise in environmental temperature (over 26°C) lead to increases of evaporation of water from respiratory tract to cooling the body**.**

Panting: observed when chickens are kept under high temperature, since chickens have no sweat glands, the lungs and air sacs have been considered the most important evaporative coolers.

Recent studies suggest that upper respiratory (nasal) passages are the main responsible for heat losses. The results showed that the majority of the heat and moisture transfer to the respiratory air occurs during inspiration. The mucosa from the nasal opening to the base of the trachea seems to be most important in heat-moisture transfer. The transfer of heat from lung and air sac surfaces was considered to be small since the inspired air was nearly at body temperature and was saturated with water before entering the lungs.

Circulatory system

The chicken has a 4 chambered heart, two atria and two ventricles which allow efficient circulation to the lungs to provide sufficient exchange of O2 and CO2 to support a high rate of metabolism. The blood of a chicken makes up about 8% of the body weight in chicks 1- 2weeks of age and about 6% of the weight of a mature hen. Avian red blood cells contain a nucleus.

Excretory system

Each kidney is divided into 3 separate readily visible lobes. The kidney is made up of many small tubules or nephrons.

Chicken urine is a yellowish fluid containing a white pasty substance that is largely uric acid, the urine passes out of the kidney through the ureters which end in the cloaca. The chicken has no urinary bladder.

Lymphatic System:

The lymphatic system of chickens does not contain lymph nodes and in general is poorly developed when compared with mammals. There are several organs which contain lymphatic tissue- the bursa of Fabricius, the **spleen**, and the **thymus**. The **thymus** gland consists of about five pairs of pale pink, flattened, irregularly shaped lobes strung out along both sides of the neck, just superficial to the jugular veins. The thymus decreases in size as the bird matures.

The **spleen** is a small, round, soft organ similar in color to the liver. The normal spleen is about ¾ inch in diameter, located near the ventriculus (gizzard) in the body cavity. Histologically, it is composed of red and white pulp. The functions of the spleen include phagocytosis of worn-out erythrocytes in red pulp, lymphocyte production in white pulp, and antibody production in both the red and white pulp.

The **bursa of Fabricius** is located as a diverticulum in the dorsal wall of the cloaca. This bursa contains lymphatic tissue and has a function related to immunity and antibody production. It regresses in size and disappears as the bird matures. On postmortem inspection, the bursa of Fabricius is called the "**rosebud**". When it is intact, it appears as a small sac on the side of the cloaca. When it has been opened during the evisceration process, it appears like a rosebud, which is the common name for this structure because it has several small folds in its mucosal surface.

Chickens - digestive system

The fowl's digestive system breaks down ingested food to basic components by mechanical and chemical means. These basic components are then absorbed and used throughout the body.

Chemical action includes the release of digestive enzymes and fluids from the stomach, pancreas and liver.

Beak / Mouth: Chickens, as with most birds, obtain feed with the use of their beak. Food picked up by the beak enters the mouth. Chickens do not have teeth so they are not able to chew their food. The mouth does contain glands which secrete saliva which wets the feed to make it easier to swallow. The saliva also contains some enzymes which start the digestion of the food eaten. The chicken's tongue is then used to push the feed to the back of the mouth so that it can be swallowed.

Esophagus: The esophagus is a flexible tube that connects the mouth with the rest of the digestive tract. It carries food from the mouth to the crop and from the crop to the proventriculus.

Crop: The crop is an out-pocketing of the esophagus and is located just outside the body cavity in the neck region. Any swallowed feed and water is stored in the crop until it is time to move on to the rest of the digestive tract. When the crop is empty, or nearly empty, it sends hunger signals to the brain so that the chicken will eat more.

Proventriculus: The esophagus continues past the crop to connect the crop to the proventriculus. The proventriculus (also known as the 'true stomach') is the glandular stomach where digestion begins. As with human stomachs, hydrochloric acid and digestive enzymes (e.g., pepsin) are added to the feed here and digestion begins.

Gizzard / Ventriculus: The gizzard, or ventriculus, is a part of the digestive tract unique to birds. It is often referred to as the 'mechanical stomach'. It is made up of two sets of strong muscles which act as the bird's teeth . Consumed feed and the

digestive juices from the salivary glands and the proventriculus pass into the gizzard for grinding, mixing, and mashing.

Small intestine: The small intestine is made up of the duodenum (also referred to as the duodenal loop) and the lower small intestine. The **duodenum** receives digestive enzymes and bicarbonate (to counter the hydrochloric acid from the proventriculus) from the **pancreas** and bile from the **liver** via the **gall bladder**. The digestive enzymes produced by the pancreas are primarily involved in protein digestion. The remainder of the digestion occurs in the duodenum and the released nutrients are absorbed mainly in the **lower small intestine**. The lower small intestine is composed of two parts, the **jejunum** and **ileum**. The Merkel's Diverticulum marks the end of the jejunum and the start of the ileum.

Ceca (plural form; singular = **cecum**): The ceca are two blind pouches located where the small and large intestines join. Some of the water remaining in the fecal material is reabsorbed here. Another important function of the ceca is the fermentation of any remaining coarse materials.

Large intestine (also known as the **colon**): Despite the name, the large intestine is actually shorter than the small intestine. The large intestine is where the last of the water re-absorption occurs.

Cloaca: In the cloaca there is a mixing of the digestive wastes together with wastes from the urinary system (urates). Fecal material is usually voided as digestive waste with white uric acid crystals on the outer surface (i.e., chickens do not urinate/pee).
The reproductive tract also exits through this area (e.g., eggs or sperm).
Its opening at the posterior end of the bird is known as the vent.

Pancreas: A yellow organ lying in the duodenal loop. Also produces insulin for the control of blood-sugar level.

Liver: The largest organ in the body, divided into two lobes, produces bile and is a major detoxification organ.

Drinking behaviour: Most birds are unable to swallow by the "sucking" or "pumping" action**,** and drink by repeatedly raising their heads after filling their mouths to allow the liquid to flow by gravity, a method usually described as "sipping" or "tipping up".

Nervous system

The nervous system consists of the nerve cells which concentrated in the brain, and spinal cord. Usually the nervous system is divided into two parts, the somatic which is responsible for the voluntary actions of the body, and the autonomic system which is responsible for the coordination of involuntary actions. The hypothalamus is well developed as well as hearing, visual, olfactory, and low intelligence.

Endocrine system: The **endocrine system** consists of a number of organs (glands) located in different areas of the body and which play an important part in the proper functioning of the animal. The organs produce special compounds called hormones, which, in turn, target particular systems or organs, and the way that they function.

Pituitary gland or hypophysis, Hypothalamus, Pineal body, Thyroid gland, Parathyroid gland, Adrenal gland, Isilet of langerhans(in pancreas), Testes, Ovary, Ultimo bronchial body.

The anterior pituitary gland is stimulated by special releasing factors from the hypothalamus of the brain to produce and release a number of chemical compounds. These compounds are hormones and include:

1. Thyroid Stimulating Hormone - stimulates the thyroid gland.
2. Adrenocorticotrophic Hormone - stimulates the adrenal cortex.
3. Sex hormones - stimulates the sex glands:
    - Luteinising Hormone
    - Follicle Stimulating Hormone
4. Melanin Stimulating Hormone - function in birds is unknown.
5. Natural Growth Hormone - stimulates growth of the animal.

The posterior pituitary gland produces **arginine vasotocin** and stores **oxytocin** that is produced by the **hypothalamus**. These play a part in the release of the yolk into the oviduct and the actual laying of the egg or oviposition. The secretions produced or stored in the pituitary gland enter the blood stream and are then transported to the part of the body that they target.

Male reproductive system

The male fowl has two testes which are situated high up in the abdominal cavity, along the back. These never descend into an external scrotum, as the case with other animals.

They produce semen; the sperm remain viable at body temperature.

TESTIS

The testis consists of a large number of very slender, much-convoluted ducts, from the linings of which the sperm are given off. These ducts appear in groups separated by delicate membranes which extend inward from a membrane surrounding the testis. They all lead eventually to the vas deferens, a tube that stores the semen and transport it from the testis to a papilla.

PAPILLA

The papilla serves as mating organ. They are located on the dorsal wall of the cloaca. The incorrectly named, "rudimentary copulatory organ" is located on the middle and front portion of the cloaca and is used to classify the sex of baby chicks.

Copulation

- Ducks, geese, storks, flamingos-erectile penis stored in the cloaca.
- Most other species of birds-sperm transfer by bringing male and female cloaca in close proximity “Cloacal Kiss”

Female reproductive system

The reproductive system in the female chicken is in two parts: the ovary and the oviduct. Unlike most female animals, which have two functioning ovaries, the chicken usually has only one. The right ovary stops developing when the female chick hatches, but the left one continues to mature.

OVARY

The ovary consists of a mass of yellowish, rounded objects called follicles, each containing an ovum or yolk.

The ovary is a cluster of developing yolks, attached to the back about midway between the neck and the tail. It is fully formed when the chicken hatches and contains several thousand tiny ova, each ovum within its own follicle. As the female matures, these ova develop a few at a time into yolk. When a mature follicle is examined an elongated area virtually free of blood vessels will be found on the distal surface of it. This area, called the **stigma**, is where the follicle normally splits to release the yolk into the oviduct.

OVIDUCT

The oviduct is a tube like organ lying along the backbone between the ovary and the tail. In a mature hen, it is approximately 63-69 cm (25-27 inches) long. The yolk is completely formed in the ovary. When a yolk is fully developed, its follicle ruptures, releasing it from the ovary. It then enters the infundibulum or entrance of the oviduct. All other parts of the egg are added to the yolk as it passes through the oviduct. The chalazae, albumen, shell membrane, and shell are formed around the

yolk to make the complete egg, which is then laid. This complete cycle usually requires a little more than 24 hours. About 30 minutes after the egg is laid, another yolk is released and the process repeats itself.

The oviduct consists of five distinct parts or sections, each having different functions:

1. **Infundibulum (or funnel)** - located adjacent to the ovary, the infundibulum collects the yolk after its release from the follicle as a funnel and directs it into the oviduct. Fertilization of the ovum by the male sperm occurs here, and is 6-9 centimeters long. It produces the first of the egg coats, the chalazae. These are the whitish string-like structures on either side of the yolk, which keep the embryo in proper position during development. Time containing yolk (ova) takes 18 minutes.
2. **Ampulla or magnum** - at approximately 40 centimeters long during which time the thick white or **albumen** is added.Time (3 hours).
3. **Isthmus** - at about 10-12 centimeters in length. The isthmus is where the inner and outer shell membranes are added. Time (1.15hour). There are two shell membranes: 1- The inner shell membrane - laid down first. 2- The outer shell membrane - laid down last and about three times the thickness of the inner membrane.
4. **Uterus or shell gland** - at approximately 10-12.5 centimeters in length it secretes about 20% of the albumen and the egg's shell. Time (19 – 20hours).
5. **Vagina** - at approximately 10-12 centimeters in length. The vagina is made of muscle which helps push the egg out of the hen's body. It secretes the egg's outer cuticle and possibly the shell pigment.

Androgen, estrogen and progesterone

In addition to the production of eggs, the female reproductive system also produces hormones that aid in the control of body functions. These include androgen, estrogen and progesterone. Androgen causes comb growth and condition, and has a function in the formation of albumen. Estrogen causes the growth of the female plumage, mating and nesting behavior, oviduct development together with the nutrient supply to the ovary/oviduct for egg formation. Progesterone, with androgen is involved in the production of albumen and the carriage of the message to the pituitary gland to release luteinizing hormone.

The formation of the hen's egg

The normal egg consists of the following major parts:

Yolk carrying the ovum - produced by the ovary

Albumen or white – produced mainly in the magnum

Shell membranes – produced in the isthmus

Shell – produced in the uterus or shell gland

Each yolk or ova takes about 10 days to grow and reach maturity when it is approximately 31% of the weight of the egg.

The composition of the yolk material is as follows:

Component	%
Water	48.0
Protein	17.5
Fat	32.5
Carbohydrate	1.0
Other compounds	1.0

Double yolked eggs: This phenomenon can be related to hen age but genetic factors are also involved. Young hens sometimes release two yolks from the ovary in quick succession. Double- yolked eggs are typically larger in size than single yolk eggs. Double-yolked eggs are not suitable for hatching. There is typically not enough nutrients and space available for two chicks to develop to hatch. It has happened, but it is rare.

Ovulation

The release of the yolk - the process of ovulation, is the major controlling factor influencing the subsequent steps in the formation and laying of the egg. The presence of a mature yolk in a follicle causes hormones from the ovary to stimulate the release of **luteinising** hormone (LH) by the pituitary gland. The presence of LH in the blood stream causes the follicle containing the mature yolk to split along the stigma thus releasing it into the oviduct abdominal cavity adjacent to the oviduct.

FERTILIZATION

When a rooster mates with a hen, it deposits spermatozoa in the oviduct. These sperm, containing male sperm cells, travel the length of the oviduct and are stored in the infundibulum.

On the surface of every yolk there can be seen a tiny, whitish spot called the blastodisc. This contains a single female cell. When a yolk enters the infundibulum, a sperm penetrates the blastodisc, fertilizing it. The blastodisc becomes a blastoderm. Shortly after fertilization, the blastoderm begins to divide into 2, 4, 8, and more cells. The first stages of embryonic development have begun and continue until the egg is laid. Development then subsides until the egg is laid.

The hen will continue to lay eggs even if she is not fertilized by the rooster. This is comparable with the unfertilized mammal which continues to ovulate but does not become pregnant, unless first fertilized by a male.

●Eggs are a biological structure intended by nature for reproduction of birds. They protect the developing chick embryo and provide food for the first few days of the chick's life. The egg is also one of the most nutritious and versatile of human foods.

●Eggs of domestic chickens may be white, many shades of brown, or yellow. One breed lays blue-green. Colored eggs occur because pigment is deposited in the shell as it is formed in the uterus.

●Each yolk or ova takes about 10 days to grow and reach maturity when it is approximately 31% of the weight of the egg.

●The protective covering known as the shell is composed primarily of calcium carbonate, with 6,000 to 8,000 microscopic pores permitting transfer of volatile compounds. The function of these pores is to provide for the gaseous exchange during incubation and embryonic development.

●The air cell is located in the large end of the egg, and is formed when the cooling egg contracts and pulls the inner and outer shell membranes apart.

●The albumen, or egg white, is secreted around the yolk.

●Four distinct layers of albumen can be recognized in an egg:

The chalaziferous layer, attached to the yolk; the **inner thin** albumen; the **thick albumen**; and **the outer thin albumen**. Three-fourths of the albumen is made up of the thick and outer thin albumen. The twisting of the egg during formation appears responsible for the separation of the albumen into the four layers.

Albumen type	%
Chalazae and the chalaziferous layer	2.7
Liquid inner layer	17.3
Dense layer	57.0
Outer liquid layer	23.0

The **chalaza are two twisted chords of albumen extending from the opposite sides of the yolk, surrounds** the yolk and holds it in its position.

●The egg shell is made up almost entirely of calcium carbonate deposited on the outer shell membrane. The process of forming the shell requires 19 to 20 hours. About two grams of calcium is deposited in each eggshell.

●Germ spot, yolk, albumen, shell membranes and egg shell, are the parts of the egg.