Anatomy of Chicken

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E. Reproductive system - female

The avian reproductive system is very different from that of mammals and is better suited to the peculiar hazards of being a bird. The biggest problem with being a bird is that everyone is trying to eat you. While most mammals (especially primates) have adopted a strategy of having relatively few offspring and devoting a fair amount of parental energy and time to caring for those few, most birds (with some notable exceptions) have gone the other way: they produce lots of offspring, give them some minimal amount of raising – in some cases, none – then toss them to the winds, literally and figuratively. The parts of an incubated egg are shown in

The female reproductive system of the chicken is divided into two main parts: the ovary and the oviduct. In the majority of avian species, including chickens, only

the left ovary and oviduct are functional. Although the right is present embryologically, it regresses during development and is vestigial in the adult bird.

The **ovary** is a cluster of developing yolks or **ova** and is located midway between the neck and tail of the bird, attached to the back. The ovary is fully formed although very small when the female chick is hatched. It is made up of 13,000 – 14,000 ova which grow by the addition of yolk fluid. Each ovum (singular of ova) starts out as a single cell surrounded by a **vitelline membrane**. As the ovum develops, yolk is added. The color of the yolk comes from fat soluble pigments called **xanthophylls** contained in the hen's diet. At hatch, chicks (like codfish and mammals) are equipped with tens of thousands of potential eggs which theoretically *could* be laid, but (as with the oocytes of mammals) most of them never develop to the point of ovulation. No new ova are produced once the chick has hatched.

Ovulation is the release of the mature ovum from the ovary into the second part of the female reproductive system, the oviduct. The ovum, which is enclosed in a sac, ruptures along the suture line or **stigma**. This

release of the ova occurs 30-75 minutes after the previous egg has been laid. The second major part of the female chicken's reproductive system is the **oviduct**. The oviduct is a long convoluted tube (25-27 inches long when fully developed) which is divided into five major sections. They are the infundibulum or funnel, magnum, isthmus, shell gland, and vagina. The first part of the oviduct, the **infundibulum** or funnel, is 3-4 inches long, and it engulfs the ovum released from the ovary. The ovum or yolk remains in the infundibulum 15-18 minutes. The infundibulum also serves as a reservoir for spermatozoa so that **fertilization** can take place. The next section of the oviduct is the **magnum** which is 13 inches long and is the largest section of the oviduct as its name implies (from the Latin word for 'large'). The ovum or yolk remains here 3 hours during which time the thick white or **albumen** is added. The third section of the oviduct is the **isthmus** which is 4 inches long. The 'egg' remains here for 75 minutes. The isthmus, as its name implies, is slightly constricted (The term 'isthmus' refers to a narrow band of tissue connecting two larger parts of an anatomical structure). The isthmus is where the inner and outer **shell membranes** are added. The next section of the oviduct is the **shell gland** or uterus. The shell gland is 4-5 inches long, and the 'egg' remains here for 20 plus hours. As its name implies, the **shell** is placed on the egg here. The shell is largely made up of calcium carbonate. The hen mobilizes 47% of her body calcium from her bones to make the egg shell, with the diet providing the remainder of the required calcium. Pigment deposition is also done in the shell gland.

The last part of the oviduct is the **vagina** which is about 4-5 inches long and does not really play a part in egg formation. The vagina is made of muscle which helps push the egg out of the hen's body. There are also glands located in the vagina where spermatozoa are stored. The **bloom** or cuticle is also added to the egg in the vagina prior to oviposition (the laying of the fully formed egg). Near the junction of the vagina and the shell gland, there are deep glands lined with simple columnar epithelium. These are the **sperm host glands**, so called because they can store sperm for long periods of time (10 days to 2 weeks!). When an egg is laid, some of these sperm can be squeezed out of the glands into the lumen of the tract, so that they can migrate farther up the oviduct to fertilize another egg. This is one of the really remarkable things about birds; ***the sperm remain viable at body temperature***. Birds lay eggs in clutches. A **clutch**

consists of one or more eggs, followed by a rest period of about a day, then another egg or set of eggs. Clutch size is species-specific and is held within fairly tight limits. Clutch size, as well as the numbers of clutches laid in a breeding season, will vary with species, but the principle is the same. In hens, ovulation usually occurs in the morning and under normal daylight conditions, almost never after 3:00 PM. The total time to form a new egg is about 25-26 hours. This includes about 3½ hours to make the albumen, 1½ hours for the shell membranes, and about 20 hours for the shell itself.

Ovulation for the next egg of a clutch occurs within an hour of laying the previous egg, and so that each day the hen gets later and later in her timing; she "runs behind," like a clock that is improperly adjusted. Eventually she gets so far behind schedule that she would have to ovulate later than 3:00 PM. Since hens do not typically ovulate after 3:00 PM, the next ovulation is delayed and egg laying is interrupted. This delay results in the break between clutches and the cycle repeats itself a day or so later. Occasionally, a hen will produce **double-yolked eggs**. This phenomenon occurs primarily due to the age of the hen, but can also be related to genetics. Young hens sometimes release two follicles from the ovary in quick succession. The highly active ovary due to high activity of reproductive hormones in peak egg production can also be a factor. Double-yolked eggs are 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. Occasionally an egg contains more than two yolks. The Guinness Book of Records lists the world's largest chicken egg (with a diameter of 9 inches or 22.5 cm) as having five yolks and the heaviest egg (1 pound or 0.45 kg) as having a double yolk and a double shell. It is rare, but not unusual, for a young hen to produce an egg with no yolk at all.

Yolkless eggs are usually formed when a bit of tissue is sloughed off the ovary or oviduct. This tissue stimulates the secreting glands of the different parts of the oviduct and a yolkless egg results.

F. Reproductive system - male

The avian male reproductive system is all inside the bird – unlike mammals which have the testes outside of the body. The male chicken possesses two **testes**, along the back, near the anterior ends of the kidneys. They are elliptical shaped and light yellow in color. Each **ductus deferens** opens into a small bump, or **papilla**, which is on the dorsal wall of the cloaca. The papillae serve as the copulatory organ. The incorrectly named, "**rudimentary copulatory organ**" is located on the medial ventral portion of the cloaca and is used to classify the sex of baby chicks. The main goal of broiler breeder management is to produce **hatching eggs**. However, the only good hatching egg is a fertilized egg. **Fertility**, the percentage of eggs laid that are fertilized, is very important in hatching egg production. If an egg is not fertilized, then, of course, it will not contain an embryo and will not hatch. Simply put, "Hatchability can never be better than fertility."

Fertility is affected by both the male and the female, and both tend to decline as the chickens age. Flock fertility is dependent on the reproductive status of the chickens (i.e., level of egg and semen production) combined with the chickens' interest and capability of mating. The fertility of a broiler breeder flock usually increases from a low of 65-75% at the start of lay (23-24 weeks of age) and peaks at 95-98% at 35-37 weeks of age.

Between 40-45 weeks of age fertility declines and the older the birds get the faster the decline in fertility. From the female side, the decline in fertility is believed to be due to faster release of sperm from the sperm storage tubules. As a result, after 40 weeks of age the breeder hen needs more frequent mating to sustain high fertility. From the male side it is presumed that there is a decrease in sperm quality as the rooster ages, as well as a decrease in mating activity. There is also believed to be an increase in early embryo death in the second half of the reproduction cycle. These early deaths often appear as 'clears' and may be mistaken for infertiles.

G. Circulatory system

The avian circulatory system consists of a heart plus vessels that transport nutrients, oxygen and carbon dioxide, waste products, hormones, and heat. The vascular system of birds differs from that of mammals in that

there is an additional renal portal system. Venous blood from the legs flows directly to the kidneys and further to the posterior vena cava.

Birds, like mammals, have a **4-chambered heart** , with complete separation of oxygenated and deoxygenated blood. The right ventricle pumps blood to the lungs, while the left ventricle pumps blood to the rest of the body. Because the left ventricle must generate greater pressure to pump blood throughout the body (in contrast to the right ventricle that pumps blood to the lungs), the walls of the left ventricle are much thicker & more muscular.

Birds tend to have **larger hearts** than mammals (relative to body size and mass). The relatively large hearts of birds may be necessary to meet the high metabolic demands of flight. Among birds, smaller birds have relatively larger hearts (again relative to body mass) than larger birds. Hummingbirds, for example, have the largest hearts (relative to body mass) of all birds, probably because hovering takes so much energy.

Avian hearts also tend to **pump more blood** per unit time than mammalian hearts. In other words, cardiac output (amount of blood pumped per minute) for birds is typically greater than that for mammals of the same body mass. Cardiac output is influenced by both heart rate (beats per minute) and stroke volume (blood pumped with each beat). 'Active' birds increase cardiac output primarily by increasing heart rate.

The **red and white blood cells** are formed in the **spleen**. A bird’s red blood cells are unique in that they are nucleated (there is a nucleus) whereas a mammal’s are not.

Significant diseases of the cardiovascular system in poultry meat inspection include pericarditis and ascites. **Pericarditis** is an inflammation of the fibroserous membranous sac called pericardium, which encloses and lubricates the heart. **Ascites** is an increase of fluid in one or more of the abdominal spaces. Broilers subject to high environmental temperatures exhibit many behavioral changes which allow them to re-establish **heat balance** with their surrounds. They tend to rest more or will position themselves close to walls or waterers. They spread their wings away from the body to promote cooling by reducing body insulation. Within the bird, blood is diverted from certain internal body organs such as the liver, kidneys and intestines to dilated blood

vessels of the peripheral tissue (i.e., skin) in order to facilitate heat loss. As ambient air temperatures increase past 85°F, chickens respond by trying to loose more heat through evaporative cooling which is accomplished by panting. However, this process also generates more heat through the muscular activity involved in panting. Normally blood pH is controlled by the lungs and kidneys along with the various buffer systems which prevent rapid changes in the pH. As the respiratory rate increases in heat stressed broilers, however, there is also a corresponding decrease in the levels of blood carbon dioxide. **Respiratory alkalosis** (i.e., elevated blood pH) results as the blood acid-base balance is disrupted. This produces a decrease in blood calcium and bicarbonate which are necessary for the production of strong egg shells. Thus, the ultimate problem with broiler breeders is a production of thin-shelled eggs produced by laying hens. As for growing chickens, heat stress affects them by depressing weight gain mainly because feed intake is depressed.

H. Nervous system

The nervous system is divided into two main parts which are the **central nervous system** (CNS) and the **autonomic nervous system** (ANS). The CNS is responsible for the voluntary actions of the body such as movement of flight, and the ANS is responsible for the coordination of involuntary actions of the organs, intestines, blood vessels and glands. The primary function of the nervous system is to integrate the functions of the body.

Electrical stunning, using a water bath stunner, is the most common method employed to slaughter poultry under commercial conditions. The purpose of electrical stunning is to induce insensibility in order to perform humane neck cutting and to avoid recovery of consciousness and wing flapping during bleeding. The basic principle involved in electrical stunning is that an electrical current is passed through the brain to induce epilepsy. The occurrence of grand mal epilepsy is considered to be an indicator of the state of unconsciousness (based on the human analogy).

I. Excretory system

The main organ of the excretory system is the **kidney**. The functional units of kidneys are **nephrons**. The functions of the excretory system are to excrete water and metabolic wastes and to regulate the acid-base

balance of the bird's body. The two kidneys of the domestic fowl each generally with three lobes are found immediately behind the lungs on each side of the vertebral column and closely associated with it . They are brownish in color and their consistency is such that they are easily damaged during their removal. The kidneys are normally left in when a broiler carcass is processed. Each kidney is divided into three distinct lobes. Chickens do not have a bladder. Urine passes from the kidney, through the **ureters**, which then empty into the **cloaca**. Chicken urine consists of yellowish fluid with a white pasty substance largely made of uric acid. ***Uric acid is the main product of nitrogen metabolism in birds*** and is not water soluble; this is why solids make up part of the urine. The straight and narrow **ureter** is a tube that leaves the medial border of each kidney and opens into the cloaca adjacent to the deferent duct of the male or the oviduct of the female.

The primary component of poultry waste is **uric acid**, the major end product of protein utilization. Uric acid is a white, pasty substance. Poultry waste is comprised of urine and feces; these are not separate. As indicated in the discussion on the Circulatory system, birds have retained the more 'primitive' renal portal system, a feature not found in mammals. The renal portal system allows blood from the back portion of the body to flow to the kidneys via the iliac veins. There is a valve that allows blood to either pass on to the kidneys where nitrogenous wastes are removed, or return directly to the heart via the renal veins.

J. Immune system

The avian immune system operates on the same general principles as the mammalian immune system. It is divided into two mechanisms – non-specific and specific.

Non-specific immune mechanism includes the inherent ways in which the chicken resists disease. This protective system is often not considered when designing a poultry health program. The non-specific mechanisms include:

• ***Genetic factors*** – Chicken strains have been developed which do not have the required receptors to allow many disease organisms to infect them. For example, some strains of chickens are genetically resistant to the lymphoid leukosis virus.

• ***Body temperature*** – The high body temperature of the chicken precludes many diseases. For example, blackleg disease and anthrax of cattle are not problems in poultry. If the body temperature of the chicken is lowered, however, the disease may occur.

Anatomic features – Many disease organisms cannot penetrate intact body coverings (**skin** and **mucous membranes**) or are trapped in the mucus secretions. Some nutritional deficiencies (biotin deficiency) or infectious diseases compromise the integrity of the body coverings, allowing penetration of disease organisms.

• ***Normal microflora*** – The skin and gut normally maintain a dense stable microbial population. This stable microflora prevents invading disease organisms from gaining a foothold. Improper use of antibiotics or poor sanitation can disrupt the balance of the microflora.

• ***Respiratory tract cilia –*** Parts of the respiratory system are lined with cilia which remove disease organisms and debris. If the air in the poultry house is of poor quality due to high levels of dust or ammonia, the ciliary system may beoverwhelmed and become ineffective. The reason that good management practices are important in maintaining poultry health is better understood when the non-specific immune mechanisms are defined. For example: the overuse of antibiotics or poor sanitation may lead to a disruption of the normal microflora; poor nutrition may lead to deficiencies which allow disease organisms to penetrate the protective body coverings; selection of disease resistant strains of chickens may preclude or lessen the effects of certain diseases; and others.

Specific immune mechanisms (acquired system) are characterized by specificity, heterogeneity, and memory. This system is divided into cellular and non-cellular

(humoral) components.

The ***non-cellular component*** includes immunoglobulins (**antibodies**) and the cells which produce them. Antibodies are specific for the foreign material (**antigen**) to which they attach. For example, the antibody against Newcastle disease virus will attach only to the Newcastle virus, not to the infectious bronchitis virus. The cells which produce antibodies are called ***Blymphocytes***. These cells are produced in the embryonic liver,

yolk sac and bone marrow. The cells move to the **Bursa of Fabricius** (BF) after 15 days of incubation through to about 10 weeks of age. The BF programs these cells which then move to the blood, spleen, cecal tonsils, bone marrow, **Harderian gland** (found in the eye socket, , and thymus. Destruction of the BF at a young age by Gumboro disease (also known as Infectious Bursal Disease, or IBD) or Marek's disease prevents programming of B-cells. Thus, the chicken will not be able to respond to diseases or vaccinations by producing antibodies.

The ***cellular component*** of the specific immune mechanisms includes all the cells that react with specificity to antigens, except those associated with antibody production. The cells associated with this system, the T-lymphocytes, begin as the same stem cells asthe B-cells. However, the T-lymphocytes are programmed in the thymus rather than the BF. A chicken may become immune to a disease organism by producing antibodies itself or by obtaining antibodies from another animal. When the chicken produces its own antibodies following exposure to a foreign material, the process is called ***active***

immunity. This occurs after the bird is exposed to a vaccine or a field disease challenge. Active immunity is harmed by anything which damages the cellular or humoral immune systems. When the chick receives pre-made antibodies from the hen through the egg, this is termed ***passive immunity***. These antibodies are not produced by the chick. Maternal antibodies are present in the yolk, albumin, and fluids of the egg. If the hen has a high antibody titer level to a disease, the chick should also be immune for several weeks. However, since the immune system of the chick is not stimulated, there will be no antibodies produced by the chick and no memory cells. The flock manager must be aware of the maternal antibody levels in the chicks to schedule vaccinations. If chickens are vaccinated when maternal antibody titer levels are elevated, the vaccine may be buffered excessively resulting in a reduced response. Conversely, if vaccinations are delayed and maternal titer levels are low, a severe vaccine reaction may result.