Section 3
Reproductive Anatomy and Egg Formation
Notes

Slide 1

In this section we will learn about both the structural and functional nature of the egg as well as the reproductive anatomy of the hen and physiological events involved in egg production.

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Fertile and infertile eggs have many of the same anatomical features. Generally these features can be classified as nutritional, protective: biological (protection from microbes) and physical, and facilitative (helps the egg with nutritional function or protective function)

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Let's evaluate the major features of egg anatomy. Working from the outside to the inside: First is the cuticle. The cuticle is a waxy coating deposited on the egg during oviposition (laying). Its primary function is protective because it helps prevent bacterial passage into the egg and also can prevent dehydration of the egg. In table eggs for human consumption the cuticle is typically removed by the egg washing procedures. Because the cuticle helps prevent dehydration and can slow the aging process of the egg some table egg producers use a mineral oil spray to try to mimic the cuticle and help with table egg storage longevity.

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The "white" of the egg termed the albumen can be classified into three sections the outer thin, middle thick and inner thin. Albumen is the protein source for the developing embryo and also a perfect protein source for human nutrition. That is why athletes will commonly consume lots of egg white. In the egg the primary function of the albumen is nutritional however it does have some biological protective function. As the egg ages the albumen breaks down and the proportion of thin albumen increases relative to the proportion of thin albumen. As the albumen begins to degrade with age the air cell grows. This is the reason eggs are graded for quality (AA, A, and B) the larger the air cell the lower the quality because the albumen is more broken down.
Chalazae which are cord like structures are found in the albumen and are attached to the yolk and act as an anchor holding the yolk in place and preventing rotation inside the egg

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As you can see from out review of egg anatomy there is much more to it than meets the eye and it really is a biological marvel. As you can imagine there are many physiological changes that occur in the hen as she approaches sexual maturity. These changes begin at 12-14 weeks of age (in a typical broiler breeder hen, could be earlier in egg laying strains). The initiation of egg production begins as the developing embryo begins to release estrogen which plays a major role in preparing the hen's body for reproduction.

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Estrogen's role in sexual maturity includes:
Enlargement and growth of the reproductive tract, also called the oviduct
Increased calcium flux to the medullary bones – critical for egg shell formation

Enlargement of the vent area
Spreading of the pubic bones for egg passage
Formation of lipid in the liver – These lipids will be transported via the blood to the ovary for deposit in the developing follicle

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While estrogen plays a significant role in egg production and preparing the hen for reproduction other factors must also be in place to initiate egg production. These factors are adequate body size and photo stimulation (increasing day length). Photo stimulation and initiation of egg production, for most hens, will occur if over 14 hours of light are provided. Increased photoperiod initiates a cascade of hormones which will result in ovulation.
Therefore the age of the hen must be correct (approximately 21 weeks), the appropriate body size and conformation must be obtained and an increased photoperiod must occur to initiate egg production.

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The hypothalamus (portion of the brain) is what responds to increasing photoperiod. Interestingly, it has been proven that even blind birds will respond to an increasing photoperiod. Once the hypothalamus detects an increasing photoperiod it will signal the anterior pituitary (in brain) to produce follicle stimulating hormone (FSH). Follicle stimulating hormone will travel to the ovary and act on the follicle to begin maturation.

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Throughout the hens productive life ovarian follicles will be in various stages of development. Initially, follicles are white; as follicles begin to mature they appear yellow because of accumulating pigment. The pigment for the follicles is derived from the shanks of the hen. Therefore, reproductive efficiency of the hen can be evaluated by the bleaching of her shanks. The whiter a hens shanks are the more eggs she laid in her productive life.
Generally follicles can be characterized as small white – most immature, large white, small yellow and large yellow (most mature follicles)

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At any given time on a hens ovary there will be several mature (or near mature) large yellow follicles. The largest follicle labeled here F1 will be the next follicle to ovulate. The next largest follicle termed the F2 follicle will be the next to be ovulated following F1 and so on F3, F4, etc.

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When the follicle is mature (F1) and ready for ovulation it releases progesterone which travels to the anterior pituitary. In response to progesterone the anterior pituitary releases luteinizing hormone which travels back to the mature follicle causing follicle rupture and release of the ovum (yolk) to the reproductive tract.

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When the follicle ruptures this is referred to as ovulation. The follicle left once ovulation has occurred is referred to as the post-ovulatory follicle. When the follicle ruptures it does so at a very specific location known as the stigma. The stigma is an area of the follicle where no blood vessels are present. If the follicle does not rupture at the stigma a blood spot will appear on the yolk.

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Once ovulation occurs and the yolk is captured by the reproductive tract. The reproductive tract of the hen is a very specialized organ capable of producing the different parts of the egg. The structures of the oviduct are as follows: Infundibulum, Magnum, Isthmus, and Uterus.
Knowing what you do about egg anatomy what parts of the egg are produced first?

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The infundibulum is a funnel shaped portion of the oviduct which engulfs the ovary and catches the yolk released at ovulation. If fertilization is to occur it will occur here. Once the infundibulum has captured the yolk it travels into the magnum which is the site of albumen synthesis. Albumen accumulates around the yolk as it travels through the magnum. Striation in the lumen of the magnum causes the yolk to spin through this portion of the oviduct. This spinning is what causes chalazae to form in the albumen.

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Calcium is not the only component required for egg shell formation however the blood contains the other required components. These include bicarbonate (HCO_3^-) and carbon dioxide (CO_2).
Calcium is absorbed from the blood and passes through the mucosal cells of the uterus, into the fluid around the developing egg.
CO_2 and water enter the mucosal cells and form carbonic acid with the aid of the enzyme catalyst carbonic anhydrase forming bicarbonate (HCO_3^-)
Bicarbonate (HCO_3^-) passes into the fluid around the developing egg where the calcium is already present forming calcium carbonate ($CaCO_3$). The H^+ removed from bicarbonate travels back through the mucosal cell where it is effectively buffered by present bicarbonate.

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Egg production is a complex physiological process which requires many factors to line up just right. So, there is a timeline of egg production to be considered. Hens usually lay eggs for several consecutive

days before they have a short break. The number of days that eggs are laid in a row is called a clutch. Clutch length is strain dependent. Leghorn hens which have been selected for egg production will have very long clutches conversely broiler breeder and turkey hens will have shorter clutch lengths (Remember the genetics section and the negative correlation between egg and meat production traits). In this example, one hen is laying a clutch of 5 eggs then she will skip a day. So in two clutches she is laying 10 eggs. The second hen is laying a clutch of 3 eggs so in two clutches she is only laying 6 eggs. Even if the second hen is laying more clutches in a year the shorter clutch length is still significantly decreasing total egg production.

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Despite the breed, the number of dark hours provided to the hens is as critical as the number of light hours. LH is released approximately 1 hour after dark hours begin. Therefore, too little dark can reduce clutch length, significantly decreasing a hen's production potential.

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Unlike mammals, in birds testicles are located in the body cavity. In birds, body temperature is not detrimental spermatogenesis as it would be in mammals. Spermatogenesis occurs rapidly in birds and the vas deferens is the main site of sperm storage and maturation. Birds do have a rudimentary phallus located in the ventral wall of the cloaca. During copulation sperm is transferred to the oviduct of the female via the cloaca.