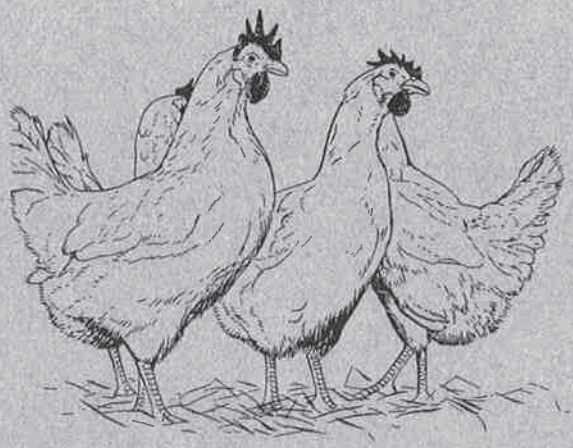
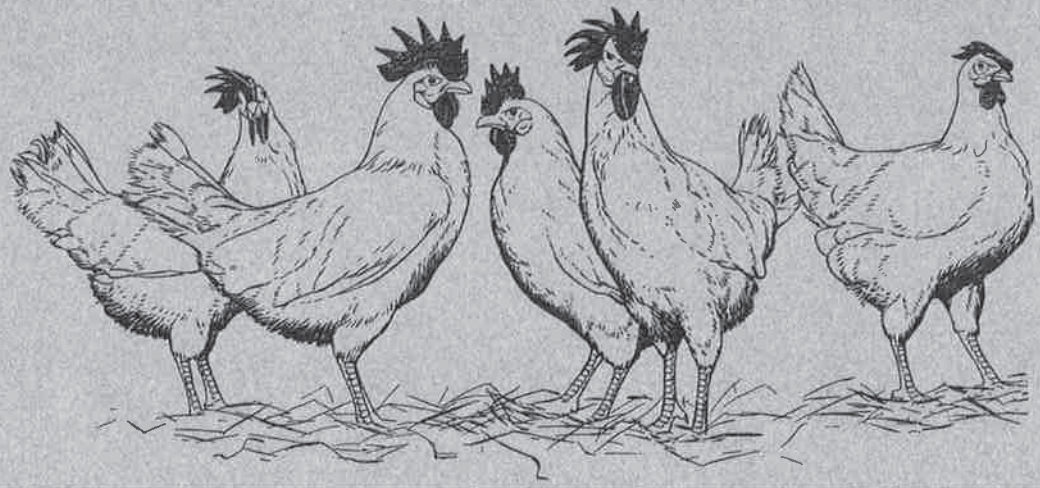


Embryology



INTRODUCTION

Embryology is the study of the development of an individual organism. In chickens, it begins after fertilization of the egg and continues through the development of the egg until the egg hatches. This chapter is designed to help one better understand life and embryonic development. The bird egg is an excellent educational subject for the study of embryology. First, unlike most animals, the embryonic development of the bird takes place within the egg and outside of the body of the female. Second, the egg is small and readily available. Third, the incubation period is short enough to maintain interest.

HOW EGGS ARE FERTILIZED

Many people wonder how and why the embryo grows within the egg. You might wonder why eggs from the supermarket don't grow and hatch when incubated. Most of the eggs that you buy at the supermarket are from hens that are raised without a rooster being present. The male chicken — cock or rooster — makes the difference. Each sex, the cock and the hen, contributes something to the embryo. The cock provides spermatozoa. The hen provides ova. One female germ cell is called an ovum, and many are called ova. A single male germ cell is called a spermatozoon, and many are called spermatozoa. When a cock mates with a hen, it deposits spermatozoa in the oviduct. There are two sperm storage sites in the hen's reproductive tract; they are located in the vagina and the infundibulum. These spermatozoa travel the length of the oviduct to the infundibulum. On the surface of every egg yolk there can be seen a tiny, whitish spot called the blastodisc. This contains a single female cell. If spermatozoa are present when a yolk enters the infundibulum, a single spermatozoon penetrates the blastodisc, fertilizing it and the blastodisc becomes a blastoderm. Technically, the blastoderm is the true egg. 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 incubated. When a spermatozoon and an ovum unite, this process is called fertilization. After fertilization, the egg can develop and become a chick. Only fertilized eggs can grow into chicks. Once the chicks are hatched, they grow and become adult birds.

The rooster must be present for an egg to be fertilized. Roosters are not necessary at egg farms where eggs are produced for human consumption. Supermarket eggs are infertile. Eggs for incubation are produced at special farms called breeder farms where roosters are present with the hens.

THE AVIAN EGG

The avian egg is a marvel of nature's architecture. A highly complex reproductive cell, it is essentially a small center of life, a world of its own.

As we know it, the egg is the single most complete food known to humans. Versatile and nutritious, it is used every day in the preparation of the most common or the most fanciful meals.

Scientifically speaking, an egg (ovum) is the reproductive cell produced by the female. It remains a single cell until the single cell (nucleus) of the male sperm fertilizes it. Once fertilized, the egg has a full complement of chromosomes and genes to start developing.

The fertilized cell (zygote) then rapidly divides into 2 cells, 4, 8, 16, 32, 64, and so on, until the faint outline of a developing embryo and a network of blood vessels surrounding the yolk and other nutrients can be seen.

The egg is a complex structure designed to nourish and protect the embryo growing from the zygote. A vigorous, healthy chick can be hatched from each fertile egg. The egg needs a warm, humid environment while the embryo is maturing.

The Parts of the Egg

Looking at the egg from the outside we see the shell, which is a hard, protective covering composed primarily of calcium carbonate. The shell is porous and the large end contains more pores than the small end of the egg. (There are about 7,000 pores in a chicken eggshell.) This permits the transfer of gases through the shell. Carbon dioxide and moisture are given off through the pores and are replaced by atmospheric gases, including oxygen.

Immediately beneath the shell are two membranes, the outer and inner shell membranes. These membranes protect the contents of the egg from bacterial invasion and prevent rapid evaporation of liquid from the egg.

The body temperature of a hen is 107 °F; therefore, eggs are very warm at the time they are laid. The temperature of the air is usually much lower than 107 °F, and the egg cools to the temperature of its surroundings. As cooling takes place, the contents of the egg contract more than does the shell of the egg. This creates a vacuum, and air is normally drawn through the pores in the large end of the shell.

As a result, an air cell forms at the large end of the egg. The air cell serves as a tiny shock absorber during early embryonic development, and on the 20th day of incubation the chick pokes its beak through the shell membranes into the air cell (which by this time has enlarged greatly) and draws its first breaths of air from this space.

While the embryo is growing, the shell membranes surround and contain the white or albumen of the egg. The albumen provides the liquid medium in which the embryo develops, but it also contains a large amount of the protein necessary for proper development.

In a fresh egg, one can see white cords attached to the yolk sac. These two cords, called chalazae, are made of twisted strands of mucin fibers, a special form of protein. The chalazae hold the yolk in the center of the egg.

The yolk contains large amounts of carbohydrates, fat, and protein. The egg white (albumen) is made of high-quality protein and water. The yolk is also a reservoir of the vitamins and minerals that are essential for normal growth. These substances, along with oxygen taken in through the pores of the shell, provide an abundant source of metabolic energy for the embryo. By-products of this process are carbon dioxide and water; the embryo uses the water and carbon dioxide is transpired through the pores of the shell. Calcium absorbed from the yolk and shell are used by the embryo to make its bone structure, or skeleton.

SCIENCE OF INCUBATION

Incubation means maintaining conditions favorable for developing and hatching fertile eggs. Still-air incubators do not provide mechanical circulation of air. Forced-air incubators are equipped with electric fans. Optimum operating temperatures differ slightly.

Four factors are of major importance in incubating eggs artificially: temperature, humidity, ventilation and turning. Of these factors, temperature is the most critical (see Table 27, below). However, humidity tends to be overlooked and causes many hatching problems. Extensive research has shown that the optimum incubator temperature is 100 °F when relative humidity is 60 percent, concentrations of oxygen 21 percent, carbon dioxide 0.5 percent and air movement past the egg is at 12 cubic feet per minute.

Table 27. Incubation Period and Incubator Operation for Eggs of Domestic Birds

Requirements	Chickens	Guinea, Peafowl, Turkey	Goose and Duck	Muscovy Duck	Pheasant	Bobwhite Quail	Coturnix Quail
Incubation period (days)	21	28	28	35	24-28	23-24	17
Still-air operating temp (F - dry bulb)	100.5	100.5	100.5	100.5	100.5	100.5	100.5
Forced-air operating temp (F - dry bulb)	99.5	99.5	99.5	99.5	99.5	99.5	99.5
Humidity (F - wet bulb)	85-87	83-85	84-86	84-86	86-88	84-86	84-86
Do not turn eggs after	day 18	day 25	day 25	day 31	day 21	day 21	day 15
Humidity during last three days of incubation (F - wet bulb)	90-94	90-94	90-94	90-94	92-95	90-94	90-94

Temperature

An incubator should be operated in a location free from drafts and direct sunlight. An incubator should be operated for 24 hours with water placed in a pan to stabilize its internal atmosphere before fertile eggs are set. During the warm-up period, the temperature should be adjusted to hold a constant 102 °F for still air, 99.5 °F for forced air. To obtain reliable readings, the bulb of the thermometer should be at the same height as the tops of the eggs and away from the source of heat. Use two thermometers to ensure you are getting an accurate reading.

Incubator temperatures should be maintained between 99 and 100 °F. High mortality is seen if the temperature drops below 96 °F or rises above 103 °F for a number of hours. If the temperature stays at either extreme for several days, the egg may not hatch. Overheating is more critical than underheating. Running the incubator at 105 °F for 15 minutes will seriously affect the embryos, but running it at 95 °F for 3 or 4 hours will only slow their metabolic rate.

Do not make the mistake of overheating the eggs. Many times, when the eggs remain clear and show no development, it is due to excessive heat during the first 48-72 hours. Do not adjust the heat upward during the first 48 hours. This practice cooks many eggs. The eggs will take time to warm to incubator temperature and many times the incubator temperature will drop below 98 °F for the first 6 to 8 hours or until the egg warms to 99 to 100 °F.

Humidity

The relative humidity of the air within an incubator for the first 18 days should be about 60 percent. During the last 3 days (the hatching period) the relative humidity should be nearer 65-70 percent. Too much moisture in the incubator prevents normal evaporation and results in a decreased hatch, but excessive moisture is seldom a problem in small incubators. Too little moisture results in excessive evaporation, causing chicks to stick to the shell.

Table 28 will enable you to calculate relative humidity using readings from a wet-bulb thermometer and the incubator thermometer.

Table 28. Relative Humidity

Incubator Temperature (Dry-Bulb Readings)	Wet-Bulb Readings					
100 °F	81.3	83.3	85.3	87.3	89.0	90.7
101 °F	82.2	84.2	86.2	88.2	90.0	91.7
102 °F	83.0	85.0	87.0	89.0	91.0	92.7
Percent Relative Humidity	45%	50%	55%	60%	65%	70%

During the hatching period, use an atomizer to spray a small amount of water into the ventilating holes to increase the humidity in the incubator. (This is especially helpful when duck or goose eggs are being hatched.)

An 8-inch pie tin or petri dish containing water placed under the tray of eggs should provide adequate moisture. The relative humidity in the incubator can also be varied by changing the size of the water pan or by putting a sponge in the pan to increase the evaporating surface area. The pan should be checked regularly while the incubator is in use to be sure that there is always an adequate amount of water.

Whenever you add water to an incubator, it should be about the same temperature as the incubator.

In the latter stages of incubation (the final three days the eggs are in the incubator), condensation on the glass indicates the presence of sufficient moisture. However, the condensation is also related to the temperature of the room where the incubator is being operated. There will be more condensation on the glass if the room is cold, so be sure the temperature in the incubator and the room remains steady.

Use a wet-bulb thermometer to determine relative humidity. The wet-bulb thermometer measures the evaporative cooling. If the wet and dry bulb read the same temperature, you would have 100 percent humidity. The greater the evaporation taking place, the lower the temperature reading on the wet-bulb thermometer and the larger the spread will be between the wet- and dry-bulb reading.

To make a wet-bulb thermometer, just add a cotton wick to the end of a thermometer. Then place the tail of the wick in water. The cotton then absorbs the water. As the water evaporates from the cotton it causes a cooling effect on the thermometer.

Ventilation

The best hatching results are obtained with normal atmospheric air, which usually contains 21 percent oxygen. It is difficult to provide too much oxygen, but a deficiency is possible. Make sure that the ventilation holes are open to allow a normal exchange of air.

Turning

Turning the eggs during the incubation period prevents the blastoderm from migrating through the albumen and sticking to the shell membrane. Chicken eggs should be turned three to five times daily from the 2nd to the 18th day. Do not turn the eggs during the last 3 days of incubation.

After the 18th day, do not open or move the incubator until the hatch is completed because the chicks are in a hatching position in the eggs and because a desirable hatching humidity must be maintained.

How the Chicken Incubates Eggs Naturally

In nature, the female chicken (hen) selects the nest site and lays a clutch of eggs (usually 8 to 13 eggs), one egg per day. Once she has a clutch of eggs, she begins sitting on the eggs full-time, leaving only for food and water.

The hen's body temperature is 107 °F. When the hen sits on the eggs, this heats the eggs to 100 to 101 °F. The hen turns the eggs on a regular basis by using her beak to scoop under the egg and roll it toward her. The humidity comes from the environment, the bird's body, and any moisture the female transfers back to the nest on her feathers. Brooding hens often leave their nests to feed at dawn or dusk when the dew is present on the grass.

Incubation Period of Other Species

One of the miracles of nature is the transformation of the egg into the chick. In a brief three weeks of incubation, a fully developed chick grows from a single cell and emerges.

Not all avian eggs hatch in 21 days. The Japanese quail needs 17 days; the pigeon 18 to 20 days. The swan and the ostrich need 42 days of incubation before hatching. The duckbill platypus is the only mammal that lays eggs, and they have an incubation period of 12 days. Never incubate the eggs of wild birds; these chicks will not live without their mother's care if they do hatch. Table 29 shows comparative incubation information for 14 domestic birds.

Table 29. Incubation Periods (species and days required to hatch)

Bobwhite Quail ..... (23-24)	Guinea ..... (27-28)
Canary ..... (13)	Muscovy Duck ..... (35)
Chicken ..... (21)	Pheasants ..... (24-28)
Chukar Partridge ..... (23-24)	Pigeon ..... (18-20)
Coturnix Quail ..... (17)	Ostrich ..... (42)
Ducks ..... (28)	Swan ..... (42)
Geese ..... (28)	Turkey ..... (28)

CHICK EMBRYO DEVELOPMENT

Where Chick Life Begins

The development of the chick begins in the single cell formed by the union of two parental cells, ovum and spermatozoon, in the process known as fertilization. In birds, fertilization occurs about 24 hours before the egg is laid.

The newly formed single cell begins to divide into 2, then 4, 8, 16, 32 and so on. At the time of laying, hundreds of cells are grouped in a small, whitish spot (the blastoderm or germinal disc) that is easily seen on the supper surface of the yolk. This spot in a fertilized, freshly laid egg is the beginning of the chick.

When the egg is laid and cools, division of the cells ceases. Cooling the egg at ordinary temperature does not result in the death of the embryo. It may resume its development after several days of rest if it is again heated by the hen or in an incubator.

Development During Incubation

As soon as the egg is heated again, the cluster of cells in the blastoderm begins to multiply by successive divisions. The first cells formed are all alike. Then, as the division of cells progresses, some differences begin to appear.

These differences become more and more pronounced. Gradually the various cells acquire specific characteristics of structure and cell grouping. These cell groupings are called the ectoderm, mesoderm and endoderm. These three layers of cells constitute the materials out of which the various organs and systems of the body are to be developed.

From the ectoderm, the skin, the feathers, beak, toes, nervous system, lens and retina of the eye, linings of the mouth, and vent are developed. The mesoderm develops into the bone, muscle, blood, and the reproductive and excretory organs. The endoderm produces the linings of the digestive tract and the secretory and respiratory organs.

Development from a single cell to a pipping chick is a continuous, orderly process. It involves many changes from apparently simple to complex structures. From these structures arise all the organs and tissues of the living chick.

Physiological Processes Within The Egg

A. Functions of the Embryonic Membranes

Many elaborate physiological processes take place during the transformation of the embryo from egg to chick. These processes are: respiration, excretion, nutrition, and protection.

For the embryo to develop without any anatomical connection to the hen's body, nature has provided membranes outside the embryo to enable the embryo to use all parts of the egg for growth and development. These "extraembryonic" membranes are the (1) yolk sac, (2) amnion, (3) chorion, and (4) allantois.

1. The yolk sac is a layer of tissue growing over the surface of the yolk. Its walls are lined with a special tissue that digests and absorbs the yolk material to provide sustenance

for the embryo. Yolk material does not pass through the yolk stalk to the embryo even though a narrow opening in the stalk is still in evidence at the end of the incubation period. As embryonic development continues, the yolk sac is engulfed within the embryo and is completely reabsorbed at hatching. At this time, enough nutritive material remains to adequately maintain the chick for up to two days.

2. The amnion is a transparent sac filled with a colorless fluid that serves as a protective cushion during embryonic development. This amniotic fluid also permits the developing embryo to exercise. The embryo is free to change its shape and position while the amniotic fluid equalizes the external pressure. Specialized muscles also develop in the amnion, which by smooth, rhythmic contractions gently agitate the amniotic fluid. The slow and gentle rocking movement apparently aids in keeping the growing parts free from one another, thereby preventing adhesions and malformations.

3. The chorion serves as a container for both the amnion and yolk sac. Initially, the chorion has no apparent function but later the allantois fuses with it to form the chorionic membrane. This brings the capillaries of the allantois into direct contact with the shell membrane, allowing calcium reabsorption from the shell.

4. The allantois has four functions: (1) It serves as an embryonic respiratory organ. (2) It receives the excretions of the embryonic kidneys. (3) It absorbs albumen, which serves as nutriment (protein) for the embryo. (4) It absorbs calcium from the shell for the structural needs of the embryo. The allantois differs from the amnion and chorion in that it arises within the body of the embryo.

B. Functions of the Embryonic Blood Vessels

During the incubation period of the chick, there are two sets of embryonic blood vessels. One set, the vitelline vessels, is concerned with carrying the yolk materials to the growing embryo. The other set, the allantoic vessels, is chiefly concerned with respiration and with carrying waste products from the embryo to the allantois. When the chick is hatched, these embryonic blood vessels cease to function.

Hatching

Several changes take place between days 18 to 21. The residual yolk sac is surrounded by the abdominal wall on the 19th and 20th days of incubation. The chick draws what remains of the yolk into its body. Fluid decreases in the amnion. The chick's head is under its right wing with the tip of the beak pointed at the air shell. The large neck muscle contracts and forces the egg tooth through the air cell, and the chick takes it first breath. This is referred to as internal pipping. At this time, you may hear the chick peeping inside the shell.

On the 21st day, the chick finishes its escape from the shell. The initial break in the shell is made by the egg tooth, a sharp, horny structure located on the tip of the upper beak. This is referred to as external pipping.

The hatching process can last 4 to 12 hours before the chick completely emerges from the shell. As the chick's head rotates from under the wing, the egg tooth pips the shell and continues to break the shell in a nearly perfect circle from the inside until it is able to push the top off the egg.

The chick, as it appears upon freeing itself from the shell, is wet and very tired. For the next several hours it will lie still and rest. A few hours later the chick, now dry and fluffy, will become extremely active.

Although used only for a single event in the life of the chick, as a tool to break through the shell, the egg tooth has served its critical purpose well. Its usefulness over, it will be lost in a few days.

DAILY EMBRYONIC DEVELOPMENT

Before Egg Laying

1. Fertilization
2. Division and growth of living cells
3. Segregation of cells into groups of special functions

Between Laying and Incubation

1. Virtually no growth. Stage of inactive embryonic life.

During Incubation

Day One:

1. Development of blastoderm.
2. Major developments visible under microscope:
   - 18 hours: Appearance of alimentary tract
   - 19 hours: Beginning of brain crease
   - 20 hours: Appearance of vertebral column
   - 21 hours: Beginning of formation of brain and nervous system
   - 22 hours: Beginning of formation of head
   - 23 hours: Appearance of blood island
   - 24 hours: Beginning of formation of eyes.

Day Two:

1. Embryo begins to turn on left side.
2. Blood vessels appear in the yolk sac.
3. Major developments visible under microscope:
   - 25 hours: Beginning of formation of veins and heart
   - 30 hours: Second, third, and fourth vesicles of brain clearly defined, as is heart, which now starts to beat
   - 35 hours: Beginning of formation of ear pits
   - 36 hours: First sign of amnion
   - 46 hours: Formation of throat

Day Three:

1. Beginning of formation of nares, wings, legs and allantois
2. Amnion completely surrounds embryo

Day Four:

1. Beginning of formation of tongue.
2. Embryo completely separate from yolk sac and turned on left side
3. Allantois breaks through amnion

Day Five:

1. Proventriculus and gizzard formed.
2. Formulation of reproductive organs - sex division

Day Six:

1. Beginning of formation of beak and egg-tooth
2. Main division of legs and wings
3. Voluntary movement begins

Day Seven:

1. Indications of digits in legs and wings.
2. Abdomen more prominent due to development of viscera.

Day Eight:

1. Beginning of formation of feathers

Day Nine:
1. Embryo begins to look bird-like
2. Mouth opening appears

Day Ten:
1. Beak starts to harden
2. Skin pores visible to naked eye
3. Digits completely separated

Day Eleven:
1. Days ten to twelve tend to run together. No different changes visible on this day.

Day Twelve:
1. Toes fully formed
2. First few visible feathers

Day Thirteen:
1. Appearance of scales and claws
2. Body fairly well covered with feathers

Day Fourteen:
1. Embryo turns its head toward blunt end of egg

Day Fifteen:
1. Small intestines taken into body

Day Sixteen:
1. Scales, claws and beak becoming firm and horny
2. Embryo fully covered with feathers
3. Albumen nearly gone and yolk increasingly important as nutrient

Day Seventeen:
1. Beak turns toward air cell, amniotic fluid decreases and embryo begins preparation for hatching

Day Eighteen:
1. Growth of embryo nearly complete

Day Nineteen:
1. Yolk sac draws into body cavity through umbilicus
2. Embryo occupies most of space within egg except air cell

Day Twenty:
1. Yolk sac completely draws into body cavity
2. Embryo becomes chick, breaks amnion, starts breathing air in air cell
3. Allantois ceases to function and starts to dry up

Day Twenty-one:
1. CHICK HATCHES

OBSERVING THE DEVELOPING EMBRYO

Candling

The development of the embryo can be observed by candling. Candling is done by holding a bright light on the large end of the egg in a darkened room and looking at the inside. "Candling" got its name from using a candle to look at the inside of the egg.

Candling serves three important functions. First, candling the egg before it is set will eliminate any cracked eggs from being set. Cracked eggs will not hatch. Second, candling helps determine which eggs are fertile. Third, by candling the eggs every few days you can observe the growth and development of the embryo without breaking the egg open.

ONCE THE CHICKS HATCH

Brooding

Whether there is one chick or 1,000 chicks in the brooding unit, the principles are the same. The chicks must be kept warm, well fed, watered, protected from predators and dampness and provided with plenty of fresh air without being exposed to drafts.

Newly hatched chicks can live on the unabsorbed yolk in their bodies for about 2 days if necessary. However, chicks with access to feed and water will begin to eat and drink when less than one day of age.

It is extremely important that you build and/or setup all necessary equipment at least two days prior to the chicks hatching.

Brooders should maintain a temperature of 95 °F (taken at one inch above the floor level, the height of the chick's back) during the first week, then decrease the temperature 5 °F per week until room temperature is reached.

The brooder should have a textured, absorbent litter on the floor. If the floor is slippery, the chicks can damage their legs.

Feed 18 to 22 percent protein chicken starter food. The feed can be placed in jar lids, egg cartons, small cans or a commercial chick feeder, any item which can hold enough feed to keep feed available at all times.

Water should be available at all times. Use watering equipment which prevents the chick from getting into it and drowning. Commercially made water fountains can be bought and added to a quart jar.

Clean the waterer and brooder daily. This will prevent odors and keep the brooder dry. Dampness provides favorable conditions for the development of molds and bacteria. Providing at least 1 square foot for every five chicks will also help keep the conditions more desirable.

GLOSSARY

albumen - a combination of the four layers of a whitish watery substance with protein that surrounds and contains the yolk within the center of the egg shell.

allantois - an organ in the embryo of birds which functions as a respiratory organ in the developing embryo. Its blood vessels transport oxygen to the embryo and carry away the carbon dioxide.

amnion - a thin, membranous, fluid-filled sac surrounding the embryo.

avian - of, or pertaining to, Aves or birds.

bacteria - microscopic single-celled organisms.

blastoderm - the collective mass of cells produced by the splitting of a fertilized ovum from which the embryo develops.

blastodisc - the germinal spot on the ovum from which the blastoderm develops after the ovum is fertilized by the sperm.

brood - (*n.*) baby chicks hatched from one nest (setting) of eggs.
- (*v.*) care for baby chicks.

candling - observing the shell and the contents of the egg (blood vessels, embryonic development, blood or meat spots, air cell, etc.) through the shell by holding the egg up to a bright light that is focused on and behind the egg shell.

cell - a mass of protoplasm (usually microscopic) within a semi-permeable membrane, containing a nucleus, and capable of functioning as an independent unit.

chalazae - prolongations of the thick inner-white that are twisted like ropes at each end of the yolk. Their function is to anchor the yolk in the center of the egg shell cavity.

chorion - a membrane enveloping the embryo, external to and enclosing the amnion.

chromosomes - a series of paired bodies in the nucleus, constant in number in any one kind of plant or animal.

cloaca - in birds, the common chamber into which the intestinal, urinary and reproductive tract come together.

dorsal - of, on or near the back.

dry-bulb thermometer - expresses a temperature reading in number of degrees Fahrenheit (F) or centigrade/Celsius (C).

egg (avian) - the female reproductive cell (ovum) surrounded by a protective calcium shell and, if fertilized by the male reproductive cell (sperm) and properly incubated, capable of developing into a new individual.

egg tooth - also called "chicken tooth". The temporary horny cap on the chick's upper beak which serves for pipping (breaking through) the shell. Usually dries and falls off within 18 hours after chick hatches.

embryo - a fertilized egg at any stage of development prior to hatching. In its later stages, it clearly resembles the fully developed chick.

embryology - the study of the formation and development of plant and animal embryos.

evaporation - changing of moisture (liquid) into vapor (gas).

fat - organic combination of carbon, hydrogen, and oxygen in such relative quantities that the caloric value of the compound is high.

fertile - capable of reproducing.

fertilized - an ovum impregnated by a sperm.

follicle (ovarian) - the thin membrane of the ovary which encloses the developing yolk; the yolk sac.

gene - an element in the chromosome of the germ plasm that transmits hereditary characteristics.

hatching egg - a fertilized egg, one with the potential of maturing.

humidity - see "relative humidity".

incubate - to maintain favorable conditions for developing and hatching fertile eggs.

incubator - a container with the proper humidity and temperature to allow fertile eggs to hatch.

infundibulum - any of various hollow, conical organs or parts thereof.

membrane - a thin, soft, pliable sheet or layer of tissue covering an organ.

nutrient - food that contains substances necessary to sustain life and growth.

ovary - the female reproductive gland in which eggs are formed.

oviduct - the tube through which eggs pass after leaving the ovary.

ovum - the female reproductive cell.

papilla - any small, pimple-like or teat-like projection.

peristaltic action - involuntary movement of the muscles of the oviduct that forces the egg onward.

pipping - a baby chick breaking from its shell.

pores - thousands of minute opening in the shell of an egg through which gases are exchanged.

protein - one of a group of nitrogenous compounds commonly known as amino acids.

pituitary - a small, oval, two-lobed vascular body attached to the infundibulum of the brain that secretes hormones affecting growth.

relative humidity - the amount of moisture in the air compared with the amount that the air could contain at specific temperatures. Expressed as a percentage.

semen - secretion of the reproductive organs of the male; composed of spermatozoa, epithelial cells, secretions of seminal vesicle.

spermatozoa (pl.) - mature male germ cells, the specific output of the testes.

spermatozoon - one of the mature germ cells of the male.

still-air incubator - a container for hatching chicks that does not have mechanical ventilation.

system - functioning unit of the anatomy, such as the skeletal, muscular, glandular, respiratory and digestive systems.

testes - the male genital glands (plural).

testicle, testis - the male genital gland (singular).

vitamin - a fat- or water-soluble substance necessary, in very small amounts, to allow for normal growth and maintenance of life.

vitelline - of, pertaining to, or like, the yolk of an egg.

wet-bulb thermometer - a device to measure the amount of moisture or water vapor in the air.

yolk - a globular mass of yellow, nutritious semi-liquid contained in a transparent membrane (the vitelline membrane) and located in the center of an egg. The yolk is the chick's food during its pre-hatching life and its first food after it emerges from the shell.

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