THE REPRODUCTIVE SYSTEM

Female Reproductive System

(See Figure 3)

The female reproductive system of the chicken is divided into two main parts: the **ovary** and the **oviduct**. The **ovary** is a cluster of developing **yolks** or **ova** and is located midway between the neck and tail of the bird, attached along the back. The ovary is fully formed although very small when the female chick is hatched. It is made up of 13,000 to 14,000 minute yolks or ova which grow by the addition of yolk fluid. It starts out as a single cell surrounded by a **vitelline membrane** which keeps water out. The color of the yolk or ova comes from fat soluble pigments called xanthophylls (*zantho fills*) contained in the hen's diet.

Ovulation is the release of the mature yolk from the ovary into the second part of the female reproductive system. The ova or yolk, which is enclosed in a sac, ruptures along the **suture line** or **stigma**. This release of the ova occurs 30 to 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 to 27 inches long) which is divided into five major sections. They are the **infundibulum** or **funnel**, the **magnum**, the **isthmus**, the **shell gland**, and the **vagina**. Unlike mammals, there is only one functional oviduct in the chicken; the oviduct on the left side of the chicken is functional, the right ovary is **rudimentary** (imperfectly developed).

The first part of the oviduct, the **infundibulum** or **funnel**, is 3 to 4 inches long, and it engulfs the ovum released from the ovary. The ovum or yolk remains here 15 to 18 minutes, and it also serves as a reservoir for spermatazoa 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. 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. In the isthmus, the shell membranes are added.

The next section of the oviduct is the **shell gland**. The shell gland is 4 to 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 made up of **calcium carbonate**, and the hen mobilizes 47 percent of her body calcium from her bones and her diet to make the egg shell. Pigment deposition is also done in the shell gland.

The last part of the oviduct is the **vagina** which is about 4 to 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 spermatazoa are stored.

Male Reproductive System

(See Figure 4)

The male reproductive tract is comprised of two **testes**, both of which are functional. Inside the testes are the **seminiferous tubules**, where sperm is produced. Leading from the testes is the **ductus deferens** which move the sperm to the outside of the body.

GROWING BLUE RIBBON PULLETS

Breed Selection

Before you choose a breed and variety for your project, decide whether you want to raise chickens for eggs or meat.

Egg-type

Single Comb White Leghorns and Leghorn-type hybrids are used for egg production. These birds live well, grow fast, and begin laying eggs at 5 to 5 1/2 months of age. They have small bodies and do not consume as much feed as larger meat-type birds. They have been bred to lay a large number of high-quality, white-shelled eggs.

The Leghorn-type cockerel does not grow fast and does not make a good broiler. If you select egg-type birds, buy only female chicks.

Meat-type

The meat-type birds are a cross between a strain of Cornish game and a brown-egg meat-type bird such as White Plymouth Rocks, Columbians, Plymouth Rocks, and New Hampshires.

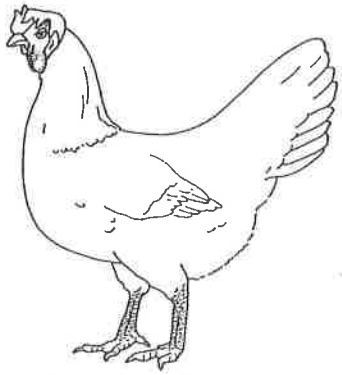
Broiler-type chickens convert feed efficiently, grow and feather rapidly, and are ready to dress for home use at 8 to 8 1/2 weeks. They should not be kept for market egg production, because they do not produce eggs as efficiently as egg-type birds.

Dual-purpose

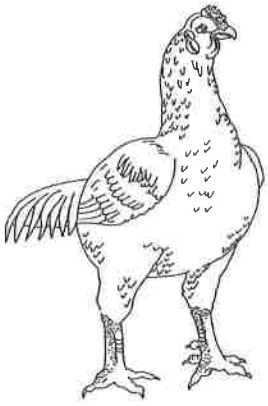
The dual-purpose birds were developed to provide both eggs and meat. These birds do not produce eggs as efficiently as birds of the egg-type strains, nor can they produce meat as efficiently as birds selected for meat production. Dual-purpose birds include Rhode Island Reds, White Plymouth Rocks, New Hampshires, Barred Plymouth Rocks, Black Sex Links, and Red Sex Links.

Black Sex Links are a cross between a Rhode Island Red male and a Barred Plymouth Rock female. The Red Sex Links are a cross between a Rhode Island Red male and a White Leghorn female.

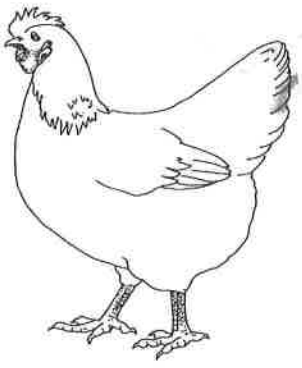
The dual-purpose birds are hardy, lay large brown-shell eggs, and are well-suited for the backyard flock.



Egg-type Chicken



Meat-type Chicken



Dual-purpose Chicken

Where to Buy Chicks

Start your project by participating in the 4-H Chick Chain. Each 4-H member who participates in the program receives 25 to 50 free chicks to brood and rear. The 4-H'ers agree to return six or 12 pullets to the show and sale. Contestants receive ribbons and prize money based on their success in raising blue ribbon pullets.

Brooding Chicks

Baby chicks require lots of tender loving care. They depend on you for all their needs. The brooding period lasts about 6 weeks. If you practice the following management techniques during the brooding period, you should have a healthy flock.

1. **Space** - Each chick should have one-half a square foot or more of floor space for the first 4 to 5 weeks. If broilers are to be housed indoors until ready for market, 1 square foot of floor space per bird is sufficient. However, if you want to raise layers, you will require about 2 square feet of floor space per bird for the egg-type birds, and 2½ to 3 square feet per bird for the dual-purpose birds.
2. **Draft-Free Ventilation** - An adequate amount of air movement through the poultry house is important for a variety of reasons: It supplies the birds with oxygen; prevents the buildup of carbon dioxide and ammonia, which in excess is harmful; and helps to regulate temperature. Good ventilation is also needed to remove excess moisture, in order to keep the litter dry and to help control diseases.

   The amount of ventilation required depends upon the season and the age of the birds. During the winter months, ventilation is necessary, but it is equally important to keep the birds away from drafts. The best arrangement for winter ventilation is to tightly close three sides and provide openings on the south wall of the house. The openings should be fairly high in the wall, since moist air is light and rises toward the ceiling. The openings should be covered with burlap in severe cold weather. When the weather is very warm, the birds need plenty of fresh air to keep cool. Cross-ventilation becomes very important, and therefore, windows should be completely removable. The openings should be covered with a ¾-inch mesh netting to keep sparrows outside.

   It is important to remember that young birds are much more sensitive to drafts than older birds.
3. **Light** - For the first 48 hours, give your chicks 24 hours of light so that they can find the feeders and waterers. One 25-watt light bulb will provide enough light for a 10 by 10-foot house. Once the chicks have found the feeders and waterers, you can take advantage of natural daylight.

   Having windows on the south side of the house will allow more sunlight to enter the house. Clean the windows once a week to give maximum light. Covering the inside of the windows with a wire mesh screen will prevent the birds from flying into the windows and breaking them. When the weather is warm, remove the windows to improve air circulation.
4. **Temperature** - Young chicks are unable to maintain their body temperature without an additional heat source. A brooder is a device used to produce heat to protect the chicks from the cold. The temperatures at which chicks are comfortable vary with the age of the chicks, and are as follow:

Temperature	Age of Chicks
95 °F	1 day to 1 week
90 °F	1 week to 2 weeks
85 °F	2 weeks to 3 weeks
80 °F	3 weeks to 4 weeks
75 °F	4 weeks to 5 weeks
70 °F	5 weeks to 6 weeks

At 6 weeks of age, the birds should be well-feathered and supplemental heat is no longer needed.

A couple of thermometers will help you to know when the temperature is right. Hang one just under the edge of the brooder about 2 inches from the floor. Place the other some distance away from the brooder so that you can tell whether you are keeping the brooder at the right temperature.

Give day-old chicks 8-percent sugar water to drink (1½ cups of sugar per gallon of water) for the first day. The sugar serves as a quick and easy-to-use energy source for thirsty chicks. If possible, give the water to the day-old chicks 3 to 5 hours before giving the feed. This will get the chicks off to a good and healthy start.

When selecting waterers and feeders, keep in mind that chicks grow fast; feeding and watering space and the size of the equipment need to increase to meet their needs. Chicks develop both a scratching and roosting behavior, which can lead to feed being scattered over the litter, and to having droppings in the feed if the birds are permitted to perch on the feeders.

It is also important to remember that the sooner the chicks are placed in the brooder house and allowed to eat and drink, the better their growth and performance. For the first few days place the feed in feeder trays. A cardboard box, cut off to 2 inches high makes an excellent feeder tray. Add some small chick feeders, and gradually remove all the feeder trays. Make sure the chicks have found the regular chick feeders before removing all the trays. Use chick-size feeders for the first 2 weeks.

Provide 1 inch of feeder space per chick, counting both sides of the feeder. For example, if your chick feeder is 12 inches long, then it can handle 24 chicks.

From the second week on, tube-type feeders can be used. These are more convenient and more practical than the trough feeders. The tube-type feeders are suspended from the ceiling and can be easily raised, keeping up with the height of the growing birds. These feeders should be adjusted to the height of the birds' backs. To determine the linear space of a round feeder, multiply the base diameter of the container by 3.14. For birds aged 2 to 6 weeks, provide 2 inches of feeder space per bird.

If you intend to use only trough feeders for your birds, the feeders should increase in depth, breadth, length, and height as the birds grow. From the second through the 6th week, use the medium-sized feeders, and provide 2 inches per chick.

Chicks should always have plenty of clean, fresh water. Use six 1-quart fountain-type waterers per 100 chicks during the first week. Replace at the end of 1 week with two 2-gallon waterers. It is a good practice to place the water fountains upon frames 2 feet square made of 1 by 2-inch boards covered with ½-inch mesh hardware cloth. This will help to keep the waterers clean and the birds away from the damp litter surrounding the water fountain. From the 4th week on, provide two 5-gallon waterers for each 100 birds. Place waterers on wire bottom stands made of 1 by 4-inch boards.

Poultry Nutrition

The commercial poultry feeds available today are the result of years of research. The rations contain 30 or 40 ingredients and are designed to meet the specific needs of the birds. Young chickens or broilers grown for meat are fed differently from pullets raised for their eggs. Because the nutrient requirements vary with the age of the birds, feed manufacturers produce a starter and finisher ration for broilers and a starter, grower, and layer ration for chickens intended for laying eggs.

Feed chicks a starter ration from the very first day, and keep them on the starter until they reach 6 weeks of age. The starter diet has the most protein. As the birds mature they need a lower percentage of protein and higher level of energy.

Once the chicks are 6 weeks old, give them either a finisher diet (to broilers) or a grower diet (to pullets or cockerels saved for breeding purposes). Feed broilers a finisher diet until they weigh about 4 pounds, and then process. Feed the pullets and cockerels a grower until they reach 20 weeks of age or until the pullets start to lay eggs. When egg production begins, feed them a layer ration.

The minimum requirements for protein, calcium, and phosphorus in poultry feeds are given in Table 11. This table should help you to determine what type of feed to purchase for your birds.

Disease Prevention

The first step in raising chickens is to start with healthy chicks. Then it is up to you to provide clean, comfortable housing for the birds. Use preventive management to avoid disease and parasite problems.

Start with a clean house and equipment. If the house was used earlier, scrub the house with a commercial disinfectant such as creosol or with hot lye water (1 pound of lye to 10 gallons of hot water). Let the house dry several days before placing the chicks in the house. Disinfect waterers and feeders with a quaternary ammonium solution. Wear protective clothing, gloves, and goggles while using creosol or lye.

Keep feed in metal cans with tight lids to keep mice and rats out. Repair holes in screen windows to prevent birds and small animals from entering the house.

Remove sick or dead birds from the poultry house as soon as they are found. Dispose of dead birds promptly by burying them deeply to discourage animals from digging.

Prevent cannibalism and feather picking by buying chicks that have been beak trimmed at the hatchery, or clip off the tip of the beak with a dog's toenail clippers. Overcrowding, nutrient deficiencies, poor ventilation, too little drinking and eating space, too much light, and the appearance of blood on an injured bird are factors which lead to picking.

External Parasites

Mites and lice are the most common parasites found on chickens. Consult your county Extension agent for advice on pesticides safe to use on or around poultry. Carefully follow instructions when using pesticides.

Internal Parasites

The large roundworm can become a problem for small flocks. A few worms do not cause any harm, but if you see worms in the droppings, you need to treat the birds. Your county Extension agent can recommend a worming compound.

Vaccination

Earlier we suggested that you have the hatchery vaccinate the chicks against Marek's disease. The protection given by the vaccine is well worth the added cost. Marek's disease is caused by a virus. It may result in weight loss, paralysis of legs or wings, and sudden death.

Although it is difficult to secure small lots of vaccine, it may be necessary to vaccinate your flock against fowl pox, Newcastle disease, and bronchitis if these diseases have been a problem in previous flocks. See Table 13 for a suggested vaccination schedule.

Fowl pox is caused by a virus and shows up as blisters and scabs on the combs and wattles. Newcastle disease and bronchitis are viral respiratory diseases.

If you do not vaccinate, do not allow visitors around your flock. Birds that are entered in poultry exhibits may be exposed to disease. Sell the birds or keep them separate from the rest of the flock for at least 2 weeks after their return home. If the birds have picked up a disease, it will appear before the birds are returned to the flock.

Table 13. Vaccination Schedule Indicating Type of Vaccine, Age to Vaccinate, and Method of Vaccination

Vaccine	Age of Bird	Method
Newcastle-Bronchitis	10 days	water
Newcastle-Bronchitis	6 weeks	water
Fowl Pox	12 weeks	wing stab
Newcastle-Bronchitis	4 months	water

4. **Temperature** - Laying birds do not need artificial heat unless the house is poorly insulated. Keep the house free from drafts. Thaw waterers promptly if they become frozen, or use an immersible water heater to keep the water from freezing. If the birds are exposed to extreme cold, the birds will stop laying, and their combs and wattles may freeze. In the summer, the poultry house should have at least 3 inches of dry litter. When the weather starts to get colder, gradually add fresh litter until it is at least 4 to 6 inches deep. The built-up litter provides a warm, dry floor. Stir the litter often to keep it in good shape. If an area becomes caked or wet, clean out the wet litter and replace with fresh.
5. **Access to Feed and Water** - Your flock should always have a fresh supply of commercial laying mash on hand. Water is very important to the laying flock. Without fresh, clean water, the birds will not eat and will go out of production.
6. **Roosts** - Check the wire mesh around the roosts and make sure the wire is not broken. Sharp points on the wire can injure the foot pads of the chickens and cause infection.
7. **Nests** - Provide one nest for every four hens. Keep clean nesting material, such as wood shavings, in the nest at all times. Place nests 18 to 20 inches above the floor. Individual nests should be 10 to 14 inches wide, 12 to 14 inches high, and 12 inches deep. Perches below the entrance help keep the nest clean.

Egg Care

Most eggs are laid with a clean shell. To keep eggs clean, change the nesting material often. Gather the eggs at least twice a day. Dirty eggs should be buffed clean with emery cloth.

Eggs should be kept in the refrigerator until used. For more information on grading eggs, ask your county Extension agent.

Culling

Culling is the removal of sick or injured birds from the flock. Culling, if done right, will reduce feed costs and may prevent the spread of disease. Culling is a daily task. Separate sick or injured birds from the flock as soon as you see them. Try to learn the cause of the problem before disposing of the bird. The information may be useful in preventing other birds in your flock from getting sick.

Toward the end of the first year of production, some hens may stop laying. You may wish to pick out these loafers, and process them for home use. It is easy to tell the difference between good layers and poor layers once you have learned what to look for.

Good Layers Have:
- A bright red comb
- A soft, pliable abdomen
- A large, moist vent
- 3 to 5 fingers' spread between pelvic bones

Poor Layers Have:
- A dull, shriveled comb
- A hard, fatty abdomen
- A small, round, dry vent
- 1 to 2 fingers' spread between pelvic bones

It is normal for hens that have been laying for 12 to 14 months to take a rest. You can now decide to either process the flock for meat and make room for new pullets or keep the hens for another production cycle.

Acknowledgments: Agricultural Extension Service, University of Tennessee

All Other Standard Breeds Class

Games

Old English

Varieties: Black Breasted Red, Brown Red, Golden Duckwing, Silver Duckwing, Red Pyle, White, Black, Spangled.
Standard weights: Cock, 5 pounds; hen, 4 pounds; cockerel, 4 pounds; pullet, 3½ pounds.
Skin color: White.
Eggshell color: White or light tint.
Use: Old English Games are strictly an ornamental fowl.
Origin: Old English Games are the modern-day descendants of the ancient fighting cocks. They are associated with England, but their heritage is almost worldwide and they have changed little in shape or appearance in more than 1,000 years.
Characteristics: A small, tightly feathered bird, Old English Games are very hardy, extremely active, and very noisy. Old English have figured in the development of many other breeds. The mature cocks should be dubbed (have the comb and wattles removed) with a characteristic cut. This is in keeping with their heritage. Old English hens usually show broodiness but are so small and aggressive as well as defensive that they are not always the best choice as mothers. Old English are capable of considerable flight and may revert to a feral (wild) state in some areas. They are the domestic breed most like the old jungle fowl in appearance.

Modern Games

Varieties: Black Breasted Red, Brown Red, Golden Duckwing, Silver Duckwing, Birchen, Red Pyle, Black, White.
Standard weights: Cock, 6 pounds; hen, 4½ pounds; cockerel, 5 pounds; pullet, 4 pounds.
Skin color: White.
Eggshell color: White or light tint.
Use: Strictly an ornamental fowl.
Origin: Modern Games were developed in Great Britain.
Characteristics: A tightly feathered bird with long legs and neck, which give it a tall, slender appearance. The males of the Modern Games should have their combs and wattles removed to enhance their long, slim shape. The feathers of Modern Games should be short, hard, and held very close to their bodies. They do not stand cold weather well because of their short feathers and need plenty of exercise to maintain muscle tone.

Orientals

Malays

Varieties: Black Breasted Red.
Standard weights: Cock, 9 pounds; hen, 7 pounds; cockerel, 7 pounds; pullet, 5 pounds.
Skin color: Yellow.
Eggshell color: Brown.
Use: Strictly an ornamental fowl.
Origin: A very old breed coming from Asia, they have changed little in modern times.
Characteristics: Maylays are very tall and appear bold and perhaps cruel due to their projecting eyebrows. They are closely feathered with short feathers and carry their bodies inclined upward with tail low or drooping. They are rugged and have a reputation for vigor and long life. They require exercise to maintain muscle tone and hardness of feather. Most hens will go broody but are not a good choice because their long legs do not fit easily in a nest.

Eggs from A to Z

Exquisitely simple, yet enormously complex, the egg is one of nature's marvels. Within this section are facts and figures, definitions and diagrams, graphs and even a few giggles—all related to various aspects of the egg. From air cell to yolk with such diverse topics as games and mythology, cooking tips and nutrient content tucked in between, the information is arranged alphabetically by subject for ease of reference. We hope it adds to your understanding and enjoyment of the incredible edible egg.

Nutrient Density of the Egg

Percentage of Reference Daily Intake (RDI)*
Provided by One Large Egg

Vitamin A	6%
Thiamin	2%
Riboflavin	15%
Calcium	3%
Iron	4%
Vitamin D	6%
Vitamin E	3%
Vitamin B_6	4%
Folic Acid	6%
Vitamin B_{12}	8%
Sodium	3%
Potassium	2%
Phosphorus	9%
Magnesium	1%
Zinc	4%
Biotin	3%
Pantothenic Acid	6%

*Based on a 2,000-calorie diet. You may need more or less depending on your calorie needs.

Angel Food Cake

A white cake, tall and light in texture, leavened only by beaten egg whites. Before the invention of the egg beater, making this heavenly delight required a deep platter, a whisk, and a very strong arm for whipping the egg whites. The electric mixer has simplified the process. (When you make this great cake you'll have leftover egg yolks, so look to *Leftover Egg Parts* for ideas on using them.)

Avidin

A protein found in small amounts (about .05 percent) in egg albumen. Avidin is inactivated by heat. *—see Biotin*

Baked Egg

—see Cooking Methods, baked

Beverages

Many nutritious beverages can be made with eggs. A nog, for example, is a well-known beverage made from eggs and milk. *—see Eggnog, Raw Egg*

Biological Value

A measurement of protein quality expressing the rate of efficiency with which protein is used for growth. Egg contains the highest quality food protein known. It is so nearly perfect, in fact, that egg protein is often the standard by which all other proteins are judged. Based on the essential amino acids it provides, egg protein is second only to mother's milk for human nutrition. On a scale with 100 representing top efficiency, these are the biological values of proteins in several foods.* *—see Nutrient, Protein*

Whole egg	93.7
Milk	84.5
Fish	76.0
Beef	74.3
Soybeans	72.8
Rice, polished	64.0
Wheat, whole	64.0
Corn	60.0
Beans, dry	58.0

*Food and Agriculture Organization of the United Nations. *The Amino Acid Content of Foods and Biological Data on Proteins*, Nutritional Study #24. Rome (1970). UNIPUB, Inc., 4611 - F Assembly Drive, Lanham, MD 20706

Biotin

One of the B vitamins which plays an important role in cell metabolism and the utilization of fats, proteins, and carbohydrates. Biotin is present in many foods including egg yolk and is synthesized by the body.

Avidin, one of the egg proteins, can combine with biotin and make it unavailable. However, a human would have to eat 24 raw egg whites a day for biotin to be inhibited by avidin. Heat inactivates the avidin and most eggs are served cooked. *—see Avidin*

Blood Spots

Also called meat spots. Occasionally found on an egg yolk. Contrary to popular opinion, these tiny spots do not indicate a fertilized egg. Rather, they are caused by the rupture of a blood vessel on the yolk surface during formation of the egg or by a similar accident in the wall of the oviduct. Less than 1 percent of all eggs produced have blood spots.

Mass candling methods reveal most eggs with blood spots and those eggs are removed but, even with electronic spotters, it is impossible to catch all of them. As an egg ages, the yolk

Grade A: A Grade A egg covers a relatively small area. The yolk is round and upstanding. The thick white is large in proportion to the thin white and stands fairly well around the yolk.

Grade B: A Grade B egg spreads out more. The yolk is flattened and there is about as much (or more) thin white as thick white.

Buying

Look for shells that are clean and whole. Cracked eggs are always removed from production lines but some may be broken in handling. Do not use an egg if it is cracked or leaking.

Important factors in maintaining egg quality are proper handling and refrigeration. Eggs lose quality very rapidly at room temperature, so buy them only from refrigerated cases, get them home quickly, and refrigerate them immediately. At temperatures of 35 to 45 °F (3 to 7 °C), eggs will maintain high quality for several weeks.

Eggs are marketed according to grade and size standards established by the USDA or by state departments of agriculture. The USDA shield on the egg carton means that the eggs have been federally inspected.

Some egg packers may follow state standards which meet or exceed USDA standards. Some states may have state seal programs which indicate that the eggs are produced within that state and are subject to continuing state quality checks. All eggs sold at the retail level must meet the standards for Grade B or better.

Size and grade are two entirely different factors bearing no relationship to one another. Grade is determined by the interior and exterior quality of the egg at the time the egg is packed. Size is determined by the average weight per dozen.

Grades: Grades are called AA, A, and B. There is no difference in nutritive value between the different grades.

Because production and marketing methods have become very efficient, eggs move so rapidly from laying house to market that you will find very little difference in quality between Grades AA and A. Although grade B eggs are just as wholesome to eat, they rate lower in appearance when broken out. Almost no Grade B's find their way to the retail supermarket. Some go to institutional egg users such as bakeries or foodservice operations, but most go to egg breakers for use in egg products. *—see Breakers, Breakout, Egg Products*

Sizes: Egg sizes are Jumbo, Extra Large, Large, Medium, Small, and Peewee. Medium, Large, and Extra Large are the sizes most commonly available. Sizes are classified according to minimum net weight expressed in ounces per dozen.

Egg Size	*Oz. Per Dozen*
Jumbo	30
Extra Large	27
Large	24
Medium	21
Small	18
Peewee	15

(To substitute one size egg for another in recipes, see *Size Equivalents.*)

Which Size to Buy: Although most of the eggs sold in supermarkets are Large, there are occasionally specials on other sizes, and it helps to have a chart to find which size is the best buy. Refer to the chart on page 108.

To compare the price of Large eggs to the price of Medium eggs for example, run your finger down the columns to the figures closest to the prices per dozen for Large and Medium eggs. Then, go across to the price per pound for each size. The one selling for the lower price per pound is the better buy. Always compare the same grade of eggs for an accurate price comparison.*—see Grading, Size Equivalents*

Calcium

One Large egg provides 3 percent of the Reference Daily Intake (RDI) for calcium, most of which is contained in the yolk. Calcium's major role is in building and maintaining bones and teeth. It is also essential for many other body functions related to the blood, nerves, and muscles. The eggshell is composed largely of calcium carbonate (about 94 percent) and contains about 2 grams of calcium. It also contains small percentages of magnesium carbonate and calcium phosphate. *—see Nutrient, Reference Daily Intakes (RDIs), Shell*

Calories

The calorie count for eggs varies with size. Here is the calorie score for one egg in different sizes. *—see Nutrient, Reference Daily Intakes (RDIs)*

Egg Size	*Calories*
Medium	66
Large	75
Extra Large	84
Jumbo	94

Candling

The step in grading that lets the egg grader look inside the egg without breaking it to judge its quality. Long ago this was done by holding the egg up before a candle. Some hand- candling, using electric equipment, of course, is still used for spot-checking or for training egg graders, but today most eggs pass on rollers over high-intensity lights which make the interior of the egg visible. The eggs are rotated so all parts can be seen. The candler checks the size of the air cell and the distinctness of the yolk outline. Imperfections such as blood spots show up in candling. Very large packing plants may also use electronic blood detectors. *—see Air Cell, Blood Spots, Grading*

Carton Dates

Egg cartons from USDA-inspected plants must display a Julian date, the date the eggs were packed. Although not required, they may also carry an expiration date beyond which the eggs should not be sold. In USDA-inspected plants, this date cannot exceed 30 days after the pack date. It may be less through choice of the packer or quantity purchaser such as your local supermarket chain. Plants not under USDA inspection are governed by laws of their states. *—see Expiration Date, Julian Dates*

Cephalin

A phospholipid found in tissues, especially brain and nerve tissues. One Large egg contains .230 gram of cephalin. *—see Nutrient*

Chalaza

Ropy strands of egg white which anchor the yolk in place in the center of the thick white. They are neither imperfections nor beginning embryos.

The more prominent the chalazae, the fresher the egg. Chalazae do not interfere with the cooking or beating of the white and need not be removed, although some cooks like to strain them from stirred custard. *—see Composition*

Cholesterol

One Large egg contains 213 milligrams cholesterol. Cholesterol is a fat-like substance found in every living cell in the body. It is made in necessary amounts by the body and is stored in the body. It is especially concentrated in the liver, kidney, adrenal glands, and brain. Cholesterol is required for the structure of cell walls, must be available for the body to produce vitamin D, is essential to the production of digestive juices, insulates nerve fibers, and is the basic building block for many hormones. In other words, cholesterol is essential for life.

White: Egg albumen in raw eggs is opalescent and does not appear white until it is beaten or cooked. A yellow or greenish cast in raw white may indicate the presence of riboflavin. Cloudiness of the raw white is due to the presence of carbon dioxide which has not had time to escape through the shell and thus indicates a very fresh egg.

On very rare occasions, a hard-cooked egg white may darken to a caramel shade due to a high amount of iron in the cooking water or to a carbonylamine-type reaction. Using fresh eggs and cooling them quickly after cooking helps to prevent this darkening.

Yolk: Yolk color depends on the diet of the hen. If she gets plenty of yellow-orange plant pigments known as xanthophylls, they will be deposited in the yolk. Hens fed mashes containing yellow corn and alfalfa meal lay eggs with medium-yellow yolks, while those eating wheat or barley yield lighter-colored yolks. A colorless diet, such as white cornmeal, produces almost colorless yolks. Natural yellow-orange substances such as marigold petals may be added to light-colored feeds to enhance yolk color. Artificial color additives are not permitted. Gold or lemon-colored yolks are preferred by most buyers in this country. Yolk pigments are relatively stable and are not lost or changed in cooking.

Sometimes there is a greenish ring around hard-cooked egg yolks. It is the result of sulfur and iron compounds in the egg reacting at the surface of the yolk. It may occur when eggs are overcooked or when there is a high amount of iron in the cooking water. Although the color may be a bit unappealing, the eggs are still wholesome and nutritious and their flavor is unaffected. Greenish yolks can best be avoided by using the proper cooking time and temperature and by rapidly cooling the cooked eggs. *—see Cooking Methods, hard-cooked*

Occasionally several concentric green rings may be seen in hard-cooked egg yolks. A yolk develops within the hen in rings. Iron in the hen's feed or water as the rings are formed may cause this coloring.

Sometimes a large batch of scrambled eggs may turn green. Although not pretty, the color change is harmless. It is due to a chemical change brought on by heat and occurs when eggs are cooked at too high a temperature, held for too long, or both. Using stainless steel equipment and low cooking temperature, cooking in small batches, and serving as soon as possible after cooking will help to prevent this. If it is necessary to hold scrambled eggs for a short time before serving, it helps to avoid direct heat. Place a pan of hot water between the pan of eggs and the heat source.

Composition

Shell

- Outer covering of egg, composed largely of calcium carbonate
- May be white or brown depending on breed of chicken
- Color does not effect egg quality, flavor, cooking characteristics, nutritive value, or shell thickness

Yolk

- Yellow portion of egg
- Color varies with feed of the hen, but doesn't indicate nutritive content
- Major source of egg vitamins, minerals, and fat and about half of the protein
- Germinal Disc

that the copper in the bowl reacts with the conalbumin of the egg whites much like cream of tartar to stabilize the egg white foam. A stainless steel or glass bowl with the addition of cream of tartar works just as well and is much less expensive.

Plastic and wooden bowls are not suitable for beating egg whites because they tend to absorb fat. Any film or residue will keep the whites from forming a stable foam.

Size and shape of bowls are important. Use the bowl size, large or small, specified in a recipe when using an electric stand mixer. A deep bowl with enough room for expansion is best for a rotary beater or portable electric mixer. For hand whipping with a balloon whisk, the bowl should be rounded at the bottom, at least 10 inches across the top and 5 or 6 inches deep.

Cooking Equipment Especially for Eggs

Egg cooking can be as simple as you want it to be. If you enjoy fancying up things a bit, there are several pieces of equipment and specialty gadgets you may find interesting.

Coddler: A small cup made of porcelain, heat-proof glass, or pottery with a screw-on top. An egg is broken into the cup, the top screwed on, and the cup submerged in simmering water until the egg is cooked. The egg is eaten directly from the coddler.

Cooker: An electric appliance which steam-cooks eggs in the shell. Most egg-cookers also have inserts or cups for steam-poaching. Some also have a flat insert for cooking omelets, fried eggs, or scrambled eggs.

Crepe Pan: A shallow, slope-sided skillet, 6 to 8 inches in diameter. These range from inexpensive, lightweight pans to sophisticated electric models, some of which cook the crepes on what appears to be the outside of the pan. Crepes can be made in almost any small, shallow pan with sloping sides. A small omelet pan will do a nice double-duty job.

Cup: A small container designed to hold a soft-cooked egg upright in its shell for table service.

Custard Cups: Small, deep, individual bowl-shaped dishes designed for oven use. They are useful for cooking or serving other foods as well as custards.

Omelet Pan: A shallow, slope-sided skillet, usually 7 to 10 inches in diameter. A double omelet pan consists of 2 shallow rectangular or semicircular pans attached by hinges. Each pan has a handle. Some purists insist that an omelet pan should be well seasoned, never washed with detergent, and used only for omelets. More practical cooks insist that a slope-sided pan with a nonstick coating is fine for omelets and for sauteeing, frying, and other purposes.

Piercer: A sharp-pointed tool for gently pricking a very small hole in the large end of an eggshell before hard-cooking. A clean, preferably sterilized, thumbtack, pin, or needle can also be used for piercing. Piercing may allow some air to escape and some water to seep into the egg during cooking which may make peeling easier. Piercing also often produces hairline cracks in the shell.

Poacher: A rack that holds one-egg-sized cups over simmering water, or a small colander-like form that holds an egg as it poaches in simmering water.

Cooked in the shell (eggs in their shells cooked in water): Place eggs in single layer in a saucepan and add enough water to cover at least 1 inch above eggs. Cover and quickly bring just to boiling. Turn off heat. If necessary, remove the pan from the burner to prevent further boiling. Let the eggs stand, covered, in the hot water, the proper amount of time.

Hard-cooked: Let stand in hot water about 15 minutes for Large eggs. (Adjust the time up or down by about 3 minutes for each size larger or smaller.) To help prevent a dark surface on the yolks, immediately run cold water over the eggs or place them in ice water until completely cooled. (Unfortunately, it is almost impossible to cook eggs to this stage at altitudes above 10,000 feet.) —*see Peeling*

Soft-cooked: Let stand in hot water about 4 to 5 minutes, depending on desired doneness. Immediately run cold water over the eggs or place them in ice water until cool enough to handle. To serve out of the shell, break the shell through the middle with a knife. With a teaspoon, scoop the egg out of each shell half into a serving dish. To serve in an egg cup, place the egg in the cup small-end down, slice off the large end of the egg with a knife or egg scissors, and eat from the shell with a spoon.

Fried (cooked in a small amount of fat in a pan): In a 7- to 8-inch omelet pan or skillet over medium-high heat, heat 1 to 2 tablespoons butter until just hot enough to sizzle a drop of water. (If you use a very large pan, more butter will be needed.) Break and slip two eggs into the pan. Immediately reduce the heat to low. Cook slowly until whites are completely set and yolks begin to thicken but are not hard, covering with lid, spooning butter over the eggs to baste them, or turning the eggs to cook both sides.

Steam-basted variation (a lower-fat version of fried eggs): Use just enough butter to grease a 7- to 8-inch omelet pan or skillet or substitute a light coating of vegetable pan spray and/or a nonstick pan. Over medium-high heat, heat the butter or the coated pan until just hot enough to sizzle a drop of water. Break and slip the eggs into the pan. Immediately reduce the heat to low. Cook until the edges turn white, about 1 minute. Add about 1 teaspoon water for each two eggs. (Decrease the proportion slightly for each additional egg being fried.) Cover the pan tightly to hold in steam. Cook until the whites are completely set and the yolks begin to thicken but are not hard.

Poached (eggs cooked out of the shell in hot water, milk, broth or other liquid): In a saucepan or deep omelet pan, bring 1 to 3 inches of water or other liquid to boiling. Reduce the heat to keep the water gently simmering. Break cold eggs, one at a time, into a custard cup or saucer or break several into a bowl. Holding the dish close to the water's surface, slip the eggs, one by one, into the water. Cook until the whites are completely set and the yolks begin to thicken but are not hard, about 3 to 5 minutes. With a slotted spoon, lift out the eggs. Drain them in a spoon or on paper towels and trim any rough edges, if desired.

Scrambled (yolks and whites beaten together before cooking in a greased pan): For each serving, beat together two eggs, 2 tablespoons milk, and salt and pepper to taste until blended. In a 7- to 8-inch omelet pan or skillet over medium heat, heat 2 teaspoons butter until just hot enough to sizzle a drop of water. Pour in the egg mixture. As the mixture begins to set, gently draw an inverted pancake turner completely across the bottom and sides of the pan, forming large soft curds. Continue until the eggs are thickened and no visible liquid egg remains. Do not stir constantly.

Add cream of tartar: Egg whites beat to greater volume than most other foods including whipping cream, but the air beaten into them can be lost quite easily. A stabilizing agent such as cream of tartar is added to the whites to make the foam more stable. Lemon juice works much the same way. *—see Cream of Tartar*

Add sugar, 1 to 2 tablespoons at a time: When making meringues and some cakes, sugar is slowly added to beaten egg whites. This serves to increase the stability of the foam. Sugar, however, can retard the foaming of the whites and must be added slowly so as not to decrease the volume. Beat the whites until foamy, then slowly beat in the sugar. *—see Meringue*

Stiff but not dry: Beat whites with a mixer, beater, or whisk just until they no longer slip when the bowl is tilted. (A blender or food processor will not aerate them properly.) If egg whites are underbeaten, the finished product may be heavier and less puffy than desired. If egg whites are overbeaten, they may form clumps which are difficult to blend into other foods in the mixture and the finished product may lack volume.

Stiff peaks form: Stiff but not dry.

Soft peaks or piles softly: Whites that have been beaten until high in volume but not beaten to the stiff peak stage. When beater is lifted, peaks will form and curl over slightly.

Gently folded: When combining beaten egg whites with other heavier mixtures, handle carefully so that the air beaten into the whites is not lost. It's best to pour the heavier mixture onto the beaten egg whites. Then gradually combine the ingredients with a downward stroke into the bowl, across, up and over the mixture motion, using a spoon or rubber spatula. Come up through the center of the mixture about every three strokes and rotate the bowl as you are folding. Fold just until there are no streaks remaining in the mixture. Don't stir because this will force air out of the egg whites. If you have a stand mixer, put the mixing bowl on the turntable for easier turning as you fold.

Copper Bowl

—see Cooking Equipment, bowls

Cream of Tartar

An acid ingredient which stabilizes beaten egg whites. As a rule of thumb, use 1/8 teaspoon cream of tartar per egg white or 1 teaspoon per cup of egg whites. For meringues, use 1/8 teaspoon cream of tartar for each two egg whites. *—see Cooking Terms*

Cream Puff

A light, but rich, hollow pastry puff which may be filled with a sweet filling for dessert or with a savory one such as chicken salad for a main dish.

Called choux pastry after the French word for cabbage, cream puffs do come out of the oven looking like little cabbages.

A high proportion of egg is necessary to form the structure of the cream puff. The egg yolk helps to emulsify the fat.

Crepe

A light, thin, egg-rich pancake. The word is French, but the crepe is so versatile that you'll find it in many other languages. It's a Russian blini, a Jewish blintz, a Chinese egg roll, a Greek krep, or a Hungarian palascinta. Depending on the filling, it can be an appetizer, a main dish, or a dessert. Crepe batter should be the consistency of heavy cream. Letting it rest for an hour or

¼ teaspoon salt
3 cups milk, heated until very hot
Ground nutmeg or cinnamon, optional

In medium bowl, beat together eggs, sugar, vanilla, and salt until well blended. Stir in milk. Place six (6-ounce) custard cups or 1½-quart casserole in large baking pan. Pour egg mixture into custard cups. Sprinkle with nutmeg, if desired. Place pan on rack in preheated 350 °F oven. Pour very hot water into pan to within ½ inch of top of custards. (The water bath, also called a *bain marie*, promotes even cooking.) Bake until knife inserted near center comes out clean, about 25 to 30 minutes for custard cups or about 35 to 40 minutes for casserole. (Time bake carefully. Too long a baking time will curdle the custard. Too short a time will prevent the custard from setting.) Remove promptly from hot water. Cool on wire rack about 5 to 10 minutes. Serve warm or chilled.

Daily Reference Values (DRVs)

A new term similar to RDIs for food components not covered by RDIs. Some DRVs are based on reference calorie intakes of 2,000 (average needed by postmenopausal women, women who exercise moderately, teenage girls, and sedentary men) and 2,500 calories (adequate for young men) and others on dietary recommendations suggested by some health and nutrition groups. Daily Reference Values are intended to serve as a yardstick for food comparisons, not as a strict dietary prescription. Based on your own calorie intake and activity level, your needs may be more or less than the DRVs. There is no DRV for sugars. Other DRVs are:

- *Calorie Intake:* 2,000*; 2,500 calories,
- *Total Fat:* No more than 30 percent of total calories (less than 65; 80 grams),
- *Saturated Fat:* No more than 10 percent of total calories (less than 20; 25 grams),
- *Unsaturated Fat***:* No more than 20 percent of total calories (less than 40; 50 grams),
- *Cholesterol:* Less than 300 milligrams,
- *Total Carbohydrate:* At least 55 percent of total calories (300; 375 grams),
- *Dietary Fiber:* 11.5 grams per 1,000 calories (25; 30 grams),
- *Protein***:* 10 percent of calories for those over 4 (50 grams; 63 grams),
- *Sodium:* Less than 2,400 milligrams, and
- *Potassium***:* 3,500 milligrams.

*Due to space limitations, food labels will show percentages of DRVs based on a 2,000-calorie diet. Some large labels may also show DRVs (but not percentages) for a 2,500-calorie diet.

**Listing percentages of DRVs for this nutrient on food labels is optional. *—see Daily Values (DVs), Reference Daily Intakes (RDIs), Recommended Dietary Allowances (RDAs), U.S. Recommended Daily Allowances (U.S. RDAs)*

Daily Values (DVs)

A term on new food labels that represents age-adjusted average levels of protein, fat, cholesterol, carbohydrate (including dietary fiber and sugars), vitamins, and minerals recommended for various groups of people of different ages and sexes as established by the National Academy of Sciences.

Since they are averages, many Daily Value figures are lower than the familiar U.S. RDAs which represented the highest values for each nutrient. In some cases, DVs are also lower due to new nutritional evidence considered by the National Academy. DVs serve as a yardstick for food comparisons and not as a strict dietary prescription. *—see Daily Reference Values (DRVs), Reference Daily Intakes (RDIs), Recommended Dietary Allowances (RDAs), U.S. Recommended Daily Allowances (U.S. RDAs)*

RATITES

A **ratite** is a family of large flightless birds with a flat, keeless breastbone. The keel bone of birds of flight is important for supporting pectoral flight (breast) muscles. Although ratites are flightless, they do have small wings which they use for cooling, for balance during running, and during courtship displays. Ratites are polyphyletic, which means they have descended from more than one evolutionary line. Some ratites can be kept as companion animals and pets. Recently in the United States they have been raised for their meat, feathers, and hide as well as other products such as oil. Ratites include such birds as rheas, kiwis, cassowaries, emus, and ostriches.

RHEAS

The rhea is from the order Rheiformes and the family Rheidae. There are two rhea species: the greater rhea (*Rhea americana*) and the lesser or Darwin's rhea (*Pterocnemia pennata*). Both are native to South America. The Rhea americana is the largest bird of the Americas, and because of this, it has several nicknames, including the "American ostrich" or the "Pampas ostrich." The greater rhea lives on the pampas (plains) of Brazil, Bolivia, and Argentina. The lesser rhea is found in the Andean foothills of Peru.

The rhea has three toes, and it does not have a hind toe (hallux). Rheas have long legs and necks, and they are 4 to 5 feet tall. Unlike the ostrich, the neck of the rhea is feathered. Rheas weigh 70 to 90 pounds. The male is larger than the female, and their diet consists primarily of roots, seeds, insects, lizards, and some small mammals. The male has a harem of 6 females, and each female lays about 15 to 18 eggs. In the United States, they lay eggs from late spring until fall. The male does the incubation of the eggs, which are laid on the ground in a nest called a scrape. Incubation lasts 30 to 43 days and the male continues to tend to the chicks until they are 4 to 5 months of age. The rhea is raised for its meat, feathers, and hide.

KIWIS

The kiwi is from the order Apterygiformes and the family Apterygidae. There are three species of kiwi: the little spotted kiwi (*Apteryx oweni*), the great spotted kiwi (*Apteryx haasti*), and the brown or common kiwi (*Apteryx australis*). The kiwi is the smallest ratite and is a nocturnal bird. The kiwi is the national bird of New Zealand and is now a protected species there.

They inhabit dense forests, wetlands, swamps, and moist forested areas. Hunting and the introduction of mammals from outside New Zealand has devastated the population.

The kiwi is sometimes called the "woodcock ostrich" because it has a long, slender, curved bill with nostrils at the tip which aid in their well-developed sense of smell. They use their excellent sense of smell along with their toes, which have tough claws, for excavating earthworms (their primary diet) and other small invertebrates at night. Because they are nocturnal, they have poor eyesight but a well-developed sense of hearing. They spend much of the day underground in burrows which are lined with twigs, grass, and feathers. The kiwi has hair-like feathers, and very small wings hidden beneath these feathers, which create a sleek, contoured appearance. The kiwi is only 15 inches high, weighs anywhere from 2 to 10 pounds, and has no tail.

The kiwi lays the largest egg in relation to body size. The egg weighs 1 pound (454 grams), which is approximately 10 percent of its body weight. The female lays one or two eggs between July and February in New Zealand; in this country, they lay eggs from late fall to spring. They have both a right and left functional ovary, unlike other birds which have only a left functional ovary. The incubation is 75 to 78 days and is done by the male. When the chicks hatch, they are not fed for 6 to 12 days. Chicks are feathered at hatch and are not covered by down. The birds do not breed until the age of 5 or 6. Since kiwis are protected, they are not raised commercially.

CASSOWARIES

The cassowary belongs to the order Causuariiformes and the family Casuariidae. They are native to New Guinea and Australia. There are three different species of cassowaries. The "double wattled" cassowary is 6 feet tall and is found primarily in New Guinea and the rain forest of northeast Australia. The "single-wattle" cassowary is 5 feet tall and can be found in the coastal swamps of New Guinea, while the "dwarf" cassowary, which is only 3½ feet tall, is found in the mountain forests of New Guinea.

Ostriches have been raised commercially in South Africa since 1850. The United States had a commercial ostrich industry based on the feathers until 1930, but the Great Depression and changes in fashion resulted in its demise. Recently, there has been a renewed interest in the commercial ostrich industry. Ostriches are now being raised for their feathers, meat, and hide. Ostriches are processed at 12 to 14 months of age and produce about 80 pounds of boneless meat, 15 square feet of hide, and about 3 pounds of feathers. The meat is red in color, low in fat and cholesterol, and high in protein.

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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 spermatazoa. 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 spermatazoon, and many are called spermatazoa. 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 spermatazoa 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 spermatazoa are present when a yolk enters the infundibulum, a single spermatazoon 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 spermatazoon 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.

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%

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 spermatazoon, 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 "extra-embryonic" 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