

Unit B: Understanding Animal Body Systems

Lesson 9: Understanding Fertilization and Embryonic Development

Student Learning Objectives: Instruction in this lesson should result in students achieving the following objectives:

1. Identify the internal structures of an egg and the functions associated with each structure.
2. Describe the sequence of embryo development and laying of an egg.
3. Describe how fertilization takes place in an egg.

Recommended Teaching Time: 4 hours

List of Resources: The following resources may be useful in teaching this lesson:

Blakely, James, Bade, David H., *The Science of Animal Husbandry: Fourth Edition*. Reston, Virginia: Reston Publishing Company, Inc., 1985. (Textbook, Chapter 29)

Lee, Jasper S., et al. *Plants and Animals: Biology and Production*. Upper Saddle River, NJ: Pearson Prentice Hall Interstate, 2004 (Textbook, Chapter 27).

www.chickscope.Beckman.uiuc.edu

www.thirteen.org/nttidb/lessons/cb/chickcb.html

www.woodrow.org/teachers/bi/1993/chick.html

List of Equipment, Tools, Supplies, and Facilities:

Writing surface

PowerPoint Projector

PowerPoint Slides

Transparency Masters

Copies of student lab sheets

Copies of technical supplement

Uncooked egg

Materials for LS: 9-1

Terms: The following terms are presented in this lesson (shown in bold italics): **PowerPoint Slide 2**.

- Air Cell
- Albumen
- Blastoderm
- Chalazae
- Ectoderm
- Entoderm
- Fertile

Germinal Disc
Infertile
Parthenogenesis
Shell
Shell Membranes
Yolk

Interest Approach: Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situations. A possible approach is included here.

Place an uncooked egg in vinegar for 2-3 days prior to introducing this less. The acetic acid will dissolve the egg shell and expose the egg membrane. Students can carefully handle the egg and observe the environment of a developing chick. Break open another uncooked egg in a shallow dish and allow students to speculate on the various egg structures and the functions of these structures. A closer examination of the egg will be conducted in this lesson.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Identify the internal structures of an egg and the functions associated with each structure.

Anticipated Problem: What are the internal structures of an egg and what are the functions associated with each structure?

Ask students how many of them have poultry of some kind at home. How many students eat eggs on a regular basis? Have students try to name some common parts of an egg like the shell and yolk. Then, ask if they know some more specific parts. Use this discussion to lead into Objective 1.

- I. The embryonic development of a chicken begins soon after the fertilization of an egg cell by sperm.

Have diagrams of an egg available for students or have them sketch the diagram on their own paper. Then, have students label each of the specific parts as you discuss them.

A. Internal structures are as follows:

1. **Shell**—The shell serves to protect the growing embryo, provide calcium, and allow for oxygen to pass into the shell and carbon dioxide to escape.
2. **Shell Membranes**—Two membranes surround the yolk and albumen and provide protection against bacterial invasion as well as water retention.
3. **Air Cell**—An air space between the two shell membranes, usually at the larger end of the egg. The air cell will enlarge as the egg matures. The air cell is formed when the cooling egg pulls the two shell membranes apart. **PowerPoint Slide 3.**

4. **Chalazae**—Two white cords that attach to each end of the yolk to support and keep the yolk centered in the albumen. The chalazae serve as a rotating axis to keep the germ cell on the top side of the yolk.
 5. **Yolk**—The round yellow mass which provides nutrients for the developing embryo.
 6. **Germinal Disc**—Found in every egg, embryo development will take place in the germinal disc if the egg is fertilized.
 7. **Albumen**—The albumen is the liquid commonly called egg white. The function of the albumen is to cushion the egg and provide water and protein during development.
- PowerPoint Slide 4.**

Use TM: 9-1 and PowerPoint Slide 5 to help students with labeling the internal structures of an egg. Ask students questions about each of the structures. For example, what would happen to the yolk if the air sac deflated? What would happen to the yolk if the chalazae were not in place? Also, use LS 9-1 Teacher Supplement and Student Worksheet as a lab for this objective.

Objective 2: Describe the sequence of embryo development and laying of an egg.

Anticipated Problem: What is the process of embryo development and laying of an egg? Have each student guess how long they think it takes for an egg to develop internally. Then, have students guess how long they think it takes different types of eggs to hatch. Lead a discussion on the length of embryo development in poultry versus the embryo development length in other animals.

- II. Chicken eggs that are capable of developing into a chick are known as **fertile**. An **infertile** egg is one that will not develop a chick or hatch.
 - A. A chick embryo will develop in 21 days under the proper conditions for incubation.
 1. Organ systems begin forming in the first few days of embryonic development.
 2. Organ systems appear in the following order:
 - a. Nervous System
 - b. Blood and Circulatory System
 - c. Skeletal and Muscular System
 - d. Digestive System **PowerPoint Slide 6.**
 3. Structure and development in a fertile egg is dependent on time, temperature, and humidity of incubation.
 - B. A normal hen requires slightly over 24 hours to completely form an egg.
 - C. **Parthenogenesis** is an inherited trait that causes the development of unfertilized eggs. About 1% of parthenogenetic embryos will develop and hatch. Parthenogenesis is more common in turkeys than in chickens. **PowerPoint Slide 7.**
 - D. After fertilization, cell division proceeds as the embryo begins to develop.
 1. The blastoderm spreads over the yolk and differentiates into the ectoderm layer and the entoderm layer.

- a. The **ectoderm** layer forms the skin, feathers, beak, claws, nervous system, lens and retina of the eye, and the lining of the mouth and vent.
 - b. The **entoderm** layer forms the linings of the digestive tract and the respiratory and secretory organs.
2. Soon after incubation begins, a third layer, the mesoderm, begins to form the bones, muscles, blood, reproductive, and excretory organs. **PowerPoint Slide 8.**

If possible, have students candle eggs to determine if the eggs have been fertilized. To learn more about candling or if candling is not available, check the following website and have students do this activity on the computer. <http://shilala.homestead.com/candling.html>

Also, if possible, have students do LS: 9-2 to better understand chick development. Also use PowerPoint Slide 9 and TM: 9-2.

Objective 3: Describe how fertilization takes place in an egg.

Anticipated Problem: How does the process of fertilization take place in a chicken egg?

Ask student to recall how and where fertilization takes place in mammals from the previous lessons covered. Does it happen internally or externally? Where does the embryo develop? Do they think it will be the same or different for poultry?

- III. Fertilization of a chicken egg takes place when the sperm unites with the egg, forming the **blastoderm**.
- A. The sperm will fertilize the egg in the funnel of the oviduct of the hen, called the infundibulum.
 1. The yolk will only stay in the funnel of the reproductive tract for 15 minutes, then moving on to other organs that will create the egg.
 2. Fertilized eggs move through the reproductive system of the hen in exactly the same way as unfertilized eggs.
 - B. Within 30 minutes of laying an egg, another yolk will be released by the ovary of the hen to begin another egg cycle. **PowerPoint Slide 10.**

Have student trace the path of the egg through the reproductive tract of the hen in TM: 9-3. Also, recall the questions asked at the beginning of the objective and see if students would like to change their answers.

Review/Summary: The review and summary should be based on the three student objectives of this lesson. Have students discuss the internal structures and functions of the chicken egg while reviewing the lab sheets and transparency masters. Embryonic chick development can be reviewed by visiting a website and having students discuss the different stages of chick development.

Application: Application can occur as students produce animals in their own facilities or later in their careers. In some cases, school laboratories may have animals where students can apply information on animal reproduction. Use the PowerPoint, lab sheets, and technical supplement to apply the information.

Evaluation: Evaluation should be based on mastery of the objectives by the students. This can occur during instruction, review, or later as students apply the information. The attached sample test can also be used.

Answers to Sample Test:

Part One: Matching

1. d
2. g
3. e
4. b
5. h
6. f
7. a
8. c

Part Two: Completion

1. 21
2. entoderm
3. Sperm

Part Three: Multiple Choice

1. d
2. a
3. a
4. d
5. c
6. a
7. b

Part Four: Short Answer

1. Parthenogenesis is the development and hatching of an unfertilized egg. About 1% of eggs are parthenogenetic and many that hatch will die soon after birth. This process is more commonly found in turkeys than in chickens.
2. Humidity, temperature, and length of time of incubation will all have an effect on hatching.

Sample Test: 9-1

Name _____

FERTILIZATION AND EMBRYO DEVELOPMENT

Part One: Matching

Instructions: Match the term with the correct response.

- | | | |
|------------------|-------------|--------------------|
| a. shell | d. fertile | g. parthenogenesis |
| b. albumen | e. chalazae | h. air cell |
| c. germinal disk | f. ectoderm | |

- _____1. an egg that will develop and hatch
- _____2. development of an unfertilized egg
- _____3. cords that support the yolk and developing embryo
- _____4. clear liquid portion inside the egg
- _____5. created by cooling of egg and membrane constriction
- _____6. forms beak, claws, nervous system, and skin
- _____7. outer protective covering of egg
- _____8. development of embryo takes place here if fertilized

Part Two: Completion

Instructions: Provide the word or words to complete the following statements.

- 1. The development of a chick from fertilization to hatch normally takes _____ days.
- 2. The linings of the digestive and respiratory tracts are formed by the _____ layer.
- 3. Fertilization is the union of _____ and egg.

Part Three: Multiple Choice

Instructions: Circle the letter of the correct answer.

- _____1. Albumen serves what function for the developing embryo?
- a. feather development
 - b. gas exchange
 - c. organ development
 - d. cushion for embryo
- _____2. Immediately after fertilization, the blastoderm differentiates into what two layers?
- a. ectoderm and entoderm
 - b. ectoderm and mesoderm
 - c. epithelium and mesoderm
 - d. epithelium and entoderm
- _____3 What structure provides nutrients for the developing embryo?
- a. yolk
 - b. chalazae
 - c. shell
 - d. germinal disk
- _____4 What is not a characteristic of parthenogenesis?
- a. heritable trait
 - b. common in turkeys
 - c. development of unfertilized eggs
 - d. most embryos survive and hatch
- _____5 Eggshells are made up mostly of what two components?
- a. potassium and amino acids
 - b. calcium carbonate and carbohydrates
 - c. protein and calcium carbonate
 - d. vitamins and protein
- _____6 Growth rate and egg production in chickens can be improved by
- a. environmental controls
 - b. artificial insemination
 - c. natural incubation
 - d. lower protein feeds
- _____7 When candling the egg, what is the space between the two shell membranes at the large end of the egg called?
- a.
 - b.
 - c.
 - d.

CHICKEN EGG INTERNAL STRUCTURES

ALBUMEN

Outer Thin

Firm

Inner Thin

Chalaziferous

Chalazae

SHELL

Cuticle

Spongy (Calcareous) Layer

Mammillary Layer

YOLK

Germinal Disc

Latebra

Light Yolk Layer

Dark Yolk Layer

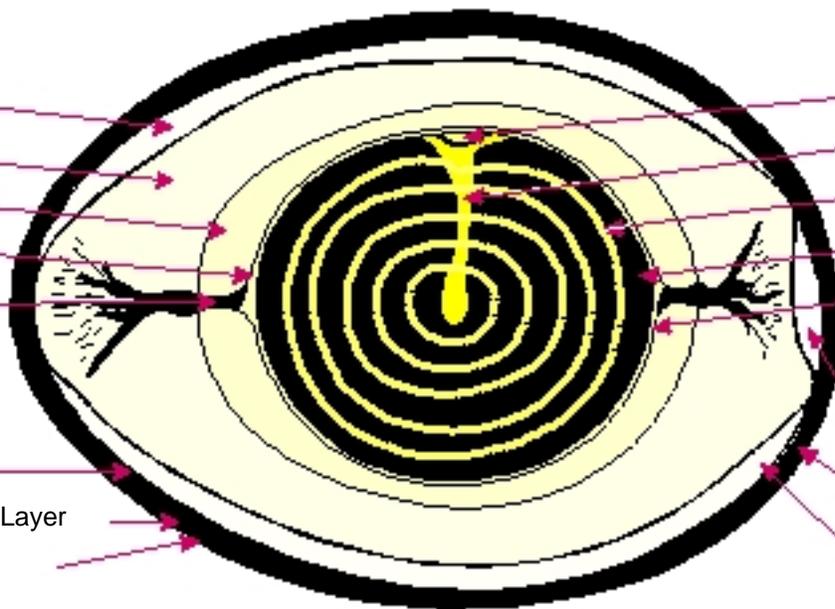
Yolk Membrane

MEMBRANE

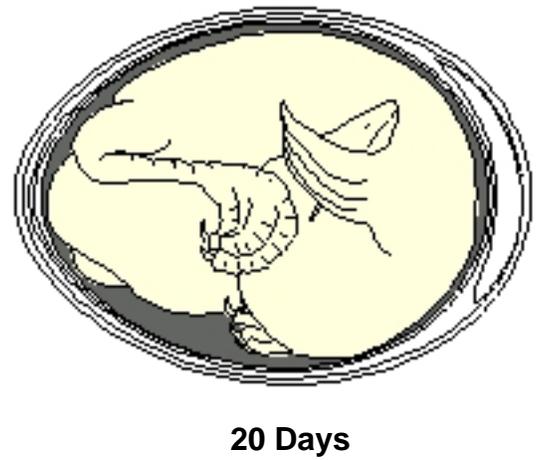
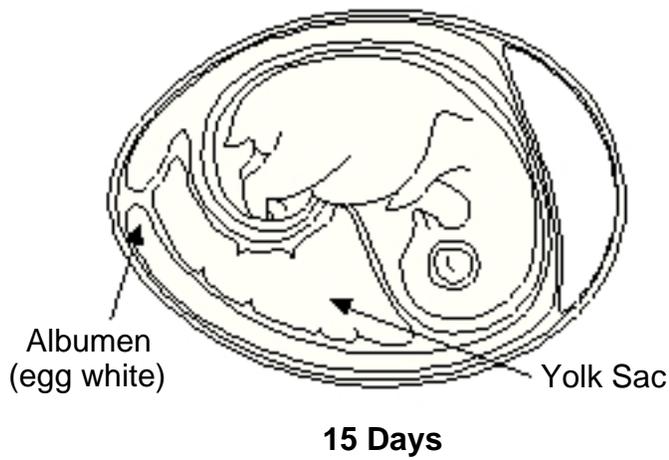
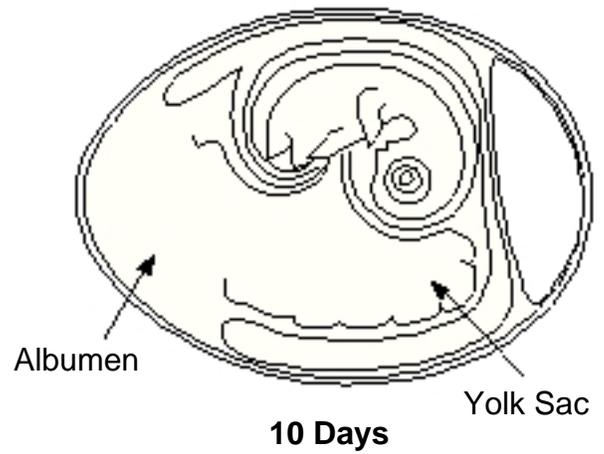
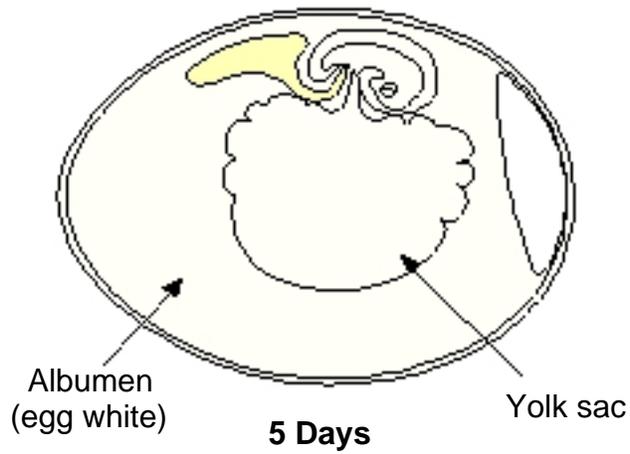
Air Cell

Outer Shell Membrane

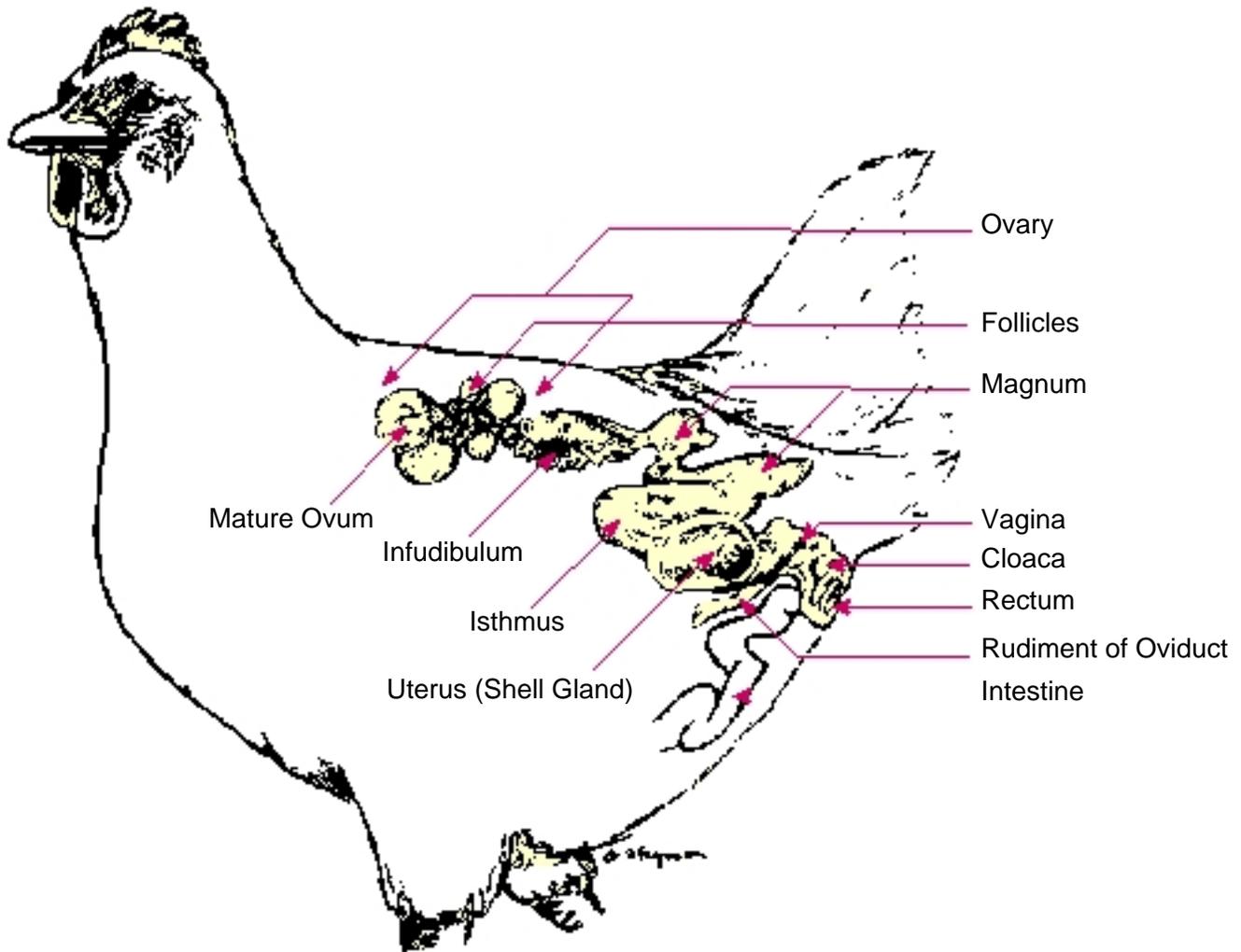
Inner Shell Membrane



DEVELOPMENTAL STAGES OF CHICK



REPRODUCTIVE TRACT OF HEN



FERTILIZATION AND EMBRYO DEVELOPMENT

Agricultural Applications and Practices

Today, poultry production is one of the most highly specialized and integrated industries in agriculture. Poultry producers, processors, and marketing specialists, often for the same company, coordinate efforts to produce ample supplies of eggs and meat at reasonable prices. Modern poultry farms are becoming larger and fewer in numbers. Growth rate and egg production will be increased through biotechnology and improved environmental control.

In many countries producers give special attention to the development of the chick during incubation so that hatching results in a vigorous live chick. The efficiency and productivity of the poultry industry is due in large part to improved breeding programs and equipment for artificial incubation. Modern hatcheries operate year-round with capacities of over one million birds. Although the process of chick incubation still takes 21 days, it is about the only factor in the industry which has not changed over time.

Science Connections—Questions for Investigation

1. What function does the egg shell provide for the embryo?
2. What does the egg white and yolk provide for a developing embryo?
3. How does structural development progress during incubation?
4. What is parthenogenesis?

Research Problem

How do chicks develop from fertilized eggs?

Purpose

The purpose of this experiment is to investigate the structure of an egg, determine the functions of internal parts, and relate the function to embryonic development of poultry. Through this laboratory exercise and related discussion, students will be able to:

1. identify the internal structures of an egg;
2. associate function with each internal structure;
3. describe the sequence of ovulation and laying an egg;
4. describe how fertilization takes place in the egg.

Materials

- 1 chicken egg per group
- hand lens
- metric ruler
- sharp scissors
- forceps
- petri dish/ plates
- paper towels
- dissecting microscope (optional)

Helpful Hints

Use extra large eggs to show more clearly the internal structures of the egg.

Procedure

Give each student or group of students a copy of each worksheet to perform the activities.

Anticipated Findings

Students should be able to visually identify structures in the unfertilized chicken egg in (TM: 9-1).

Students should understand the 21 days of chick development (TM: 9-2).

Data Summary and Analysis

Students should draw the internal structures of an egg and submit the drawing with their laboratory report.

Laboratory reports should contain answers to the following questions:

1. What function does the shell provide for the developing embryo?
2. What is the function of the chalazae?
3. What does albumen provide for the developing embryo? The egg yolk?
4. How does a human embryo obtain nutrients for development? How is this similar and different than the chick egg?

Ideas for Additional Experiments

1. Hard boil an egg, remove shell, and cut into slices. Compare the structure of the egg with one that is uncooked.
2. Obtain prepared slides of developing chick embryos. Identify and describe the different stages of development.

FERTILIZATION AND EMBRYO DEVELOPMENT

Procedure

1. Place an egg on its side in a petri dish. A crumpled paper towel in the bottom of the dish will prevent the egg from rolling.
2. Draw an oval on the egg approximately 3 cm × 4 cm.
3. Use the sharp pointed scissors to carefully cut the oval making shallow cuts just beneath the egg shell. Remove the oval.
4. Examine the outside of the egg shell with a hand lens.
5. Examine the internal structures with a hand lens or a dissecting microscope.
6. Locate the two white cord-like chalazae. Use the forceps to pull on one cord and observe what happens.
7. Measure the small, white round dot on the surface of the yolk (germinal disc).
8. Locate the air space between the shell membrane and the shell.
9. Make a drawing of the egg you are examining and label the following parts: albumen, air space, chalazae, germinal disc, shell, shell membrane, and yolk.
10. Break the egg into the dish, being careful not to break the yolk. Observe the albumen and the yolk.
11. Dispose of the egg according to teacher instructions.
12. Include your drawing with a laboratory report that answers the following questions:
 - a. What function does the shell provide for the developing embryo?
 - b. What is the function of the chalazae?
 - c. What does albumen provide for the developing embryo? The egg yolk?
 - d. How does a human embryo obtain nutrients for development? How is this similar and different than the chick egg?

CHICK DEVELOPMENT BY DAY

Research Problem

What happens on the 21 days of incubation?

Directions

Fill in the major events of development for a chick embryo.

Day 5:

Day 10:

Day 15:

Day 20:

Day 21:

FERTILIZATION AND EMBRYO DEVELOPMENT

1. What function does the egg shell provide for the embryo?

The shell protects the embryo from injury, permits gas exchange, and provides calcium for the developing embryo. Eggs shells, made up mostly of calcium carbonate and protein, have approximately 6000-8000 microscopic pores which allow for oxygen to pass into the egg and carbon dioxide to escape. The shell also allows moisture to evaporate from the egg contents. This causes the air sac to enlarge.

2. What does the egg white and yolk provide for a developing embryo?

The egg white cushions the embryo and provides water and protein for development. The egg yolk contains food for the developing embryo. The yolk, however, is largely unused by the embryo and is drawn into the body of the chick on the 19th day, just before it hatches. It is highly nourishing and provides proteins, fats, vitamins, minerals, and water for the first several hours of the chick's life. The yolk is gradually used up during the first 10 days of the chick's life. This is quite different from the nourishment of human young. Babies get their "food" from their mother via the umbilical cord.

3. How does structural development progress during incubation?

Chicken eggs have an incubation period of 21 days. Structural development begins so after fertilization and continues throughout incubation. During the first few days of development, the organ systems begin to form. The first system to develop is the nervous system, followed by the blood and circulatory systems, the skeletal and muscular systems, and the digestive system.

The fertilized egg forms in two layers. This process is called gastrulation. The two layers include the ectoderm and the entoderm. The ectoderm is the first layer and forms the skin, feathers, beak, claws, nervous system, lens and retina of the eye, and the lining of the mouth and vent. The entoderm is the second layer which produces the linings of the digestive tract and the respiratory and organs of secretion. Soon after incubation begins, a third layer, the mesoderm, originates. The mesoderm forms the bones, muscles, blood, and the reproductive and excretory organs.

4. What is parthenogenesis?

Parthenogenesis is the development of an unfertilized egg. This occur in both chickens and turkeys; however, it is more common in turkeys. It is a heritable trait. Most parthenogenetic embryos die early in development, but nearly 1% of these embryos complete development and hatch.

