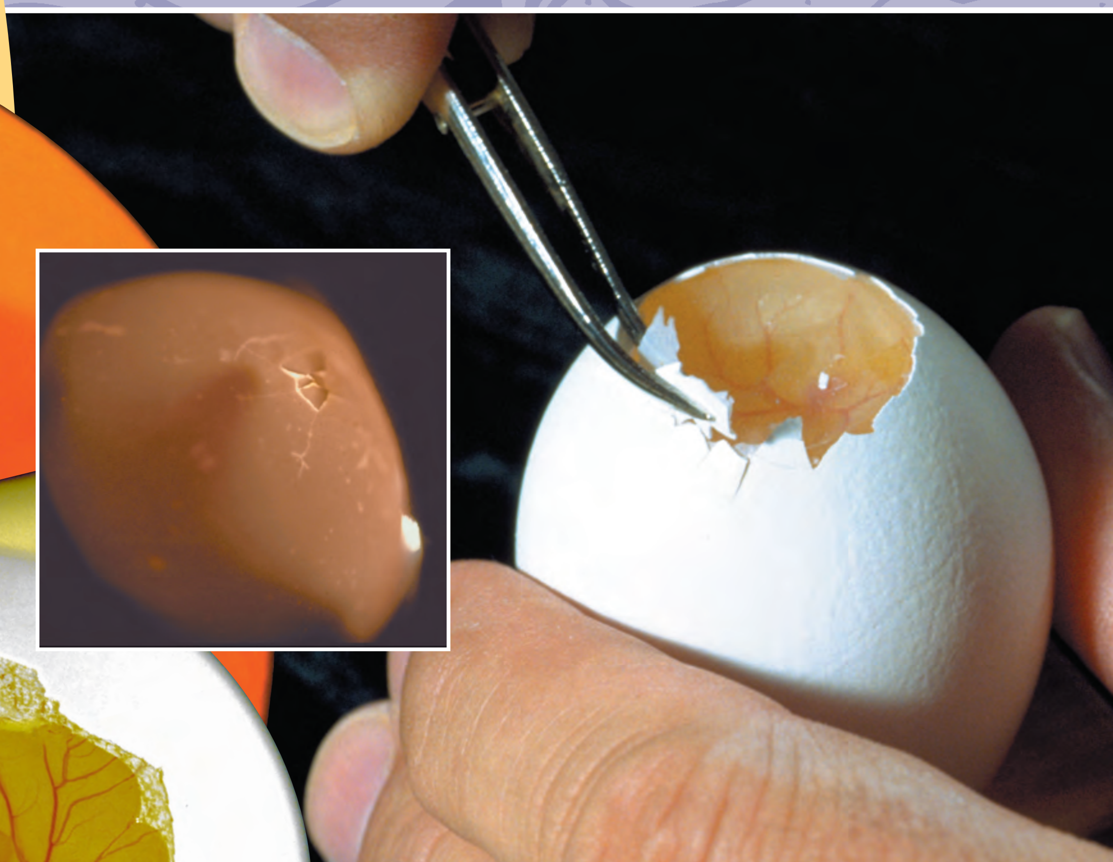
National 4-H Curriculum
BU-07596

Embryology IN THE CLASSROOM

Experiments in Poultry Science



Helper's Guide
Advanced
Grades 6-8

REVIEWED & RECOMMENDED
National 4-H Curriculum

Dear Educator,

Embryology: Experiments in Poultry Science is designed to provide you with background information and exciting experiential activities dealing with life science for use in your classroom. Each activity is designed to be grade-level appropriate and has been correlated to U.S. National Science Education Standards.

Children have a natural sense of curiosity about living things in the world around them. Building on this curiosity, students can develop an understanding of biology through direct experience with living things, their life cycles and their habitats. This curriculum was developed with your students in mind. Many believe students learn best by interacting with the world – listening, observing, experimenting and applying their knowledge to real-world situations. Each activity within this curriculum follows these steps in the experiential learning model.

An additional goal of this curriculum is to help students develop life skills. Life skills help an individual live a productive and satisfying life. Within this curriculum your students will have the opportunity to develop life skills related to science processes, teamwork, keeping records, and planning and organizing.

We hope that *Embryology: Experiments in Poultry Science* is an enjoyable experience for both you and your students as well as a beneficial unit in your life science curriculum. Here are a few quotes from students who worked with our pilot:

The best part of learning about chickens and embryos was...

> *"I enjoyed everything we did, because we got to learn by doing, not just reading."*
>
> *"Enjoyed the whole project because we actually did something instead of just looking at pictures."*
>
> *"This was wonderful because it did not seem like school, even though we were learning the whole time."*
>
> *"It was fun the whole time."*
>
> *"The best part was seeing how the chick hatched. It was cool how it pecked its way around the shell."*
>
> *"The best thing was when they hatched. It was really exciting. I also liked learning about hatching eggs. I learned so much that I didn't know before."*

Acknowledgements

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Experiments in Poultry Science

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Embryology and national science standards

A classroom unit in embryology will help you meet the following national science standards:

In order to conduct a scientific inquiry, you must be able to

- Identify questions that can be answered through scientific investigations.
- Design and conduct a scientific investigation.
- Use appropriate tools and techniques to gather, analyze and interpret data.
- Develop descriptions, explanations, predictions and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

Structure and function in living systems

Living systems at all levels of organization demonstrate the complementary nature of structure and function.

All organisms are composed of cells—the fundamental unit of life.

Cells carry on many functions needed to sustain life.

Specialized cells perform specialized functions in multicellular organisms.

Reproduction and heredity

Reproduction is a characteristic of all living systems.

In many species, females produce eggs and males produce sperm. An egg and sperm unite to reproduce.

Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.

The characteristics of an organism can be described in terms of a combination of traits.

Regulation and behavior

All organisms must be able to obtain and use resources, grow, reproduce and maintain stable internal conditions while living in a constantly changing external environment.

Behavior is one response by an organism to an internal or environmental stimulus.

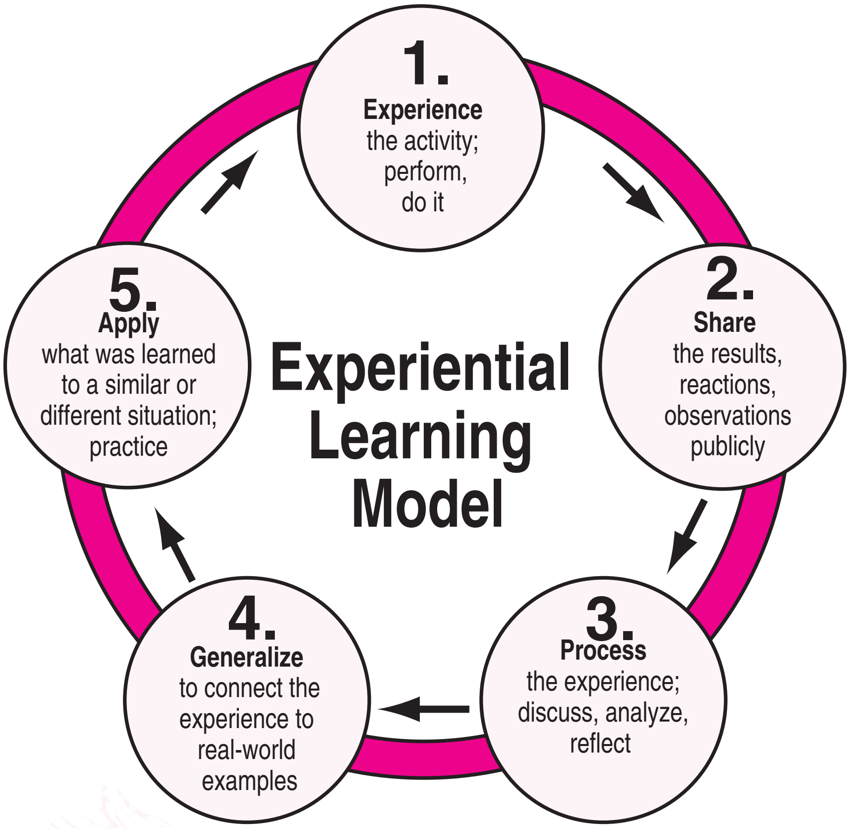
An organism's behavior evolves through adaptation to its environment.

To succeed in technological design, you must

- Identify appropriate problems for technological design.
- Design a solution or product.
- Implement a proposed design.
- Evaluate completed technological designs or products.
- Communicate the process of technological design.

Experiential learning model

Experiential learning means having students do hands-on activities, reflect on the meaning and apply what they learned. This process helps ensure that the students learn actively and make knowledge a part of their world. It also helps students answer questions such as "Why should I learn this?" and "Now that I know this, what do I do next?"



Pfeiffer and Jones' Model

Pfeiffer, J.W., & Jones, J.E., "Reference Guide to Handbooks and Annuals" © 1983 John Wiley & Sons, Inc. Reprinted with permission of John Wiley & Sons, Inc.

Providing an experience alone does not create "experiential learning." The activity comes first. The learning comes from the thoughts and ideas created as a result of the experience. This is a "learn by doing" or experiential process. Addressing each step in the process assures a purposeful plan to obtain a specific goal.

Experience
The model begins with experience, action. This immediately focuses the attention on the learner rather than the teacher. This requires active co-operation from the learner, coupled with guidance from the teacher to help maintain the learner's curiosity. Teaching becomes a cooperative enterprise.

Share
Sharing is simply asking the group or individuals, What did you do? What happened? What did it feel like to do (whatever)? This step should generate lots of information to lead to the process step.

Process
The questions and discussion now become more focused on what was most important about the experience. Common themes that emerge from the sharing session are explored further. Often the key teaching points related to the subject matter are discussed.

Generalize
In this step the experience is related to a real-world example. This step helps the student to answer the questions, Why should I learn this? What did the experience mean to me personally? To my everyday life? Subject matter and life skill development can be discussed in this step. For example, if you hope that the activity helps students develop teamwork skills, then questions about teamwork would be appropriate.

Apply
This step helps the student answer the question, Now that I know this, what do I do next? Can students express what they learned? Can they use what they learned? Can the student actually apply the learning to a new situation?

Life skill development

A skill is a learned ability to do something well. Life skills are abilities individuals can learn that will help them to be successful in living a productive and satisfying life. The following is a list of skills that students will develop through experiencing the activities within this curriculum. Also included is a set of criteria that can act as indicators to determine if the life skill is being developed.

Planning and organizing—A method for doing something that has been thought out ahead of time; how the parts can be put together.

Indicator:
Student can develop a part of a plan.

Keeping records—Recording selected useful information, usually focused for a specific purpose.

Indicator:
Student is able to categorize information and select useful information.

Teamwork—Work done by two or more people, each doing parts of the whole task. Teamwork involves communicating effectively, identifying and agreeing on a common task, dividing a task by identifying contributions by each person, accepting responsibility for one's part of the task, working together to complete the task and sharing accomplishment.

Indicator:
Understands roles as essential and enjoys working together with others of similar interests/abilities.

Science skill

These skills represent the scientific thinking and process skills that are essential to scientific inquiry. An inquiry based science classroom uses and encourages the use of these skills in science activities.

Observing—Generating reasonable questions about the world based on observation.

Examples:
Seeing, hearing, tasting, smelling and feeling.

Comparing and measuring—Using simple measurement tools to provide consistency in an investigation.

Examples:
Sensory observations, weight, quantity, quality, temperature and capacity.

Relating—Developing solutions to unfamiliar problems through reasoning, observation and experimentation.

Examples:
Asking questions, making a hypothesis, understanding relationships, designing and conducting simple investigations, and identifying the control and variables in an investigation.

Applying—Using sources of information to help solve problems.

Examples:
Applying science learning to resolve current issues, inventing a new technology, using math and forming additional questions.

Poultry incubation

The Activities	Embryology Skill	Life Skill	Science Skill
Doing the right thing Page 14	Hatching, observing and experimenting with embryos; caring for the developing egg and chicks	Decision-making	Communicating
Give eggs a break Page 16	Identifying parts of an egg and their functions	Contributing to a group effort	Comparing and measuring
Warming up with eggs Page 19	Incubation of fertile eggs	Planning and organizing	Observing
Developing an experiment Page 21	Collecting data about embryos and chicks	Learning to learn	Observing and measuring
Building an eggs-ray viewer Page 23	Preparing a candler	Planning and organizing	Comparing and measuring
Life is not always what it seems Page 25	Observing the embryo's development and learning its parts	Record keeping	Observing
Building the brooder Page 29	Preparing a brooder	Planning and organizing	Comparing and measuring
Who rules the roost? Page 31	Understanding chicken behavior (pecking order) for better care and management	Planning and organizing	Observing
Eggonomics Page 32	Learning how the poultry industry works	Critical thinking	Applying

Planning and scheduling

Checklist

Planning is crucial to the success of an embryology project.
Use this section as a checklist to help you plan the project activities.
As you complete each part check it off so you know what has been finished.
Other important details to assist you with this project follow this checklist.

One to six months before you plan to start the project

- ☐ Plan the exact dates during which you wish to do this project.

  Dates of the embryology project:

  ________________ to __________________ .

- ☐ Before you order eggs, decide what you will do with the chicks that hatch. Contact a farmer, zoo or other animal caretakers who are equipped to properly care for the chicks.

  The chicks will be placed with

  ____.

- ☐ To insure egg availability, order the eggs at least one to three months in advance of the day you plan to set them.
- ☐ Secure an incubator at least a month before the start of the project and be sure it works properly.
- ☐ Read the lesson plan and secure any materials you will need at least a month before the project begins.

Starting the project

- ☐ Set up the incubator in a safe area and start running it 48 hours before eggs are to arrive.
- ☐ Prepare the students a few days before the project begins. Help them understand the principles of incubation and embryology. Discuss what the class wishes to accomplish and what role they will play in reaching the goals of the project. This includes preparing calendars and other project resources.
- ☐ If your class plans to incubate eggs, prepare the eggs for incubation.
- ☐ Turn the eggs three times daily.
- ☐ Keep water pans full at all times. Always add water that is warm to the touch.
- ☐ Keep daily records of all activities involving the eggs (i.e., turning, temperature, water added, candling, and other activities). These records are extremely helpful for trouble-shooting causes of poor hatches.
- ☐ Candle the eggs every three days to check progress.
- ☐ Stop turning eggs three days (after 18 days for chicken eggs) prior to expected hatch.
- ☐ Prepare brooder box at least two days prior to expected hatch.
- ☐ Remove the chicks from the incubator and place them in a warm brooder within two to six hours after they hatch.
- ☐ Remove and discard all remaining unhatched eggs 60 hours after the first chick hatches, then disconnect incubator power.
- ☐ Clean and disinfect the incubator as soon as the power is disconnected.
- ☐ Let the incubator dry. Then store it in a safe, cool and dry place.

Background for a successful project

Important procedures to consider

A. Plan the exact dates for your project. Many teachers use this material as a supplement to a specific curriculum like biology, human sexuality, human development or other related topics. It is extremely important that you understand that this is a continuous project for at least a 25-day period. Plan the project around holidays and testing periods. It is usually best to plan to set your eggs on a Tuesday. This allows you to prepare on Monday and insures that the chicks will not hatch on a weekend.

B. To prevent bacterial contamination, make sure that all students and teachers wash their hands after handling the eggs, raw egg products, incubated eggs, chicks and litter.

C. Before you order eggs, plan what you will do with the chicks that hatch. Contact a farmer, zoo or other animal caretakers who are equipped to care for the chicks properly. **NEVER** allow chicks to go home with students from your class. It is your responsibility to make sure that the chicks get a good home.

About the eggs

A. Obtaining fertile hatching eggs. Locating fertile eggs may present a problem, especially in an urban area. Most eggs sold in grocery stores are not fertile and cannot be used for incubation. Fertile eggs can usually be obtained from hatcheries or poultry breeding farms. Large hospitals may also be able to provide them. Contact your local Extension office for suggestions.

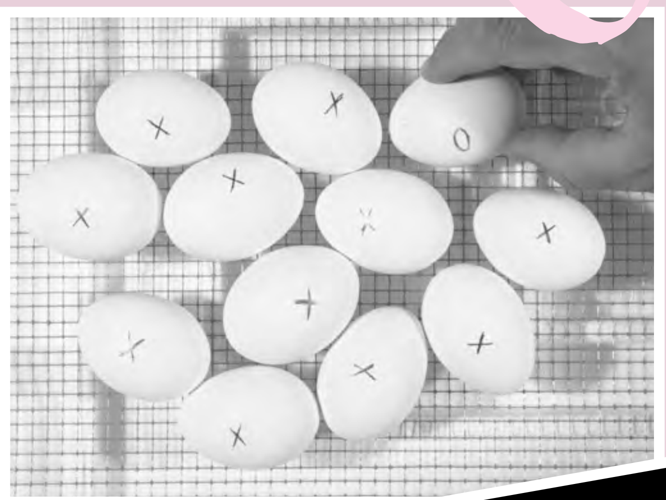
1. For a basic observation and hatching project, 12 eggs per incubator are adequate. If you are planning to do an experiment or activities, additional eggs may be required.
2. When you obtain fertile eggs from a source that does not routinely hatch its own eggs, you may want to test the eggs in an incubator to ensure that good fertility and hatchability can be obtained before you use the eggs as part of the class project. The presence of a male with a laying hen does not guarantee fertility or hatchability. You are also *strongly* encouraged to use chicken or coturnix quail eggs to hatch in the classroom. Duck, goose, pheasant and other species of fowl can be more difficult to hatch in classroom incubators. Duck and goose eggs often rot and may explode in the incubator.
3. When you have located a source of fertile eggs, pick them up yourself, if possible, rather than have them shipped or mailed. It is difficult for hatcheries, the postal service and transportation companies to properly handle small orders of eggs.

B. Caring for eggs prior to incubation. Timing, temperature and position are critical to safe storage.

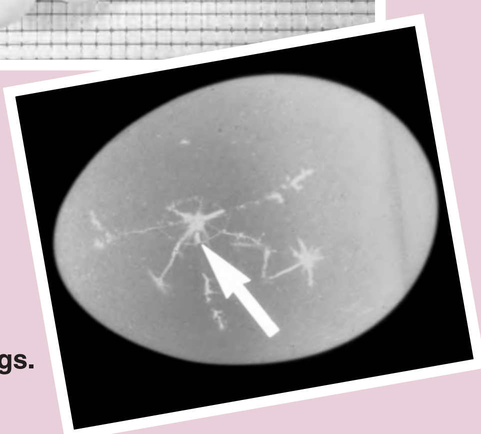
1. The eggs should be collected within four hours from when they were laid.
2. If it is necessary to store fertile eggs before setting, store small end down at a temperature between 50 and 65°F and at 70 percent humidity.
3. Never store eggs more than 10 days after the eggs are laid. Hatchability drops quickly if they are stored for more than 10 days.
4. Transport fertile eggs in a protective carton, small end down. Do not leave eggs in the sun or a hot car. In winter, don't let the eggs get below 35°F.
5. It is always best to set the fertile eggs in a heated incubator within 24 hours of obtaining them.

C. **Preparing the eggs for incubating.** Fertile eggs from a commercial hatchery are usually already presorted. However, it is usually wise to check your eggs before setting them.

1. Candle eggs prior to setting to check for cracked eggs, thin-shelled eggs and double-yolked eggs. Do not incubate these eggs since they usually do not hatch.
2. Do not wash the eggs unless necessary. The eggs have a natural protective coating that is removed by washing. Only wash eggs that are visibly dirty. Then wipe the egg clean with a wet cloth warmer (at least 10 degrees warmer) than the temperature on the eggs. Do not set eggs that are excessively dirty.
3. Bring fresh eggs to be placed in the incubator to room temperature two hours prior to setting.
4. Mark the eggs with "X" and "O" on opposite sides to aid in daily turning. Also, number the eggs on the top of the large end to aid in identification and record keeping during the project. When marking eggs always use a pencil or wax crayon. Do not use permanent or toxic ink pens or markers.
5. Eggs that are warmed to room temperature should be immediately placed in the incubator.



Setting eggs that are marked with X's and O's.



Do not set cracked eggs.

About the incubator and incubation

A. Secure an incubator and make sure it is in good working order. You may choose a new or used incubator.
   1. If buying a **new incubator**, order at least one month prior to the start of the project. Forced air incubators (with a fan to circulate the air) are best. Once the new incubator arrives, assemble if necessary and follow instructions for operation.
   2. **Used incubators** should be checked one month prior to the start of the project. Make sure your equipment is clean and working correctly. This will allow you time to order parts or a new incubator if necessary.

B. Turn the incubator on a couple of weeks before the project starts and run it for 48 hours to insure that everything is working properly. Once you know it is in proper working order, unplug and set in a safe area until a few days before the start of the project.

C. Inform the administration and maintenance staff that you are doing this project and ask them to tell you if the electricity needs to be shut off for any reason.

D. Proper incubator placement in the classroom helps avoid problems.
   1. Set up the incubator in a room that stays above 65°F.
   2. Make sure the electrical outlet that you are using will be "on" 24 hours a day. Some schools turn off entire sections of the school at night and on weekends.
   3. Place the incubator on a sturdy level surface.
   4. Place the incubator at least six inches away from the edge of the surface to avoid accidental bumps.
   5. Avoid high traffic areas, hot sunny windows, heating and cooling vents, drafty windows and doors.

E. Turn incubator on 36 to 48 hours prior to setting the eggs.
   1. Adjust the incubator so it holds the desired temperature. Follow manufacturer guidelines for adjusting the temperature. In still-air units (without fans) adjust the temperature to 101°F. In forced-air units (with fans), adjust the temperature to 100°F. Always adjust the thermostat so the heat source goes off when the temperature reaches the desired temperature and comes on when the temperature drops below the desired temperature.
   2. Use at least two thermometers to insure you are getting an accurate temperature reading.
   3. Check the temperature often. Improper temperature can result in a poor hatch and weak chicks.

During incubation

A. Turn the eggs three times daily. Stop turning eggs three days (after 18 days for chicken eggs) prior to expected hatch.

B. Keep water pans full at all times. Always add water that is warm to the touch. It is best to add the water when you open the incubator to turn the eggs.

C. Keep daily records of all activities involving the eggs (i.e., turning, temperature, water added, candling, and other activities). These records are extremely helpful for trouble-shooting causes of poor hatches.

D. Candle the eggs every three days to check progress.

E. Stop turning eggs three days (after 18 days for chicken eggs) prior to expected hatch.

F. Never help the chicks from the shell.

G. Remove the chicks from the incubator and place them in a warm brooder within two to six hours after they hatch. If your incubator has good levels of humidity the chicks may not dry in the incubator. They will dry once moved to the brooder.

H. Remove and discard all remaining unhatched eggs 60 hours after the first chick hatches, then disconnect incubator power.

I. Clean and disinfect the incubator as soon as the power is disconnected. Once the dirt has dried to the surface, it becomes difficult to remove.

J. Let the incubator dry. Then store it in a safe, cool and dry place.

Brooding the chicks

A. Make sure the brooder box is working 2 to 4 days prior to hatch.

B. Brooders should maintain a temperature of 92 to 95°F (taken at one inch above the floor level, the height of the chick's back) during the first week. If you keep the chick beyond the first week, decrease the temperature 5°F per week until room temperature is reached.

C. The brooder should have textured, absorbent litter on the floor. If the floor is slippery, the chicks can damage their legs. Pine or cedar shaving or textured paper towel work best in the classroom.

D. Feed 18 to 22 percent protein chicken starter food. This completely balanced ration can be obtained from any feed and garden store. The feed can be placed in jar lids, egg cartons, small tuna-sized cans or a commercial chick feeder.

E. Water should be available at all times. Use watering equipment that will not allow the chick to get into the water and drown. Commercially made water fountains for use with a quart jar work best. If you need to use a watering device that is not proven, it is recommended that you place clean marbles or gravel in the water so the chicks can drink between them but not get into the water and drown.

F. 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.

Turn egg three times daily until the 18th day.

The end result: A newly hatched chick.

The reproductive system and fertilization

The rooster

The male fowl has two testes along its back. These never descend into an external scrotum, as do those of other farm animals. A testis consists of a large number of very slender, convoluted ducts. The linings of these ducts give off sperm. The ducts eventually lead to the ductus deferens, a tube that conducts the sperm to a small papilla. Together, the two papilla serve as an intermittent organ. They are on the rear wall of the cloaca.

The rooster responds to light in the same way as the hen. Increasing day length causes the pituitary to release hormones. These, in turn, cause enlargement of the testes, androgen secretion and semen production, which stimulates mating behavior.

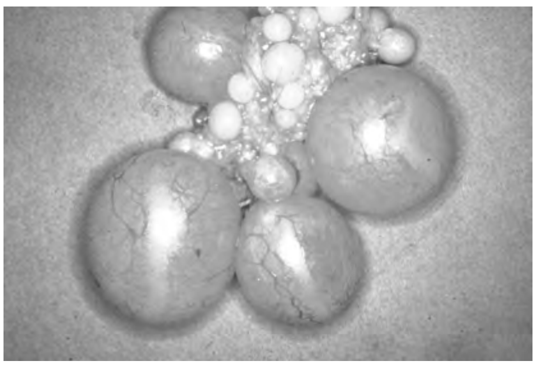


Figure 7 - Ovary

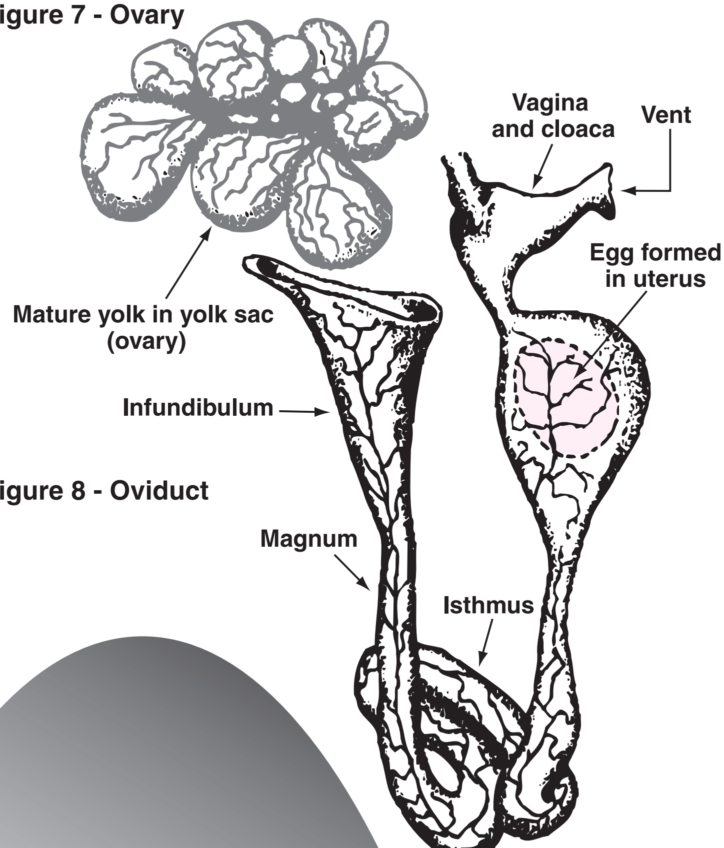


Figure 8 - Oviduct

The hen

The reproductive system of the female chicken is in two parts: the ovary and oviduct. Unlike most female animals, which have two functioning ovaries, the chicken usually has only one. The right ovary stops developing when the female chick hatches, but the left one continues to mature.

The ovary is a cluster of sacs attached to the hen's back about midway between the neck and the tail. It is fully formed when the chick hatches and contains several thousand tiny ova—each ovum within its own follicle. As the female reaches maturity, these ova develop a few at a time into yolks. **(Figure 7)**

The oviduct is a tube-like organ lying along the backbone between the ovary and the tail. In a mature hen, it is about 25 to 27 inches long. The yolk is completely formed in the ovary. When a yolk is fully developed, its follicle ruptures at the stigma line, releasing it from the ovary. It then enters the infundibulum, the entrance of the oviduct **(Figure 8)**.

The other parts of the egg are added to the yolk as it passes through the oviduct. The chalazae, albumen, shell membranes and shell then form around the yolk to make the complete egg, which is then laid. This complete cycle usually takes from 23 to 32 hours. About 20 minutes after the egg is laid, another yolk is released and the process repeats itself. Development takes place as follows:

Parts of oviduct	Length of part	Time there	Function of part
Infundibulum	2 in.	15 min.	Picks up yolk, egg fertilized
Magnum	13 in.	3 hr.	40–50% of white laid down, thick albumen
Isthmus	4 in.	1¼ hr.	10% albumen shell membrane laid down, shape of egg determined
Uterus	4.2 in.	20¾ hr.	40% of albumen, shell formed, pigment of cuticle laid down
Vagina and cloaca	4 in.	—	Egg passes through as it is laid

How eggs are fertilized

Each gender, the rooster and the hen, contributes something to the egg. The rooster provides sperm; the hen provides an ovum. When a rooster mates with a hen, it deposits sperm in the end of the oviduct. These sperm, containing male germ cells, travel the length of the oviduct and are stored in 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 sperm is present when a yolk enters the infundibulum, a single sperm penetrates the blastodisc, fertilizing it and causing it to become a blastoderm. Technically, the blastoderm is the true egg. Shortly after fertilization, the blastoderm begins to divide into two, four, eight 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. The joining of sperm and ovum is called fertilization. After fertilization, the egg can develop and become a chick.

The rooster must be present for an egg to be fertilized. Supermarket eggs are from hens that are raised without a rooster. Roosters are not necessary at farms where eggs are produced for people to consume. Eggs for incubation are grown at special farms called breeder farms where roosters are with the hens.

Development during incubation

As soon as the egg is heated and begins incubation, the cluster of cells in the blastoderm begins to multiply by successive divisions. The first cells formed are 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 or layer. 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 develop.

From the **ectoderm**, the skin, feathers, beak, claws, nervous system, lens and retina of the eye, linings of the mouth and vent develop. The **mesoderm** develops into the bone, muscle, blood, 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 new, complex structures. From the structures arise all the organs and tissues of the living chick.

Physiological processes within the egg

Many 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 being connected to the hen's body, nature has provided membranes outside the embryo's body to enable the embryo to use all parts of the egg for growth and development. These "extra-embryonic" membranes are the yolk sac, amnion, chorion and allantois.

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 food for the embryo. As embryonic development continues, the yolk sac is engulfed within the embryo and completely reabsorbed at hatching. At this time, enough nutritive material remains to feed the chick for up to three days.

The **amnion** is a transparent sac filled with colorless fluid that serves as a protective cushion during embryonic development. This amniotic fluid also permits the developing embryo to exercise. Specialized muscles developed in the amnion gently agitate the amniotic fluid. The movement keeps the growing parts free from one another, preventing adhesions and malformations.

The **chorion** contains the amnion and yolk sac. Initially, the chorion has no apparent function, but later the allantois fuses with it to form the choric-allantoic membrane. This enables the capillaries of the allantois to touch the shell membrane, allowing calcium reabsorption from the shell.

The **allantois** membrane has many functions. It:

- serves as an embryonic respiratory organ
- receives the excretions of the embryonic kidneys
- absorbs albumen, which serves as nutriment (protein) for the embryo
- 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. In fact, its closest portion remains within the embryo throughout the development.

Daily embryonic development

Before egg laying
- Fertilization.
- Division and growth of living cells.
- Segregation of cells into groups with special functions.

Between laying and incubation
- Very little growth; inactive stage of embryonic life.

During incubation
Day 1

Major developments visible under microscope:

18 hours — Appearance of alimentary tract.

19 hours — Beginning of brain crease.

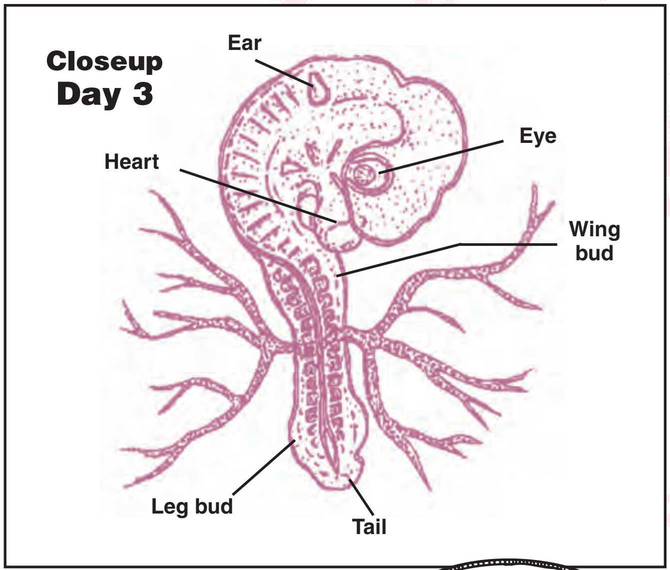
20 hours — Appearance of vertebral column.

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 2

24 hours — Embryo begins to turn on left side.

24 hours — Blood vessels appear in the yolk sac.

24 hours — 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 the heart, which starts to beat.

35 hours — Beginning of formation of ear pits.

36 hours — First sign of amnion.

46 hours — Formation of throat.

Day 3 (see figure)

Beginning of formation of beak, wings, legs and allantois.

Amnion completely surrounds embryo.

Day 4 (see figure)

Beginning of formation of tongue.

Embryo completely separates from yolk sac and turns on left side.

Allantois breaks through amnion.

Day 5

Proventriculus and gizzard formed.

Formulation of reproductive organs—sex division.

Day 6 (see figure)

Beak and egg tooth begin to form.

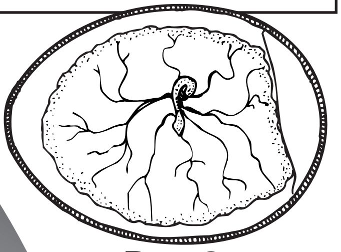
Main division of legs and wings.

Voluntary movement begins.

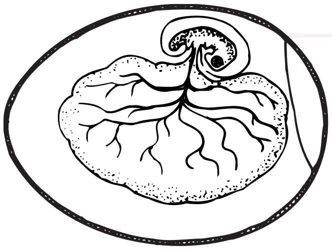
Day 7

Digits on legs and wings become visible.

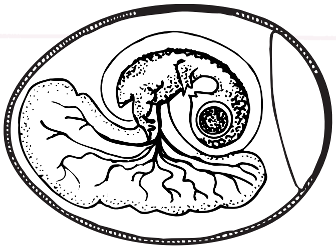
Abdomen becomes more prominent due to development of viscera.



Day 3



Day 6



Day 9

Day 8

Feathers begin to form.

Day 9 (see figure)

Embryo begins to look bird-like.

Mouth opening appears.

Day 10

Beak starts to harden.

Skin pores visible to naked eye.

Digits completely separated.

Day 11

Days 10 to 12 tend to run together. No different changes visible on these days.

Day 12 (see figure)

Toes fully formed.

Down feathers visible.

Day 13

Scales and claws become visible.

Body fairly well covered with feathers.

Day 14

Embryo turns its head toward blunt end of egg.

Day 15

Small intestines taken into body.

Day 16

Scales, claws and beak becoming firm and horny.

Embryo fully covered with feathers.

Albumen nearly gone and yolk increasingly important as nutrient.

Day 17

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

Day 18 (see figure)

Growth of embryo nearly complete.

Day 19

Yolk sac draws into body cavity through umbilicus.

Embryo occupies most of space within egg except air cell.

Day 20 (see figure)

Yolk sac completely draws into body cavity

Embryo becomes chick, breaks amnion and starts breathing air in air cell.

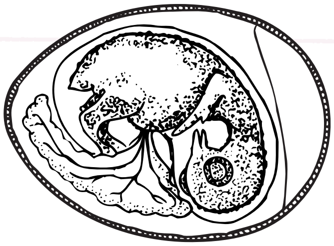
Allantois ceases to function and starts to dry up.

Day 21

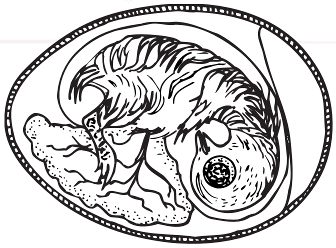
Chick hatches.

Although used only to break through the shell, the egg tooth serves its critical purpose well.

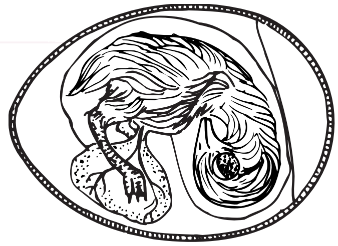
Coturnix (Japanese) quail	16–18 days
Chicken	21 days
Pheasants	24–26 days
Ducks	28 days
Geese	28 days
Guinea	28 days
Turkey	28 days
Swan	35 days
Muscovy duck	35 days
Ostrich	42 days



Day 12



Day 15



Day 18

Day 21

Doing the right thing

Embryology skill:
Hatching, observing and experimenting with embryos,
and caring for the developing egg and chicks

Life skill:
Decision-making

Science skill:
Communicating

School subjects supported:
Science

Preparation time:
10 minutes

Activity time:
50 minutes: 20 minutes for group to prepare, 20 minutes for debate, and 10 minutes for class discussion

What you need:
Access to resources from scientific, agricultural and animal rights groups including Animal Industry Foundation, People for the Ethical Treatment of Animals, Animal Welfare Information Center, Americans for Medical Progress, Animalrights.net, Foundation for Biomedical Research, National Animal Interest Alliance, National Association for Biomedical Research and American Association for Laboratory Animal Science

Introduction

Because this embryology curriculum involves the use and study of a living organism, there are certain decisions and responsibilities that the class should consider before actually doing all the activities. This activity will help the class make decisions that are best for your class situation.

Some decisions that your class may want to consider include:

1. Should the class incubate the eggs or do a project without incubating eggs?
2. How many eggs does the class need?
3. Should the class create shell windows, conduct experiments and study in-vitro development, which will require the sacrifice of a few embryos?

Get ready

What does the class hope to learn from this embryology in-classroom project? Be familiar with the teachers' guide and the individual projects contained within the material. Discuss the possibilities with the class.

You may also wish to pull together information from various sources discussing the pros and cons of experiments and using animals to study science. There are links to this information on the World Wide Web site (URL). Pull a cross-section of this information down off the Web and make it available for the students to read as part of this activity.

Do it

A. List the project objectives and some of the activities the class could conduct to accomplish them, such as incubating the eggs, shell windows, experiments and in-vitro development.

B. Select two of the activities for the class to discuss in more detail. The class might wish to select an ethical decision they deal with in their day to day life as well, i.e., lying, stealing, gossiping, or cheating.

C. Divide the class into six groups of at least three students each. This activity provides an opportunity to practice communication skills with real life situations. Ask each student to read background information on the topic and prepare for a debate of the pros and cons of these activities. They should take into consideration the decisions, consequences and responsibilities that must be made and undertaken for each activity. Ask them to compare the activity and possible alternatives. Give the students 20 minutes to assemble their arguments. This is not to be a debate but rather a time for sharing views and each group's side of the argument. This will allow the groups to find facts that support their side or become more understanding of the other groups' viewpoints. If you see that they are getting stuck on a strategy to use or need help clarifying their points, you will want to ask questions to help them think rather than giving them an answer.

D. The next day or the next class period ask the group to present its recommendation to the class. This recommendation should include but not be limited to the following points:

1. What benefits are there to doing the activity and to doing the alternative activity?
2. What decisions should the class make before the activity starts?
3. Are alternatives available for class members who are not comfortable with the class's decision?

   Ask the class to discuss the recommendation. Try to come to a consensus for each activity.

Talk it over

Share
- What factors did your group consider in making its decision?
- Where did you find information to help you make an informed decision?
- What decisions were the hardest? Why?
- How did you feel when the final decision by the group or class was different than the way you felt?

Process
- Why is it important to consider the ethical implications of doing these activities in a classroom setting?
- How did your group work through disagreements when trying to make a decision for the class?
- Why are ethics important to science and other professions?
- Why is it important to consider alternative ways of learning about embryology and other living things?

Generalize
- How has society benefited from research, studying embryos and chickens?
- What other ethical decisions have you made in your daily life?
- What type of ethical decisions do scientists, doctors and politicians have to make?
- Why do groups of individuals feel strongly about some issues?

Apply
- What did you learn about working in groups that may help you in the future?
- How might this exercise help you make ethical decisions in the future?
- Why is it important to consider the ethical implications of decisions you make in everyday life?

Break Out

- Consider having teams debate issues about this project or a current issue in society.
- Ask students to write a paper that presents both sides of an ethical issue facing society or their community.

Evaluate it

- ☐ Did the students think through their recommendations to the class?
- ☐ Did the students find reasonable alternatives to some activity?
- ☐ Did the students explain why they made the decisions they did?

Give eggs a break

Embryology skill:
Identifying parts of an egg and their functions

Life skill:
Contribution to a group effort

Science skill:
Comparing/measuring

School subjects supported:
Biology

Preparation time:
Twenty minutes

Activity time:
Class period

What you need:

- ☐ Grade AA, A and B eggs (You can create A and B grade eggs by keeping a few fresh eggs in the refrigerator for a week and two weeks or you can keep fresh eggs at room temperature for one to two weeks).
- ☐ scalpels
- ☐ a flat surface on which to place broken eggs
- ☐ an egg separator (optional)
- ☐ Copies of Student Activity Sheet "Parts of the Egg/Nutrition" (page 40)

Introduction

Ever wondered what an egg yolk is? Or why there is a stringy thing in the white of an egg? Or how a Grade AA egg is different from a Grade A egg?

There are many different parts in an egg. The condition of these parts determines the grade of an egg. This activity will help you understand what makes up an egg and how it is sized and graded.

Get ready

The success of this activity depends on the freshness of the eggs. Freshness is important because the higher the grade of the egg, the better the quality of the **albumen**. Purchase all eggs—especially Grade AA eggs—a day or two before the activity so you will have the freshest eggs possible. When buying eggs, allow several Grade AA eggs per group in case students damage their egg before they finish the activities.

Prepare a few eggs in vinegar before the class meets to do this lesson. To do this, place several eggs in a glass or bowl and completely immerse them in regular vinegar. Allow the eggs to soak in the vinegar solution for one to two days. The shell should dissolve completely. Once this has happened, you may carefully remove the eggs from the vinegar and place them in water until the class uses them.

Do it

Part 1—Identify the Parts of Eggs.

1. Divide the class into small teams of three to five students. Each team should have a plate, a non-fertile Grade AA egg, and a fertile egg.
2. Make sure that after handling the raw eggs, all students wash their hands to prevent possible bacterial contamination.
3. In this activity, teams identify parts of an egg using the definitions and identify which egg is fertile and which is not fertile. Allow time for the students to experiment with finding the structures and complete the Student Activity Sheet "Parts of the Egg Nutrition" on their own. Should they need help in locating specific structures, try to ask questions like:

   Where would you expect to find the inner thick albumen?

   What might its relationship to the yolk be?

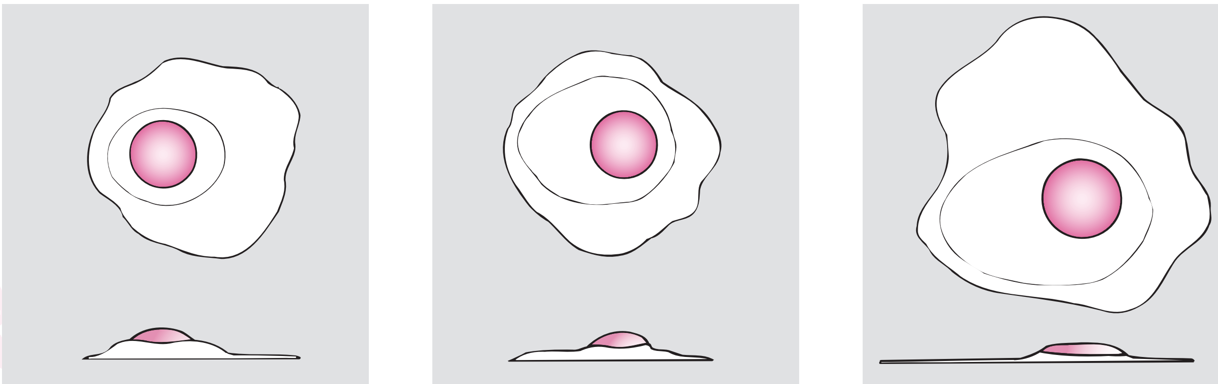
   How might you be able to separate the inner and outer albumen?

   Where would you find the air cell in the eggshell?

   Can you separate the inner and outer shell membrane?

   What is the purpose of each part for the developing embryo?

4. To help the students better see the inner thick albumen, use a scalpel to gently lift the thick albumen on the top of the yolk. Avoid puncturing the **vitelline membrane** surrounding the yolk. Also, have the teacher use a scalpel to cut the albumen. Cut from the inner thick albumen out toward the outer thin albumen. This should release the inner thin albumen.
5. Ask the students to separate the albumen from the yolk to better see the vitelline membrane. Do this by using an egg separator or by gently picking up the yolk with your fingers.
6. Finally, to see another view of the **inner** and **outer shell membranes**, allow the students to look at an egg that has been prepared in vinegar.



Grade AA **Grade A** **Grade B**

Part 2—Grade the Eggs.

As the eggs get older, some of their cooking properties also decline. This is one reason why we grade eggs. For instance, while Grade B eggs might be fine for scrambled eggs, you might want to use Grade AA eggs for meringue or baking because a fresh Grade AA egg will give the cake a fluffier texture. A Grade B egg, on the other hand, will cause the cake to come out flat.

In this section, teams differentiate between the grades of eggs. At first, give them no direction and see how they approach the problem. Some might draw a profile of the egg, while others may try to determine measurements. Encourage creativity and, if necessary, offer hints with questions like:

"What parameters could you look at?"

"How might you share what you observed so that other class members would know what you were talking about even if they were absent?"

Ask your students to follow these steps:

1. Label three dishes: 1, 2 and 3.

   In the first dish, break out a Grade AA egg. In the second dish, break out a Grade A egg. In the third dish, break out a Grade B egg.
2. Look at the three eggs, and note their differences.
3. Draw a top and side view of the eggs on your Student Activity Sheet "Parts of the Egg/Nutrition."
4. Compare a fertile and infertile egg.

FYI

Although you usually may think of an egg as being just a shell, yolk and white, it actually is more complex. There are many parts to an egg that most people do not notice because they are unaware of them. The quality of egg parts is examined closely when a United States Department of Agriculture grader decides whether an egg is Grade AA, A or B.

The nutritional quality of all three egg grades is the same. The grade becomes important when the appearance or reaction of the egg or food item matters. Grade AA eggs have very small air cells. When a Grade AA egg is broken out, the yolk sits up high and the white spreads very little. The chalaza also is easy to see in high-quality, fresh eggs.

The yolk in Grade A eggs stands up but not as high as in Grade AA eggs. Grade A eggs spread out more, but the thick white still is larger than the thin white. In Grade B eggs, the yolk is flattened and most of the white is thin and spreads easily from the yolk. The differences in the eggs' appearance come from differences in the proteins.

Talk it over

Share
- What parts of the egg were hard to see?
- What differences did you see between the fertile and infertile eggs?
- What differences were there between the various grades of eggs?

Process
- What should you look for when trying to decide if an egg is Grade AA, A or B?
- How did your group decide who would do the individual tasks?

Generalize
- What other products receive quality ratings?
- How do you decide which grade or quality to buy?
- Why is it important to be a part of a team?

Apply
- The egg has a shell to protect it, **chalaza** to hold the yolk in place, and membranes to help keep out bacteria. What parts of your body perform similar tasks for you?
- Can you think of other instances in which it would be helpful to be part of a team?

Share it

Students may share their experience by teaching a younger class to grade eggs or by making a bulletin board that describes the parts of eggs and how to grade them.

Evaluate it

- ☐ How many more egg parts could student identify after the activity?
- ☐ Did all students participate as a functional member of a team?

Break Out

Invite a USDA inspector to tell the class how grading takes place in an egg processing facility.

Get a variety of eggs from a local farm. Obtain eggs with different shapes, with calcium deposits, and with meat and blood spots. Ask the class to examine the eggs, learn why the imperfections occur and why consumers seldom see them in the store.

Have students research the reproductive cycle of hens and learn when the different egg components are added.

CONSIDER this

- The 1999 estimate for eggs produced was 192.5 million cases. A case of eggs is 30 dozen.
- The top 10 egg-producing states are
  1. Ohio
  2. Iowa
  3. California
  4. Indiana
  5. Pennsylvania
  6. Texas
  7. Minnesota
  8. Georgia
  9. Nebraska
  10. Florida

ON THE W.W.W.

The record for egg production in one year, the number of eggs that the average consumer uses each year can be found on the AEB Web site at: **www.aeb.org**

Warming up with eggs

Embryology skill:
Incubation of fertile eggs

Life skill:
Contribute to group effort

Science skill:
Observing

School subjects supported:
Science

Preparation time:
10 minutes

Activity time:
20 minutes (egg preparation)
10 minutes daily (turning eggs, filling water canals or water pan)
4 to 12 hours (hatching process)

What you need:

- ☐ Incubator
- ☐ Fertile eggs
- ☐ No. 2 Pencil
- ☐ Embryology record sheet (page 45)
- ☐ Copies of Student Activity Sheet "Warming up with Eggs" (page 41)
- ☐ Dish sponge (1/2 inch by 4 inches)

Introduction

We're all used to seeing things grow and develop—watching changes that take place over months and years. But watching chicken embryos is different. Huge changes happen in days or weeks. It's like putting the growth process on fast forward.

In this lesson you will study chicken embryos as they grow. The science of studying the unborn—and in the chicken's case, the unhatched—is embryology. The unhatched chick is called the embryo, and the development of the embryo is called embryogenesis.

We use a thermometer to measure temperature. Temperature regulation is very important during the incubation process. The range of temperatures inside the incubator should be from 98 to 101°F with 99.5° being the best. We should not let the temperature rise above 101° because higher temperatures can harm or kill the embryo. Temperatures below 98°F can delay the hatch time.

The chicks inside the eggs need humidity to keep them from drying out. When they begin to hatch, increase the humidity to soften the eggshell membranes. At Day 18, increase the humidity by adding small, wet dish sponges next to the water canals or pan.

The eggs need to be turned at least three times a day. This will keep the developing embryo from sticking to one side of the eggshell.

It takes about 21 days for the chicks to hatch. When a chick hatches, it has a special structure at the end of its beak called an egg tooth. The egg tooth helps the chick to break out of its shell. A few days after hatch, the egg tooth will fall off.

Get ready

Discuss the information in the Introduction section with the class. Ask them how they might keep track of these tasks.

Do it

1. Divide the students into teams of three to five. Have each team answer the following questions:
   - How will you mark the eggs?
   - How will you turn the eggs?
   - How will you fill the water canals or water pan?
   - How will you monitor the temperature?
2. Have the teams share their plans with the class. Discuss the plans and determine which plan provides for the best care of the eggs and the incubator by reviewing the preceding questions.
3. A suggested plan follows:

   With a No. 2 pencil, mark an "X" on one side of each egg and an "O" on the other side. Do not use ink, because it may poison the embryos. Set the eggs in the incubator with all "X" sides up. This arrangement will help you monitor egg turning.

   Fill the water canals or water pan with tap water. Adjust the incubator temperature to 99.5°F or as close as possible. Turn the eggs three times per day from Day 2 in the incubator to Day 18.

Talk it over

Share
- Why was marking the eggs important?
- Describe your team's plan for incubating the eggs.
- How did your marks on the eggs differ from others?
- What is your team's plan for the best way to mark the eggs?
- What is your team's average incubator temperature?
- What is your team's plan for the best way to fill the water canals or pan?

Process
- What should we use to identify the eggs?
- What ways can you think of to keep the humidity at the required levels?
- How could you determine that turning the eggs three times a day is necessary?
- How might you maintain the proper temperature if electricity was not available?
- What will you do differently the next time you hatch chicks? Why?

Generalize
- How does the thermostat that controls the heating and air conditioning at home compare to the incubator?
- What other thermometers have you read?
- How are those thermometers different from the one inside the incubator?

Apply
- What did you learn about working as a group that you can use in the future?

Evaluate it

Did the students learn…
- ☐ the importance of turning the eggs?
- ☐ the importance of keeping the water canals filled?
- ☐ the importance of proper regulation of the incubator temperature?
- ☐ about the egg tooth and its function?
- ☐ how long it takes a chick to hatch?
- ☐ how to average numbers?

Break Out

- Using the Embryology record on page 45, have the students record the temperature inside the incubator each time the eggs are turned. Take a daily average and an overall average at the end of the project.
- Can you measure relative humidity? If so, describe.
- Using thermometers (for humans), have the students take their body temperatures every hour during the school day and then figure their average temperature.
- If the incubator does not have to be returned right away, consider incubating other things to observe bacterial or mold growth. Try a table egg broken out in a dish, a piece of a potato or a piece of an apple. After a few days, note any changes in these substances.
- If available, look at these substances under a light microscope or dissecting microscope. Have the students describe what they see. Can they identify what they are observing?

Find out how long it takes for other types of chicks to hatch.

Turkey	____ days
Duck	____ days
Geese	____ to ____ days
Pigeon	____ days
Ostrich	____ days
Parakeet	____ days
Cockatiel	____ days

Developing an experiment

Embryology skill:
Collecting data about embryos and chicks

Life skill:
Planning and organizing

Science skill:
Observation

School subjects supported:
Math

Preparation time:
30 minutes

Activity time:
15 minutes

What you need:

- ☐ Two glass containers of equal size (about 2 inches tall) that can hold an egg and fluid
- ☐ Absolute ethanol (the chemical name for alcohol) without formalin (Do not use methanol because it will kill the embryos.)
- ☐ Incubator
- ☐ No. 2 Pencil
- ☐ Black and blue fine point markers
- ☐ Scale that can weigh grams or ounces (A typical fertile egg will weigh about 2 ounces. When hatched, chicks will approximately double their body weight each week.)
- ☐ Notebook
- ☐ Thermometer
- ☐ Egg candler
- ☐ Two dozen fertile chicken eggs

Introduction

Have you ever wanted to conduct an experiment? You can, and you don't even need a laboratory and white coat. An experiment begins with an idea or hypothesis. Once you have developed your hypothesis, you test it with an experiment. In other words, an experiment is a planned search for new facts (about your hypothesis), or a search that confirms or denies results or hypotheses from other experiments.

To conduct an experiment, you must use two or more groups. One group is called the control group, which you use for comparison. The other group(s) receives the treatment or procedure that you are testing. Then you measure the effects of the treatment and compare the results with the control group.

For example, to study the effect alcohol has on chick embryos, compare 12 fertile eggs that were not exposed to alcohol (control group), with 12 fertile eggs that were (treatment group). The difference between the two groups shows the effect alcohol had on the embryos.

In this case, this approach not only demonstrates scientific methods; it demonstrates the dangers of alcoholism. The aim of this project is to teach students how to set up an experiment and to show how alcohol can affect a developing embryo.

Get ready

Set up the incubator before you receive the fertile eggs. Make sure the temperature is correctly regulated at 99.5°F.

Do it

Involve the students in planning the experiment. Divide the students into teams of three to five.

Discuss the experimental designs and determine which design provides for the best experiment. Each team should answer the following questions.

- What is a hypothesis?
- What is an experiment?
- Why are there control and treatment group(s) in an experiment?

Have the teams share their experimental design with the class. Have the teams answer the first two Share questions in the "Talk it over" section.

Have the class select an experimental design developed by one of the teams to do during this activity. Begin the experiment as a total class project.

The following instructions provide information for development of another possible experiment.

1. Divide the eggs into two groups, a dozen each. Mark each egg with a No. 2 Pencil (not pen or marker) according to the group it is in. For example, use "T–1" through "T–12" for the treatment group and "C–1" through "C–12" for the control group. Also, mark an "X" on one side of the egg and an "O" on the other side to keep track of egg turning (unless the incubator automatically turns the eggs).
2. Fill one glass container with about two inches of absolute ethanol. Fill the other glass container with about two inches of water. Write "T" (for treatment) on the container with ethanol. Write "C" (for control) on the container with water. Cover both containers to prevent evaporation, and keep them at room temperature.

3. Incubate the fertile eggs for one day. On the second day, dip the treatment eggs into the alcohol and the control eggs into the water. Dip the eggs, pointed ends down for five seconds, once a day. Because the eggshell is porous and warmer than the liquids, it will absorb the ethanol or water. Dip the eggs for 17 days or until the 18th day of embryogenesis.
4. After the first seven days of incubation, candle the eggs to determine whether they are fertile. Discard any infertile eggs.
5. Have the students determine egg weight. Each day before dipping, weigh each egg and record the information. Normally, fertile eggs will lose 12 to 15 percent of their weight during incubation. (The egg loses moisture when the embryo metabolizes the egg albumen and yolk.) Determine the weight loss percentage for each egg and create a graph to show daily weight loss. (There may be a difference between the two groups.) Record the number of eggs that hatch in each group and determine the percent hatchability.

   (Number of eggs hatched ÷ Number of fertile eggs) X 100 = Percent hatchability

   Answer the remaining Share question and proceed through the remaining questions.

Talk it over

Share
- How was your experimental design different from the class design?
- How did you distinguish between the control and treatment groups?
- What kind of information did you record during this project? Why?

Process
- What happens to the fertile egg weight during development? Why?
- Why would percent hatchability be important to a commercial hatchery?
- Why is creating hypotheses or ideas important?
- What might you do differently the next time you do this experiment? Why?

Generalize
- What other ideas or hypotheses might you try?
- Can you think of other times when you have made evaluations of information in order to learn something new?

Apply
- How might the information you gained transfer to other species?
- What other experiments would you like to try? Why?

Break Out

☐ Ask students to put milk, cola, juice and an egg into containers filled with common rubbing alcohol.

What happens? Record the results and share them with the class.

☐ Students may try additional experiments using liquids other than alcohol: caffeinated versus decaffeinated beverages, a solution with Vitamin C versus plain water or a sugar solution versus plain water.

☐ Try an additional experiment.

- After the chicks hatch and dry out, number the treatment chicks 1 through 12 with a black fine-point marker.
- Number the control chicks 1 through 12 with a blue fine-point marker.
- Weigh each chick and record the weight by the chick's number.
- Place all of the chicks into the same brooder box with feed and water.
- Weigh each chick every day until the end of your experiment, and record the data. Note any physical differences between the two groups. For example, is one group more vocal and active? Does one group eat or drink more?
- To measure differences in feed consumption, separate the two groups but feed them the same amount of feed. Weigh the feed each day to determine how much each group is eating.

Evaluate it

☐ Did the students understand the experimental process?

☐ Did the students understand the difference between a treatment group and a control group?

☐ Did the students learn the health risks of consuming alcohol?

☐ Did the students learn about Fetal Alcohol Syndrome?

Building an eggs-ray viewer

Embryology skill:
Preparing a candler

Life skill:
Planning and organizing

Science skill:
Comparing and measuring

School subjects supported:
Math

Preparation time:
An hour to secure the needed materials. This can be shortened if you ask the students to bring the cardboard and small boxes from home.

Activity time:
30 to 40 minutes

What you need:
- ☐ Heavy cardboard boxes at least 1 by 1-foot in size
- ☐ Small box, such as a pencil box (at least 3 by 4 inches, and 1-inch deep)
- ☐ Scissors
- ☐ Electrical or duct tape
- ☐ Overhead projector (with light source from below the glass surface
- ☐ Copies of Student Activity Sheet "Building an Eggs-ray Viewer" (page 42)

Introduction

If you like sneak previews, then candling is for you. Candling fertile eggs plays an important role in the embryology project. A candler is used to examine fertile eggs by shining a bright light through the egg. Candling serves three important functions.

First, candling eggs before they are set identifies cracked eggs that might burst.

Second, candling helps detect which eggs are developing into an embryo.

Third, candling the eggs every few days allows you to watch the embryo grow and develop without damaging the egg.

In the poultry industry eggs are candled for two reasons:

1. At the hatchery, eggs are candled to help remove cracked eggs before setting and infertile eggs that are not developing after a week of incubation.
2. At the consumer grading plants, eggs are candled to help remove cracked eggs and those that have defects that make them undesirable for human markets.

Get ready

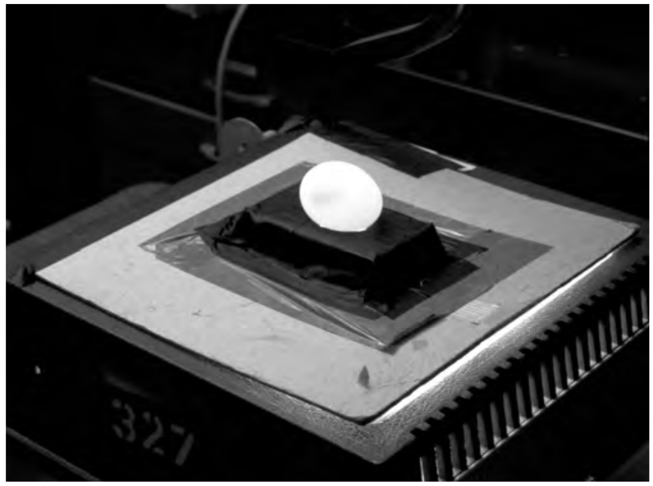
Involve the students in building a candler by dividing the class into teams. Supply each team with the same supplies and ask each group to design and build their own candler. Plans for using an overhead projector are also included so that you (the teacher) can build a candler for class use if you would like. However, you are encouraged to use a candler designed and built by one of the teams.

Do it

1. Divide the class into teams of 3 to 5 individuals. Each team should use the Student Activity Sheet "Building an Eggs-ray Viewer" to help them design and build a candler. Explain that they have 30 minutes to design and build an egg candler with the supplies you give them. Also, show them the overhead projector and explain that it will be the source of light for their candler. Basic questions to answer include:
   a) *Does the candler provide enough light to see cracks in an eggshell or the embryo inside the egg?*
   b) *Can you candle eggs without damaging them?*
   c) *Does the candler limit the amount of light that escapes? So the room can be darkened properly to allow seeing inside the egg?*
   d) *Does the way the egg sets on the candler allow optimal viewing of the different parts of the egg and embryo?*
2. Have the teams share their candler with the class. Ask them to explain:
   a) How did your team decide on the plan before they started to build?
   b) What is unique about your plan?
   c) How does your plan meet the basic needs of a candler mentioned in step 1 above?
3. Try each candler in a darkened room and discuss which candler best allows the students to see inside the egg. If you already have a candler, compare it with the class designs.

The following instructions provide information for development of a typical candler. You may want to build one of these for use in class or to compare it to the candlers developed by the class.

1. Cut out a flat 1 by 1-foot piece of cardboard.
2. Remove one of the large sides of the small box.
3. Cut an egg-shaped hole 1½ inches by 1 inch in the topside of the small box (opposite side as the side you just removed). This hole holds the egg so you can see the embryo while handling the egg as little as possible.
4. Place the small box on the center of the piece of cardboard and trace the box outline. Cut a hole in the center of the piece of cardboard the same size as the small box.
5. With duct tape, fasten the small box to the piece of cardboard (with the egg-shaped hole up).
6. Place the cardboard on top of the glass base of the overhead projector, and you are ready to candle.



Talk it over

Share
- How did your candler differ from the others that were built?
- What do you like about your team's plan compared to the others? Why?

Process
- Why do we candle eggs?
- What things make a good candler?
- How would you improve your candler?
- What plans did you have to make before starting this project?

Generalize
- What other items have you built? How was this building process like or different from those?
- How can planning and organizing help you in other parts of your life?
- How did not having instructions and specifications affect the building process?

Apply
- What did you learn about working as a group that you can use in the future?
- What will you do differently the next time you plan to build something?

Break out

Have students design and make their own egg candler at home (with a flashlight rather than an overhead projector).

Candle some eggs at home and show your family how to look at eggs. Why does the store-bought egg look differently than the ones at school?

Evaluate it

☐ Did the students learn the three reasons why candling is performed?

☐ Were the students able to take measurements to construct a candler?

☐ Did all students make a contribution to constructing the candler?

Life is not always what it seems

Embryology skill:
Observing the embryo's development and learning its parts

Life skill:
Record keeping

Science skill:
Observing

School subjects supported:
Biology

Preparation time:
10 minutes

Activity time:
10 minutes for student to record expectations (written or art)

20 minutes for making the shell window and the initial observations. Allow the student to observe the embryo at different intervals until Day 15 of development.

What you need:

- ☐ For embryo activity with egg: one three-day-old developing embryo (incubating eggs with developing embryo), paper and writing utensil for writing and drawing.
- ☐ For embryo activity without egg: graphic(s) of a developing embryo, paper and writing utensil for writing and drawing.
- ☐ Copies of Student Activity Sheet "Observing an Embryo" (page 43)

Introduction

The shell window is an advanced way to observe the embryo. You must sacrifice an embryo for this activity unless your class has elected to do the egg-less embryo version of this activity. However, this activity will allow the students to get a very close look at what is occurring in the egg during development.

Get ready

Review the suggested activities for this lesson and the science of the developing embryo. Determine which suggestions would be most appropriate for your students. During the activity, give your students the freedom to use their imagination and draw or write from their background and experiences.

If using eggs you will ask the students to record what they think a three-day-old chicken embryo will look like without any prior opportunity to observe graphic or an embryo. Have them write, draw or both. Then allow them to observe a three-day-old chicken embryo by developing a shell window in a developing egg.

For the egg-less activity, you will use graphics of developing embryos in similar stages of development. Ask the students to record how the embryo was different than what they expected (orally, written, drawn or combination).

Do it

1. Candle three or four developing eggs at least two hours before you plan to start the activity. Select two eggs with a well-defined embryo in them, and stand these eggs on the small end in the incubator. A section of egg carton works well.
2. While you are preparing to make the shell window ask the students to think about what the three-day-old embryo will look like. Without any prior opportunity to observe graphic or an embryo, ask the students to record what they expect a three-day old chicken embryo to look like. Have them write, draw or both. Give your students the freedom to use their imagination and draw or write from their background and experiences.
3. Allow them to observe a three-day-old embryo through the shell window (see instructions on page 26). For the egg-less activity use graphics of developing embryos in similar stages of development. Ask the student to answer these questions:
   - What do you see?
   - How will or has the embryo changed between observations?
   - Is anything moving?

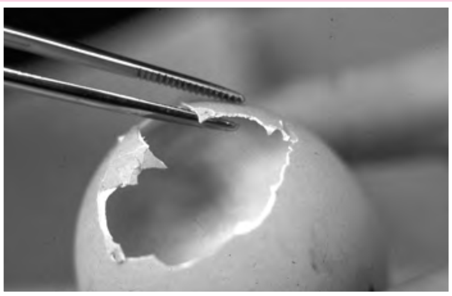
4. After observing the developing embryo, ask students to record how the embryo was different than what they expected (orally, written, drawn or combination).
5. Repeat this activity at other stages of development.

The shell-window method

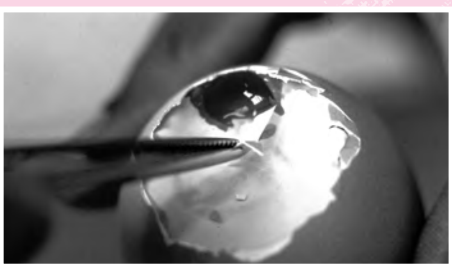
Removing part of the shell of an egg provides another way to study embryo development. In embryos more than two days old, most of the development can be observed inside the egg by removing the shell and shell membranes from the air-cell end of the egg.

What you need

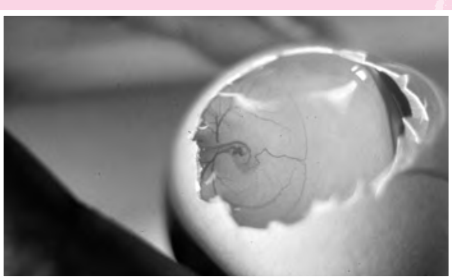
- ☐ Petroleum jelly
- ☐ 3-day-old developing embryo egg
- ☐ tweezers or forceps
- ☐ scissors
- ☐ water pan
- ☐ water
- ☐ egg carton
- ☐ eye dropper
- ☐ plastic wrap.



Carefully remove the shell and outer shell membranes with a tweezers.



Carefully remove the inner shell membrane, without grabbing any blood veins. Grab the inner shell membranes and pull back across the embryo.



Place on a stand or egg carton so contents can not spill for the end result.

The biggest obstacle after assembling the necessary equipment is to open the shell without damaging the embryo and its membrane. This is not as difficult as it appears. Just follow these steps:

1. Carefully crack the shell at the air-cell (broad) end of the egg. You may wish to candle the egg before beginning, to make sure the egg is developing and to find the location of the air-cell. Do not puncture the inner shell membrane.
2. Cut or peel off the shell covering the air cell. Do not puncture the inner shell membrane.
3. Using forceps or tweezers, remove the inner shell membrane covering the air cell. To help soften the inner-shell membrane, place a few drops of warm water on the membrane with an eyedropper.
4. Set the egg in an egg carton, window up, and observe the embryo with a magnifying glass.
5. To continue to observe the embryo as it develops you will need to seal the window. It is important that you keep the environment as clean as possible as you cover the window.
   A. Carefully apply a thin layer of petroleum jelly (1/2 inch wide) to the shell all the way around the window opening.
   B. Cut a 2 by 2-inch piece of plastic wrap. Place the plastic over the opening and press the plastic to the petroleum jelly to create a seal.

You can then remove the plastic wrap and observe the embryo as long as it lives. Most embryos will survive in a shell window throughout 15 to 17 days of development.

In young embryos (three to eight days), a rich network of blood vessels spreads from the embryo and surrounds the yolk. This network is the vitelline or yolk sac circulatory system. In embryos two to four days old, observe the tiny red heart beating rapidly and pumping the blood throughout the intro- and extra-circulatory systems. One characteristic of birds is the remarkable growth and development of the eye after the embryo is 24 hours old.

Discuss:

Explain what the main membranes (amnion, allantois and yolk sac) do.

Identify the parts of the embryo. How will these parts change as the embryo grows?

Talk it over

Share

- What happened as you observed the embryo for the first time?
- What differences did you see between the eggs?
- What parts of the embryo were easiest to see?
- What was the most interesting thing you saw? Why?

Process

- What are some things you should do to keep the eggs from cooling off too much during candling?
- Why is it helpful to candle the eggs?
- Why do the heart and eye develop so fast?

Generalize

- Why would it help a doctor to be able to view an unborn human baby?
- How do we view the developing fetus in human or other animal pregnancies?

Apply

- Why is it important to chart the growth of a developing fetus?
- How will what you learned in this lesson be useful in the future?

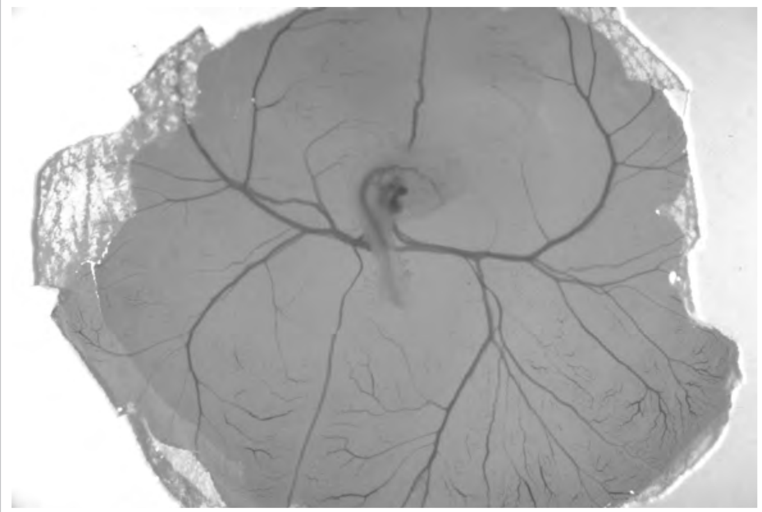
Evaluate it

- ☐ Can students identify parts of the embryo?
- ☐ Can students explain what they are seeing?
- ☐ Student should be able to identify the "extra-embryonic" membranes (yolk sac, amnion and allantois) and explain their basic functions.

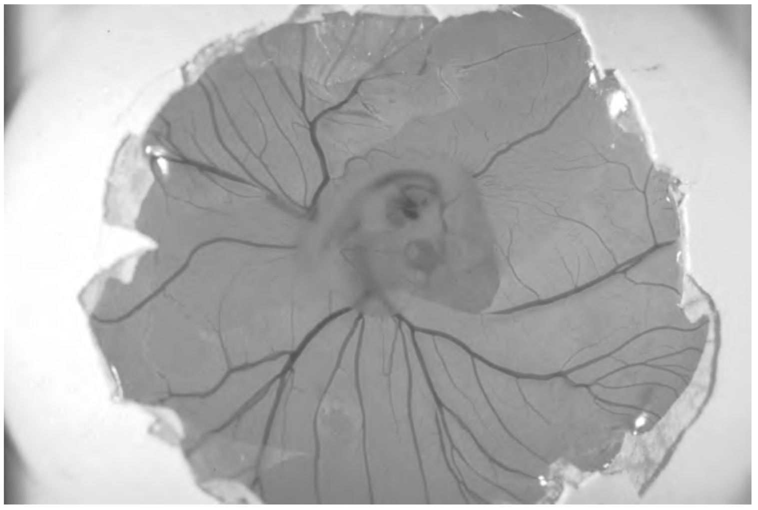
Break Out

Students may display their drawings or writings about what they saw and how the embryo parts compared to what they expected. Students also may share any birthing experiences they may have had with a mother's pregnancy, younger siblings being born, pets reproducing, and so on.

Ask students to study pictures or graphics of other species that develop as an embryo or fetus. Observe similarities and differences. Have a parent or doctor bring in ultrasounds of a human fetus, and discuss how being able to observe and identify the different parts is important. (Obtain permission from parents, if necessary.)



6-Day embryo
Notice the distinct blood system and eye (black spot).



12-Day embryo

Building the brooder

Embryology skill:
Preparing a brooder

Life skill:
Planning and organizing

Science skill:
Comparing and measuring

School subjects supported:
Math

Preparation time:
45 minutes

Activity time:
60 minutes (will vary)

What you need:

- ☐ Cardboard box 24 to 36 inches square
- ☐ Cardboard box about 12 inches by 18 inches, and at least 12 inches tall
- ☐ Goose necked lamp or an insulated light socket on an electric cord
- ☐ 40-watt light bulb
- ☐ Waterer
- ☐ Newspapers, magazines, or pine shavings
- ☐ Roll of paper towels
- ☐ Roll of clear wrapping paper
- ☐ Thermometer

Introduction:

Brooders are fairly easy and inexpensive to build. You may change the proportions if necessary. The brooder is designed to trap heat in one half to keep the chicks warm. The other half allows your students to observe the chicks eating and moving about.

Get ready:

Build the brooder at least two days before hatching. The brooder should maintain a temperature of 95°F (temperature taken at chick level) during the first week. If you keep chicks beyond one week, decrease the temperature 5°F per week until you reach room temperature. Use fresh pine shavings for litter. If shavings are not available, use five layers of newspaper with two layers of paper towels on top of the newspaper. Do not use news or magazine paper for the top layer because the surface may become slick, which can cause the chicks to develop “spraddle legs.”

Do it:

1. Involve the students in planning the brooder for their chicks. Divide the students into teams of 3 to 5. Basic questions to consider are:

   Does the brooder provide shelter for the chicks?

   Does the brooder provide heat for the chicks?

   Does the brooder provide food for the chicks?

2. Have the teams share their brooder plan with the class.
3. Discuss the plans and determine which plan provides for the best brooder.
4. Build one brooder box as a total class project. The following instructions provide information for development of a typical brooder. You may wish to build one of these and compare it to the one built by the class.

Teacher note:

You may choose which brooder you would like your class to build.

The courtyard brooder will be used for an example in this lesson since it is easily made with supplies in an everyday classroom. However, teachers who plan to do this project again and would like to construct something more permanent may wish to build a wooden observation brooder.

Building a courtyard brooder

A. Remove the top of each cardboard box. Cut the sides of the largest box (24 by 18 inches) down to 6 inches in height. This is the chick courtyard where the feed and water will be placed.

B. Cut a hole 4 inches high by 6 to 10 inches across (depending on the size of the box) in three of the four sides of the small box. These holes serve as doors to the heat source. Cut these holes close to the open-end edge of the three sides. (Remember that the chicks have to get in and out.)

C. Turn over this small box so the covered side is up. Cut a round hole the size of your light socket in the center of the covered end of the box.

D. Cut three slits from the inside of the round hole about 1 inch out into the box top. (Cut these three slits at different angles.)

E. Punch the light socket down into the hole about ¾ of the length of the socket.

F. Tape the electric cord to the box top. This will help keep the light bulb from falling to the floor and causing a fire. Never place the light closer than 18 inches from the brooder floor or walls.

G. Cover the bottom of the largest box (courtyard) with shavings or newspaper and then with two layers of paper towels. The paper towels give the chicks traction and prevent leg damage.

H. Place the other box (the open end down) in the center of the box with the paper towel surface.

I. Add waterer and feeder, and your brooder is ready for the chicks.

J. Test the brooder temperature for several days before the chicks hatch. Be sure that the temperature is 95°F for the first week, and then lower it 5 degrees a week by raising the light bulb or decreasing the light bulb size.

Talk it over

Share

- What materials did you use to make the brooder? Why?
- What does the chick need to stay alive?
- What is your team's plan for the best brooder?
- What is the difference between homeothermic and poikilothermic? Which are you?

Process

- How could you help the chick that is shivering or panting?
- Why was it necessary to have pine shavings or paper towels in the bottom of the brooder box?
- How was the planning process different from other items you have planned?

Generalize

- Why is it important to organize your plan before doing it?
- How was the final brooder plan like or different from the ideas generated at the beginning of class?

Apply

- How can you use what you learned about planning and organizing in other work that you might have?

Break Out

1. At home, read about animals that are cold-blooded. Make a list and share it with your class at school. A warm-blooded animal is called homeothermic. A cold-blood animal is called poikilothermic.
2. Scientists use Celsius temperature. Practice converting temperatures from Fahrenheit to Celsius and vice versa.
3. To convert Fahrenheit temperature to Celsius, subtract 32 from the Fahrenheit temperature and multiply by $5/9$. For example, if the temperature is 212°F, then Celsius = 212−32 ($5/9$) = 100°C.
4. To convert Celsius temperature to Fahrenheit, multiply the Celsius Temperature by $9/5$ and add 32. For example, if the temperature is 100°C, then Fahrenheit = $9/5$ (100) + 32 = 212°F

Evaluate it

- ☐ Did the students learn why a brooder box is required for chicks?
- ☐ Did students learn the proper temperatures to brood chicks?
- ☐ Did the students learn why the bottom of the brooder box must be covered with pine shavings or paper towels?
- ☐ Do the students understand the importance of planning and organizing?

Who rules the roost?

Embryology skill:
Understanding chicken behavior (pecking order) for better care and management

Life skill:
Planning/organizing

Science skill:
Observing

School subjects supported:
Psychology and social studies

Preparation time:
30 minutes

Activity time:
One class period

What you need:
- ☐ Copies of Student Activity Sheet "Pecking out" (page 44)

Introduction

Although not given much credit for their intelligence, chickens have the ability to learn conditioned responses. In other words, if chickens are rewarded when they perform a certain behavior, they will learn to perform that behavior to get the reward. For example, a chicken could learn to ring a bell to receive a kernel of corn.

Trained chickens may not rank up there with show dogs and tamed lions, but studying their conditioned responses is important. In fact, by observing how chickens treat each other you can understand how they learn their place within the flock.

When a chicken is placed in a flock, one chicken will peck at another to establish dominance. In some cases, fights will occur. The winner of each encounter then has the right to peck the loser. At the bottom of the social order is a chicken that will be dominated by all of the rest. This social arrangement, a famous metaphor for many hierarchies, is known as a pecking order.

Get ready

Prepare a study sheet with questions about the embryology project that your students have been learning in class.

For example:

- How many days does it take for a chicken egg to hatch?
- At what temperature is the incubator set?
- How often do you have to turn a chicken egg in a day?
- Why do you put water in the bottom of the incubator?
- Without breaking the egg, how would you see whether the embryo is developing?
- What is a candler?

A day or two before class, ask the students to write a short story, poem or article, create artwork, or research information from the Internet. The work should relate to the species they will study.

Do it

The students will create their own temporary and flexible pecking order.

Begin the class with a question about chickens from your study sheet. The first student who raises his or her hand and has the correct answer should "go to the head of the class." That person doesn't have to answer any more questions for the rest of the class period. That student also gets to ask the next question from the study sheet and pick the person to answer the question. If that next person answers the question correctly, he or she gets to go to the head of the class. He or she asks the next question and calls on the next person. This process continues until everyone has had an opportunity to share his or her work.

Talk it over

Share
- What happened in the class when preferences were being given?
- How did the person at the head of the class feel?
- How did the last person feel?

Process
- What factors determine a pecking order?
- Why is a pecking order important in chickens?
- Why is knowing about pecking order important for the care of chickens?

Generalize
- What would happen if you didn't plan something to present to the class?
- What did you learn from this exercise? What role did luck play?
- Why is it important to write good questions for the game?
- What social orders exist in your school? What is their significance?
- How do you prioritize your work for school? At home?

Apply
- Why is planning and organizing important in doing your homework?
- How does planning and organizing help you keep a schedule?
- How did this activity develop your planning and leadership skills?

Evaluate it

- ☐ Did the students understand the importance of the pecking order and how it relates to managing chickens?
- ☐ Did the students understand why chickens act the way they do?
- ☐ Did the students want to learn more about chicken behavior? Other animal behavior? Human behavior?
- ☐ Did the students learn how to measure animal behavior, especially in chickens?

FYI

Conditioned responses take place among chickens and help establish a social order within a flock. When a small flock of chickens is confined in a pen, each bird will establish its rank by pecking at another bird or by allowing another bird to peck it. In this way, a social order develops. The hen in the first rank of the pecking order has the right to peck all others in the group. The others may peck only those beneath them in the social order. At the bottom of the pecking order is a single hen that can be dominated by all the rest and does not fight back in any way.

With males, the fights are more intense. Usually in a mixed flock of males and females, the males will be at the top of the pecking order. The existence of a pecking order among chickens indicates that they are able to recognize each other as individuals. Some researchers believe this recognition is based on features of the head, because changing the position of the comb (or removing it) can disrupt the hen's position in the pecking order. The pecking order will determine which birds get to eat and drink first.

Other types of behavior common to most birds are definite patterns of sexual activity. Breeding can influence some behaviors. For example, genetic selection easily can affect the degree of aggression.

Break Out

When the chicks hatch, mark them and observe which one is at the top of the pecking order.

Materials needed

- ☐ Colored tape or a felt-tip marker
- ☐ Stop watch, watch or clock.

After the chicks have been in the brooder for one week, mark each one with a small piece of colored tape around the left or right leg. Or place a small mark on the back of the chick with a felt-tip marker. Spend 15 minutes each day counting the number of times each chick goes to the feeder and waterer. After five days, total the number of times each chick went to the feeder and waterer.

- Would the chick with the highest number be at the top of the pecking order?
- What could you do to ensure that all the chicks got to eat and drink regularly?
- How does the space that the chicks have affect the pecking order?

Eggonomics

Embryology skill:
Learning how the poultry industry works

Life skill:
Critical thinking

Science skill:
Applying

School subjects supported:
Social studies

Preparation time:
20 to 30 minutes

Activity time:
One hour

What you need:
Game board (see insert) and game cards (pages 34–35)

Introduction

You have learned how to incubate eggs and care for chicks. You know how much work is involved. Imagine how much work is needed to care for thousands of birds and move their eggs to the store.

Fortunately, along with the work, goes salaries and careers. The poultry industry is much larger than most people think. To succeed, it requires a diverse group of talented and knowledgeable people working together to produce the poultry products we all enjoy.

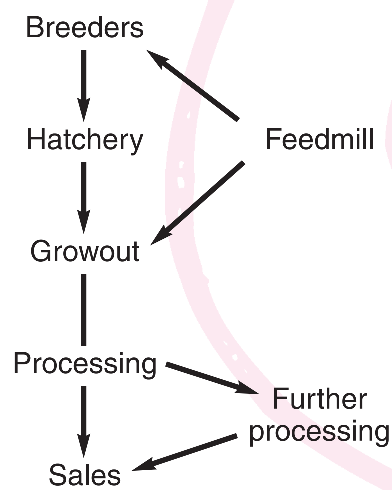
The following activity will acquaint you with various careers in the poultry industry and demonstrate how each aspect affects the overall industry.

Get ready

Encourage students to think about what they experience during the game and to answer the questions. Allow plenty of time for them to discuss and answer the activity questions when the game is over. There are many ways the industry can work and many possible answers to the questions. Encourage students to think of a variety of answers.

Do it

Give each player a game piece. Players should take turns choosing cards and following the card's instructions. After the game, the small groups of players should discuss the questions on the students sheet.



Acknowledgement:
The NCSU Poultry Science Club developed "Chance Card" scenarios.

Talk it over

Share
- Why are games a fun way to learn?
- What careers did you learn about?

Process
- What could the poultry industry do to share its successes and losses?
- What is the significance of marketing to the poultry industry?

Generalize
- How have you handled unexpected problems in your life?

Apply
- What do the problems and breakthroughs in the poultry industry have in common with other industries you know about?
- What have you learned that could help you choose a career?

Evaluate it

- ☐ Consider how the students answered the questions and how well they worked as a group.
- ☐ Did any students express an interest in a poultry-related career?
- ☐ Did the students develop some creative innovations for the poultry production?

Break Out

- Students may visit with an adult about his or her work or business, how decisions are made and how the business compares to the poultry industry.
- Have students research another agricultural industry and present their findings to the class.
- Tour a farm or processing plant. Some may even allow a student to spend a day with a worker.

FYI

The poultry industry involves many companies from around the world. There is a career for almost any interest that connects with poultry. Poultry farmers house and care for the birds; other farmers provide the soybeans, corn and cottonseed that goes into feed. Poultry scientists improve poultry genetic characteristics, create better feeds and look for ways to prevent disease. Food scientists use poultry products to create new foods and improve the quality of existing products.

Marketers find new ways of encouraging the public to eat poultry. Processing plant managers have the difficult job of making sure that the right amount of birds are ready for processing on a given day and that the processing plant is ready to handle these birds. Professors conduct research and teach the future leaders of the industry.

How do all of these people work together to supply the products consumers enjoy? The answer is "vertical integration." Through vertical integration, a company owns parts of the production process between the farm and the finished product. For example, the company that produces the eggs you buy in the grocery store may own feed mills and processing plants. It may employ veterinarians who care for the birds, and geneticists who study how certain characteristics develop. The company also may contract with farmers to raise the birds or to supply feed components.

Many companies in the poultry industry have adopted vertical integration. This system spreads out the financial risk and allows a company to make up for losses in one part of the production process by changing another part.

Game cards

Photocopy, cut, and stack on the game board.

1. Genetic researchers discover new breeding techniques that cause hens to produce more eggs each year.
Advance five spaces.

2. Your company buys a new processing plant.
Advance five spaces.

3. A drought in the Midwest causes corn prices to rise… Feed becomes more expensive.
Move back one Space

4. New henhouse designs use cheaper materials.
Advance three spaces.

5. One of your largest farms loses laying flock to disease.
Move back one space.

6. Your company contracts with five more farmers to raise birds.
Advance four spaces.

7. New lighting systems improve energy efficiency.
Advance five spaces.

8. Food scientists develop new egg products that increase market demand for eggs.
Advance five spaces.

9. Your company hires three more veterinarians.
Advance three spaces.

10. Three more farms contract to supply feed.
Advance three spaces.

11. Disease strikes the parent stock of your company's laying hens.
Move back one space.

12. Geneticists find genes that influences feed conversion.
Advance three spaces.

13. A better incubation system is created that improves hatchability.
Advance four spaces.

14. One of the company incubators breaks and the eggs inside are lost.
Move back one space.

15. Reports about adverse effects of cholesterol cause people to buy fewer eggs.
Move back one space.

16. Your company buys a feed mill.
Advance three spaces.

17. A salmonella outbreak in a diner scares consumers.
Move back one space.

18. A news group airs a segment on the health benefits of poultry.
Advance two spaces.

19. Flooding destroys 30 percent of your broiler houses.
Move back one space.

20. There is an economic boom in Asia causing a demand for poultry exports.
Advance four spaces.

21. A higher feed conversion saves you 3 percent on costs.
Advance two spaces.

Game cards

22. A sweet-potato processing plant moves into area providing lower cost feed additives.

Advance two spaces.

23. City officials lower the amount of organic solids acceptable in wastewater. This will cost your company money at first, but it will also lead to better environmental conditions.

Stay where you are.

24. A new deboner is installed in your plant. It increases productivity by 10 birds per minute.

Advance three spaces.

25. A new egg storage method is found extending shelf life by four weeks.

Advance three spaces.

26. Your HACCP (Hazard Analysis Critical Control Points) plan fails to prevent fecal contamination in chillers.

Move back one space.

27. There is an avian influenza outbreak and you lose most of your birds.

Move back one space.

28. Geneticists find a hybrid cross that yields a more heat-tolerant bird.

Advance four spaces.

29. A major fast-food chain that you supply for has started a new chicken sandwich promotion.

Advance five spaces.

30. Your company merges and stocks split.

Advance two spaces.

31. Computer errors miscalculate the feed additives reducing production.

Move back one space.

32. A new egg white separating system is manufactured, saving you $100,000 a year.

Advance four spaces.

33. You sponsor the 4-H Poultry Record Book Award for your state 4-H program.

Advance four spaces.

34. You invest in ratite farming. This has a bright future, but you are uncertain.

Stay where you are.

35. Your egg farm becomes infested with rats.

Move back one space.

36. You attend seminars at your local extension office on proper application of poultry litter to farmland.

Advance two spaces.

37. Your caged layer house was built with the floor slanting away from the coolers making collection harder. You have to redesign the house.

Move back one space.

38. Your company wins an award for being one of the "Top 20" employers to work for.

Advance five spaces.

39. A new marketing campaign increases your company's sales 10 percent.

Advance five spaces.

40. Your company's nutritionists develop a new feed formula for your laying hens, giving the eggs stronger shells that don't break as easily.

Advance four spaces.

41. You give $100,000 to a local program that provides teens safe and fun activities after school.

Advance five spaces.

42. You pay for a new course that is offered on the Web to educate company workers on good sanitation practices.

Advance four spaces.

Advanced Glossary

Air cell – the air pocket that forms between the inner and outer shell membranes to replace moisture the egg loses as it cools and is stored.

Albumen – a combination of four layers of a whitish watery substance (88 percent water, 11 percent protein) that surround and contain the yolk within the center of the egg shell. Inner and outer thick albumen is the major source of egg riboflavin and protein. In high-grade eggs, it stands higher and spreads less than the thin albumen. In lower-grade eggs, it thins and looks like the thin albumen.

Allantois – an organ in the embryo of birds that develops into part of the umbilical cord and unites with the chorion, forming the placenta. Responsible for respiration, absorption of minerals from the shell and handling waste.

Amino acid – the building blocks for the synthesis of proteins and the end products of protein digestion.

Amnion – a membranous, fluid-filled sac surrounding the embryo. Important for protection and allows the embryo to exercise during development.

Average – the arithmetic mean. Computed by dividing the total value by the number of items that make up the total.

Avian – of, or pertaining to, Aves or birds.

Bacteria – microscopic single-celled organisms.

Bantam – a miniature fowl, some distinctive breeds, others being miniatures of a large breed or variety, approximately one-fourth (1/4) to one-fifth (1/5) normal weight.

Blastoderm or germinal spot – the collective mass of cells produced by the splitting of a fertilized ovum from which the embryo develops.

Blastodisc or germinal disc – the germinal spot on the ovum from which the blastoderm develops after the ovum is fertilized by the sperm.

Bloom – the coating or covering on the eggshell that seals its pores.

Breed – a group of birds that have the same physical features, like body shape or body type, skin color, number of toes, feathered or non-feathered shanks (legs) and carriage or station.

Brood – baby chicks hatched from one nest (setting) of eggs.

Brooding – caring for the young of animals.

Candling – shining a bright light through an egg in order to observe its interior.

Carbohydrate – compounds containing carbon, hydrogen, and oxygen, a sugar or starch.

Career – a job that is undertaken as a long-term commitment.

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

Celsius – a temperature scale that registers freezing point of water as 0°C and the boiling point as 100°C under standard atmospheric pressure. Named after Anders Celsius (1701–1744).

Chalazae – prolongations of the thick inner-white or albumen that are twisted like ropes at each end of the yolk. Their function is to anchor the yolk in the center of the eggshell 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.

Class – a group of chicken breeds from the same geographical origin (large fowl) or showing similar characteristics (bantams).

Cloaca – in birds, the common chamber into which the intestinal, urinary and generative canals discharge.

Cold-blooded (poikilothermic) – having a body temperature that varies with the environment (reptiles).

Control – to verify or regulate (a scientific experiment) by conducting a parallel experiment or by comparing with some other standard.

Data – numerical information in a form suitable for processing.

Diffusion – the movement of atoms, ions, or molecules from a region of higher concentration to one of lower concentration.

Dorsal – of, on or near the back).

Ectoderm – a cell layer grouping responsible for the development of the skin, feathers, beak, claws, nervous system, lens and retina of the eye, linings of the mouth and vent.

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 offspring.

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

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

Embryogenesis – the formation and development of plant and animal embryos.

Embryology – the study of the formation and development of plant and animal embryos.

Endoderm – a cell layer grouping responsible for the development of the linings of the digestive tract and the secretory and respiratory organs.

Evaporation – changing of moisture (liquid) into vapor (gas).

Experiment – a test made to demonstrate a known truth, to examine the validity of a hypothesis, or to determine the efficacy of something previously untried.

Fahrenheit – a temperature scale that registers freezing point of water as 32°F and boiling point as 212°F under standard atmospheric pressure. Named after Gabriel D. Fahrenheit (1686–1736).

Fertile egg – an egg that has been fertilized by sperm or is capable of developing an embryo.

Fertilized – an ovum or egg that has been impregnated by 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 cell that transmits hereditary characteristics.

Germs – microorganisms that can cause sickness or disease.

Gram (g) – unit of weight of the metric system. There are 28+ grams in an ounce and 454 grams in a pound.

Hatchery – a facility where eggs are incubated commercially.

Hatching egg – a fertilized egg with the potential of developing an embryo.

Humidity – see "relative humidity."

Hypothesis – an explanation that accounts for a set of facts and that can be tested by further investigation.

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 – the entrance to the oviduct.

Lysozyme – a protein enzyme in the egg albumen that kills bacteria.

Mean – a number that represents a set of numbers in any of several ways determined by a rule involving all members of the set, i. e. average.

Membrane – a soft, pliable sheet or layer of tissue covering an organ.

Mesoderm – a cell layer grouping responsible for the development of the bones, muscle, blood and the reproductive and excretory organs.

Metabolism – the chemical energy changes that occur within a living organism that are involved in various life activities.

Methanol – a colorless flammable liquid, CH_2 (OCH#)2, used as an antifreeze, general solvent, fuel, and denaturant for ethyl alcohol.

Nutritious – food or feed 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.

Pecking order – the basic pattern of social organization within a flock of poultry in which each bird can peck the birds lower in the order without fear of retaliation. Social hierarchy.

Peristaltic action – involuntary movement of the muscles of the oviduct that forces the egg onward.

Pipping – a baby chick breaking from its shell.

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

Pores – miniature 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.

Relative humidity – the amount of moisture in the air compared with the amount the air could contain at specific temperatures. Expressed as a percentage.

Semen – the fluid secreted by the male reproductive organs that serves as a vehicle for the sperm.

Shell – the egg's outer covering consisting mainly of Calcium Carbonate. The shell is the egg's first line of defense against bacterial contamination.

Shell membrane – the membranes between the shell and the liquid portion of the egg. The outer shell membrane is fused to the shell, and the inner shell membrane surrounds the liquid portion of the egg. The air cell forms between the two membranes, usually at the large end of the egg.

Sperm – the male reproductive cell.

Standard deviation – a measure of distribution around a mean.

Statistics – the science of creating, developing, and applying techniques such that the uncertainty of specific reasoning may be evaluated.

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

Strain – families or breeding populations of chickens that possess common traits.

System – a functioning unit of the anatomy, such as the skeletal, muscular, glandular, respiratory and digestive systems.

Testes – the male genital glands (plural) **testicle, testis** (singular).

Treatment – the act or manner of handling.

Variance – the measure of the difference around a mean.

Variety – a subdivision of a breed. Different characteristics include feather color, comb type and the presence of a beard and muffs.

Vertical integration – a method of organizing a business in which one company owns many different parts of the production cycle in order to minimize costs.

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

Vitelline membrane – the clear seal that holds the yolk.

Warm blooded (homeothermic) – having a body temperature that stays the same, despite the temperature of the environment.

Wet-bulb thermometer – a device used 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.

Yolk sac – a membrane that surrounds the yolk of the egg.

Embryology Student assessment rubric

Science as inquiry

☐ 5 points
Student demonstrates above average ability to identify questions for investigation, plan and conduct experiments, use appropriate tools to gather and analyze data, develop explanations and predictions, think critically, use math, and communicate results.

☐ 3 points
Student demonstrates satisfactory ability to identify questions for investigation, plan and conduct experiments, use appropriate tools to gather and analyze data, develop explanations and predictions, think critically, use math, and communicate results.

☐ 1 point
Student demonstrates unsatisfactory ability to identify questions for investigation, plan and conduct experiments, use appropriate tools to gather and analyze data, develop explanations and predictions, think critically, use math, and communicate results.

Structure and function in living systems

☐ 5 points
Student demonstrates above average understanding that the embryo and the chick are composed of cells that specialize for functions needed to sustain life.

☐ 3 points
Student demonstrates satisfactory understanding that the embryo and the chick are composed of cells that specialize for functions needed to sustain life.

☐ 1 point
Student demonstrates unsatisfactory understanding that the embryo and the chick are composed of cells that specialize for functions needed to sustain life.

Reproduction and heredity

☐ 5 points
Student demonstrates above average understanding of reproduction in chickens and that heredity is the passage of traits from one generation to another.

☐ 3 points
Student demonstrates satisfactory understanding of reproduction in chickens and that heredity is the passage of traits from one generation to another.

☐ 1 point
Student demonstrates unsatisfactory understanding of reproduction in chickens and that heredity is the passage of traits from one generation to another.

Regulation and behavior

☐ 5 points
Student demonstrates above average understanding that the behavior of the chicks is related to their internal and external environment, i.e., warmth, shelter, food. A chick's behavior changes as it adapts to its environment.

☐ 3 points
Student demonstrates satisfactory understanding that the behavior of the chicks is related to their internal and external environment, i.e., warmth, shelter, food. A chick's behavior changes as it adapts to its environment.

☐ 1 point
Student demonstrates unsatisfactory understanding that the behavior of the chicks is related to their internal and external environment, i.e., warmth, shelter, food. A chick's behavior changes as it adapts to its environment.

Abilities of technological design

☐ 5 points
Student demonstrates above average understanding of the steps in the process of design, i.e., identify the problem, design solution, implement solution, evaluate and improve, communicate the process.

☐ 3 points
Student demonstrates satisfactory understanding of the steps in the process of design, i.e., identify the problem, design solution, implement solution, evaluate and improve, communicate the process.

☐ 1 point
Student demonstrates unsatisfactory understanding of the steps in the process of design, i.e., identify the problem, design solution, implement solution, evaluate and improve, communicate the process.

Planning and organizing skills

☐ 5 points
Student shows above average skills in developing and implementing a simple plan. They involve others in planning and can accept responsibility within the plan.

☐ 3 points
Student shows satisfactory skills in developing and implementing a simple plan. They somewhat involve others in the plan and accept some responsibility within the plan.

☐ 1 point
Student is not capable of developing and implementing a simple plan. Student does not involve others in planning and does not accept responsibility within the plan.

Record-keeping skills

☐ 5 points
Student demonstrates above average skills in categorizing information, selecting useful information, and applying the skill of keeping records for specific tasks.

☐ 3 points
Student shows satisfactory skills in categorizing information, selecting useful information, and applying the skill of keeping records for specific tasks.

☐ 1 point
Student shows unsatisfactory skills in categorizing information, selecting useful information, and applying the skill of keeping records for specific tasks.

Teamwork skills

☐ 5 points
Student understands their role in the team, enjoys working with others, and appreciates the contributions of other team members.

☐ 3 points
Student shows some understanding of their role in the team, likes to work with others, and somewhat appreciates the contributions of other team members.

☐ 1 point
Student does not understand their role as part of a team, does not like to work with others, and does not appreciate the contributions of other team members.

Science skill of observation

☐ 5 points
Student generates reasonable questions about the world based on observations. Student uses all senses when observing.

☐ 3 points
Student generates satisfactory questions about the world based on observations. Student uses most senses when observing.

☐ 1 point
Student does not generate reasonable questions about the world based on observations. Student uses only one sense when observing.

Science skill of comparing and measuring

☐ 5 points
Student demonstrates above average skills in using simple measurement tools to provide consistency in an experiment.

☐ 3 points
Student demonstrates satisfactory skills in using simple measurement tools to provide consistency in an experiment.

☐ 1 point
Student is not able to use simple measurement tools to provide consistency in an experiment.

Science skill of relating

☐ 5 points
Student demonstrates above average skills in developing solutions to unfamiliar problems through reasoning, observation, and experimentation.

☐ 3 points
Student demonstrates satisfactory skills in developing solutions to unfamiliar problems through reasoning, observation, and experimentation.

☐ 1 point
Student is not able to develop solutions to unfamiliar problems through reasoning, observation, and experimentation.

Science skill of applying

☐ 5 points
Student demonstrates above average skills in using sources of information to help solve problems.

☐ 3 points
Student demonstrates satisfactory skills in using sources of information to help solve problems.

☐ 1 point
Student is not capable of using sources of information to help solve problems.

Planning and organizing skills

☐ 5 points
Team was capable of considering the situation and coming up a good plan.

☐ 3 points
Team was capable of considering the situation and coming up with a satisfactory plan.

☐ 1 point
Team developed an unsatisfactory plan.

Record-keeping skills

☐ 5 points
Student shows above average skills in categorizing and selecting useful information.

☐ 3 points
Student shows satisfactory skills in categorizing and selecting useful information.

☐ 1 point
Student shows poor skills in categorizing and selecting useful information.

Teamwork skills

☐ 5 points
Team demonstrates above average skills in communication and sharing responsibilities.

☐ 3 points
Team demonstrates average skills in communication and sharing responsibilities.

☐ 1 point
Team demonstrates poor skills in communication and sharing responsibilities.

Adding Up

Science as inquiry .... ____________
Structure and function in living systems . . ____________
Reproduction and heredity .... ____________
Regulation and behavior .... ____________
Abilities of technological design .... ____________
Planning and organizing skills .... ____________
Record-keeping skills .... ____________
Teamwork skills .... ____________

Science skill of observation .... ____________
Science skill of comparing and measuring ____________
Science skill of relating .... ____________
Science skill of applying .... ____________
Planning and organizing skills .... ____________
Record-keeping skills .... ____________
Teamwork skills .... ____________

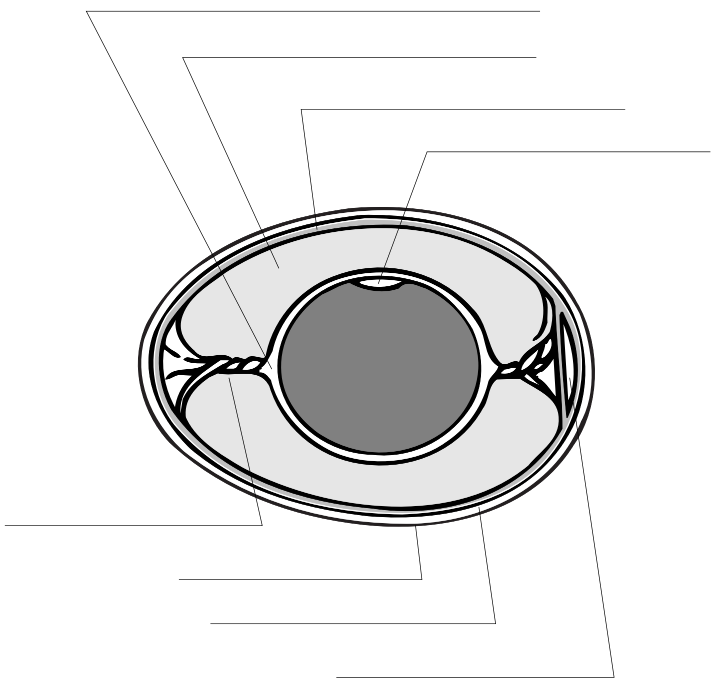
Student name ______________________________

Total points ◯

____
Name

Parts of the egg/nutrition

1 Fill in the blanks with the name of the correct egg part.



What nutrients do the following parts contribute to the embryo?

Yolk ________________ Albumen__________________

Shell__________________

2 Break out an egg.
In the space on the right, draw the top and side view of your egg.

Label the grade.

____

Name

Warming up with eggs

(Incubating eggs)

What's the problem?

Write about why we need to turn the eggs, fill the water canals, and monitor the incubator temperature.

____

____

____

How could you solve the problem?

Write about your ideas for turning the eggs, filling the water canals, and monitoring the incubator temperature.

____

____

____

How could you test your plan?

Share the plan. Listen as each team shares its plans. Write down the ideas that you think are best.

____

____

____

1. **What could you do to improve your ideas?**
   With your teacher's help, work as a class to turn the eggs, fill the water canals, and monitor the incubator temperature. Consider setting up a schedule that would allow teams to rotate responsibilities.

2. **Test your measurements.**
   Using the embryology record sheet, record the temperature each time you turn the eggs and take an average.

____
Name

Try it yourself

Building an eggs-ray viewer

Have you thought about what the chick might look like as it is developing inside the egg? With the candler, you will be able to see different parts of the egg and portions of the chick as it develops. Use your planning skills to design a candler. Answer the following questions to make your plan.

1 What's the problem?

Write about why we need to candle fertile chicken eggs.

____

____

____

2 How could you solve the problem?

Write about your ideas for the candler.

____

____

____

Draw a picture of what the candler will look like.

3 How could you test your plan?

____

____

____

4 Share the plan.

Listen as each team shares their plans.
Write down the ideas that you think are best.

____

____

____

5 How could you improve the candler?

Draw a new picture.

- ☐ Help your team design and make a candler.
- ☐ Test your candler. Candle an egg. Can you see what is inside?

Write down the egg parts that you can identify with the aid of your candler.

____

____

____
Name

Observing an embryo

Life is not always what it seems

Did you know a chicken embryo looks a lot like you did during your first three months of life inside your mother? Don't feel insulted. Many embryos look alike during their early development.

What makes chickens special is that the embryo develops outside the mother's body. This arrangement lets us get a closer look at how the embryo develops without harming the mother or other embryos.

1. **Use the back of this paper to write or draw what you think a chicken embryo looks like.**
2. **After you have observed a developing embryo, draw what you saw in the space below. Then answer the questions.**
3. **Compare what you expected to see and what you actually saw. Write a paragraph explaining the difference between your expectations and what you actually experienced.**

What did you learn?

- [ ] What shape did the embryo have for the first five days of incubation? Draw the shape and label the head, heart and tail. Circle the first part of the embryo you noticed.

What does the yolk sac supply for the embryo?

____

What supplied food for you when you were developing in your mother?

____

What does the amnion (sac of clear fluid that surrounds the embryo) do for the embryo?

____

Break out

How does this activity relate to other life experiences?

Have you ever gotten involved in something or started a project and found that your expectations and what actually happened were different?

How did you adjust your approach to the situation?

What did you learn from those situations?

____
Name

Pecking out who's in charge?

When the chicks hatch, mark them and observe which one is at the top of the pecking order.

Materials needed

- ☐ colored tape or a felt-tip marker
- ☐ stopwatch, watch or clock.

Directions
After the chicks have been in the brooder for one week, mark each one with a small piece of colored tape around the left or right leg or place a small mark on the back of the chick with a felt-tip marker.

Spend 15 minutes each day counting the number of times each chick goes to the feeder and waterer.

After five days, total the number of times each chick went to the feeder and waterer.

Day 1 Date observed: ____________

Chick color	Number time eating	Number times drinking
1.		
2.		
3.		
4.		
5.		

Day 2 Date observed: ____________

Chick color	Number time eating	Number times drinking
1.		
2.		
3.		
4.		
5.		

Day 3 Date observed: ____________

Chick color	Number time eating	Number times drinking
1.		
2.		
3.		
4.		
5.		

Day 4 Date observed: ____________

Chick color	Number time eating	Number times drinking
1.		
2.		
3.		
4.		
5.		

Day 5 Date observed: ____________

Chick color	Number time eating	Number times drinking
1.		
2.		
3.		
4.		
5.		

Weekly Total

Chick color	Total time eating	Total times drinking
1.		
2.		
3.		
4.		
5.		

Would the chick with the highest number be at the top of the pecking order?

____

What could you do to ensure that all the chicks got to eat and drink regularly?

____
____
____

How does the space that the chicks have affect the pecking order?

____
____
____
____
____

Advanced

Embryology record sheet

Name

Day set Day expected to hatch	Number eggs set: Number eggs fertile: Number eggs pipped: Number eggs hatched:	Percent fertility = ______ % (Number of fertile eggs / Number of eggs set) Percent hatchability = ______ % (Number of fertile eggs / Number of eggs set) Hatch = ______ % (Number of fertile eggs / Number of eggs set)

Every time the eggs are turned make an entry in each column. Make special notes if the class did anything other than turn the eggs, i.e., add water, candle, weigh eggs, other experiments and activities that could have affected the eggs, etc.

Date			Temperatures			Special Notes
	Time Turned		In Room	In Incubator	Humidity	
Day 1	1st					
	2nd					
	3rd					
Day 2	1st					
	2nd					
	3rd					
Day 3	1st					
	2nd					
	3rd					
Day 4	1st					
	2nd					
	3rd					
Day 5	1st					
	2nd					
	3rd					
Day 6	1st					
	2nd					
	3rd					
Day 7	1st					
	2nd					
	3rd					
Day 8	1st					
	2nd					
	3rd					
Day 9	1st					
	2nd					
	3rd					

Advanced

Embryology record sheet *continued*

Date	Time Turned		Temperatures			Special Notes
			In Room	In Incubator	Humidity	
Day 10	1st					
	2nd					
	3rd					
Day 11	1st					
	2nd					
	3rd					
Day 12	1st					
	2nd					
	3rd					
Day 13	1st					
	2nd					
	3rd					
Day 14	1st					
	2nd					
	3rd					
Day 15	1st					
	2nd					
	3rd					
Day 16	1st					
	2nd					
	3rd					
Day 17	1st					
	2nd					
	3rd					
Day 18	1st					
	2nd					
	3rd					
Day 19	1st					
	2nd					
	3rd					
Day 20	1st					
	2nd					
	3rd					
Day 21	1st					
	2nd					
	3rd					

Egg-stra notes

Poultry resources

Breed reference

American Bantam Standard
American Bantam Association
P. O. Box 127
Augusta NJ 07822
e-mail: fancybntms@aol.com

American Standard of Perfection
American Poultry Association
133 Millville St.
Mendon MA 01756-1210
(508) 473-8769
e-mail: apanetcontact@home.com

Extension publications

The following publications are available from:

Extension Publications
630 W. Mifflin St.
Madison WI 53706
(608) 262-3346

- *Bantams* NCR 209
- *Chicken Breeds and Varieties* A2880 (1989)
- *Home Slaughter of Poultry* A1478 (1989)
- *Poultry for Fun and Food* 4H281 (1993)
- *Pigeons* 4H135 (1985)
- *Raising a Small Turkey Flock* NCR060 (1981)
- *Raising Waterfowl* A3311

4-H "Skills for Life" Poultry Science Series

- NCR 507 Poultry 1 – *Scratching the Surface*
- NCR 508 Poultry 2 – *Testing Your Wings*
- NCR 509 Poultry 3 – *Flocking Together*
- NCR Poultry 4 – *Group Activity Guide*

Minnesota Chicken Pattern BU–2350
Distribution Center
20 Coffey Hall
Minnesota Extension Service
University of Minnesota
St. Paul MN 55108
(612) 625-8173

Poultry Judging 408-050
Cooperative Extension Bulletin Distribution
P. O. Box 68583
University of Nebraska
Lincoln NE 68583
(402) 472-9712
(402) 472-0542 fax
e-mail: gnickels@unl.edu

National poultry archives

National 4-H Poultry and Egg Conference
Contact: Ken Koelkebeck
282 Animal Sciences Lab
1207 West Gregory Dr.
University of Illinois
Urbana IL 61801
(217) 244-0195
http://www.ext.vt.edu/national4hpoultry/index.html

Organizations

American Egg Board
1460 Renaissance Dr.
Park Ridge IL 60608
http://www.aeb.org/

American Bantam Association
P. O. Box 127
Augusta NJ 07822

American Poultry Association
133 Millville St.
Mendon MA 01756-1210
(508) 473-8769
e-mail: apanetcontact@home.com
http://www.ampltya.com/

Poultry Science Association
111 N. Dunlap Ave.
Savoy IL 01874
(217) 356-3182
http://www.psa.uiuc.edu/

National Chicken Council
1155 15th St. NW
Washington DC 20005
(202) 296-2622
http://www.eatchicken.com/

The National Turkey Federation
1225 New York Ave. NW, Suite 400
Washington D.C. 20005
(202) 898-0100
(202) 898-0203 fax
http://www.turkeyfed.org/

U.S. Poultry & Egg Association
1530 Cooledge Road
Tucker GA 30084
Telephone: (770) 493-9401
Fax: (770) 493-9257
http://www.poultryegg.org/

Periodicals

Game Breeders Gazette
1155 E. 4780 South SS
Lake City UT 84117

Hen House Herald
(exhibition poultry)
Box 1647
Easley SC 29641

Poultry Digest
(egg and meat chickens)
Watt Publishing Co.
122 S. Wesley Ave.
Mount Morris IL 61054

Poultry Press (monthly)
P. O. Box 542
Connersville NY 47331
http://www.poultrypress.com/pp

Turkey World
Watt Publishing Co.
122 S. Wesley Ave.
Mount Morris IL 61054

Supply catalogs

Carolina Biological Supply
2700 York Rd.
Burlington NC 27212
(800) 334-5551

Wards Natural Science, Inc.
5100 West Henrietta Rd.
P. O. Box 92912
Rochester NY 14692
(800) 962-2660

"Development of the Chicken Embryo" (color poster)
Jamesway Incubator Company
1712 Williams Rd.
P. O. Box 629
Monroe NC 28111
(704) 291-9113

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- Outdoor Adventures

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- Gardening

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- Science Discovery Series

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- Child Development—Kids on the Grow
- Keeping Fit and Healthy

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- Foods
- Microwave Magic

Citizenship

Communication and Expressive Arts
- A Palette of Fun
- Communications—Express Yourself!
- Photography
- ¡Qué Rico! Latino Cultural Arts
- Theatre Arts
- Visual Arts

Community Action
- Citizenship—Public Adventures
- Service Learning

Leadership
- Exploring 4-H
- Step Up To Leadership

Personal Development
- Consumer Savvy
- Financial Champions

Workforce Preparation
- Be the E—Entrepreneurship
- Get in the Act!

Resources

- Experiential Learning Video

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www.4-hcurriculum.org

6 Day Embryo

The 4-H Pledge

I pledge
my Head to clearer thinking,
my Heart to greater loyalty,
my Hands to larger service, and
my Health to better living,
for my club, my community,
my country, and my world.

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