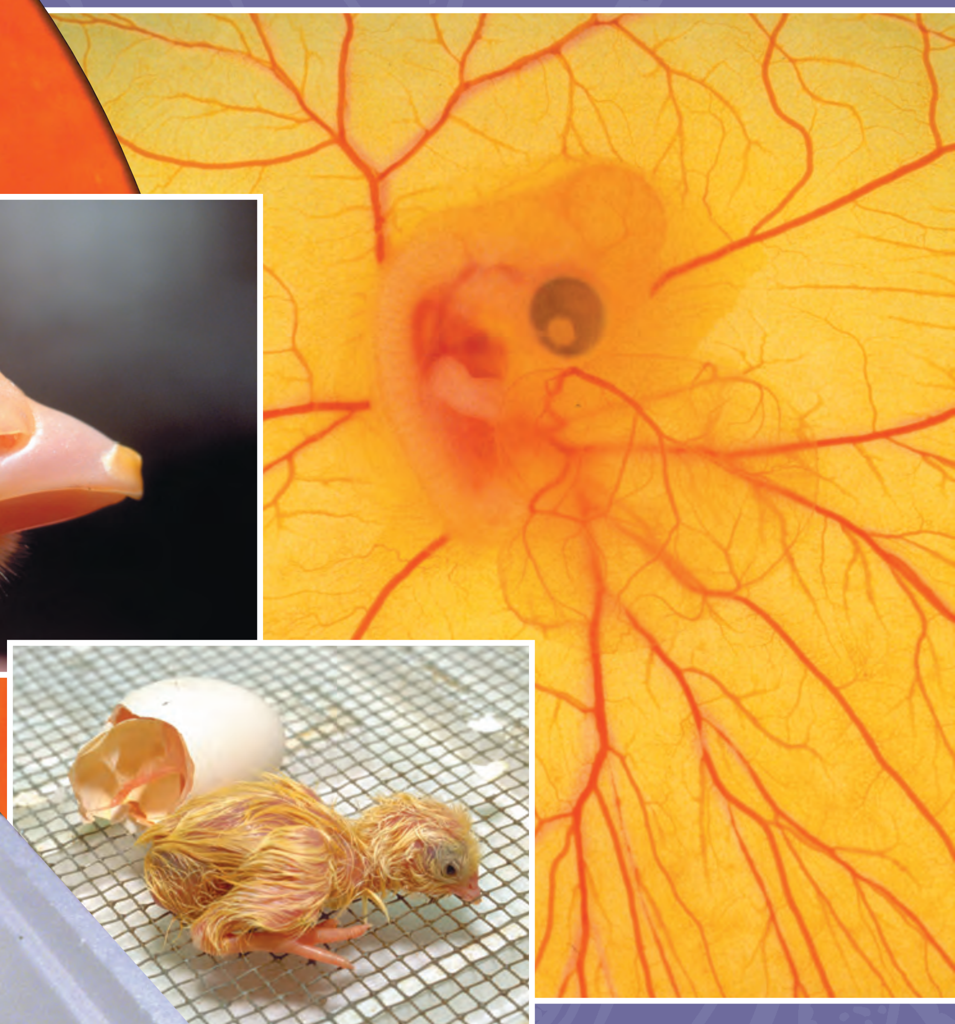
National 4-H Curriculum
BU-07595

Embryology IN THE CLASSROOM

Hatching Classroom Projects



Helper's Guide
Beginner
Grades 2-5

REVIEWED & RECOMMENDED
National 4-H Curriculum

Dear Educator,

*Embryology: Hatching Classroom Project*s 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—by 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, managing, thinking, working, relating and living a healthy lifestyle.

We hope that *Embryology: Hatching Classroom Projects* 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 kids who worked with our pilot:

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

> *"Watching the eggs hatch and getting to play with the little chicks."*
>
> *"Seeing the cute little chicks after they had hatched."*
>
> *"Seeing how the embryos develop inside the shells. I also liked watching the chicks get their first white feathers and see them grow."*
>
> *"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

Design Team: Phillip J. Clauer, Design Team Chairperson, Extension Poultry Specialist, Virginia Tech; Donna Bailey, 4-H Extension Agent, Maryland; Caitlin Boon, Poultry Science Student; Debbie Curry, Vice President Programs and Education, Discovery Place, Inc., Nature Museum; Gary Davis, Extension Poultry Specialist, NC State University; Mickey Hall, Extension Poultry Specialist, Clemson; Ed Maxa, Extension 4-H Specialist, NC Cooperative Extension Service.

Writing: Mark Jost
Editing: Kate McCarthy
Photography: Mark Sumner, Virginia Tech
Design and Production: Northern Design Group, MN

Other assistance from:
Tom Zurcher
Jim Adams
Pam Segall–Roberts

Hatching Classroom Projects

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Embryology and the National Science Standards

A classroom unit in embryology will help you meet the following National Science Standards:

Abilities necessary to conduct scientific inquiry

Ask questions about objects, organisms and events in the environment.

Plan and conduct a simple investigation.

Use simple equipment and tools to gather data.

Use data to construct a reasonable explanation.

Communicate investigations and explanations.

The characteristics of organisms

Organisms have basic needs. Organisms can survive only in environments in which their needs can be met.

Each animal has different structures that serve different functions in growth, survival and reproduction.

The behavior of individual organisms is influenced by internal cues and by external cues.

Life cycles of organisms

Animals have life cycles including birth, maturation, reproduction and death.

Animals closely resemble their parents.

Organisms and their environments

All animals depend on plants. Some animals eat plants for food. Other animals eat animals that eat the plants.

An organism's patterns of behavior are related to the nature of that organism's environment, including the kinds and numbers of other organisms present, the availability of food, resources and the physical characteristics of the environment.

Abilities of technological design

Identify a simple problem.

Propose a solution.

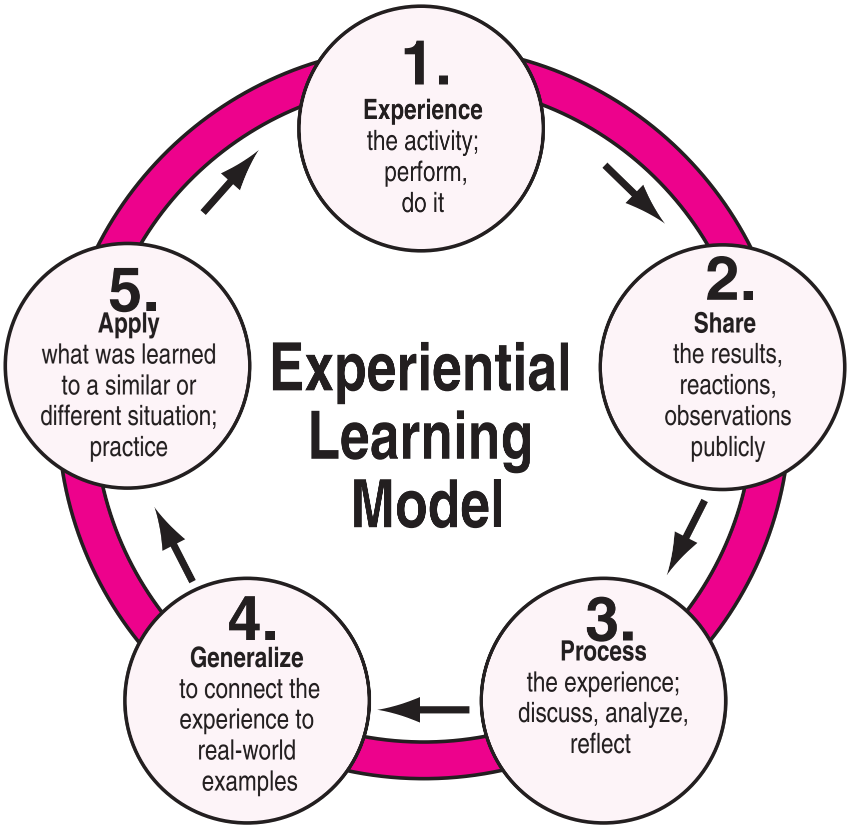
Implement proposed solutions.

Evaluate a product or design.

Communicate a problem, design and solution.

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 we can learn that will help us 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, identifying the control and variables in an investigation.

Poultry incubation

The Activities	Embryology Skill	Life Skill	Science Skill
Eggsploring the egg Page 14	Identifying parts of eggs	Learning to learn	Observing
Pick a chick Page 16	Selecting chicken breeds by characteristics	Communication and decision making	Categorizing
Warming up with eggs Page 18	Incubation of fertile eggs	Planning and organizing	Observing
Building an eggs-ray viewer Page 20	Preparing a candler	Relating to others, cooperation	Comparing and measuring
Playing peek-a-boo with embryos Page 22	Observation of embryos	Record keeping	Observing, communicating, relating
Building a home 'tweet home Page 24	Preparing a brooder	Planning and organizing	Comparing and measuring
Counting the chicks Page 26	Connecting embryology and math	Record keeping	Comparing and measuring
Caring and handling Page 28	Handling chicks safely	Relating to others	Observing and communicating
Eggsploring careers Page 30	Exploring careers in the poultry industry	Developing teamwork	None

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.

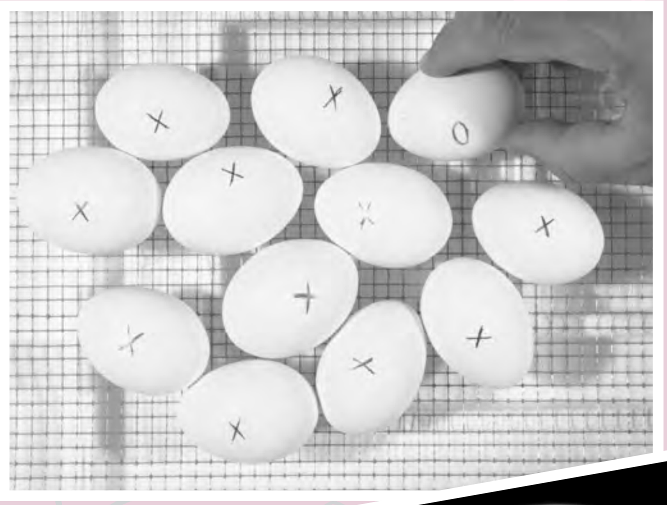
1. For a basic observation and hatching project, 12 eggs per incubator are adequate. If you are planning to do an experiment or activities, additional eggs may be required.
2. When you obtain fertile eggs from a source that does not routinely hatch its own eggs, you may want to test the eggs in an incubator 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.

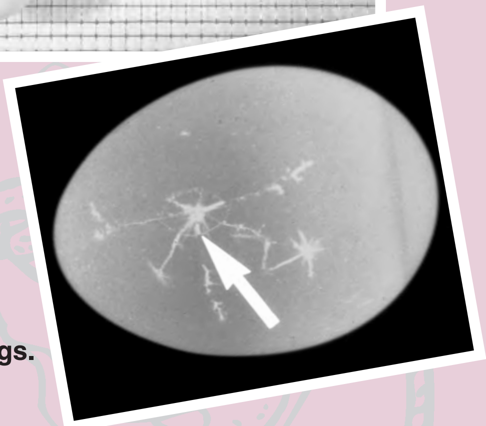
1. The eggs should be collected within four hours after they are laid.
2. If it is necessary to store fertile eggs before setting, store small end down at a temperature between 50 and 65°F and at 70 percent humidity.
3. Never store eggs more than 10 days after the eggs are laid. Hatchability drops quickly 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. Remember to wash hands.

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.

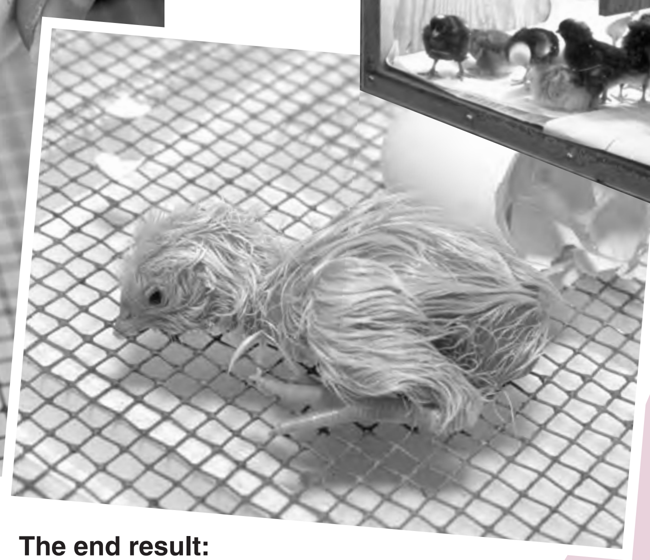
C. The brooder should have textured, absorbent litter on the floor. If the floor is slippery, the chicks can damage their legs. Pine or cedar shaving or textured paper towel work best in the classroom.

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.

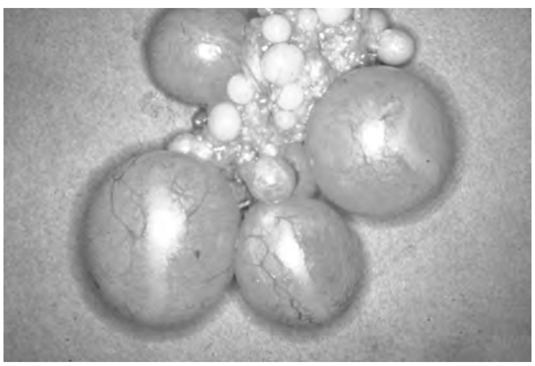


Figure 7 – Ovary

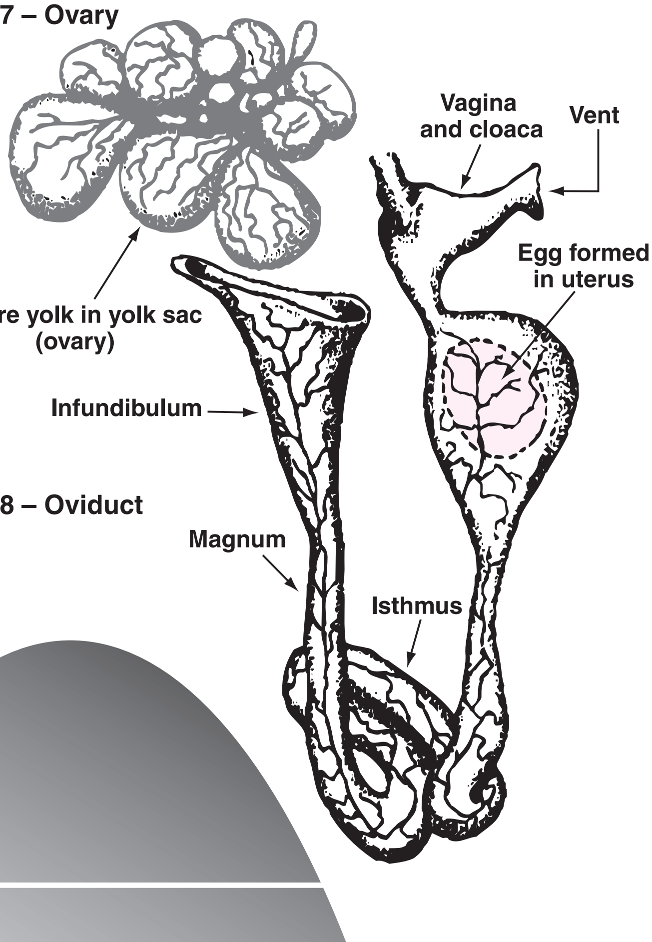


Figure 8 – Oviduct

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.

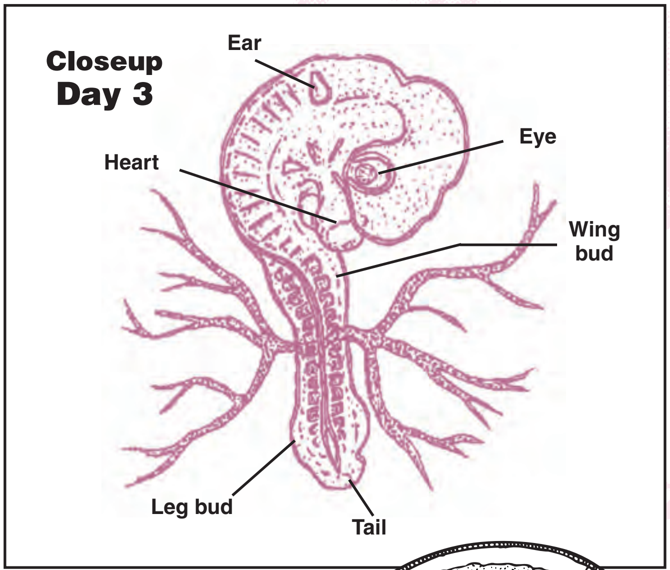
20 hours — Appearance of vertebral column.

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.

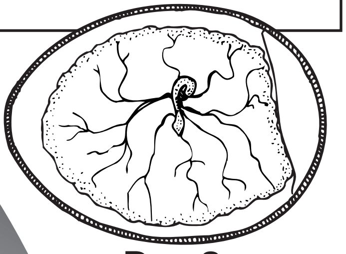
Main division of legs and wings.

Voluntary movement begins.

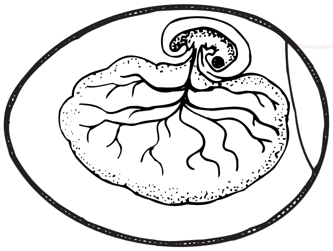
Day 7

Digits on legs and wings become visible.

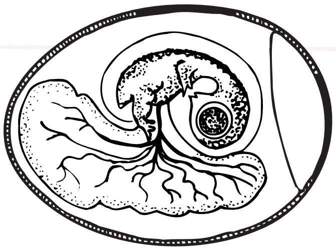
Abdomen becomes more prominent due to development of viscera.



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.

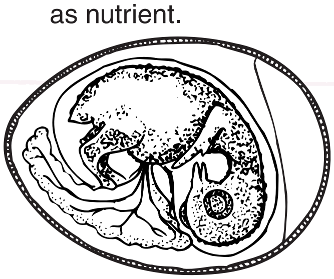
Allantois ceases to function and starts to dry up.

Day 21

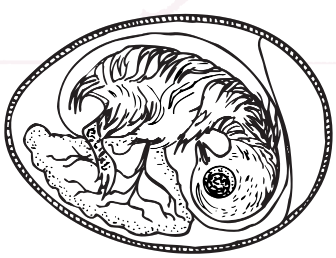
Chick hatches.

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

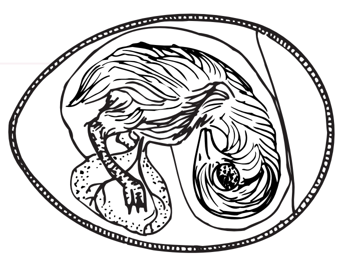
Coturnix (Japanese) quail	16–18 days
Chicken	21 days
Pheasants	24–26 days
Ducks	28 days
Geese	28 days
Guinea	28 days
Turkey	28 days
Swan	35 days
Muscovy duck	35 days
Ostrich	42 days



Day 12



Day 15



Day 18

Day 20