Incubation Handbook
A hobbyist’s guide to hatching backyard poultry

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Incubation Checklist

This checklist highlights several important factors to consider during the incubation process but does not serve as a substitute for reading and understanding all factors outlined in this guide.

☐ **DO** prepare your breeding stock prior collecting incubation eggs including selecting the best, unrelated parents, worming your birds, feeding high quality feed, and cleaning nests, & renewing nesting material.

☐ **DO** carefully plan your incubation and hatch schedule. Whenever possible, avoid setting eggs at different times or of different species unless you have a second incubator dedicated to hatching only.

☐ **DO NOT** wash or refrigerate eggs for incubation. For best results, use eggs that are less than 7 days old. However, eggs up to 14 days old can be successfully hatched if stored correctly.

☐ **DO** consider the accuracy of any digital thermometer you decide to purchase. Most thermometers are only accurate to +/1.0 to 2.0° when an accuracy of +/0.1 to 0.2° is required.

☐ **DO NOT** trust the gauges built into your incubator. **DO** use a separate, calibrated thermometer to monitor the incubation environment. Improper temperature control is the primary reason for hatch failure.

☐ **DO** place your incubator in a room with a steady temperature, away from windows, drafts, or direct sunlight. Difficulties with regulating an incubator are often the result of poor incubator placement.

☐ **DO** calibrate and regulate your incubator at least 48 hours prior to setting eggs. For best results, use water bottles to fill empty space during the regulation and calibration process.

☐ **DO** become familiar with warm and cool spots within your incubator by measuring the temperature at various locations during the regulation and calibration process.

☐ **DO NOT** keep your eggs in the same spot for the entire incubation period. For best results, move the eggs sitting on the outer edges to the center and the eggs sitting in the center to the outer edges daily.

☐ **DO NOT** fiddle with the thermostat while eggs are in the incubator. Some fluctuation in temperature is normal and you’re likely to cause more problems by fiddling with the temperature controls.

☐ **DO** remove any automatic egg turner at the beginning of day 19 to avoid injury or death of newly emerged hatchlings.

☐ **DO** completely fill troughs/pans full prior of water prior to lockdown – the last three days of incubation. **DO NOT** open the incubator unless absolutely necessary until the hatch is complete.

☐ **DO** add sufficient warm, wet sponges during lock down to raise the humidity to at least 60% or until a small amount of moisture accumulates on the viewing pane.

☐ **DO** remember that chicks burn a great deal of oxygen during the hatching process. **DO** remove any vent plugs during lockdown. **DO NOT** sacrifice fresh air for humidity during the final days.

☐ **DO** remember that hatchlings live for 36-48 hours after hatch by feeding from the absorbed egg yolk. The bumping of unhatched eggs by hatchlings encourages the unhatched to pip, zip, and emerge.

☐ **DO** remember that 12 or more hours may elapse from the first pip to the first emergence and that hatching is an exhausting process... hatchlings may rest for extended periods of time during the process.

☐ **DO NOT** assist eggs during the hatching process unless it is absolutely necessary. In most cases, a healthy hatchling will emerge on their own and assisting can easily cause more harm than good.

☐ **DO** carefully evaluate your hatch results using the recommendations in this guide. **DO** view each hatch as a learning process with a primary goal of improving with each subsequent batch.

☐ **DO NOT** forget that home flock hatching should be an enjoyable process... not every egg will hatch and not every hatchling will survive. Celebrate your successes and do not focus on your failures.
Beginner's Guide

- **TARGET AUDIENCE:** Chicken eggs take 21 days of incubation under a specific temperature and humidity. While not rocket science, the challenge can seem overwhelming for beginners. This section is intended to assist inexperienced hobbyists who want to incubate a small number of eggs in a desktop foam incubator.

- **EGG COLLECTION & STORAGE:** Proper egg collection and storage has a significant impact on hatching success.
  1. Use fresh, large pine shavings to line nesting boxes or nesting areas. Replace any soiled lining as soon as it becomes contaminated.
  2. Thoroughly WASH YOUR HANDS prior to collection and use a clean container for collection.
  3. Collect eggs two or three times a day, more frequently if temperatures are unusually high or low.
  4. Remove eggs that are unusually dirty, large, small, or misshaped as these eggs hatch poorly and consume valuable incubator space.
  5. Using a pencil or non-toxic marker, label eggs with the species, pen, date laid, and any other important information. These markings aid in identifying hatchlings and assist with accurate record keeping.
  6. DO NOT WASH or wipe off dirt or waste from the egg. If the egg is marred by a small amount of waste, allow it to dry and then gently scrape it off with a finger nail. Washing, wiping, or sanding dirty eggs removes the bloom, the natural antibacterial coating and also pushes any contamination into the pores.
  7. Store eggs in new, paper cartons with the small end down at a temperature between 65-69°F. Tilt the container to its side 45° and change the direction daily. Do not store eggs in the refrigerator as the temperature is too cold and will have a negative impact on hatching and chick health.
  8. For best results, store eggs for no longer than 10 days. However, clean eggs stored at 55-62°F and a humidity of 70% and turned daily can remain viable for up to 21 days.

    Whenever possible, AVOID mixing eggs in different stages of development in the same incubator – doing so complicates hatching and may lead to poor results. It is better to collect and carefully store eggs for 14-18 days and hatch all eggs at the same time.

  9. Allow cool eggs to warm to 75-80°F for 4-6 hours before placing in the incubator.
  10. **SHIPPED EGGS:** Shipped eggs should be allowed to settle with the large end pointed up for at least 24 hours prior to setting. This settling may help any detached air cell to reattach before incubation.

- **THERMOMETERS:** An accurate and consistent temperature is essential to a successful hatch.
  1. DO NOT TRUST the gauges built into the incubator and DO NOT use the small, cheap thermometers that might have come with your incubator.
    - An inexpensive red spirit filled, glass thermometer is well suited for desktop incubation:
      - They react well to changes in temperature without overreacting like digital ones.
      - They are easily obtained from Wal-Mart, Lowe’s, or Tractor Supply.
      - They are easily calibrated to ensure temperature readings are accurate.
      - They are necessary when checking the accuracy of digital thermometers.
      - They are not difficult to read if you draw a clear red line at the target temperature.
  2. When buying a separate digital thermometer, BE SURE that it has an ACCURACY of not less than ±0.2°F.

    There is a huge difference between READOUT PRECISION and ACCURACY. Although a thermometer may read 99.5°F, it may not be accurate to that 0.1°F. Carefully check the package and be sure it says, “Reads to 0.1°F with an accuracy of ± 0.2°F.”

  3. **DO CALIBRATE** your thermometer by submerging in settled ice water. It should read 32°F. Most digital thermometers cannot be calibrated but must be checked against an old fashioned glass thermometer. To calibrate a glass thermometer, submerge it in melting ice water – it should read 32°F. If not, loosen the glue, slide the glass portion up or down until it is accurate, and then place a drop of hot glue to reattach.
**INCUBATOR PREPARATION**: Incubators should be calibrated **AT LEAST TWO DAYS BEFORE** setting eggs.

1. Read the instructions that came with the incubator. While most provide very little information, the instructions will help you learn how to operate your incubator and troubleshoot most problems.

2. Place your incubator in a room with a steady temperature. Place the incubator away from heating/cooling vents, direct sunlight, or drafts. It is impossible to maintain a consistent incubator environment if room conditions are constantly changing. Many beginners find it helpful to place their incubators in an unused closet or bathroom.

3. Place your separate, calibrated thermometer in the middle of the incubator where it is easily visible through the viewing pane. Use this thermometer to calibrate your incubator’s temperature.

4. Turn on your incubator and allow a warm-up period of no less than two or three hours. When making adjustments, make only small ones and allow at least one hour between adjustments. Do not expect the temperature calibration to take less than 24 hours.

   **AVOID** getting in a hurry to set your first batch of eggs. Most beginners get into trouble by not taking the time to ensure that their incubator is operating properly, that the temperature is steady, and that the humidity is constant.

5. **TEMPERATURE SETTINGS**: Temperature should be measured at the top of the eggs. When calibrating your incubator, place your thermometer on top of eggs that you can throw away when the calibration process is complete. Circulated air incubators (those with a fan) operate best at a consistent temperature of 99.5° F. Still air incubators (those without a fan) operate best at a consistent temperature of 101.0-101.5° F. Your incubator instructions may give a different recommended temperature; for best results, follow your incubator instructions.

6. **HUMIDITY SETTINGS**: The best humidity setting for chicken eggs is often debated. I prefer a humidity of between 43% and 48% for days 1-18 increasing the humidity to about 65% on days 19-21. When calibrating your incubator, fill only one water chamber at first. Check your humidity, and fill a second chamber if your reading is low. **DO NOT TRUST** the built in gauge rather use a separate hygrometer.

   **CHECKING YOUR HYGROMETER**: Dampen a towel (not dripping wet) then wrap the hygrometer in the towel for 30 to 45 minutes. Then unwrap it and quickly read the humidity; it should read exactly 100%. You should make a mental note of how far over or under the actual humidity is from the reading from your hygrometer.

**SETTING EGGS – NO AUTOMATIC TURNER**: **DO NOT** attempt to set any eggs until the incubator’s temperature and humidity has been stable for at least 24 hours doing so will lead to multiple problems that are difficult to correct once eggs are in the incubator.

1. Allow the eggs to warm if they have been stored below 75-80° F.

2. Using a pencil, mark one side of each egg with an X and the other side with an O. These markings will help ensure that each egg is completely turned.

3. Lay the eggs on their side, on top of the mesh, in the middle of the incubator. It is perfectly fine for the eggs to touch but they should not be overly crowded or stacked.

4. Close the lid, walk away, and do not return for several hours. It is normal for the incubator to take some time before warming to the set temperature. It is also not uncommon for the temperature to spike a degree or two above the set temperature after setting eggs. **Avoid fiddling with the thermostat during the first 24 hours.**

5. Before opening the incubator to turn your eggs, examine your temperature and humidity readings. While you will need to occasionally add water to keep the humidity up, you should not need to touch the thermostat. If the temperature is off, do nothing and check the temperature in another hour. If the thermometer continues to read high or low, you may carefully make a small adjustment.
Temperatures normally fluctuate from time to time. If your incubator has difficulty maintaining the set temperature, look at where you placed your incubator... perhaps a more stable place will help. Always be reluctant to alter your thermostat settings as fiddling with the thermostat frequently causes more problems than it solves.

6. Three times a day – morning, afternoon, and bedtime – move the eggs in the middle to the edge and roll the ones on the edge to the center. Check to ensure that each egg has been turned by checking your X’s or O’s.

- **SETTING EGGS – WITH AUTOMATIC TURNER:** *DO NOT* attempt to set any eggs until the incubator’s temperature and humidity has been stable for at least 24 hours doing so will lead to multiple problems that are difficult to correct once eggs are in the incubator.

1. Allow the eggs to warm if they have been stored below 75-80° F.
2. Identify the large end of the egg and draw a small circle on that end with a pencil. If you have difficulty determining which end is the large one, place a small flashlight on each end – the large end contains the air cell.
3. Place the eggs in the center section of the turner with the large end up – the small (pointy) end down.
4. Close the lid, plug in the auto-turner, walk away, and do not return for several hours. It is normal for the incubator to take some time before warming to the set temperature. It is also not uncommon for the temperature to spike a degree or two above the set temperature after setting eggs. *Avoid fiddling with the thermostat during the first 24 hours.*
5. Twice daily check your temperature and humidity. While you will need to occasionally add water to keep the humidity up, you should not need to touch the thermostat. If the temperature is off, do nothing and check the temperature in another hour. If the thermometer continues to read high or low, you may carefully make a small adjustment.

Temperatures normally fluctuate from time to time. If your incubator has difficulty maintaining the set temperature, look at where you placed your incubator... perhaps a more stable place will help. Always be reluctant to alter your thermostat settings as fiddling with the thermostat frequently causes more problems than it solves.

6. Some automatic turners turn at a very slow pace and you may not see any motion. Occasionally, take a look at which way the eggs are tilted. You know that your egg turner is working when the eggs are tilted in different directions at various times.

- **CANDLING EGGS:** Candling is not a necessity but can help ease anxiety about how eggs are progressing.
1. Candling is the process of applying a strong light to the outside shell allowing a glimpse of the inside. A small LED flashlight and a dark room is sufficient to candle lightly colored eggs, many utilize their smart-phone flashlight app.
2. Most people candle their eggs on day 7, 10, and 18. However, on day 4 you should be able to see a small reddish embryo with blood vessels in white eggs. For darker colored or thick eggs, you may not be able to see much until after day 10.

![Day 0](image1.png) ![Day 4](image2.png) ![Day 7](image3.png) ![Day 14](image4.png) ![Day 18](image5.png)

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3. Eggs that are clear and show no signs of development may be discarded on day 10. If in doubt, leave the egg in the incubator. If an egg develops a bacterial infection, it probably will develop an odor. You can locate the bad egg by sniffing each egg individually.

4. Potential problems such as cracks or internal bacterial infections should be removed as early as possible to prevent possible contamination of other eggs.

5. You will also want to examine the size of the air cell. The longer the egg is in the incubator, the more water will evaporate. This is normal. If the humidity is too high, the air cell will be small. If the humidity is too low, the air cell will be large. The air cell should approximate the size illustrated to the right.


- **HATCHING**: How many chicks will hatch? There are numerous variables involved in incubation and if any single variable goes wrong, a chick will not hatch. For your first few hatches, focus on your successes not your failures.

1. **TIMING**: Lockdown begins at the end of day 18 and includes days 19, 20, and 21.

2. **AIR VENTILATION**: Remove all plugs from ventilation holes. Hatching requires great physical exertion and the chicks need fresh air in order to prevent exhaustion and possible death.

3. **TURNING**: Eggs should be removed from the turner and placed on their side with the large end angled slightly upward.

Some hobbyists prefer to allow eggs to stay in the turner during hatching; they simply unplug the automatic turner. Eggs remaining in the upright position place the chick in an unnatural position delaying hatching and making zipping more difficult. For best results, remove the eggs from the tray and lay them on their side.

4. **HUMIDITY**: Humidity should be increased to 65-70%. Fill all chambers in the lower portion of the incubator with water. If additional moisture is needed, add as many warm, wet sponges as needed.

Many beginners become overly worried about humidity during these last three days. If a small amount of moisture forms on the viewing pane then you know your humidity is sufficient. When the chicks begin to emerge, the humidity will naturally increase – don’t worry, the chicks will not drown from this extra humidity.

5. **CLOSED LID**: Close the incubator lid and keep it closed. Open the incubator only if additional water is needed performing the task as quickly as possible.

The membrane that protects the chick from outside bacteria or an excess loss of water during incubation can dry out in as little as 60 seconds if humidity is lost during the hatching process. Once dried out, this membrane prevents the chick from hatching and becomes a death shroud. Guarding your humidity – it’s a matter of life and death.

6. **INTERNAL PIPPING**: One or two days before hatching, the chick will puncture the air cell membrane with its beak and begin to breathe. You may hear chirping at this time. If the humidity level is low during this time, the air cell membrane may dry out making it difficult or impossible for the chick to puncture it. Chicks who cannot puncture this membrane will eventually suffocate – they will drown.

7. **EXTERNAL PIPPING**: On the day of hatch, the chick will punch a small hole in the shell – pipping. After the initial pip, the chick may rest for 12 or more hours before continuing.

8. **ZIPPING**: Once the initial hole is made, the chick will turn inside the shell and proceed to make a crack around the diameter of the shell – zipping. If the humidity is low during this process, the membrane may dry out, shrink, and the chick may become stuck – shrink wrapped. The task of zipping may take anywhere from a few minutes to a few hours.

9. **EMERGENCE**: Once zipping is complete, the chick may rest for a spell. Once it regains strength, it will push against the bottom of the shell using its feet eventually freeing itself from the shell.
Assisting a chick too early can easily result in permanent harm or death. In most cases, a healthy chick will rest periodically and will emerge in time. If you decide you must assist a chick, please use caution and follow the advice in the following article:


10. **UMBILICAL CORD**: Prior to hatching, the chick will absorb the remainder of the egg yolk and the blood vessels attached to the shell contends will dry out. If a chick emerges too quickly, what appears to be an umbilical cord will be attached to its bottom. This cord will fall off without any assistance.

11. **HERNIATED YOLK SAC**: On rare occasions, a chick will emerge from its shell before the egg yolk is completely absorbed – herniated yolk sac. It should absorb on its own if the area remains moist.

12. **PATIENCE**: Even the experienced feel anxiety at hatch time; beginners may be overwhelmed with excitement and concern. Be patient. Mother Nature has designed each step in the process for a reason and each step takes time.

13. **EARLY HATCHING**: If the incubation temperature has been a little high throughout incubation or the eggs are small, the chicks may begin to hatch early. If they do, there is little you can do except maintain your temperature and humidity.

14. **LATE HATCHING**: If the incubation temperature has been a little low throughout incubation or the eggs are large, the chicks may begin to hatch late. If they do, there is little you can do except maintain your temperature and humidity.

15. **ENDING THE HATCH**: How long should you give an egg to hatch? Many people wait 2-3 days after the due date before discarding unhatched eggs. Personally, I will end the hatch a few hours after any visual activities have stopped. With experience, you will adopt your own preference on how long to wait.

16. **REMOVING HATCHLINGS**: Hatchlings should be completely dry and actively moving about before removing from the incubator. Hatchlings absorb their egg yolk just prior to hatch and can easily survive 36-48 hours after hatch without food or water. In most cases, it is best to wait until the entire hatch is complete before removing any hatchlings... Do not be in any hurry to remove hatchlings.

17. **CLEAN-UP**: Although styrofoam incubators appear flimsy and easy to destroy, they are actual durable. After the hatch, gently remove gunk using dish soap and a gentle brush – some soaking may be necessary. Then saturate all non-electronic surfaces with a 10% bleach solution, rinse completely, and allow to air dry. Bright sunlight is one of the most effective means to disinfecting your incubator.

18. **HATCH EVALUATION**: In order to improve future hatches, carefully consider what went right and what went wrong with each batch. Consider the following:

- **DID THE CHICKS HATCH ON TIME?** If they hatched early, then your temperature may have been a little high. If they hatched late, then your temperature may have been a little low. You may need to recalibrate your thermometer.

- **DID ALL EGGS HATCH WITHIN A 24 HOUR PERIOD?** If more than 24 hours transpired between the first chick and the last chick, then you may have warm and cool spots. Randomly moving the eggs around periodically will prevent an egg from staying within a warm or cool spot for a long period of time. Additionally, eggs will begin developing if they are stored in temperatures above 70° causing older eggs to hatch a little earlier than fresh ones. When possible, store eggs at below 70 °.

- **EGGTOPSY**: Not all chicks will hatch. There are multiple reasons why this occurs from hen nutrient deficiencies, cold temperatures during collection, bacterial contamination, genetic flaws, and flaws in incubation methods. Eggs that did not hatch should be opened and examined to determine, if possible, why the chick failed to hatch. The following link from The Chicken Chick provides an excellent look at the stages of development: http://www.the-chicken-chick.com/2012/03/chicken-embryo-development-views-from.html.
# PROBLEM SOLVING

<table>
<thead>
<tr>
<th>Problem</th>
<th>Possible Causes</th>
</tr>
</thead>
</table>
| Eggs candle clear | ♦ Rooster too young or too old  
♦ Too many hens for each rooster  
♦ Poor hen health  
♦ Eggs stored at below 40° F |
| Eggs candle clear with blood ring present | ♦ Eggs stored too long  
♦ Eggs stored at wrong temperature  
♦ Spike in temperature  
♦ Excessively high temperature  
♦ Hens too old or in poor health |
| Dead embryos before day 18 | ♦ Insufficient turning  
♦ Lack of ventilation  
♦ Dirty eggs – pores blocked  
♦ Egg contamination  
♦ Hens too old or in poor health |
| Eggs pipped but not hatched | ♦ Low average humidity  
♦ Low average temperature  
♦ Low humidity at hatching time  
♦ Insufficient turning  
♦ Lack of ventilation |
| Chick dead in shell  
Sticky chicks  
Shell sticking to chick | |
| Chick pips wrong end | ♦ Eggs incubated small end up  
♦ Inadequate turning  
♦ Not placed on side end of day 18 |
| Eggs hatch early | ♦ Temperature too high  
♦ Small eggs  
♦ Humidity too low days 1-18 |
| Eggs hatch late | ♦ Temperature too low  
♦ Large eggs  
♦ Humidity too high days 1-18 |
| Hatch window longer than 24 hours | ♦ Eggs stored above 70° F  
♦ Temperature variations in incubator  
♦ Mix of both large and small eggs  
♦ Mix of eggs from young and old hens  
♦ Eggs stored for different lengths of time |
| Crippled chicks | ♦ Air cell too large – low overall humidity  
♦ Poor nutrition of hens  
♦ Genetic defects |
| Weak chicks | ♦ Temperature too high at hatching  
♦ Lack of ventilation  
♦ Contaminated eggs |
NOTES

- **BAD EGGS:** Eggs with severe bacterial infections can be identified during candling by multiple small dark spots floating within the egg or by an unusually large dark area. For best results, compare a questionably bad egg with other eggs that possess a normal appearance.

  There should be very little odor coming from your incubator. If you notice an unusual smell, open the incubator and sniff each egg individually. Removing any egg that smells will reduce the chances of a bad egg leaking or exploding and contaminating other eggs within the incubator.

- **CLEANLINESS:** Placing porous, cloth shelf liner placed on top of the mesh prior to hatching will allow moisture to pass through from the bottom water chambers but prevent the gunk from dropping into the lower portion of the incubation... easing the task of cleaning the incubator following a hatch.

- **CRACKED EGGS:** It is generally a bad idea to incubate cracked eggs; it is also generally a good idea to discard any eggs that develop a crack during incubation. However, if an expensive or prized egg has or develops a crack, the cracked can be repaired using a small amount of un-perfumed wax. Use as little as possible and watch the egg during hatching as the seal may make hatching more difficult.

- **FERTILITY:** The fertility rate is calculated by dividing the total number of eggs that show signs of development by the total number of eggs set. \[ \frac{28 \text{ set}}{30 \text{ show development}} = 0.93 \text{ or } 93\% \] The recommended rooster to hen ratio is 1 rooster for every 8-10 hens. In some breeds such as rare bantams, that ratio may be lower – 1:6. A hen generally remains fertile for 10 days following the removal of a rooster. To guarantee that chicks are fathered by a specific rooster, hens should be separated from other roosters for three or four week.

- **HUMIDITY:** Humidity is determined by surface area not water depth. To increase the humidity, increase the area water is exposed to the air either by using a wider pan or sponge.
  - When adding water to an incubator, the water should be lukewarm – neither hot nor cold. Adding hot water will temporarily boost the humidity and may result in temporary uneven heating.
  - During the final three days, placing warm wet kitchen sponges on top of the mesh will boost the humidity. Be sure all detergent is washed out of the sponges before using. Also be sure to carefully wash and scald sponges after each batch to prevent bacterial growth.
  - To decrease humidity within an incubator, add uncooked dry rice to the incubator pan.
  - If you have difficulty seeing the water in the water chambers, add a drop or two of food coloring. As the water level drops, the color will drop. It will lighten once again as you add more water.
  - You can add water to the chambers underneath the mesh without opening the incubator. At lockdown, thread a small tube through a ventilation hole, through the mesh, and into the chambers. Attach a children’s medical syringe with the plunger removed to the tubing and then use the syringe as a funnel.

- **POWER OUTAGES:** Power outages do occur and usually at the most inopportune time. Fortunately, an outage of 2-3 hours and a temperature drop in to the mid-80s will have little effect on embryos. Longer power outages may harm the embryos and a delayed hatch. Placing a blanket over your incubator will help reduce heat loss. Additionally, if you have access to non-electric heat source, such as natural gas, cranking up a space heater can reduce possible negative effects. Regardless of the length of the power outage, do not abandon the hatch; candling the eggs a few days later will help determine if any embryos died.

- **SEPARATING CHICKS AT HATCH:** Using plastic canvas knitting sheets, construct cages for each group of eggs you wish to keep separate. The cages should be as large and tall as possible avoiding the heating or other incubator components. Each mini-cage must have a lid to prevent the hatchling from climbing over the side and into the next cage.

- **TEMPERATURE STABILITY:** Full incubators will experience fewer temperature fluctuations than nearly empty ones. If you must incubate only a small number of eggs, add a heat sink – sealed water bottles or rocks. A heat sink will absorb excess heat during short spikes in temperature and release that heat during short dives.
Incubation Timelines

**Standard Chicken Incubation Timeline**

- **Set Eggs**: No turning 1st 12 hours
- **1st Candling**: Not required
- **Candle Questionable Eggs**: Not Required
- **Relative Humidity Range**: 48 - 53%
- **Humidity**: +65%
- **Temperatures**:
  - Day 1: 99.5°F
  - Day 2: 99.5°F
  - Day 3: 99.5°F
  - Day 4: 99.5°F
  - Day 5: 99.5°F
  - Day 6: 99.5°F
  - Day 7: 99.5°F
  - Day 8: 99.5°F
  - Day 9: 99.5°F
  - Day 10: 99.5°F

**Goose Incubation Timeline**

- **Set Eggs**: No turning 1st 12 hours
- **1st Candling**: Not required
- **Candle Questionable Eggs**: Not Required
- **Relative Humidity Range**: 48 - 53%
- **Humidity**: +65%
- **Temperatures**:
  - Day 1: 99°F
  - Day 2: 99°F
  - Day 3: 99°F
  - Day 4: 99°F
  - Day 5: 99°F
  - Day 6: 99°F
  - Day 7: 99°F
  - Day 8: 99°F
  - Day 9: 99°F

**Incubation Days**

<table>
<thead>
<tr>
<th>Species</th>
<th>Incubation Period</th>
<th>*Temp</th>
<th>Humidity (RH)</th>
<th>*Stop Turning</th>
<th>Hatch Humidity</th>
<th>Setting Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken</td>
<td>21 days</td>
<td>99.5°F</td>
<td>40-43%</td>
<td>19th day</td>
<td>+60%</td>
<td>Pointed end down</td>
</tr>
<tr>
<td>Duck, Mallard</td>
<td>26.5 days</td>
<td>99.5°F</td>
<td>43-48%</td>
<td>23rd day</td>
<td>+65%</td>
<td>Pointed end down</td>
</tr>
<tr>
<td>Duck, Domestic</td>
<td>28 days</td>
<td>99.5°F</td>
<td>43-48%</td>
<td>25th day</td>
<td>+65%</td>
<td>Pointed end down</td>
</tr>
<tr>
<td>Duck, Muscovy</td>
<td>35 days</td>
<td>99.5°F</td>
<td>43-48%</td>
<td>32nd day</td>
<td>+65%</td>
<td>Place on side</td>
</tr>
<tr>
<td>Geese, Chinese</td>
<td>30 days</td>
<td>99.5°F</td>
<td>43-48%</td>
<td>27th day</td>
<td>+60%</td>
<td>Place on side</td>
</tr>
<tr>
<td>Guinea Fowl</td>
<td>26 days</td>
<td>99.5°F</td>
<td>40-43%</td>
<td>23rd day</td>
<td>+60%</td>
<td>Pointed end down</td>
</tr>
<tr>
<td>Quail, Bobwhite</td>
<td>23 days</td>
<td>99.5°F</td>
<td>40-43%</td>
<td>20th day</td>
<td>+60%</td>
<td>Pointed end down</td>
</tr>
<tr>
<td>Peafowl, India Blue</td>
<td>28 days</td>
<td>99.5°F</td>
<td>43-48%</td>
<td>26th day</td>
<td>+60%</td>
<td>Place on side</td>
</tr>
<tr>
<td>Pheasant, Golden</td>
<td>22 days</td>
<td>99.5°F</td>
<td>40-43%</td>
<td>19th day</td>
<td>+60%</td>
<td>Place on side</td>
</tr>
<tr>
<td>Turkey, Bronze</td>
<td>28 days</td>
<td>99.5°F</td>
<td>40-43%</td>
<td>26th day</td>
<td>+60%</td>
<td>Pointed end down</td>
</tr>
</tbody>
</table>

Temperatures are for forced air/circulated air incubators. FOR STILL AIR INCUBATORS, PLEASE ADD 2.0° F.

*Stop turning eggs, remove turner, and increase humidity at the very beginning of the day indicated – three days before the hatch.
Standard Duck Incubation Timeline (© Roberts Farm)

1st Candling: Not required

Candle Questionable Eggs: Not Required

Standard Turkey Incubation Timeline (© Roberts Farm)

1st Candling: Not required

Candle Questionable Eggs: Not Required

http://www.thechickenwhisperer.co.uk/2013/01/hatching-chicks-week-2.html
Incubator Types

A common question among beginners, “Which incubator should I buy?” The answer is fairly simple, “The best one that you can comfortably afford.” In general, incubator manufacturers produce the best product possible within a given price range — if they didn’t, they wouldn’t stay in business very long. Incubation problems generally stem from the user, not the equipment. If used properly, almost all incubators can reliably hatch eggs. My first incubator was an inexpensive styrofoam Little Giant desktop model; it has been extremely reliable and is still in use today.

- **DESKTOP MODELS:** ($50.00-$800.00) Small desktop models holding between 3-48 chicken eggs. For beginners, I recommend purchasing a relatively inexpensive foam model with circulated air and an automatic egg turner. Although these models require greater time and effort, they give the hobbyist time to figure out the incubation process enabling them to better understand the type, style, and price range of the incubator best suited for their needs. Some hobbyists discover they don’t like incubating eggs while others realize they need greater capacity and flexibility.

  *Automatic Egg Turners:* Most desktop automatic egg turners do not tilt the eggs a full 45 degrees — the optimal angle for embryonic development. While they function adequately for chicken eggs, other, more sensitive species such as mallards and peafowl should be laid on their side and turned manually.

- **CABINET MODELS:** ($700.00-$2,350.00) Large floor models holding between 190-600 chicken eggs. These models, intended for serious hobbyist or small professionals, range from semi-automatic to fully automatic operation with almost all models having automatic egg turning capabilities. Which one is right for you? Each brand has its loyal fans who assert that their brand has the best hatch rate and is the easiest to use. My recommendation? Choose the one within an affordable price range and the capacity to meet your needs.

- **INDUSTRIAL MODELS:** If you’re reading this guide, then an industrial incubator should be outside your realm of consideration. Before reaching this level, you may wish to consider multiple cabinet models along with a dedicated hatcher.

- **HOMEMADE MODELS:** My first cabinet incubator was made from ½ inch foam board sandwiched between two sheets of ½ inch plywood. It had three tilt trays that held 54 chicken eggs each — I was too cheap to spend the money necessary for a commercially made model. It worked superbly and continues in use today. Its only problem was the trays had to be tilted manually. If you’re an industrial individual who likes to build things, then you may want to consider building your own. Multiple examples of homemade incubators can be found at:

- **MAJOR COMPONENTS:** An effective artificial incubator maintains a constant temperature, generally 99.5°F, provides a means to regulate humidity, and permits routine egg turning. They can either be manual where the user does all the work, semi-automatic where the incubator does some of the work, or automatic where the incubator does all of the work. The more you spend, the more automated the process:
  1. **INSULATION:** What materials are used to separate the eggs from the room environment? The least expensive models utilize polystyrene foam (styrofoam) or simple plastic, others use plastic board, while still others use insulation sandwiched between plastic and metal. While all incubators do best in a climate controlled room, better insulated incubators have fewer temperature and humidity fluctuations than those that use a thin layer of plastic.
2. **THERMOSTAT**: How is the temperature regulated? The simplest, and perhaps most accurate, thermostat uses a simple wafer switch to regulate temperature – as the temperature warms, the wafer expands and opens the heating element contact. Unfortunately, these models rely upon a screw or knob to set the temperature. Many manufacturers are currently using digital thermostats employing an LED panel to display and control temperature. While this type of control is certainly easier to use, quality may suffer in lower end units. Additionally, most digital controls can only be calibrated by the manufacturer and may lose accuracy over time – it is best to always use a separate, calibrated thermometer to validate the control’s reading.

3. **AIR CIRCULATION**: How are all sides of the eggs warmed? The least expensive incubators are “still air” and contain no fan to circulate the warmed air. Many claim that this method is the best one in that is closely resembles a hen setting on eggs where only one side is heated. However, most prefer a “circulated” or “forced” air system where a fan circulates the warmed air throughout the incubator. In lower-end models, a fan in an optional component and must be purchased separately. A third and rare method attempts to replicate a broody hen using a plastic bladder to cover and warm the eggs; this method but is rare because of the expense and limited batch size.

<table>
<thead>
<tr>
<th>Example of Hobbyist Type Incubators</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
</tr>
<tr>
<td>Rcom Mini</td>
</tr>
<tr>
<td>Brinsea Mini ECO</td>
</tr>
<tr>
<td>Brinsea Mini ADV</td>
</tr>
<tr>
<td>Janoel JN-12</td>
</tr>
<tr>
<td>Rcom Max 20</td>
</tr>
<tr>
<td>Brinsea Octagon 20 ECO</td>
</tr>
<tr>
<td>Rcom King Suro Eco 20</td>
</tr>
<tr>
<td>Janoel JN-24</td>
</tr>
<tr>
<td>Rcom King Suro 20</td>
</tr>
<tr>
<td>Brinsea Octagon 20 ADV</td>
</tr>
<tr>
<td>HovaBator 1602</td>
</tr>
<tr>
<td>Farm Innovators 2100</td>
</tr>
<tr>
<td>Little Giant 10300</td>
</tr>
<tr>
<td>Farm Innovators 4200</td>
</tr>
<tr>
<td>Little Giant 9300</td>
</tr>
<tr>
<td>Janoel JN-48</td>
</tr>
<tr>
<td>Brinsea Octagon 40 ECO</td>
</tr>
<tr>
<td>Brinsea Octagon 40 ADV</td>
</tr>
<tr>
<td>Rcom Max 50</td>
</tr>
<tr>
<td>HovaBator 2362E</td>
</tr>
<tr>
<td>HovaBator 1588</td>
</tr>
<tr>
<td>Janoel JN5-60</td>
</tr>
<tr>
<td>Rcom Max 190C</td>
</tr>
<tr>
<td>Brinsea Ova-Easy 190</td>
</tr>
<tr>
<td>Sportsman 1502</td>
</tr>
<tr>
<td>Rcom Maru 380C</td>
</tr>
<tr>
<td>Brinsea Ova-Easy 380</td>
</tr>
</tbody>
</table>

**NOTATION:** This chart is intended only as an example of types, options, and price ranges. Model numbers, features, and prices will vary. Carefully compare current models before purchasing.
Broody Hens vs. Artificial Incubation?

Many hobbyists and breeders prefer to incubate eggs the old fashion way – let a broody hen do all the work. This method is helpful in that we don’t need to worry about temperature, humidity, turning, or power outages. Unfortunately, it also removes the hen from egg production. Many report that a broody hen improves hatch rates and viability especially with more difficult species such as peafowl and rare bantams. Some professional breeders, such as Legg’s Peafowl Farm\(^1\), allow broody hens to incubate eggs for the first week before placing them in an incubator.

<table>
<thead>
<tr>
<th>Artificial Incubation</th>
<th>Broody Hen Incubation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incubators are easily obtained</td>
<td>Broody hens availability may be limited</td>
</tr>
<tr>
<td>Initial investment high with low maintenance cost</td>
<td>Initial investment low with some maintenance cost</td>
</tr>
<tr>
<td>Incubators available 365 days a year</td>
<td>Broody hens generally limited to Spring and Summer</td>
</tr>
<tr>
<td>Batch size virtually unlimited</td>
<td>Clutches limited by hen size</td>
</tr>
<tr>
<td>Hatching hatch within a 24 hour period</td>
<td>The hatch window may be spread over several days</td>
</tr>
<tr>
<td>No effect of egg production</td>
<td>Removes the hen from egg production</td>
</tr>
<tr>
<td>Scheduled according to incubator space availability</td>
<td>Scheduled according to broody hens availability</td>
</tr>
<tr>
<td>Success rate generally stable and predictable</td>
<td>Success rate may vary according to hen traits</td>
</tr>
<tr>
<td>Lower success among more difficult breeds &amp; species</td>
<td>Higher success among difficult breeds &amp; species</td>
</tr>
<tr>
<td>Must manually monitor temperature and humidity</td>
<td>No manual input required</td>
</tr>
<tr>
<td>Requires electricity</td>
<td>Self-powered</td>
</tr>
<tr>
<td>Losses due to human error</td>
<td>Losses due to hen’s weather, predators, and accidents</td>
</tr>
<tr>
<td>Artificial brooding required</td>
<td>Hens brood the hatchlings</td>
</tr>
<tr>
<td>Must manage exposure to Coccidiosis</td>
<td>Coccidiosis exposure naturally occurring, less impact</td>
</tr>
<tr>
<td>Loss due to brooder disease and power outages</td>
<td>Losses due to predators and other flock members</td>
</tr>
</tbody>
</table>

Personally, I artificially incubate all eggs during the spring months to keep up egg production. I do allow most species to go broody during the summer months and have experienced mixed results:

1. **Bantams:** My bantams tend to go broody frequently and do an excellent job in hatching and brooding their young. Since they usually nest inside their coop, fire ants are less of a problem than with those that nest on the ground. While my Old English bantams share in the responsibility of incubating and brooding a clutch, my bantam Cochins squabble over the chicks and from time-to-time will crush chicks in the struggle.
2. **Brown Chinese Geese:** My geese have yet to successfully hatch a gosling primarily due to our warm climate and the presence of bacteria in the ground. In most instances, one or more eggs will spoil, break, and contaminate the nest. For my Brown Chinese geese, I usually incubate the eggs artificially and then return the goslings to the parents a week after hatch. Both male and female Brown Chinese geese are excellent parents.
3. **Guineas:** Guinea hens are known to lay their eggs on the ground and are not known to be particularly good mothers. My only experience ended in failure when fire ants invaded the nests killing any keets that successfully hatched or were in the process of hatching.
4. **Heritage Turkeys:** I raise both standard Bronze and Royal Palm turkeys. Both are quick to go broody and do an excellent job hatching pouls. Unfortunately, neither tends to be good parents as I usually find small pouls wondering about the yard after they hatch. If a hen is successful in tending to the brood, the heavier males can easily crush the young pouls.
5. **Mallard Ducks:** My mallard ducks are excellent about both hatching and tending to their young. Since ducks are terribly messing, allowing the mother to brood young ducklings eliminates the need for messy brooders. Unfortunately, fire ants frequently invade nesting sites and kill the ducklings once they start to hatch.
6. **Peafowl:** Peafowl are known to do a good job at incubating and brooding their young; however, since peachicks are expensive and peahens will only lay about 18 eggs each year, I artificially incubate all eggs.

\(^1\) Brad Legg, "Incubation & Hatching Peafowl Eggs," Legg’s Peafowl Farm, NDA, \(<http://www.leggspeafowl.com/incub.htm>\)

\(^2\) Several ideas drawn from "INCUBATOR VS. BROODY HEN," Community chickens, NDA, \(<http://www.communitychickens.com/incubator-vs-broody-hen/>\)
**How do I get a hen to go broody?** Generally, a hen will go broody when she’s is good and ready. Silkees and Cochins tend to go broody frequently; however, many breed, such as Leghorns have been bred over many decades not to go broody – they’re expected to lay eggs not hatch chicks.

---

**Five Ways to Encourage a Hen to go Broody**

1. The first thing you can do is choose breeds that tend towards being broody, such as Australorps, Brahmas, Buffs, or Cochins and bantam breeds such as Silkees, bantam Cochins or Orpingtons.
2. A second way to encourage a hen to go broody is to leave some eggs in the nests (‘dummy’ eggs, such as golf balls or plastic Easter eggs work just as well as real eggs and don’t risk being broken). This can encourage your hen to start sitting on them.
3. You can also encourage a hen’s broody nature by providing her a dark, safe place to sit on the eggs. Hang some curtains across the front of the nesting boxes, even a piece of sheet or fabric will help convince her the nest is a secret place to raise her chicks.
4. Adding some herbs to the nesting boxes such as lavender or chamomile can help the hen relax and feel safe and secure.
5. Check the nesting boxes for insects, mites and mice. A hen generally won’t sit if she senses critters in the boxes that could harm her eggs or chicks. Be sure the nesting box material is fresh and clean, and that there is a nice thick layer so the eggs won’t touch the wooden floor and risk breaking.

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**How to I Break a Broody Hen?** When I was a child, I noticed a neighbor’s hen in a small wire cage and asked him why he had locked her up… His response, “She stopped laying eggs and a chicken that doesn’t lay eggs isn’t worth much.” Within my flock, spring eggs are valuable; they produce hatchlings; and hatchlings pay the feed bill… I collect eggs two or three times a day to discourage broodiness.

---

**Five Ways to Break a Broody Hen**

1. Collect the eggs frequently; however, some hens will sit on anything that looks like an egg or even imaginary eggs.
2. Remove the hen from the nest, carry her for 10-15 minutes, and then place her outside the coop; however, since broodiness generally involves hormones, I wouldn’t have high expectation.
3. Deny access to her nesting spot or place her in a small pen without any nesting spots; sometimes, just a change in the environment or making it difficult to nest may be sufficient to end the process.
4. Dunking the lower portions of her body in cool water until her feather is wet; some give a full bath hoping the “cooling off” will break the cycle.
5. Place her up in a wire cage for five days, a small dog crate with food and water but no nesting material. (Old timers, like my neighbor did not always include food or water.)

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**Care for a Broody Hen:** Hens are designed by Mother Nature to spend three to four weeks on a broody nest. They will select a nesting site best suited to their needs. During incubation, a hen will stop laying, consume 80% less feed, and lose up to 20% of their total body weight. During the first week, hens almost never leave their nest relying upon body stores for the water and nutrient needs. After the first week, a hen may leave the nest seeking food, water, and waste elimination. The length of time she is off the nest depends upon the stage of development, the weather, and her personality. Some species, such as mallard ducks, may stay off of the nest for hours at a time during warm weather. A broody hen’s needs are few but food and water should be available close for her convenience. In most cases, a broody hen will do an excellent job at incubating her eggs, and it is usually best just to leave her and her eggs alone… she knows what she is doing!

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The Importance of Fresh Feed

Several factors have a significant impact on egg production and hatchability; one of the most important is hen nutrition. Commercial poultry feed is a cooked product and is therefore perishable – it loses nutritional value as it ages. When stored under ideal conditions, poultry feed has a shelf life of up to 120 days. Feed stored under less than ideal conditions has a shelf life of less than 60 days. Nutrena recommends using pelleted feeds, including crumbles, within 60 days during summer months and 90 days during winter months.¹

For best results, learn to decipher (decode) the Lot # printed on each bag of feed and check those numbers each time you make a purchase. It is especially important to check the mill dates for less popular feeds such as Game Bird Starter or specialty feed such as Chick Starter during the off-season. Additionally, farm stores often employ individuals who may not understand FIFO (First In, First Out)... they may stack new feed on top of old feed.

Examples of Lot # Deciphering

<table>
<thead>
<tr>
<th>Purina Mills</th>
<th>Year</th>
<th>Month</th>
<th>Day of Month</th>
<th>Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>7MAY01RVI</td>
<td>7</td>
<td>MAY</td>
<td>01</td>
<td>EV1</td>
</tr>
<tr>
<td>Manna Pro</td>
<td>Plant</td>
<td>Month</td>
<td>Day</td>
<td>Year</td>
</tr>
<tr>
<td>A05/01/17J</td>
<td>A</td>
<td>MAY</td>
<td>01</td>
<td>2017</td>
</tr>
<tr>
<td>AE701J</td>
<td>A</td>
<td>MAY</td>
<td>2017</td>
<td>01</td>
</tr>
<tr>
<td>Nutrena</td>
<td>Plant</td>
<td>Year</td>
<td>Day of Year</td>
<td></td>
</tr>
<tr>
<td>WB7121</td>
<td>WB</td>
<td>7</td>
<td>121</td>
<td></td>
</tr>
<tr>
<td>567121</td>
<td>56</td>
<td>7</td>
<td>121</td>
<td></td>
</tr>
<tr>
<td>Lone Star</td>
<td>Plant Code</td>
<td>Day of Year</td>
<td></td>
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</tr>
<tr>
<td>D121</td>
<td>D</td>
<td>121</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FEED STORAGE:

1. DO store feed in a well ventilated, cool (below 77°F), dry location away from direct sunlight. When selecting a storage location, DO consider the temperature during the hottest summer months.

2. DO NOT store on a concrete floor – moisture will wick through the concrete into the bags. Store feed on pallets or similar barrier permitting air to circulate around and underneath.

3. DO protect feed from rodents and insects. Using chocolate as rodent bates can be more attractive than the feed. Consider galvanized or plastic containers for smaller feed amounts.

4. DO NOT mix old and new feed in the same container which can easily cross-contaminate new feed with mold, mildew, mites, and other pests.

PROTEIN CONTENT: Layer feeds are basically formulated for hens laying table eggs (16% protein). Small benefits may be gained by providing breeder hens with feeds with slightly higher protein levels (17-18%). However, significantly higher protein levels tend to decrease fertility and unnecessarily strains the metabolic process because excess protein must be converted to nitrogen and then excreted.

Mold & Bacteria Contamination

Mold and bacteria (microbes) thrive in a warm, moist environment... the same environment used to incubate eggs. Mother Nature has a wonderful egg design; however, her design is imperfect and contamination remains a leading cause in hatch failure. While gross infections are easily detected by their pungent smell and oozing exudate, milder forms can be more difficult:

1. Eggs candle clear (appear infertile),
2. Deaths occurring at various stages of development,
3. Fully developed chicks failing to pip, zip, or hatch,
4. Unhealed or wet navels or mushy, soft chicks, and
5. Abnormally small, weak, or fragile chicks.

Bacteria and mold which can affect hatching eggs are endemic – everywhere: in the soil, the nest, the manure, even the dust particles in the air. We can work to limit the effects of mold and bacteria by understanding how contamination occurs and then taking steps to reduce contamination.

- **THE SHELL**: Although eggs appear solid, they contain thousands of pores that permit moisture and gases to escape and oxygen and contaminants to enter. Thick shells help reduce contamination, but microscopic cracks, thin shells, and overly porous eggs compromise its effectiveness. Several factors affect shell quality including nutrition, stress, weather, health, and disease. Weather and hen age may be of particular importance:
  1. **Weather**: During the warmer summer months, a hen responds to excess heat by panting changing the blood pH and reducing the available blood calcium. Additionally, hens naturally decrease their feed intake further reducing available calcium.
  2. **Hen Age**: The older the hen, the larger the eggs and the more calcium is required; however, as the hen ages she less able to absorb and mobilize the available calcium... more than a 50% decrease of normal after 40 weeks of age.

- **THE CUTICLE**: (Bloom) a liquid protein layering applied to the outside of the shell. Once dried, the cuticle it the most effective barrier in preventing movement of microbes from the outer to the inner shell. The cuticle, however, is not perfect and its integrity can be compromised:
  1. **Dirty Nests**: Eggs are most vulnerable to bacterial penetration in the first 30 to 60 seconds after lay before the cuticle hardens and effectively caps the pores.
  2. **Hen Age**: Eggs from hens older than 70 weeks have poorer quality cuticles than younger hens.
  3. **Wetting**: Any process that wets the exterior of the egg partially dissolves the cuticle decreasing its effectiveness. Moisture also promotes microbial growth on the shell and acts as a media to aid microbe movement through the shell.

- **SHELL MEMBRANES & ALBUMEN**: The egg contains two permeable (penetrable) membranes – the inner membrane attached to the inside shell surface and the outer membrane surrounding the egg contents. These membranes act as filters to discourage microbe penetration into the egg interior. Additionally, the chemical composition of the albumen (egg whites) discourages bacterial growth. However, these defenses are far less effective than a healthy, intact cuticle.

Bacteria inside the egg may use the nutrients found in the egg to multiply, robbing the embryo of a crucial food source or perhaps producing a toxin harmful to the embryo. During incubation, bacteria can actually prevent embryonic development, ultimately causing the embryo to die. Even if the embryo of a contaminated egg survives hatching, the chick will either die in the broiler house or simply not grow as it should.¹

² Lokesh Gupta, PhD, "Factors Influencing Shell Quality," Regional Technical Manager, Avitech, March 1, 2008.
• **CONDENSATION**: (Sweating) Place a glass of ice water on a cabinet and you will notice condensation (water droplets) form on the exterior of the glass. Under similar circumstances, condensation accumulates on egg shells when moved from a cool to a warm environment – such as from the nest during winter months. When moving eggs from a cool to warm climate, avoid exposing cool eggs to warmer air… keep them inside their cartons or tightly cover the eggs with a clean towel until they reach room temperature.

• **CROSS-CONTAMINATION**: Cross contamination involves accidentally transferring microbes from one surface to another and can occur several points in the incubation process:

1. **Hands**: Failure to wash hands before touching eggs or inadvertently touching a dirty surface and then touching an egg. This can occur anywhere in the process: collection, storage, setting, candling, and transfer. **Action**: Wash hands before touching eggs and remain aware of what your hands touch.

2. **Collection Basket**: Using the same basket to collect incubation and eating eggs and/or not sanitizing the basket between collections. **Action**: The simplest solution may be to use a new, clean paper towel to line the collection basket and to use two baskets – one for incubation eggs and one for eating eggs.

3. **Countertops**: Placing incubation eggs on a countertop, especially a kitchen countertop. **Action**: Transfer eggs directly from the collection basket to their storage carton or sanitize the countertop using an antimicrobial cleanser.

4. **Used Egg Cartons**: Using egg cartons from eating eggs and/or reusing incubation egg cartons. **Action**: Use only new cartons to store hatching eggs or use other suitable containers that can be sanitized.

5. **Candling**: Candling usually involves picking up an egg, shining a light into it, looking at the contents, and placing the egg back into the setting tray, and then picking up the next egg. This is an ideal situation for transferring contaminants from one egg to another. **Action**: Candle eggs as infrequently as necessary. Wash and dry hands thoroughly before candling and at any time you suspect that a touched egg might be contaminated. Use your nose (smell) instead of candling to locate and identify any “bad” eggs.

• **WEATHER**: For the backyard hobbyist, weather can play a significant role in mold and bacteria contamination, especially in warmer climates. When it rains, hens track wet mud into the coop and nest. Even with absorbent pine shavings, moisture accumulates. Add warm temperatures (over 85°F) and some chicken droppings, and you have the ideal environment for mold and bacteria. For waterfowl and birds that lay their eggs on the ground, the problem is compounded. Remember, mold and bacteria is microscopic and may not be visible… change nesting frequently during warm, wet weather even if it looks clean and dry. It might also be beneficial to change floor bedding often and take other measures to limit the introduction of moisture into the coop.

• **SHOULD I WASH EGGS?** Should hatching eggs, especially dirty one, be washed? Although often debated, the best answer is only if absolutely necessary. The following explain why:

1. **Cosmetic Only**: Washing eggs may be more visually appealing but this often only cosmetic. Mold and bacteria are microscopic and often remain of the egg surface even after washing.

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2. **Wetting Increases Microbial Problems:** Mold and bacteria need moisture in order to multiply. Dry dirt and droppings remain relative inert (inactive). Adding moisture not only provides microbes access to nutrition necessary to multiply, the liquid also compromises the cuticle and provides the medium that allows the microbes to move into the inner shell. Adding moisture to the shell egg should be an option of last resort.

3. **The Wrong Focus:** Entry of microbes into the inner shell primarily occurs in the nest before the cuticle fully dries. Egg washing is not capable of addressing bacteria already inside the egg but damaging the cuticle may allow bacteria to enter other eggs... ones that have not yet been affected. The focus should be on maintaining a clean, dry nest before the problem occurs.

4. **Washing Damages the Cuticle:** Simply wetting the cuticle can damage it. Rubbing the egg and using cleansers are likely to severely damage, if not completely remove, the cuticle. Remember, the cuticle is the first and best defense in limiting microbes to the outside of the egg.

5. **An Inexact Process:** Unlike commercial hatcheries that primarily rely upon fumigation rather than traditional washing, most hobbyists do not have the chemicals or the equipment to thoroughly sanitize the egg surface. An inexact cleansing can cause more harm than good:
   - Too cool of water will cause the air in the pores to contract pulling microbes and cleanser inside the egg.
   - Too hot of water for too long can possibly damage the internal components by changing the characteristics of the albumen and/or harming the small embryo.
   - Using the wrong or too strong of a disinfectant agent can leave microbes on the outer surface while leaving a wet surface than better enables the microbes to move to the inside of the shell.
   - Washing multiple eggs in one setting increases the chances of cross-contamination... transferring harmful microbes from a dirty eggs to those that are not contaminated.

6. **False Security:** Many people wash eggs to keep contaminates out of their incubator. Unfortunately, incubator contamination is more likely to originate from microbe growth starting inside the egg and then seeping out. Washing gives a false sense of security and lessen their focus avoiding contamination without washing and possibly increase instances of on cross-contamination.

7. **Washing Concerns:** In some cases, washing eggs may be beneficial especially eggs of high value and/or eggs laid on the ground.
   - DO understand that an egg cannot be sterilized without killing the embryonic germ. The objective of washing is to decrease the colony count, not kill all microbes.
   - Do use cleansers that have been especially formulated for washing eggs such as Brinsea Incubation Disinfectant. AVOID harsh cleansers or disinfectants, such as bleach, as they are likely to change egg shell characteristics or damage the inner contents.
   - DO use water warmer (110-120°F) than the egg so as to draw contaminates out of the shell. Colder water will draw contaminates into the shell.
   - DO use a very gentle rubbing motion with your fingers doing as little damage to the cuticle (bloom) as possible. DO NOT use scrub brushes, cloth, or other abrasive material.
   - DO place the eggs in a setting tray that permits the egg to dry quickly and on all sides. DO NOT place eggs into their storage container until the egg is completely dry.
   - DO understand that you will likely remove the cuticle and the egg will be more susceptible to contamination, especially cross-contamination.
   - DO understand that removing the cuticle will result in greater moisture loss during incubation and you will need to increase your humidity by 5%.

8. **Spray Disinfectants and Cleansing Wipes:** Some will sometimes claim that certain spray disinfectants and/or cleaning wipes will reduce the odds of problems with microbial contamination. Use of such products may be of some use but it is important to remember that wetting the cuticle will damage it and any disinfectant strong enough to sterilize the outside of the egg will likely damage its contents. Approach such products with caution.
EGG COLLECTION:
1. Use fresh, large pine shavings to line nesting boxes or nesting areas. Hay, straw, or other materials may contain mold possibly infecting the egg. Replace any soiled or moist lining as soon as possible. Remember, the cuticle cannot protect the inner egg from microbial invasions until it is completely dry.
2. Be sure hens have access to crushed oyster shells so they produce thick, hard shelled eggs. Be sure nest boxes and collection baskets are sufficiently padded to prevent breakage. Do not collect cracked or broken eggs. Internal egg contents provide the ideal nutrients for bacteria to multiply and spread. Remember, thick shells help prevent internal egg contamination and egg content from broken eggs splattered on other eggs provides an excellent nutrition source for bacterial growth.
3. Collect eggs two or three times a day, more frequently if in wet conditions or when temperatures are unusually high or low. Remember, adverse weather conditions – especially warm, humid conditions – encourages the growth of bacteria even in relatively clean nests.
4. Handle the egg as little as possible. Wash hands before collection and avoid touching dirty surfaces during the process. Sanitize or line collection baskets. Avoid getting the eggs wet during collection, do not place eggs on unsanitized surfaces, and place them in new cartons as soon as possible. Remember, cross-contamination can be a significant source of microbial contamination.
5. Remove eggs that are unusually dirty, large, small, or misshaped as these eggs hatch poorly and consume valuable incubator space. Remember, dirty eggs can be especially troublesome as bacteria thrive in the warm, moist incubation environment and can result in exploding eggs that spread contamination.
6. Do NOT wash or wipe off dirt or waste from the egg. Do NOT use sand paper to sand off dirt or waste. If the egg is marred by a small amount of waste, allow it to dry and then gently scrape it off with a finger nail. Remember, the cuticle is the first and best line of defense against microbial contamination and wetting or damaging the cuticle decreases its effectiveness.
7. Store eggs in a cool environment that is free condensation or puddling moisture. Be sure that the egg shells are completely dry before placing in their cartons. Remember, bacterial thrives in a warm, moist environment.

Genetics & Inbreeding
The term “inbreeding” is frequently associated with the term taboo... something repulsive, forbidden, particularly offensive... an act that creates horribly disfigured monsters. However, line-breeding (organized inbreeding) has long been used in husbandry to improve livestock uniformity, vigor, and productivity. When used in a haphazard manner, inbreeding can have undesirable results. When carefully monitored, line-breeding can be beneficial.

- GENETIC DIVERSITY: In sexual reproduction, two parents contribute genetic information to produce unique offspring allowing a species to adapt to changes in weather, disease, parasites, and food supply. Through the blending of genetic material, the chance that an offspring will inherit an unfavorable trait is cut by half; and of those unfavorable traits inherited, many are masked by a more dominant gene. Unfortunately, diversity is the adversary to poultry breeders... diversity dilutes desirable traits such as uniformity and color.
- FACT: Much of the genetic diversity in the today's chicken was lost long before the creation of the modern super-chicken. Research indicates that any two chickens are now more closely related than aunts and nieces in a typical human population. Some lines share as much as 90% of their genetics – they are nearly clones. Obtaining stock that is entirely unrelated is not possible.
- DRAWBACKS: The act of inbreeding does not create bad genes or bad genetic traits – the genes themselves do not mutate. Rather, since closely related birds share many of the same genetic alleles (markers), inbreeding increases the odds that two undesirable, recessive (hidden) alleles will be paired – one from the mother and one from the father – and allow the undesirable trait to be expressed (unmasked). Considering that thousands of alleles are involved, managing these traits can be difficult.

• **BENEFITS**: Desirable traits are controlled primarily through genetics. The best way to replicate those desirable traits is to pass the genes responsible for those traits down to the offspring. Naturally, if both parents share the same desirable traits, odds are great that the offspring will also possess those traits. In most instances, the characteristics of all bird breeds were stabilized through systemic linebreeding.

• **HYBRID VIGOR**: A hybrid is the offspring of two plants or animals of different species, varieties, or breeds. The phenomenon of hybrid vigor has been used in both plants and animals to increase fertility, hatchability, offspring vigor, and both quantity and quality of production (meat or eggs). Within the poultry world, the sex-link is probably the most common that not only can be visually sexed at hatch but also are excellent producers of meat or eggs. Oddly, the benefits of hybrid vigor are lost in subsequent generations.

• **INBREEDING DEPRESSION**: Inbreeding depression is similar in nature to hybrid vigor but with opposite results. It occurs primarily in “exhibition quality” stock or extremely rare breeds where the genetic pool is extraordinarily small. Inbreeding depression results in a decreased fertility, hatchability, offspring vigor, and both quantity and quality of production. In most cases, backyard hobbyists are unlikely to encounter inbreeding depression unless their original breeders are closely related. The best way to avoid inbreeding depression is to obtain breeding stock from two or more sources or one with a very large flock.

• **OUTCROSSING**: Outcrossing involves bringing in “fresh blood” in order to improve genetic diversity and avoid the effects of inbreeding. Outcrossing may be necessary if there becomes a problem of inbreeding depression. However, bringing in “fresh blood” can also be problematic. Since many genetic traits are recessive (hidden), the “perfect” male may very well introduce a number of undesirable, hidden traits into the flock...many of those traits may not physically appear until the second generation and may be especially difficult to eliminate completely.

• **INBREEDING INTENSITY**: How much inbreeding is too much? Opinions vary and it is known that breeding siblings (brother to sister) becomes more intense after the third generation than breeding parent to offspring (father to daughter, mother to son). Careful monitoring of fertility rate, hatch rates, chick quality, instances of defects, and adult production should reveal when an inbreeding intensity has reached an unacceptable level.

• **CULLING**: The term “culling” refers to the process of removing or separating animals from a breeding stock based on specific traits. In livestock, this often involves either killing the animal or selling them as “pet” or “production” quality. While it is common among backyard hobbyists to try to save all chicks, this practice can have detrimental results in any line-breeding system. Although defects, lack of vigor, or undesirable traits may be caused by several factors,

1. End incubation at the end of day 21. A genetically healthy chick will hatch on-time and without assistance.
2. Eliminate any hatchling with any defect, that fails to thrive, or that demonstrates any undesirable traits.
3. Grow-out three to four times the number of future breeding stock needed, cull those juveniles that display any undesirable traits, make the final selection based upon either the breed standard and/or other qualities considered most desirable, and then sell the remaining stock as “pet” or “production” quality.

• **SEX-LINKS & HYBRID VIGOR**: My favorite breed of layer is not a breed at all but rather a hybrid – a Black Star using a Rhode Island Red rooster and Dominique hens. Even though they come from the same hens, my Black Stars have a 93% hatch rate for all eggs set compared to 87% for their purebred Dominique half-sisters. The chicks are more vigorous consuming twice the feed as their young sisters; yet, as adults the eat less feed, lay more and larger eggs, produce all winter, and are superior at free ranging. They are also beautiful black birds with a lustrous green sheen.

Sex-links are the result of first generation crossing of two different breeds. Hybrid vigor makes them better and more efficient producers of eggs, meat, or both. The “sex” and “link” parts come into play because of
genetic sex characteristics found in specific breeds. When specific breeds are crossed, differences in down color or pattern enables differentiation between male and female chicks. Thus, a hobbyist who wants a vigorous, productive, sexable chick would do well to consider sex-links.

### Popular Hybrids

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Rooster</th>
<th>Hen</th>
<th>Female Chicks</th>
<th>Male Chicks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Star</td>
<td>Rhode Island Red</td>
<td>Dominique</td>
<td>all black</td>
<td>yellow headspot</td>
</tr>
<tr>
<td>Gold Star</td>
<td>Rhode Island Red</td>
<td>Rhode Island White</td>
<td>buff</td>
<td>white</td>
</tr>
<tr>
<td>Gold Comet</td>
<td>New Hampshire</td>
<td>White Rock</td>
<td>buff</td>
<td>white</td>
</tr>
<tr>
<td>Cinnamon Queen</td>
<td>New Hampshire</td>
<td>Silver Laced Wyandotte</td>
<td>buff</td>
<td>white</td>
</tr>
<tr>
<td>Red Star</td>
<td>Production Red</td>
<td>Delaware</td>
<td>buff</td>
<td>white</td>
</tr>
<tr>
<td>Brown Star</td>
<td>Rhode Island Red</td>
<td>White Rock</td>
<td>buff</td>
<td>white</td>
</tr>
<tr>
<td>California White</td>
<td>California Gray</td>
<td>White Leghorn</td>
<td>white w/ black headspot</td>
<td>white</td>
</tr>
<tr>
<td>Hy-Line Browns&lt;sup&gt;b&lt;/sup&gt;</td>
<td><em>Rhode Island Red</em></td>
<td><em>White Leghorn</em></td>
<td>Available only from a commercial sources.</td>
<td></td>
</tr>
<tr>
<td>ISA Browns&lt;sup&gt;b&lt;/sup&gt;</td>
<td><em>Rhode Island Red</em></td>
<td><em>White Leghorn</em></td>
<td>Available only from a commercial sources.</td>
<td></td>
</tr>
<tr>
<td>Cornish Cross&lt;sup&gt;b&lt;/sup&gt;</td>
<td><em>Cornish</em></td>
<td><em>White Rock</em></td>
<td>Available only from a commercial sources.</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Common names and breeding combinations differ from breeder-to-breeder.

<sup>b</sup> Commercial hybrids are not true sex-links as they cannot be sex by color at hatch and are the result of selected breeding probably using several specialized line. *The exact combination is only known by the company producing those lines.

NOTATION: This chart only serves as a general reference. Do not use this chart for breeding purpose; instead, research the specific combination that may be of interest.

### Breeding Sex-link Hybrids

- **FURTHER READING:**
Factors Influencing Fertility

- **EGGS CANDLE CLEAR:** Among hobbyist, the term “non-fertile” eggs generally refer to the number of incubated eggs that show NO development upon candling on day seven. However, that use is probably inaccurate... Lack of signs of development may reflect a problem with true fertility or may indicate early embryonic death:

1. **TRUE INFERTILITY:** (eggs candle clear) True infertility occurs when the hen’s eggs are not fertilized by the rooster’s sperm. True infertility can be caused by too few or too many roosters, young or old males, males too heavy, females under or overweight, poor nutrition, drugs or toxins in feed, disease, poor legs or feet condition, stress, or extreme climate change.

2. **EARLY EMBRYONIC MORTALITY:** (eggs candle clear) Eggs that are candle clear on day seven can also be caused by early embryonic death – the chick dies very early during the incubation process. Early embryonic mortality can be caused by a number of factors such as improper storage, excess jarring, extreme high or low temperature, blocked pores, poor egg quality, etc.

The only accurate way to distinguish between true infertility and early death is to break the egg open and examine the blastodisc — the white spot lying on top of the egg yolk. The infertile blastodisc will be a simple white spot while fertile blastoderm will have a ring surrounding it (bullseye) or will show signs of development — such as enlargement or small blood vessels.

**NOTATION:** The egg begins to dissolve tissues associated with early embryonic death; in checking fertility, it is best to candle, break open, and examine the egg contents as early as possible.

- **SPERM STORAGE:** Birds store a large amount of sperm internally inside Sperm Storage Tuubes and release a portion of that sperm each time they ovulate – hens need not mate daily in order to achieve a high fertility rate. Once insemination occurs, maximum fertility is achieved by day five. The average length of time the sperm remains viable inside the female varies by species and can vary greatly among individual birds.¹

  - Peafowl: 26 days
  - Turkeys: 45 days
  - Chickens: 12 days
  - Ducks: 10 days
  - Japanese Quail: 6 days

- **IMPROVING FERTILITY:**

  1. **HEN–ROOSTER RATIO:** In general, a young healthy rooster can successfully mate with up to 12 hens. However, most hobbyist utilize a smaller ratio:

     - Light Breeds (Leghorns): 1:12
     - Bantams (Silkies): 1:6
     - Domestic Ducks (Mallards): 1:5
     - Heavy Breeds (Rhode Island Red): 1:10
     - Heritage Turkeys (Royal Palms): 1:5
     - Domestic Geese (Chinese): 1:3

  2. **YOUNG ROOSTERS:** Males tend to mature sooner than females and young roosters are often too aggressive to be successful in the mating process.

  3. **SOCIAL ROLES:** Stimulate mating by sprinkling grain on the litter in the afternoons. Let the males play the role of landlords, so they have the chance to show their leading position in the flock.²

  4. **SPIKING:** Exchanging roosters between pens creating a new social order and increasing interaction between rooster and hens.

  5. **KNOCK-OFF–SYNDROME:** Avoid having too many roosters; competition may result in roosters knocking each other off the hens before the breeding sequence is complete.

  6. **REPLACE AGING ROOSTERS:** Roosters continue to be fertile long after most hens have passed their prime. However, increased age may result in lower mating interest requiring the introduction of younger males.

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Egg Storage

- **QUESTION:** How long can I safely store my hatching eggs before setting them in the incubator?
- **BEST ANSWER:** Seven days when stored below 68°F in new cartons (10 days at the most) tilting the eggs 45° to the left or right once a day. That answer is the best answer; however, the best answer may not necessarily be the only correct answer.
- **OBSERVATION:** It can easily take a broody chicken 14 days to lay a clutch of eggs... my turkeys take about 16 days, and my mallard ducks up to 21. Under ideal conditions, those hens do a pretty good job hatching those eggs. What do they know that we don’t? Perhaps an egg is designed to last longer than 7 days?
- **BENEFITS OF EXTENDED STORAGE:** I have only a small number of hens for some breed and species; however, I don’t like brooding mixed batches, e.g. mallard ducks and bantams. I prefer to incubate and brood in batches larger than what a 7 day period can provide. Therefore, I routinely collect for 15 days.
- **EMBRYO DEVELOPMENT:** The embryo starts to develop within five hours of fertilization inside the hen and this development continues for approximately 11 hours. By the time the egg is laid, the embryo consists of approximately 60,000 cells. Personal observation reveals that turkey and duck hens often remain in the nest for 3 to 4 hours after laying a fresh egg possibly extending this initial developmental period. Experiments with pre-incubation, heating the egg to incubation temperature before storage, increases the hatch rates by 4.1%.

It may not be wise to gather hatching eggs as soon as they are laid but rather allow the egg to naturally cool before collecting and storing. When hens share the same nest, this additional heating pre-incubates the eggs and can be beneficial.

- **PHYSIOLOGICAL ZERO:** Physiological zero – the temperature where the embryo stops developing – is 68.9°. Storing eggs above 69° allows the embryo to continue to grow and can lead to an extended hatch window – chicks hatch at different times.

It may not be wise to store hatching eggs on the counter in your kitchen or other similar warm places. Since the hatch window is one of the most important tools in evaluating a hatch, we should strive to make that window as small as possible.

- **COST OF STORAGE:** Once an egg is stored, embryonic cells begin to die, the egg’s chemical makeup changes, and the egg begins to deteriorate: (a) one day’s storage adds one hour to incubation time, (b) after the initial six-day period, expect a loss of 0.5 to 1.5% per day with the percent increasing as storage extends, and (c) chick quality will be affected from eggs that have been stored for 14 days or more.

There is a cost to storing eggs beyond six days even if they are stored under optimal conditions.

- **STORAGE TEMPERATURE:** Cooler temperatures minimize the negative impact storage has on the egg. The longer the egg is stored, the cooler the temperature should be. Eggs stored for less than 7 days should be held at 61-63°F, while eggs stored longer than 7 days should be held at 50-54°F.

Backyard hobbyist rarely has the facilities to store eggs at different temperatures and, therefore, might do well by selecting a medium range. Household refrigerators rarely have settings that within the acceptable range and usually require an external thermostat ($15.00 on Amazon).

- **STORAGE HUMIDITY:** During storage, moisture is lost through the egg shell into the atmosphere. If humidity levels in the air are high, less moisture will

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1 "Incubation Guide," Hubbard Breeders, NDA, pg. 12.
2 Jacob Hamidu, "Biological Factors Affecting Poultry Embryo Quality," University of Alberta, 2011.
5 Jacob Hamidu, "Biological Factors Affecting Poultry Embryo Quality," University of Alberta, 2011.
be drawn from the egg. Therefore, a relative humidity target of 75-80% is required to prevent eggs from losing too much moisture before incubation starts.¹

- Eggs stored in an open container on the kitchen counter may not be a good idea as older eggs become drier than newer eggs complicating humidity settings during incubation.

**Just like inside an incubator, humidity for egg storage should be monitored using a calibrated hygrometer. Humidity levels are controlled by water surface area. If the humidity is too high, use a smaller bowl. If the humidity is too low, use a larger bowl.**

- **SWEATING:** Set a glass of ice water on the counter and water will form on the outside of the glass – condensation. Moving eggs from a cool environment to a warm one will cause condensation. Condensation on hatching eggs is a really bad thing as it provides a moist environment for mold and bacteria development.

- Use great care when moving eggs from cool environments (a cold hen house) to a warm environment (the kitchen counter).

**PRACTICE:** Understanding the risks of storing eggs for more than seven days, the following storage practice is designed to minimize the harms of storage while allowing larger, more efficient batches:

1. Collect eggs daily (more frequently in cold or hot weather) bring them inside and allow them to rest and cool/warm for 3-4 hours.
2. Using a small fridge controlled by an external thermostat or a wine cooler, refrigerate the eggs at 58-59° F with the humidity between 70-80%.
3. Store the eggs in new, paper cartons – one breed or species for each carton with the large end up. Once a carton is filled, begin tilting the cartons 45° to the left or right on a daily basis.
4. 24 hours before setting, remove the eggs, set them in an incubation tray, and wrap them in a large towel allowing them to warm to room temperature.

**USING A REGULAR REFRIGERATOR:** The temperature within a regular kitchen refrigerator is usually too cold and has had a significant negative impact on my hatch rate, as much as a 20% decrease.

**STORING EGGS POINTY END UP:** Tradition dictates that hatching eggs should be stored with the pointy end facing down; however, there is evidence demonstrating this practice may limited for longer storage periods.

- Dr. Anthony Macharia King’ori, Egerton University, 2011, “Eggs stored with the small end up have higher hatchability as compared to the large end up.”
- J.C.S. de Lima, Federal University of Uberlândia, 2012, “Storing eggs with the small end up is an alternative method to improve hatchability and to reduce egg weight and hatching weight losses in eggs derived from young and old breeders stored up to 14 days.”
- O. Elibol, University of Ankara, 2008, “the detrimental effects of a long storage period may be practically ameliorated by either storage in the SEU position or by an increased turning frequency during subsequent incubation.”
- Dr. Inge van Roovert-Reijrink, Senior Researcher at HatchTech, 2011, “the decline in hatchability can be reduced by 15% when eggs are stored in the small end up position instead of the large end up position.”

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Hygrometers

- **DIGITAL HYGROMETERS**: Digital hygrometers are easy to read, easy to find, and generally inexpensive. Quality, however, is heavily dependent on the quality of its electronic sensor. Most digital hygrometers are “factory set” and not capable of being manually calibrated or adjusted. Humidity is a key component to successful incubation and most digital hygrometers that can be purchased locally are completely inadequate. When purchasing a digital hygrometer, *if it doesn't specifically state its accuracy, do not buy it!*

There is a huge difference between **READOUT PRECISION** and **ACCURACY**. Although a hygrometer may read 45%, it may not be accurate to that 1%... the actually humidity may be much higher or lower than the reading. Carefully check the package and be sure it specifically states that it is accurate to ± 1% and user calibratable.

- **ANALOGUE HYGROMETERS**: Analogue hygrometers are mechanical, have a dial and dial indicator (similar to a clock face with hands), and require fine tuning from time-to-time, usually using a small screw. Much like digital hygrometer, the quality of analogue hygrometers is heavily dependent upon the quality of material used and most devices that can be purchased locally are inadequate for incubation purposes. For best results, examine the packaging to ensure that it can be calibrated and that it is accurate to ± 1%. Personally, I have a strong preference for analogue hygrometers and utilize the one pictured. If I ever begin to doubt their accuracy, I simply re-calibrate them. It most instances, they only require adjusting once per season.

- **CALIBRATING A HYGROMETER**:\(^1\)
  
  **Step 1**: Determine that your hygrometer can be hand calibrated. To check this, look for a small screw head or a hole with a small screw head inside. You’ll need to locate a screwdriver small enough to turn this screw.
  
  **Step 2**: Evaluate the accuracy of the general reading. Wrap the hygrometer in a moistened hand towel or napkin. After a period of about 30 minutes, check the reading. It should read approximately 95%. If it does not, turn the calibration either clockwise or counter clockwise until it reads between 95-100%.
  
  **Step 3**: Gather the following materials: (1) a clean, dry, quart size zip lock bag, (2) a clean, dry water bottle cap (or other similar sized container), (3) sufficient table salt to fill the container, and (4) distilled or filtered water.
  
  **Step 4**: Fill the cap with salt. Wet the salt until it is saturated but not pooling (the salt is not expected to dissolve).
  
  **Step 5**: Place the salt filled cap into one side of the bag.
  
  **Step 6**: Place the hygrometer in the bag on the opposite side and zip the bag closed.
  
  **Step 7**: After 6 hours, check the hygrometer. It should read exactly 75%. If it does not, turn the calibration either clockwise or counter clockwise until it reads 75%. Repeat Steps5-7 until the hygrometer is reading accurately.

- **WET/DRY BULB METHOD**: A method that measures relative humidity by comparing the dry-bulb temperature (a regular thermometer) to the wet-bulb temperature (bulb covered with a wet, cotton muslin). Once the two readings have been obtained, a chart is used to find the relative humidity value.
  
  - **BENEFITS**: When used correctly, the wet/dry bulb method is the most accurate means of measuring relative humidity, especially when the temperature varies greatly. Unfortunately, this advantage tends to disappear under an incubation environment – the temperature (dry-bulb) should remain constant throughout incubation.

\(^1\)^*Calibrating Your Analog Hygrometer,* Cigar Manor, 2017. https://www.cigamanor.com/pages/calibrating-your-analog-hygrometer
DRAWBACKS: Unfortunately, the wet/dry bulb method is cumbersome and many people fail to use them correctly frequently such as using a shoelace for a cotton sleeve and/or taking the dry-bulb reading above the eggs and the wet-bulb reading under the eggs. Use the following to ensure an accurate reading:

1. Both the wet and dry bulb thermometers should be the same type and both must be calibrated.
2. The bulb of both thermometers must be in close proximity to each other and the readings must be taken at the same time to avoid measuring regular temperature variations within the incubator.
3. The cotton sleeve should be made of thin cotton muslin and use distilled water. Alternatives introduce variables that compromise the method’s accuracy.

RECOMMENDATION: The wet/dry method is cumbersome and prone to error in many hobbyist incubation environments. Considering that incubation humidity generally falls within a range of values (e.g. 40-43%), then a good, calibrated analogue hygrometer is sufficiently accurate and much easier to use.

Humidity

Humidity – the amount of moisture in the air – plays a significant role in incubation. Too high of humidity during the first two-thirds of incubation, the air cell is too small to support respiration and the hatchling grows too large to comfortably turn within the egg. Too low of humidity during the first two-thirds, the hatchling can become weak due to dehydration and the lubricating fluids that help the chick turn inside the egg will dry. Unfortunately, finding the perfect humidity setting can be difficult and will vary from situation-to-situation.

NOTATION: Humidity during hatch time is discussed within the hatching section of this guide.

- VARIABLES: During incubation, an egg must lose between 11-12% of its weight primarily in the form of water. How much water is lost depends on a number of variables:
  1. Shell Thickness & Pore Size: Some breeds such as Marans, produce thick shells with small pores; they tend to lose less water than average.
  2. Cuticle: (bloom) The cuticle tends to block pores and reduce moisture loss. Washed eggs without a cuticle lose more moisture than unwashed eggs.
  3. Air Movement: The less air movement (still air incubators) the less the drying effect; the greater air movement (cabinet incubators) the greater the drying effect.
  4. Ambient Humidity & Ventilation: Incubators draw in fresh air and release stale air. The combination of ambient (room) humidity and how much fresh air enters the incubator affects water loss.
  5. Humidity: The higher the humidity = less water loss; the lower the humidity = greater the water loss.
• **RESULTS OF HIGH HUMIDITY (Days 1-18):** The effects of too high of humidity during incubation are not usually seen until hatch time. If the humidity is too high, the air cell will be small and the chick may have difficulty placing its beak into the air cell. In such cases, the chick never takes its first breath. Frequently, hobbyists will claim that these chicks drown but this is not technically correct. Additionally, the chick will grow to fill the available fluid space often becoming too large to comfortable turn inside the shell. In these cases, the chick may not pip externally or, if it does, may not completely zip the shell. Signs of too high of humidity during incubation include:
  - No internal pip with full term embryo
  - Membrane incompletely broken
  - Sticky chicks smeared with albumen
  - Malpositioning
  - Herniated egg sac
  - Delayed hatch
  - Red hocks or unhatched chicks
  - Large chicks

• **RESULTS OF LOW HUMIDITY (Days 1-18):** Hobbyists are often quick to blame low humidity during hatch time on numerous hatching problems. However, this is frequently an error as a healthy chick is likely to hatch even if the hatch humidity is relatively low. Low humidity during incubation (days 1-18) is more likely the culprit and “dry incubation” the likely cause. For the hobbyist, a lower humidity during incubation can improve hatch rates; however, if the humidity is too low, then a number of ill effects can occur:
  - Abnormalities of aortic arches
  - Premature death
  - Internal pipped full term embryo dead in shell
  - Chick stuck in shell; shell fragments stuck to down
  - Early hatch, noisy chicks
  - Thin, weak, or small chicks

• **RECOMMENDED HUMIDITY (Days 1-18):** What is the best humidity to use days 1-18? A simple question; unfortunately, there is no simply answer. Brinsea Products lists 40-50% as idea while Mississippi State University promotes 58-60%. Many backyard enthusiasts promote “dry incubation” (no added water) while still others swear anything less than 60-65% will lead to dried out chicks. There does not appear to be a consensus among the “experts.”

<table>
<thead>
<tr>
<th>Humidity &amp; Temperature Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Carolina State</td>
</tr>
<tr>
<td>Brinsea Products</td>
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<tr>
<td>Hubbard Hatcheries</td>
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<tr>
<td>Murray McMurray</td>
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<td>Pas Reform Academy</td>
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<tr>
<td>Cobb Hatchery</td>
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<td>Ross Technology</td>
</tr>
</tbody>
</table>

| Mean | 51-56 | Average |
| Median | 50-55 | Middle |
| Mode | 50-55 | Most Common |
| High | 60-65 | Highest |
| Low | 40-45 | Lowest |

**Why so much variation in recommendations?** Remember, there are a number of variables involved – shell thickness, pore size, cuticle condition, air movement, ambient humidity, and ventilation. The humidity setting in a small, still air desktop incubator using unwashed eggs will be different than that of room size incubator using washed eggs. What works for one incubator in one part of the country will not work for a different incubator in a different part of the country. Each situation requires unique settings.
Where, then, should I start? For best results, start with the median recommended humidity setting of between 50-55% for days 1-18. Routinely monitor both the humidity and the size of the air cell. Once the chicks hatch, evaluate the results of that hatch and then either raise or lower the humidity depending on what you find.

Never attempt to incubate expensive, precious, or rare eggs until you have had a number of successful hatches. It takes both time and experience to become familiar with your incubator and what works best in your situation. Always start with a batch of barnyard mixes.

- **ADJUSTING HUMIDITY:** The humidity within an incubator is affected by the air flow, ventilation volume, ambient humidity, and water surface area. While the air flow remains constant, ventilation volume should increase with development and ambient humidity will change with the weather. To compensate for these variables, increase the water surface area to increase the humidity or decrease the surface area to lower it.

  Never adjust the humidity level by closing ventilation ports. Developing embryos and hatching chicks are living creatures taking in fresh oxygen and expelling carbon dioxide – the shell has more than 7,000 pores. Reducing ventilation to increase humidity is a dangerous practice.

1. **Desktop Incubators:** Desktop incubators usually have a number of channels in the bottom section. Begin by filling one channel and then increasing the number of channels filled until the desired humidity level is achieved. Using an oven baster, large needle and syringe (available at most feed stores), a funnel with attached tubing, or transfer pipette can ease adding and removing water without the need to remove the eggs. Alternatively, when eggs are hand turned, using wet kitchen sponges on top of the grill can make controlling the humidity easier; simply adjust the size or number of sponges as needed.

2. **Cabinet Incubators:** In my GQF, I cover the water pan with aluminum foil and adjusting the area exposed to increase or decrease the humidity. In my Brinsea 380, I’ve removed the original water pan completely and use a plastic Tupperware bowl in the bottom of the incubator – the larger the pan, the higher the humidity. For hatching in my hatcher, I use a large plastic pan containing numerous large kitchen sponges to raise the humidity to 60%. These methods may seem tedious, but they are simple, inexpensive, and generally need not be adjusted once the desired humidity is achieved.

3. **Humidity Pumps:** A number of commercial humidity pumps and controls are available for purchase or can be fabricated using various components. They are rumored to make the task of controlling the humidity level worry free – simply connect the components, fill with water, set the desired humidity, and let the device do the work. Personally, I’ve never had difficulty maintaining the desired humidity and another gadget would add expense and provide another potential point of failure. However, several people claim that they have improved their overall hatch rates.

Never use ventilation holes to attach a humidity pump. Ventilation holes are intended for one purpose only – to permit fresh O₂ to enter and stale CO₂ to escape. Blocking these ports can result in death of an embryo or impede hatching. Keep ventilation holes clear of obstruction.

- **DRY INCUBATION:** Classical “dry incubation” includes adding no water to the incubator days 1-18 and not monitoring humidity levels. This method has often proven beneficial over traditional settings primarily because desktop incubators have (1) small fans with minimal air circulation and (2) small ventilation holes which are frequently plugged – eggs lose less water than in incubators with stronger fans and greater ventilation. However, because humidity is not monitored, the results can be unpredictable working well during humid months such as March while having disastrous results in dry months such as August.

**How can you tell if dry incubation is not working for you?** If the humidity was too low days 1-18, the classical signs appear at hatch time: fully formed chicks dead in the shell, chicks that pip but get stuck, and abnormally small, weak or noisy chicks. If you find a need to assist in hatching, then your humidity days 1-18 was likely low.
Successful incubation should focus on producing as many healthy, vibrant chicks as possible. Low humidity may produce a slightly higher hatch rate but hatchlings experiencing some levels of dehydration may not perform well in the brooder and be less productive later in life.

Using a “dryer incubation” approach is preferential to “dry incubation.” Lower humidity settings in desktop incubation seem to have a positive correlation with higher hatch rates. But, finding the setting that works best for you takes time, observation, and experience. Closely monitoring your humidity and maintaining a steady humidity during days 1-18 allows you to evaluate the effects of your humidity setting. Was my humidity too high or too low?

- If you see no internal pip with full term embryos, small air cells, membranes incompletely broken at hatch, or sticky chicks, then you can lower your humidity during the next batch.
- If you see fully formed chicks dead in the shell, chicks that pip but get stuck before hatching, and abnormally small, weak or noisy chicks, then you can raise your humidity.

- MONITOR WATER LOSS DURING INCUBATION: The most accurate method of monitoring water loss during incubation is to weigh the eggs every three days. Using this method, the entire batch of eggs including the setting tray before setting the eggs and then every third day during incubation. After subtracting the weight of the setting tray, the entire batch of eggs should about 97.86% of its weight relative to the previous weighing. Unfortunately, few hobbyists have the means to accurately weigh eggs in such a manner and removing eggs from the incubator can potentially damage the eggs through bumping/jarring or excess cooling.

Alternatively, a simpler and safer method is to simply candle a sampling of the eggs, examine the relative size of the air cell, and compare to diagram below. If the air cell is growing too slowly, lower the humidity. If the air cell is growing too rapidly, increase the humidity. Although less accurate than weighing eggs, monitoring humidity by air cell size can be effective – with time and experience.

Hatching is more of an art than a science. A person can follow all the rules exactly to the letter and still have bad hatches. You see, Mother Nature doesn’t provide a broody hen with a rule book. She instinctively knows how much material to pull up around her nest and how much to push away. She doesn’t candle her eggs but she knows which ones to kick out of the nest. She knows when she can safely leave the nest and how long she can be gone. She listens to her eggs and knows when they will hatch. And, she does a pretty good job... all without a rule book.

There are people who hear something in a hatching group and they adopt that something as a golden rule, never to be broken. These people never become Master Hatchers because they never deviate from the rules... they never get a sense... they never get a feel... they never develop an instinct that the eggs need something a little different.

Be a Master Hatcher!
Thermometers

- **OBJECTIVE:** Chickens should hatch on day 21. If they hatch early, then your temperature is too high. If they hatch later, then your temperature is too low. While early and late chicks may survive, they are not among the healthiest or vigorous. It is important that you get your incubation temperature correct.

- **INCUBATOR GAuges:** Do Not Trust the gauges that came with your incubator. Verify that both the temperature and humidity readings are correct with a calibrated thermometer and hygrometer. It is recommended that this verification be repeated periodically. If there is a reading difference between the incubator panel and the calibrated thermometer, trust the calibrated thermometer.

- **DIGITAL SENSITIVITY:** Most digital thermometers are inadequate for incubation. While they may read to 0.1° F, they are only sensitive to 2.0° F – while the readout may display 99.5° F the temperature will range anywhere from 98.5° F to 100.5° F. Before purchasing a digital thermometer, read the packaging. If it does not specifically list an accuracy of ±0.2° F, do not buy it...

- **RESPONSE TIME:** When the heating element comes on, the temperature will rise and continue to do so for a short time after the element switches off. Some digital thermometers will incorrectly register this rise as a temperature spike and cause concern... “Why does my temperature seem to bounce all over the place?” Digital thermometers encase in plastic frequently continue to register this increase long after the air temperature has returned to normal. For best result, buy only digital thermometers with a probe type sensor where the probe can be slipped into one of the vent holes.

- **THERMOMETER TYPES:**

<table>
<thead>
<tr>
<th>STEM</th>
<th>RED, SPIRIT GLASS</th>
<th>DIGITAL PROBE</th>
<th>DIGITAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRO: Slips thru vent May be calibrated</td>
<td>PRO: Easily calibrated Inexpensive</td>
<td>PRO: Slips thru vent Easily to read</td>
<td>PRO: Easy to read Inexpensive</td>
</tr>
<tr>
<td>CON: May be difficult to read Not readable to 0.1°</td>
<td>CON: Difficult to read Not readable to 0.1°</td>
<td>CON: Can be Expensive</td>
<td>CON: Cannot be calibrated</td>
</tr>
<tr>
<td>PRO: Slips thru vent</td>
<td>CON: Most not accurate ±0.2°</td>
<td>PRO: Inexpensive</td>
<td></td>
</tr>
</tbody>
</table>

- **MERCURY THERMOMETERS:** Silver mercury glass thermometers are the most accurate thermometers but are not readily available because of toxicity associated with mercury.
- **CALIBRATING A THERMOMETER:**

<table>
<thead>
<tr>
<th>FREEZING POINT</th>
<th>BOILING POINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fill a glass with crushed ice cubes and cold water.</td>
<td>1. Boil a pot of distilled water.</td>
</tr>
<tr>
<td>2. Stir the water and let sit for 3 minutes.</td>
<td>2. Once the water has reached a rolling boil, insert your thermometer, making sure not to touch the sides.</td>
</tr>
<tr>
<td>3. Stir again, then insert your thermometer into the glass, making sure not to touch the sides.</td>
<td>3. The temperature should read 212°F (100°C).</td>
</tr>
<tr>
<td>4. The temperature should read 32°F (0°C).</td>
<td>4. If it doesn’t, loosen the glue holding the glass to the scale, move the glass up or down as needed.</td>
</tr>
<tr>
<td>5. If it doesn’t, loosen the glue holding the glass to the scale, move the glass up or down as needed.</td>
<td>5. Recheck accuracy and secure tube with a drop of glue.</td>
</tr>
<tr>
<td>6. Recheck accuracy and secure tube with a drop of glue.</td>
<td></td>
</tr>
</tbody>
</table>

- **REMINDERS:**

1. NEVER trust the gauges on your incubator. ALWAYS use a separate, calibrated thermometer.

2. ALWAYS calibrate your thermometer before using. If your thermometer cannot be calibrated, do not use it. If your thermometer was calibrated at the factory, recalibrate it yourself. You don’t need three or four thermometers – use only one that has been carefully calibrated.

3. ALWAYS be sure that your thermometer is accurate to ±0.2°F… most digital thermometers will read to 0.1°F but are only accurate to ±2.0°F. Read the package carefully before purchasing. If it doesn’t say accurate to ±0.2°F then do not buy it.

4. ALWAYS measure the air temperature at the top of the eggs – this includes circulated air and cabinet incubators. This task can be difficult in cabinet incubators but can be accomplished using a thermometer with a long probe.

5. NEVER take a temperature reading while the heating element is on… there will be a little light that turns on when the heating element is on.
Glass Thermometers

**A CASE FOR GLASS THERMOMETERS:** Lately, there’s been a great deal of focus on the best humidity settings for incubation and hatch. Unfortunately, far too many novices seem to blame humidity for poor hatch results. The more experience I gain, the more I believe that a healthy, vigorous chick will hatch regardless of the humidity settings... temperature remains the most important key to a successful hatch.

- **AIR TEMPERATURE:** the air temperature within the incubator. Even with the most expensive incubator, air temperatures will consistently fluctuate (vary). The temperature will rise when the heating element comes on and then it will drop when the element goes off – frequently as much as a full degree (even more so with cheaper incubators). The more insulation and effective the air flow, the less the air temperature will vary. However, these variations only have a minimum impact on the developing embryo.

- **REALIZED TEMPERATURE:** the temperature physically experienced by the embryo. The developing chick is insulated from the air temperature by its cuticle (bloom), shell, inner and outer membranes, and the albumen (egg white). Just as it takes time to boil a pot of water or freeze water in an ice tray, it takes time for the embryo to physically experience a rise or fall in air temperature. How quickly an egg’s temperature changes depends on factors such as humidity, air speed, and egg size.

- **BROODY HEN EXAMPLE:** When a broody hen sits on a clutch of eggs, she is using conduction (touch) to transfer heat to the eggs with only one side being warmed at a time. A hen’s internal body temperature runs between 105-107°F and we can assume that the temperature of heated side of the egg is well above the 99.5°F that we commonly use in artificial incubation. That broody hen will turn her eggs up to 50 times a day so that no one side is heated/cooled for an extended period of time. From her example, we can learn that temperature variation is of less importance than the AVERAGE temperature physically experienced by the developing embryo – the “realized” temperature.

- **THE PROBLEM WITH DIGITAL THERMOMETERS:** When I started back incubating a few years ago, I spent quite a bit of money on thermometers. Unfortunately, those expensive thermometers were useless in an incubation environment. In fact, most were detrimental (damaging) especially the most responsive ones like the renowned Brinsea Spot Check. You see, accurate and responsive digital thermometers react to even the slightest change in air temperature. When the heating element comes on, the reading rises. When the heating element cuts off, the reading drops. These variations caused me to fiddle with my thermostat... and fiddling with the thermostat with eggs in the incubator can cause all sorts of problems.

- **THE SOLUTION:** Expensive digital thermometers do not work well for me. They accurately and precisely measure the “air” temperature but they aren’t very helpful in measuring the “realized” temperature. What I needed was a thermometer that reacted to changes in air temperature more slowly... one that measured the average air temperature... one that better represented the “realized” temperature. My solution was to return to the inexpensive, calibrated, red spirit filled thermometer (old faithful) I had first purchased at Tractor Supply shortly after my wife gave me a Little Giant incubator for Christmas. That thermometer responds to changes in air temperature but more slowly... more in line with what the embryo actually experiences. Since I returned to using old faithful, my babies hatch when they are scheduled – and that is the true measure of a good thermometer.

- **LESSON LEARNED:** Newer and more expensive does not mean better. Since my Little Giant days, I’ve moved on to bigger and more expensive incubators; however, my good and faithful glass thermometer remains the cornerstone of my temperature monitoring. At this very moment, she sits in my hatcher constantly keeping vigilance over my hatching babies.

A glass thermometer need not be expensive. However, it MUST read down to 32°F do that it can be calibrated and it must be large enough to easily read. You can easily judge the accuracy of the glass thermometer... if chicks begin to hatch on day 21, then your thermometer is spot on.
Temperature

Nothing has a stronger influence on a successful hatch than temperature. Most hobbyists know to set the temperature to 101.5°F for still air incubators and 99.5°F for circulated air; but there is more...

We often think in human terms – our normal body temperature is 98.7°F, a temp of 101.2°F indicates a serious infection, and a temp of 105°F can be deadly. However, a chicken’s internal body temperature is between 105° to 107°F and 103.5°F for newly hatch chicks. While humans dislike high humidity because it decreases the effectiveness of sweating (heat index), chickens, however, do not sweat and benefit from higher humidity. When we incubate eggs, we need to think in chicken terms, not human ones.

It is not uncommon for temperatures within desktop incubators to spike to 104-105°F. The cause is not always clear; however, as long as the temperature does not stay too high for too long, the eggs may experience only a minimal negative impact... chickens can tolerate higher temperature than humans. Don’t give up hope. Simply candle in a few days to evaluate the effect.

• BROODY HEN VS INCUBATOR: If a hen’s internal body temperature is 105-107°F, why do we set 99.5°F as the ideal air temperature? As parents, we know that our normal body temperature depends on how we measure that temperature. If we take the temperature under the arm, 96.6°F is normal; if by mouth, 98.6°F; or if rectally, 99.6°F – heat dissipates (scatters) the closer it gets to the external air temperature. So although the hen’s body temperature is between 105-107°F, the temperature physically felt by the eggs is only about 101.5°F on one side at a time with frequent turning averaging that temperature to around 99.5°F.

It is an error to directly compare broody hens and artificial incubation. Hens heat eggs through conduction (touch) – incubators through convection (air). Hens control water loss through skin moisture and physical contact; incubators through relative humidity and air flow. Hens know what to do by instinct – humans through directions. We can’t match a broody hen and shouldn’t try.

• METABOLIC WASTE: Metabolism is a chemical process that uses oxygen to convert raw materials into usable substances. This chemical process produces two waste byproducts – heat and CO₂. In incubating eggs, these byproducts pass through the shell into the surrounding air and are eliminated from the incubator through ventilation. During the early phases, waste byproducts are few because embryo metabolism is minimal; however, as the chicks approach hatch-time, both byproducts – heat and CO₂ – can build up within the incubator and pose significance health risks to the developing chicks.

Never block ventilation ports. Near the end of incubation, a chick’s internal body temperature rises to 103.5°F – four degrees above the set temperature for forced air incubators. Without adequate ventilation, air temperature can spike to above 105°F causing heat injury or death. Additionally, blocking air holes deprive chicks of the oxygen necessary for the physical exertion needed to hatch.

• REALIZED TEMPERATURE: The air temperature within the incubator does not accurately reflect the temperature physically experienced by the embryo. The realized temperature is the temperature physically experienced by the embryo. The developing chick is insulated from the air temperature by its cuticle (bloom), shell, inner and outer membranes, and the albumen (egg white). As the embryo develops, it increasingly produces its own heat through metabolism. Around days 11-12, the egg’s internal temperature will be greater than the air temperature of 99.5°F and will steadily rise to 103.5°F by hatch time.

Do not permit the thermometer bulb or probe to touch an egg. Near the end of incubation, a chick’s internal body temperature rises to 103.5°F – four degrees above the air temperature in circulated air incubators. If the temperature bulb or probe is touching an egg, then you’ll be measuring the shell temperature not the air temperature.

• **IDEAL TEMPERATURE**: The air temperature for a forced air incubator is normally set at 99.5°F; however, this is only an average, not the ideal temperature for incubation... the ideal temperature will change as egg development advances:
  – When set, the egg generates no heat. By hatch, a lot of heat is generated.
  – When set, the egg is at ambient temperature. By hatch, the egg is at 103.5°F.
  – When set, the ideal incubation temperature is 100.5°F is ideal. By hatch, the ideal is 98.0°F.

**BOB’S RESPONSE**: “Are you telling me that a hen decreases her body temp over the 21 days?”

Well, yes, of course... If you watch a broody hen, you’ll notice that she has ways of regulating the temperature of her nest. If the eggs need more heat, she’ll build up the nesting material and sit tight on the eggs. If the eggs need less heat, she’ll spread her wings, stand up slightly, and/or leave the nest for longer periods of time. During the latter portions of incubation, I’ve seen hens off the nest for up to four hours at a time – and the eggs hatch perfectly fine.

In the old days, when the temperature of all incubators was controlled by either bi-metal or wafer thermostats, fiddling with the thermostat was dangerous. Turn the screw knob to the left or right too much, and you could increase/decrease the temperature by several degrees... not a good thing. Keeping the temperature at the same temperature throughout incubation was the safest, most productive route. Not fiddling with the thermostat became a cardinal rule – a rule that should never be broken.

However, with the advent of accurate, reliable digital controllers, fiddling with the thermostat is far less dangerous, and we can begin to consider deploying more ideal temperature settings depending on our method of incubation:

1. **MULTI-STAGE INCUBATION** (Batch Incubation): Eggs within the incubator were set at different times and are expected to hatch at different times. There is just no practical way to calculate all the different ideal temperatures for eggs at various stages of development. Those who use batch incubation will need to stick with a temperature of 99.5°F.

2. **SINGLE STAGE INCUBATION**: All eggs within the incubator were set at the same time and are expected to hatch at the same time. For those using single stage incubation, the attached chart reflects the ideal temperatures during the various stages.

3. **COMBINED APPROACH**: Those of us who have multiple incubators can take a combined approach. I start eggs off in my Coca-Cola incubator with a setting of 100.2°F. After candling on day 7, I move them to my Brinsea 380 cabinet with a temperature of 99.9°F. After about a week, I move them to my GQF 1500 with a temperature of 99.3°F. Then at the end of day 18, I move them to my hatcher with a temperature of 98.5°F.

<table>
<thead>
<tr>
<th>Incubation Day</th>
<th>Air Temperature</th>
<th>Embryo Temperature</th>
<th>Ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>100.0-100.5</td>
<td>100.0-100.0</td>
<td>0-10%</td>
</tr>
<tr>
<td>5-8</td>
<td>99.8-100.0</td>
<td>100.0-100.2</td>
<td>10-20%</td>
</tr>
<tr>
<td>9-10</td>
<td>99.5-99.9</td>
<td>100.0-100.5</td>
<td>30-40%</td>
</tr>
<tr>
<td>11-12</td>
<td>98.5-99.6</td>
<td>100.0-101.0</td>
<td>40-50%</td>
</tr>
<tr>
<td>14-16</td>
<td>98.0-98.8</td>
<td>100.0-101.0</td>
<td>50-60%</td>
</tr>
<tr>
<td>17-18</td>
<td>98.0-98.5</td>
<td>100.0-101.0</td>
<td>60-70%</td>
</tr>
<tr>
<td>19-20</td>
<td>98.0-98.5</td>
<td>-</td>
<td>30-50%</td>
</tr>
<tr>
<td>21</td>
<td>97.0-98.0</td>
<td>-</td>
<td>50-70%</td>
</tr>
</tbody>
</table>

*Use great caution when fiddling with the thermostat while eggs are in the incubator.* Adjusting temperature according to stages of development is ONLY suitable with single stage incubation and ONLY with advanced digital equipment. Fiddling with a tricky thermostat while eggs are in the incubator can have disastrous results. Beginners should NOT consider altering temperatures.

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I tested various spots in both my new cabinet incubator and hatcher. There is over a 1.5 degree temperature difference thru-out. The fans are running. Would some please give me advice on how they've modified theirs to get better distribution of heat? I am very handy and have lots of tools. Thank you in advance!

Bree G. – Hatchaholics Anonymous

**THE PROBLEM:** ALL incubators that are within most hobbyists’ budget have both warm and cool spots... temperatures that are consistently warmer or cooler than the average. This includes higher-end incubators such as those made by Brinsea. Variations under 0.5°F are tolerable; greater variations are problematic:

<table>
<thead>
<tr>
<th>Effects of Temperature Variations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prolonged High Temperature</strong></td>
</tr>
<tr>
<td>early embryonic death</td>
</tr>
<tr>
<td>blood ring (early death)</td>
</tr>
<tr>
<td>death of embryo days 7-17</td>
</tr>
<tr>
<td>early hatch</td>
</tr>
<tr>
<td>extended hatch window</td>
</tr>
<tr>
<td>small, weak chicks</td>
</tr>
<tr>
<td>chicks with unhealed dry navel</td>
</tr>
<tr>
<td>malpositioning</td>
</tr>
<tr>
<td>deformities</td>
</tr>
<tr>
<td>short wiry down</td>
</tr>
</tbody>
</table>

**DIAGNOSIS:** Before using for the first time, ALL incubators should be carefully checked to identify temperature variations and location the warm spots and the cool spots. For small incubators, this can be achieved by simply moving the thermometer around to the various locations. For larger incubators, a thermometer with a long probe is need. I use a calibrated Willhi Temperature Controller and generate a temperature map for reference:

**MODIFICATIONS:** If there are temperature variations greater than 0.5°F, then modifications to the incubator are required. The simplest modification would be simply adding a fan to moves more air. Intermediate modifications may include adding insulation around the incubator and exchanging the current fan for one that moves more air. Extensive modifications may include adding baffles, ducts, and/or fans to alter air circulation. For my GQF Sportsman 1500, I added an insulation jacket (½” foam board and ½” hardwood plywood) and installed an exterior air duct with axial fan ultimately reducing the temperature variation from 1.2°F to 0.5°F.

**EGG ROTATION:** Once variations have been reduced to 0.5°F then a simple egg rotation will reduce the ill effects of minor variations:

1. Placing the newest eggs in the warmest and the oldest eggs in the coolest spots provides more of an ideal temperature for the eggs in their stage of development. (See Ideal Temperature in the previous section.)
2. For desktops, periodically shuffle egg position usually moving eggs from the center to the edges and those on the edges to the center.
3. For cabinets, periodically remove each setting tray, turn the tray around, and place on a separate shelf.

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**Proper incubator placement has a significant impact on temperature stability.** All incubators should be placed in a room with minimal temperature and humidity variations. Place incubators away from windows, doorways, vents, and drafts. Tuck small incubators away in a corner of the room.
Temperature: Heat Sinks

A common question asked in poultry groups is, "What incubator should I buy?" Within the responses, we'll almost always see, "Buy a Brinsea. They're the best." Unfortunately, most people cannot afford a Brinsea -- those things are expensive. Some people can barely afford one of those cheap Little Giants sold in Tractor Supply. (I own a cheap Little Giant and think of it as gold.) Successful incubation of chicken eggs need not be an expensive endeavor. Those cheap foam incubators can do a good job if we adopt practices to help them out a little bit.

- **DEFINITION:** A heat sink is an inert substance used to absorb excess heat when the temperature rises and release heat when the temperature decreases. In desktop foam incubation, a heat sink is an important component in maintaining a stable temperature.

- **HEAT RETENTION:** In simple terms, air has a low Heat Capacity -- air does a poor job of holding heat -- air warms up very quickly and air cools very down quickly.

  This is not a big problem for large cabinet style incubators because they have powerful heating elements (225-250 watts coil). When additional heat is needed, the coil turns red hot quickly and heats the air quickly. When no longer needed, the coil cools down quickly. The latency (wait time) of coil heating elements is small.

  This is not true for smaller, desktop foam incubators. They have weak heating elements (25-40 watts rod) that take time to heat up when needed and time to cool down when no longer needed. The latency of rod elements is large. This leads to greater temperature instability... not good.

- **INCUBATOR PLACEMENT:** For desktop foam incubators, we first combat temperature instability through careful placement -- placing the incubator in the corner of an environmentally controlled room away from doors, windows, vents, and drafts. If possible, we place it between tall furniture to block air from flowing over it. If necessary, we place it in a small bathroom or we construct cardboard walls to place around it. (A closet is not a good spot because of the lack of fresh air.)

- **USING A HEAT SINK:** A second tool we can deploy to combat temperature instability is a heat sink. Heat sinks take up space... the less empty air space, the less temperature instability. Heat sinks also absorb excess heat when the temperature goes too high, and heat sinks release some of that heat when the temperature drops too low. Heat sinks help balance out flaws with the heating element.

  1. **EGGS:** The best heat sinks are the eggs themselves. Since they are mostly water, they have a high Heat Capacity... they hold heat well. Whenever possible, fill your incubator to capacity. If necessary, use infertile, store bought eggs to fill up the empty spaces... simply throw them away when you are done.

  2. **WATER BOTTLES:** Sealed water bottles make superb heat sinks. They consume a good deal of empty space and have a good deal of surface area to absorb/release heat. When using automatic turners, remove one or two of the unused rails to make room for a couple of water bottles.

  3. **ROCKS:** Some people fill the bottom of their incubators with small aquarium type rocks to serve as a heat sink. While not ideal, rocks decrease the amount of empty air space and do absorb/release excess heat. However, using rocks does require special care: (1) the rocks must be washed and sterilized periodically to avoid the growth of mold/bacteria, (2) the rocks should not impede air flow under and around the eggs, (3) moist rocks can play havoc with humidity, and (4) the rocks should not be placed in the water channels.

- **SUMMARY:**

  1. Incubator placement is extremely important in reducing incubator temperature instability.

  2. We want to decrease the amount of empty space without blocking air flow.

  3. We can assist weak heating elements by adding heat sinks that absorb excess heat when the temperature rises and release heat when the temperature falls.

  *We can be successful incubating chicken eggs even with cheap incubators if we take steps to improve temperature stability.*
Turning Eggs

Why do eggs need to be turned during incubation? The most frequent response usually involves, “So the chick will not stick to the shell.” Unfortunately, this simple answer is INACCURATE and tends to permit poor practices to creep into our incubation protocols.

- **BENEFITS OF TURNING:** A broody hen will turn her eggs as often as four times per hour, that’s up to 96 times per day.\(^1\)\(^2\) The primary reason she does this is to ensure all sides of the eggs are equally heated. This turning has a number of other positive effects necessary for proper embryonic development:\(^3\)

1. **Adhesion:** Prevents premature adhesion of the embryo to the inner shell membrane... the chick should not stick to the side before day 6-8.
2. **Growth:** Embryos in unturned eggs grow at a lower rate compared to embryos in eggs turned each hour over 90°.
3. **Yolk:** Stimulates the rate of development of the area vasculosa (the membrane which grows around the yolk and is rich in blood vessels).
4. **Albumen:** Allows normal transfer of albumen proteins into the amniotic fluid, promoting optimum use of the albumen.
5. **Blood Vessels:** Supports the growth of the chorio-allantois (blood vessels under the shell) to maximize oxygen absorption.
6. **Positioning:** Facilitates movements of the embryo into the normal hatching position and reduces the incidence of malpositions in unhatched embryos.

- **ILL EFFECTS OF INADEQUATE TURNING:** The effects of inadequate turning during the first half of incubation is only seen during the second half of incubation, but by then it is too late to take corrective actions.

1. **Early Death or Weak Chicks:** The embryo simply does not have the access to the nutrients, proteins, and oxygen necessary for optimal development. Inadequate access to the necessary building blocks can result in early death or weak chicks. Weak chicks that survive until hatch time may fail to hatch or lack vigor.
2. **Malpositioning:** The chick is not situated in the correct position come hatch time.

**Inadequate turning, along with improper temperature and humidity, is a leading cause of hatch failure.**

- **OPTIMUM TURNING DAYS, ANGLE, & RATE:**

1. **Initial Resting Period:** Not turning for the first 12 hours after setting permits the egg to rest and restore its internal balance. Some advocate not turning shipped eggs for 24-48 hours to allow the shell membranes to re-attach in eggs with detached air cells.
2. **1st Week Critical:** Turning eggs is most critical during the first week of incubation. During this time, the embryo is very, very small and can only access the nutrients in its immediate vicinity. Turning helps “churn” the nutrients making them more readily accessible as well as providing the benefits listed earlier. Even though it is generally accepted that turning is not essential after day 15, studies indicates that continued turning improves metabolism and air cell CO\(_2\) content both having a positive effect on the hatch rate.\(^4\)
3. **Optimum Turning Angle:** Numerous studies have demonstrated that tilting eggs a full 45° from the horizontal plane every hour generally provides for satisfactory results. For devices that do not tilt a full 45° or with eggs from older hens, increasing the frequency of turning can produce similar results.

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\(^2\) “Poultry Facts,” Purdue Agriculture, Purdue University, NDA, http://www.ansc.purdue.edu/faen/poultry%20facts.html


4. **Hand Turning**: The practice of hand turning eggs has largely disappeared with the advent of automatic turners. This is unfortunate for a few of reasons. First, desktop auto-turners only tilt eggs a relatively small degree – there’s just not much churning going on. Second, hand turning promotes bonding between the hobbyist and the egg – the entire experience becomes more personal. And, third, briefly opening the incubator for short periods of time better replicates the cooling cycles of the hen periodically leaving the nest.

Hand turned eggs should be turned at least three spacing the intervals as evenly as possible. In still air incubators, turning five or more times per day promotes more even heating of both sides of the egg. Developing a routine may be helpful – turn once in the morning upon getting up, once in the afternoon upon getting home from work, and turning once in the late evening before going to bed. For best results, wash hands before turning, move the eggs from the center to the edges and roll the eggs on the edge to the center. Placing an “X” on one side of the egg and an “O” on the other helps to ensure that each egg has been adequately turned.

5. **Desktop Turners May Be Inadequate**: Desktop turners have become commonplace and have greatly eased the burden of hand turning eggs three or five time per day. Unfortunately, most desktop models tilt the eggs only 30-35° from the horizontal plane. While this degree may produce satisfactory result, it is far from ideal. Experimentation by Funk and Forward, 1953, with similar results by Cutchin, 2009, demonstrated that turning eggs at a 45° angle increased the overall hatch rate by 5.9% over a turning angle of 30°.\(^1\)\(^2\) If you are using a desktop turner and experiencing less than ideal results, consider hand turning the eggs or purchasing an alternative desktop turning devices, such as Incubator Warehouse’s *IncuTurn*.\(^3\)

6. **Cabinet Incubator Tilt Trays**: Not all cabinet incubators tilt eggs a full 45° from the horizontal plane. For example, the newer GQF Sportsman 1502 only tilts eggs about 35°. If possible, increasing the turning time to once at least every 60 minutes may help correct this deficiency. Alternatively, incubating eggs on their side and flipping them 180° at least once a day has proving helpful with larger or more difficult eggs such as goose, duck, and peafowl. Additionally, personal experience demonstrates that early development rates are significantly increased with cabinets that turn once each hour (Brinsea Ova-Easy 380) compared to those that turn only every four hours (GQF Sportsman 1500).

- **EGG ROTATION & TWISTING**: Unfortunately, even the most expensive incubators contain areas that are warmer (hot spots) or cooler (cold spots) that the average incubator temperature. If an egg remains in a hot spot for the entire incubation period, that chick will hatch early – an egg in a cold spot will hatch late. As we know, chicks hatching early or late have greater risk of health problems, consume more feed, and produce less eggs/meat than those that hatch on schedule.

To combat this flaw in technology, pull each tray daily beginning on day 4, turn it around, and place it on a different shelf. This rotation system ensures that no individual egg sits in a hot or cold spot for an extended period of time. Additionally, the embryo traditionally experiences turning on only two axes (side-to-side). To combat this flaw in technology, periodically twisting each egg 30-45° to the left permits the embryo to experience turning on multiple axes.

Does rotation and twisting have a significant impact on hatchability and chick quality? Anecdotal, personal evidence suggests that it does... to the extent that both are included in my incubation protocol.

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\(^1\) E. M. Funk and James Forward, *"The Effect of Angle of Turning Eggs During Incubation on Hatchability,"* University of Missouri, June, 1953.

\(^2\) H. R. Cutchin, et. al. *"Embryonic development when eggs are turned different angles during incubation,"* Poultry Science Association, 2009.

Shrink-Wrapped & Drowning

Frequently, metaphors (symbols) are used among hobbyists to help beginners understand complex processes. Unfortunately, these metaphors are often taken literally (factually) and lead to an inaccurate understanding. This section is intended to clarify two such metaphors: “shrink-wrapped” and “drowning.”

**It is perfectly normal and desirable for a chick to be shrink-wrapped prior to hatch.** Very rarely does a chick physically drown within its shell.

- **ANATOMY:** The egg shell contains two membranes – an outer and inner membrane. The outer membrane clings to the shell and protects from the loss of excess moisture and hinders mold, bacterial, and viral penetration. The inner membrane clings to the egg contents (albumen) and serves a similar purpose. The air gap between these two membranes is the air space; it is normally located towards the large end of the egg. As incubation progresses, moisture is lost and the gap between these two membranes increases.

- **SHRINK-WRAPPED:** By day 20, most of the amniotic fluid is gone, the chick has grown to fill the available space, and the inner shell membrane is tightly wrapped around the chick. If we were to open the egg, the chick would appear to be shrink-wrapped... this is perfectly normal and does not indicate a problem. The membrane should fit snugly around the chick.

When someone says that a chick is “shrink-wrapped,” what they truly mean is that the chick failed to pip internally (place its beak into the air cell) and that the inner membrane has dried out – turned white, tough, and leathery. The problem is not likely low humidity during hatch time. Rather, the problem is that the chick is too weak to complete the physically demanding task of pipping, zipping, and hatching. The membrane dries out because the chick takes too long to hatch. Increasing the humidity the final three days slows the drying process but it does not correct the main problem – a weak chick. Instead of focusing on humidity days 19-21, you should focus on what caused a weak chick such as poor ventilation, too much or too little humidity days 1-18, inadequate turning, poor egg quality, temperature too low or too high, or bacteria contamination.

- **DROWNING:** I've never seen a healthy egg with free fluid inside the egg. The term “drowning” is rarely mentioned in academic literature and references high humidity days 1-18. It is not related to the humidity at hatch time. By day 20, most of the amniotic fluid is gone, the chick has grown to fill the available fluid space, and the inner shell membrane is snugly wrapped around the chick. The remaining internal fluid coats the chick and serves as a lubricant to assist the chick in turning within the egg and eventually pushing its way out of the shell. The air cell is large consuming nearly 1/3 of the total egg space and remains fluid free.

> ! Not all eggs are created equally. Some eggs may have a thick cuticle, thick shell, and/or thick membranes. Such eggs only reluctantly surrender their internal moisture even if the humidity is perfect days 1-18.

There should NEVER be fluid within the air cell. If there is fluid within the air cell, then a serious problem exists unrelated to humidity... most likely a bacterial infection resulting in a compromised inner membrane. Regardless of the cause, fluid within the air cell results in a gloomy prognosis.

Rather than drowning, it is more likely that the chick was unable to place its beak into the air cell and take its first breath – it suffocates. If the humidity was too high days 1-18, then the chick grows too large and the air cell is too small. The chick has difficulty turning and may not locate the small air cell. If the humidity was excessively high, then there may also be excessive amniotic fluid within the inner membrane. In such cases, the problem is unrelated to the humidity levels days 19-21. To correct this problem, lower the humidity days 1-18.

Some people have mistakenly associated this “drowning” with an excessively high humidity during hatching, days 19-21. They claim, “Your humidity is too high. You’re going to drown those chicks.” This is unfortunate because reducing humidity during hatching increases drying and gives the chick less time to escape.

> ! Excessively high humidity during lockdown can present a problem in the form of heat exhaustion. A combination of excessively high humidity, high temperature, and low ventilation can lead to heat exhaustion – hatching takes a lot of physical labor.
Hatching Eggs Upright

- **GENERAL PHILOSOPHY**: Many individuals see the incubation of poultry eggs as a science and believe following guidelines established by experts is the best path to a successful hatch. In general, I agree BUT also believe that incubation is partially an art form. While I believe that my current methods are effective, I recognize that others may have good ideas and attempting some those ideas may improve my technique.

- **BACKGROUND**: Some hobbyists have taken to placing chicken eggs inside egg cartons during the last phase of incubation. They claim that the cartons hold the egg in a desirable position and prevent unhatched eggs from being bumped by early hatchlings ultimately leading to an improved hatch rate. As a side benefit, the upright shells tend to contain the “gunk” associated with hatching making for easier clean-up.

- **QUESTIONS**:
  1. Does placing the egg in an upright position improve pipping and shell emergence?
  2. Does limiting the bumping of unhatched eggs improve their chances of successfully hatching?
  3. Does placing the egg in an upright position lead to a cleaner hatch requiring less clean-up?

- **CONCERNS**: In Nature, eggs lay on their side during the hatching process and the chick rotates vertically to zip the end of the shell. Placing the egg in an upright position would require the chick to rotate horizontally which seems unnatural. Additionally, with the egg on its side, the hatchling uses its feet to push the shell away. With an upright egg, the bottom of the shell remains stationary while the hatchling must push its entire body out of the shell.

- **SETUP**: Fifty eggs – 49 laying hybrids of ¾ Rhode Island Red and ¼ Rhode Island White heritages along with one Serama – were incubated for a period of 18 days on the same tray within a GQF 1500 incubator. No untold events occurred during the first 18 days of incubation. Prior to being transferred to the dedicated hatcher, 25 eggs were placed on their side in a hatching basket (TRADITIONAL) while the remaining 25 were kept in their incubation tray and the entire tray placed in a hatching basket (CARTON). The TRADITIONAL was placed in the hatcher on the third shelf while the CARTON was placed on the second shelf. Prior experience has shown that the second shelf is slightly warmer than the third and that eggs on the second shelf hatch a little earlier than those on the third. Humidity was maintained at ~68%.

- **INITIAL OBSERVATIONS**: The first external pip occurred in the TRADITIONAL. Within two hours a total of five eggs had pipped externally with three being in the TRADITIONAL and two from the CARTON. Within 12 hours of the initial pip, a total of seven hatchlings had fully emerged with five being from the TRADITIONAL and only two from the CARTON. Additionally, multiple pips and nearly emerged hatchlings were observed in the TRADITIONAL with only two additional small pips noted in the CARTON. The initial observations caused concern as the hatchlings from the second shelf were expected to emerge sooner than those of the third.

- **HATCH SUMMARY**: Forty-one of the total 50 eggs hatched – 23 from the TRADITIONAL and 18 from the CARTON. Three from the CARTON were removed from the carton, the shell over the air cell removed, the eggs laid on their side, and the chicks permitted to exit under their own power. From the TRADITIONAL basket, the Serama egg was under-developed and the other unsuccessful hatching had pipped and zipped the small end of the egg but failed to emerge. From the CARTON basket, two were under-developed, two had pipped internally but not externally, and the remaining three had failed to pip internally. One leg from a CARTON hatching had become glued to the carton; the leg was dislodged, and, hopefully, the hatchling will make a full recovery.

- **CONCLUSIONS**: In my opinion, the results are fairly conclusive. *Eggs placed in an upright position for hatch does not improve pipping or emergence*. In all likelihood, this unnatural positioning tends to inhibit internal and external pipping. Additionally, although the bumping of unhatched eggs may seem disruptive, such bumping does not appear to have a negative impact upon late hatchers. As the “gunk” associated with hatching does remain in the bottom portion of the shell, less clean-up is required when eggs are hatched inside of cartons. However, utilizing porous shelf lining serves a similar purpose without the negative consequences.
Hatch Rate

WHAT IS A GOOD HATCH RATE FOR A BEGINNER? A simple question; unfortunately, there is no simple answer. Many people claim 95%, 96%, even 100% hatch rates but those figures may be slightly exaggerated and certainly are not the average.

- **FERTILITY RATE** is the number of eggs that show development upon day seven candling compared to the number of eggs originally set:
  
  \[
  \frac{85 \text{ show development}}{100 \text{ eggs set}} = 85\% \text{ Fertility Rate.}
  \]

- **HATCH RATE**: The term “hatch rate” is used in two different manners:
  1. **HATCH RATE FOR ALL FERTILE EGGS**: The number of hatchlings compared to the number of eggs that show development upon day 7 candling:
    
    \[
    \frac{75 \text{ hatchlings}}{85 \text{ show development on day seven}} = 88\% \text{ of All Fertile Eggs}
    \]
  2. **HATCH RATE FOR ALL EGGS SET**: The number hatchlings compared to the number of eggs originally set
    
    \[
    \frac{75 \text{ hatch}}{100 \text{ eggs set}} = 75\% \text{ of All Eggs Set}
    \]

- **PERSPECTIVE**: Mother Nature is not perfect, and even if the incubation environment is perfect, not all eggs will hatch. Human mothers only have a birth rate of 69% of all fertile eggs (*New England Journal of Medicine*). Commercial hatcheries only set their expectations at 90% of all eggs set... even lower with ducks at 70-75% (*Metzer Farms*). If commercial hatchers – with the best science, genetics, feed, and equipment – only have an expectation of 75-90%, then we should be careful about setting our expectations too high.

- **REALISTIC HATCH RATE**: What then is a realistic hatch rate? In reviewing a *BackYardChicken* thread, 37 hobbyists listed their honest results of several individual batches.
  
  Average: 49.7% (normal)  
  Mode: 54% (most common)  
  Median: 50% (middle)  
  High: 62% (high)  
  Low: 35% (low)

  From this dataset, it appears that a rate of 50% of all eggs set appears to be a realistic goal.

Would I be happy with a 50% hatch rate? No, but I have a solid investment of time, money, and effort in improving my flock, my equipment, and my knowledge. A good hatch rate for me depends on the species, weather, age of flock, genetic pool, and collection conditions. I’m disappointed if I get a goose hatch rate under 90% in February but thrilled with a 50% rate in June. If my black sex-link rate falls below 90% then I’m sad; however, if I get an 85% rate from those same hens using a Dominique rooster then I’m happy.

- **EVALUATION**: How do I tell if it’s my incubation process and not a different factor? I use three factors: hatch timing, hatch window, and broody comparison.
  1. **HATCH TIMING**: (Hatch Start) Chicks should begin to hatch towards the start of day 21 – hour 488 is my target. If they start to hatch earlier, then my temperature was too high. If they start to hatch later, then I need to check my thermometer or evaluate my storage method.
  2. **HATCH WINDOW**: (Hatch Spread) All chicks should hatch on day 21. If the last chick hatches more than 24 hours after the first chick, then I need to evaluate my incubator for hot/cold spots, evaluate my storage method, consider the age/health of my hens, or search for clues of contamination.
  3. **BROODY COMPARISON**: If I establish ideal incubation conditions, then my hatch rate should be the same as a broody hen. Last year, my hatch rate was significant higher than my ducks, geese, and turkeys but significantly lower than my Serama bantams. I had no standard size chicken go broody. I need to figure out how the Serama hens are doing better than me.

- **A LITTLE TALE**: When I first started incubating duck eggs, I thought I was doing a horrible job – my ducks had a 100% hatch rate. My hatch rate was significantly lower. It puzzled me for a while, but then I discovered their secret. Those girls were cheating... I caught them rolling the bad eggs out of the nest so the turkeys would eat them. They only had a hatch rate of 70%; mine was much better.

*Your hatch rate is a tool that can help you evaluate your hatching capabilities, but it is not a measure of success or failure. Any hatchling is reason to celebrate because if you didn’t try, you would have no hatchlings at all.*
Hatch Evaluation

Poor hatches happen; and when they do, a wise person will carefully evaluate the entire incubation process to determine what went wrong. Even those with experience will examine each hatch in an attempt to discover what can be improved in future hatches. After completion of each hatch, consider the following points to determine where improvements are warranted:

- **FERTILITY RATE**: Number of eggs set ÷ Number of eggs begin development = Fertility Rate. The fertility rate varies between breeds and species. Although it is unreasonable to expect a fertility rate of 100%, you can improve your odds by:
  1. **FEMALE: MALE RATIO**: Although a ratio of 8 females to 1 male may be suitable for laying type chickens, fertility rate will be much lower if that rate is used with rare, bantam chickens.
  2. **BREEDER HEALTH**: Poor nutrition, inadequate exercise or ventilation, and using a male or female that is too young or too old will have a negative impact on fertility rates.
  3. **GENETIC DIVERSITY**: Breeds or species from a small genetic pool will have a lower fertility rate than more of the more common types. Inbreeding can also lower fertility and hatch success.
  4. **CLIMATE EXTREMES**: Eggs laid during excessively hot or cold weather will suffer a lower fertility rate.
  5. **EGG STORAGE**: Eggs that are stored too long or are poorly handled will suffer a lower fertility rate.
  6. **INCUBATOR CALIBRATION**: Incubators that have not been properly warmed and regulated may experience spikes in temperature killing the embryonic germ prior to development.

- **HATCH RATE**: Number of hatched hatchlings ÷ Number of fertile eggs = Hatch Rate. A hatch rate of 85% is generally considered satisfactory among most breeds of fowl. Some species, such as turkeys and bantams will naturally produce a lower hatch rate than average. Other breeds, such as hybrid laying hens, will produce a higher hatch rate than average. The same factors that influence the fertility rate also play a role in the hatch rate. Other factors include:
  1. **LOW INCUBATION TEMPERATURE**: In general, it is better to incubate at a slightly higher temperature, such as 100° F, rather than a slightly lower temperature, such as 99°F.
  2. **HIGH INCUBATION HUMIDITY**: High humidity during incubation leads to inadequate water loss and a small air cell at hatch. Hatchlings experience difficulty in maneuvering within the shell, locating the air cell, and pipping internally leading to drowning.
  3. **INADEQUATE TURNING**: Routine turning provides the embryo with some exercise, allows the embryo to develop uniformly, and prevents the embryo from sticking to the shell. Failure to turn eggs an adequate number of times or an adequate number of degrees decrease hatchling viability and performance.
  4. **LOW HATCH HUMIDITY**: Once a hatchling externally pips, the hatchlings begins to dry and if it takes too long for the them to emerge from the shell, the membrane can dry out gluing them to the shell.
  5. **INADEQUATE VENTILATION**: While studies indicate that high CO² levels during the first several days of incubation can improve fertility rates, high CO² levels during hatch can prove disastrous. For best results, be sure that all vents are open during hatch. Open vents work to lower the humidity during hatch, but this effect can be countered by adding as many wet sponges as needed.
  6. **HIGH HATCH TEMPERATURE**: Hatching is an exhausting activity that required a hatchling’s full energy. If the temperature during hatch is too high, hatchlings are more likely to exhaust themselves prior to emergence from the egg. I maintain a hatch temperature of 98.5° F to avoid this problem. However, this temperature should only be used with dedicated hatching units. It is unwise to alter temperature settings while eggs are in the unit.
  7. **UNANTICIPATED EVENTS**: Unavoidable events such as power outages, the door accidentally left unlatched or equipment failure happen.
  8. **ENVIRONMENTAL**: Fluctuations in temperature and humidity caused by inadequate placement of incubator, room temperature and humidity variations, and poorly operating or designed equipment.

- **EGGTOPSY**: Not all chicks will hatch. There are multiple reasons why this occurs from hen nutrient deficiencies, cold temperatures during collection, bacterial contamination, genetic flaws, and flaws in incubation methods. Eggs that did not hatch should be opened and examined to determine, if possible, why the chick failed to hatch. The following link from The Chicken Chick provides an excellent look at the stages of development:
21 Days of Incubation

Chickens should hatch on day 21 of incubation. The elapsed time between first chick and last chick should be no more than 24 hours.

While each incubator and each batch of eggs are unique, hatch time should be fairly consistent. Evaluating imperfect hatch results will help us identify flaws in our incubation method, take corrective actions, and ultimately improve our techniques. After each batch, I consider each of the following items to discover how I can make the next batch better:

GOAL 1: THE HATCH SHOULD BE COMPLETE BY THE END OF DAY 21

- MOST EGGS HATCH LATE: POWER OUTAGE: If the electricity goes off or the incubator inadvertently becomes unplugged, the temperature will drop. While most eggs can tolerate lower temperatures for several hours, the hatch will be delayed. Small eggs lose heat faster than large eggs and will usually hatch even later.

- MOST EGGS HATCH LATE: LOW AVERAGE TEMPERATURE:

| Ye, I had my thermometer in the wrong place (taped in the window at top) first hatch - failed miserably it was a 10° degree difference! | Nichole Hansen, Backyard Chickens |

1. THERMOMETER PROBE TOUCHING EGG SHELL: As the chick grows, it begins to generate its own heat through metabolism. As development progresses, the shell temperature becomes warmer (101° F) than the circulated air. If the bulb or probe is resting on the egg shell, the thermometer will read high.

2. THERMOMETER PLACEMENT LEVEL TOO HIGH: Warm air rises and cool air sinks. The incubator’s temperature should be measured at the TOP of the eggs especially for still air incubators. While the fan in desktop forced air models circulates air, they still experience heat layering and the thermometer probe should be kept at egg top level.

3. THERMOMETER INACCURATE: Digital thermometers should be accurate to ±0.2° F. Unfortunately, most are only accurate to ±2.0° F meaning if the display reads 99.5° F the actual temperature can be anywhere from 98.5° F to 100.5° F. When buying a digital thermometer ensure that it is accurate to ±0.2° F.

4. THERMOMETER UNCALIBRATED: Most thermometers claim to be calibrated at the factory, but almost all thermometers are incorrect. Thermometers should be calibrated by placing its bulb/probe in a pan of crushed ice and water – the thermometer should read 32.0° F.

5. THERMOMETER PROBE/BULB IN COOL SPOT: All incubators have warm and cool spots. If the thermometer is kept in a warm spot, then the overall temperature will be cooler than needed. When regulating your incubator, measure the temperature is several different areas. Place the thermometer in an area that is neither cool nor warm.

- MOST EGGS HATCH EARLY: HIGH AVERAGE TEMPERATURE:

| Because overheated chicks hatch earlier than they should, they are often smaller, weaker and more prone to infections as well as a host of other health problems. | Cobb Hatcheries |

1. THERMOMETER PLACEMENT LEVEL TOO LOW: Warm air rises and cool air sinks. The incubator’s temperature should be measured at the TOP of the eggs especially for still air incubators. While the fan in desktop forced air models circulates air, they still experience heat layering and the thermometer probe should be kept at egg top level.

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GOAL 2: ALL CHICKS SHOULD HATCH WITHIN A 24 HOUR PERIOD (HATCH WINDOW)

- **EGGS STORED ABOVE 68° F:** A chicken embryo begins to grow before the hen lays the egg; however, this process ceases at temperatures below 68°F permitting hens to lay full clutches before incubation begins.¹ Common practices allow eggs to be stored at room temperature for seven to ten days; unfortunately, older eggs may experience greater development than newer ones as room temperature approaches 80° F. For best results, store eggs below 68°F (55-65°F) allowing them to warm to 75-80°F prior to setting.

> Cooling at ordinary temperatures will not kill the embryo, and it will begin to develop again when the egg is placed in the incubator. Keeping eggs at temperatures above about 80° F (27 C) prior to incubation will cause a slow growth which leads to a weakening and eventual death of the embryo.  
> *University of Illinois, 1988*

- **HOT & COLD SPOTS INSIDE INCUBATOR:** Few incubators maintain perfectly even temperatures in all areas – some spots will be warmer and some spots cooler – differing as much as one full degree. Fans help circulate the air reducing temperature variations; however, automatic egg turners, covering the mesh flooring, and cramming eggs into a small space decrease air flow and fan effectiveness. Many hobbyist set their eggs in the turner and then hope that the incubator will do all of the work; unfortunately, eggs resting in a cool spot for the entire incubation will hatch later than those resting in a warm spot. For best results, eggs should be shuffled periodically – eggs in the center moved to the sides and those on the sides to the center.

> Broody hens provide optimum conditions for embryos developing in the eggs they are sitting on. The brood patch provides heat from one direction only, and the eggs at the side of the patch are cooler than those in the middle of the nest. However, because the broody hen regularly turns and moves the eggs in the nest, uniform egg temperature is achieved.  
> *Pas Reform Hatchery Technologies*

- **EGGS STORED DIFFERENT LENGTHS OF TIME:** According to Cobb Hatcheries, not only does prolonged storage decrease hatchability (about 1% for each day after the initial six) but it also prolongs incubation time, “On average, one day’s storage adds one hour to incubation time.”² To decrease the storage effect, eggs should be carefully stored using the following recommendations. Warm eggs for 4-6 hours before setting.

<table>
<thead>
<tr>
<th>Hubbard Hatcheries</th>
<th>Days of Storage</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>1-2</td>
</tr>
<tr>
<td>Temperature</td>
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<tr>
<td>Humidity</td>
<td>70.0</td>
</tr>
<tr>
<td>Turning</td>
<td>No</td>
</tr>
<tr>
<td>Small end up</td>
<td>No</td>
</tr>
</tbody>
</table>

- **EGGS FROM YOUNG & OLD HENS:** Research indicates that eggs from hens 32-45 weeks old produce the healthiest and most vigorous chicks. Unfortunately, most home flocks consist of hens from various age groups. For best results, attempt to avoid eggs from very young or very old pullets. While these may produce healthy chicks, they expand the hatch window and experience more difficulties.

> Maternal age directly affects the rate of embryonic development. Embryos from ‘pubescent’ flocks (< 32 weeks) require longer incubation periods than embryo’s from ‘mature’ flocks (>32 weeks).  
> *The Poultry Site, 2006*

- **EGG SIZE VARIATIONS:** Within an environmentally stable and consistent environment, small eggs will hatch at the same time as large eggs. When the temperature within an incubator is inconsistent – bounces up and down – smaller eggs will hatch significantly earlier or later than larger eggs – small eggs heat up and cool down faster. If this occurs, consider your incubator placement and move to a location free of drafts, heating/cooling vents, and direct sunlight or a room with a more stable environment.

¹ from Gaylene M. Fasenko, “Optimal egg storage conditions,” University of Alberta, 2006  
Incubating Waterfowl

Much of the information pertaining to hatching chickens applies to ducks and geese, but there are differences.

- **DUCK TURNING TRAYS**: Duck eggs, except mallard and call ducks, are usually larger and may not fit comfortably into regular trays. In desktop models, it is probably best to remove the automatic turner, lay the duck eggs on their side, and turn manually. For cabinet models, extra-large trays used for turkey, ducks, and peafowl are required.

- **GOOSE TURNING TRAYS**: Goose eggs are large, sometimes very large and require a special incubation tray or set on their side during incubation. I do not recommend commercially manufactured goose egg trays as they are relatively expensive and hold only very few eggs. Personally, for desktop models, I simply lay the eggs on their side and turn them by hand. For cabinet incubators, I fabricate a goose egg tray using ½ inch hardware cloth by folding the wire in a |_|_|_|_| manner.

- **INCUBATION PERIOD**: Instead of 21 days, Mallard ducks hatch in 26.5 days, Pekin in 28, Muscovy ducks in about 35 days, and geese 30 days.

- **HUMIDITY**: While chicken eggs do well with low humidity during their first 18 days, ducks and geese usually require a higher relative humidity – 43-48%.

- **COOLING & MISTING**: Many waterfowl egg shells are thick and hard making it difficult for the duckling/ gosling to emerge at hatch time. Although the exact mechanism is unknown, allowing the eggs to cool followed by a misting of lukewarm water causes the shell to become more brittle. Personally, following day 7 of incubation, I remove the eggs from the incubator, allow them to sit on a counter at room temperature for 15 minutes, mist one side with lukewarm water, flip each egg 180°, mist the other side, and then replace them in the incubator. If you have an infrared temperature gun, the shell surface should cool to 86° F. I do not cool or mist the eggs once I stop turning three days before hatch.

- **DIRTY EGGS**: Unlike chickens or larger domesticated duck, Mallards do everything in their power to hide their nests and sometimes their nesting sites are unsanitary. Geese usually do a better job of utilizing prepared nesting sites, but their eggs may become fouled as well. For best results, incubate only clean eggs; however, if your options are limited, dirty eggs can be washed if the following is observed:

- **HATCHING TEMPERATURE**: If you can do so without affecting other eggs, ducklings and goslings benefit from a lower temperature during hatch – 98.0-98.5° F. Do not attempt to adjust on models where you must turn a small knob to adjust the temperature; the risk of causing excessive temperature swings outweighs any benefits from a slightly lower temperature.

- **HATCHING**: Normally, the first pip will occur 36-48 hours prior to the hatch date. It can take 24-36 hours for a duckling to completely zip the shell and emerge. They will naturally rest between efforts so resist any temptation to help a tired duck from their shell. Be patient, unless there has been an unexpected incubation event, healthy ducklings will emerge from the shell under their own power.

- **BROODING**: Ducks and geese are excessively messy birds. Do not use water containers that allow them to play in the water as the litter will become damp promoting the growth of mold. Additionally, the down of artificially brooded ducklings and goslings does not repel water; a wet ducklings and goslings chills easily resulting in death. Personally, I brood waterfowl on old, cloth towels for the first three days and then raise them on ½ inch hardware cloth thereafter. I do not allow ducklings or goslings to swim until their down has been largely replaced with feathers.
### Hatch Result Analysis

<table>
<thead>
<tr>
<th>Clear eggs found at candling: No signs of embryonic development, eggs are infertile</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Immature males</td>
</tr>
<tr>
<td>• Too many hens or not enough males</td>
</tr>
<tr>
<td>• Extreme climatic conditions</td>
</tr>
<tr>
<td>• Old breeder flock</td>
</tr>
<tr>
<td>• Health problem</td>
</tr>
<tr>
<td>• Males or females too heavy</td>
</tr>
<tr>
<td>• Excess or deficiency of nutrients, feed control too strong</td>
</tr>
<tr>
<td>• Parasites</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clear eggs found at candling: Signs of embryonic development (enlarged germinal disc), eggs are fertile</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Storage period too long</td>
</tr>
<tr>
<td>• Inappropriate storage conditions</td>
</tr>
<tr>
<td>• Heat shock</td>
</tr>
<tr>
<td>• Pores blocked</td>
</tr>
<tr>
<td>• High temperature at the start of incubation</td>
</tr>
<tr>
<td>• Flock too young or too old</td>
</tr>
<tr>
<td>• Health problems</td>
</tr>
<tr>
<td>• Frequency of egg collection is insufficient or incomplete</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clear eggs found at candling: Presence of the blood ring or a dead embryo before 3 days of incubation, no black eye visible</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Egg storage too long or wrong temperature</td>
</tr>
<tr>
<td>• High temperature at the start of incubation</td>
</tr>
<tr>
<td>• Insufficient temperature at the start of incubation</td>
</tr>
<tr>
<td>• Health problems</td>
</tr>
<tr>
<td>• Flock too old</td>
</tr>
<tr>
<td>• Severe nutritional deficiencies</td>
</tr>
<tr>
<td>• Contamination</td>
</tr>
</tbody>
</table>

**Dead embryos: 3 to 17 days of incubation**

<table>
<thead>
<tr>
<th>As above</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Inadequate ventilation or blocked pores</td>
</tr>
<tr>
<td>• Inadequate turning</td>
</tr>
<tr>
<td>• Inadequate turning angle</td>
</tr>
</tbody>
</table>

**Dead embryos: >18 days of incubation**

<table>
<thead>
<tr>
<th>Inadequate temperature, humidity, turning or ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Contamination</td>
</tr>
<tr>
<td>• Eggs cooled during transfer, or transfer done too late</td>
</tr>
<tr>
<td>• Broken eggs</td>
</tr>
<tr>
<td>• Malposition of the embryo</td>
</tr>
<tr>
<td>• Hatcher opened too frequently during pipping or hatching</td>
</tr>
</tbody>
</table>

**Non pipped eggs, embryos completely formed, a part of the yolk is not completely absorbed**

<table>
<thead>
<tr>
<th>Inadequate turning</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Humidity too high during incubation or after transfer</td>
</tr>
<tr>
<td>• Insufficient temperature during incubation</td>
</tr>
<tr>
<td>• Hatcher temperature too high</td>
</tr>
<tr>
<td>• Inadequate ventilation</td>
</tr>
<tr>
<td>• Prolonged storage</td>
</tr>
</tbody>
</table>

**Eggs pipped, embryos completely formed, dead in shell**

<table>
<thead>
<tr>
<th>Insufficient humidity or temperature during long periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Insufficient humidity in the hatcher</td>
</tr>
<tr>
<td>• High temperature in the hatcher</td>
</tr>
<tr>
<td>• Insufficient ventilation</td>
</tr>
<tr>
<td>• Inadequate turning during the first 12 days</td>
</tr>
<tr>
<td>• Prolonged storage</td>
</tr>
</tbody>
</table>

**Early hatch, noisy chicks**

<table>
<thead>
<tr>
<th>Small eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Difference between breeds</td>
</tr>
<tr>
<td>• Incubator temperature too high</td>
</tr>
<tr>
<td>• Incubator humidity too low</td>
</tr>
</tbody>
</table>

**Delayed hatch**

<table>
<thead>
<tr>
<th>Big eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Old flock</td>
</tr>
<tr>
<td>• Prolonged storage</td>
</tr>
<tr>
<td>• Insufficient temperature during incubation</td>
</tr>
<tr>
<td>• Weak embryos</td>
</tr>
<tr>
<td>• Humidity too high during incubation</td>
</tr>
</tbody>
</table>

**Hatch window is too long**

<table>
<thead>
<tr>
<th>Mixing of eggs stored for different lengths of time in</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Mixing of eggs from both young and old flocks</td>
</tr>
<tr>
<td>• Mixing of both small and big eggs</td>
</tr>
<tr>
<td>• Incorrect egg handling</td>
</tr>
<tr>
<td>• Hot or cold spots in the incubator or hatcher</td>
</tr>
<tr>
<td>• Incubation or hatch temperature too high or too low</td>
</tr>
</tbody>
</table>

**Poor uniform hatch between the different hatch trays**

<table>
<thead>
<tr>
<th>Mixing of small and big eggs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Mixing of eggs from both young and old flocks</td>
</tr>
<tr>
<td>• Mixing of eggs from different breeds</td>
</tr>
<tr>
<td>• A part of the eggs were stored for too long</td>
</tr>
<tr>
<td>• Inadequate ventilation in either the incubator or hatcher</td>
</tr>
<tr>
<td>• Health problem in one or more flocks</td>
</tr>
<tr>
<td>• Different storage conditions</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th><strong>Sticky chicks, traces of albumen on the fluff</strong></th>
<th><strong>Chicks stuck to the shell, chicks with part of the shell stuck to their fluff</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Insufficient temperature during incubation</td>
<td>• Humidity during incubation too high</td>
</tr>
<tr>
<td>• Humidity during incubation</td>
<td>• Inadequate turning</td>
</tr>
<tr>
<td>• Inadequate turning</td>
<td>• Old eggs</td>
</tr>
<tr>
<td></td>
<td>• Eggs too big</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Early hatch, umbilical buttons</strong></th>
<th><strong>Small chicks</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Temperature too high during incubation or hatching</td>
<td>• Small eggs</td>
</tr>
<tr>
<td>• Inadequate turning</td>
<td>• Insufficient humidity during storage or incubation</td>
</tr>
<tr>
<td>• Eggs broken or poor shell quality</td>
<td>• Temperature too high during incubation</td>
</tr>
<tr>
<td></td>
<td>• Porous or weak shells</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Navel not closed, dry fluff</strong></th>
<th><strong>Navel not closed, wet, smelly. Big chicks, lethargic, soft abdomen</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Temperature high during incubation</td>
<td>• Insufficient temperature in the incubator</td>
</tr>
<tr>
<td>• Variation of temperature</td>
<td>• Humidity high in either the incubator or hatcher</td>
</tr>
<tr>
<td>• Insufficient temperature during hatching</td>
<td>• Inadequate ventilation</td>
</tr>
<tr>
<td>• Humidity during hatch too high</td>
<td>• Temperature too high during incubation or hatching</td>
</tr>
<tr>
<td>• Insufficient ventilation at the end of hatching</td>
<td>• Porous or weak shells</td>
</tr>
<tr>
<td>• Inadequate breeder nutrition</td>
<td>• Poor transport and storage conditions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Weak chicks</strong></th>
<th><strong>Mal-position</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Temperature high in the hatcher</td>
<td>• Old flock</td>
</tr>
<tr>
<td>• Ventilation insufficient in the hatcher</td>
<td>• Eggs too big</td>
</tr>
<tr>
<td></td>
<td>• Poor transport and storage conditions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Malformation</strong></th>
<th><strong>Curlu toes, splayed legs</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Inappropriate storage conditions</td>
<td>• Temperatures during incubation high or low</td>
</tr>
<tr>
<td>• Poor hatching eggs transport conditions</td>
<td>• Nutritional deficiencies</td>
</tr>
<tr>
<td>• Nutritional deficiencies</td>
<td>• Inadequate ventilation</td>
</tr>
<tr>
<td>• Inadequate turning</td>
<td>• Poor orientation of the eggs (eggs small end up)</td>
</tr>
<tr>
<td>• Humidity high</td>
<td>• Temperatures during incubation too high or low</td>
</tr>
<tr>
<td></td>
<td>• Health problems</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Curled toes, splayed legs</strong></th>
<th><strong>Short fluff, dry, rough</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Temperatures during incubation high or low</td>
<td>• Nutritional deficiencies</td>
</tr>
<tr>
<td>• Nutritional problems</td>
<td>• High temperature during the first 14 days of incubation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Dwarf like chicks, insufficient growth</strong></th>
<th><strong>Exploding eggs</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Contaminated eggs</td>
<td>• Condensation on the egg shell surface</td>
</tr>
<tr>
<td>• Contamination particularly during hatching</td>
<td>• Using a contaminated solution to spray the eggs</td>
</tr>
<tr>
<td></td>
<td>• Health problems</td>
</tr>
<tr>
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<td></td>
</tr>
</tbody>
</table>

| | • Nutritional deficiencies |
| | | • Thyroid anomaly |

| | | • Condensation on the egg shell surface |
| | | • Using a contaminated solution to spray the eggs |
| | | • Eggs contaminated by other exploding eggs |
| | | • Handling eggs with dirty hands |
Artificially Brooding Hatchlings

- **BROODER:** A brooder is a heated enclosure in which young fowl or livestock are raised. Brooders need not be sophisticated or permanent structures; they need only to protect young hatchlings from cold, drafts, and dampness. A simple plastic tub with a screen covering placed in a back room is well suited for many beginners. A good brooder has the following traits:

- **LOCATION:** Brooders should be located within a structure with a relatively stable environment free from drafts and moisture. Almost any small building with good ventilation is suitable in the late spring or early summer. Greater protection is required when temperatures are extremely low or high. An insulated or semi-heated garage or shed may be suitable for a brooder during colder weather.

- **SPACE:** Hatchlings need sufficient space to move, when necessary, away from the heat source. A large 30 gallon plastic tote is large enough for 10 chicks for up to 3 weeks. General space recommendations include:

<table>
<thead>
<tr>
<th>Age of chicks</th>
<th>Floor space per bird</th>
<th>Sample Enclosure for 10 birds</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 4 weeks</td>
<td>½ square feet</td>
<td>2 ½ foot x 1 foot</td>
</tr>
<tr>
<td>4 to 8 weeks</td>
<td>1 square feet</td>
<td>3 foot x 3 ½ foot</td>
</tr>
<tr>
<td>Small chick juveniles</td>
<td>1 ½ to 2 square feet</td>
<td>3 foot x 6 ⅜ foot</td>
</tr>
<tr>
<td>Large chick juveniles</td>
<td>2 to 2 ½ square feet</td>
<td>3 foot x 8 ½ foot</td>
</tr>
</tbody>
</table>

Since chicks tend to push and pile on top of one another, any enclosure with more than 25 chicks should have rounded corners to prevent suffocation.

- **ENCLOSURE:** The brooder should have a wall height of 12-18 inches or more to protect against drafts and to keep hatchlings corralled. A screen or wire lid will prevent older chicks from flying out of the enclosure.

- **HEAT:** A single 250 watt red heat lamp suspended 18 inches above the brooder floor is sufficient to brood 80 chicks. Two 60 watt yellow bug light may provide sufficient warmth for 20 or less chicks within a controlled environment. When possible, avoid bright, white light as it induces picking and may be disrupt sleep. Temperature is very important and the use of a thermometer at floor level is highly recommended. For small birds, such as bantam, the temperature may need to be slightly higher.

<table>
<thead>
<tr>
<th>General Heating Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week</td>
</tr>
<tr>
<td>Temp</td>
</tr>
</tbody>
</table>

**CAUTION:** Over time, heat will accumulate in the brooder and bedding. Always ensure that hatchlings have sufficient space to move away from the heat source should they become overheated. Too small of space can result in injury or death.

**CAUTION:** Heat lamps in brooders and coops are a major source of home fires. Use only ceramic receptacles with an appropriate reflector. When using clamp-on types, secure the lamp with a secondary safety cord in case the lamp falls.

Visual observation best evaluates hatchling comfort.

If the hatchlings bunch up under the heat source, they are too cold. If the hatchlings scatter to the edge of the enclosure, they are too hot.
Two lamps are important. If one burns out in the wee hours of the night, the other will keep the chicks warm until morning. Placing a sheet of cardboard over the brooder helps retain heat, but be very cautious about keeping anything flammable away from hot bulbs.

- **BEDDING:** Large flake pine wood shavings are the favorite bedding for brooders. Rice hulls, dry straw, or hay can also make good bedding. For the first few days, place an old sheet, cloth towels, paper towels, or similar material on top of the shavings. This better enables the hatchlings to gain their feet, move about easily, and find their feed. **DO NOT USE** fine shavings, saw dust, or sand as very young chicks may consume these materials which can lead to an impacted craw, decrease consumption of feed, and possibly death. Fine shavings and sand may be suitable after a week or two after the chicks learn to eat. Cedar or cypress shavings should be avoided because many consider them toxic.

- **WIRE FLOORING:** My brooders have ½” hardware cloth wire flooring with a plastic tray underneath to capture and easily remove droppings. For standard size chicks, the wire is covered with old towels for the first two weeks; for bantams for three to four weeks; and mallard ducks for the first week only. Although some claim that hardware cloth flooring may harm a hatchling’s feet, I have had no such incidents but rather find the practice more sanitary with less odor than traditional pine shavings.

- **OUTDOORS:** Except in extremely cold climate, most hatchlings can safely be placed in an unheated outdoor shelter once they fully feather (about 6 weeks for chicken) as long as the shelter is well ventilated but draft free.

- **FEEDING & WATERING:** Just before a hatchling emerges from its shell, it absorbs the remainder of its yolk. This absorbed yolk provides the hatchling with sufficient food and water for 48 to 72 hours. A hatchling may be reluctant to eat or drink for the first 24 hours but should actively be doing both by the end of the second day.

- **FIRST DAY:** When moving the hatchlings from their transit box to the brooder, dip each beak into waterer before turning them loose. For the first day, sprinkle feed about the feeder and waterer to make it easy for the hatchling to locate the feed. Avoid sprinkling any feed directly under the heat source. Do place the feeder inside the brooder – the hatchlings should soon locate and use it. Adding smashed boiled egg yolk on top of the feed may help the hatchlings get started and eating right away; remove uneaten boiled eggs after a couple of hours.

- **FEED:** Individual species may require a specific starter feed formula, and different feed companies formulate their feed differently. For best results, follow the feeding instructions found on the bag of the feed you use. The following chart illustrates common recommendations.

### General Feed Recommendations

<table>
<thead>
<tr>
<th>Age in Weeks</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CHICKENS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lone Star</td>
<td>Chick Starter 20%</td>
<td>Chick Grower 18%</td>
<td>Layer 17%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agway</td>
<td>Chick Starter-Grower 18%</td>
<td>Start &amp; Grow 18%</td>
<td>Layer 16%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purina</td>
<td>Chick Starter/Grower 20%</td>
<td>Grower/Finisher 15%</td>
<td>Layer 16%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dumor</td>
<td>Chick Starter G rower 18%</td>
<td>Layer 16%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Nutrena</td>
<td>Layer 16%</td>
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</tr>
<tr>
<td><strong>MIXED FLOCK</strong></td>
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</tr>
<tr>
<td>Purina</td>
<td>Chick Starter/Grower 20%</td>
<td>Flock Raiser 20%</td>
<td>Layer 16%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dumor</td>
<td>All Flock 18%</td>
<td>Layer 16%</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td><strong>TURKEYS</strong></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purina</td>
<td>Game Bird Startena 30%</td>
<td>Flock Raiser 20%</td>
<td>Layer 16%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dumor</td>
<td>Chick Starter 24%</td>
<td>Chick Starter/Grower 20%</td>
<td>Layer 16%</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agway</td>
<td>Gamebird/Turkey Starter 26%</td>
<td>Gamebird/Turkey Grower 21%</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lone Star</td>
<td>Gamebird Starter 28%</td>
<td>50/50 Mix Gamebird &amp; Chick Grower 23%</td>
<td>Layer 17%</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DUCKS &amp; GEES</strong></td>
<td></td>
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<td></td>
<td></td>
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<td>General</td>
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• **MEDICATED FEED**: Medicated chick feed DOES NOT contain antibiotics but rather most likely amprollium—a thiamine uptake inhibitor. Amprollium does not treat Coccidiosis (a protozoa parasite) but rather discourages its overgrowth... it attempts to prevent an outbreak. The dosage of amprollium in chick feed is small and unlikely to result in a thiamine deficiency in hatchlings. Coccidiosis is naturally occurring and present in all chickens. Overgrowth, however, can be devastating in hatchlings. Unless you have a very specific reason for not using amprollium, it should be seriously considered in all chicken hatchlings.

Decades ago, some medicated chick starter might have been harmful to waterfowl... such is not the case with modern feeds. Although they do not require medicated starter as they rarely suffer from an outgrowth of Coccidiosis, feeding medicated chick starter to ducks and geese is not harmful.1

• **WATER**: Using additives to water is generally discouraged as the taste may discourage drinking. Clean, chemical-free water is generally the healthiest choice. I use bottled water for the first few days when the quality of the tap water is questionable. For bantams, I also add a packet of Sav-A-Chick to the first gallon. Before letting a hatchling loose inside the brooder, dip its beak into the water source. Never allow hatchlings to run out of water and keep the waterer as clean as possible.

• **OTHER CONCERNS**:
  - **DROOPY HATCHLINGS**: If hatchlings look droopy upon arrival, adding two tablespoons of sugar in one quart of 100°F water and shaken well may help perk them up. Additionally, adding this solution to a small amount of feed and sprinkling the mixture around may prove helpful. Remove any left-over portions of feed/sugar water mixture after a couple of hours to prevent souring.
  - **GRIT**: Chick grit is unnecessary for hatchlings to properly digest starter or grower crumbles. Once placed on the ground, birds will gather what grit they need from the ground. You will need to add chick grit if you intend to feed hatchlings food that requires “chewing” while they remain in the brooder. Chick starter and grower provides all the necessary ingredients for healthy hatching growth; provide additional “treats” sparingly.
  - **PASTY BUTT**: Stress, overheating, and natural occurrence may result in droppings to accumulate on the hatchling’s vent – pasty butt. In most instances, this condition is temporary and results in no harm. However, if sufficient quantities accumulate, it may block the vent. Remove by gently pulling off using a warm moist wash cloth.
  - **PECKING**: Hatchlings may peck each other if they are too hot, too crowded, without fresh air, and even when they are bored. Occasionally, bright lights can cause them to pick and having lights on 24 hours a day can cause stress; changing to a red light may help. An ounce of prevention is worth a pound of cure when it comes to picking. To treat chicks that have been picked, smear some type of menthol ointment on the area that has been injured and keep up the treatment until healed.2
  - **DUCKLINGS & GEESE**: Ducklings and geese mature quicker and require less heat than baby chicks. Medicated feed is not required although the medication will cause them no harm. Waterfowl like to play with water and are messy creatures. Because of this reason, it is not recommended that waterfowl and chickens be brooded together. Special care should be taken with bedding material to ensure that it stays clean and dry. Although tempting, waterfowl should not be allowed to become wet or swim. Wet down may cause chilling and hatchlings can easily drown. Wait until birds are fully feathered before allowing them to swim freely in small pools or ponds.
  - **TURKEYS**: Turkeys require higher protein than baby chicks and their size difference may result in harm to smaller chicks. Chickens may carry diseases and parasites that barely affect them but can be deadly to turkeys, e.g. Blackhead. In general, professional breeders do not recommend turkeys and chickens be raised together or that turkeys be raised on ground where chickens have been in the previous three years. Contact your local county extension agent for further details.

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