HATCHING

with thanks to Donna Young

The avian egg is a marvel of nature, a self-enclosed and perfectly effective living environment for the developing bird embryo. The shell is sturdy but flexible, hard but porous. The egg contains all that is necessary to enable a small and weak organism to develop into a chick with all its parts and enough strength and skill to break through and emerge into the outside world. Here is an account of the many factors involved in a chick's hatching.

Inside the shell

- The **eggshell** is a complex structure of hard calcium carbonate crystals interwoven with collagen fibers and coated by a thin layer of crystalline calcite and smooth protein cuticle. The structure is sturdy to protect the developing embryo, yet permeable with microscopic pores that allow oxygen to pass into the egg and carbon dioxide and water vapors to pass out.
- Two **soft keratin membranes line the inside of the shell**, both formed in the isthmus of the oviduct a few hours after fertilization. These membranes facilitate the exchange of oxygen, carbon dioxide, and water through the hard shell. The outer membrane becomes fused to the inside of the shell near the time of hatching, and the thinner membrane lines the inner surface of the outer membrane. A gap between the two membranes forms a small **air cell in the large (blunt) end** of the egg, which will become very important when hatching is near.
- A third membrane is adjacent to the inner shell membrane, the **chorioallantoic membrane** (**CAM**), which surrounds the embryo and effects the exchange of oxygen and carbon dioxide via a network of blood capillaries connecting it to the embryo. It also collects wastes that cannot be evaporated through the shell from the growing embryo, which it sheds after the egg hatches. The CAM is homologous to the mammalian placenta.
- The embryo is attached to the **yolk sac** — which contains fat and protein to feed the growing chick — by a cord, the **umbilicus**, leading into the abdominal cavity.
- The yolk sac is greatly reduced in size by hatching time. Now the **egg weighs less than when it was laid** because it has absorbed and metabolized fats from the yolk and lost evaporated water through the shell. At hatch a Bald Eagle egg might weigh 91-102 g (3.2-3.6 oz.), as opposed to 113-127 g (4-4.5 oz.) when laid.
- The **eggshell itself is much thinner at hatch** than when the egg was laid because the chick has absorbed much of the shell's calcium into its developing bones.
- Starting about a third of the way through 36-39 days of the embryo's growth in the egg, an "egg tooth" or "pipping tooth," a small, hard, sharp protuberance of calcified keratin on the beak's upper mandible, begins to develop. Here is a closeup of the egg tooth on a hatchling eaglet at the Institute for Wildlife Studies. The egg tooth gradually wears away within a couple of weeks after hatch.
- A muscle in the back of the chick's neck (the ***complexus*** or **hatching muscle**) swells in response to the influx of lymphatic fluids. This muscle recedes in size after hatching (although it later plays a role in neck extension in grown eagles).

The hatching process

- When hatching nears, the **air cell in the large (blunt) end** of the egg quickly **expands** and **spreads partway down along the upper side of the egg**.
- As the embryo nears full development it takes up most of the space inside the shell – it is crowded in there! The chick has gradually rolled to **curl up tightly**, lying on its **left side** with its legs bent in the smaller end of the shell, its back against the air cell. Its **head is tucked forward** against its breast **near the blunt end** of the shell and **turned to the right under its right wing**. This puts the beak and the egg tooth close to the air cell. Here is a drawing of the position of the chick in a chicken egg at 20 days, just before hatching.
- As it takes hatching position, the embryo **absorbs the remainder of the yolk sac** into its abdominal cavity.
- The ***complexus*** **muscle begins to contract**, causing the entire body of the chick to straighten and contract, pushing the egg tooth against the air cell and piercing it. This results in what is called the **internal pip**. The air cell releases a small supply of oxygen and prompts the chick's **lungs and its 9 air sacs to begin functioning**.
- With its lungs now working, the chick can also begin to **vocalize**, as can be heard in this video of an egg just as it pips the shell at the Institute for Wildlife Studies incubation facility in 2008.
- After the internal pipping **the chick rests** as its lungs learn to directly inhale oxygen and exhale carbon dioxide. At this point the blood circulation and gas exchange via the **CAM** (**chorioallantoic membrane**) are winding down and the cord that connects the CAM to the embryo begins to wither.
- After a few hours the **buildup of carbon dioxide** inside the shell stimulates the ***complexus*** **muscle to contract more**. The head and beak begin to jerk back against the shell repeatedly and the spine and legs push against the shell, finally piercing it with the egg tooth **near the blunt end of the egg**. This is seen from the outside as a "pip" or tiny hole or crack in the shell, usually on the side of the shell and near the larger end of the egg. This is called the **external pip**.
- After the first external pip that allows outside oxygen into the egg, the chick usually **rests again for several more hours** while its respiratory and circulatory systems continue to adapt.
- The external pip accelerates **fluid loss** inside the egg as well as in the chick's body, which is good because a slightly reduced body mass allows the chick more room to maneuver as it pushes against the shell.
- The pip may begin as a tiny hole that increases in size over the next few hours. Or it may begin as a cracking of tiny bits of the shell, possibly taking a star-like appearance ("**starring**"). As the chick pushes outward, small bits of shell may bulge from the hole, often visible in profile as the pip is turned to the side. The chick's legs flex and contract and the egg tooth pokes and scrapes the shell, creating larger holes and cracks. The chick's **beak,** pipping tooth**, and head might be visible** through some of the cracks. The **enlarged** ***complexus*** **muscle** at the nape provides cushioning and support during this shell-breaking process.
- As it pushes against the shell, the chick may begin to **rotate**, usually counterclockwise, perhaps halfway or more around the inside, until a part of the shell, often a roundish disc at one end, or a "**cap**," separates and breaks the shell apart. This has led to the term **symmetrical hatching**, referring to the more or less symmetrical shape of both the broken-off cap and the rest of the egg. Symmetrical hatching is the norm for most avian species.
- However, as observers of Bald Eagle cams over the years have noted, **not all hatches result in a symmetrical breakup of the shell**; in fact, some hatches look downright chaotic and messy. Sometimes the first external pip seems to simply grow in size until the chick breaks through the gap. Sometimes the shell membrane holds the shell together so that it does not break apart cleanly and the chick has to push through both shell and membrane to be free.
- The hatching process is strenuous and can take from 24 to 48 hours to complete. The chick **rests inbetween efforts to break through the shell**.
- Most biologists and observers consider the egg to be "**hatched**" when **the chick fully emerges free from the shell**.
- The new hatchling is covered with a thin layer of downy feathers – its natal down – which is damp from the fluids inside the shell, matted against its mostly pinkish skin (but dark gray around the eyes). The down will dry out to a soft light gray color within a couple of hours.
- The hatchling **weighs about three-quarters of the weight of the egg when first laid** about 37-39 days before – decreasing from about 113-127 g (4-4.5 oz.) to about 85 g (3 oz.). (Sizes vary with latitude – larger in the north than in the south – and also with hatch order – first eggs in a clutch are larger than subsequent eggs.)
- After hatching the chick will lie in the nest **resting** for several hours. It will roll about a little, and the wings, legs, neck, and head may jerk spasmodically from time to time. Its breathing can be seen, and it will let out some tiny cheeps, which can be both heard and seen.

Parental behavior during hatching

- The parents are **aware of the hatching** when they hear the chick's vocalizations and possibly also its pecking at the shell. The incubating adult may stand above or to the side of the egg and lean in or cock its head, seeming to listen. Parents may chirp softly to the chick, or champ or click their beaks, perhaps another attempt to communicate.
- They might continue to gently **nudge** the hatching egg and even the emerging chick with their beak.
- They may exhibit **restlessness** in the egg cup, rising to check the eggs every few minutes, circling the cup, leaning in often to listen. They often pull soft nesting material in toward the nest cup (sometimes building a wall between the cup and the viewers!).
- Both parents, but especially the male as the female does more of the incubating, may **bring food to the nest** in anticipation of both the chick's and the mother's need for food as brooding begins.
- The parents **do not assist** the chick in breaking the shell because they could damage the still fragile blood vessels in the CAM. They may move shell fragments away from the hatching egg.

Post-hatching

- Bald Eagle hatchlings are "**semi-altricial**," which means they are nearly helpless when they hatch, with **limited motor skills and strength**, entirely **dependent on parents** for **food** and **warmth**, and **confined to the nest** ("**nidicolous**" – "nest inhabiting"). All raptors are semi-altricial and must spend several weeks being cared for by their parents in the nest before they fledge and are capable of fending for themselves.
- Raptors are **not considered fully altricial** (like songbirds and parrots) because their eyes are open at hatch, they are covered with downy feathers, and they have some mobility.
- At the other end of the developmental spectrum from altricial are "**precocial**" chicks, like geese, ducks, swans, chickens, quail, etc., which are capable of walking (and often swimming) and thermoregulating soon after they hatch. They are "**nidifugous**" ("nest fleeing"), meaning they leave the nest almost immediately after hatching.
- In the days before it hatched the eagle chick has **absorbed the yolk sac** into its body, whose nutrients feed it in the few hours before and after hatch. It will not need to be fed by its parents for several hours.

Clearly, hatching is a complex process, and most of the time it ends successfully. Sometimes, though, things can go wrong. This page surveys reasons **why an egg might fail to hatch**.

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Here is a compilation video of the hatch of the
first eaglet at the West End nest on Catalina
Island on 20 March 2018.
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Detailed description of the development of a
chicken embryo from fertilization through hatch,
with great drawings and images.
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