

Science Education Collection

An Introduction to the Chick: *Gallus gallus domesticus*

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Abstract

The chicken embryo (*Gallus gallus domesticus*) is an extremely valuable model organism for research in developmental biology, in part because most of their development takes place within an egg that is incubated outside of the mother. As a result, early developmental stages can be accessed, visualized and manipulated by simply creating a small hole in the eggshell. Since billions of chickens are raised worldwide for meat and egg production, scientists can easily and economically acquire large numbers of fertilized eggs throughout the year. Furthermore, chickens share significant genetic conservation with humans, so the genetic mechanisms that have been found to regulate chicken development are also relevant to our own biology.

This video focuses on introducing the domesticated chicken as a scientific model. The discussion begins with a review of chicken phylogeny, revealing the features that make them amniotes, like other birds, reptiles, and mammals. Highlights from the millennia of chicken research will be presented, ranging from Aristotle's postulates about the function of extra-embryonic membranes to more recent, Nobel-prize winning discoveries in neuroscience. Additionally, some current examples of studies performed in chicken embryos will be provided, such as in vivo tracking of cell movements during development and the recruitment of blood vessels to developing tumors (a process known as angiogenesis).

Transcript

The developing chicken, or chick, formally known as *Gallus gallus domesticus*, is an important model system for biomedical research. Within each chicken egg is an embryo that can be subjected to genetic and embryological manipulations. Such experimentation is relevant to human health and disease, because of the similarities between human and chick genomes. This video covers an overview of the chick model system, some key discoveries made in chick, and a few exciting examples of how they are used in labs today.

Before talking about the chick's scientific value, let's review some basic chicken biology. Like reptiles and mammals, *Gallus gallus* belong to the vertebrate clade Amniota, defined by the presence of extraembryonic membranes that support embryo development. The evolution of this system of membranes within the egg allowed the ancestral amniote to inhabit a land environment millions of years ago, which pretty much proves that it was the egg that came first!

Within the class Aves, chickens belong to the Phasianidae family of terrestrial birds, which spend most of their life on land. The birds we know as a tasty food source are in fact a subspecies of *Gallus gallus*, commonly known as the Red Junglefowl, which inhabits southeast Asia. Today, billions of chickens are raised for meat and egg production all over the world.

Clearly these birds are a big part of the human diet, but what do they like to eat? Chickens are omnivores that scour the ground for bugs, seeds, and vegetation. Female chickens, or hens, are especially in need of a good meal since they put a lot of energy into making eggs, which are laid almost every day. If a male is around, you'll know it; roosters are bigger, more colorful, and a lot louder!

When roosters and hens get together to mate, the life cycle begins with internal fertilization. An egg is laid 25 hours later, containing a multicellular embryo. After 21 days of incubation, a chick hatches. Sexual maturity occurs by 31 weeks in most chickens, completing the cycle.

Now, let's see why this common farm animal is popular in scientific research. First, it is easy to obtain fertilized chicken eggs at a relatively low cost, year-round. Second, developmental experiments can be precisely timed by regulating incubation temperature.

Third, since the embryo develops externally, scientists only need to cut a window in the shell to access most developmental stages. The embryos also tolerate experimental manipulations quite well, because the egg white, or albumin, is naturally antibacterial.

Last, but certainly not least, the chicken and human genomes are highly conserved. Despite the fact that the chicken genome is about a third of the size of the human's, it packs a similar number of genes. Of these, 60% correspond to a human gene, and are on average 75% identical to their human counterpart.

Now that we've discussed what makes chicks a great model, let's review some key discoveries made in this system. Chick research dates back to ancient Greece, when Aristotle postulated that the extraembryonic membranes he observed in developing chicken eggs, and the human placenta and umbilical cord, both provide crucial nutrition to the embryo. Many years later, in 1672, Marcello Malpighi first described fundamental vertebrate structures in the developing chicken embryo, such as the neural tube, which forms the nervous system; and the somites, which will give rise to multiple tissues, like skeletal muscle.

In 1817, Heinz Christian Pander studied early stage chicken embryos and discovered three primordial layers of cells known as the germ layers. Cells from these layers: the ectoderm, mesoderm, and endoderm, go on to form all of the tissues that make up an organism. For this work, Pander earned the title: The Founder of Embryology.

In 1951, Viktor Hamburger and Howard L. Hamilton published a 46 part staging series to identify embryos based on anatomy, from freshly laid eggs to hatching. The Hamburger and Hamilton staging series provides chick biologists with a way to standardize the staging of the embryos they study, cutting down on variables introduced by differing incubation temperatures.

Also in the 1950s, Rita Levi-Montalcini discovered a mysterious factor that caused chick neurons to grow when exposed to engrafted mouse tumors. Stanley Cohen helped identify this unknown compound as NGF, or nerve growth factor. For this work, they won the Nobel Prize in 1986.

Now that we've discussed how chick research has led to important discoveries, let's take a look at how chicks are used in labs today.

First, chicken embryos are frequently used to track early cell movements. To be able to distinguish cells from their neighbors, scientists transplant cells from other avian species, like the quail, into chick embryos. Using quail-specific markers, the cells are followed over days as they are incorporated into developing structures.

Chicks are also extremely useful for studying neuronal patterning. Neural tissue harvested from an embryo can be used to examine axonal tracing, circuitry and even neuronal activity.

Lastly, the chorioallantoic membrane, otherwise known as the CAM, is a highly vascularized membrane that is frequently used for cancer research. Chicken embryos are naturally immunodeficient, which allows transplanted human cancer cells to readily commandeer blood vessels within the CAM to establish tumors. The spread of cancerous cells, or metastasis, can be easily studied in this highly useful assay.

You've just watched JoVE's introduction to *Gallus gallus*. This video has provided a brief overview of these birds, features that make their embryos great model organisms, important scientific discoveries made in chick, and a glimpse into the ways they are used in biological research. Thanks for watching!