

Organogenesis lab – 9 October

The chicken (*Gallus gallus*) is an excellent animal model for the study of early vertebrate embryogenesis and later organogenesis. The embryo is encased within a hardened eggshell which provides a natural incubator or culture dish. Through a hole in the eggshell, the embryo can be visualized and easily manipulated with microsurgical tools or gene constructs, then allowed to continue development *in ovo* to determine the consequence of the experimental manipulation.

Fertilized chicken eggs are readily available anywhere in the world and the equipment needed is minimal – a humidified incubator (39°C, no CO₂ required), a dissecting microscope, microsurgical tools that can be prepared in the lab or purchased, and either a hand-held mouth pipette or a manufactured micromanipulator and picospritzer.

Fertilized eggs can be held at ~13-16°C for up to 1 week prior to incubation. They are incubated at 38°C-39°C to the desired stage in a humidified incubator with the eggs placed on their side (horizontal). For long-term post-operative survival, it is best that the eggs be left in the incubator until experimental manipulation. However, eggs can be removed from the incubator and held at room temperature to slow development.

For staging of chicken embryos:

https://embryology.med.unsw.edu.au/embryology/index.php/Hamburger_Hamilton_Stages

SAFE WORKING PROCEDURES AND ANIMAL ETHICS

Risks Associated with Practical

Eggs have the potential to be contaminated with Salmonella. Wear gloves throughout and students should wash their hands before leaving the lab.

Dissection implements are sharp, so students should take care not to cut themselves or other students.

Students should wear a labcoat, gloves and enclosed shoes to protect themselves from egg splatter.

Animal Ethics Compliance

The procedures used in this practicum are in compliance with the UNSW Animal Care and Ethics Committee and the National Health and Medical Research Council 'Australian code of practice (8th edition, 2013).

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EXPERIMENTAL PROCEDURES

Opening of the egg (<https://www.youtube.com/watch?v=V06pm0fKaHA%7CVideo>)

1. Eggs were incubated for several days at 38.5°C to generate embryos that undergo organogenesis.
2. Each student pair should have one egg and an egg holder, a pair of blunt forceps and a pair of scissors, petridishes, PBS, disposable pipet, syringe and 23G needle, dissection microscope.
3. Put the egg into the holder with the blunt end up (pointed end down).
4. Stick sticky tape to top and bottom of the egg.
5. Tap a small hole in the bottom narrow end of the egg. The hole should just fit the needle, but not allow the leakage of albumin.
6. Insert syringe 5 and needle about 5 mm into the hole, and draw 4 mls of albumin. (This will lower the position of the embryo). Avoid puncturing the egg yolk! Discard albumin in waste bin.
7. Use the pointy end of the scissors to tap a hole in the wider end of the egg into the air chamber, be very careful not to push the scissors too far into the egg.
8. Use the forceps to remove bits of shell. Do not remove egg shell beyond the air chamber. You will see the air chamber and the vitelline membrane.
9. Carefully remove the vitelline membrane at the top.
10. If you do not see the embryo (a ring of blood vessels should be visible) then gently swirl the egg so that it floats up to the top of the yolk. If this doesn't work you will need to take another egg if available.
11. Use the forceps to break off pieces of shell down to the yolk so that the rim of the shell is just above the surface of the egg white or albumen.
12. Carefully tear a hole in the vitelline membrane so that the embryo (visible as a ring of blood vessels) is exposed.
13. You may be able to see the heart beating without magnification. If not, then put the egg under the dissection microscope.

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Organogenesis embryos

14. Cut off side of wide end of the disposable pipet to make a spoon.
15. Very carefully tilt egg contents into the deep half of a petri dish, holding the egg very close to the dish.
16. Find the embryo and transfer it to a clean petri dish with PBS.
17. Study embryo under a dissection microscope, determine Hamburger & Hamilton (HH) developmental stages using the guide.
18. Draw your embryo and annotate the embryonic structures that you have identified.
19. Hand your drawing in at the end of the prac.

Observation of developmental stages

Move around the class to study the embryonic chicken stages of your colleagues. Identify the following structures:

- Somites
- Brain vesicles
- Heart and vasculature
- Optic vesicles
- Branchial arches
- Nasal placodes
- Nasal pits and nasal processes
- Otic vesicle
- Limb buds
- Autopod, stylopod and zeugopod
- Handplate and fingers

Observation of developmental stages

Move around the class to study the embryonic chicken stages of your colleagues.

Tidying up after the prac

- Please discard egg waste and disposable consumables into the yellow bins (not the paper bins).
- Dispose of Syringes and needles in sharps bins
- Wash forceps and scissors with water, and wipe with ethanol, place in provided containers on the sink.
- Clean surfaces (microscope stages, benches) with water and ethanol, and wipe dry.

Draw your embryo on this page

Identify the developmental stage and annotate the embryonic structures above.

STAGING CHICK EMBRYOS - HAMBURGER HAMILTON STAGES

(Full tables available: <http://www.ncbi.nlm.nih.gov/pubmed/1304820>)

HH Stage	Time and Features
2	6-7 hr: Initial primitive streak, 0.3-0.5 mm long
3	12-13 hr: Intermediate primitive streak
4	18-19 hr: Definitive primitive streak, ± 1.88 mm long
5	19-22 hr: Head process (notochord)
6	23-25 hr: Head fold
7	23-26 hr: 1 somite; neural folds
7 to 8-	ca. 23-26 hr: 1-3 somites; coelom
8	26-29 hr: 4 somites; blood islands
9	29-33 hr: 7 somites; primary optic vesicles
9+ to 10-	ca. 33 hr: 8-9 somites; anterior amniotic fold
10	33-38 hr: 10 somites; 3 primary brain vesicles
11	40-45 hr: 13 somites; 5 neuromeres of hindbrain
12	45-49 hr: 16 somites; telencephalon
13	48-52 hr: 19 somites; atrioventricular canal
13+ to 14-	ca. 50-52 hr: 20-21 somites; tail bud
14	50-53 hr: 22 somites; trunk flexure; visceral arches I and II, clefts 1 and 2
14+ to 15-	ca. 50-54 hr: 23 somites; premandibular head cavities
15	50-55 hr: 24-27 somites; visceral arch III, cleft 3
16	51-56 hr: 26-28 somites; wing bud; posterior amniotic fold
17	52-64 hr: 29-32 somites; leg bud; epiphysis
18	65-69 hr: 30-36 somites extending beyond level of leg bud; allantois
19	68-72 hr: 37-40 somites extending into tail; maxillary process
20	70-72 hr: 40-43 somites; rotation completed; eye pigment faint grey
21	3.5 da: 43-44 somites; pharyngeal arch IV, pharyngeal cleft 4; eye pigment faint
22	3.5 da: Somites extend to tip of tail; eye pigmentation distinct
23	3.5-4 da: Dorsal contour from hindbrain to tail is a curved line
24	4 da: Toe plate in leg-bud distinct; 4th pharyngeal cleft reduced to small pit
25	4.5 da: Elbow and knee joints; 3rd & 4th pharyngeal clefts reduced to small pits
26	4.5-5 da: 1st 3 toes; 3rd and 4th pharyngeal clefts no longer visible
27	5 da: Beak just barely recognisable
28	5.5 da: 3 digits, 4 toes; beak outgrowth distinct in profile
29	6 da: Rudiment of 5th toe; beak more prominent; no egg tooth
30	6.5 da: Feather germs; scleral papillae; egg tooth
31	7 da: Web between 1st and 2nd digits; feather germs dorsally continuous from brachial to lumbosacral level
32	7.5 da: Anterior tip of mandible has reached beak
33	7.5-8.0 da: Web on radial margin of wing and 1st digit
34	8 da: Nictitating membrane
35	8 - 9 da: Phalanges in toes

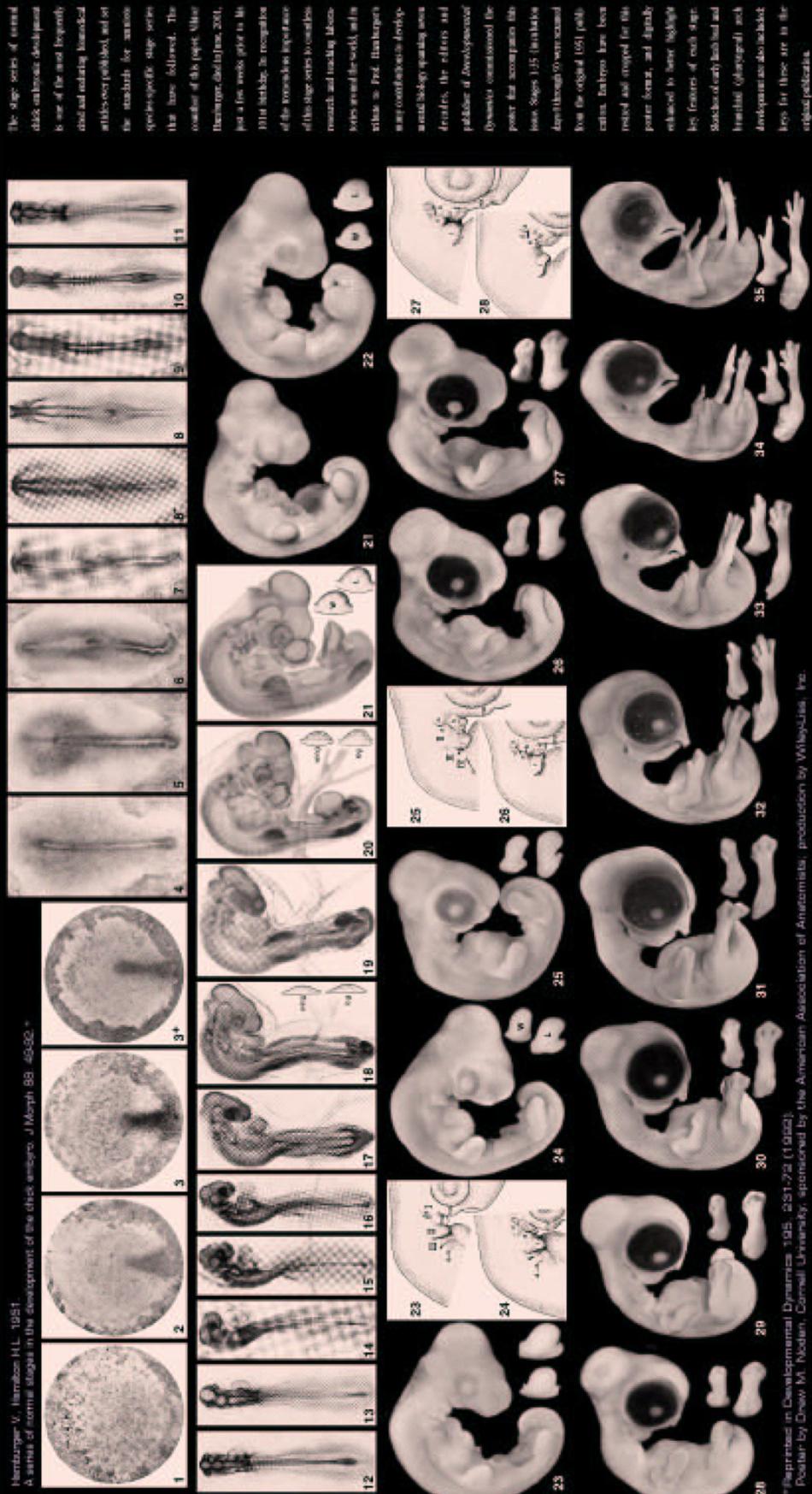
STAGING CHICK EMBRYOS - HAMBURGER HAMILTON STAGES

36	10 da: Length of 3rd toe from tip to middle of metatarsal joint = 5.4 ± 0.3 mm; length of beak from anterior angle of nostril to tip of bill = 2.5 mm; primordium of comb; labial groove; uropygial gland
37	11 da: Length of 3rd toe = 7.4 ± 0.3 mm; length of beak = 3.0 mm
38	12 da: Length of 3rd toe = 8.4 ± 0.3 mm; length of beak = 3.1 mm
39	13 da: Length of 3rd toe = 9.8 ± 0.3 mm; length of beak = 3.5 mm
40	14 da: Length of beak = 4.0 mm; length of 3rd toe = 12.7 ± 0.5 mm
41	15 da: Length of beak from anterior angle of nostril to tip of upper bill = 4.5 mm; length of 3rd toe = 14.9 ± 0.8 mm
42	16 da: Length of beak = 4.8 mm; length of 3rd toe = 16.7 ± 0.8 mm
43	17 da: Length of beak = 5.0 mm; length of 3rd toe = 18.6 ± 0.8 mm
44	18 da: Length of beak = 5.7 mm; length of 3rd toe = 20.4 ± 0.8 mm
45	19-20 da: Yolk sac half enclosed in body cavity; chorio-allantoic membrane contains less blood and is "sticky" in living embryo
46	20-21 da: Newly-hatched chick

In Memory of Viktor Hamburger: 1900-2001

NORMAL STAGES OF CHICK EMBRYONIC DEVELOPMENT

Hamburger V., Hamilton H.L. (1951)
A series of normal stages in the development of the chick embryo. *J Morphol* 88: 49-92.



Reprinted in *Developmental Dynamics* 195: 251-26 (1992).
Poster by Drew M. Nolan, Cornell University, sponsored by the American Association of Anatomists, production by Wiley-Liss, Inc.

DEVELOPMENTAL DYNAMICS

WWW.INTERSCIENCE.WILEY.COM/DEVELOPMENTALDYNAMICS



The stage series of normal chick embryonic development is one of the most thoroughly studied and extending knowledge in embryology published, and set the standards for an entire species-specific stage series that have followed. The content of this paper, after Hamburger (Hamburger, 2001), just a few weeks prior to his 101st birthday, is recognition of the tremendous importance of this stage series to countless research and teaching laboratories around the world, and in tribute to Prof. Hamburger's major contributions to embryology and developmental dynamics. In addition, the editors and publisher of *Developmental Dynamics* commissioned the dynamic illustrations for poster that accompany this issue. Stages 1-5 (hatched) depart through 10 were scanned from the original 1951 publication. Embryos have been retouched and cropped for this poster format, and slightly enhanced to better highlight key features of each stage. Stages of early hatched and hatched (epiblast) and development are also included. Keys for these are in the original publication.