

How the Embryonic Chick Brain Twists

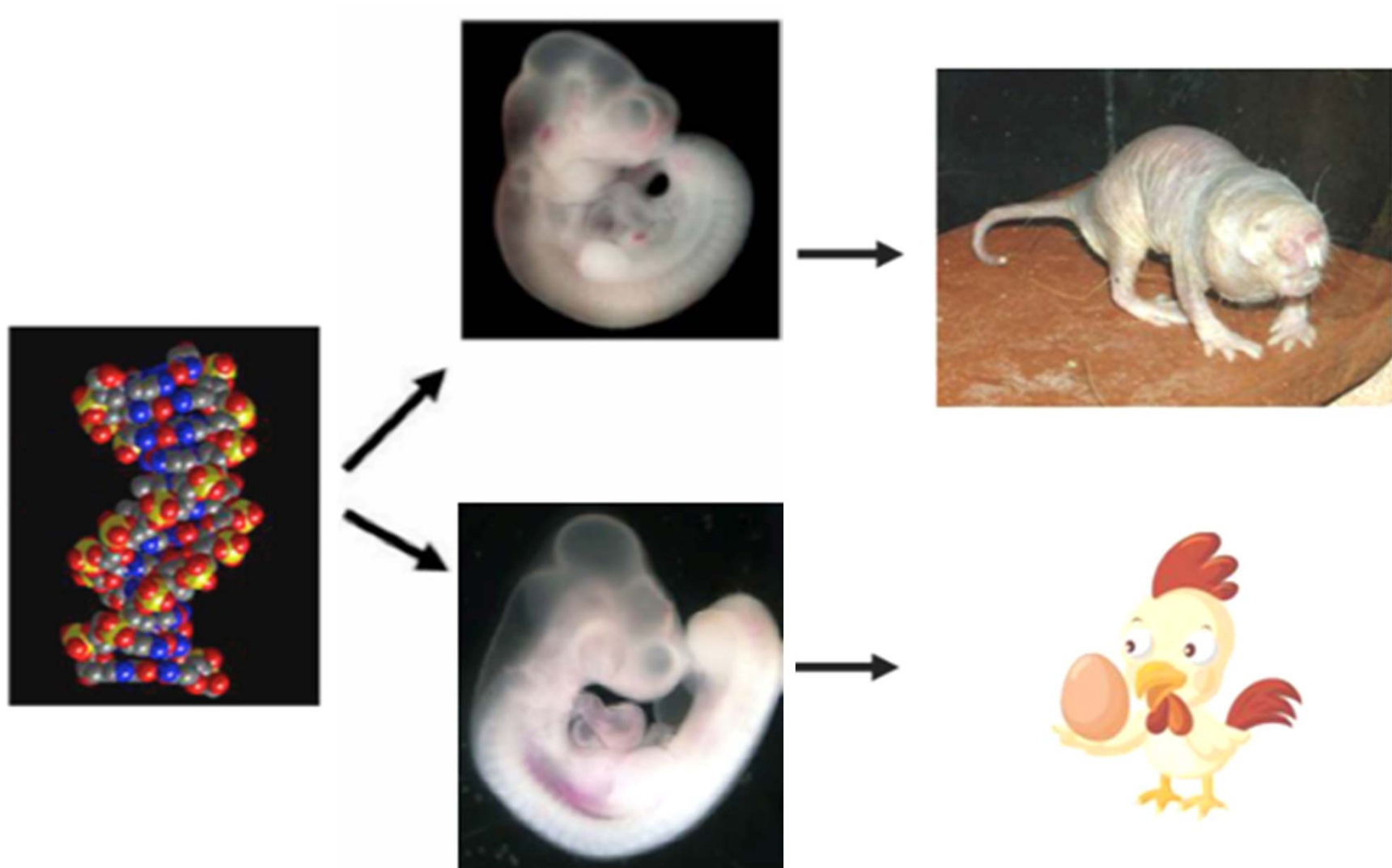
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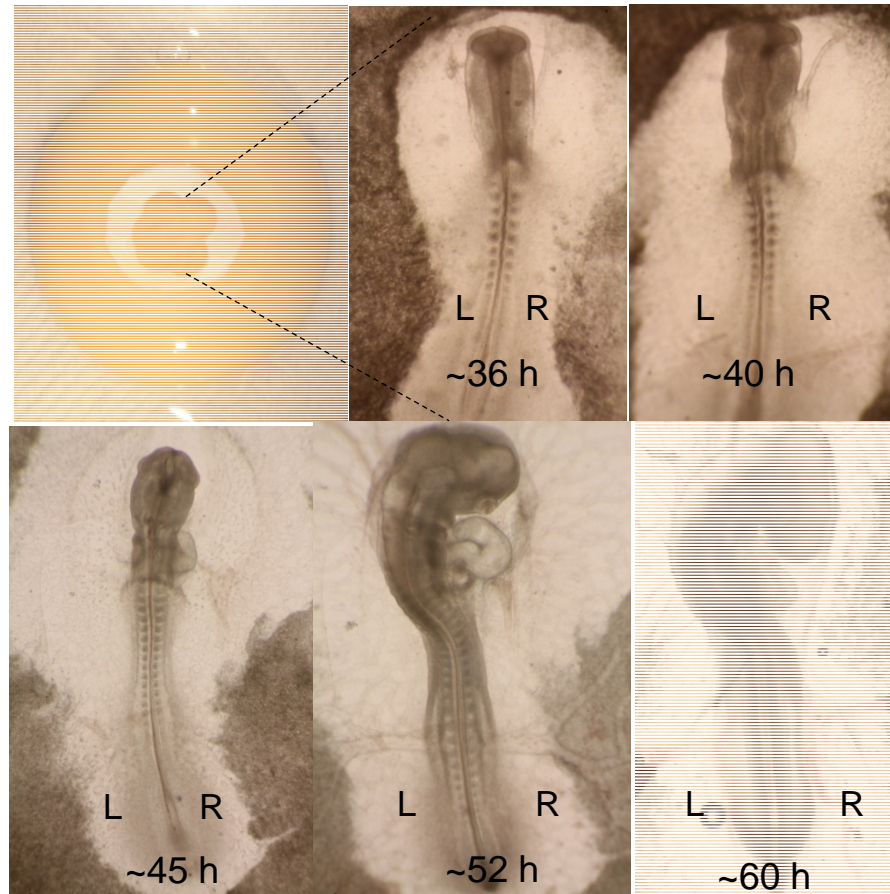
Mechanics of Morphogenesis



Congenital Brain Defects

- Brain defects occur in approximately 1% of live human births.
- Abnormalities in size and shape of the developing brain are known to cause serious neurological disorders:
 - Anencephaly (missing part of brain)
 - Hydrocephalus (swelling of brain)
 - Autism
 - Schizophrenia
 - Mental retardation

Brain Development



Brain tube bends and twists.
(dorsal view)

Brain Torsion

- One of the earliest organ-level left-right asymmetry event
- Inversed rotation associated with birth defects such as *situs invertus*

Mechanical Origins of Brain Torsion



Questions:

- What forces cause the brain to twist?
- What determines the direction of twist?
- Does bending affects torsion?

Heart Looping and Brain Torsion: Is there a connection?

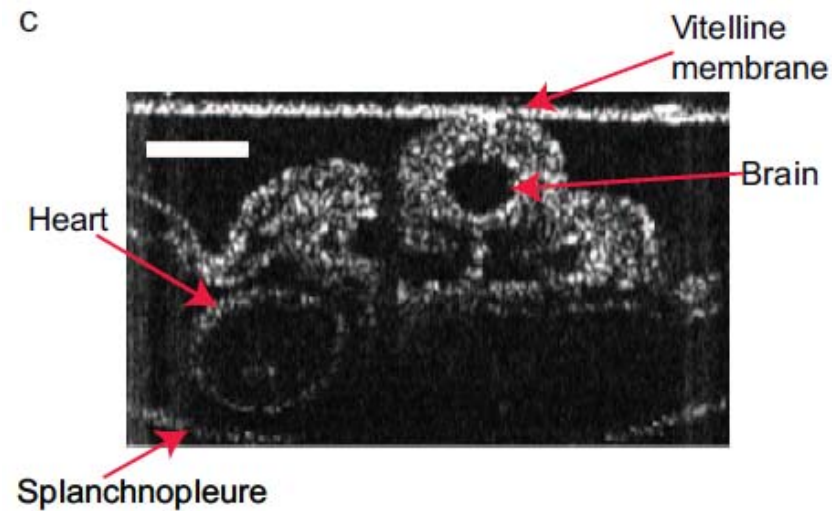
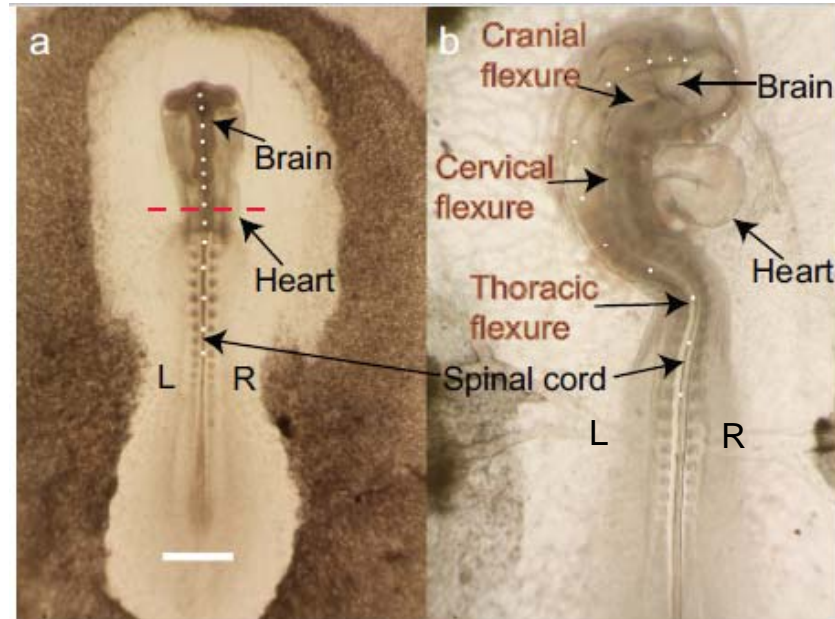


Normal
(right/right)

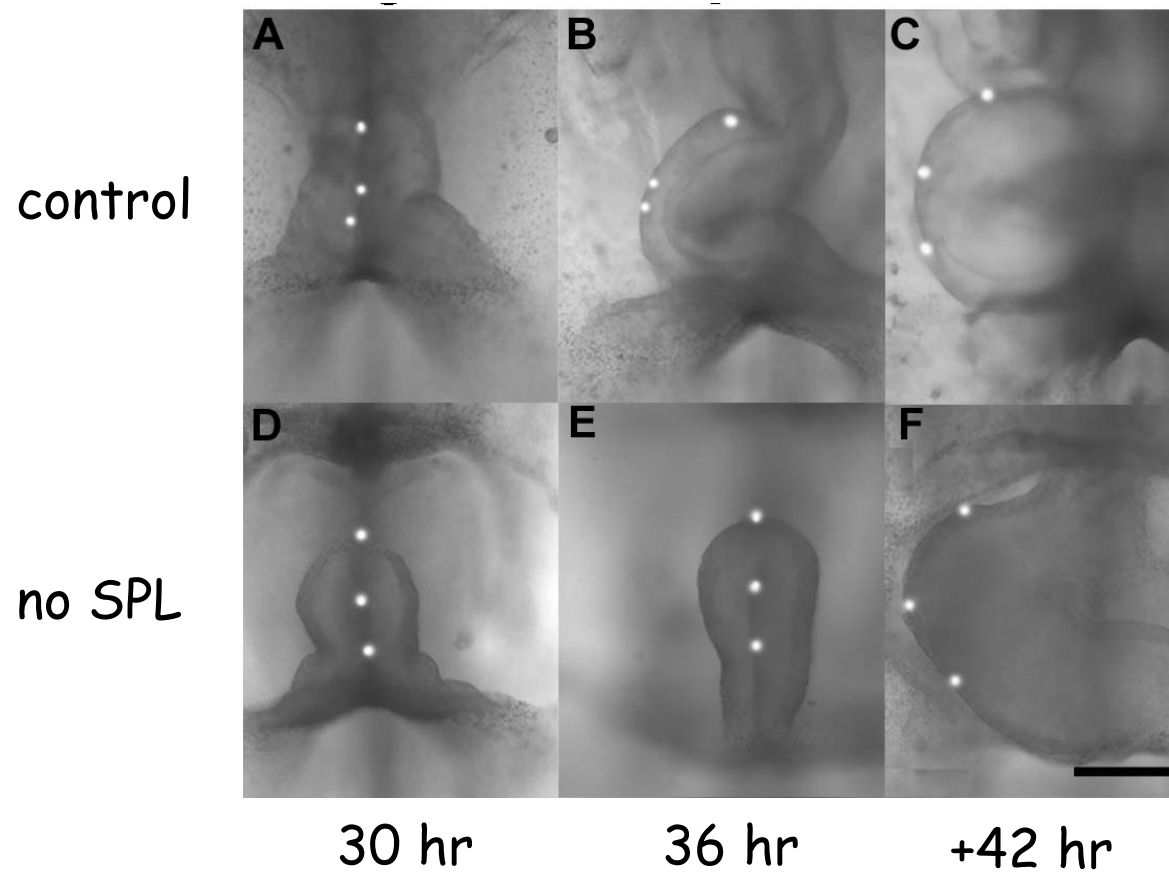


Abnormal
(left/left)

Anatomic Observations



Effects of SPL on Looping Heart Tube



Hypotheses

- The vitelline membrane constrains brain flexure, causing the brain to twist.
- The direction of the looping heart determines the direction of brain torsion.
- The degree of flexure affects brain torsion.

Effects of VM on Brain Torsion

Control



40h



57h

Vitelline membrane is necessary
for normal brain torsion.



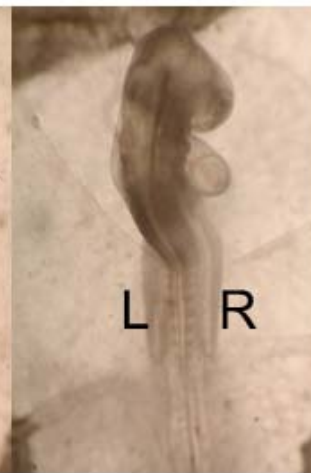
40h

Dorsal view

- VM



57h



68h

+ ST



68h

Effects of Heart Looping Direction



Ventral view
(48 hr)



Heart pushed
to left.



Brain twists
to left (60 hr).



Control

Effects of Heart Looping Direction



Ventral view
(52 hr)



Heart pushed
to left.



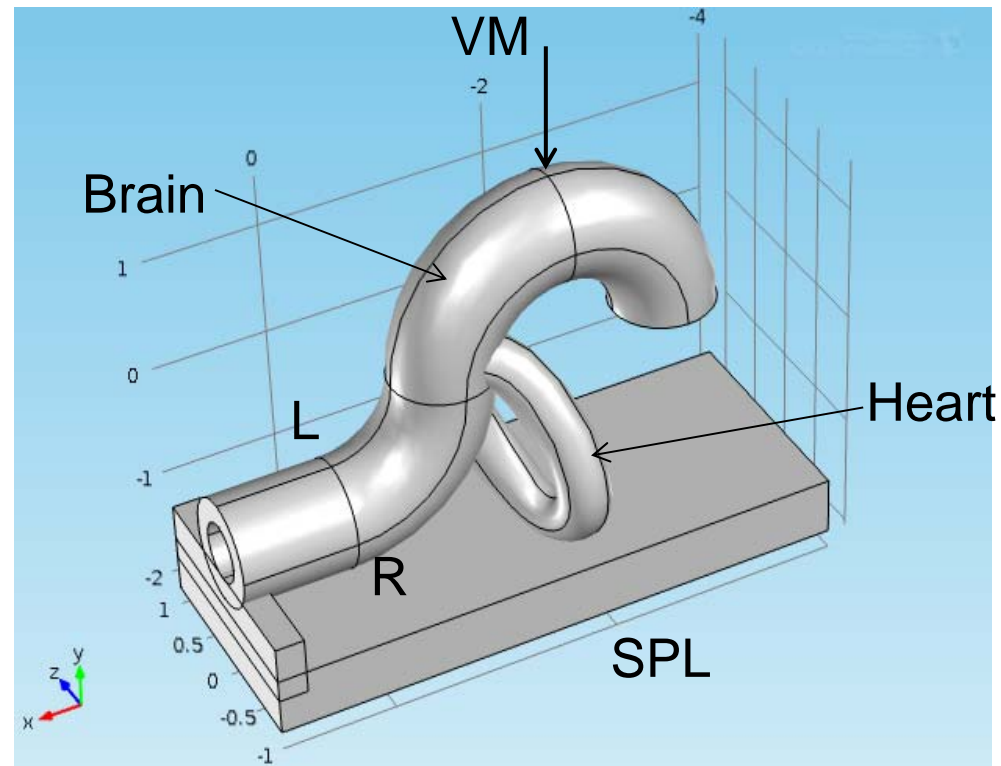
Brain twists
to left (60 hr).



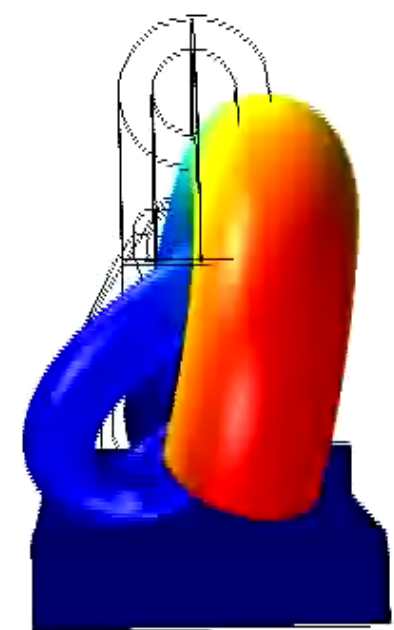
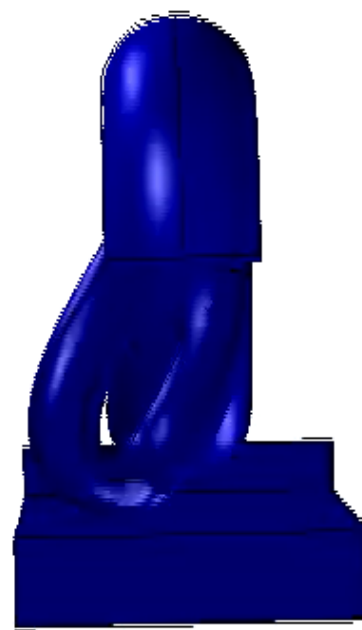
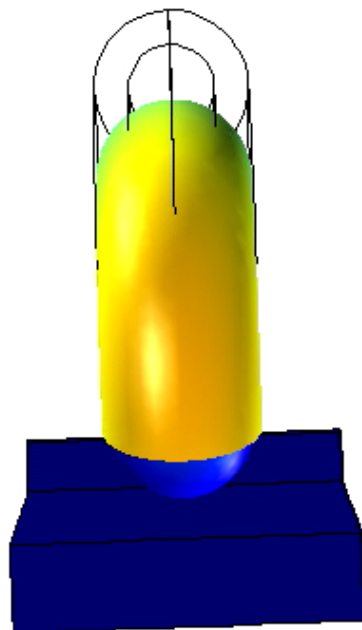
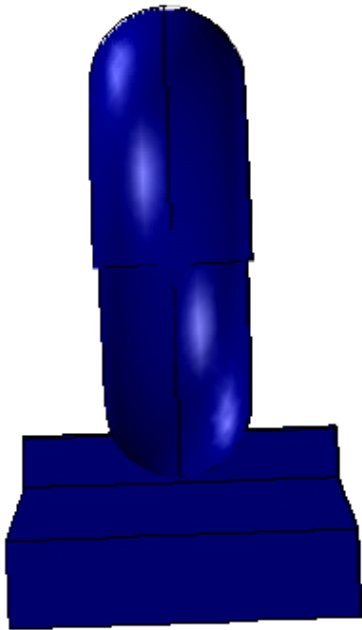
Control

Effects of Heart Looping Direction

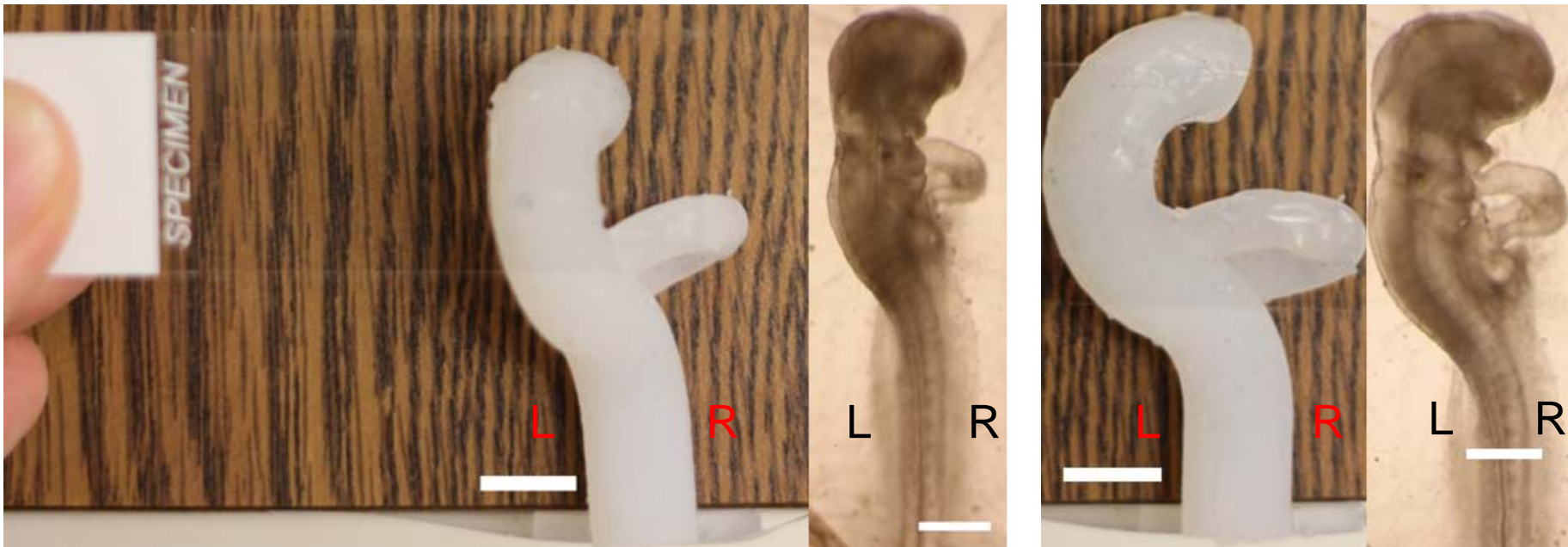
Finite-Element Model



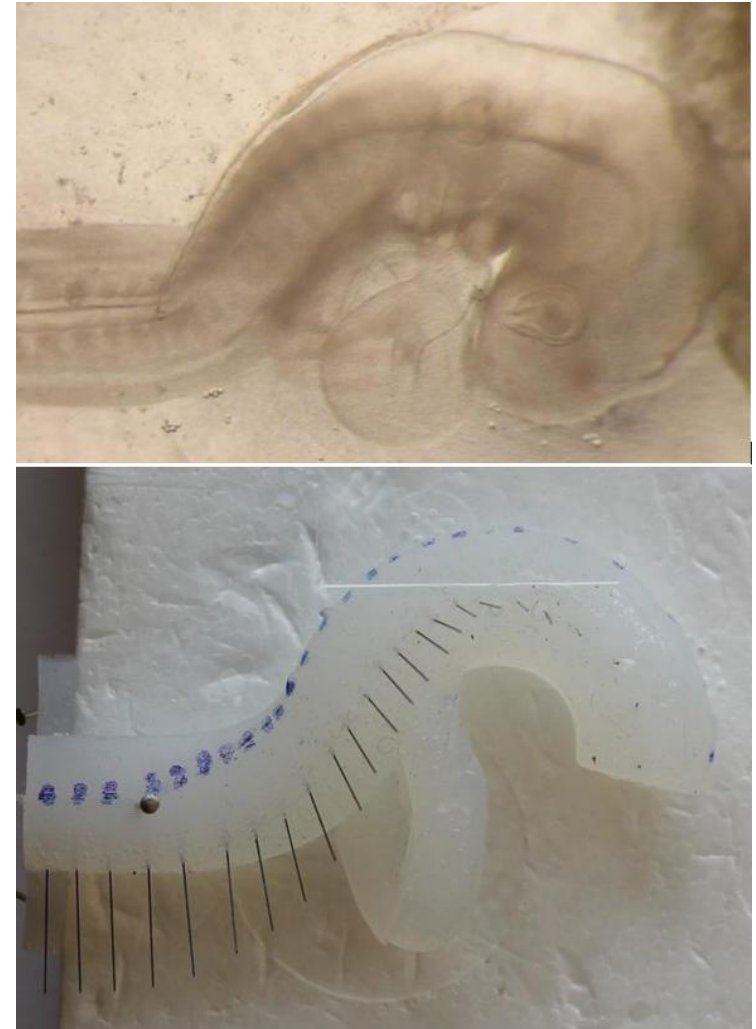
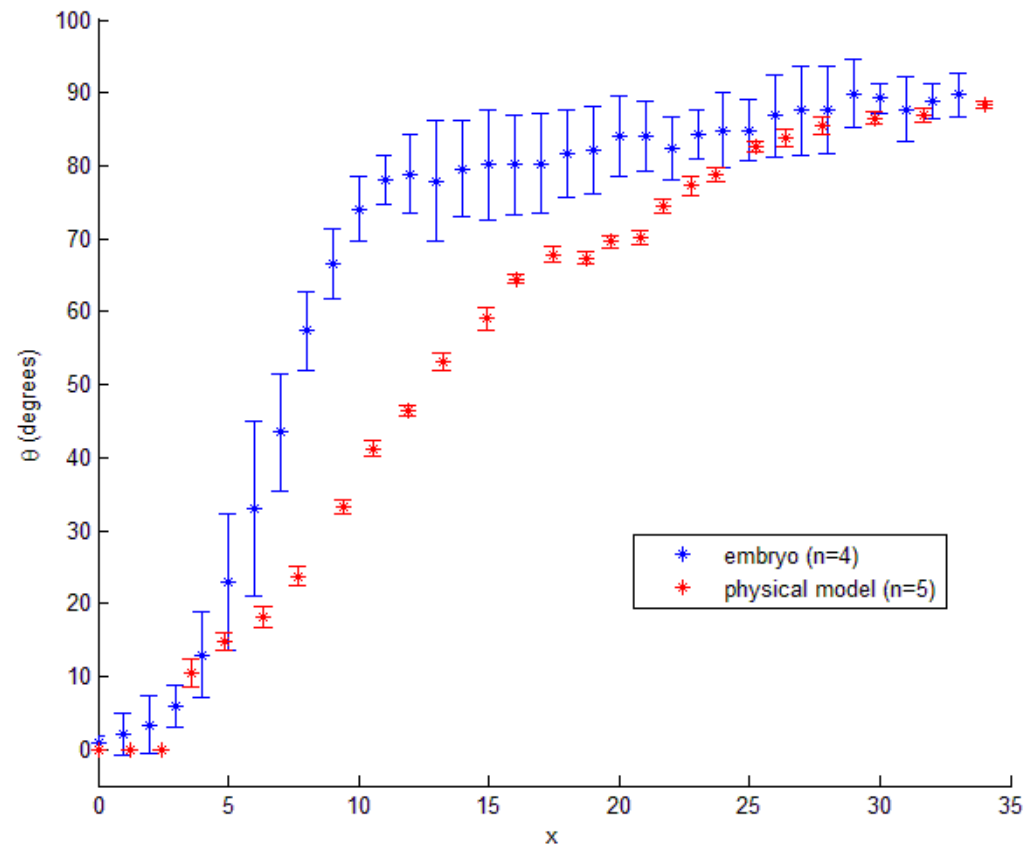
Finite-Element Model



Effects of VM on Brain Torsion



Torsional angle



Relationship between flexure and torsion



Ventral view
(41 hr)



An eye lash is implanted
(59 hr).

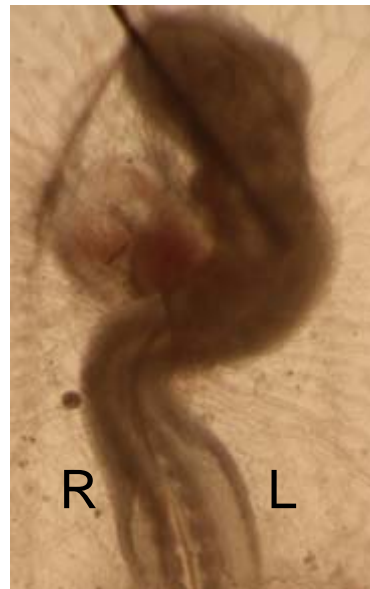


Control

Relationship between flexure and torsion



Ventral view
(38 hr)



An eye lash is implanted
(58 hr).



Control

Summary

- The vitelline membrane supplies forces that cause the brain to twist in the chick embryo.
- The direction of heart looping determines the direction of brain torsion.
- The suppression of flexure reduces brain torsion.

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Thank you for your attention!

Q

