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JT Biohistory Research Hall

Our institute has tied with Graduate School of Science, Osaka University for more than 20 years.

Laboratory of Biohistory

Search by brh spider

Morphological diversity in animals

Present

Morphological diversity in animals

Present

Past

Depth of time

Morphological diversity in animals

Present

How can we know the mechanisms behind the diversity?

Past

Depth of time

Morphological diversity in animals

Present

How can we know the mechanisms behind the diversity?

Past

with mutations

Genetic information (genome)

Depth of time

Morphological diversity in animals

Model species

Present

How can we know the mechanisms behind the diversity?

Past

with mutations

Genetic information (genome)

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Morphological diversity in animals

Model species

Present

Arthropods

How can we know the mechanisms behind the diversity?

Past

with mutations

Genetic information (genome)

Depth of time

Morphological diversity in animals

Model species

Present

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Arthropods

hanisms behind the diversity?

ast

with
mutations

Depth of time

c information
genome)

Morphological diversity in animals

Model species

Present

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Arthropods

hanisms behind the diversity?

What happened to the genome?

ast

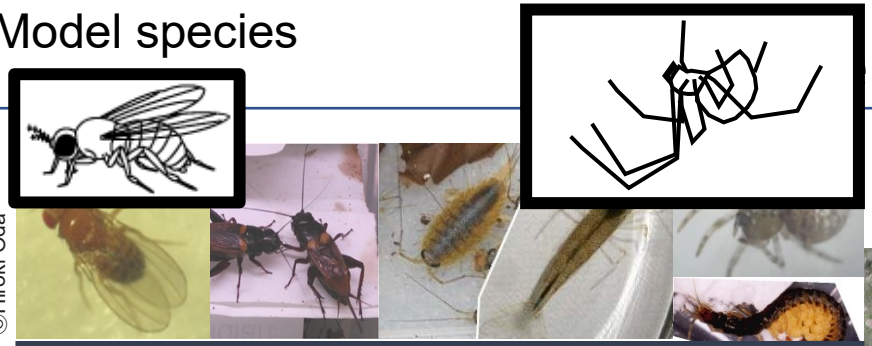
with mutations

Depth of time

c information genome)

Morphological diversity in animals

Model species



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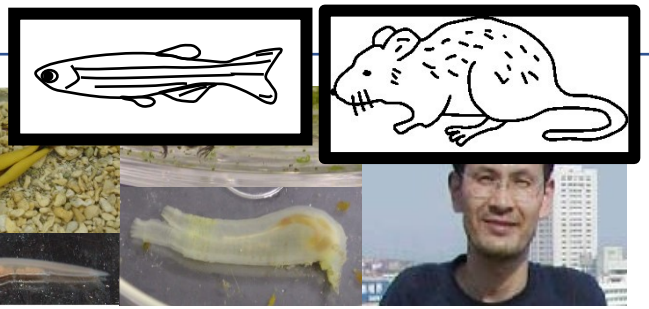


Arthropods

hanisms behind the diversity?

What happened to the genome?

ast

with mutations

Depth of time

c information genome)

The common house spider

Parasteatoda tepidariorum

The spider genome has been already sequenced!

Schwager *et al. BMC Biology* (2017) 15:62
DOI 10.1186/s12915-017-0399-x

BMC Biology

RESEARCH ARTICLE Open Access

The house spider genome reveals an ancient whole-genome duplication during arachnid evolution

Evelyn E. Schwager[1,2†], Prashant P. Sharma[3†], Thomas Clarke[4,5,6†], Daniel J. Leite[1†], Torsten Wierschin[7†], Matthias Pechmann[8,9], Yasuko Akiyama-Oda[10,11], Lauren Esposito[12], Jesper Bechsgaard[13], Trine Bilde[13], Alexandra D. Buffry[1], Hsu Chao[14], Huyen Dinh[14], HarshaVardhan Doddapaneni[14], Shannon Dugan[14], Cornelius Eibner[15], Cassandra G. Extavour[16], Peter Funch[13], Jessica Garb[2], Luis B. Gonzalez[1], Vanessa L. Gonzalez[17], Sam Griffiths-Jones[18], Yi Han[14], Cheryl Hayashi[5,19], Maarten Hilbrant[1,9], Daniel S. T. Hughes[14], Ralf Janssen[20], Sandra L. Lee[14], Ignacio Maeso[21], Shwetha C. Murali[14], Donna M. Muzny[14], Rodrigo Nunes da Fonseca[22], Christian L. B. Paese[1], Jiaxin Qu[14], Matthew Ronshaugen[18], Christoph Schomburg[8], Anna Schönauer[1], Angelika Stollewerk[23], Montserrat Torres-Oliva[8], Natascha Turetzek[8], Bram Vanthournout[13,24], John H. Werren[25], Carsten Wolff[26], Kim C. Worley[14], Gregor Bucher[27*], Richard A. Gibbs[14*], Jonathan Coddington[17*], Hiroki Oda[10,28*], Mario Stanke[7*], Nadia A. Ayoub[4*], Nikola-Michael Prpic[8*], Jean-François Flot[29*], Nico Posnien[8*], Stephen Richards[14*] and Alistair P. McGregor[1*]

Abstract

Background: The duplication of genes can occur through various mechanisms and is thought to make a major

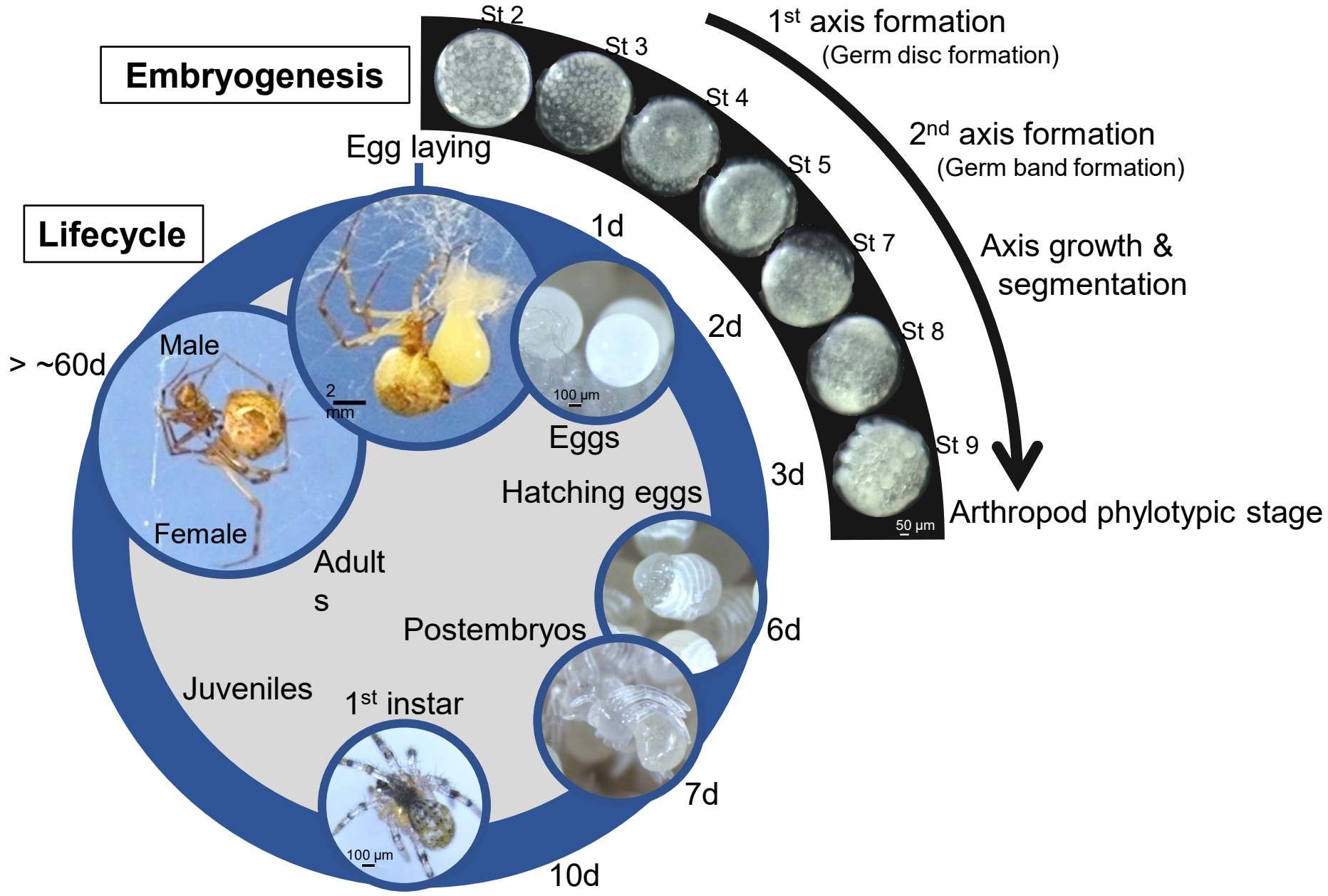
The common house spider

Parasteatoda tepidariorum

The common house spider

Parasteatoda tepidariorum

The common house spider *Parasteatoda tepidariorum*



Shared characteristics of arthropod body structures formed in early embryos

Body Axes

anterior-posterior/dorsal-ventral

Repetitive Units

called segments

Live embryo of the spider *Parasteatoda tepidariorum*

Spherical symmetry

↓

Radial symmetry

↓

Bilateral symmetry

Akiyama-Oda and Oda (2006) *Development* 133 CC-BY

Three experiments that can affect body axes formation

1.

2.

3.

Three experiments that can affect body axes formation

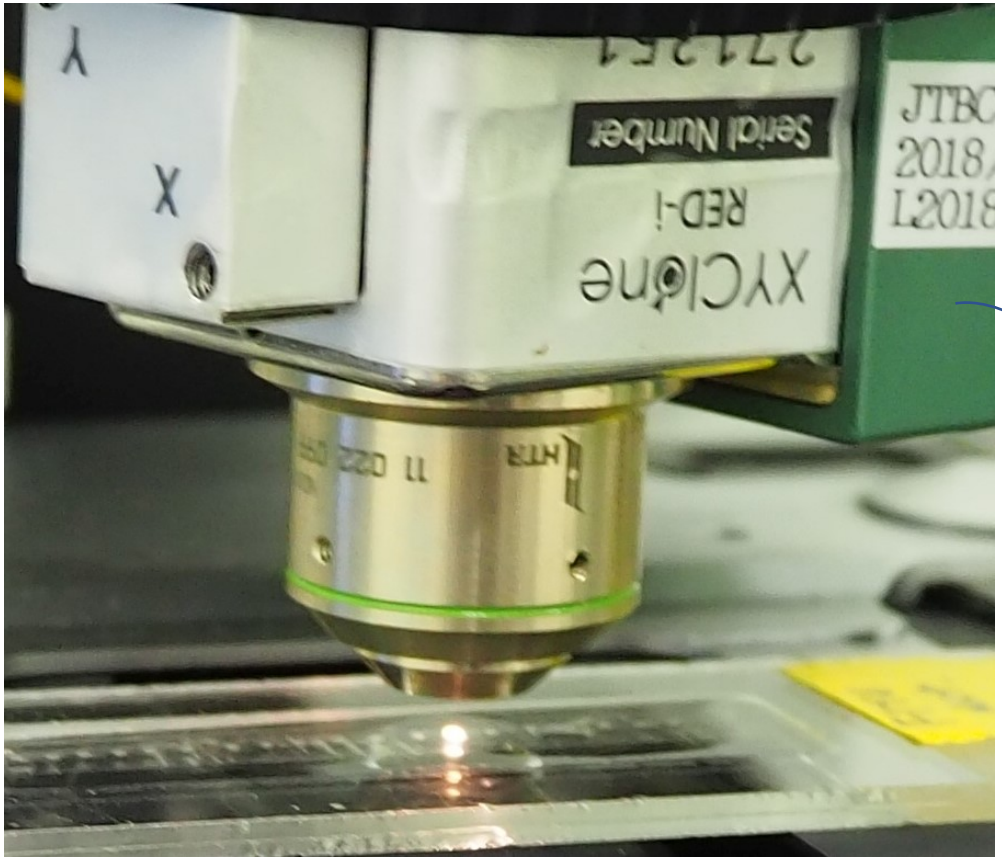
1. Laser ablation of cells in a specific small region of spider embryo

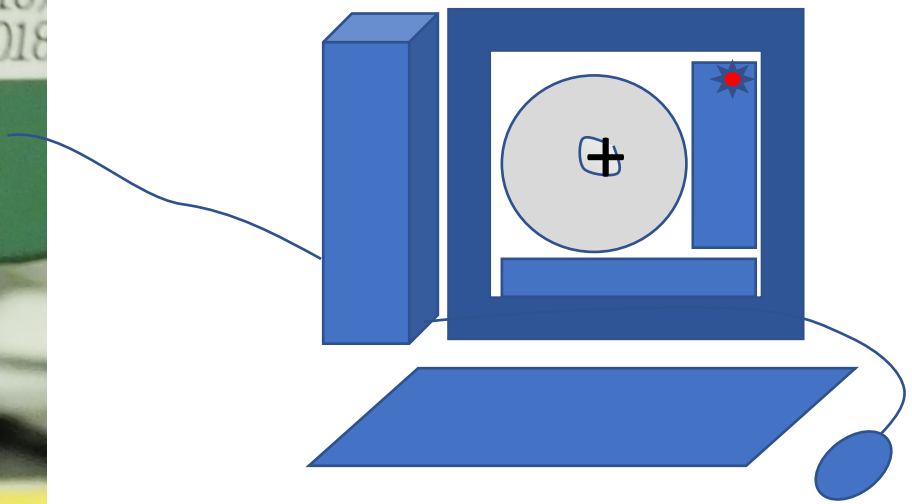
2.

3.

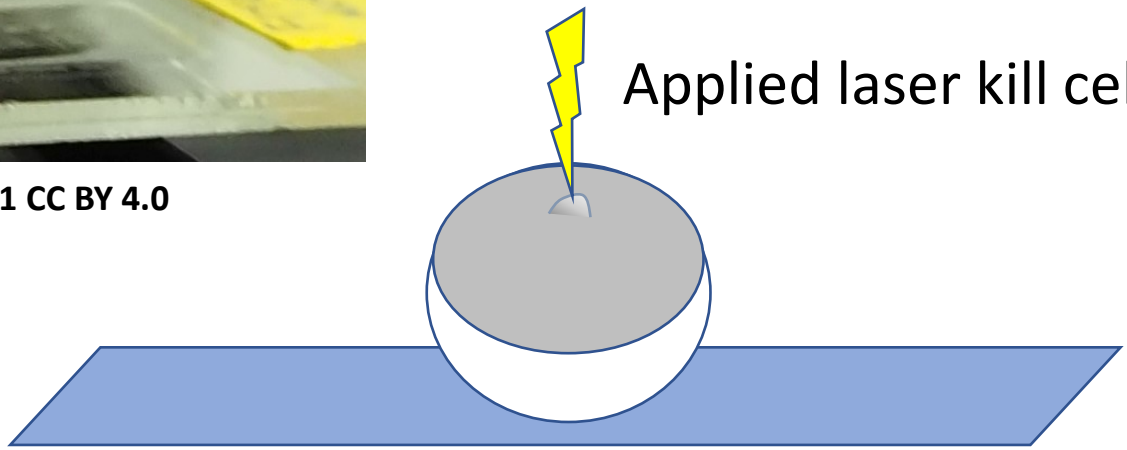
Kill cells in a target region of spider embryo

Laser ablation system

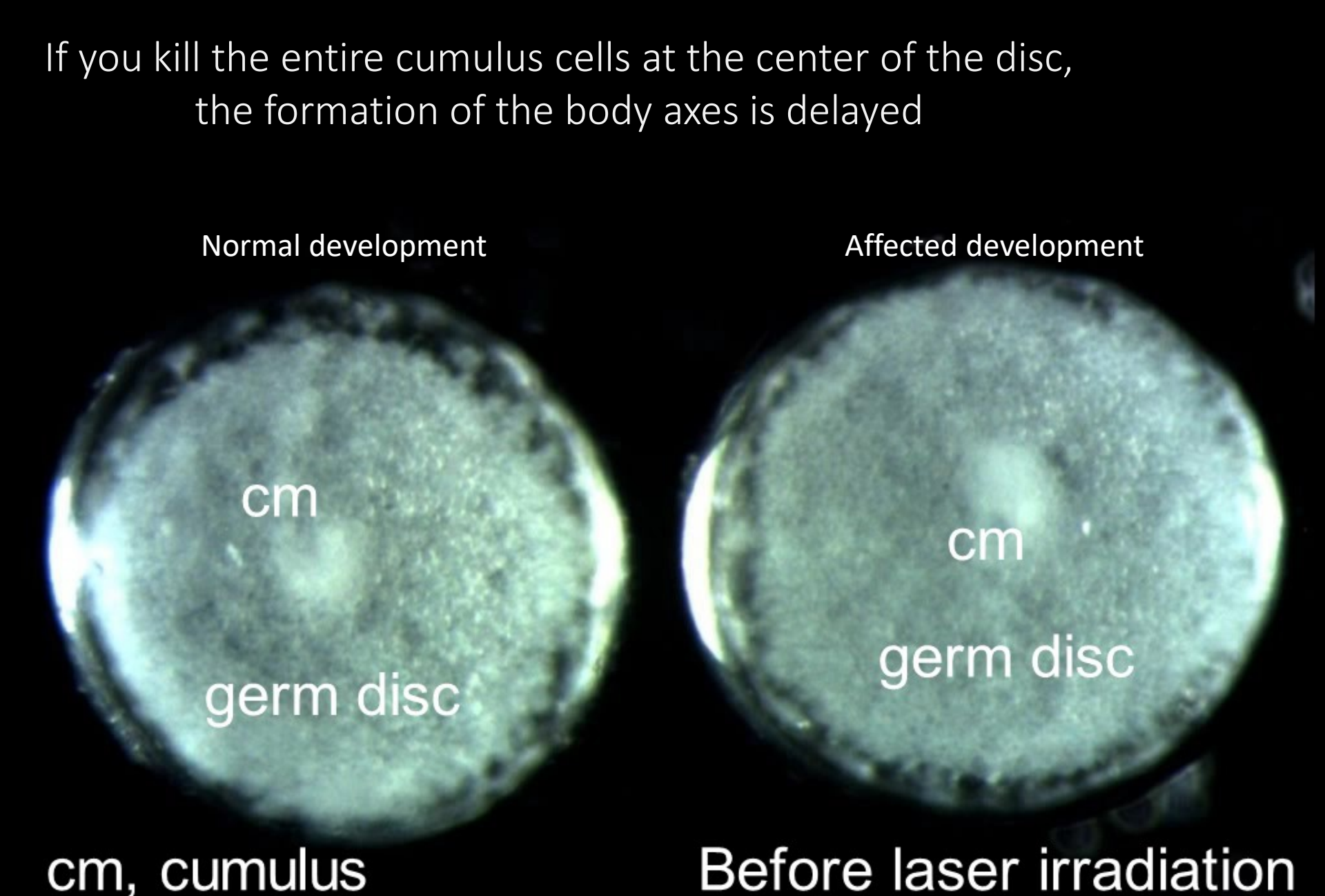




Applied laser kill cells



If you kill the entire cumulus cells at the center of the disc,
the formation of the body axes is delayed



Three experiments that can affect body axes formation

1. Laser ablation of cells in a key small region of spider embryo

Delayed development of the body axes

2.

3.

Three experiments that can affect body axes formation

1. Laser ablation of cells in a key small region of spider embryo

   Delayed development of the body axes

2.

   Formation of twinned embryos

3.

   Formation of twinned embryos

Three experiments that can affect body axes formation

1. Laser ablation of cells in a key small region of spider embryo

Delayed development of the body axes

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Formation of twinned embryos

3.

Formation of twinned embryos

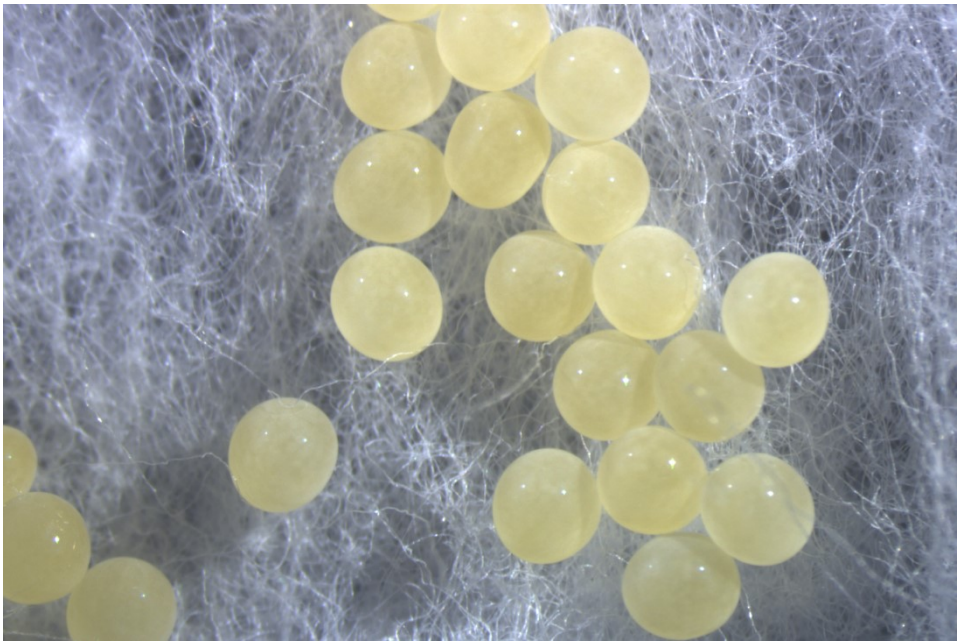
Jumping spider

Hasarius adansoni

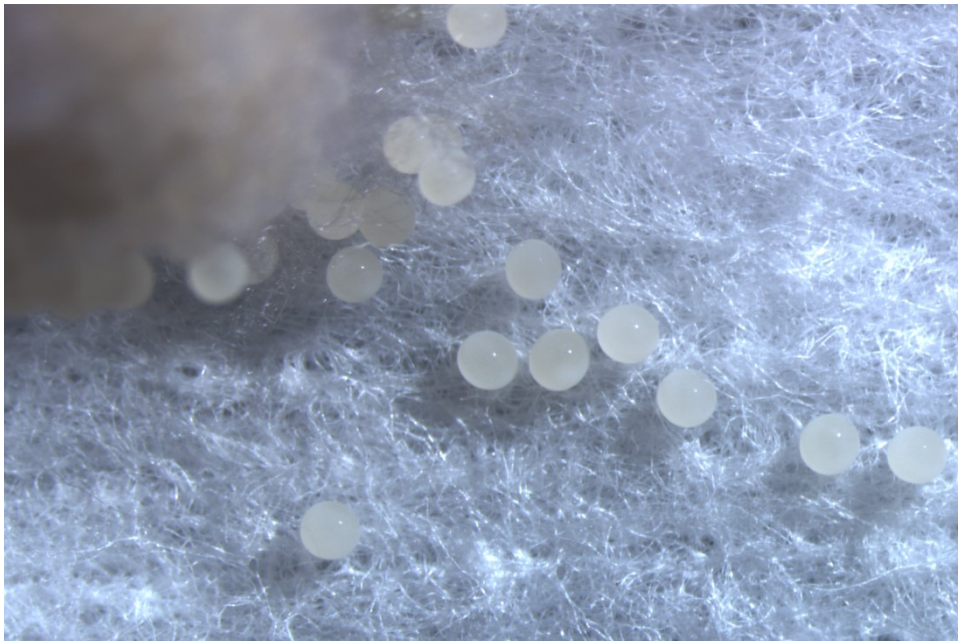
Jumping spider

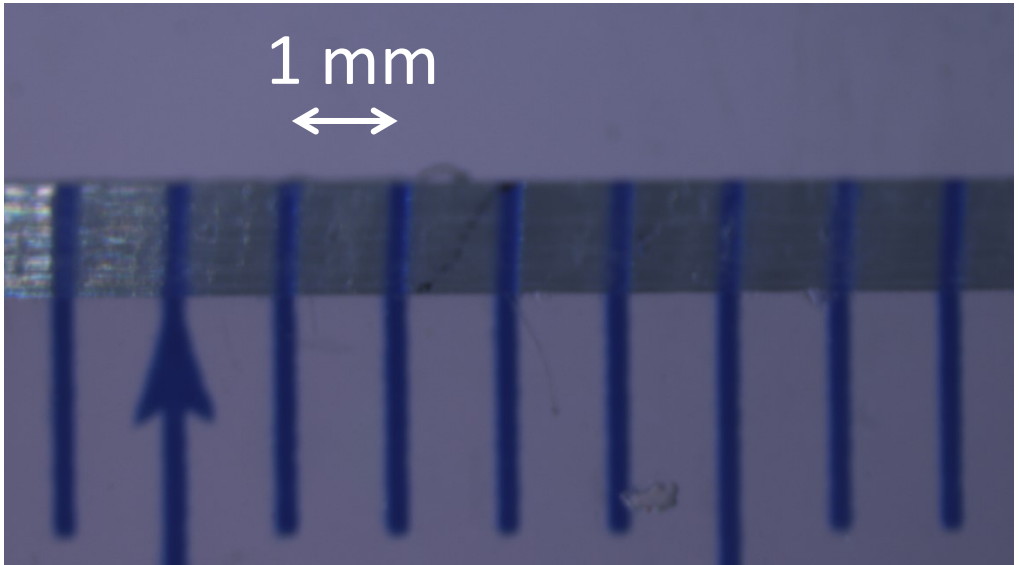
Hasarius adansoni

Jumping spider's eggs



House spider's eggs

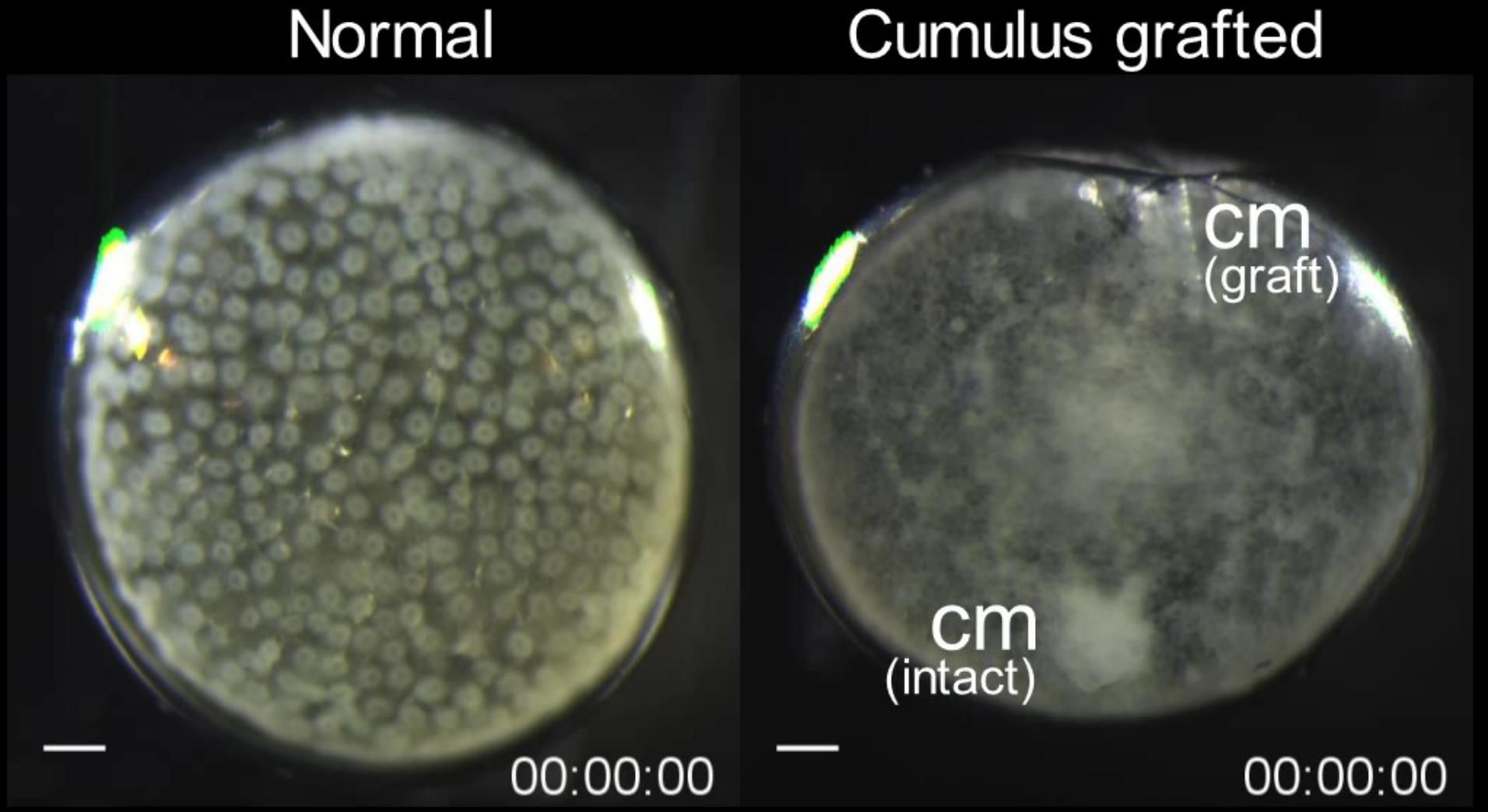




Embryogenesis of the jumping spider

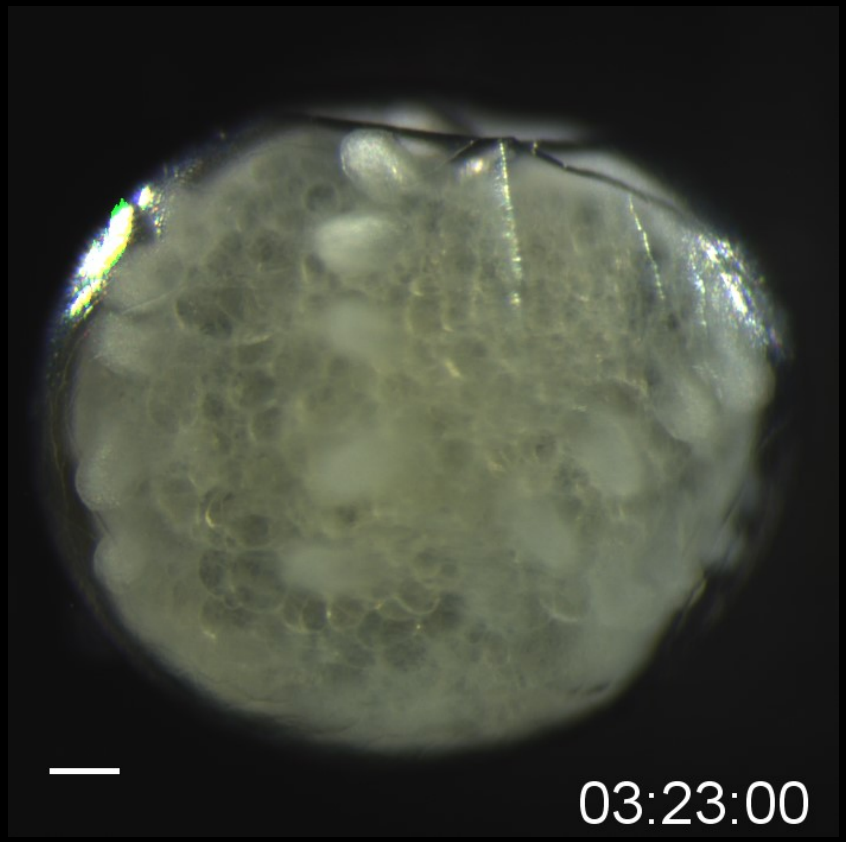
Hasarius adansoni

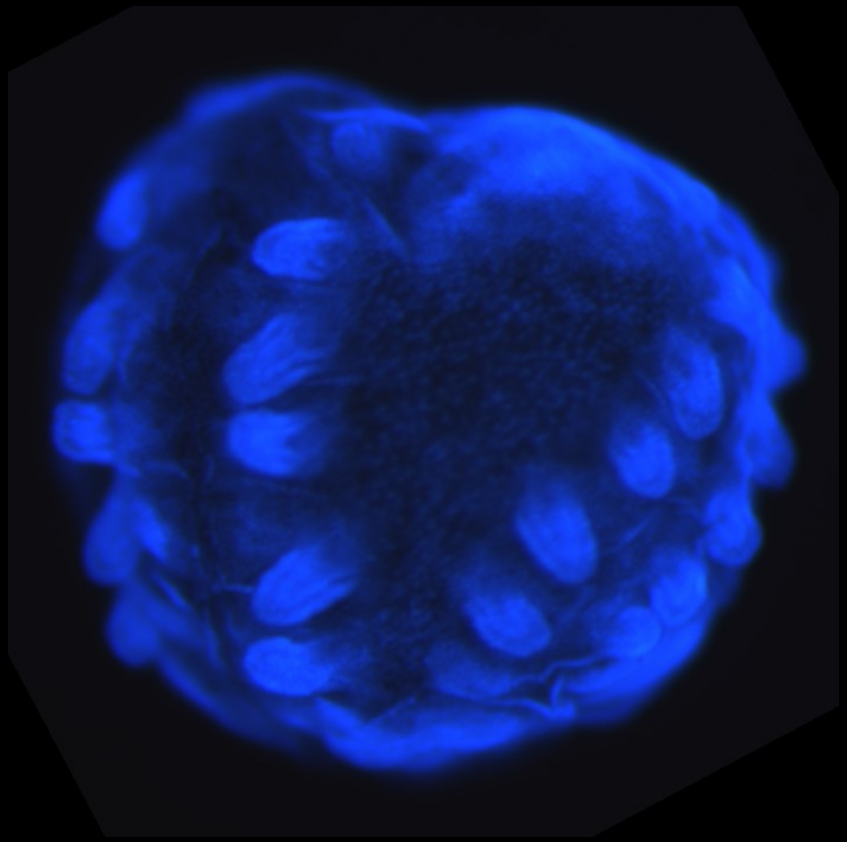
The cumulus was grafted to the opposite side of embryo



The cumulus was grafted to the opposite side of embryo

Partially twinned embryos were formed





Three experiments that can affect body axes formation

1. Laser ablation of cells in a key small region of spider embryo

Delayed development of the body axes

2. Transplantation of the key cells to the opposite side of embryo

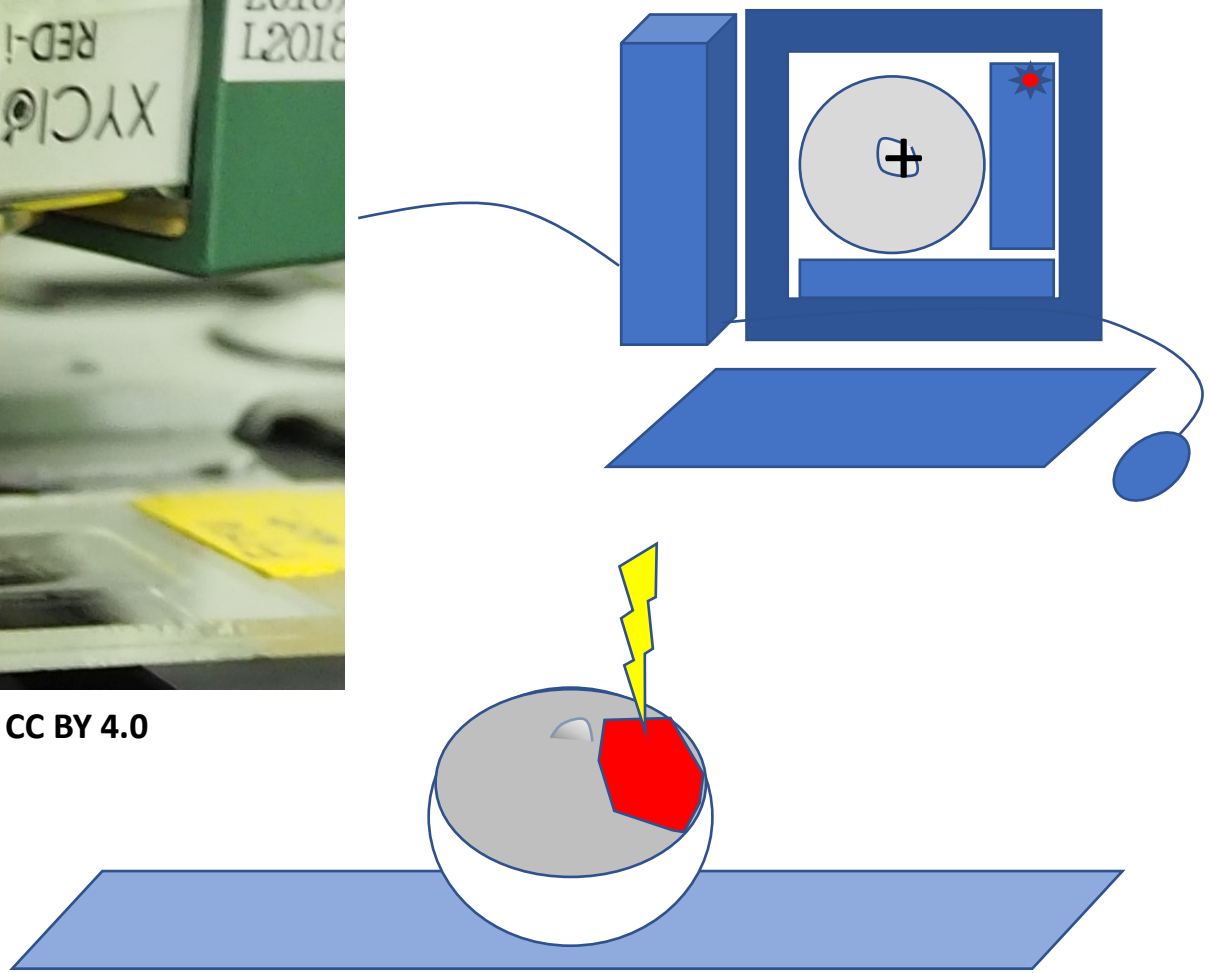
Formation of twinned embryos

3.

Formation of twinned embryos

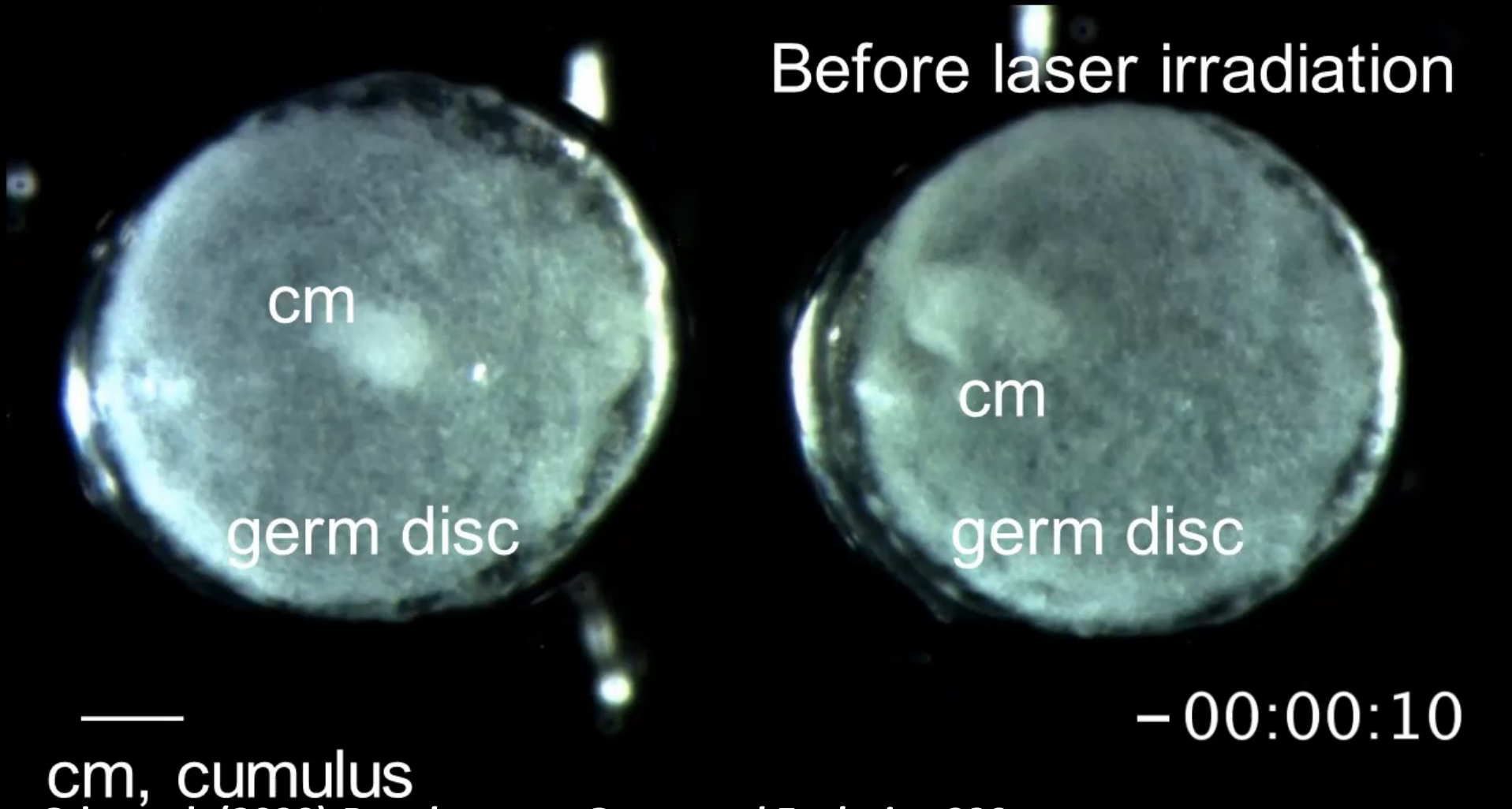
Laser ablation of a large region that separates the left- and right-side fields

Laser ablation system

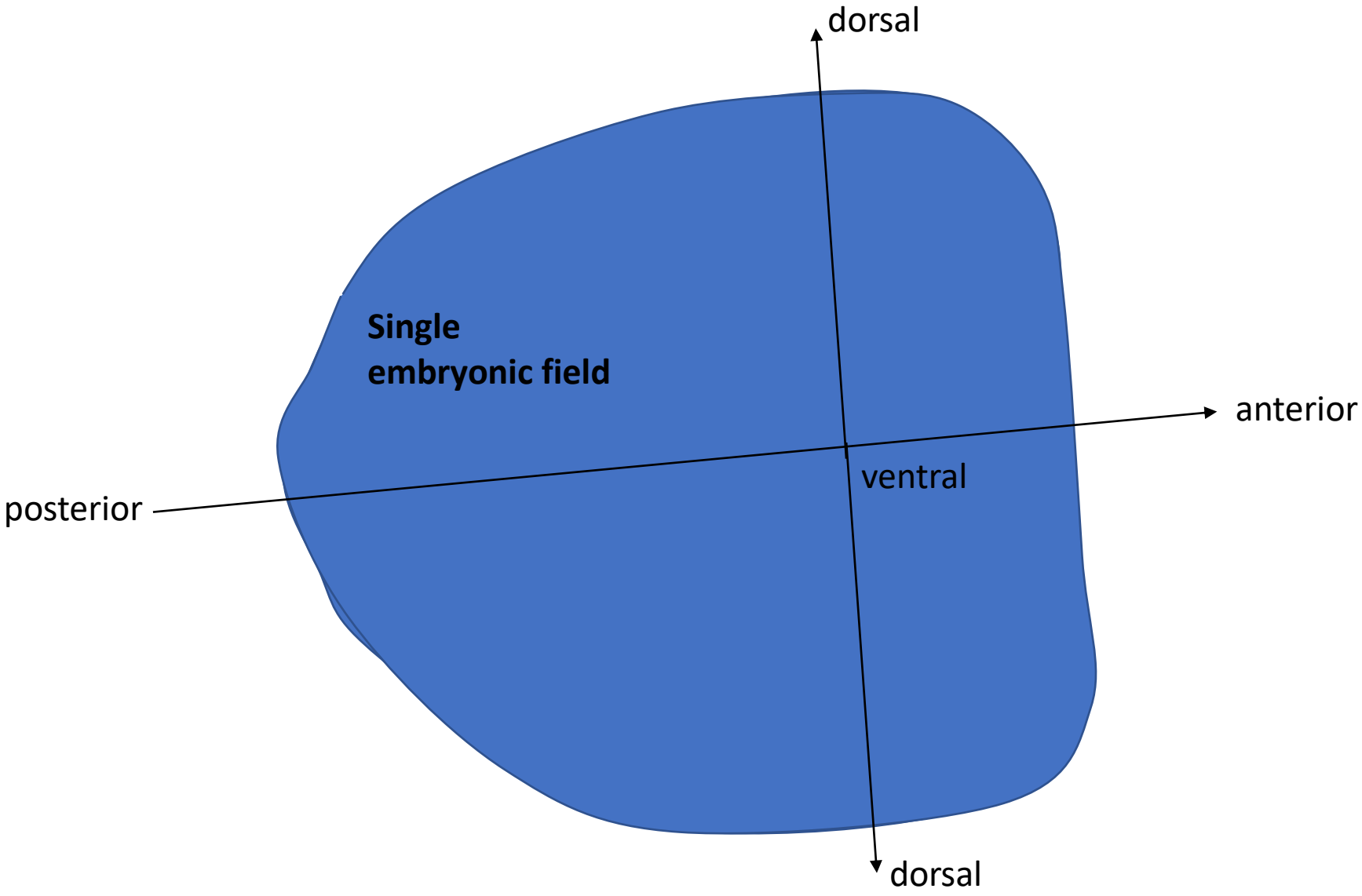


Laser ablation of a large region that separates the left- and right-side fields

Partially twinned embryos were formed



Each separated embryonic field self-regulates to recover the bilateral symmetry



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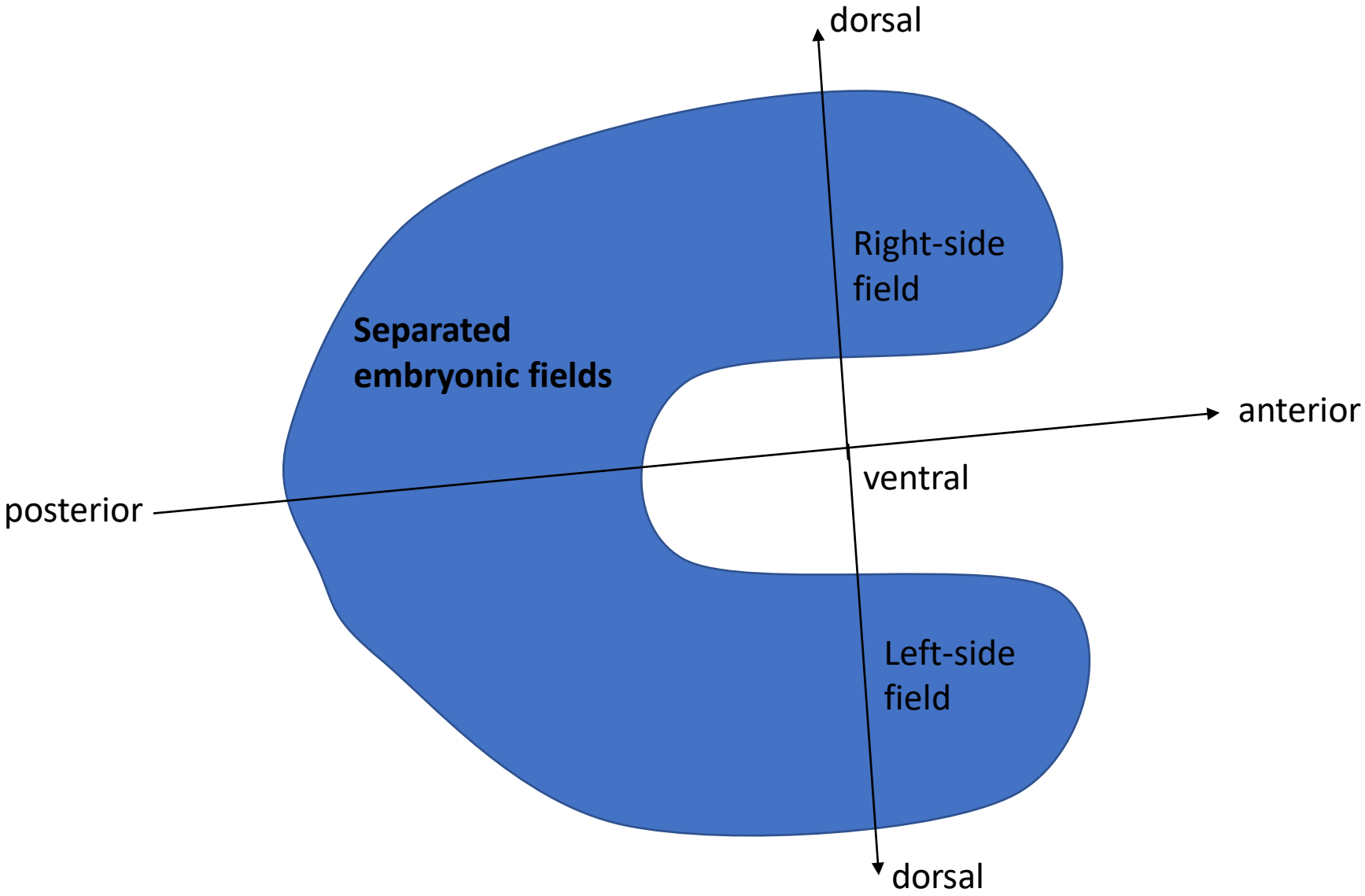

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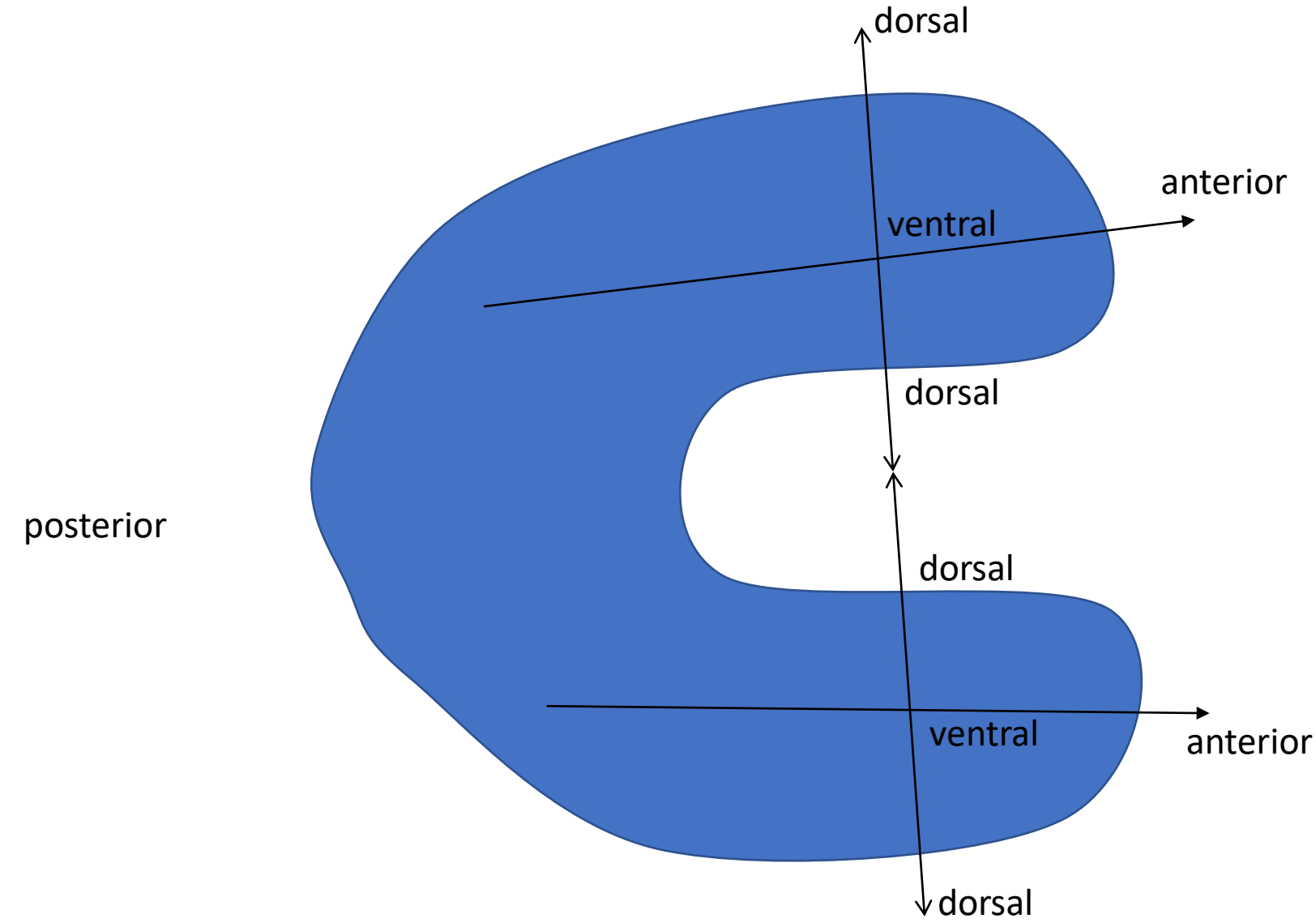


Three experiments that can affect body axes formation

1. Laser ablation of cells in a key small region of spider embryo

Organizer

Delayed development of the body axes

2. Transplantation of the key cells to the opposite side of embryo

Organizer

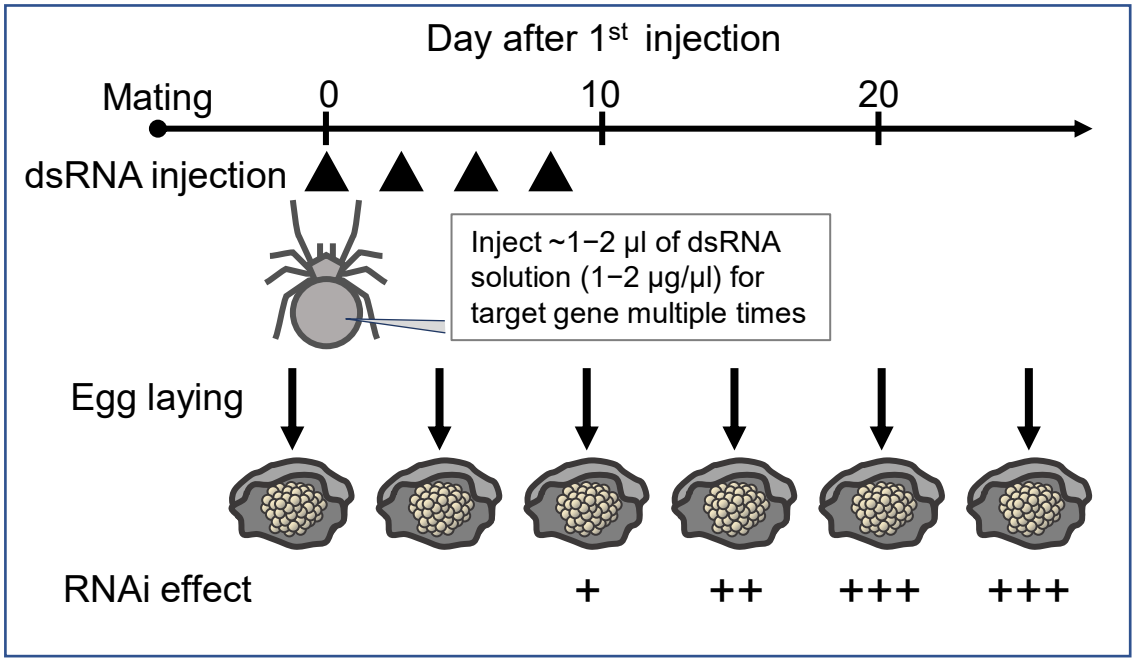
Formation of twinned embryos

3. Laser ablation of cells in a large region to separate the left and right

Formation of twinned embryos **Self-regulation**

Identification of genes involved in the formation of the body axes in the spider

Parental RNA interference, pRNAi, is a powerful technique in the spider



Oda and Akiyama-Oda (2020) *EvoDevo* 11

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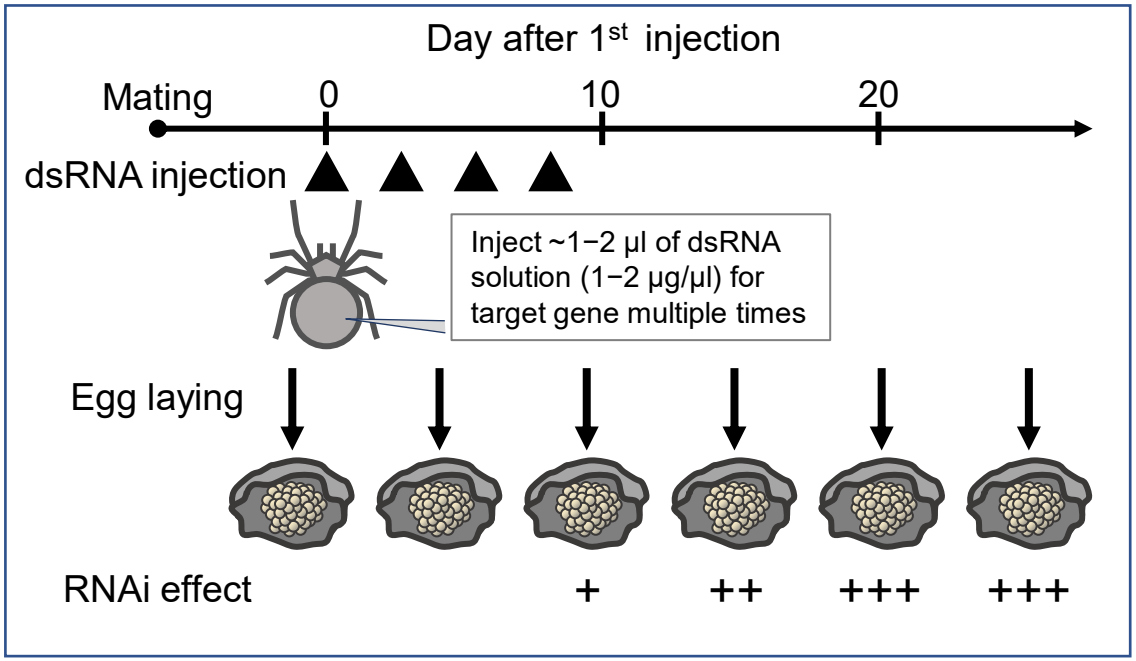
Injection of dsRNA for parental RNA interference in the model spider *Parasteatoda tepidariorum*

The method first described by Akiyama-Oda and Oda (Development 2006, 133: 2347-57)

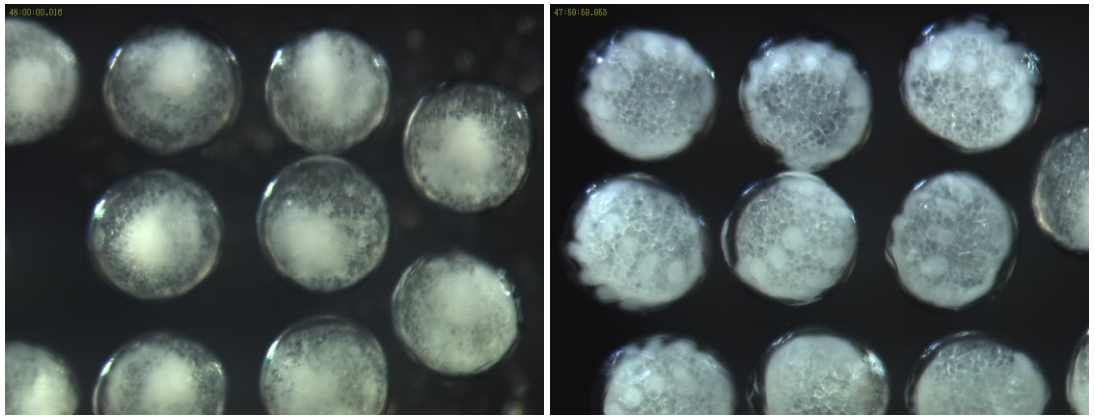
You can see the full version of this video at https://www.brh2.jp/

Parental RNA interference, pRNAi, is a powerful technique in the spider



Oda and Akiyama-Oda (2020) *EvoDevo* 11 CC BY 4.0

pRNAi for *hedgehog* pRNAi for *gfp* (control)

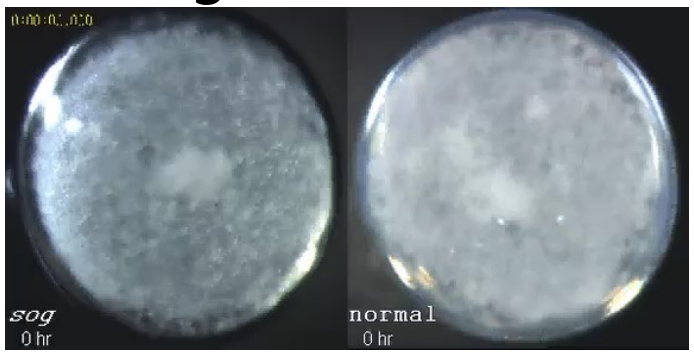


Akiyama-Oda and Oda (2010) Development 137

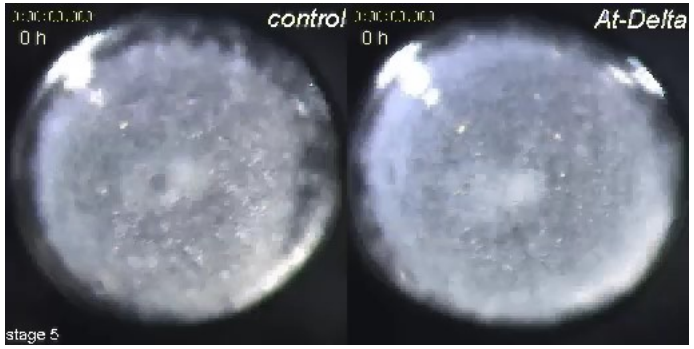
Easy to analyze gene functions

Parental RNAi that affects the body axes

sog normal



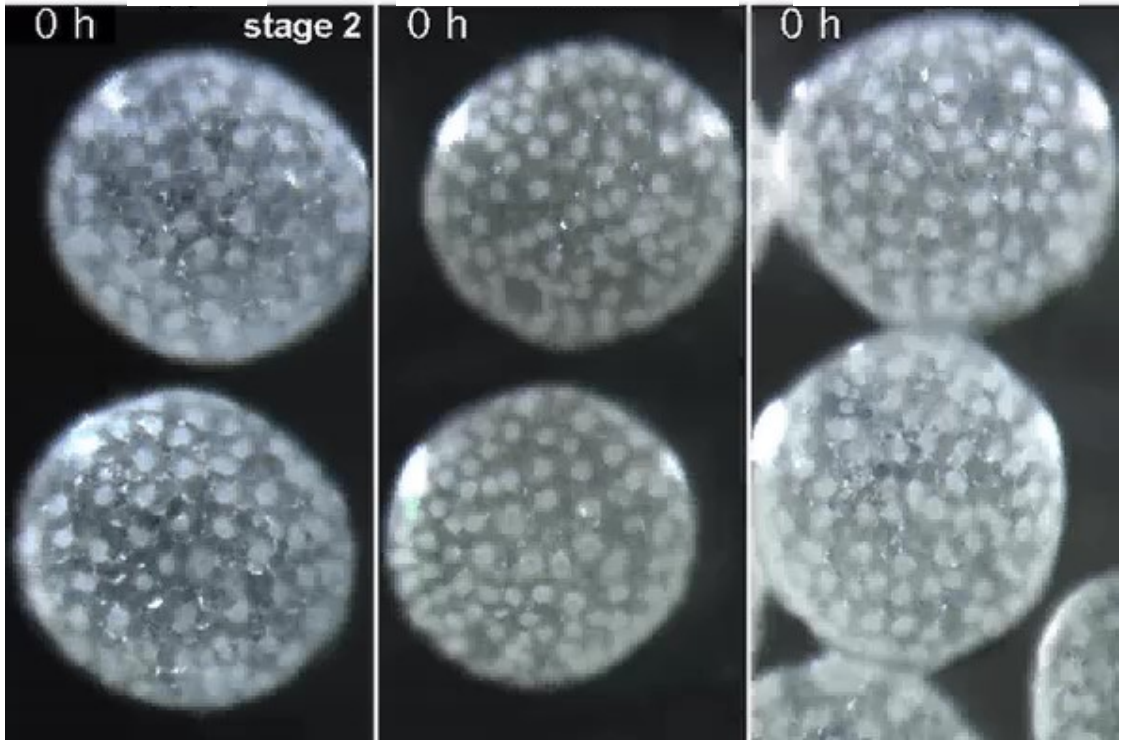
gfp *Delta*



Akiyama-Oda and Oda (2006) *Development* 133

Oda et al. (2007) *Development* 134

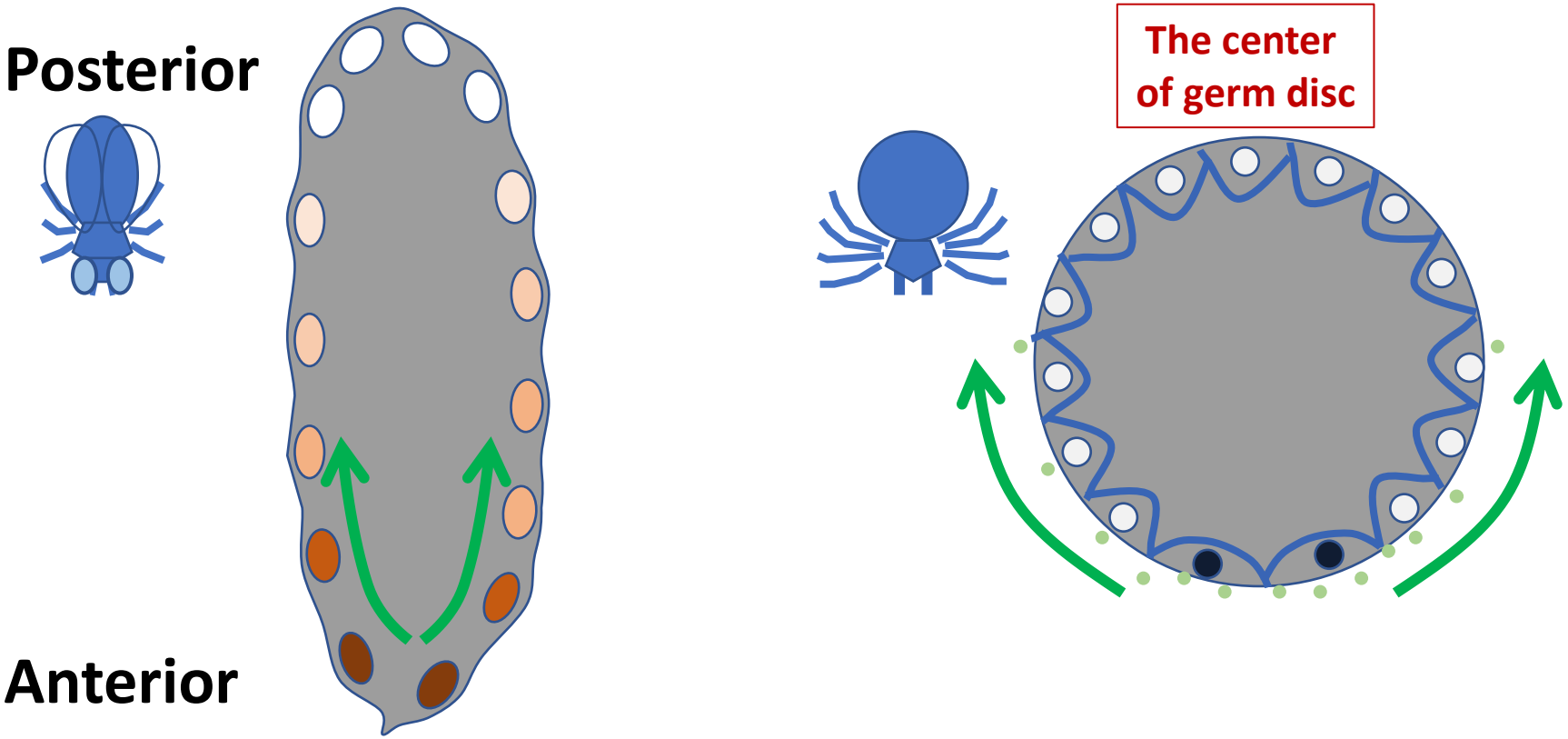
gfp *hedgehog* *patched*



Akiyama-Oda and Oda (2010) Development 137

Morphogens operate

inside the cell vs **outside the cells**



Bicoid
(transcription factor)
Syncytial

Hedgehog
(secreted protein)
Cell-based

Akiyama-Oda and Oda (2010) *Development* 137
Kanayama et al. (2010) *Arthrop. Struct. Devlop.* 39

Basic characteristics of arthropod body structures formed in early embryos

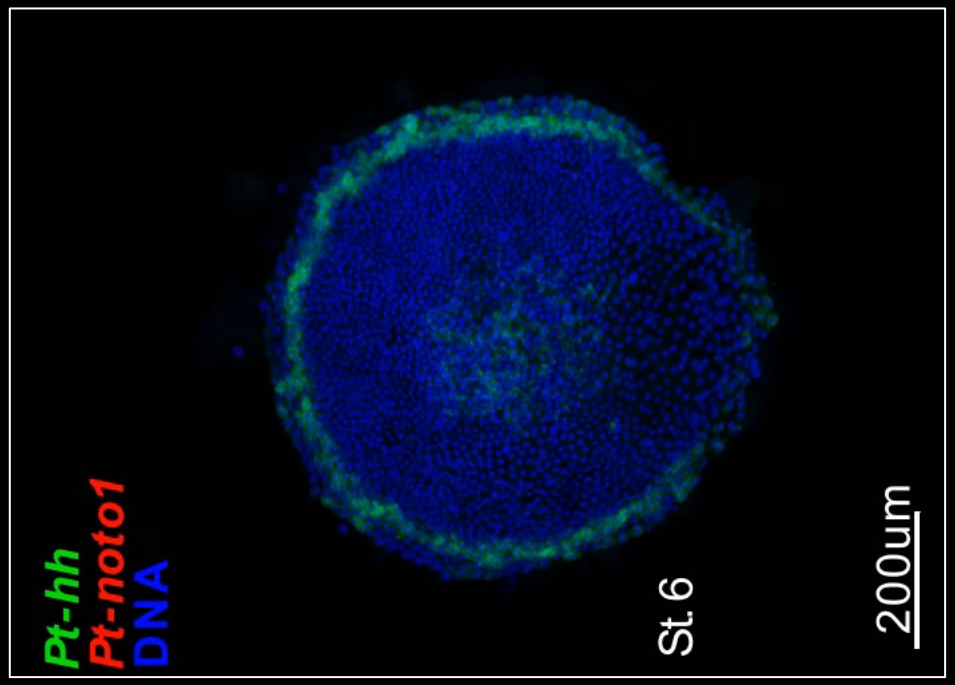
Body Axes

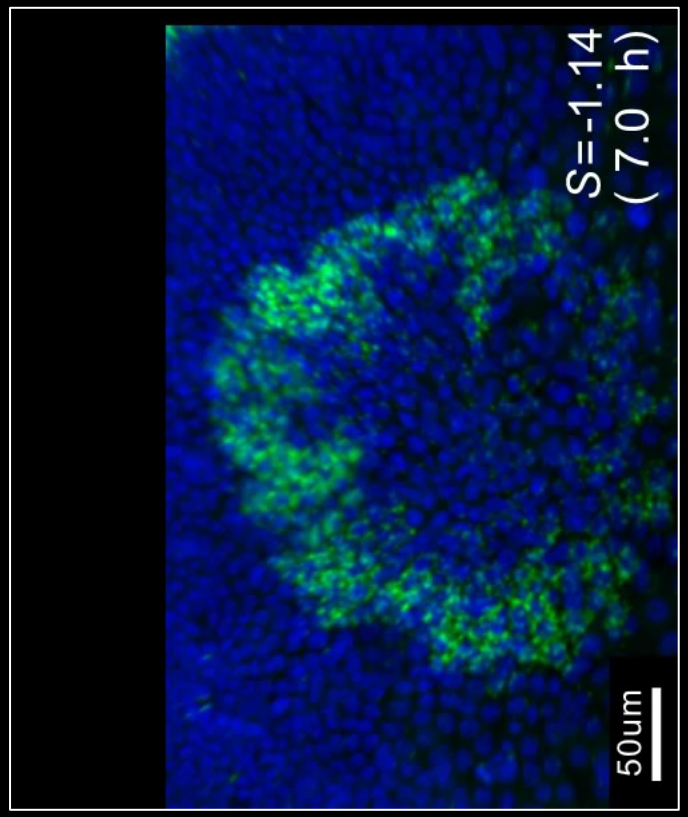
anterior-posterior/dorsal-ventral

Repetitive Units

called segments

Diversity of dynamic processes generating periodic stripes (reconstructed by staining of sibling spider embryos)

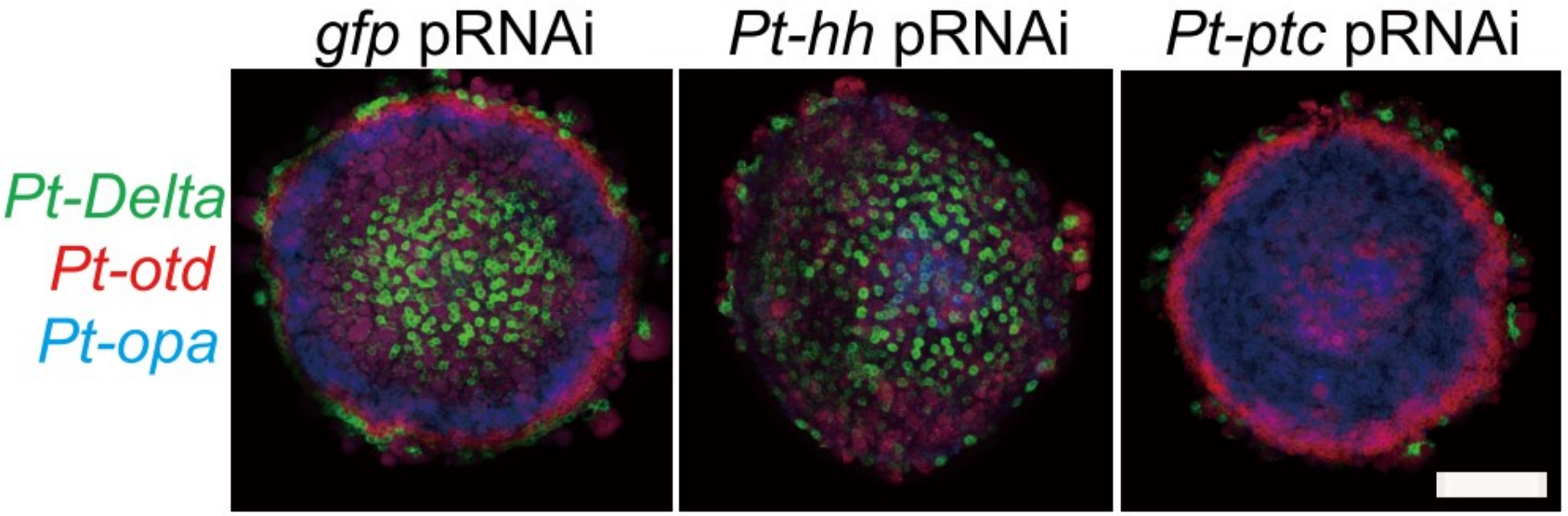




Hemmi et al. (2018) *Dev. Biol.* 437, 84-104 (CC BY 4.0)

Hh signaling plays a role in the formation of the total polarity in the spider embryo

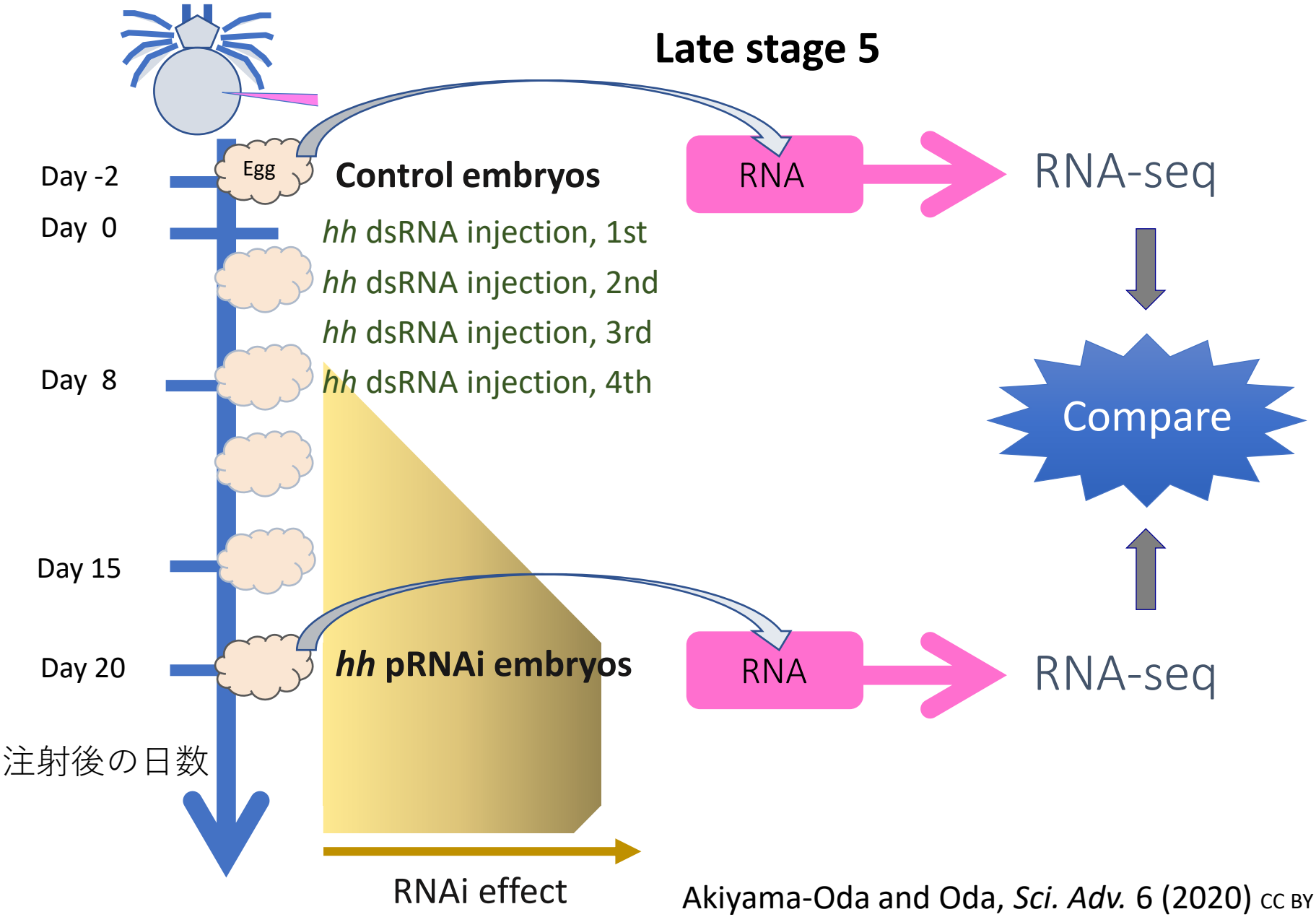
before its components appear to function as segment polarity genes.



Akiyama-Oda and Oda, *Sci. Adv.* 6 (2020)

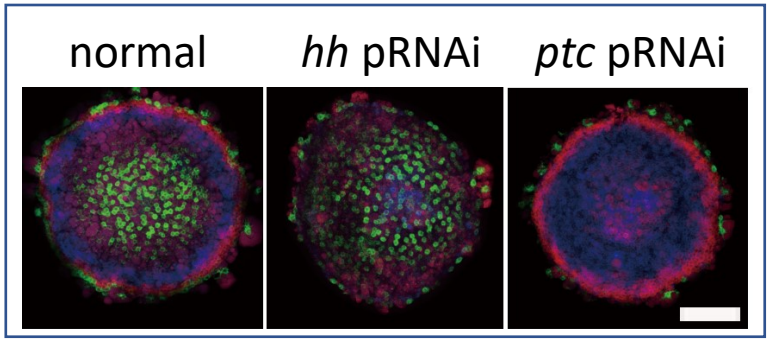
Double negative regulation and negative feedback

pRNAi and RNA-seq enables genome-wide gene discovery



Genome-wide identification of *hedgehog* signaling targets

pRNAi for *hh* and *ptc*



Egg laying

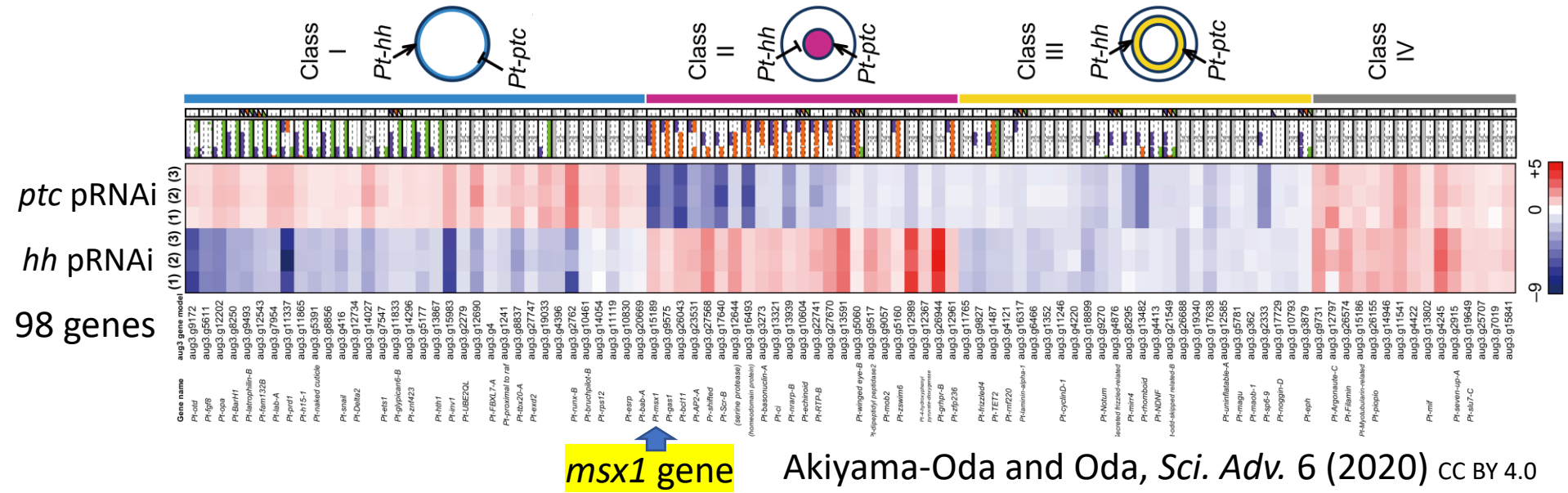
hh pRNAi embryos

ptc pRNAi embryos

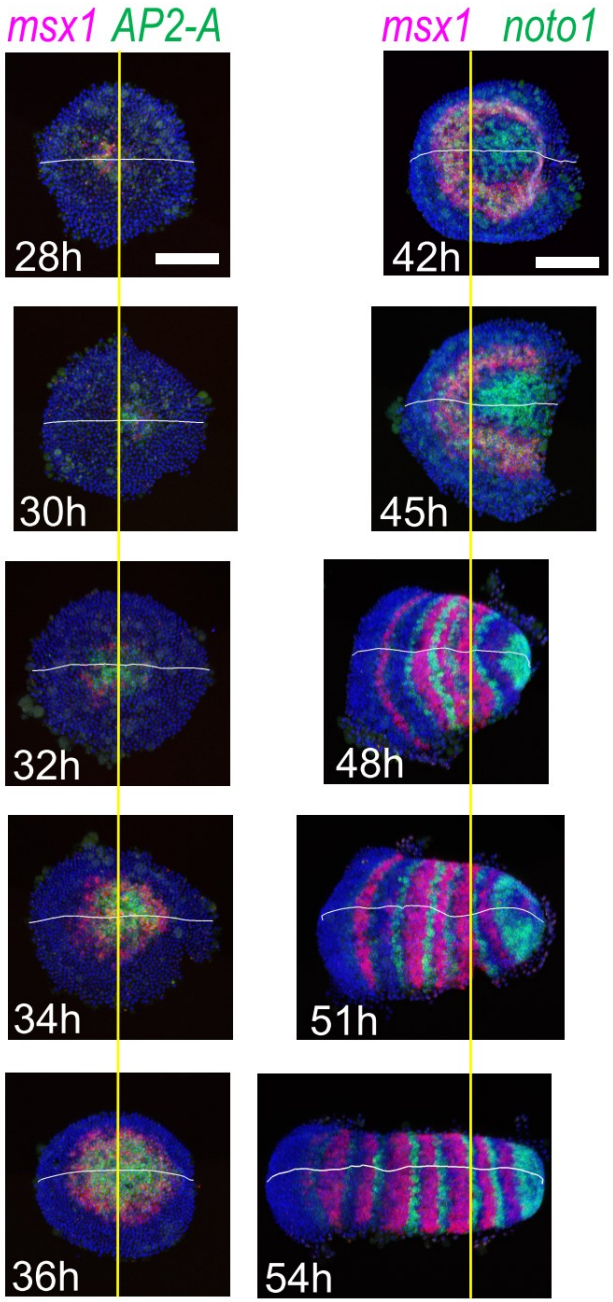
Identify differentially expressed genes by RNA sequencing

Positively regulated by *hh*

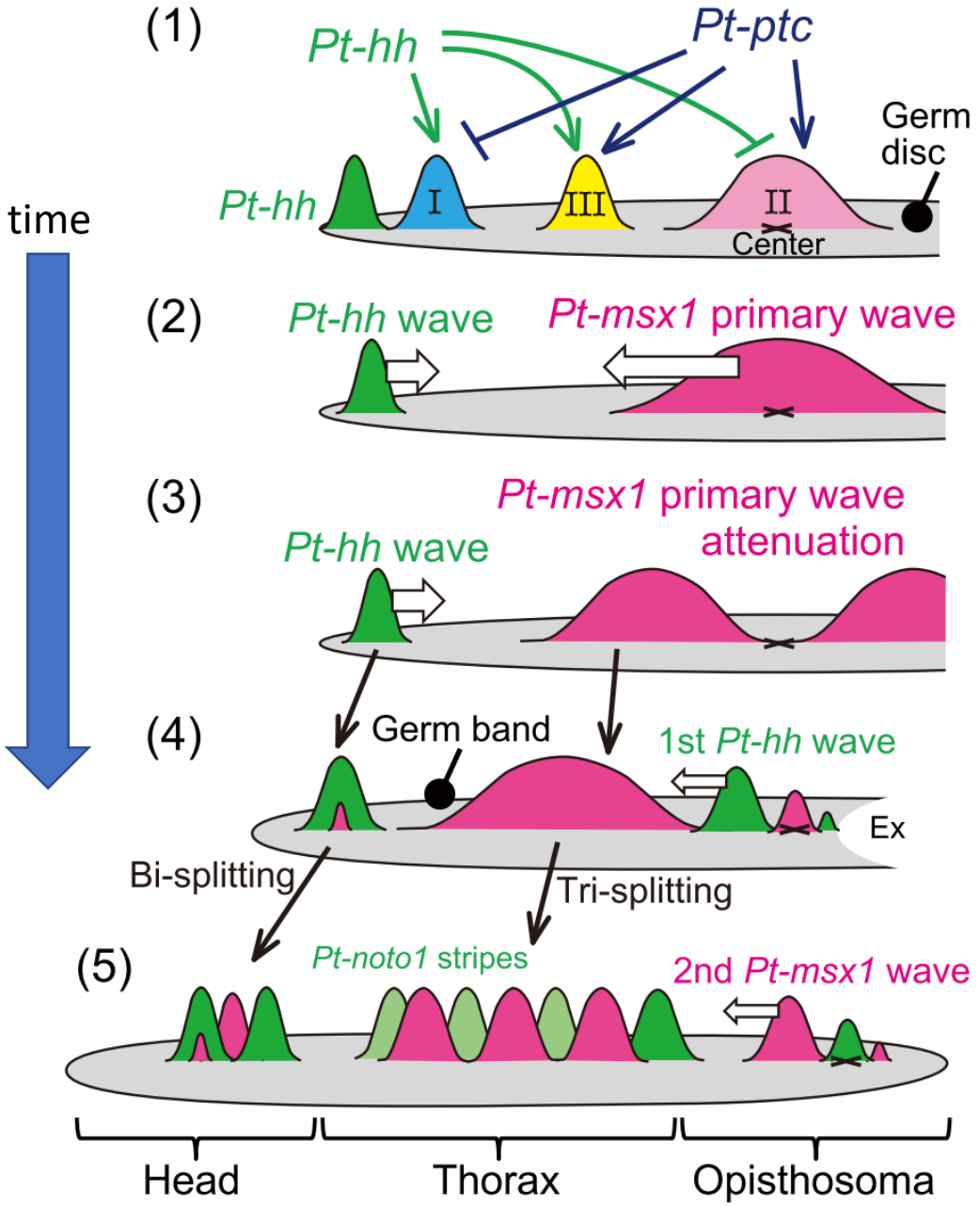
Negatively regulated by *hh*



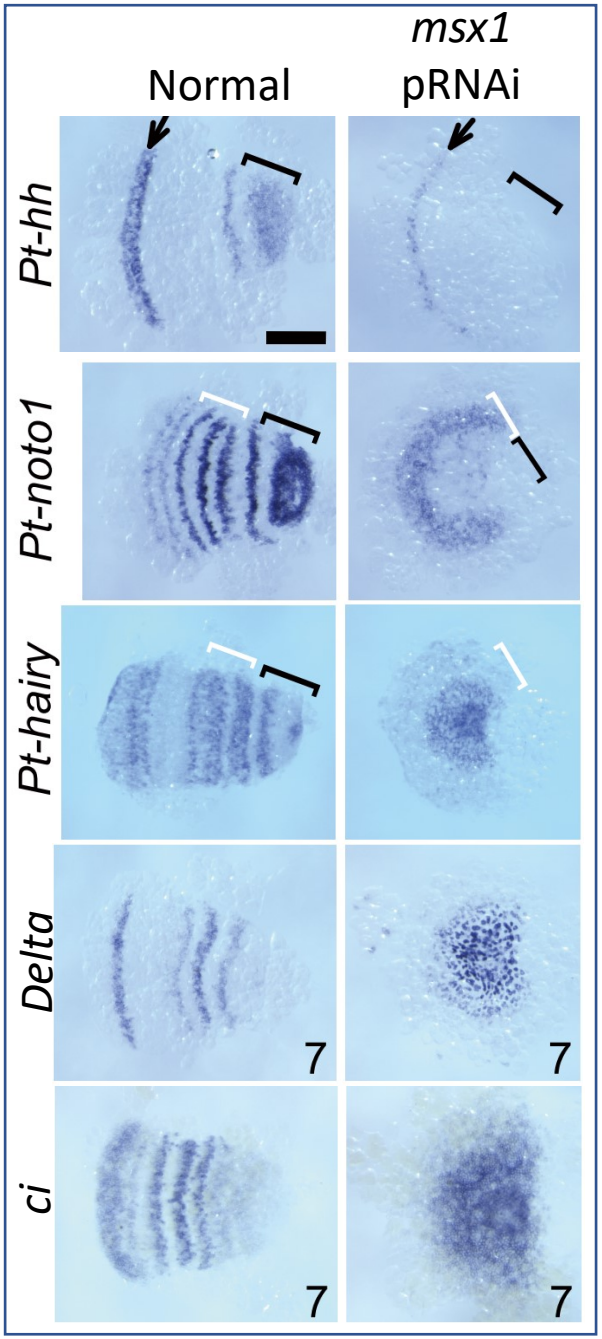
Embryo shows dynamic *msx1* expression giving rise to spatial periodicity



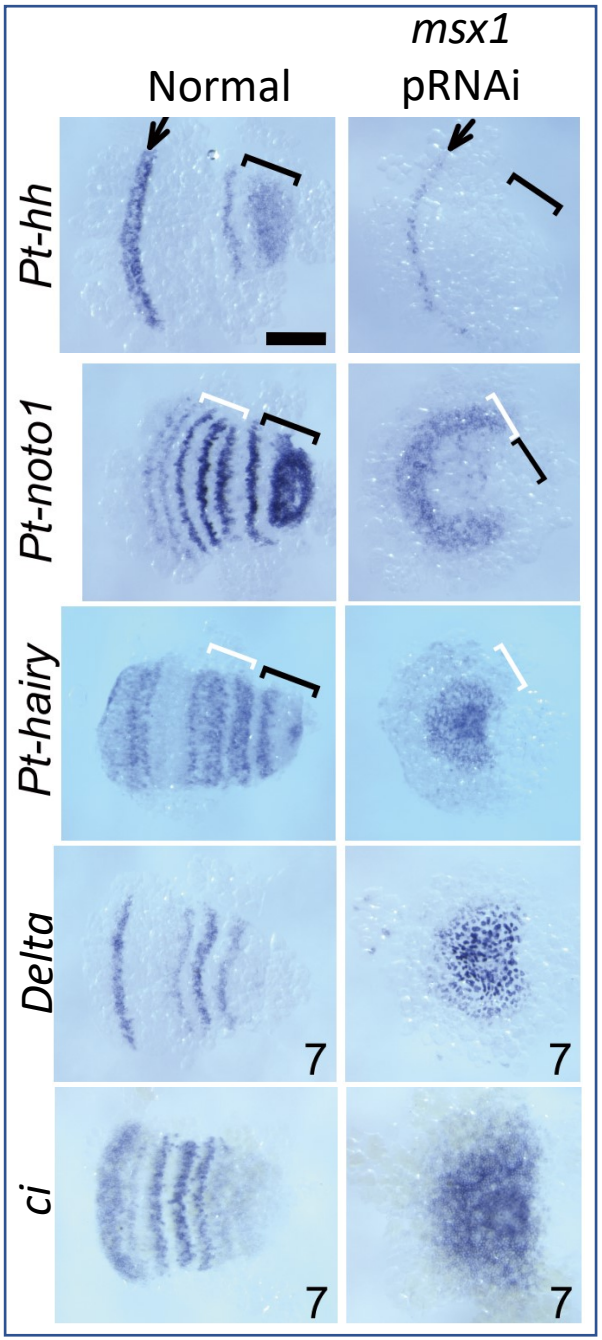
time



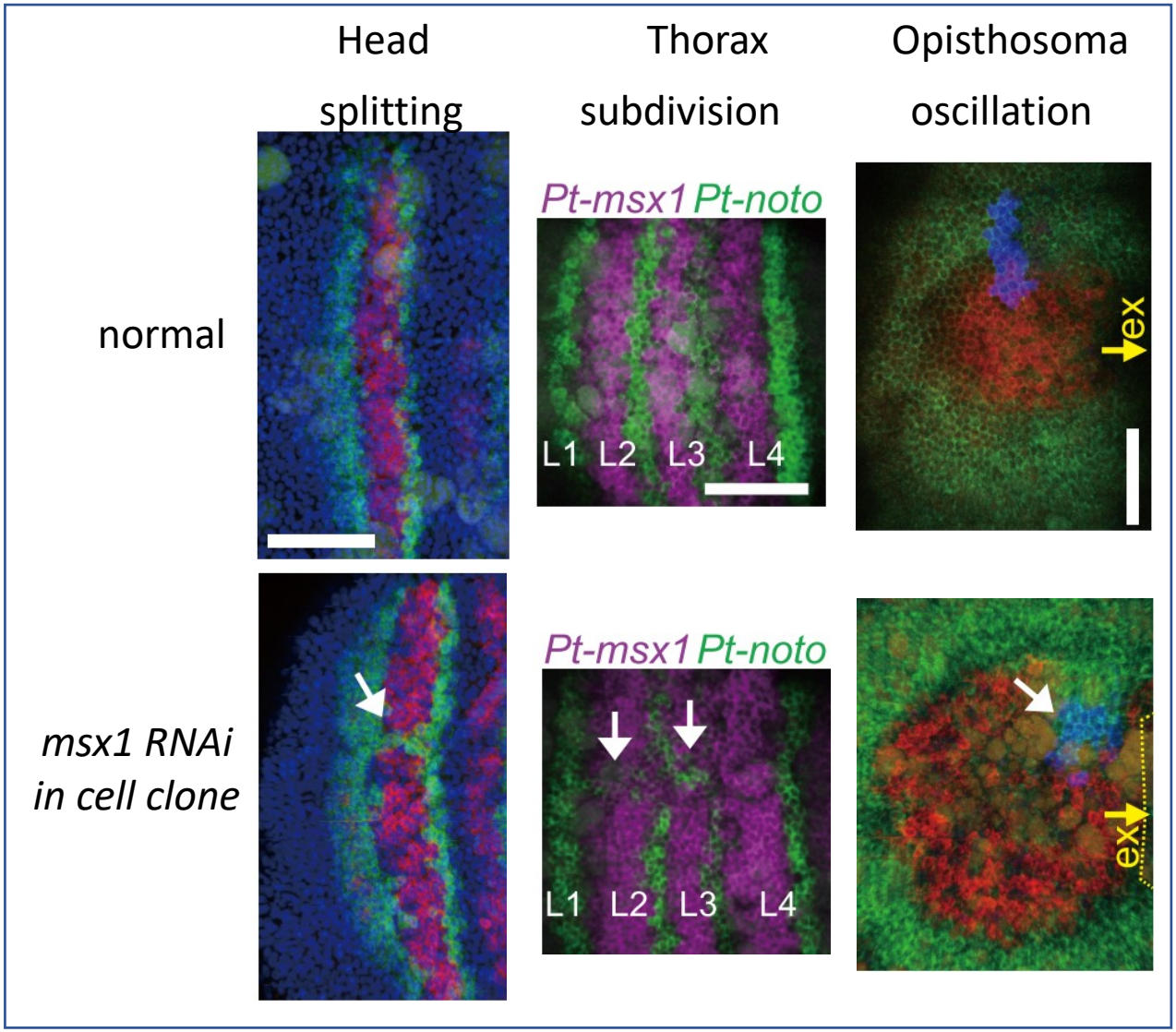
All dynamic processes that generate spatial periodicity are blocked by *msx1* knockdown



All dynamic processes that generate spatial periodicity are blocked by *msx1* knockdown



msx1 gene suppression in cell clones （see arrows）



Akiyama-Oda and Oda, *Sci. Adv.* 6 (2020)

What differs between fly and spider?

Insect (fruit fly)

Chelicerate (spider)

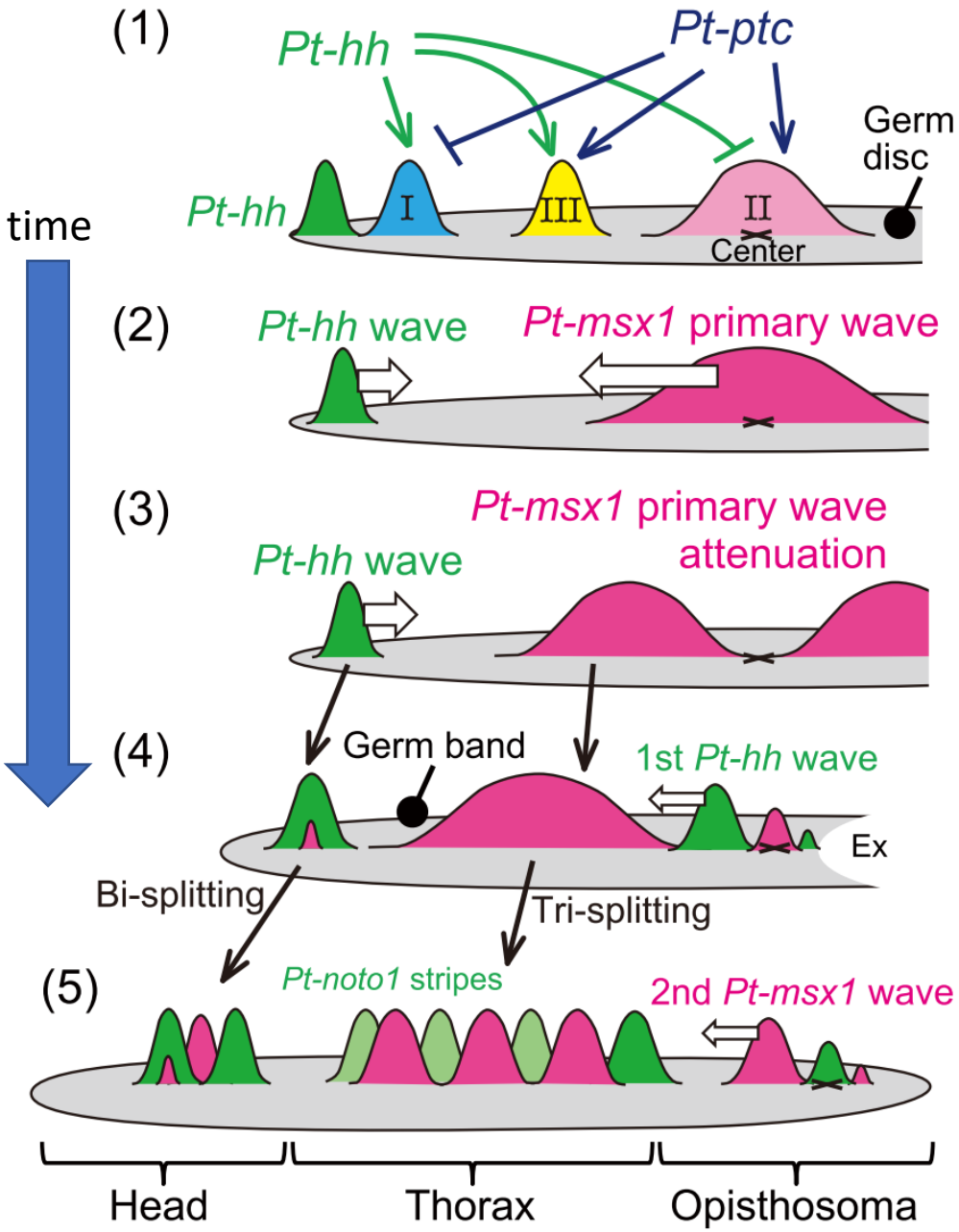
Gene expression behaves like waves

Temporal repetition gives rise to spatial repetition

There are different modes of gene expression dynamics depending on the body regions

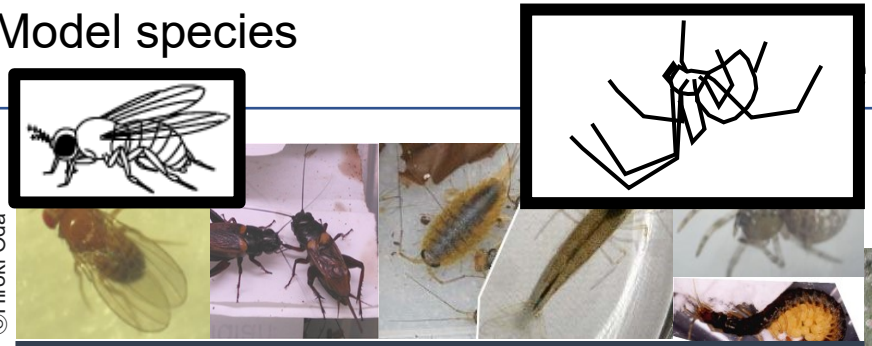
The possible causes of the differences

Nature of the field (syncytium vs cells)
Nature of morphogen/signal
Historical aspects (derived vs ancestral)



Morphological diversity in animals

Model species



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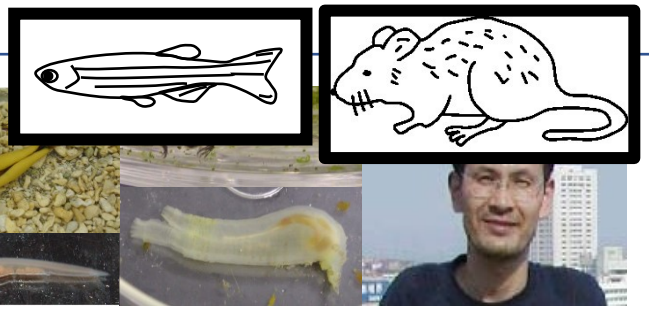

Arthropods

hanisms behind the diversity?

What happened to the genome?

ast

Many drastic changes occurred!

with mutations

Depth of time

c information
genome)

Yasuko Akiyama-Oda,
PhD

Model system development,
Technical development,
Genome studies,
Body axes, Segmentation

JT Biohistory Research Hall

Contributors

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Laser ablation,
twinned embryos

Please visit our web sites:

Search by brh spider

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Splitting-type segmentation,
Microinjection

Natsuki Hemmi,
Previous student,
MS

Reconstruction of pattern development