Model Organism

Model organisms for developmental biology research

Definition:

A model organism is a species that is extensively studied to understand particular biological phenomena.

Purpose:

General purpose:

provide insight into the workings of other organisms.

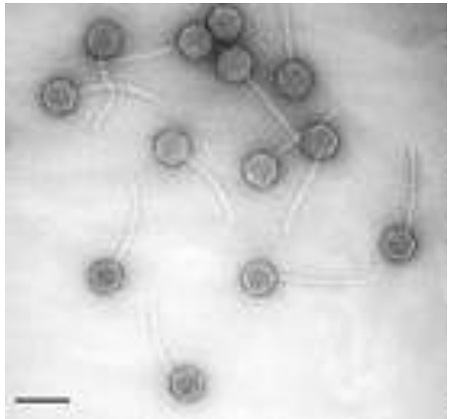
Specific purpose:

investigate the causes and treatments for human diseases when human experimentation would be unfeasible or unethical.

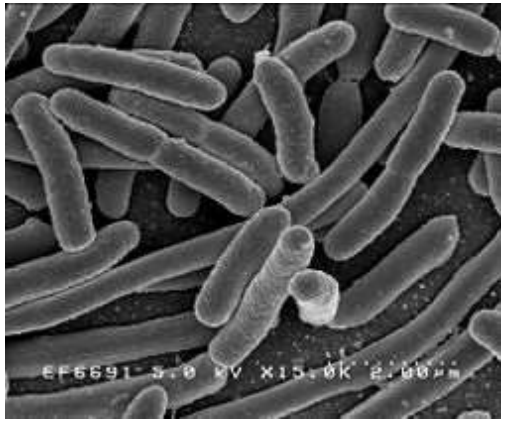
Model Organisms

1. Viruses: Phage Lambda 噬菌体
2. Prokaryotes: E. coli 大肠杆菌
3. Eukaryotes: Yeast 酵母菌
4. Plants: Arabidopsis 拟南芥

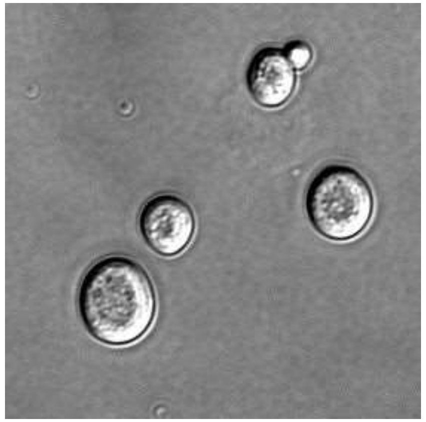
Lambda



E. Coli



S. cerevisiae



Arabidopsis

Animal Model Organisms

Invertebrates

sea urchin 海胆

C. elegans 线虫

D. melanogaster (fruit fly) 果蝇

sea urchin

C. elegan

Fruit fly

Animal Model Organisms

Vertebrates

zebrafish 斑马鱼

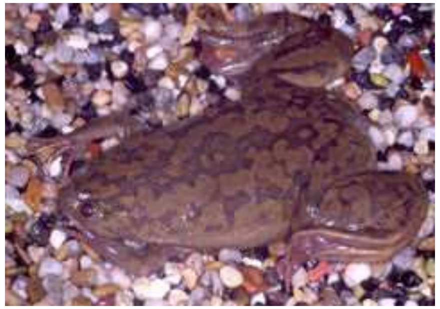
X. laevis (frog) 非洲爪蟾

chicken 鸡

mouse 小鼠

Zebrafish

X. laevis

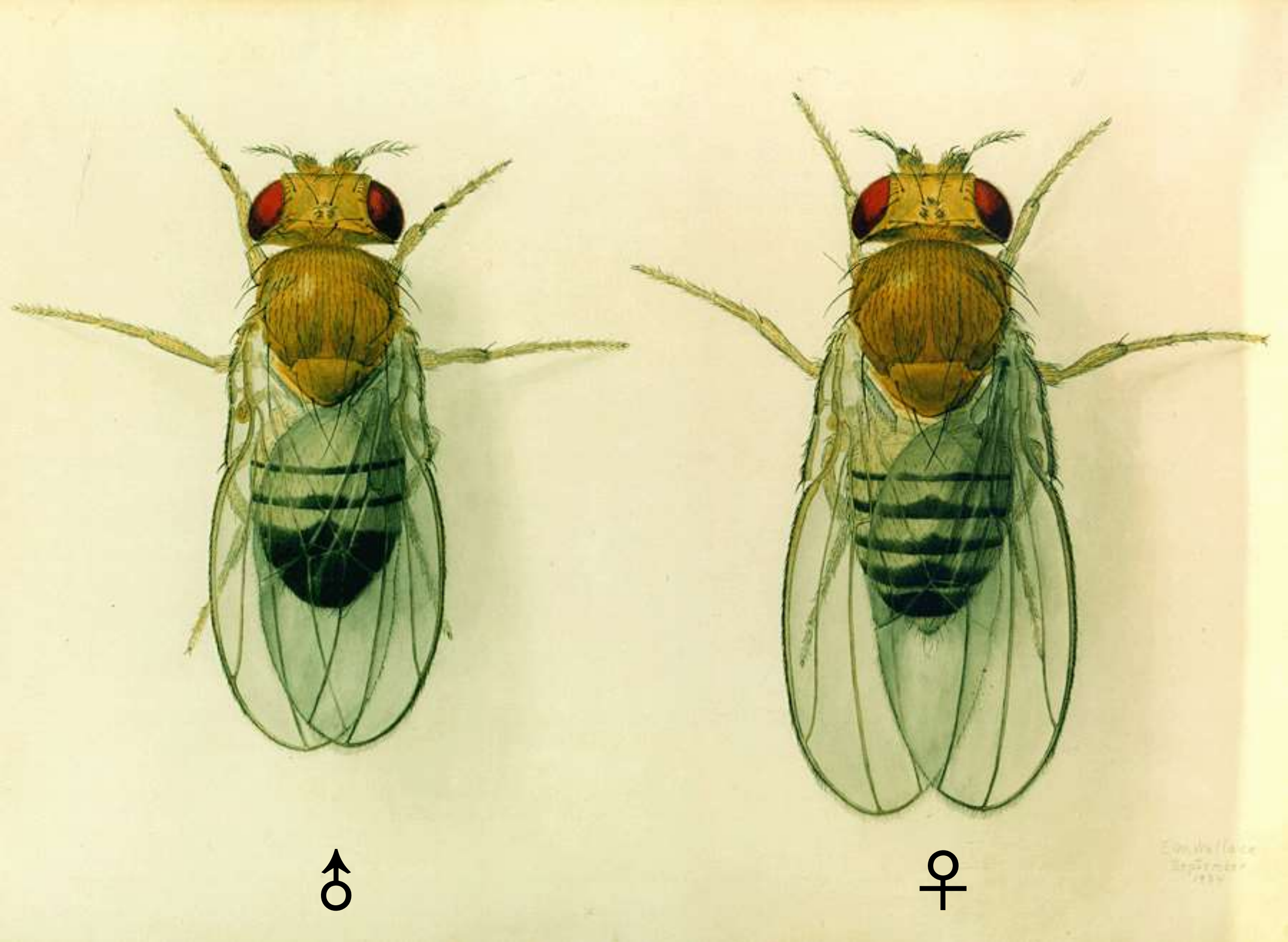


chicken

mouse

Drosophila melanogaster

黑腹果蝇



Drosophila 果蝇

means “dew-loving”

Latin：	*drósos*	*phílos*
English：	dew	loving
	露水	

also called: fruit fly

reason: linger around overripe or rotting fruits, in particular, grapes.

Drosophila melanogaster

Scientific classification

Kingdom:	Animalia	动物界
Phylum:	Arthropoda	节肢动物门
Class:	Insecta	昆虫纲
Order:	Diptera	双翅目
Family:	Drosophilidae	果蝇科
Genus:	Drosophila	果蝇属
Species:	Drosophila melanogaster	黑腹果蝇种

Drosophila

about 1,500 species totally

found all around the world, in deserts, tropical rainforest, cities, and alpine zones

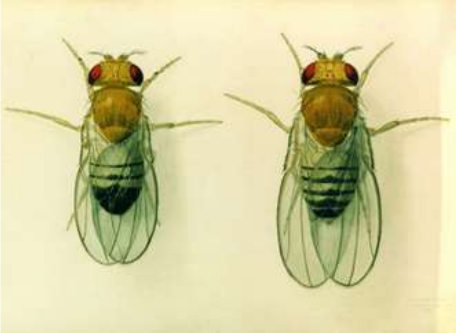
more species in the tropical regions

493 species in China

Food: fruit, decaying plant, flowers, fungal and mushrooms

Drosophila melanogaster

The most important model organism for studies in
Genetics and Developmental Biology



Small size：	**5 mm**	
A short generation time：	**10 days**	
Large number of offspring：	**a female lays 50 - 80 eggs everyday**	
Life span:	**60 - 90 days**	
Compact genome:	**sex chromosome**	**1 pair**
	autosome	**3 pairs**
Easy to obtain mutant animals:	**X-ray, chemical mutagen (EMS),**	
	transposable element	
Genetic manipulation is easy：	**100 years of genetics**	
Easily cultured and Inexpensive:	**fruits or medium**	
Genome:	**sequenced in 2000, about 15000 genes**	
	77% of human disease genes (714/929 genes)	

The Nobel Prize in Physiology or Medicine 1933

"for his discoveries concerning the role played by the chromosome in heredity "

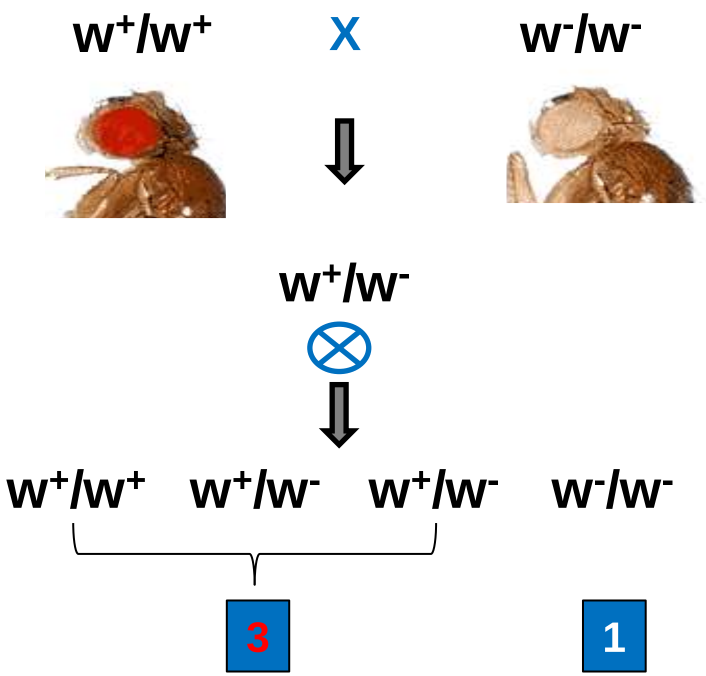
Thomas Hunt Morgan

(1866 –1945)

1906, began his work on D. melanogaster at Columbia University

1910, reported the white eyed mutant – the first gene (white) identified

1933, rewarded Nobel Prize in Medicine



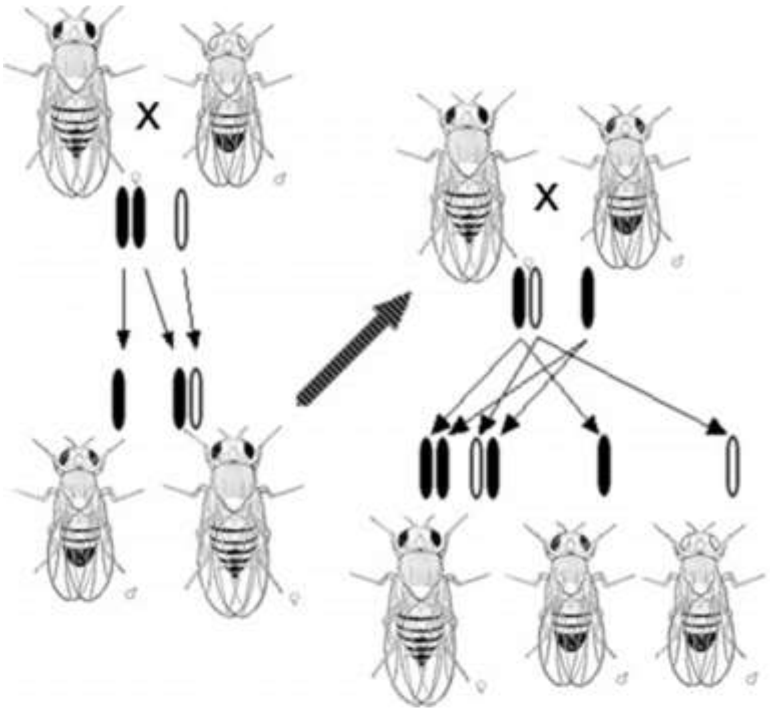


Table 1: Expected Mendelian Ratios versus Morgan's Actual Results

Cross	Outcome	
	Expected Phenotypes	Observed Phenotypes
P_1 Red ♀ × P_1 White ♂	F_1 = All Red	F_1 = All Red*

P1

♀ w^+/w^+

X

♂ w^-/Y

F1

♀ w^+/w^-

X

♂ w^+/Y

F2

♀ w^+/w^+, w^+/w^-

♂ w^+/Y, w^-/Y

P1

♀ w^+/w^+

X

♂ w^-/Y

F1

♀ w^+/w^-

♂ w^+/Y

♀ w^+/w^-

♀ w^-/w^-

♂ w^+/Y

♂ w^-/Y

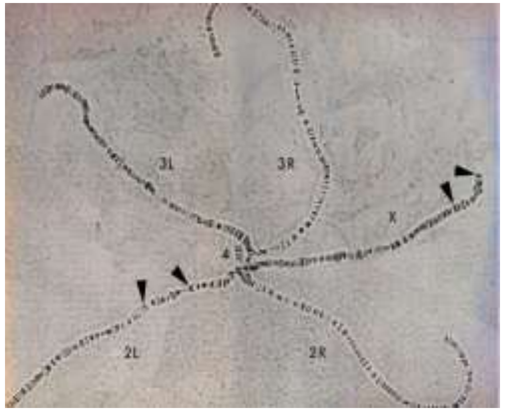
Alfred Sturtevant

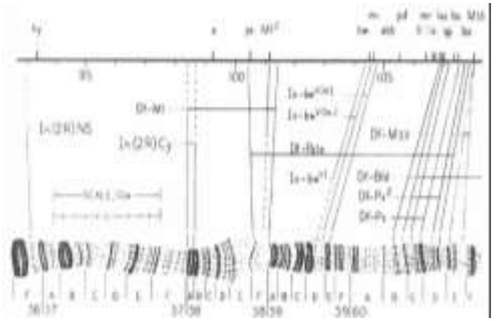
Identified chromosomes as the carriers of the hereditary material as a undergraduate student of Morgan in 1911

Thomas Morgan

Calvin Bridges

Ph.D. thesis - the 1st paper in the 1st issue of *Genetics* in 1916





Polytene chromosome and banding pattern

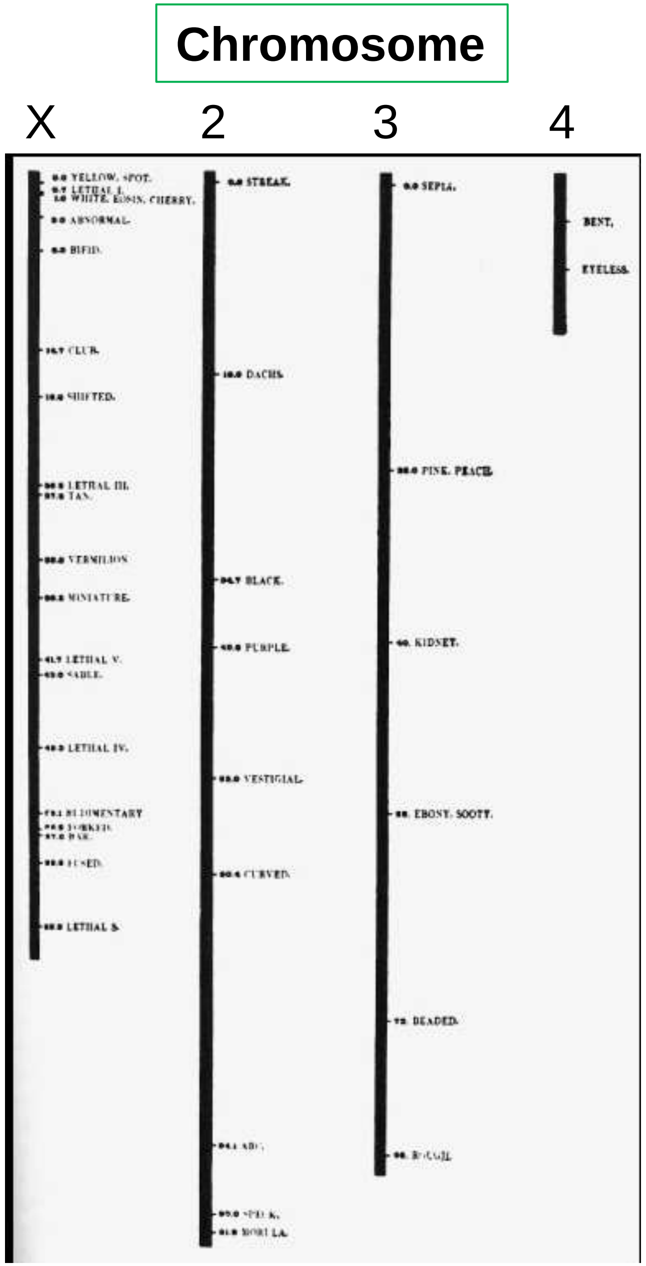
Thomas Morgan

Alfred Sturtevant

Calvin Bridges

Ph.D. thesis - the 1st paper

in the 1st issue of *Genetics* in 1916

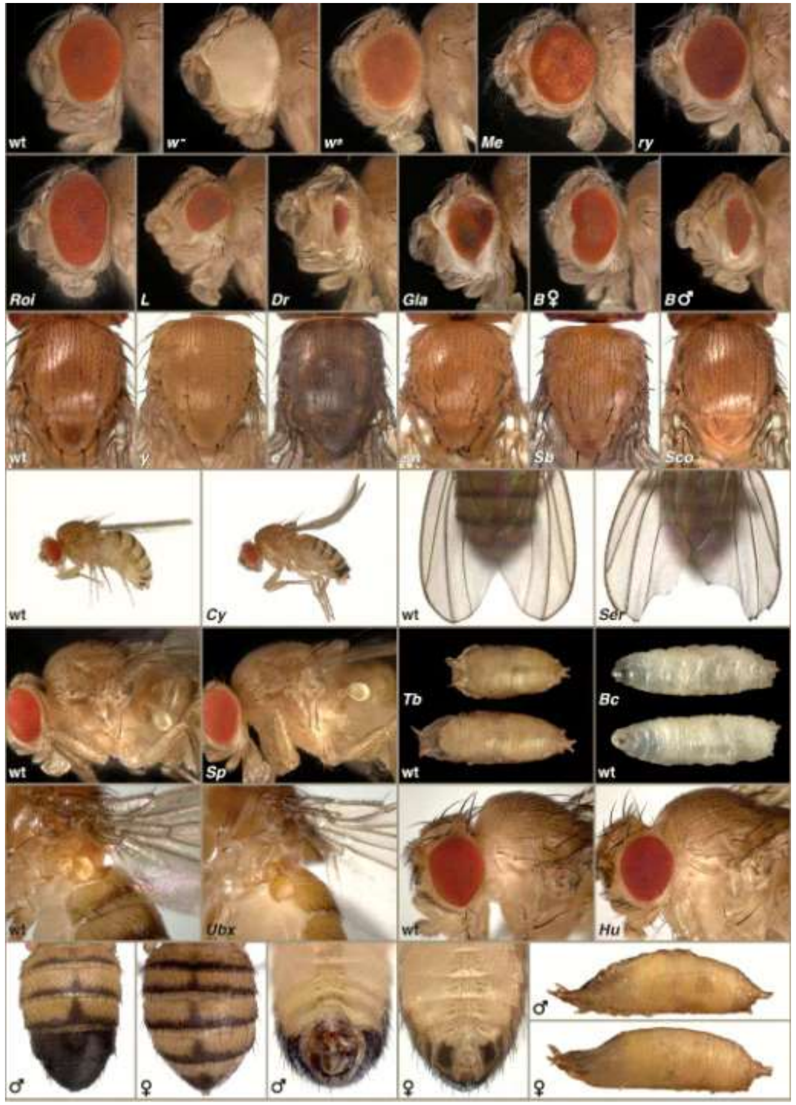


The Nobel Prize in Physiology or Medicine 1946

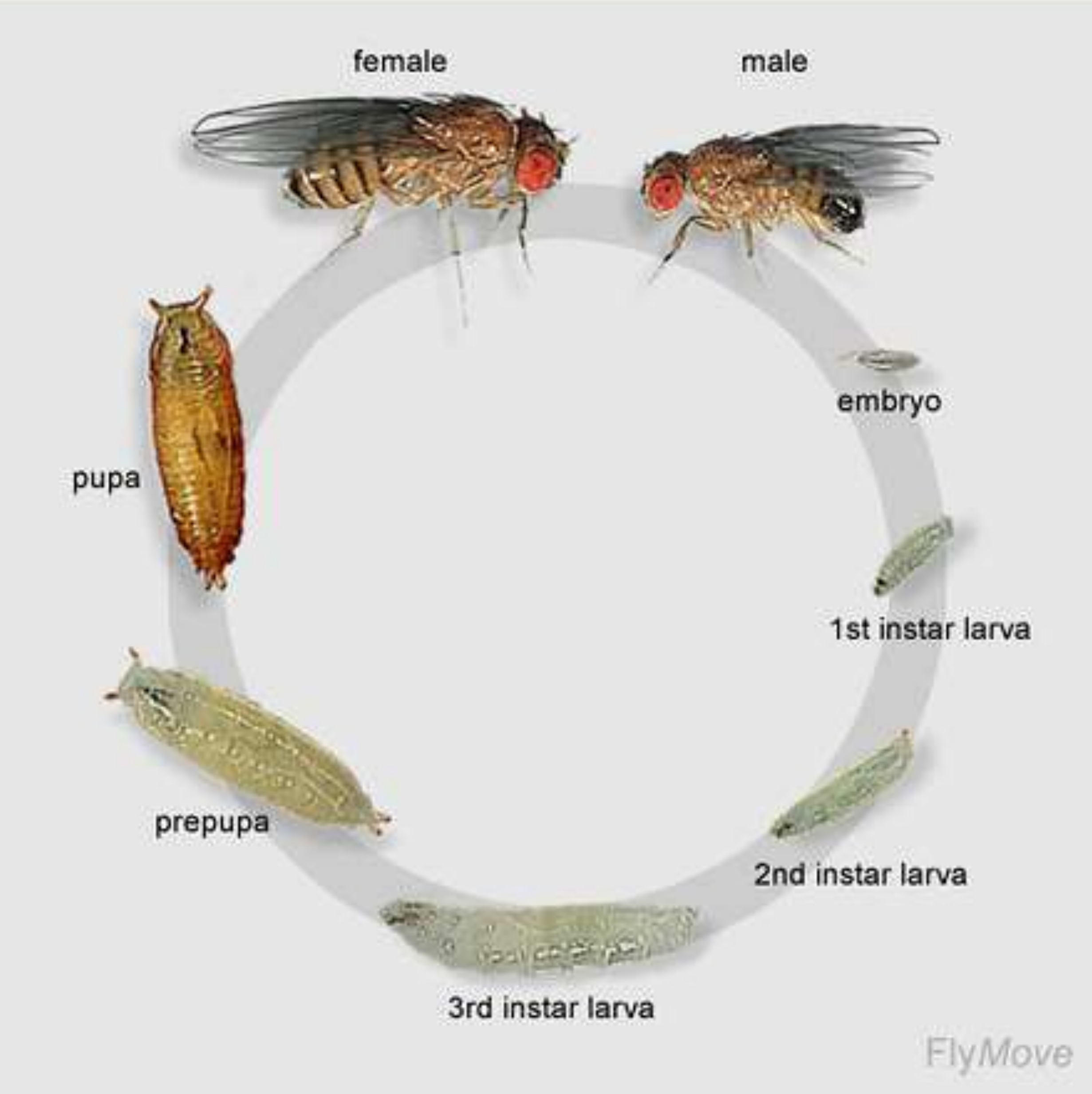
"for the discovery of the production of mutations by means of X-ray irradiation "

Hermann Joseph Muller

(1890 –1967)



The life cycle of *Drosophila melanogaster*



Drosophila oocyte

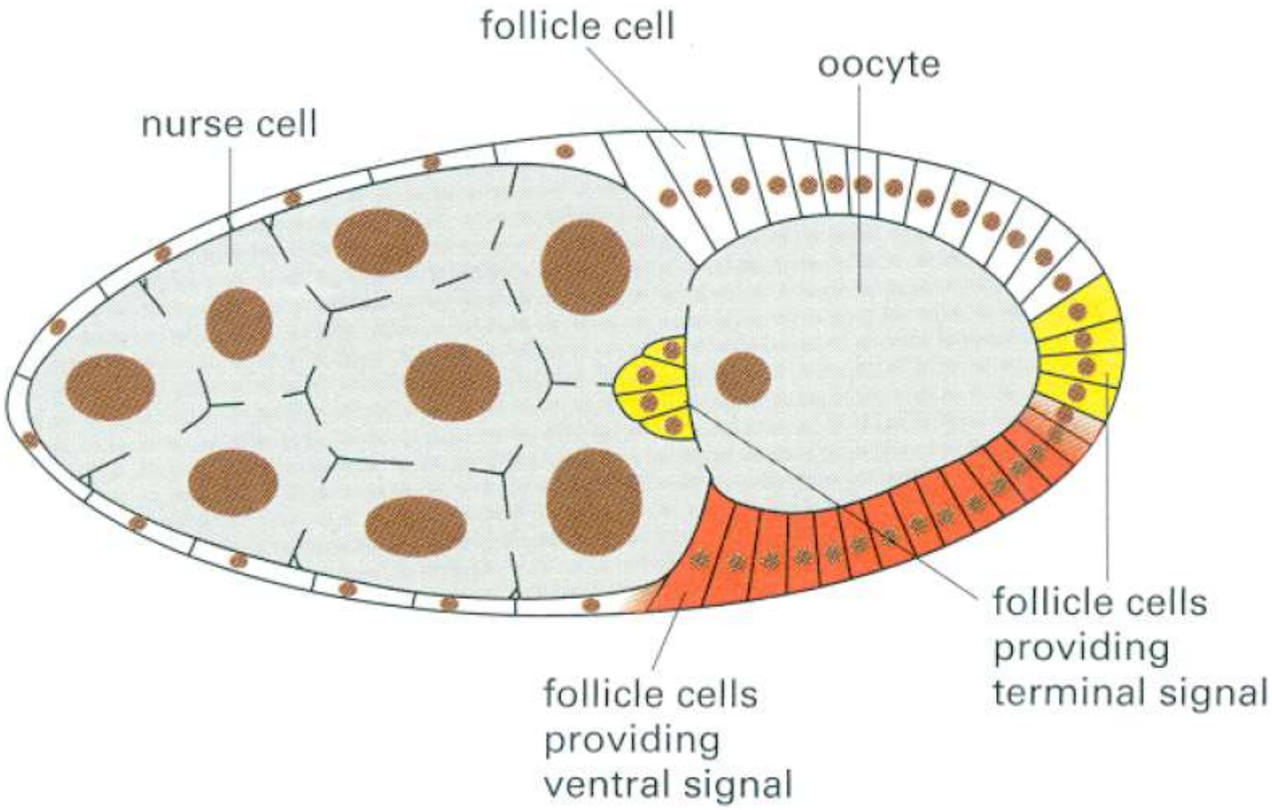
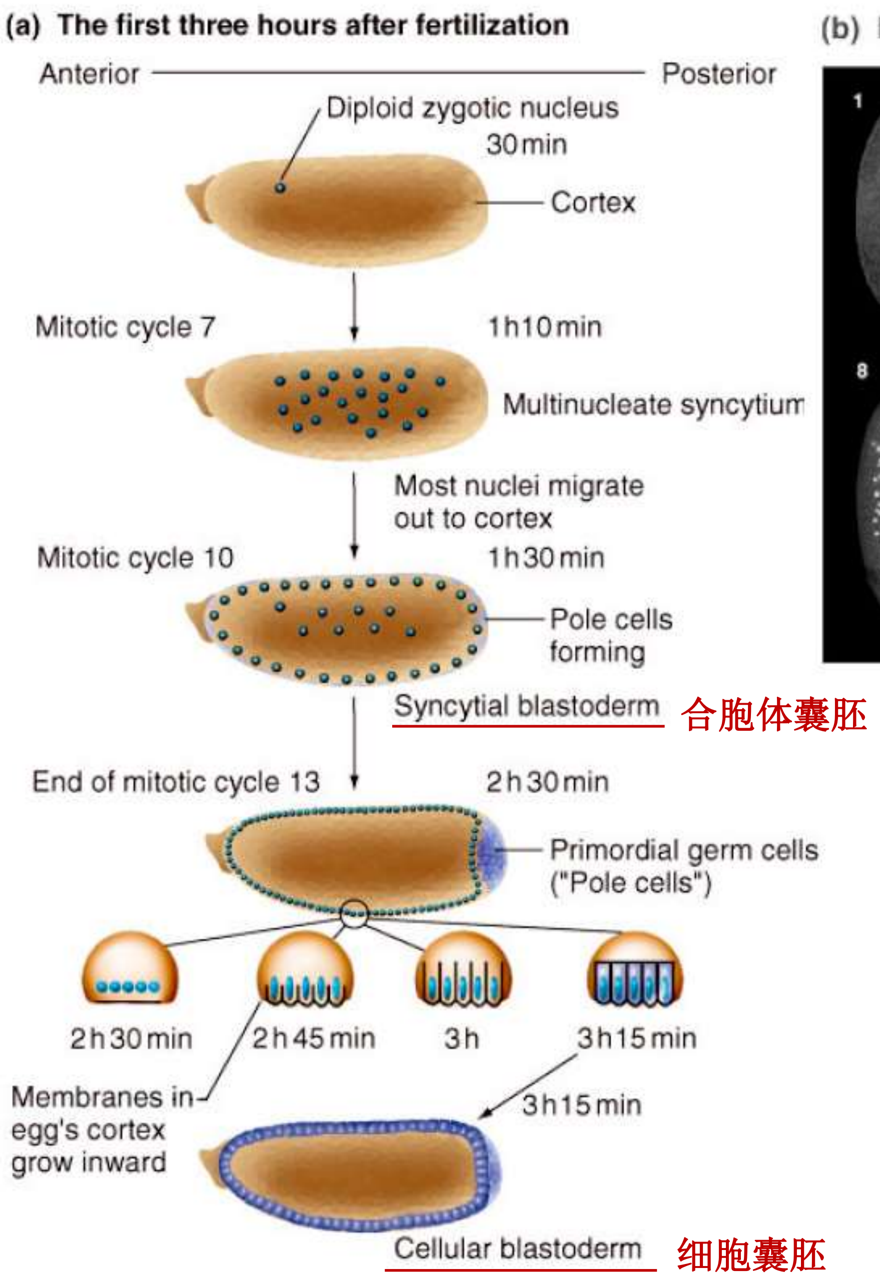
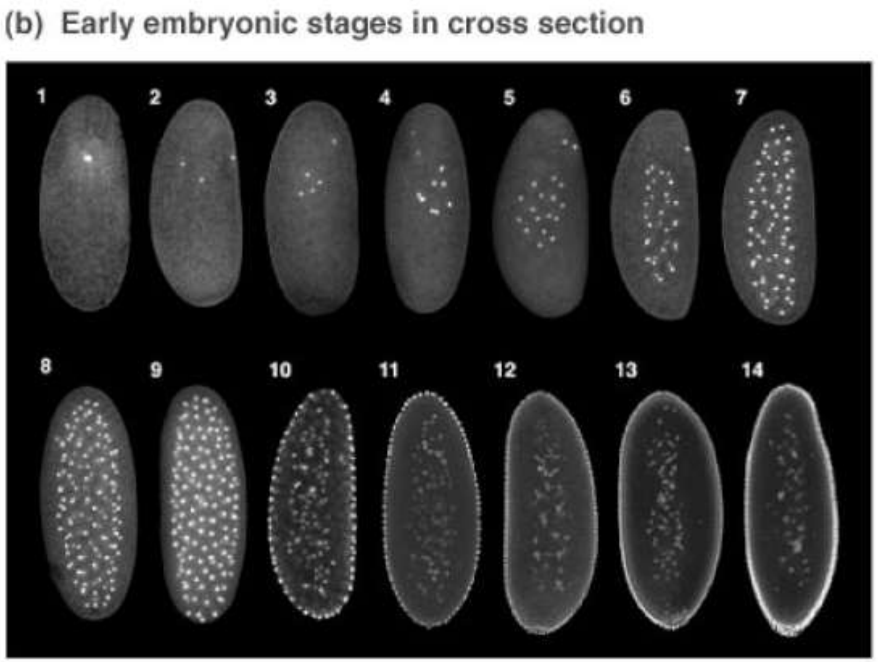


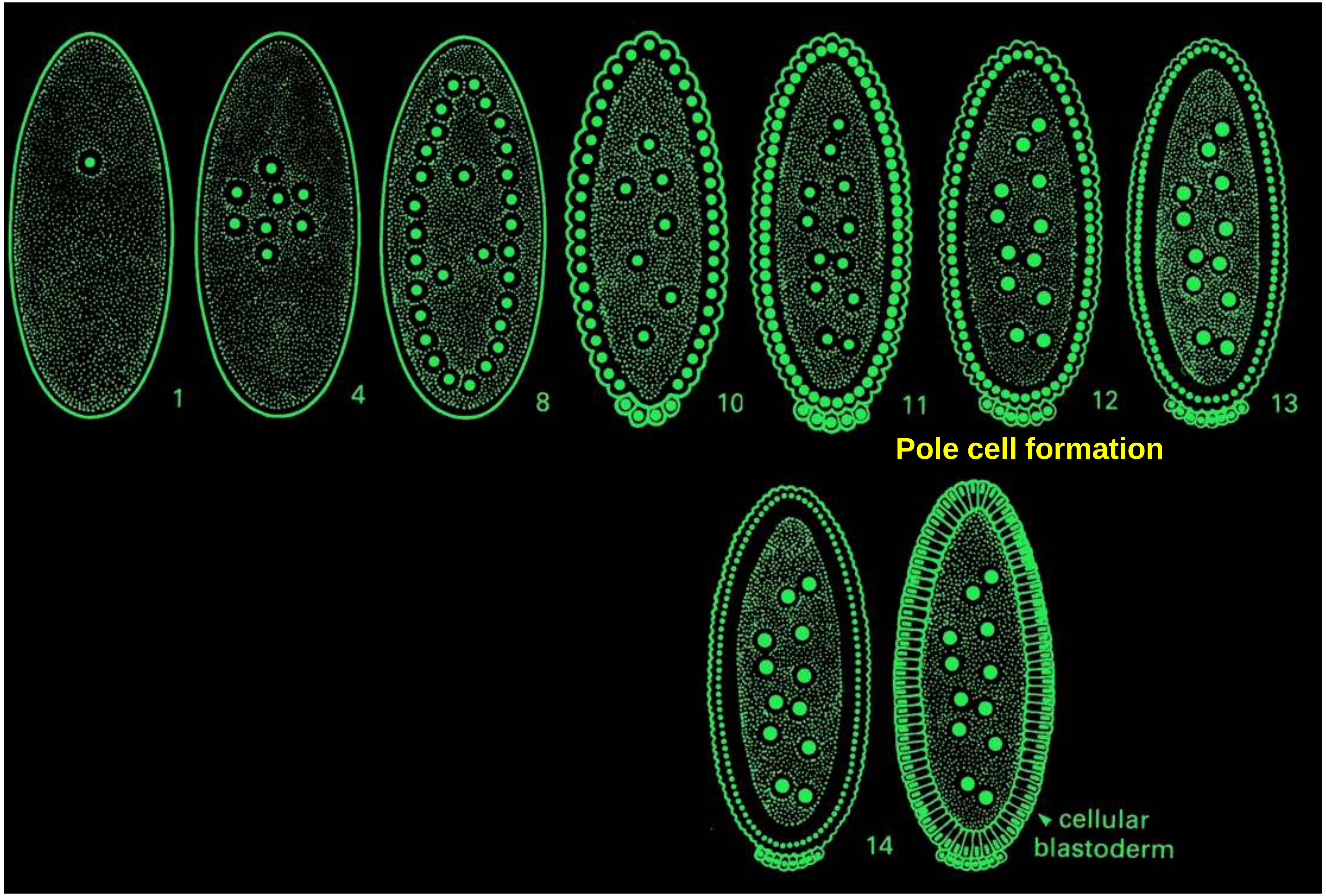
Figure 21-30. A Drosophila oocyte in its follicle. The oocyte is derived from a germ cell that divides four times to give a family of 16 cells that remain in communication with one another via cytoplasmic bridges (gray). One member of the family group becomes the oocyte, while the others become nurse cells, which make many of the components required by the oocyte and pass them into it via the cytoplasmic bridges. The follicle cells that partially surround the oocyte have a separate ancestry. As indicated, they are the sources of terminal and ventral egg-polarizing signals. (**From Bruce Albert Book**)





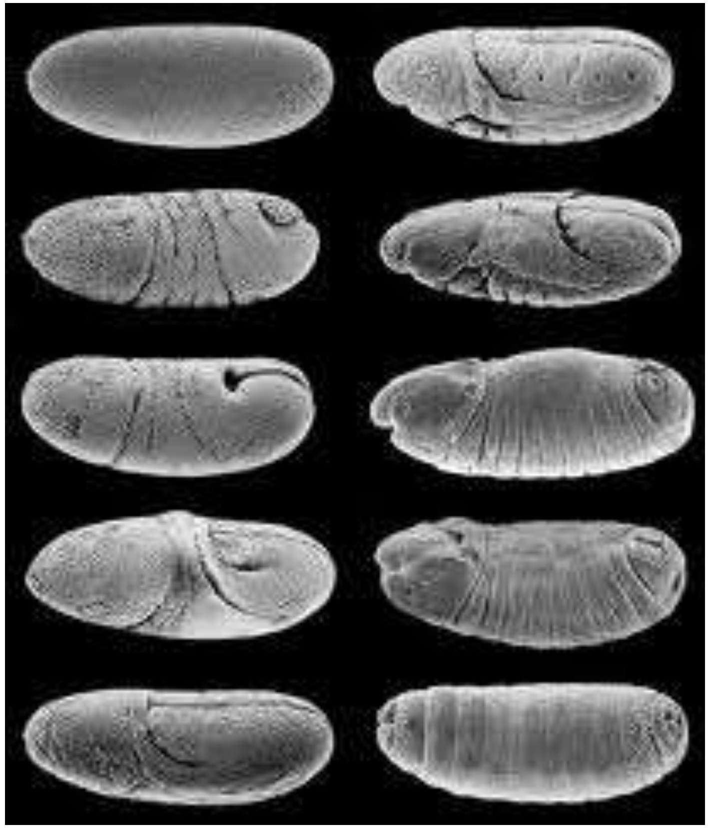
Drosophila Embryogenesis

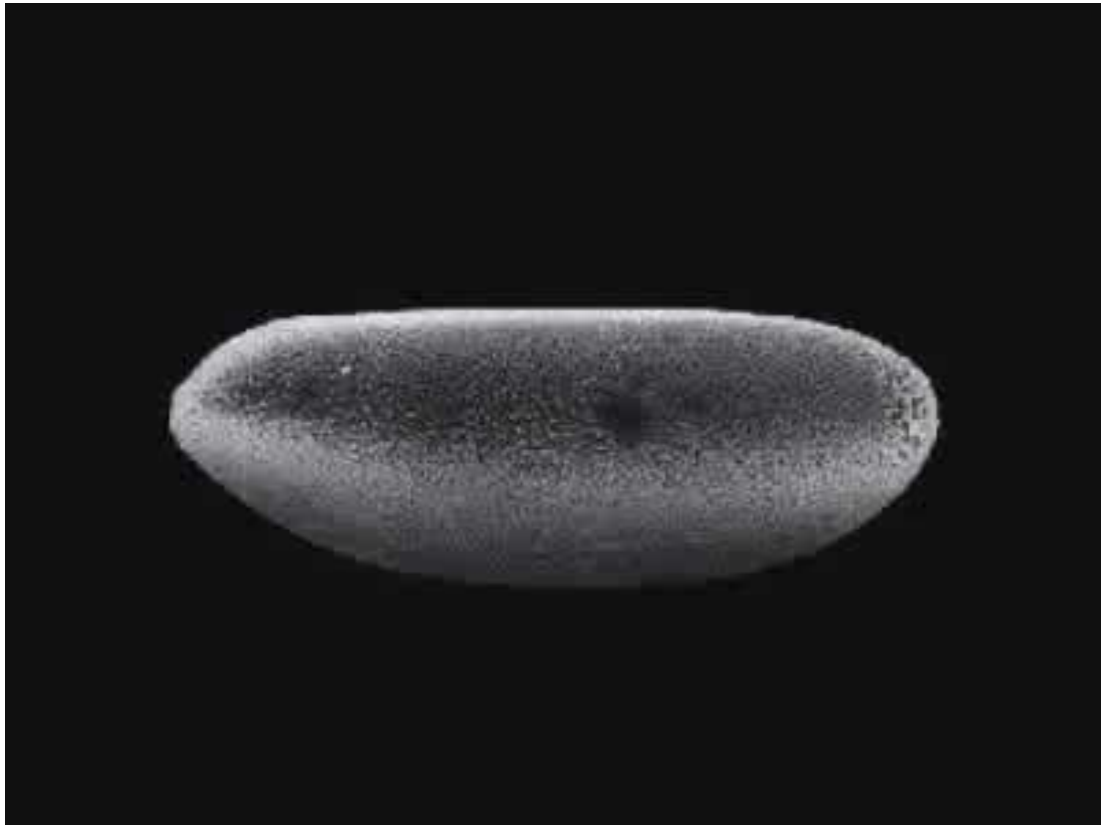
syncytial blastoderm



Drosophila embryogenesis

Dorsal





Ventral

Drosophila embryogenesis

Drosophila embryo morphogenesis is the process from which

a fertilized single cell egg becomes a multicellular embryo

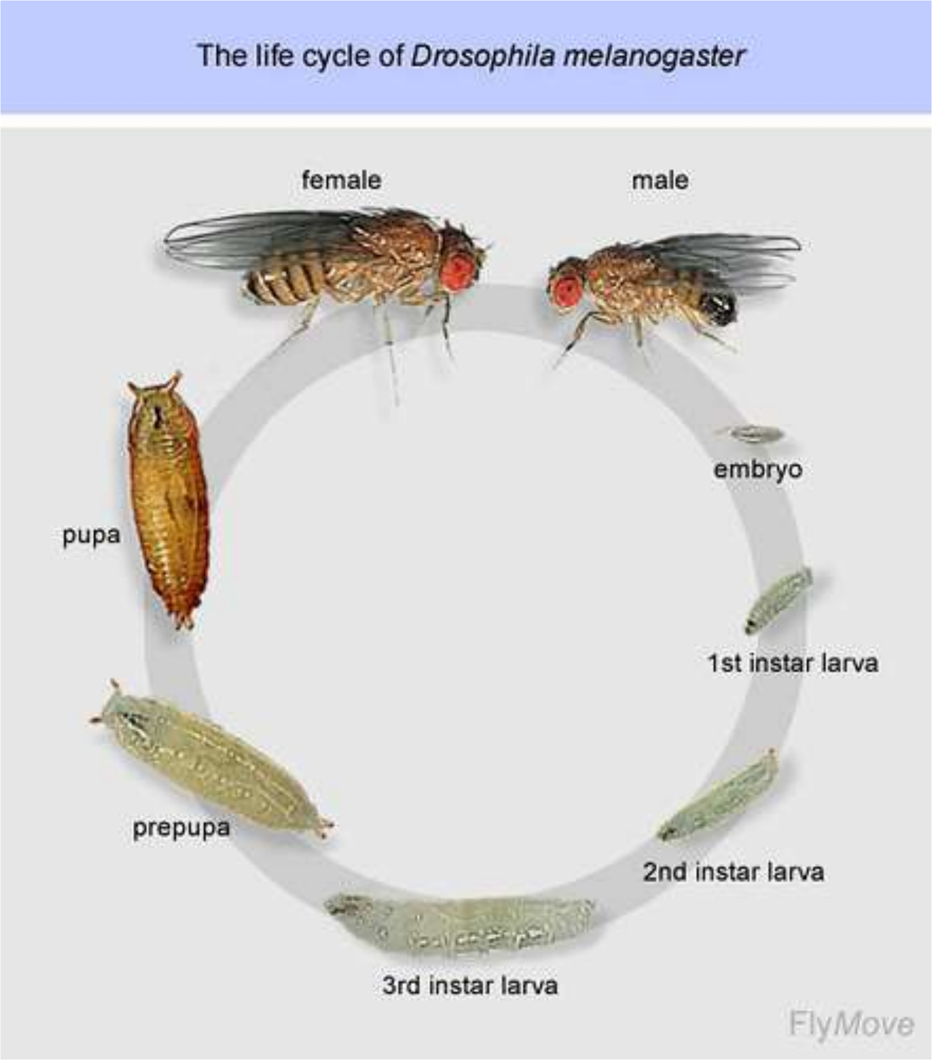
with structured tissues and specialized cells/organs.

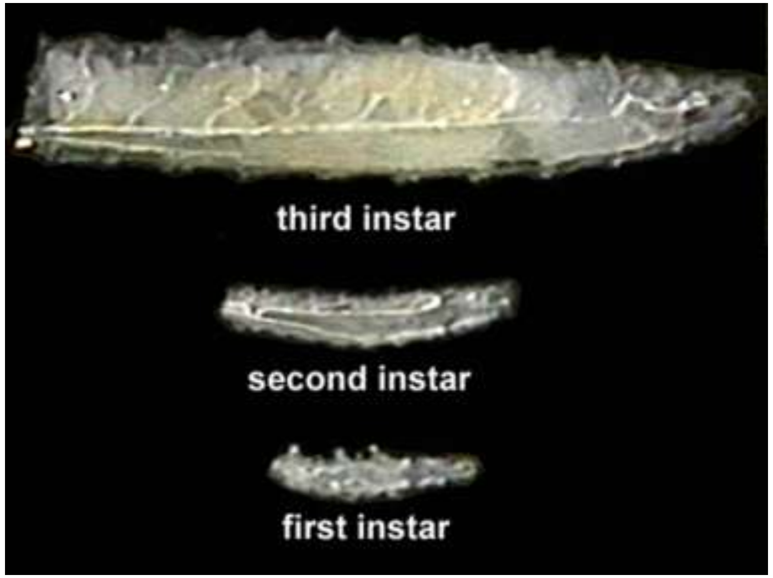
This process occurs through many complex

cell shape changes and movements,

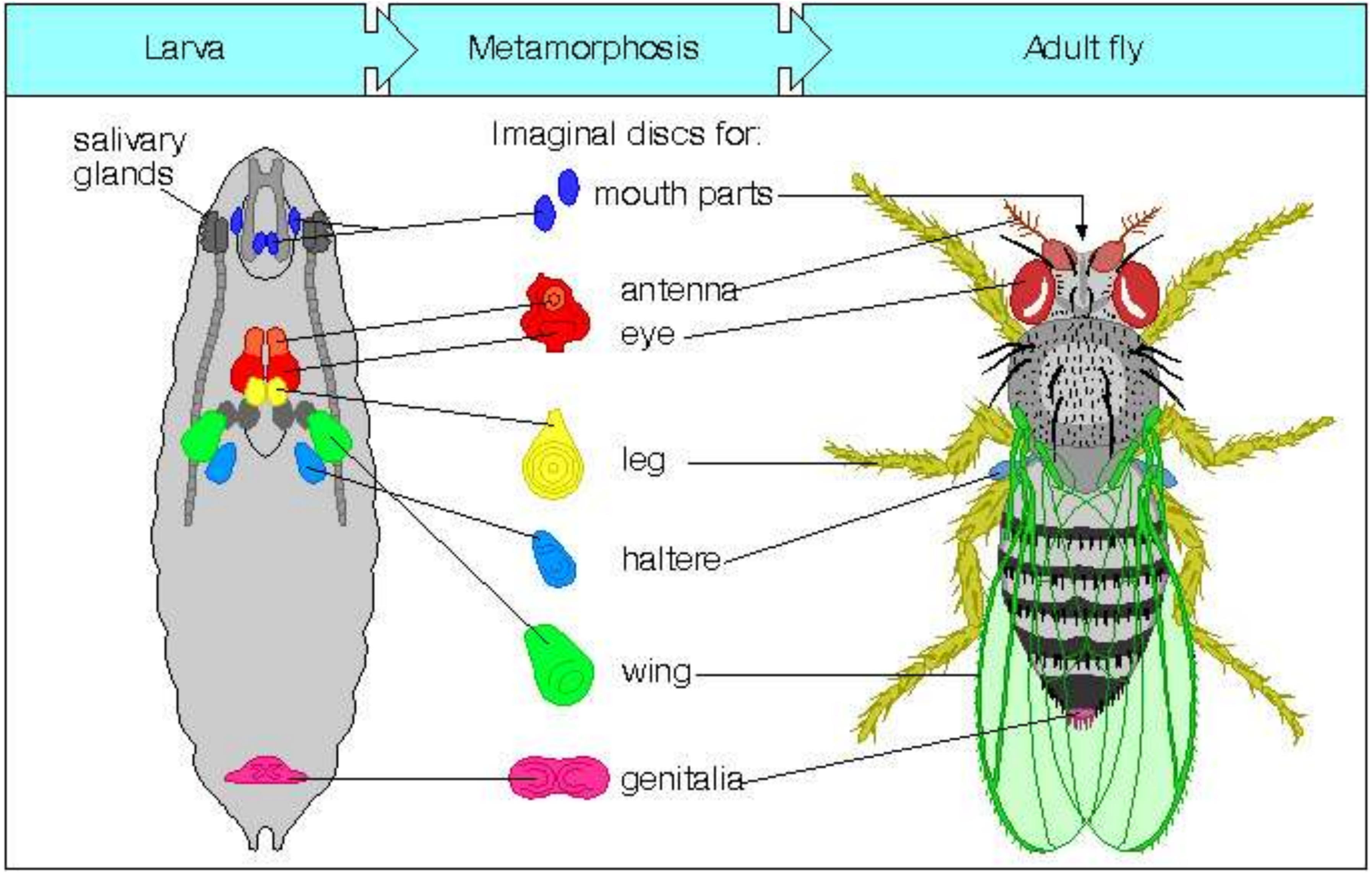
including the formation of cellular blastoderm,

gastrulation, and germ band elongation/retraction.


The life cycle of *Drosophila melanogaster*
female
male
embryo
1st instar larva
2nd instar larva
3rd instar larva
prepupa
pupa
FlyMove

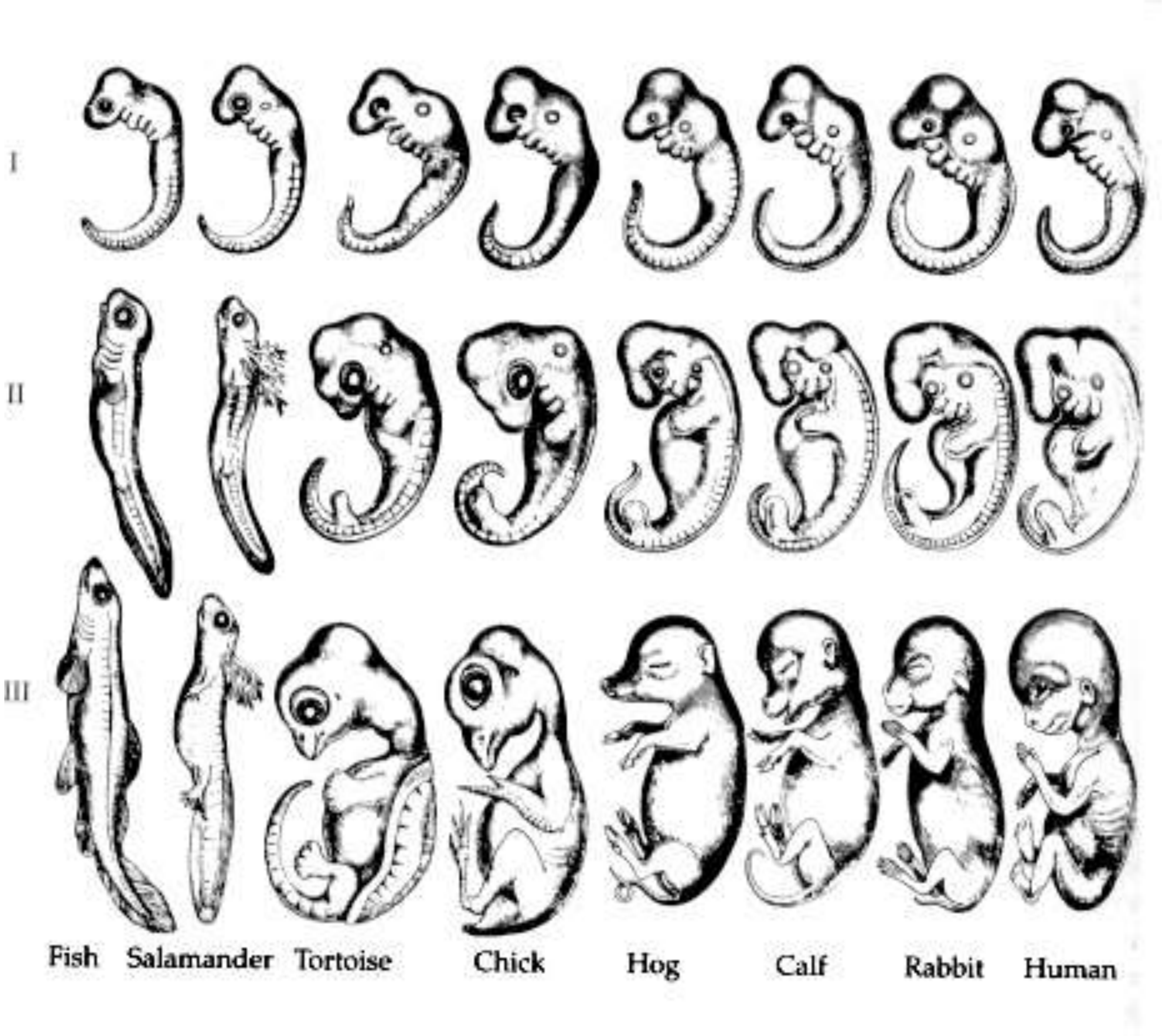

third instar
second instar
first instar

Drosophila Development

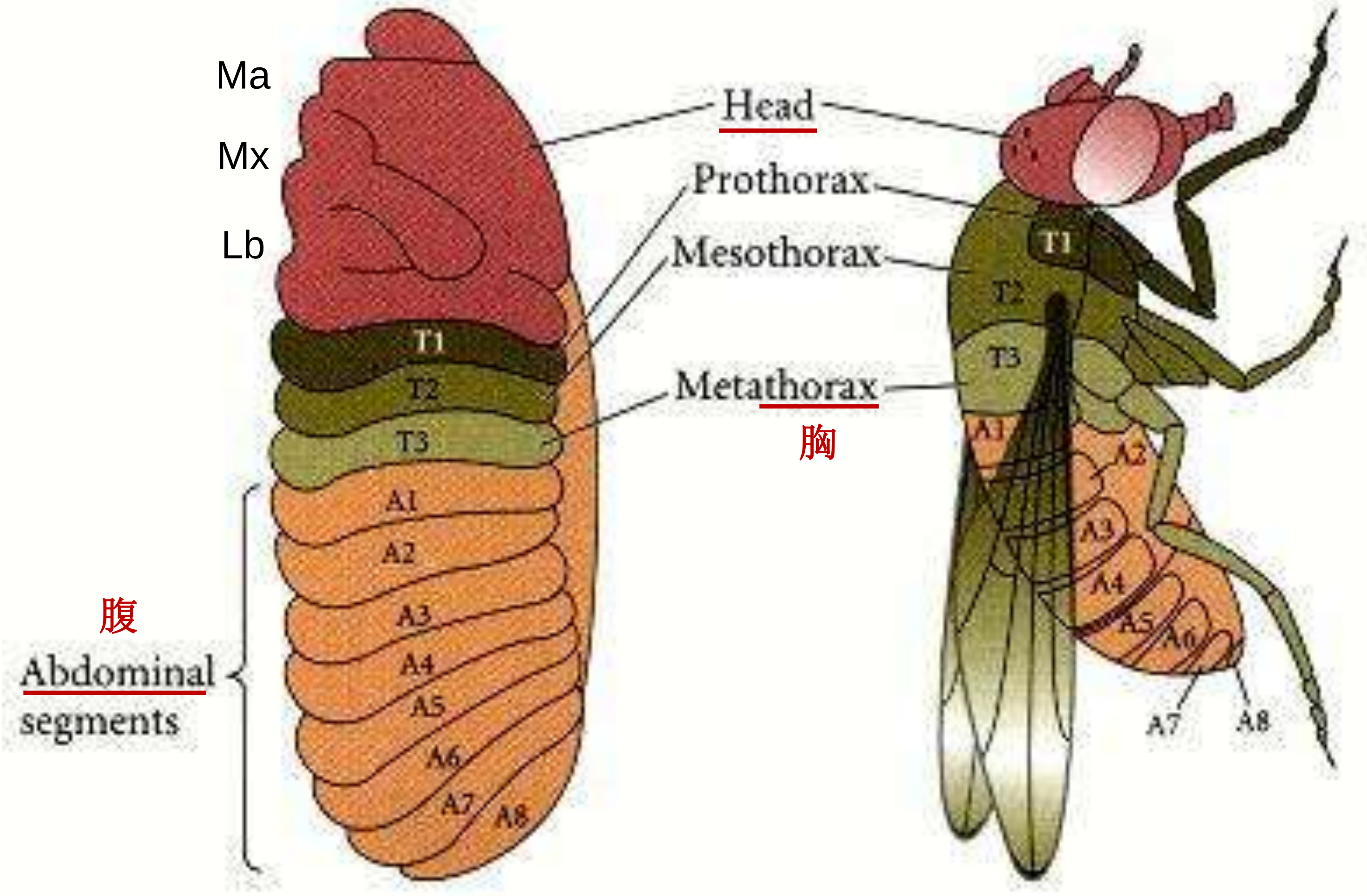


Haeckel's 1874 version of vertebrate embryonic development.

Drosophila



Segmentation in *Drosophila*

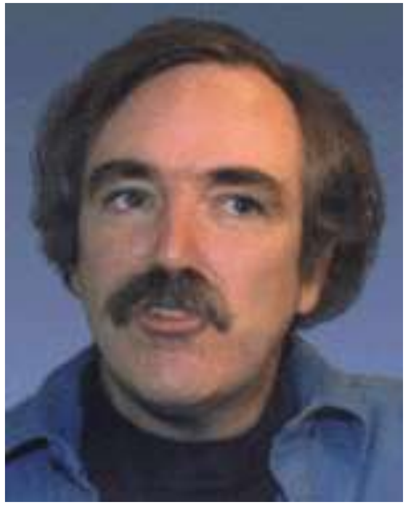


The Nobel Prize in Physiology or Medicine 1995

"for their discoveries concerning the genetic control of early embryonic development "

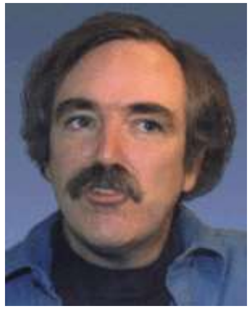
Edward B. Lewis

Christiane Nüsslein-Volhard

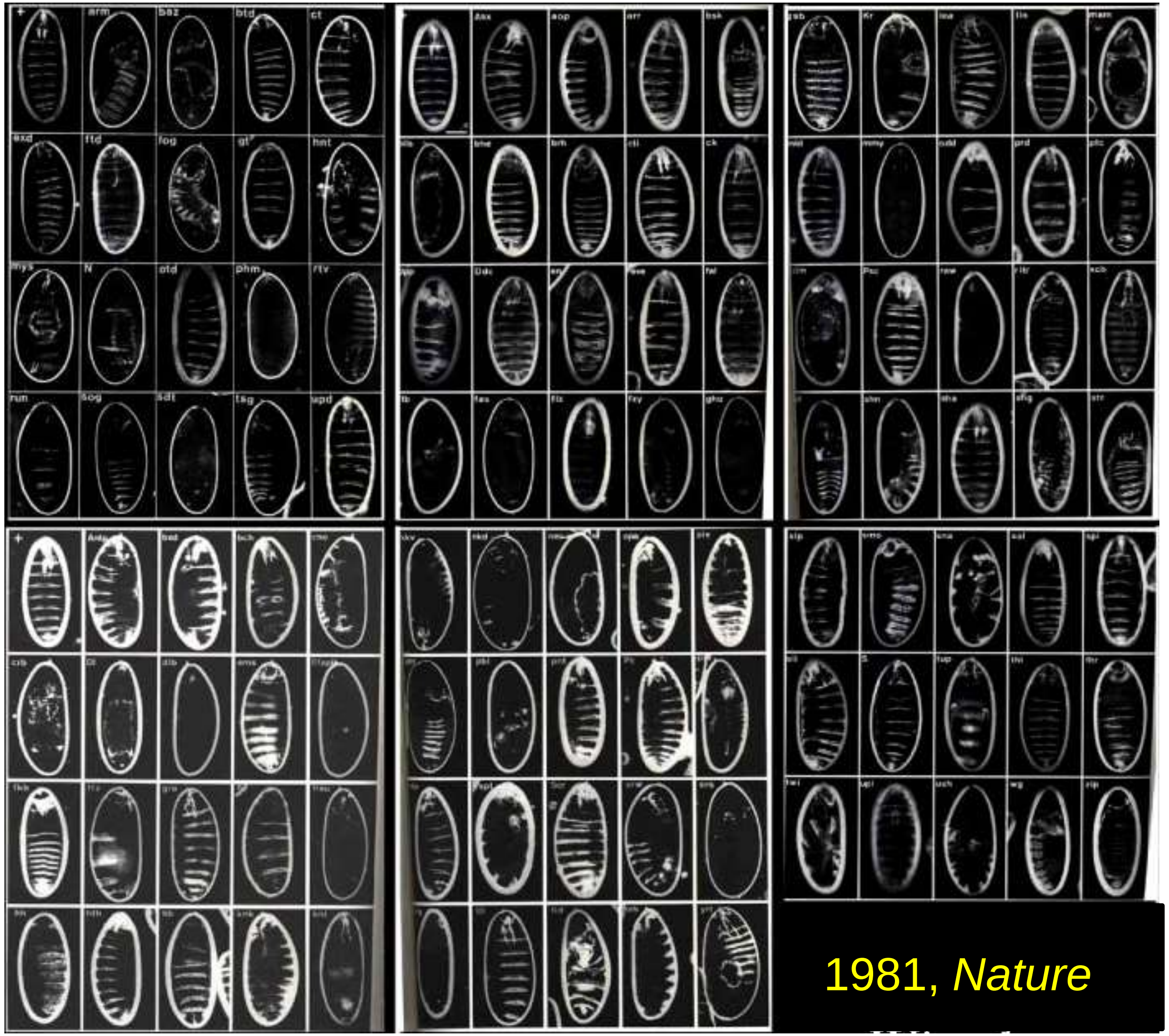


Eric Wieschaus

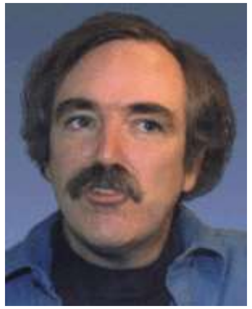
Christiane Nüsslein-Volhard



Eric Wieschaus



Christiane Nüsslein-Volhard



Eric Wieschaus

Four classes of genes responsible for formation of segments

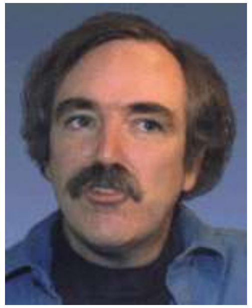
- Maternal genes
- Gap genes
- Pair-rule genes
- Segmentation polarity genes

Function in hierarchy

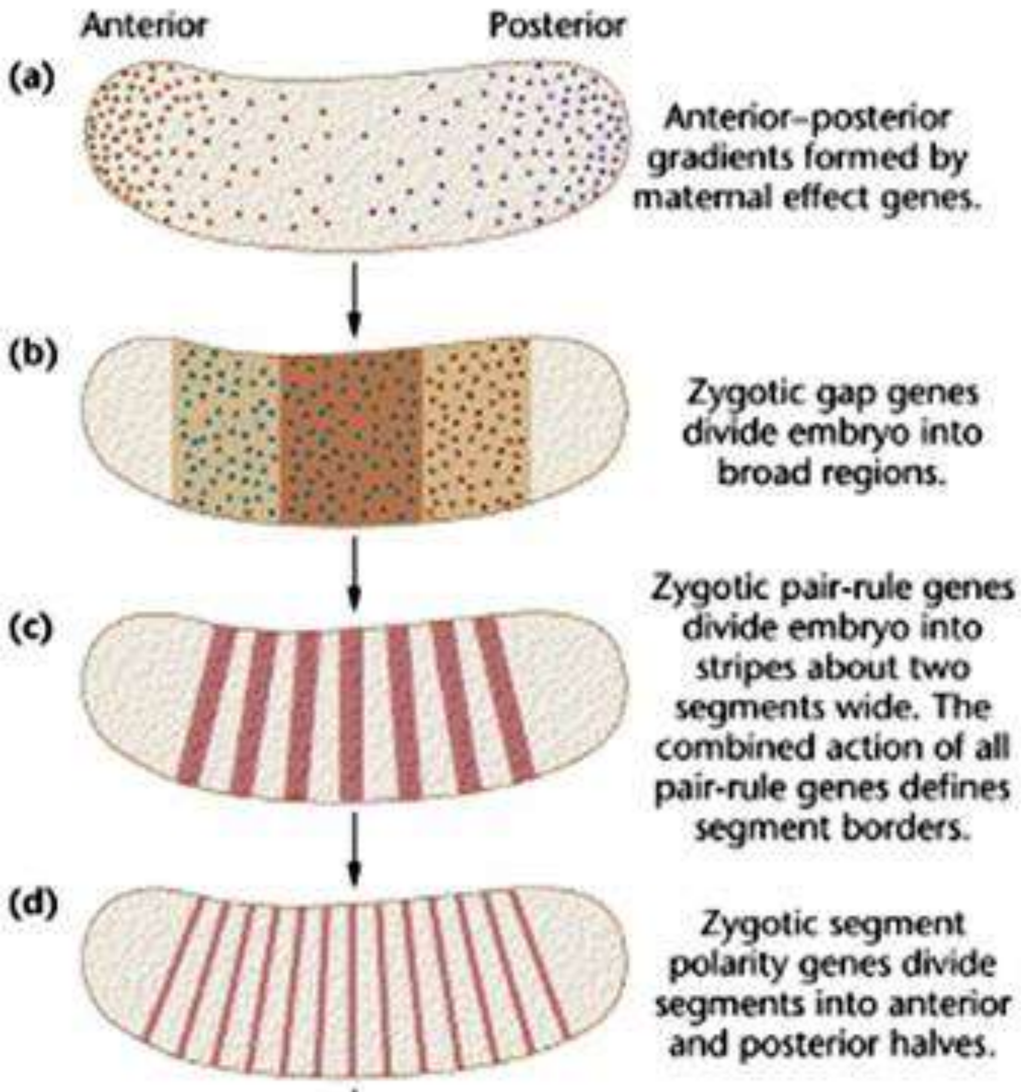
that progressively subdivides

the embryo into successively small units

Christiane Nüsslein-Volhard

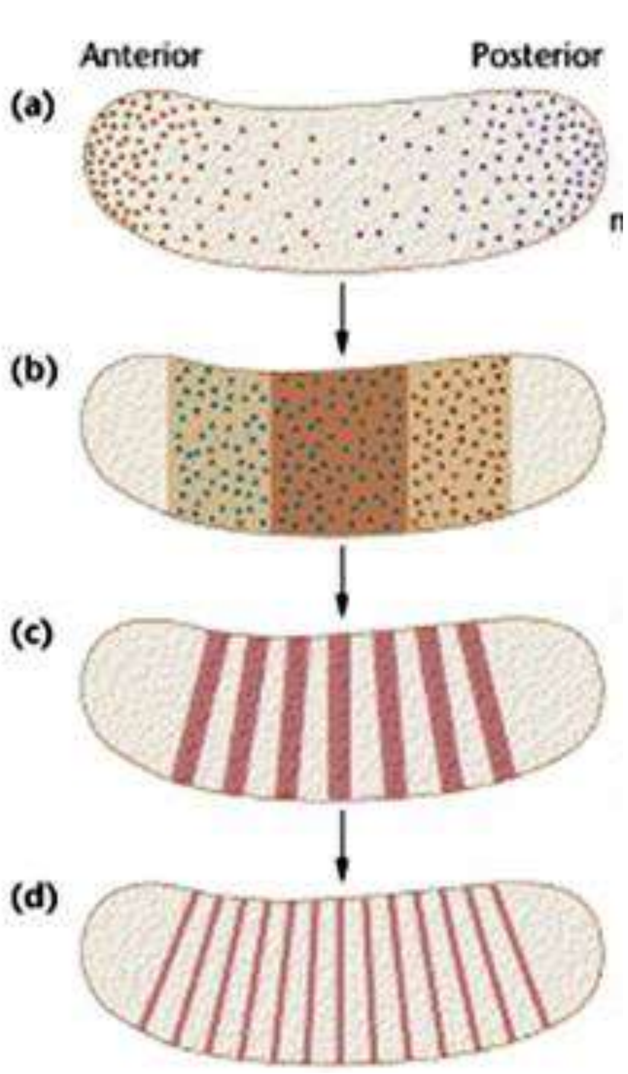


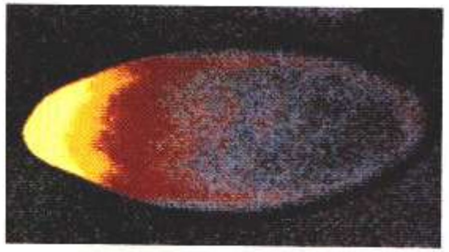
Eric Wieschaus



Edward B. Lewis

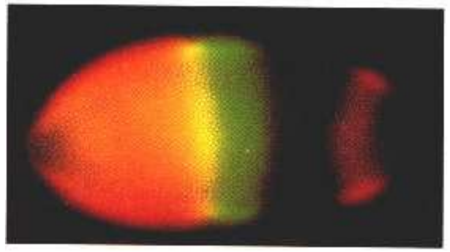
Anterior-posterior (A/P) polarity and Segmentation





bicoid

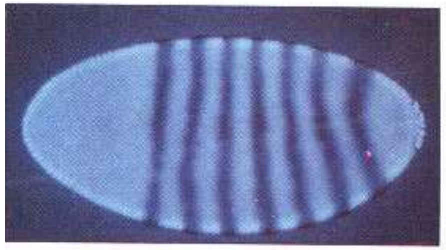
Maternal gene



Hunchback (red)

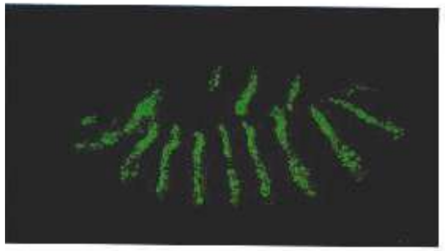
kruppel (green)

Gap gene



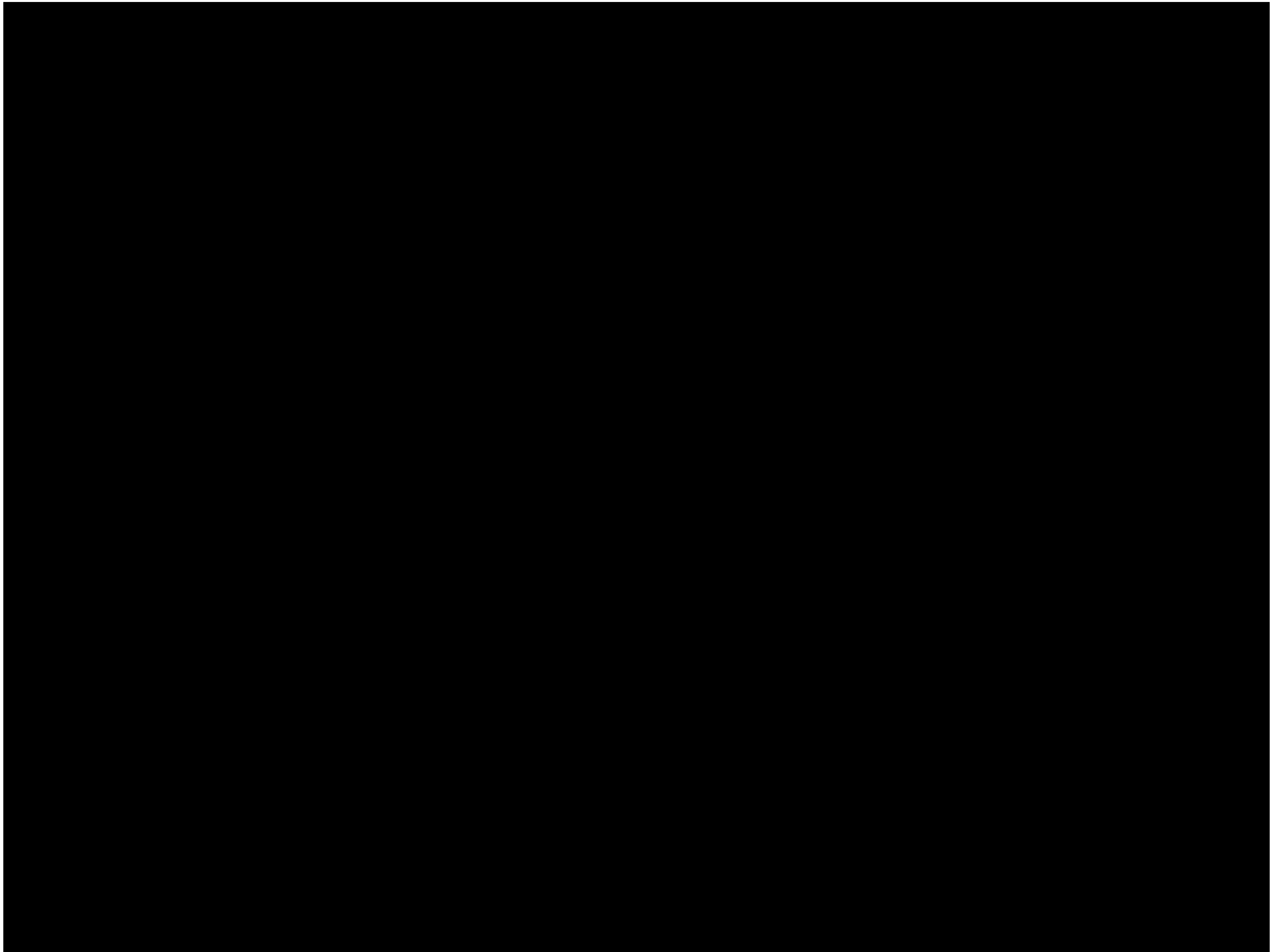
fushi tarazu

Pair-rule gene



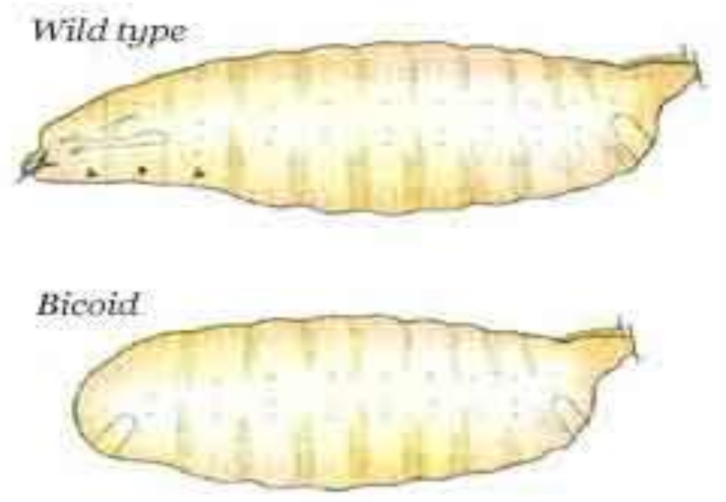
engrailed

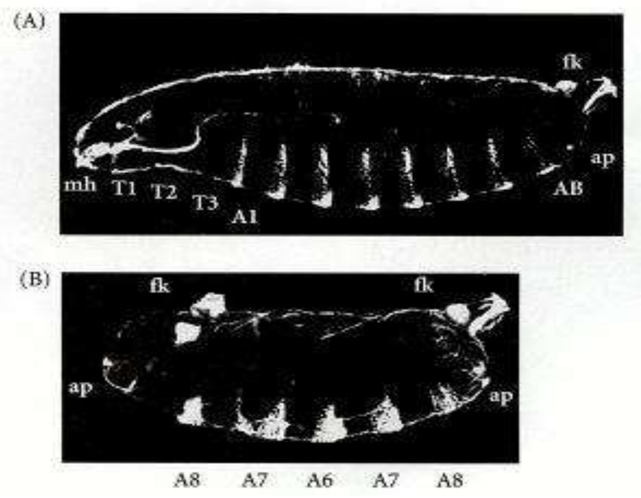
Segment polarity gene



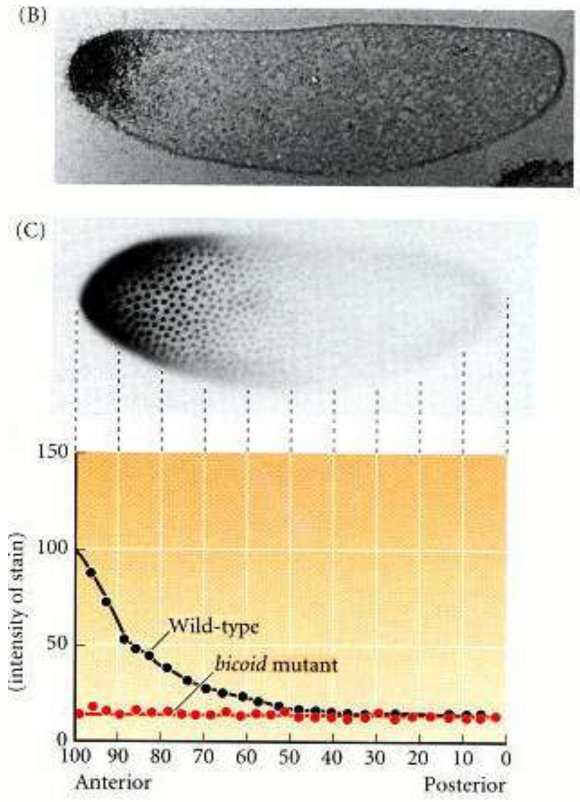
Eric Wieschaus

Maternal gene *bicoid* control anterior structures





bicoid is a morphogen 形态发生素

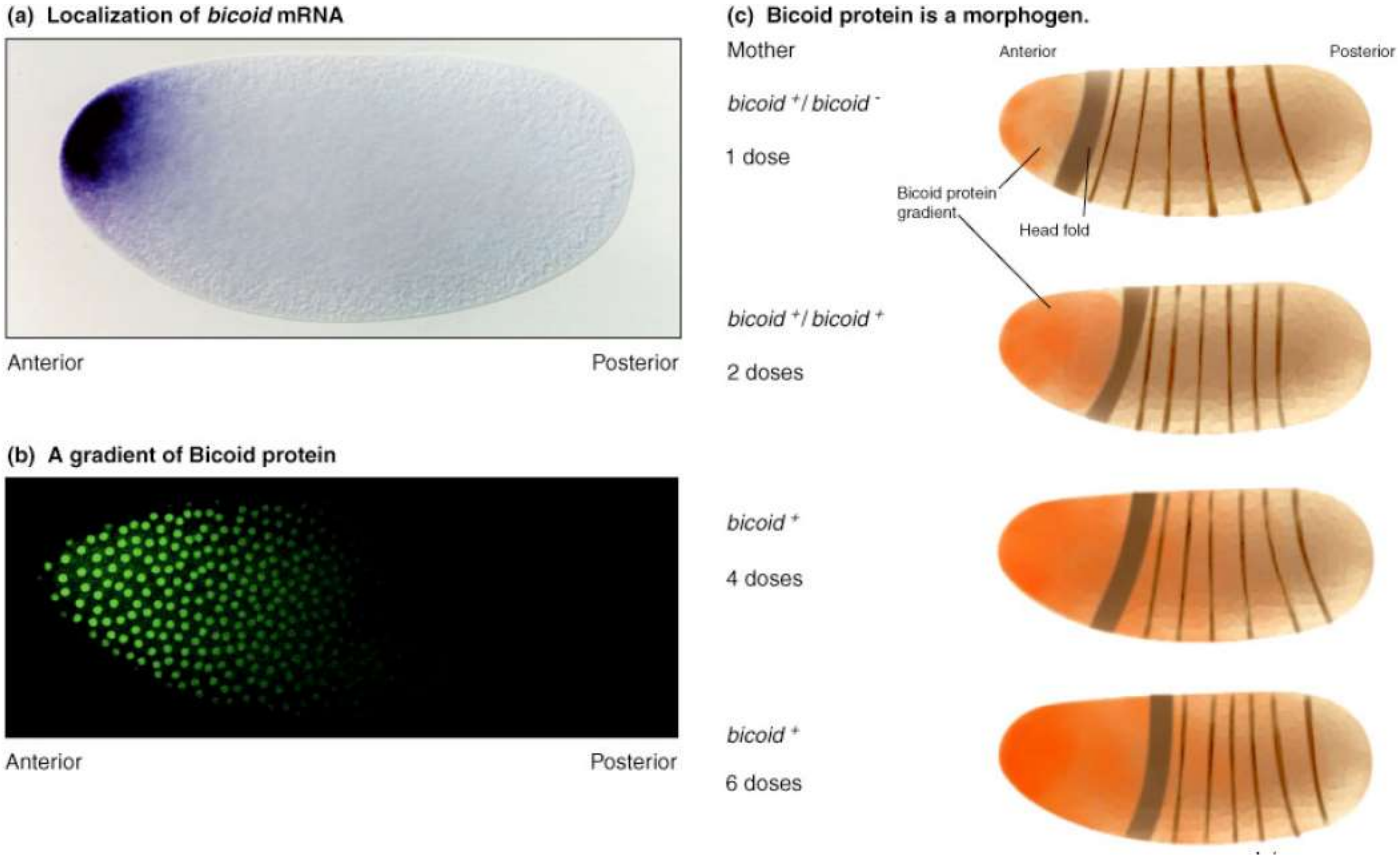


bicoid mRNA

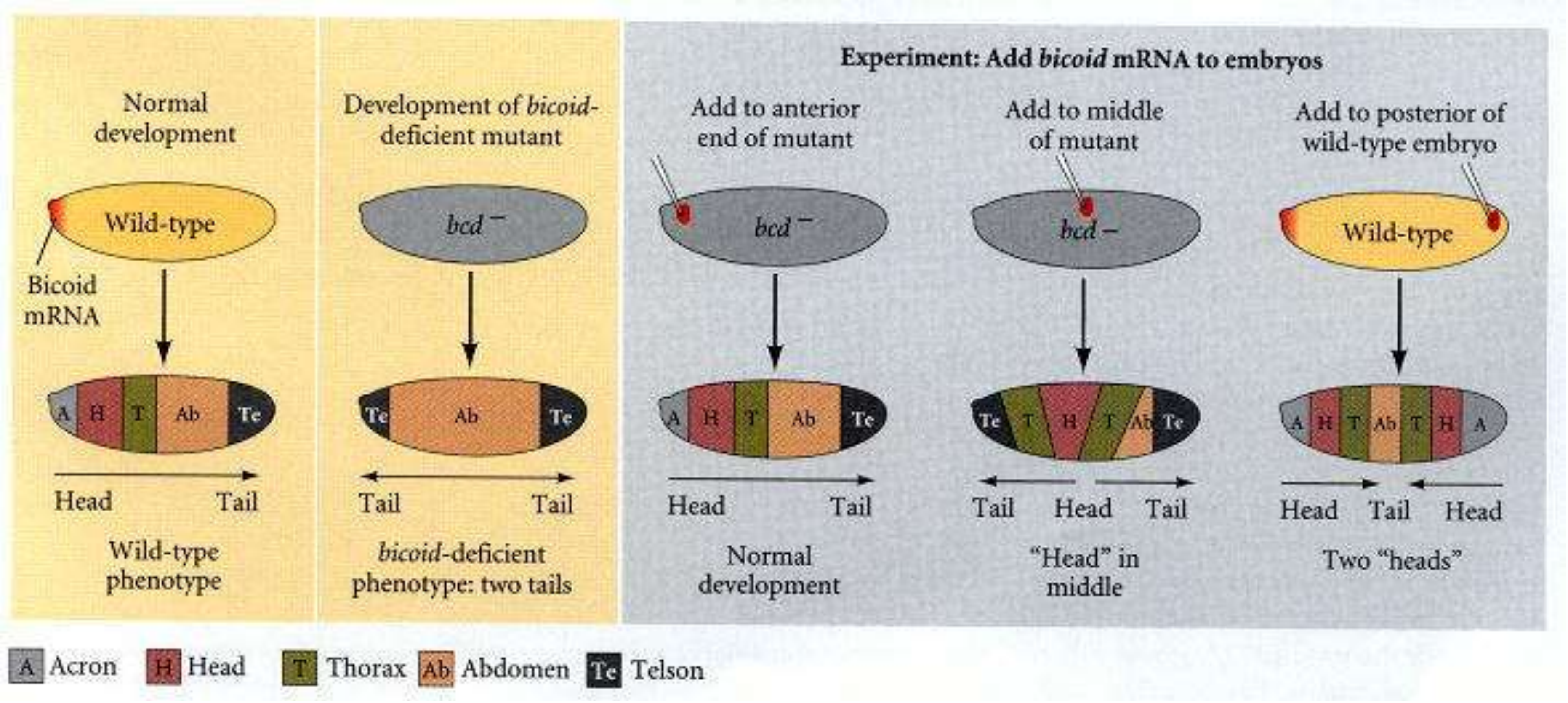
bicoid protein

Morphogens: Substances that define different cell fate in a concentration-dependent manner

bicoid is a morphogen 形态发生素

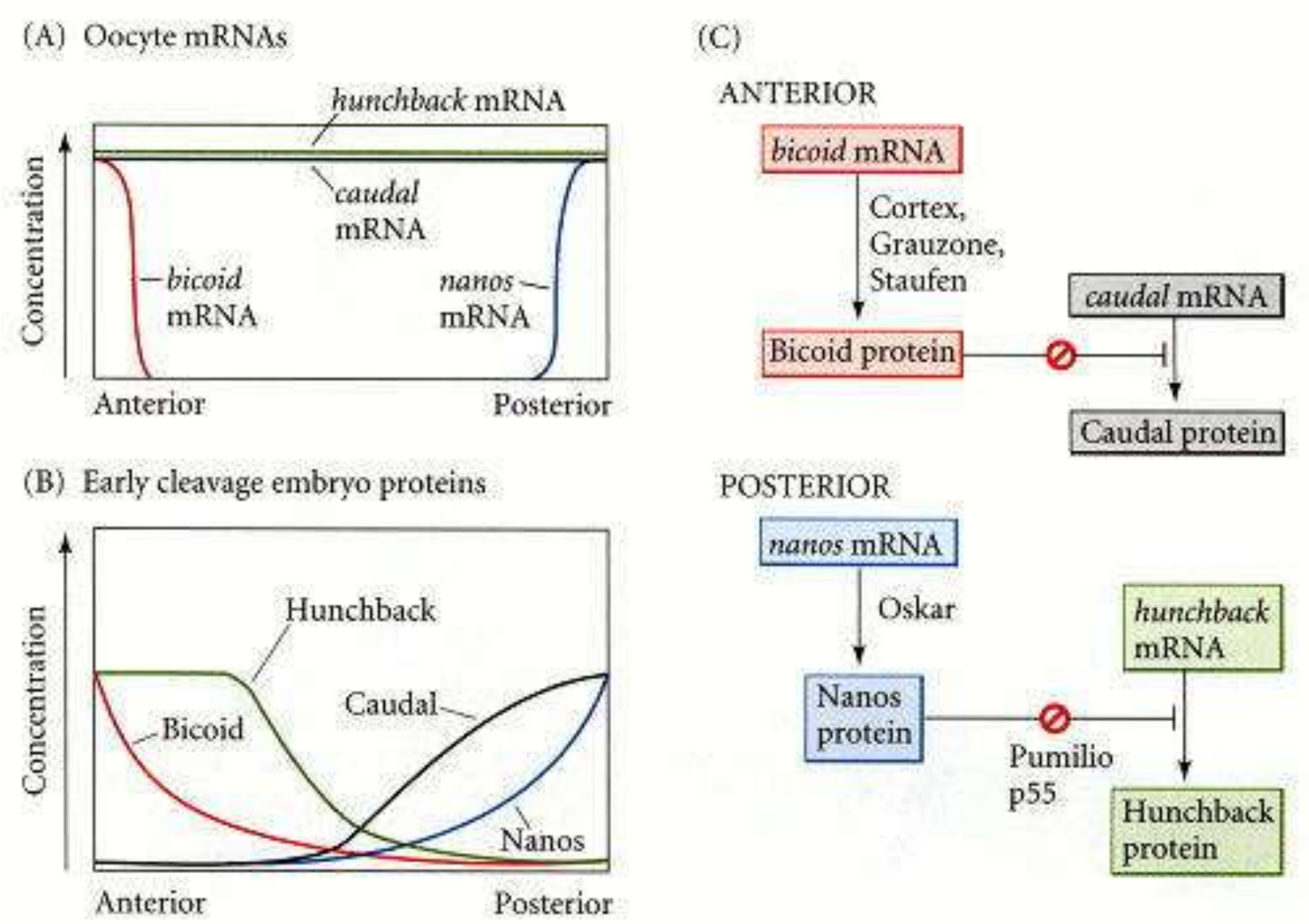


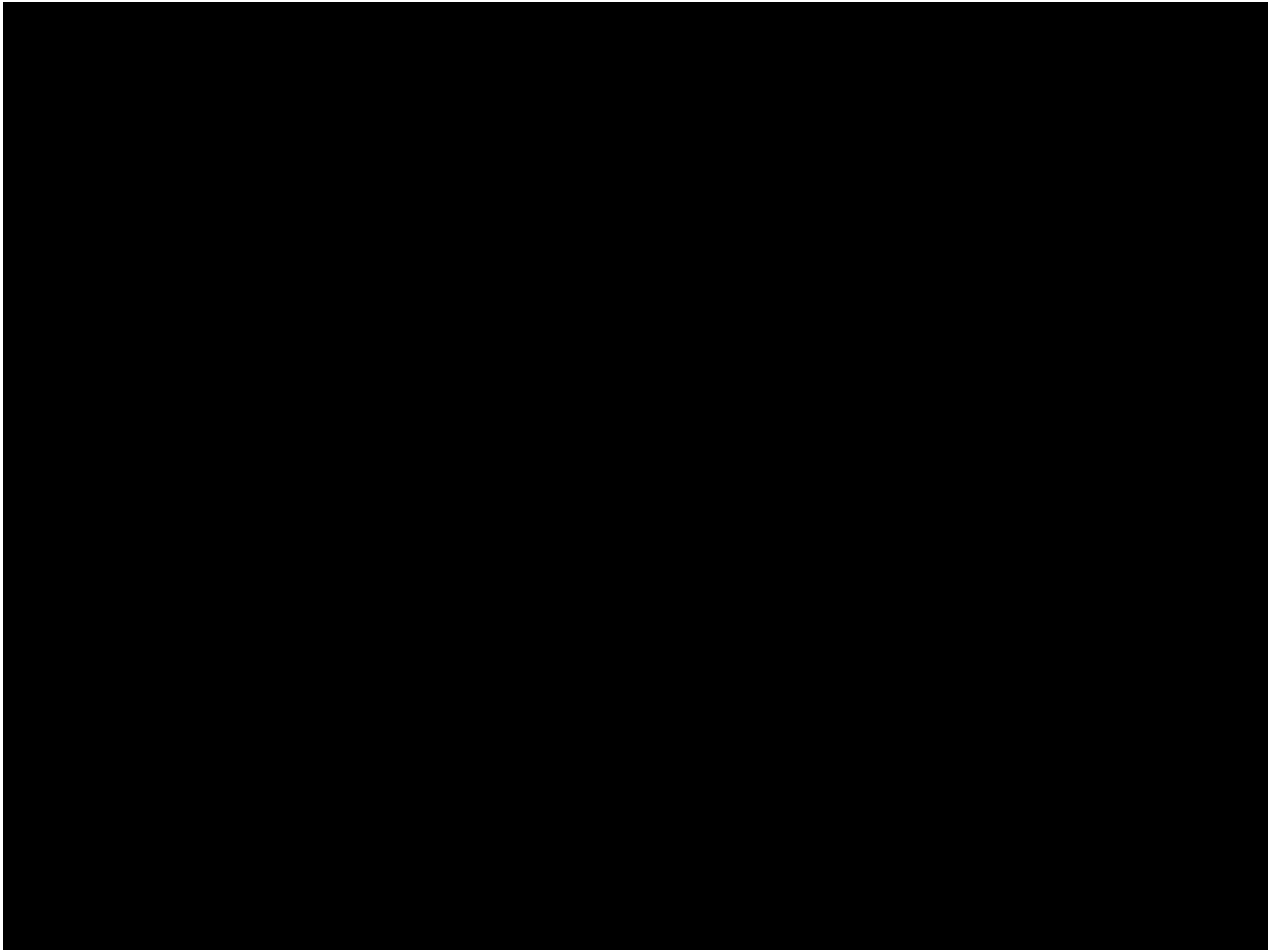
Maternal gene *bicoid* control anterior structures



顶节 尾节

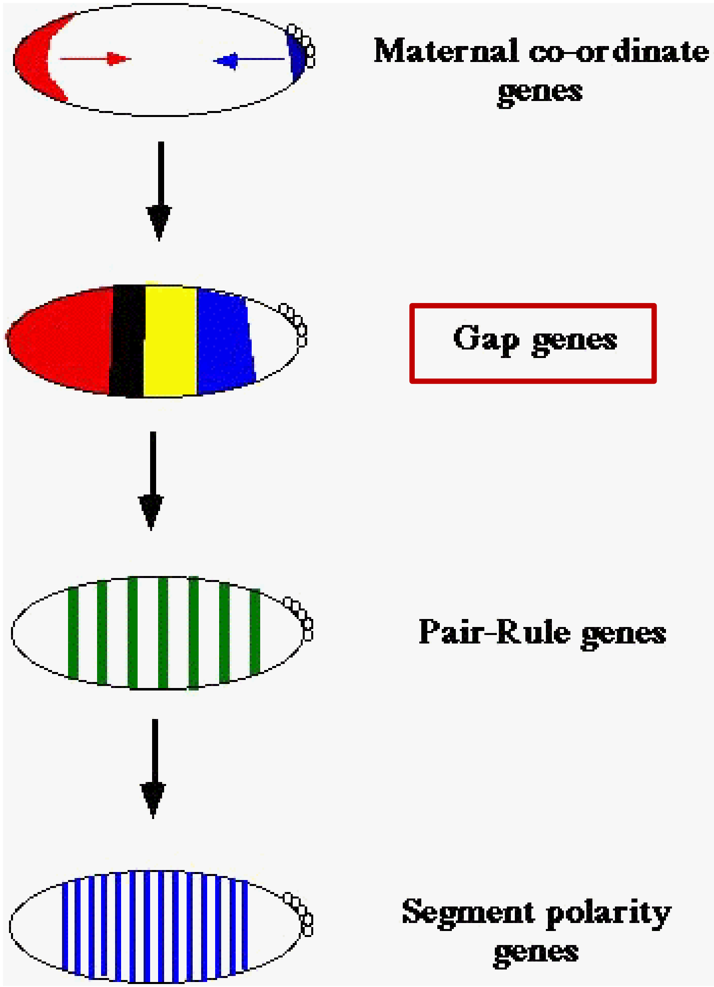
Maternal Genes





Eric Wieschaus

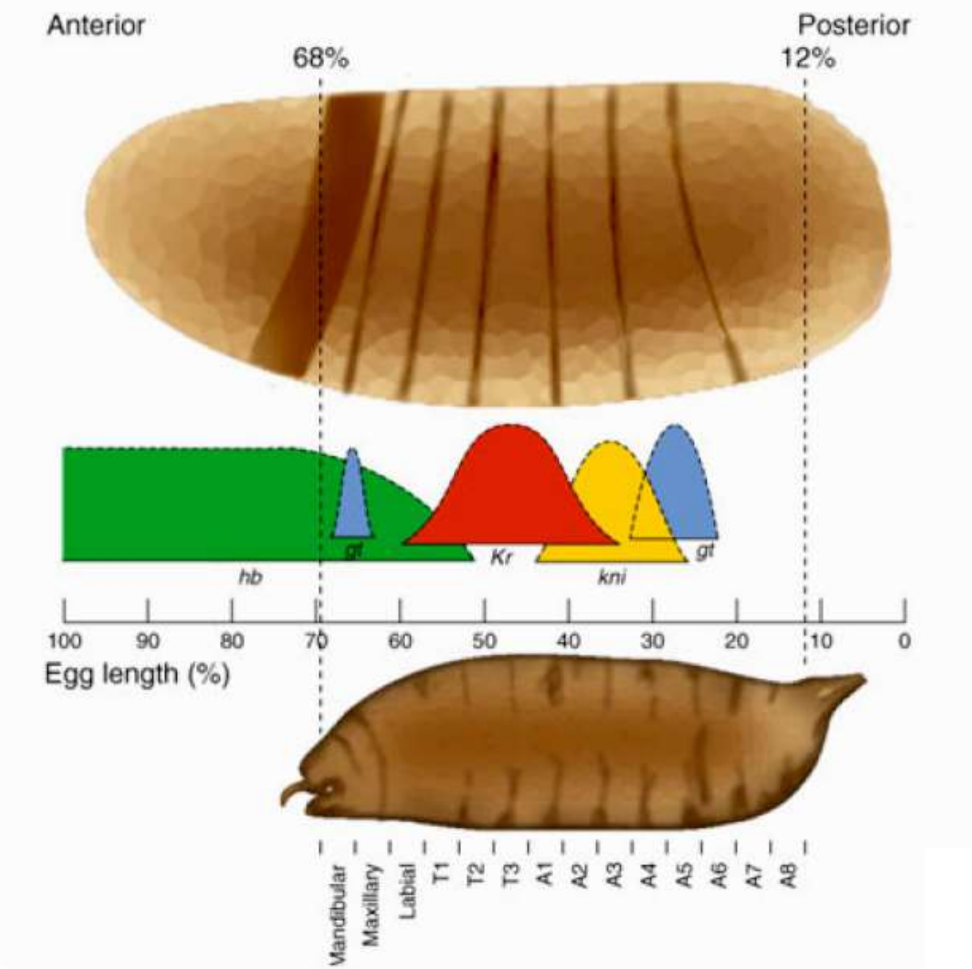
Anterior-posterior (A/P) polarity and Segmentation



Gap genes

- Gap mutants show a gap in segmentation pattern at positions where particular gene is absent
- Binding sites in promoter have different affinities for maternal transcription factors
- Gap genes encode transcription factors that influence expression of other gap genes

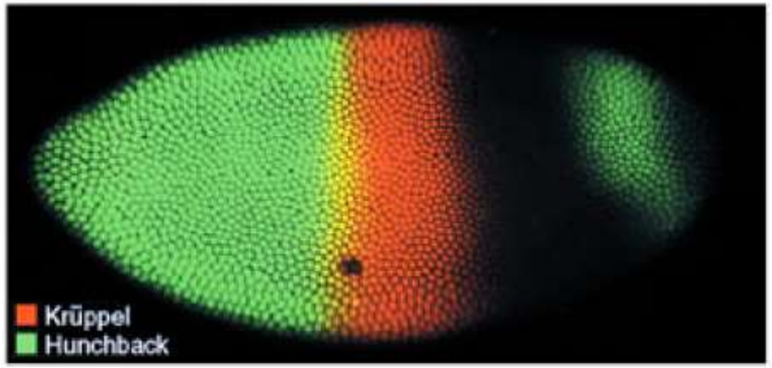
Mutations in gap gene result in loss of segments corresponding to zone of expression

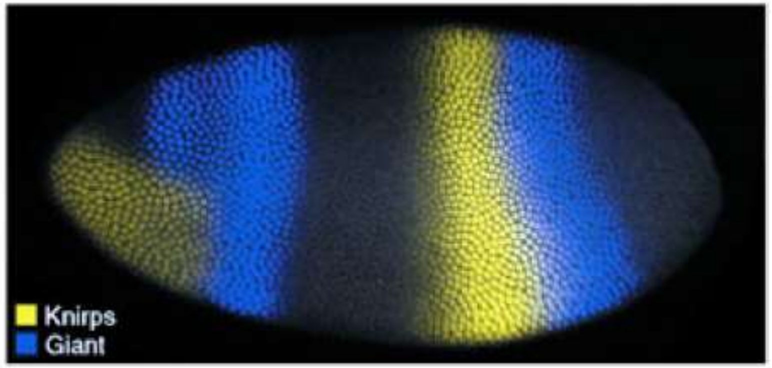


Gap genes

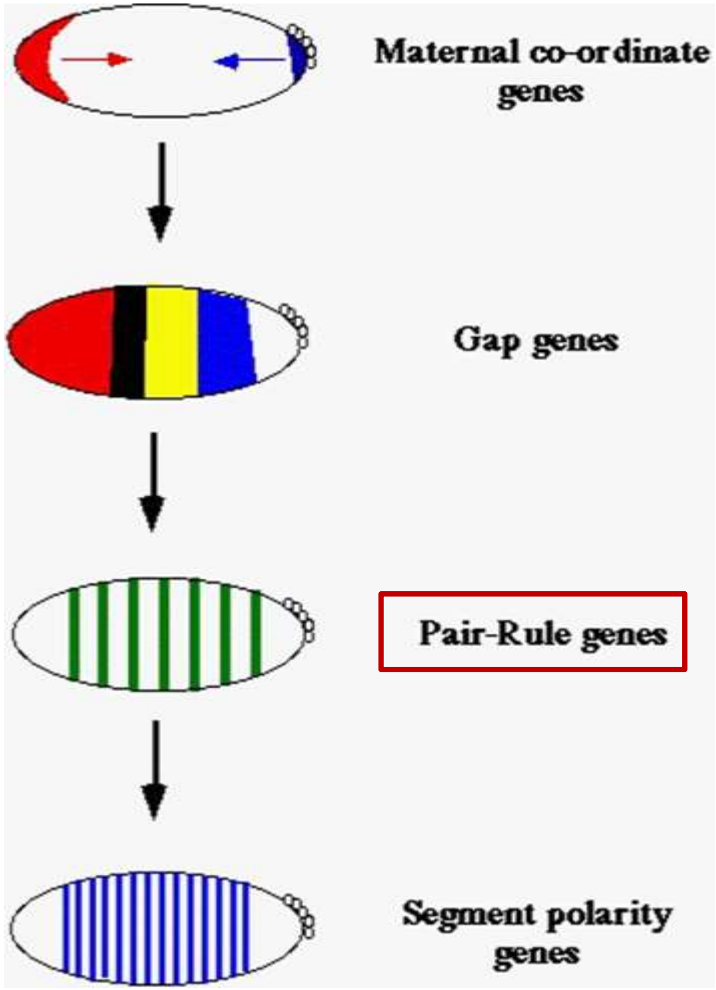
Zones of expression of four gap genes: *hunchback*, *Kruppel*, *knirps*, and *giant* in late syncytial blastoderm embryos

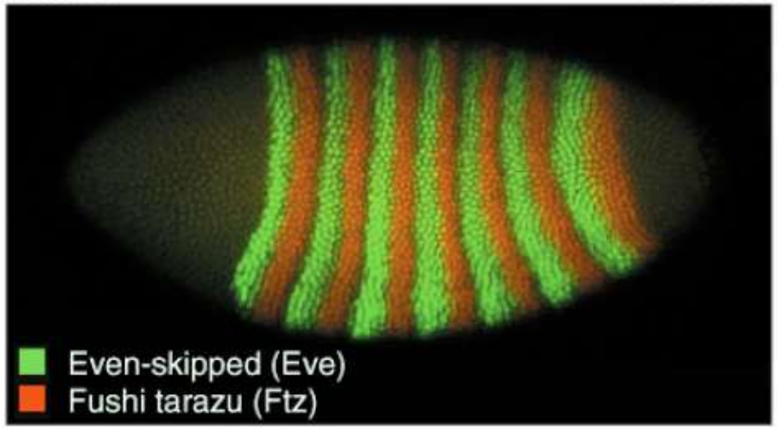
(a) Zones of gap gene expression

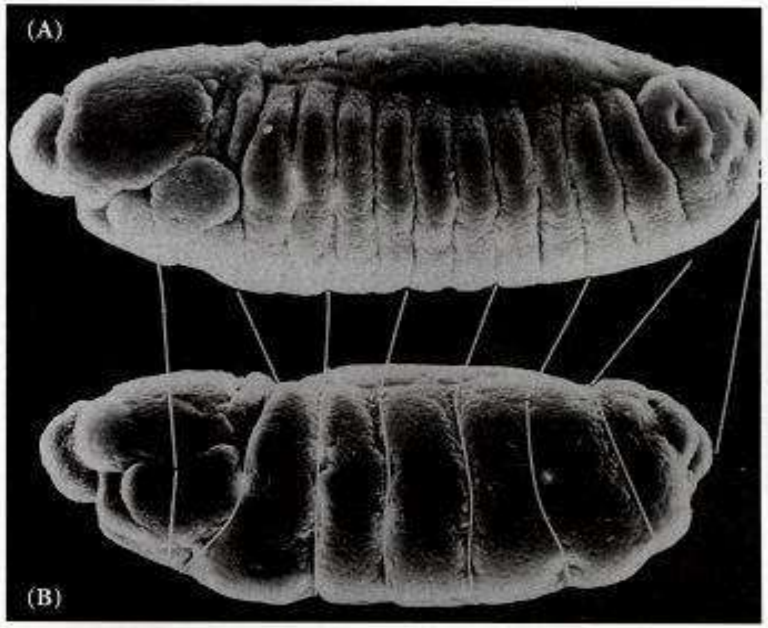




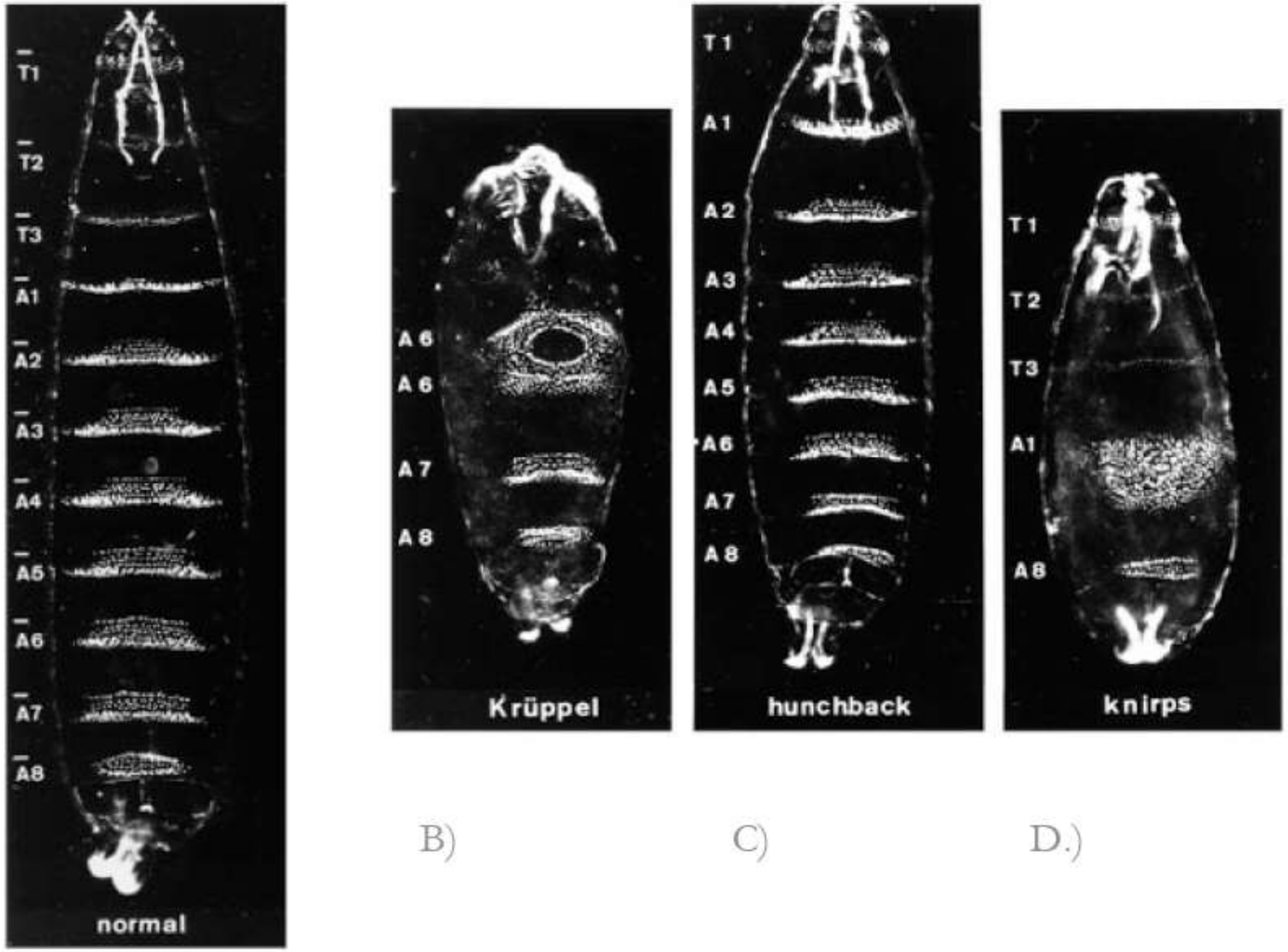
Pair-rule Genes







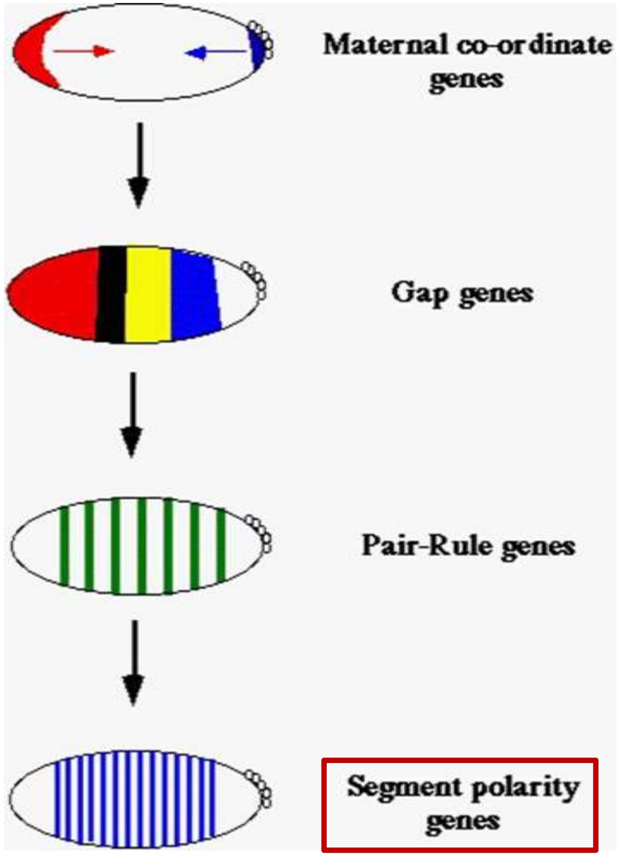
Defects in segmentation from mutations in gap genes



B) C) D.)

A)

Segment polarity genes are lowest level of segmentation hierarchy



Segment polarity genes

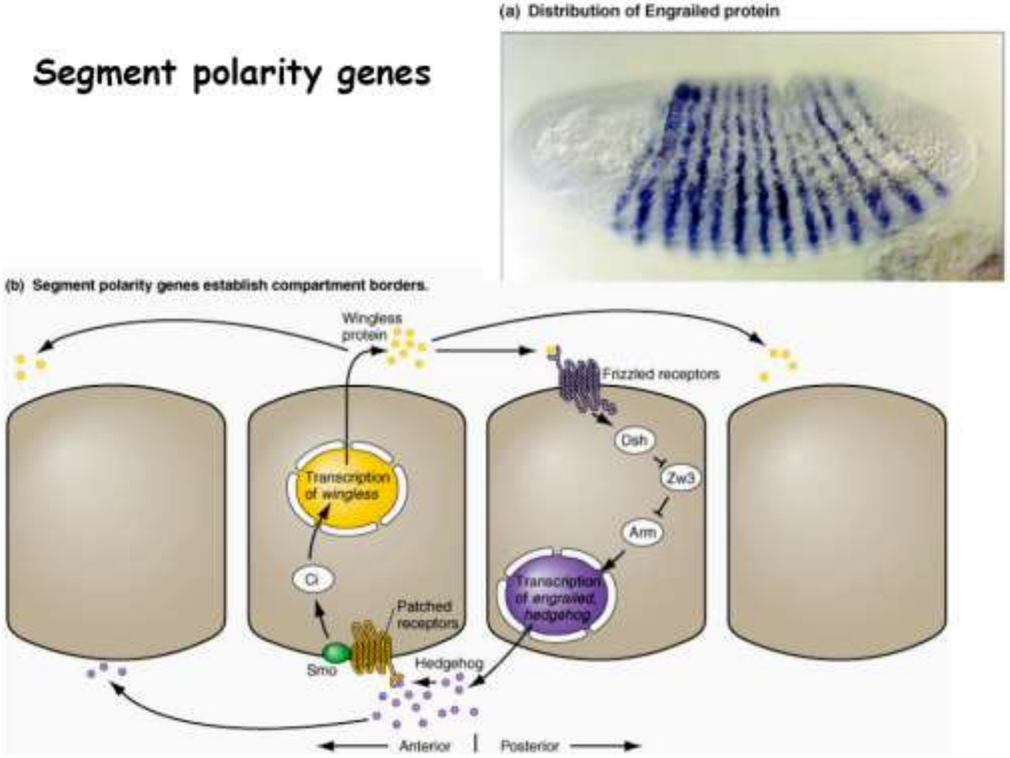
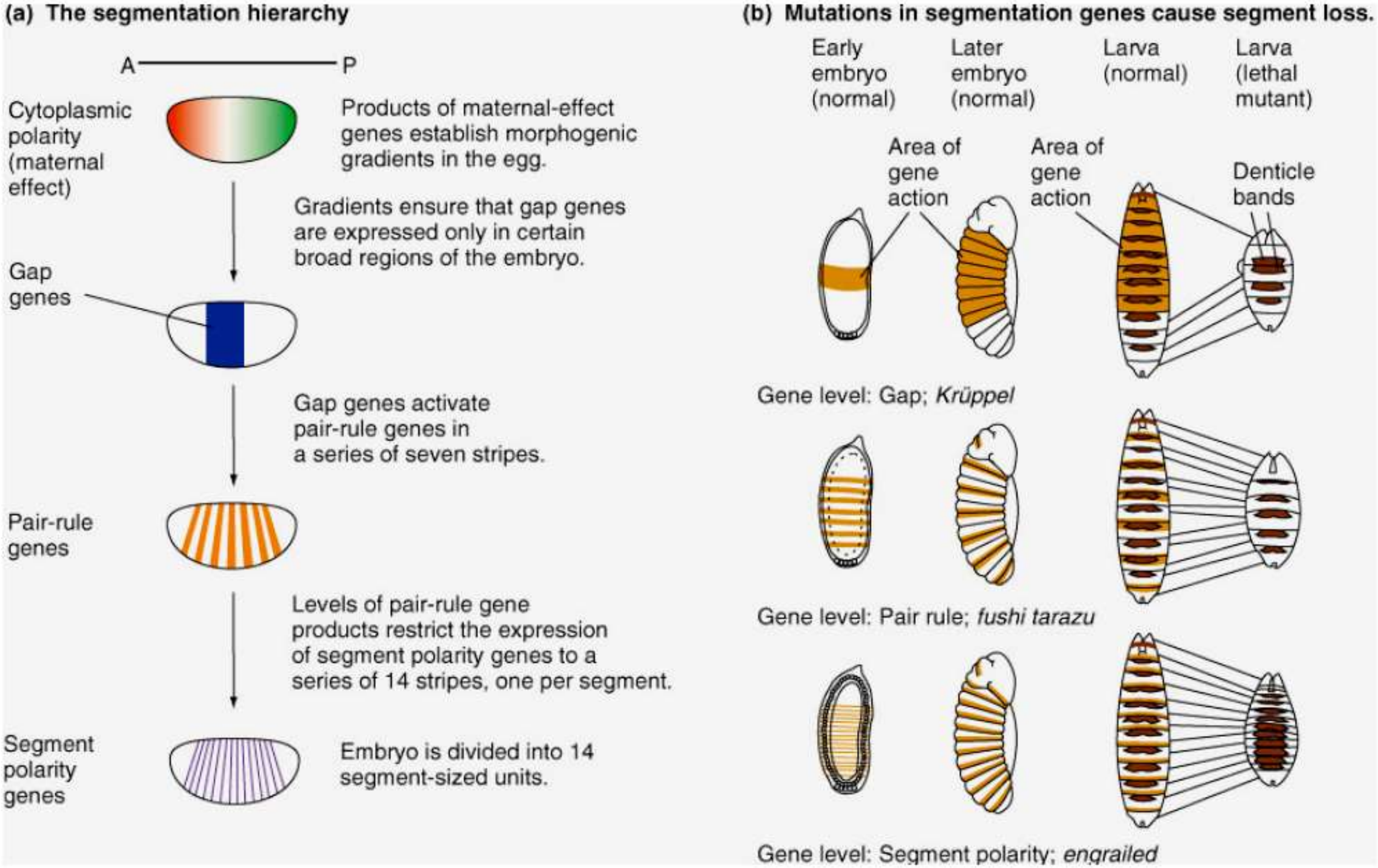


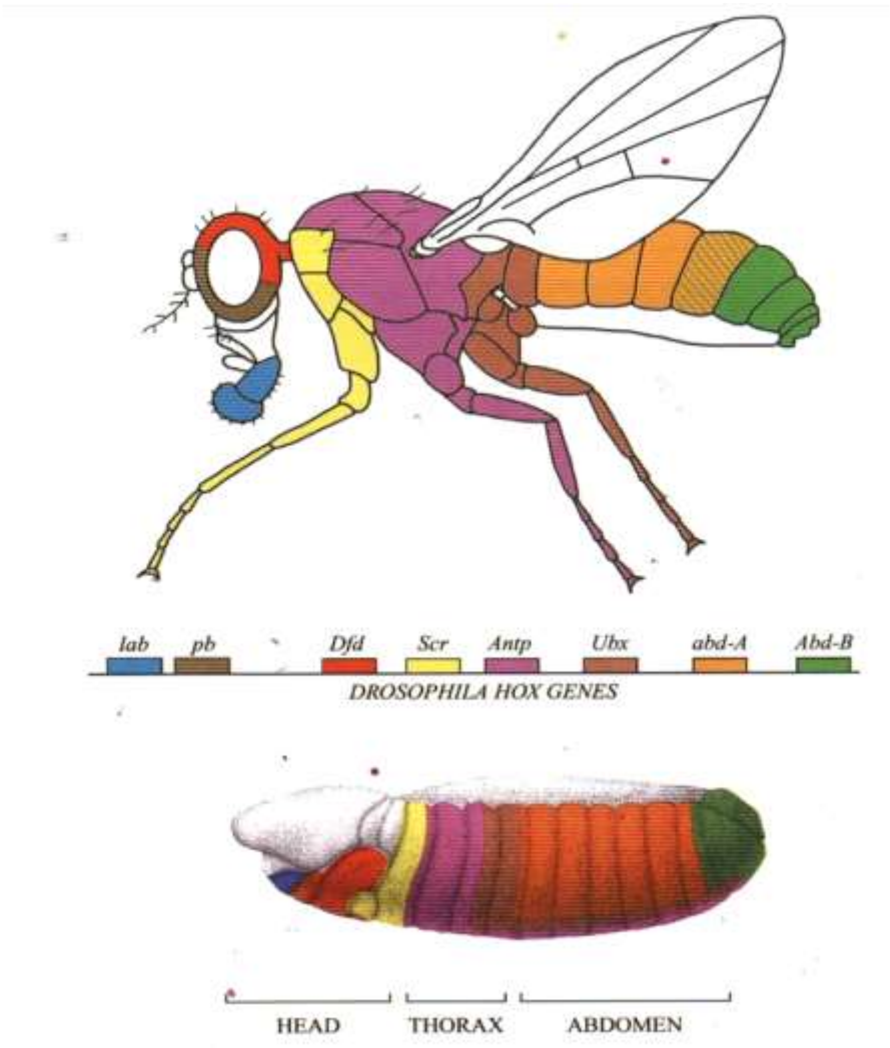
Fig. D.24

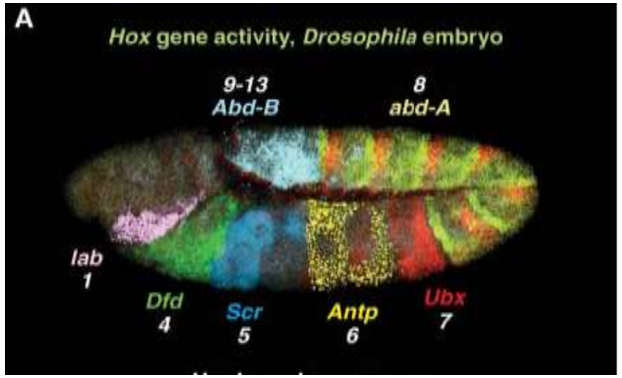
Drosophila embryogenesis: Segmentation genes



Homeotic genes:
determine the fate of each segment

Edward B. Lewis

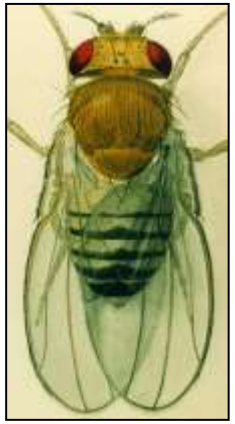




Drosophila Homeotic mutants
同源异形

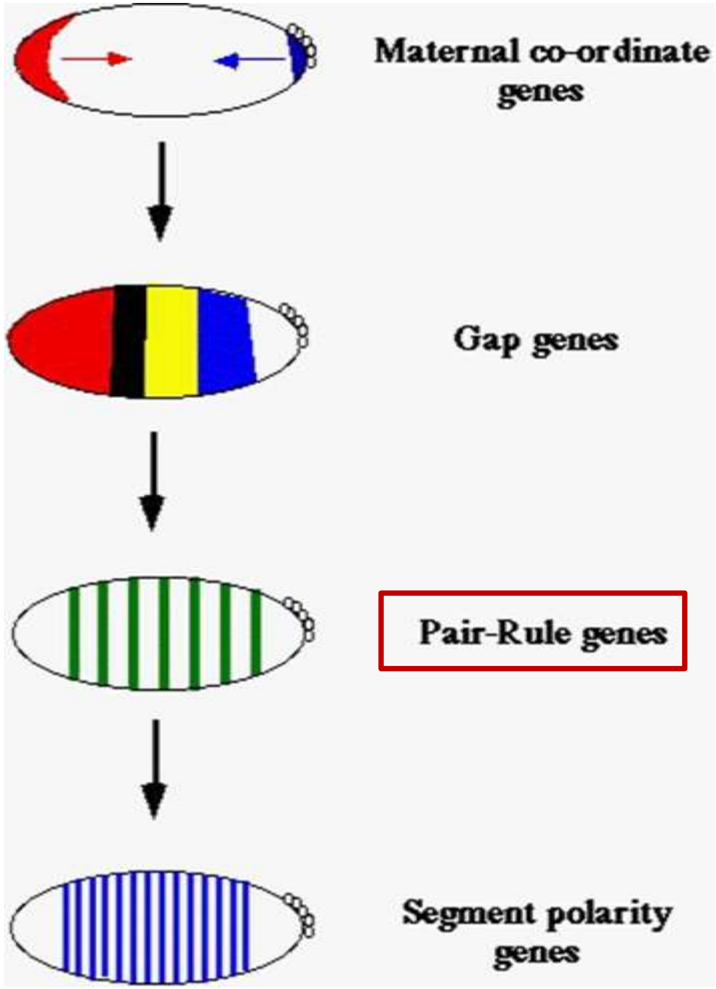
Edward B. Lewis

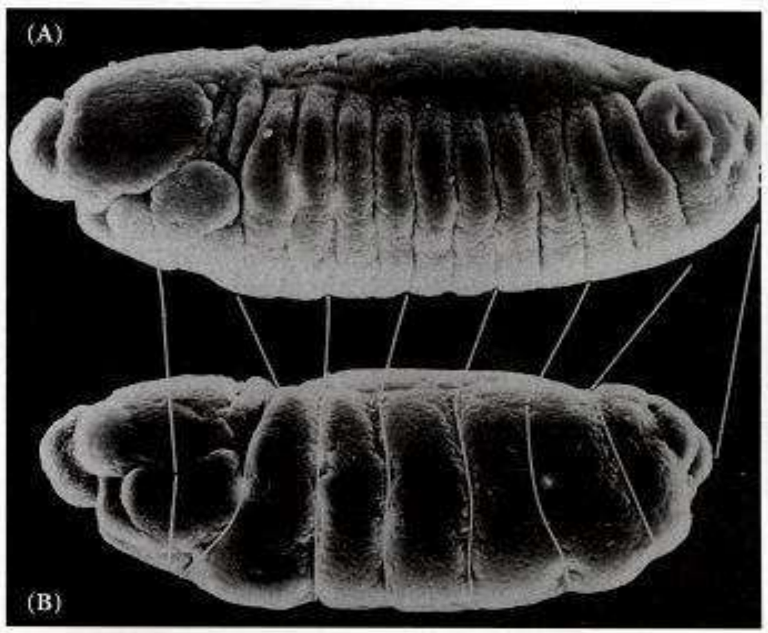
Wild type



Ubx

Pair-rule Genes

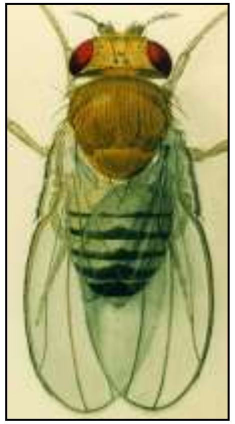




Drosophila Homeotic mutants

同源异形

Wild type



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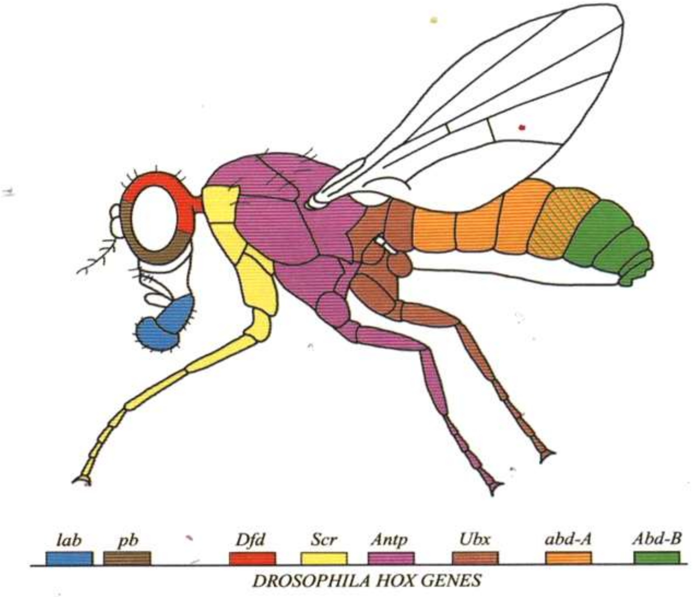
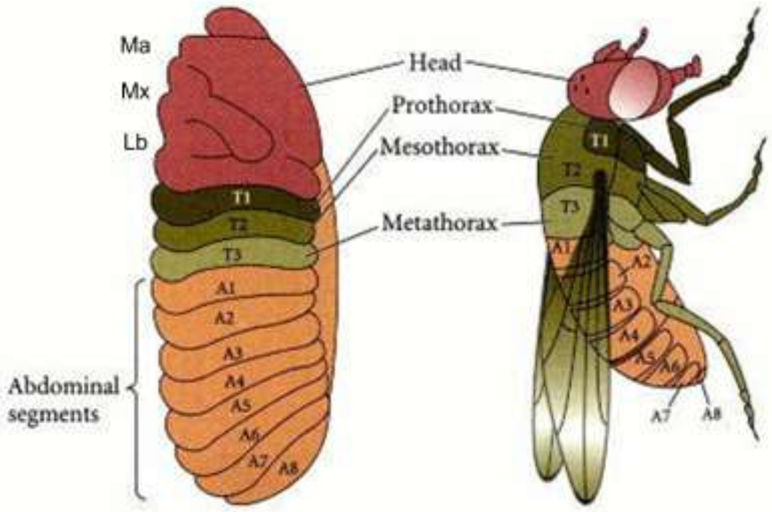
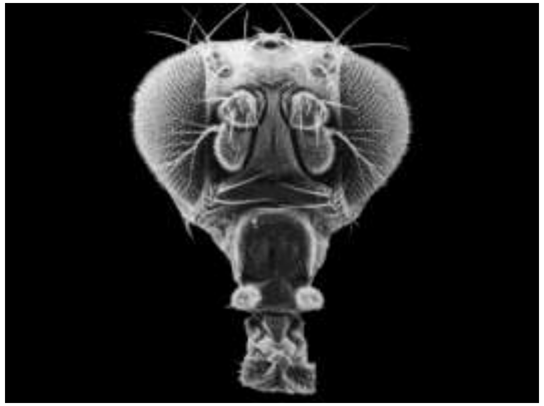
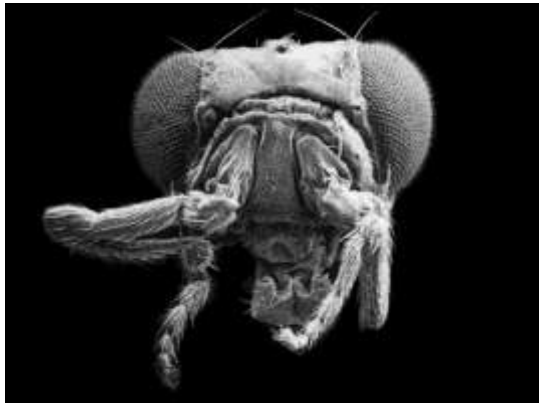


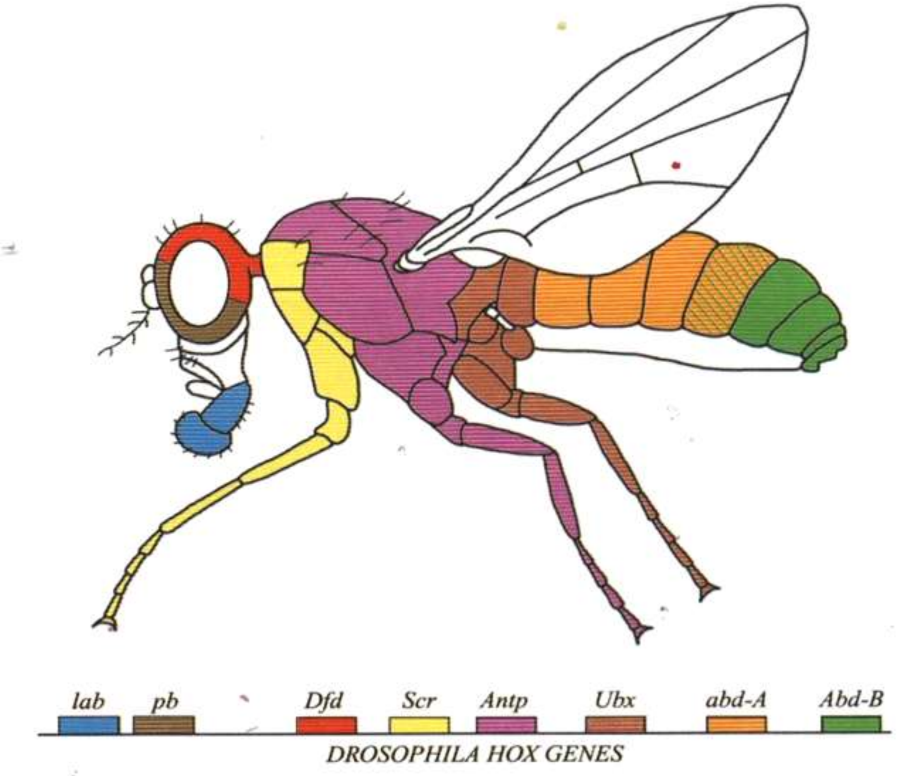


Drosophila Homeotic mutants

同源异形







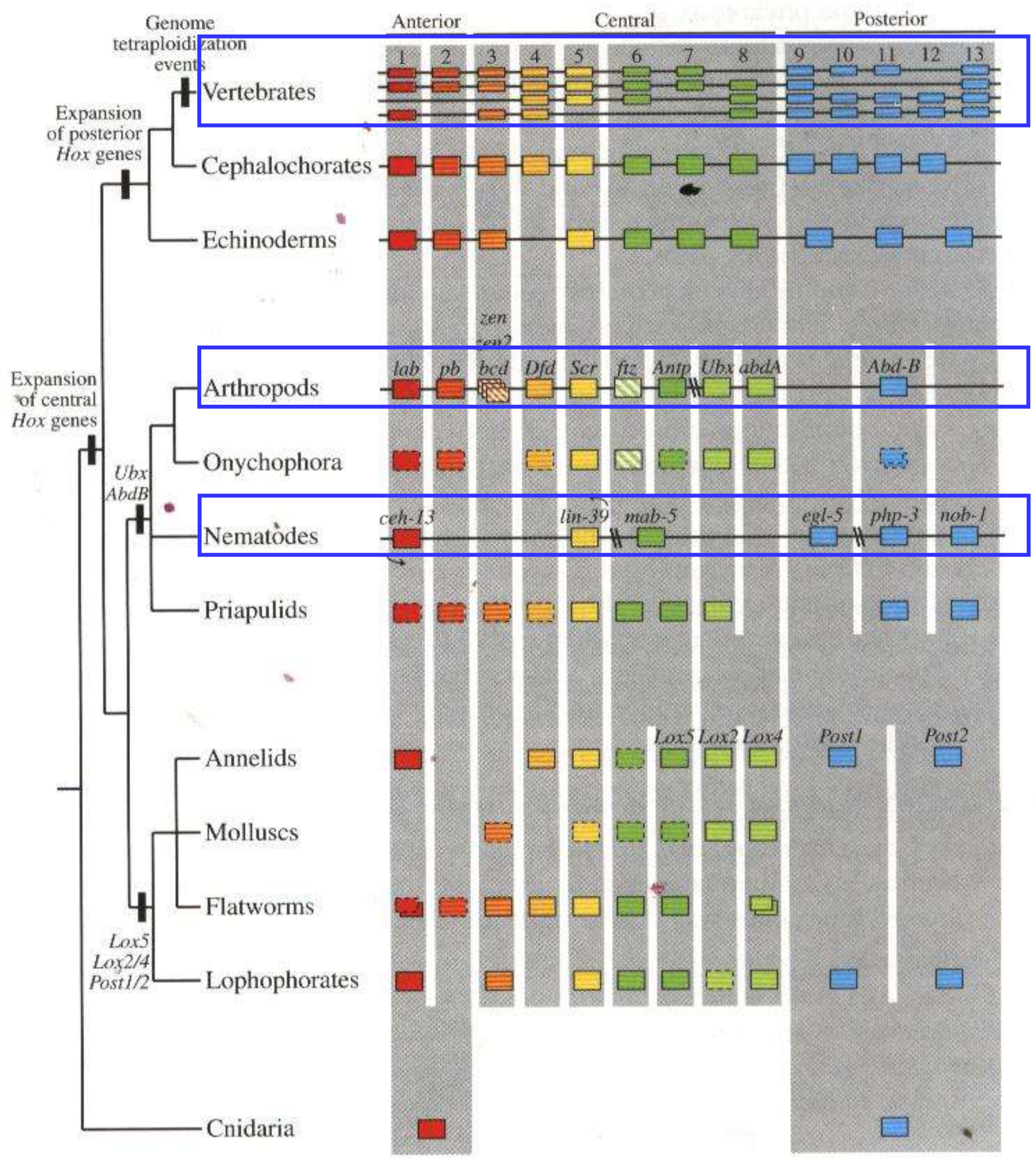
Antp: gain-of-function mutant

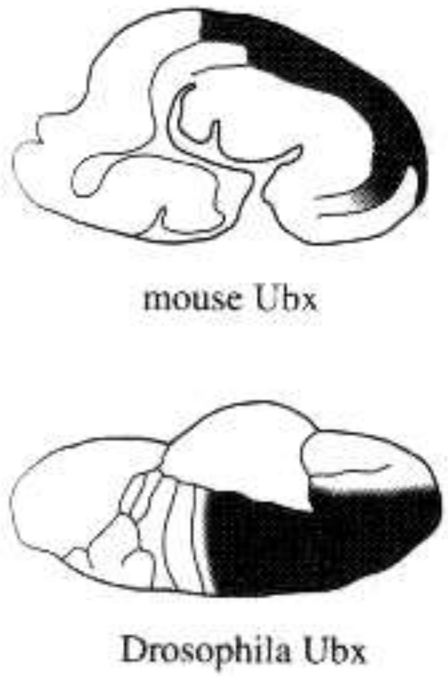
The homeotic genes contain a highly conserved homeobox (Hox)

The Homeobox (*Hox)* genes are transcription regulators

the Homeo<u>box</u> encodes a Homeo<u>domain</u>

Evolution of Metazoan *Hox* genes





刺胞动物: 珊瑚虫、水螅

The Nobel Prize in Physiology or Medicine 2011

"for their discoveries concerning **the activation of innate immunity**"

Jules Hoffmann

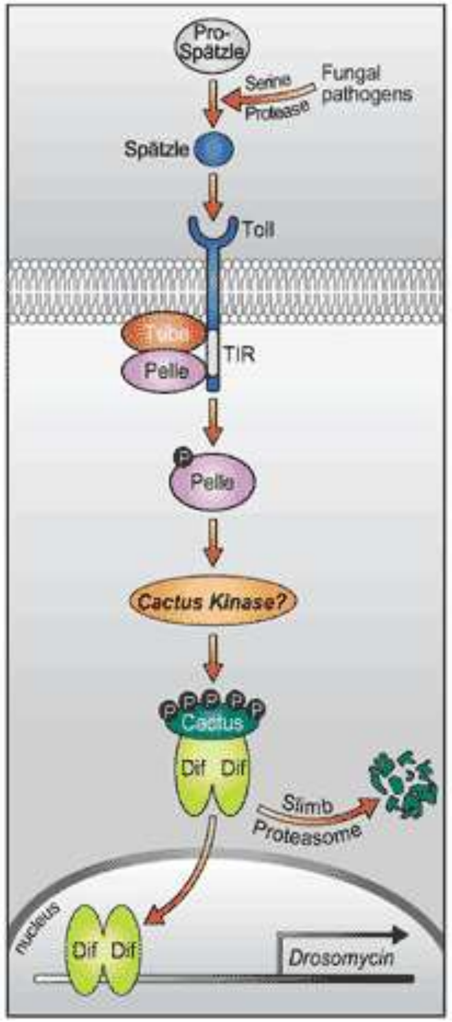
Toll/NF-κB 信号通路

调控先天免疫

Cell, Vol. 86, 973–983, September 20, 1996, Copyright ©1996 by Cell Press

The Dorsoventral Regulatory Gene Cassette *spätzle/Toll/cactus* Controls the Potent Antifungal Response in Drosophila Adults

Bruno Lemaitre, Emmanuelle Nicolas, Lydia Michaut,
Jean-Marc Reichhart, and Jules A. Hoffmann



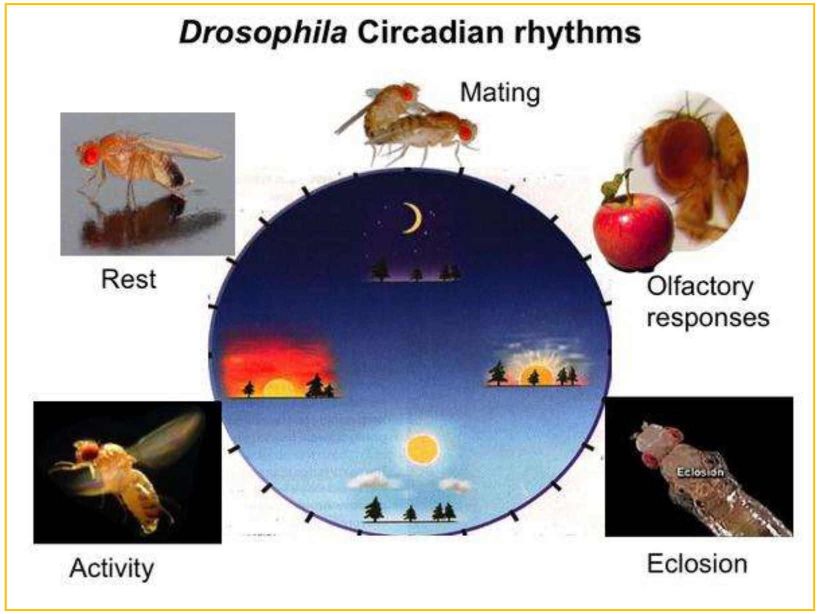
The Nobel Prize in Physiology or Medicine 2017

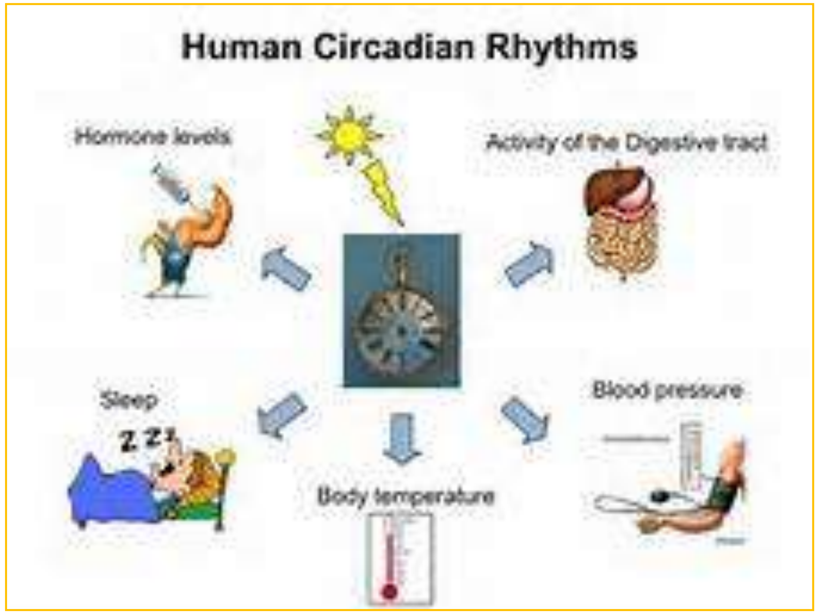
"*for their discoveries of molecular mechanisms controlling the circadian rhythm*"

Jeffrey C. Hall

Michael Rosbash

Michael W. Young





Seymour Benzer

1921 - 2007

Ronald Konopka

1947 - 2015

Proc. Nat. Acad. Sci. USA
Vol. 68, No. 9, pp. 2112–2116, September 1971

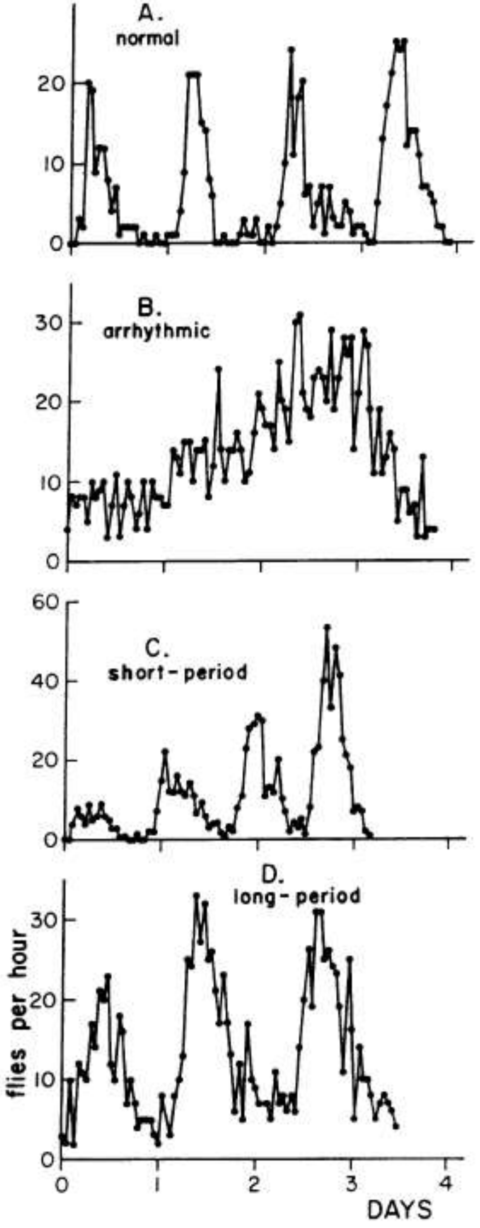
Clock Mutants of *Drosophila melanogaster*

(eclosion/circadian/rhythms/X chromosome)

RONALD J. KONOPKA AND SEYMOUR BENZER

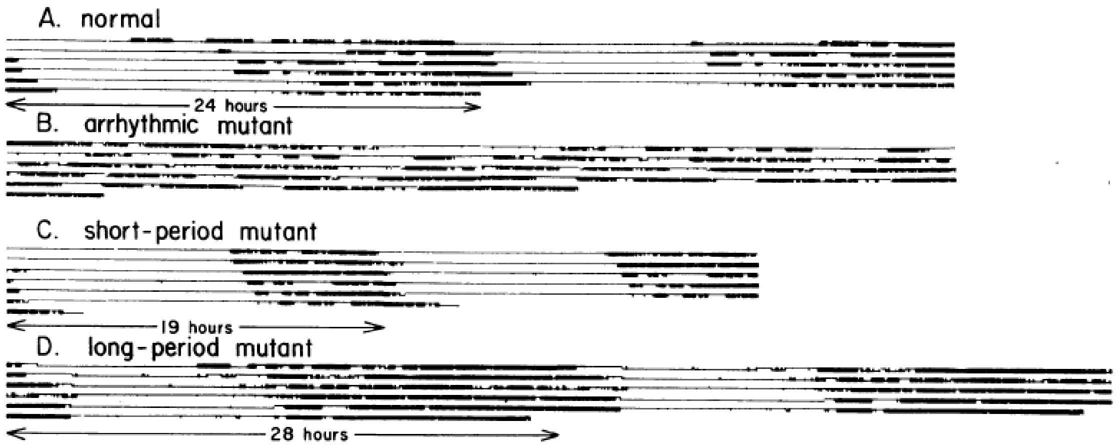
Division of Biology, California Institute of Technology, Pasadena, Calif. 91109

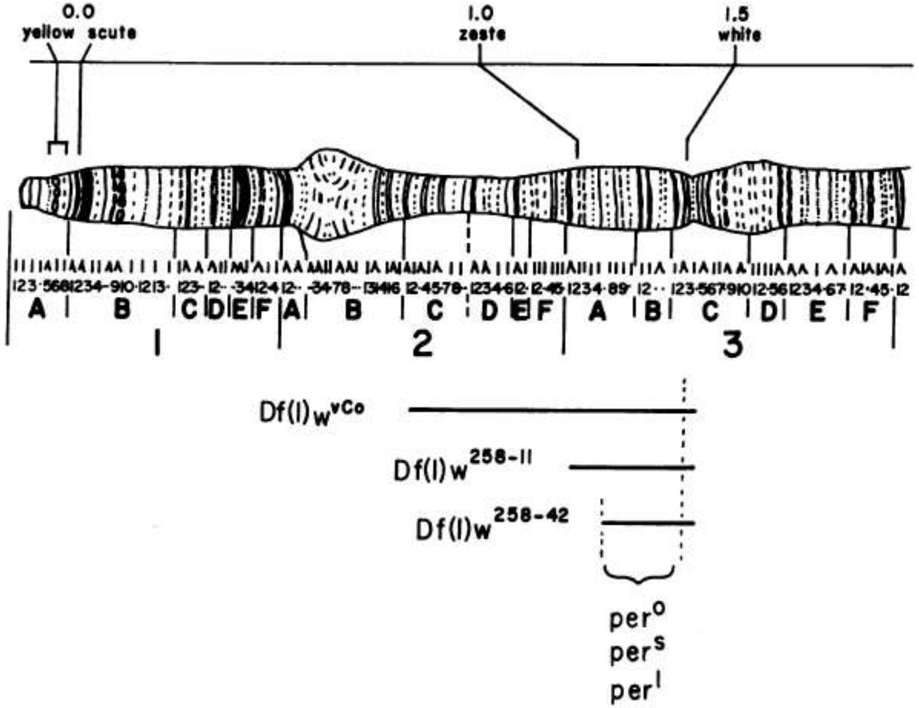
ABSTRACT Three mutants have been isolated in which the normal 24-hour rhythm is drastically changed. One mutant is arrhythmic; another has a period of 19 hr; a third has a period of 28 hr. Both the eclosion rhythm of a population and the locomotor activity of individual flies are affected. All these mutations appear to involve the same functional gene on the X chromosome.



Eclosion rhythms, in constant darkness,

Locomotor activity rhythms,





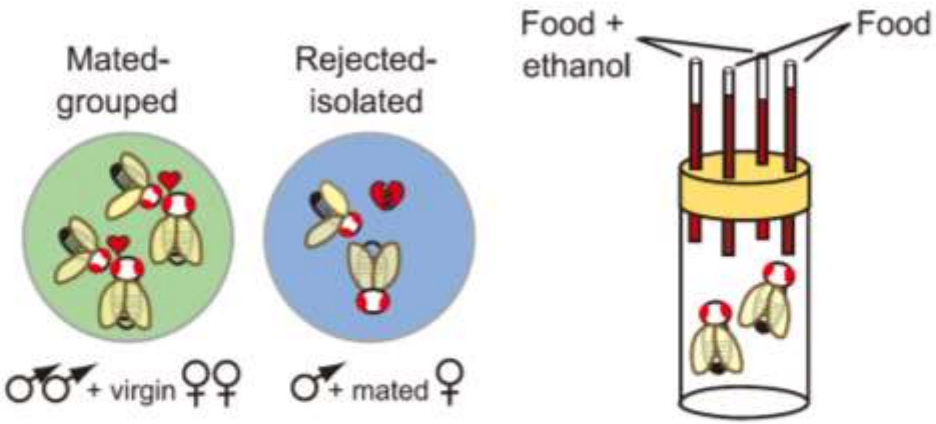
果蝇失恋也会“借酒消愁”

REPORT

Sexual Deprivation Increases Ethanol Intake in *Drosophila*

G. Shohat-Ophir[*,†], K. R. Kaun[†], R. Azanchi[†], H. Mohammed, U. Heberlein[*,†]

Science 16 Mar 2012:



果蝇也“争强好胜”

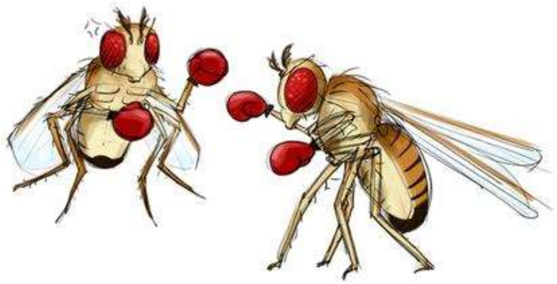
ARTICLE

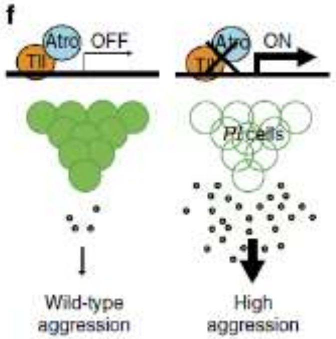
Received 18 Jul 2013 | Accepted 23 Dec 2013 | Published 4 Feb 2014

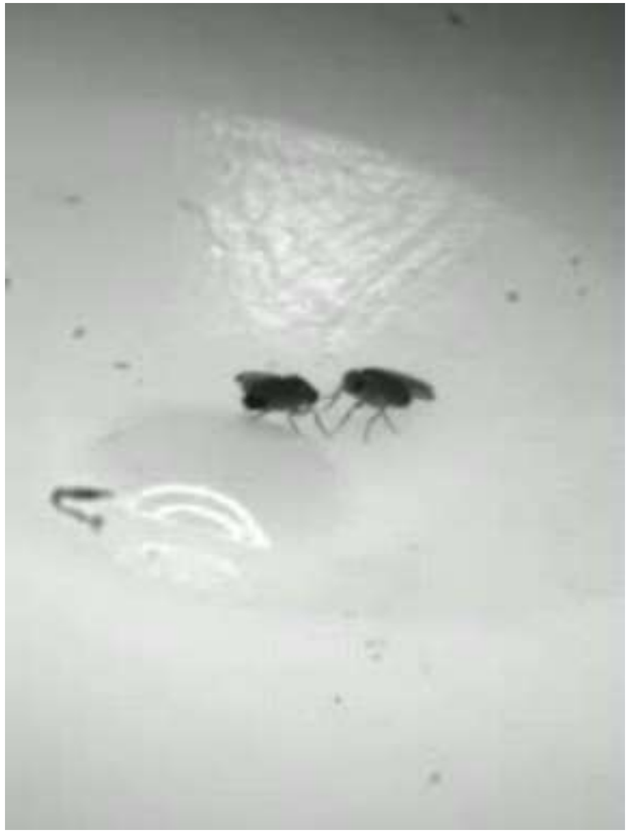
DOI: 10.1038/ncomms4177

Tailless and Atrophin control *Drosophila* aggression by regulating neuropeptide signalling in the *pars intercerebralis*

Shaun M. Davis[1,*], Amanda L. Thomas[1,*], Krystle J. Nomie[1,*], Longwen Huang[3] & Herman A. Dierick[1,2,3,4]







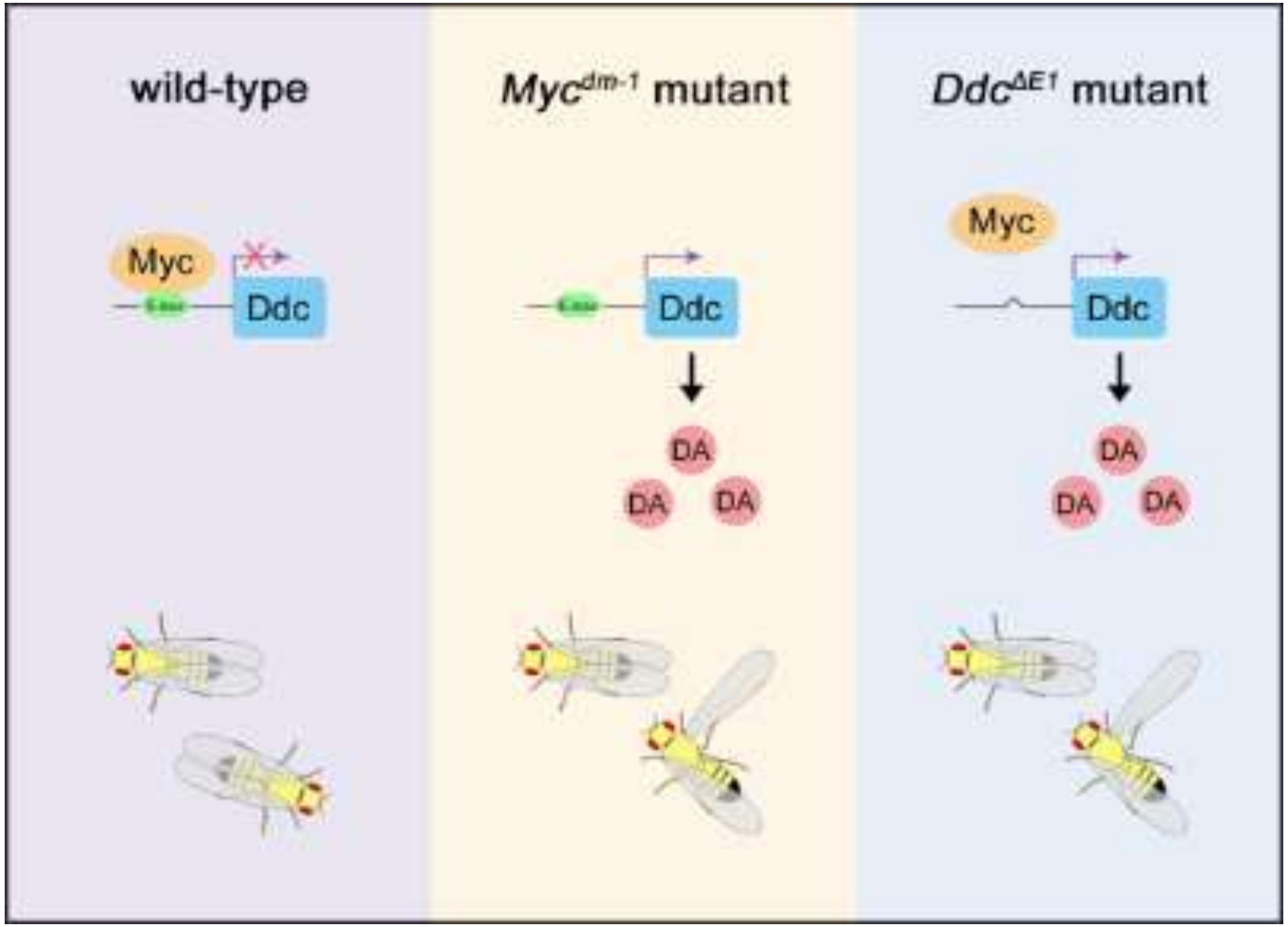

HEATH LEDGER
JAKE GYLLENHAAL
ANNE HATHAWAY
MICHELLE WILLIAMS
BROKEBACK MOUNTAIN


Born Gay
Follow the Ray
Born Straight
Refuse to
Hate
© TopPun.com
Got Pride?

› EMBO J. 2022 Feb 15;e109905. doi: 10.15252/embj.2021109905. Online ahead of print.

Myc suppresses male-male courtship in Drosophila

Yu Pan [1], Wanzhen Li [1], Zhu Deng [2], Yihao Sun [3], Xianjue Ma [4], Ruijuan Liang [1], Xiaowei Guo [1], Ying Sun [1], Wenzhe Li [1], Renjie Jiao [2], Lei Xue [1] [3]



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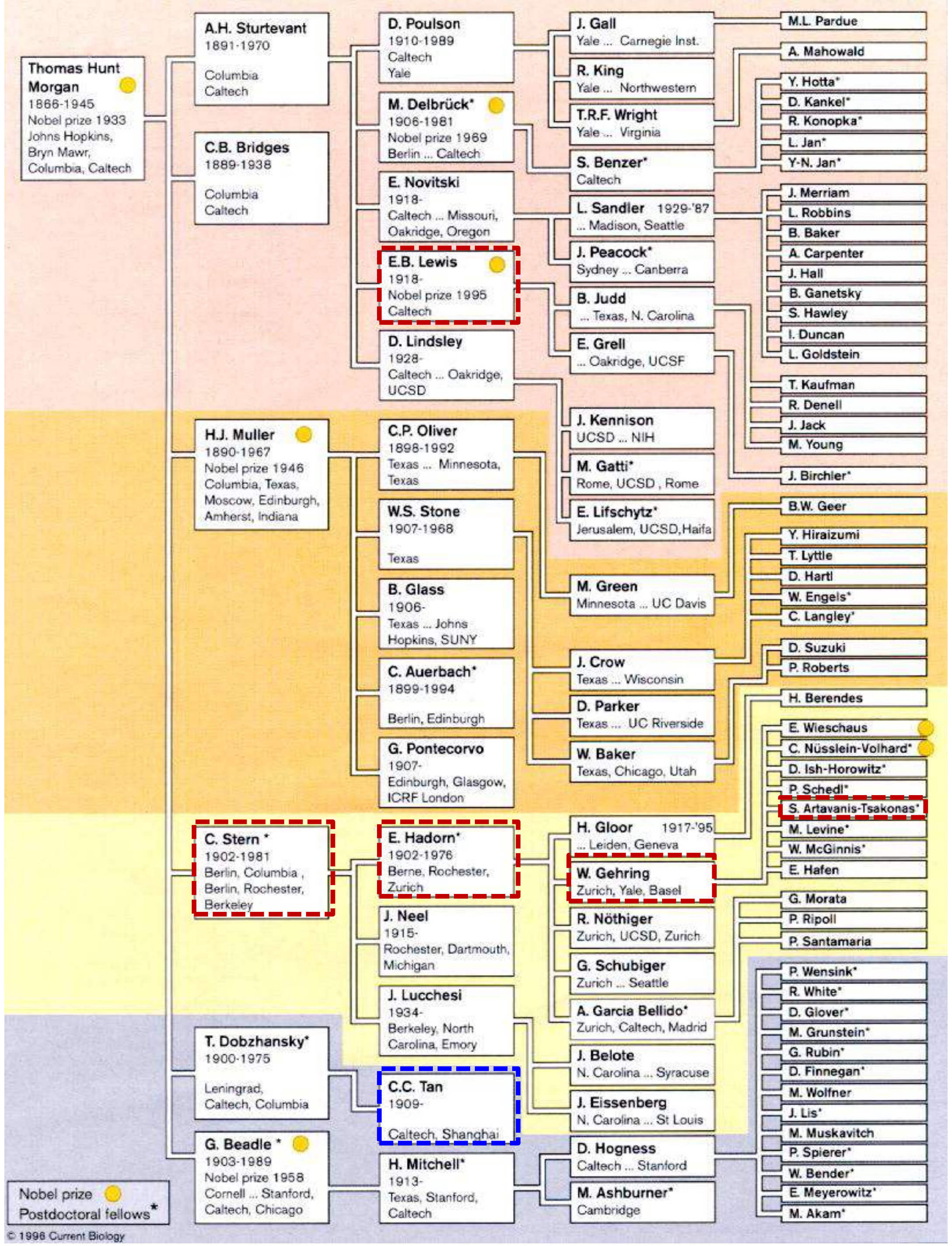

Homeotic mutants

Segmentation genes: maternal, gap, pair-rule, segment polarity

Homeobox