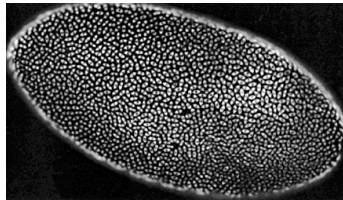


Drosophila early development

II. MEROBLASTIC CLEAVAGE

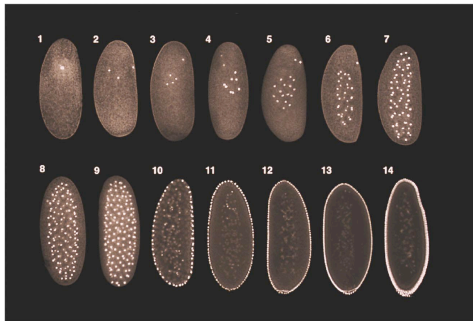
B. Centrolecithal

Superficial cleavage
Most insects



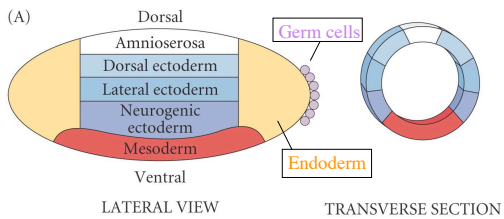
Drosophila blastoderm, cycle 13

Figure 9.1 Laser Confocal Micrographs of Stained Chromatin Showing Superficial Cleavage in a *Drosophila* Embryo



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Fly Cellular Blastoderm Fate Map



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Figure 9.40 Gastrulation in Drosophila

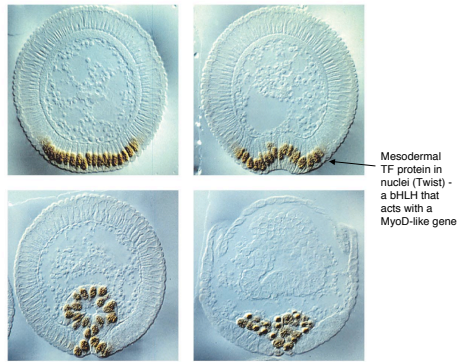


Figure 9.5(1) Gastrulation in Drosophila

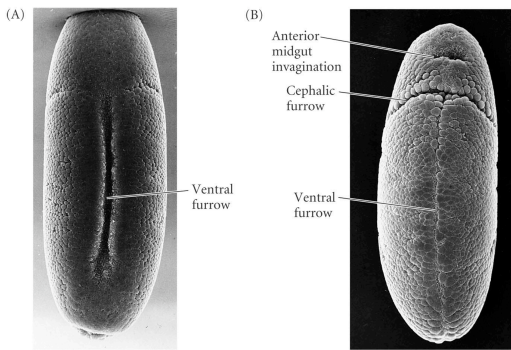


Figure 9.5(2) Gastrulation in Drosophila

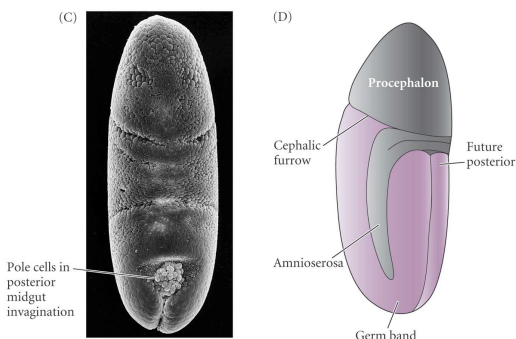
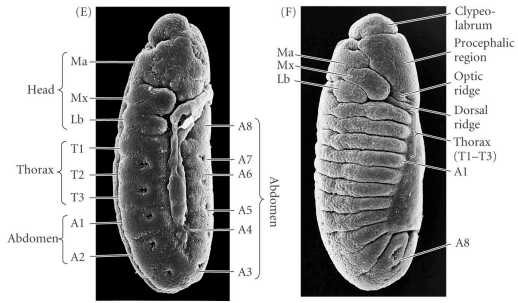
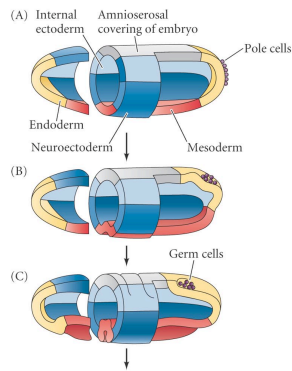


Figure 9.5(3) Gastrulation in Drosophila



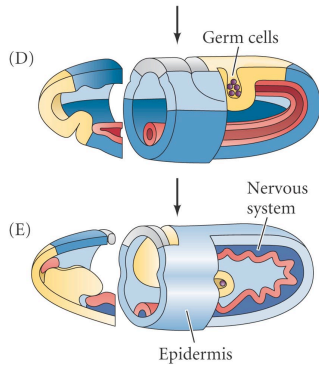
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Figure 9.6(1) Schematic Representation of Gastrulation in Drosophila



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Figure 9.6(2) Schematic Representation of Gastrulation in Drosophila



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Figure 9.5(4) Gastrulation in Drosophila

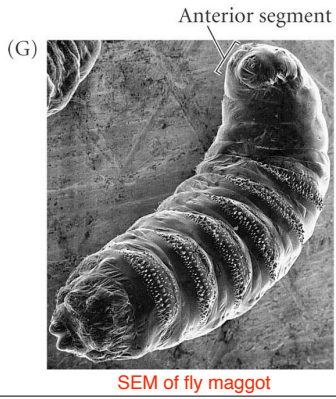
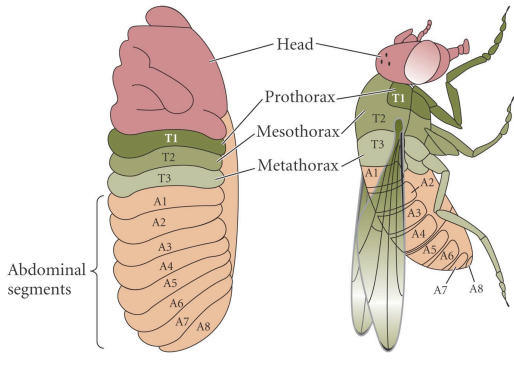
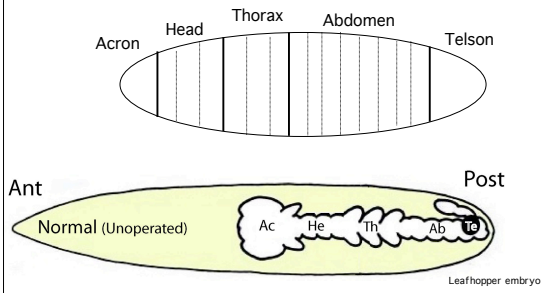


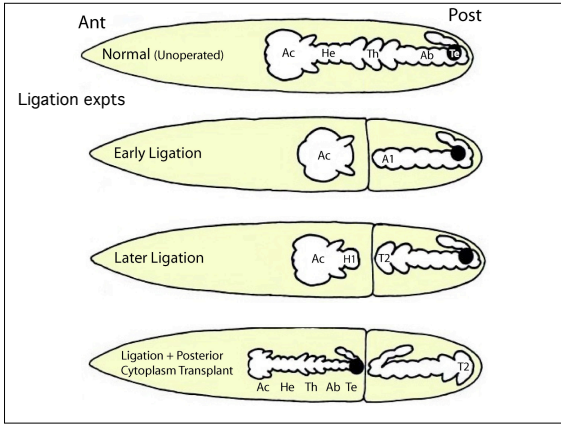
Figure 9.7 Comparison of Larval and Adult Segmentation in Drosophila

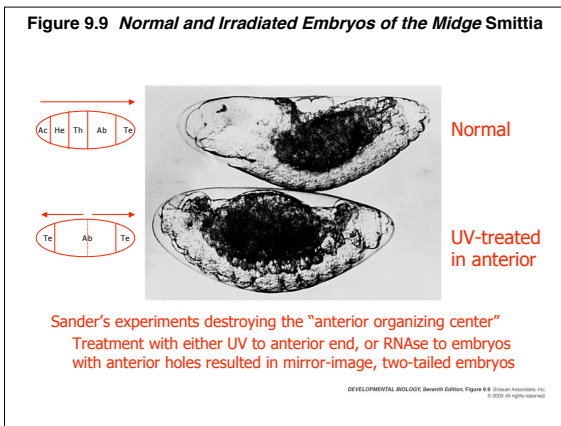


Classic Embryology Experiments in Insect Patterning - Sander, Kalthoff

Basic Anterior-Posterior Pattern of Insect Embryo







**Nüsslein-Volhard & Wieschaus:
Saturation Mutagenesis for Embryonic Mutants**

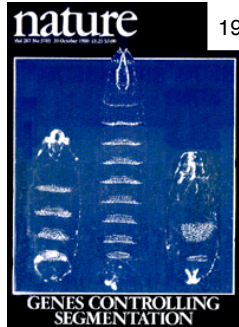
- they found some mutants with phenotypes similar to the results of Sander and Kalthoff's experiments
- the greatest overall disruption of pattern was seen in **maternal effect** mutants
 - e.g., two-tailed embryos - progeny of bicoid(-)/bicoid(-) mothers - resembled those of Kalthoff's expts destroying the "anterior organizing center"
- embryos with 'gaps' in the A-P pattern - resembling results of Sander's ligation experiments. These were zygotic mutants.

[Saturation mutagenesis - make so many mutants that you find begin to find multiple alleles of genes, and few to no new genes]

Nüsslein-Volhard & Wieschaus
Saturation Mutagenesis for Embryonic Mutants





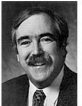
1970's



1980

 Nobelprize.org

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 F. Wieschaus
1/3 of the prize USA	1/3 of the prize Federal Republic of Germany	1/3 of the prize USA
California Institute of Technology (Caltech) Pasadena, CA, USA b. 1918 d. 2004	Max-Planck-Institut für Entwicklungsbiologie Tübingen, Federal Republic of Germany b. 1912	Princeton University Princeton, NJ, USA b. 1917

Nüsslein-Volhard & Wieschaus today

Max-Planck-Institut für Entwicklungsbiologie

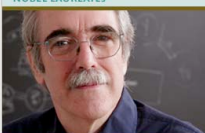


Prof. Dr. Christiane Nüsslein-Volhard

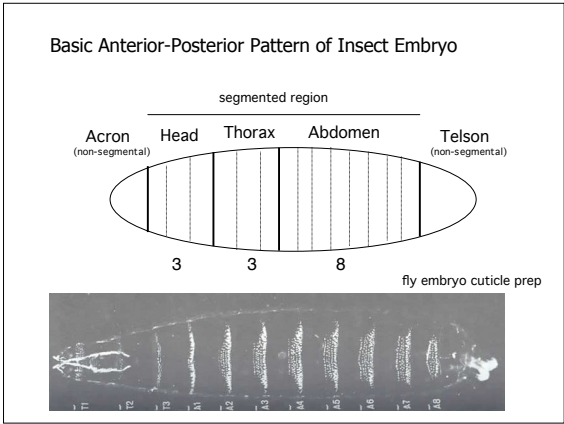
Direktorin - Abteilung 3 (Genetik)
Max-Planck-Institut für Entwicklungsbiologie
Spemannstr. 35
D-72076 Tübingen
Germany

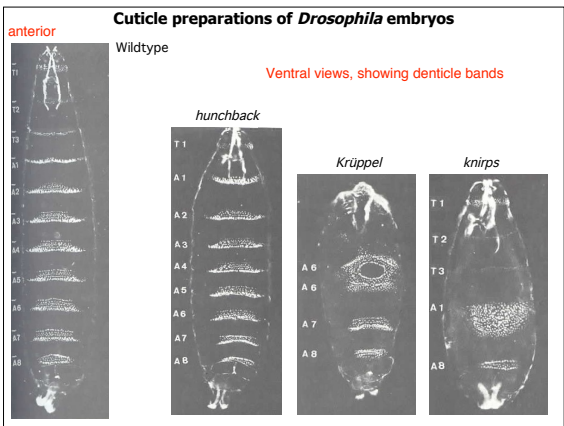
Phone: +49-70 71-601-489
Fax: +49-70 71-601-384
christiane.nueslein-volhard@tuebingen.mpg.de

NOBEL LAUREATES



Eric Wieschaus
1995 NOBEL PRIZE
IN PHYSIOLOGY OR MEDICINE





Nüsslein-Volhard & Wieschaus - Saturation Mutagenesis for Embryonic Mutants

Maternal Group

Anterior - *bicoid* (*bcd*)
 Posterior - *nanos* (*nos*)
 Terminal - *torso* (*tor*)

Nüsslein-Volhard & Wieschaus - Saturation Mutagenesis for Embryonic Mutants

Maternal Group

Anterior - *bicoid* (*bcd*)
 Posterior - *nanos* (*nos*)
 Terminal - *torso* (*tor*)

Zygotic Group

Segmentation Genes

Gap - *hunchback* (*hb*), *Krüppel*, *knirps*, *giant*, *huckebein*, *tailless*
 Pair Rule, primary - *even-skipped* (*eve*), *hairy*, *runt*
 Pair Rule, secondary - *fushi tarazu* (*ftz*), *odd-paired*, *odd-skipped*, *paired*
 Segment Polarity - *wingless*, *hedgehog*, *frizzled*, *patched*,
engrailed, *gooseberry*

Nüsslein-Volhard & Wieschaus - Saturation Mutagenesis for Embryonic Mutants

Maternal Group

Anterior - *bicoid* (*bcd*)
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 Segment Polarity - *wingless*, *hedgehog*, *frizzled*, *patched*, *engrailed*, *gooseberry*

Homeotic Selector/Segmental Identity Genes

Antennapedia complex - *lab*, *pb*, *def*, *scr*, *Antp*
Bithorax complex - *bithorax*, *abdA*, *abdB*

Figure 9.8(1) Model of Drosophila Anterior-Posterior Pattern Formation

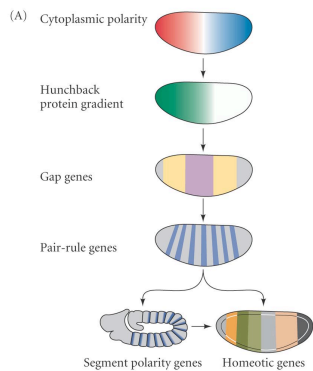


Figure 9.8(2) Model of Drosophila Anterior-Posterior Pattern Formation

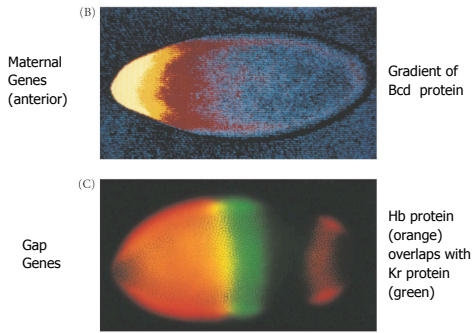


Figure 9.8(3) Model of Drosophila Anterior-Posterior Pattern Formation

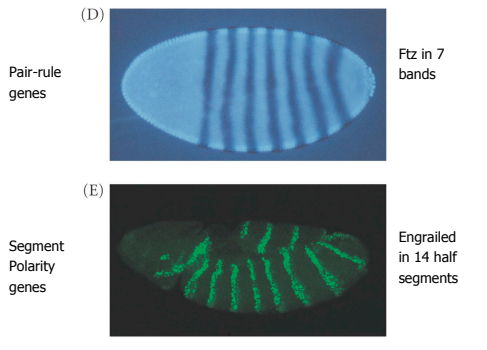


Figure 9.13 Phenotype of a Strongly Affected Embryo From a Female Fly Deficient in the Bicoid Gene

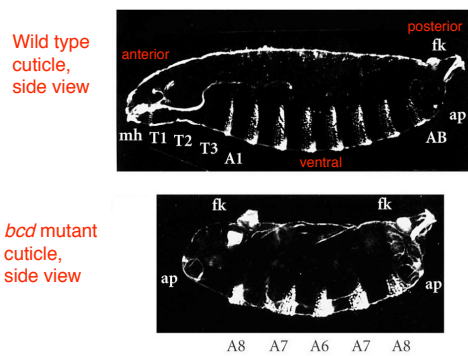
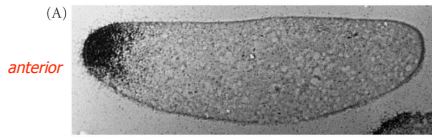


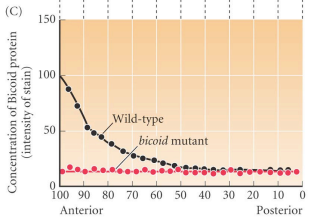
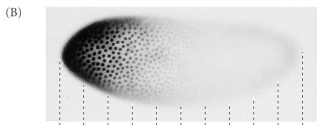
Figure 9.14(1) Gradient of Bicoid Protein in the Early Drosophila Embryo

In situ hybridization showing *bcd* mRNA



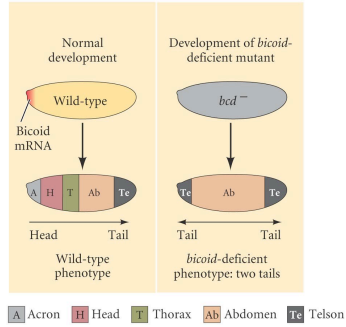
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Figure 9.14(2) Gradient of Bicoid Protein in the Early Drosophila Embryo



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Figure 9.15(1) Experiments Demonstrating That the Bicoid Gene Encodes the Morphogen Responsible for Head Structures in Drosophila



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Figure 9.15(2) Experiments Demonstrating that the Bicoid Gene Encodes the Morphogen Responsible for Head Structures in Drosophila

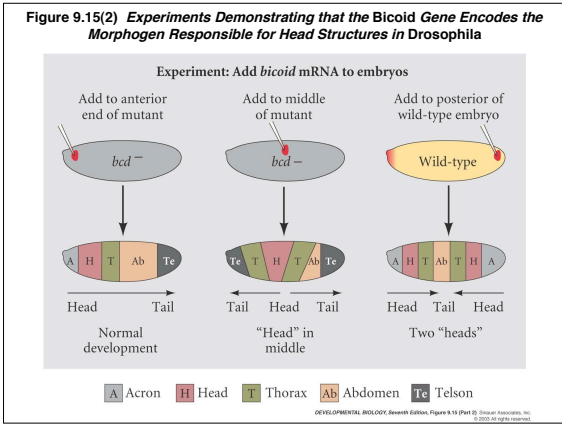


Figure 9.10(1) Three Independent Genetic Pathways Interact to Form the Anterior-Posterior Axis of the Drosophila Embryo

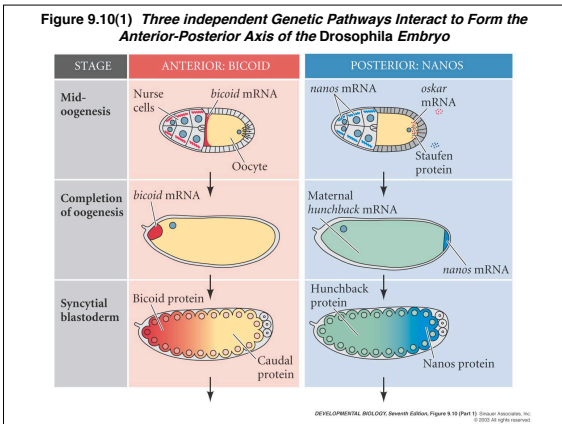


Figure 9.10(2) Three Independent Genetic Pathways Interact to Form the Anterior-Posterior Axis of the Drosophila Embryo

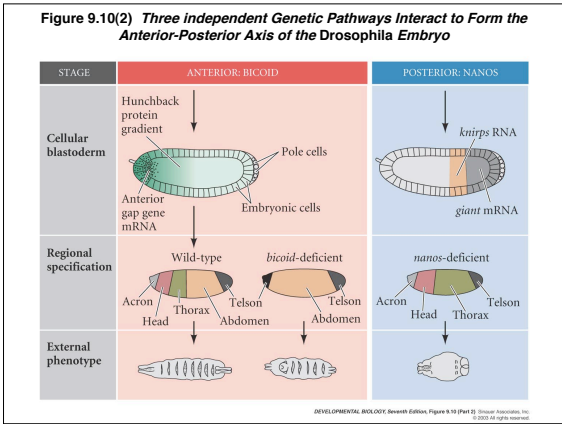
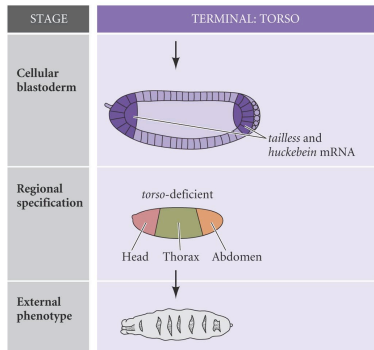
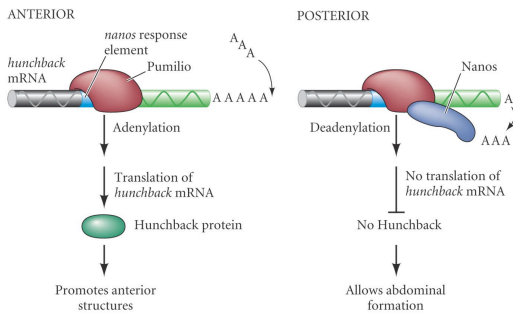


Figure 9.10(4) Three Independent Genetic Pathways Interact to Form the Anterior-Posterior Axis of the Drosophila Embryo



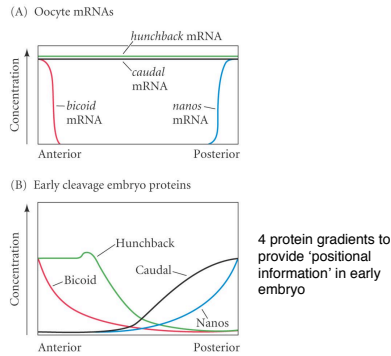
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Figure 9.17 Control of hunchback mRNA Translation by Nanos Protein



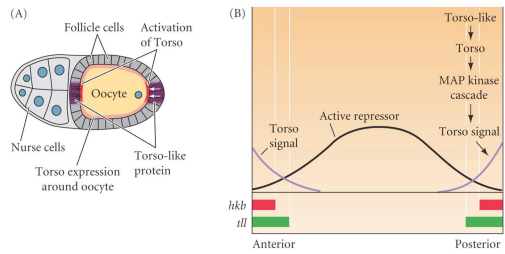
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Figure 9.12(1) Anterior-Posterior Pattern Generation by the Drosophila Maternal Effect Genes



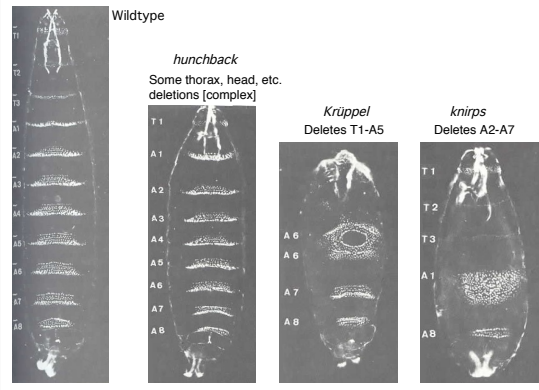
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Figure 9.18 Formation of the Unsegmented Extremities by Torso Signaling

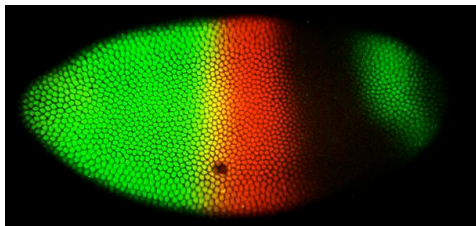


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Cuticle preparations of *Drosophila* embryos - Gap mutants

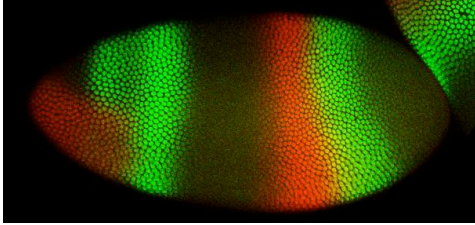


***Drosophila* Gap gene expression patterns**



Hunchback (green) and *Krüppel* (red)

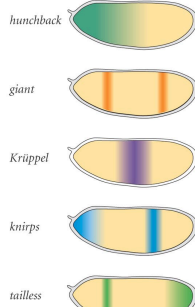
Drosophila Gap gene expression patterns



giant (green) and *knirps* (red) - note the central dark band (Krüppel)

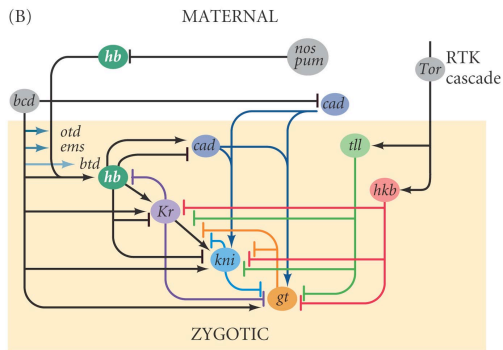
Figure 9.22(1) Conversion of Maternal Protein Gradients into Zygotic Gap Gene Expression

(A) Expression of the gap genes

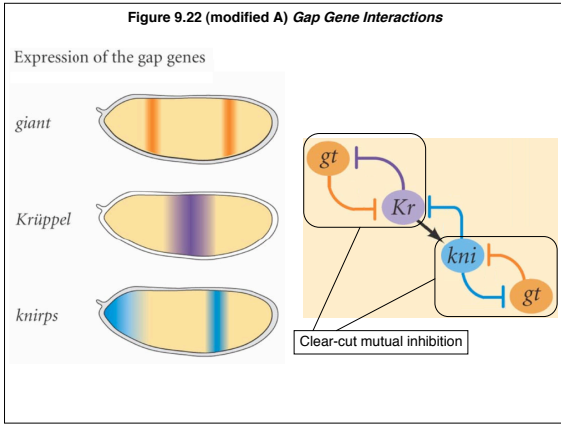


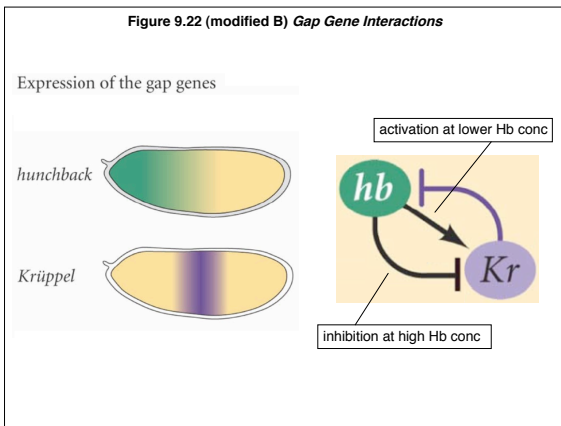
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Figure 9.22(2) Conversion of Maternal Protein Gradients into Zygotic Gap Gene Expression



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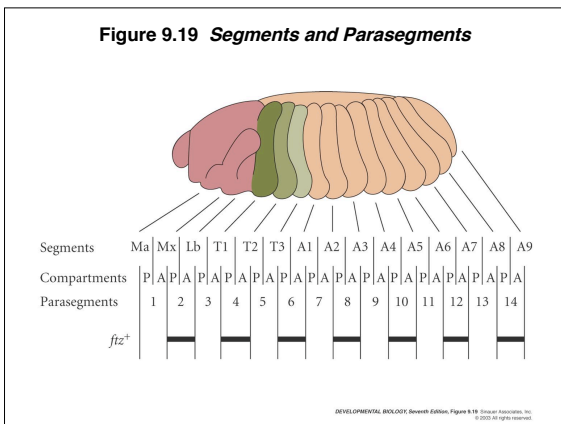


Figure 9.20(1) Three Types of Segmentation Gene Mutations

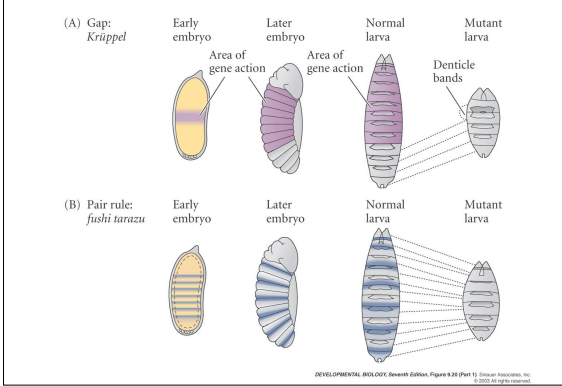


Figure 9.20(2) Three Types of Segmentation Gene Mutations

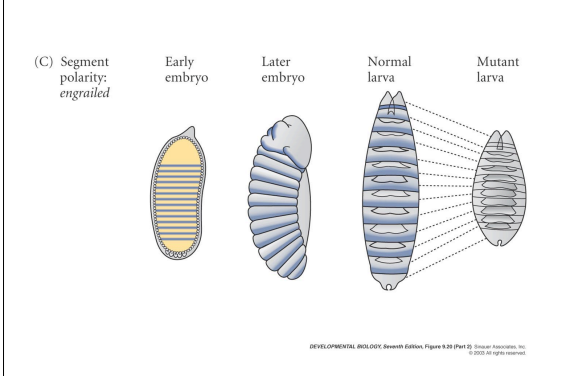


Figure 9.21(1) Defects Seen in the Fushi Tarazu Mutant

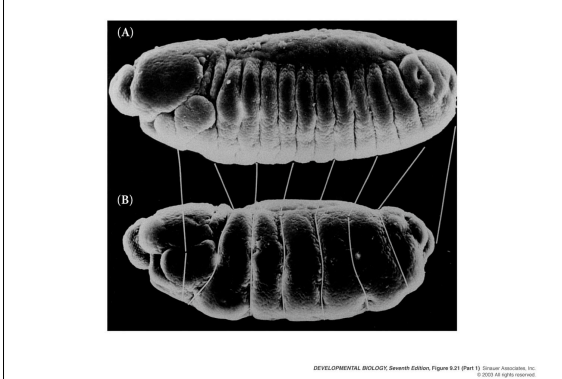


Figure 9.24(1) Hypothesis for the formation of the Second Stripe of Transcription from the even-skipped Gene

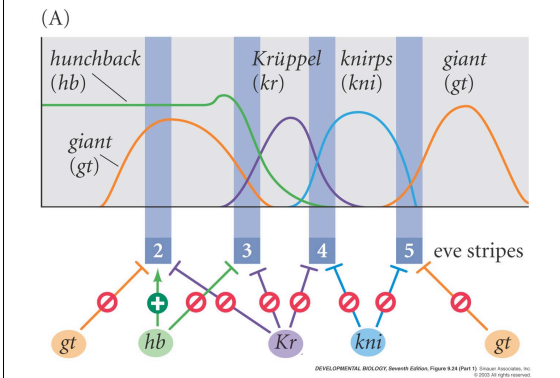
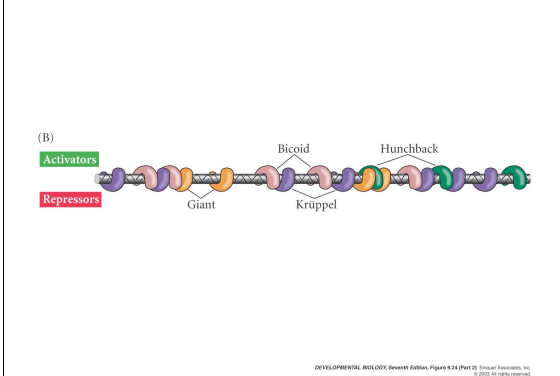


Figure 9.24(2) Hypothesis for the Formation of the Second Stripe of Transcription from the even-skipped Gene



Segment polarity genes take over from maternal, gap and pair-rule genes

Segment polarity genes act in cells, not in syncytium.

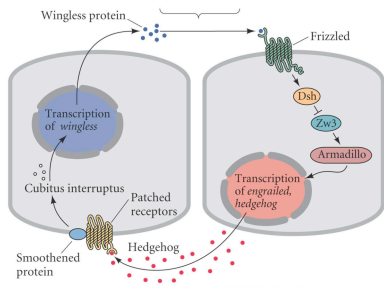
Expression of early patterning genes is transient.

Segment polarity genes turn on to maintain integrity of established pattern.

Some segment polarity genes remain on throughout life of organism to maintain segmental pattern.

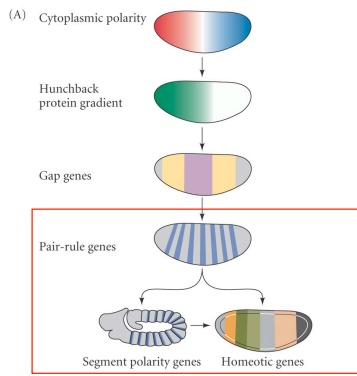
Interactions among cells within the segment are key to the intrasegmental A-P pattern.

Figure 9.26(3) Model for Transcription of Segment Polarity Genes engrailed (en) and wingless (wg)



Hedgehog signaling pathway Wnt signaling pathway

Figure 9.8(1) Model of Drosophila Anterior-Posterior Pattern Formation



Bateson quotation

I therefore propose ... the term *Homoësis* ...
for the essential phenomenon is not that there
has merely been a change, but that something
has been changed into the likeness of
something else.

William Bateson, 1894
in *Materials for the Study of Variation*

Figure 9.30 (a) Head of a Wild-type Fruit Fly. (B) Head of a Fly Containing the Antennapedia Mutation

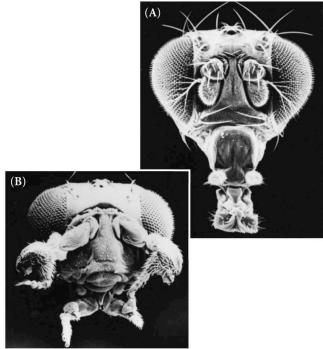
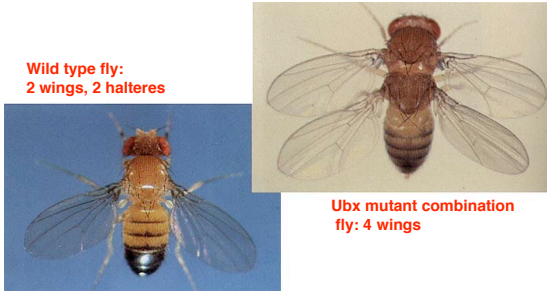


Figure 9.29 A Four-winged Fruit Fly Constructed by Putting Together Three Mutations in cis Regulators of the Ultrabithorax Gene

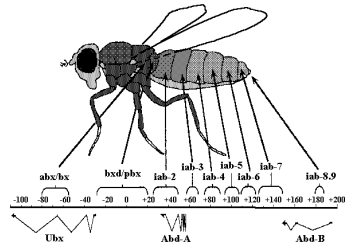
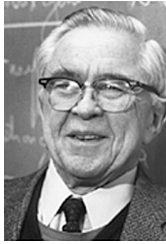


Another homeotic mutant

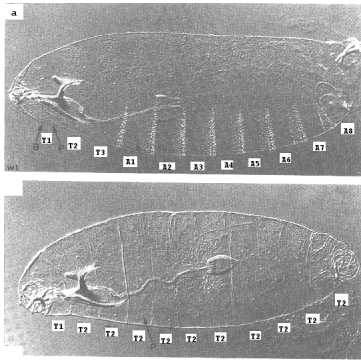


Proboscipedia?

Ed Lewis and the Bithorax complex



Complete Deletion of the Bithorax complex



Homeotic Selector/Segmental Identity Genes

Antennapedia complex - lab, pb, def, scr, Antp

Bithorax complex - Ubx, abdA, abdB

can be viewed as a single homeotic gene complex (HOM-C)

Figure 9.28 Homeotic Gene Expression in Drosophila

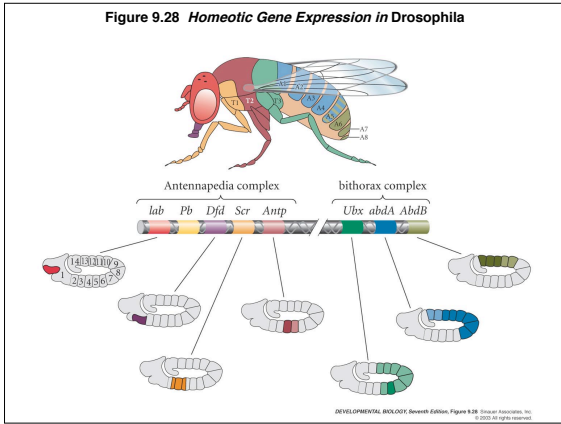


Figure 9.33(1) Homeodomain-DNA Interactions

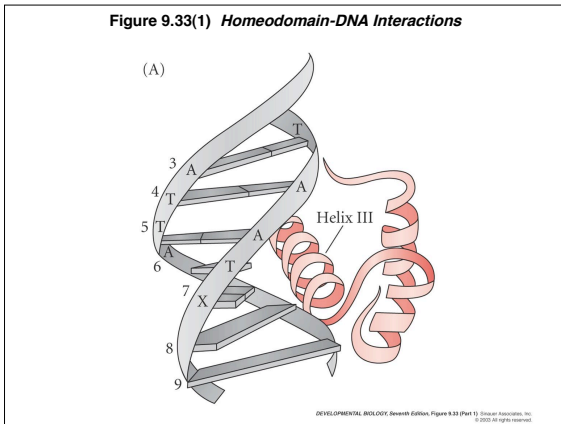


TABLE 9.1 Maternal effect genes that effect the anterior-posterior polarity of the Drosophila embryo

Gene	Mutant phenotype	Proposed function and structure
ANTERIOR GROUP		
<i>bicoid</i> (<i>bcd</i>)	Head and thorax deleted, replaced by inverted telon	Graded anterior morphogen; contains homeodomain; represses caudal
<i>crumpled</i> (<i>cxu</i>)	Anterior head structures deleted	Anchors <i>bicoid</i> mRNA
<i>swallow</i> (<i>swt</i>)	Anterior head structures deleted	Anchors <i>bicoid</i> mRNA
POSTERIOR GROUP		
<i>nanos</i> (<i>nos</i>)	No abdomen	Posterior morphogen; represses <i>hunchback</i> mRNA
<i>nanor</i> (<i>nan</i>)	No abdomen, no pole cells	Localization of Nanos protein
<i>oskar</i> (<i>osk</i>)	No abdomen, no pole cells	Localization of Nanos protein
<i>vasa</i> (<i>vas</i>)	No abdomen, no pole cells; oogenesis defective	Localization of Nanos protein
<i>valois</i> (<i>val</i>)	No abdomen, no pole cells; cellularization defective	Stabilization of the Nanos localization complex
<i>pumilio</i> (<i>pum</i>)	No abdomen	Helps Nanos protein bind <i>hunchback</i> message
<i>caudal</i> (<i>cad</i>)	No abdomen	Activates posterior terminal genes
TERMINAL GROUP		
<i>torso</i> (<i>tor</i>)	No termini	Possible morphogen for termini
<i>trunk</i> (<i>trk</i>)	No termini	Transmits Torso-like signal to Torso
<i>fs(1)Nasat1/fs(1)N</i>	No termini; collapsed eggs	Transmits Torso-like signal to Torso
<i>fs(1)pedestal/fs(1)pb</i>	No termini; collapsed eggs	Transmits Torso-like signal to Torso

Source: After Anderson 1989.

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TABLE 9.2 Major genes affecting segmentation pattern in *Drosophila*

Category	Gene name
Gap genes	<i>Krüppel (Kr)</i> , <i>knirps (kni)</i> , <i>hunchback (hb)</i> , <i>giant (gt)</i> , <i>tailless (tll)</i> , <i>huckebein (hkb)</i> , <i>buttonhead (btD)</i> , <i>empty spiracles (ems)</i> , <i>orthodenticle (otd)</i>
Pair-rule genes Primary	<i>hairy (h)</i> , <i>even-skipped (eve)</i> , <i>runt (run)</i>
Pair-rule genes Secondary	<i>fushi tarazu (ftz)</i> , <i>odd-paired (opa)</i> , <i>odd-skipped (odd)</i> , <i>sloppy-paired (slp)</i> , <i>paired (prd)</i>
Segment polarity genes	<i>engrailed (en)</i> , <i>wingless (wgl)</i> , <i>cubitus interruptusD (cid)</i> , <i>hedgehog (hh)</i> , <i>fused (fu)</i> , <i>armadillo (arm)</i> , <i>patched (ptc)</i> , <i>gooseberry (gsb)</i> , <i>pangolin (pan)</i>

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