

# BE/APH161 – PHYSICAL BIOLOGY OF THE CELL

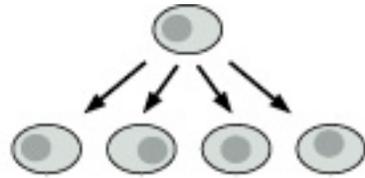
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California Institute of Technology

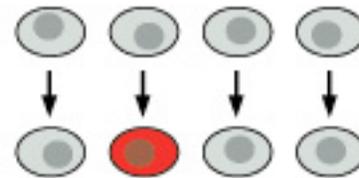
# PATTERNING DURING DEVELOPMENT: SPACETIME GENE EXPRESSION



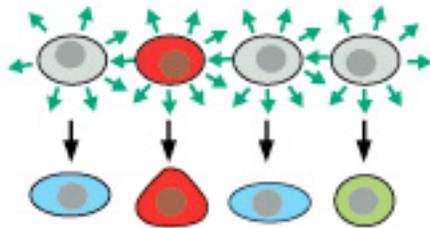
# BUILDING A MULTICELLULAR ORGANISM



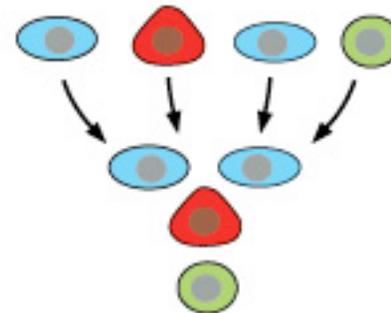
CELL PROLIFERATION



CELL SPECIALIZATION



CELL INTERACTION



CELL MOVEMENT

Figure 21-1. Molecular Biology of the Cell, 4th Edition.

# CHANGES IN THE REGULATORY LANDSCAPE: AN EVOLUTIONARY VIEW

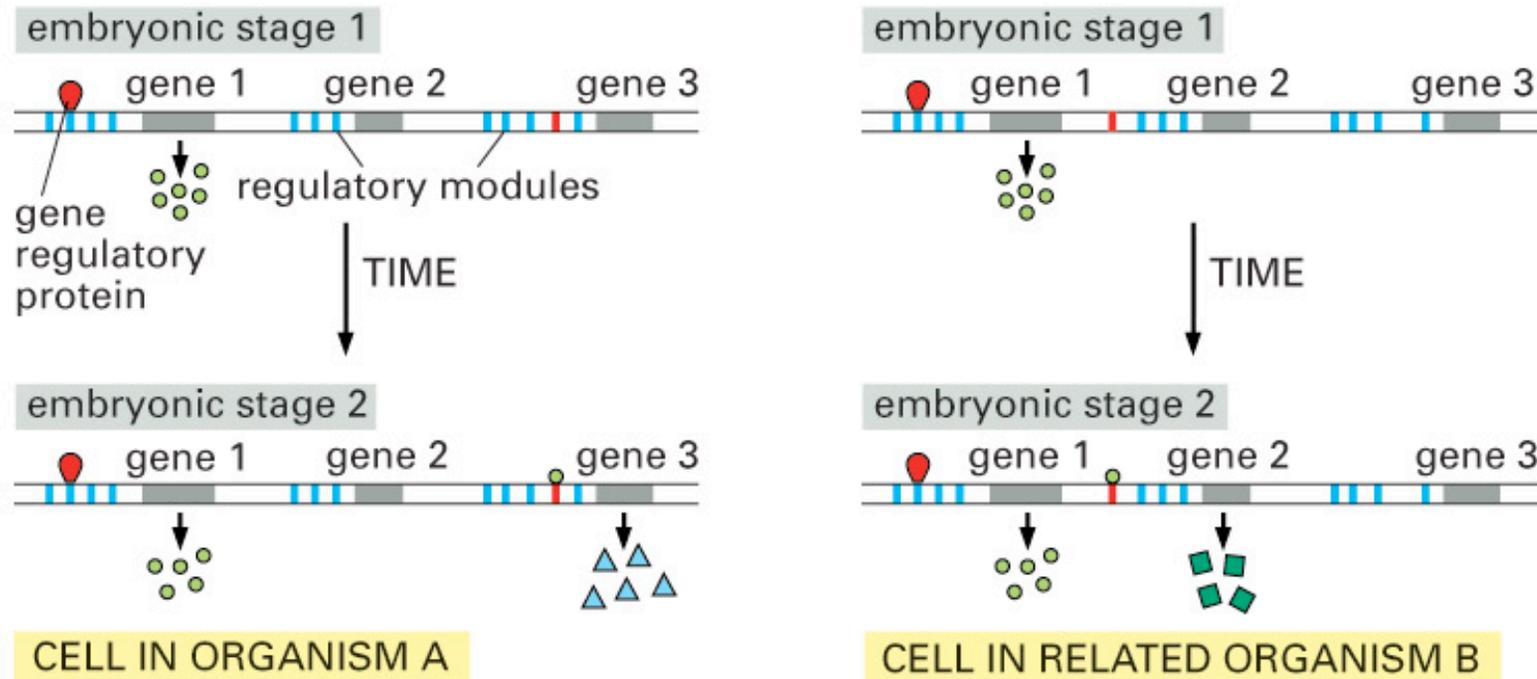


Figure 21–4. Molecular Biology of the Cell, 4th Edition.

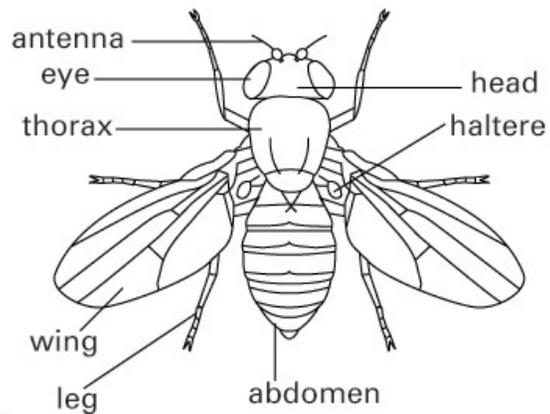
Figure 21–4 How regulatory DNA defines the succession of gene expression patterns in development.

The genomes of organisms A and B code for the same set of proteins but have different regulatory DNA. The two cells in the cartoon start in the same state, expressing the same proteins at stage 1, but step to quite different states at stage 2 because of their different arrangements of regulatory modules.

# FLIES AND THEIR DEVELOPMENT



(A)



(B)

Figure 21-23. Molecular Biology of the Cell, 4th Edition.

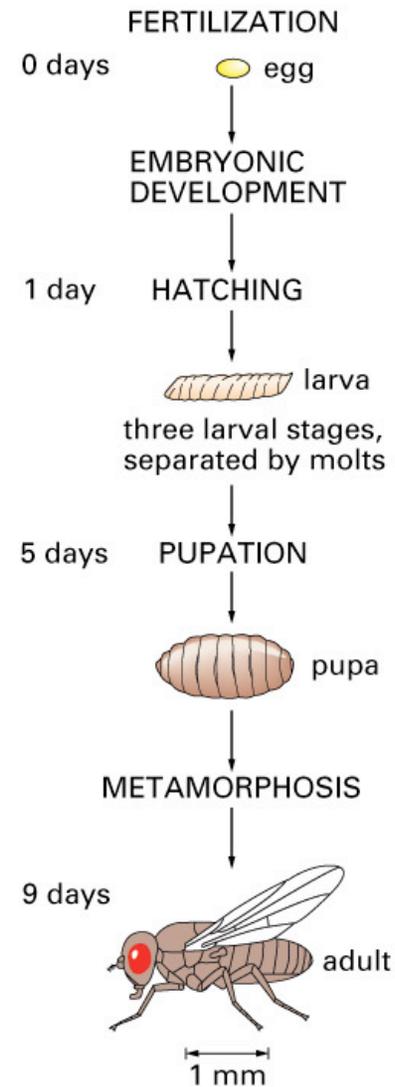
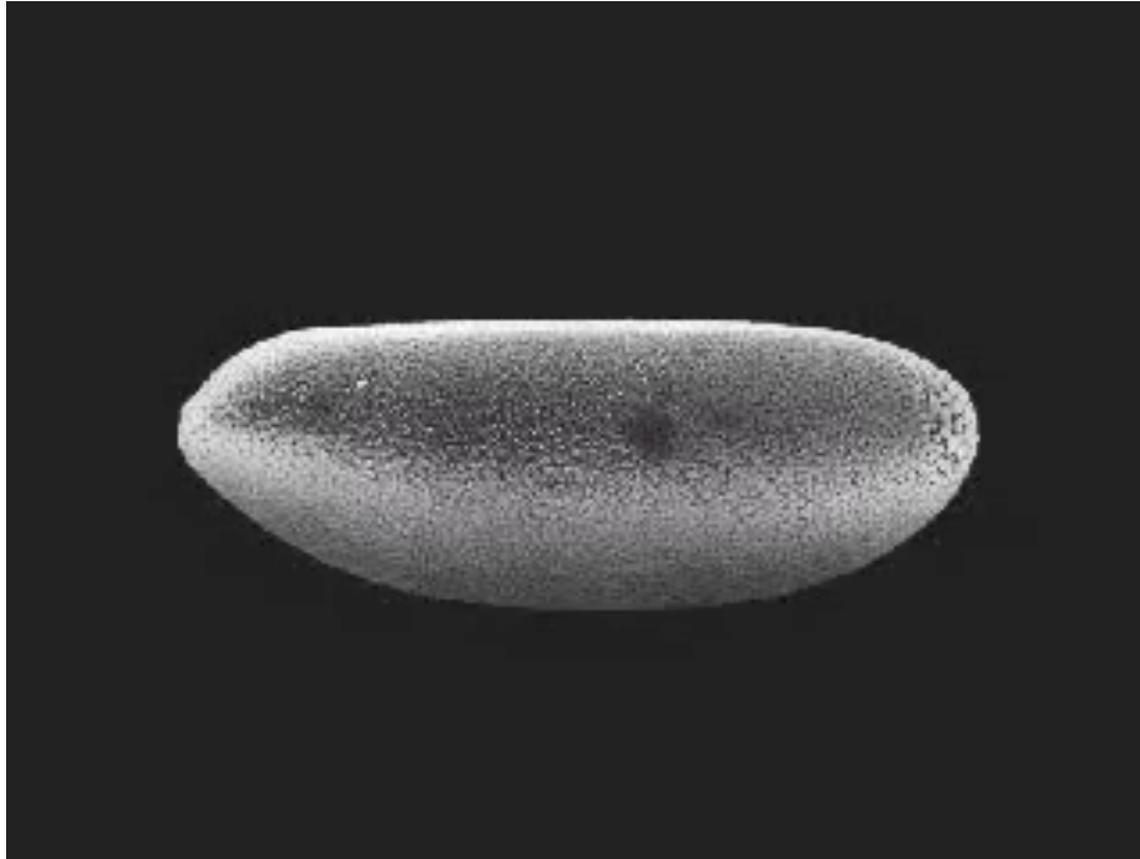


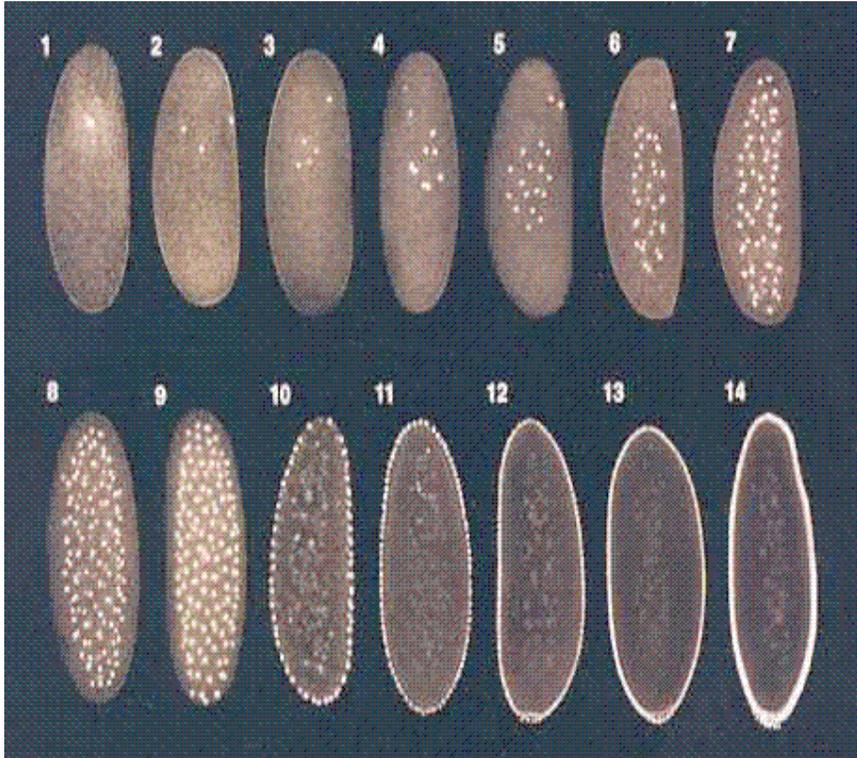
Figure 21-24. Molecular Biology of the Cell, 4th Edition.

# FLY DEVELOPMENT

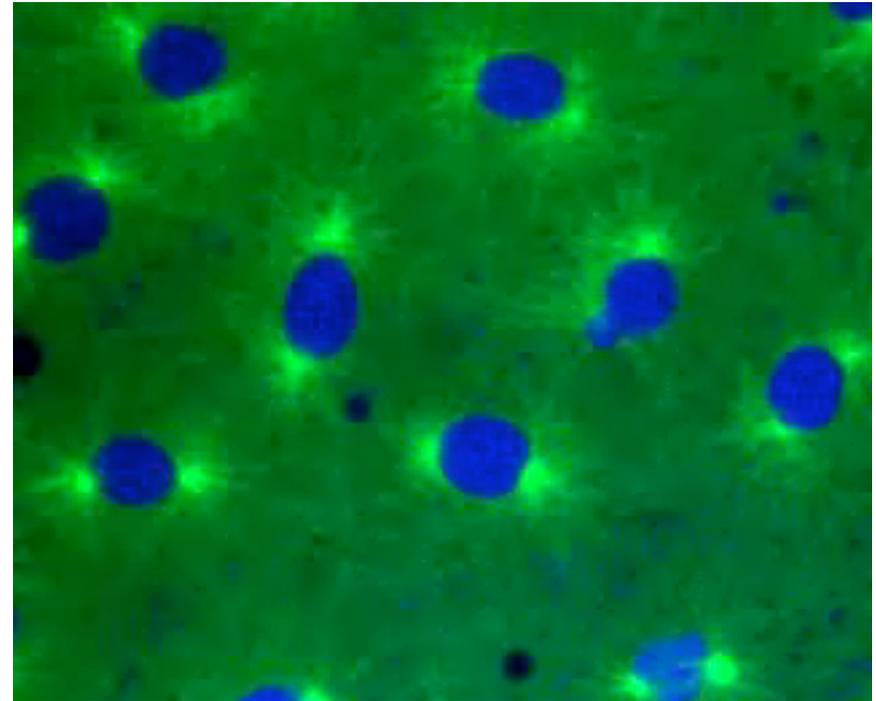


# FLY EARLY EMBRYO

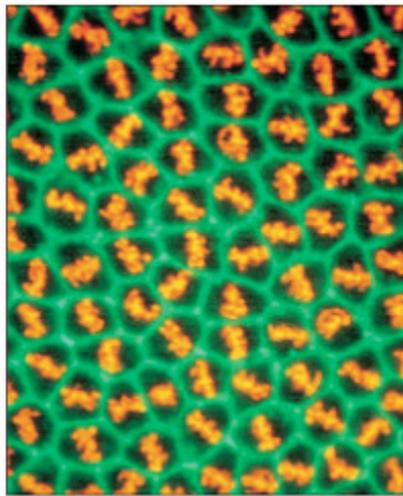
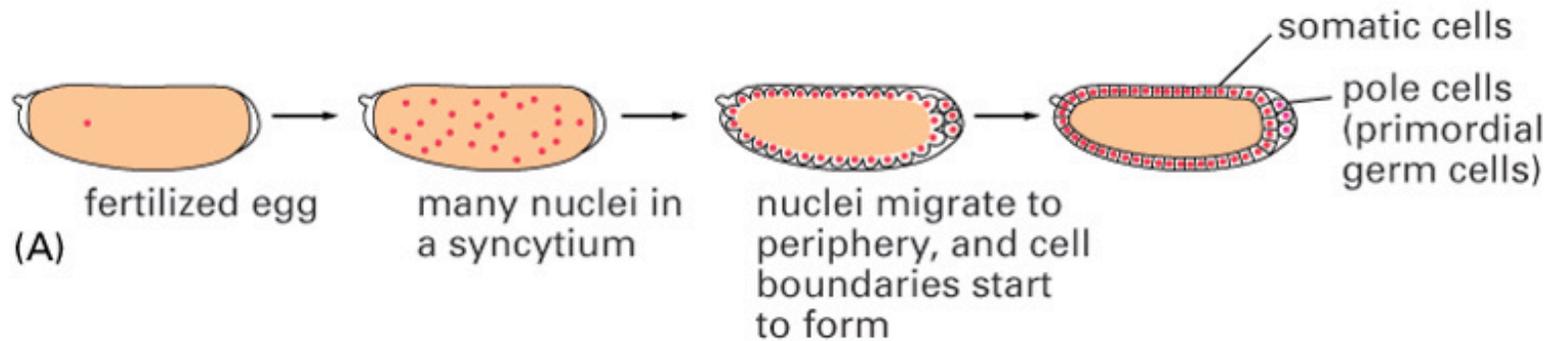
Development in a box!



Doubling time = 8min



# FLY EARLY EMBRYO



(B)

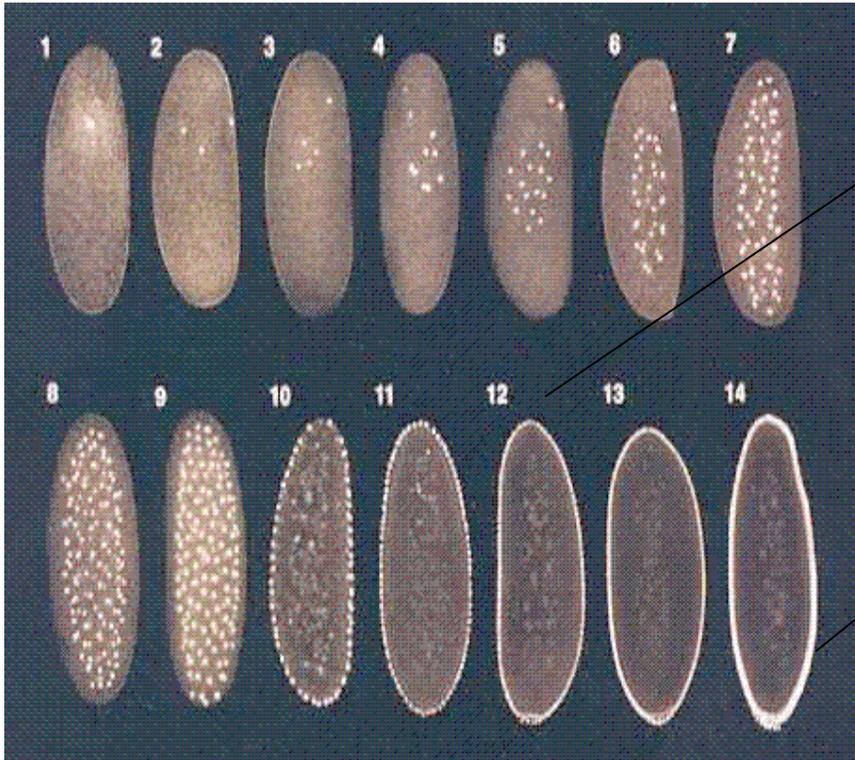
Figure 21–27. Molecular Biology of the Cell, 4th Edition.

Figure 21–27 Development of the *Drosophila* egg from fertilization to the cellular blastoderm stage.

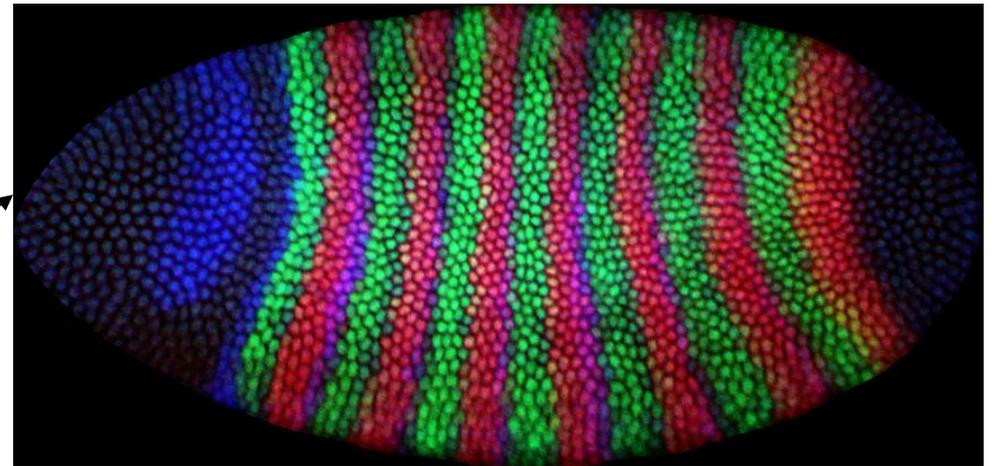
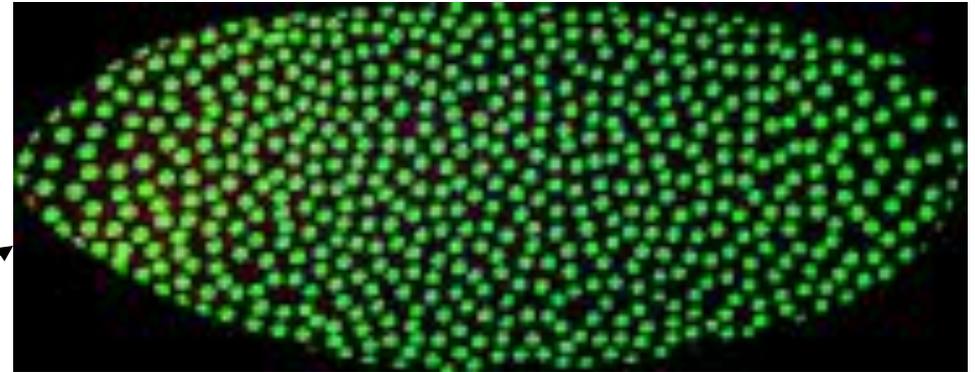
(A) Schematic drawings. (B) Surface view—an optical-section photograph of blastoderm nuclei undergoing mitosis at the transition from the syncytial to the cellular blastoderm stage. Actin is stained green, chromosomes orange. (A, after H.A. Schneiderman, in *Insect Development* [P.A. Lawrence, ed.], pp. 3–34. Oxford, UK: Blackwell, 1976; B, courtesy of William Sullivan.)

# FLY EARLY EMBRYO

Development in a box!



Doubling time = 8min



How are these spatial patterns of gene expression established?

# FLY EARLY EMBRYO

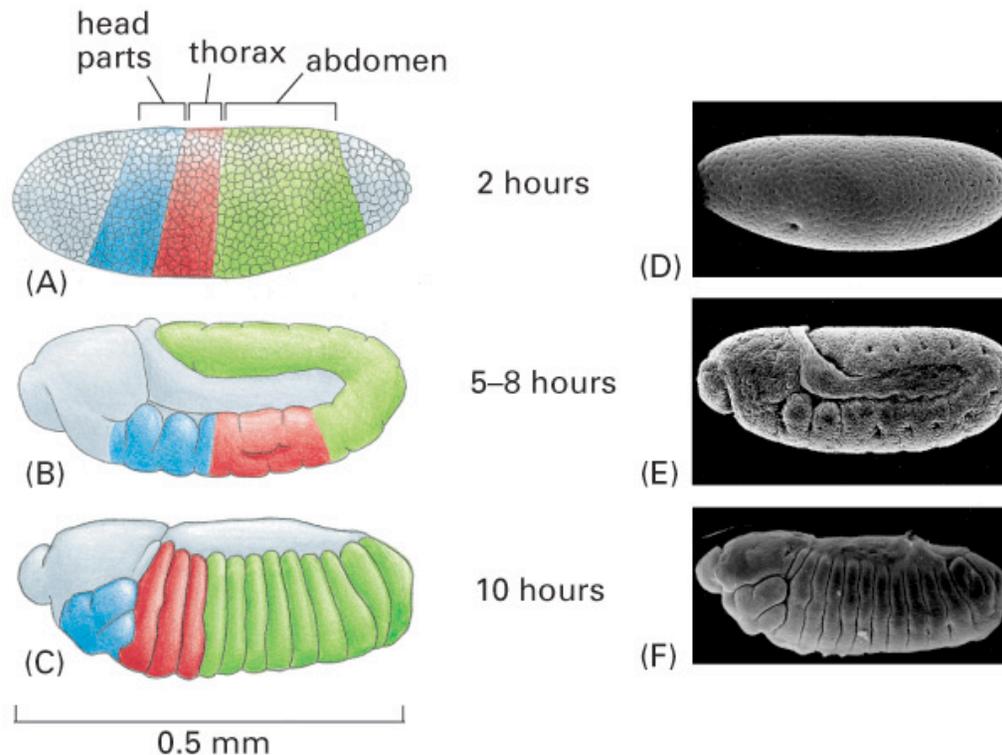


Figure 21-25. Molecular Biology of the Cell, 4th Edition.

Figure 21-25 The origins of the *Drosophila* body segments during embryonic development.

The embryos are seen in side view in drawings (A–C) and corresponding scanning electron micrographs (D–F). (A and D) At 2 hours the embryo is at the syncytial blastoderm stage (see Figure 21-51) and no segmentation is visible, although a fate map can be drawn showing the future segmented regions (color in A). (B and E) At 5–8 hours the embryo is at the extended germ band stage: gastrulation has occurred, segmentation has begun to be visible, and the segmented axis of the body has lengthened, curving back on itself at the tail end so as to fit into the egg shell. (C and F) At 10 hours the body axis has contracted and become straight again, and all the segments are clearly defined. The head structures, visible externally at this stage, will subsequently become tucked into the interior of the larva, to emerge again only when the larva goes through pupation to become an adult. (D and E, courtesy of F.R. Turner and A.P. Mahowald, *Dev. Biol.* 50:95–108, 1976. © Academic Press; F, from J.P. Petschek, N. Perrimon, and A.P. Mahowald, *Dev. Biol.* 119:175–189, 1987. © Academic Press.)

# FLY EMBRYO BY THE NUMBERS

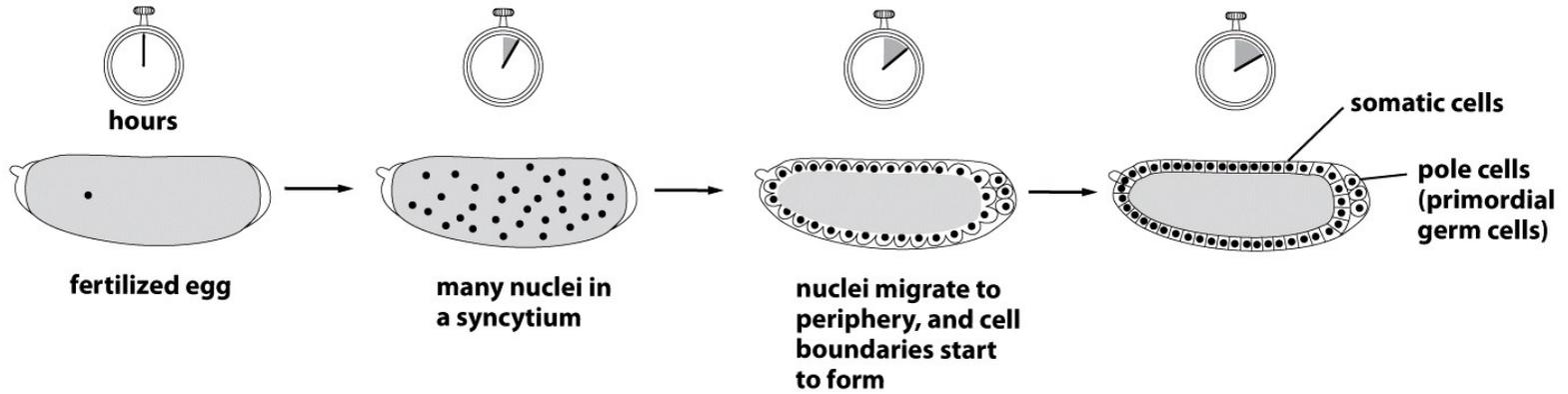


Figure 3.22 Physical Biology of the Cell (© Garland Science 2009)

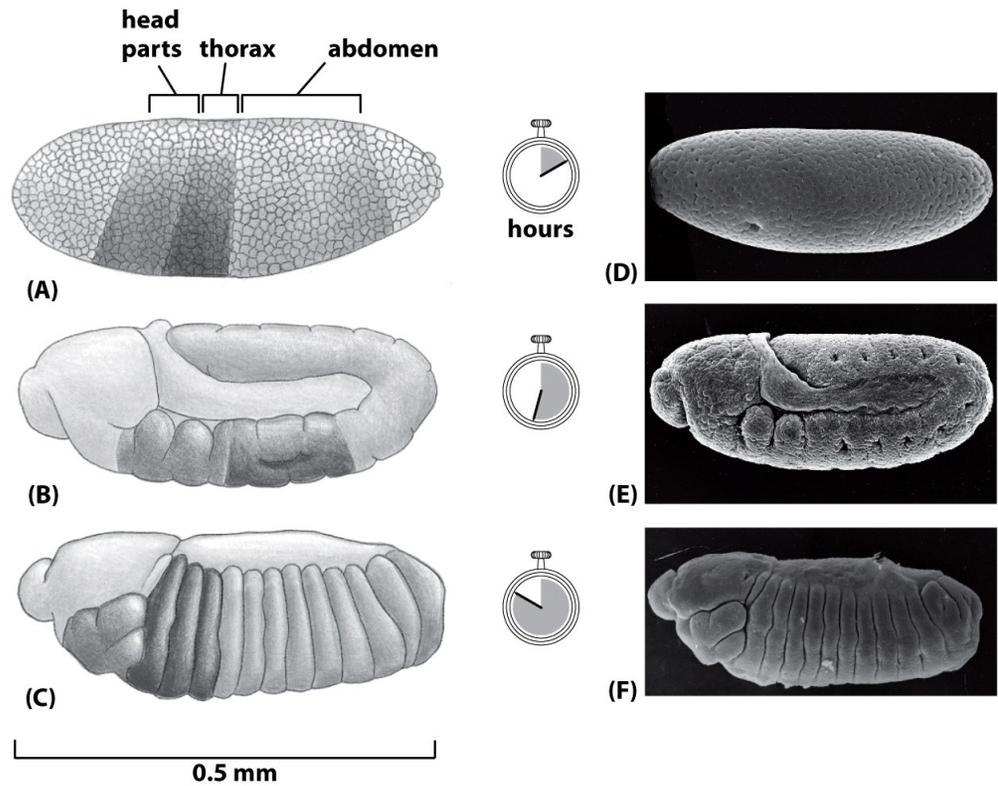


Figure 3.23 Physical Biology of the Cell (© Garland Science 2009)

# SETTING UP POSITIONAL INFORMATION

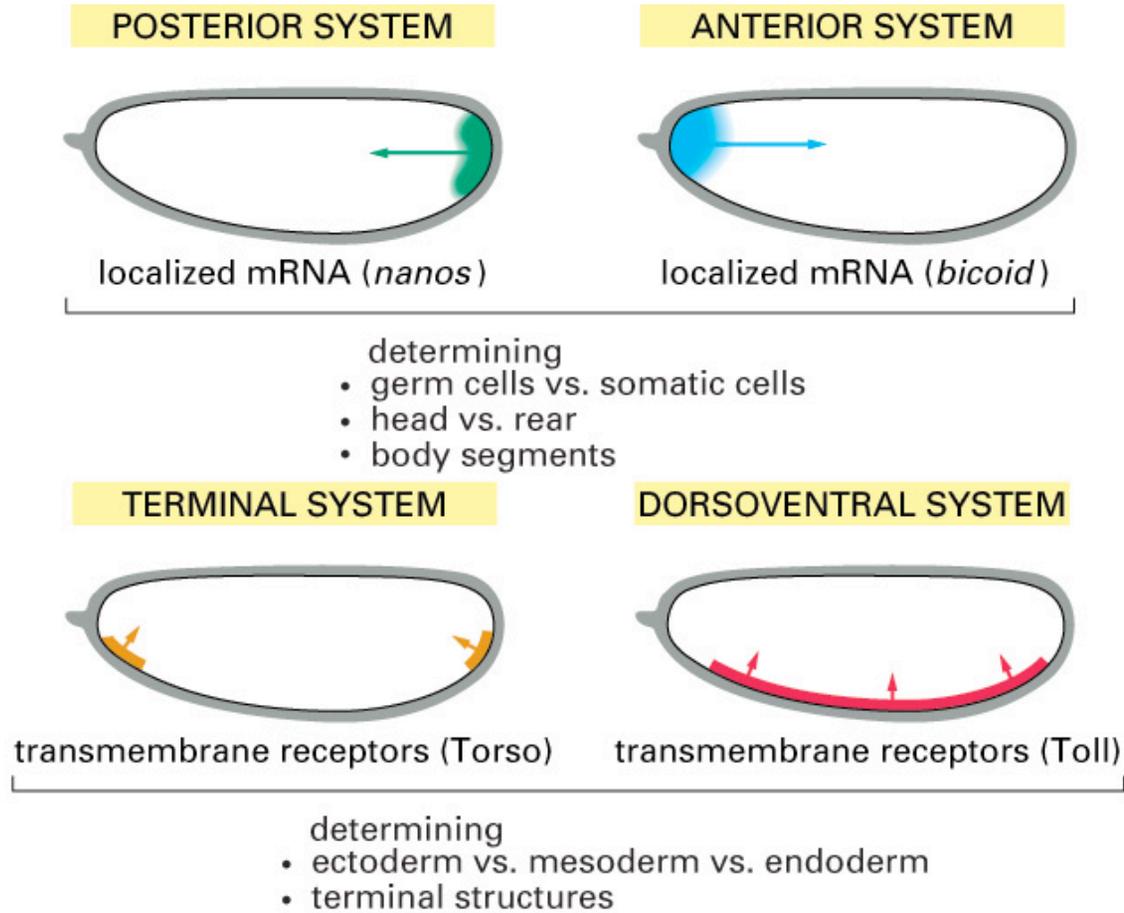


Figure 21-31. Molecular Biology of the Cell, 4th Edition.

# KEY REGULATORY PROTEINS AND THEIR GRADIENTS

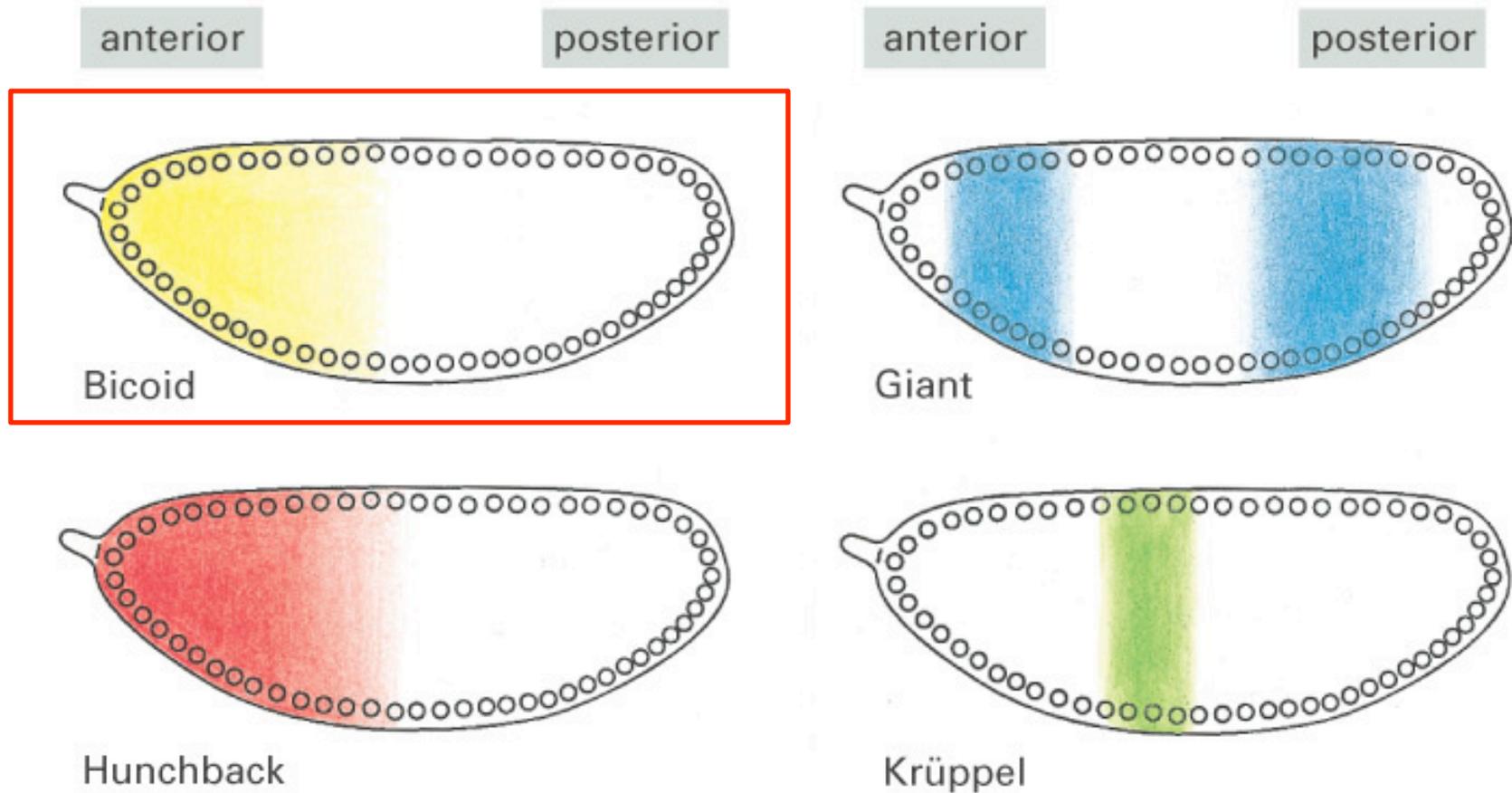
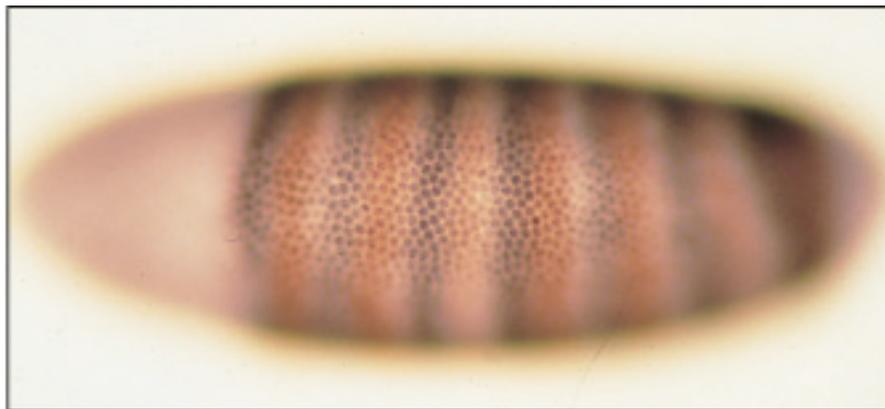
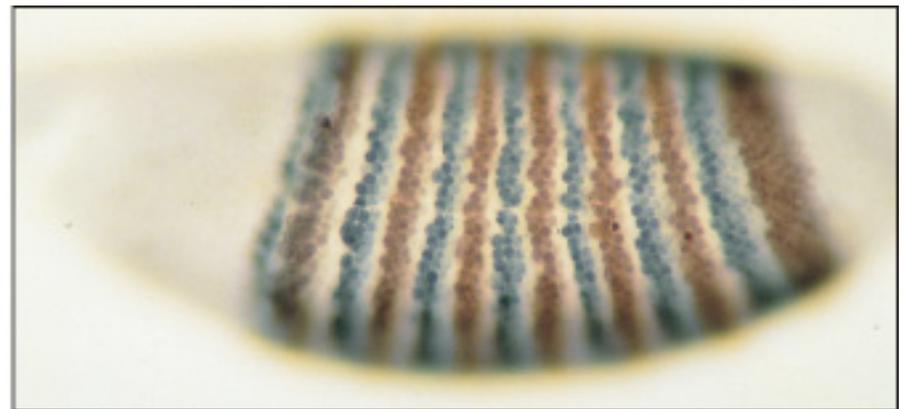


Figure 8-17 Essential Cell Biology, 2/e. (© 2004 Garland Science)

# PATTERNS OF GENE EXPRESSION ON THE ANTERIOR-POSTERIOR AXIS



2.7 hours after fertilization



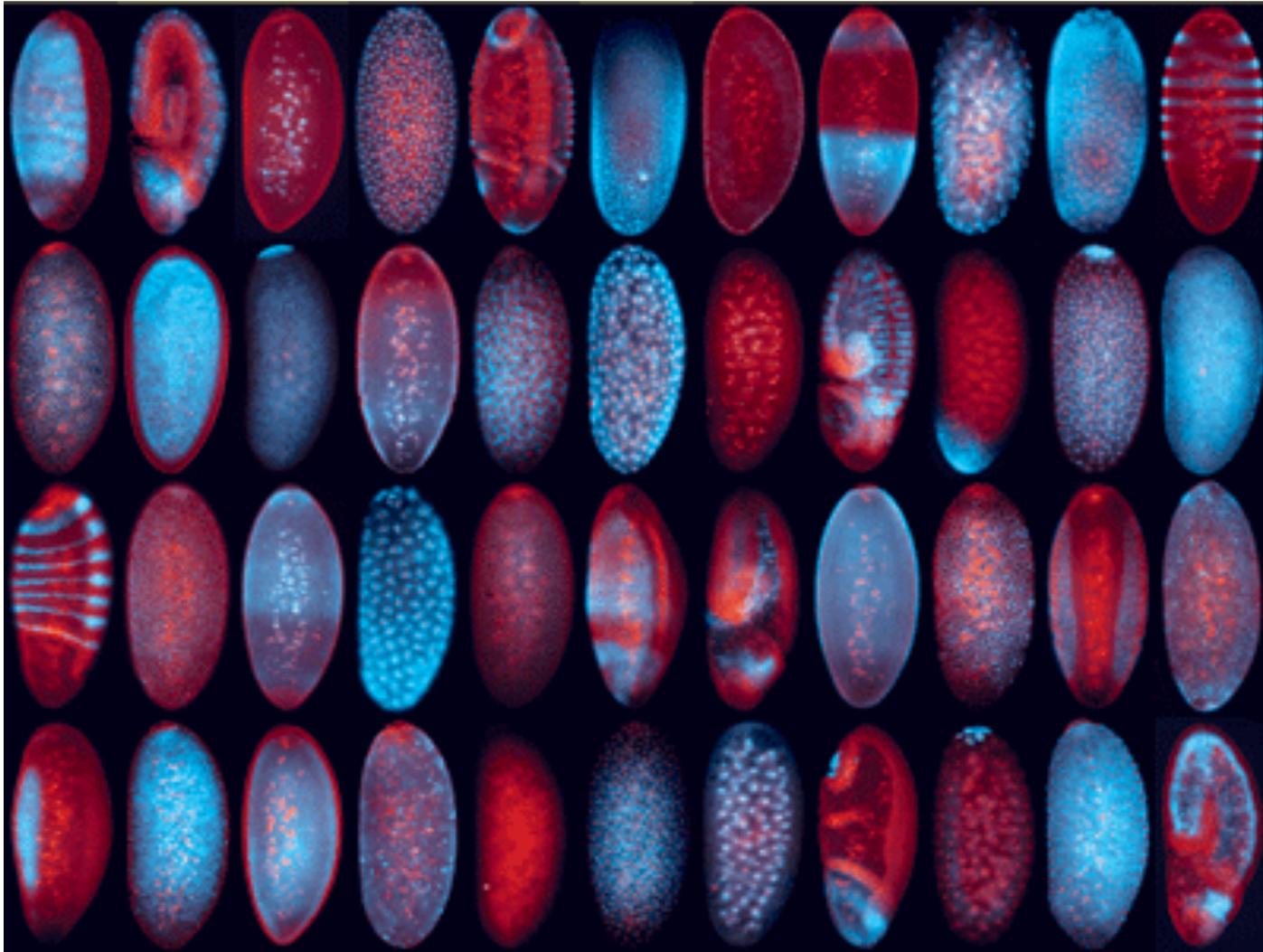
3.5 hours after fertilization

Figure 21–39. Molecular Biology of the Cell, 4th Edition.

Figure 21–39 The formation of ftz and eve stripes in the *Drosophila* blastoderm.

ftz and eve are both pair-rule genes. Their expression patterns (shown in brown for ftz and in gray for eve) are at first blurred but rapidly resolve into sharply defined stripes. (From P.A. Lawrence, *The Making of a Fly*. Oxford, UK: Blackwell, 1992.)

# MEASURING PATTERNS OF GENE EXPRESSION DURING FLY DEVELOPMENT



<http://fly-fish.cabr.utoronto.ca/>

# SETTING UP POSITIONAL INFORMATION: ANTERIOR-POSTERIOR AXIS

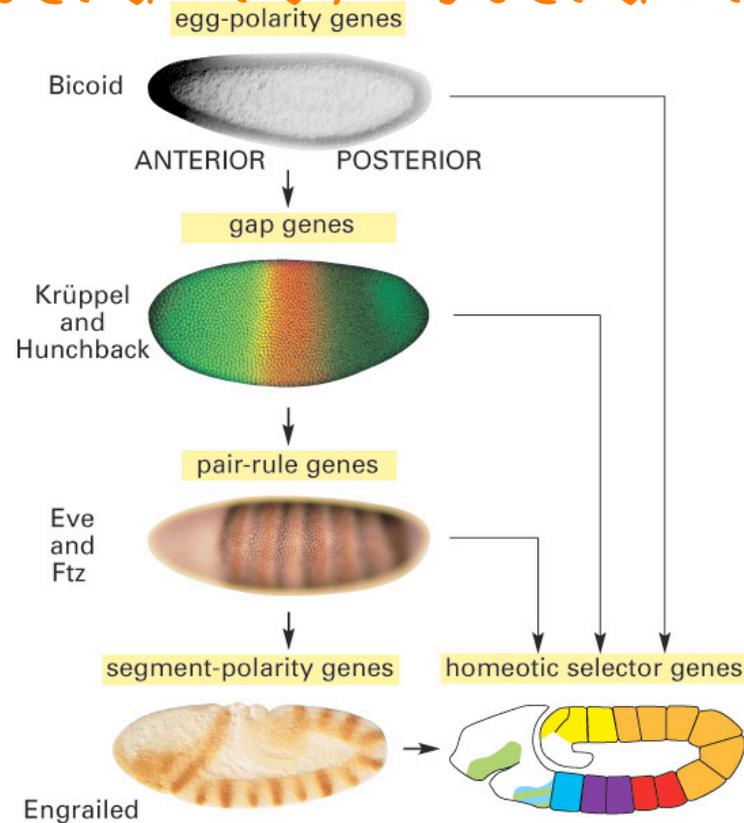


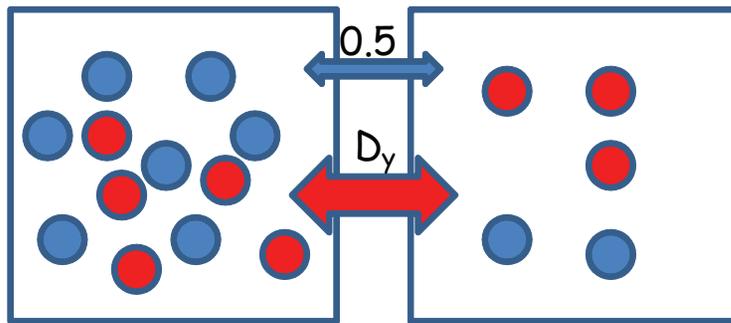
Figure 21–37. Molecular Biology of the Cell, 4th Edition.

Figure 21–37 The regulatory hierarchy of egg- polarity, gap, segmentation, and homeotic selector genes.

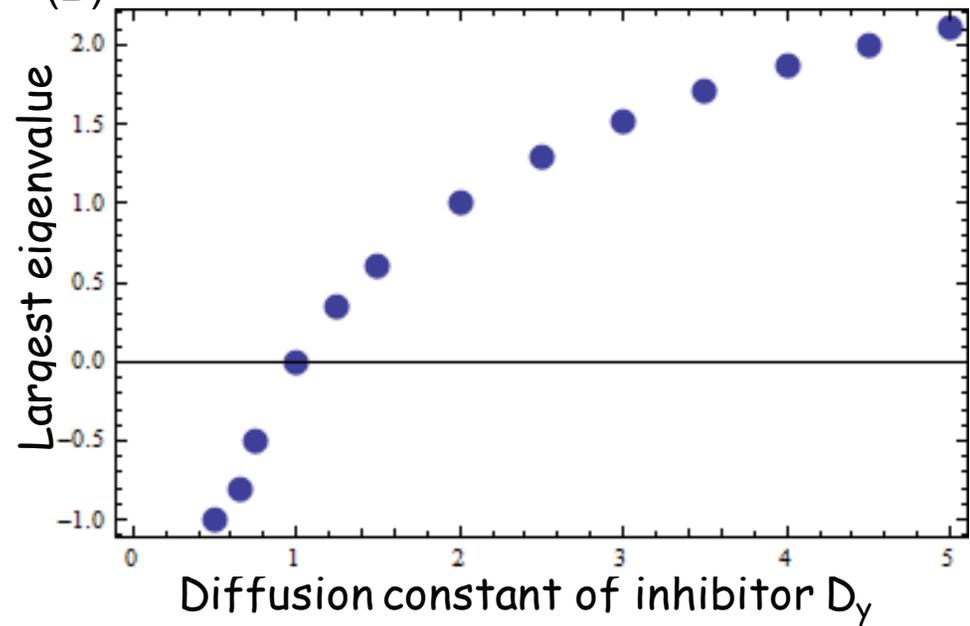
The photographs show expression patterns of representative examples of genes in each category, revealed by staining with antibodies against the protein products. The homeotic selector genes, discussed below, define the lasting differences between one segment and the next. (Photographs (i) from W. Driever and C. Nüsslein-Volhard, *Cell* 54:83–104, 1988. © Elsevier; (ii) courtesy of Jim Langeland, Steve Paddock, Sean Carroll, and the Howard Hughes Medical Institute; (iii) from P.A. Lawrence, *The Making of a Fly*. Oxford, UK: Blackwell, 1992; (iv) from C. Hama, Z. Ali, and T.B. Kornberg, *Genes Dev.* 4:1079–1093, 1990. © Cold Spring Harbor Press.)

# TURING MODEL TWO CELL MODEL

(A)

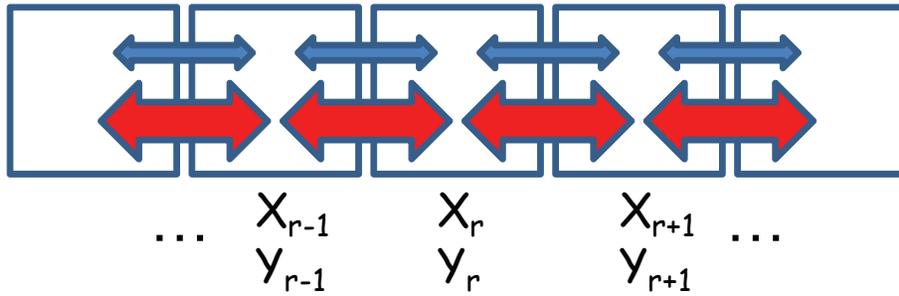


(B)



# TURING WAVES

(A)



(B)

