Evolutionary Developmental Biology
Ecological Developmental Biology

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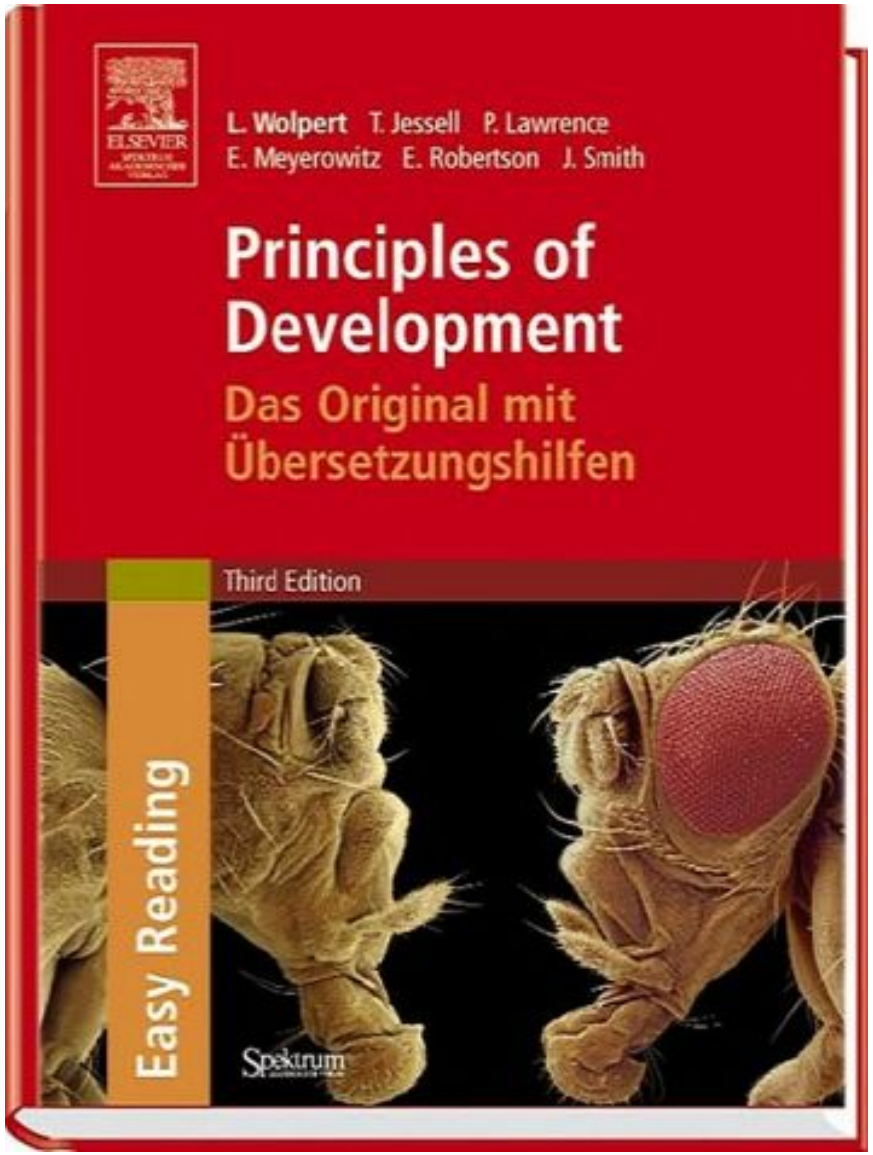
Ernst-Caspari-Haus, Justus-von-Liebig-Weg 11

Evolutionary Developmental Biology

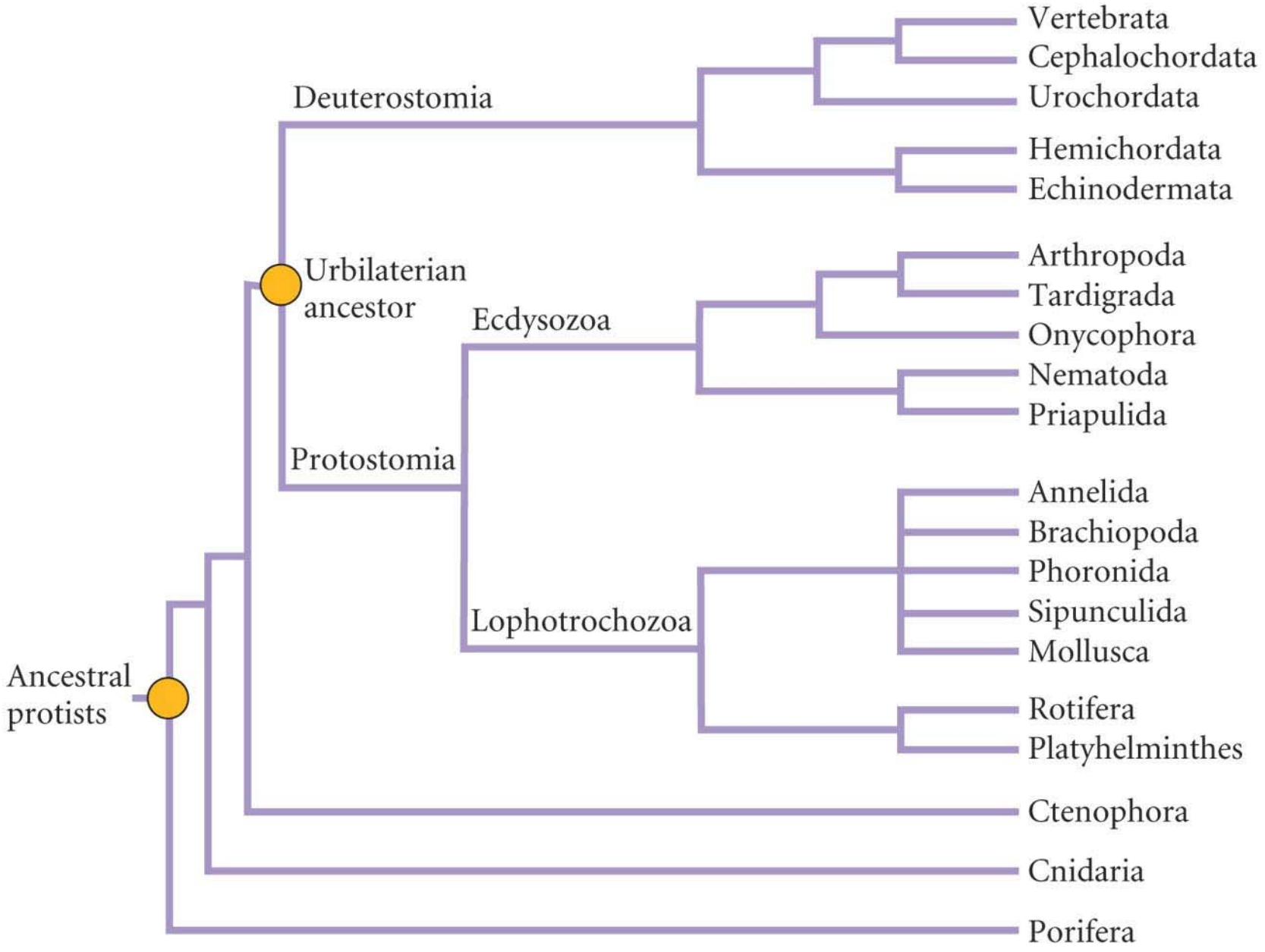
Chapter 14



Evolutionary Developmental Biology

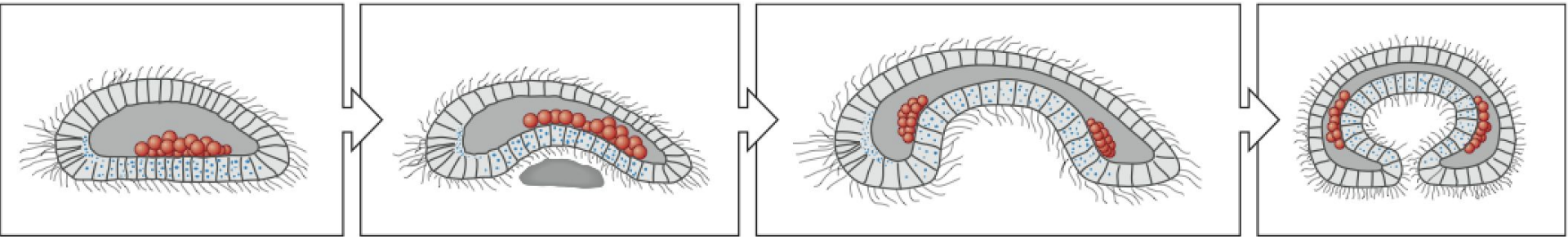
Human Opossum Chicken Salamander (axolotl) Fish (gar)

(A)



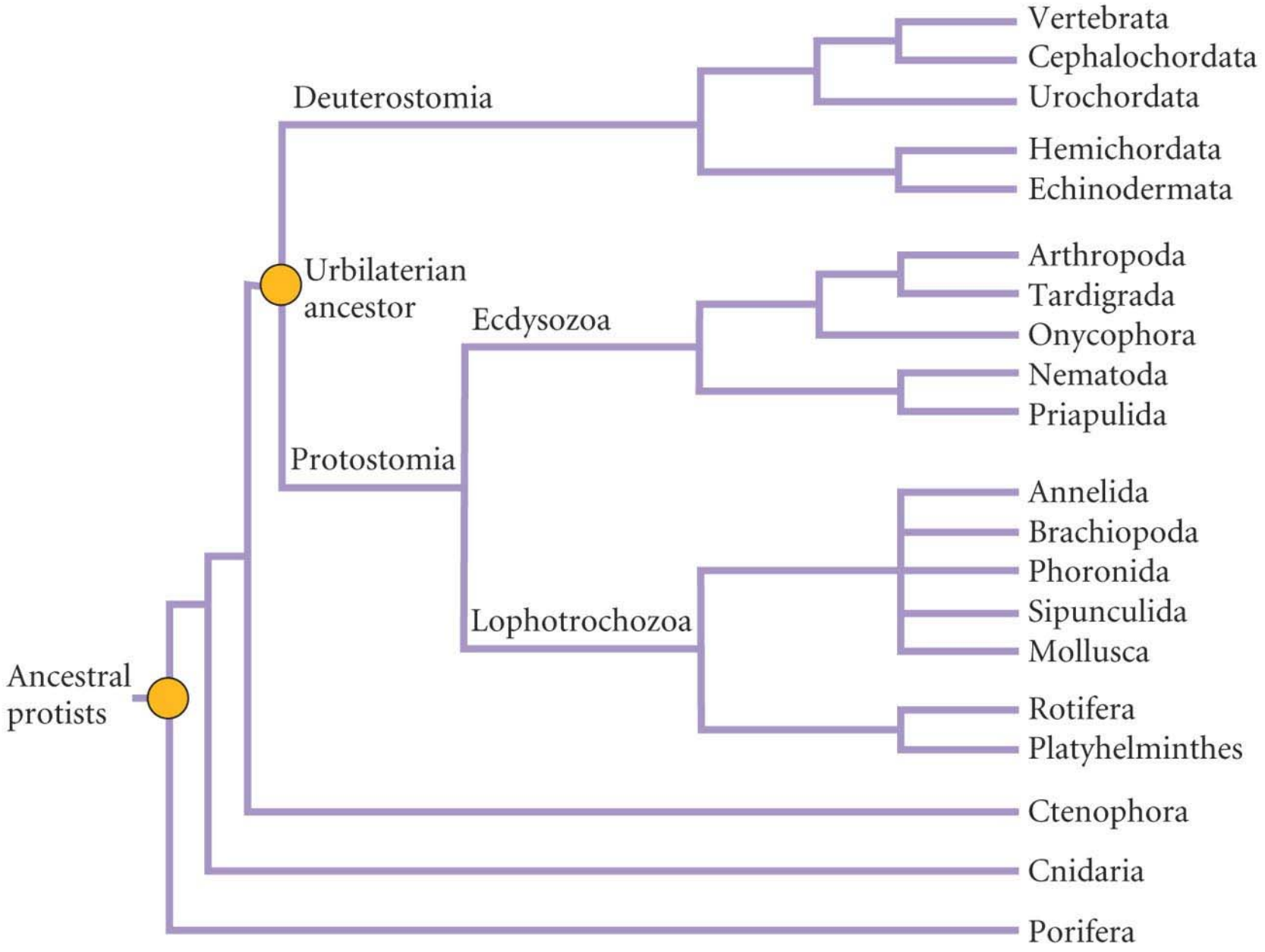
DEVELOPMENTAL BIOLOGY, Seventh Edition, **Figure 23.1 (Part 1)** Sinauer Associates, Inc.

Gastraea-Theory (Ernst Haeckel): Monophyly of the Metazoa



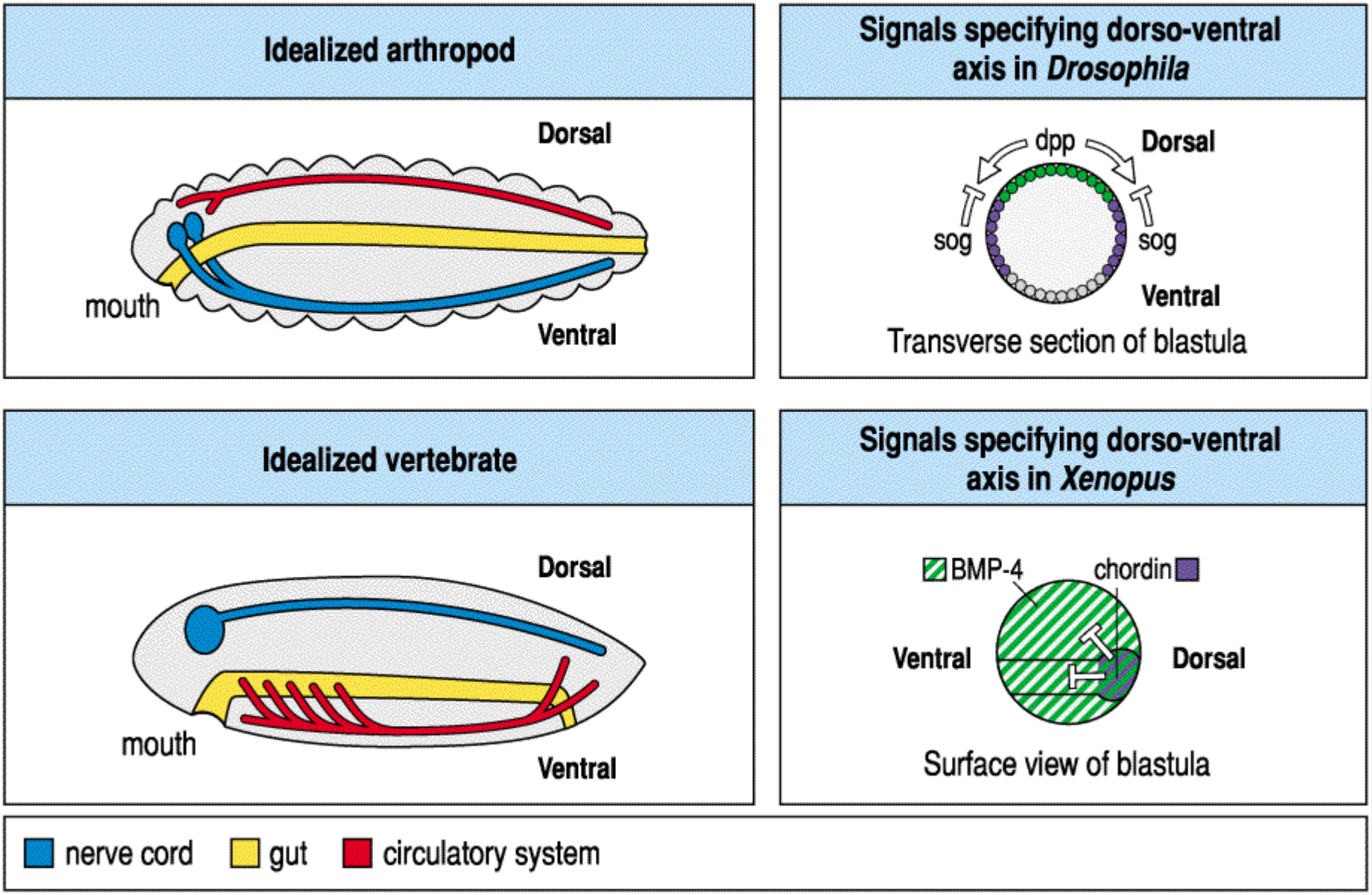
Placozoa **Porifera** **Cnidaria**

(A)



DEVELOPMENTAL BIOLOGY, Seventh Edition, **Figure 23.1 (Part 1)** Sinauer Associates, Inc.

Urbilateria



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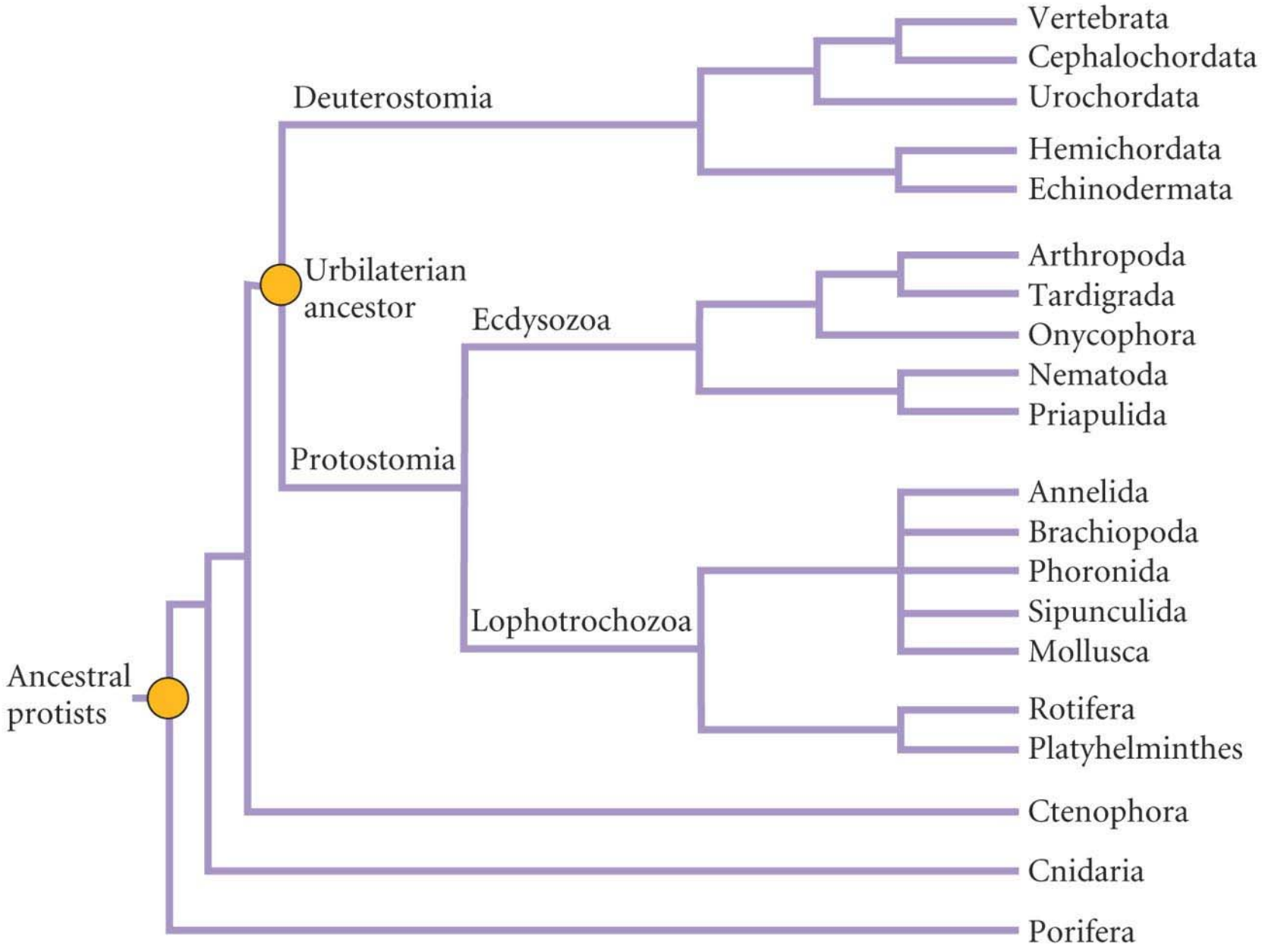

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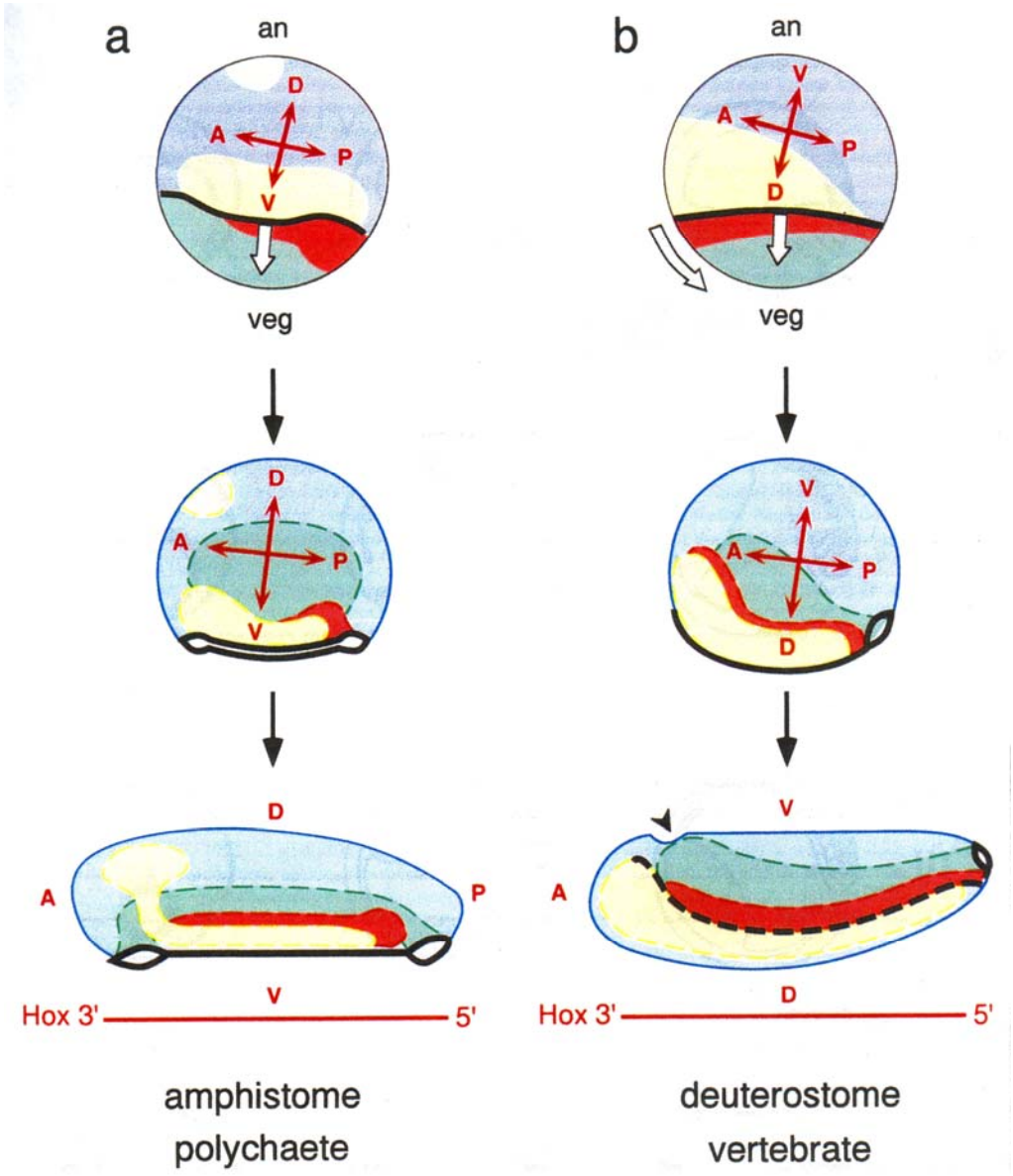
Protostomia - Deuterostomia



Human Opossum Chicken Salamander (axolotl) Fish (gar)

***DEVELOPMENTAL BIOLOGY, Seventh Edition,* Figure 1.5** Sinauer Associates, Inc.

Ontogeny contra Phylogeny

- **Ontogeny** (an individual‘s development):
  Development of an individual organism
  from a fertilized egg cell.

- **Phylogeny** (evolutionary history):
  Change of the appearence of organismic lineages
  over many generations, which equals **Evolution.**

Haekel‘s biogenetic law

- Ernst Haeckel (1834 – 1919), 1866:
- Darwinist
- Multicellular organisms recapitulate during their ontogeny their phylogeny in a shortened form.
- **wrong** in ist original version.

Human Opossum Chicken Salamander (axolotl) Fish (gar)

***DEVELOPMENTAL BIOLOGY, Seventh Edition,* Figure 1.5** Sinauer Associates, Inc.

von Baer‘s Laws

- Carl Ernst von Baer, 1828:

- The general features of a large group of animals appear earlier in development than do the specialized features of a smaller group.
- Less general characters develop from the more general until finally the most specialized appear.
- The embryo of a given species, instead of passing through the adult stages of lower animals, departs more and more from them.
- Therefore, the early embryo of a higher animal is never like a lower animal, but only like its early embryo.

Human Opossum Chicken Salamander (axolotl) Fish (gar)

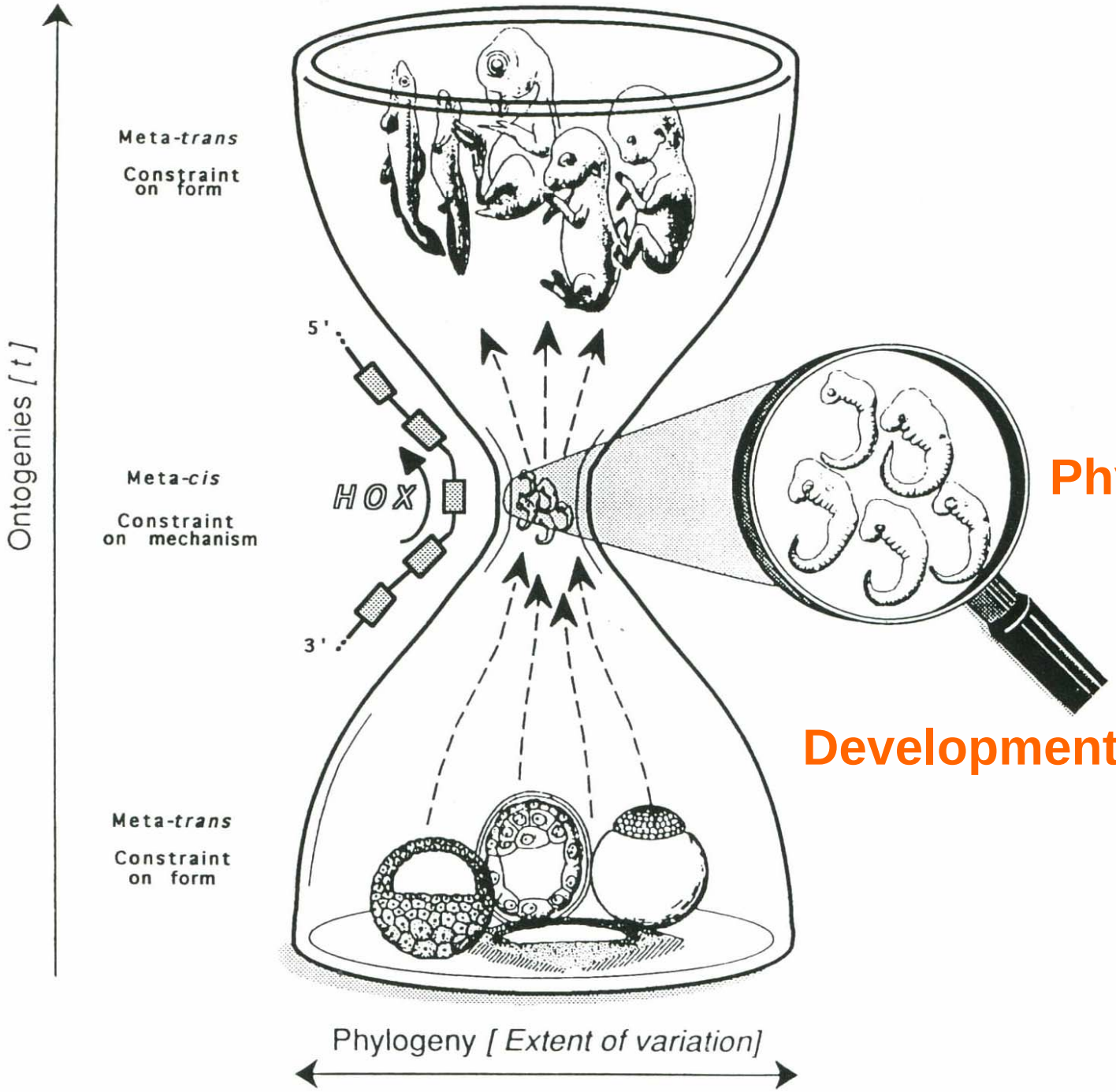
***DEVELOPMENTAL BIOLOGY, Seventh Edition,* Figure 1.5** Sinauer Associates, Inc.

Ontogeny creates Phylogeny

- Walter Garstang (1868-1949), 1922:
- Phylogeny is the result of heritable changes in Ontogeny.

Phylotypic Stage

Human Opossum Chicken Salamander (axolotl) Fish (gar)



Phylotypic Stage

Developmental Constraints

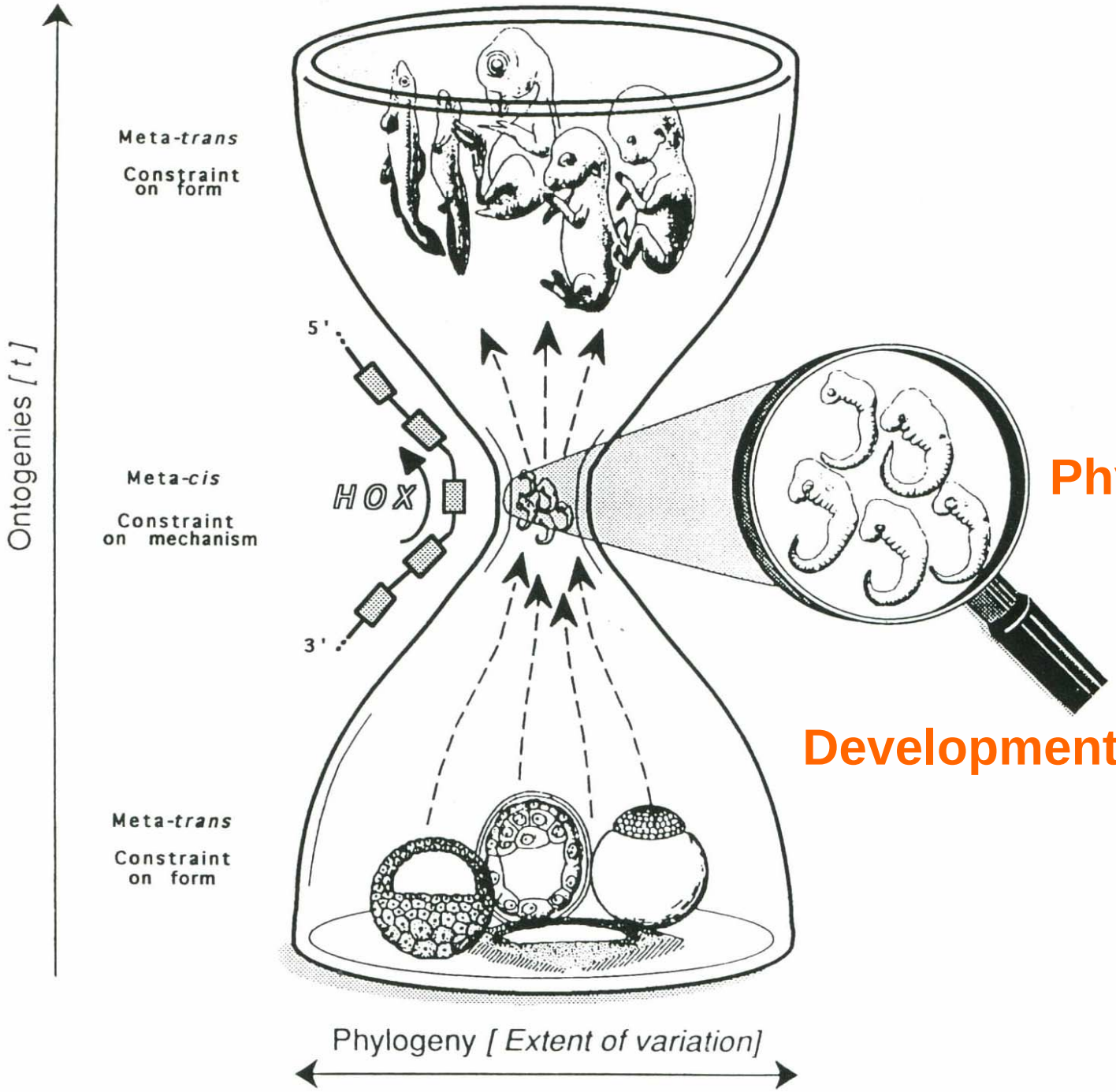
Phylotypic Stage – Developmental Constraints

Development 1994 Supplement, 135-142 (1994)
Printed in Great Britain © The Company of Biologists Limited 1994

Temporal colinearity and the phylotypic progression: a basis for the stability of a vertebrate Bauplan and the evolution of morphologies through heterochrony

Denis Duboule

Department of Zoology, University of Geneva, Sciences III, Quai Ernest Ansermet 30, 1211 Geneva 4, Switzerland



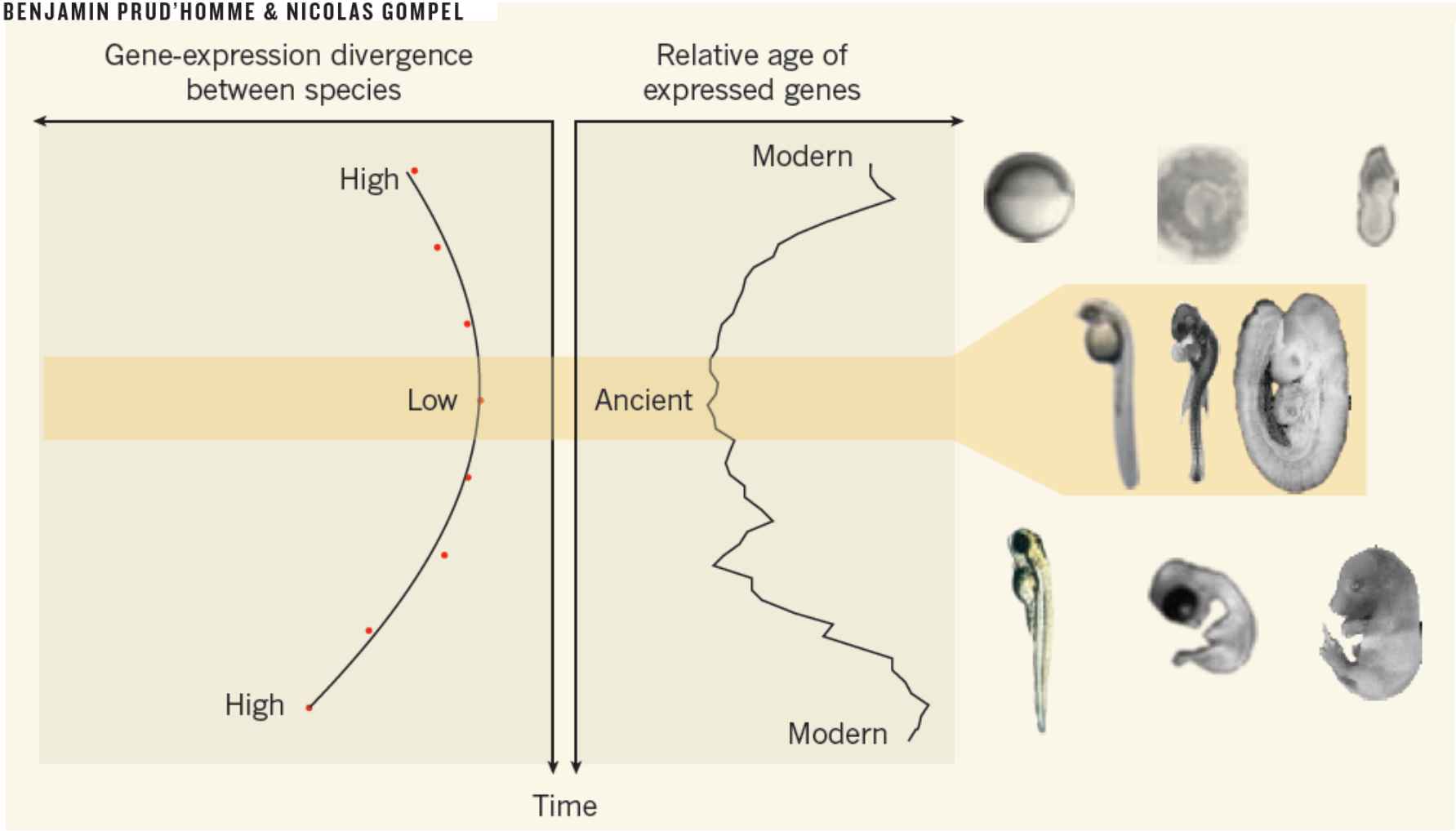
Phylotypic Stage

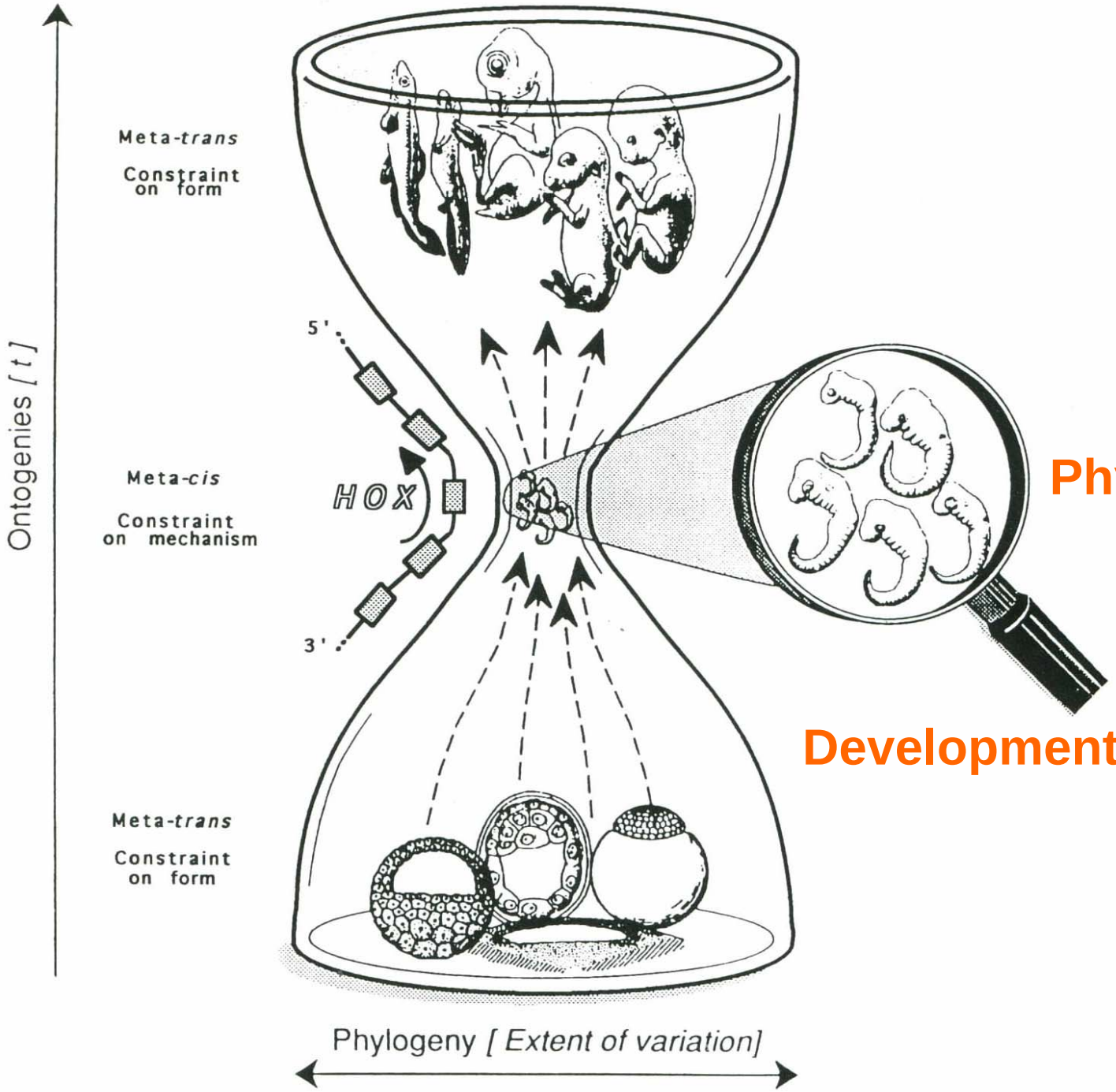
Developmental Constraints

Genomic hourglass

Comparative genomics studies reveal molecular signatures of the controversial 'phylotypic' stage — a time when embryos of members of an animal phylum all look more alike than at other embryonic stages. SEE LETTERS P.811 & P.815

BENJAMIN PRUD'HOMME & NICOLAS GOMPEL





Phylotypic Stage

Developmental Constraints

Phylotypic Stage

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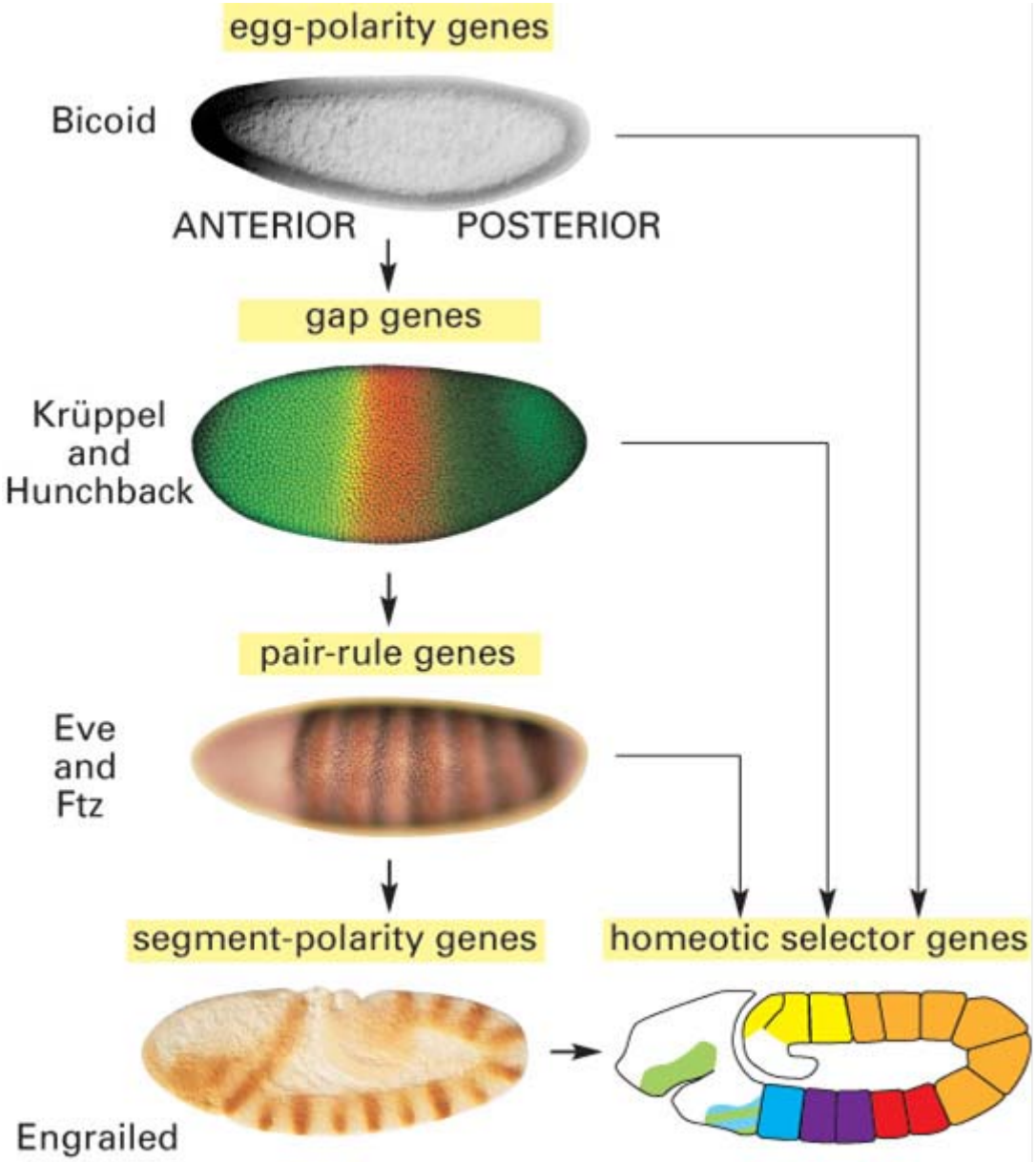


Figure 21–37. Molecular Biology of the Cell, 4th Edition.

Metamerization

Segment Specification: Regionalisation

Phylotypic Stage of Arthropods

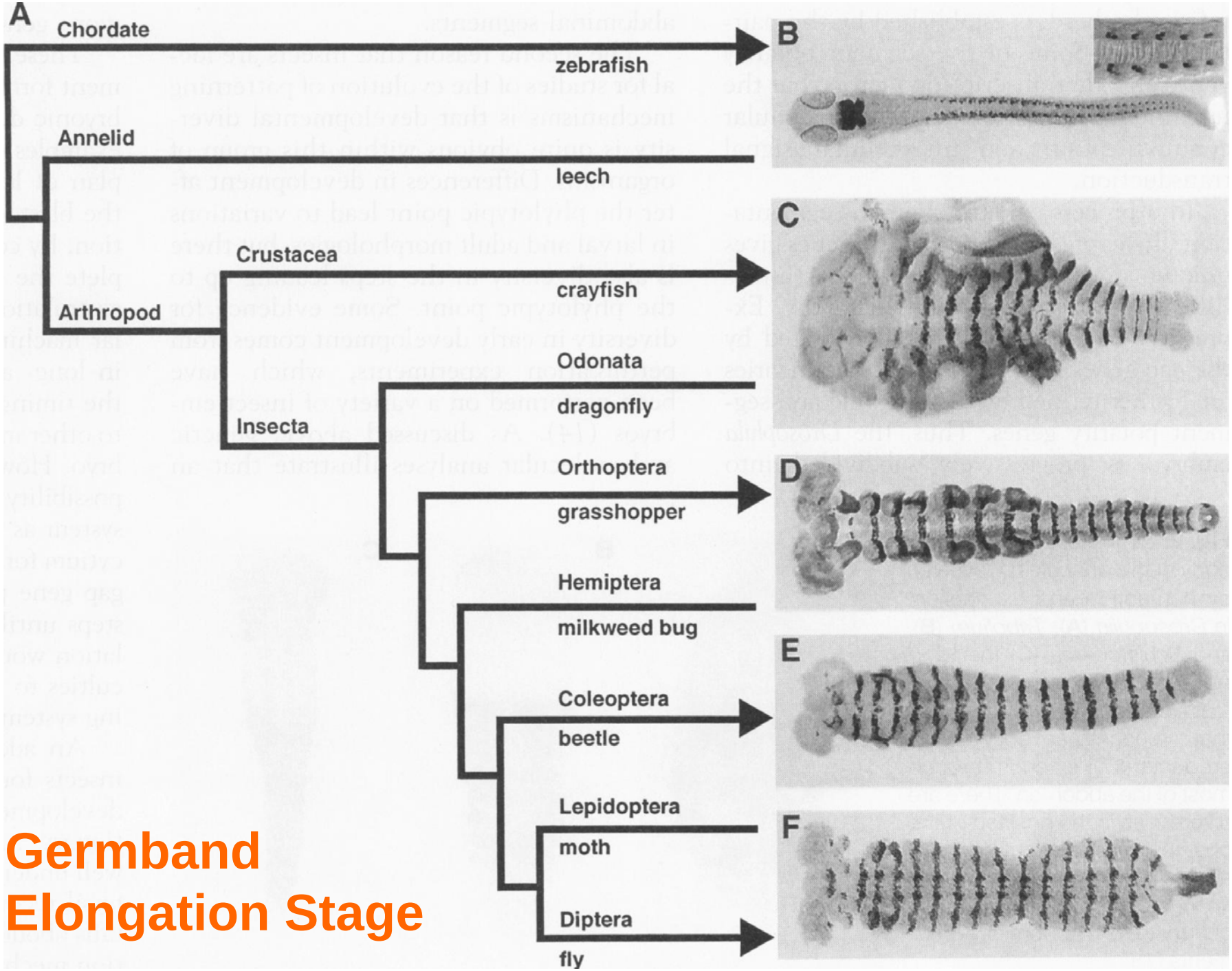
ARTICLES

Developmental Evolution: Insights from Studies of Insect Segmentation

Nipam H. Patel

Rapid advances have been made in the understanding of the genetic basis of development and pattern formation in a variety of model systems. By examining the extent to which these developmental systems are conserved or altered between different organisms, insight can be gained into the evolutionary events that have generated the diversity of organisms around us. The molecular and genetic basis of early pattern formation in *Drosophila melanogaster* has been particularly well studied, and comparisons to other insects have revealed conservation of some aspects of development, as well as differences that may explain variations in early patterning events.

mice (7). These and similar findings represent a triumph of developmental biology, but to understand the evolution of animal diversity, we need to learn about the genetic basis of the variations (not just the similarities) in developmental programs. Diversity in the molecular genetic level of developmental pathways has been documented in several instances, even in cases in which superficial similarities exist. For example,



Germband Elongation Stage

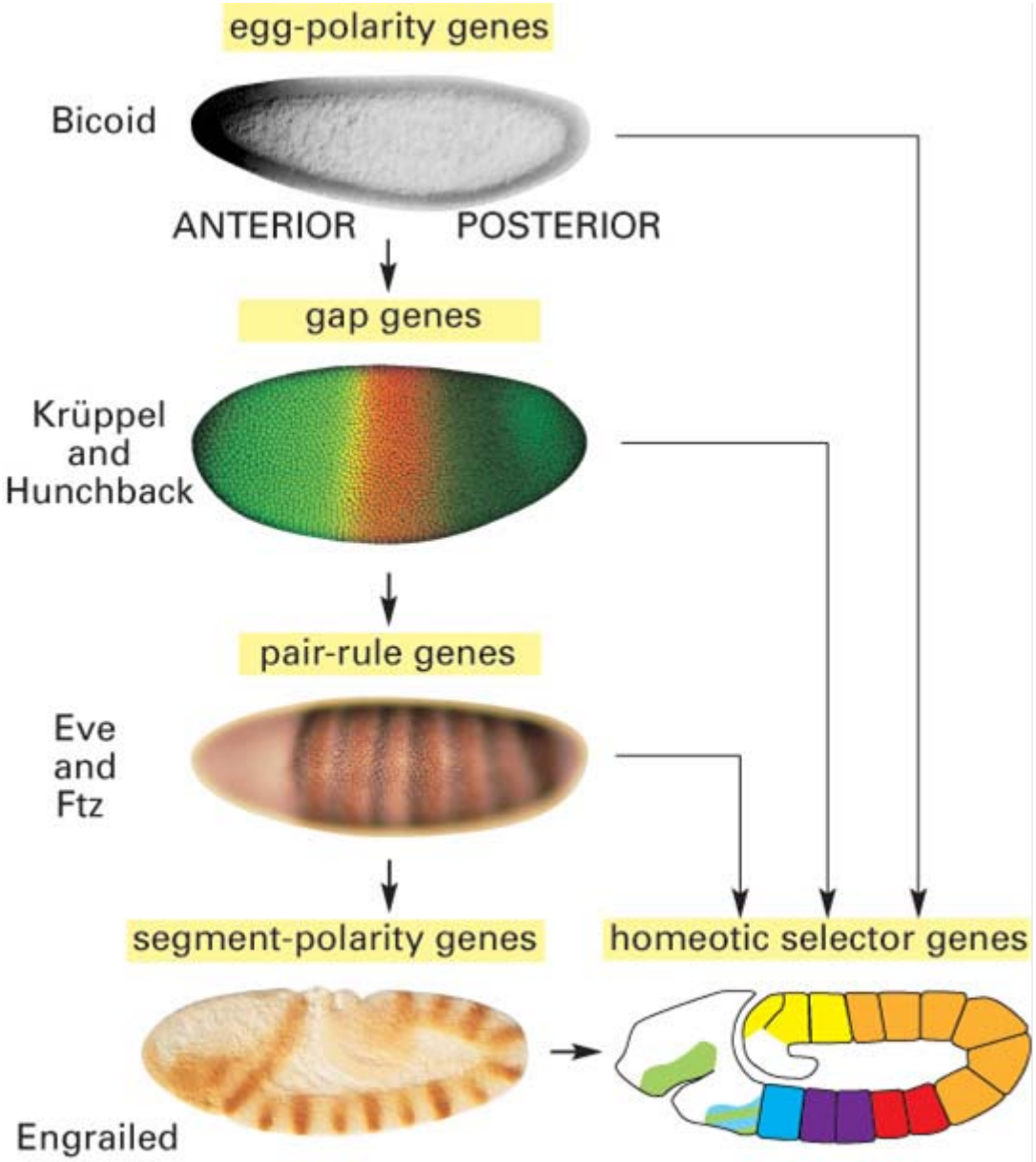


Figure 21–37. Molecular Biology of the Cell, 4th Edition.

Metamerization

Segment Specification: Regionalisation

Life long continuation of spatial expression pattern of the segment polarity gene *engrailed*

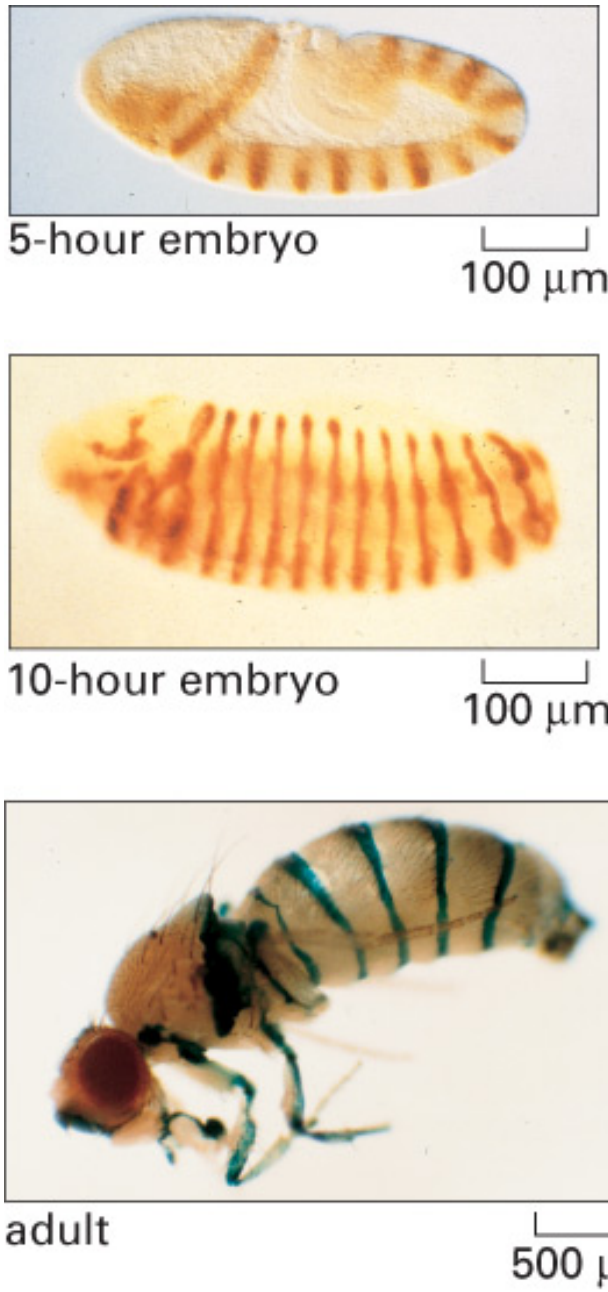


Figure 21–40. Molecular Biology of the Cell, 4th Edition.

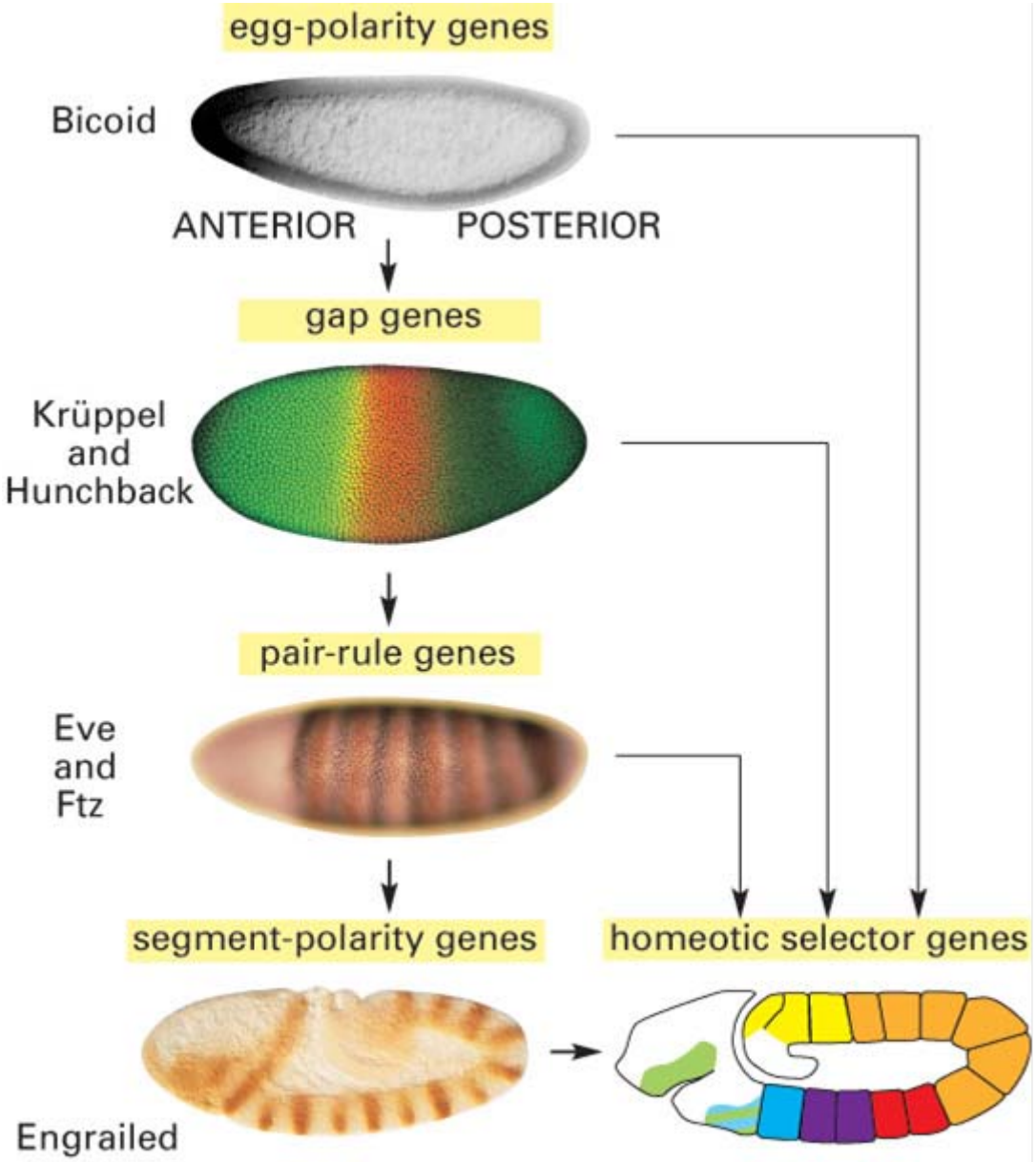


Figure 21–37. Molecular Biology of the Cell, 4th Edition.

Metamerization

Segment Specification: Regionalisation

Hox-Genes control development along the anteroposterior axis of all bilateria

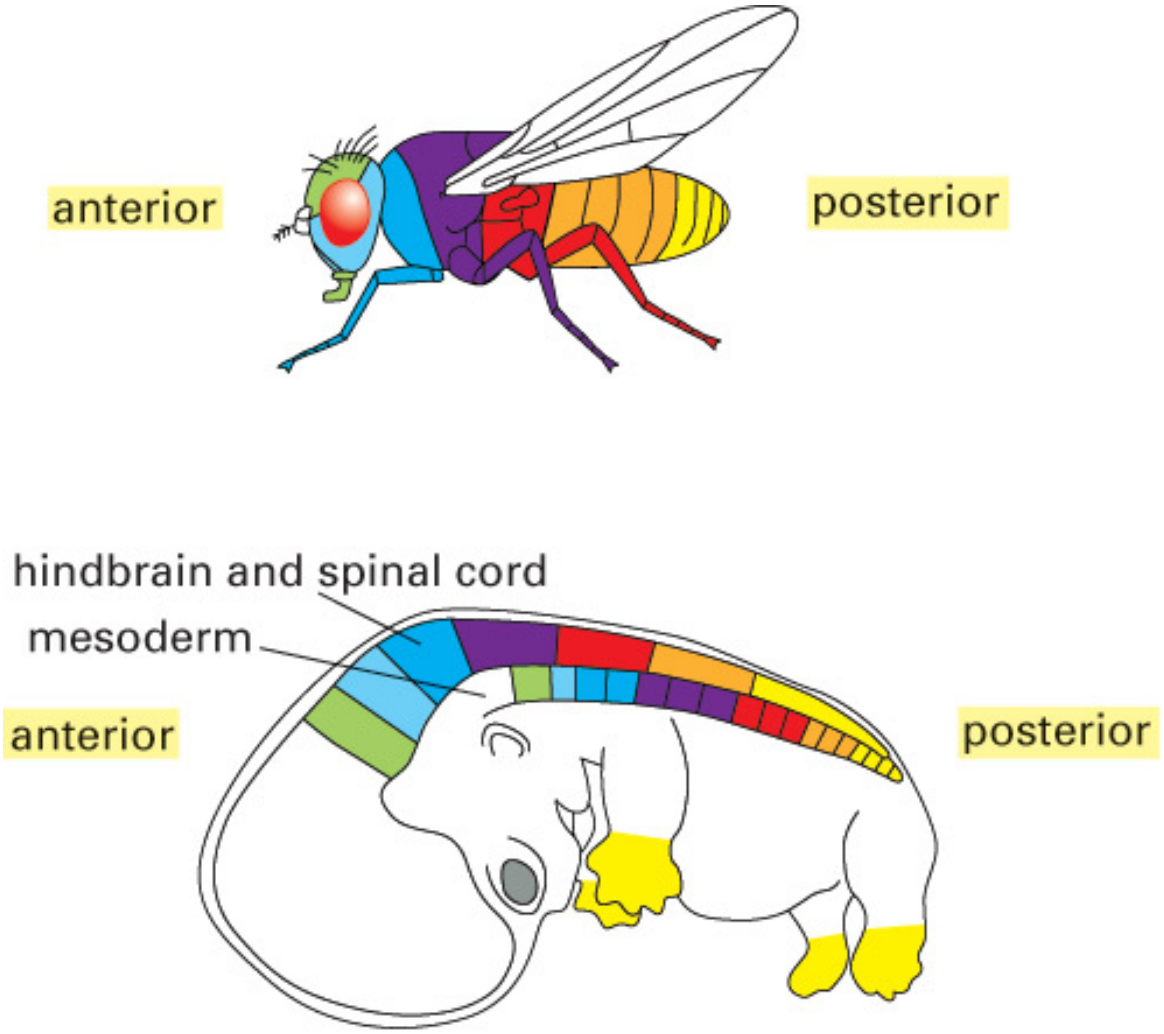


Figure 21–45 part 2 of 2. Molecular Biology of the Cell, 4th Edition.

Hox-Genes control development along the anteroposterior axis of all bilateria

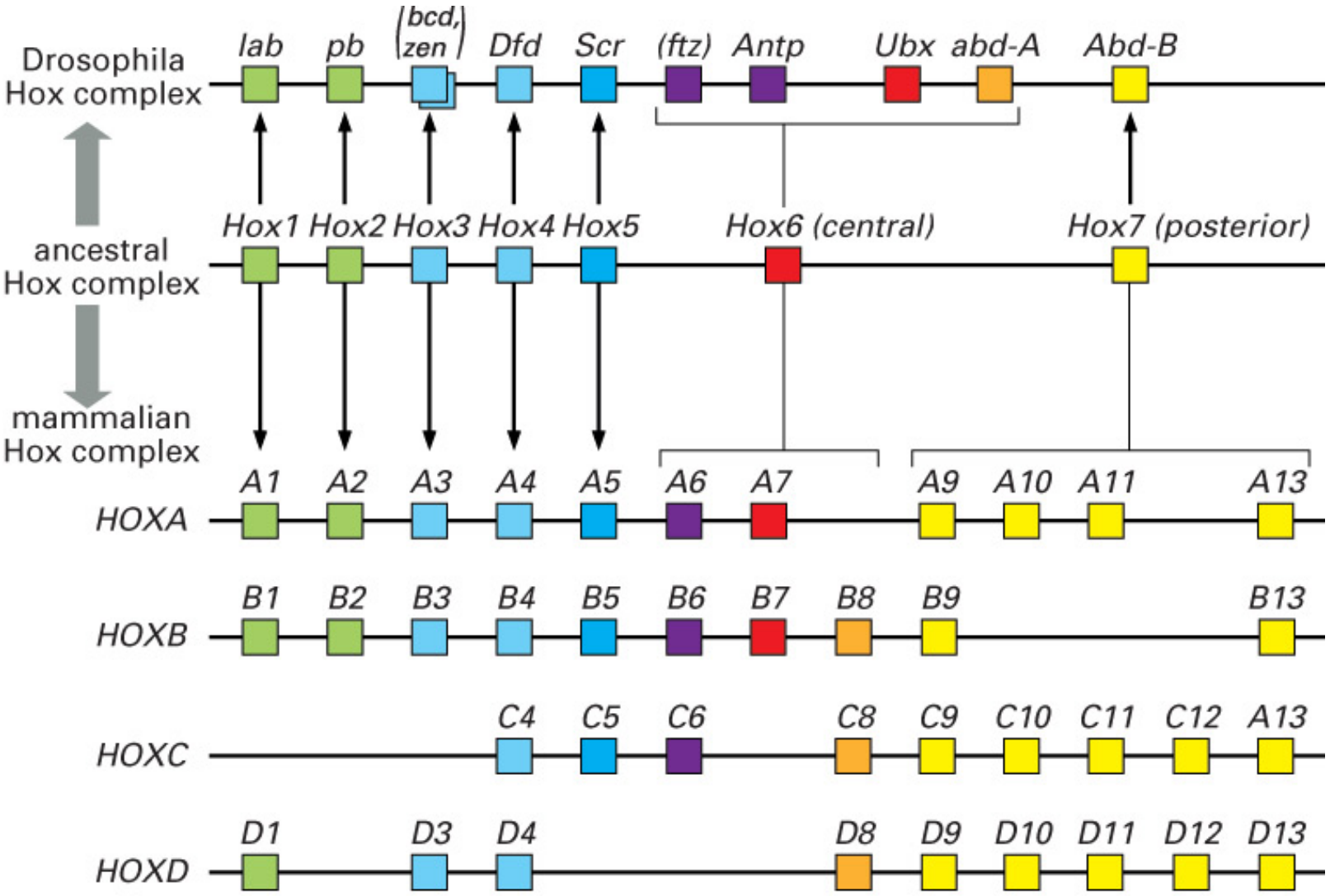
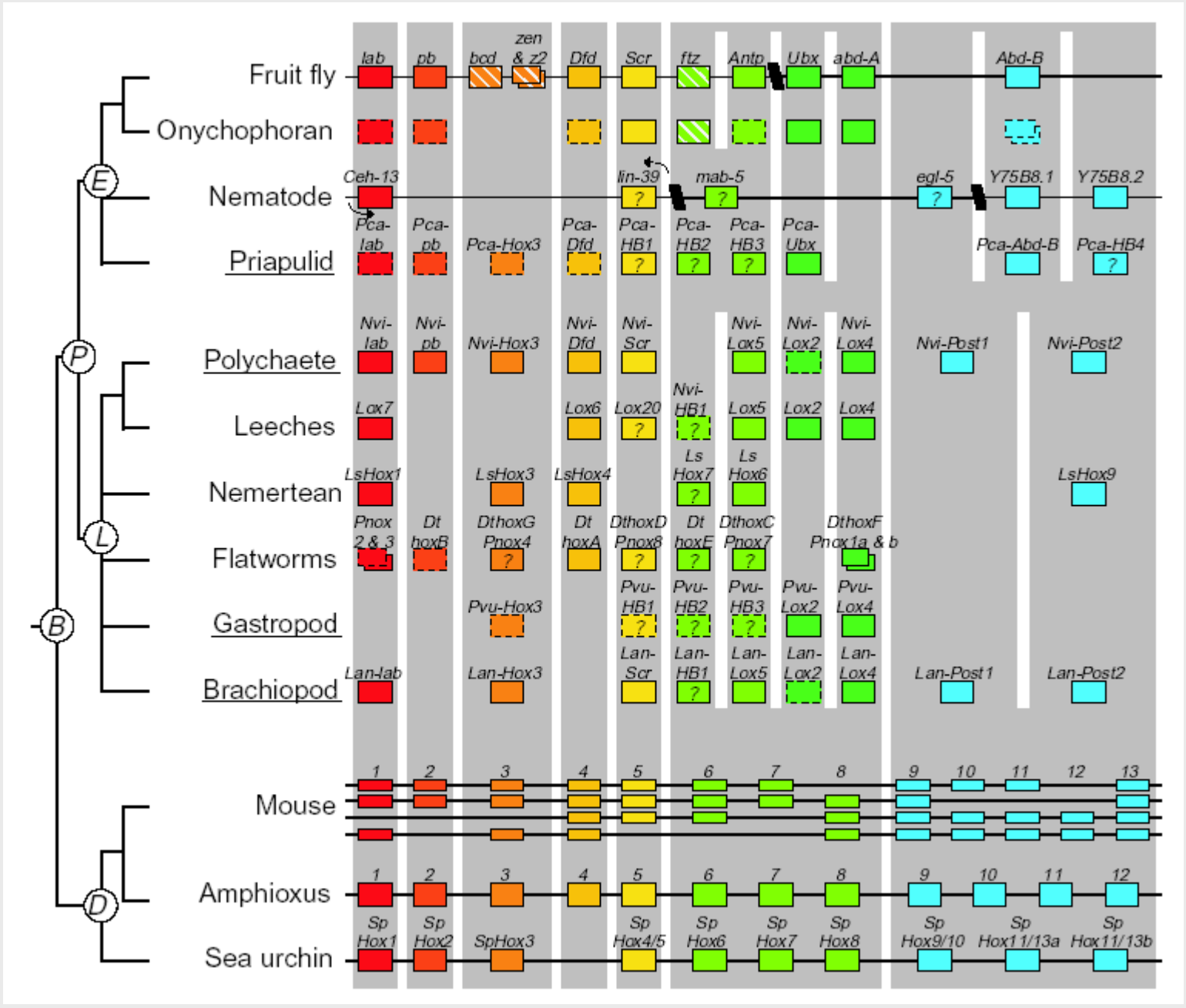


Figure 21–45 part 1 of 2. Molecular Biology of the Cell, 4th Edition.


Fruit fly
Onychophoran
Nematode
Priapulid
Polychaete
Leeches
Nemertean
Flatworms
Gastropod
Brachiopod
Mouse
Amphioxus
Sea urchin
E
P
L
B
D
lab
pb
bcd
zen & z2
Dfd
Scr
ftz
Antp
Ubx
abd-A
Abd-B
Ceh-13
lin-39
mab-5
egl-5
Y75B8.1
Y75B8.2
Pca-lab
Pca-pb
Pca-Hox3
Pca-Dfd
Pca-HB1
Pca-HB2
Pca-HB3
Pca-Ubx
Pca-Abd-B
Pca-HB4
Nvi-lab
Nvi-pb
Nvi-Hox3
Nvi-Dfd
Nvi-Scr
Nvi-Lox5
Nvi-Lox2
Nvi-Lox4
Nvi-Post1
Nvi-Post2
Lox7
Lox6
Lox20
Nvi-HB1
Lox5
Lox2
Lox4
LsHox1
LsHox3
LsHox4
Ls Hox7
Ls Hox6
LsHox9
Pnox 2 & 3
Dt hoxB
DthoxG Pnox4
Dt hoxA
DthoxD Pnox8
Dt hoxE
DthoxC Pnox7
DthoxF Pnox1a & b
Pvu-HB1
Pvu-HB2
Pvu-HB3
Pvu-Lox2
Pvu-Lox4
Pvu-Hox3
Lan-lab
Lan-Hox3
Lan-Scr
Lan-HB1
Lan-Lox5
Lan-Lox2
Lan-Lox4
Lan-Post1
Lan-Post2
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9
10
11
12
13
Sp Hox1
Sp Hox2
SpHox3
Sp Hox4/5
Sp Hox6
Sp Hox7
Sp Hox8
Sp Hox9/10
Sp Hox11/13a
Sp Hox11/13b

Evolution of Homeotic Selector Genes

Shockwave:
Evolution of Homeotic Selector Genes

EVOLUTION & DEVELOPMENT 4:6, 459–499 (2002)

Hox genes and the evolution of the arthropod body plan[1]

Cynthia L. Hughes and Thomas C. Kaufman*

Howard Hughes Medical Institute, Department of Biology, Indiana University, Bloomington, IN 47405, USA

*Author for correspondence (e-mail: kaufman@sunflower.bio.indiana.edu)

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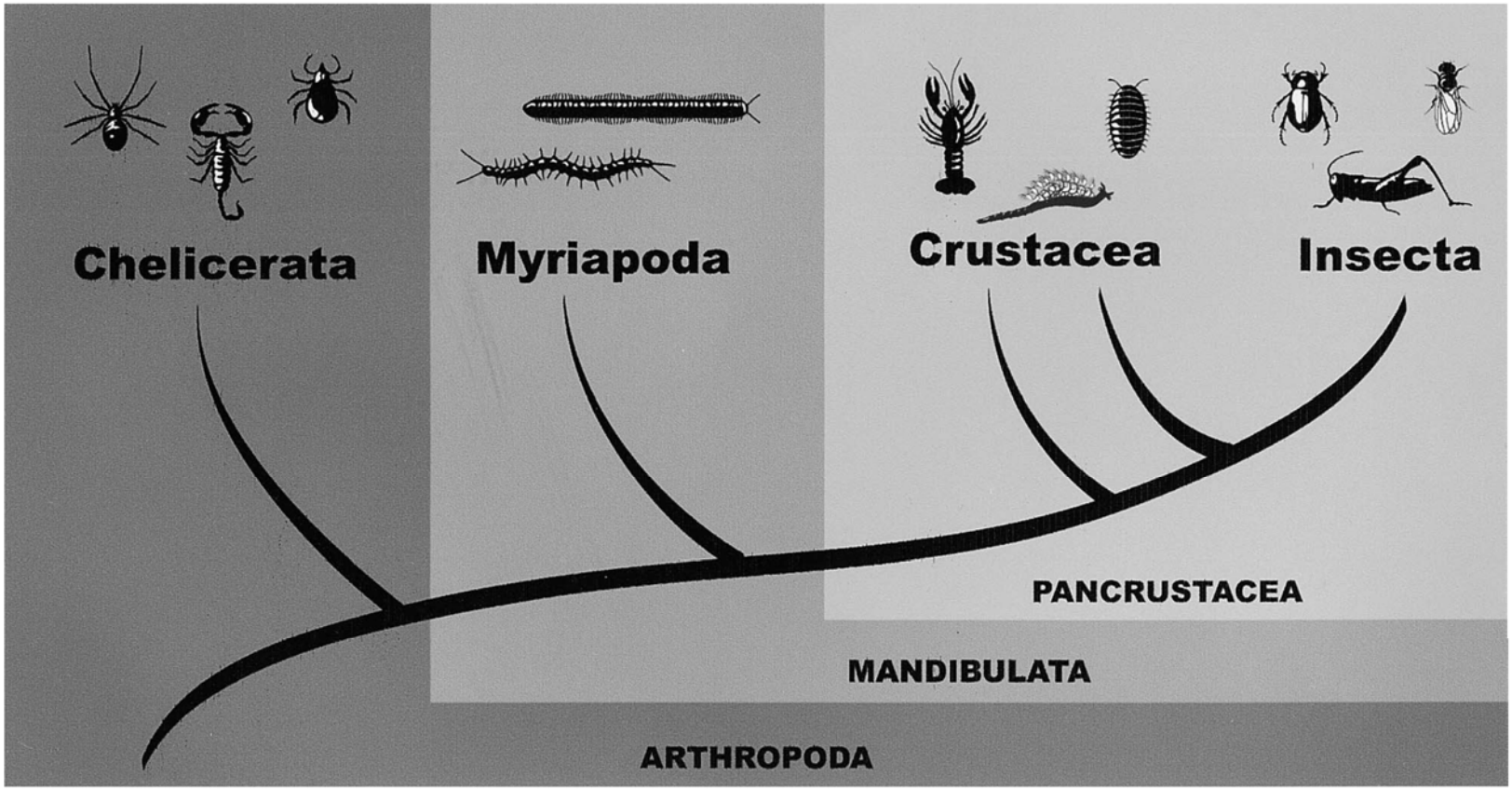

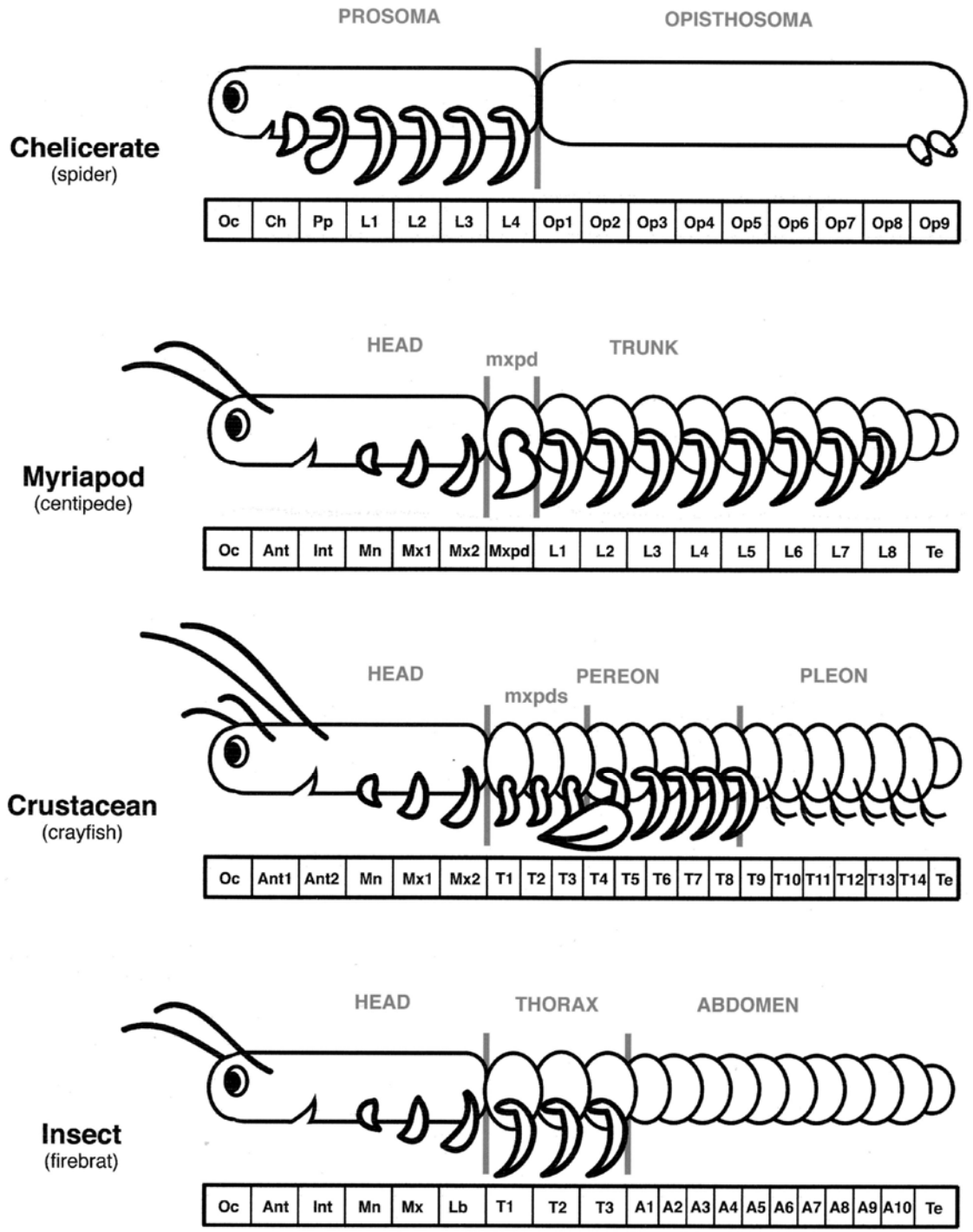
PROSOMA
OPISTHOSOMA
Chelicerate
(spider)
Oc Ch Pp L1 L2 L3 L4 Op1 Op2 Op3 Op4 Op5 Op6 Op7 Op8 Op9
HEAD
mxpd
TRUNK
Myriapod
(centipede)
Oc Ant Int Mn Mx1 Mx2 Mxpd L1 L2 L3 L4 L5 L6 L7 L8 Te
HEAD
mxpds
PEREON
PLEON
Crustacean
(crayfish)
Oc Ant1 Ant2 Mn Mx1 Mx2 T1 T2 T3 T4 T5 T6 T7 T8 T9 T10 T11 T12 T13 T14 Te
HEAD
THORAX
ABDOMEN
Insect
(firebrat)
Oc Ant Int Mn Mx Lb T1 T2 T3 A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 Te

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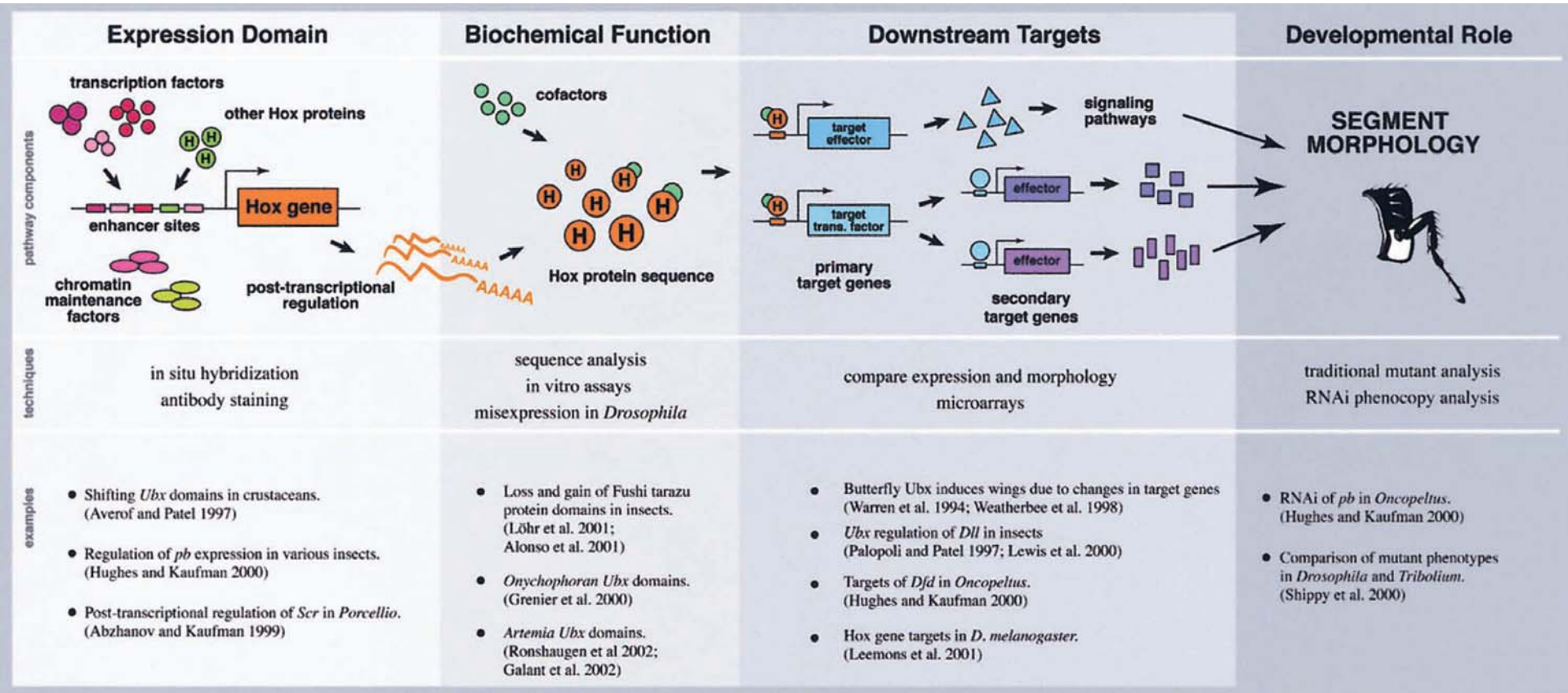

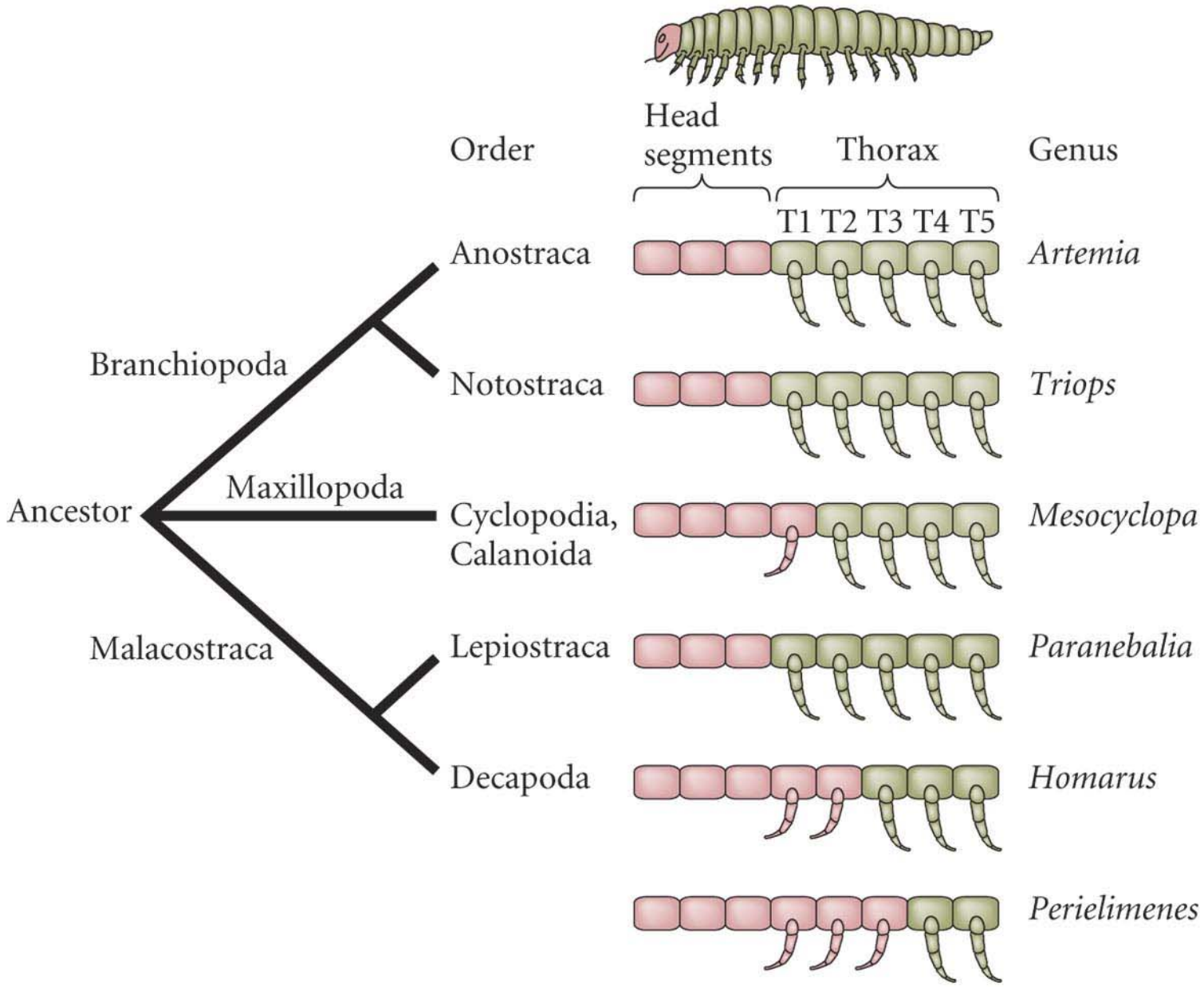

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EVOLUTION & DEVELOPMENT 4:6, 459–499 (2002)

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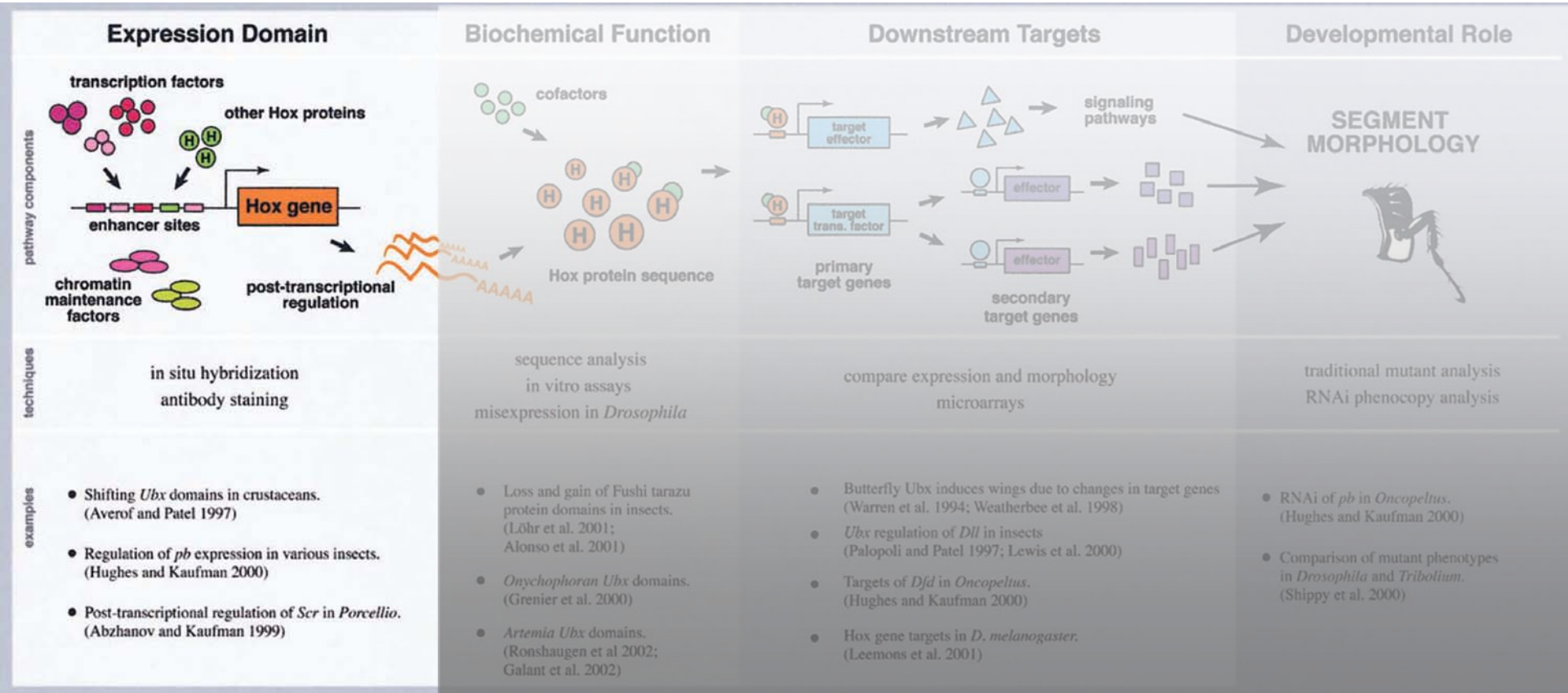

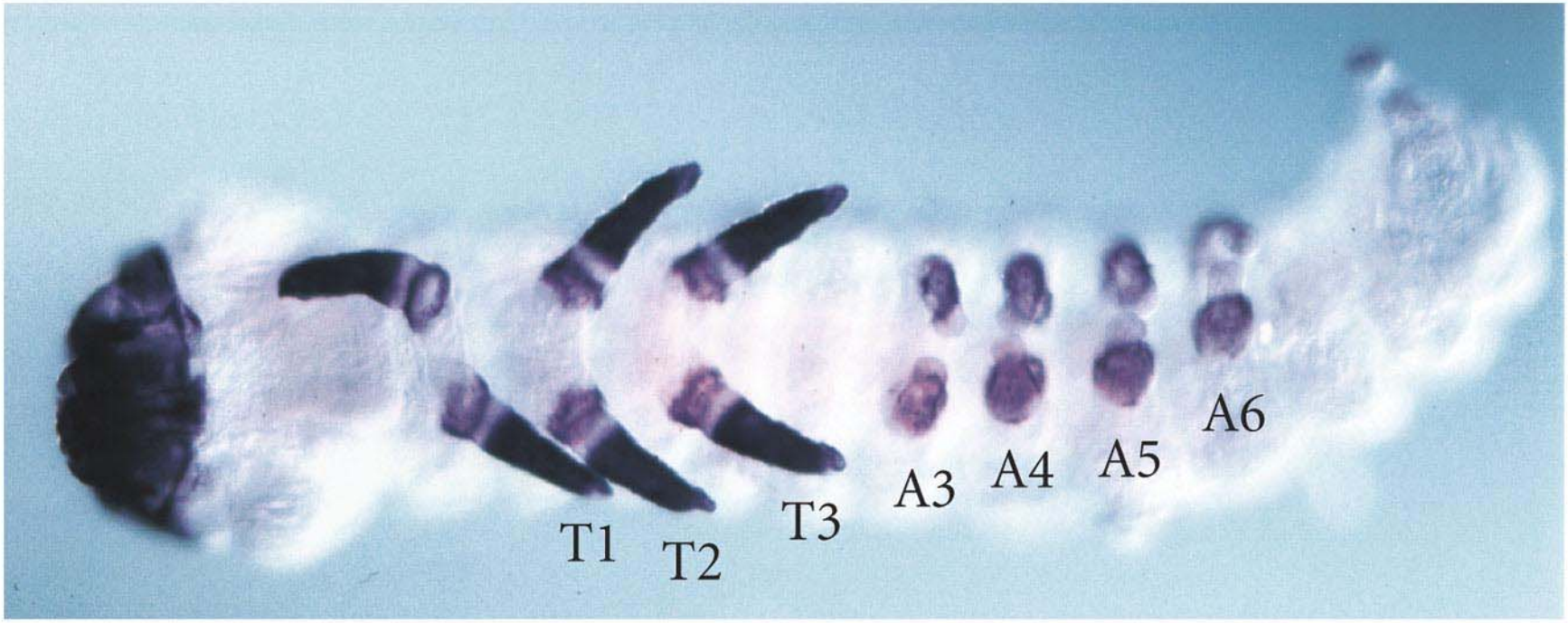

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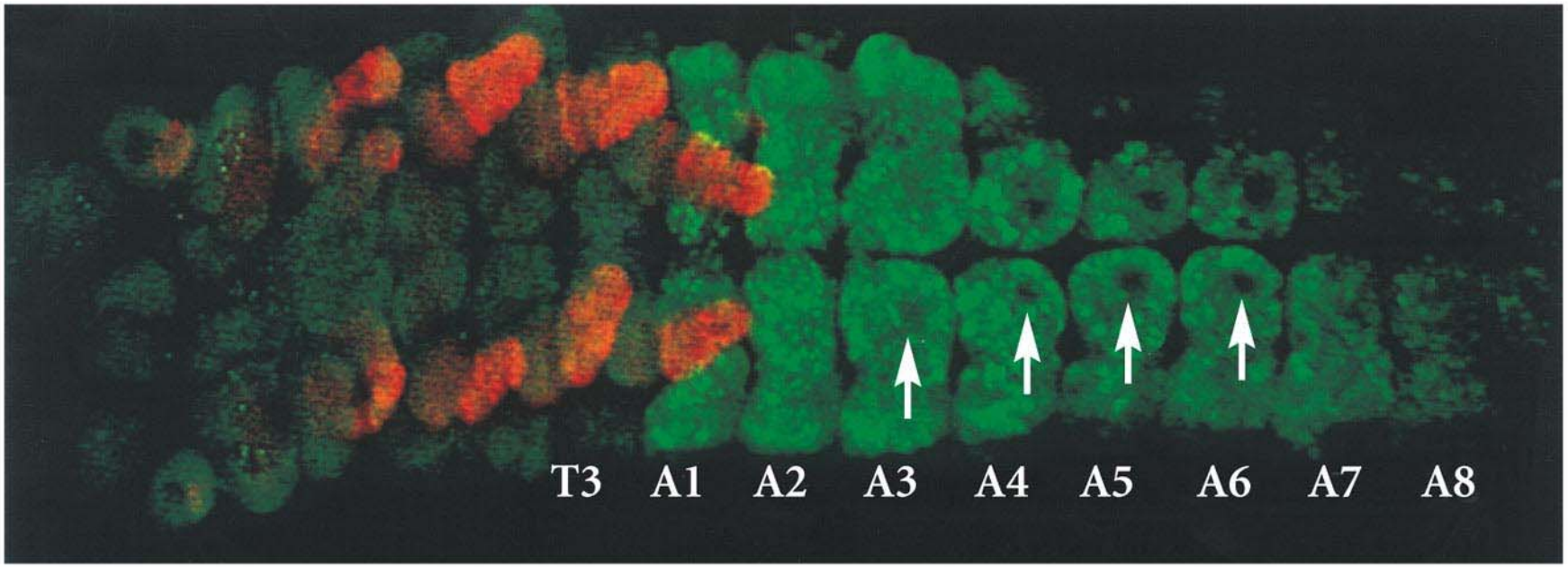
(A)



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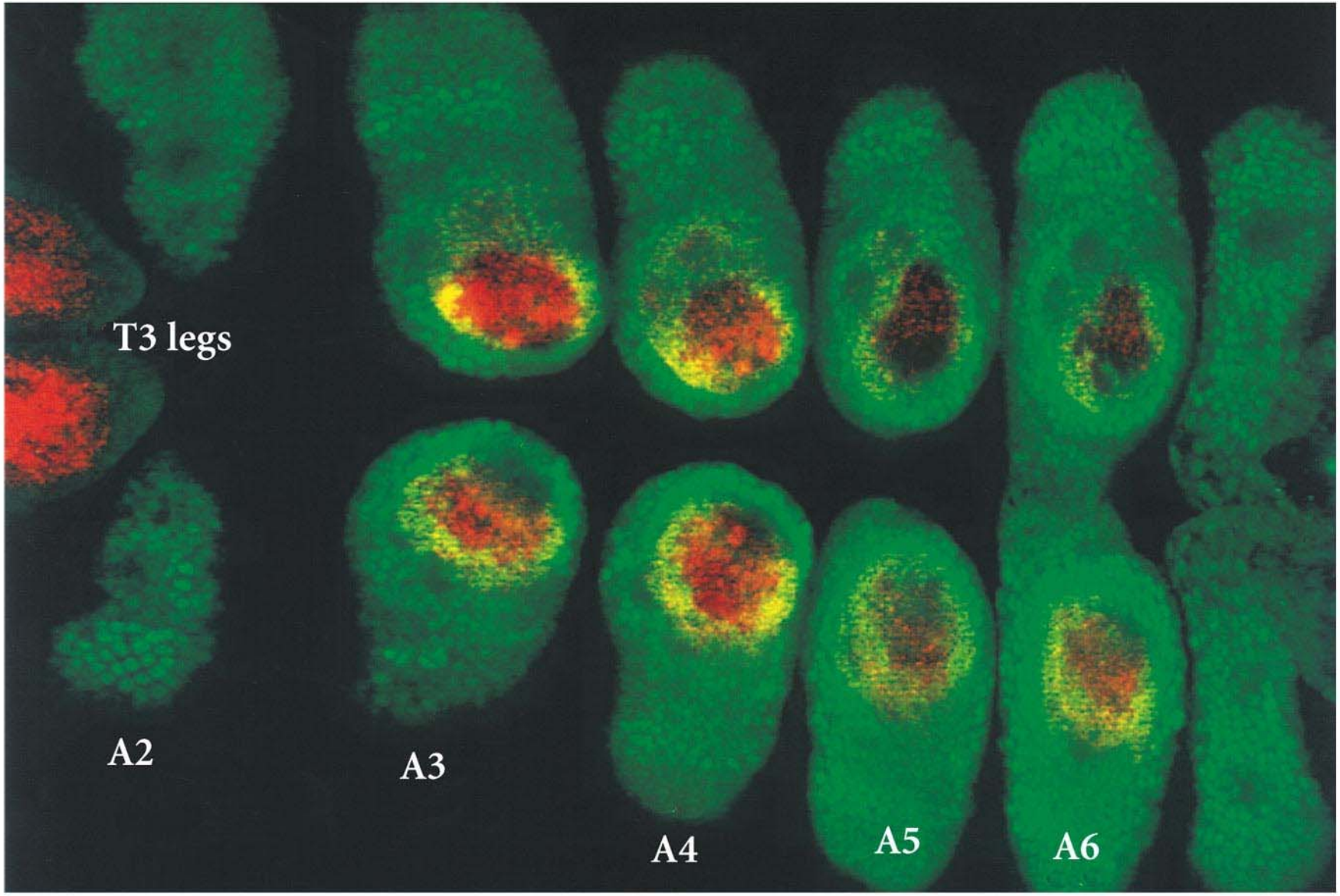
(B)



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EVOLUTION & DEVELOPMENT 4:6, 459–499 (2002)

Hox genes and the evolution of the arthropod body plan[1]

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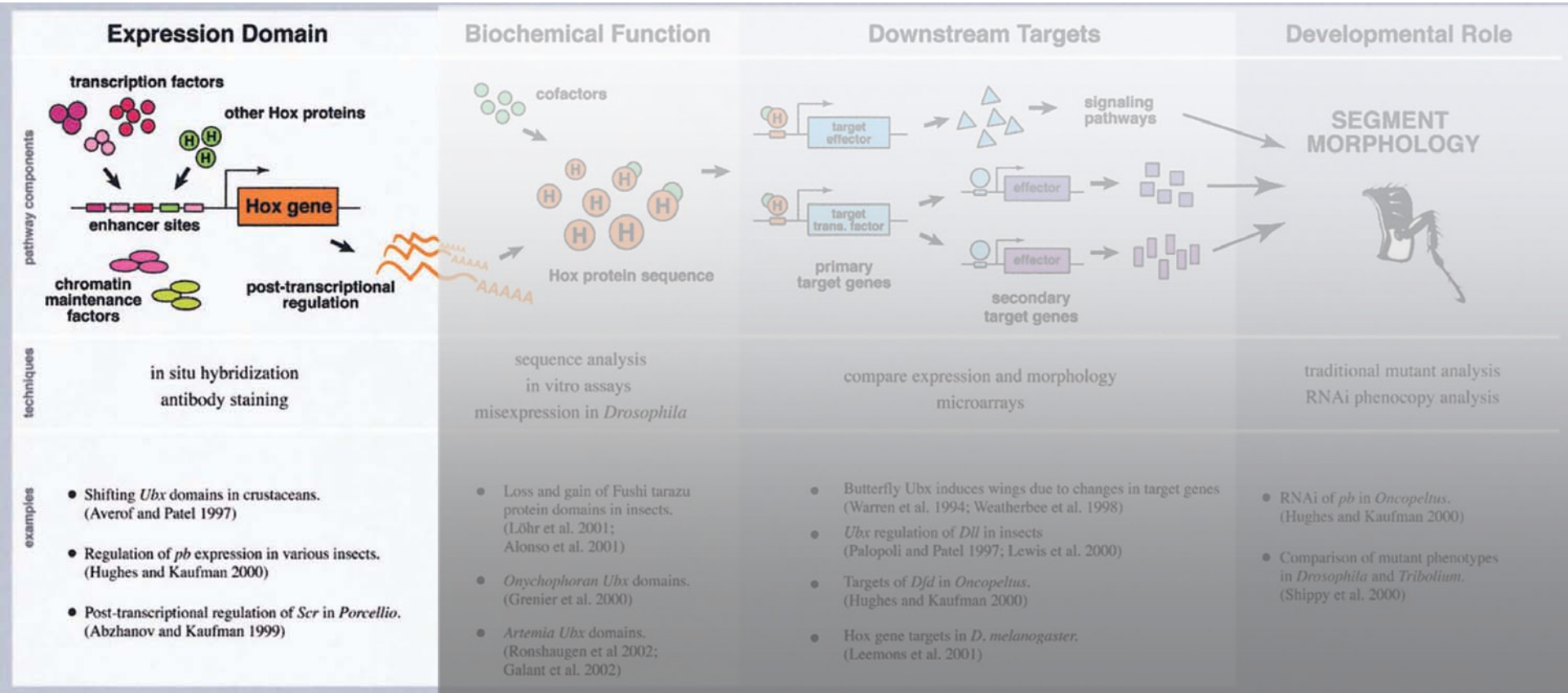

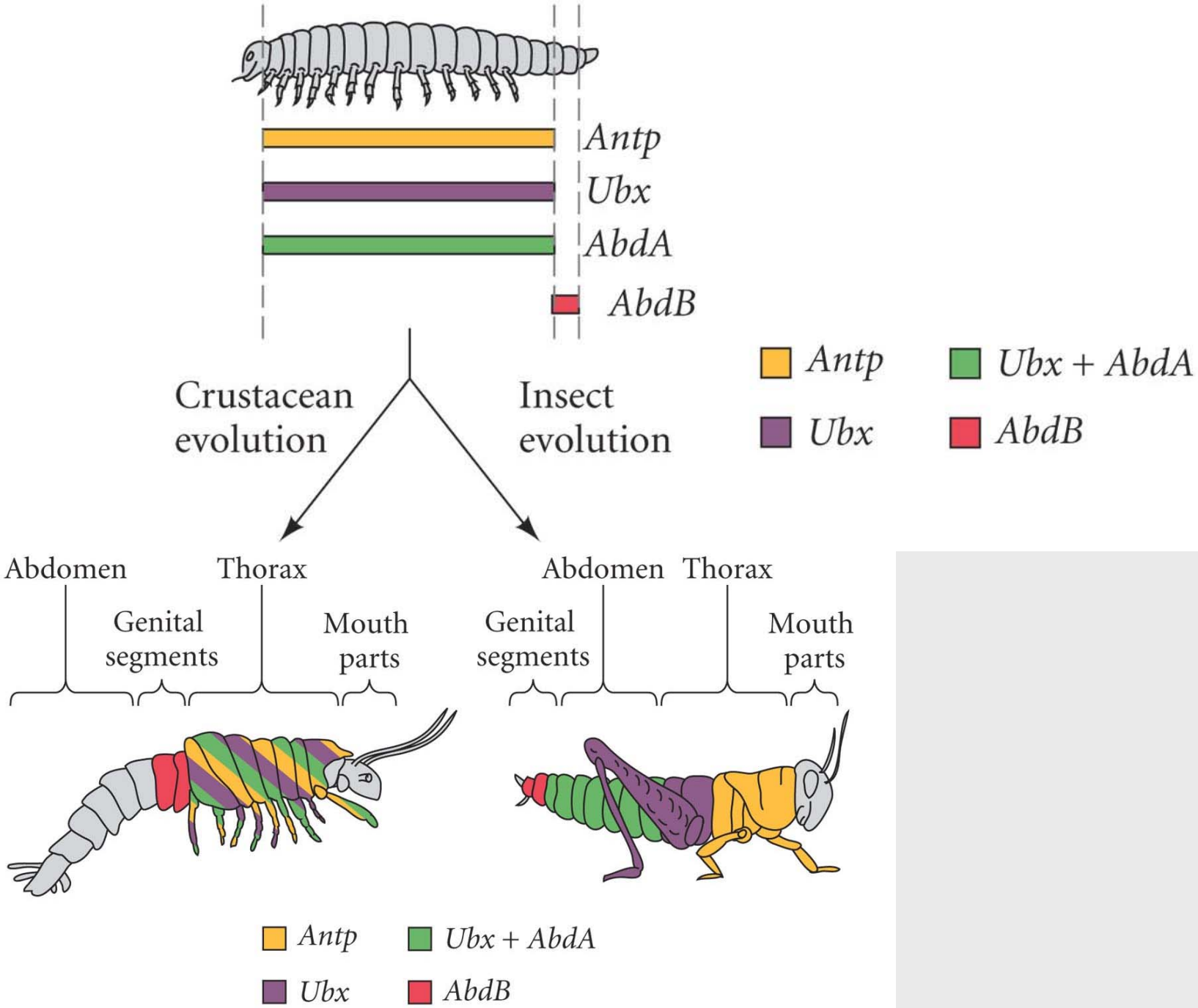

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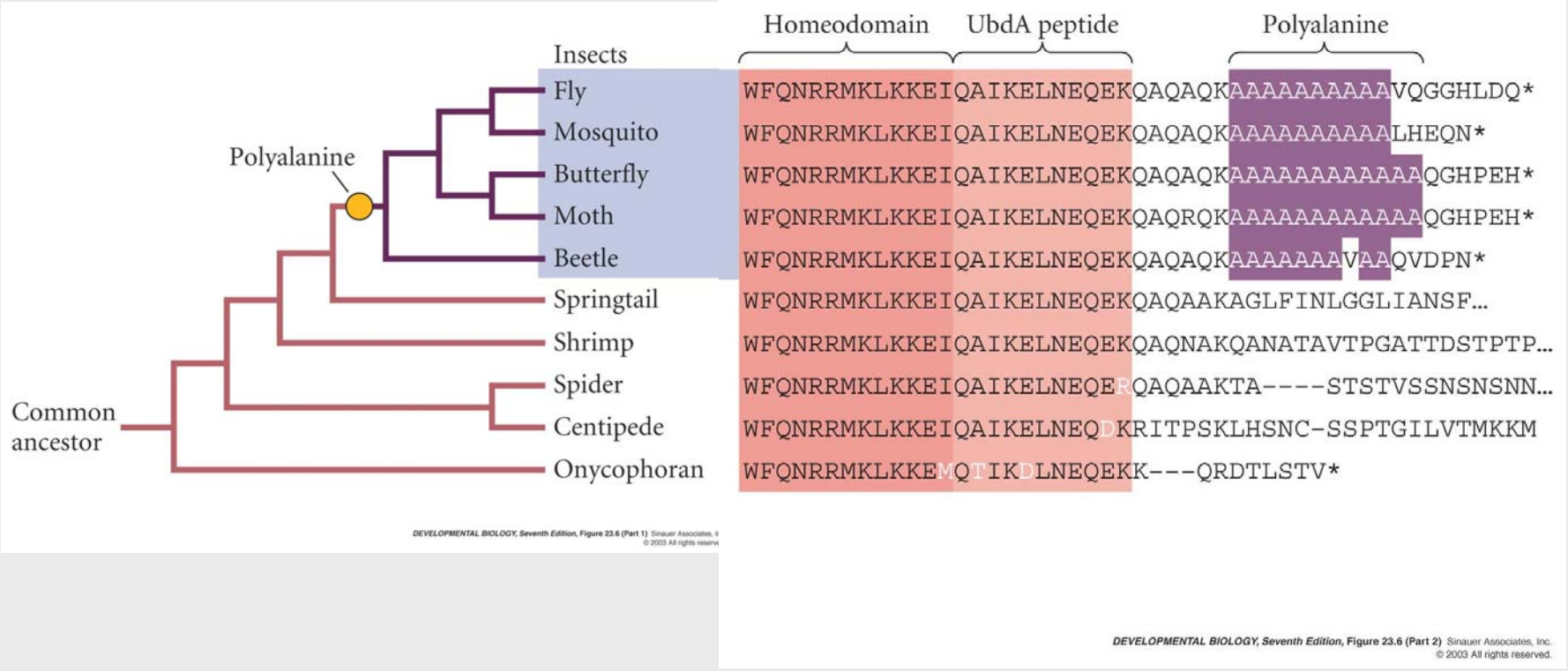

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EVOLUTION & DEVELOPMENT 4:6, 459–499 (2002)

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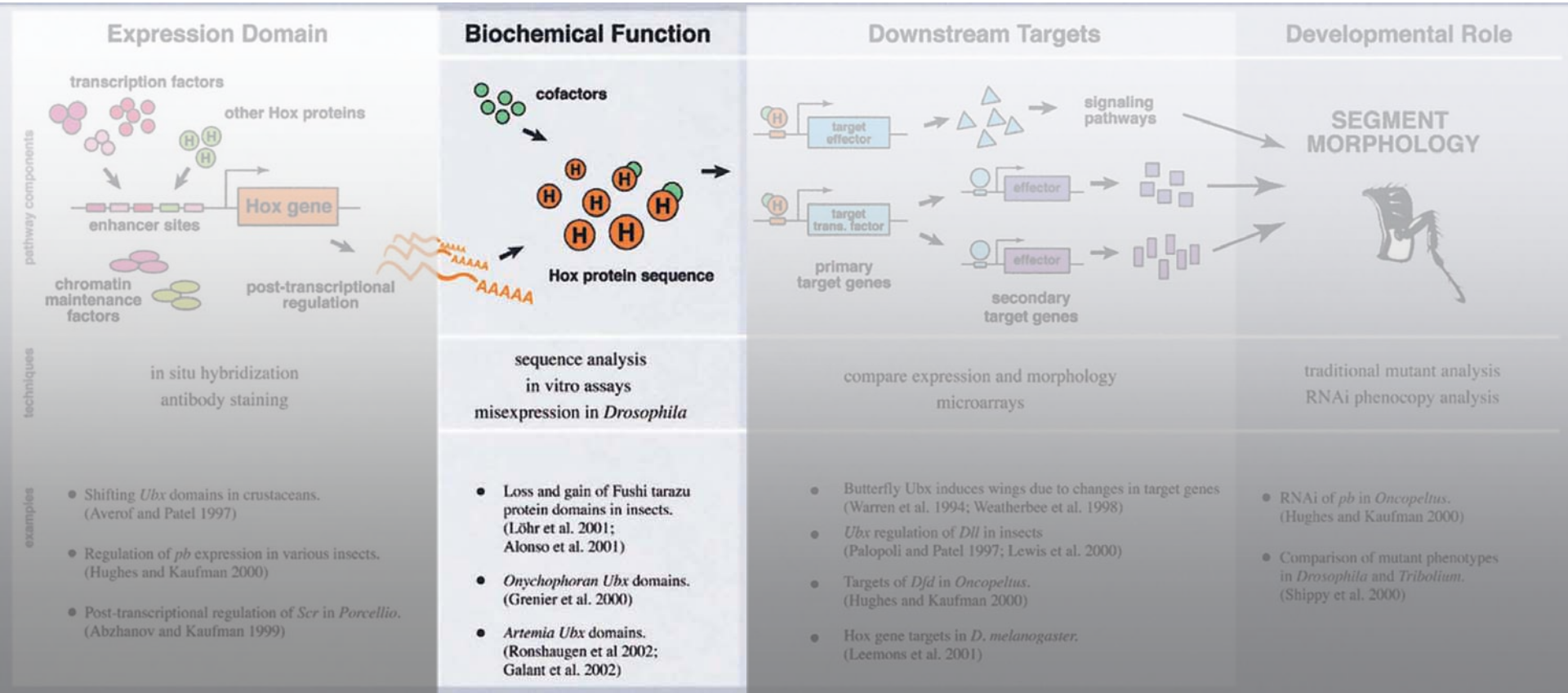

Diptera

Lepidoptera

Coleoptera

Evolution der durch *Ubx* regulierten Ausbildung von Hinterflügeln

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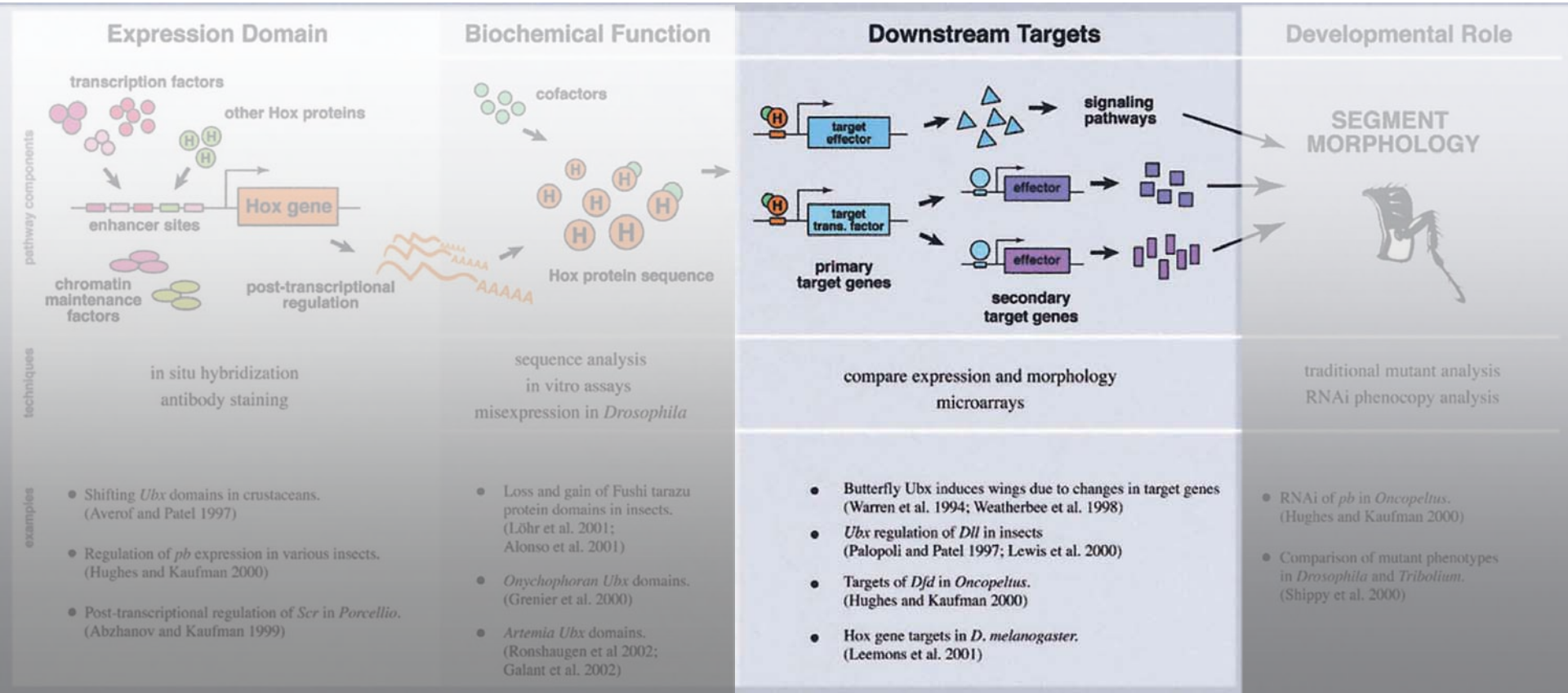

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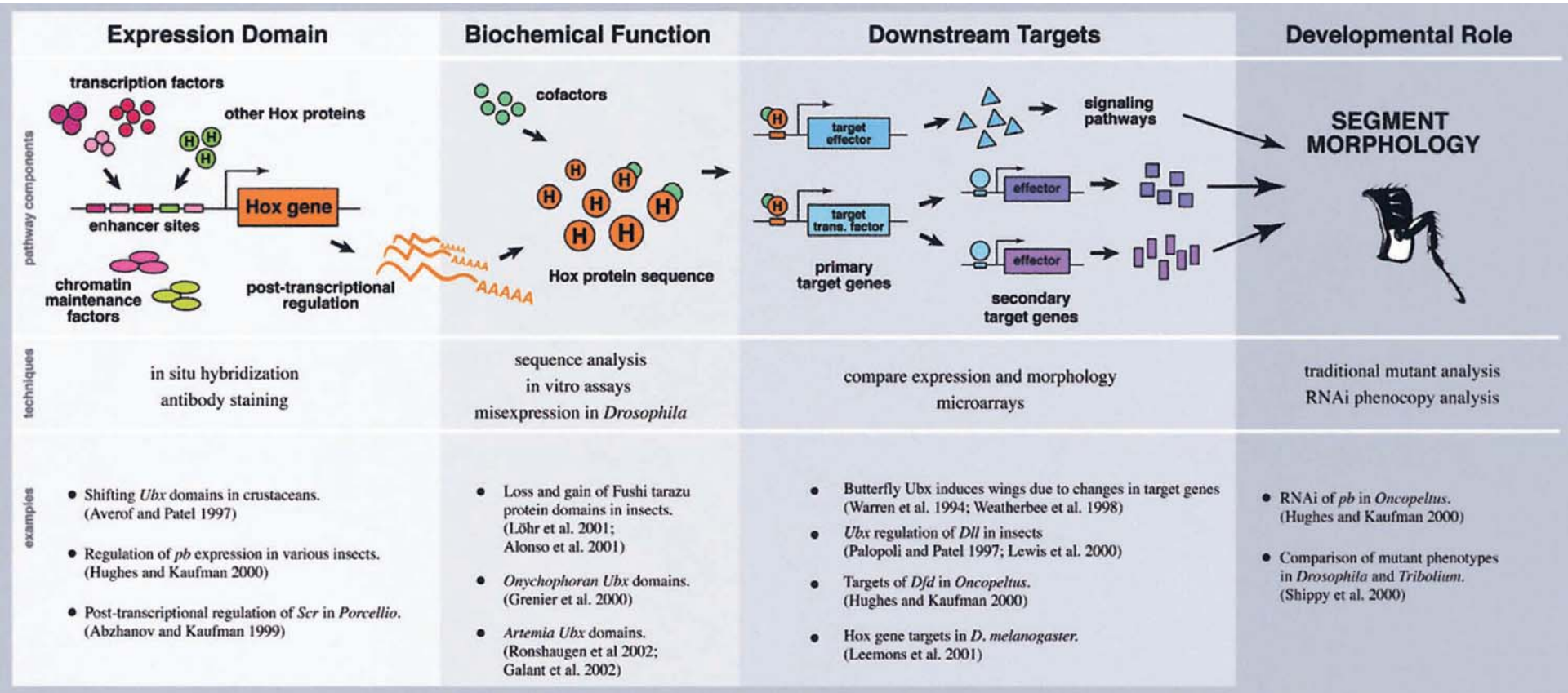
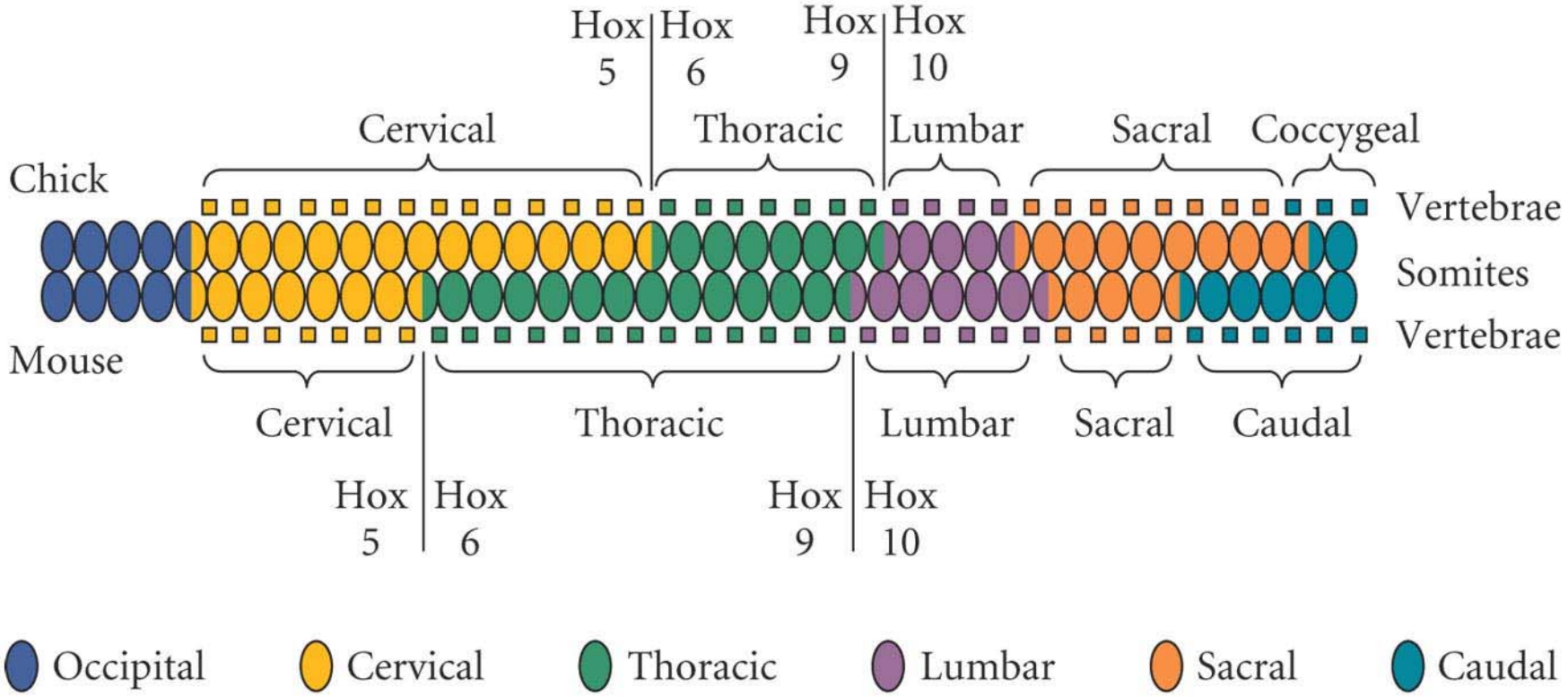
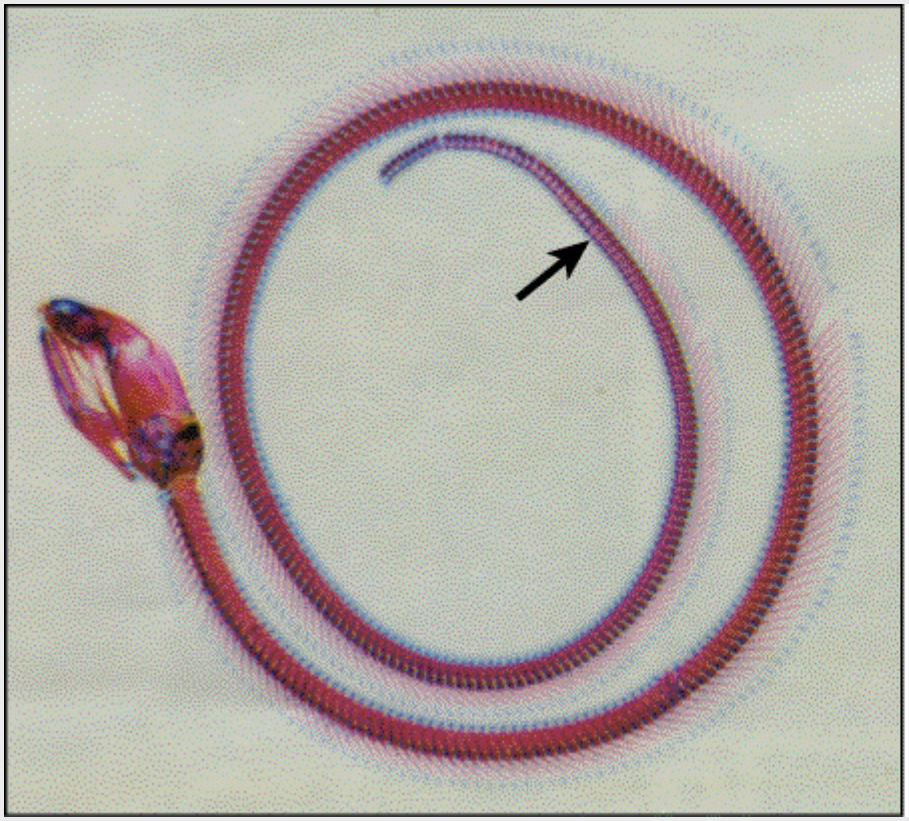
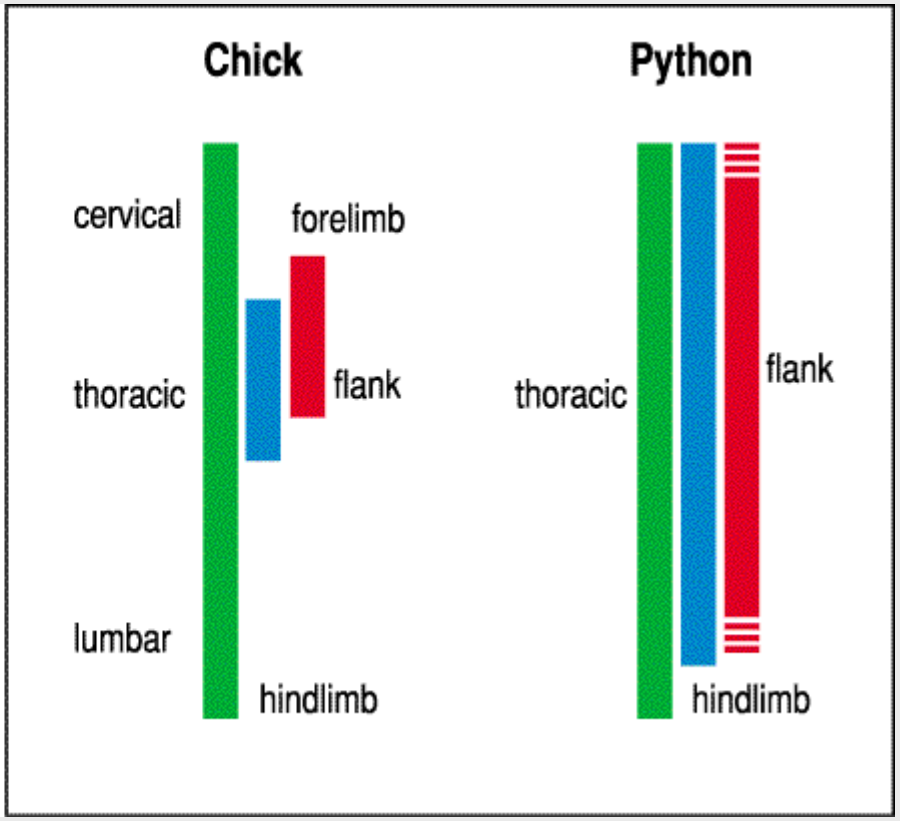
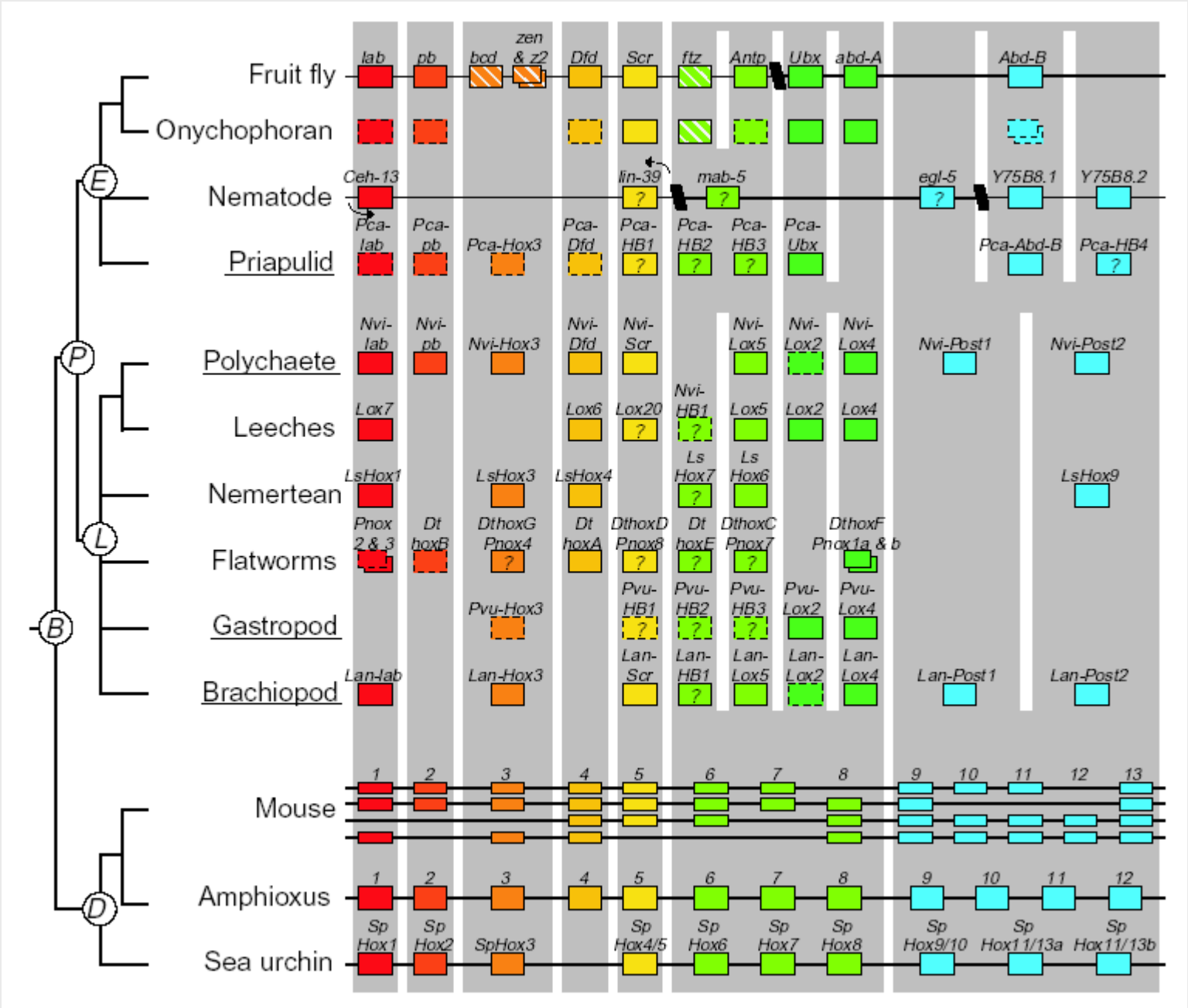







Chick
Python
cervical
forelimb
thoracic
flank
lumbar
hindlimb
thoracic
flank
hindlimb

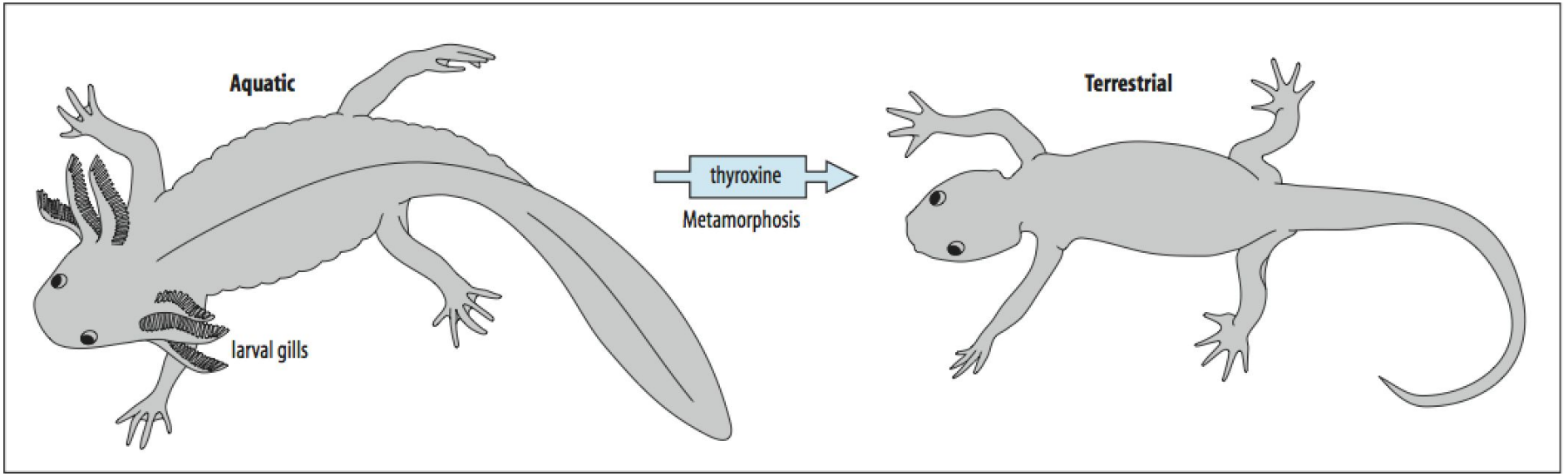
Changes in the number of Hox genes or Hox gene complexes



Mechanisms for Evolution through Development

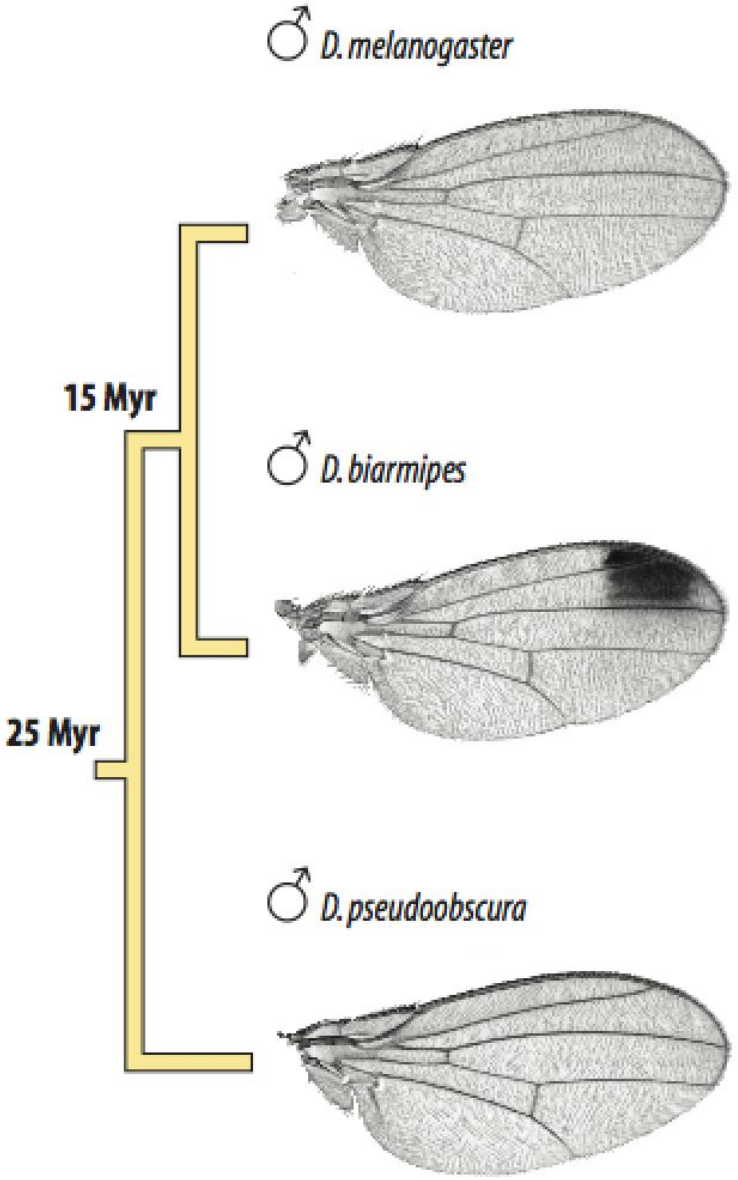
- Modularity

- Dissociation of Modules:
  - Heterochrony (Neoteny)
  - Allometry



Mechanisms for Evolution through Development

- Modularity
- Dissociation of Modules:
  - Heterochrony (Neoteny)
  - Allometry
- Gene Duplication and Divergence
- Changes in *cis*-regulatory elements



Mechanisms for Evolution through Development

- Modularity
- Dissociation of Modules:
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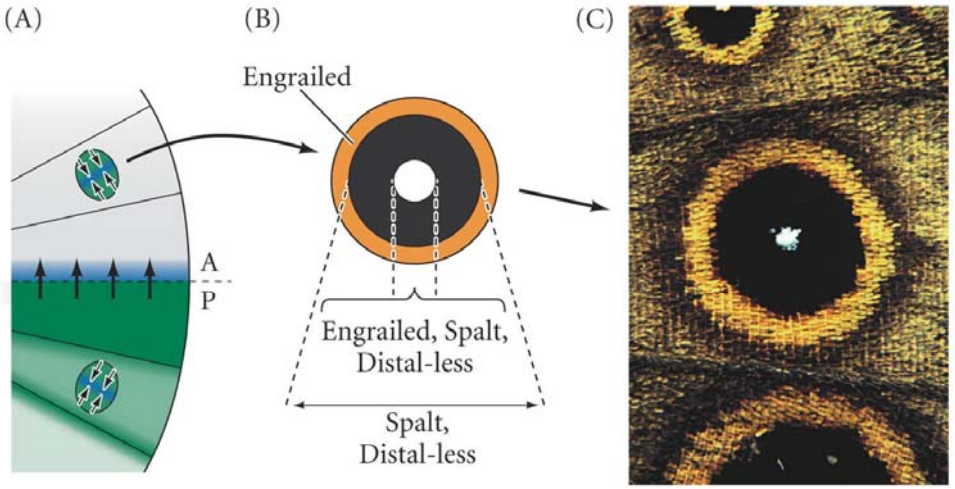
  - Allometry
- Gene Duplication and Divergence
- Changes in *cis*-regulatory elements
- Co-option



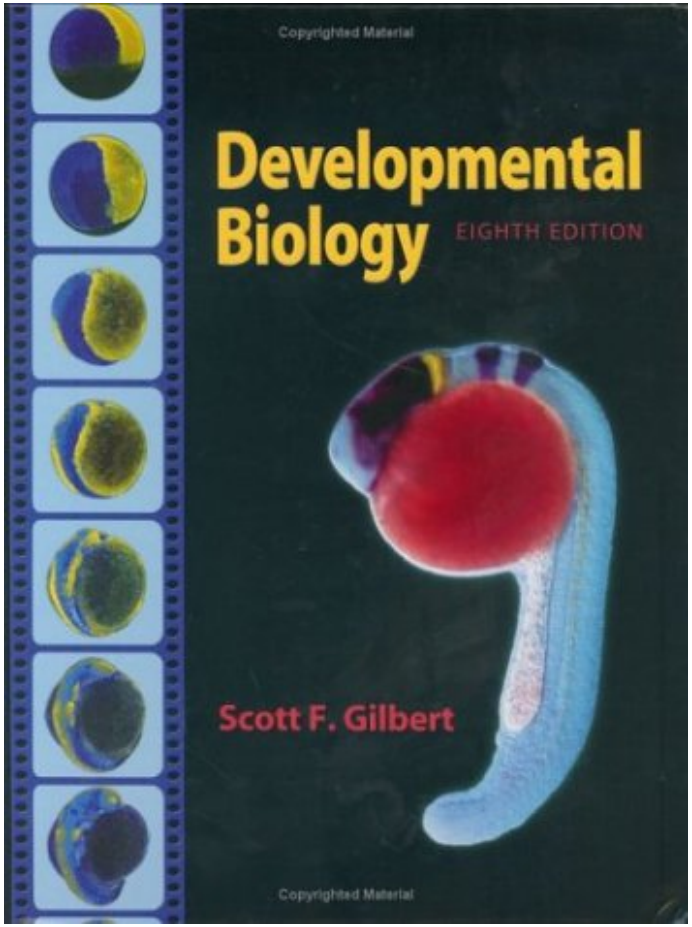
Mechanisms for Evolution through Development

- Modularity
- Dissociation of Modules:
  - Heterochrony (Neoteny)
  - Allometry
- Gene Duplication and Divergence
- Changes in *cis*-regulatory elements
- Co-option
- Macroevolution versus Microevolution

Ecological Developmental Biology

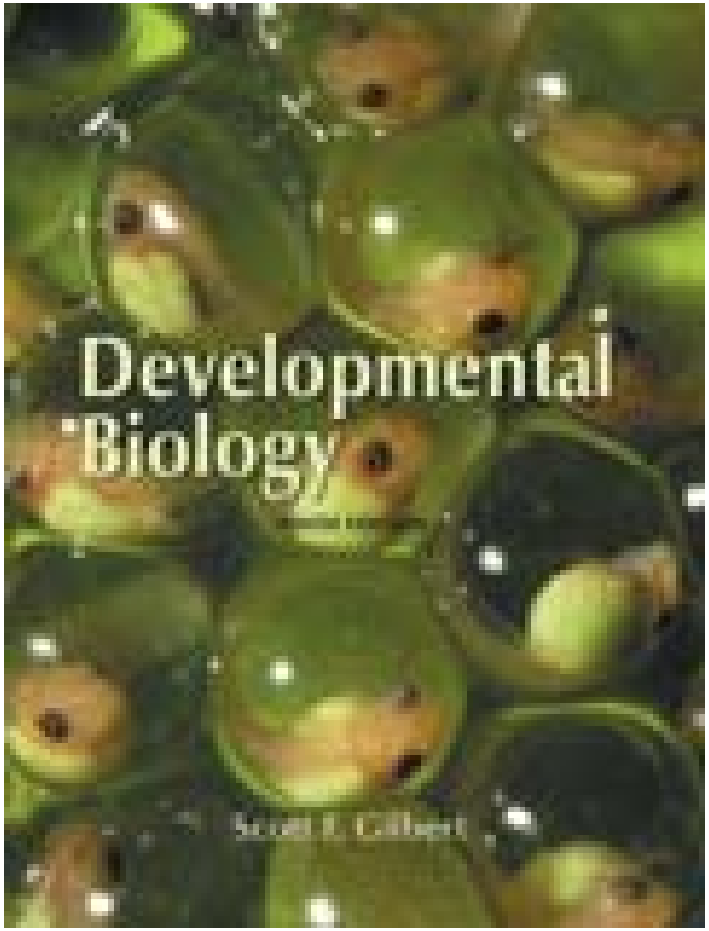
- Gilbert, **Developmental Biology**,
  8th edition, 2006. Sinauer Associates, Sunderland.

  Chapter 22



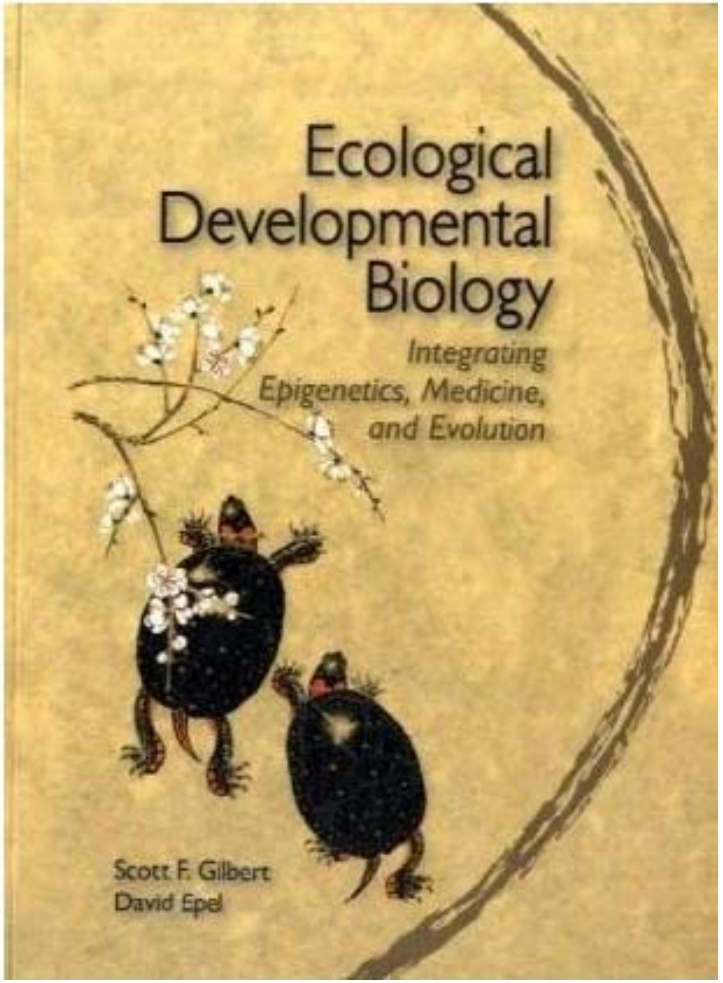
Ecological Developmental Biology

- Gilbert (englisch), **Developmental Biology**,
  9th edition, 2010. Sinauer Associates, Sunderland.
  www.devbio.com



Ecological Developmental Biology

- Gilbert and Epel, **Ecological Developmental Biology**, 2009. Sinauer Associates, Sunderland.



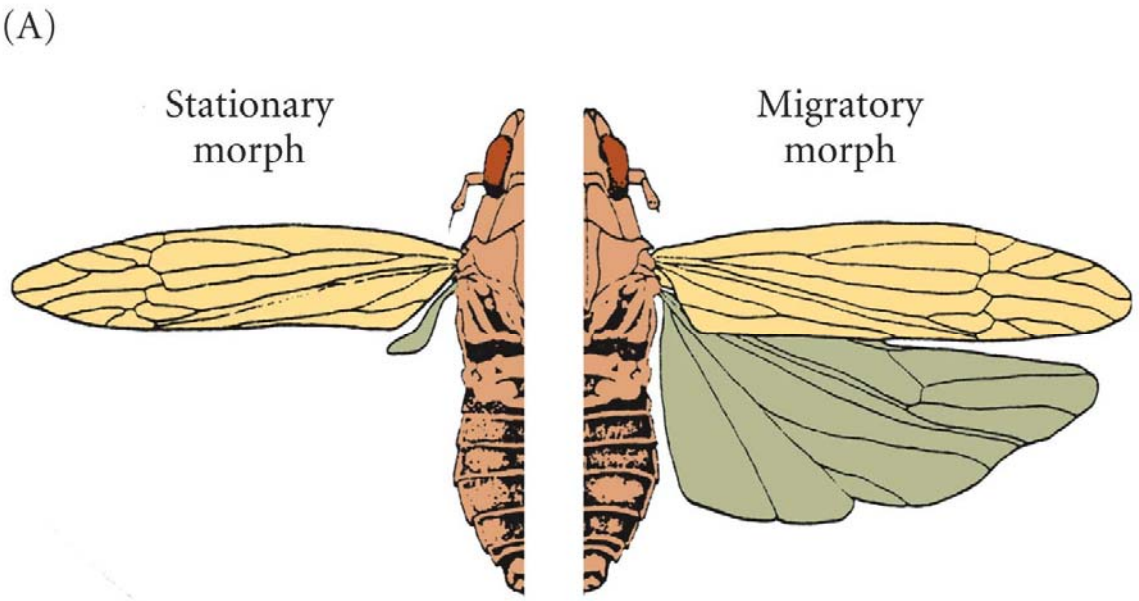
Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

- Reaction Norms

- Polyphenism
  - Density induced



Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

- Reaction Norms
- Polyphenism
  - Density induced

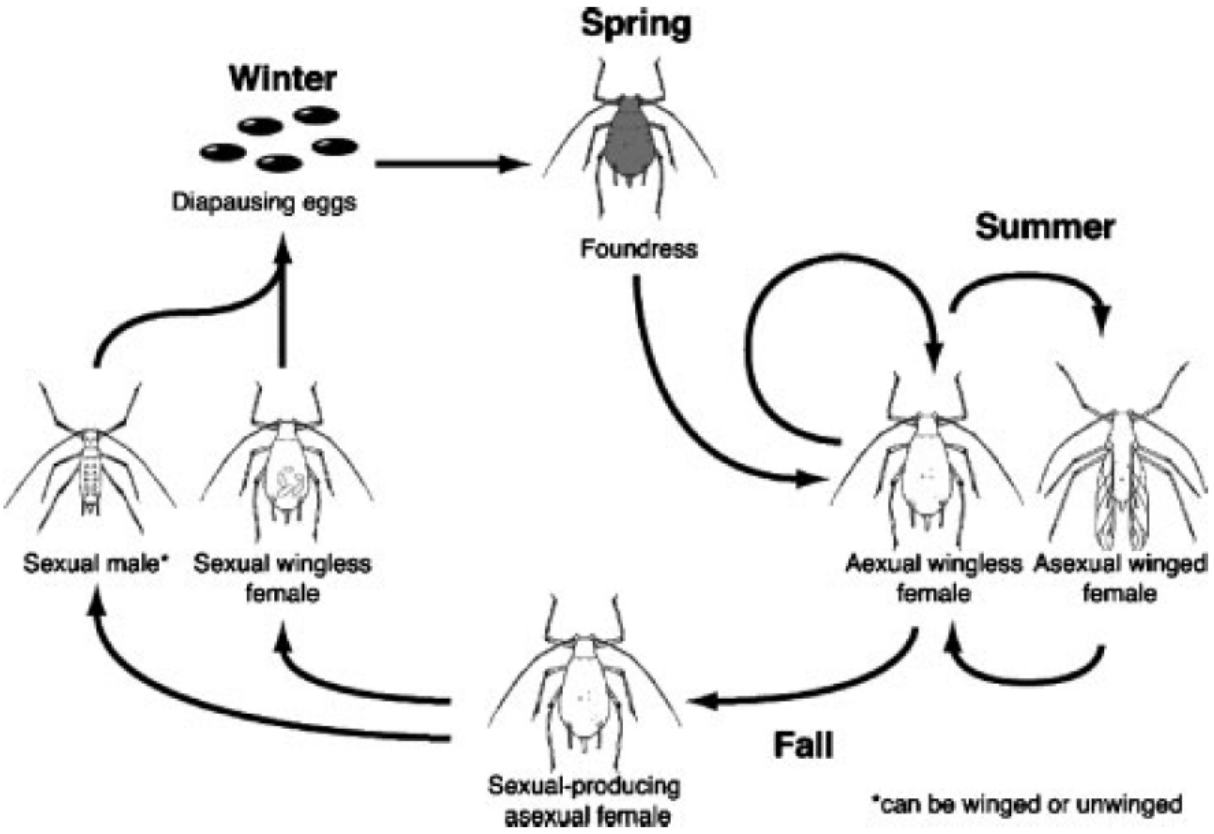
DEVELOPMENTAL BIOLOGY, Seventh Edition, Figure 22.6 (Part 2)

Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

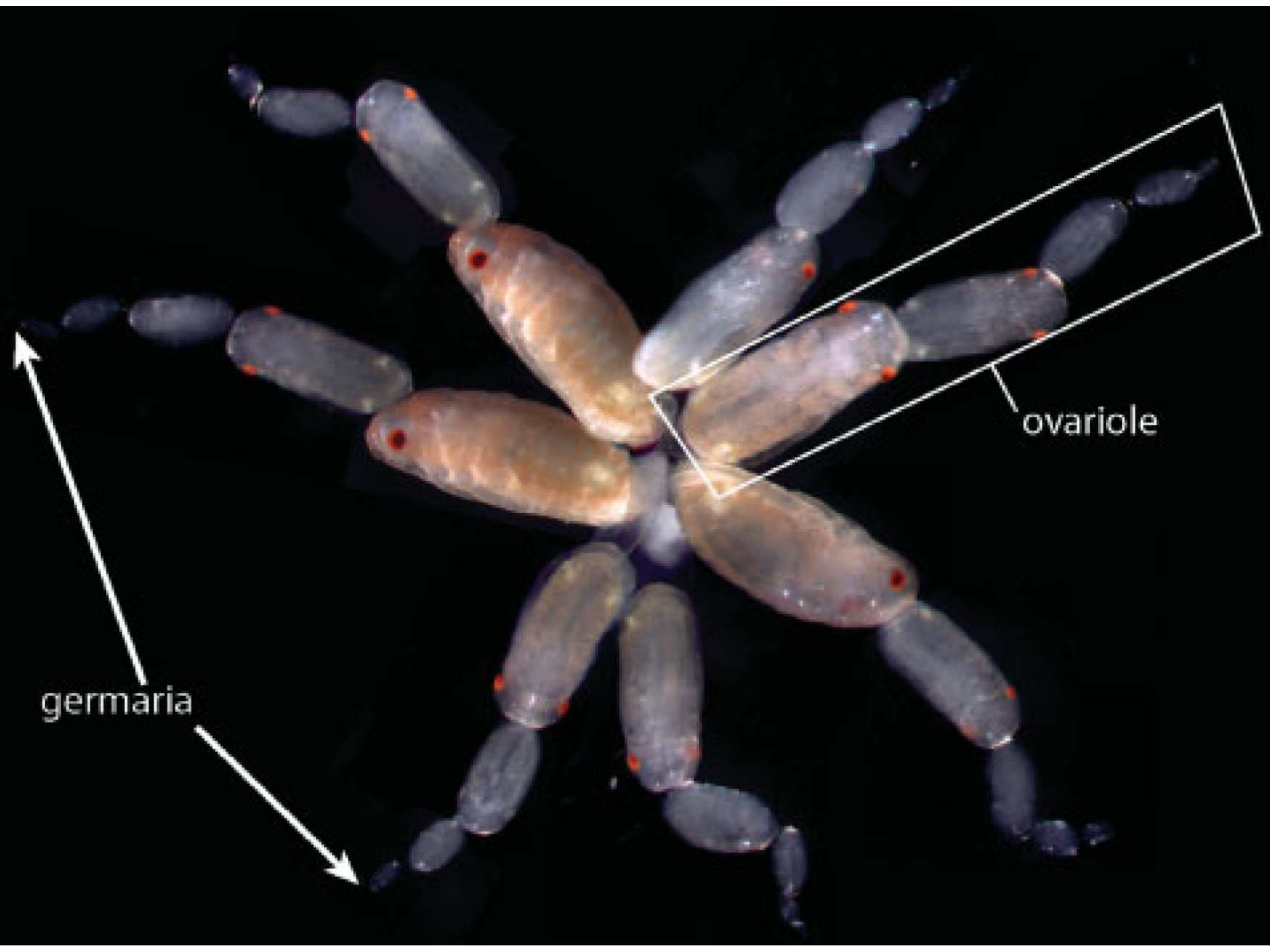
- Reaction Norms
- Polyphenism
  - Density induced



The pea aphid, *Acyrthosiphon pisum*: an emerging genomic model system for ecological, developmental and evolutionary studies

Jennifer A. Brisson* and David L. Stern

BioEssays 28:747–755, © 2006 Wiley Periodicals, Inc.

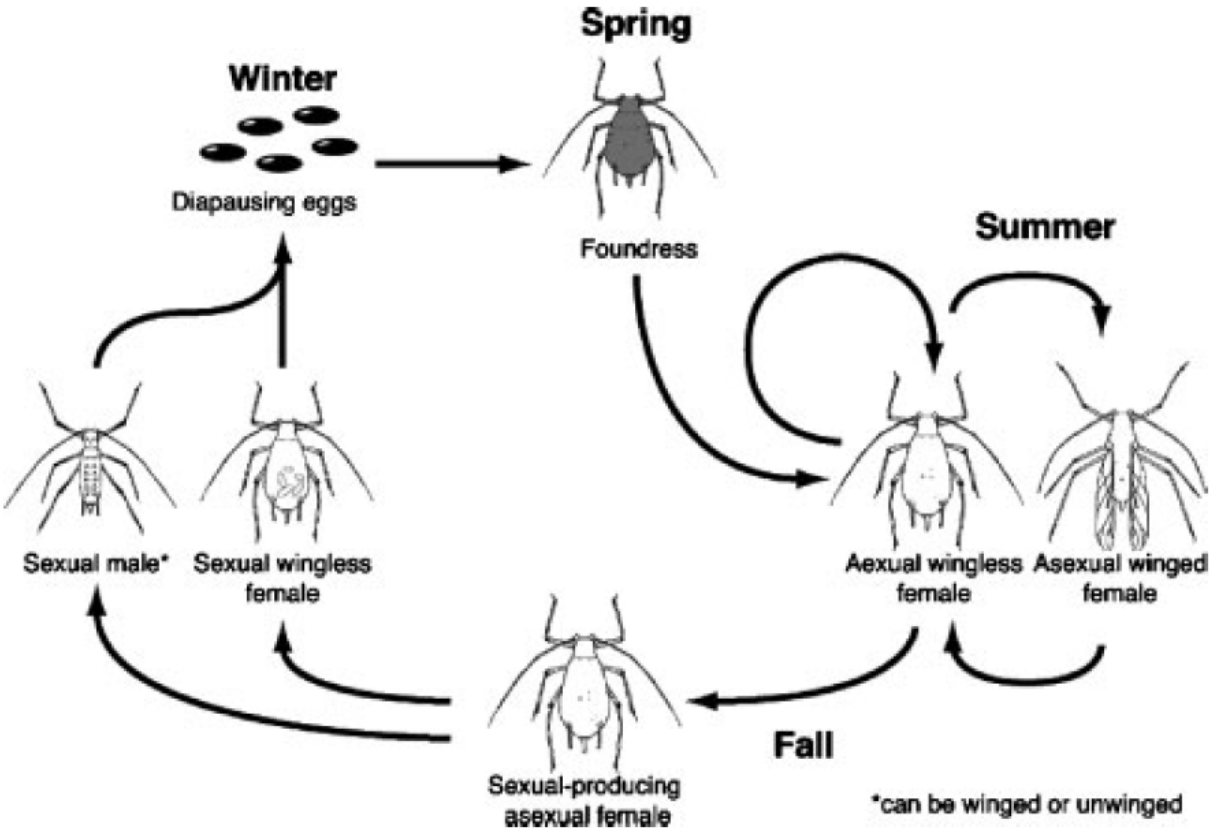

ovariole
germaria

Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

- Reaction Norms
- Polyphenism
  - Density induced
  - Seasonal



Environmental Regulation of Animal Development

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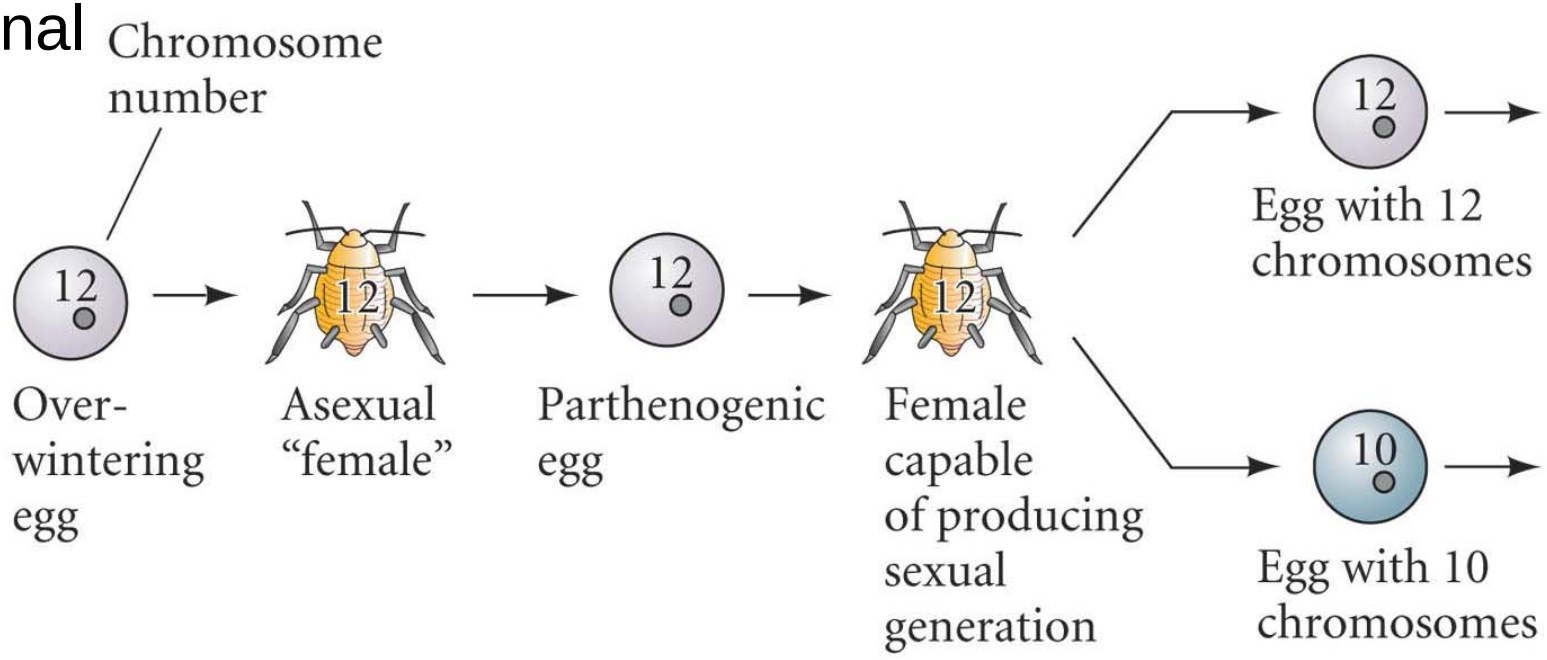

Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

- Reaction Norms
- Polyphenism
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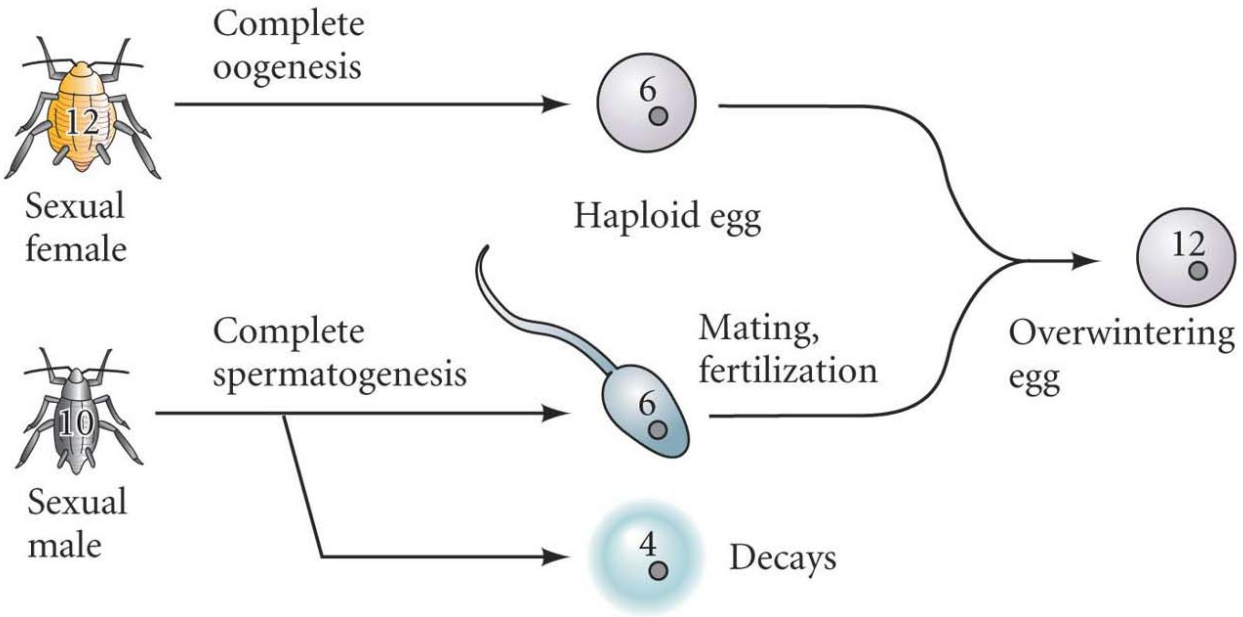

Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

- Reaction Norms

- Polyphenism
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  - Seasonal

DEVELOPMENTAL BIOLOGY, Seventh Edition, **Figure 22.7** Sinauer Associates, Inc.

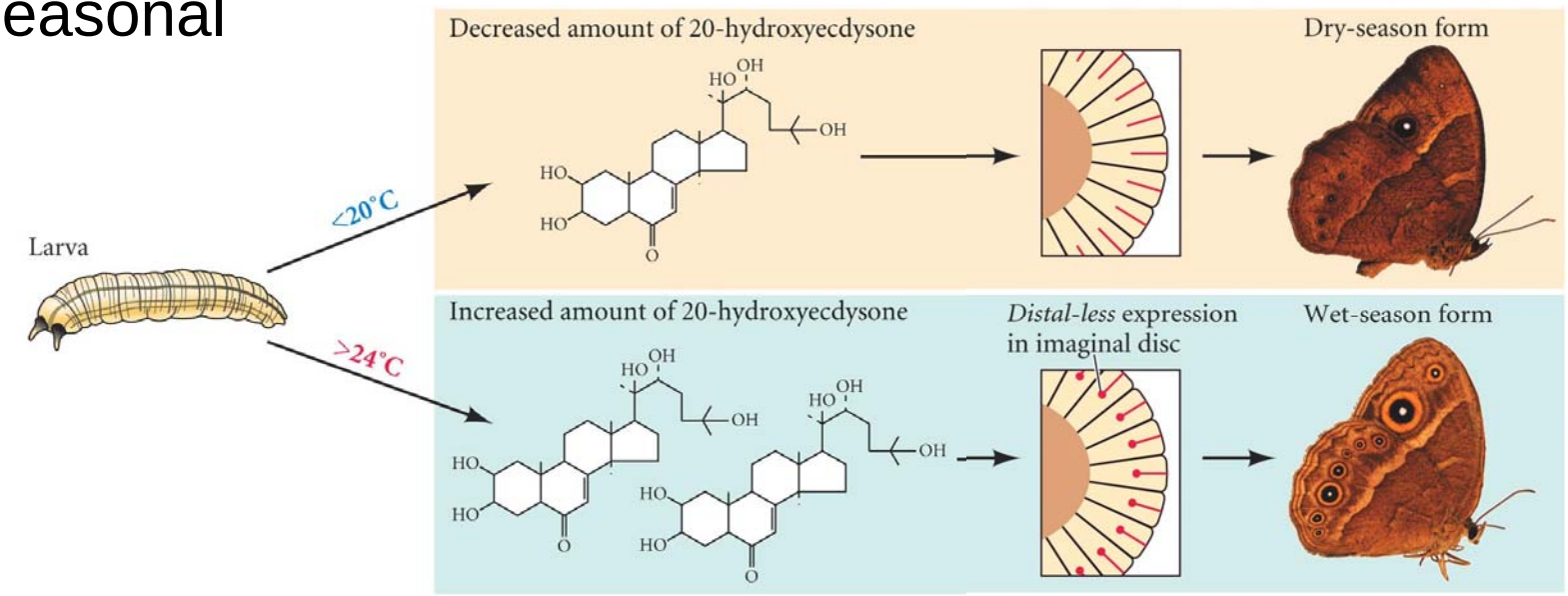
Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

- Reaction Norms

- Polyphenism
  - Density induced
  - Seasonal



DEVELOPMENTAL BIOLOGY, Seventh Edition, Figure 22.8 (Part 2) Sinauer Associates, Inc.

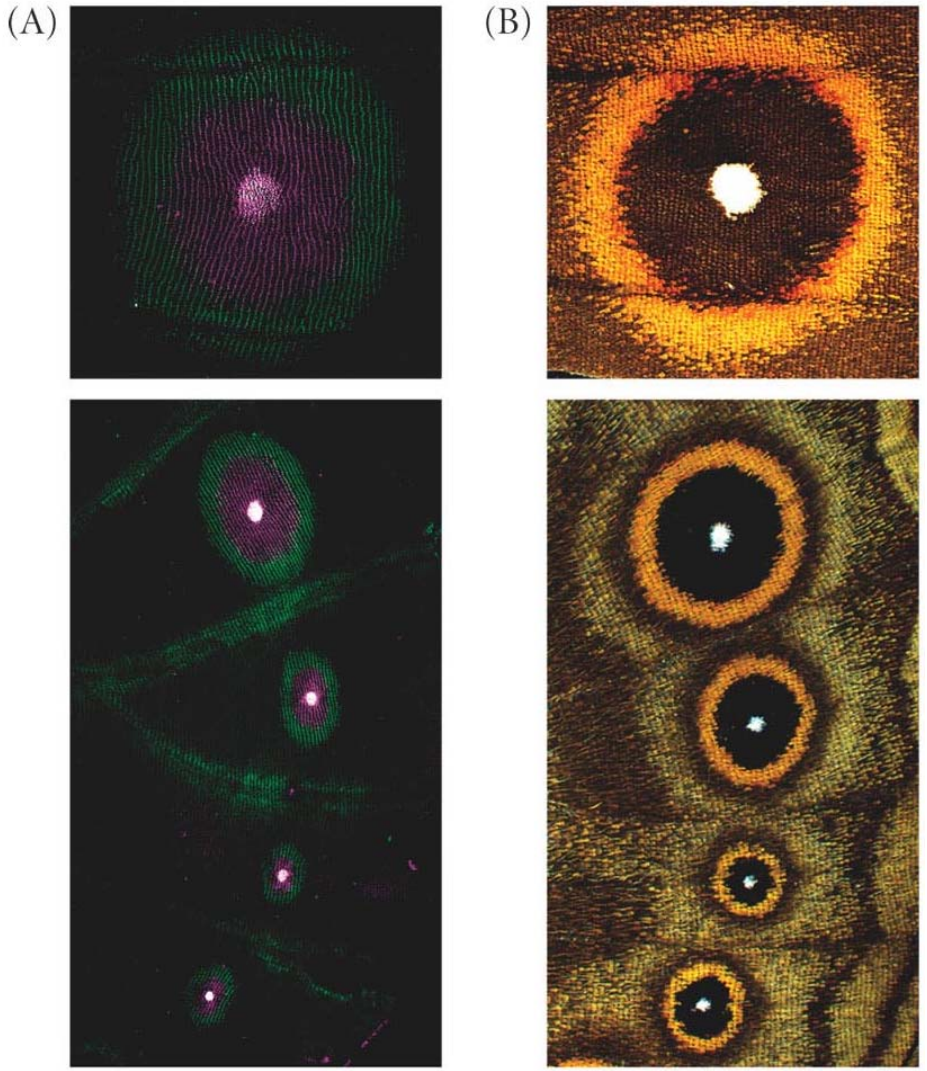
Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

- Reaction Norms

- Polyphenism
  - Density induced
  - Seasonal



Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

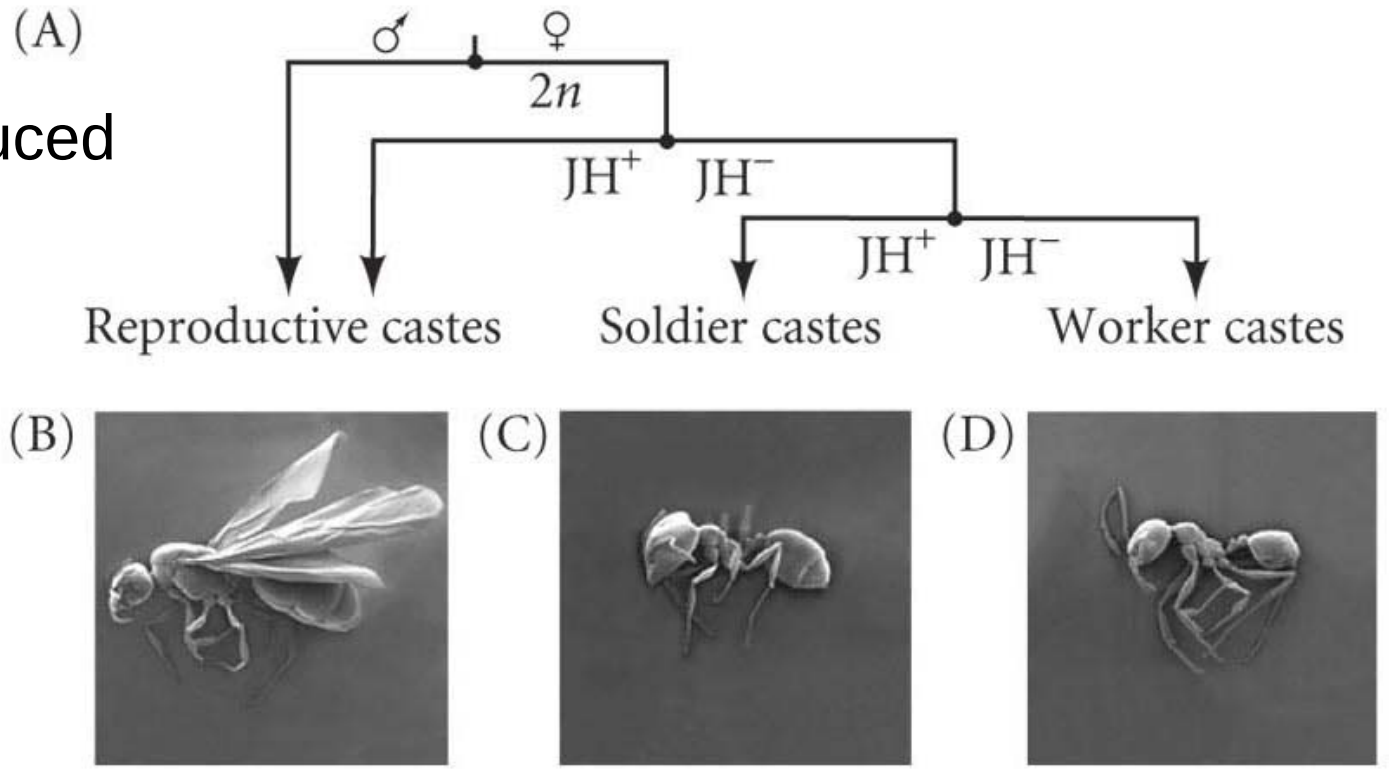
- Reaction Norms
- Polyphenism
  - Density induced
  - Seasonal

Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

- Reaction Norms
- Polyphenism
  - Density induced
  - Seasonal
  - Nutritional



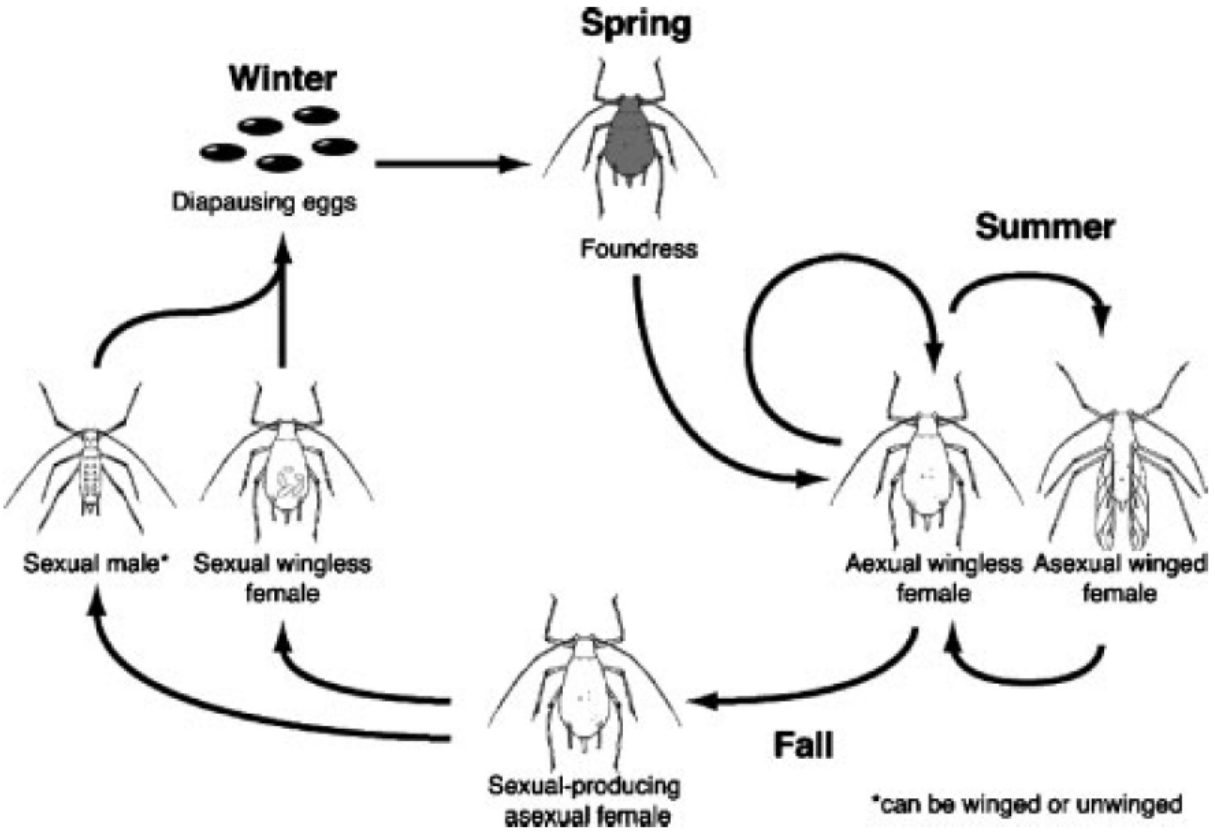
Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

- Reaction Norms

- Polyphenism
  - Density induced
  - Seasonal
  - Nutritional
  - Predator-induced



Environmental Regulation of Animal Development

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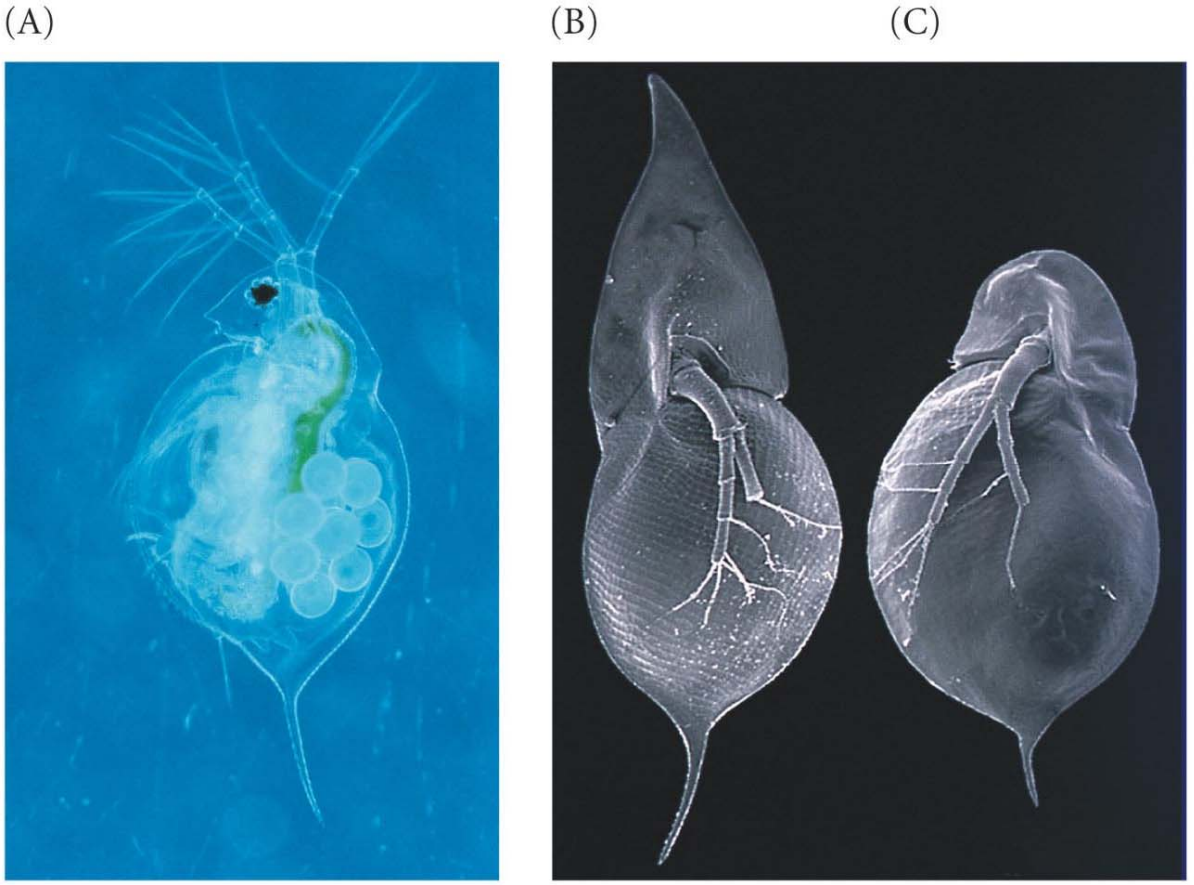

DEVELOPMENTAL BIOLOGY, Seventh Edition, **Figure 22.16** Sinauer Associates, Inc.

Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

- Reaction Norms

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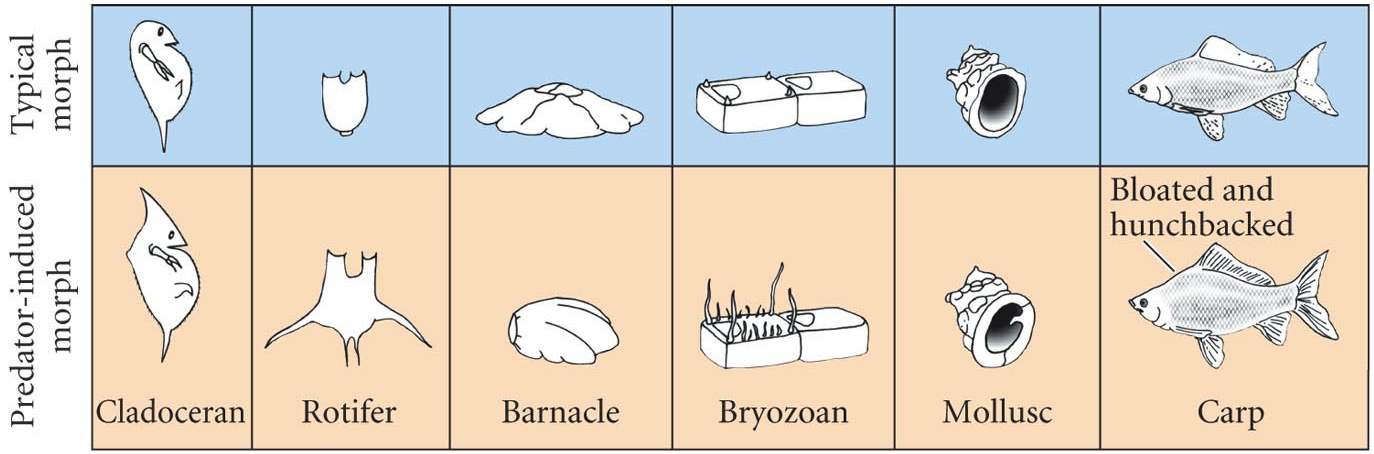
  - Seasonal
  - Nutritional
  - Predator-induced



Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

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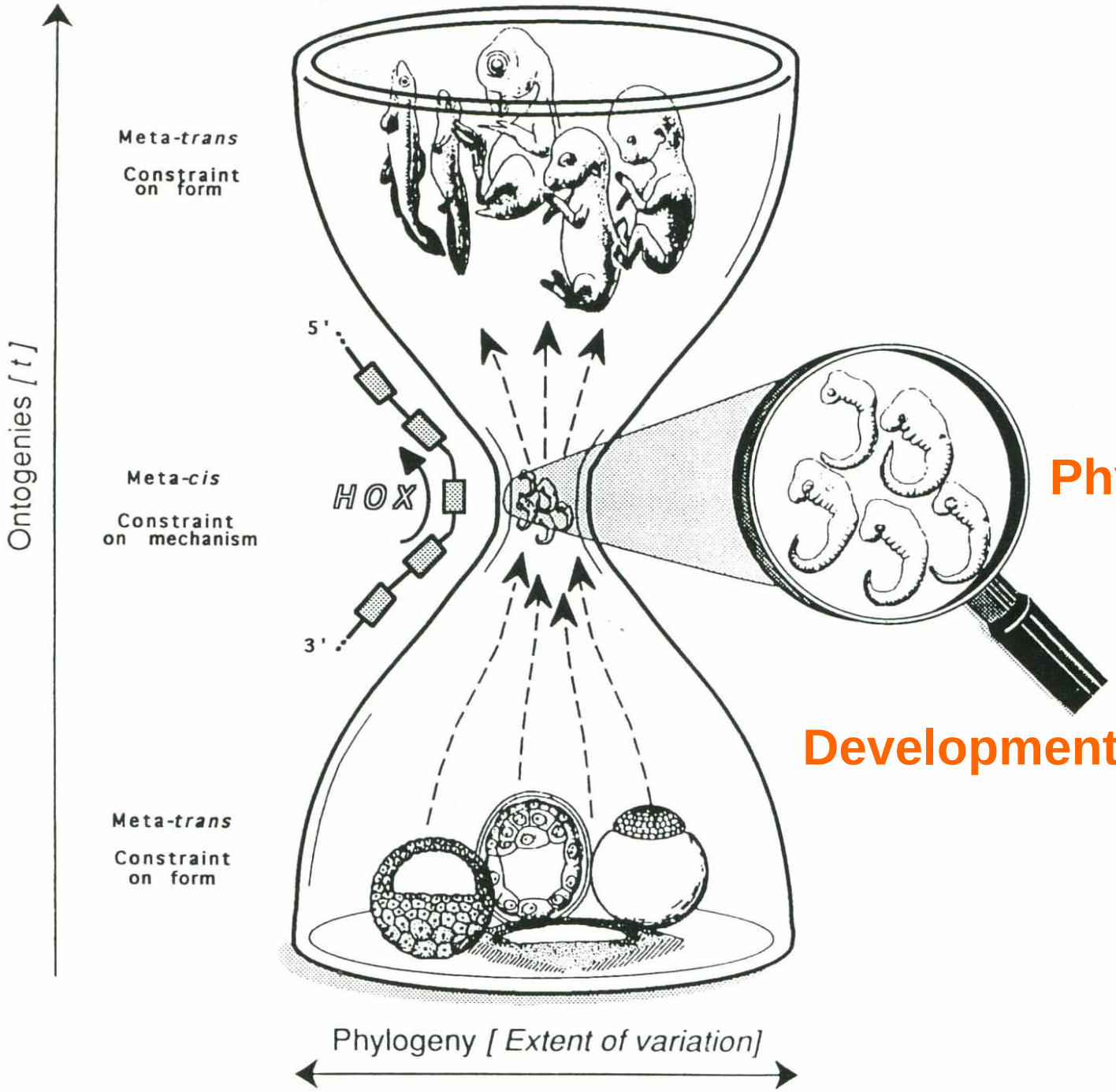
  - Seasonal
  - Nutritional
  - Predator-induced

- Environmental Adaptability – Evolutionary Adaptability
  Selection for Evolvability



Phylotypic Stage

Developmental Constraints

Environmental Regulation of Animal Development

Phenotypic Plasticity

Specific Genotype can Generate More Than One Phenotype

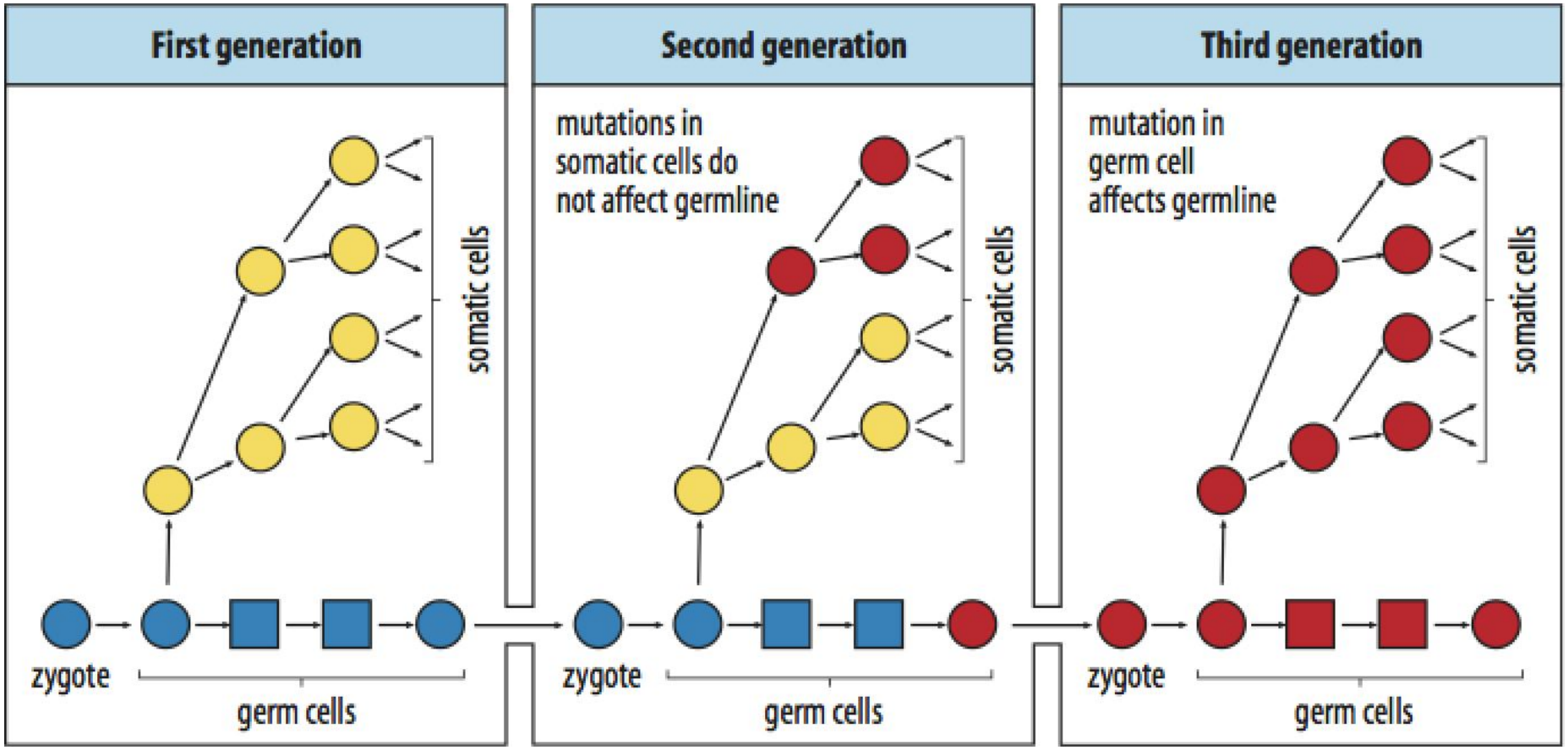
- Reaction Norms

- Polyphenism
  - Density induced
  - Seasonal
  - Nutritional
  - Predator-induced

- Environmental Adaptability – Evolutionary Adaptability
  Selection for Evolvability

- Epigenetic Inheritance Systems – The Ghost of Lamarck

Distinction between Germ Cells and Somatic Cells



M.Bio.349

Evolutionary Developmental Biology

SoSe 2011
(lecture weeks 11 to 13; June 20th to July 8th)

Nikola-Michael Prpic-Schäper
Johann-Friedrich-Blumenbach-Institut
Universität Göttingen

e-mail: nprpic@uni-goettingen.de

During the course you will compare the embryonic expression pattern of selected Hox genes in three different arthropod species:

Drosophila melanogaster **(Vinegar Fly)**
Tribolium castaneum **(Red Flour Beetle)**
Achaearanea tepidariorum **(Common House Spider)**