

**Integrated Science 9**

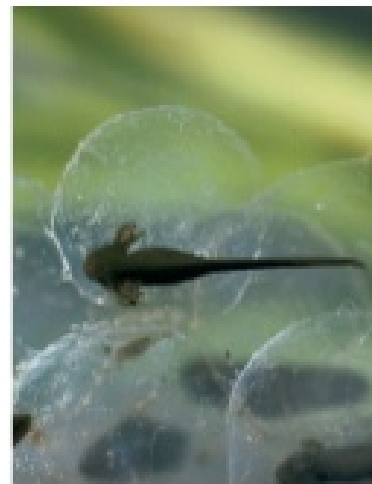
**Genetic basis for  
development**

## *In embryonic development*

A single-celled zygote gives rise to cells of many different types, each with a different structure and corresponding function



(a) Fertilized eggs of a frog

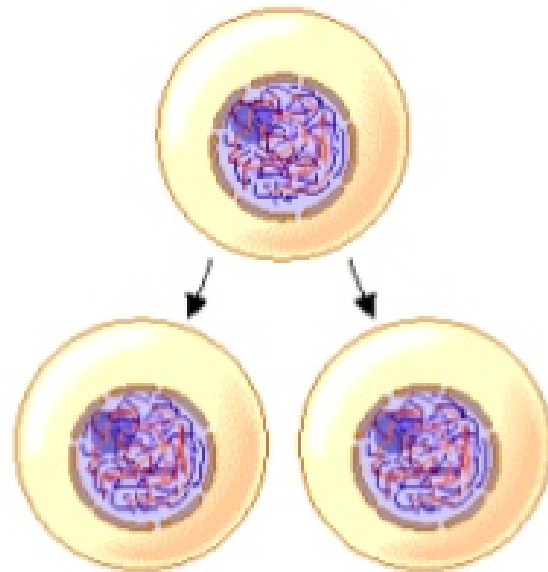


(b) Tadpole hatching from egg

Results from three interrelated processes:  
**cell division, cell differentiation, and morphogenesis**

# cell division

a process wherein a parent cell divides to two or more daughter cells

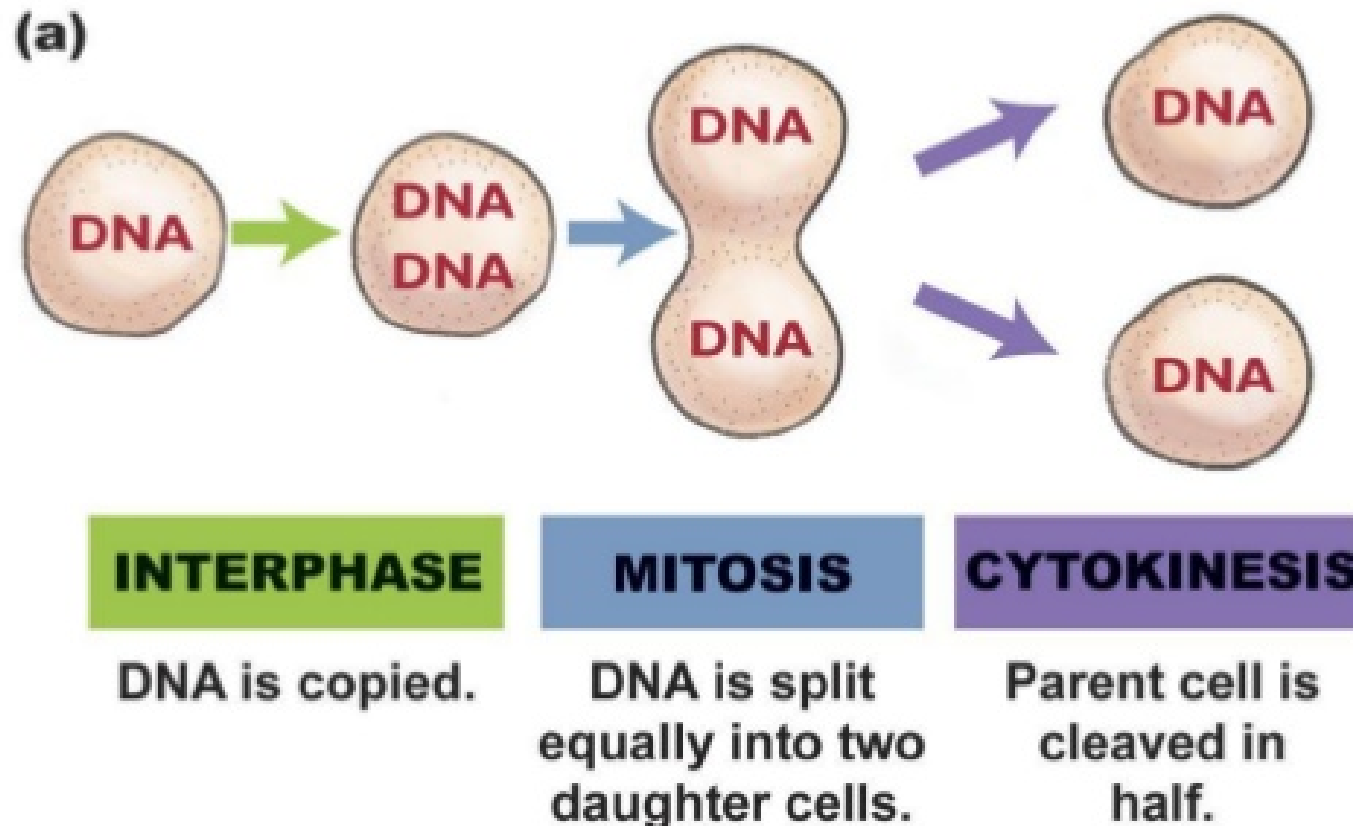


parent cell

daughter cells

# cell division

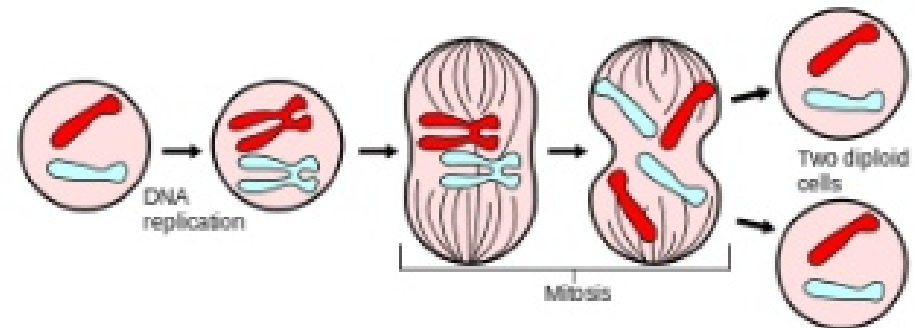
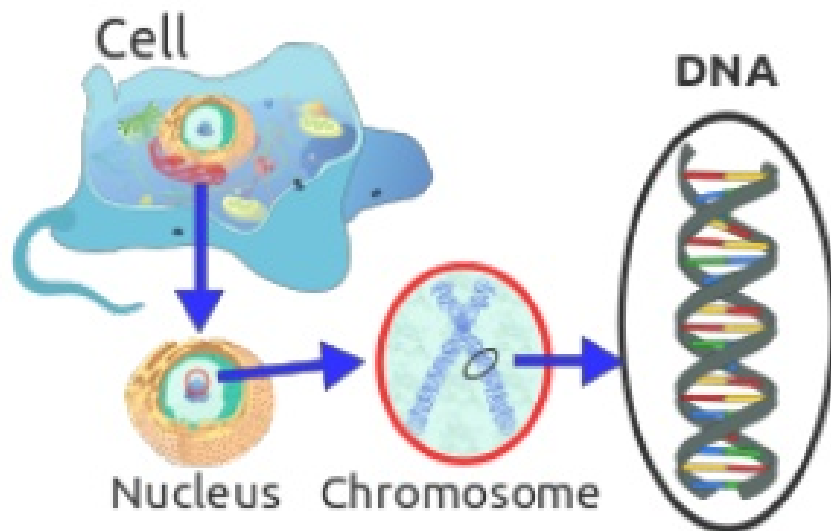
involves the distribution of genetic material (DNA) to daughter cells



# cell division

involves the distribution of genetic material (DNA) to daughter cells

because DNA are in the chromosomes

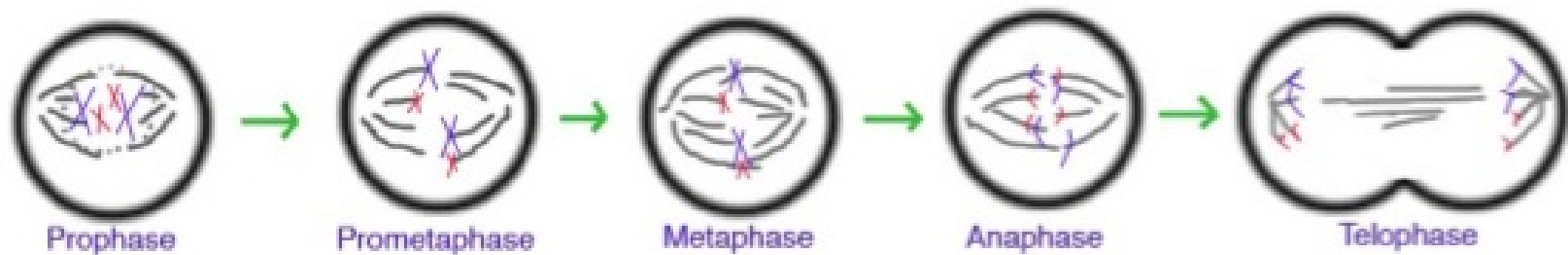


and chromosomes are duplicated and divided into daughter cells

# cell division

may be mitosis or meiosis

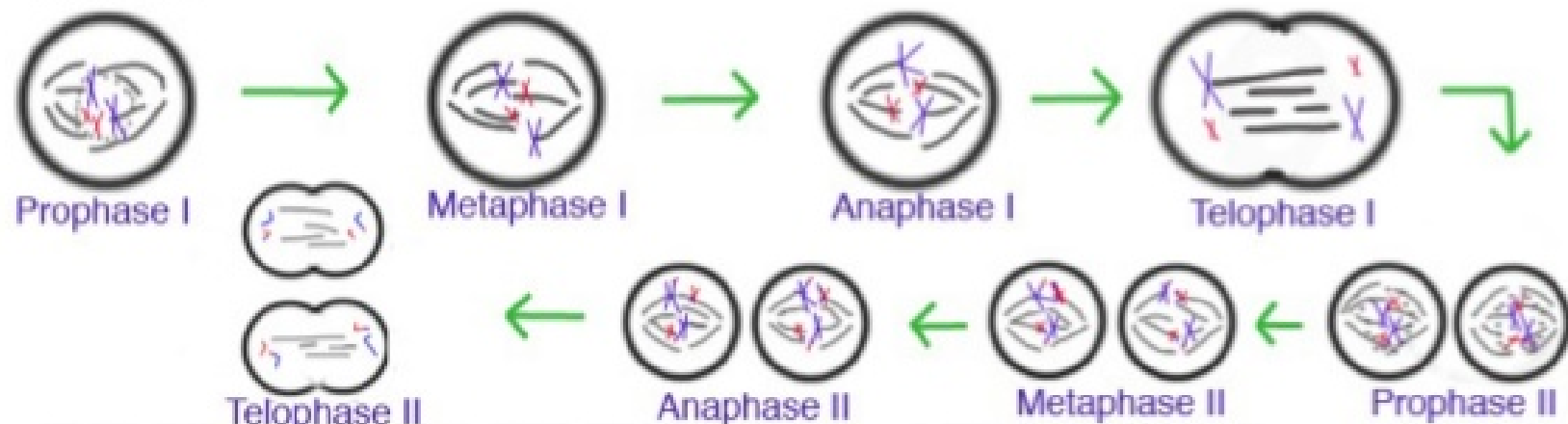
## Mitosis



Adapted by Molecular Biology of the Cell, Figure 17.22002 by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter

& The Cell: A Molecular Approach, Figure 14.23, Stages of mitosis in an animal cell, 2000, Geoffrey Cooper.

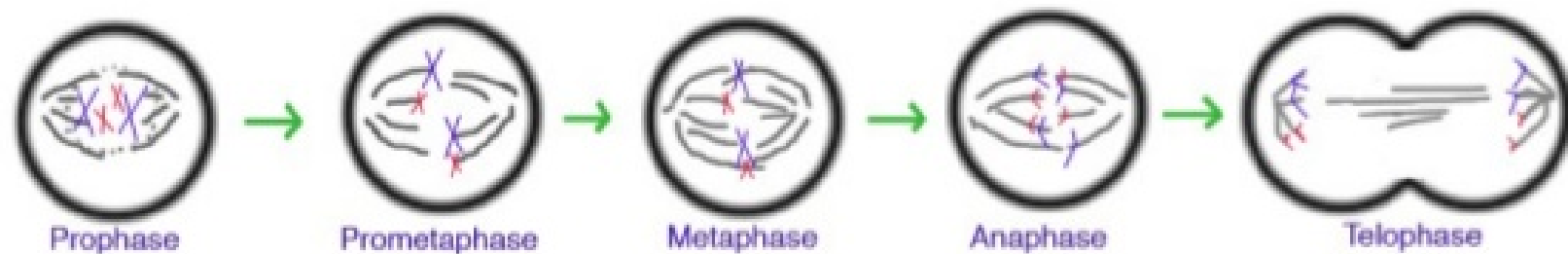
## Meiosis



Adapted from <http://www.estrellamountain.edu/faculty/farabee/biobk/BioBookmeiosis.html#Comparison%20of%20Mitosis%20and%20Meiosis>

# cell division

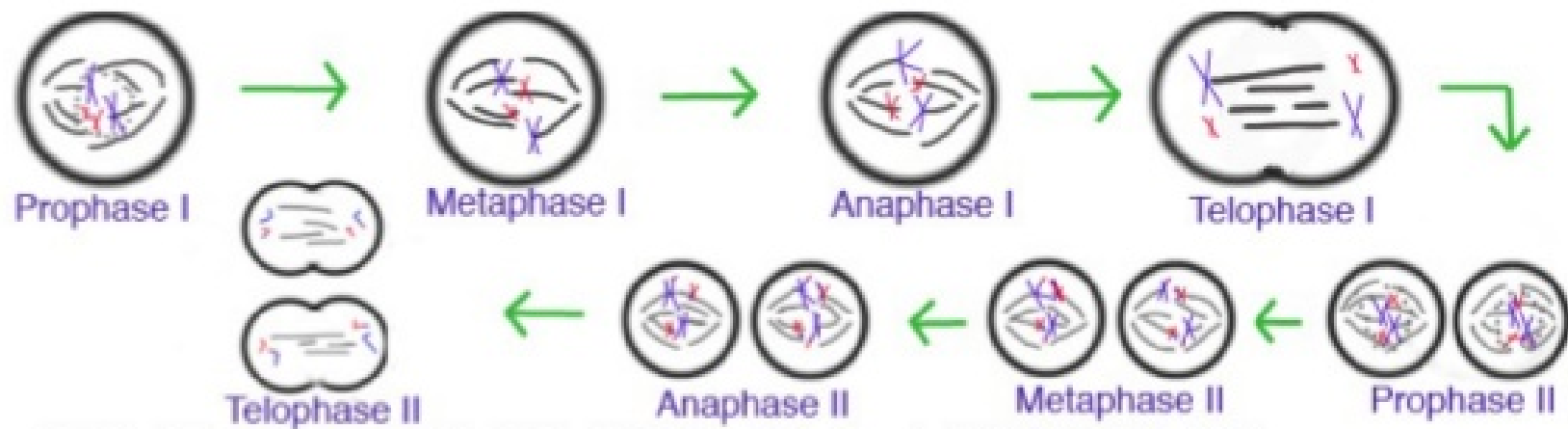
## mitotic cell division



Through a series of many mitotic division, zygote gives rise to a multicellular organism

# cell division

## meiotic cell division

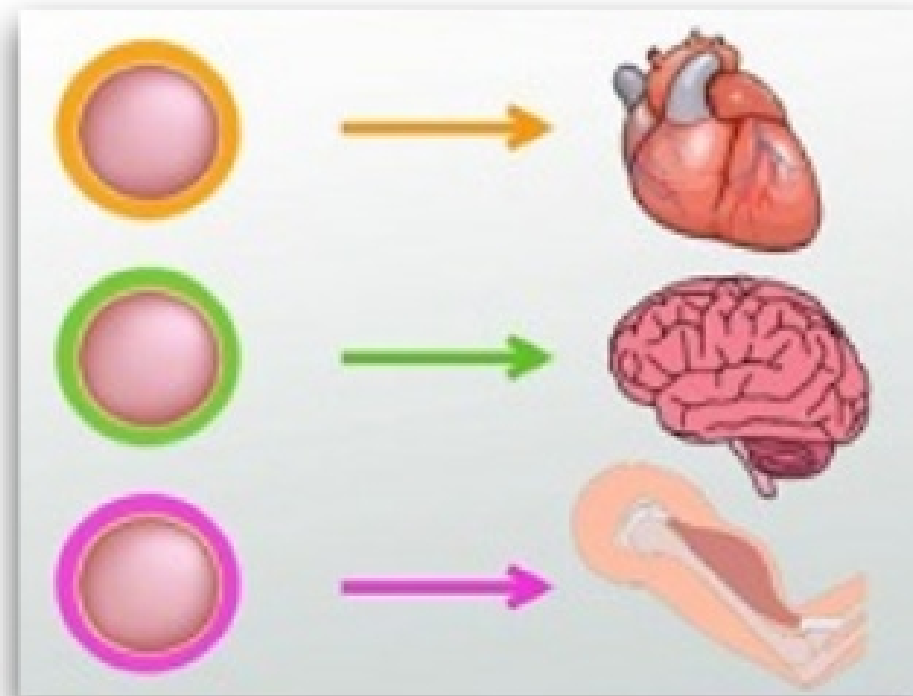


process of cell division for sexually  
reproduce eukaryotes



# Cell differentiation

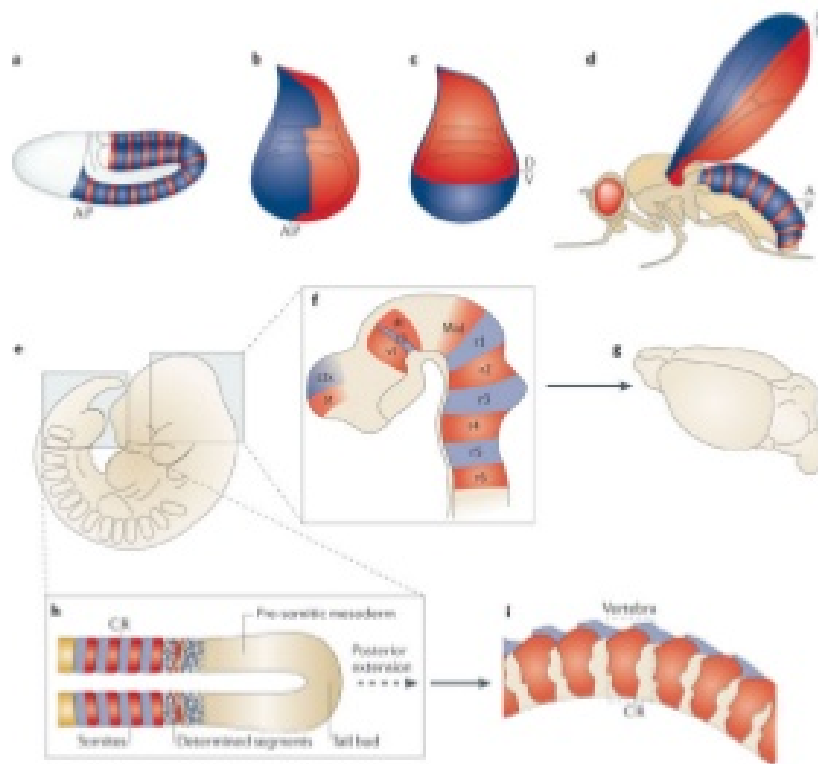
a process wherein a less specialized cells become more specialized in structure and function





# morphogenesis

biological process that causes an organism to develop its form



model organism:

*Drosophila melanogaster*

- Thomas Hunt Morgan
- Fruitfly
- Easily grown (2 weeks)
- Embryonic dev't = outside of the womb

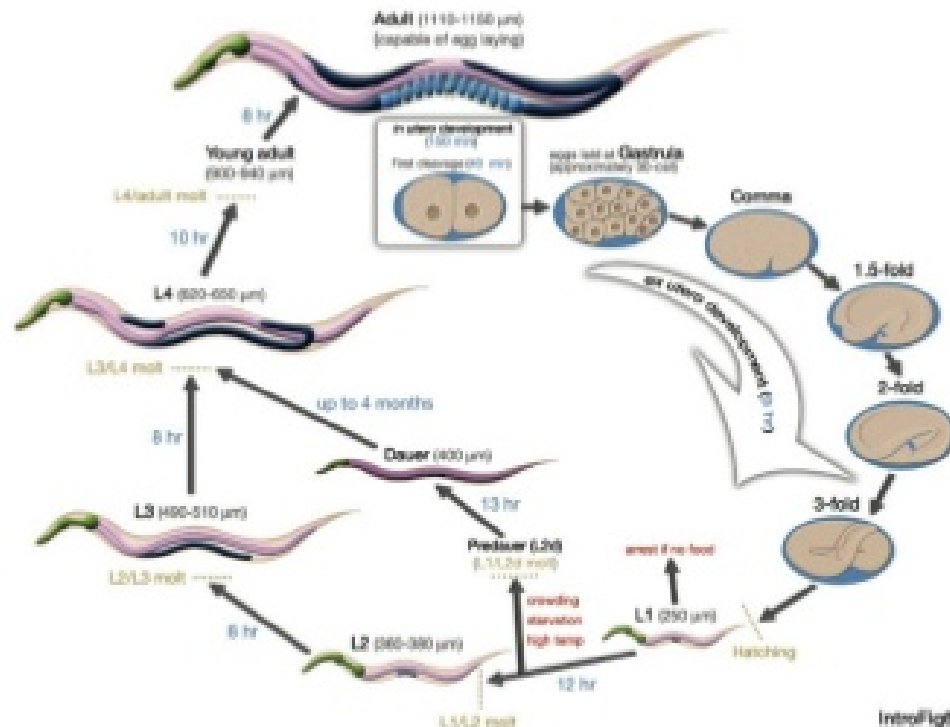
# morphogenesis

biological process that causes an organism to develop its form

model organism:

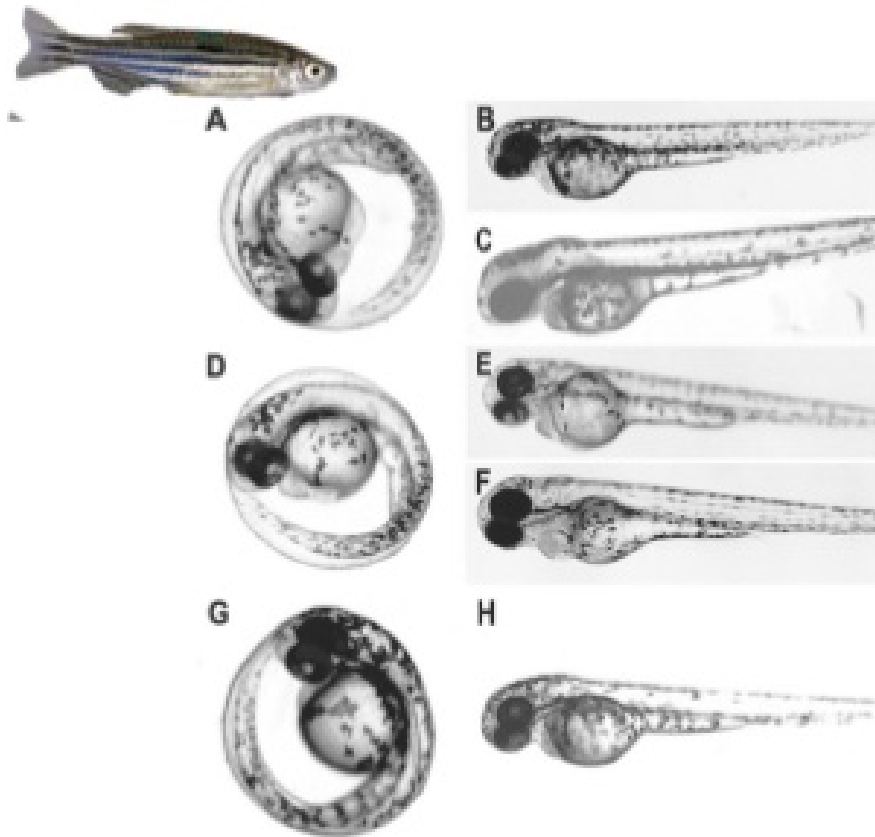
*Caenorhabditis elegans*

- Nematode
- Can grow on petri dishes
- Hermaphrodites = easy to detect mutations



# morphogenesis

biological process that causes an organism to develop its form



model organism:

## *Danio raerio*

- Zebrafish
- Easy to breed
- Embryonic dev't = outside of the mother's womb

# *weather in plants or animals*

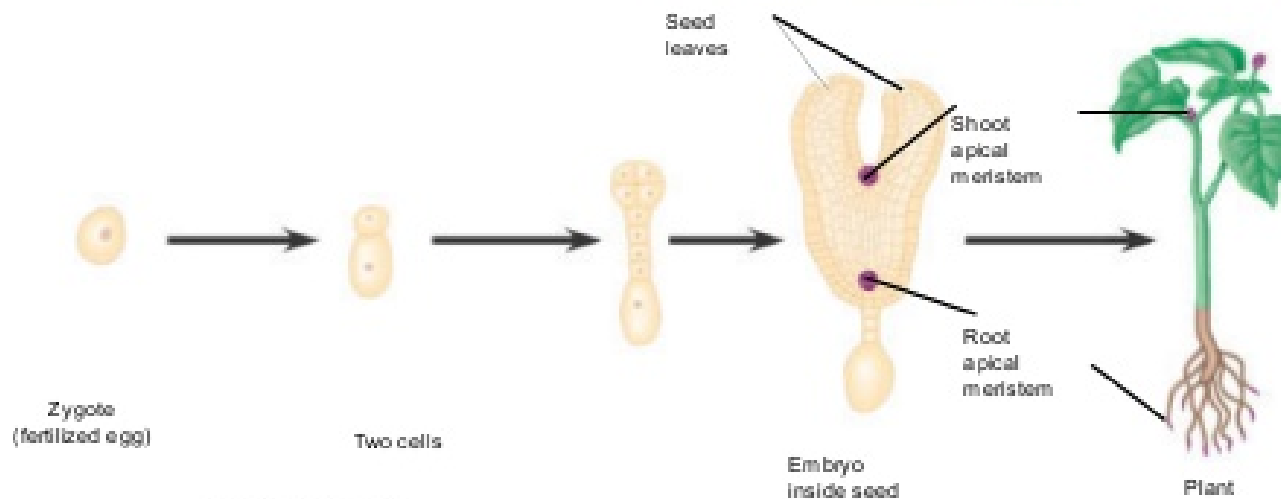
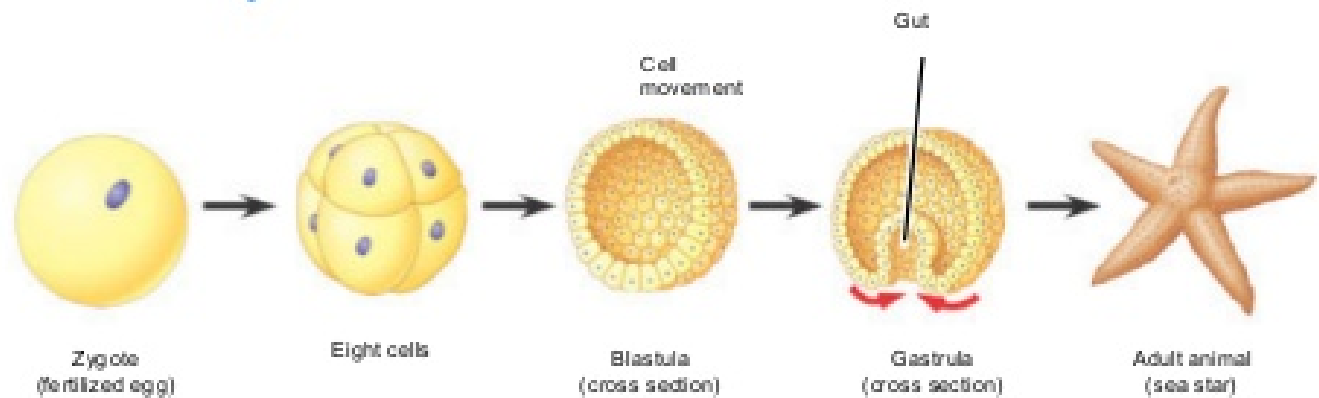


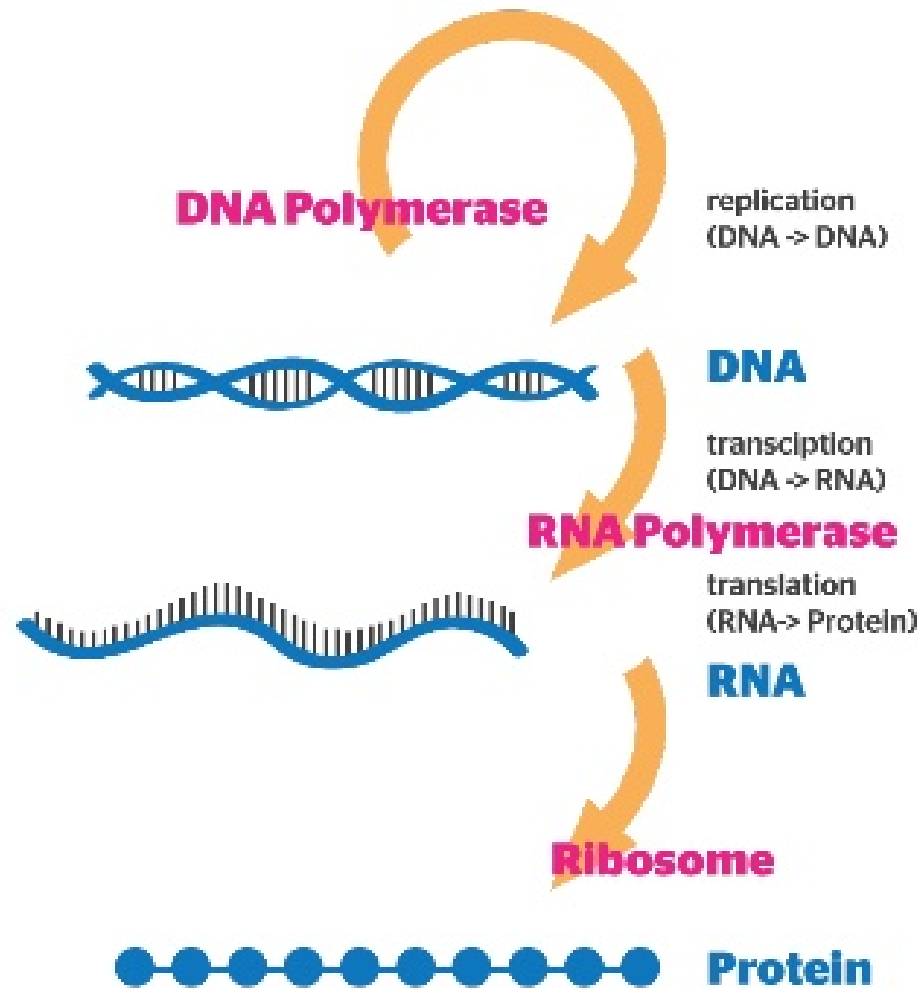
Figure 21.4a, b

## *differences in cell types*

result from differential **gene expression** in cells with the same DNA, not from differences in the cells' **genomes**

# gene expression

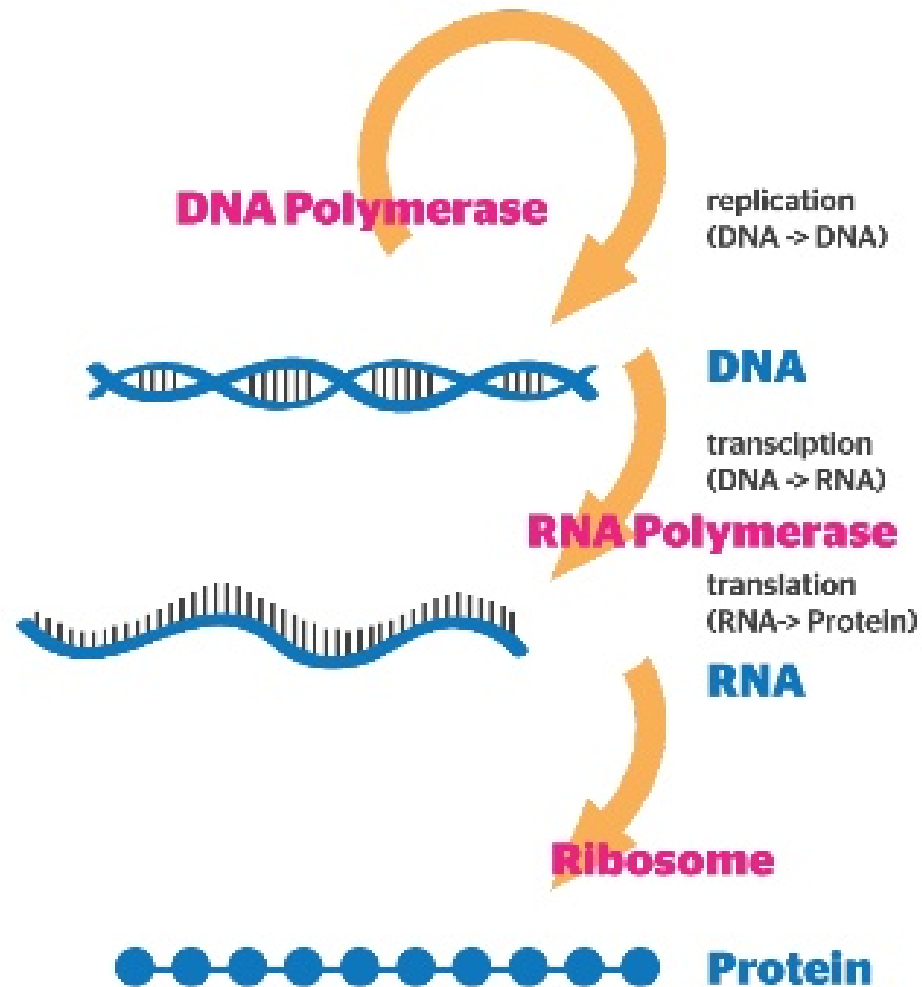
a process by which the genetic information (DNA) is used to synthesise a product (protein or RNA)





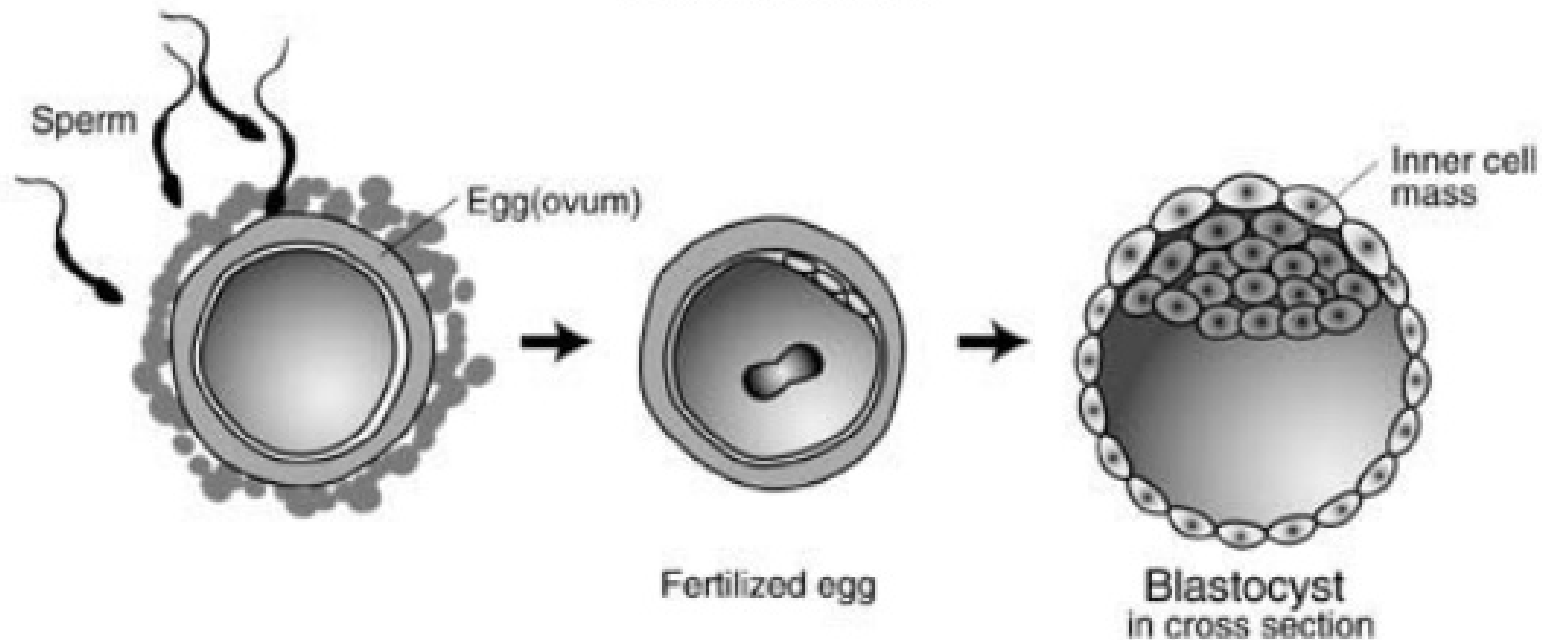
# gene expression

involves  
replication,  
transcription,  
and translation



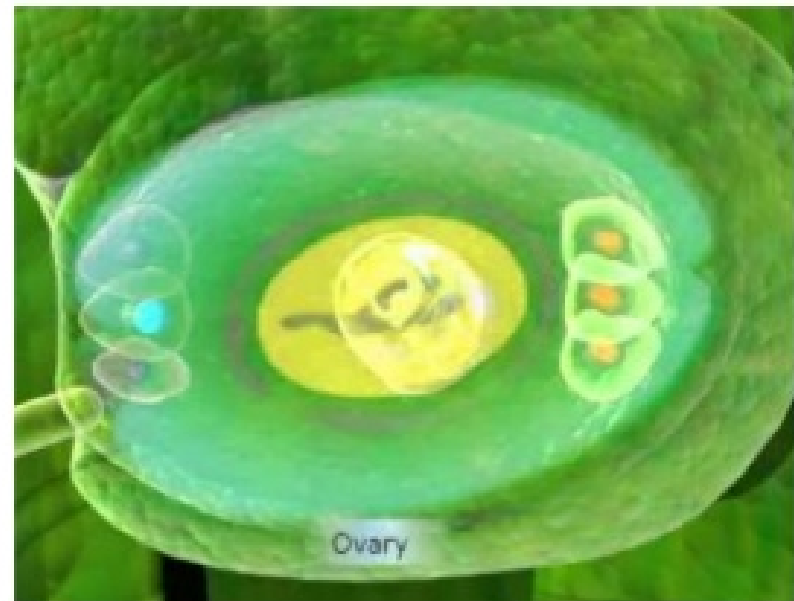
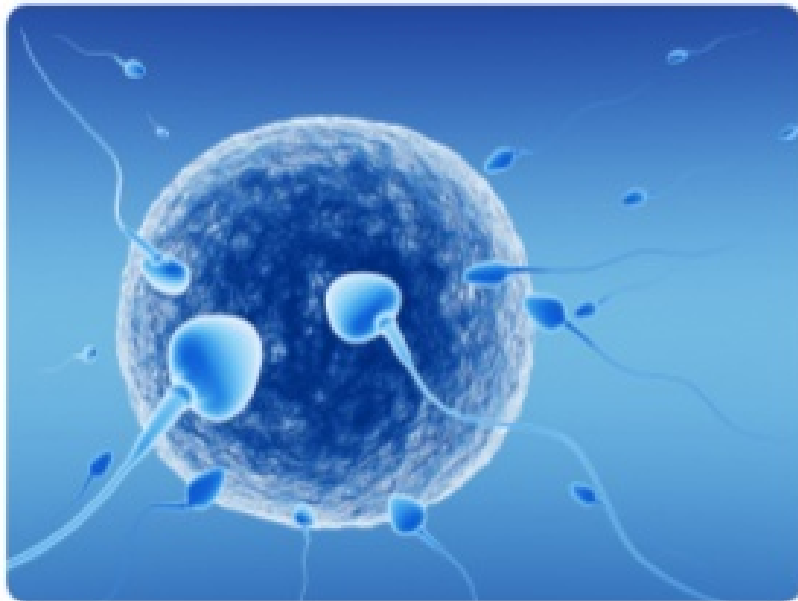
# zygote

Fertilized egg cell that results from the union of a female and a male gamete



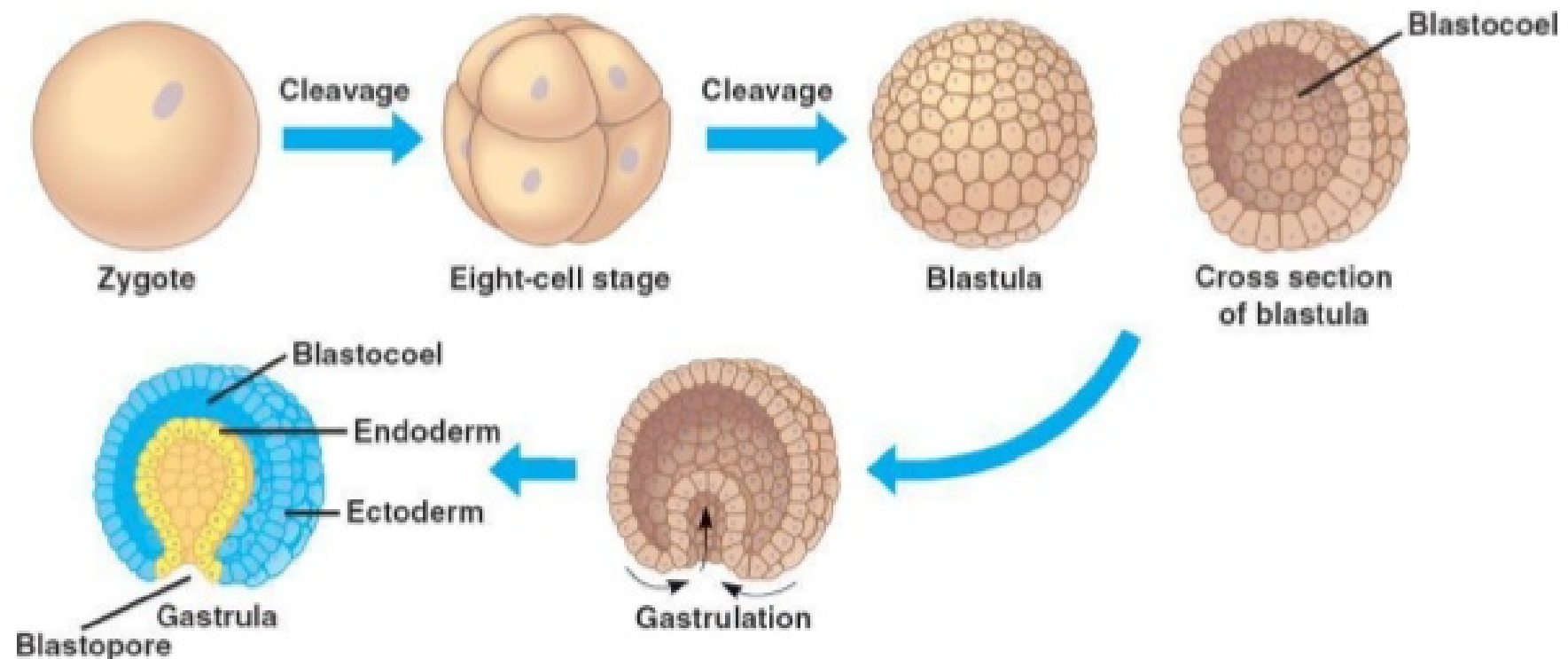
# fertilization

fusion of gametes to form an embryo



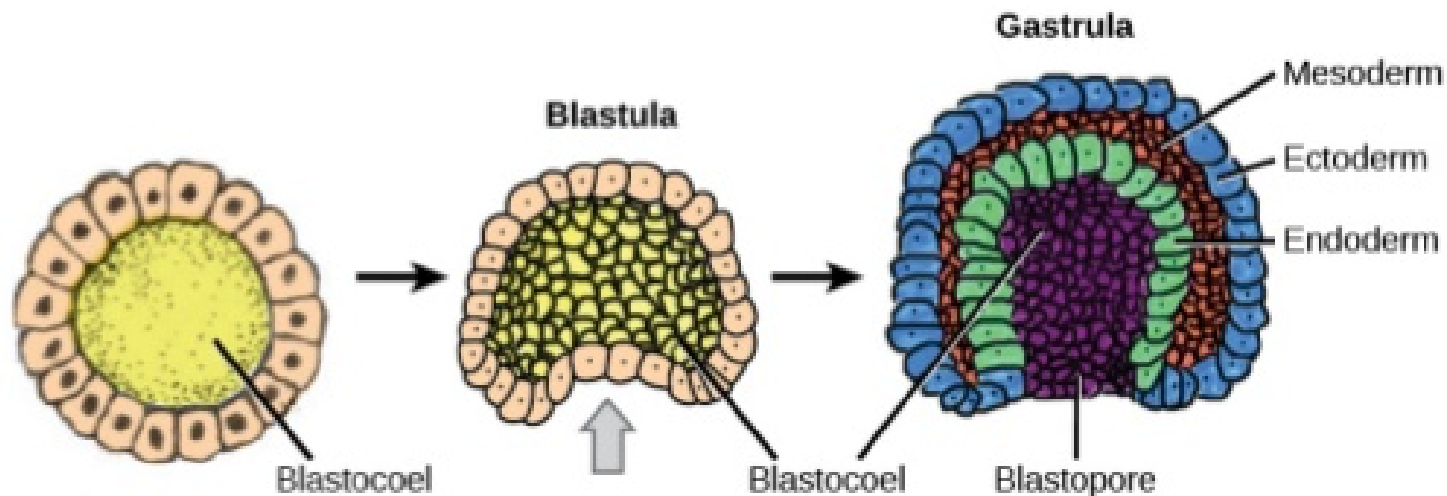
# blastula

hollow sphere of cells (blastomeres)  
surrounding an inner fluid-filled cavity  
(blastocoel) which forms epithelial layer



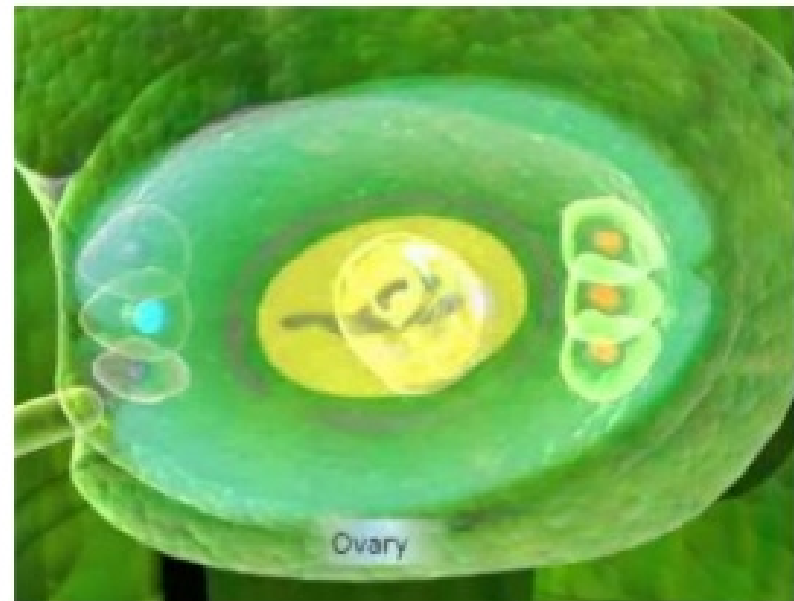
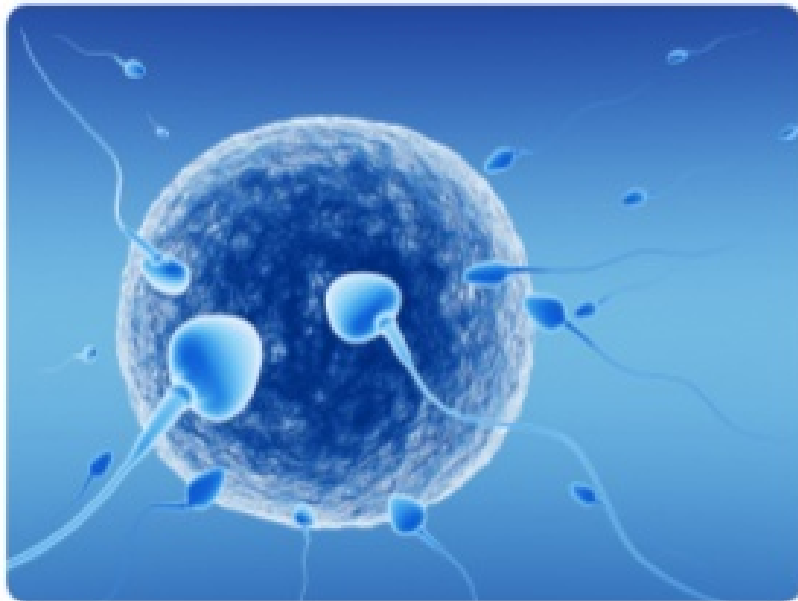
# gastrula

three-layered reorganised blastula  
which eventually forms:  
ectoderm, mesoderm, endoderm



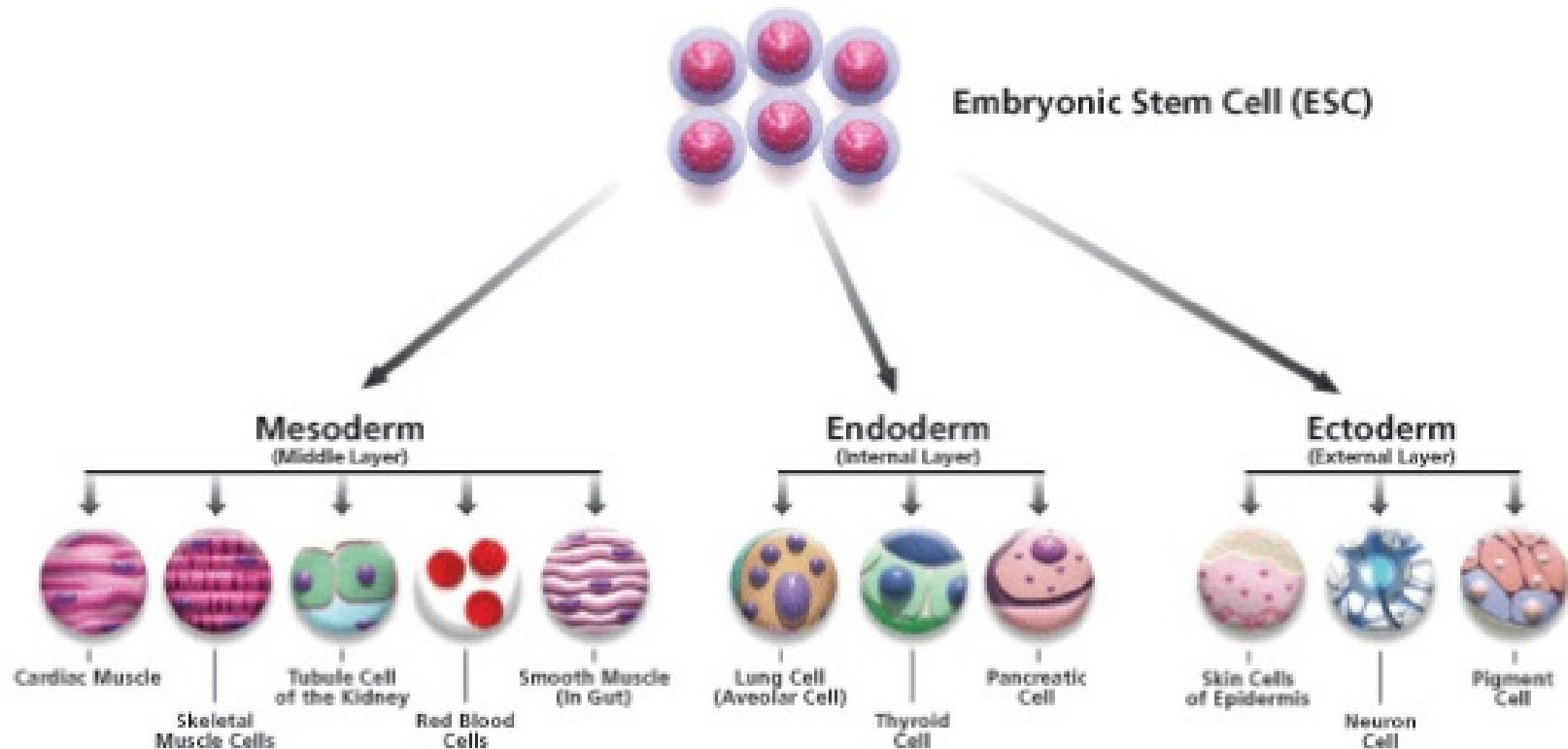
# fertilization

fusion of gametes to form an embryo



# cell lineage

a type of fate map that traces the development of an embryo



# genomic equivalence

similarity of genes of cells in an organism



# clone

organisms that are exact genetic copies

# cloning

process of producing similar populations of genetically identical individuals

# totipotent

ability of a stem cell to give rise  
to multiple cells which may be  
any cell type

# Stem cell

a relatively unspecialized cell  
which can reproduce itself indefinitely  
and can differentiate into specialized  
cells of one or more types, given  
appropriate conditions

# Stem cell cultivation

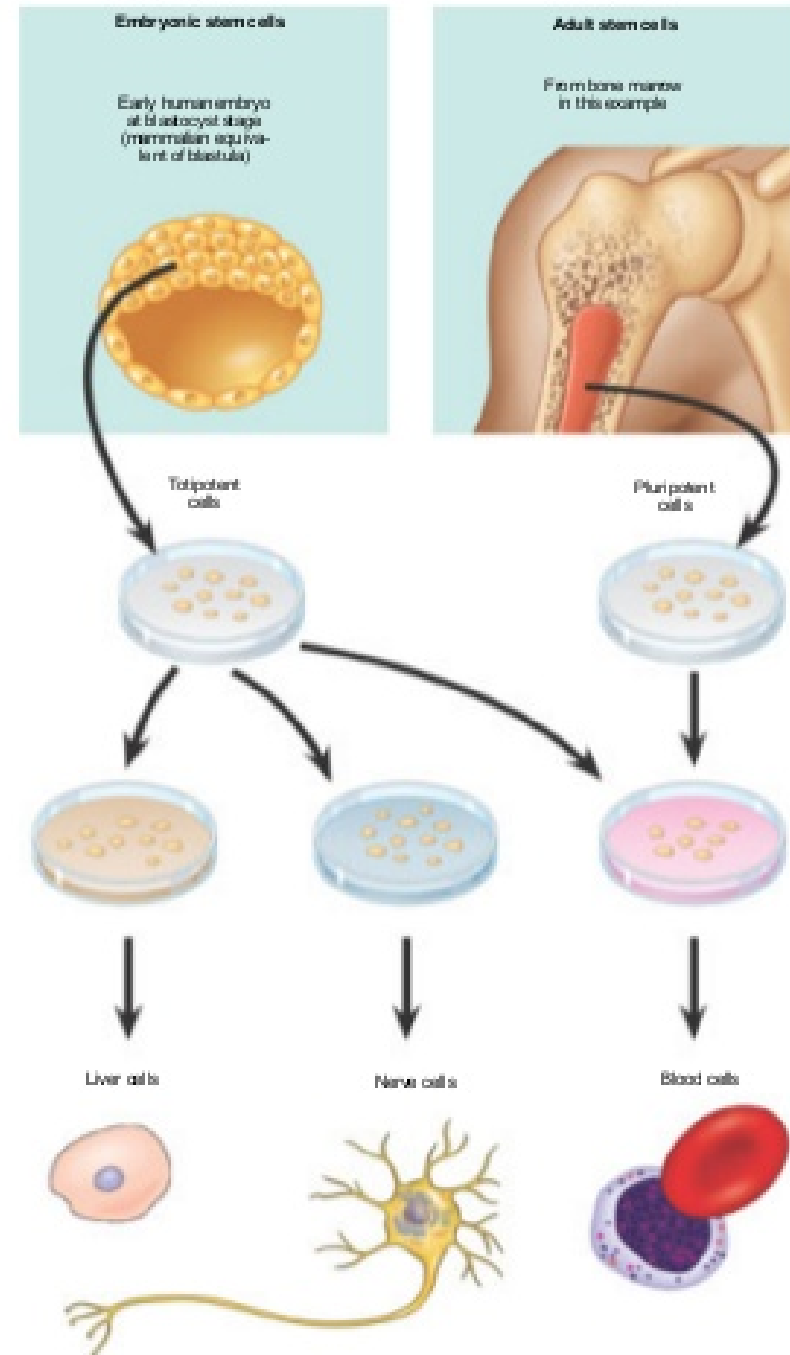


Figure 21.9

# pluripotent

a stem cell's ability to give rise to multiple cells but not all cell types

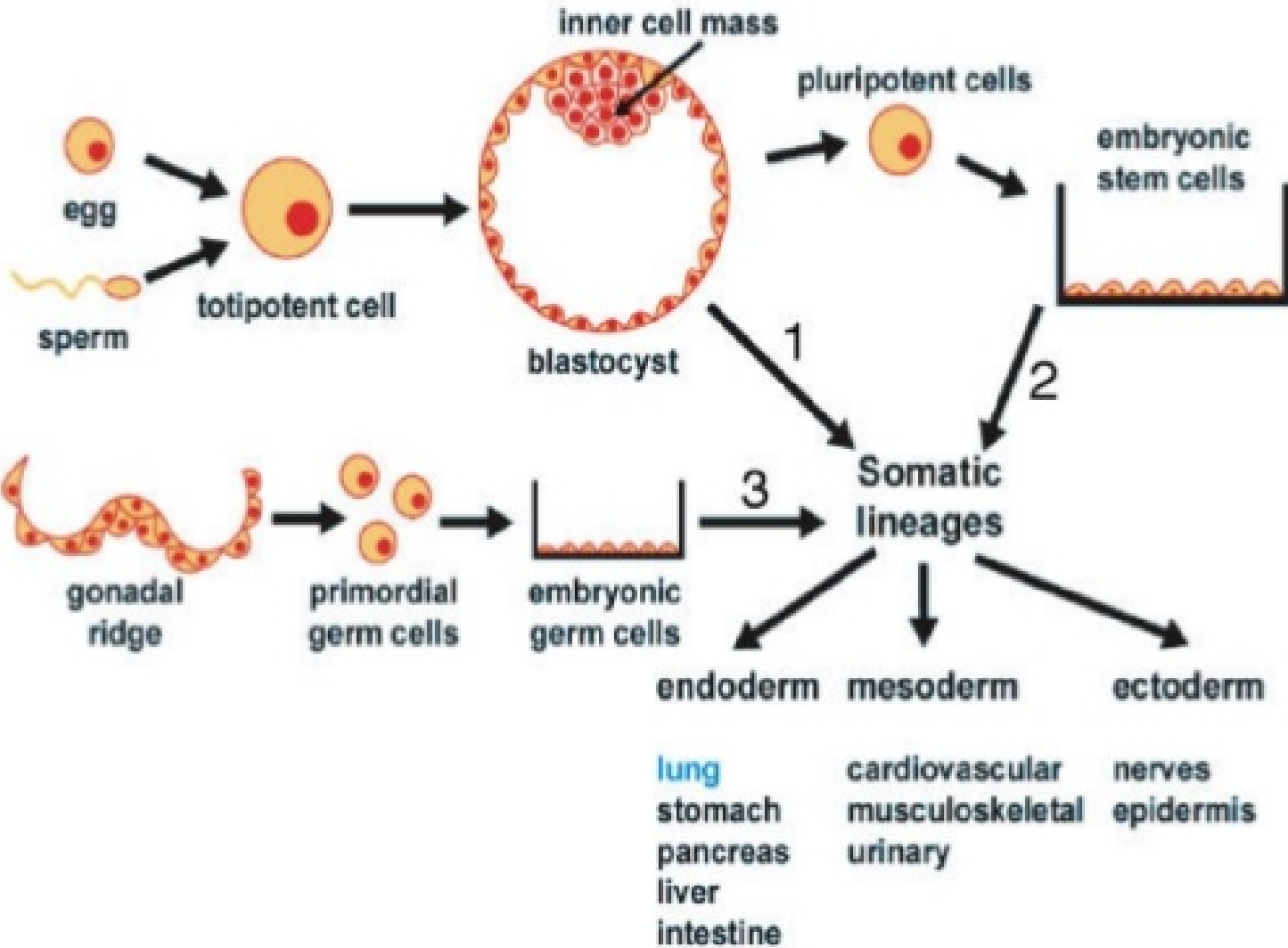
# cell determination

involves the expression of genes for  
tissue-specific proteins

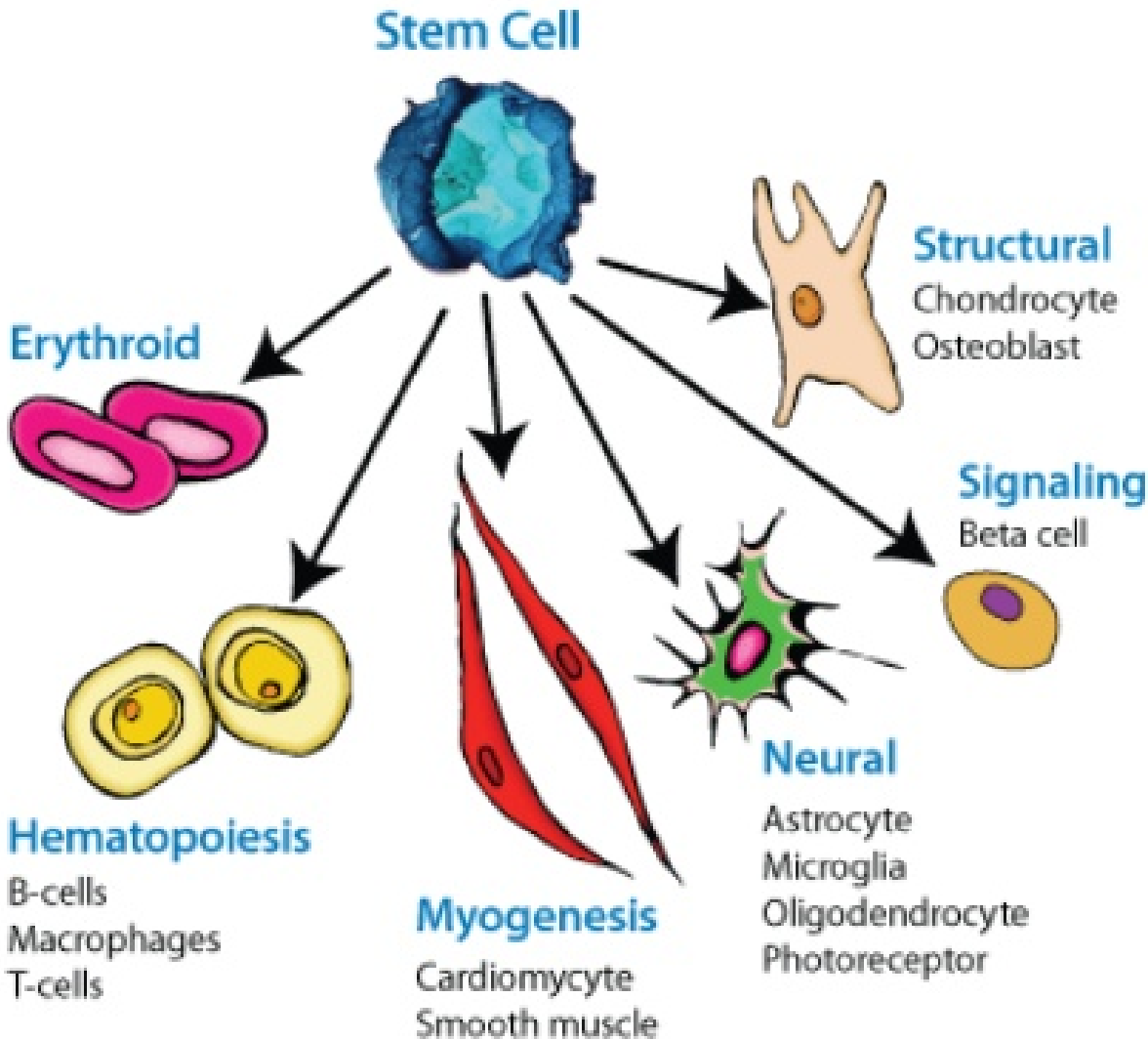
precedes cell differentiation

a process which involves initially  
identical cells which become  
committed to different pathways of  
development

# cell determination



# cell determination



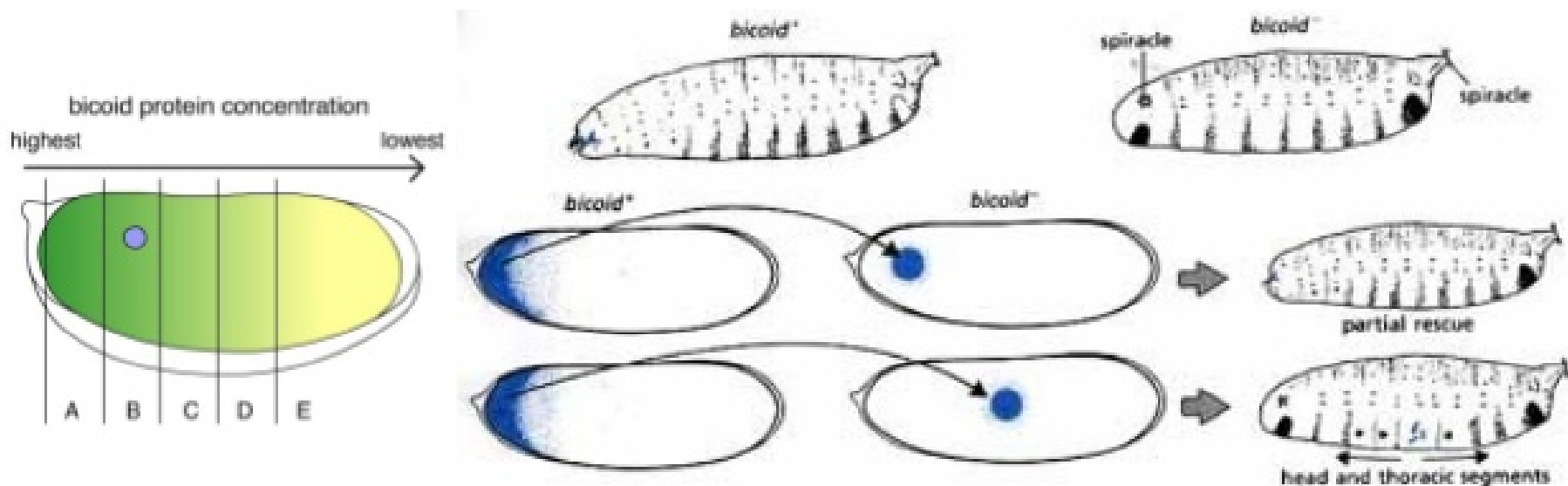


# cytoplasmic determinant

substance that determines the  
fate of cells

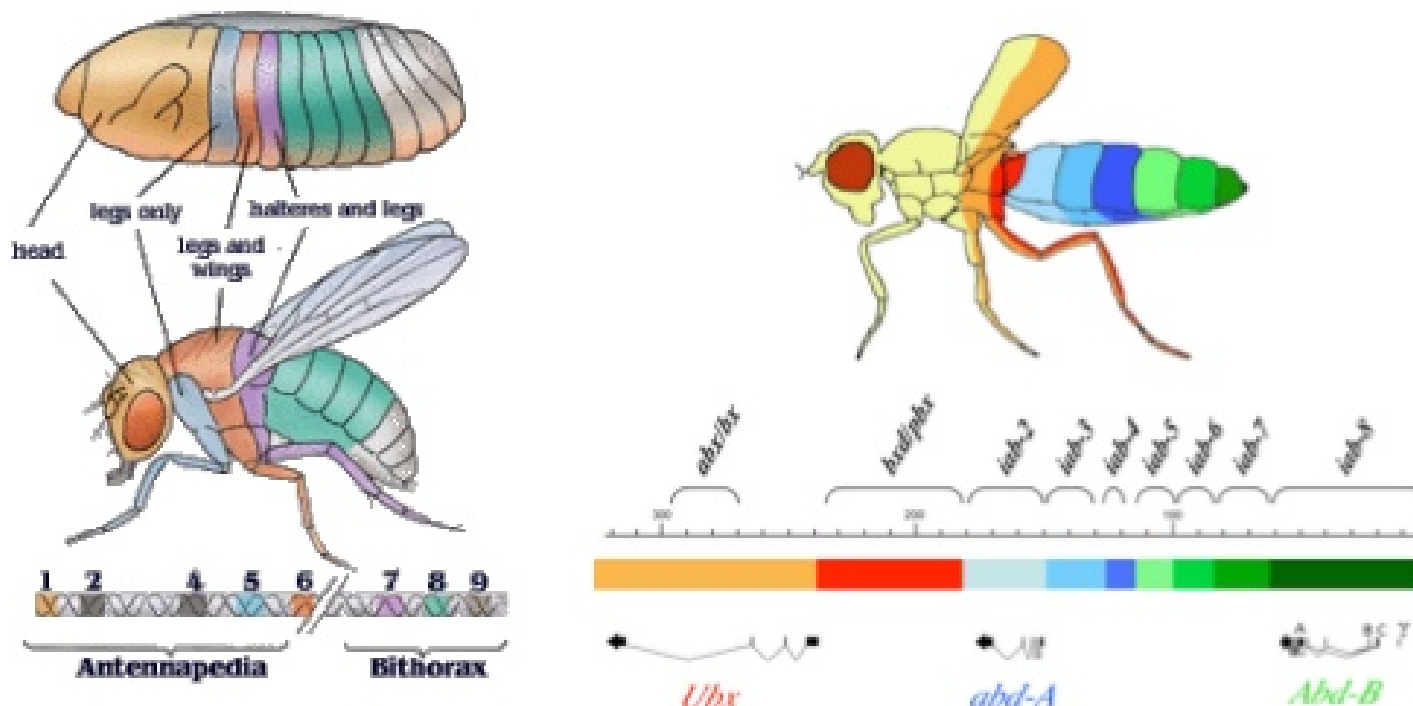
# bicoid gene

a kind of maternal-effect gene which functions to code for products used to establish the normal patterning or **anterior** parts of the embryo



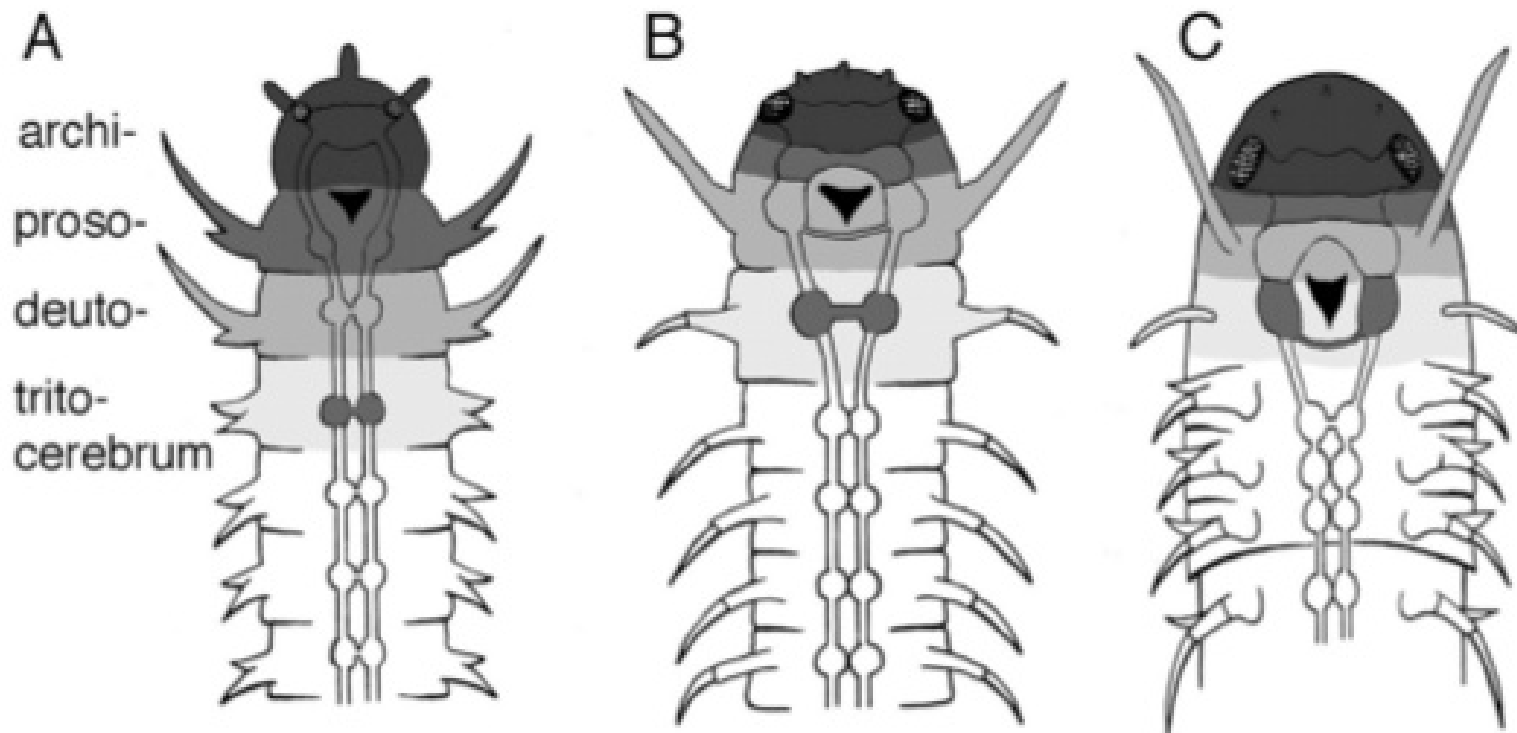
# Segmentation gene

the genes that direct the actual formation of segments after the embryo's major axes are defined



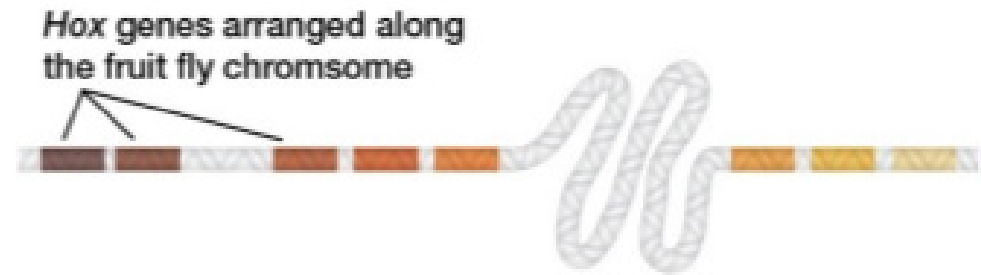
# Segmentation gene

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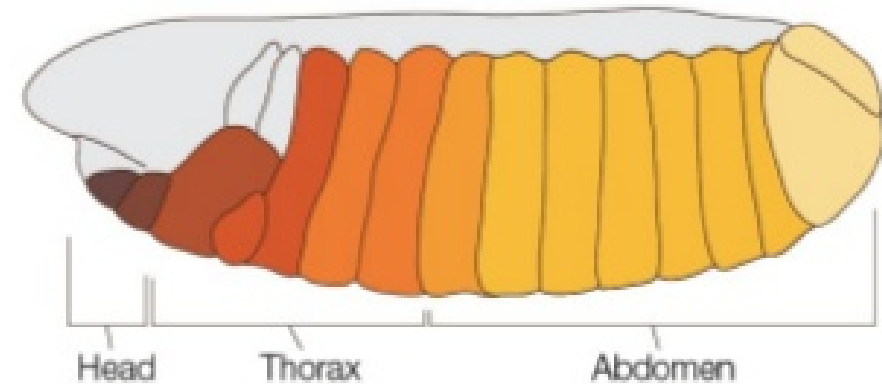


# homeotic gene

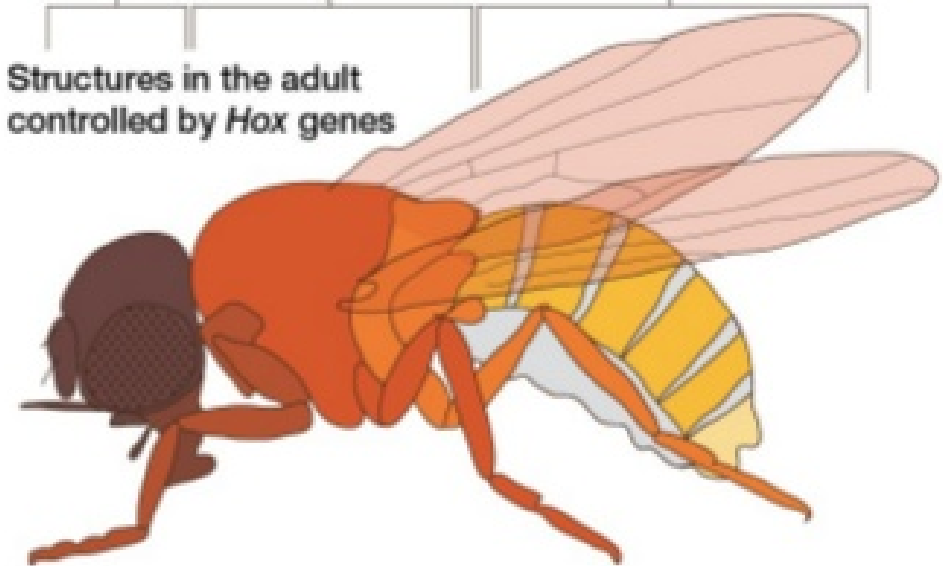
gene that specifies the types of appendages and other structures that each segment will form



Zones of *Hox* gene activity in the embryo



Structures in the adult controlled by *Hox* genes



# apoptosis

process of programmed cell death  
(PCD)

is essential to the development of  
animal morphogenesis (prevents  
webbing between fingers and toes).