# Developmental Biology

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# Basic concepts of developmental biology

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## (一)、Five major developmental processes

### 1. Cleavage (卵裂):

Rapid division of cells in the early embryo with no significant growth, producing a cluster of cells the same size as the original zygote

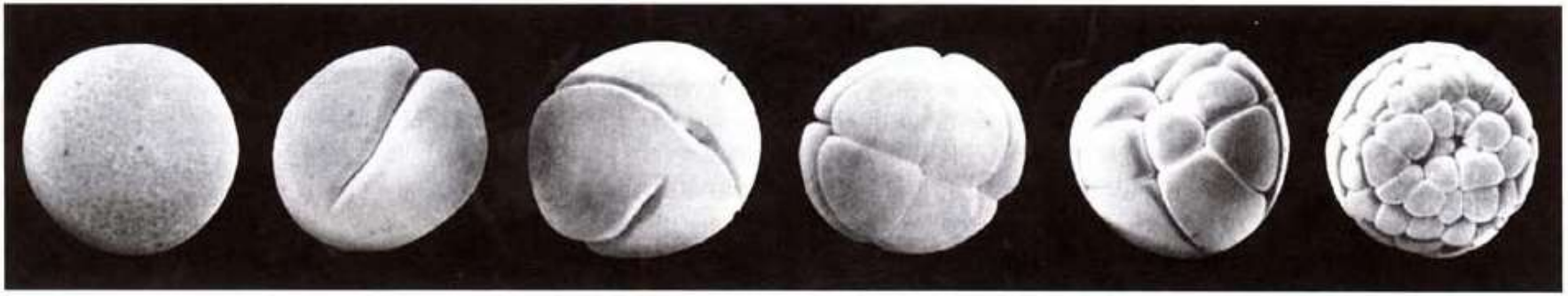


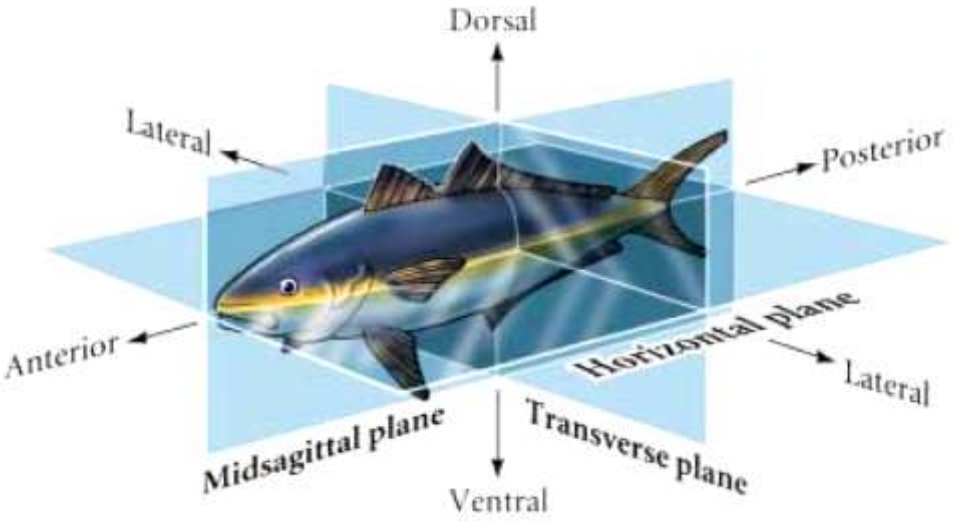
**Fig. 2.5 Cleavage of the *Xenopus* embryo.** The *Xenopus* embryo undergoes successive cleavages at intervals of about 20 minutes. Photographs courtesy of R. Kessel, from Kessel, R.G. *et al.*: 1974.

# Basic concepts of developmental biology

## (一)、Five major developmental processes

**2. Pattern formation（图式形成）:**

Establishment of body axis and formation of germ layers.




Vocabulary

A/P axis: Anterior ~ head 头
Posterior ~ tail 尾

D/V axis: Dorsal ~ upper or back 背
Ventral ~ lower or front 腹

P/D axis: Proximal ~ near 近
Distal ~ far 远

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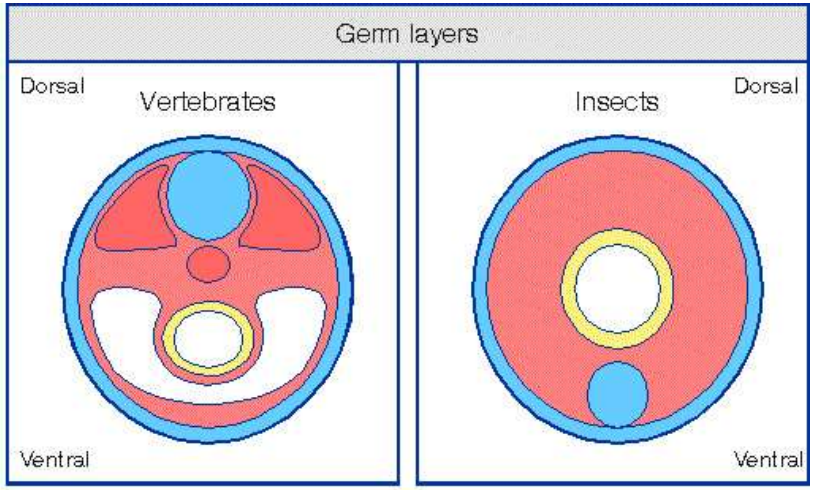
## (一)、Five major developmental processes

### 2. Pattern formation（图式形成）:

Establishment of body axis and formation of germ layers




| Germ layers | Organs | |
|---|---|---|
| Endoderm | gut, liver, lungs | gut |
| Mesoderm | skeleton, muscle, kidney, heart, blood | muscle, heart, blood |
| Ectoderm | skin, nervous system | cuticle, nervous system |

Vocabulary

Vertebrate: 脊椎动物

Insect: 昆虫

Germ layer: 胚层

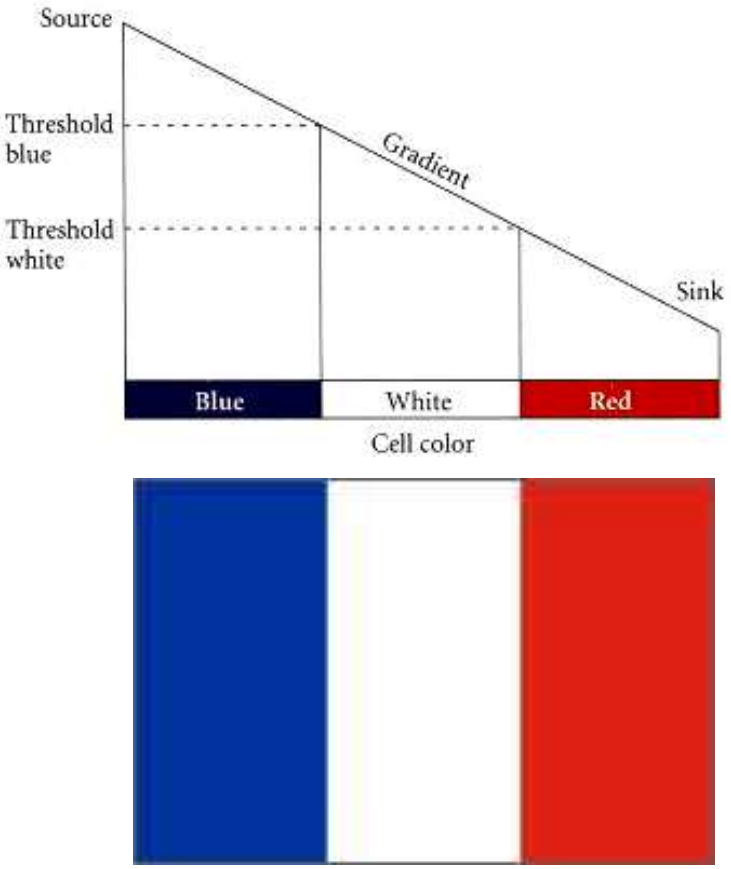
Endoderm: 内胚层

Mesoderm: 中胚层

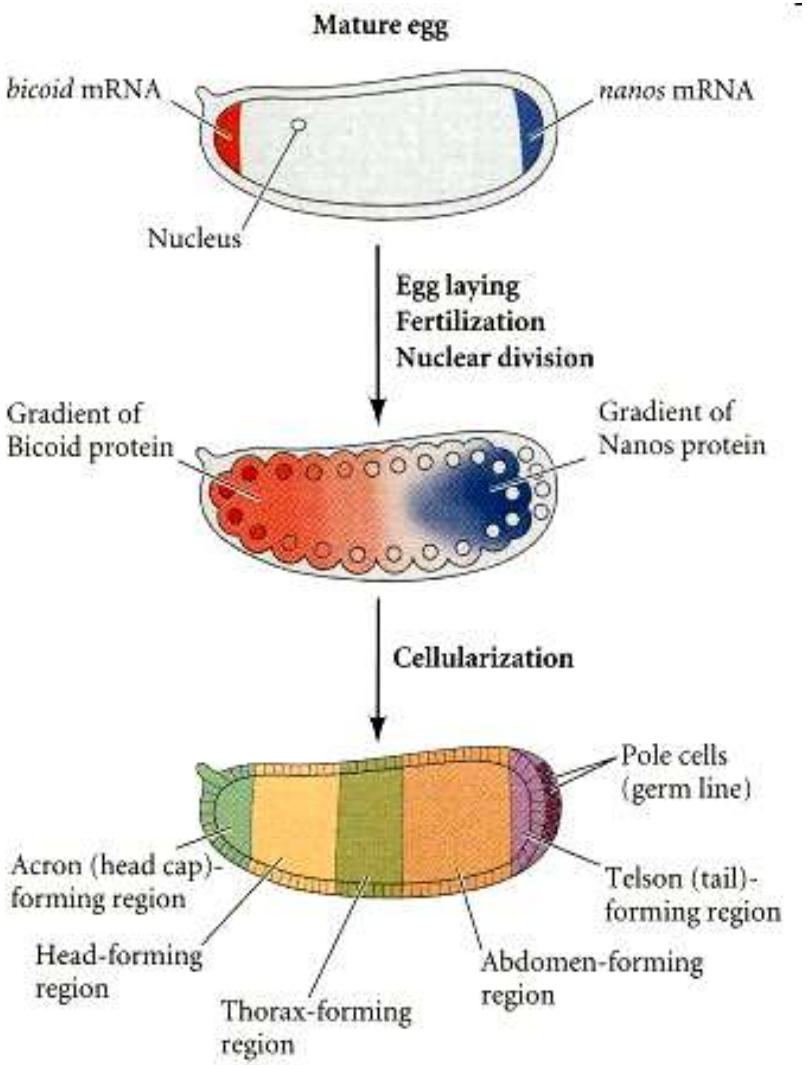
Ectoderm: 外胚层

# Pattern formation: the morphogen theory and positional information

形态发生素



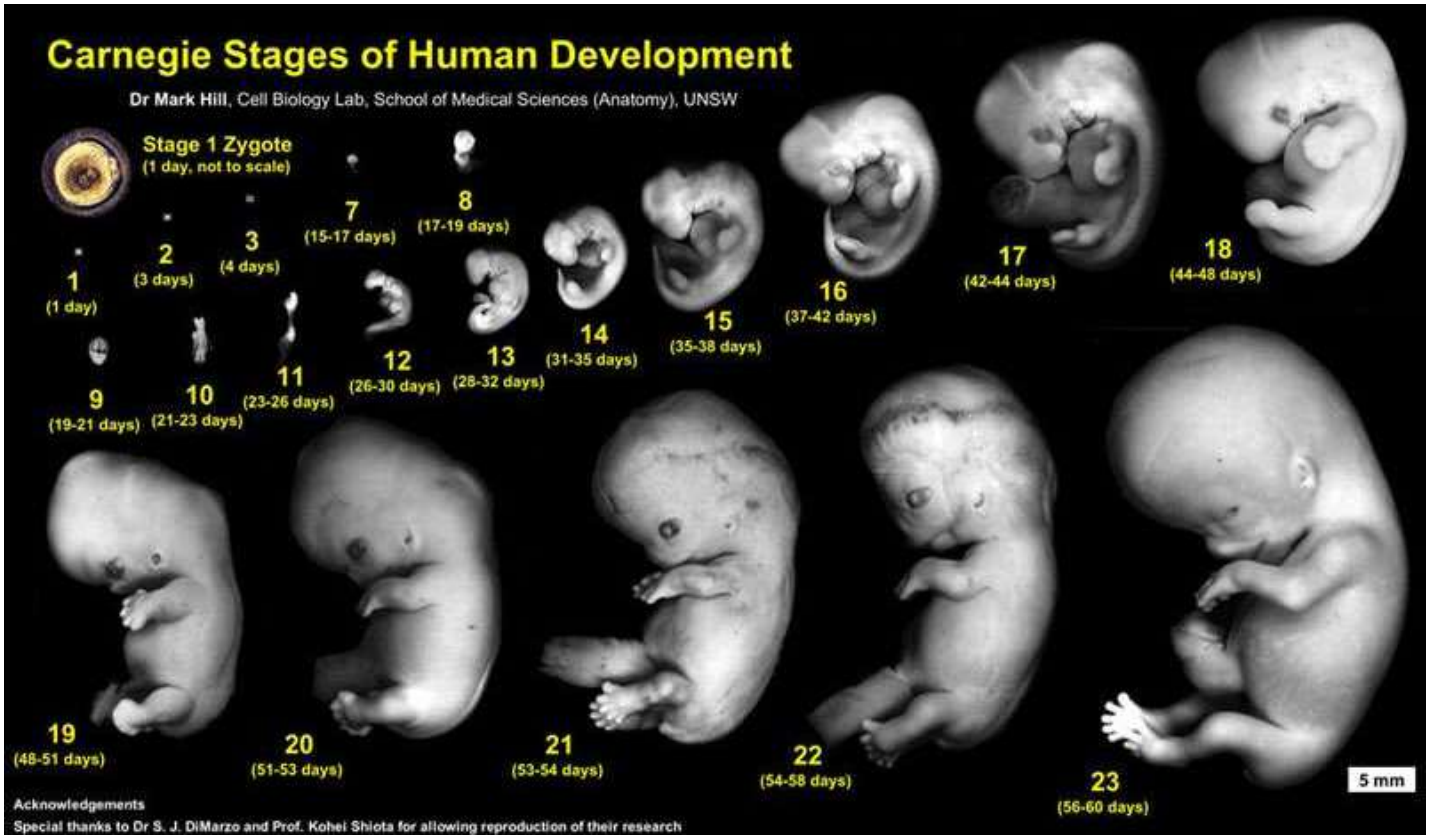

The French flag model of pattern formation



# Basic concepts of developmental biology

## (一)、Five major developmental processes

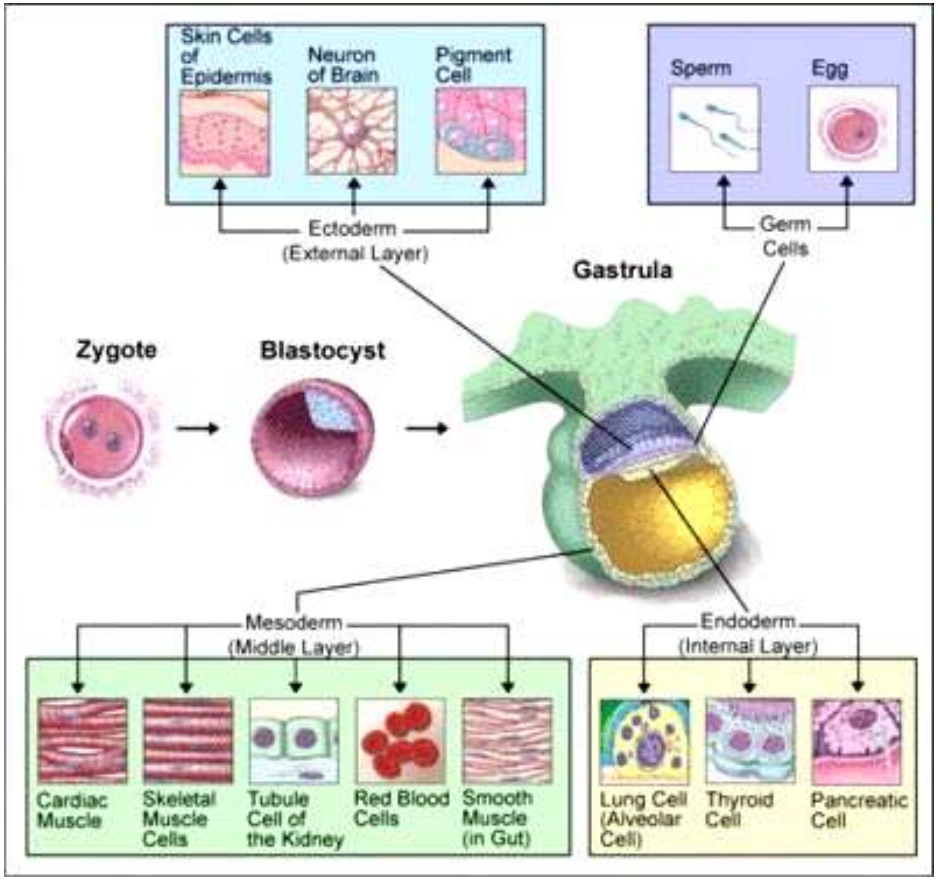
**3. Morphogenesis（形态发生）:** Beginning of the shape



# Basic concepts of developmental biology

## (一)、Five major developmental processes

**4. Cell differentiation:** Specialized cell types are produced from 3 germ layers.




Ectoderm (外)

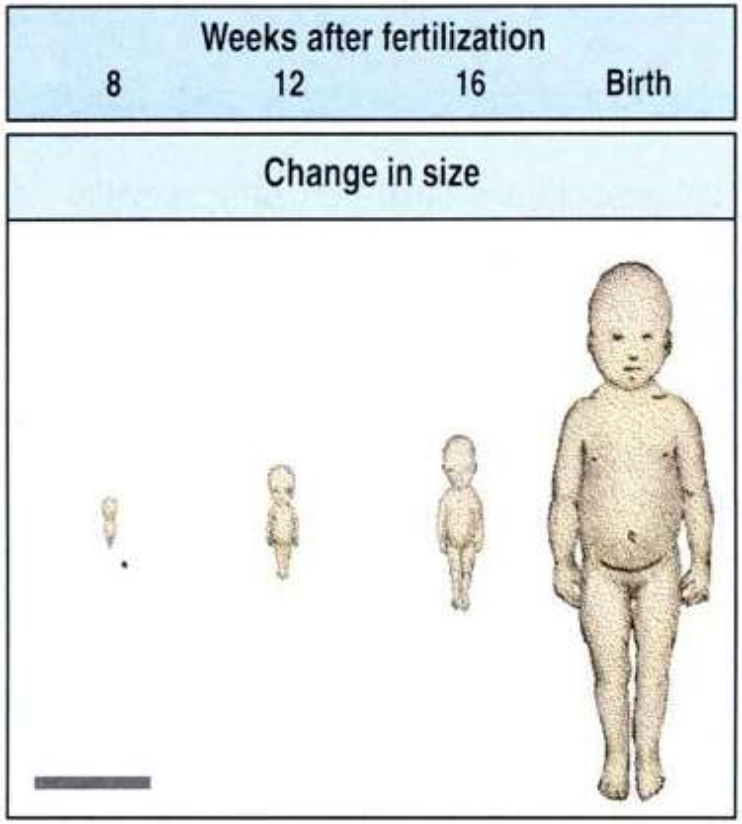
Mesoderm (中)

Endoderm (内)

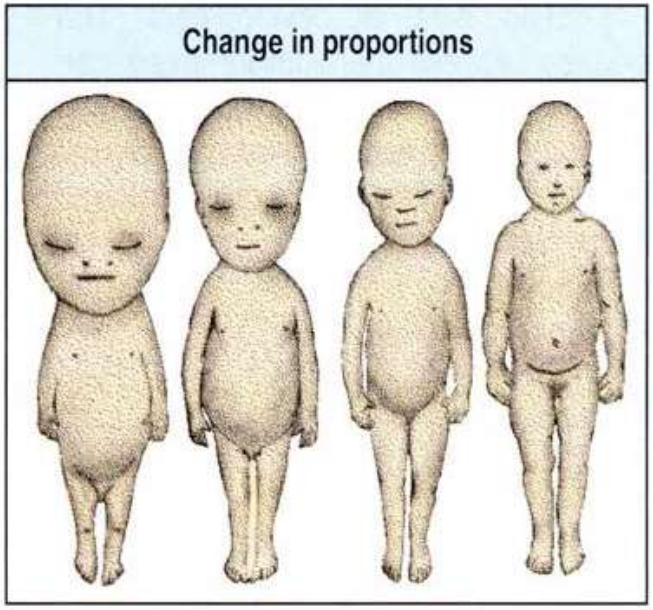
# Basic concepts of developmental biology

## (一)、Five major developmental processes

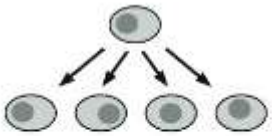
**5. Growth:** Increase of body size due to increase of cell number, cell size and accumulation of extra cellular matrix (细胞外基质).



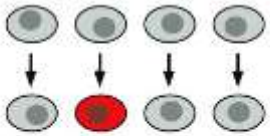

Different organs have different growth rate



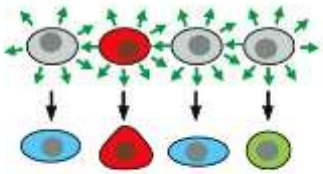
# (二)、Cell behaviour



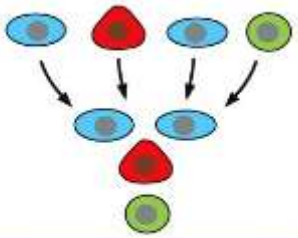
CELL PROLIFERATION



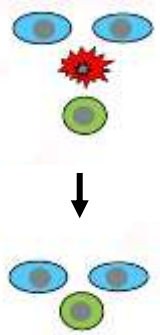
CELL SPECIALIZATION



CELL INTERACTION



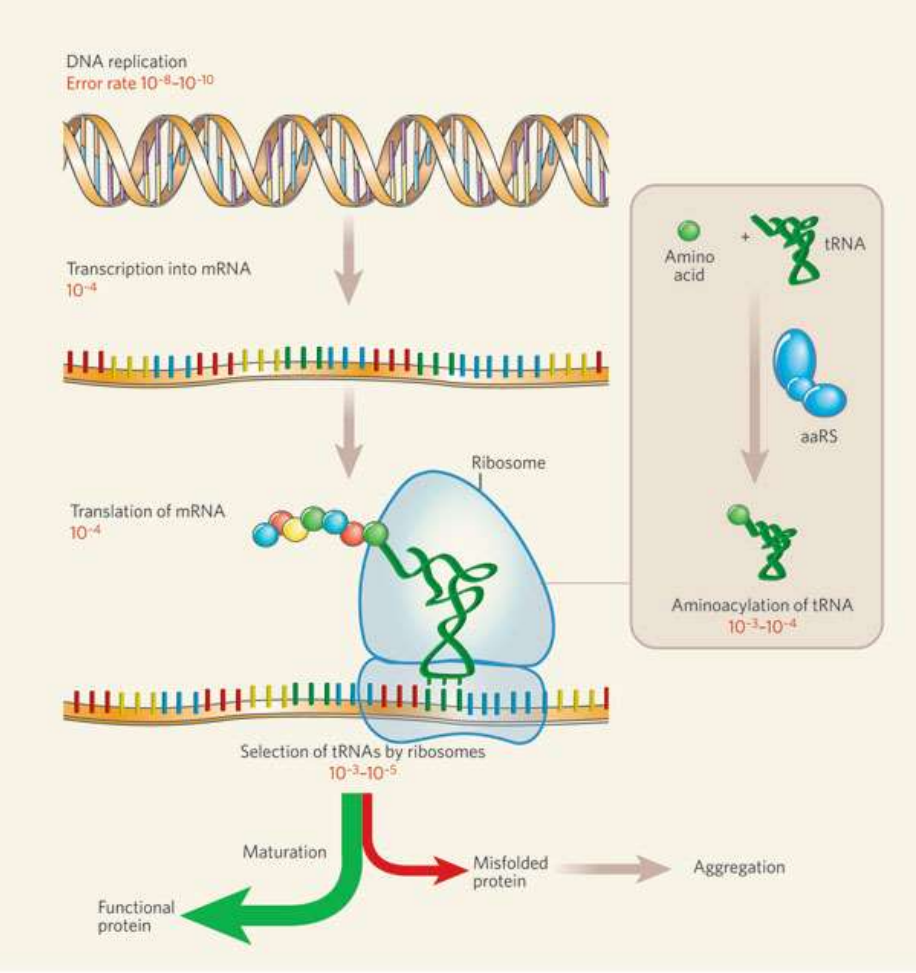
CELL MOVEMENT



CELL DEATH

# Basic concepts of developmental biology

## (三)、Gene regulates cell behavior through syntheses of tissue specific proteins




**House keeping gene**

- constitutively expressed in all tissues to maintain basic cellular functions

Examples?

- actin, tubulin, histone, ribosome proteins

**Tissue specific genes**

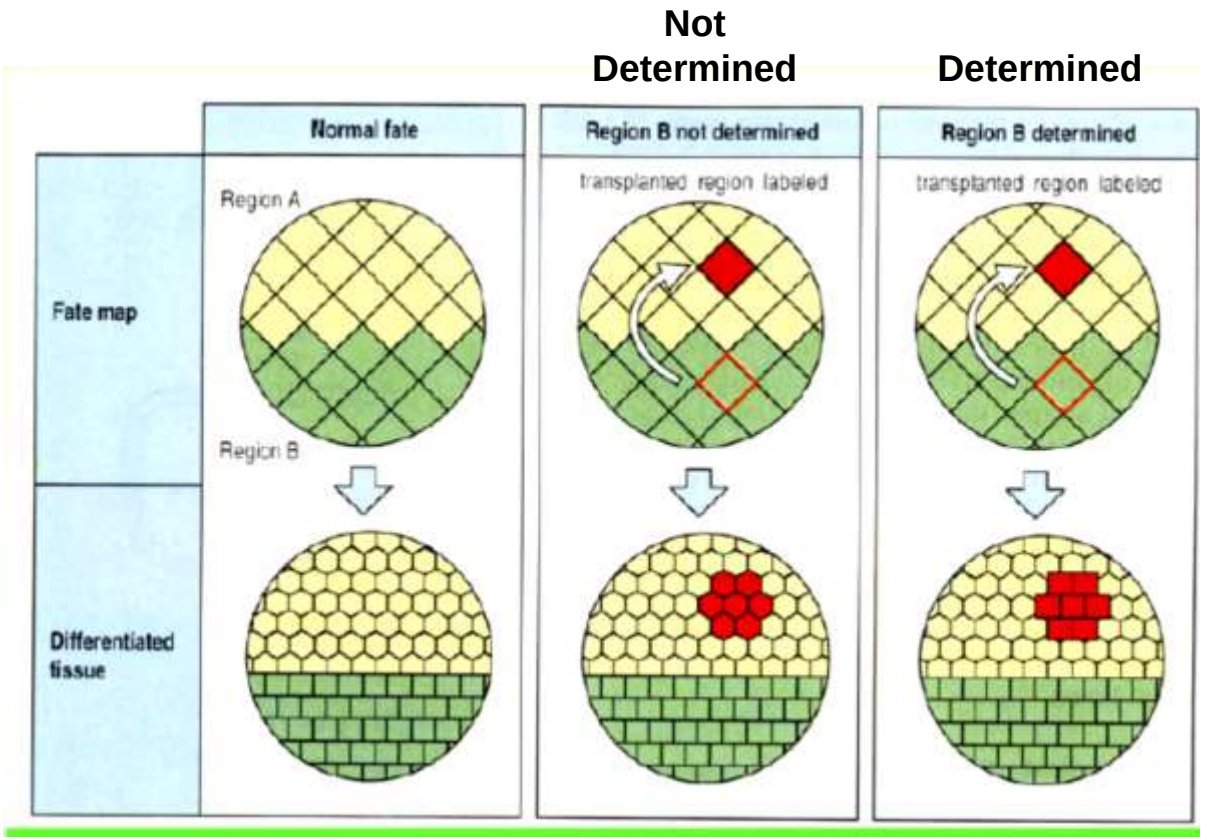
- expressed in specific tissues
- performs a tissue-specific function

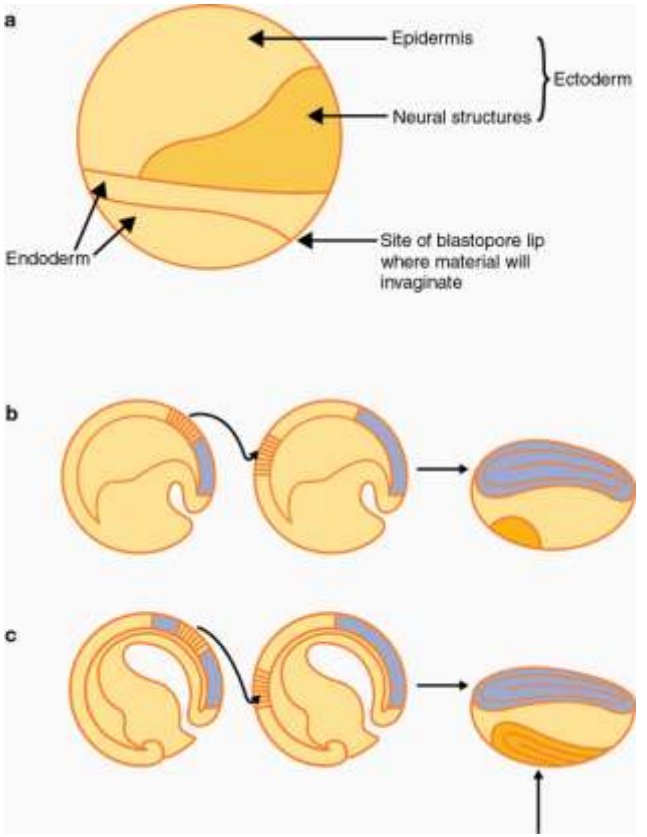
Examples?

- keratin, myoglobin, hemoglobin

# Basic concepts of developmental biology

## (四)、Cell fate are determined at different developmental stages
## 发育是渐进式的、细胞命运决定于不同的发育时间



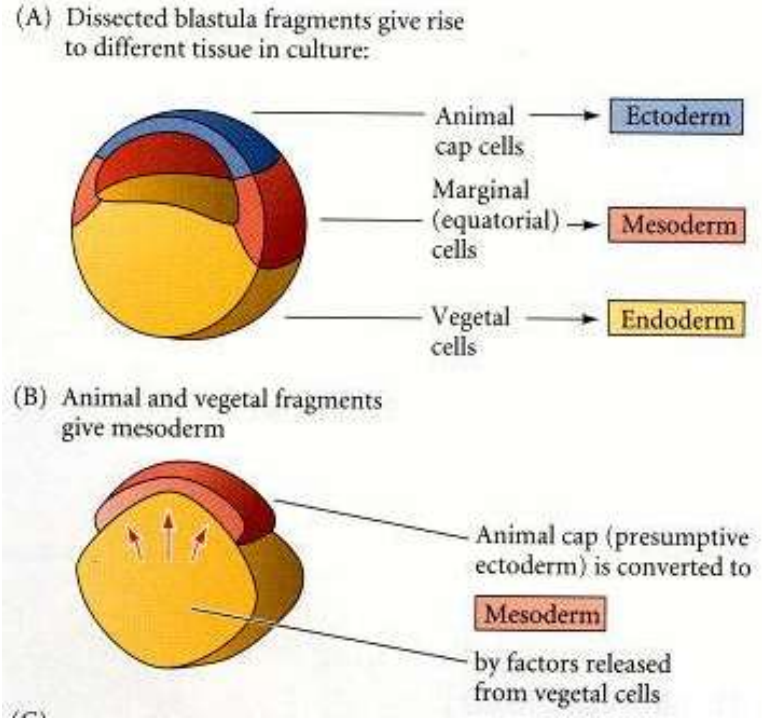

Determination: the cell fate cannot be reversed or transformed to another fate according to the environment

# Mesoderm induction

**Hans Spemann**

**1869 – 1941**

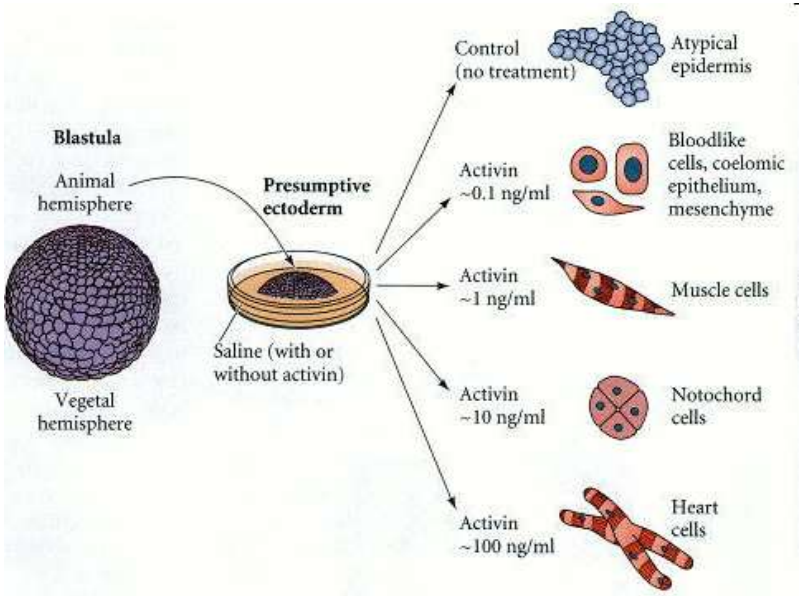
Nobel Prize 1935

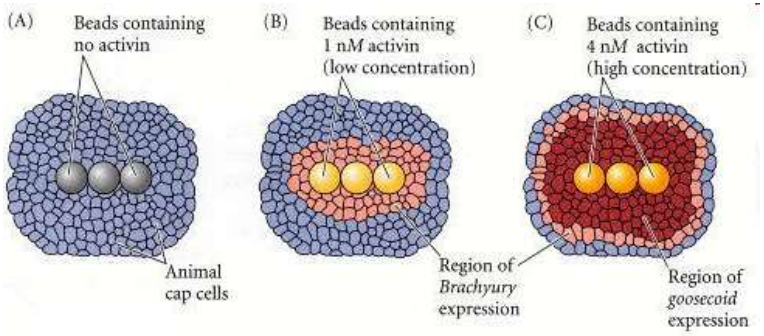



# Inducer - Activin

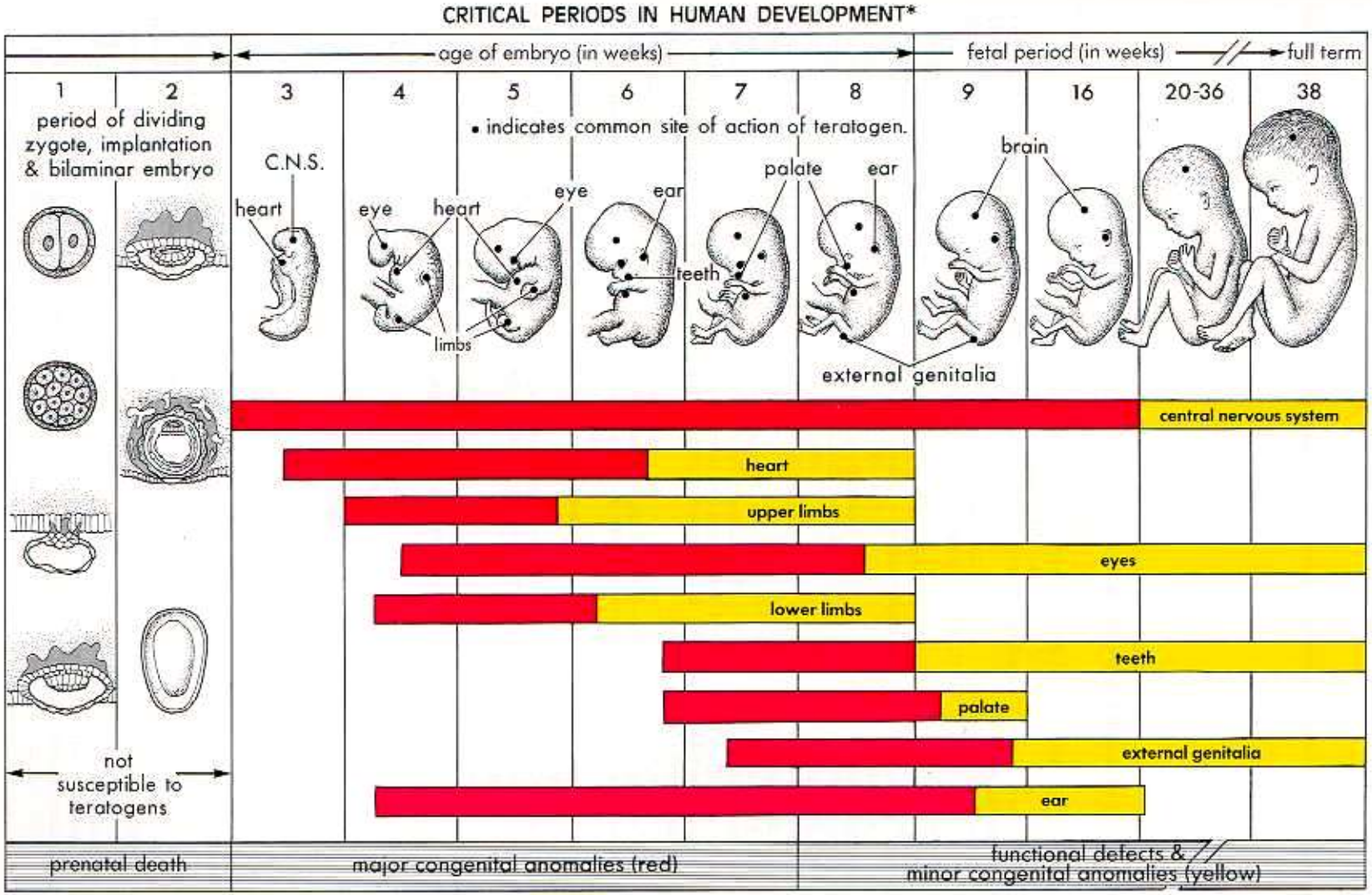
**Gurdon, 1990s**

Nobel Prize 2012



# Critical periods for organ development in human embryo




* Red indicates highly sensitive periods when teratogens may induce major anomalies.

# Sex

# Determination

# Sex Determination

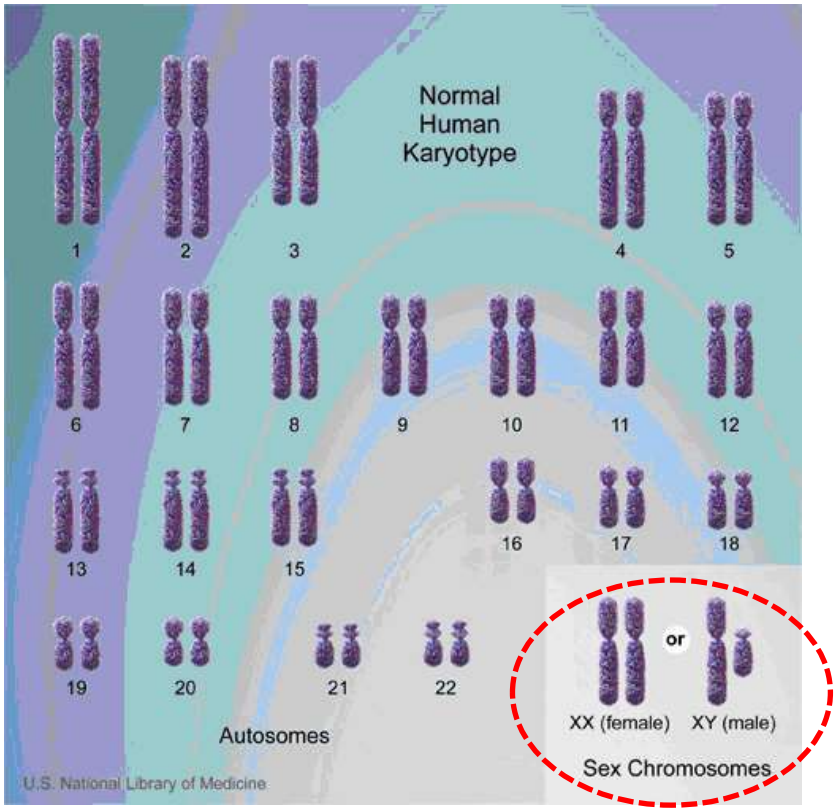
**Genetics:**

- XX/XY: mammal, fruitfly
- ZZ/ZW: bird
- Haplodiploid: bee, ant

**Environment:**

- Temperature: alligator, turtle
- Other factors: size, contact, etc

# The XX/XY System - Human




SRY: Sex-determining Region Y

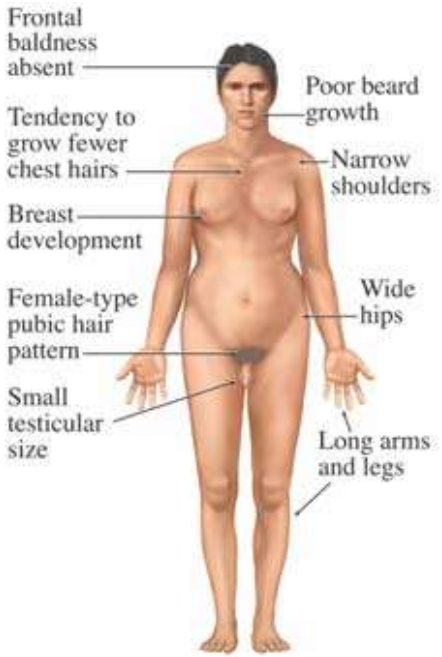
Sex is determined by the presence of **Y** chromosome (SRY gene)

- XX: produce estrogen (雌激素), drive the female pathway (default)
- XY: produce testosterone (睾酮), turn the sex organs into male

# Abnormal Sex Chromosome

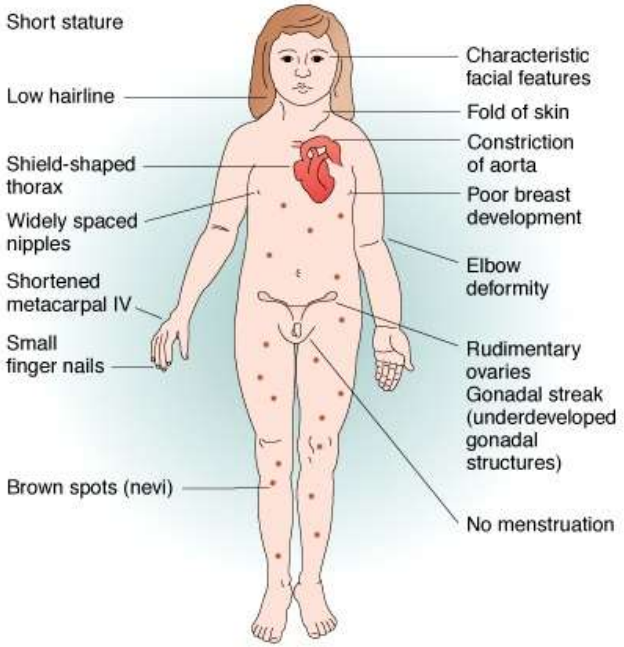
**XXY**: Male

Klinefelter Syndrome




**XO**: Female

Turner Syndrome





XY

Androgen (雄激素)

Mutation in Androgen Receptor (AR)

**Androgen insensitivity syndrome (AIS)**

# The XX/XY sex-determination system

**Drosophila**: by the number of X chromosome

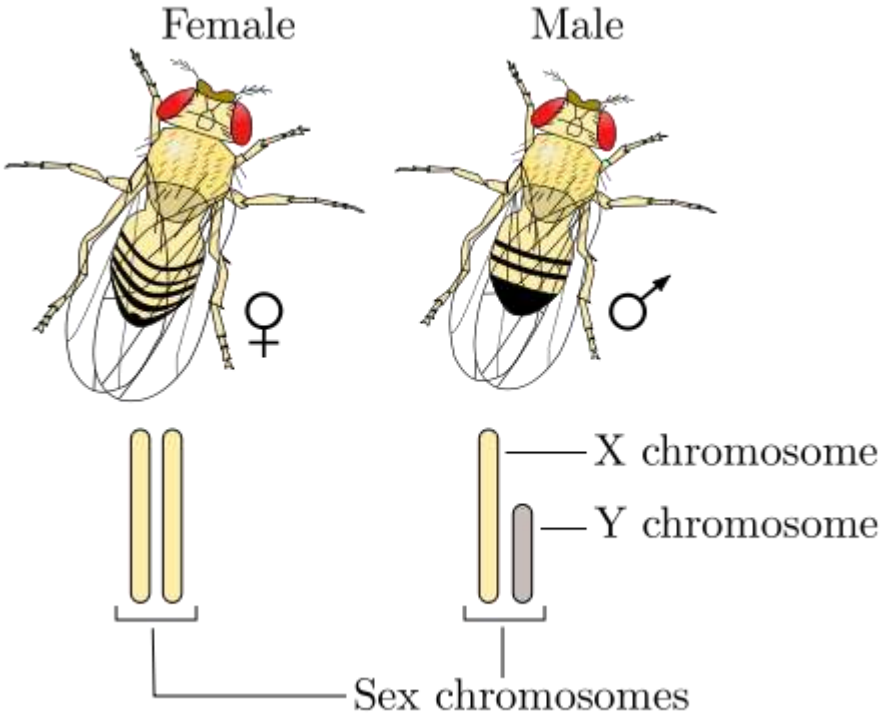
- two X: female
- one X: male

XX: female

XY: male

XXY: female

X0: male



# The ZZ/ZW sex-determination System

**Sex determined by the presence of W chromosome**

- ZZ: male
- ZW: female

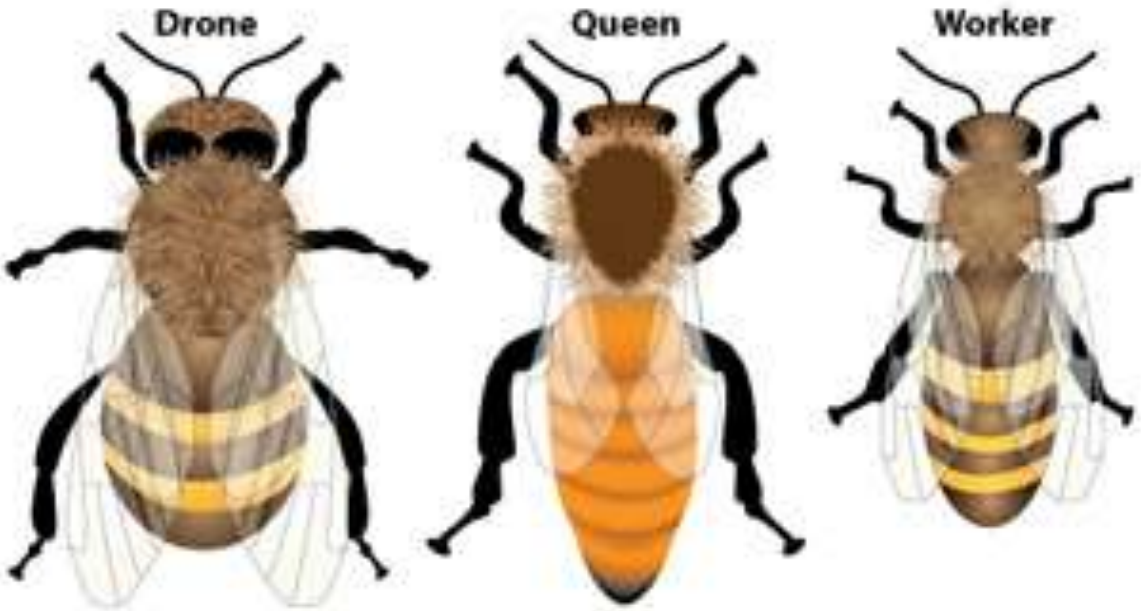



# The Haplodiploidy sex-determination system

Haploid (单倍体): male (Drone), developed from unfertilized egg

Diploid (双倍体): female, developed from fertilized egg

- Queen
- Worker bee




**Chromosomes:** **16** **32** **32**

# Non-genetic sex-determination system

## Temperature

Female promoting temperature

Male promoting temperature

## Size

dominant individual in a group becomes female

clown fish

Blue-headed wrasse

dominant individual in a group becomes male

# 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.

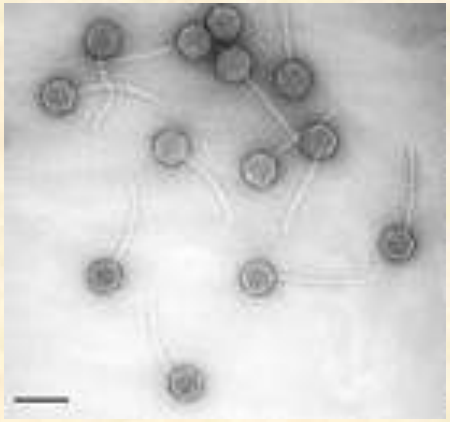
**Specific purpose:**

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

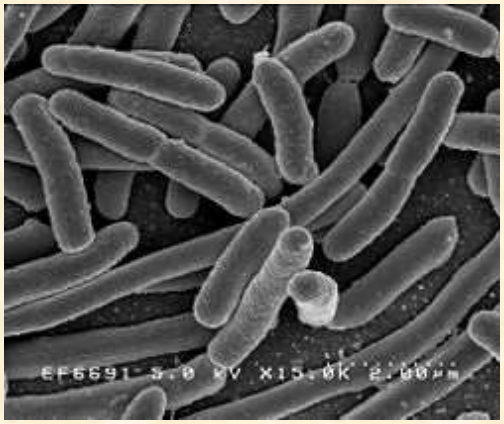
# Model Organisms

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

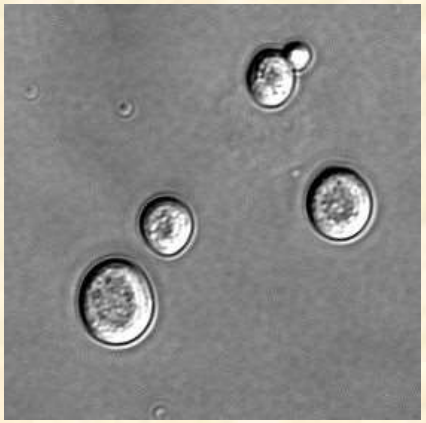
**Lambda**



**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**