

发育生物学

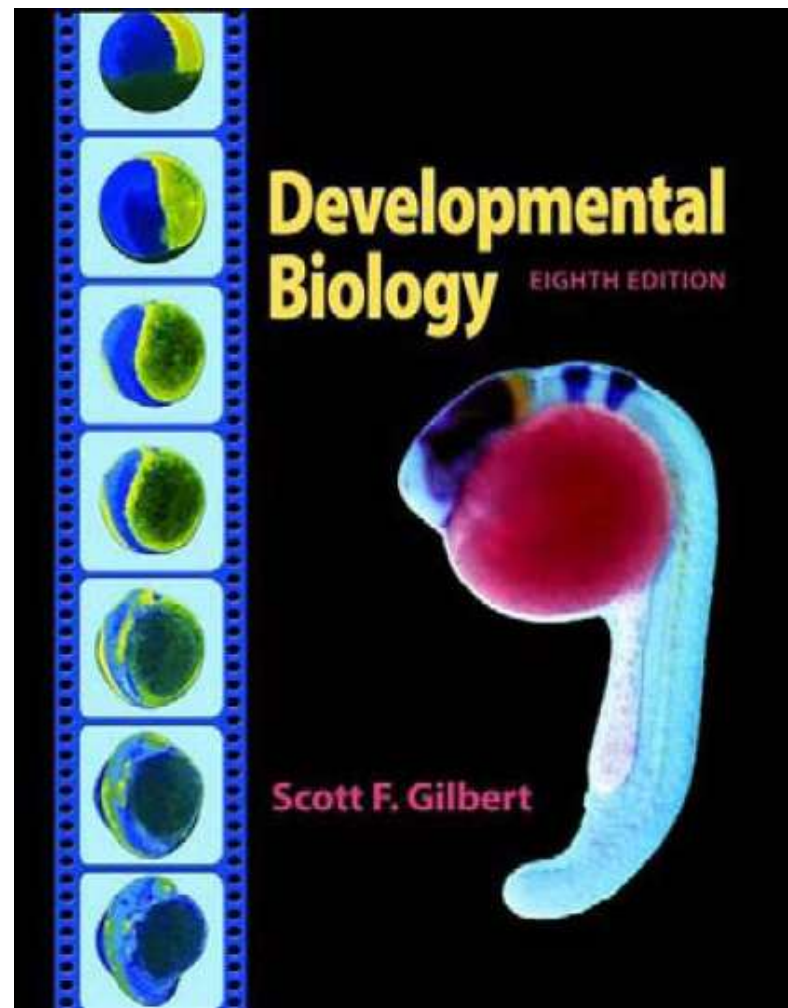
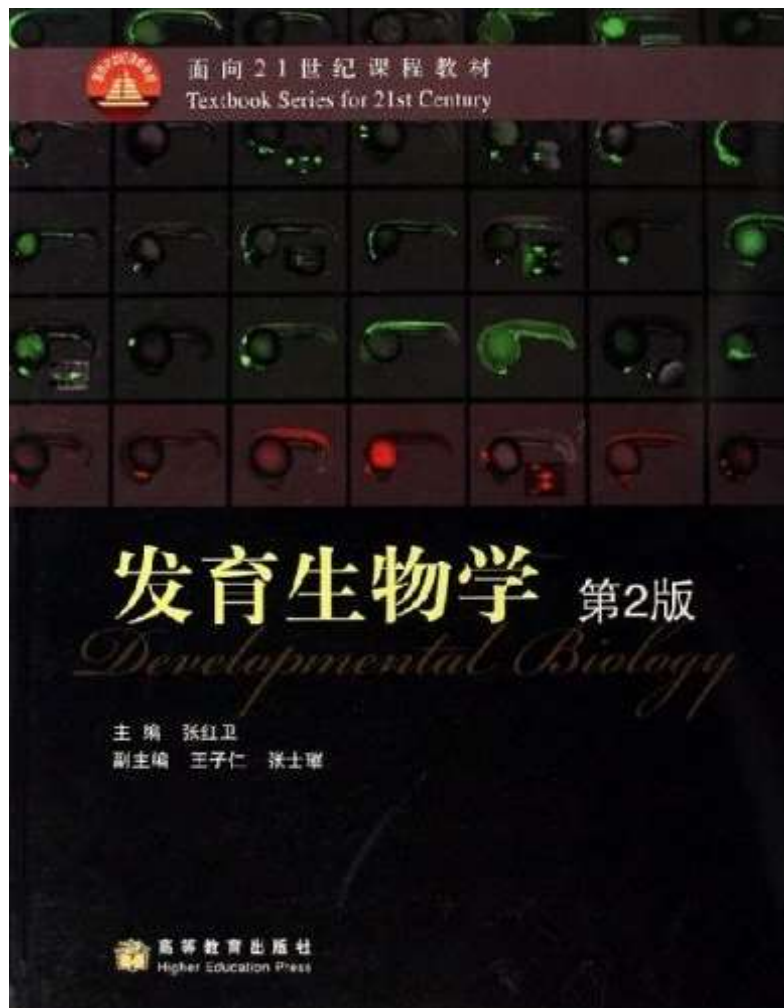
# Developmental Biology

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## Lei Xue

- |                        |         |
|------------------------|---------|
| - Beijing University   | B.S.    |
| - University of Zurich | Ph. D   |
| - Yale University      | Postdoc |

Research field: Developmental genetics and disease

Model organism: *Drosophila*



Principles of Developmental Biology

Model Organism - *Drosophila*

Signal transduction

Aging, stem cell and cloning

Sex determination



# Contents

# Professor

Principles of Developmental Biology

薛雷

Gametogenesis

杨晓梅

Fertilization

杨晓梅

Embryogenesis

杨晓梅

Development of model organisms

worm - *C. elegans* 线虫

李伟

insect – *Drosophila* 果蝇

薛雷

fish – Zebrafish 斑马鱼

曹莹

frog - *Xenopus* 非洲爪蟾

曹莹

Signal transduction in development

薛雷

Aging, stem cell and cloning

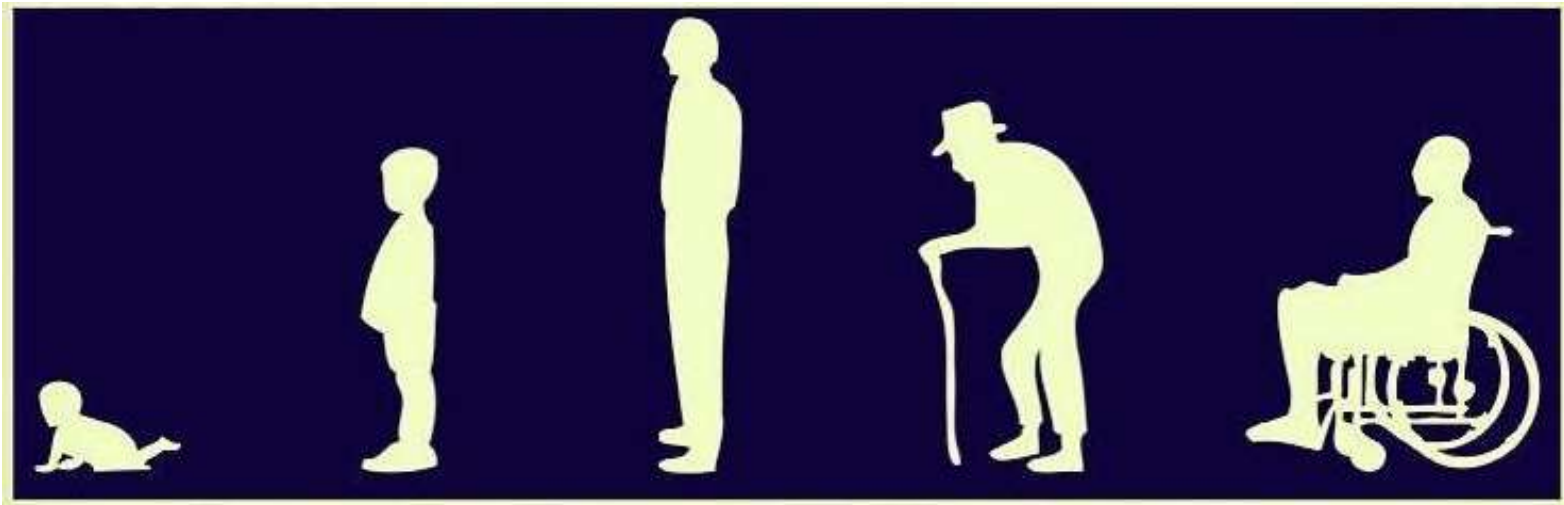
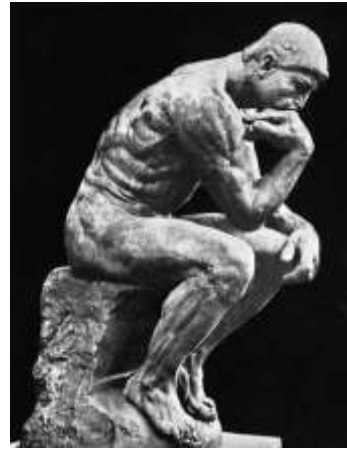
薛雷

# The Universal Questions

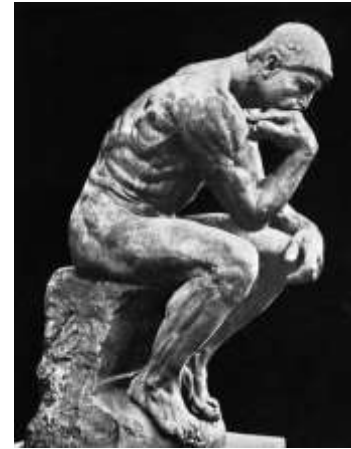
Where did I come from?

Where am I going?

How?



# The Universal Questions



Philosophy



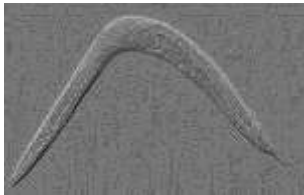
Religion



Developmental  
Biology



# Model Organism



Worm



Fruit fly



Zebrafish



Mouse

Similarity

65%

75%

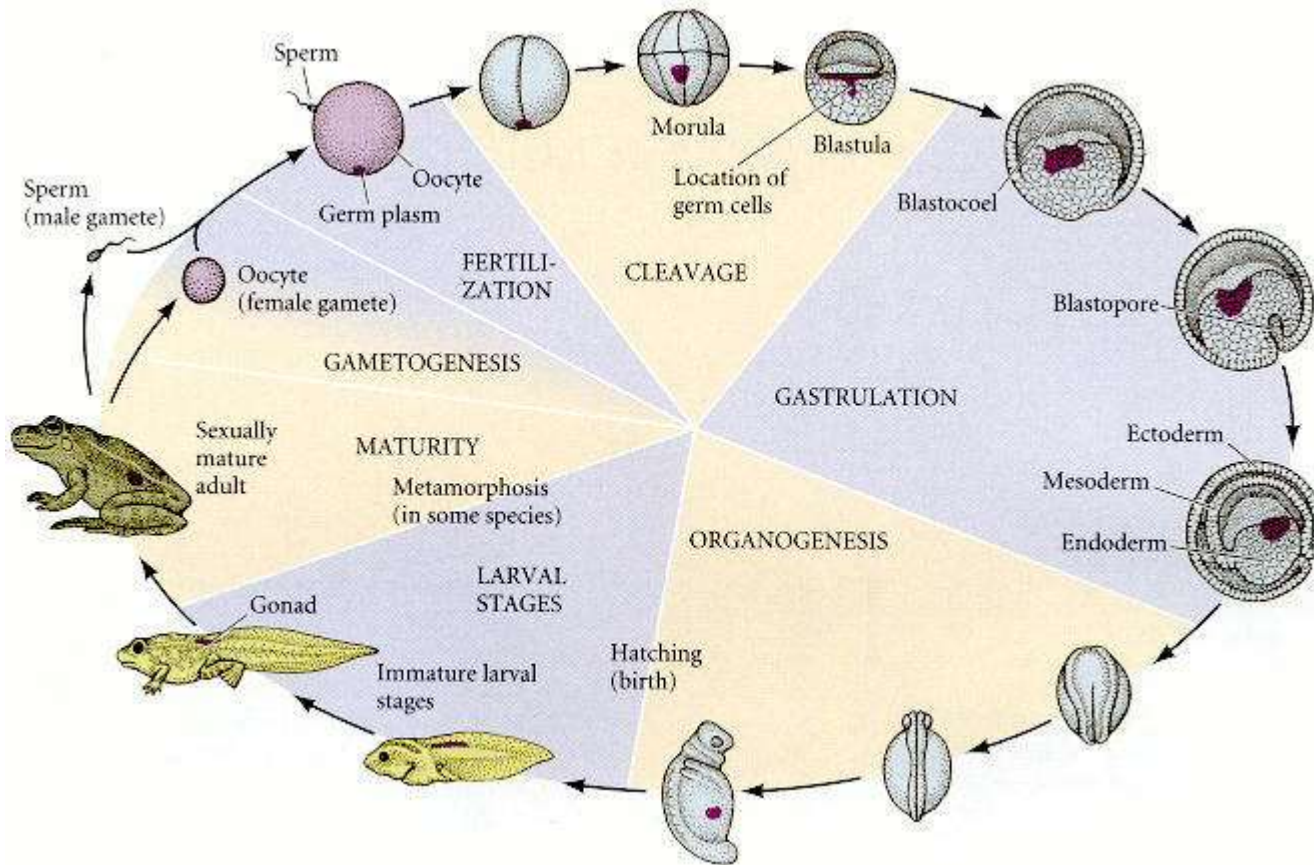
85%

95%





**Developmental biology**  
studies the **process** and **mechanism**  
by which organisms **grow** and **develop**



**The frog life cycle**

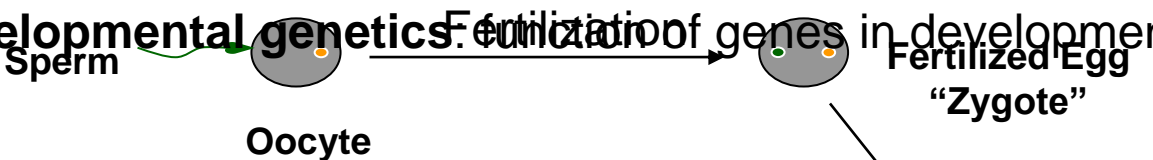
**Gametogenesis**  
配子发生  
↓  
**Fertilization**  
受精  
↓  
**Cleavage** 卵裂  
↓  
**Gastrulation**  
原肠形成  
↓  
**Organogenesis**  
器官发生  
↓  
**Metamorphosis**  
变态  
↓  
**Growth** 生长  
↓  
**Aging** 衰老



# Developmental biology came from three main fields:

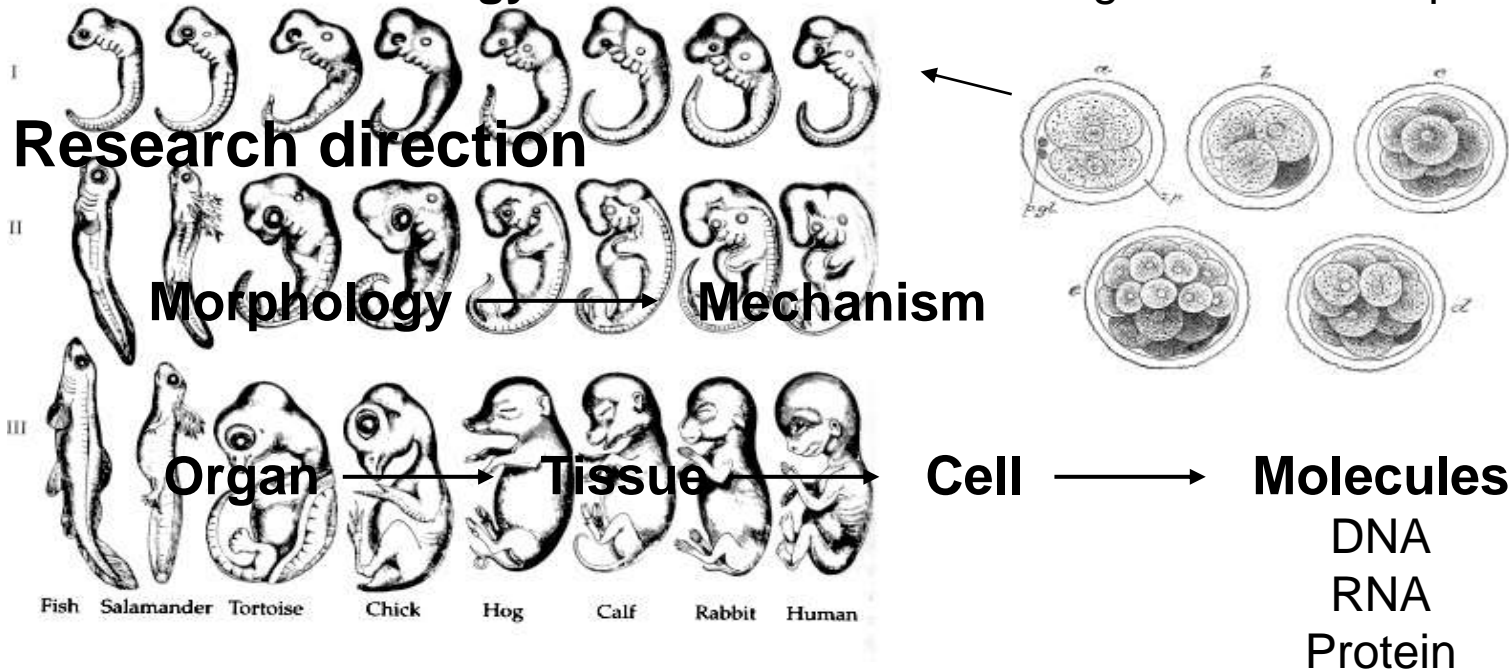
1. **Embryology**: developmental stage from fertilization to birth

2. **Developmental genetics**: Fertilization of genes in development



The diagram shows a green circle labeled 'Sperm' and a grey circle labeled 'Oocyte' with an arrow pointing to a grey circle labeled 'Fertilized Egg "Zygote"'. The text 'Fertilization of genes in development' is written above the arrow.

3. **Molecular biology**: molecular mechanism of genes in development



**Developmental biology:** central position in biology

**Developmental biology** unites the disciplines of  
molecular biology, cell biology and genetics.

When thinking about developmental problems

it is necessary to be able to use concepts

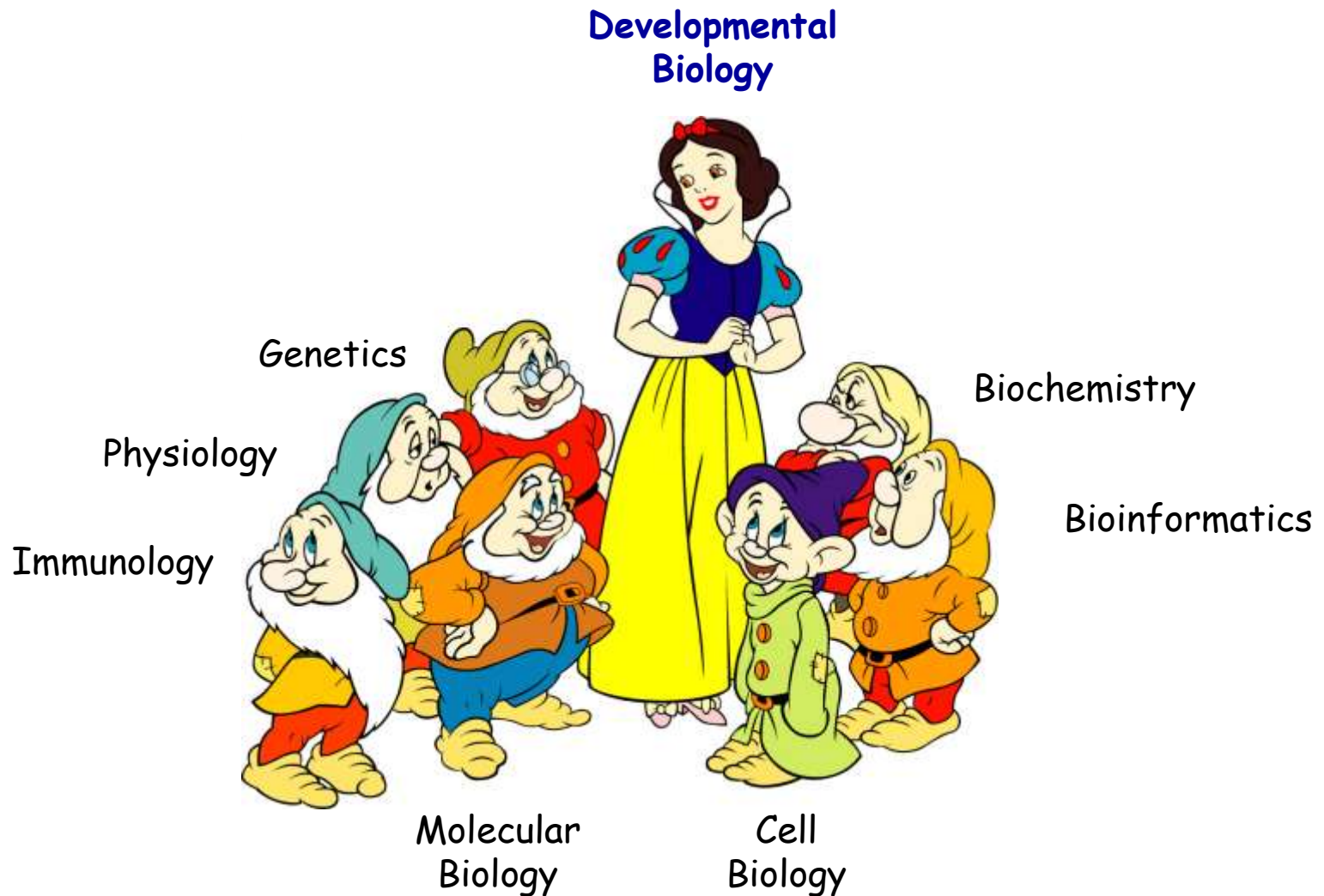
from these areas simultaneously

because they are all necessary to achieve a complete picture.

# Developmental Biology – Center of Biology



# Developmental Biology – Center of Biology



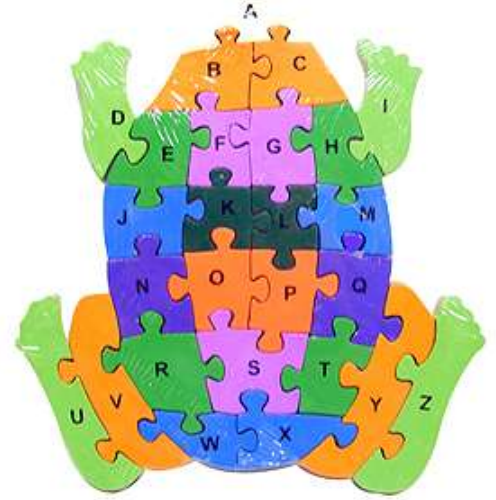
# History of Developmental biology

1. Epigenesis 后成论      vs      Preformation 先成论

# Epigenesis

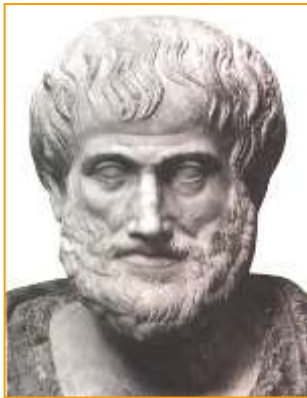
each embryo is gradually produced  
from an undifferentiated mass  
by a series of steps and stages  
during which new parts are added.

在胚胎的发育过程中，  
各种结构是逐渐形成的。



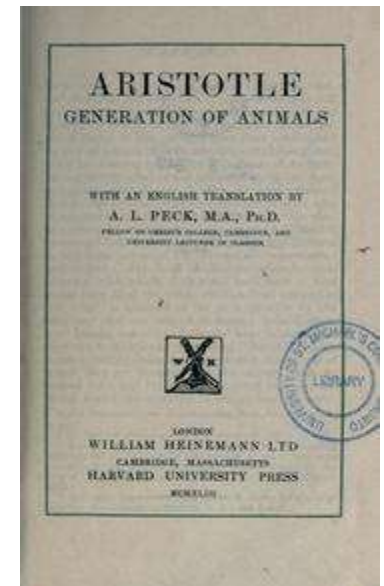
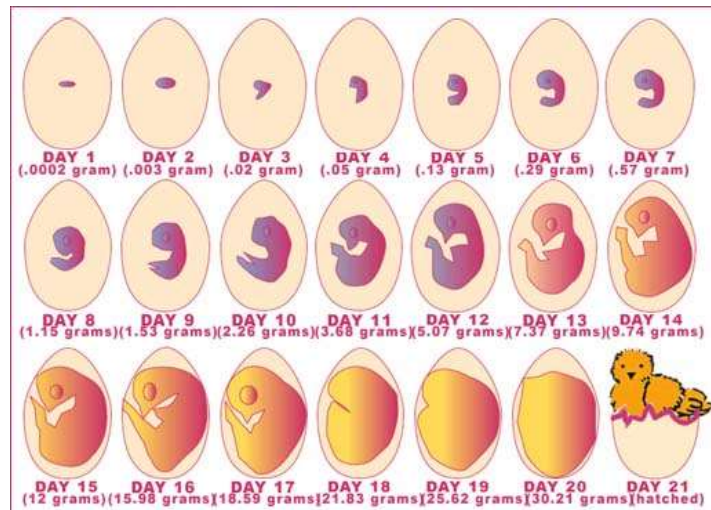


# Epigenesis

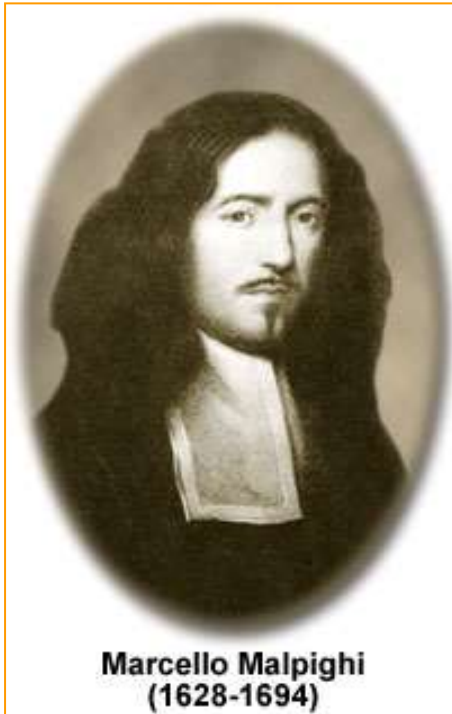


**Aristotle**

**384- 322 BC**

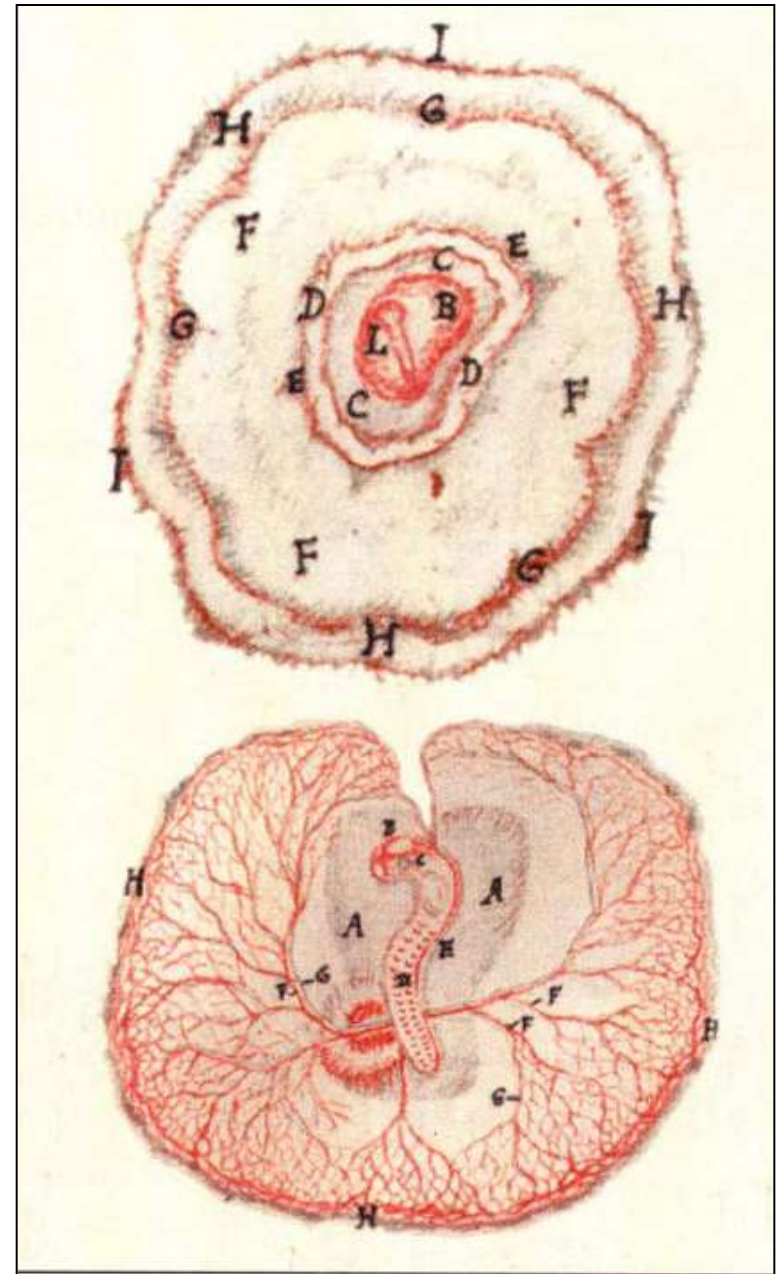


Generation of Animals



**Marcello Malpighi, 1673**

Development of **blood system**  
in **chick embryo**  
after 2 days of incubation



## Preformation



all organisms were created at the same time

succeeding generations grow from fully

formed but miniature versions of themselves

that have existed since the beginning of creation

they just get larger over time

所有生物及其结构早在创世一刻便已形成

各个部分随着时间长大而已



**Leonardo da Vinci**  
**1452 –1519**



**"Views of a Fetus in the Womb"**



**Ovism**

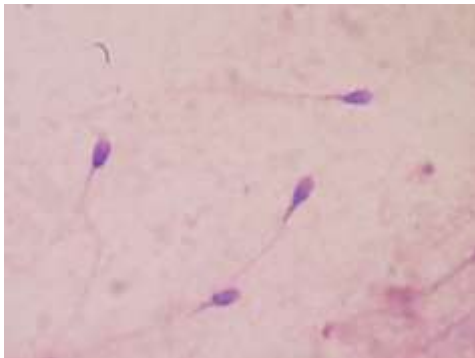
**卵原学说**





**Antonie van Leeuwenhoek**  
**1632 – 1723**

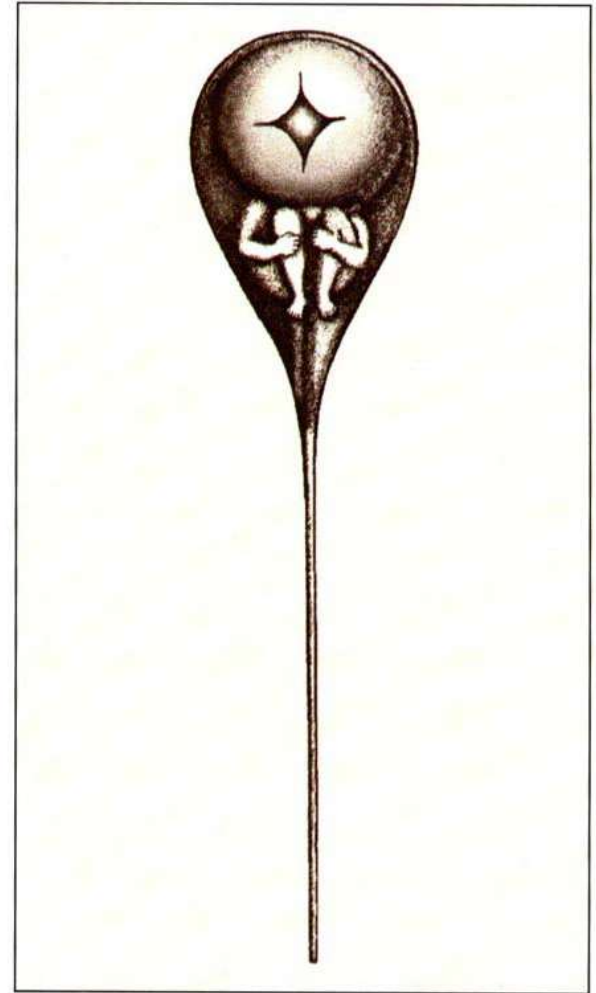
**1677 - discovery of sperm**



## **Spermism**

精原学说

a little human embryo was hidden  
in the head of every sperm



**Nicolas Hartsoeker, 1694**

# History of Developmental biology

## 2. Cell theory (细胞学说)

1665      Robert Hooke      discovered cell



Monk cells





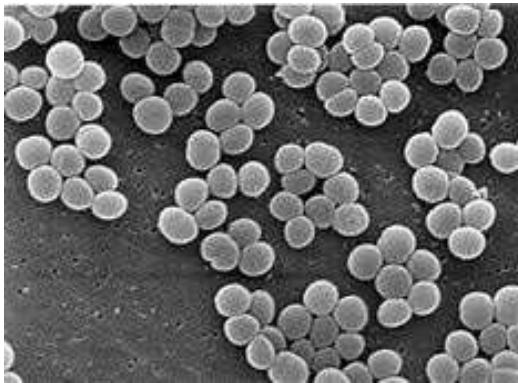
## 2. Cell theory

1665      Robert Hooke

discovered cell

1674      Antonie van Leeuwenhoek

observed live cell



## 2. Cell theory

1665      Robert Hooke

discovered cell

1674      Antonie van Leeuwenhoek

observed live cell

1839      Schleiden and Schwann

the cell theory

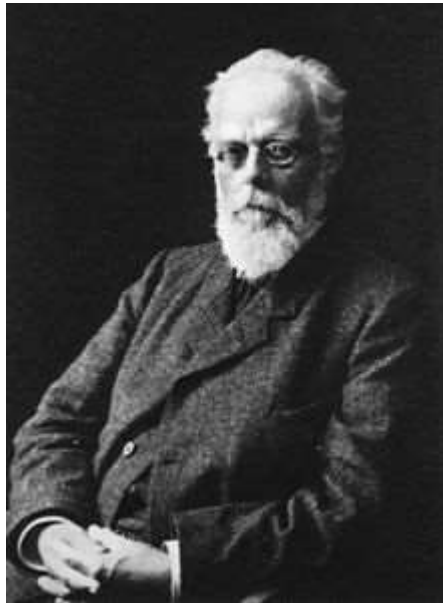


- Cells are the basic building units of life
- All living organisms are made of cells
- All cells arise from pre-existing cells

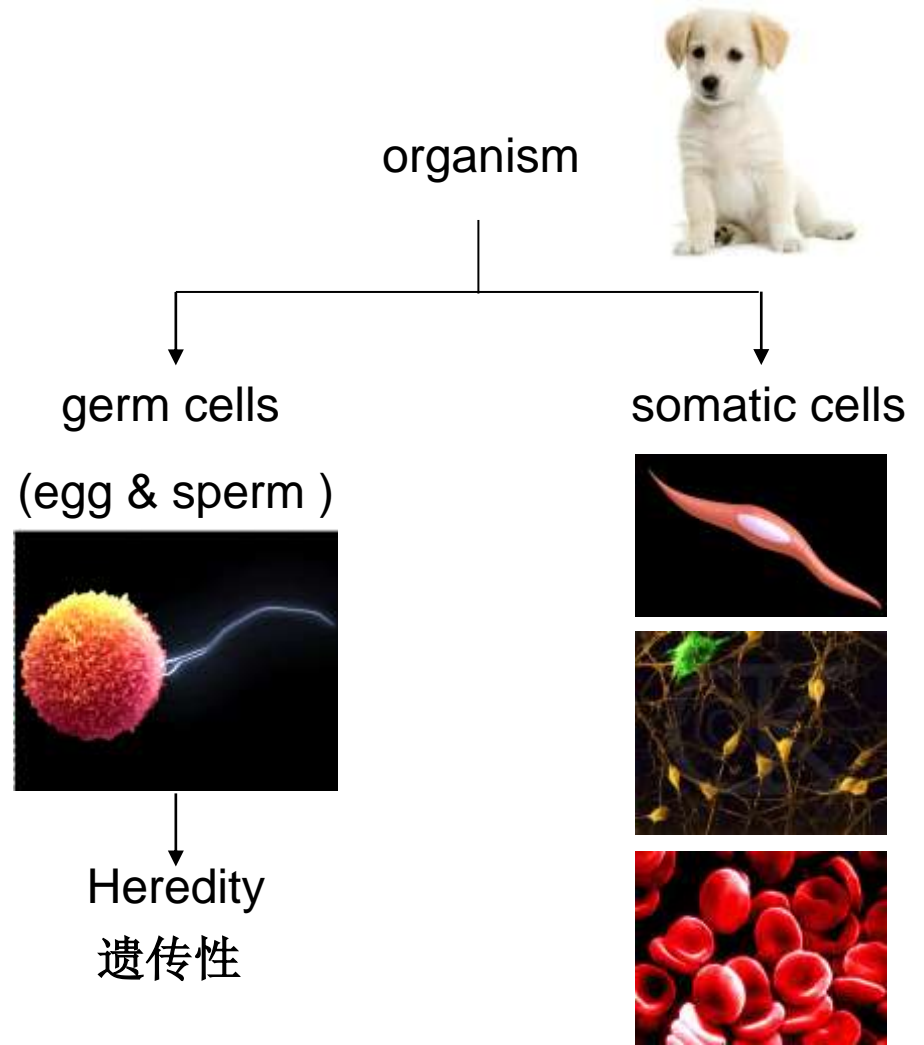
### 3. germ plasm theory 种质学说

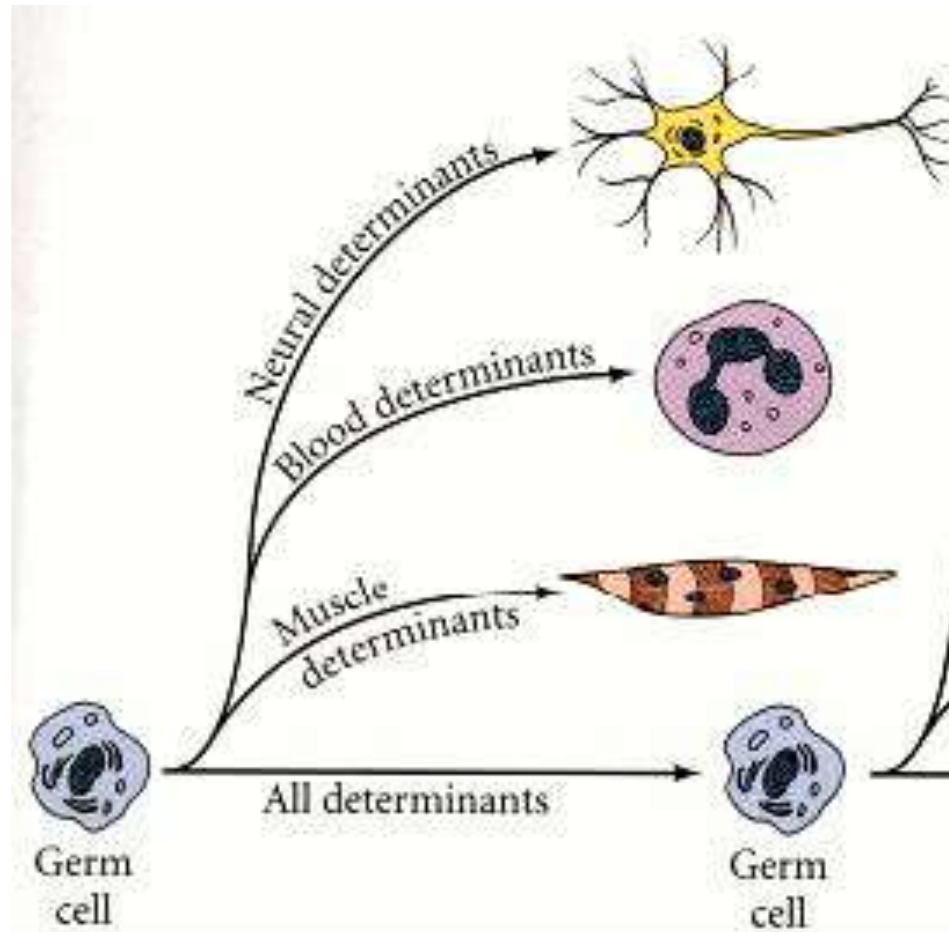
germ cells (生殖细胞): contain and transmit heritable information

somatic cells (体细胞): : carry out ordinary bodily functions



**August Weismann**  
1834 – 1914





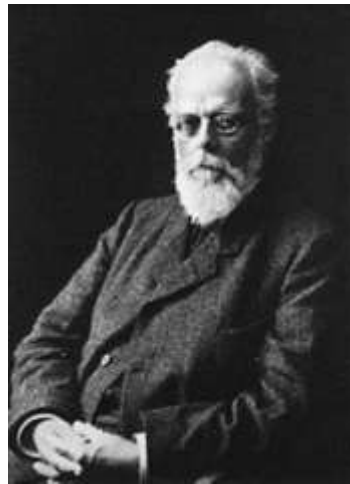
A single fertilized egg  $\longrightarrow$  More cells  $\longrightarrow$  Different cell types  
 Division ?

# History of Developmental biology

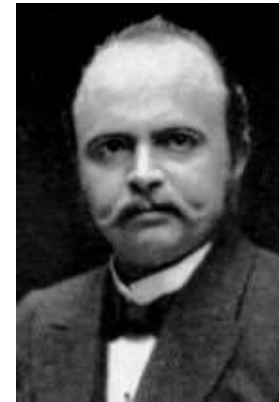
## 4. Mosaic or Regulative Development (嵌合型或调整型发育)



**Wilhelm Roux**  
1850 – 1924



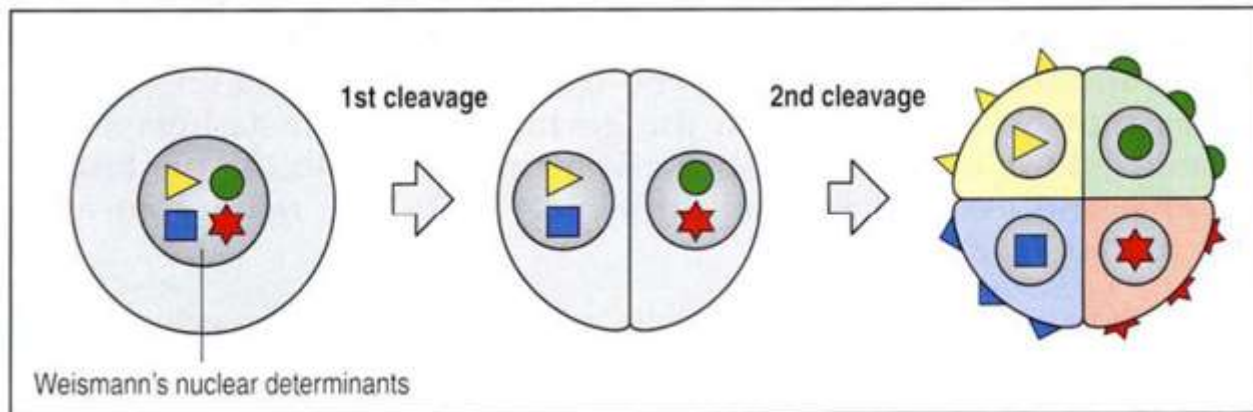
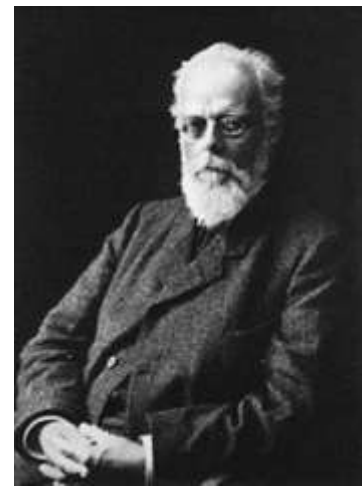
**August Weismann**  
1834 – 1914



**Hans Driesch**  
1867 – 1941

## Mosaic Development (嵌合型发育)

1883 August Weismann



The fertilized eggs carry the full complement of **determinants** (决定子)  
Somatic cells retain the specific **determinants**.

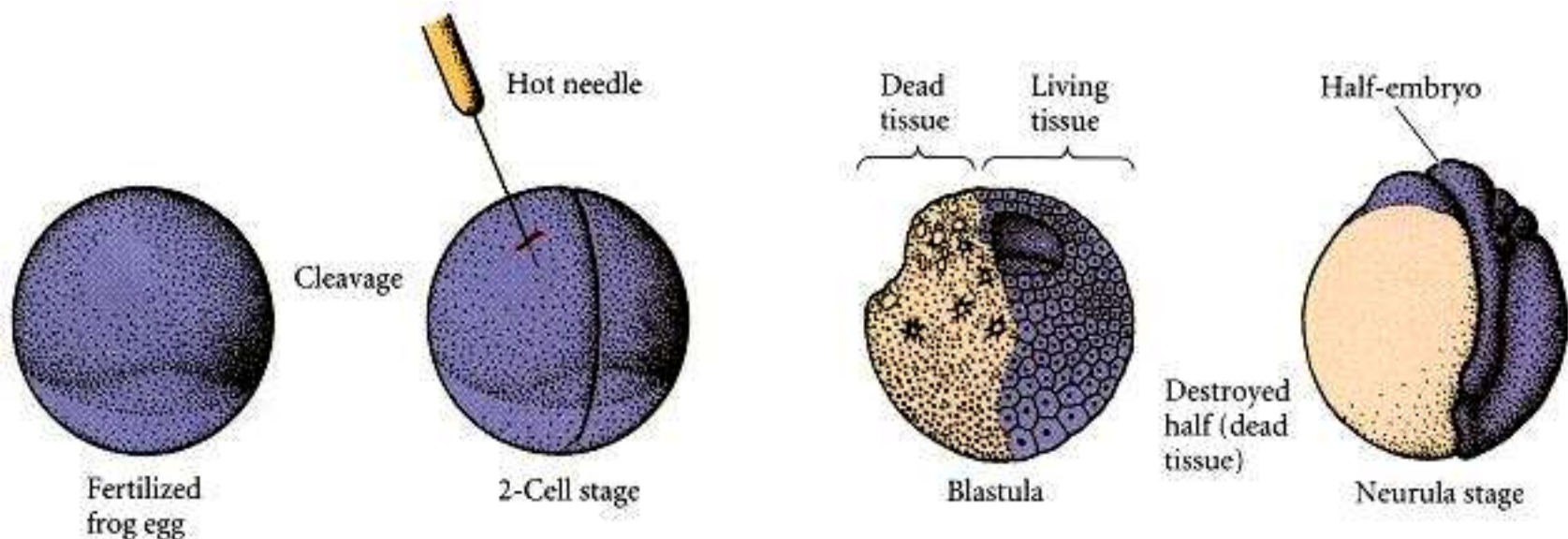


# Mosaic Development

1888 Wilhelm Roux

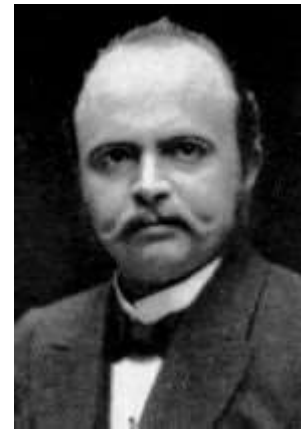
The "Mosaic" theory:

After cell divisions the embryo would be like a mosaic,  
the fate of each cell has been determined.

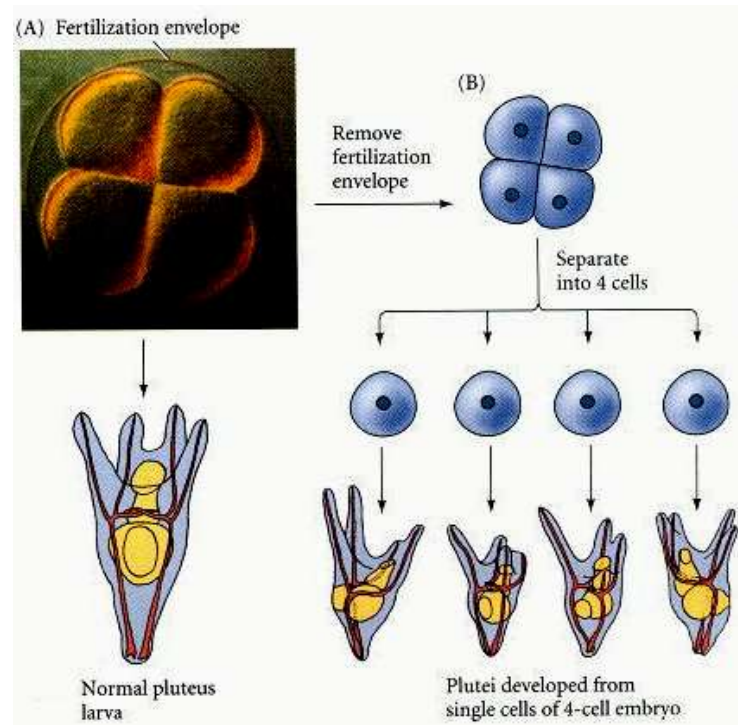


# Regulative Development (调整型发育)

1892 Hans Driesch



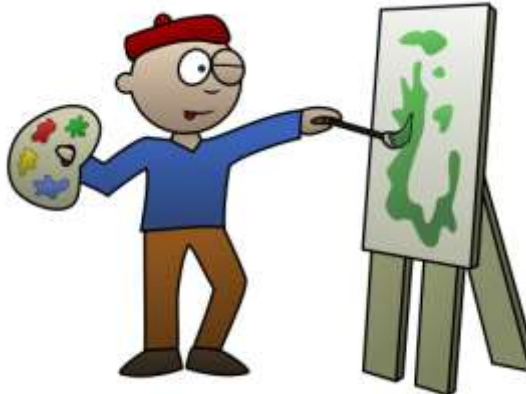
Sea urchin



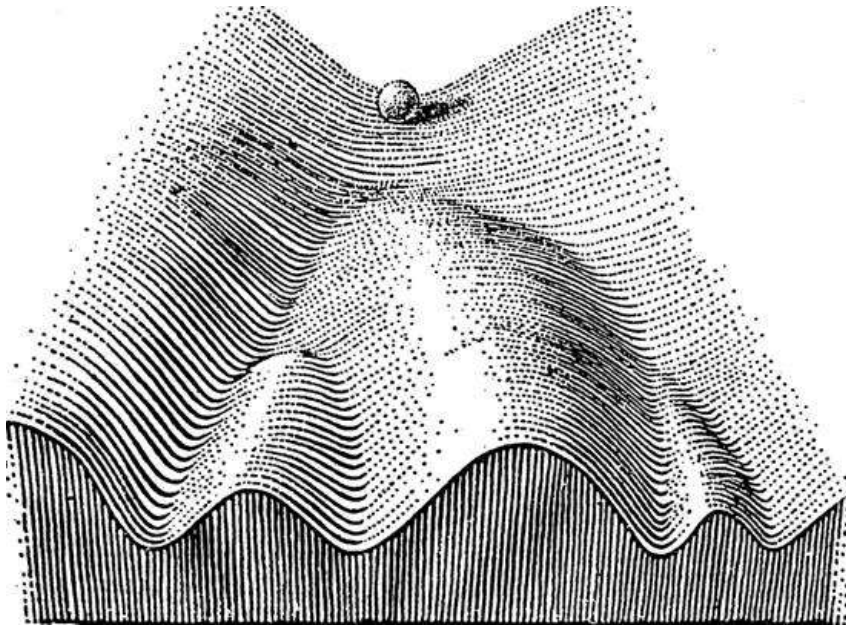
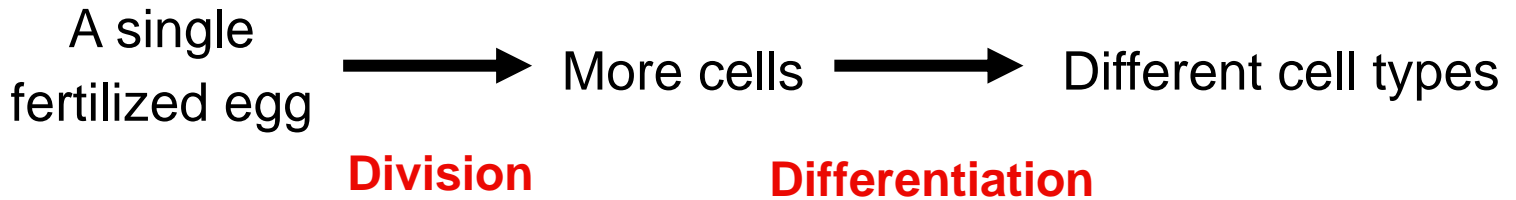
After separation, each isolated blastomere **regulated** its development so as to produce a complete organism.

A single fertilized egg  $\longrightarrow$  More cells  $\longrightarrow$  Different cell types

**Division** **?**







Conrad Waddington

## Epigenetics (表观遗传学), 1942

Stable and long-term changes in **gene activity**

that are not caused by changes in the DNA sequence



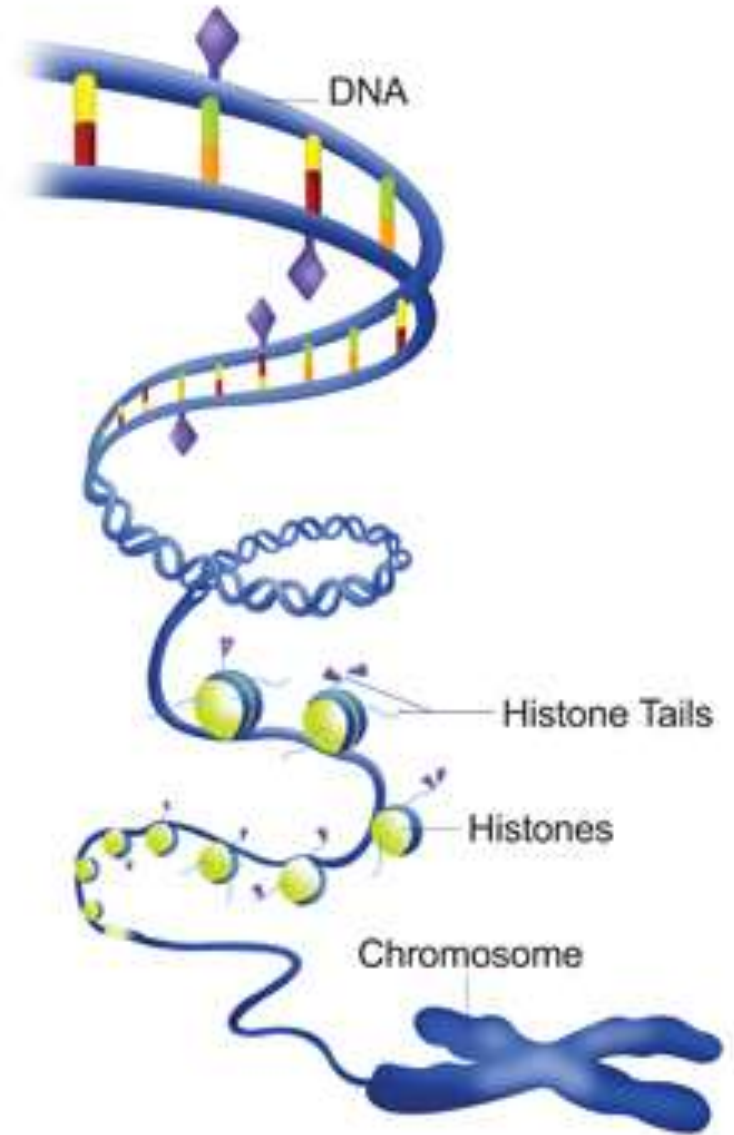
## 5. Epigenetics (表观遗传学)

### Transcriptional control

- DNA methylation
- Histone modification
- Chromatin remodeling

### Post-transcriptional control

- MicroRNA
- double-stranded RNA (dsRNA)

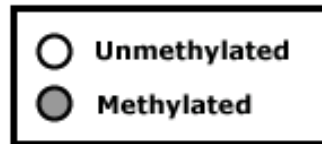
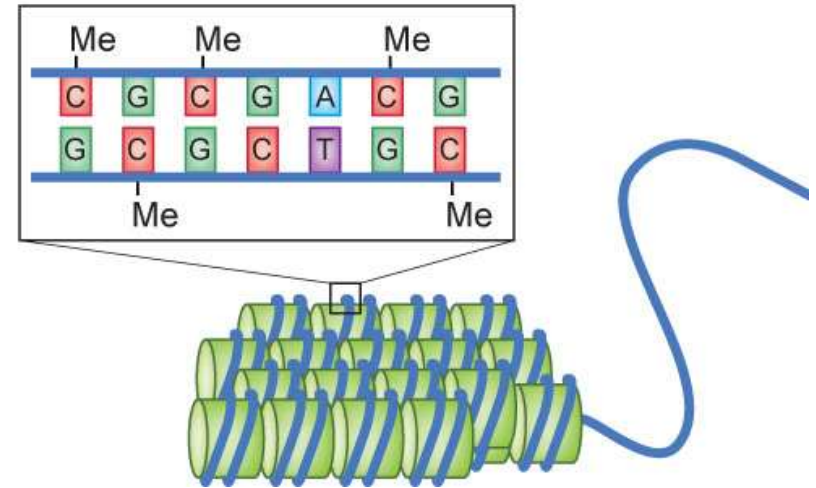
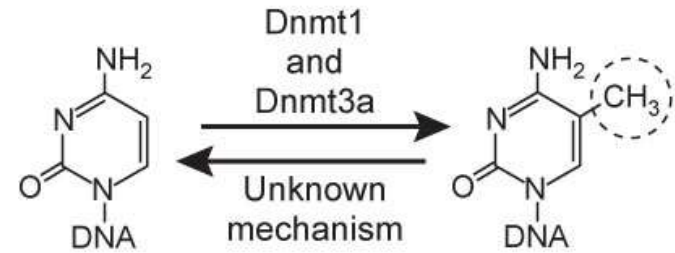




# Epigenetics (表观遗传学)

## Transcriptional control

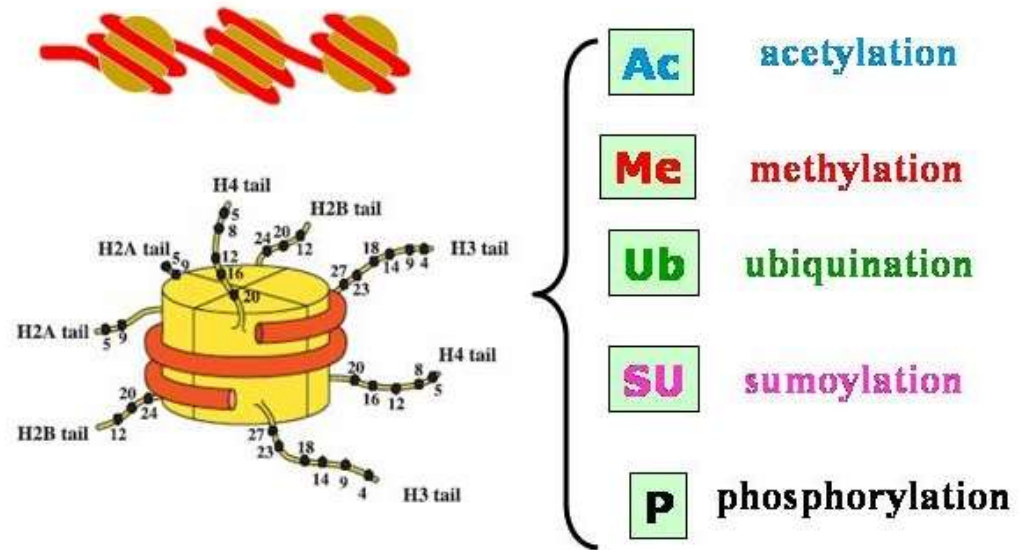
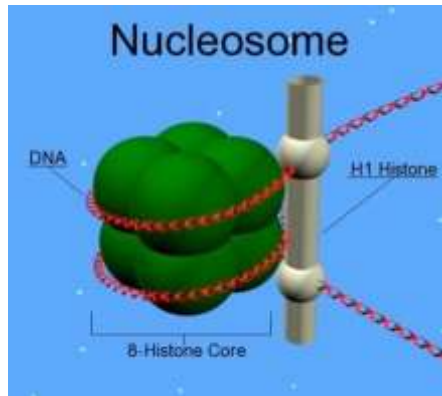
### - DNA methylation



# Epigenetics (表观遗传学)

## Transcriptional control

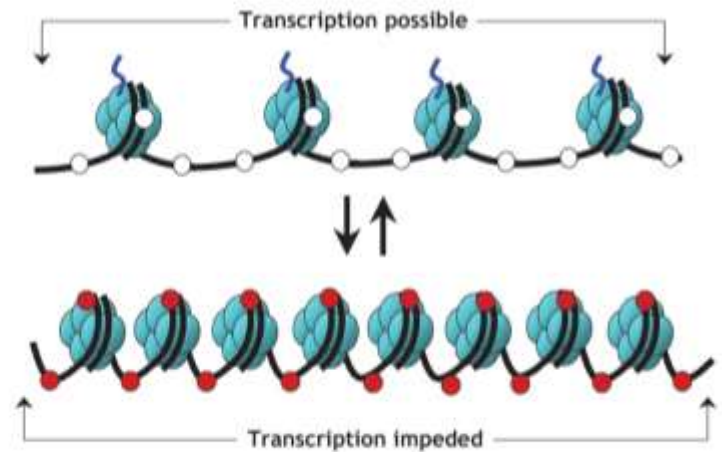
- DNA methylation
- Histone modification



B

- Gene "switched on"
- Active (open) chromatin
  - Unmethylated cytosines (white circles)
  - Acetylated histones

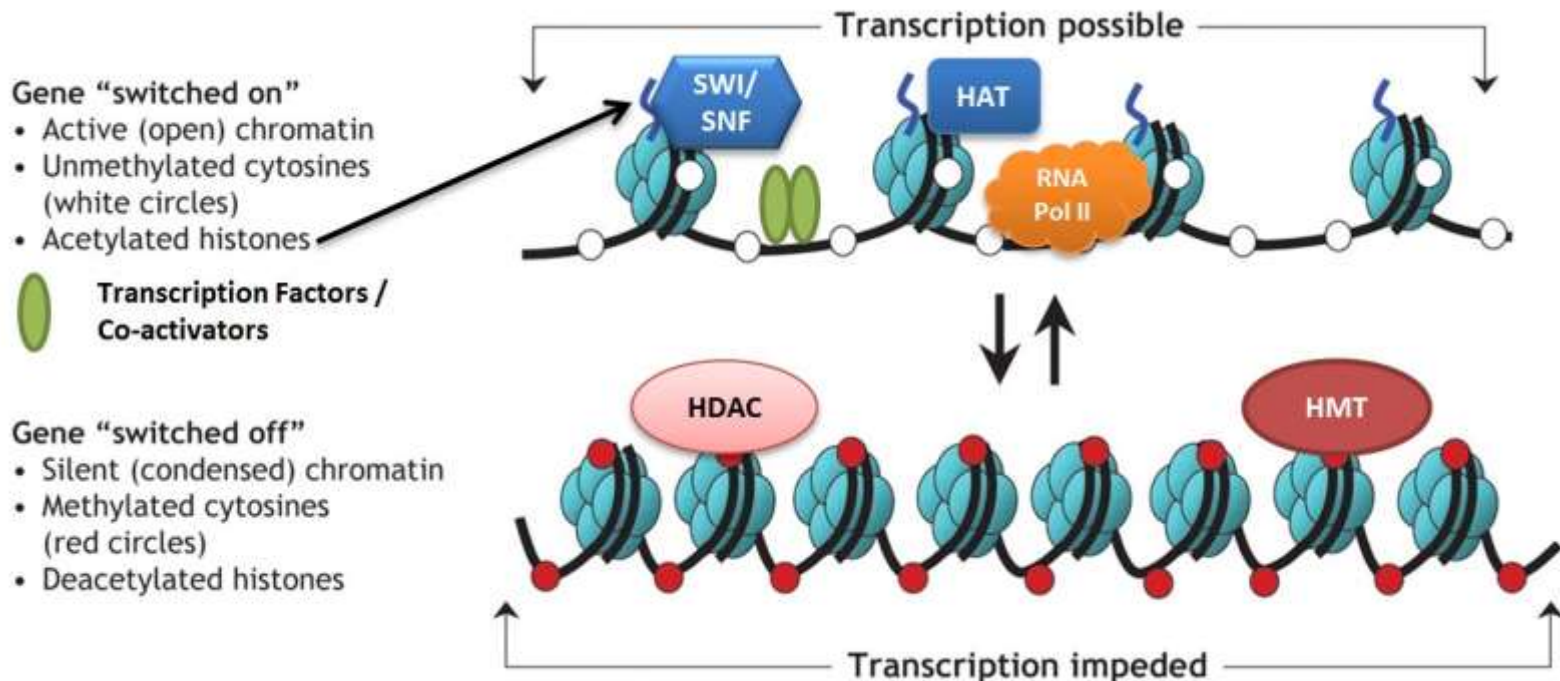
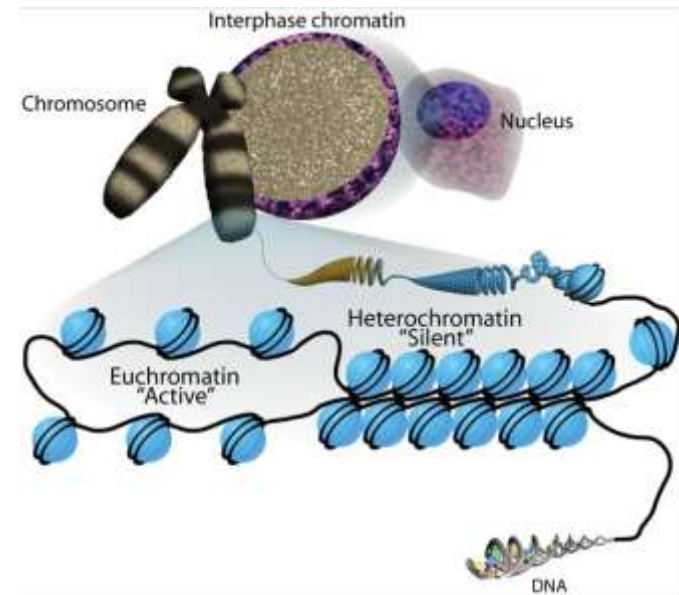
- Gene "switched off"
- Silent (condensed) chromatin
  - Methylated cytosines (red circles)
  - Deacetylated histones



# Epigenetics (表观遗传学)

## Transcriptional control

- DNA methylation
- Histone modification
- Chromatin remodeling



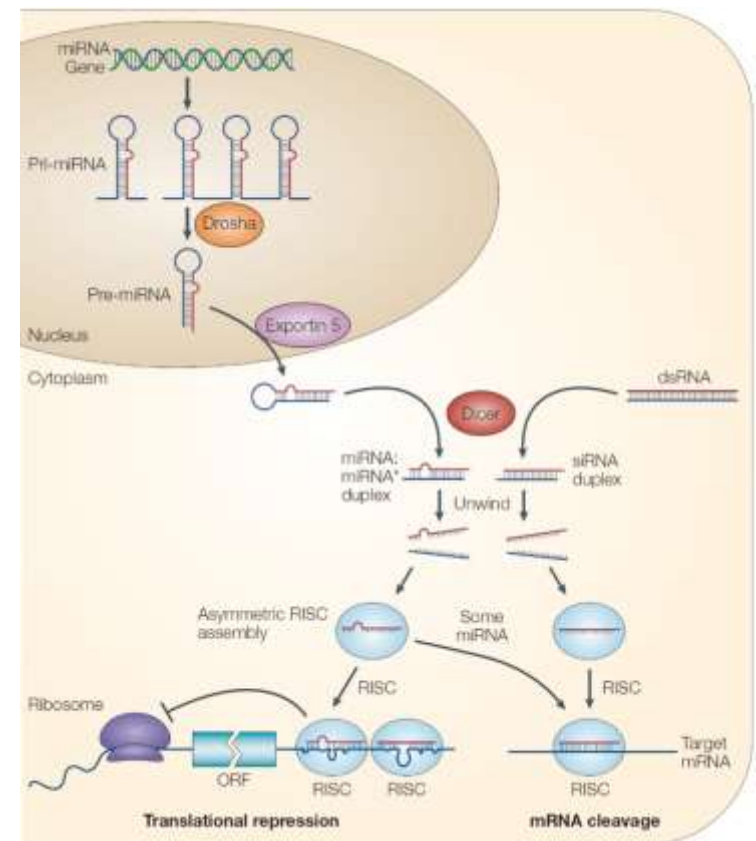
## Epigenetics (表观遗传学)

### Transcriptional control

- DNA methylation
- Histone modification
- Chromatin remodeling

### Post-transcriptional control:

- **MicroRNA:** non-coding RNAs , 17 to 25 nucleotides.
- **double-stranded RNA (dsRNA):** produce small interfering RNAs (siRNAs), 20–25 base pairs.
- **RNA binding protein:** binds to 3'UTR of mRNA, regulates its stability.





# History of Developmental biology

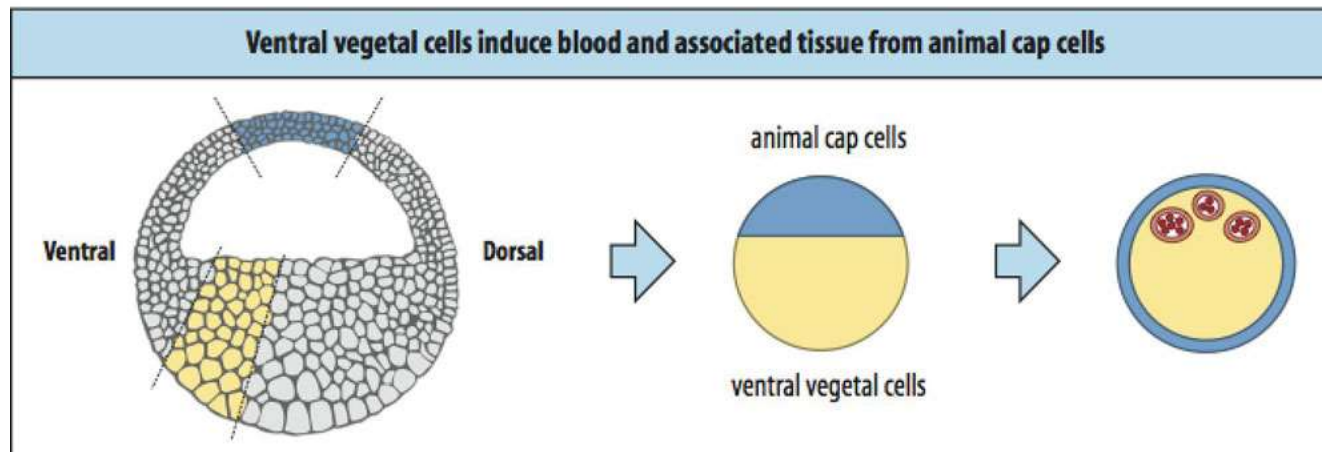
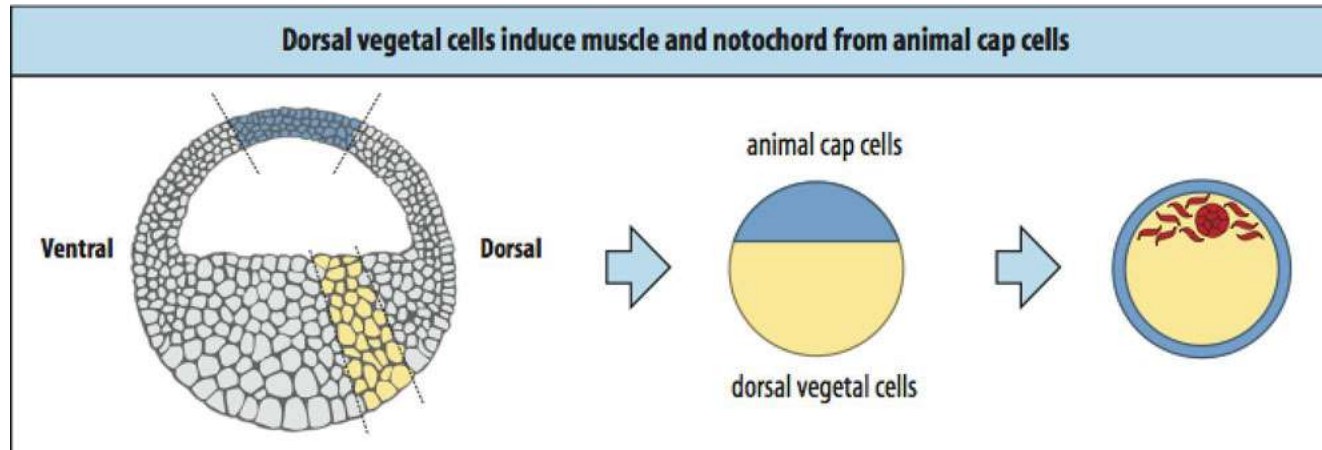
## 6. Induction (诱导)

### 1924 Transplantation Experiment



Hans Spemann

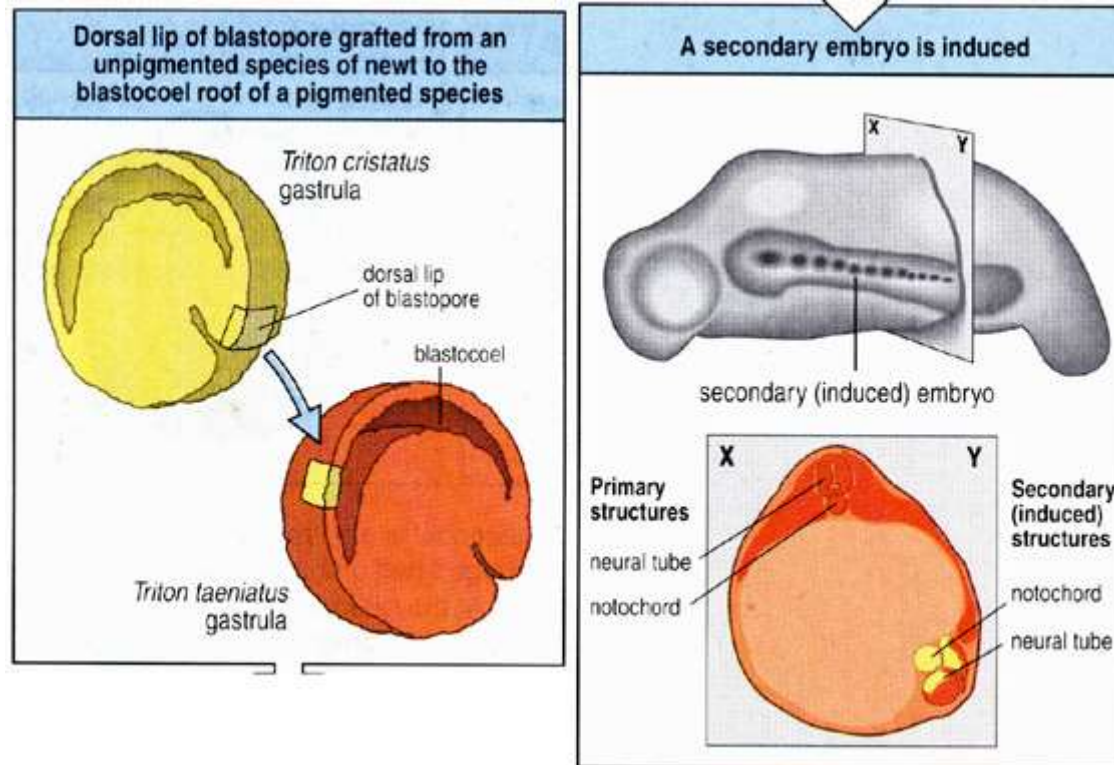
1869 – 1941



# History of Developmental biology

## 6. Induction (诱导)

### 1924 Transplantation Experiment



Hans Spemann

1869 – 1941

Nobel Prize 1935



The **Organizer** region can induce the formation of a new body axis

# History of Developmental biology

## 7. Integration of genetics and molecular biology

1865	Gregor Mendel	Law of Genetics
1910	Thomas Morgan	genes are on chromosomes
1944	Oswald Avery	DNA is the genetic material
1953	Watson & Crick	the structure of DNA
1960'	Crick & others	DNA → mRNA → Protein 中心法则 Genetic code 遗传密码
1970'		DNA sequencing, genetic engineering
1980'		Transgenic animal, knock out
1990'		Animal cloning
2000		Human Genome Project, Stem cell



Thank You