

Chapter 10

# Cells Differentiate



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# 1. 발생 생물학 (Developmental Biology)



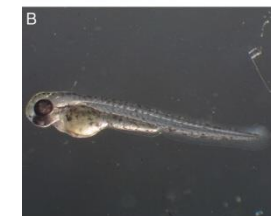
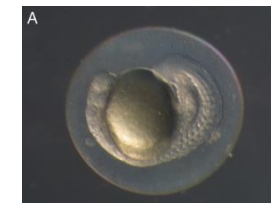
# Developmental Biology

- Development
  - The process of transformation from fertilized egg to adult
- History of developmental biology
  - Until 20<sup>th</sup> century : Observation
  - 20<sup>th</sup> century : Identification of underlying mechanism using genetics and molecular biology

# Developmental Biology

## ■ Model systems

- Fruit fly (*Drosophila melanogaster*)
  - Small, a short life cycle, well characterized, many mutant strains
  - Thomas H. Morgan
- Nematode worm (*Caenorhabditis elegans*)
  - Sydney Brenner (1965, UK)
    - Trace the lineage of all the cells (<1000 cells)
- Vertebrate
  - Frogs, chicken, fish (zebrafish)
    - Develop in eggs outside the mother's body
  - Mouse
    - Identifying the gene function using genetically modified mice



# Fundamental Developmental Processes

- Development
  - Differentiation
    - Generation of different specialized kinds of cells from zygote (fertilized egg) or other precursor cells
      - Generate blood cells, muscle cells, neurons ...
  - Morphogenesis
    - Creation of form and structure
      - Generate the shape of legs, eyes, wings, skin, organs, tissues, and structures

## 2. 분화 (Differentiation)

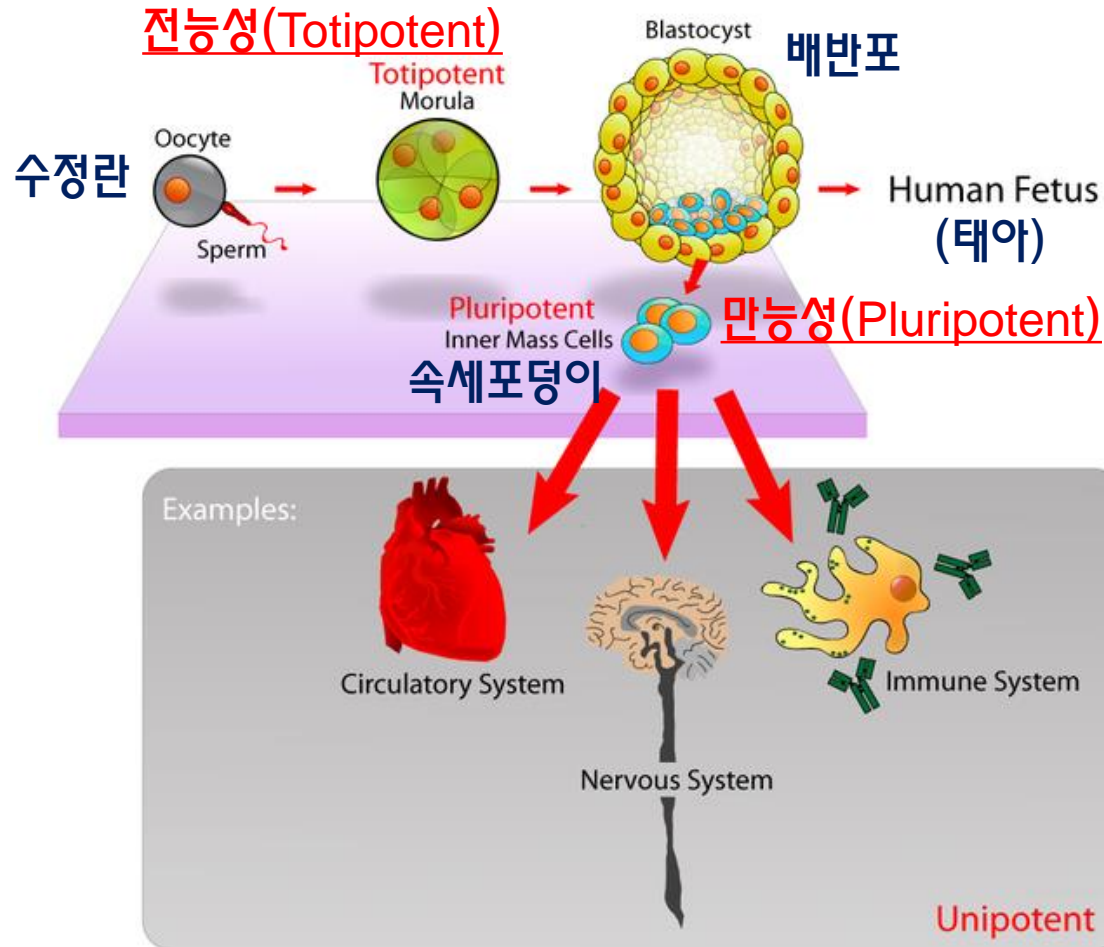


# Differentiation

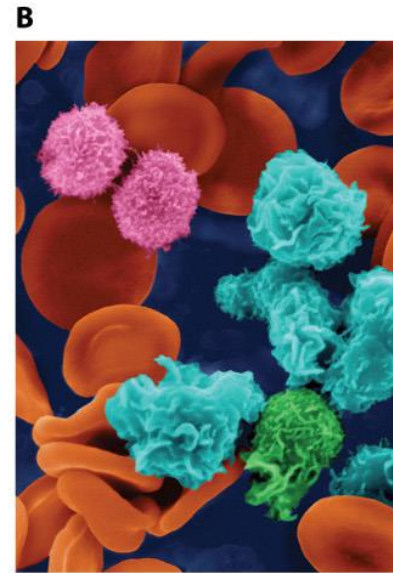
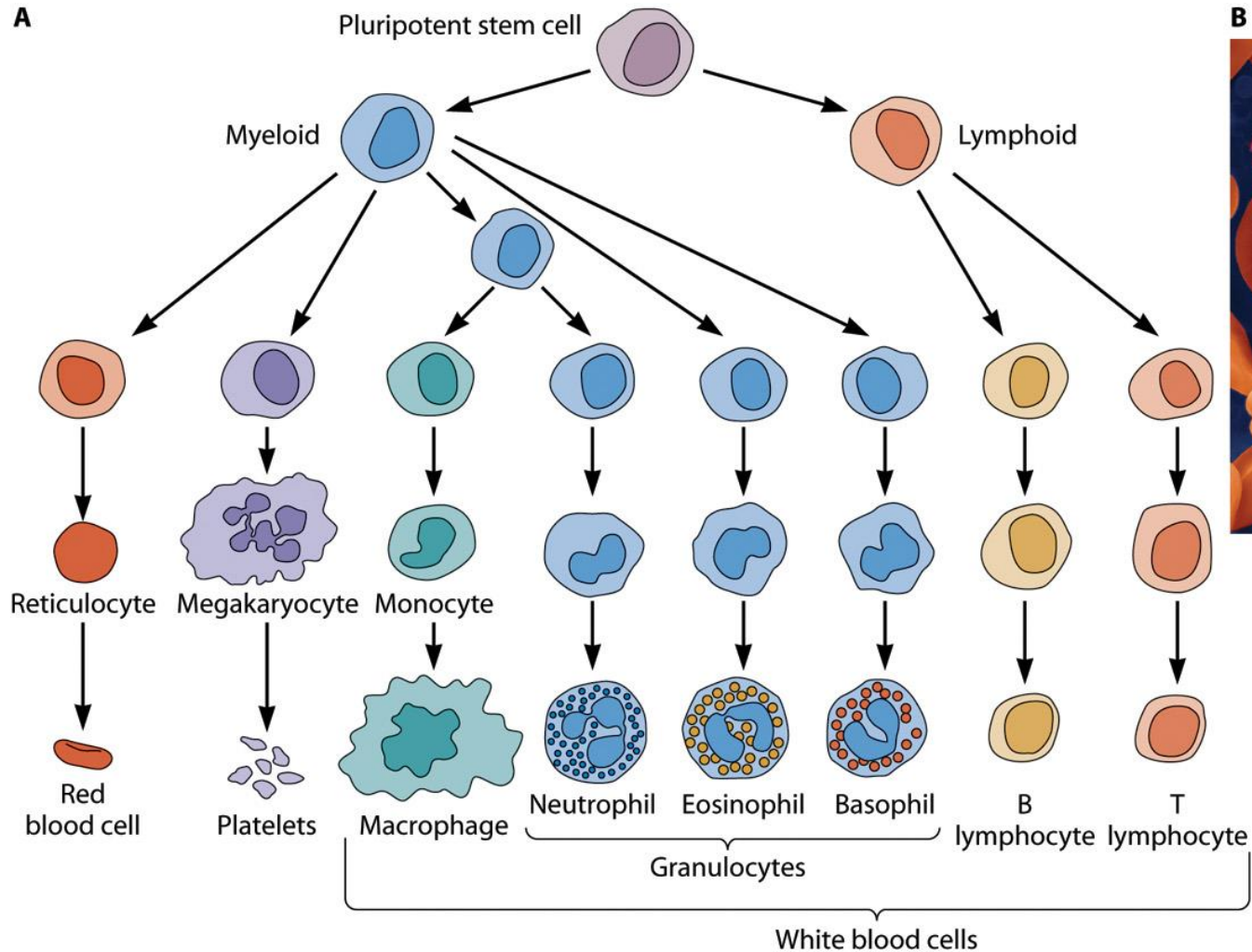
- **Totipotent**
  - Fertilized egg : can form all the cell types in a body, plus the extraembryonic, or placental, cells.
  - Embryonic cells within the first couple of cell divisions after fertilization are the only cells that are totipotent.
- **Pluripotent**
  - Inner cell mass : can give rise to all of the cell types that make up the body
  - Embryonic stem cells are considered pluripotent.
- **Multipotent**
  - Can develop into more than one cell type, but are more limited than pluripotent cells
  - Adult stem cells and cord blood stem cells are considered multipotent.
- **Terminally (or fully) differentiated**
  - A cell with specialized properties of a particular cell type
  - Usually no reproduction



# Differentiation



# Differentiation of Blood Cells



# Differentiated Cells

- Same set of genes
- Different expression pattern
  - Common expression of essential genes : housekeeping genes
  - Differential expression of cell-specific genes
  - Cellular differentiation is the process of turning on and off of specific genes

**Table 10.1** Specialized products of differentiated cell types

<b>Cell type</b>	<b>Specialized product</b>	<b>Specialized function</b>
Keratinocyte (skin cell)	Keratin (protein)	Protection against abrasion and drying out
Erythrocyte (red blood cell)	Hemoglobin (protein)	Transport of oxygen
Melanocyte	Melanin (pigment)	Pigment production
Myocyte (muscle cell)	Actin and myosin (proteins)	Muscle contraction
Pancreatic islet cells	Insulin (peptide)	Regulation of glucose metabolism
Hepatocyte (liver cell)	Numerous enzymes (proteins)	Glycogen storage and breakdown; fatty acid synthesis; gluconeogenesis; other metabolic functions
Neuron (nerve cell)	Neurotransmitters (various)	Transmission of nerve signals

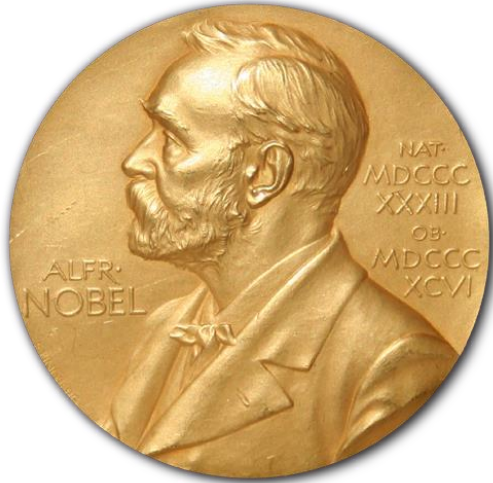
### 3. 줄기세포 (Stem Cell)



# Stem Cell

- Stem Cell: less differentiated cell
- Embryonic Stem Cell
  - From inner cell mass
  - Pluripotent
- Adult Stem Cell
  - From adult body
  - Multipotent
- Induced Pluripotent Stem Cell (iPS cell)
  - Dedifferentiation of differentiated cells
  - Pluripotent

# The Nobel Prize in Physiology or Medicine 2012



**Sir John B. Gurdon**

**Shinya Yamanaka**

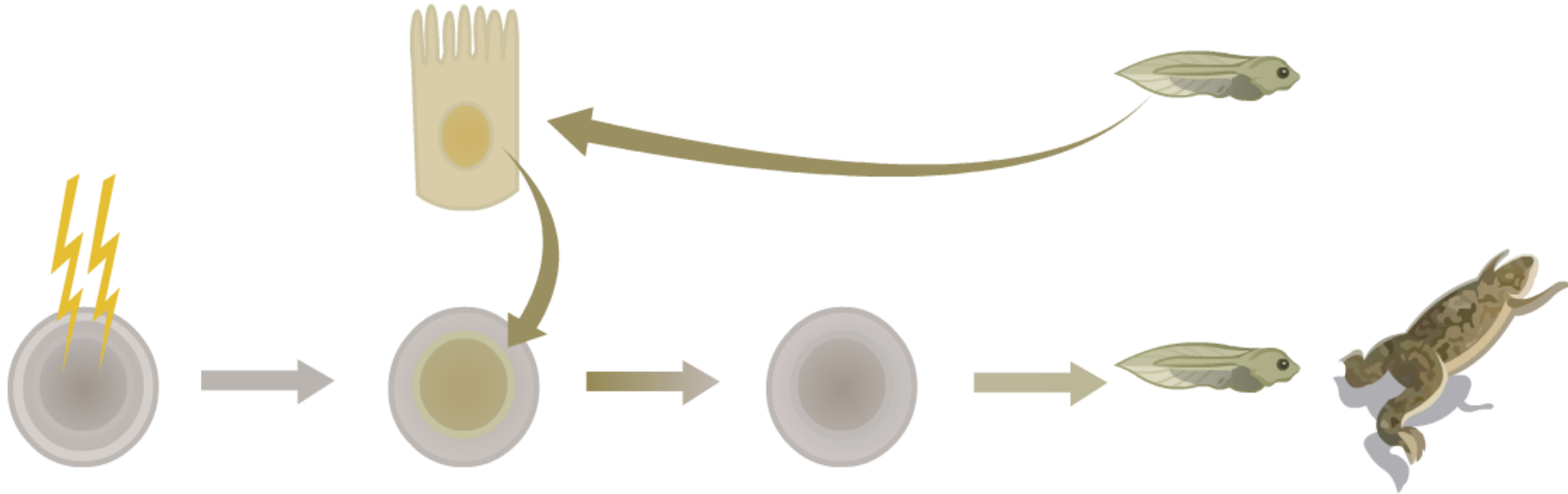
“for the discovery that mature cells can be reprogrammed to become pluripotent”

--- iPS cell (induced Pluripotent Stem cell)

# Milestones of Reprogramming

- 1962, J. Gurdon
  - Cloning of a tadpole
- 1997, I. Wilmut
  - First cloned mammal: Dolly
- 1998, J. Thomson
  - Human embryonic stem cell
- 2006, S. Yamanaka
  - Induced pluripotent stem cell

# 올챙이 복제



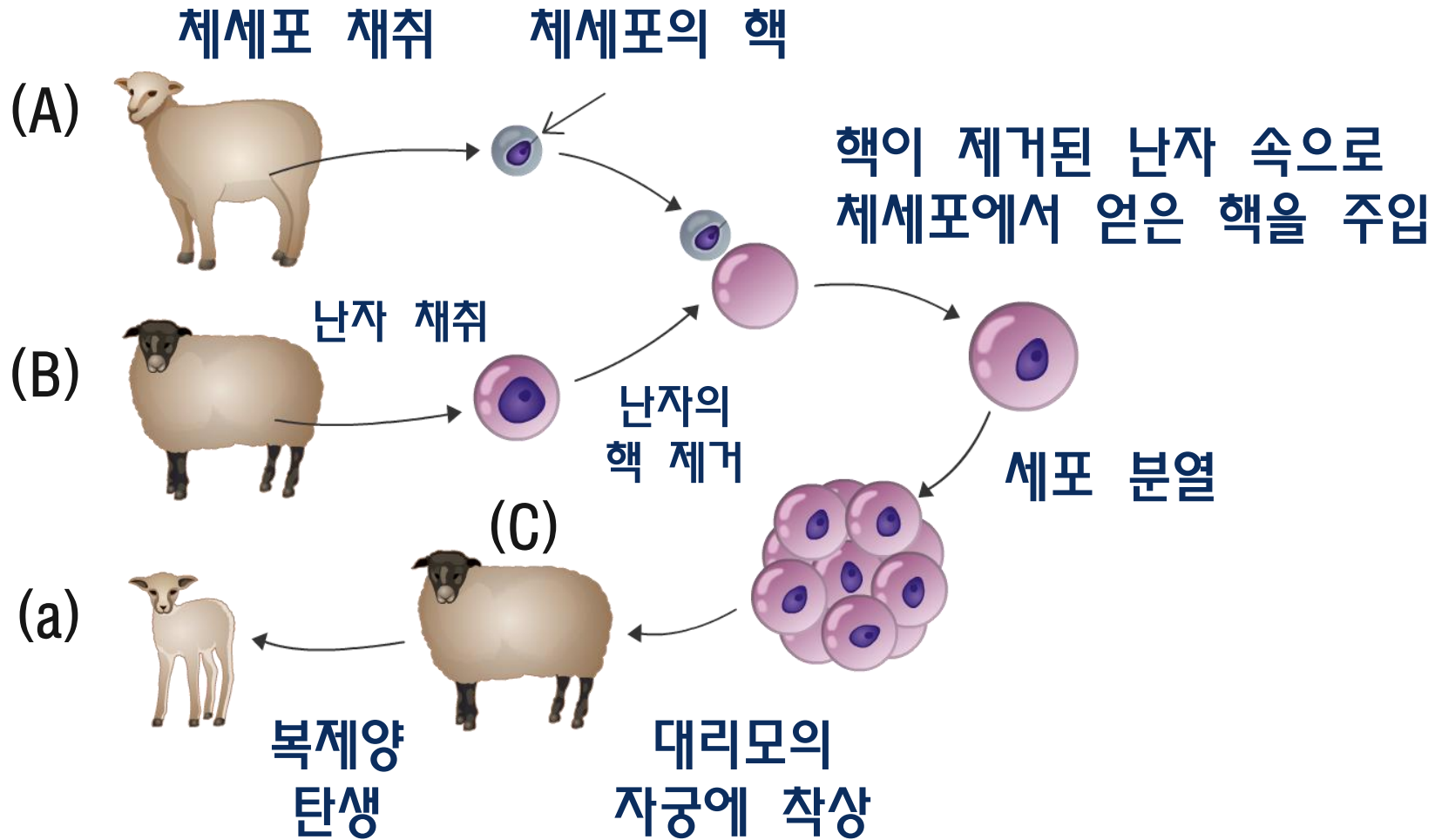
개구리알  
핵 제거

올챙이핵  
주입

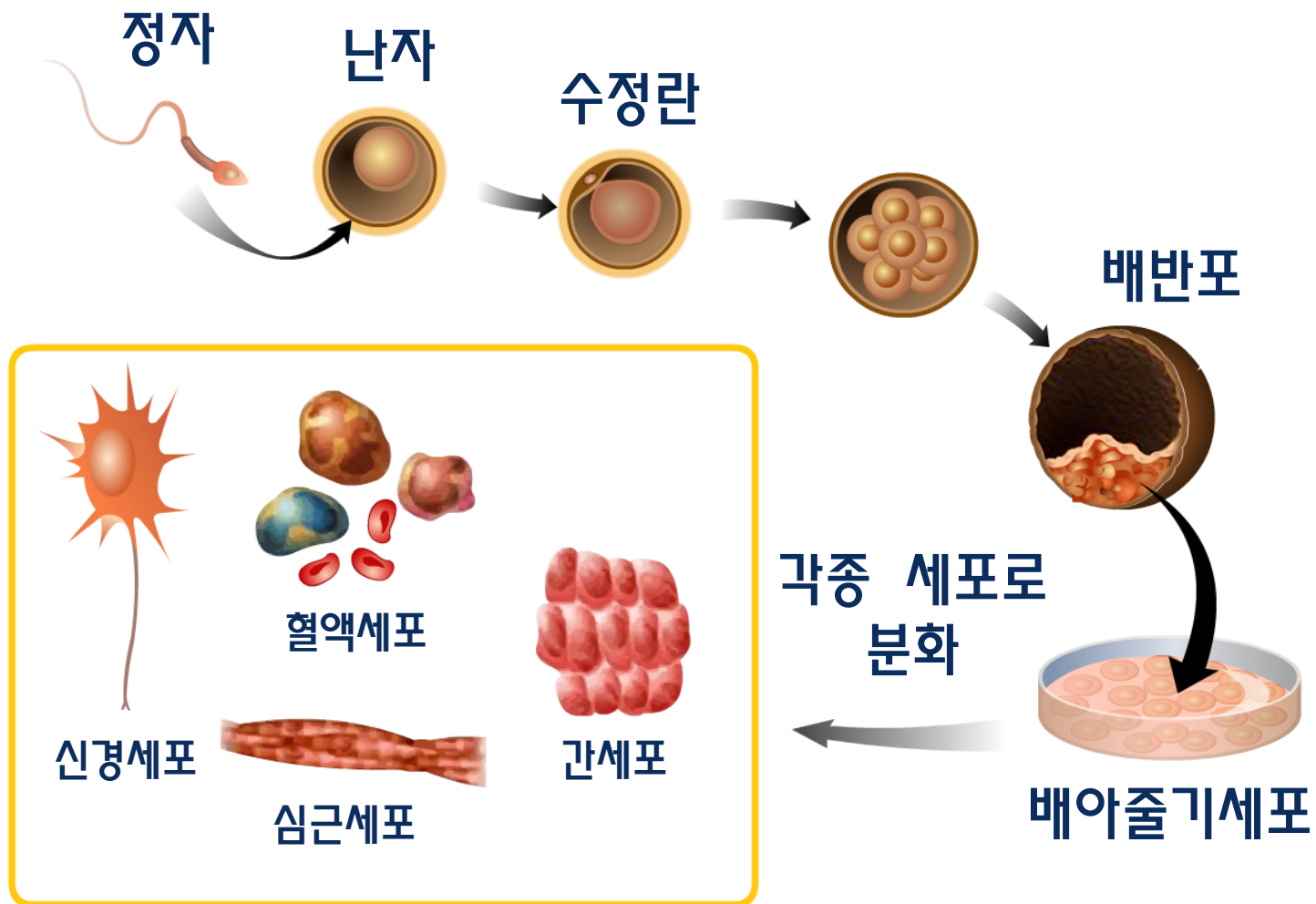
복제 올챙이



# 포유동물 복제



# 배아줄기세포 (Embryonic Stem Cell)



# 생체 시계를 거꾸로 돌릴 수 있을까?



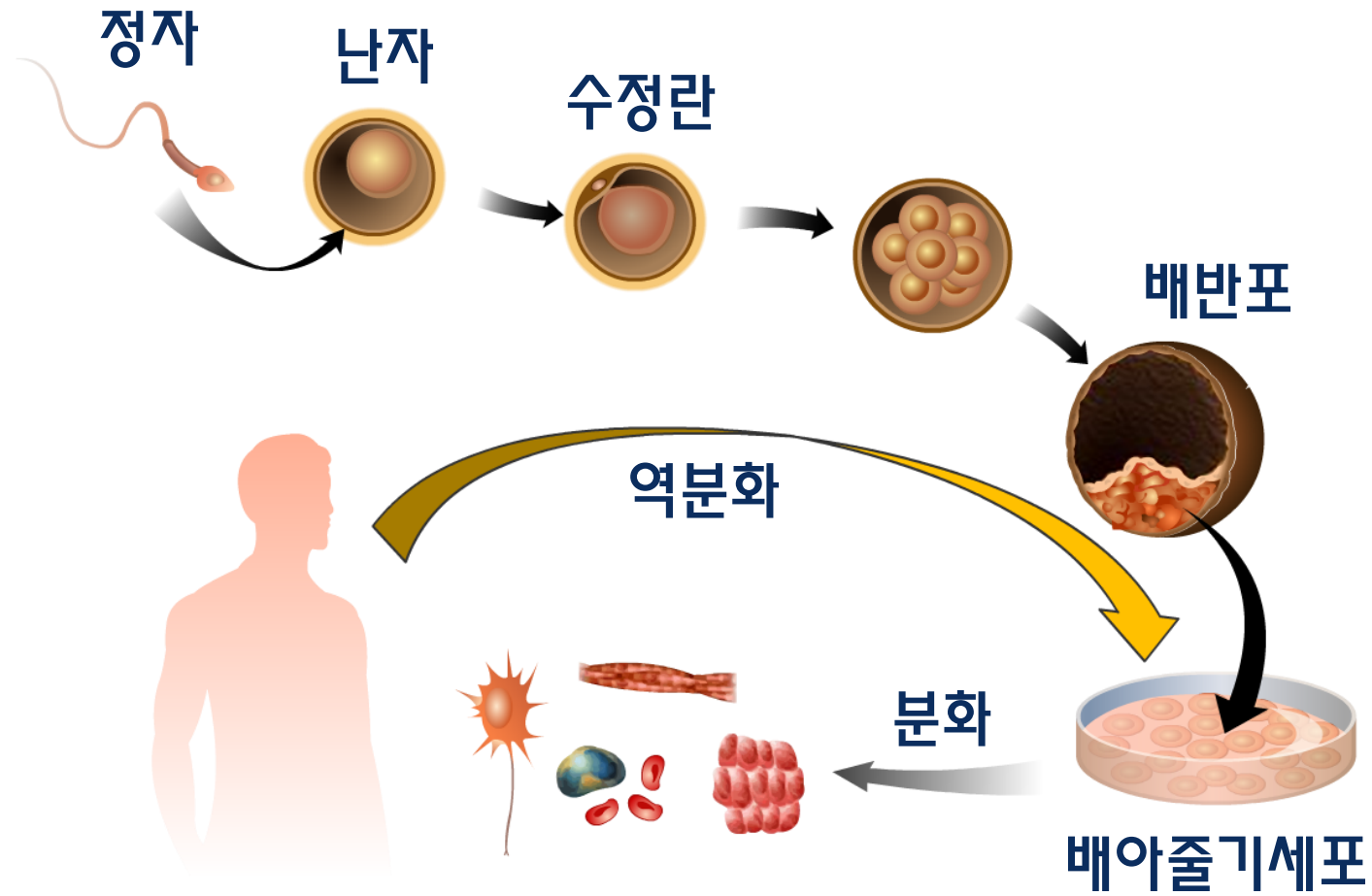
# 유도만능 줄기세포

## 2012년 노벨상

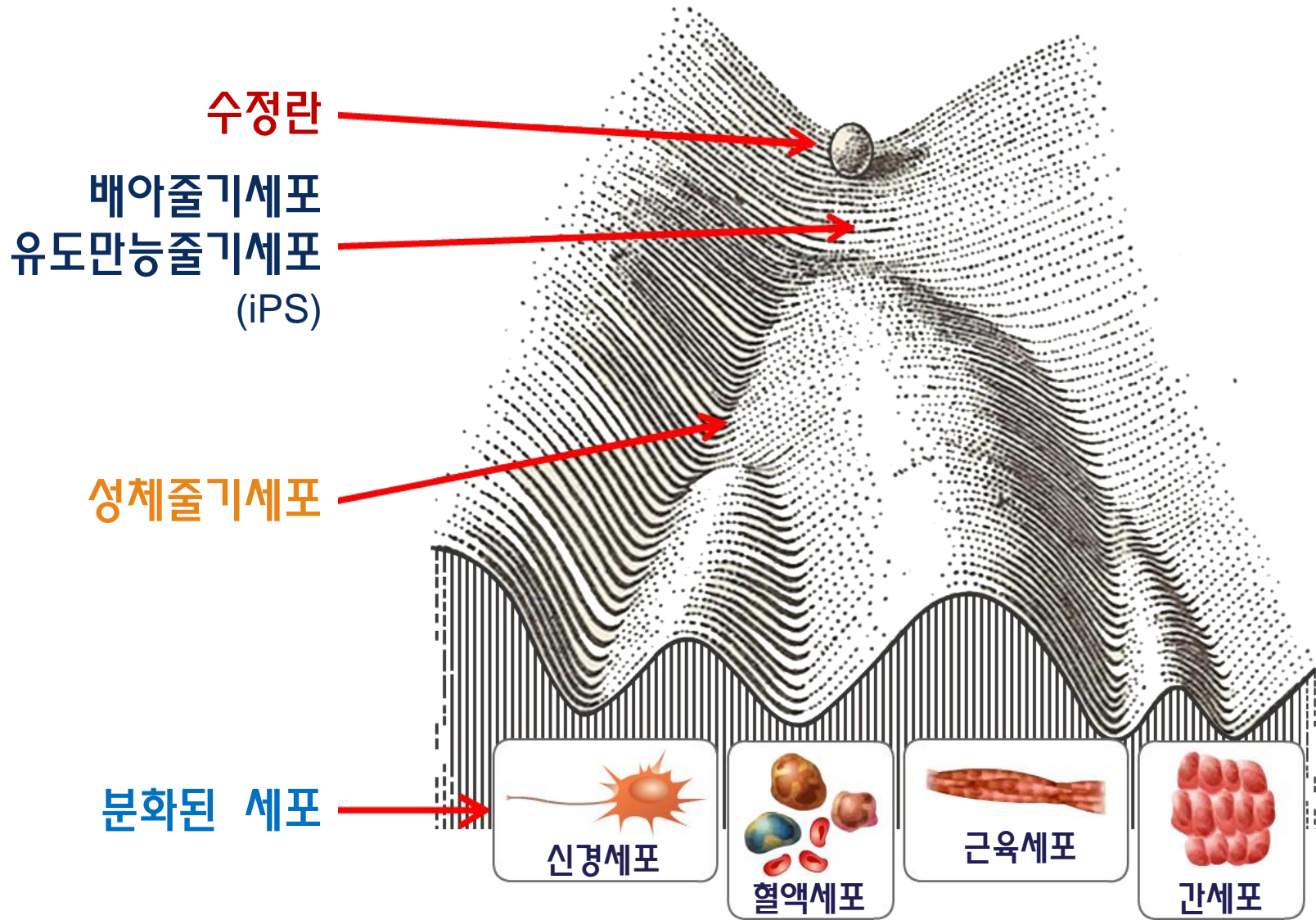
- iPS Cell  
역분화 줄기세포  
(유도만능 줄기세포)
- 교토대 야마나카 교수  
4개 유전자



# 유도만능 줄기세포



# 각종 세포로의 분화



## 4. 형태형성 (Morphogenesis)



# Morphogenesis

- Morphogenesis
  - Movement, migration, proliferation, and death of cells
  - Triggered by communication between cells
- Morphogenesis in vertebrate
  - Generation of neural tube → brain and spinal cord
    - Cells in the neural tube
      - migration and generate neural circuits
  - Formation of limbs
    - Migration of bone and muscle precursor cells
      - Formation of limb buds under the outer layer of embryo



# Morphogenesis

- Cell migration and fur pigmentation
  - Cells migrate outward from the region of spinal cord and differentiates into different types of cells including melanocytes.
  - No melanocytes in the hair follicle  
→ white hair
- Apoptosis in morphogenesis
  - Apoptosis: programmed cell death
  - Apoptosis in development
    - Webbed foot vs. nonwebbed foot
    - Development of male or female sexual organs

