# Introduction: What is Developmental Biology?

## A. Developmental Biology: What Is It?

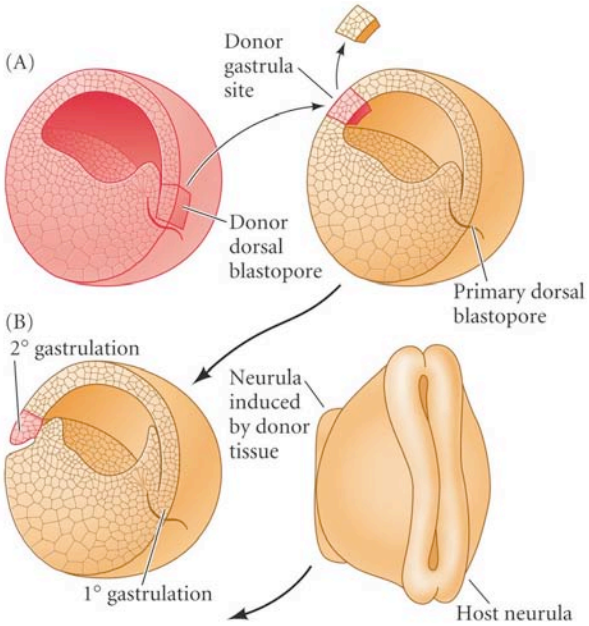
1. The motivation for studying biology in general and developmental biology in particular: *wonder*!

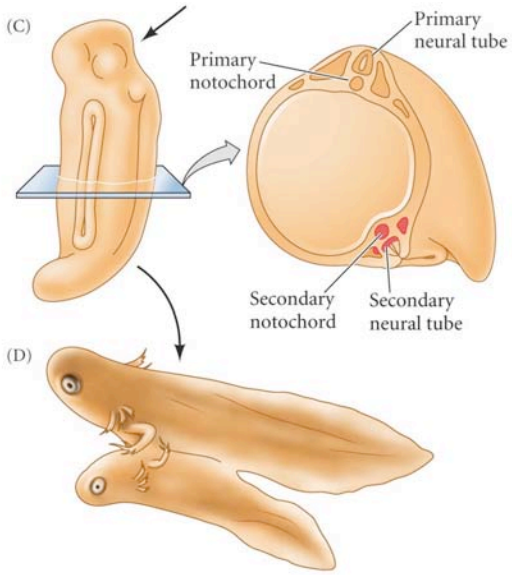
**Albert Einstein**: "The most beautiful thing we can experience is the mysterious. It is the source of all true art and science. He to whom this emotion is a stranger, who no longer pauses to wonder and stand rapt in awe, is as good as dead."

**David (Psalm 139):** "For Thou didst form my inward parts; Thou didst weave me in my mother's womb. I will give thanks to Thee, for I am fearfully and wonderfully made; wonderful are Thy works, and my soul knows it very well. My frame was not hidden from Thee, when I was made in secret, skillfully wrought in the depths of the earth. Thine eyes have seen my unformed substance; and in Thy book they were all written, the days that were ordained for me, when as yet there was not one of them."

2. The central problem of developmental biology: *how do parts become different*?
   a. **Tools** and **model organisms** are central to the rise of modern developmental biology
   b. **Epigenesis** vs. **preformation**- a chicken and egg problem
   c. **Differentiation** = The process by which differing properties are conferred on parts of the embryo at different times and in specific locations, such that specialized structures arise in a reliable fashion in the mature organism.
   d. **Morphogenesis** = How form (Greek μορφη) arises
   e. Spemann, the video: A classic case study

## B. Developmental Biology: Big Ideas




Gilbert, 7e, Fig. 10-21

1. Review from the video
   a. **Cell lineage** (Vogt): a cell's ancestry is sometimes crucial for its differentiation and behavior, and we need to know that ancestry in detail to interpret "disruption" experiments.
   b. **Organizer** (Spemann/Mangold): sends signals to surrounding tissues, but "remembers" its own fate when placed in a new environment
2. What Experiments Tell Us
   a. **Sufficiency and necessity**

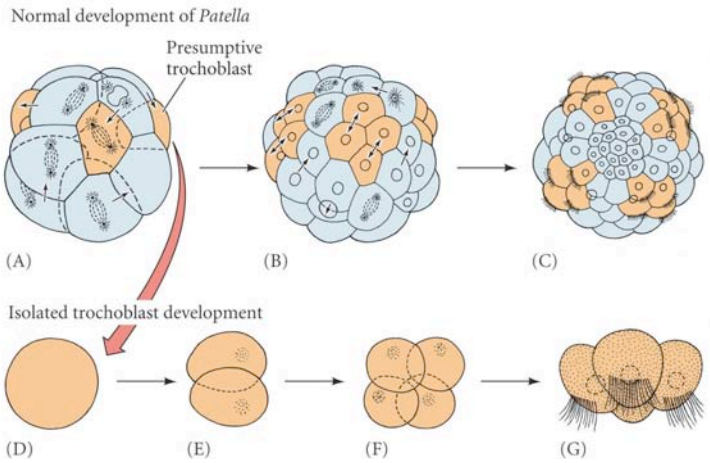
• *Sufficiency:* When a group of cells (or molecule), when added to a cell, embryo, or tissue, confers the ability to differentiate in a particular way. Does NOT mean a molecule or group of cells is necessary. Example: Bill Gates vs. the lottery. If a cell or molecule is sufficient but not necessary, this often indicates **functional redundancy**.

• *Necessity:* When a group of cells (or molecule), is removed from a cell, embryo, or tissue, the ability to differentiate in a particular way is lost. Does NOT mean a molecule or group is sufficient. Example: Air and water. If something is necessary but not sufficient, it indicates it acts together with other essential cells/molecules.

b. **Specification**: the extent to which a cell or tissue will differentiate normally when placed into a new surrounding.

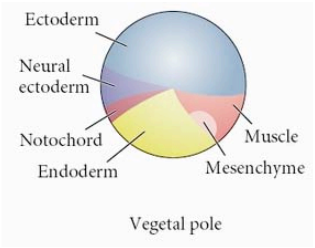
• *Autonomous specification*: "to thine own self be true" (e.g. E.B. Wilson and mollusks) – differentiation occurs as it would in the intact embryo.

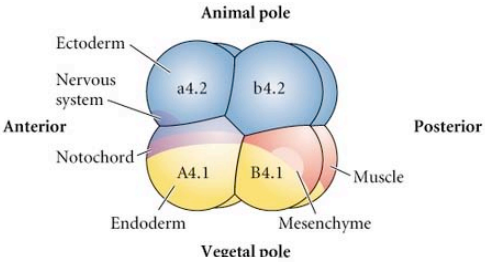
• It often involves *localized determinants*. Example: ascidians

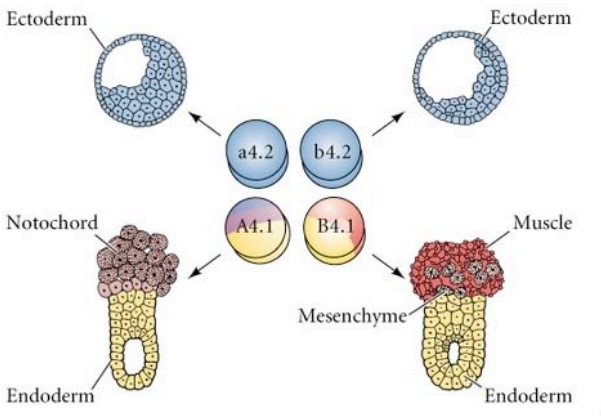



Gilbert, 8e, Fig. 3-7

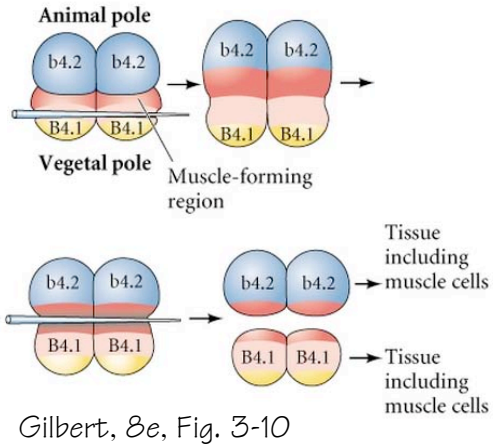
Gilbert, 8e, Fig. 1-7



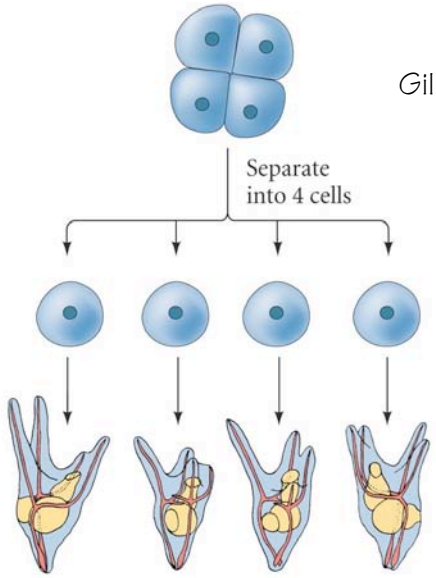




Gilbert, 8e, Fig. 3-8




Gilbert, 8e, Fig. 3-10

• *Conditional specification*: the differentiation of a cell or tissue depends on its local environment. Example: Hans Driesch and sea urchins.




Gilbert, 8e, Fig. 3-17

Plutei developed from single cells of 4-cell embryo

c. **Induction**: the process by which one cell or tissue (the inducer) sends a signal to a second cell or tissue (the induced tissue), resulting in a specific and reproducible change in its differentiation

d. **Pattern formation**: The process by which regions of an embryo or structure become specified to give rise to different tissues. This process is completed by subsequent morphogenesis and differentiation.

## C. Developmental Biology: Modern Approaches

a. **Model systems** have continued to be keys to unlocking the mechanisms of differentiation

b. **Cellular control** of development. Judith Kimble's dictum: "Developmental biology is cell biology over time".

c. **Molecular contro**l of development: Studying **genes**, their function and regulation (example: *homeotic genes*)

## D. Developmental Biology: Societal Implications

1. Ethical issues arise from science, but aren't solved by science. Examples: cloning and stem cells

2. Really important questions this course will raise, but won't answer:

i. What does developmental biology tell us about **the nature of persons**?

ii. What new technologies made available by developmental biology are **ethically permissible**?

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Required reading: Gilbert, 8e, Ch. 1, pp. 3-7, 10-11, Ch. 2, pp. 25-30; Ch. 3, pp. 57-62; Ch. 10, pp. 302-306 (through Fig. 10.19)