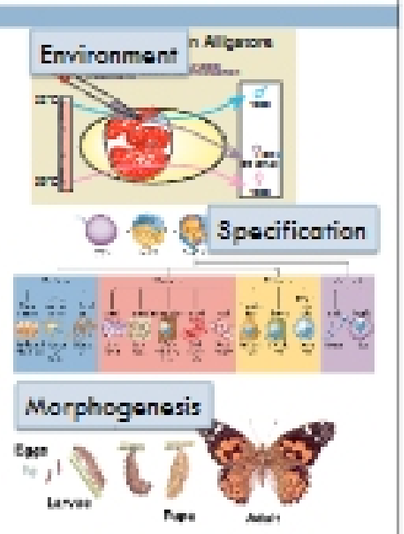
CHAPTER 3 PRINCIPLES OF EXPERIMENTAL EMBRYOLOGY

ZOO3603C

Three major research programs in experimental embryology

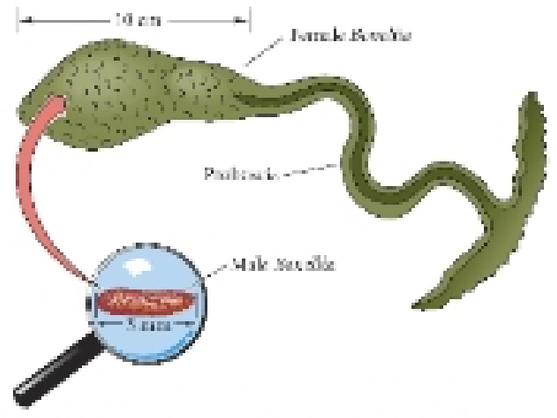
1. How forces outside the embryo influence its development.
2. How forces within the embryo cause the differentiation of its cells.
3. How the calls order themselves into tissue and organ



Environmental Developmental Biology

- Environmental sex determination
- Adaptation of embryos and larvae to their environment

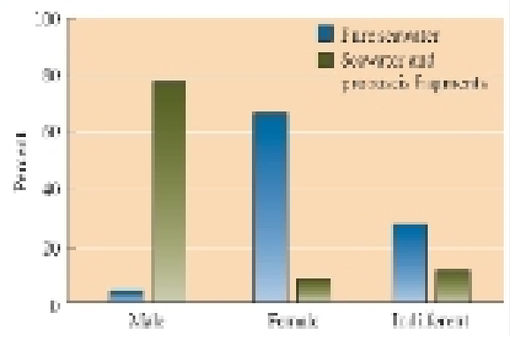
Environmental sex determination: Sexual determination in *Bonellia viridis*



Chemical signal-dependent sex determination
Female proboscis has the chemical to make a larva to male.

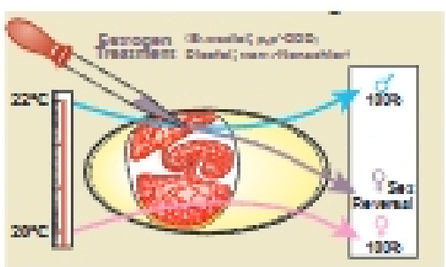
In vitro analysis of *Bonellia* sex determination

Larvae were incubated in
(1) Control group: pure seawater
(2) Experimental group: seawater + proboscis.



Environmental sex determination: Sex determination in American alligator

- No sex chromosomes
- Temperature dependent sex determination (TSD)
  - 33°C produces male, 30°C produces female
- Chemical signal dependent sex determination
  - Sex reverse can be induced by estrogens or environmental contaminants.

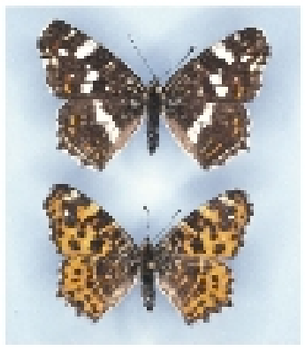


Adaptation: Two morphs of *Araschnia levana*, the European map butterfly

Two morphs can be induced by changes in both day light and temperature.

Summer Morph

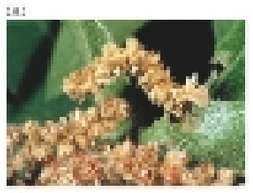
Spring Morph



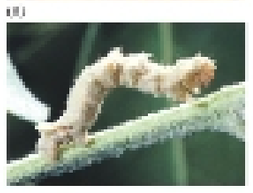
Adaptation: Two morphs of *Nemoria arizonaria*

Spring morphs can be induced by feeding them oak leave.

Spring Morph

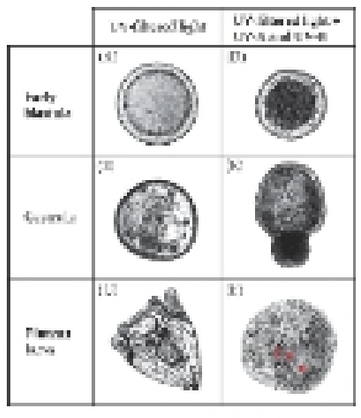


Summer Morph



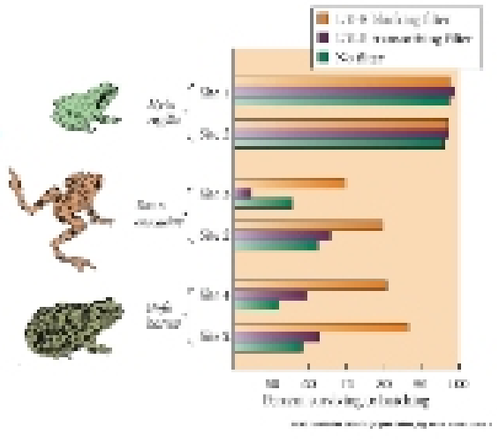
Adaptation: Effect of ultraviolet radiation on embryos of the sea urchin *Strongylocentrotus droebachiensis*

- Mycosporine-like protein is a natural sunscreen.
- Incubated in seawater without source of mycosporine-like protein.



Adaptation: Hatching success rates in three amphibian species in the field

1. UV-B Blocked.
2. UV-B Transactivated
3. No protection



Environmental Developmental Biology

Developing organisms are adapted to the ecological niches in which they develop.

- Environmental sex determination
- Seasonal phenotypic changes in caterpillars and butterflies.
- The ability of frog eggs exposed to sunlight to repair DNA damage

The Developmental Dynamics Of Cell Specification

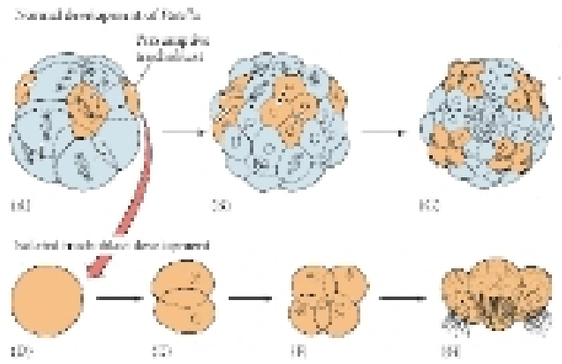
- Autonomous specification
- Conditional specification
- Stem cells and commitment
- Syncytial specification

Process of differentiation

- Differentiation
  - Commitment
    - 1st stage: Specification --- still reversible
    - 2nd stage: Determination --- irreversible

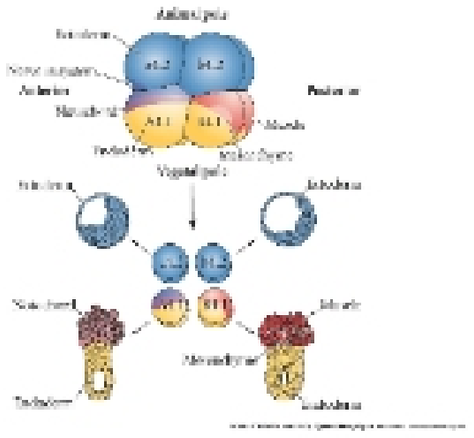
Autonomous specification

Characteristic of most invertebrates.

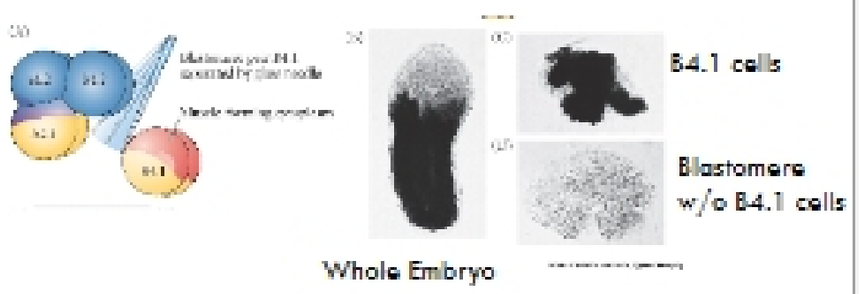


Even in isolated culture, the trochoblast cells keep the collect development.

Autonomous specification in the early tunicate embryo

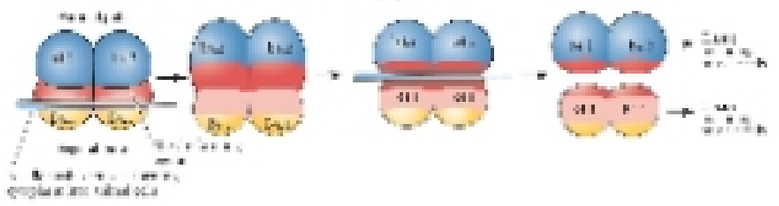


Acetylcholinesterase in the progeny of the muscle lineage blastomeres (B4.1) isolated from a tunicate embryo at the 8-cell stage



Autonomous specification in tunicate embryo

Microsurgery on tunicate eggs forces some of the yellow crescent cytoplasm of the muscle-forming B4.1 blastomeres to enter the b4.2 blastomere pair



1. **Autonomous specification**
   - Characteristic of most invertebrates.
   - Specification by differential acquisition of certain cytoplasmic molecules present in the egg.
   - Invariant cleavages produce the same lineages in each embryo of the species. Blastomere fates are genetically invariant.
   - Cell type specification precedes any morphogenetic or cytodynamic cell migration.
   - Produces "mosaic" development with cannot change fate if a blastomere is lost.