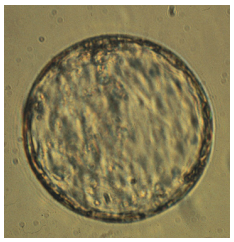
Embryo Development



Animal Science 434

John Parrish

Timing of Insemination

Species	Time of Ovulation	Optimal Insemination Time
Cow	29 hr after start of estrus	End of estrus (12 hr after first seen in estrus)
Ewe	End of estrus	End of 1st day or start of 2nd day of estrus
Sow	End of estrus	End of 1st day or start of 2nd day of estrus
Mare	1-2 days before end of estrus	Every other day beginning day 3 of estrus

Errors in Fertilization

- Polyspermy - polyandry
  - » Multiple sperm penetration
  - » Invertebrates
    - excess sperm eliminated because sperm centriole contributes to first embryonic cleavage spindle
  - » Mammals
    - Sperm centriole not essential so development continues but fails early to midpregnancy due to multiploidy
    - Occurs most often in aged oocytes due to failure of zona block to polyspermy

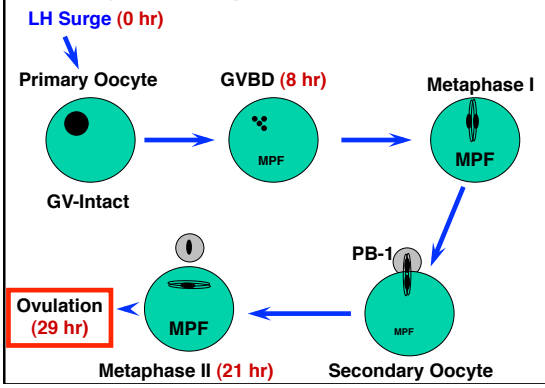
Errors in Fertilization (cont.)

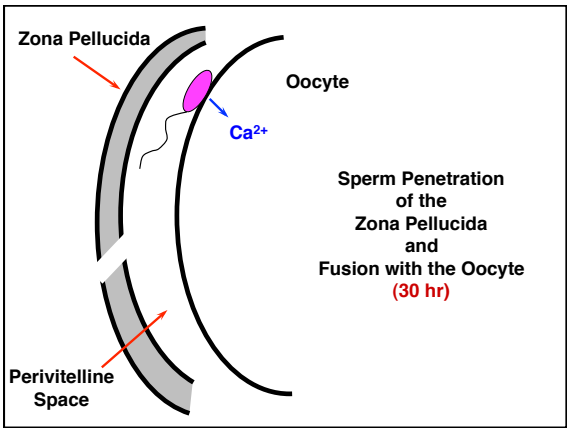
- Polygyny
  - » Multiple maternal pronuclei + 1 paternal pronuclei
  - » Artificially created only
    - Suppress extrusion of the PBII
- Androgenote
  - » Union of 2 paternal pronuclei
  - » Artificially created only
    - From pronuclear exchange

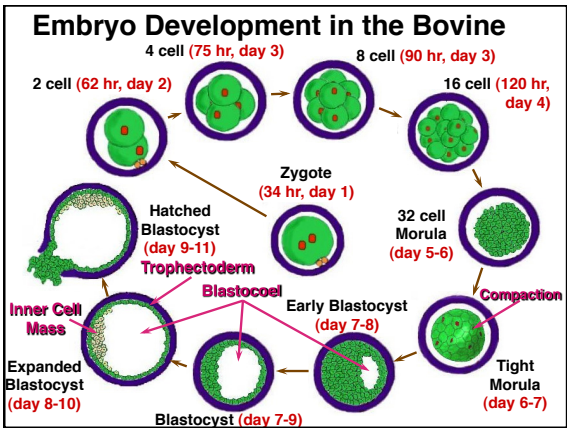
Errors in Fertilization (cont.)

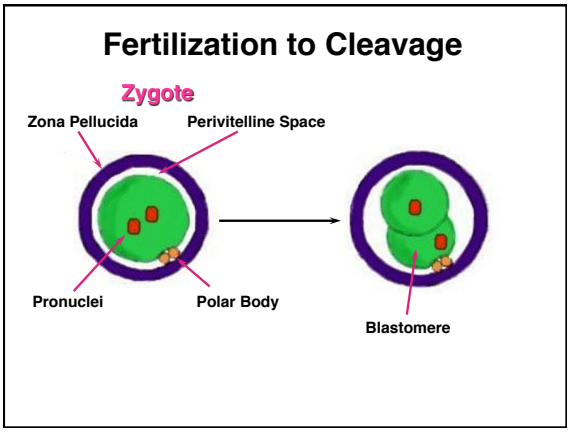
- Gynogenote
  - » Union of 2 maternal pronuclei
  - » Artificially created
    - Induced oocyte activation and supression of PBII extrusion
- Parthenogenesis
  - » Activation of the oocyte without a sperm
  - » Embryo is either haploid or gynogenesis occurs to form diploid
    - Platties - sperm activates but then gynogenesis occurs and sperm extruded from embryo

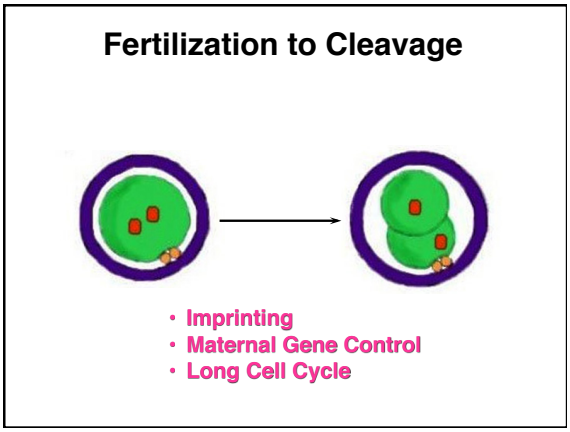
Oocyte Development and Fertilization

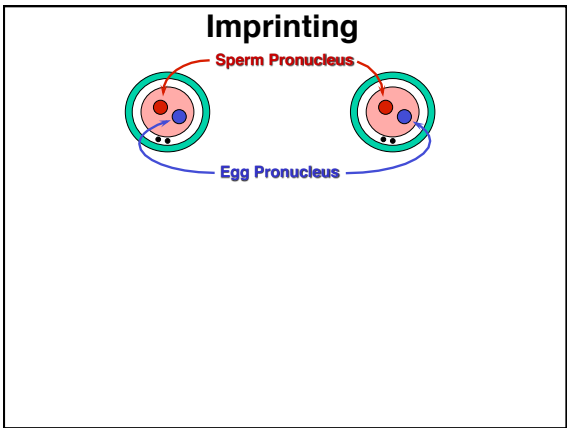


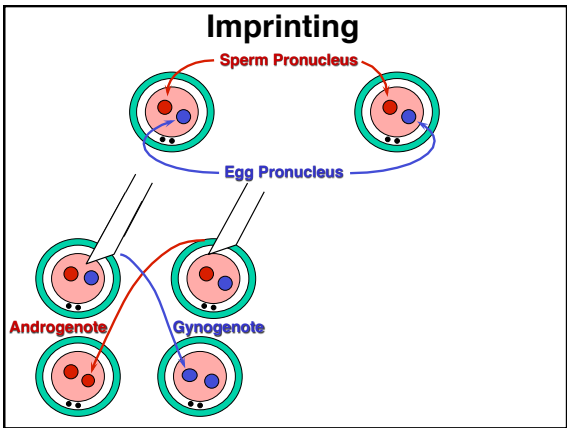

Zona Pellucida
Oocyte
Ca^{2+}
Sperm Penetration
of the
Zona Pellucida
and
Fusion with the Oocyte
(30 hr)
Perivitelline
Space


Embryo Development in the Bovine
2 cell (62 hr, day 2)
4 cell (75 hr, day 3)
8 cell (90 hr, day 3)
16 cell (120 hr, day 4)
Zygote
(34 hr, day 1)
32 cell
Morula
(day 5-6)
Hatched
Blastocyst
(day 9-11)
Trophectoderm
Blastocoel
Inner Cell
Mass
Early Blastocyst
(day 7-8)
Compaction
Expanded
Blastocyst
(day 8-10)
Tight
Morula
(day 6-7)
Blastocyst (day 7-9)

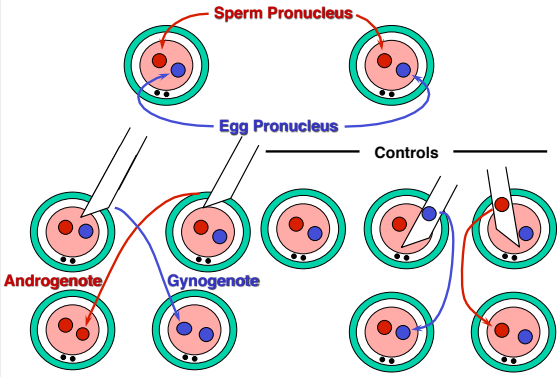

Fertilization to Cleavage
Zygote
Zona Pellucida
Perivitelline Space
Pronuclei
Polar Body
Blastomere


Fertilization to Cleavage
• Imprinting
• Maternal Gene Control
• Long Cell Cycle

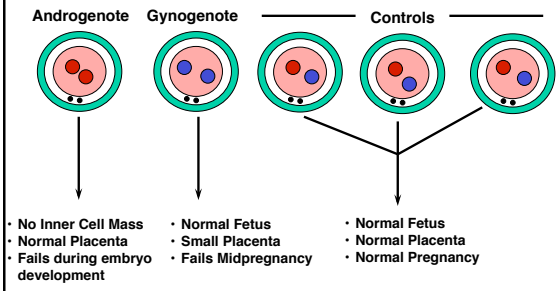

Imprinting
Sperm Pronucleus
Egg Pronucleus


Imprinting
Sperm Pronucleus
Egg Pronucleus
Androgenote
Gynogenote

Imprinting

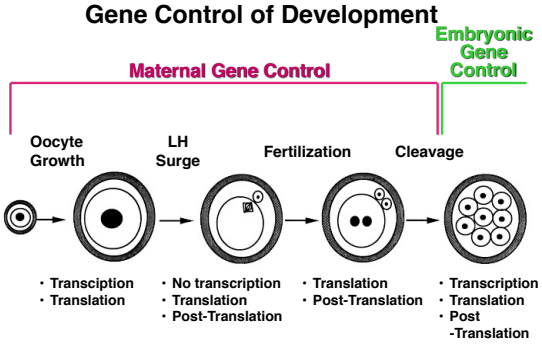


Imprinting



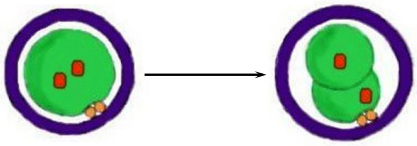
Maternal and Paternal Genomes Are Expressed Differently in the Embryo and Fetus

Gene Control of Development



Fertilization to Cleavage

Maternal Gene Control

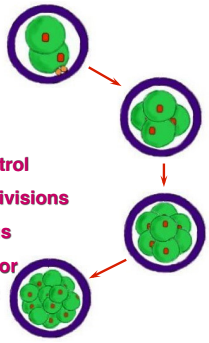


Fertilization to Cleavage

- Long Cell Cycle
  - » Penetration to Cleavage

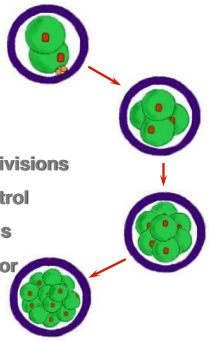
Precompaction Cleavage

- Cell size decreases
- Cell cycle
- Embryonic gene control
- Asynchrony of cell divisions
- Movement into Uterus
- Early pregnancy factor



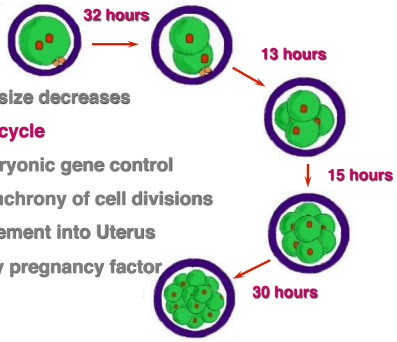
Precompaction Cleavage

- Cell size decreases
- Cell cycle
- Asynchrony of cell divisions
- Embryonic gene control
- Movement into Uterus
- Early pregnancy factor

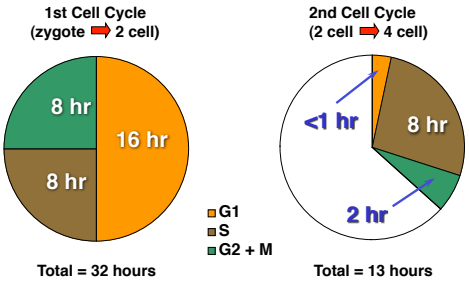


Precompaction Cleavage

- Cell size decreases
- Cell cycle
- Embryonic gene control
- Asynchrony of cell divisions
- Movement into Uterus
- Early pregnancy factor

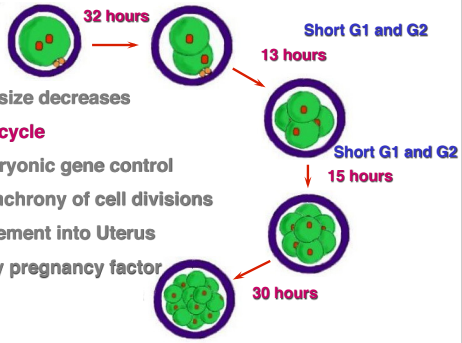


Cell Cycle Lengths



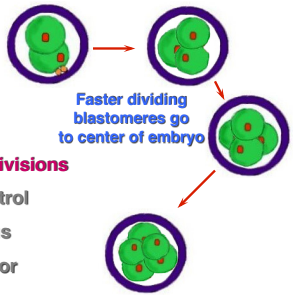
Precompaction Cleavage

- Cell size decreases
- Cell cycle
- Embryonic gene control
- Asynchrony of cell divisions
- Movement into Uterus
- Early pregnancy factor



Precompaction Cleavage

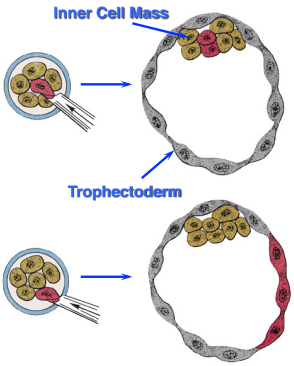
- Cell size decreases
- Cell cycle
- Asynchrony of cell divisions
- Embryonic gene control
- Movement into Uterus
- Early pregnancy factor



Asynchronous Cleavage - Inside Outside Theory

If a marked blastomere is placed into the interior of a 8-cell embryo, it and its progeny become part of the ICM.

If a marked blastomere is placed on the outside of a 8-cell embryo, it and its progeny become part of the trophectoderm.

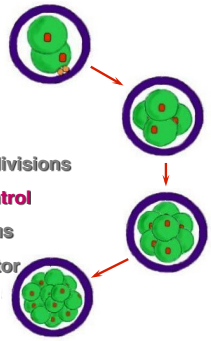


Asynchronous Cleavage Use

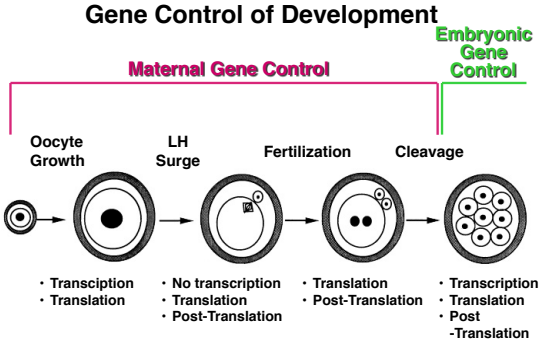
- Create embryos from different species
  - » Placenta from one species
    - Host mother
  - » Embryo from some other species
    - Donor mother

Precompaction Cleavage

- Cell size decreases
- Cell cycle
- Asynchrony of cell divisions
- Embryonic gene control
- Movement into Uterus
- Early pregnancy factor



Gene Control of Development

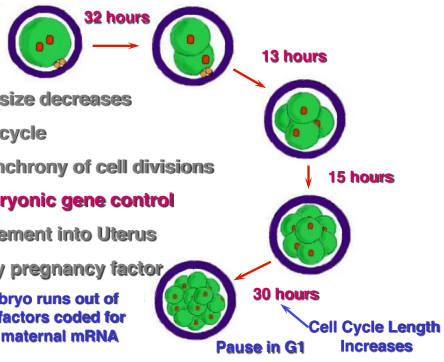


Transition from Maternal to Embryonic Gene Control

Species	Transcription of the embryonic genome: First begins	Transcription of the embryonic genome: Development is dependent on
Mouse	1 cell	2 cell
Rabbit	2 cell	8 cell
Pig	4 cell	8 cell
Cattle	4 cell	8-16 cell
Sheep	8 cell	16 cell
Human	4 cell	8 cell

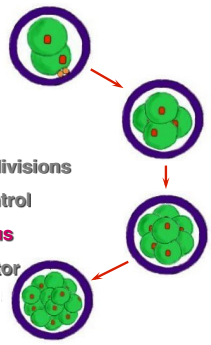
In vitro blocks to development often occur here!!!!!

Precompaction Cleavage



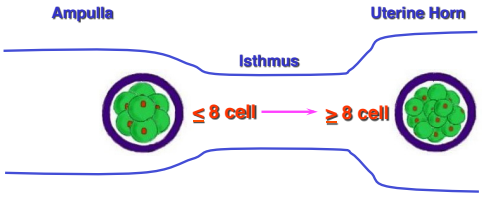
- Cell size decreases
- Cell cycle
- Asynchrony of cell divisions
- Embryonic gene control
- Movement into Uterus
- Early pregnancy factor

Precompaction Cleavage



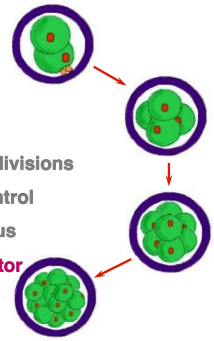
- Cell size decreases
- Cell cycle
- Asynchrony of cell divisions
- Embryonic gene control
- Movement into Uterus
- Early pregnancy factor

Movement into the Uterus



- Occurs around day 4
- Cause
  - » Change in estrogen ➡ progesterone

Precompaction Cleavage



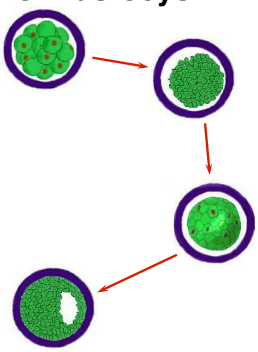
- Cell size decreases
- Cell cycle
- Asynchrony of cell divisions
- Embryonic gene control
- Movement into Uterus
- Early pregnancy factor

Early Pregnancy Factor

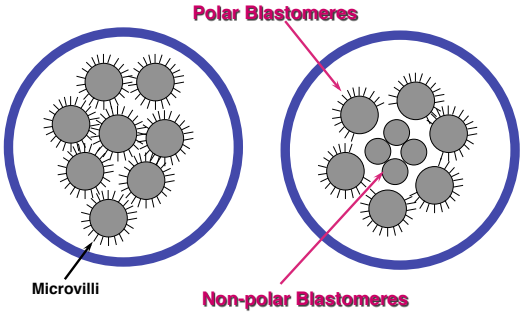
- Found at 24 - 72 hours after fertilization
  - » Mice, hamster, sheep, cattle, swine, human
- Seen only in viable pregnancy
  - » More recent experience in cattle may not agree with this
- Function
  - » Sensitize the uterus to implantation
  - » Basis for early pregnancy kit in cattle

Morula to Blastocyst

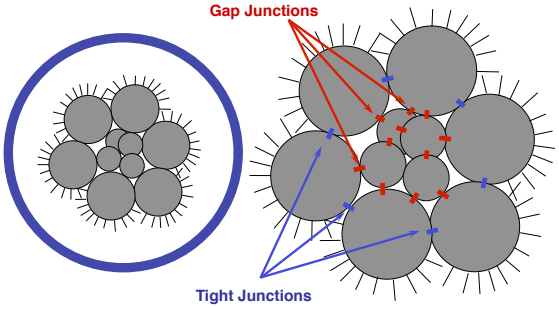
- Polarization
- Compaction



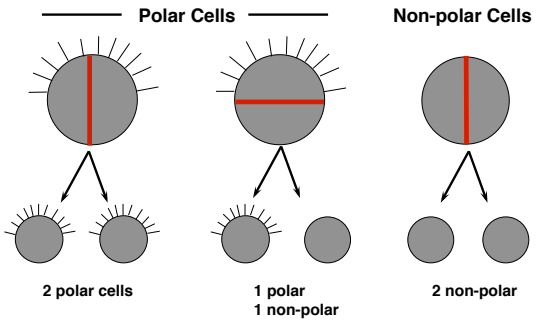
Polarization



Polarization (cont.)

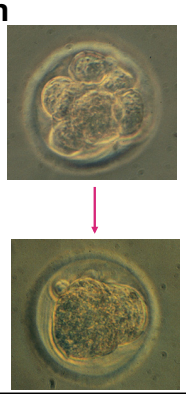


Cell Linage



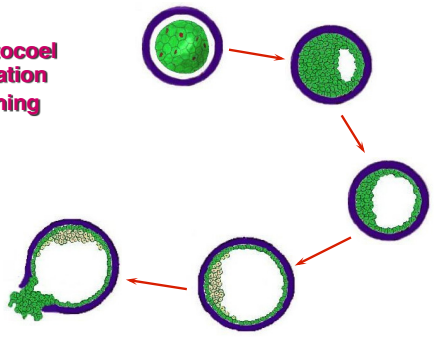
Compaction

- Occurs at fixed time after fertilization
- Membranes are very close and begin to flatten. Resulting in loss of the round cell outlines.
- Differentiational event
- Genome controlled and involves microtubules and microfilaments.

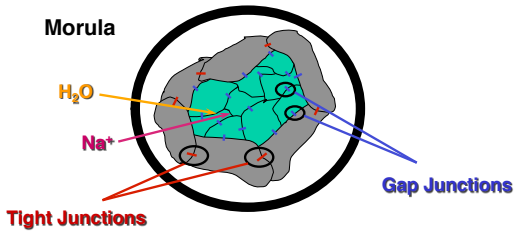


Blastocyst Formation and Hatching

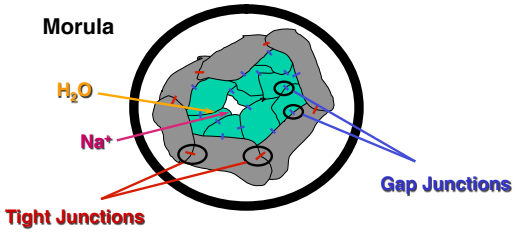
- Blastocoel formation
- Hatching



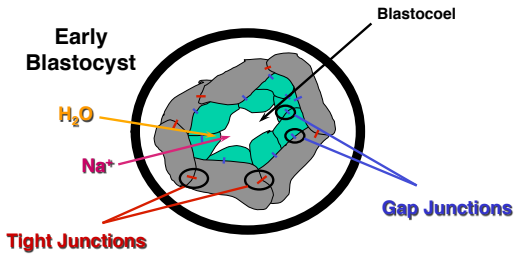
Blastocoel Formation



Blastocoel Formation

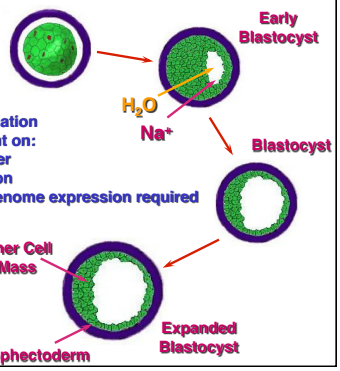


Blastocoel Formation



Blastocyst Formation and Hatching

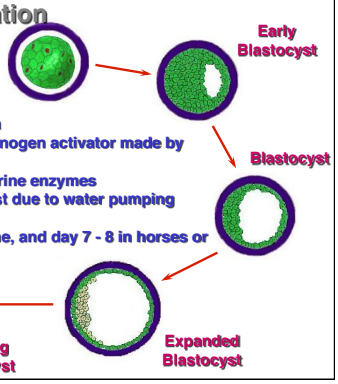
- Blastocoel formation
- Hatching



Blastocoel formation
- not dependent on:
  - » Cell number
  - » Cell division
- Embryonic genome expression required

Blastocyst Formation and Hatching

- Blastocoel formation
- Hatching



- Enzymatic digestion of zona
  - » Plasminogen and plasminogen activator made by embryo
  - » Softening of zona by uterine enzymes
- Increase in size of blastocyst due to water pumping
  - » Most important
- Day 9 - 11 in cattle, 6 in swine, and day 7 - 8 in horses or sheep

Formation of Twins

- Dizygotic
  - » Not identical
  - » Double ovulation
- Monozygotic
  - » Identical
  - » Several potential mechanisms

Formation of Monozygotic Twins