Cell Division
The Cell Cycle
Cloning

Cell Division
The Cell Cycle

Cloning 411

- cellular differentiation
  - is the process by which a less specialized cell becomes a more specialized cell type.
  - occurs numerous times as the organism changes from a single zygote to a complex system of tissues and cell types.
  - a common process in adults as well: adult stem cells divide and create fully-differentiated daughter cells during tissue repair and during normal cell turnover.

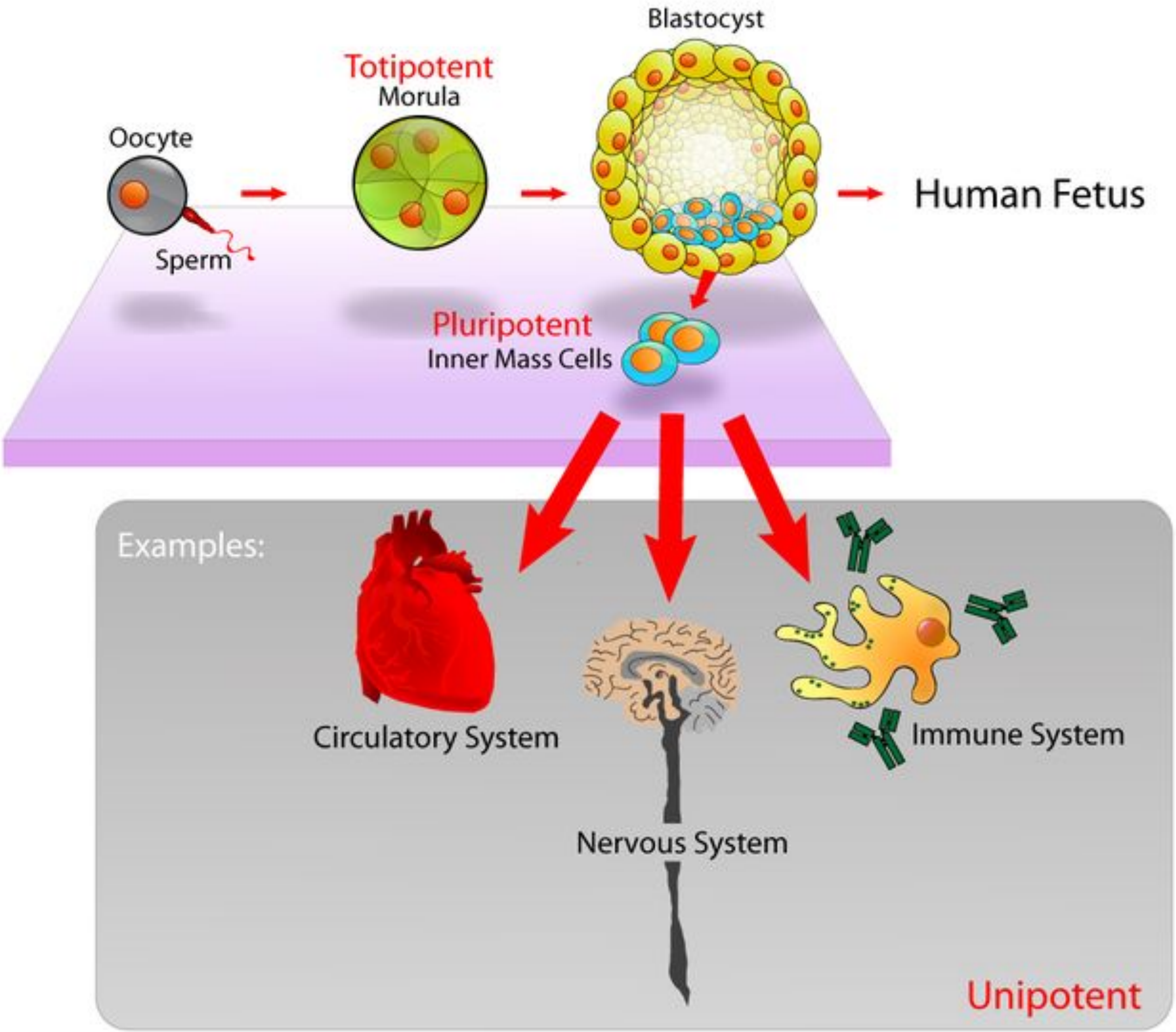
Cell Division
The Cell Cycle

- causes a cells size, shape, polarity, metabolic activity, and responsiveness to signals to change dramatically.
- these changes are largely due to highly-controlled modifications in gene expression.
  - different cells can have very different physical characteristics despite having the same genome.

- a cell that is able to differentiate into many cell types is known as pluripotent.
  - called stem cells in animals
  - called meristematic cells in higher plants

Cell Division
The Cell Cycle

- a cell that is able to differentiate into all cell types is known as totipotent.
  - in mammals, only the zygote and early embryonic cells are totipotent, while in plants (and in animals), many differentiated cells can become totipotent with simple laboratory techniques.


Blastocyst
Totipotent
Morula
Oocyte
Sperm
Human Fetus
Pluripotent
Inner Mass Cells
Examples:
Circulatory System
Immune System
Nervous System
Unipotent

Cell Division
The Cell Cycle

What is Cloning?

- cloning is the process of forming identical offspring from a single cell or tissue of a parent organism.
  - both the clone and the parent have identical or near identical DNA (random mutations occur)
  - does not result in variation of traits
- considered a form of asexual reproduction
  - clones occur naturally

    example)
    - Hydra undergoing mitosis during the process of budding

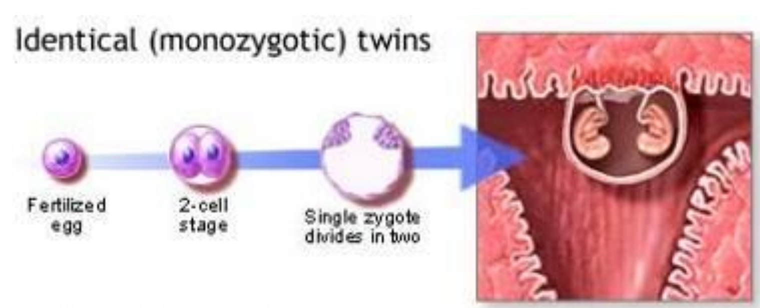
Cell Division
The Cell Cycle

example:

- Hydra undergoing mitosis during the process of budding

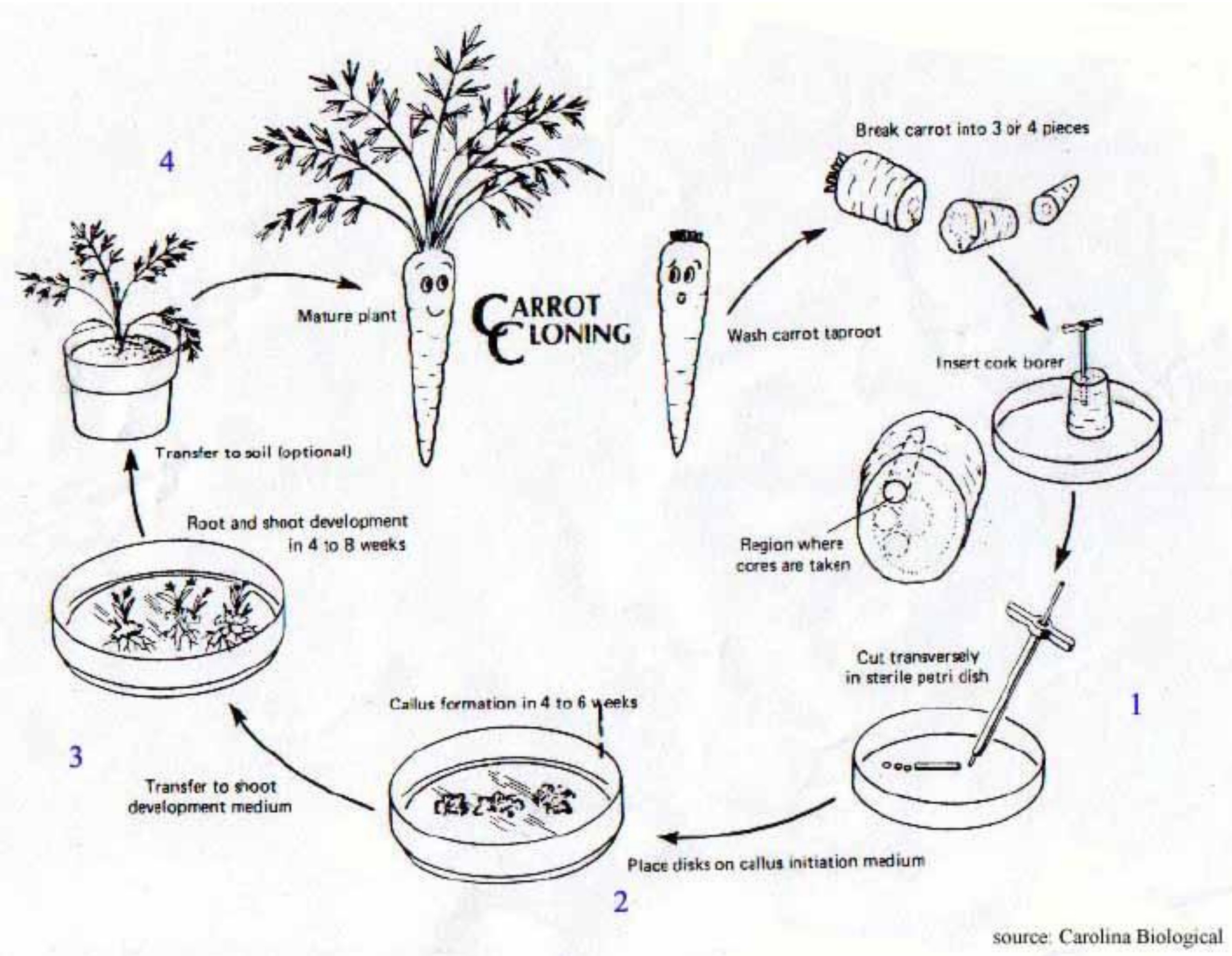
- Runner of a strawberry plant

- Monozygotic twins (zygote undergoes mitosis and splits into two)



Cell Division
The Cell Cycle

- Plant Cloning
  - In 1958 Fredrick Stewart produced a carrot plant from a single carrot cell
    - now cloning is widespread in the agriculture/horticulture industries.
      - it is desirable (profitable) to have plants of predictable characteristics
        - Easy to clone plants: carrots, tobacco, lettuce
        - Hard to clone plants: grasses, legumes.


CARROT CLONING
Break carrot into 3 or 4 pieces
Wash carrot taproot
Insert cork borer
Region where cores are taken
Cut transversely in sterile petri dish
1
Place disks on callus initiation medium
Callus formation in 4 to 6 weeks
2
Transfer to shoot development medium
3
Root and shoot development in 4 to 8 weeks
Transfer to soil (optional)
4
Mature plant
source: Carolina Biological

Cell Division
The Cell Cycle

- Animal Cloning
  - Robert Biggs and Thomas King
    - investigated nuclear transplants in frogs.
    - first to clone a frog.

Cell Division
The Cell Cycle

- the cloning of the sheep "Dolly" by Dr. Ian Wilmut's team was the first to clone an animal using adult cells.
  - the nucleus of an udder cell of an adult sheep was placed in the enucleated egg cell from another sheep.
    - the egg developed in a Petri dish until an early embryo stage.
      - then the egg was placed into the womb of another sheep.

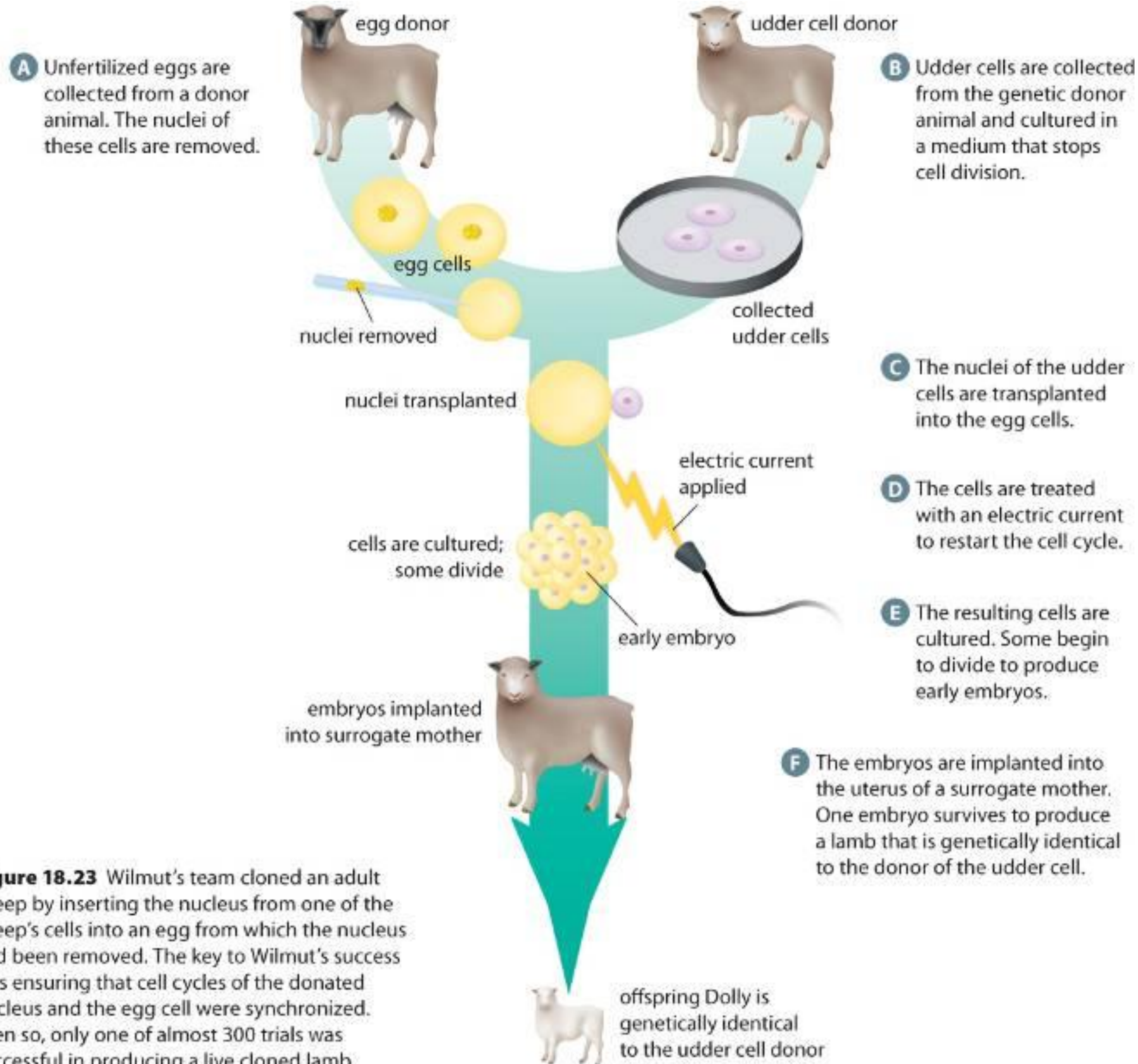


Figure 18.23 Wilmut's team cloned an adult sheep by inserting the nucleus from one of the sheep's cells into an egg from which the nucleus had been removed. The key to Wilmut's success was ensuring that cell cycles of the donated nucleus and the egg cell were synchronized. Even so, only one of almost 300 trials was successful in producing a live cloned lamb.

Cell Division
The Cell Cycle

- DNA donor: adult Finn Dorsett Sheep
- Egg donor: Poll Dorsett Sheep
- Womb provider: a third sheep
- Clone: Dolly was a clone of the adult Finn Dorsett Sheep

http://en.wikipedia.org/wiki/Dolly_(sheep)

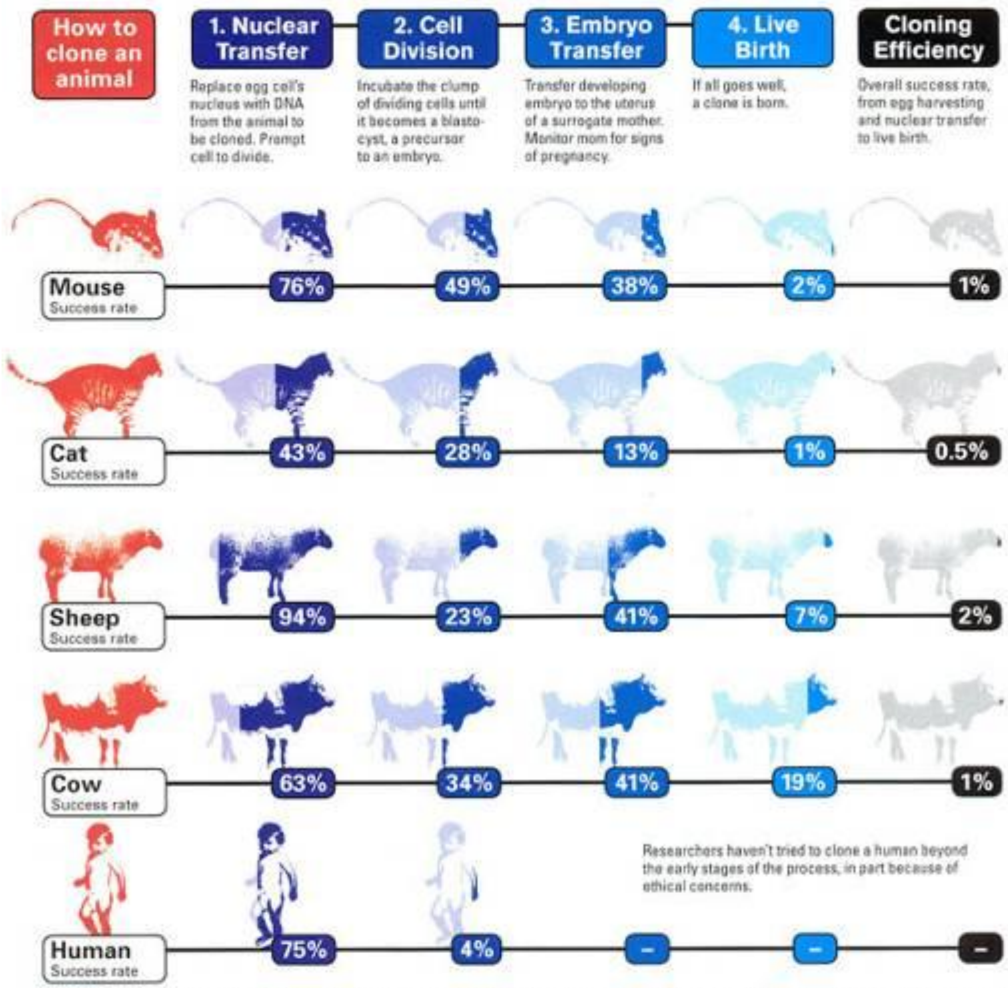
CLONING

Are scientists able to clone human beings?

The Killer Task of Cloning

Copying mammals fails 98 percent of the time.

Fears surrounding cloning are based more in hysteria than in science. After all, producing a genetic duplicate isn't exactly a trip to the Xerox machine; cloning is really hard. Researchers face significant drop-offs in success rates at each step of the process, and less than 2 percent of their efforts produce a live animal. Dolly the sheep arrived after some 250 attempts, and she lived only half as long as the average ewe. Until the science improves, there's not much to be afraid of. – **Greta Lorge**



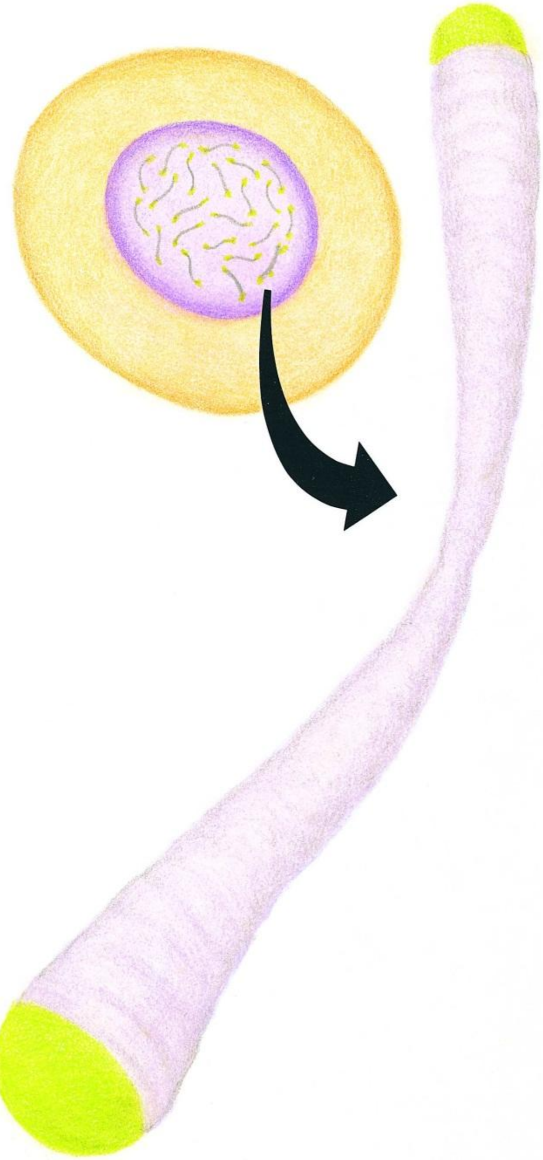
Sources: *Biology of Reproduction; Cloning and Stem Cells; Genetics and Molecular Research; Journal of Reproduction and Development; Journal of Reproduction and Fertility; Lancet; Molecular Reproduction and Development; Nature; Nature Biotechnology; Nature Genetics; Proceedings of the National Academy of Sciences; Reproduction; Reproduction, Fertility and Development; Reproductive BioMedicine; Science; Theriogenology*

Cell Division
The Cell Cycle
Cell Aging

Cell Division
The Cell Cycle

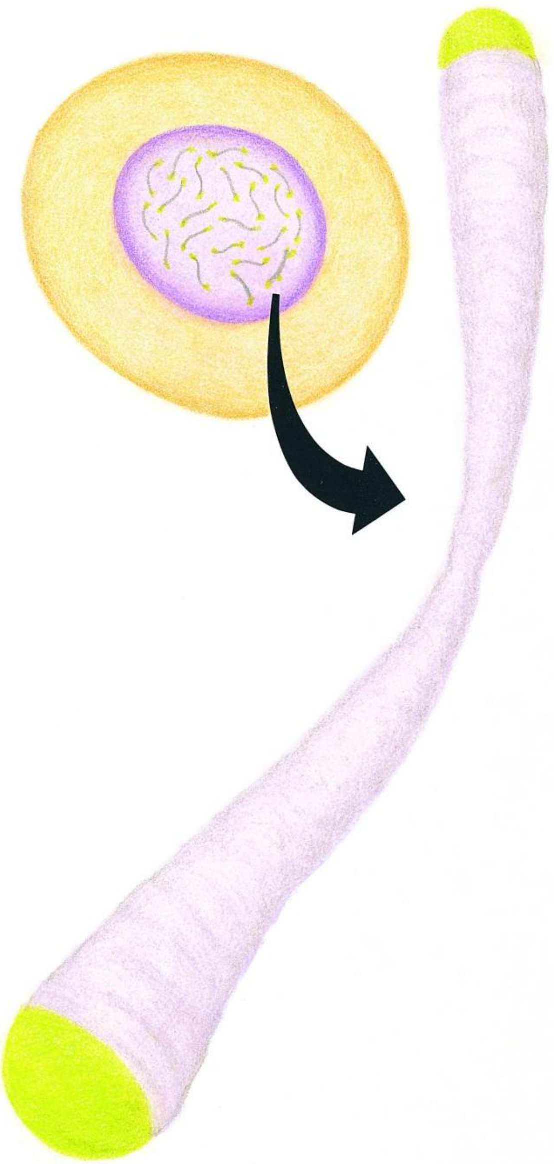
Cell Aging

- Telomeres
  - are caps at the ends of chromosomes.
  - they reduce in length each time a cell undergoes the cell cycle
  - have a role in cell aging and cancer cells.
  - the length of telomeres is affected by the enzyme telomerase.



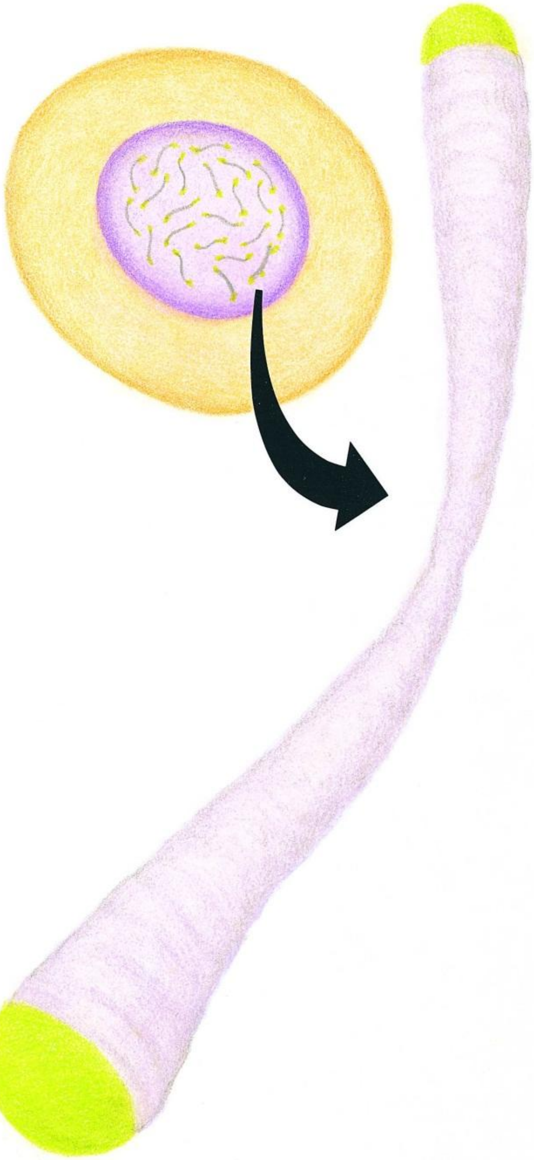
Cell Division
The Cell Cycle

- as cells go through the cell cycle their telomeres become shorter.
  - eventually the telomeres become very short and the cell stops going through the cell cycle and dies.
    - telomerase is an enzyme that keeps the telomeres long but is only found at limited levels in somatic cells.
      - embyronic stem cells have a high level of telomerase.
    - telomere length acts as a biological clock.



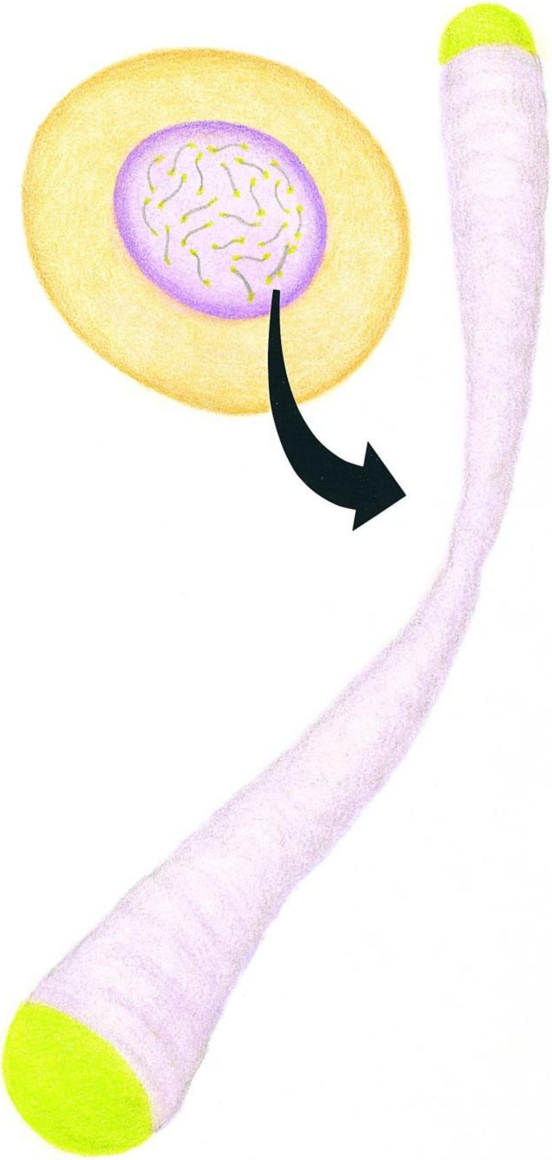
Cell Division
The Cell Cycle

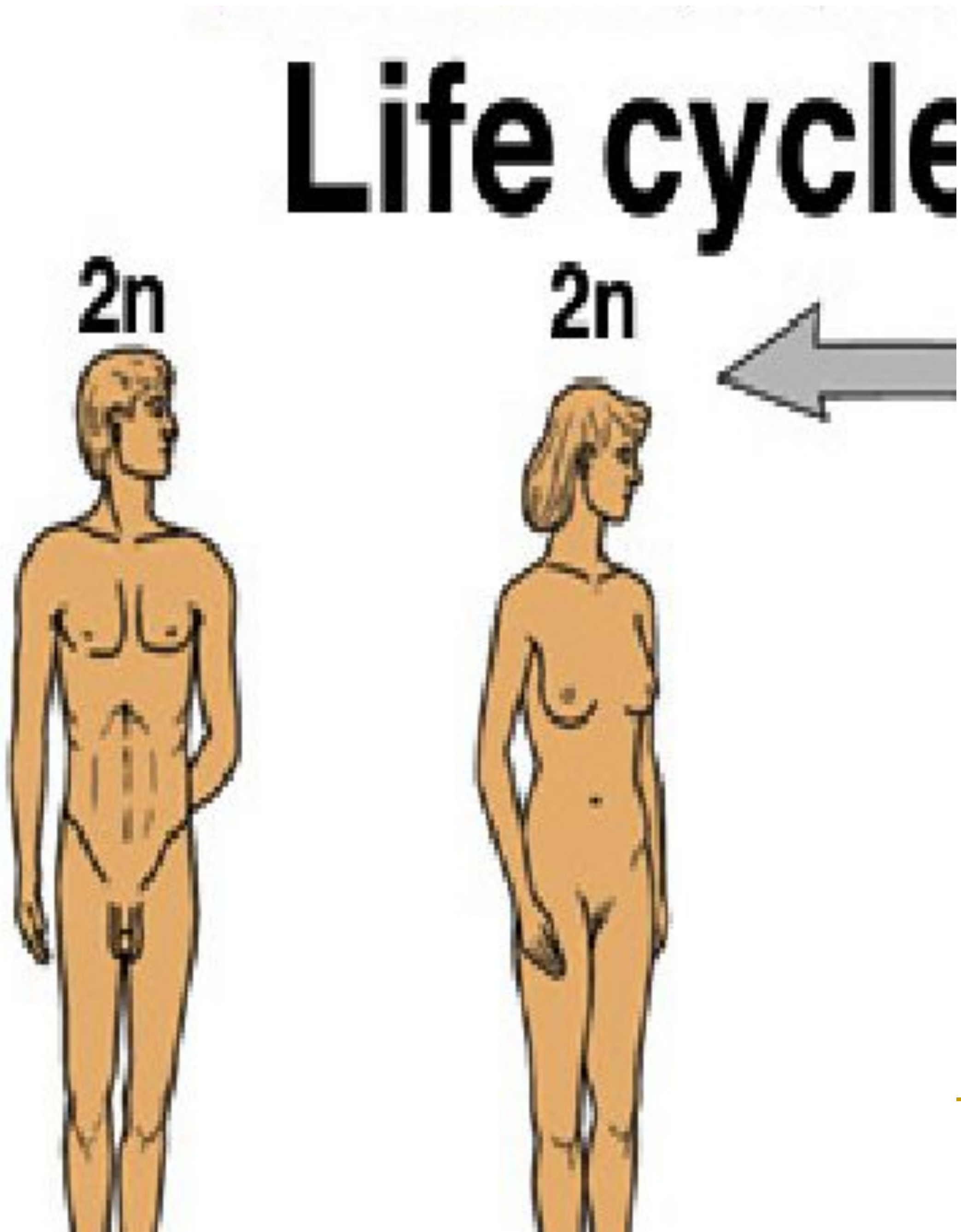
- the case of "Dolly" the prematurely aging sheep.
  - Dolly was cloned using an adult nucleus with telomeres that had already began to shorten.
  - Dolly developed arthritis and died of a lung disease at only half her life expectancy. (controversy)



Cell Division
The Cell Cycle

- the case of Cancer
  - cancer cells never seem to lose their ability to divide.
    - the telomeres of cancer cells do not shorten.
    - telomerase is reactivated in cancer cells allowing the cancer cells to maintain telomere length and keep on dividing.




Life cycl
2n
2n

DEVELOPMENT OF ♂ AND ♀ GAMETES

- Formation of sex cells during meiosis is gametogenesis
- Cytoplasm of female gametes does not divide equally after each division- oogenesis.
  - One of daughter cells, ootid, receives most of cytoplasm
  - Other cells, polar bodies, die, and nutrients are absorbed
    - Only one egg cell is produced from meiosis

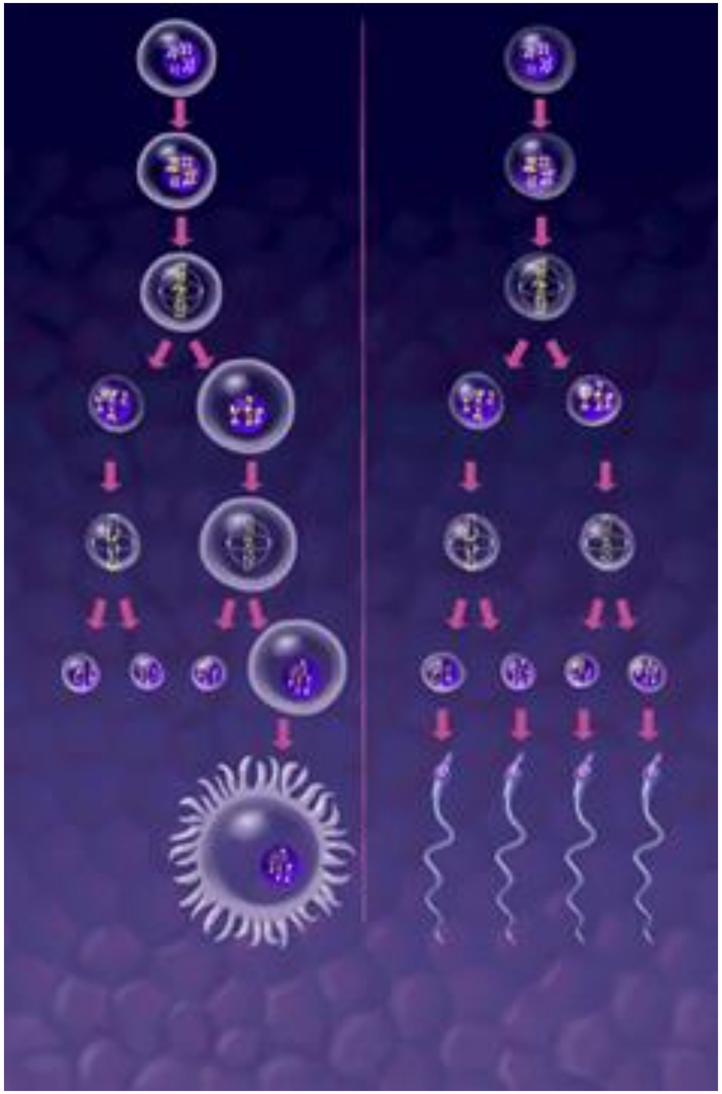
Meiosis II- splits 1st polar body and forms 3rd polar body- all disintegrate.

Sperm fuses with ovum (egg cell)

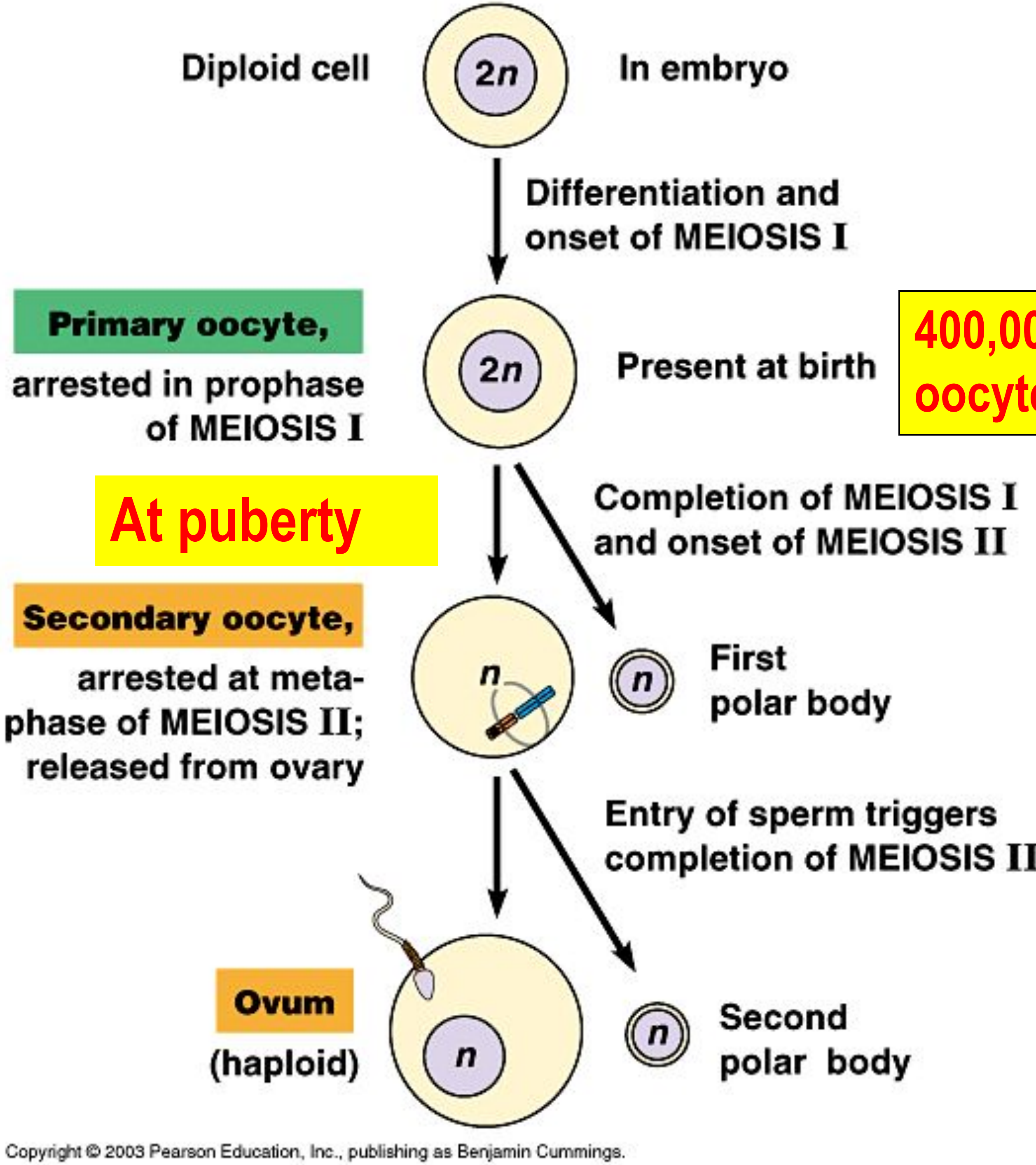
Egg does not move

Egg cells require nutrients

Fuel future cell divisions in event that egg cell becomes fertilized

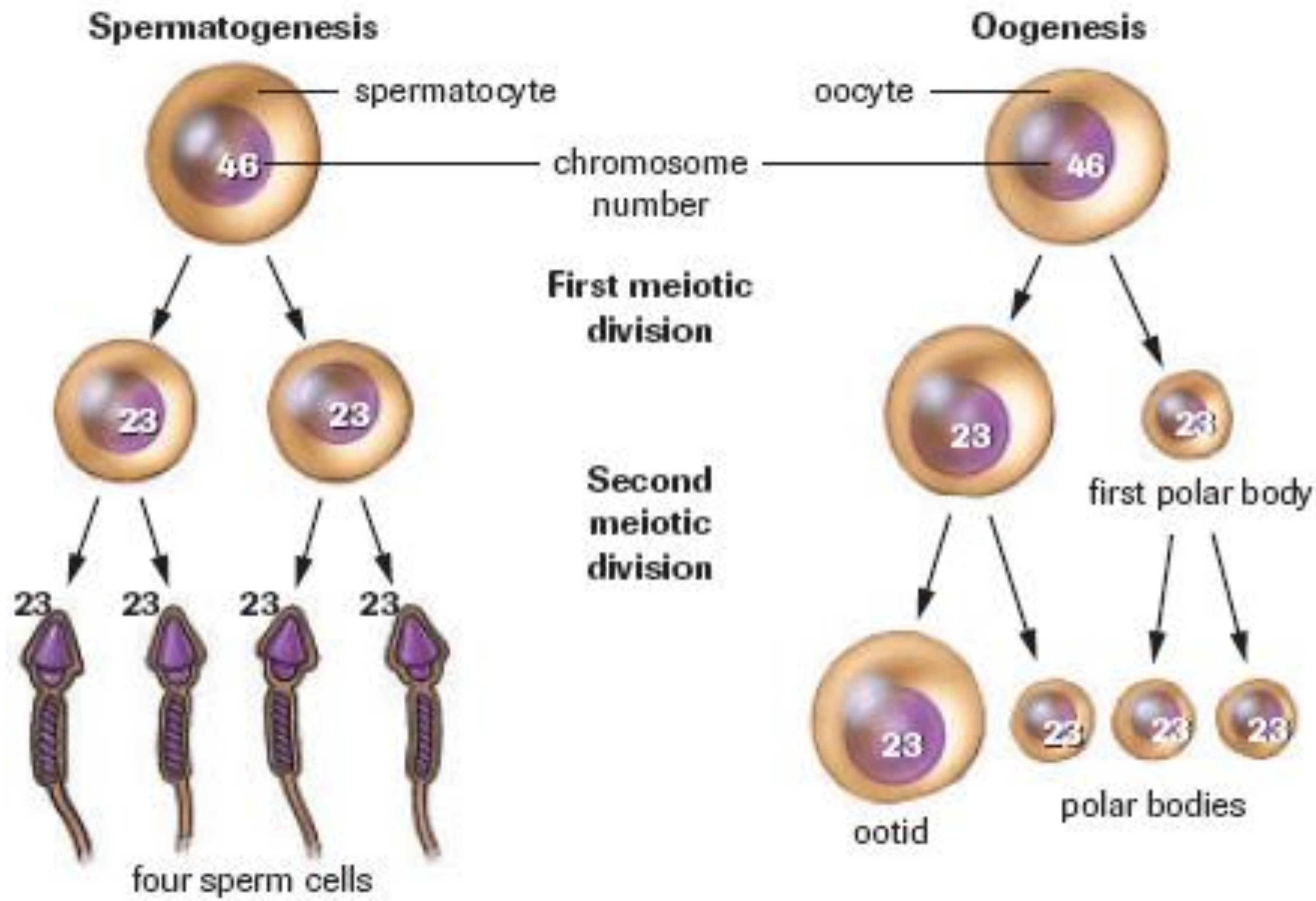


- ♀ - born with 400 000 egg cells (only 400 mature)
- 1000 egg cells mature within ovary every 28 days
  - Only 1 egg cell leaves ovary, the rest break down and are absorbed by body
    - Oocyte - cell that produces egg cells
      - Does not continue to divide after a woman reaches puberty
- As a ♀ ages:
  - # of egg cells in ovary declines until about age 50 or 60
  - No eggs remain in ovary = Menopause

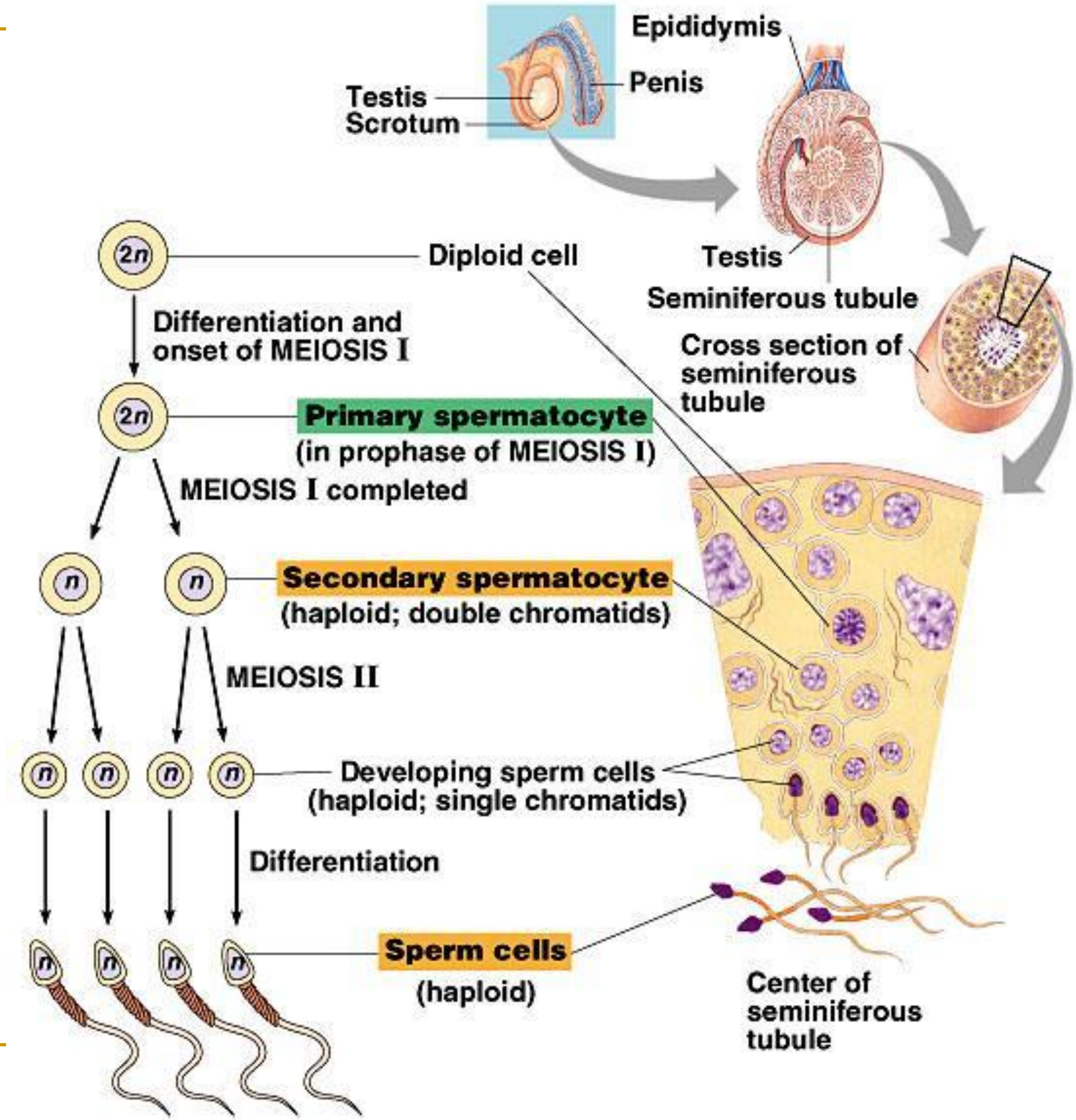


400,000 primary oocytes

At puberty

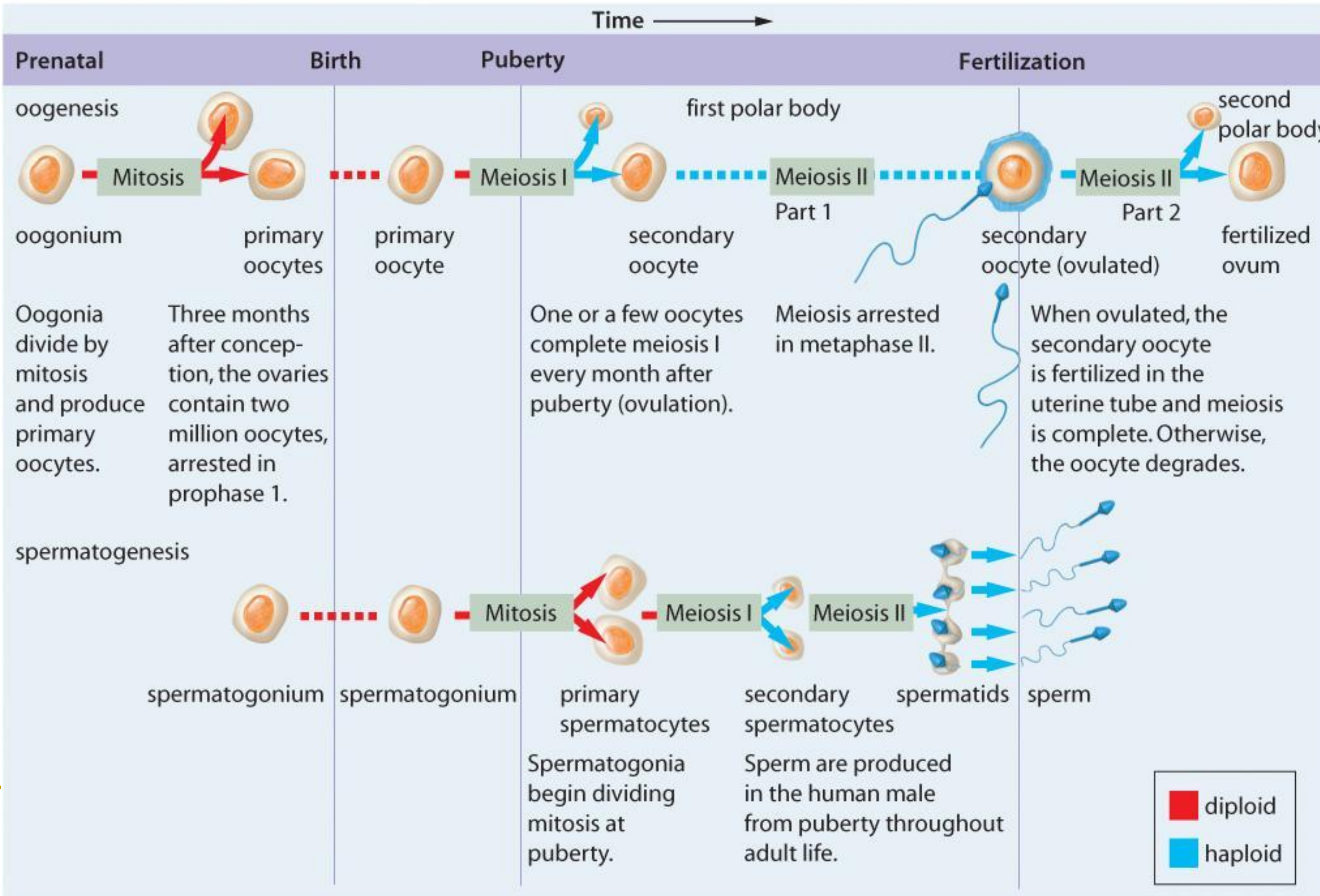

Spermatogenesis
Oogenesis
spermatocyte
oocyte
46
46
chromosome number
First meiotic division
23
23
23
23
first polar body
Second meiotic division
23
23
23
23
four sperm cells
23
23
23
23
ootid
polar bodies

- Diploid spermatocytes
  - Cells that give rise to sperm cells
    - Are capable of many mitotic divisions before meiosis ever begins
- Males can produce 1 billion sperm cells every day
  - Spermatogenesis
- Sperm cells show equal division of cytoplasm
  - Because of their function, sperm cells have much less cytoplasm than egg cells


Epididymis
Penis
Testis
Scrotum
Testis
Seminiferous tubule
Cross section of seminiferous tubule
2n
Diploid cell
Differentiation and onset of MEIOSIS I
2n
Primary spermatocyte
(in prophase of MEIOSIS I)
MEIOSIS I completed
n
n
Secondary spermatocyte
(haploid; double chromatids)
MEIOSIS II
n
n
n
n
Developing sperm cells
(haploid; single chromatids)
Differentiation
n
n
n
n
Sperm cells
(haploid)
Center of seminiferous tubule

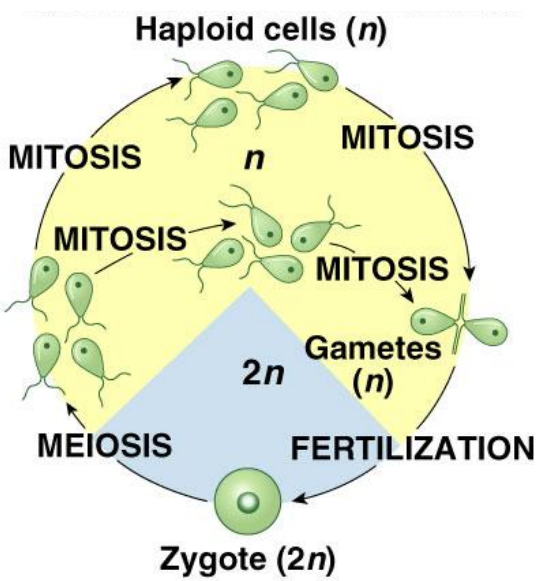
SUMMARY OF GAMETOGENESIS

Figure 16.16 The processes of spermatogenesis and oogenesis in mammals. This illustration is not drawn to scale. In reality, the diameter of the egg is about 20 times greater than the length of the sperm head.

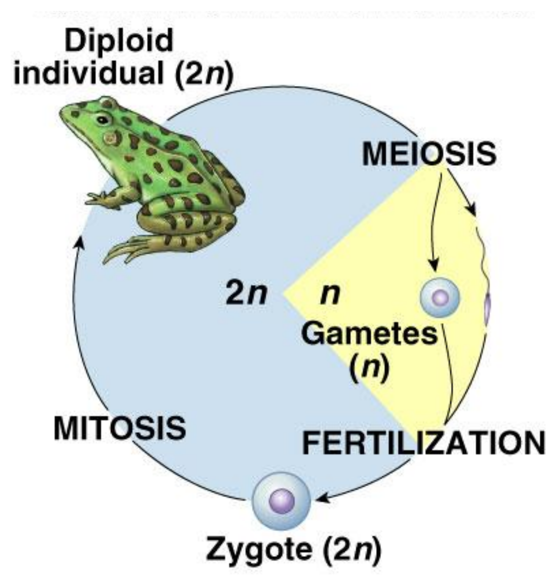


Differences across kingdoms

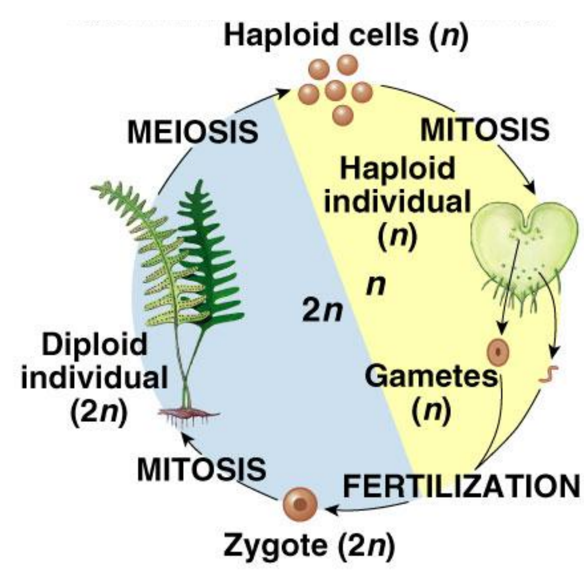
- Not all organisms use haploid & diploid stages in same way
  - which one is dominant (2n or n) differs
  - but still alternate between haploid & diploid
    - have to for sexual reproduction



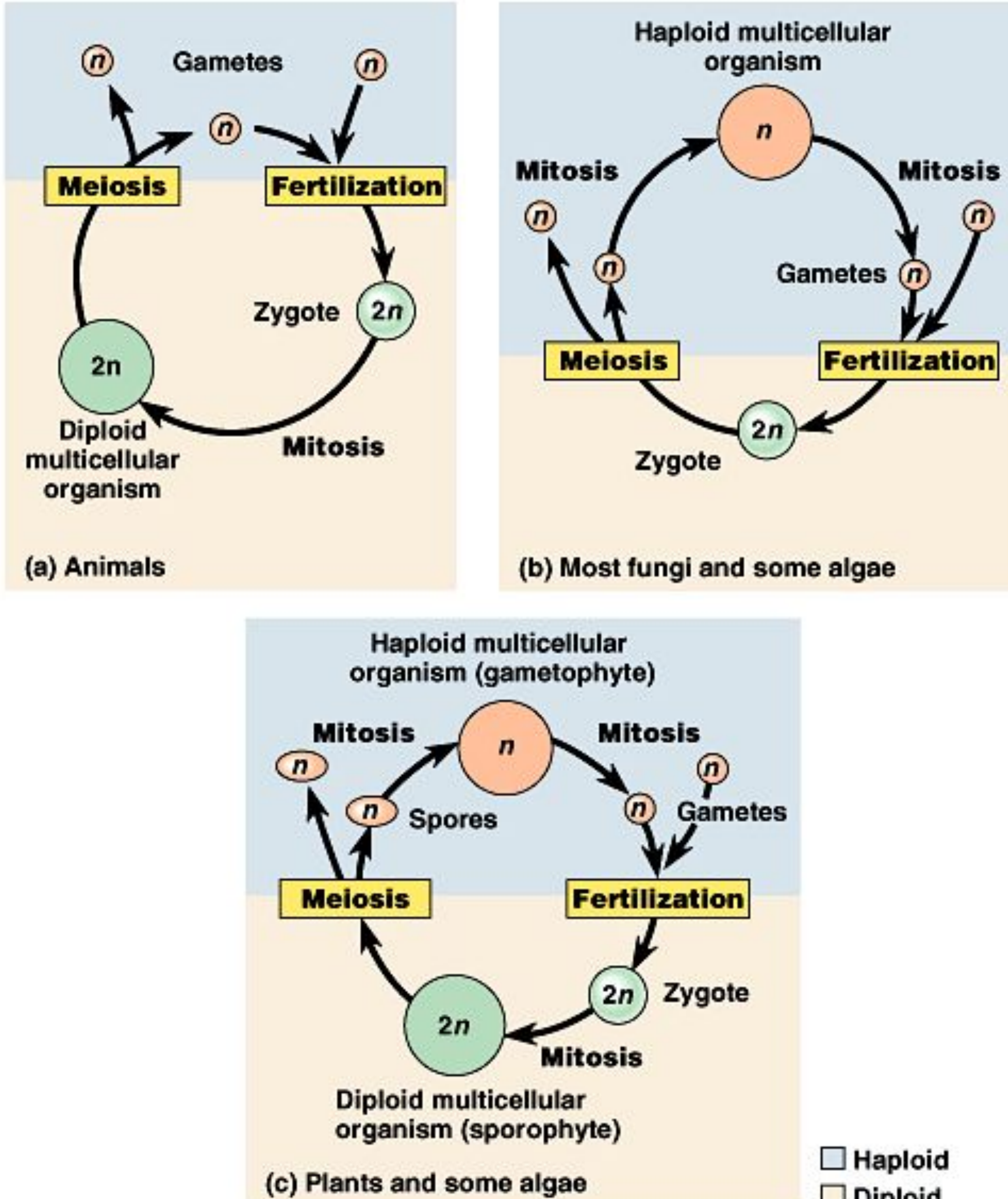
(a) Some types of algae



(b) Most animals



(c) Some plants and some algae

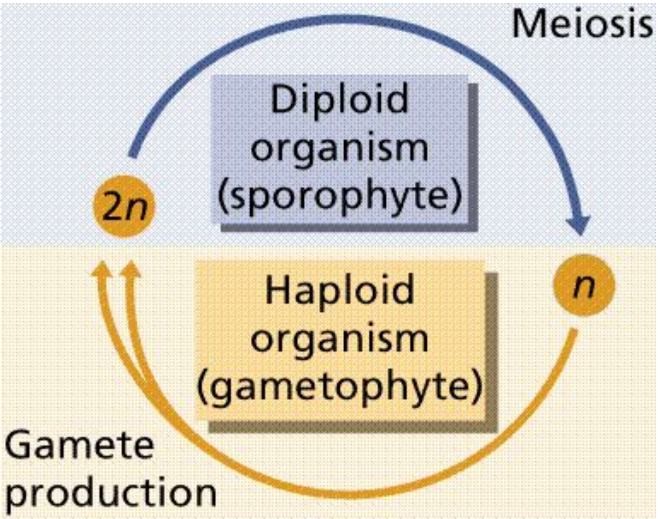

Gametes
n
n
n
Meiosis
Fertilization
Zygote
2n
2n
Diploid multicellular organism
Mitosis
(a) Animals
Haploid multicellular organism
n
Mitosis
Mitosis
n
n
n
Gametes
n
Meiosis
Fertilization
2n
Zygote
(b) Most fungi and some algae
Haploid multicellular organism (gametophyte)
Mitosis
n
Mitosis
n
n
n
Spores
n
Gametes
Meiosis
Fertilization
2n
Zygote
2n
Mitosis
Diploid multicellular organism (sporophyte)
(c) Plants and some algae
Haploid
Diploid

How About Plants?

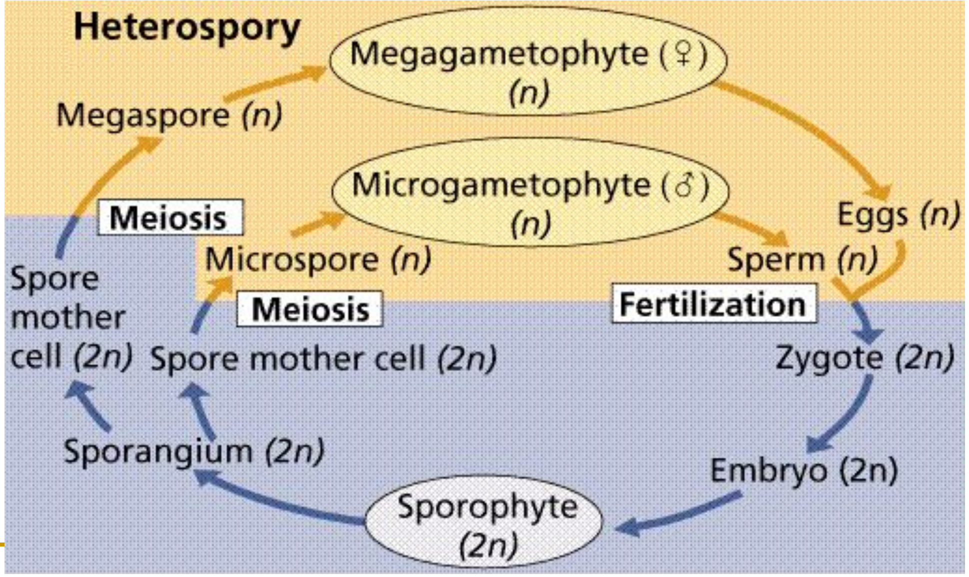
- Plants also form gametes, by meiosis
  - Pollen cells are ♂ sex cells
  - Egg cells are stored in a variety of structures
  - Contain a haploid chromosome number
  - Fusion of ♂ and ♀ gametes restores diploid chromosome number

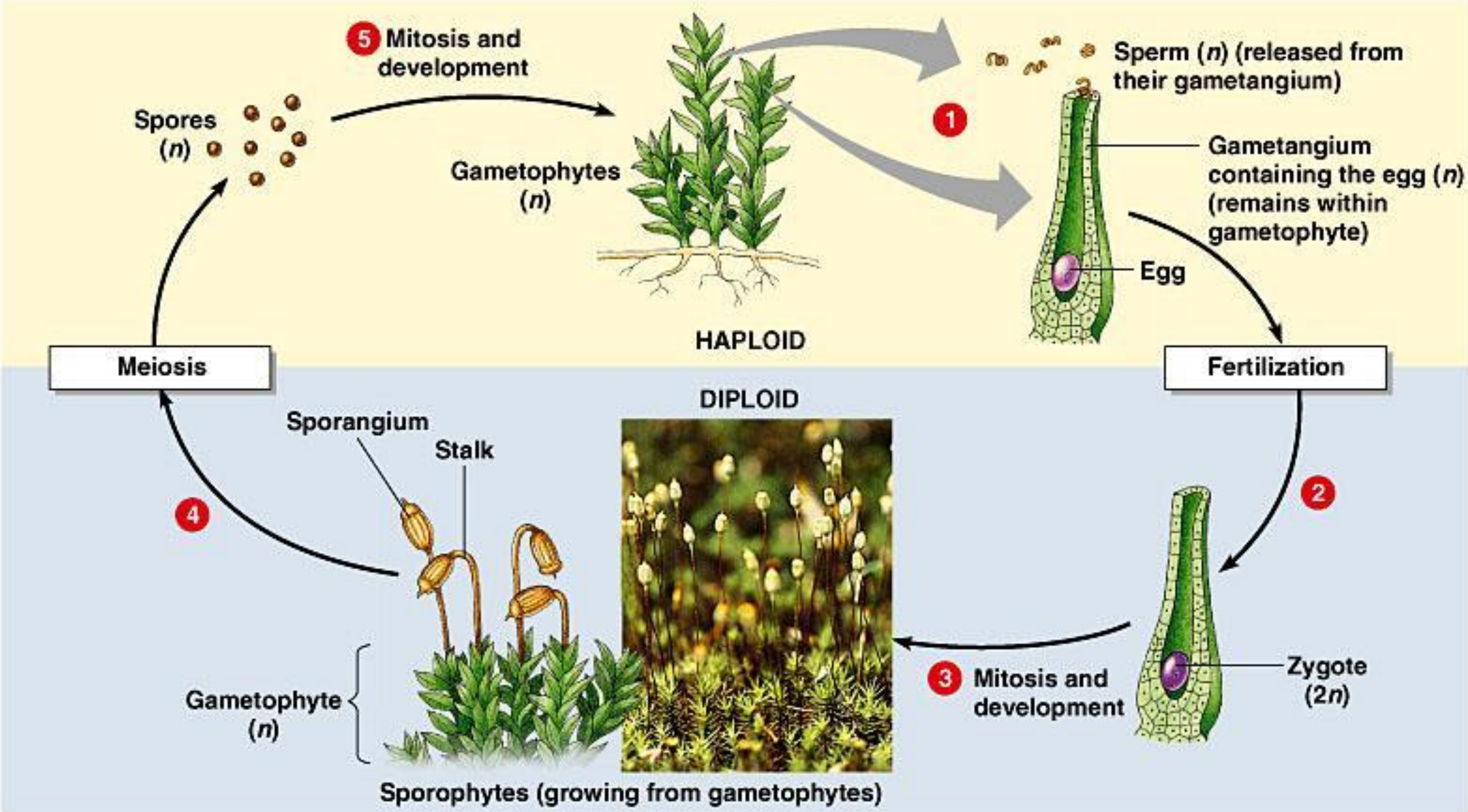
Plants vs. Fungi Reproduction

- Generalized Plant Life Cycle
- Alternation of Generations

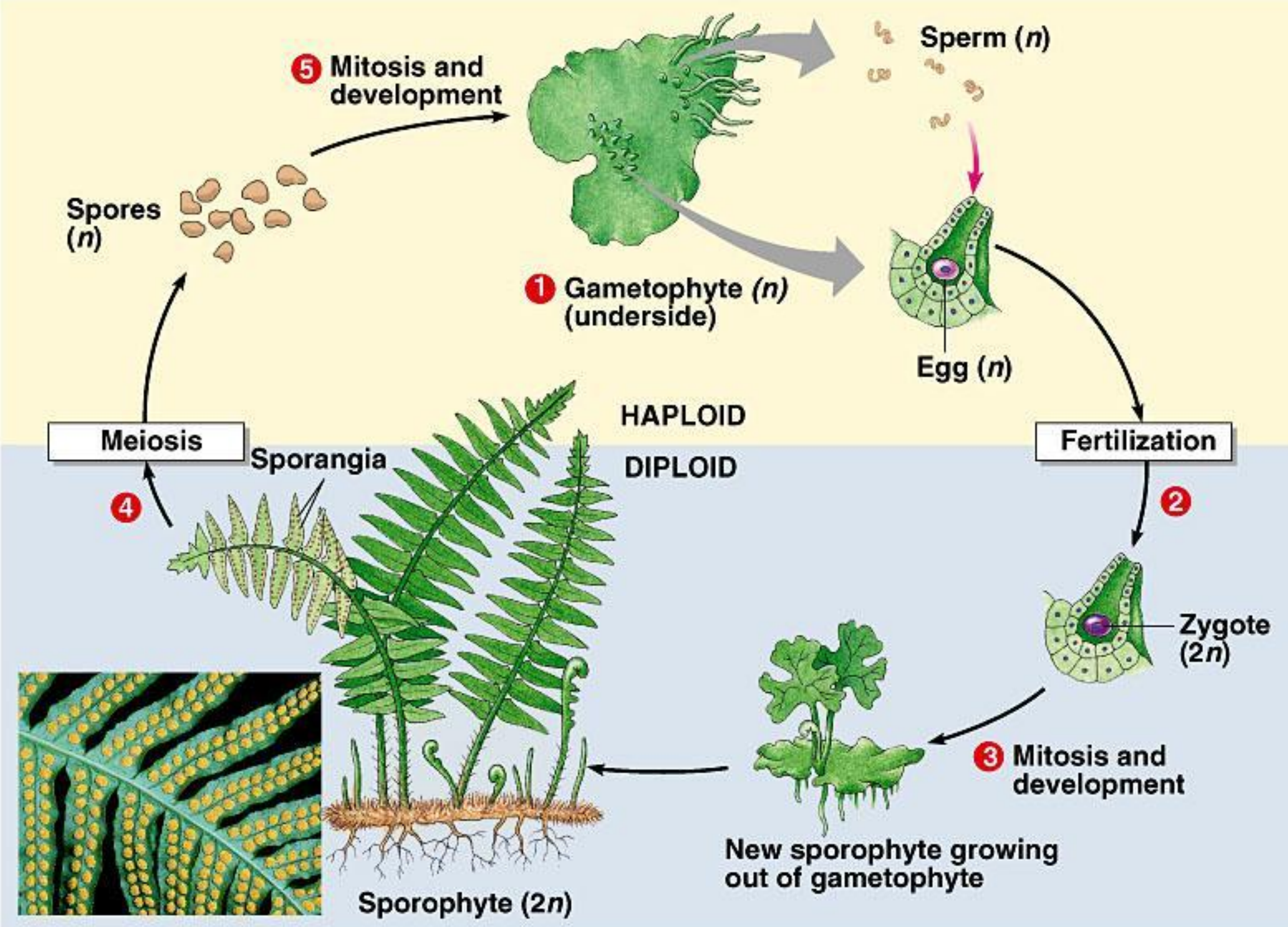


- Sporophyte and gametophyte take turns reproducing each other

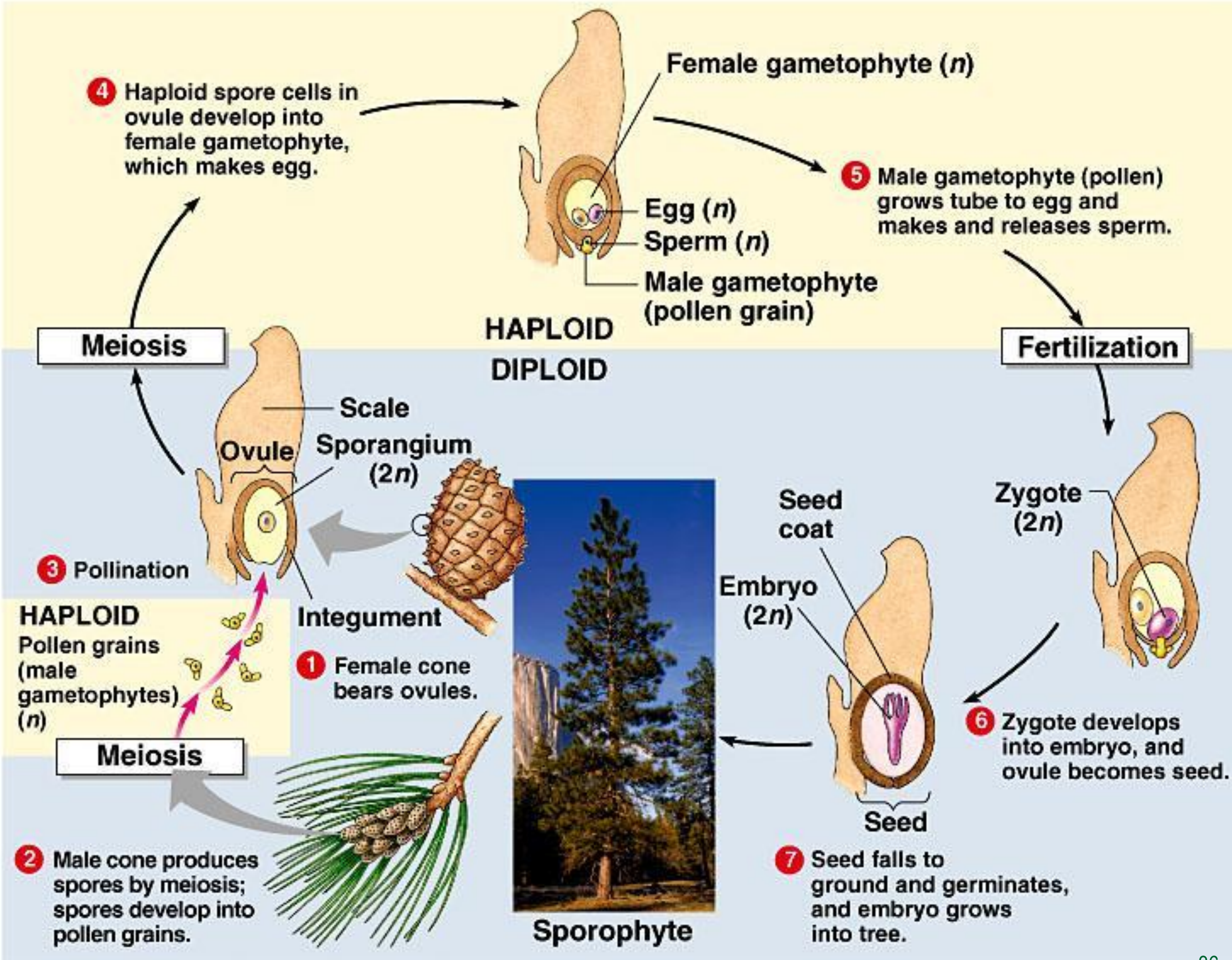


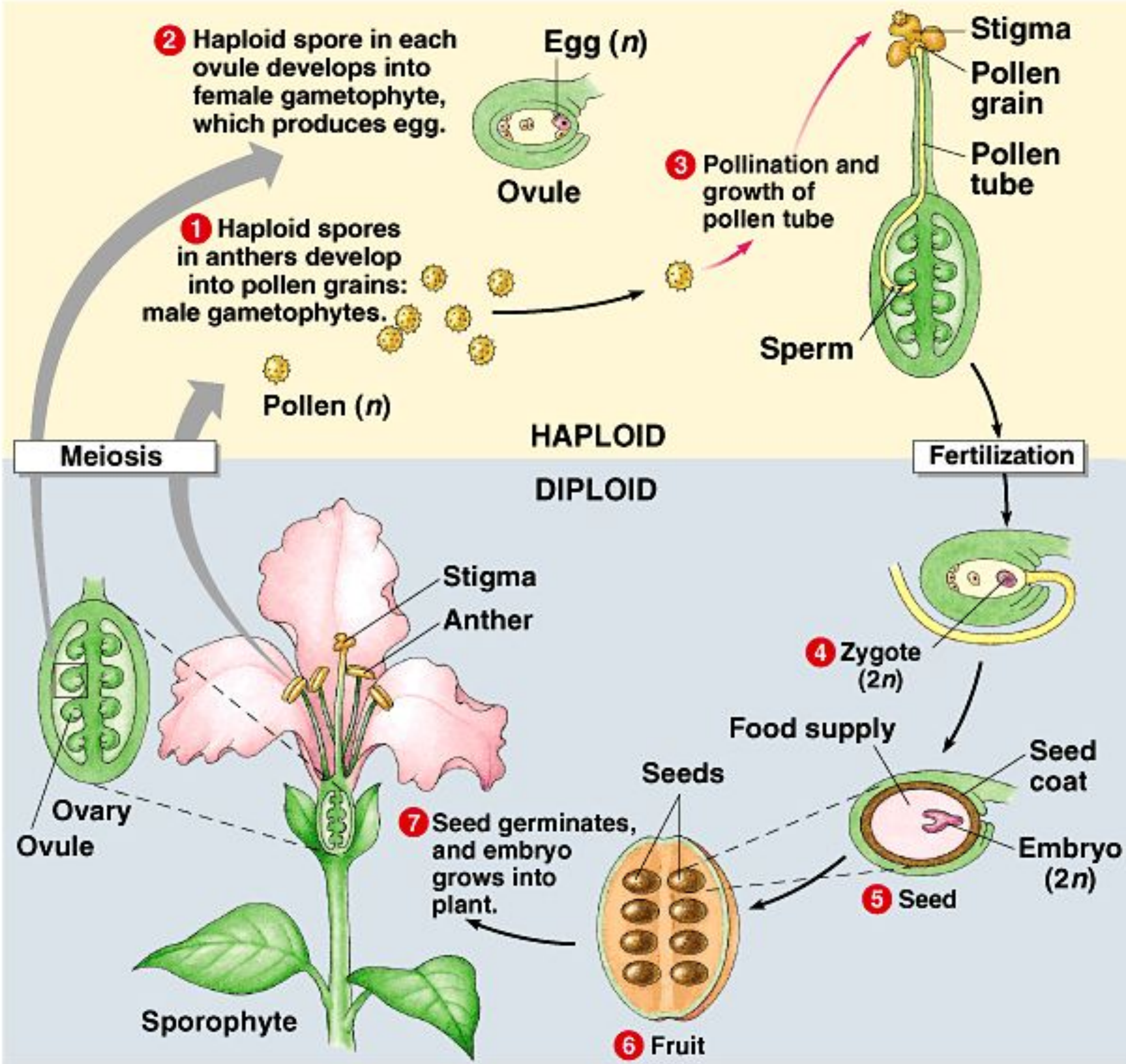


5 Mitosis and development
Spores (n)
Gametophytes (n)
Sperm (n) (released from their gametangium)
1
Gametangium containing the egg (n) (remains within gametophyte)
Egg
HAPLOID
Meiosis
Fertilization
DIPLOID
Sporangium
Stalk
4
2
Gametophyte (n)
3 Mitosis and development
Zygote (2n)
Sporophytes (growing from gametophytes)



5 Mitosis and development
Sperm (n)
Spores (n)
1 Gametophyte (n) (underside)
Egg (n)
HAPLOID
DIPLOID
Meiosis
Sporangia
Fertilization
4
2
Zygote (2n)
3 Mitosis and development
New sporophyte growing out of gametophyte
Sporophyte (2n)


4 Haploid spore cells in ovule develop into female gametophyte, which makes egg.
Female gametophyte (n)
Egg (n)
Sperm (n)
Male gametophyte (pollen grain)
5 Male gametophyte (pollen) grows tube to egg and makes and releases sperm.
Meiosis
HAPLOID
DIPLOID
Fertilization
Scale
Ovule
Sporangium (2n)
Zygote (2n)
Seed coat
Embryo (2n)
3 Pollination
Integument
HAPLOID
Pollen grains (male gametophytes) (n)
1 Female cone bears ovules.
Meiosis
6 Zygote develops into embryo, and ovule becomes seed.
Seed
2 Male cone produces spores by meiosis; spores develop into pollen grains.
Sporophyte
7 Seed falls to ground and germinates, and embryo grows into tree.


2 Haploid spore in each ovule develops into female gametophyte, which produces egg.
Egg (n)
Ovule
1 Haploid spores in anthers develop into pollen grains: male gametophytes.
Pollen (n)
3 Pollination and growth of pollen tube
Stigma
Pollen grain
Pollen tube
Sperm
HAPLOID
Meiosis
Fertilization
DIPLOID
Stigma
Anther
Ovary
Ovule
Sporophyte
4 Zygote (2n)
Food supply
Seed coat
Embryo (2n)
5 Seed
Seeds
7 Seed germinates, and embryo grows into plant.
6 Fruit