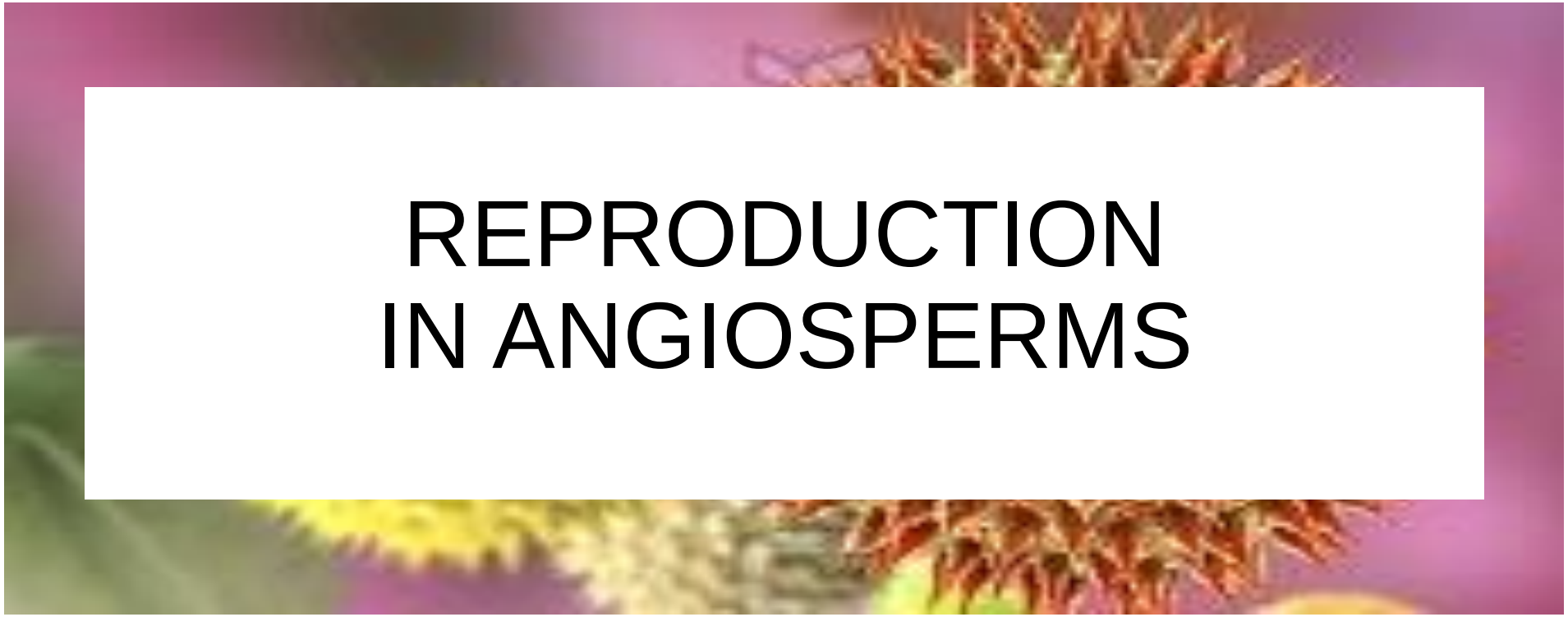


REPRODUCTION IN ANGIOSPERMS

Plan

I. Gametogenesis

I.1. Female gametogenesis

I.2. Male gametogenesis

II. Fertilisation

II.1 Pollination

II.2 Pollen germination

II.3. Double fertilisation

II.4. The development cycle in angiosperms

I. GAMETOGENESIS

- Definition of gametogenesis

Gametogenesis is the formation of male and female gametes. These gametes are used in the sexual reproduction of plants.

- Types of gametogenesis

❖ **Female gametogenesis** (or macrogametogenesis): Formation of the embryo sac inside the ovule in the ovary.

❖ **Male gametogenesis (**or microgametogenesis): Production of male gametes in the anthers of the stamens.

I.1. Female gametogenesis

a. Ovule

In angiosperms, the ovule is small and composed of :

- **Two teguments**, inner (primine) and outer (secondine). composed of diploid cells (2n). Protective role of the ovule;

Micropyle: an opening at the top of the ovule. Allows the pollen tube to pass through during fertilisation; Nucellum: this is a tissue with diploid cells (2n) in which the embryo sac develops;Funiculus: Corresponds to the narrow base of the ovum by which it is connected to the placenta. The cells of the funiculus are diploid (2n);

- **Hile:** a precise point where the ovule is attached to the funiculus;
- **Chalaza:** point where the conducting bundle of the ovary branches;
- **Embryo sac:** female gametophyte comprising 8 nuclei divided into 7 haploid cells (n), one of which is binucleated (= 2 polar nuclei).

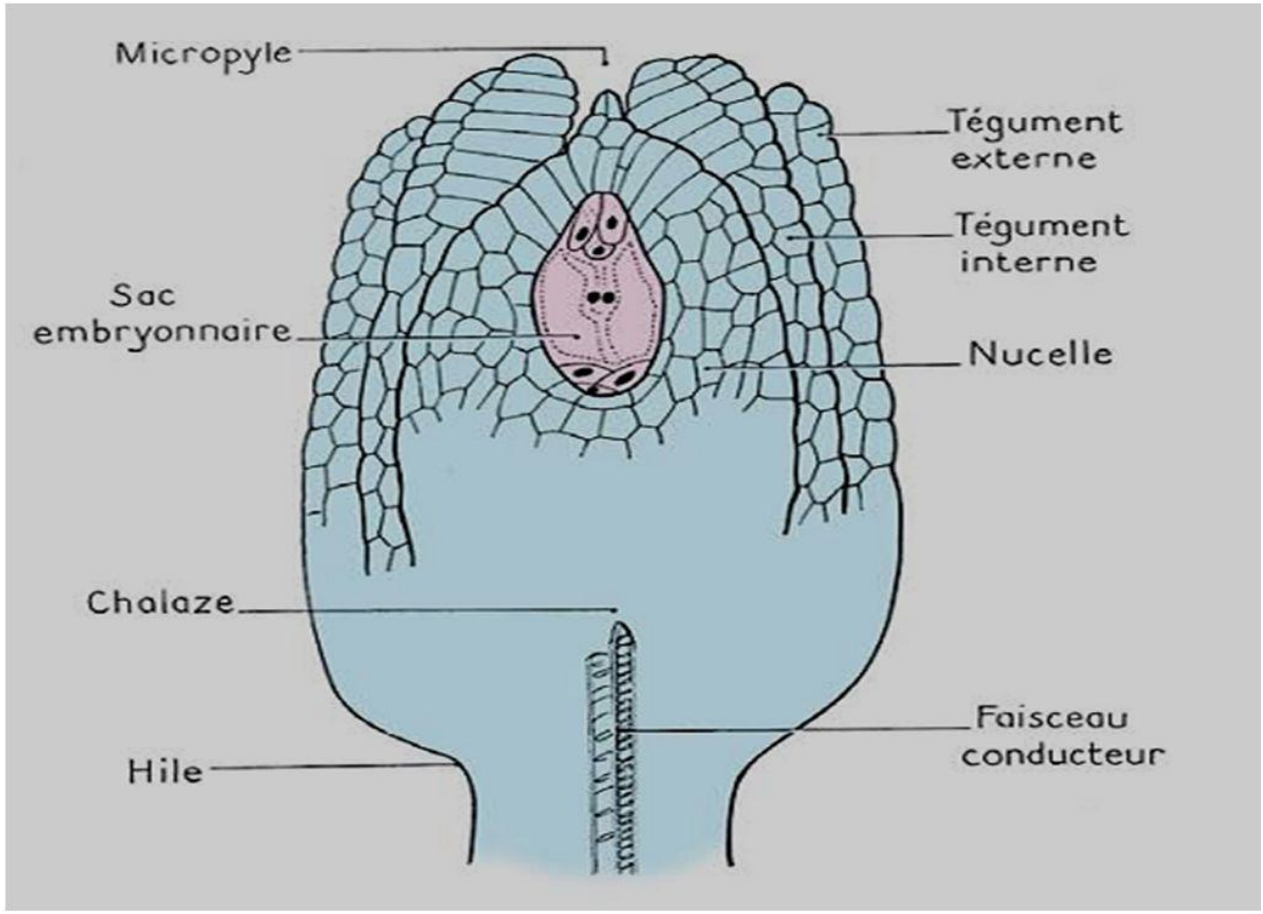
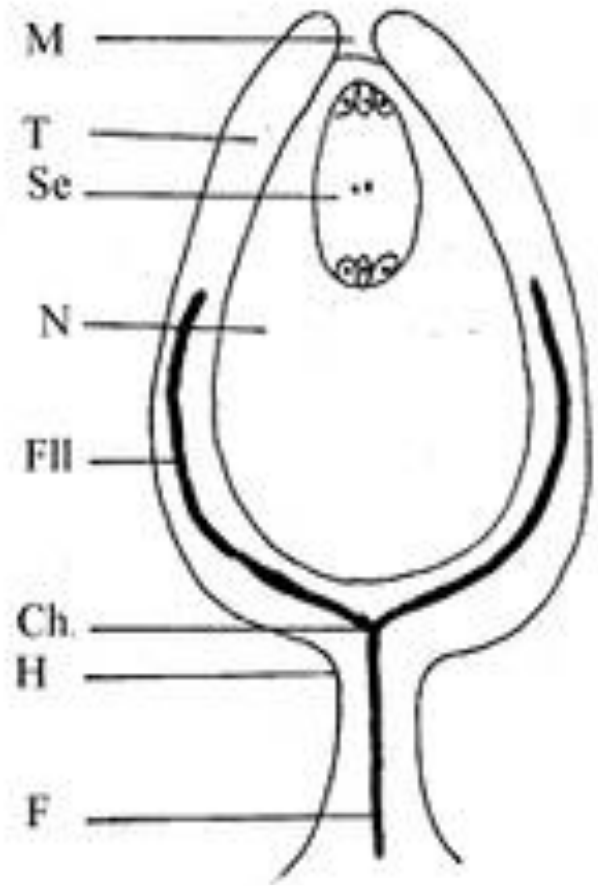
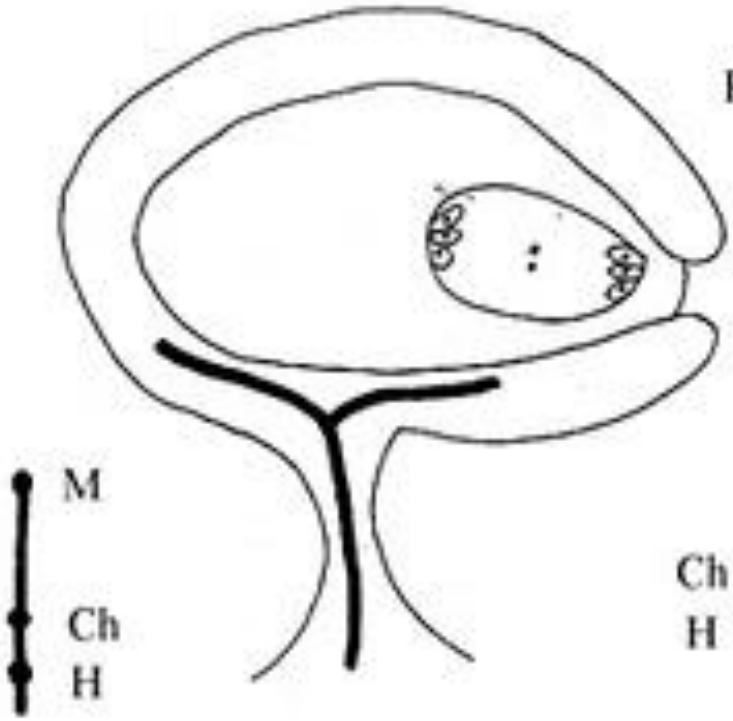


Diagram of an ovule

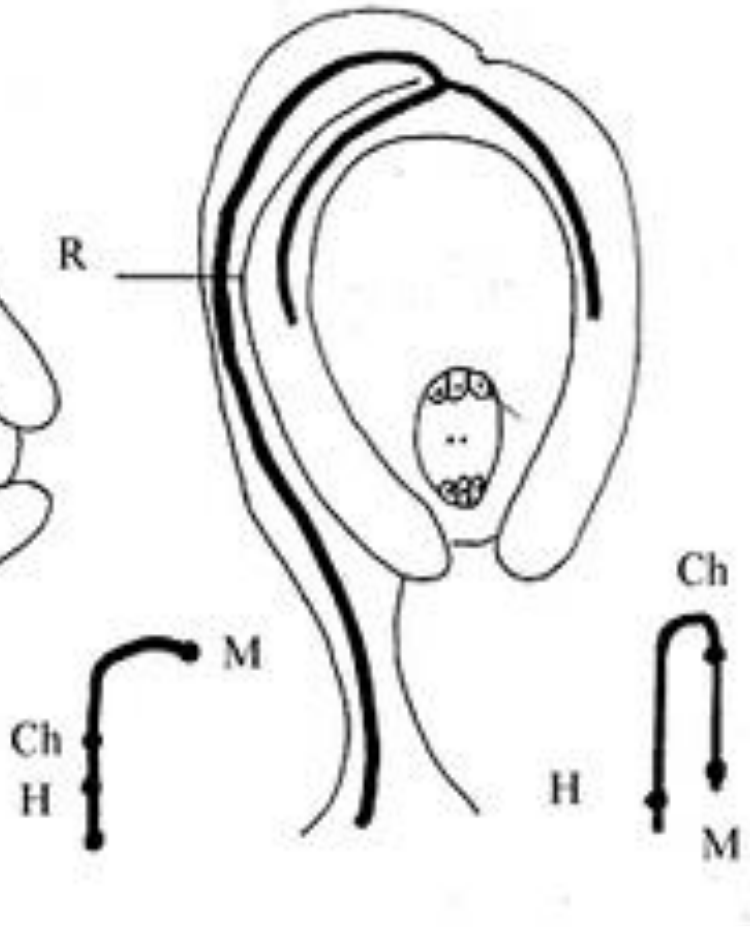
The 3 types of ovules



Orthotropic ovule = Straight ovule (in monocotyledons)



Campylotropic ovule = Tilted ovule (in legumes)



Anatropic ovule = Reversed ovule (frequent case)

Caption: **F:** funiculus / **H:** hilum / **Ch:** chalaza / **F:** woody libero bundle **/ N:** nucelle **Se:** embryo sac / **T:** tegument / **M:** micropyle

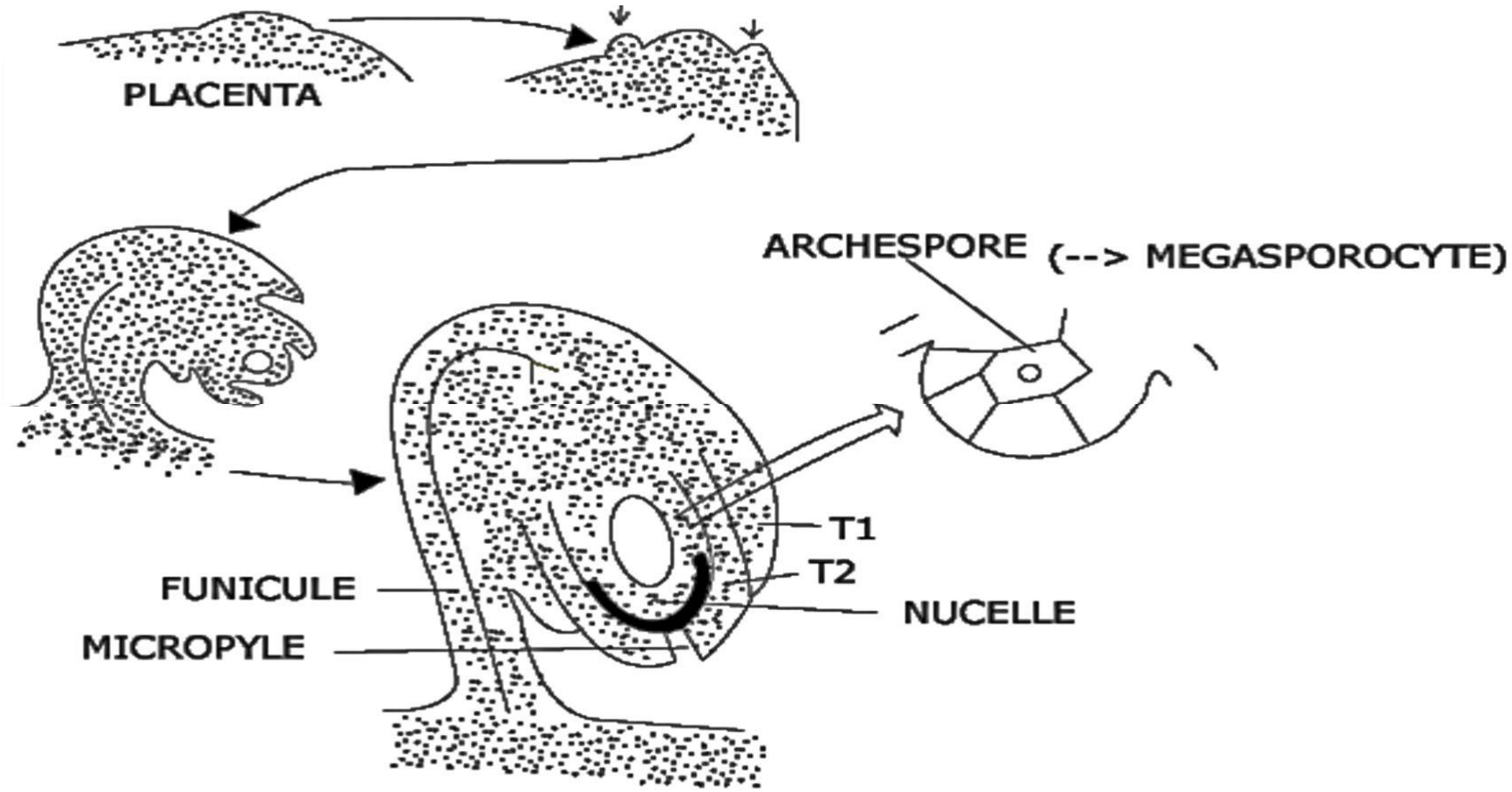
b. Origin and formation of the ovule

- Local proliferation of the placenta, which is a cell mass that rises to form the nucellus. At the same time, the archaeal mother cell differentiates in the centre of the nucellus;

The mother cell of the archaepore undergoes mitosis to form a parietal cell and another archaepore;

The T1 and T2 teguments appear following cell division; they increase in volume, covering the nucellus and leaving an opening known as the micropyle;

Once the ovule has reached its maximum size, it is attached to the placenta by the funiculus. The teguments and the nucellus are fused at the base.

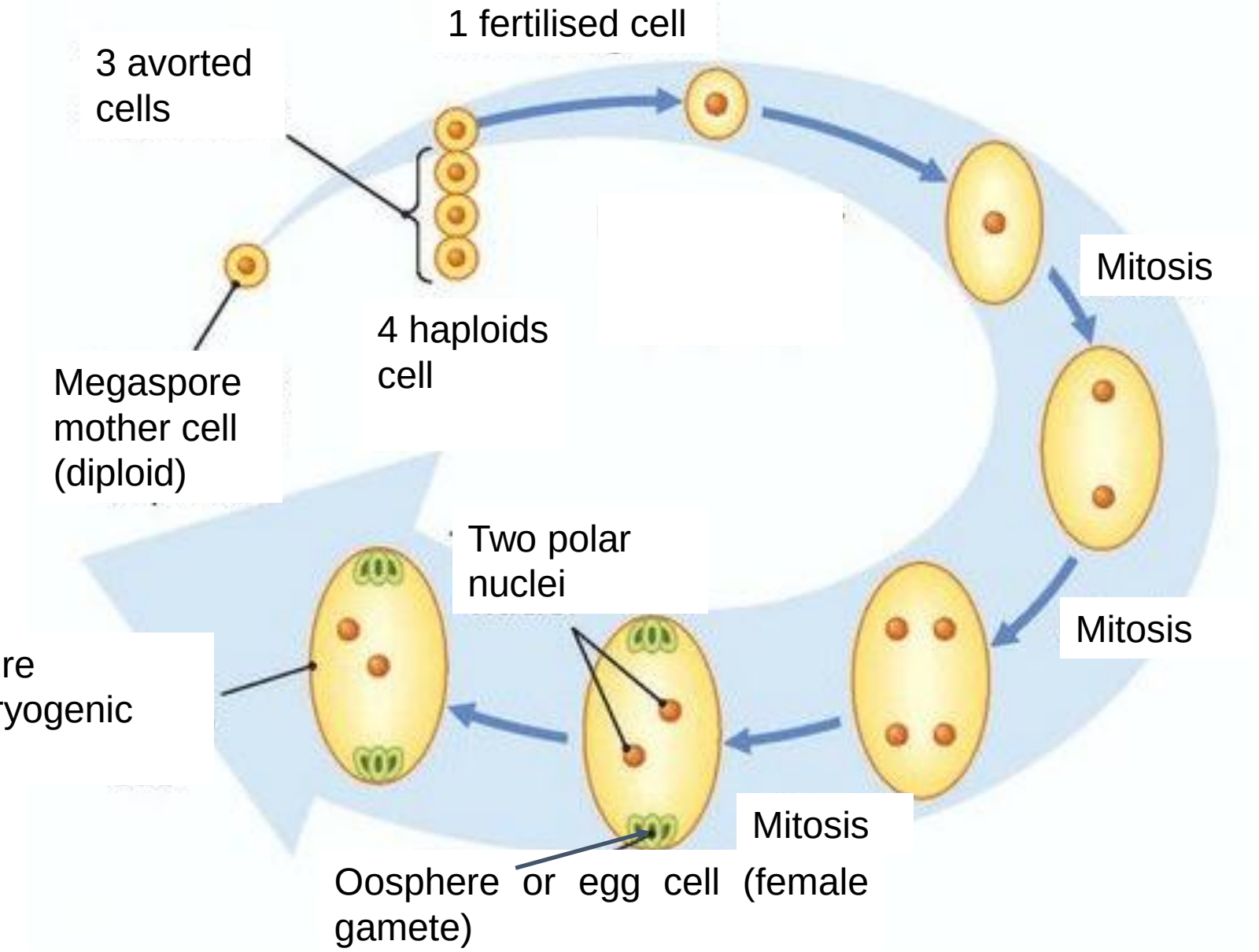


Origine and formation of an ovule

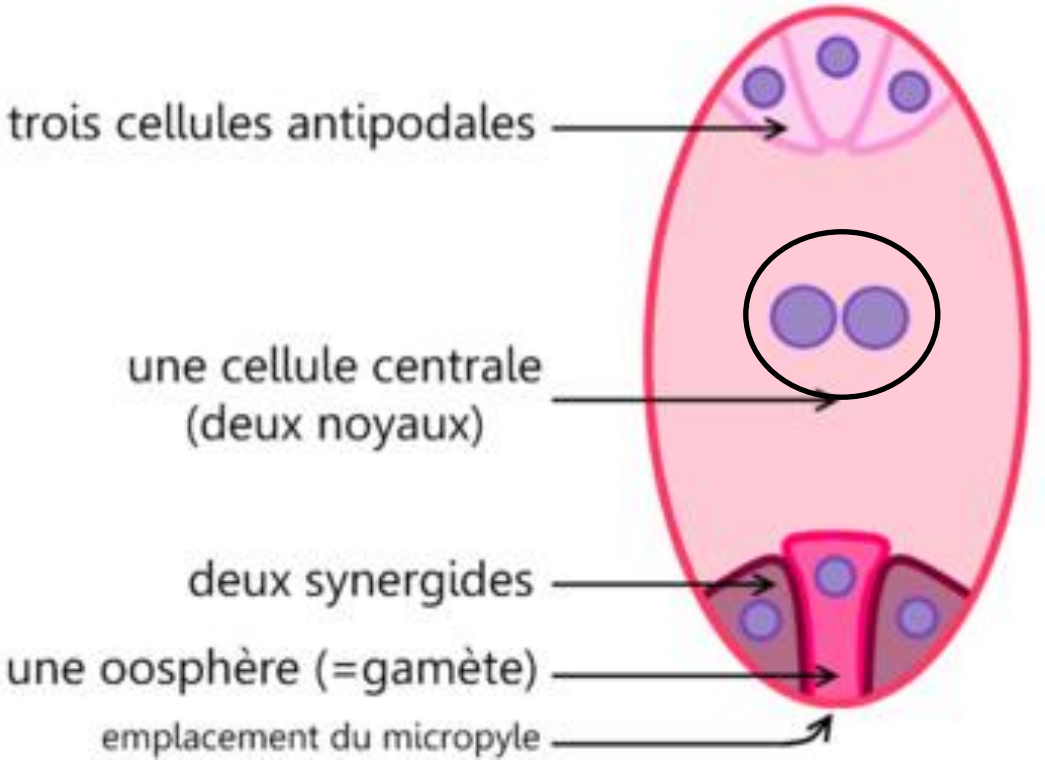
c. Formation of the embryo sac (in the ovule) :

Division of the nucleus of the functional megaspore. The 2 daughter nuclei obtained are each placed at one pole of the binucleate structure. Each of these 2 nuclei divides again to give 2 other nuclei. There will therefore be 2 nuclei in each pole. After a final mitosis, these 4 nuclei produce 8 free nuclei, contained in an embryo sac.

Development of the female gametophyte
(Formation of the embryo sac)

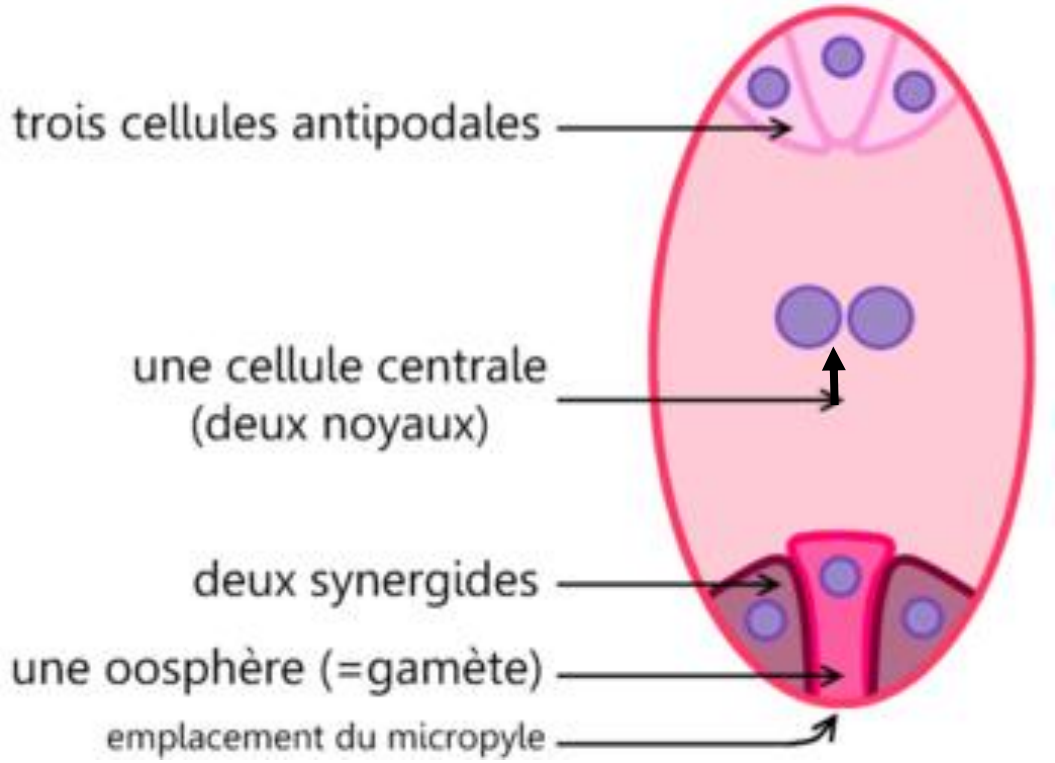


- The 8 haploid nuclei of the embryo sac are divided into 2 equal batches at each pole.
- From each of the 2 batches, one nucleus moves towards the centre; these 2 nuclei are known as polar nuclei.
- The 6 remaining nuclei (3 nuclei in each pole) are then surrounded by plasma membranes and thin pectocellulosic walls;
- The embryo sac then becomes cellular (7 cells in total, of which the central one is binucleated),



d. Structure of the embryo sac

1. Three cells: a female gamete (oosphere) and 2 synergids located on either side of the oosphere. The synergids provide nutrition for the oosphere;
2. Three antipodes occupy the basal pole of the embryo sac;
3. The centre of the embryo sac contains two polar haploid nuclei.



The embryogenic sac

I.2. Male Gametogenesis

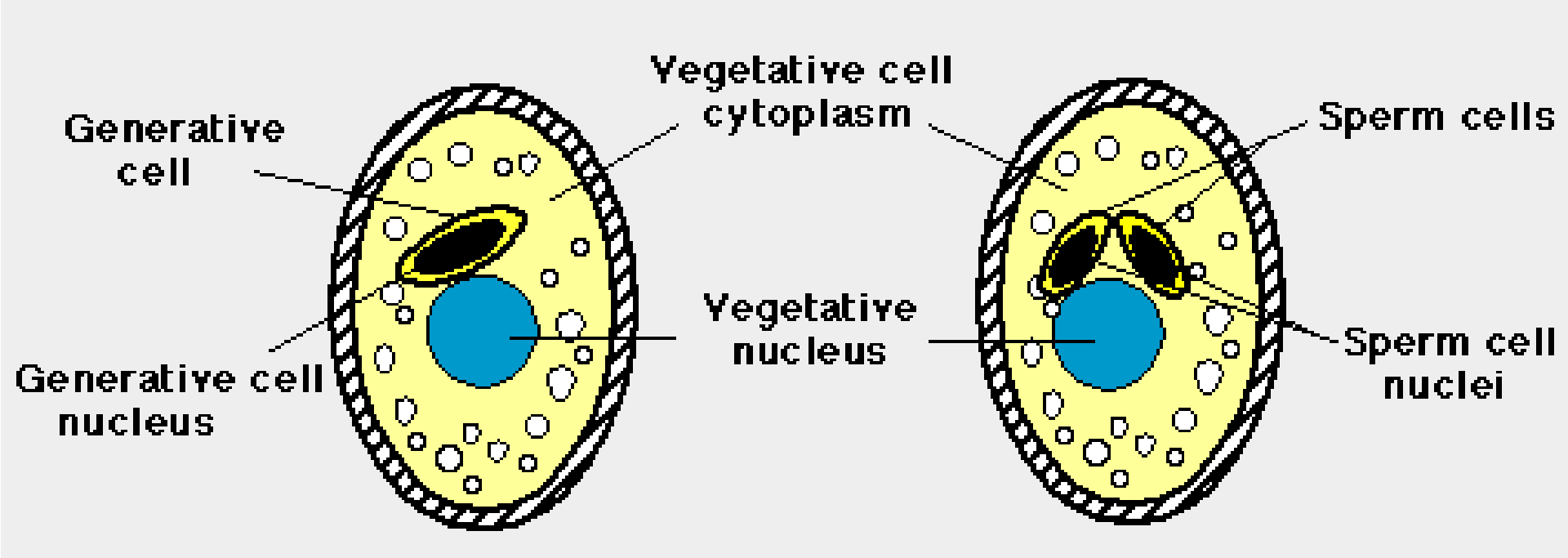
Male gametogenesis is the pollen grain inside the anther in angiosperms.

a. Grain of pollen

The **pollen grain** is generally spherical in structure, with a diameter of 7 to 150 µm. It consists of a thick pollen coat composed of exine on the outside and intine on the inside.


Grains de pollen

Two Types of the grain pollen



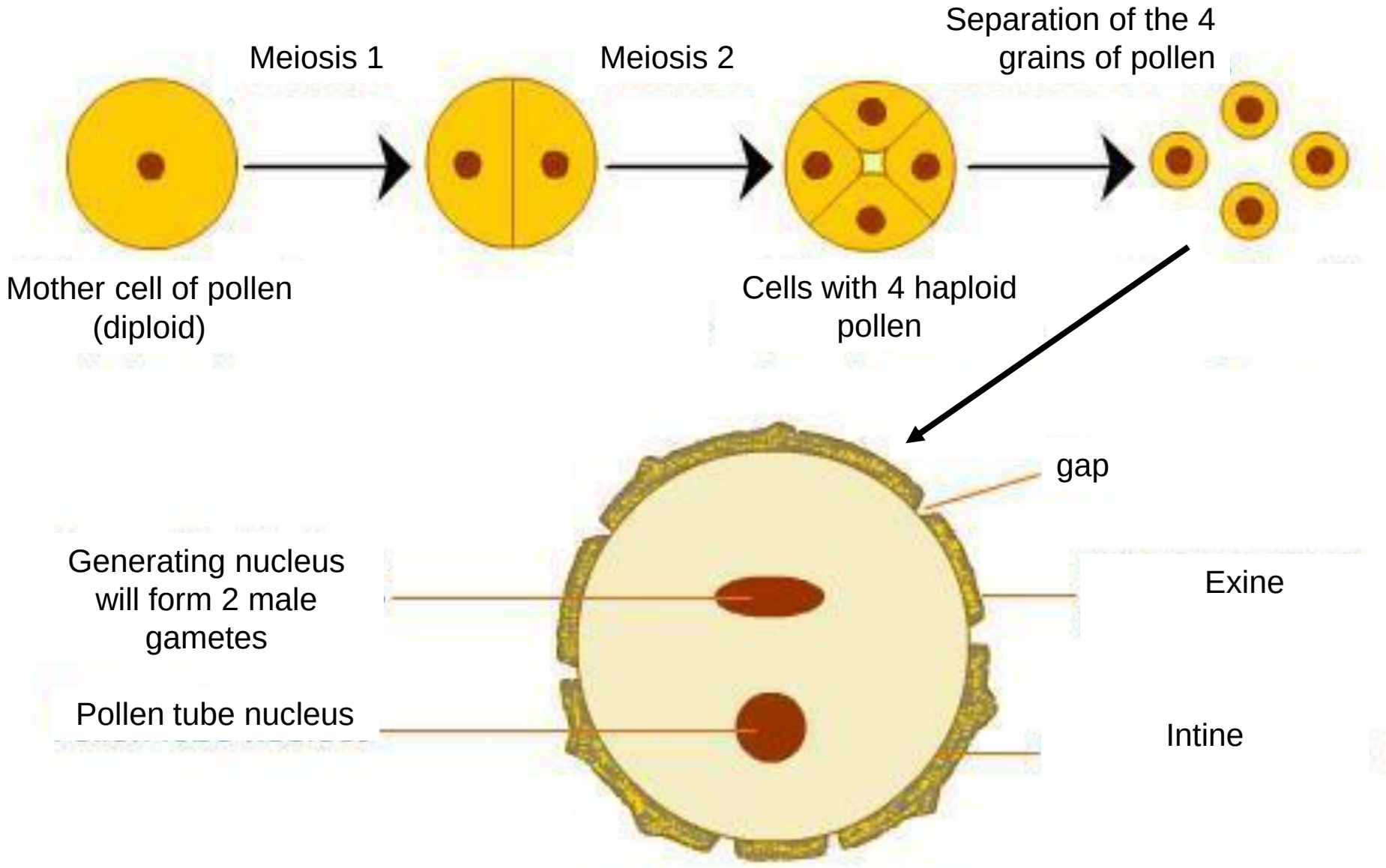
Two-celled pollen grains: This is the most common. The spermatogenic cell produces 2 male gametes by mitosis after pollination.

Grain de pollen tricellulaire : La cellule spermatogène subit une mitose et donne 2 gamètes mâles. Avant la déhiscence de l'anthère mûr, le pollen devient tricellulaire (1 cellule végétative et 2 gamètes mâles)

b. Formation of the grain pollen :

The pollen grain forms in the young anther in the 4 pollen sacs. Each of these diploid cells (2n) undergoes meiosis, resulting in the formation of 4 haploid microspores (n). Each haploid microspore undergoes asymmetric mitosis, which gives rise to the vegetative cell and the spermatogenic cell, as well as complex differentiation leading to the formation of intine and exine. The pollen grain is a male gametophyte.

Mother cell mûrs		4 microspores		4 grains of mature pollen
(2n)	meiosis →	(n)	Asymetric division →	bicellular (n)



A mature pollen grain

c. Structure of the grain pollen

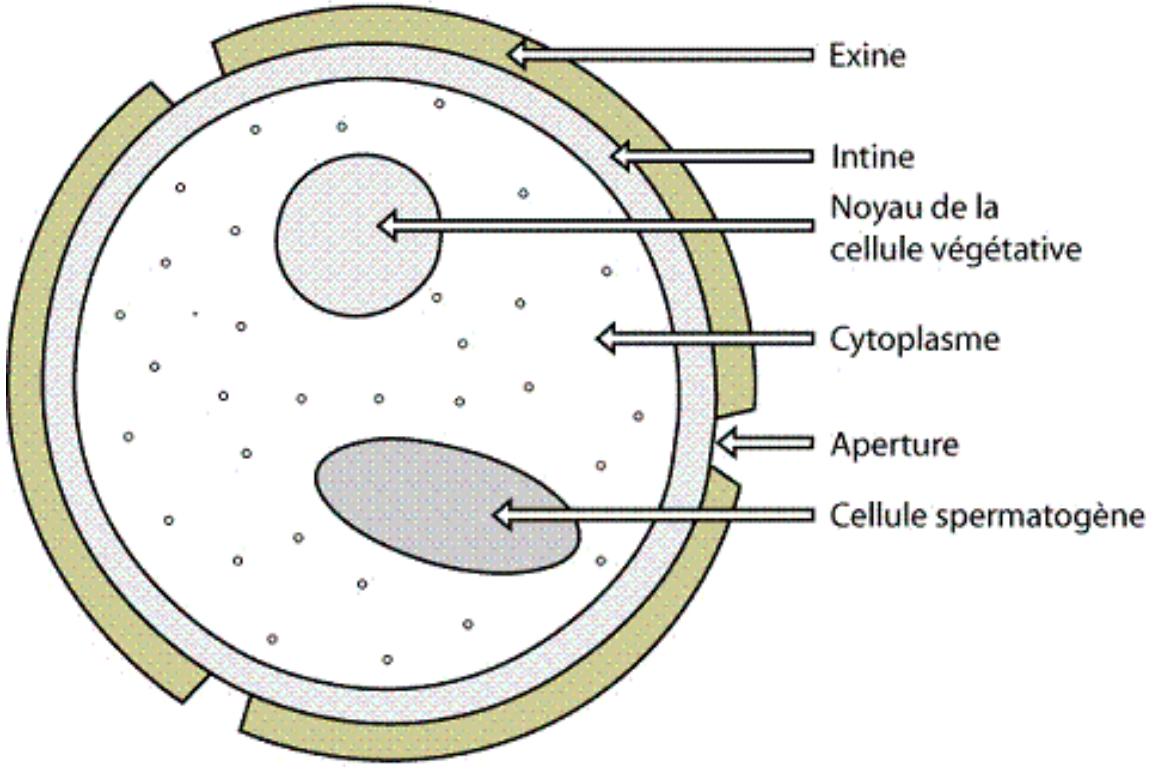
The **pollen grain** generally consists of two haploid cells (n) :

Vegetative cell: Large cell rich in reserves with a central nucleus. Nourishing role, involved in the germination of the pollen grain and the growth of the pollen tube.

Spermatogenic cell: Elongated cell with a central lenticular nucleus, surrounded by a plasma membrane and a very thin pectocellulose wall.

Intine: Thin, internal cellulose wall surrounding the vegetative cell. During germination of the pollen grain, the intine forms the pollen tube by evagination.

Exine: Thick outer wall. Made up of sporopollenin, which makes the exine more resistant to climatic conditions (heat, cold, etc.). It has openings to allow the pollen tube to emerge when the pollen grain germinates.



Schematic representation of a pollen grain with its two cells

II. FECONDATION

II.1. The pollination

Pollination is the transport of pollen grains from the male reproductive organ (androecium) to the female reproductive organ (gynoecium, exactly to the stigma).

There are two types of pollination:

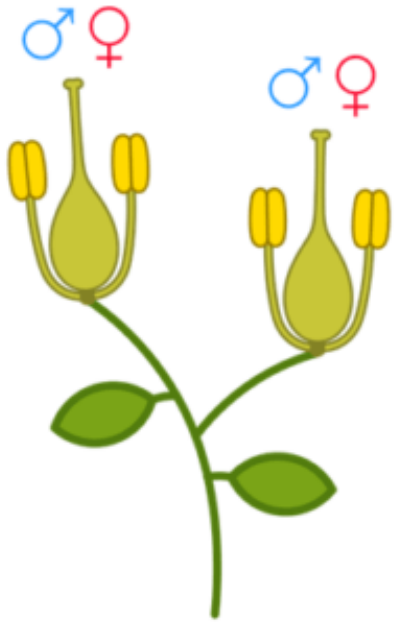
a. Self-pollination

b. Allopollination

a. Autopollination: (or autogamy)

Hermaphroditic flower; the stigma of the gynoecium is directly pollinated by pollen from the stamens of the same flower. Unisexual flower (monoecious plant); the female flower is pollinated by pollen from a flower bearing the male organ of the same individual (same plant) of a monoecious species.

Hermaphrodit plant



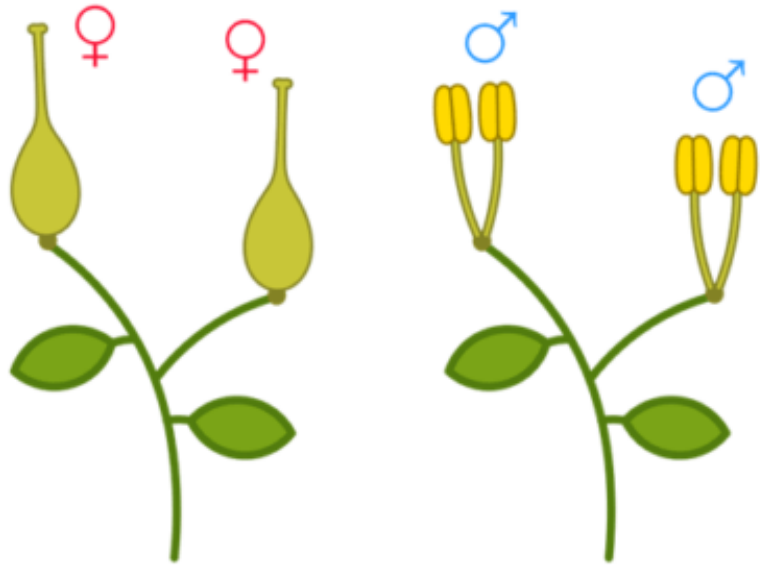
Exemples: lilas, tussilage, primevère officinale, sorbier des oiseleurs

Plant with flowers unisex: Dioic plant

Exemples: épicéa, mélèze, pin sylvestre, sapin blanc, bouleaux, noisetier, hêtre

b. Allopollination: Cross-pollination or allogamy. Pollen from a flower of the 2nd individual is carried to the stigma of a flower of the 1st individual of the same plant species as the 2nd. Example: Willow, Common Nettle, Holly

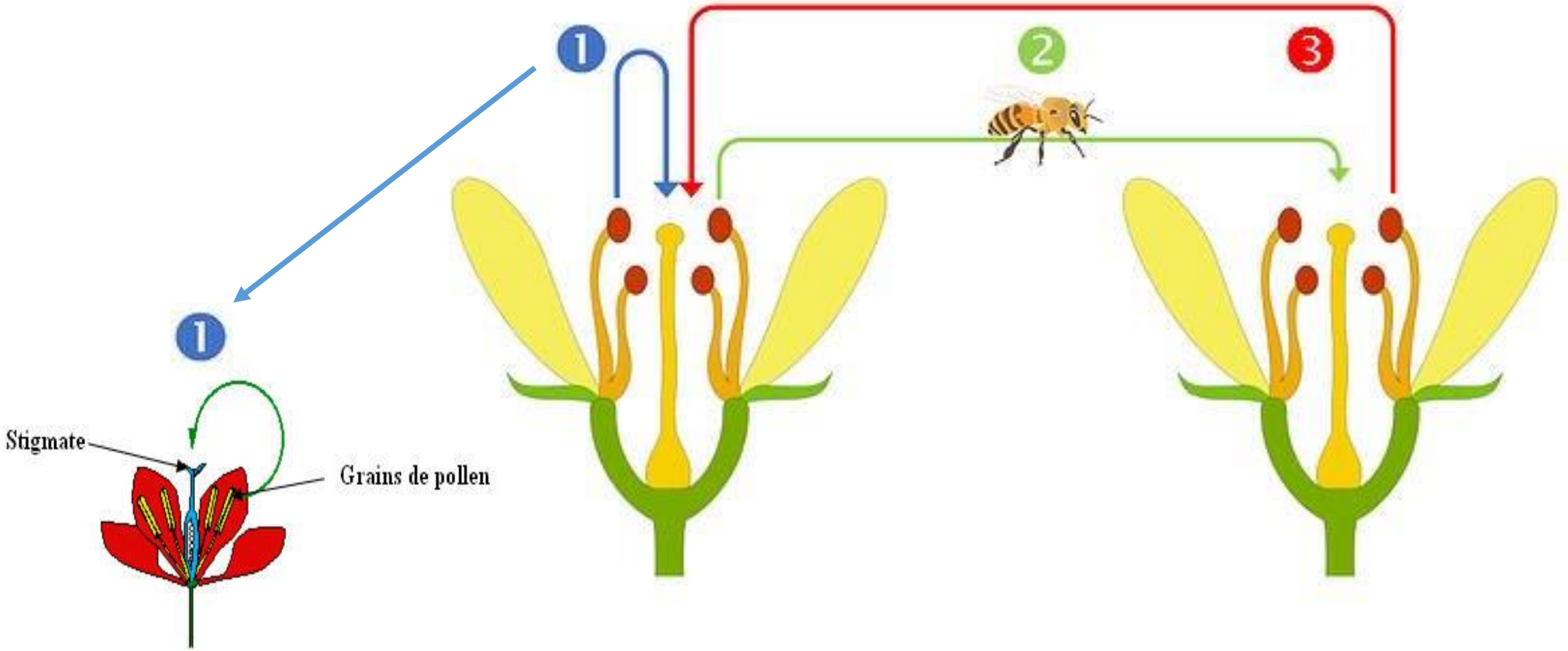
Plant with unisex flower : Dioic plant



Individu 1 Individu 2

Same plant species

RESUME OF THE POLLINATION MODES :

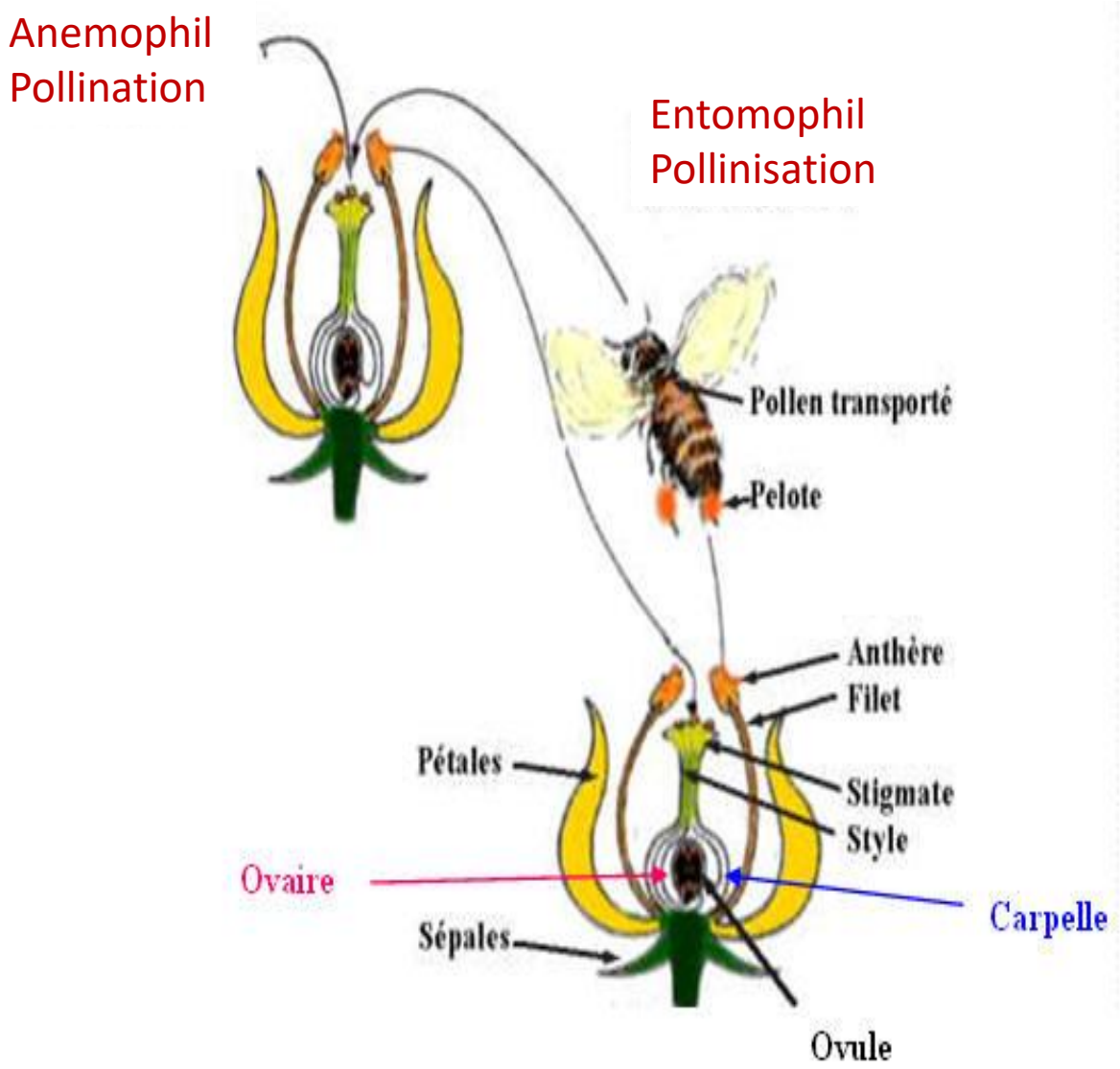


AutogamY 1 Pollination of a flower by its proper pollen = autopollination

2 and 3 = Allogamy or allopollination

Pollinating agents. Several factors are pollen carriers, such as :

- **Wind;** a good pollen carrier (very light). Anemophilous pollination.
- **Insects** are important for transporting pollen. Entomophilous pollination.
- **Birds** play a part in pollination and this is known as ornithophilic pollination.



II.2. The germination of the grain pollen

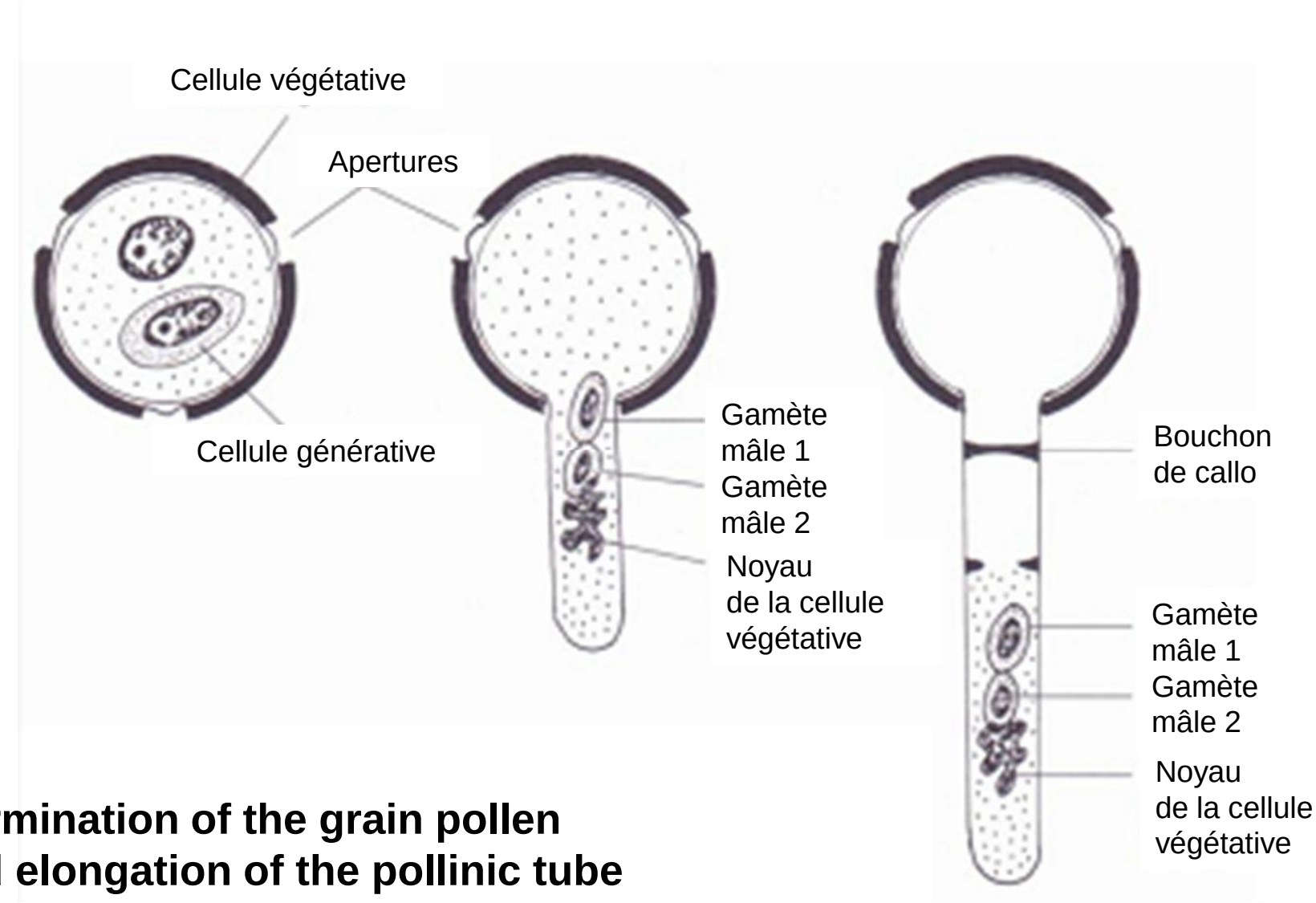
Pollen deposited on the stigma.

Flower stigma:The stigma receive and moisturise the pollen grain.

Germination of the pollen grain: After hydration, the pollen grain germinates and the pollen tube develops in the stigma towards the base of the flower.

The spermatozoa in the pollen tube move towards the oosphere of the ovule (in the ovary). This is where fertilisation of the oosphere takes place.

Fertilisation of the oosphere = double fertilisation

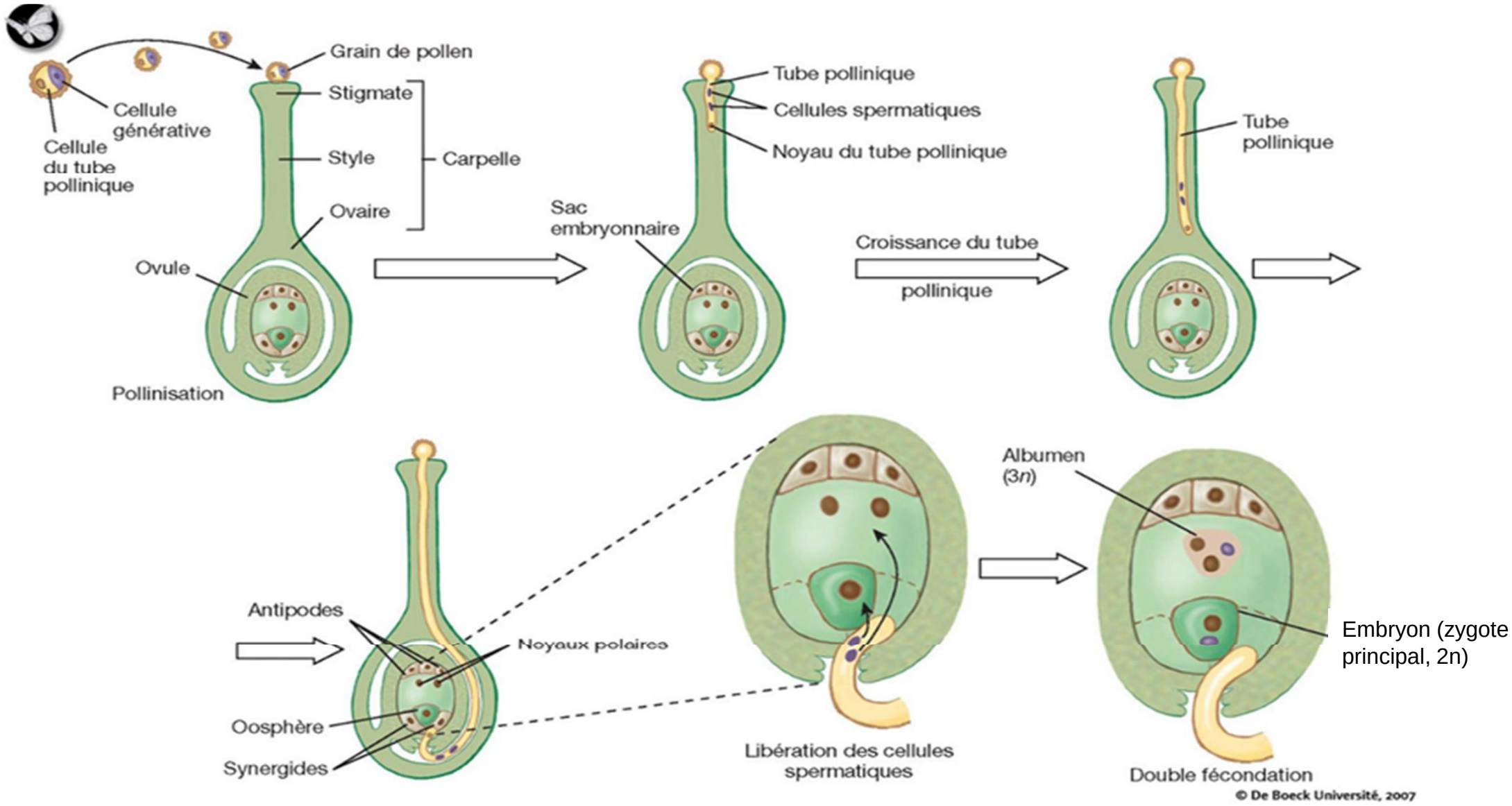


Germination of the grain pollen and elongation of the pollinic tube

II.3. The double fecondation

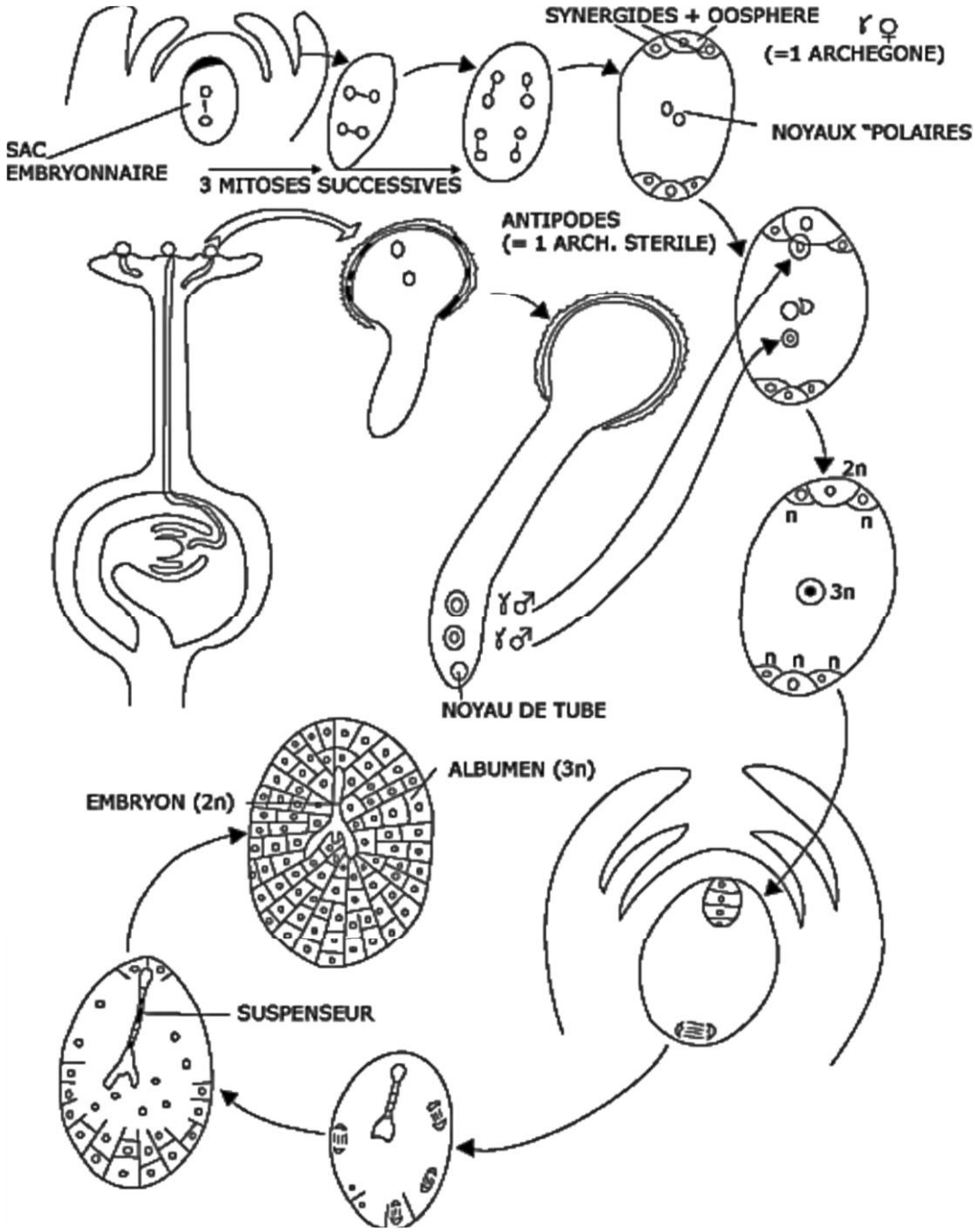
- Transport of the pollen grain from the anther to the stigma of a flower: by wind and insects
- Germination of the pollen tube in the stigma and its elongation through the style to reach the ovarian cavity and the micropyle of the ovule.
- At the ovule: the pollen tube passes through a synergid and releases the 2 spermatozoa. One of the spermatozoa fertilises the oosphere and forms the embryo (main zygote, 2n).
- The 2nd spermatozoid fertilises the diploid central cell with 2 polar nuclei, giving a cell (3n) which is the albumen (accessory zygote).
- The albumen tissue gradually replaces the embryo sac and is important in the development of the embryo.

The double fecondation process



- The albumen tissue may disappear before the seed matures, developing cotyledons.
- The teguments of the ovule form the seed teguments and the wall of the ovary is transformed into the pericarp of the fruit.
- The zygote divides transversely, forming a terminal cell and a basal cell.
- The apical (or terminal) cell is the only one responsible for the formation of the embryo.
- The cells from the basal cell form the suspensor, which anchors the embryo in the seed.
- The embryo contains the outlines of the plant's future organs: a radicle, the future root, and a gemmule, the future aerial part.

Gametogenesis, fecondation and embryogenesis of Angiosperms



Note :

- In some seeds, it is the cotyledons that accumulate reserves. In angiosperms, depending on the number of cotyledons, there are 2 groups: monocotyledons and dicotyledons.

- Germination of the seed: absorption of water, the hydrated tissues of the seed swell, causing the teguments to rupture. At the same time, the embryo begins to metabolise the seed's reserves. The radicle, then the small stem, elongate. The chloroplasts become active and allow the plant to develop independently, giving rise to a new plant.

II.4. Cycle of developpement in angiosperms