Hand-out 1: The life cycle (due next Tuesday)

Purpose: This exercise is designed for you to develop a better understanding of the different stages of life cycles. This exercise consists in a purely theoretical approach to this objective. Although the exercises may at times seem repetitive, you are encouraged to proceed through all of them, as this will allow you to become familiar with the terminology

A life cycle is the "complete sequence of phases in the growth and development of any organism from the zygote formation to the gamete formation.

The key words are: **zygote** and **gametes**, two stages of any life cycle. How would you define these terms?

Zygote: _____

_____

_____

Gametes: _____

_____

_____

If you were given a cell, and asked whether this cell was a zygote or a gamete, what feature would you use to differentiate them? _____

This difference is the key to understanding the concept of life cycles. Why? Well, imagine now a life cycle reduced to these two stages. How would these stages be connected in an organism undergoing sexual reproduction? In other words, what mechanisms account for the transition from one stage to the other?

Let's start with the transition from "gamete" to "zygote". The zygote has twice the number of chromosomes than the gamete. How is this achieved? Sexual reproduction involves the **fusion** of two cells. These cells are the *gametes*. "Gamete" is a generic term. An egg is a gamete and so is a sperm. Eggs and sperms are strikingly different in morphology (this is called **anisogamy**), but sometimes, the gametes cannot be told apart (**isogamy**). The fusion of gametes, also called **syngamy**, thus leads to a cell that bears two sets of chromosomes, one from each gamete.

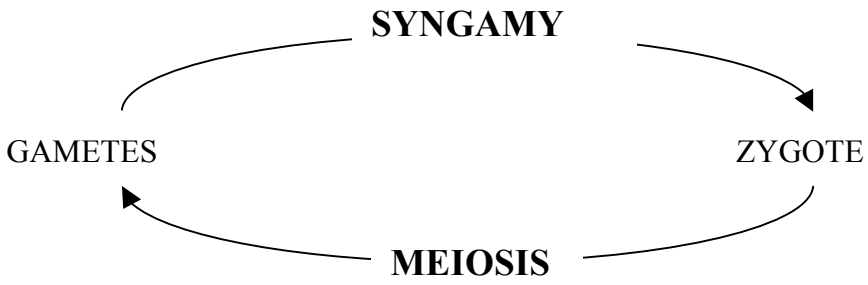
Remember that a life cycle is a "complete sequence of phases". It is thus necessary for the zygote-phase to be connected to the gamete-phase. A transition from a cell with two complements to one with a single set of chromosomes is thus needed. Simple! The zygote only has to be divided in two cells. In theory this is correct, but is practice, the mechanism is somewhat more sophisticated than a simple division.

Meiosis is a set of **two successive divisions** in which the chromosome number is reduced from diploid (2N) to haploid (N). Meiosis thus differs from the simple division we imagined above, by the occurrence of one additional division. It is during this division that chiasmata are established between homologous chromosomes.

Because there are two divisions in meiosis, a zygote undergoing meiosis always yields four daughter cells.

If the parents are genotypically distinct (i.e., not clones), it is highly likely that none of the daughter cells is genetically identical to either parent, and that any two daughter cells are identical (this is why, from an evolutionary point of view, sexual reproduction is "better" than asexual [clonal] reproduction).

We have now linked two fundamental stages of a life cycle involving sexual reproduction:



This is the most simple life cycle in which sexual reproduction occurs. A species characterized solely by these two phases would be a unicellular algae.

Many plants are, however, multicellular, that is their body is composed of numerous cells. Such multicellular organism forms through the proliferation of cells. Imagine that the cells resulting from meiosis did not function as gametes, but instead remained **vegetative**. How would you develop a multicellular organism from these cells. If these cells merely aggregated, the result may seem like a multicellular organim, but would actually be a colonial organism composed of unicellular individuals. A multicellular organism is obtained by the cells undergoing cell division.

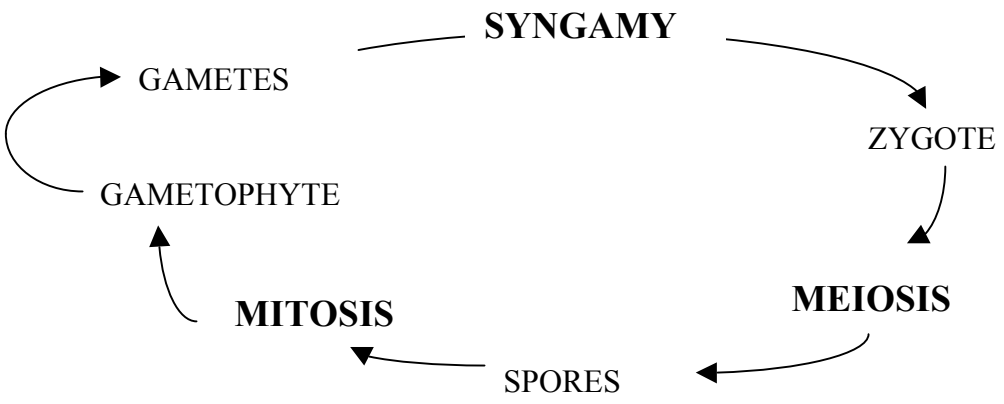
Would meiosis be the mode of cell division? _____. Justify your answer: _____
_____
_____

The proliferation of cells relies on the duplication of the parental cell. What is needed for the daughter cells to be genetically identical to the parental cell, i.e., for them to have the exact same number of chromosomes as in the parent? _____
_____
_____

How is this mode of cell division called? _____

For a cell to undergo mitosis, does it have to be a diploid cell? ___. Justify: _____
_____
_____

We could thus imagine that the cells produced through meiotic division of the zygote, undergo mitosis, thereby developing into a multicellular organism.



Since the term gamete is restricted to "*haploid reproductive cells*" a new term is needed: the gametophyte. A gametophyte is thus a haploid multicellular organism. If involved in sexual reproduction, this organism will have to develop reproductive cells (i.e., the gametes).

Parallel to a multicellular gametophyte, we could imagine that the zygote develops into a multicellular phase prior to undergoing meiosis. The diploid stage emanating from the zygote is called a sporophyte.

Draw a life cycle with a multicellular gametophyte and sporophyte:

In land plants as well as some aquatic algae, the reproductive cells are developed in specialized tissues or organs. Such **gametangia** occur only in anisogamous plants. We can thus distinguish a male gametangium (antheridium) from a female gametangium (archegonium). Are gametangia haploid or diploid? ____ Justify: _____

Draw a life cycle with a multicellular sporophyte and a gametophyte developing female and male gametangia:

Similarly, plants with multicellular sporophyte bear differentiated tissues wherein spores are formed. These "organs" are called sporangia (one sporangium). Are sporangia haploid or diploid?____
Justify: _____
_____

In what stage of the life cycle is sex expressed? _____.