COURSE-III: PTERIDOLOGY, GYMNOSPERMS AND PALAEOBOTANY (BSCBO-103)

BLOCK – I-: PTERIDOPHYTA

Heterospory and Life Cycle

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HETEROSPORY

Heterospory is a phenomenon in which two kinds of spores are borne by the same plant. The spores differ in size, structure and function.

The smaller one is known as **microspore** and larger one is known as **megaspore**.

Such Pteridophytes are known as heterosporous and the phenomenon is known as **heterospory**.

Most of the Pteridophytes produce one kind of similar spores, Such Peridophytes are known as homosporous and this phenomenon is known as **homospory.**

The sporangia show greater specialization. They are differentiated into micro and megasporangia. The microsporangia contaion microspores whereas megasporangia contain megaspores.

The production of two types of sproes with different sexuality was first evolved in pteridophytes. Even though, the condition of heterospory is now represented by 9 genera viz. *Selaginella, Isoetes, Stylites, Marsilea, Pilularia, Regnellidium, Salvinia, Azolla and Platyzoma.*

Origin of Heterospory

A detailed study of homosporus forms has revealed that heterospory originated due to reduction in number of spores within sporangia i.e., if more number of spores are functional than there is more competition for nutrition and limited nutrients are provided to developing spores.

In this way microspores are formed, they are smaller in size and more in number.

On the other hand, if some of the spore mother cell in a sporangium disintegrates during development, the remaining ones get sufficient nutrients. These are megaspores; they are larger in size but less in number.

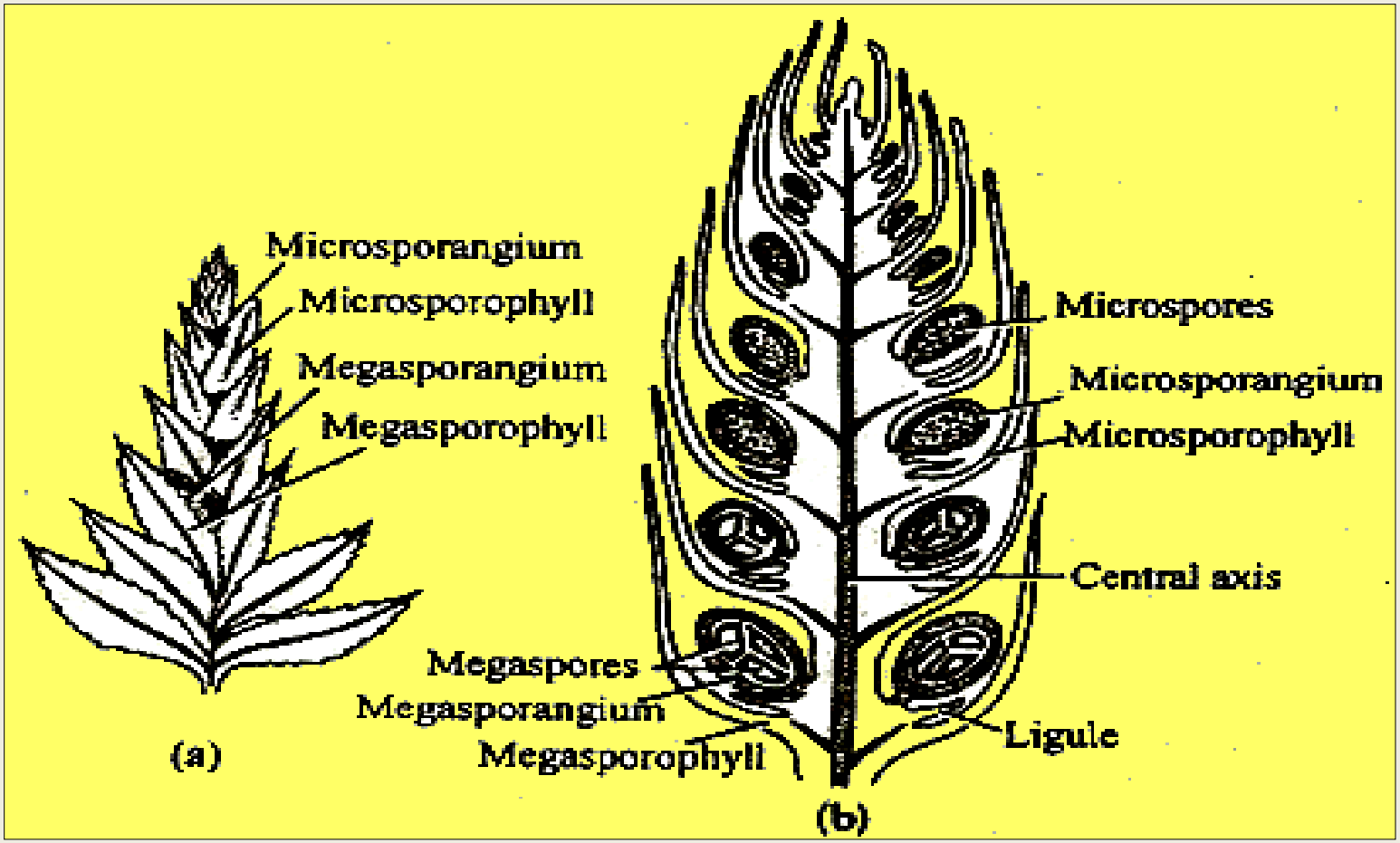


Diagramme showing morphology of heterosporous cone (a) and L.S. of a heterosporous cone (b)

Evidences of Heterospory

Paleobotanical evidences: These were concluded on the basis that earlier vascular plant were heterosporus eg. *Lepidocarpon, Lepidostrobus* etc. According to Scott (1894) an indication of heterospory can be traced in *Calamostachys binneyana* and *C. casheana*. In former the sporangia were with large number of small spores in tetrads. In later two distinct types of sporangia microspoorangia and megasporangia occurred.

A similar disintegration was observed in some species of *Lepidocarpon*, *Calamocarpon* and *Stauropteris*.

The above example indicates that:
Heterospory has not only evolved in living forms but was present in the fossil plants.

It originated due to integration of spores in a sporangium.
However, the reduction in number of spores or spore mother cell was achieved but it cannot be determined as there is no information regarding the development of sporangia and spore.

Evidences from developmental studies:

Developmental studies in pteridophytes, during the formation of sporocytes, meiosis and maturation of spore provide a real insight in the understanding of heterospory.

In *Selaginella, Isoetes, Marsilea, Salvinia* etc. early development of microsporangium and magasporangium is similar till the formation of sporocytes.

In *Selaginella* all the sporocyte in microsporangia undergoes meiosis as a result a large number of microspores is formed. On the other hand all the megasporocytes except one abort and the surviving magasporocyte undergo meiosis to form four large functional megaspore of same or variable size.

Developmental studies have thus, showed that the process of heterospory becomes operative either before meiosis (e.g. *Selaginella*) or after meiosis (e.g. *Marsilea*).

Evidences from Experimental studies: On the basis of experimental studies on *Selaginella* and *Marsilea* it has been found that heterospory originated due to nutritional factors. It was observed that if the photosynthetic activity of *Selaginella* was slowed down by keeping it in low light intensity, then only microsporangia developed. Due to the low photosynthetic activity, nutrition became a limiting factor and spores could not grow in size. Thus, under such conditions only microspores were produced. Similar experiments were preformed on *Marsilea* by Shattak (1910). In variable conditions of light, temperature and nutrients, he found that in plants growing in favourable conditions the microsporangium contains aborted microspore and microsporangium showing microspore abortion developed spore that were 16 times larger than the original size. In extreme cases of abortion only a single spore survived and looked alike a megaspore and showed all structural features of megaspore.

Under unfavourable conditions of light, temperature and nutrients, he was able to induce the formation of the larger number of smaller spore in megasporangia. However, it was not possible to germinate these altered spores therefore; no conclusive results can be achieved.

Advantage of heterospory

Hetrospory expresses sex determining capability of plant. In homosporus species, differentiation of sex takes place at the gametophytic stage, whereas in heterosporus species difference in size of the spore is related to the sex of the gametophyte. A microspore always gives rise to male gametophyte and megaspore gives rise to female gametophyte. Therefore, in heterosporus forms sex can be predicted at the spore stage.

The biological significance of heterospory is that in heterosporus forms the development of gametophyte is endosporic (spore germinate within the sporangium)and its nutrition is derived from the sporophyte hence is not affected by the ecological factors as in the case of independently growing gametophytes which has to manufacture not only its own food but also for the developing embryo.

It is an evolutionary step towards seed habit.

Heterospory and Seed habit

In seed bearing plants, there are two kinds of spores (microspores and megaspores) which grow to form male and female gametophyte respectively, In these plants the single megaspore is not shed from the megasporangium but retained within it while still attached to the mother plant. It germinates within the megasporangium producing the much reduced female gametophyte (nucellus) bearing archegonia.

Later the nucellus and the gametophyte are protected by a covering known as integument and the whole structure is known as ovule. After fertilization zygote within ovule give rise to the embryo and the rest of the gametophyte including endosperm and integument thickens to form a seed coat. This entire structure (integumented ovule) is known as seed.

Thus, the important features leading to the development of seed habit are:

The evolution of heterospory i.e. production of two kinds of spores
The retention and germination of megaspore to form female gametophyte, fertilization of the egg and embryo formation within the megasporangium.
Elaboration of the apex of the megaspore for receiving microspores or pollen grains.
Envelopment of the megasporangium (nucellus) by an integument except at the apex thus forming micropyle.

Selaginella shows a remarkable approach to seed habit because of the following features:
It is heterosporus.
The megaspore starts germinating within the megasporangia and their time of release varies with species.
The number of megaspore in *S. rupestris* and *S. monospora* is reduced to one.

In *S. rupestris* the megaspore is never shed and the fertilisation and the development of embryo takes place while megaspore is enclosed within the megasporangium.

However the seed development in these species cannot be called as true seed habit because-:

•The megasporangium is not covered with integuments.

•The retention of megaspore permanently within the megasporangium has not become established.

•Histological union between the megaspore and magasporangium is absent.

•Absence of resting period after the devlopment of embryo.

LIFE-CYCLE OF PTERIDOPHYTES

The life-cycle of a pteridophyte comprises of two distinct phases or generation, each of which produces other. One phase or generation is **sporophytic** and another is **gametophytic.** The **sporophyte** is diploid and dominant part of the life-cycle, for it is organised into stem, leaves and roots. It is the part of life-cycle in which vascular tissue is developed. The sporophyte plant develops sporangia within which are diploid cells, called **spore mother cells or sporocytes**. Each spore mother cell or sporocyte divides by **meiotic or reduction division.** As a result of **meiosis,** spores are produced, which are therefore, haploid. In some, members, all spores produced by sporangia are of one type; such a plant is said to be homosporous *(Lycopodium, Dryopteris).* These spore on germination produce the **haploid or gametophyte generation.** These gametophytes are of same kind. The gemetophytic generation is always small, inconspicuous and bears male and female gametes. The male gametes, *i.e., sperms* are produced in large number within the antheridium. The female gamete, *i.e., egg* is generally borne singly within the archegonium.

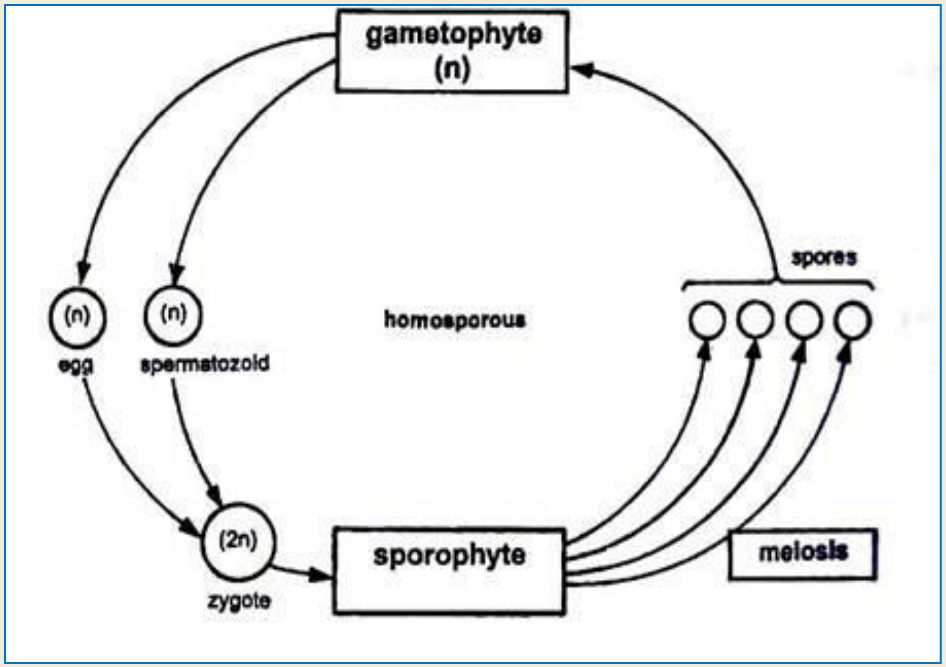
Fertilization takes place in presence of water when a sperm fuses with an egg to produce a diploid *zygote.* The **zygote** germinates to form the new *sporophyte.* The generation is called **sporophytic generation.**

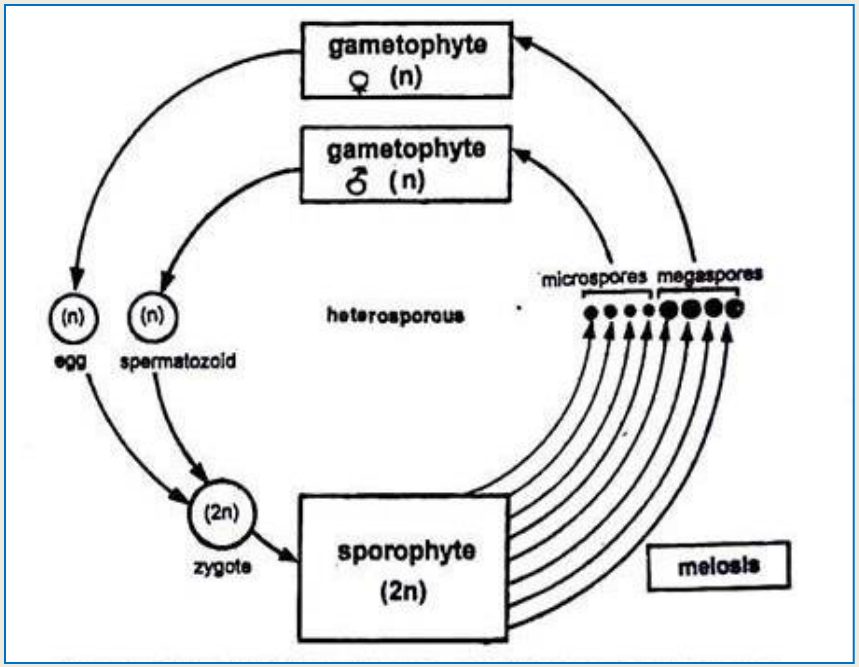
In heterosporous pteridophytes, *i.e., Selaginella, Isoetes, Azolla* and *Marsilea,* the spores are of two kinds- the smaller spores termed as *microspores* or *male spores* and are developed in *microsporangia,* while the larger spores are termed as *megaspores* or *female spores* and are formed in *megasporangia.*

The microspores on germination produce the male gametophyte on which only the male gametes, *i.e.,* the *sperms* are produced.

The megaspore produce the female gametophyte, the fertilization occurs in presence of water resulting in the formation of a diploid cell or *zygote* which in turn develops into a sporophytic generation.

Thus, the life cycle of a pteridophyte consists of an alternate succession of heteromorphic sporophytic and gemetophytic generation.





Diagrammatic representation of life cycle of homosporous (A) and heterosporous (b) pteridophyte

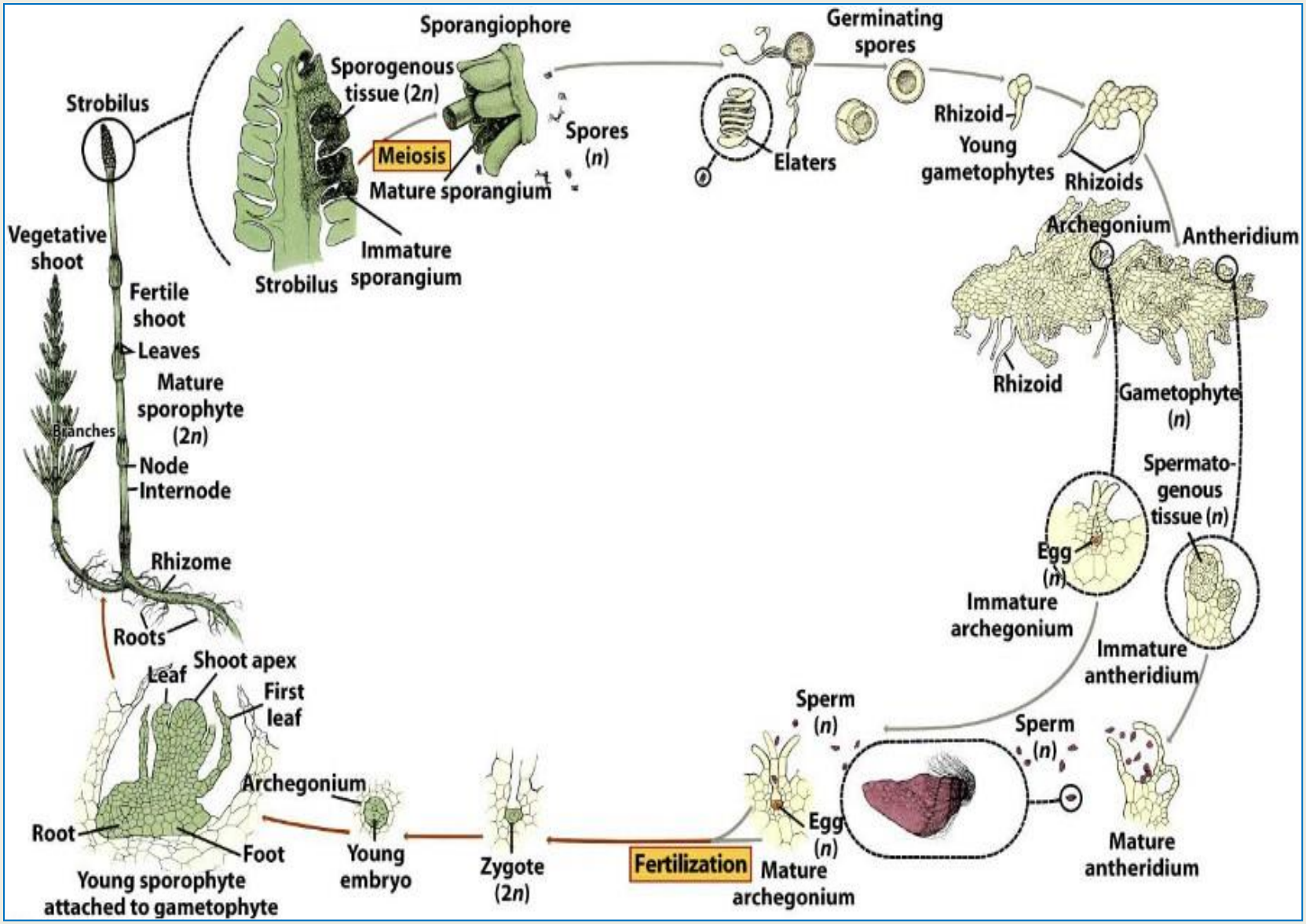


Diagramme showing different stages in Life cycle of a homosporous pteridophyte (Equisetum).

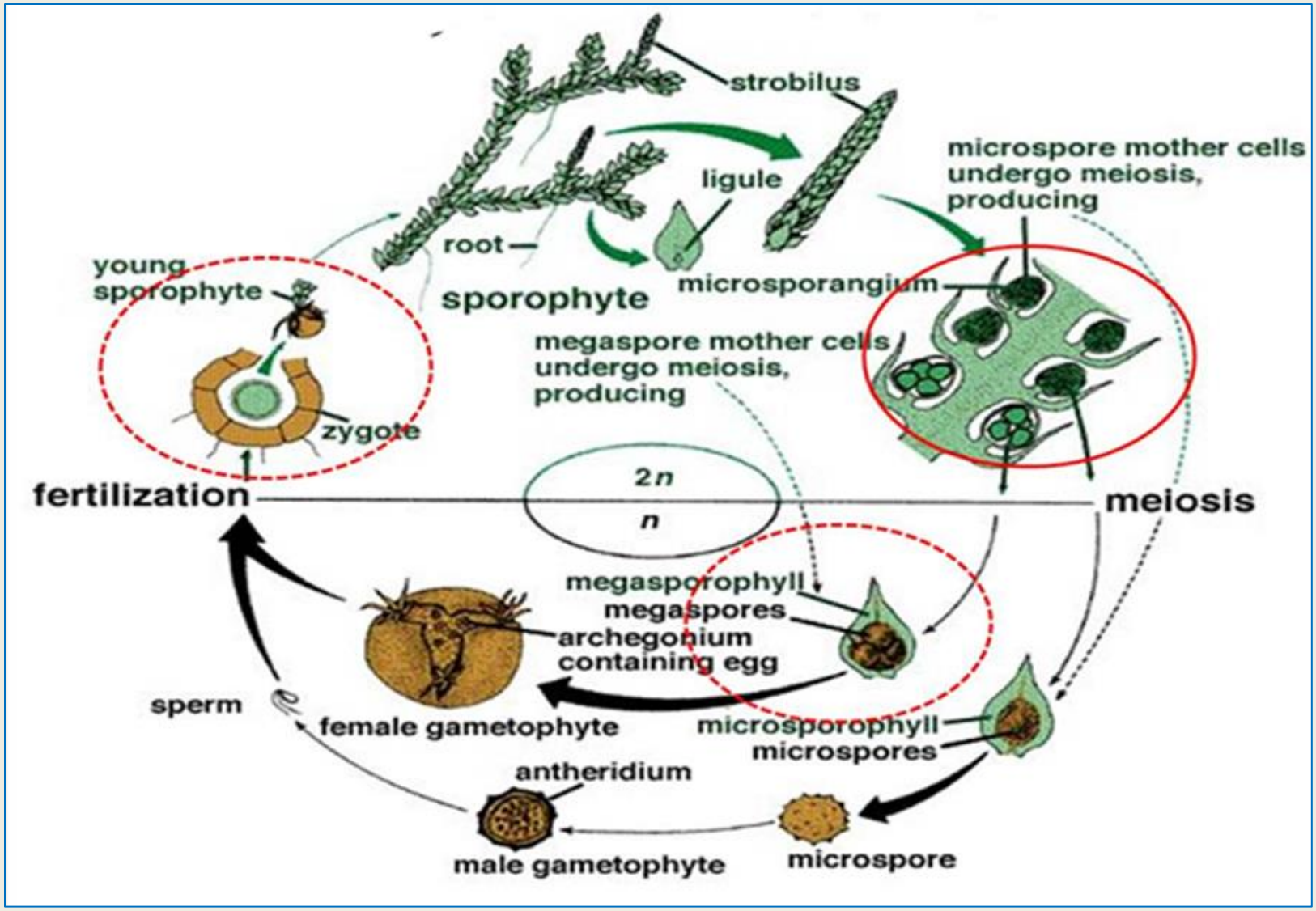


Diagramme showing different stages in Life cycle of a heterosporous pteridophyte (Selaginella)

Suggested Readings

Books

A Text Book of Botany : V. Singh, P.C. Pande and D.K. Jain (2008).

Botany for Degree Students –Pteridophyta (vascular cryptogams) : P.C. Vashishta, A.K. Sinha and A. Kumar (2006).

College Botany. Vol. 2 : H.C. Ganguly and A.K. Kar (1999).

Pteridophyta, Sharma, O P (2012).

Pteridophyta : Rashid, A (1999).

Important websites and links

http://www.biologydiscussion.com/pteridophytes
https://species.wikimedia.org/wiki/Pteridophyta

Thank You