TRULY AMAZING BIO CLASS IN EM

Sampath Biology

UNIT 04

4.4.0. Reproductive Process in Plants

4.4.1. Trends in life cycles to relate the adaptations of plants for a terrestrial life

Biology
ENGLISH MEDIUM

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4. 4.0 : Inquires into the reproductive process in plants

4.4.1: Uses the trends in life cycles, to relate the adaptations of plants for a terrestrial life

Learning Outcomes :

- states the special features of sexual reproduction of terrestrial plants
- explains the terms haploid generation, diploid generation, sphorophyte and gametophyte
- briefly explains alternation of generation
- states the basic features of life cycles of *Pogonatum, Nephrolepis, Selaginella,Cycas, and* Anthophyta
- accepts that in the evolution of land plants, gametophytic generation gradually reduced and the sporophytic generation became dominant as an adaptation to land habit

Suggested Teaching-Learning Process

- Introduce haploid and diploid generations in a life cycle.
- Introduce the gametophyte and saprophyte in relation to plant life cycle.
- Introduce the alternation of generations in relation to plant life cycle.
- Briefly explain the basic features of the common life cycle of terrestrial plants.
- Briefly describe the basic features of the following life cycles using diagrams and teaching aids.
  1. Life cycle of *Pogonatum*and the terrestrial adaptations.
  2. Life cycle of *Nephrolepis*andtheterrestrial adaptations.
  3. Life cycle of *Selaginella*and the terrestrial adaptations.
  4. Life cycle of *Cycas*and the terrestrial adaptations.
  5. Life cycle of Angiosperms and terrestrial adaptations.
- Explain how the gametophyte generation has gradually reduced and the saprophytic generation became dominant as an adaptation in the evolution of land plants.
- Let student groups prepare a presentation on plant life cycles and let them present it.

Assessment and Evaluation:

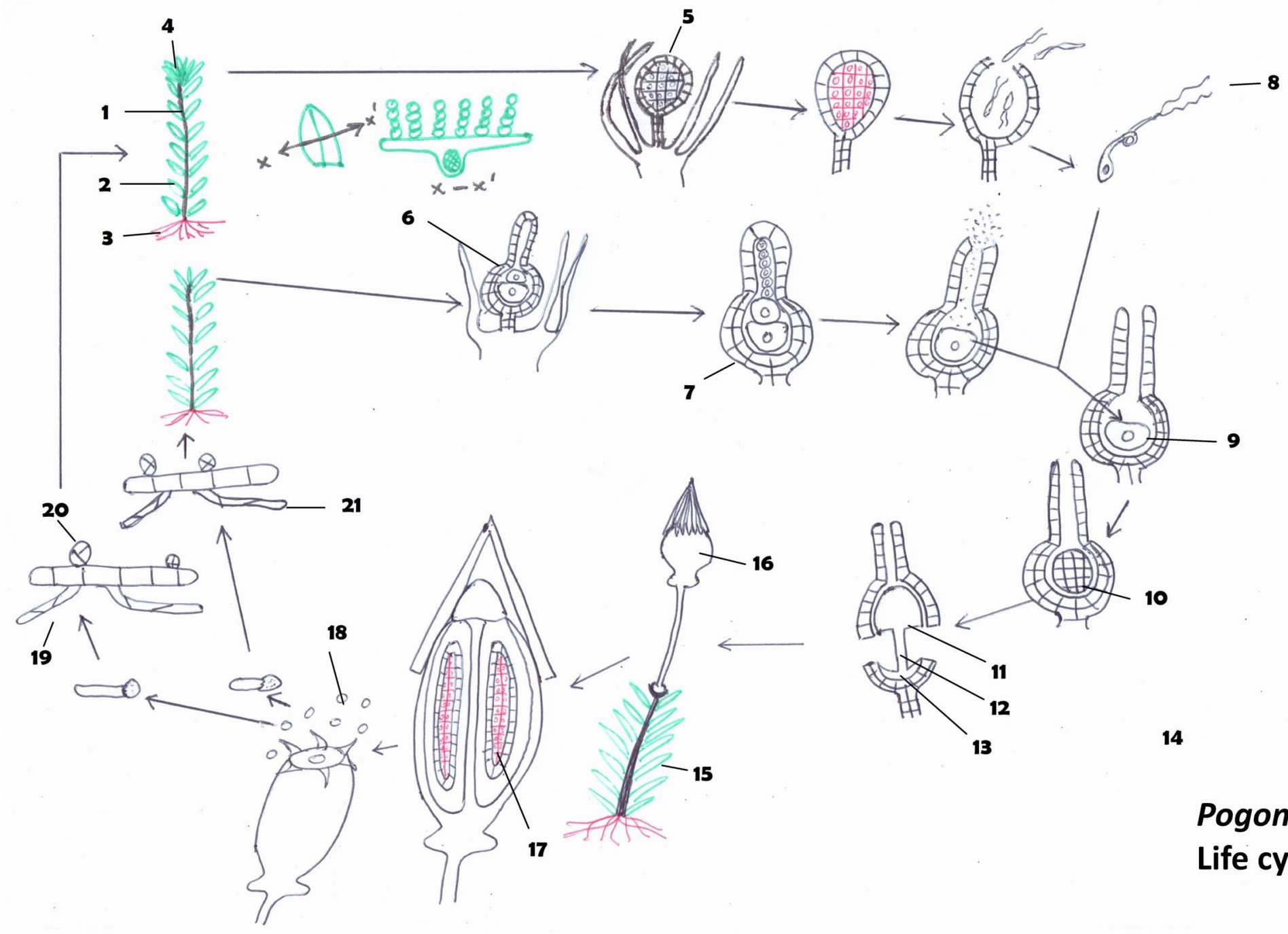
- Use the following criteria to assess student group presentations.
- Attractiveness
- Clarity
- Accuracy of information
- Adequacy of information

Sexual reproduction of terrestrial plants

- **The life cycles of all land plants exhibit alternation of generations, which means the presence of haploid generation and diploid generation alternatively, with each producing the other.**
- **The two multicellular body forms that alternate in the life cycles of land plants are the haploid gametophyte and diploid saprophyte which are morphologically different.**
- **Therefore called heteromorphic alternation of generations. Their reproductive organs (gametangia and sporangia) are protected by sterile cell layers to prevent desiccation of mother cells. (gamete forming cells and spore forming cells).**
- **Gametophytes produce gametes by mitosis.**
- **All land plants carryout internal fertilization to prevent desiccation of gametes.**
- **Female gamete (ovum) is retained in the archegonium and male gametes (anthrozoids) are released from the antheridium. Seedless plants depend on external water for fertilization, but seed plants do not depend on external water for their fertilization.**
- **After fertilization, diploid zygote is retained within the gametophyte to produce an embryo which is nourished by the gametophyte.**
- **Embryo develops into the diploid sporophyte.**
- **Delay of meiosis after fertilization results in creating a diploid sporophytic generation.**
- **Diploid sporophyte produces haploid spores by meiosis.**
- **Spores grow into haploid gametophytes.**
- **In the course of evolution of land plants, diploid sporophytic generation acquire adaptations needed for successful colonization on land and become dominant plant in the life cycle.**
- **Gametophytic generation gradually reduced and has become dependent on the sporophytic generation in seed plants.**

Life cycle of *Pogonatum*

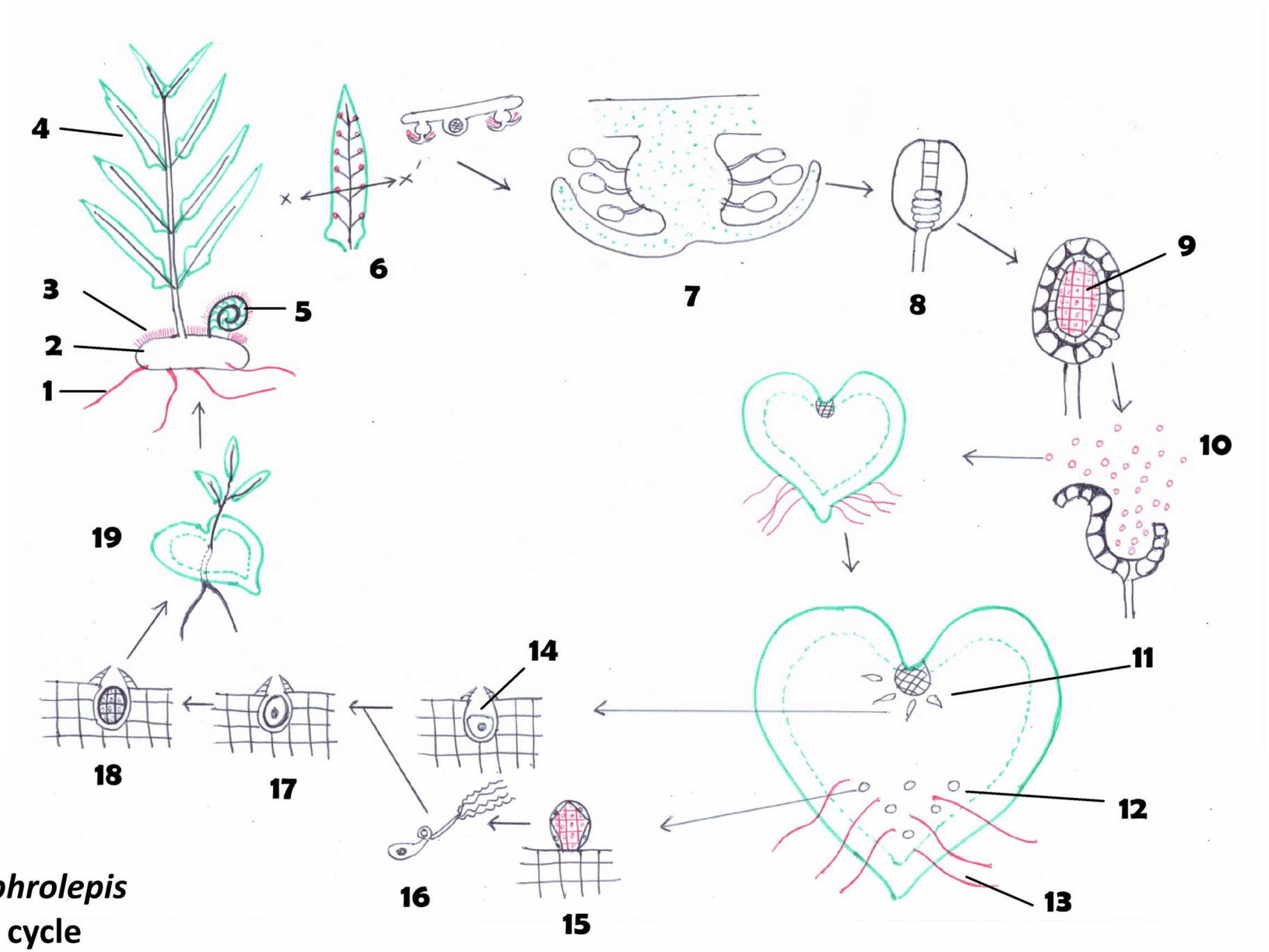
- **Gametophyte is the dominant plant, larger and longer-living than sporophyte.**
- **Gametophyte is photosynthetic.**
- **'Stem', 'leaves', and rhizoids are present in the gametophyte**
- **Gametophytes are dioecious (unisexual). Mature male gametophytes produce antheridia in which several sperms are produced.**
- **Female gametophytes produce archegonia. A single ovum is produced within the archegonium.**
- **The ovum is not released.**
- **Flagellated, motile sperm swims through external water towards ovum, entering the archegonium in response to chemical attractants.**
- **Sperm fuses with the ovum resulting diploid zygote. This occurs in the archegonium.**
- **After fertilization zygote develops into the embryo.**
- **The embryo is also retained within the archegonium and develops into the diploid sporophyte by obtaining nutrients from the gametophyte.**
- **The sporophyte remains attached to the gametophyte.**
- **The sporophyte consists of a foot, seta and a capsule (sporangium).**
- **The foot absorbs nutrients and water from the gametophyte.**
- **The capsule produces spores by meiosis. Homosporous.**
- **If spores are dispersed to a favorable habitat, (such as moist soil or tree bark) they may germinate and grow into a green, branched filament called protonema.**
- **Protonema produces buds that grow into gametophytes.**



Pogonatum
Life cycle

Life cycle of *Nephrolepis*

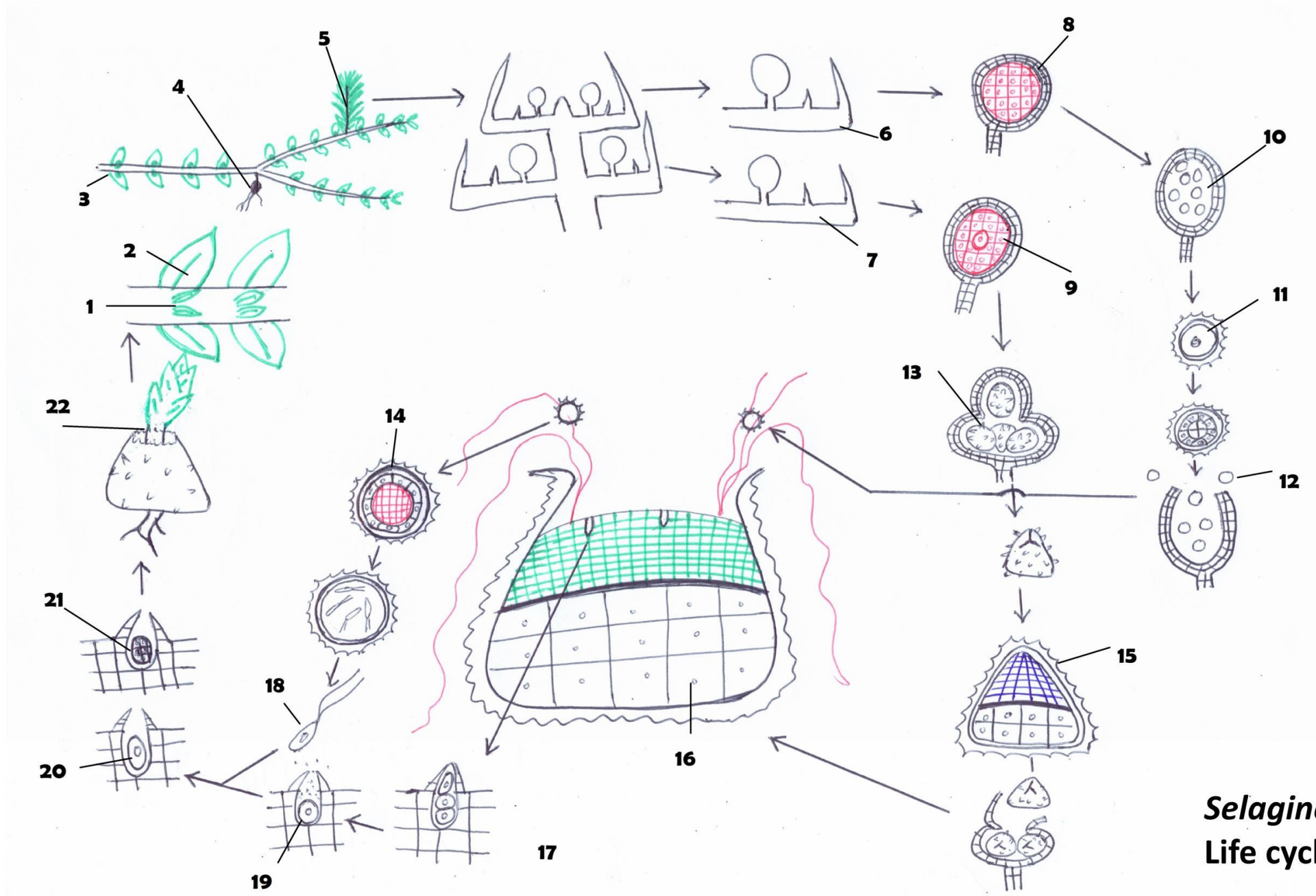
- **Sporophyte is dominant**
- **Gametophyte is reduced and short lived.**
- **Both sporophytes and gametophytes are independent and photosynthetic.**
- **Sporophytes have more complex structure.**
- **Plant body is differentiated into roots, stem and leaves.**
- **Cuticle is found on aerial parts of the plant body**
- **Stomata are developed on aerial parts for gaseous exchange.**
- **Two types of vascular tissues, xylem and phloem are developed**
- **They have fiddlehead young leaves**
- **Stem is an underground rhizome**
- **Leaves are compound pinnate leaves**
- **Long underground branches called stolons arise from the rhizome which gives rise to new plantlets.**
- **Sporangia are developed as clusters called sori on the underside of mature leaflets. Sori are covered by the indusium, protecting the young sporangia from desiccation. Spores are produced in the sporangium by meiosis and are homosporous.**
- **When the sorus matures, indusium dries up and shrivels, exposing mature sporangia.**
- **Under dry environmental conditions sporangium wall ruptures, releasing spores.**
- **Spores are dispersed by wind.**
- **When spores are dispersed to a favourable habitat they may germinate and grow into a gametophyte**
- **Gametophyte is a small heart shaped, macroscopic, green coloured photosynthetic thallus.**
- **Rhizoids develop on the ventral surface.**
- **Gametophytes are monoecious (bisexual).Antheridia and archegonia are developed on the ventral side.**
- **Antheridium produces sperms and releases them into the external environment.**
- **Archegonium produces one ovum and retains it.**
- **Motile sperms swim through external water towards ovum entering the archegonium in response to chemical attractants.**
- **Sperm fuses with the egg resulting the diploid zygote.**
- **After fertilization zygote develops into the embryo and then to the young sporophyte while retained in the gametophyte.**
- **All the developmental stages are nourished by the gametophyte.**
- **When the young sporophyte develops its photosynthetic tissues, it becomes an independent plant.**



Nephrolepis
Life cycle

Life Cycle of *Selaginella*

- Sporophytes are dominant and photosynthetic.
- Gametophytes are reduced in structure and short-lived, partially depend on the sporophyte.
- Sporophyte plant body is differentiated into roots, stem and leaves. Vascular tissues present.
- Herbaceous.
- Heterophyllous leaves are arranged as pairs.
- Stem is dorsiventrally flattened.
- Sporangia are borne on the specialized leaves called sporophylls.
- Sporophylls are compactly arranged in a terminal strobilus.
- Two types of sporophylls called megasporophyll and microsporophyll are arranged in the same strobilus.
- Megasporophyll produces a single megaspongium and microsporophyll produces a single microsporangium.
- Morphologically two different types of spores are produced. This nature is called heterospory.
- Megasporangium produces four large megaspores by meiosis.
- Microsporangium produces numerous small microspores by meiosis.
- Both types of spores have thick/tough walls.
- Microspores are retained in the microsporangium and develop into young male gametophytes.
- Young male gametophytes are enclosed by the wall of microspore which, are released by the microsporangium.
- In the external environment they become mature male gametophytes.
- Male gametophytes is microscopic, enclosed in the microspore wall, non-photosynthetic, depend on stored food.
- Male gametophytes produce flagellated sperms and release them into the external environment.
- Megaspores are released into the external environment. In the external environment they develop into female gametophytes.
- Female gametophyte is multi-cellular, surrounded by the thick wall of megaspore, Few rhizoids develop.
- Photosynthetic, but partially depend on stored food in the megaspore.
- Archegonia develop at the superficial regions and are fully embedded in the gametophytic tissue.
- One egg is produced inside the archegonium.
- Sperm swims towards the egg (n)using flagella through external water, entering into the archegonium and fertilizes the egg (n) resulting in a zygote(2n).
- Zygote develops to form an embryo and then embryo develops to form a young sporophyte by obtaining nutrients from the female gametophyte.
- Sporophyte generation is the larger and more complex form in the alternation of generation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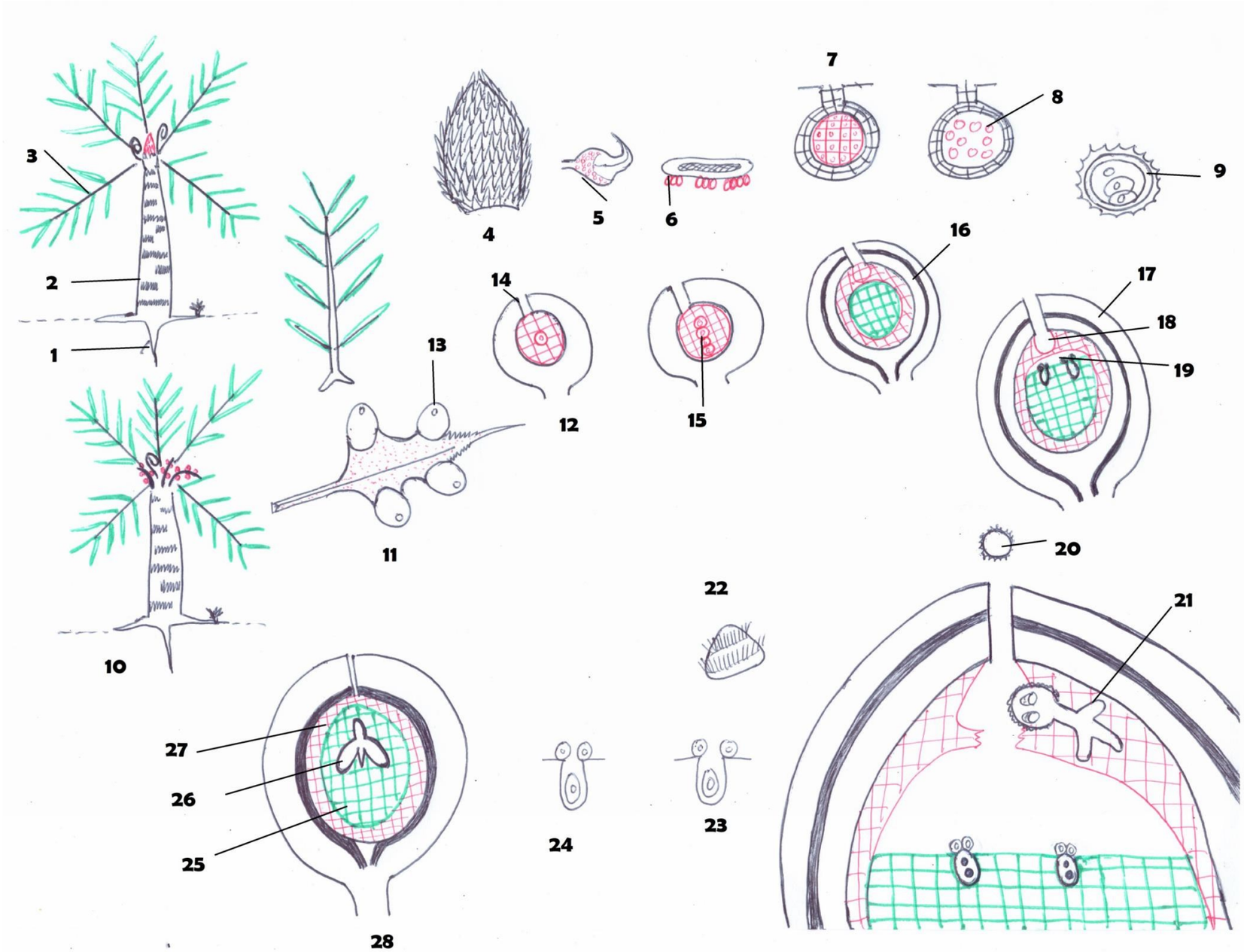
Selaginella
Life cycle

Life cycle of *Cycas*

- **Sporophytes are the dominant photosynthetic plants in the life cycle, gametophytes are reduced and depend on the sporophyte throughout its life.**
- **Sporophytes are a perennial tree with roots, stem and leaves.**
- **Stem is unbranched columnar and woody.**
- **Leaves are arranged in crowns.**
- **Compound leaves showxerophytic adaptations and young leaves are fiddleheads.**
- **Sporophytes are heterosporous and dioecious. Sporophytes have developed a tap root system.**
- **Secondary growth is present.**
- **Sporophytes which produce megaspores are called female plants and those which produce microspores are called male plants.**
- **Mature female plant produces a crown of megasporophylls.**
- **Megasporangium is enclosed in the protective layer called integument to form the ovule.**
- **Integument has a small pore in the distal end of the ovule called micropyle.**
- **One of the cells in the megasporangial tissue differentiates into a single megaspore mother cell.**
- **Megaspore mother cell undergoes meiosis to form four haploid megaspores out of which only one remains functional.**
- **The remaining megasporangial tissue functions as nucellus which provides nourishment.**
- **Megaspores are not released to the external environment megaspore develop into the female gametophyte (n) while within the ovule.**
- **Mature ovule contains the female gametophyte.**
- **The female gametophyte produces several archegonia. Each archegonium produces a single egg cell within it.**
- **Mature male plants produce male cones with microsporophylls which consist of microsporangia on the lower surface.**
- **Large number of microspores (n) are produced from microspore mother cells (2n) within the microsporangium by meiosis.**
- **They develop into pollen grains within the sporangium and then discharge.**
- **Pollen grains are dispersed by wind and deposited on the micropyle of amature ovule is called pollination.**
- **Pollen grains enter into pollen chamber of the ovule through the micropyle. In the pollen chamber, pollen grains develop into male gametophytes.**
- **Male gametophytes consists of a branched pollen tube which involves in absorption of nutrients from the nucellus. Male gametophyte is short-lived.**
- **Produce two large sperms with a spiral and of numerous flagella.**
- **The basal end of the pollen tube ruptures releasing sperms into the archegonial chamber of the ovule.**
- **Sperms swim through the liquid medium and fertilizes the egg resulting the 2n zygote.**
- **Zygote develops into the embryo.**
- **Remaining female gametophyte becomes the endosperm which provides nutrients for the developing embryo during seed germination. Integument becomes the seed coat.**
- **The ovule becomes the seed. Seed is the dispersal unit which contains the embryo and stored food that are enclosed in the seed coat.**
- **Seeds are dispersed and under favorable environmental conditions seeds germinate producing the seedlings (young Sporophyte).**



Cycas

Life cycle

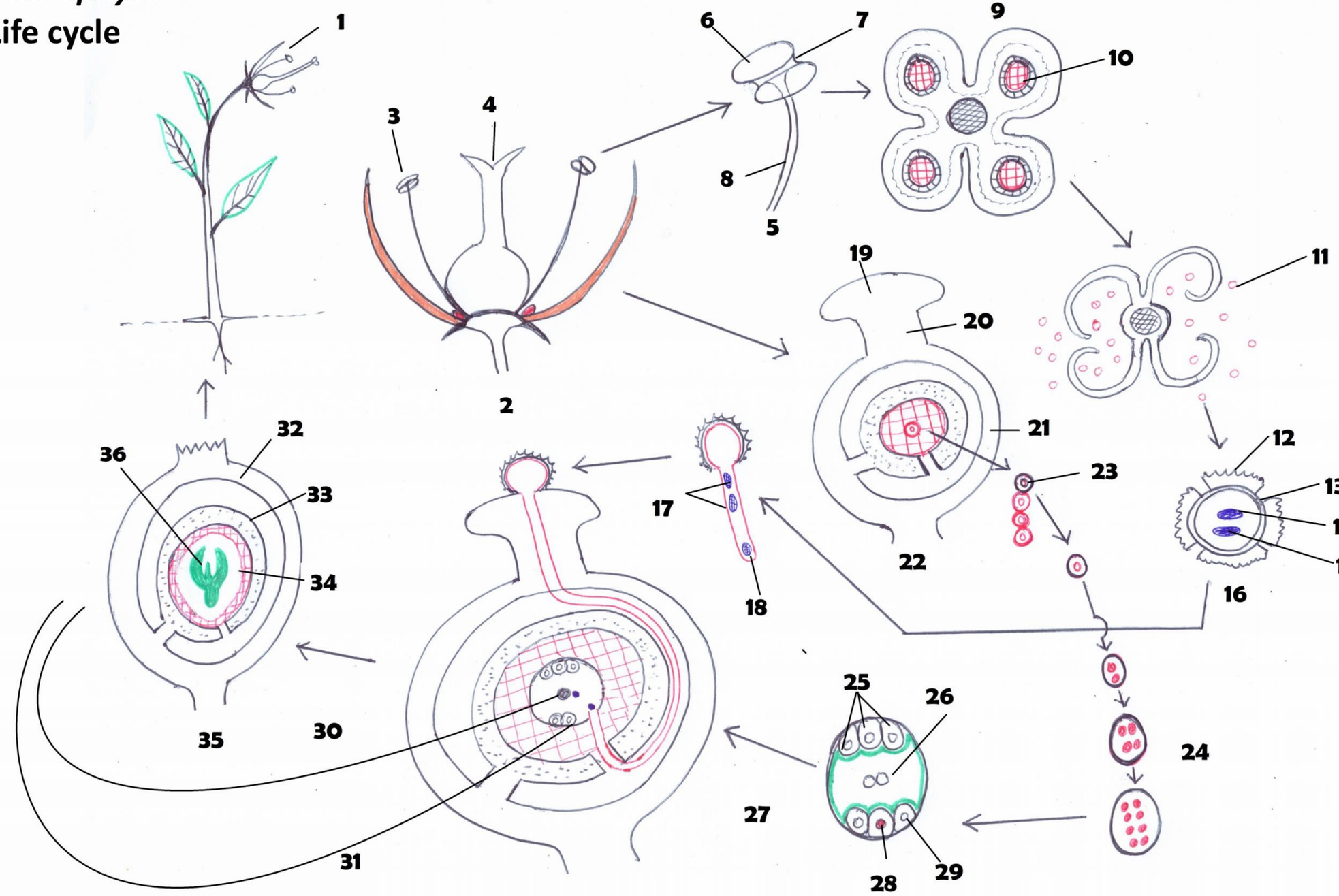
4.4.2. structures and functions associated with sexual reproduction in flowering plants.

Life cycle of flowering plants

- **Sporophyte is the dominant plant. Gametophytes are short-lived, microscopic, entirely depend on the sporophyte.**
- **Sporophyte produces the reproductive structures called flowers.**
- **A flower is a specialized shoot with four whorls of modified leaves named sepals, petals, stamens and carpels.**
- **Sepals are usually green, enclose and protect the flower before it opens.**
- **Petals are brightly coloured in most flowers and aid in attracting pollinators. (But wind pollinated flowers generally lack brightly coloured parts).**
- **The sepals and petals are sterile floral organs. They do not directly involve in reproduction.**
- **Stamens are the microsporophylls.**
- **The stamen consists of a stalk called filament and two terminal lobes called anther.**
- **Anther is made up of microsporangia (pollen sacs) containing microspore mother cells which produce microspores by meiosis. Microspores develop into pollen grains within the anther.**
- **A pollen grain contains two nuclei, the tube nucleus and generative nucleus.**
- **Carpels are the megasporophylls. At the tip of the carpel is a sticky stigma that receives pollens.**
- **The swollen base of the carpel forms the ovary.**
- **Ovary contains one or more ovules A long, slender neck called style connects ovary with stigma.**
- **Ovule produces four megaspores by meiosis of which only one becomes functional.**
- **Functional megaspore develops into the female gametophyte called the embryo sac.**
- **It is a highly reduced microscopic structure.**
- **The mature embryo sac consists of eight nuclei contained within seven cells three antipodal cells, two polar nuclei in the central cell, two synergids and one egg.**

Anthophyta

Life cycle



4.4.2 : Examines structures and functions associated with sexual reproduction in flowering plants
Number of Periods : 08
Learning Outcomes:

- Briefly explains the structure and functions of the important parts of the flower as the reproductive organ of anthophyta (parts of androceium and oogonium)
- Defines pollination, self-pollination, and cross pollination
- Writes down the importances/advantages of cross pollination
- Bbriefly explains the fertilization process
- States the important features of embryo, seed, and fruit development
- States the differences between parthenogenesis and parthenocarpy with examples
- State what is seed dormancy
- States the importance of seed dormancy
- States the main physiological differences taking place at the beginning of seed germination
- Appreciates the diversification of plants for the existence of the all forms life on land

Suggested Teaching-Learning Process

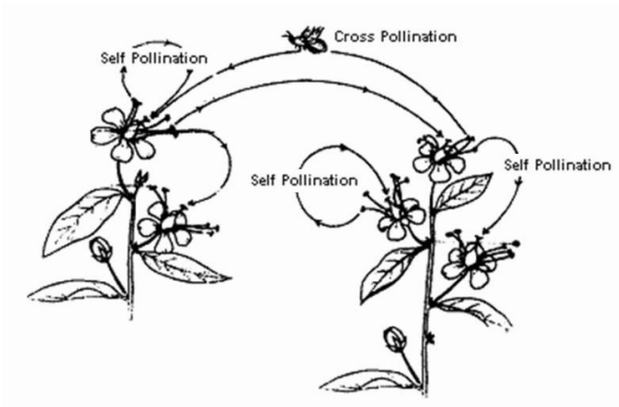
- Assign each student to bring different types of flowers including *Hibiscus rosasinensis.*
- Conduct an open discussion on the flower *Hibiscus rosasinensis* as the typical flower.
- Let them study the parts of a flower using the flower of *Hibiscus rosasinensis.*
- Describe how pollen is produced and released by stamens.
- Use suitable diagrams/ video clips/ charts to describe the structure of typical ovary, structure of an ovule and the development of the female gametophyte.
- Define pollination, self pollination and cross pollination.
- State the mechanisms that prevent self-pollination.
- Discuss the significance of cross pollination.
- Guide students to identify adaptations for cross-pollination.
- Explain how pollen germinates on stigma, and how fertilization, seed development, fruit development take place using pictures/diagrams/ video clip etc.
- Ask students to collect samples of seeds and fruits and help them to identify parts of them.
- Discuss differences between parthenocarpy and parthenogenesis with examples.
- Explain physiological changes of seed germination.
- Explain seed dormancy, significance of dormancy and common causes of seed dormancy.

Assessment and Evaluation

- Assess student group work based on identification of ;
- parts of a flower
- parts of a fruit
- Use the following criteria to assess student performance on identification of parts
- Accuracy
- Team work
- Time management

Pollination

- **Transfer of pollen grains to a mature stigma is known as pollination.**
- **In some plant species, pollen grains are transferred from an anther of a flower on to the stigma of the same flower or flower of same plant. This is self-pollination**
- **Pollen may be transferred to a stigma of a flower of another plant of same species. This is cross pollination.**
- **Most angiosperm plants are adapted for cross pollination.**
- **Typical characteristics of flowers like such as colour and odour, favour cross pollination.**
- **In addition, some plants show special types of adaptations cross pollination.**



Eg. Heterostyly, Self infertility, Uni -sexuality

Adaptations for Cross Pollination

1. **Heterostyly**
- Stamens and stigma arranged in different manner.
- One form of flowers bears long stamens and short styles, other form bear short stamens and long style.

2. **Self sterility**
- In certain flowers the pollen grains are unable to germinate on its own stigma.
  Eg: *Passiflora* (Passion flower)

3. **Unisexuality**
- Stamens and carpels lie in separate flowers.
  Eg: *Zea mais, Cocos*.

4. **Dichogamy**
- In many bisexual flowers the anther and stigmas often mature at different times.

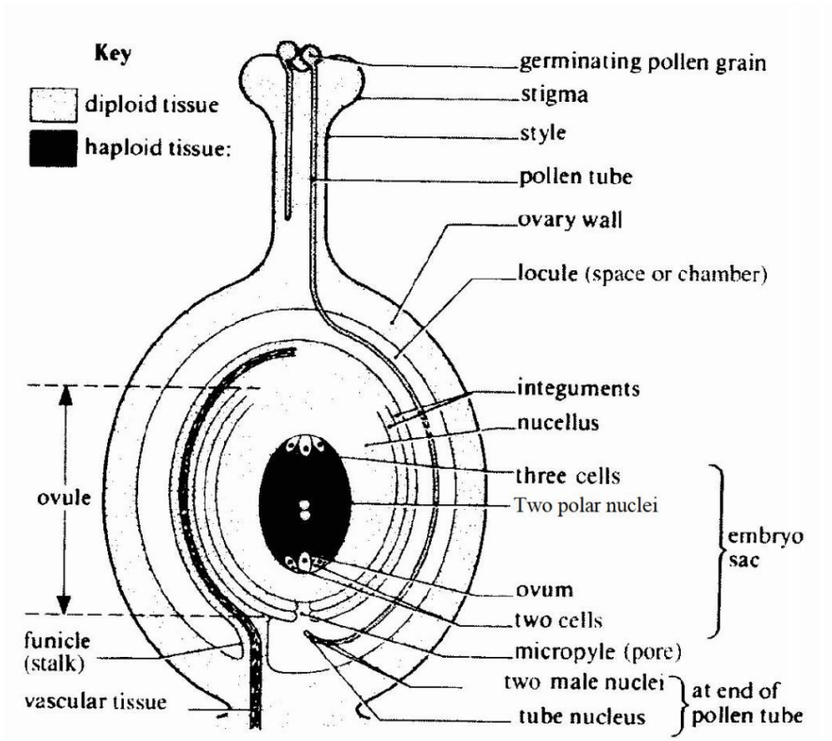
Significance of cross pollination

1. **Cross pollination results in cross fertilization.**
2. **Cross fertilization allows shu□?ing of genes within a species, producing new genetic combinations resulting increased genetic variation within the species.**
3. **These features are very important for survival and also might lead to evolution.**

Fertilization

- **The pollen grain germinates after it is placed on the stigma.**
- **It extends a pollen tube that grows down through the style of the carpel.**
- **The generative nucleus divides forming two sperm nuclei.**
- **When the pollen tube reaches the ovary, it moves through the micropyle (The pore in the integuments of the ovule) and discharges two sperm nuclei into the embryo sac.**
- **One sperm nucleus fuses with the egg cell forming a diploid zygote and the other sperm nucleus fuses with the 2 polar nuclei. This type of fertilization is called double fertilization and is unique to angiosperms.**

- After double fertilization, the ovule matures into a seed. The zygote develops into the embryo. The triploid nucleus develops into the endosperm that store food.



- The significance of double fertilization is that it synchronizes with the development of the embryo.
- If fertilization does not occur that prevents plants from wasting nutrients on infertile ovules.
- The seed consists of the embryo, endosperm with store food and a seed coat.
- Seeds are enclosed in the fruit.

- Fruit is an enlarged and developed ovary, usually after being stimulated by fertilization. Fertilization triggers hormonal changes that cause the ovary to form a fruit.
- If a flower has not been pollinated, fruit does not develop, and entire flower falls away.
- During fruit development, the ovary wall gets converted to the pericarp.
- In some plants fruits develop from the ovary without fertilization. This is called parthenocarpy.
- Parthenocarpic fruits do not develop seeds.
- Parthenocarpy occurs naturally in some species. Eg. Banana
- It also can be induced with plant growth substances to get seedless fruits. Eg. Grapes, Orange
- In some plants, seeds develop without fertilization. This is called parthenogenesis. Eg. certain grasses
- In parthenogenesis,
  1. The egg is resulted by mitosis and hence is diploid, or
  2. Haploid ovum fuses with a polar nucleus, or
  3. The genetic content of the egg is duplicated to become diploid, enabling seed development without fertilizing by the sperm.

Significance of development of seed and fruit

Seed

- Seed is the dispersal unit of seed plants which contains the embryo and stored food, surrounded by the seed coat
- The seed habit has a strategy for life on land:
- The presence of,
  1. Seed coat - Helps to survive in extreme conditions
  2. Food reserves - Provide nourishment to the embryo during development
  3. Dormancy period - Helps to survive during unfavorable conditions
  4. Adaptations for dispersal - Give a better chance for growth, development and survival.

Practical

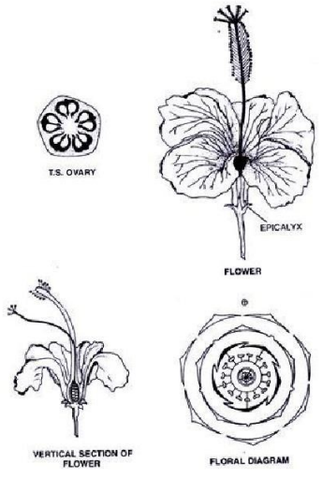
- Assign each student to bring different types of flowers including *Hibiscus rosasinensis.*
- Conduct an open discussion on the flower *Hibiscus rosasinensis* as the typical flower
- Let them study the parts of flower using the flower of *Hibiscus rosasinensis*
- Describe how pollen is produced and released by stamens
- Use suitable diagrams/ video clips/ charts to describe the structure of typical ovary, structure of an ovule and the development of female gametophyte

Fruits

- Protects the enclosed seeds.
- When mature, aids in their dispersal by wind, water or animals.
- After being dispersed, if environmental conditions are favourable, a seed may germinate to form a seedling.

Seed Dormancy

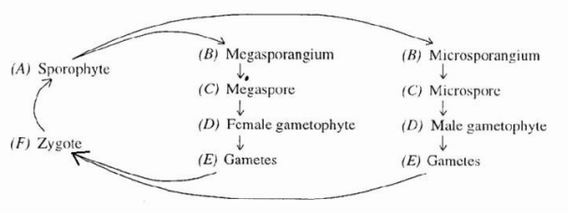
- Inhibition of embryo within the seed at one stage of maturation, naturally prevents germination of seeds within fruit, which is called seed dormancy.
- Many seeds have mechanisms of inhibiting germination and remain dormant.
- Presence of inhibitors, presence of thick/strong seed coats, presence of seed coats impervious to water are common causes of seed dormancy.
- After breaking seed dormancy, when water, oxygen and suitable temperature are provided, seeds start to germinate.
- Absorption of water, activation of enzymes, mobilization of food resources (nutrients) followed by rapid growth process of the embryo extending radical through the seed coat is called seed germination.
- Radical shows positive geotropism and plumule shows negative geotropism.



MCQ

1. Which of the following statements regarding *Pogonatum* is **incorrect?**
(1) Rhizoids are multicellular (2) Scales are absent (3) Photosynthetic filaments are exposed
(4) Do not produce asexual reproductive bodies (5) Protonema shows dichotomous branching

Questions No. 2, 3 4 and 5 are based on the following diagram of a life cycle.



2. Between which two stages of the above life cycle does meiosis take place?
(1) E and F (2) G and A (3) A and B (4) B and C (5) C and D

3. The haploid generation in the above life cycle is represented by stages.
(1) *A, B,* and C. (2) *B, C,* and D. (3) *C, D,* and E. (4) *D, E,* and F. (5) E, F and A

4. Which of the following pairs of plants show the type of life cycle shown above?
(1) Nephrolepis and *Pogonatum* (2) *Nephrolepis* and *Selaginella* (3) *Pogonatum* and *Selaginella*
(4) *Nephrolepis* and *Cycas* (5) *Cycas* and rice

5. If the life cycle shown above is that of *Selaginella* which of the following represent unicellular stages?
(1) E only (2) B only (3) F and E only (4) B, D and E only (5) B, C, D and E only

6. Which of the following statements regarding *Cycas* is **incorrect?**
(1) Sporophyte is dioecious (2) Megasporangium produces several gametophytes
(3) Female gametophyte produces endosperm. (4) Male gametophyte produces two gametes.
(5) Single seed may contain several embryos

7. A fern differs from a moss in having.
(1) An independent gametophyte (2) An independent sporophyte (3) Motile sperms (4) Archegonia (5) Haploid spores

8. Select the correct statement.
(1) The sporophyte of *Pogonatum* is better developed than the sporophyte of *Nephrolepis.*
(2) The sporophyte of *Pogonatum* is differentiated into roots, stem and leaves.
(3) Some fungi can lead an autotrophic existence.
(4) Production of motile gametes is a characteristic feature of all algae.
(5) Both antheridia and archegonia are usually present on the same gametophyte of *Nephrolepis.*

9. Which of the following represents a pair of homologous structures?
(1) Megasporophyll of *Cycas* and carpel of an Angiosperm (2) Rhizoid of *Mucor* and the root of *Nephrolepis*
(3) Sorus of *Nephrolepis* and male cone of *Cycas*
(4) Archegonium of *Selaginella* and embryo sac of an Angiosperm.
(5) Capsule of *Pogonatum* and megasporangium of *Cycas.*

10. Which of the following statements is / are incorrect regarding *Nephrolepis?*
(A) Plant body is differentiated into roots, stem and leaves. (B) Possesses multicellular reproductive structures.
(C) No thallus phase is present in the life cycle. (D) Show heterospory. (E) Vascular tissues are present.

11. Which of the following comparisons between algae and plant is correct?
(1) Thallus mature vegetative body is found in algae but not in bryophytes.
(2) The life cycles of all algae and all bryophytes show heteromorphic alternation of generations.
(3) The gametophytic generation of both algae bryophytes is autotrophic while sporophytic generation of both is totally dependent on gemetophytic generation for nutrition. (4) All algae and all bryophytes contain chlorophyll a only.
(5) Reproductive structures of algae are mostly unicellular those of bryophytes are multicellular.

12. Which of the following is incorrect regarding both ***Selaginella*** and ***Cycas****?*
(1) Male gametes are motile.(2) Female gametophyte produces several archegonia.
(3)Megaspore produces one female gametophyte.
(4) Embryo is nutritionally supported by female gametophyte. (5) Sporophytes are dioecious.

13. In *Pogonatum,*
(1) The sporophyte is totally dependent on the gametophyte.(2) Gametophyte is dioecious.(3) Two types of spores are formed
(4) Male gametes are multiflagellate. (5) Spores germinate while still within the sporangium, before their release.

14. What is/are the feature is that can be seen in *Nephrolepis* but not in *Pogonatum?*
(A) Well developed vascular tissue. (B) Independent gametophyte. (C) Independent sporophyte. (D) Haploid spores
(E) Motile reproductive cells.

15. What taxon/taxa contain marine life'?
(A) Chlorophyta (B) Bryophyta (C) Chondrichthyes (D) Reptilia (E) Lycophyta

16. Plants which show heteromorphic alternation of generations always
(1) have independent gametophytes and independent sporophytes
(2) have morphologically dissimilar gametophytes and sporophytes.
(3) have sporophytes which are more differentiated than gametophytes.
(4) have sporophytes which are less differentiated than gametophytes.
(5) have -small gametophytes and large sporophytes.

17. Which of the following statements regarding life cycles of plants is incorrect?
(1) *Pogonatum* has unisexual gametophytes. (2) *Nephrolepis* spores are dispersed by water.
(3) *Selaginella* produces two types of sporangia. (4) *Cycas* produce seed without fruits.
(5) *Selaginella* gametophyte grows inside spore wall.

18. Which of the following statements regarding a comparison of the ovules of *Cycas* and angiosperms is incorrect?
(1) *Cycas* ovule has archegonia but angiosperm ovule does not.
(2) *Cycas* ovule has a pollen chamber but angiosperm ovule does not.
(3) Angiosperm ovule has one embryo sac while *Cycas* ovule has several embryo sacs.
(4) Angiosperm ovule has only one egg cell while *Cycas* ovule has several egg cells.
(5) Angiosperm ovule has a funiculus but *Cycas* ovule does not.

19. Which one of the following statements regarding a comparison of life cycles of *Nephrolepis* and *Selaginella* is incorrect?
(1) *Nephrolepis* produces sori but *Selaginella* does not.
(2) *Nephrolepis* produces one type of gametophyte but *Selaginella* produces two types of gametophytes
(3) Gametophytes of *Nephrolepis* are photosynthetic but gametophytes of *Selaginella* are not photosynthetic
(4) Sperms of *Nephrolepis* are multiflagellate while those of *Selaginella* are biflagellate.
(5) Gametophytes of *Nephrolepis* produce many antheridia while gametophytes of *Selaginella* produce only a one antheridium

20. Which of the following is **incorrect** regarding the embryo sac of angiosperms?
(1) The embryo sac contains a two haploid nuclei in central cell. (2) Meiosis takes place inside the embryo sac.
(3) Embryo sac is nourished by nucellus (4) Embryo sac gives rise to endosperm.
(5) Embryo sac contains only one female gamete.

21. Which of the following statements of comparison between *Pogonatum* and *Nephrolepis* is **incorrect**?

	Pogonatum	***Nephrolepis***
(1)	Sporophyte is not differentiated into stem, root and leaves	Sporophyte is different into stem, roots and leaves.
(2)	Gametophyte is unisexual	Gametophyte is bisexual.
(3)	Male gametes are biflagellate	Male gametes are multi -flagellate.
(4)	Sporangia are not produced in groups.	Sporangia are produced in groups.
(5)	Zygote does not produce an embryo	Zygote produces an embryo.

22. Which of the following is/are least likely to have contributed to the dominance of flowering plants on earth?
(A) Autotrophic mode of nutrition (B) Large size of the plants (C) Evolution of seeds (D) Presence of cutin on the aerial surface of plants (E) E□?cient mechanisms for dispersal of spores and seeds

23. Which of the following is not an adaptation of flowers to ensure cross pollination?
(1) Unisexuality (2) Dichogamy (3) Bisexuality (4) Heterostyly (5) Self sterility (AL 1990)

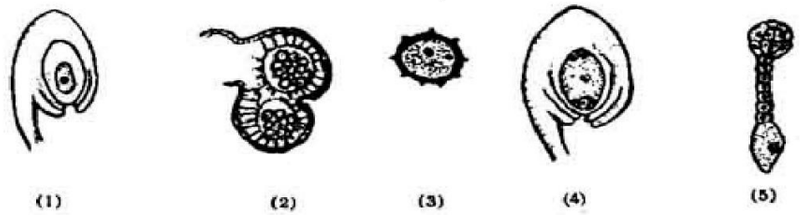
24. Which of the following cells in the angiosperms ovule contain haploid nuclei.
(1) Cells of funicle (2) Cells of integument (3) Cells of nucellus (4) Megaspore mother cell (5) Antipodal cells (AL 1990)

25. The male gametophyte of an angiosperm is
(1) Anther with pollen sacs. (2) Sperm cells (3) A microspore (4) A germinated pollen grain. (5) Male nuclei. (AL 1995)

26. Which of the following does not develop from the zygote of Angiosperms?
(1) Endosperm (2) Plumule (3) Hypocotyl (4) Radicle (5) Cotyledon (AL1995)

Question No: 27 and 28 based on the diagrams given below. These diagrams represent different stages is reproduction of an Angiosperm.

27. In which of the structures shown above are all nuclei haploid?



28. In which of the structures shown above is a meiotic division bout to take place?

29. Pollination is said to occur when a pollen grain
(1) Matures and has three nuclei (2) Lands on stigma (3) Releases sperm nuclei
(4) Release its sperm nuclei and fertilizes the egg polar nuclei
(5) When he anther dehisces releasing the pollen.

30. Which of the following is correct regarding the life cycle of flowering plants?
(1) Homospory (2) They have an independent diploid stage. (3) They have an independent haploid stage.
(4) Carpel represents the megasporophyll. (5) Diploid endosperm is formed.

31. Which one of the following is incorrect regarding angiosperms?
(1) Beginning with the outside and proceeding towards the center of the flower the order in which flower parts occur is sepals, petals, stamens and gynoecium.
(2) Unisexual flower is one that lacks either stamens or gynoecium.
(3) Dioecious species are those which have male and female flowers on separate branches of the same plant.
(4) A mature embryo sac before fertilization usually consists of eight cells.
(5) Essential parts of a flower are stamens and Gynoecium.

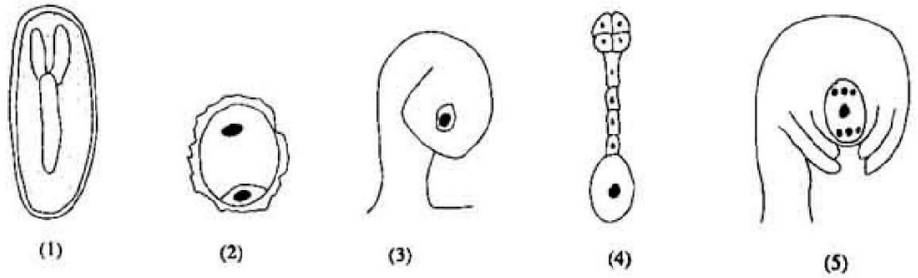
32. Which part of the developing seed of a flowering plant is derived from the female parent only?
(1) Seed coat (2) Endosperm (3) Radicle (4) Plumule (5) Cotyledon

33. Which one of the following statement/s is/ are correct?
(1) Flowers, fruits and companion cells are three features typical of angiosperms.
(2) There is only one ovule in an ovary
(3) Gametophytes of gymnosperms and angiosperms have neither antheridia nor archegonia.
(4) In angiosperms pollen chamber is a cavity in the ovule in which pollen grains are found.
(5) A seed is composed of tissues belonging to two sporophytic generations and one gametophytic generation of flowering plants.

34. Which of the following structural feature of land plants cannot be regarded as an adaptation to land habit?
(1) Cuticle (2) Pollen grains (3) Stomata (4) Vascular system (5) Epidermis

35. Which of the following can be considered to be a common character in aquatic angiosperms?
(1) Absence of stomata (2) Presence of dissected leaves (3) Pollination by water (4) Elongated petioles
(5) Presence of a reduced vascular system

Questions No 36 and 37 are based on the diagrams given below. Diagrams (1 -5) illustrate some stages of the life cycle of a flowering plant whose chromosome number is 20 (twenty)



36. In which of the above stages all the nuclei have 10 chromosomes?

37. Which of the above stages contain some nuclei with 30 chromosomes?

38. Which of the following does not develop from the zygote of a flowering plant?
(1) Cotyledon (2) Radicle (3) Plumule (4) Endosperm (5) Hypocotyl

Structured Essay

A/L 2004

1. A list of organisms and a table of important characteristics of those organisms air given below, in this Select the organism that shows any one of the characteristics given in the table and write the number of that organism in the column labeled as 'organism number' against the relevant characteristic. The first line of the table is completed as an example. Use one organism number only once.

List of Organisms
1.Selaginella/2.rice/3.*Pogonatum/4.Cycas/5.Mucor/6.Ulva/7.Nephrolepis*

Characteristic	**Organism Number**
Seeds produced by self-pollination	2.
Presence of haploid endosperm	.....
Presence of morphologically similar gametangia	.....
Heterophyllus plants	.....
Presence of a flat thalloid body	.....
Presence of free living male and female gametophytes	.....
Presence of antheridia and archegonia on the ventral surface of a **gametophyte**	.....

A/L 2007

2. The following diagram represents the life cycle of *Selaginella*. Name the structures/ Stages labelled as a, b, c, d and e.
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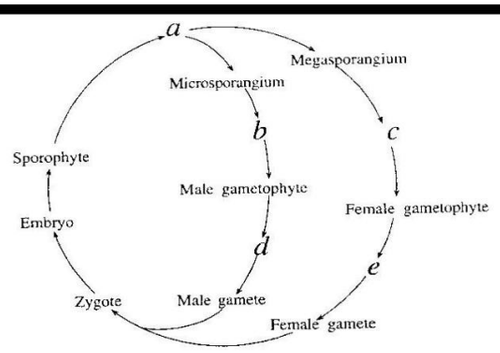
.....
.....
.....



4. What are the names of structures/ stages angiosperm life cycle correspond to the following structures/ Stages in the above diagram?

   a. ……

   b. ……

   c. Female gametophyte ……

A/L 2001

5. (A) The diagram given below indicates different stages of the life cycle of *Cycus* plant.

   Name the stages labelled as 1, 2, 3. 4. 5 and 6.

   1 - ……

   2 - ……

   3 - ……

   4 - ……

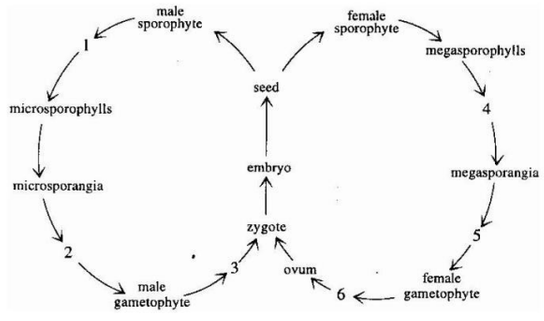
   5 - ……

   6 - ……

(B) Which stage of the above diagram is homologous to the stamens of flowering plants?

(C) Which stage of the above diagram is homologous to carpels of flowering plants?

(D) Explain how microscopes are produced and dispersed in flowering plants.



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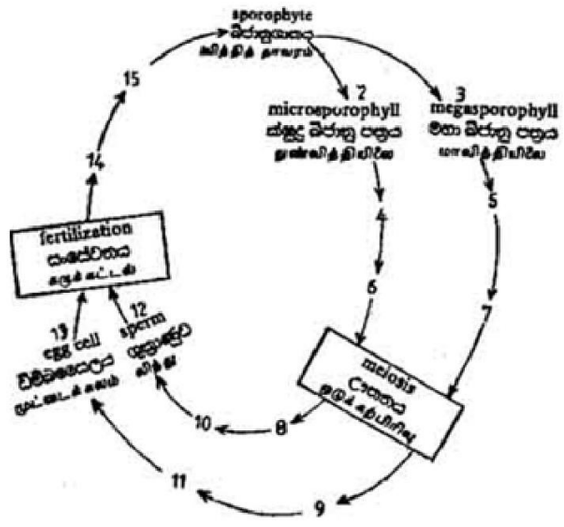
A/L 1990

1. Given below is the typical life cycle of an angiosperm with 15 different stages labeled 1-15. Five (5) of the numbered stages have been named. Select the most suitable word or words from those given below and complete the remaining.

Megaspore	Female gametophyte	Antheridium
Megasporangium	Male Gametophyte	Archegonium
Microsporangium	Prothallus	Endosperm
Megaspore mother cell	Zygote or oospore	Sorus
Microspore mother cell	Embryo	Microspore



4. …… 5. …… 6. ……

7. …… 8. …… 9. ……

10. …… 11 …… 12 ……

13 …… 14 …… 15……

2. Mention two main structural difference you have observed under the light microscope between the hypha of *Mucor* and protonema of *Pogonatum*.

Mucor	***Pogonatum***
1. ……	
2. ……	

3. List two important difference between the spermatozoid of *Pogonatum* and that of *Cycas*.

   1 ……

   2. ……

2016 AL

i. Name the parts that can be seen in a longitudinal section of a mature unfertilized ovule of an angiosperm

....

....

....

....

ii. list the post fertilization changes that take place in the major structures of the angiosperm ovary

....

....

AL 2013

2. (A) (i) Presence of flower is a major distinguishing characteristic of angiosperms. Indicate five other major distinguishing characteristics of angiosperms.

....

....

....

(ii) The following are reproductive structures seen in gymnosperms. Name the corresponding structure for each of them in the angiosperm flower.

Megasporophyll ....

Microsporophyll ....

(iii) State the major characteristic features seen in the life cycle of Selaginella.

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(iv) State the difference between cross-pollination and self-pollination.

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(v) What is the significance of cross-pollination in nature?

....

(vi) What are the adaptations seen in plants for cross-pollination?

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(B) (i) What is a seed?

....

(ii) What features of seeds have enabled seed plants to colonize land?

....

....

....

(iii) What is parthenocarpy?

....

(iv) Name a crop where parthenocarpy occurs naturally.

....

(v) What is parthenogenesis?

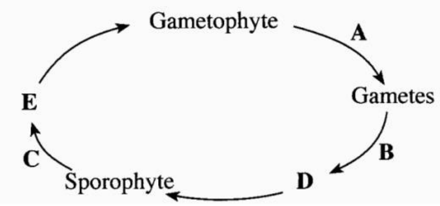
....

(vi) State how parthenocarpy is induced in horticulture and give an example of a crop where it is practiced.

....

2020 AL

(B) (i) A sketch of the life cycle of a land plant is given below. Name the processes denoted by A, B and C and the structures denoted by D and E.



A : ....

B : ....

C : ....

D : ....

E : ....

(ii) State the following types of symbiosis.

Beneficial to both organisms : ....

Beneficial to one organism and no effect on the other : ....

Essay

1. **(a) Describe what is alternation of generation.**
   (b) Describe details of basic lifecycle of *Pogonatum.*

2. **(a) Describe significant features of seedless vascular plants;**
   (b) Describe details of basic lifecycle of *Nephrolepis.*

3. **(a) Describe significant features of seedless vascular plants;**
   (b) *Describe life cycle of Selaginella*

4. **Describe life cycle of Cycas**

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1. (a) Describe what is alternation of generation.
(b) Describe details of basic lifecycle of *Pogonatum.*
Model Answer

(a) Describe what is alternation of generation.

1. The life cycles of all land plants exhibit alternation of generations, which means the presence of haploid generation and diploid generation alternatively, with each producing the other.
2. The two multicellular body forms that alternate in the life cycles of land plants are the haploid gametophyte and diploid sporophyte which are morphologically different.
3. Therefore called heteromorphic alternation of generations.
4. Their reproductive organs (gametangia and sporangia) are protected by sterile cell layers to prevent desiccation of mother cells. (gamete forming cells and spore forming cells).
5. Gametophytes produce gametes by mitosis.
6. All land plants carryout internal fertilization to prevent desiccation of gametes.
7. Female egg (ovum) is retained in the archegonium and male gametes (antherozoids) are released from the antheridium.
8. After fertilization, diploid zygote is retained within the gametophyte to produce an embryo which is nourished by the gametophyte. Embryo develops into the diploid sporophyte.
9. Delay of meiosis after fertilization results in creating a diploid sporophytic generation.
10. Diploid sporophyte produces haploid spores by meiosis.
11. Spores grow into haploid gametophytes.

(b) Describe details of basic lifecycle of *Pogonatum.*

12. Gametophyte is the dominant plant, larger and longer-living than sporophyte.
13. Gametophyte is photosynthetic.
14. 'Stem', 'leaves', and rhizoids are present in the gametophyte
15. Gametophytes are dioecious (unisexual).
16. Mature male gametophytes produce antheridia in which several sperms are produced.
17. Female gametophytes produce archegonia.
18. A single egg is produced within the archegonium
19. The egg is not released.
20. Flagellated, motile sperm swims through external water towards egg, entering the archegonium in response to chemical attractants.
21. Sperm fuses with the ovum resulting diploid zygote.
22. This occurs in the archegonium.
23. After fertilization zygote develops into the embryo.
24. The embryo is also retained within the archegonium and develops into the diploid sporophyte by obtaining nutrients from the gametophyte.
25. The sporophyte remains attached to the gametophyte.
26. The sporophyte consists of a foot, seta and a capsule (sporangium).
27. The foot absorbs nutrients and water from the gametophyte.
28. The capsule produces spores by meiosis. Homosporous.
29. If spores are dispersed to a favourable habitat, (such as moist soil or tree bark) they may germinate and grow into a green, branched filament called protonema.
30. Protonema produces buds that grow into gametophytes

2. (a) Describe significant features of seedless vascular plants;
(b) Describe details of basic lifecycle of *Nephrolepis.*
Essay : Answer

(a) Describe significant features of seedless vascular plants;

1. Transportation through Xylem and Phloem
2. Xylem consists of tracheids, fibers and parenchyma cells- conducts water and minerals.
3. Cell walls of tracheids and fibers are strengthened by the polymer lignin.
4. These tissues permit plants to grow tall.
5. This may facilitate them to obtain a high amount of light for photosynthesis and ease the spore dispersal.
6. Phloem- this tissue has cells arranged in tubes.
7. They distribute sugars, amino acids and other organic products among different parts of the plant.
8. Evolution of roots
9. Roots are organs that absorb water and nutrients from the soil.
10. They anchor the plants and allow the shoot system to grow taller.
11. They are to replace the rhizoids seen in bryophytes.
12. Root tissues of living plants resemble stem tissues of the early vascular plants preserved in fossils.
13. Evolution of leaves-
14. Leaves increase the surface area for efficient photosynthesis.
15. Modified leaves that bear sporangia are known as sporophylls.
16. Most seedless vascular plant species produce one type of sporangium and one type of spores.
17. Therefore, they are known as homosporous.
18. Some plant species produce two types of sporangia and produce two kinds of spores called mega spores and micro-spores.
19. This condition is known as heterosporous.
20. Mega spores develop into female gametophyte while microspores develop into male gametophyte.

(b) Describe details of basic lifecycle of *Nephrolepis.*

21. Sporophyte is dominant
22. *Gametophyte is reduced and short lived.*
23. *Both sporophytes and gametophytes are independent and photosynthetic.*
24. *Sporophytes have more complex structure.*
25. *Plant body is differentiated into roots, stem and leaves.*
26. *Cuticle is found on aerial parts of the plant body*
27. *Stomata are developed on aerial parts for gaseous exchange.*
28. *Two types of vascular tissues, xylem and phloem are developed*
29. *They have fiddlehead young leaves*
30. *Stem is an underground rhizome*
31. *Leaves are compound pinnate leaves*

32. *Long underground branches called stolons arise from the rhizome\which gives rise to new plantlets.*
33. *Sporangia are developed as clusters called sori on the underside of mature leaflets.*
34. *Sori are covered by the indusium, protecting the young sporangia from desiccation. Spores are produced in the sporangium by meiosis and are homosporous.*
35. *When the sorus matures, indusium dries up and shrivels, exposing mature sporangia.*
36. *Under dry environmental conditions sporangium wall ruptures, releasing spores.*
37. *Spores are dispersed by wind.*
38. *When spores are dispersed to a favourable habitat they may germinate and grow into a gametophyte*
39. *Gametophyte is a small heart shaped, macroscopic, green coloured photosynthetic thallus.*
40. *Rhizoids develop on the ventral surface.*
41. *Gametophytes are monoecious (bisexual). Antheridia and archegonia are developed on the ventral side.*
42. *Antheridium produces flagellated sperms and releases them into the external environment.*
43. *Archegonium produces one egg and retains it.*
44. *Motile sperms swim through external water towards egg entering the archegonium in response to chemical attractants.*
45. *Sperm fuses with the egg resulting the diploid zygote.*
46. *After fertilization zygote develops into the embryo and then to the young sporophyte while retained in the gametophyte.*
47. *All the developmental stages are nourished by the gametophyte.*
48. *When the young sporophyte develops its photosynthetic tissues, it becomes an independent plan.*

3. (a) Describe significant features of seedless vascular plants;
(b) *Describe life cycle of Selaginella*
Essay : Answer
(a) Describe the properties of Phylum: *Lycophyta*

1. Lycophytes are terrestrial and some are epiphytes.
2. The dominant plant is sporophyte.
3. They produce upright stems and ground hugging stems.
4. In upright stems small leaves can be found.
5. Ground hugging stems produce dichotomously branching roots.
6. They have strobili. In many club mosses and spike mosses sporophylls are clustered into club shaped cones/ strobili.
7. They are homosporous or heterosporous.
8. Spike mosses are usually relatively smaller and often grow horizontally.
9. All Club mosses are homosporous; e.g. *Lycopodium sp.*
10. All Spike mosses are heterosporous. e.g. *Selaginella*
11. In some species the tiny gametophyte live above the ground and are photosynthetic. Others live below the ground and are nourished by symbiotic fungi.

(b) Describe life cycle of *Selaginella*

12. Sporophytes are dominant and photosynthetic.
13. Gametophytes are reduced in structure and short-lived, partially depend on the sporophyte.
14. Sporophyte plant body is differentiated into roots, stem and leaves. Vascular tissues present. Herbaceous.
15. Heterophyllous leaves are arranged as pairs.
16. Stem is dorsiventrally flattened.
17. Sporangia are borne on the specialized leaves called sporophylls.
18. Sporophylls are compactly arranged in a terminal strobilus.
19. Two types of sporophylls called megasporophyll and microsporophyll are arranged in the same strobilus.
20. Megasporophyll produces a single megasporangium and microsporophyll produces a single microsporangium.
21. Morphologically two different types of spores are produced.
22. This nature is called heterospory.
23. Megasporangium produces four large megaspores by meiosis.
24. Microsporangium produces numerous small microspores by meiosis.
25. Both types of spores have thick/tough walls.
26. Microspores are retained in the microsporangium and develop into young male gametophytes.
27. Young male gametophytes are enclosed by the wall of microspore which, are released by the microsporangium.
28. In the external environment they become mature male gametophytes.
29. Male gametophytes is microscopic, enclosed in the microspore wall, non-photosynthetic, depend on stored food.
30. Male gametophytes produce flagellated sperms and release them into the external environment.
31. Megaspores are released into the external environment. In the external environment they develop into female gametophytes.
32. Female gametophyte is multicellular, surrounded by the thick wall of megaspore, Few rhizoids develop.
33. Photosynthetic, but partially depend on stored food in the megaspore.
34. Archegonia develop at the superficial regions and are fully embedded in the gametophytic tissue.
35. One egg is produced inside the archegonium.
36. Sperm swims towards the egg (n) using flagella through external water, entering into the archegonium and fertilizes the egg (n) resulting in a zygote(2n).
37. Zygote develops to form an embryo and then embryo develops to form a young sporophyte by obtaining nutrients from the female gametophyte.
38. Sporophyte generation is the larger and more complex form in the alternation of generation

4. Describe life cycle of Cycas
Essay: Answer

1. Sporophytes are the dominant photosynthetic plants in the life cycle, gametophytes are reduced and depend on the sporophyte throughout its life.
2. Sporophytes are a perennial tree with roots, stem and leaves.
3. Stem is unbranched columnar and woody.
4. Leaves are arranged in crowns.
5. Compound leaves show xerophytic adaptations and young leaves are fiddleheads.
6. Sporophytes are heterosporous and dioecious.
7. Sporophytes have developed a tap root system.
8. Secondary growth is present.
9. Sporophytes which produce megaspores are called female plants and those which produce microspores are called male plants.
10. Mature female plant produces a crown of megasporophylls.
11. Megasporangium is enclosed in the protective layer called integument to form the ovule.
12. Integument has a small pore in the distal end of the ovule called micropyle.
13. One of the cells in the megasporangial tissue differentiates into a single megaspore mother cell.
14. Megaspore mother cell undergoes meiosis to form four haploid megaspores out of which only one remains functional.
15. The remaining megasporangial tissue functions as nucellus which provides nourishment.
16. Megaspores are not released to the external environment megaspore develop into the female gametophyte (n) while within the ovule.
17. Mature ovule contains the female gametophyte.
18. The female gametophyte produces several archegonia.
19. Each archegonium produces a single egg cell within it.
20. Mature male plants produce male cones with microsporophylls which consist of microsporangia on the lower surface.
21. Large numbers of microspores (n) are produced from microspore mother cells (2n) within the microsporangium by meiosis.
22. They develop into pollen grains within the sporangium and then discharge.
23. Pollen grains are dispersed by wind and deposited on the micropyle of a mature ovule is called pollination.
24. Pollen grains enter into pollen chamber of the ovule through the micropyle.
25. In the pollen chamber, pollen grains develop into male gametophytes.
26. Male gametophyte consists of a branched pollen tube which involves in absorption of nutrients from the nucellus.
27. Male gametophyte is short-lived.
28. Produce two large sperms with a spiral band of numerous flagella.
29. The basal end of the pollen tube ruptures releasing sperms into the archegonial chamber of the ovule.
30. Sperms swim through the liquid medium and fertilize the egg resulting the 2n zygote.
31. Zygote develops into the embryo
32. Remaining female gametophyte becomes the endosperm which provides nutrients for the developing embryo during seed germination.
33. Integument becomes the seed coat.
34. The ovule becomes the seed.
35. Seed is the dispersal unit which contains the embryo and stored food that are enclosed in the seed coat.
36. Seeds are dispersed and under favorable environmental conditions seeds germinate producing the seedlings (young Sporophyte).