**Flowering Plant Reproduction and Development Notes Guide**

Most angiosperms reproduce sexually

Flowers are the sex organs of angiosperms. This bee is gathering pollen that might deliver sperm to the next flower it visits.

Angiosperms seeds develop from fertilized egg cells

This cedar waxwing is carrying a seed, which developed from a fertilized egg cell.

Sexual reproduction results in genetically unique offspring

Flowers and seeds are produced by angiosperms that sexually reproduce, yielding genetically \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ offspring with traits derived from two parents.

Some angiosperms reproduce asexually

Some species of angiosperms also reproduce asexually, forming new individuals by mitotic division.

Asexual reproduction produces clones

Offspring produced asexually are genetically identical

to each other and to their parents.

Some angiosperms can reproduce sexually or asexually

These aspen trees can reproduce either asexually, as suckers grow from \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, or sexually via seeds.

An example of asexual reproduction

Similarly, the leaves of this kalanchoe plant produce genetically identical plantlets.

Advantages of asexual and sexual reproduction

Asexual reproduction is advantageous when conditions are stable and plants are well-adapted to their surroundings.

Sexual reproduction produces variable offspring, increasing reproductive success in a changing world.

Angiosperm sex: Flowers, fruits, and seeds

The angiosperm life cycle is an alternation of generations with multicellular diploid and haploid stages.

Alternation of generations

This diagram is an overview of the angiosperm life cycle.

Let’s start with the flower.

Angiosperm sex: Flowers

The first step in angiosperm reproduction is the formation of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ on the mature sporophyte.

Angiosperm flower structures

A typical flower has four whorls of structures, all of which are modified leaves.

Angiosperm flower structures: Calyx

The outer whorl is the calyx. It consists of sepals, which enclose and protect the inner floral parts.

Angiosperm flower structures: Corolla

The second whorl is the corolla, which is made of petals.

Angiosperm flower structures: Stamen

The third whorl is the male reproductive parts. Stamens are filaments with pollen-producing \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ on top.

Angiosperm flower structures: Carpel

The fourth whorl is the female reproductive parts. A carpel includes:

-the ovary, which encloses one or more ovules.

-a stalklike style. The top of the style, called the stigma, receives pollen.

Inside the flower: Meiosis

Inside the flower, meiosis produces haploid spores that develop into gametophytes.

Inside the flower: Microspores and megaspores

Anthers produce microspores, which divide into male gametophytes (pollen grains).

Ovules produce megaspores, which divide into female gametophytes (embryo sacs).

Modes of pollen dispersal: Wind

Some flowers release pollen grains in the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Modes of pollen dispersal: Animals

Other flowers attract animal pollinators, which unwittingly carry pollen between plants.

Plant and pollinator: A mutualistic relationship

Often, the pollinator benefits from its association with plants—animals use plants for food, shelter, or a mating ground.

Angiosperm sex: Pollination

If a pollen grain lands on a receptive stigma, pollination occurs.

Angiosperm sex: Pollen tube

When the pollen grain germinates, a pollen tube begins to grow toward the ovule.

Angiosperm sex: Two sperm nuclei

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ sperm nuclei travel through the pollen tube to the ovule.

Angiosperm sex: Fertilization

The stage is now set for fertilization.

Angiosperm sex: Double fertilization

In double fertilization, these sperm nuclei fertilize the egg and the two polar nuclei.

Angiosperm sex: Triploid endosperm

Double fertilization results in a diploid zygote and triploid endosperm nucleus.

Angiosperm sex: Seeds

After fertilization, the seed starts to develop.

A seed consists of an embryo, endosperm, and seed coat.

Seeds contain an embryo

The zygote develops from a single cell into an embryo.

Seeds contain cotyledons

Cotyledons are the embryo’s “seed leaves.” Embryonic shoots and roots also form.

Endosperm feeds the embryo

Endosperm cells divide rapidly and nourish the embryo.

The seed coat

The seed coat is a tough outer layer that protects

the embryo from damage, dehydration, and predators.

Angiosperm sex: Fruits

At the same time, a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ develops from the ovary enclosing the developing seed(s).

Fruit formation

These photos show how the fruit forms. After pollination, the flower loses its petals.

1. Pollination occurs.
2. Petals are shed.
3. Ovary and receptacle swell as seeds develop.
4. Fruit protects and disperses seeds.

Hormones and fruit formation

A developing seed releases hormones that trigger fruit formation. The ovary swells.

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There are many types of fruit

Fruits come in many forms.

1. Simple- Derived from one flower with one carpel- Olive, cherry, peach, plum, coconut, grape, tomato, pepper, eggplant, apple, pear
2. Aggregate- Derived from one flower with many separate carpels- Blackberry, strawberry, raspberry, magnolia
3. Multiple- Derived from tightly clustered flowers whose ovaries fuse as the fruit develops- Pineapple, fig

The function of fruit

Fruits protect and disperse seeds.

Seeds carried away from parent plants \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the chance of competition among parents, offspring, and siblings.

When does fruit ripen?

Unripe fruits, which contain immature seeds, are usually distasteful. Ripe fruits are tasty; mature seeds are deposited in droppings.

Prickly fruits

Prickly fruits \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to feathers or fur.

Flying and floating fruit

Some fruits catch the wind with tufts of fluff.

Still others float in water currents.

Plant growth begins with seed germination

How does the embryo continue developing into a mature sporophyte?

Seed germination

Continued development requires seed germination, the resumption of growth and development after a period of seed dormancy.

Germination requires water, O\_2, and a favorable temperature.

Seed germination: Rupturing the seed coat

The seed absorbs water and swells, rupturing the seed coat and exposing the embryo to O\_2.

Seed germination: Endosperm fuels the growth of the embryo

Meanwhile, enzymes break down the endosperm’s starch into sugars.

The availability of O\_2 and sugars means cellular respiration can resume in  
the embryo. Cell division at \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ meristems rapidly lengthens the young roots and shoot.

Plant growth before photosynthesis

At first, the only energy source is fuel stored in the endosperm.

Photosynthesis takes over

After the shoot emerges from the ground and the first leaves unfold, photosynthesis begins.

Seed germination in monocots and dicots

Monocots and eudicots, two groups of plants, have slightly different development patterns.

Hormones regulate plant growth

Chemicals called \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ travel between cells and regulate many aspects of plant growth.

Five hormones regulate most plant growth

Five hormones cue many of the major changes in plant growth and development:

auxins, cytokinins, gibberellins, ethylene, abscisic acid.

Hormones regulate plant growth: Auxin

Auxins control plant responses to light and gravity, promote elongation of cells in a stem, and suppress the growth of lateral buds.

Hormones regulate plant growth: Cytokinins

Cytokinins stimulate cell division in many plant parts, delay shedding of leaves, and stimulate growth of lateral buds.

Apical dominance

Auxins are primarily released from the shoot tip, and cytokinins are primarily released from the roots.

The counteracting effect of these hormones is called apical dominance.

The role of auxin

If the shoot tip is in place, auxins suppress the growth of lateral buds.

The role of cytokinins

Removing the shoot tip reduces the auxin concentration. Cytokinins stimulate cell division in lateral buds.

The plant’s growth becomes \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Apical dominance

Hormones regulate plant growth: Gibberellins

Gibberellins also stimulate shoot elongation. Farmers use these hormones to stimulate stem elongation and fruit growth.

Hormones regulate plant growth: Ethylene

Ethylene hastens fruit ripening and stimulates shedding of leaves, flowers, and fruits.

The effects of ethylene

Ethylene is the hormone responsible for the changes in texture, softening, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and other processes involved in ripening. Ethylene gas is used commercially to ripen tomatoes. If the tomatoes on the left were exposed to ethylene, they would turn red.

Hormones regulate plant growth: Abscisic acid

Abscisic acid inhibits shoot growth, maintains seed dormancy, and stimulates closure of stomata.

A summary of hormones and plant growth

This table summarizes how hormones affect plant germination and development.

Light is a powerful influence on plant life

Many plants grow toward light.

Phototropism

Phototropism is a plant’s tendency to grow toward or away from \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. How does this process occur?

Light and auxin

The hormone auxin has a role in phototropism. As auxin molecules migrate away from light, they accumulate on the shaded side of a stem.

Auxin accumulation on the shaded side of the shoot

How auxins stimulate cell elongation

1. Auxins stimulate proteins in cell membrane to pump protons out of cytoplasm into the cell wall.
2. High acidity in cell wall loosens bonds between cellulose fibers.
3. Cell elongates as water moves in by osmosis and turgor pressure stretches the weakened cell wall.

Auxin and phototropism

Auxin binds to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ pumps, which transport hydrogen ions out of the cell. As the acidity in the cell wall increases, the bonds between cellulose fibers loosen.

Auxin and phototropism, continued

Water enters cells on the shaded side of the stem by osmosis. Since the cell wall is less rigid, inflowing water causes the cells elongate.

The effect of phototropism

Elongation of these cells causes the stem to bend toward the light.

Light and phytochrome

Light also regulates seed germination, daily rhythms, and flowering by means of a photoreceptor in plants called phytochrome.

1. Red light converts phytochrome from its inactive form (P\_r )to its active form(P\_fr ).
2. Some P\_fr enters the nucleus and alters gene transcription.
3. Translation produces proteins controlling seed germination, flowering, etc.
4. Far red light converts P\_fr back to P\_r. P\_fr also slowly converts to P\_r in darkness.

Phytochrome

Phytochrome transforms to its active form when it absorbs red light.

The effects of phytochrome

Phytochrome helps plants sense day \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. Plants flower when periods of darkness meet certain thresholds.

Phytochrome and flowering

The dominant form of phytochrome determines whether flowering will occur. In this experiment, the last flash of light determines the prevalent form of phytochrome.

Plants respond to gravity and touch

Gravity is another important environmental \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Gravitropism

Gravitropism is directional growth in response to gravity. Shoots always grow upward.

Gravitropism and statoliths

Roots always grow downward. Statoliths sink to the bottom of cells and therefore might help plants detect gravity.

Thigmotropism

Plants also respond to touch, a reaction called thigmotropism.

An example of thigmotropism

Specialized epidermal cells detect contact with an object, which stimulates the tendril to bend.

Plant parts die or become dormant

During senescence, metabolism changes from synthesis to breakdown.

Senescence

Senescence also occurs in plants that survive for multiple growing seasons (perennial plants).

An example of senescence

Each year, deciduous trees loose their \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Ethylene and senescence

Influenced by a high level of ethylene, the leaf separates from the tree at the abscission zone.

Dormancy

During the winter, some plants enter a seasonal state of dormancy, during which metabolism slows down.