Fundamentals of the morphology of generative organs. The structure and functions of the fruit.

Plan.

Fruits
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FRUITS.

Seeds of the angiosperms plants are covered with a pericarp.

The fruit is an organ of the angiosperms that contains seeds and develops from a single flower. The function of the fruit is to form, protect, and propagate seeds. Fruits are found only in angiosperms plants. They develop after pollination and fertilization from the ovaries of pistils. The pericarp develops from the walls of the ovary and the seeds develop from the ovules. In some fruits the sepals, petals, stamens and/or the style of the flower fall away as the fleshy fruit ripens. However, for simple fruits derived from an inferior ovary —i.e., one that lies below the attachment of other floral parts, (see graphic re 'insertion point')— there are parts (including petals, sepals, and stamens) that fuse with the ovary and ripen with it. For such a case, when floral parts other than the ovary form a significant part of the fruit that develops, it is called an accessory fruit. Examples of accessory fruits include apple, rose hip, strawberry, pineapple.

The pericarp is usually distinguished in three layers: **epicarp (exocarp)** (outer layer), **mesocarp** (middle layer) and **endocarp** (inner layer). The pericarp usually constitutes the main mass of the fruit. Various protrusions are often formed on the pericarp surface: bristles, papules, hooks, wings. These outgrowths promote seed dispersal.

Fruits are extremely diverse in size, shape, pericarp structure, color, methods of dechiscenese, presence of outgrowths and appendages.

The principles of fruit classification are different: according to

- **the number of seeds in the fruit (single-seeded and multi-seeded),**
- **pericarp consistency (dry and fleshy),**
- **dehiscent and indehiscent, lomentaceous (constricted between each seed and falling apart at the constrictions into singleseeded units etc.**

There are many different types of fruit dehiscence involving different types of structures. Some fruits are indehiscent, and do not open to disperse the seeds. Xerochasy is dehiscence that occurs upon drying, and hygrochasy is dehiscence that occurs upon wetting, the fruit being hygroscopic. Dehiscent fruits that are derived from one carpel are follicles or legumes, and those derived from multiple

carpels are capsules or siliques.

Explosive dehiscence is a ballistic form of dispersal that flings seeds or spores far from the parent plant. This rapid plant movement can achieve limited dispersal without the assistance of animals. A notable example is the sandbox tree (Hura crepitans), which can fling seeds 100 meters (300 ft) and has been called the "boomer plant" due to the loud sound it generates. Another example is Impatiens, whose explosive dehiscence is triggered by being touched, leading it to be called the "touch-me-not". Ecballium elaterium, the "squirting cucumber", uses explosive dehiscence to disperse its seeds, ejecting them from matured fruit in a stream of mucilaginous liquid.

Dehiscence occurs through breakage of various parts of the enclosing structure; the mechanisms can be classified in various ways, but intermediate forms also occur.

Septicidal and loculicidal dehiscence

In **loculicidal dehiscence**, the locule wall splits between the septa, leaving the latter intact, while in septicidal dehiscence the split is at the septum that separates the loculi. Septicidal and loculicidal dehiscence may not be completely distinct; in some cases both the septa and the walls of the locules split.

Septicidal dehiscence. The septa between the locules of Ledum palustre capsules split as the fruit opens, and the seeds are released.

Loculicidal dehiscence. The locules of Lagerstroemia capsules split as the fruit opens, and the septa remain intact.

Poricidal dehiscence through a small hole (pore) is referred to as poricidal dehiscence. The pore may have a cover (operculate poricidal dehiscence or operculate dehiscence) that is referred to as an operculum or it may not (inoperculate poricidal dehiscence or inoperculate dehiscence).

Poricidal dehiscence occurs in many unrelated organisms, in fruit, causing the release of seeds.

Circumscissile dehiscence involves a horizontal opening that causes a lid to separate completely. This type of dehiscence occurs in some fruit for exsample fruit of henbane (Hyoscyamus).

One example of a dehiscent fruit is the silique. This fruit develops from a gynoecium composed of two fused carpels, which, upon fertilization, grow to become a silique that contains the developing seeds. After seed maturation, dehiscence takes place, and valves detach from the central septum, thus freeing the seeds. This is also known as shattering and can be important as a seed dispersal mechanism. This process is similar to anther dehiscence and the region that breaks (dehiscence zone) runs the entire length of the fruit between the valves (the outer walls of the ovary) and the replum (the persisting septa of the ovary). At maturity, the dehiscence zone is effectively a non-lignified layer between two regions of lig-

nified cells in the valve and the replum. Shattering occurs due to the combination of cell wall loosening in the dehiscence zone and the tensions established by the differential hygro-responsive properties of the drying cells.

The modern classification of fruits is based on the structure of the gynaecium of the flower, so four types of fruits are distinguished:

1. Monocarpous.
2. apocarpous or apocarpia.
3. Syncarpous or syncarpia.
4. Pseudomonocarpous or pseudomonocarpia.

Multiple fruits form many flowers —i.e., an inflorescence of flowers.

In the Russian and English botanical schools, the classification of fruits does not always and does not completely coincide.

In the English school of botany, apocarpous and monocarpous fruits are combined under the name apocarpous: Apocarpous fruits develop from a single flower (while having one or more separate, unfused, carpels); they are the simple fruits.

Syncarpous and pseudomonocarpous are combined under the name syncarpous: Syncarpous fruits develop from a single gynoecium (having two or more carpels fused together).

We study in Russia, so we will teach the classification of fruits as is customary in the Russian botanical school.

Monocarpic fruits are formed by a single peduncle (Fig. 116).

The follicle is a multi-seeded fruit that dehiscence along the abdominal suture. The follicles can be dry (larkspur (*Consolida regalis*)) and juicy (*Actaea simplex*).

The legume is a multi-seeded fruit, opened with two stitches (characteristic of the legume family) (bean, pea, peanut: botanically, the peanut is the seed of a legume, not a nut). The legumes may be dry (beans (*Phaseolus*)) and juicy (*Sophora*), open (peas (*Pisum*)) and fractional (peanuts (*Arachis hypogaea*)).

The drupe is a juicy or dry one-seeded unopened fruit with a woody endocarp (juicy drupe in apricots (*Armeniaca vulgaris*), cherries (*Cerasus fruticosa*), plums (*Prunus domestica*), peaches (*Persica vulgaris*), dry in almonds (*Amygdalus communis (=Prunus dulcis)*)). Fibrous drupe – (coconut (*Cócos nucífera*), walnut

(*Juglans regia*): botanically, neither is a true nut.)

The achene a one-seeded unopened fruit (up to 5 mm in diameter) with a woody pericarp (*Alchemilla vulgaris*).

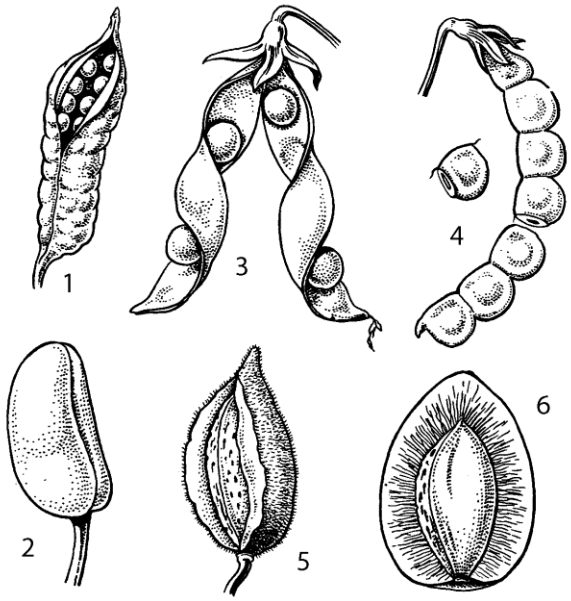

Fig. 116. Monocarpic fruits (Cited from Yakovlev G.P., Averyanov L.V., 1996). 1 – the dry follicle of *Consolida*, 2 – the fleshy follicle of *Actaea*, 3 – the legume of *Vicea*, 4 – the dry drupe of *Amygdalus*, 5 – the legume of *Hedysarum*, 6 – the fleshy drupe of *Prunus*

Apocarpic fruits are formed by two or many non-fused pistils (Fig. 117). Apocarpic fruits, also called aggregate fruits, are called aggregates, or etaerio. It develops from a single flower that presents numerous simple pistils. Each pistil contains one carpel; together they form a fruitlet. The ultimate (fruiting) development of the aggregation of pistils is called an aggregate fruit, etaerio fruit, or simply an etaerio.

An etaerio of achenes – two or many achenes from two or many pistils are formed on the receptacle of one flower (the *Ranunculaceae* species, including *Clematis* and *Ranunculus*).

Utricle is an etaerio of achenes on a succulent sprawling flower head (strawberry (*Fragaria vesca*)).

Cynarrhodium is an etaerio of achene inside a jug-shaped, sprawling succulent receptacle (rose hips (*Rosa* species)).

An etaerio of follicles – two or many follicles are formed on the receptacle

of one flower. An aggregate follicle may be dry (peony (*Paeonia anomala*), magnolia (*Magnolia obovata*)) and fleshy (*Schisandra chinensis*).

An etaerio of drupelets – many drupelets are formed on a convex receptacle (raspberries (*Rubus idaeus*), blackberries (*Rubus caesius*))

Syncarpic fruits are formed by two to many fused carpels (Fig. 118).

The **berry** is a fleshy multi-seeded fruit, not opened, having no cavity inside (currants (*Ribes nigrum*), gooseberries (*Ribes uva-crispa*), potatoes (*Solanum tuberosum*), nightshade (*Solanum nigrum*)).

The **pepo** is a large multi-seeded fruit with a hard thick rind (exocarpium), formed from the lower ovary, which consists of three peduncles (watermelon (*Citrullus lanatus*), melon (*Cucumis melo*), pumpkin (*Cucurbita pepo*), cucumber (*Cucumis sativus)*). The watermelon is a good example of a pepo, a berry with a hard, thick rind. This is a triploid, seedless "yellow watermelon" (*Citrullus lanatus var. lanatus*). Although it is called as "seedless," there are some seeds in the fleshy interior.

A **pome (apple)** is an accessory fruit; in addition to the ovary, the lower parts of stamens, petals, sepals, and pedicel take part in its formation. The seed-bearing ovary is surrounded by a thick, fleshy hypanthium that is not part of the pericarp. It derived from the fusion of the bases of the perianth segments (petals and sepals). Some references state that the hypanthium may also contain tissue from the receptacle. In the pome, the thickened, fleshy hypanthium is fused with the ovary wall or core. The outer skin of an apple is the multi-seriate epidermis of the hypanthium surrounded by a waxy cuticle. The seeds are surrounded by cartilaginous endocarp tissue. Inside the endocarp containing from one to five pyrenes that resemble the "stones" of plums, peaches, etc., which are drupaceous fruit in the same subfamily. When you eat an apple, you are primarily biting into the hypanthium tissue. You may also consume some of the outer ovary (exocarp and mesocarp) that is fused with the thick hypanthium. Since the fruit contains tissue not derived from the pericarp, it is called an accessory fruit. This is the typical fruit

of certain members of the rose family (*Rosaceae*), including apple (*Malus domestica*), pear (*Pyrus communis*), quince (*Cydonia oblonga*) and hawthorn (*Crataegus* spesies).

Pomegranate (*Punica granatum*), showing persistent calyx at the top of fruit. The calyx is cut away on right fruit to show the numerous stamens. The fruit is technically a leathery-skinned berry containing many seeds, each surrounded by a juicy, fleshy aril.

The **silique (pod)**. A silique has 2 narrow pieces (valves) separated by a partition (replum). The length of the fruit is greater than the width (*Sinapis arvensis, Raphanus sativus, Sisymbrium species*). A rounded form is called a silicle (*Capsela bursa pastoris, Rorippa brachycarpa*). These are fruits of the mustard family (*Brassicaceae*).

The **capsule** – dry multi-seeded fruit, formed by two or several numerous fused carpels. Capsules are classified by the mode of opening (dehiscence). The septicidal capsule opens in the plane of carpel union. A loculicidal capsule opens around a horizontal line. A poricidal capsule releases seeds through pores at the top.

The **schizocarp**. Carpels of a compound ovary break apart into mericarps, which function as achenes in the schizocarp type fruit (fruit of Celery (*Apium graveolens*)). Schizocarp disintegrates into several mericarps (fruit of *Malvaceae*). The indehiscent schizocarp of musk mallow *Malva moschata* will later split into segments called mericarps.

The **coenobium** – schizocarp that usually splits into four segments that resemble seeds disintegrates into four nut-shaped erems, the calyx is preserved in the fruit (fruit of the *Cynoglossum*).

The **hesperidium** is the fruit of citrus (orange, lemon), exocarpium is colored, with essential oil reservoirs, mesocarpium is dry, spongy, white, fleshy endocarpium. Lemon (*Citrus lemon*) is a hesperidium, a berry with a leathery rind. The exocarp (peel) contains volatile oil glands (essential oils) in pits. The fleshy interior (endocarp) is composed of separate sections (carpels) filled with fluid-

filled sacs (vesicles) that are actually specialized hair cells.

Pseudomonocarpic fruits are unopened single-seeded cenocarpic fruits (Fig. 119).

A **nut** is a fruit with a single layer woody pericarp (hazelnut). Sometimes, wing-shaped outgrowths are formed on its pericarp, then we speak about the winged nut (birch (*Betula pendula*)).

Acorn is a nut with a cup-shaped cupula (characteristic of the family *Fagaceae*, for example, *Querqus robur*).

Cypsela is a semi-woody or leathery pericarp (typical of the Nettle (*Urtica dioica*) and *Asteraceae* family, for example, *Helianthus annuus*).

The **grain (caryopsis)** is a leathery pericarp, fused with the seed skin (the fruit of the Cereal).

The **samara** is single-seeded fruit with large outgrowths (wings) by which such fruits are propagated by the wind for example elm (*Ulmus laevis*) and maple (*Acer platanoides*).

Structure of seeds

Seeds of dicotyledonous plants

The bean seed is surrounded by a relatively thick, glossy seed coat (spermoderm) of varying coloration. It has a somewhat flattened and elongated shape with a concavity on one side. On the concave side there is a small projection towards the central part of the sperm. This is the root of the embryo. In the center, an oval spot can be seen – the seedpod attachment site – the seed scar.

Between the seed scar and the tip of the spine, a small hole can be seen leading inside the seed – the trace of the micropile (the former pollen exit of the ovule).

A chalazal trace (hilum) can be seen on the opposite end of the seed. The thickening on the seed rind is called the seed rib or its suture and is on the opposite side of the micropile.

The cotyledons are the primary leaflets in which stored nutrients are deposited because of the absence of the endosperm.

The embryo axis is represented by a well-defined root, a bud (plumula) and a very short stem to which the cotyledons are attached. In the bud, the two leaflets are clearly distinguished, with the apex of the stem between them.

Seeds of monocotyledonous plants for example seeds of wheat.

The shape of the seed is oblong, rounded and convex. On one side there is a groove running along the whole grain, on the opposite side there is an oblong ledge, the embryo, which occupies a small part of the grain. The endosperm occupies the largest part of the grain.

The surface cells are the pericarp and the inner cells are the seed coat. The embryo consists of a plumula, a scutellum, a radicle and a single seedpod. The plumula is in the form of capsules overlapping each other – this is the longitudinal slice of the leaf initiation. The radicle is on the opposite side, with the spine and root cap clearly visible here. The scutellum is shortened, ending in an apex enclosed by the plumula. The cotyledon is a thin lamina (shield) consisting of parenchymal cells without any spare substances. Nutrients from the endosperm go through the shield (cotyledon) to the rest of the embryo. Endosperm is represented by homogeneous parenchyma cells rich in starch grains. The layer adjacent to the covering of the germ is sharply distinguished from the rest of the cells by its cubic cell shape and its contents consisting of small rounded bodies, not resembling starch grains. When a drop of iodine solution is placed on this aleurone layer it turns yellow as it is composed of protein.

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