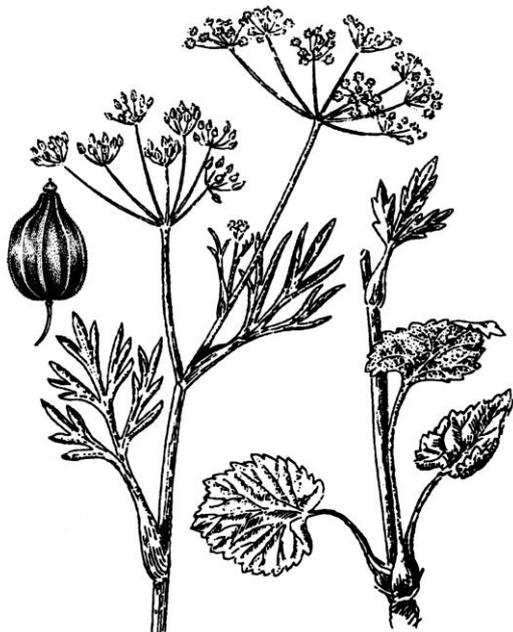


Anise fruit - *Fruclus Anisi vulgaris*

Anise seed, aniseed, sweet cumin - *Anisum vulgare* Graerth.

Family *Apiaceae* (*Umbelliferae*)

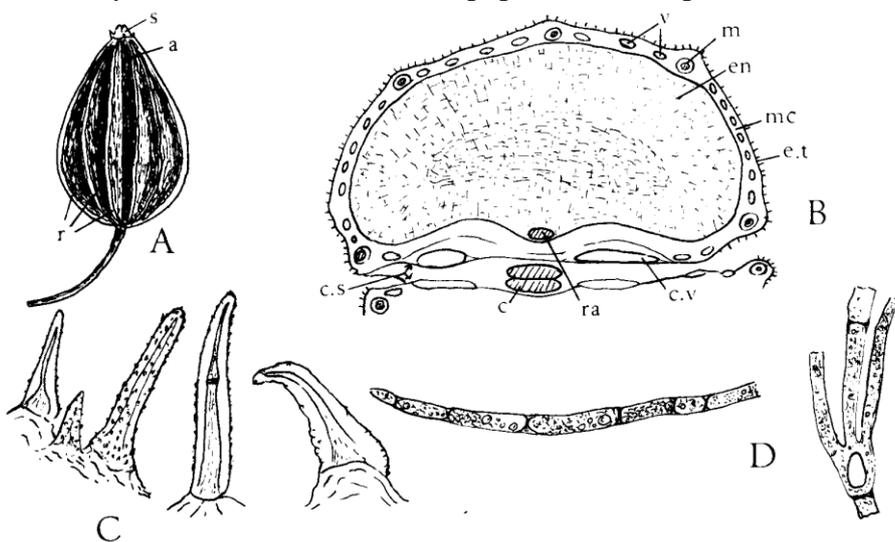


**Definition.** Aniseed consists of the whole dry cremocarp of *Pimpinella anisum* L. It contains not less than 20 ml/kg of essential oil.

**Description.** The cremocarp is ovoid or pyriform and slightly compressed laterally, yellowish-green or greenish-grey, 3 mm to 5 mm long and up to 3 mm wide, surmounted by a stylopod with two short, reflexed styler points. The mericarps are attached by their tops to the carpophore with a plane commissural surface and a convex dorsal surface, the latter being covered with short, warty trichomes visible using a lens; the fruit shows five primary ridges, running longitudinally, comprising three dorsal ridges and two lateral ridges, non-prominent, and lighter in colour, odor and taste characteristically aromatic, resembling *Illicium*.

*Fig. 11.31. Anise.*

**Anatomical characteristics.** The powder is greenish-yellow to brownish-green. Examine under a microscope using chloral hydrate solution R. The powder shows the following diagnostic characters: whole or broken trichomes, mostly unicellular, sometimes curved, with blunt apex and warty cuticle; fragments of epidermis with striated cuticle, occasional anomocytic stomata; fragments of numerous narrow, branched vittae, fragments of endosperm containing aleurone grains and micro-rosettes of calcium oxalate; oblong sclereids from the commissural zone and bundles of sclerenchymatous fibres from the carpophore and the pedicel. Starch is absent.



*Fig. 11.32. Aniseed.*

A, side view of cremocarp showing line of attachment to the two mericarps (X 8); B, transverse section of mericarp (X 25); C, covering trichomes of epicarp (X 200); D, branched and unbranched vittae isolated by alkali maceration (x 25). *a*, line of attachment of mericarps; *c*, carpophore; *c.s*, commissural surfaces; *c.v*, commissural vitta; *en*, endosperm; *e.t*, epicarp bearing trichomes; *m*, meristele; *mc*, mesocarp; *r*, three of five primary ridges of one mericarp, *ra* raphe; *s*, stylopod; *v*, vittae.

**Anise Oil (*Aetheroleum Anisi*).** Oil of Anise is the volatile oil distilled from the dried ripe fruit of

### ***Volatile oil containing medicinal plants and herbal drugs***

*Anisum vulgare*. If solid material has separated the oil should be carefully warmed until completely liquefied before it is dispensed. Stimulant, carminative, aromatic; flavoring agent. Preparation: Anise Water. Anise Spirit.

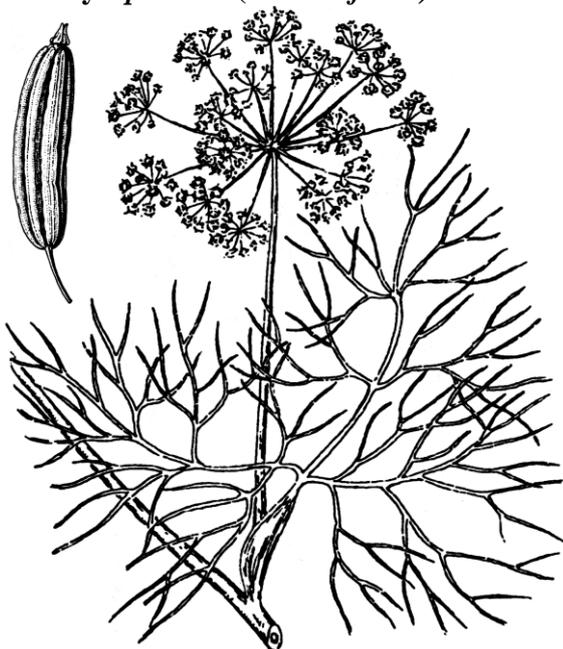
Anethole is parapropenyl anisole. It is the main constituent of the oils of anise, star anise and fennel and is obtained from these by fractionating, chilling and crystallizing. It is also prepared synthetically. Stimulant, carminative and flavor. Enters into Anisated Ammonia Spirit and Compound Cardamon Spirit.

**Adulterants.** Foreign seeds, and fruits, pebbles, exhausted fruits, and Conium. The latter is poisonous and may readily be detected by triturating a portion of a suspected sample with an alkaline solution, when an odor resembling mouse urine develops.

**Fennel fruit - *Fructus Foeniculi amari*,**

**Fennel - *Foeniculum vulgare* Miller.**

**Family *Apiaceae (Umbelliferae)***

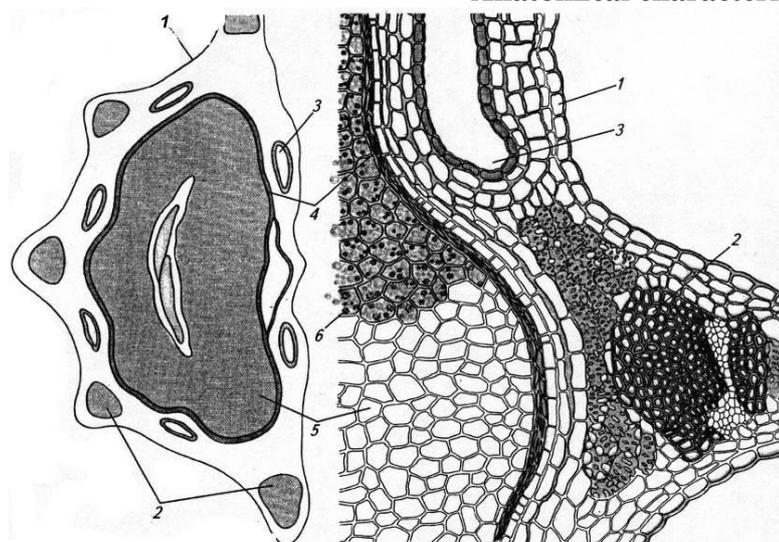


**Definition.** Bitter fennel consists of the dry, whole cremocarps and mericarps of *Foeniculum vulgare* Miller sp. *vulgare* var. *vulgare*. It contains not less than 40 ml/kg of essential oil, calculated with reference to the anhydrous drug. The oil contains not less than 60.0 percent of anethole and not less than 15.0 percent of fenchone.

**Description.** The fruit of bitter fennel is a cremocarp, of almost cylindrical shape with a rounded base and a narrower summit crowned with a large stylopod. It is generally 3 mm to 12 mm long and 3 mm to 4 mm wide. The mericarps, usually free, are glabrous. Each bears five prominent slightly crenated ridges. When cut transversely, four vittae on the dorsal surface and two on the commissural surface may be seen with a lens, odour and taste characteristically aromatic.

**Fig. 11.33. Fennel fruit and flowering plant**

#### **Anatomical characteristics**



The powder shows the following diagnostic characters: yellow fragments of wide secretory canals(3), often made up of yellowish-brown-walled polygonal secretory cells, frequently associated with a layer of thin-walled transversely elongated cells, having a parquetry arrangement; reticulate parenchyma of the mesocarp; numerous fibre bundles (2) from the ridges, often accompanied by narrow spiral vessels; very numerous endosperm(4) fragments containing aleurone grains and very small calcium oxalate microsette(6) crystals, as well as some fibre bundles from the carpophore.

**Fennel, sweet = *Fructus Foeniculi dulcis***

### *Volatile oil containing medicinal plants and herbal drugs*

**Definition.** Sweet fennel consists of the dry, whole cremocarps and mericarps of *Foeniculum vulgare* Miller sp. *vulgare* var. *dulce* (Miller) Thellung. It contains not less than 20 ml/kg of essential oil, calculated with reference to the anhydrous drug. The oil contains not less than 80.0 percent of anethole. Sweet fennel has a sweet taste

**Description** The fruit of sweet fennel is a cremocarp of almost cylindrical shape with a rounded base and a narrower summit crowned with a large stylopod. It is generally 3 mm to 12 mm long and 3 mm to 4 mm wide. The mericarps, usually free, are glabrous. Each bears five prominent slightly crenated ridges. When cut transversely, four vittae on the dorsal surface and two on the commissural surface may be seen with a lens.

**Anatomical characteristics.** The powder shows the following diagnostic characters: yellow fragments of wide secretory canals, often made up of yellowish-brown-walled polygonal secretory cells, frequently associated with a layer of thin-walled transversely elongated cells 2  $\mu$ m to 9  $\mu$ m wide, having a parquetry arrangement; reticulate parenchyma of the mesocarp; numerous fibre bundles from the ridges, often accompanied by narrow spiral vessels; very numerous endosperm fragments containing aleurone grains and very small calcium oxalate microrosette crystals, as well as some fibre bundles from the carpophore.

### **Fruits of Star anise - *Fructus Anisi stellati***

**Star Anise - *Anisum stellatum* = *Illicium verum* Hooker**

**Family *Magnoliaceae* (*Illicaceae*)**

**Definition.** Star anise consists of the dried composite fruit of *Illicium verum* Hooker fil. It contains not less than 70 ml/kg of essential oil, with reference to the anhydrous drug.



**Fig. 11.34. Star anise plant (a) and fruit (b)**

**Description.** Star anise is a composite fruit, consisting of follicles. Each follicle is about 12 mm to 20 mm long and 6 mm to 11 mm high. The seeds are up to 8 mm long.

The fruit is formed of six to eleven (usually eight), often unequally developed, boat-shaped follicles, radially arranged around a short, central, blunt-ending columella. Separated follicles and seeds may occur. The distal portion of each follicle is prolonged to a blunt beak. The outer surface is reddish-brown to greyish-brown and roughly wrinkled. The inner surface is shiny, reddish-brown and smooth.

Ripe follicles have a split ventral suture uppermost, revealing a single hard ovoid, compressed, shiny, brown seed. The fruit stalk, often absent, is small and strongly curved at the distal end.

**Anatomical characteristics.** The powder shows the following diagnostic characters: brown epicarpal cells, polygonal in surface view, with strongly striated cuticles and occasional anomocytic stomata; fragments of the endocarp with palisade-like cells up to about 600  $\mu$ m long; fragments of the mesocarp with large parenchymatous cells, vessels, oil-containing cells and groups of large very elongated stone cells with thickened and pitted walls; fragments of the seed with palisade-like, yellow stone cells up to 200  $\mu$ m long, with strongly pitted walls; fragments of the endosperm containing droplets of oil and aleurone grains; separate fragments of the columella and the fruit stalk with strongly thickened irregular stone cells up to 400  $\mu$ m long and about 150  $\mu$ m wide, with pointed, partly star-shaped projections (astrosclereids), rhomboidal or rectangular crystals of calcium oxalate.

*Volatile oil containing medicinal plants and herbal drugs*

Thyme herb - *Herba Thymi vulgaris*

Thyme, Garden Thyme, Mother of Thyme - *Thymus officinalis* L.

Family *Lamiaceae* (*Labiatae*)

**Definition** Whole leaves and flowers separated from the previously dried stems of *Thymus vulgaris* L. or *Thymus zygis* L. or a mixture of both species. *Content:* minimum 12 ml/kg of essential oil of which a minimum of 40 per cent is thymol and carvacrol (both  $C_{10}H_{14}O$ ;  $M_r$  150.2) (anhydrous drug).

**Description.** The dried leaves and flowering tops. The drug occurs chiefly as leaves mixed with a small amount of segments of the flowering tops, and flowers. Stems mostly 4-angled, dusky purplish-red to dusky yellow-green, simple or opposite-branched, pubescent, of variable length and usually 0.5 to 1 mm in diameter, the nodes up to 20 mm. apart, occasionally with attached opposite leaves; leaves linear, linear-lanceolate, ovate or oblong, up to 6 mm. in length and from 0.5 to 2 mm. in breadth, lamina apex acute, base obtuse, tapering into a petiole from 0.5 to 2 mm. in length, margin revolute, upper surface light gray or light brownish grey to weak olive green, puberulent, with numerous hairs; lower surface, grayish, pubescent and glandular-punctuate; inflorescence of about 12-flowered; flowers, the calyx

tubular-bilabiate, about 4 mm. in length, pubescent, upper lip 3-toothed, lower lip with 2 hairy, corolla about twice-as long as the calyx, purplish, bilabiate, upper lip emarginated, lower spreading and 3-lobed; stamens 4, ovary 4-parted; stigma bifid; nutlets spheroidal, about 0.5 mm. in diameter, finely tuberculate, odor aromatic; taste aromatic and warming.

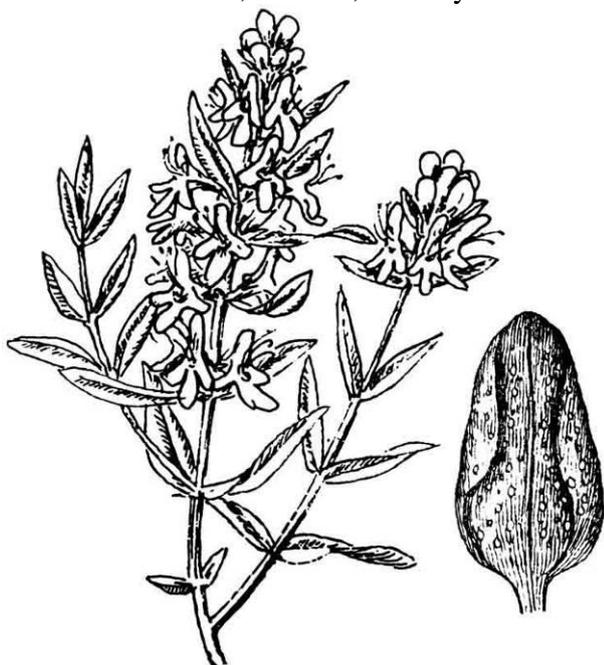
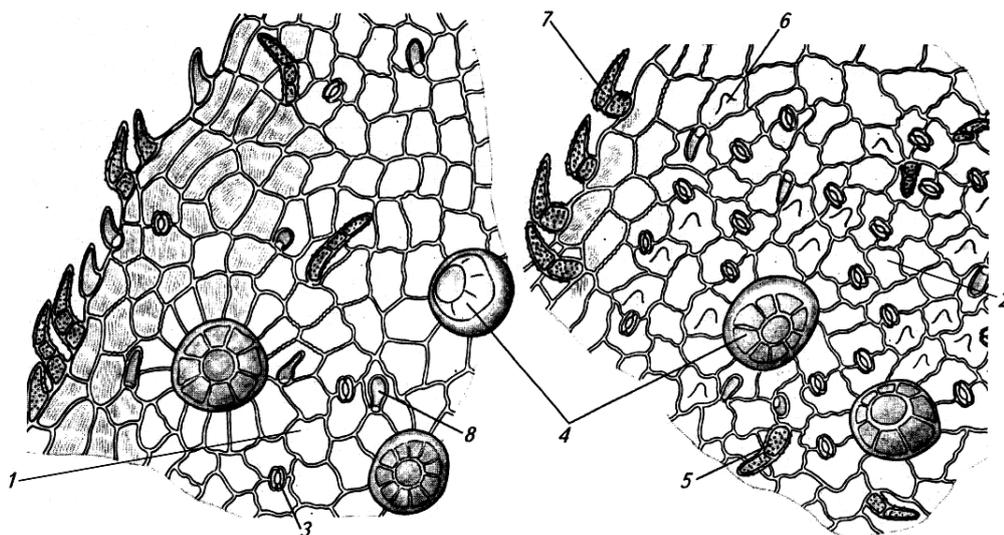


Fig. 11.35. *Thymus vulgaris* (A) and its leaf (B)

**Anatomical characteristics.**



Surface of the leaf present the following for examination: 1. *Upper epidermis.*(A) Cells tangentially elongated in transverse section with a thick cuticle and few stomata, somewhat polygonal in surface section with beaded vertical walls and striated cuticle, the stoma being at a right angle to the 2 parallel neighboring cells (3).

Numerous unicellular, non-glandular hairs and uniseriate, 2- to 3-celled, nonglandular hairs (4) with papillose wall and apical cell, straight, or pointed, curved or hooked. Numerous glandular hairs of 2 kinds, one with a short stalk embedded in the epidermal layer and a unicellular head, the other with

### ***Volatile oil containing medicinal plants and herbal drugs***

an 8- to 12-celled head and no stalk.

*Lower epidermis* (B) similar in aspect to the upper epidermis except for the presence of numerous stomata and more numerous non-glandular hairs of the uniseriate type, which are mostly appressed.

**Thyme Oil** (*Aetheroleum Thymi*) is a volatile oil distilled from the flowering; plant of *Thymus vulgaris* L. It is a colorless, yellow or red liquid with a pungent a sp. gr. of 0.910 to 0.935 at 25 °C. It yields not less than 40 %, by volume, of phenols. Stimulant, carminative and antiseptic.

Food: Very aromatic, thyme is used as a spice and condiment in many foodstuffs.

**Thymol** is a phenol occurring in large, colourless, transparent crystals or as a white powder having a thyme-odor and a pungent taste. It is used as an anthelmintic (for hook worm) as an antiseptic and deodorant in mouth washes and gargles and occasionally as an intestinal antiseptic. The average dose, as an anthelmintic, is 2 g. divided into 3 doses. *Thymol can be irritant!*

### **Wild thyme herb - *Herba Serpylli***

**Wild Thyme, Creeping Thyme; Mother of Thyme - *Thymus serpyllum* L.**

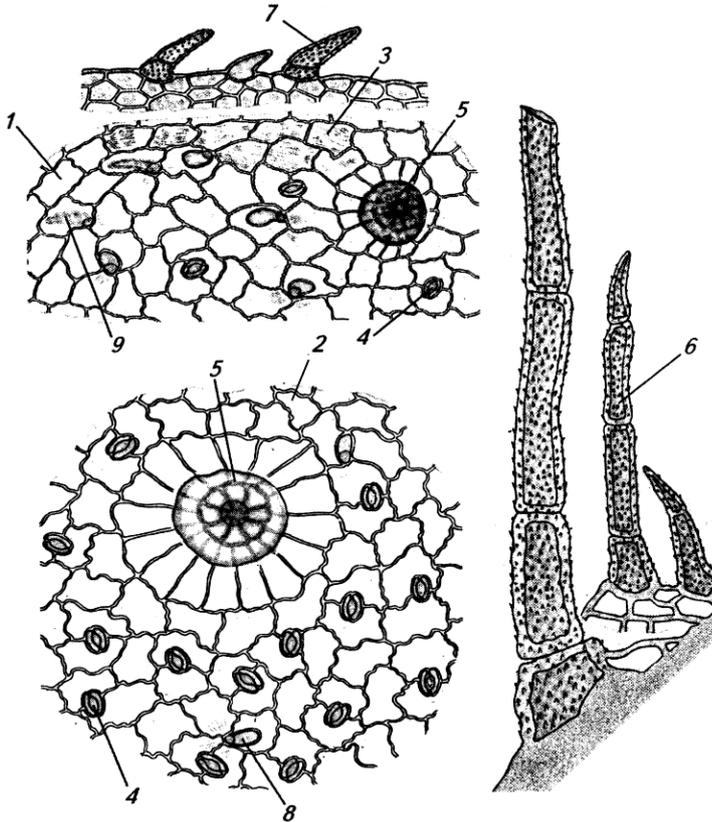
**Family *Lamiaceae*(*Labiatae*)**

**Description.** Stems quadrangular, about 1 mm. in diameter, dusky red-purple, brown to dusky greenish yellow in colour, pubescent, nodes up to 35 mm. apart, occasionally with opposite leaves attached. Leaves obovate, elliptical or ovate, up to 15 mm. in length and from 2 to 5 mm in width; summit obtuse; base attenuate, tapering into a short petiole; margin revolute, ciliate, upper surface weak olive green, pellucid-punctate, lower surface light green, pellucid-punctate, with few non-glandular and glandular hairs. Inflorescence in 12-flowered short, terminal spikes; flowers polygamous; calyx tubular-bilabiate, glandular hairy with a tuft of white hairs in the throat, upper lip 3-lobed. Lower lip of 2 slender attenuate lobes bearing bristly marginal hairs; corolla tubular, bilabiate, purple, or pink, red or white in varieties, as long or longer than the calyx; stamens slightly didynamous and exserted; stigma bifid; nutlets ovoid or oblong, smooth; odor and taste characteristically aromatic.



**Fig. 11.36. *Thymus serpyllum* (A) and its leaf (B)**

Anatomical characteristics



Leaf: upper epidermal cells (1) with thick striated cuticle (3) and wavy vertical walls and few elliptical stomata; hairs of several types, unicellular, non-glandular (7), papilla-like hairs up to 30 mkm, in length, occasional uniseriate, non-lignified (6), non-glandular hairs up to 6-celled but mostly 2- to 3-celled and up to 60 mkm long, deep seated glandular hairs (5) with a 2-celled stalk and an up to 8-celled head; stomata (4) few; a palisade layer consisting of two layers of columnar cells becoming three layers in some places; a spongy parenchyma region made up of about eight rows of irregular-shaped chlorenchyma cells and numerous fibrovascular bundles; lower epidermis similar to upper except that stomata are more numerous.

Pot majoram herb - *Herba Origanii vulgare*

Pot majoram, wild majoram - *Origanum vulgare* L.

Family *Lamiaceae* (*Labiatae*)

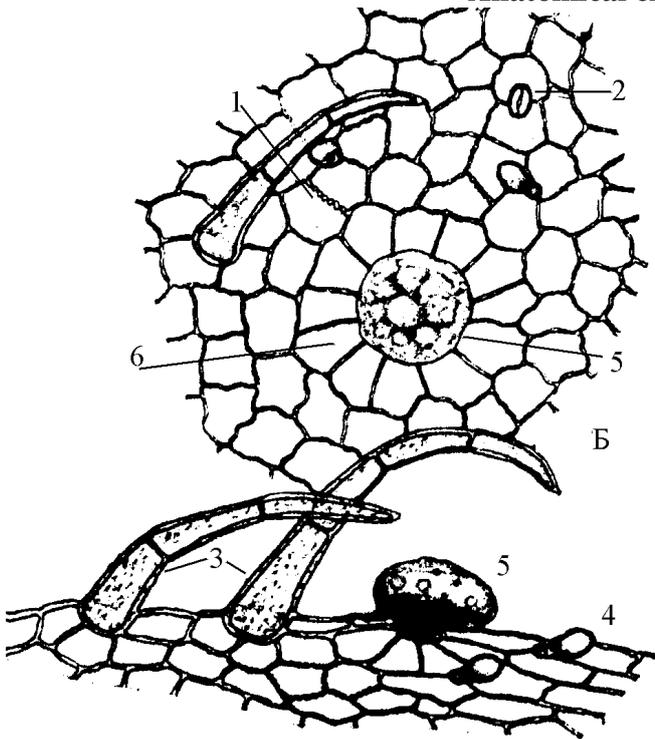
**Definition.** *Herba Origanii vulgare* consists of dried herb of *Origanum vulgare* L.



**Description.** The raw material consists of the upper parts of stems up to 20 cm with leaves and inflorescences; partly crumbled. Stems are green or purple, roughly hairy. Leaves are oblong-ovate in shape, short-petiolate, acuminate at the apex, opposite and have entire or denticulate margin. Flowers are small, pink-purple or white bilabiate. The corolla is brownish-purple or brownish-pink in colour. The odour is aromatic, the taste is bitterish, spicy, slightly astringent.

*Fig. 11.37. Flowering pot majoram*

Anatomical characteristics



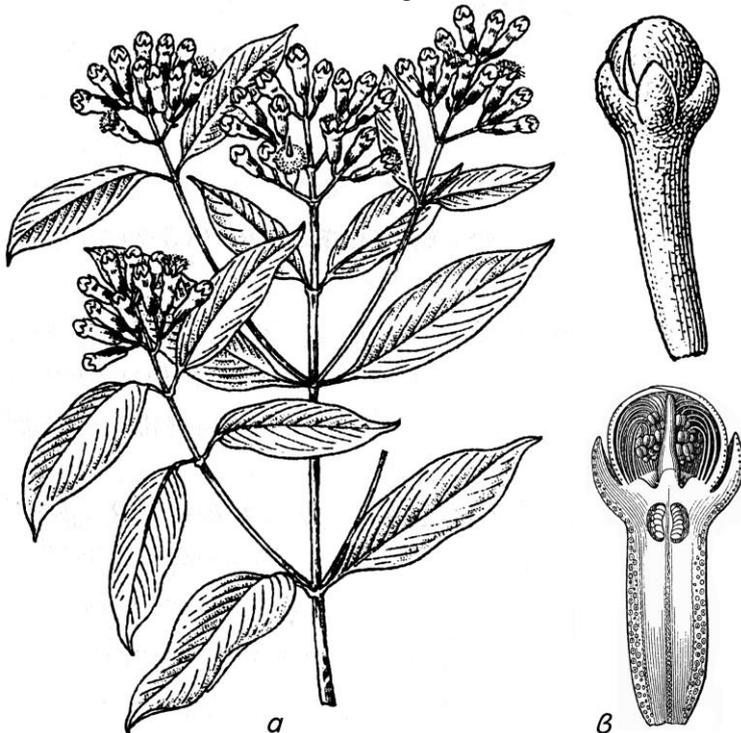
Leaf: *Upper epidermis* composed of large, clear epidermal cells (1) with slightly wavy vertical walls and possessing few or no stomata (2). *Lower epidermis*, of small epidermal cells with wavy vertical walls and numerous elliptical stomata. This epidermis on all surface exhibits as outgrowths non-glandular and glandular hairs (5). The non-glandular hairs are uniseriate (3), papillose (4), 1- to 8-celled. The glandular hairs (5) have a 1- to 2-celled stalk and a 1- to 8-celled glandular head. These hairs contain the volatile oil.

Clove - *Caryophylli flos*

Clove - *Eugenia caryophyllus* (Spr.) Bull. et Harr. (*E. caryophyllata* Thunb.) or *Syzygium aromaticum* (L.) Mer. et L.

Family *Myrtaceae*

**Definition.** Clove consists of the whole flower buds of *Syzygium aromaticum* (L.) Merrill et L. M. Perry (*Eugenia caryophyllus* (C. Spreng.) Bull. et Harr.) dried until they become reddish-brown. It contains not less than 150 ml/kg of essential oil.



**Description.** The flower bud is reddish-brown and consists of a quadrangular stalked portion, the hypanthium, 10 mm to 12 mm long and 2 mm to 3 mm in diameter, surrounded by four divergent lobes of sepals which surround a globular head 4 mm to 6 mm in diameter. A bilocular ovary containing numerous ovules is situated in the upper part of the hypanthium. The head is globular and dome-shaped, composed of four imbricated petals that enclose numerous incurved stamens and a short, erect style with a nectary disc at the base. The hypanthium exudes essential oil when indented with the fingernail. Clove has a characteristic, aromatic odour.

Fig. 11.38. Flowering shoot (a) and bud (b) of *Caryophylli*

**Anatomical characteristics.** The hypanthium, in the region below the ovary, shows in transverse section (Fig. 11.39) a heavy cuticularized epidermis in which occur stomata, slightly raised above the surface and showing well-defined substomatal spaces. Within this is a zone of roughly radially arranged parenchymatous cells containing numerous schizolysigenous oil glands

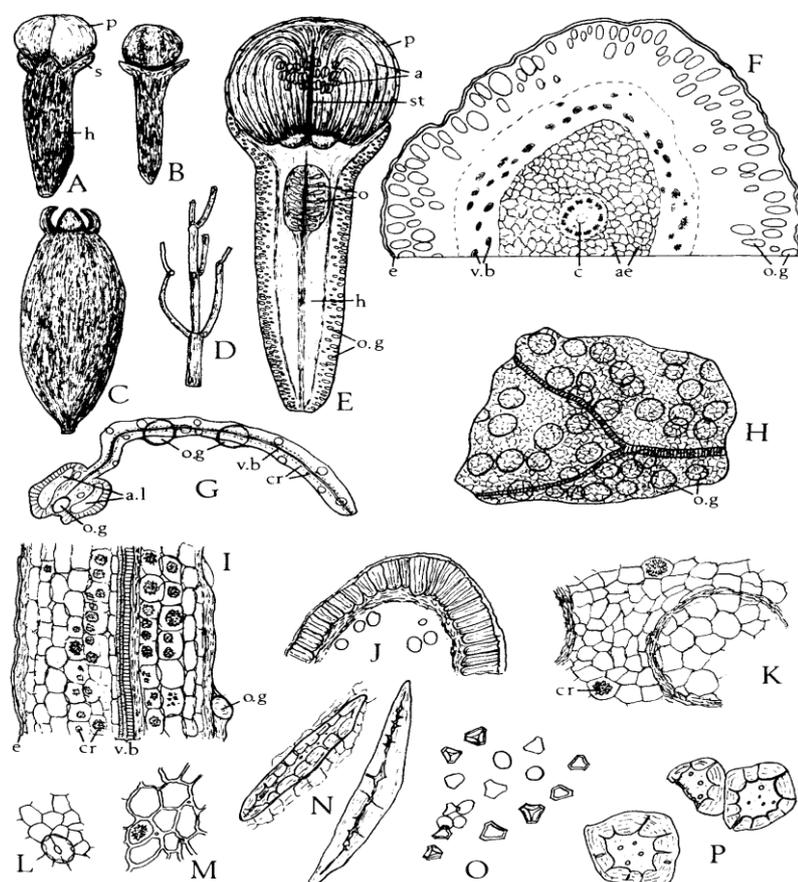
### *Volatile oil containing medicinal plants and herbal drugs*

arranged in two or three more or less intermixed layers. The oil glands are ellipsoidal in shape, with the long axis radial, and show an epithelium composed of two or three layers of flattened cells. The contents of the oil glands are soluble in alcohol and are blackened by treatment with alcoholic ferric chloride or osmic acid. The ground mass of parenchyma also gives the blackening with ferric chloride. Cluster crystals of calcium oxalate (5—25  $\mu\text{m}$  in diameter) occur in many of the parenchymatous cells. Within the oil gland layer is a zone of cells with somewhat thickened walls, embedding a ring of bicollateral vascular bundles. The ground tissue of this zone contains cluster crystals of calcium oxalate. The meristemes are enclosed in an incomplete ring of lignified fibres the xylem is composed of 3—5 lignified spiral vessels. Within the ring of vascular bundles is a zone of aerenchyma, composed of air spaces separated by lamellae one cell thick, which supports the central columella. The ground tissue of the columella is parenchymatous and is particularly rich in calcium oxalate clusters. In the outer region of the columella is a ring of some 17 small vascular bundles.

The hypanthium, in the region of the ovary, shows epidermis, oil gland layer and ring of bicollateral bundles. Within this is a zone of cells with very strongly thickened cellulose walls, limited internally by an inner epidermis forming the wall of the ovary. The dissepiment of the ovary is parenchymatous; the placentae are rich in cluster crystals and contain vascular bundles. If sections of the hypanthium are mounted in a concentrated solution of potassium hydroxide, acicular and radiately aggregate crystals separate, owing to the presence of the phenol eugenol in the oil.

The sepals and petals show a simplified leaf structure. The mesophyll parenchyma contains calcium oxalate and embeds numerous oil glands. The epidermis of the sepals shows stomata. The epidermis of the petals is devoid of stomata and is composed of very irregular cells.

The stamens are composed of filament, connective and anther. The filament shows an epidermis of longitudinally elongated cells, a ground mass of parenchyma embedding numerous oil glands and a single vascular strand enclosed in a sheath of crystal cells. The vascular strand is continuous into the connective, which is terminated by an oil gland. The fibrous layer of the anther-wall is composed of cells showing spiral bands of lignified thickening. The pollen grains are triangular in outline and 15—20  $\mu\text{m}$  in diameter.



**Fig. 11.39. *Syzygium aromaticum*.**

A, Penang clove; B, Zanzibar clove; C, fruit (mother clove), (all  $\times 2$ ); D, clove stalk ( $\times 1$ ); E, clove cut longitudinally ( $\times 5$ ); F, transverse section of hypanthium; G, portion of anther (both  $\times 15$ ); H, surface view of petal ( $\times 50$ ); I-P, elements of powdered clove (all  $\times 200$ ); I, portion of anther filament; J, fibrous wall of anther lobe and immature pollen; K, fragment of hypanthium showing portions of oil glands; L, epidermal cells and stoma of hypanthium; M, parenchyma of hypanthium; N, phloem fibres; O, pollen grains; P, sclereids from clove stalk, a, stamens; ae, aerenchyma; a.l, anther lobes; c, columella; cr, cluster crystal of calcium oxalate; e, epidermis; h, hypanthium; o, ovules; o.g, oil gland; p, imbricated petal; s, sepal; st, style; yb, vascular bundle.

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Starch, prisms of calcium oxalate and lignified sclereids are absent from a powder consisting of the flower buds only. Clove stalks contain lignified sclereids (Fig. 11.39, F) and reticulately thickened xylem vessels. Clove fruits ('anthophylli', 'mother cloves') contain starch. As there is a permissible BP limit for these structures in the drug, a few sclereids and starch grains may therefore be found in the powder.

### Nutmeg seed – *Semen Myristicae*

#### Nutmeg or myristica - *Myristica fragrans* Houttuyn

#### Family *Myristicaceae*

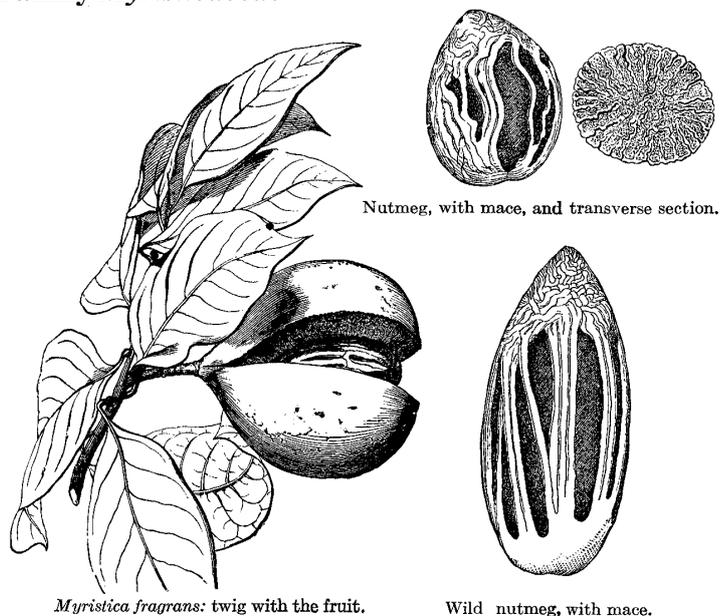


Fig. 11.40. Flowering nutmeg

**Definition.** Nutmeg or **myristica** is the dried, ripe seed of deprived of its seed coat and arillode and with or without a thin coating of lime.

**Description.** Nutmegs are broadly oval in outline, 2-3 cm in length and about 2 cm in breadth. If not heavily limed, the surface is of a brown or greyish-brown colour and is reticulately furrowed. At one end is a lighter-coloured patch with brown lines radiating from the hilum, which is surrounded by a raised ring. From this an ill-defined furrow (imprint of the raphe) runs to the chalaza, at the opposite end of the kernel, where there is a small dark depression. Odour, strong and aromatic; taste, pungent and slightly bitter.

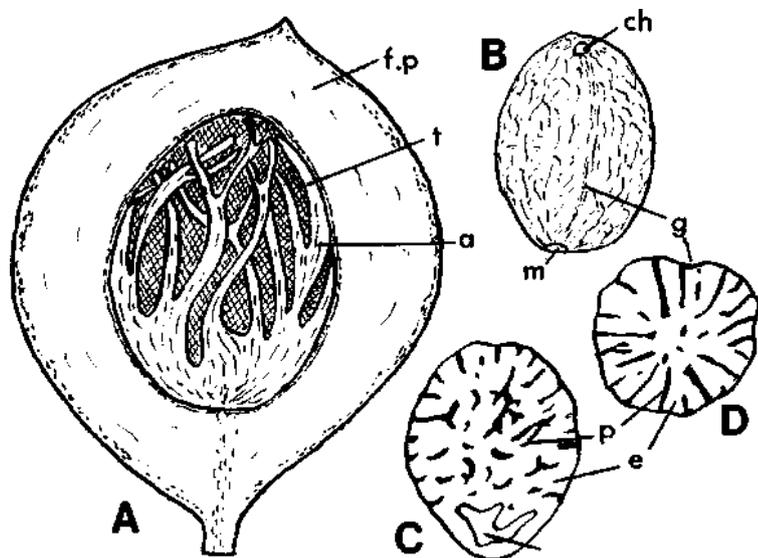


Fig. 11.41. *Myristica fragrans*. A, Fruit with half of the pericarp removed; B, nutmeg (dried kernel); C, longitudinal section nutmeg; D, transverse section nutmeg (all x 1) a, Aril (mace); ch, chalaza; e, endosperm, e.c. cavity left by embryo; f.p. fleshy pericarp; g, groove marking line of raphe; m, micropyle region; p, perisperm; t, testa.

A longitudinal section (Fig.11.41, C) has a lustrous, marbled appearance. The outer tissue, which consists of dark brown perisperm, penetrates the light brown endosperm, the infoldings branching and giving rise to the marbled appearance. The perisperm possesses fibrovascular bundles, the position of which is indicated by the reticulate furrows found on the outer surface.

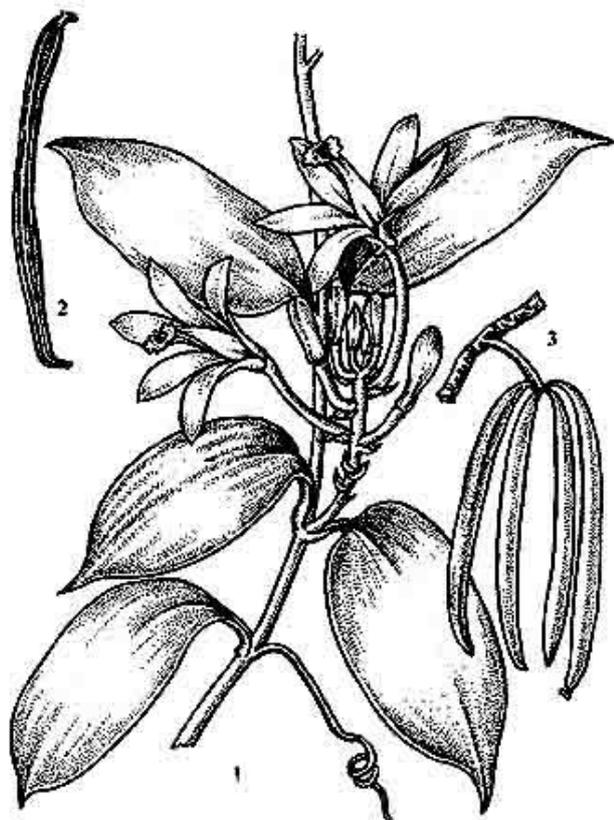
**Nutmeg oil or myristica oil** is the volatile oil distilled with steam from the dried kernels of the ripe seeds of *Myristica fragrans*. The oil is a colorless or pale yellow liquid that has the characteristic odor and taste of nutmeg. The oil contains safrole, myristicin (methoxysafrole), methoxyeugenol, (+)-camphene, terpineol,  $\alpha$ - and  $\beta$ -pinene, myrcene, ( $\pm$ )-limonene, and sabmene.

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**Vanilla fruits - *Fructus Vanilla***

**Vanilla - *Vanilla planifolia* Andr.**

**Family *Orchidaceae***



**Description.** Vanilla bolls are 15-25 cm in length, 8-10 mm in diameter and somewhat flattened. The surface is longitudinally wrinkled, dark-brown to violet-black in colour and frequently covered with needle-like crystals of vanilin. The fruits are very pliable and have a very characteristic odour and taste.

*Fig. 11.42. 1 – Flowering vanilla, 2,3 – vanilla bean*

**Bark of Cinnamon - *Cortex Cinnamomi zeylanici***

**Cinnamon - *Cinnamomum zeylanicum* Blume**

**Family *Lauraceae***

**Definition.** Cinnamon consists of the dried bark, freed from the outer cork and the underlying parenchyma, of the shoots grown on cut stock of *Cinnamomum zeylanicum* Nees. It contains not less than 12 ml/kg of essential oil.



*Fig. 11.43. A - Flowering Cinnamon, B - bark of Cinnamon*

**Description.** The drug consists of single or double compound quills about 6-10 mm in diameter and of varying length. In the different grades the thickness of each piece of bark varies considerably, but in good quality cinnamon it is usually not more than about 0-5 mm.

The external surface of each piece is yellowish - brown and shows longitudinal shining, wavy lines (pericyclic fibres) and occasional scars and holes (indicated the position of leaves or twigs).

The inner surface is somewhat darker and longitudinally striated. The bark has a short, splintery fracture. The odour is aromatic, fragrant; the taste is sweet, spicy and slightly astringent.

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**Anatomical characteristics.** The powder shows the following diagnostic characters: groups of rounded sclereids with pitted, channelled and moderately thickened walls; numerous colourless single fibres, often whole with narrow lumen and thickened, lignified walls and few pits; small acicular crystals of calcium oxalate. Examine under a microscope using a 50 percent V/V solution of glycerol R; the powder shows abundant starch granules. Cork fragments are absent or very rare.

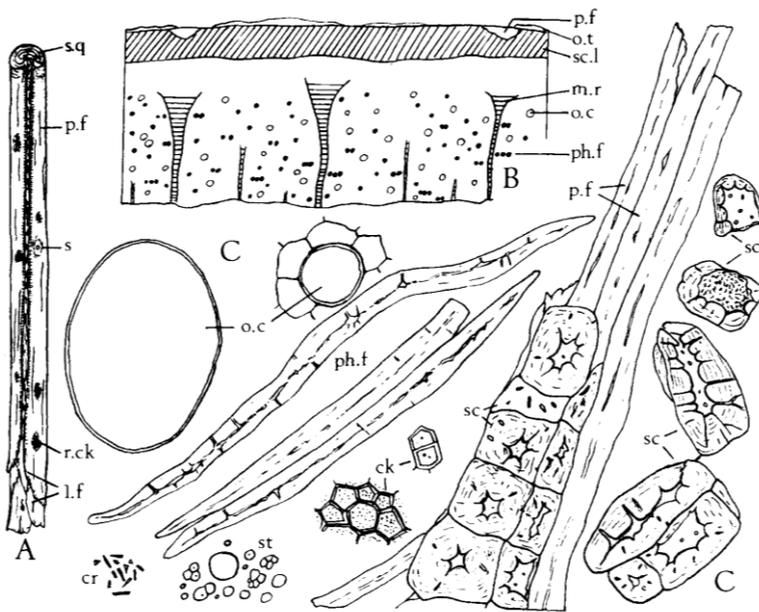
#### **Cassia bark, Bark of Cinnamon - *Cortex Cinnamomi cassiae***

#### **Chinese Cinnamon - *Cinnamomum cassia* Blume**

#### **Family Lauraceae**

**Description.** Cassia bark occurs in channelled pieces or single quills up to 40 cm in length, 1-2 cm in width and 1-3 mm in thickness. The outer surface is dark brown; some places are covered by layer of grey cork. The fracture is flat. The odour is aromatic, pleasant; the taste is sweetish, spicy and slightly astringent.

**Anatomical characters.** Transverse sections of cinnamon (Fig. 11.44, B) show under the microscope a complete absence of epidermis and cork. Shrivelled remains of cortex occur in patches. The outer limit of the bark is marked by a pericycle composed of a continuous ring of three to four layers of sclereids with small groups of pericyclic fibres embedded in it at intervals. The latter produce the lighter-coloured, wavy, longitudinal lines on the outside of the commercial bark. The sclereids (Fig. 11.44, C) have thickened lignified walls, showing well-defined pit-canals. The thickening on the outer walls is often less pronounced than on the radial and inner tangential walls. The lumen is clearly visible and sometimes contains starch. The pericyclic fibres range from 1000 to 2500  $\mu\text{m}$  in length and have strongly thickened lignified walls showing stratification and pit-canals. Primary phloem cannot be distinguished. The secondary phloem is composed of phloem parenchyma, containing oil and mucilage cells; phloem fibres; and medullary rays. The sieve-tube tissue, embedded in the phloem parenchyma, is often obliterated. The phloem parenchyma is composed of thin-walled cells, with yellowish-brown walls, and contains starch in compound and simple grains, the latter not exceeding 10  $\mu\text{m}$  in diameter (those of *Cinnamomum cassia* often exceed this figure) and numerous acicular crystals of calcium oxalate about 5—8  $\mu\text{m}$  in length. Some of the phloem parenchyma cells contain tannin. The secretion cells, containing volatile oil or mucilage, are two or three times the diameter of the phloem fibres, and are axially elongated. The phloem fibres, which occur isolated or in tangential rows, are more abundant towards the inner part of the bark. They are usually less than 30  $\mu\text{m}$  in diameter (those of *C. cassia* measure 30—40  $\mu\text{m}$  in diameter) and have a length of 200—600  $\mu\text{m}$ . The thick lignified walls show stratification. The secondary phloem is divided up by the radial medullary rays, which are uni- or hiseriate near the cambium but become broader towards the outside by tangential growth of the cells. The rays are 7—14 cells in height. The medullary ray cells are radially elongated, thin-walled with yellow-brown cell contents containing numerous acicular crystals of calcium oxalate.



**Fig. 11.44. Cinnamon.** A, Compound double quill (x 1/2); B, transverse section (x50); C, elements of the powder (x200); *ck*, cork cells; *cr*, acicular crystals of calcium oxalate; *lf*, laminated fracture of compound quill; *m.r.*, medullary ray; *o.c.*, oil cells; *o.t.*, remains of outer tissues; *p.f.*, pericyclic fibres; *ph.f.*, phloem fibres; *r.ck*, residual patches of cork; *s*, scar of twig; *sc*, sclereids; *scl*, sclereid layer of pericycle; *s.q.*, transverse surface of compound quill; *st*, starch granules.