Wood Anatomy of Eastern Mediterranean Species
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Pictures on the cover
The big cover picture:
Quercus infectoria subsp. *boissieri*

The small pictures in turn:
Pinus pinea
Spartium junceum
Liquidambar orientalis
Quercus petraea subsp. *pinnatiloba*
Rhamnus nitidus
Pterocarya fraxinifolia

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Preface

The eastern Mediterranean Basin has a rich woody flora including Mediterranean-type vegetation and locally mesomorphic woody taxa. The wood anatomy of these taxa is crucially important to understand their nature and formation. Wood anatomy is also important in the Old World because of having wooden parts in archaeological sites.

A few wood anatomy books including the species of the eastern Mediterranean basin have been published. This book aims to make a contribution to the wood anatomy world by presenting the wood anatomical characteristics of some species of the eastern Mediterranean basin, mainly of Turkey. Anatomical features are given together with some main results of the relating studies here.

106 species from 67 genera from mainly the Mediterranean region of Turkey are included in this book. Most of the species are also included in Merev (2003), which is an important wood anatomy book published in Turkish, as well as Fahn et al. (1986) and Schweingruber (1988). However, we include endemic and some regional woody plants such as *Abies cilicica* Carr., *Pterocarya fraxinifolia* (Poiret) Spach, *Liquidambar orientalis* Miller, *Crataegus aronia* (L.) Bosc. ex DC., *Prunus cocomilia* Ten., *Pyrus syriaca* Boiss., *Pyrus serikensis* Güner & H. Duman, *Rosa dumalis* Bechst, *Quercus macranthera* Fisch. & Mey. ex. Hohen. subsp. *syspirensis* (C. Koch.) Menitsky, *Quercus petraea* (Mattuschka) Liebl. subsp. *pinnatiloba* (C. Koch.) Menitsky, *Quercus vulcanica* Boiss. ex Kotschy, *Quercus aucheri* Jaub. et Spach. and *Phlomis lycia* D. Don.

This book has also IAWA (International Associate of Wood Anatomists) Index for each species, and an identification key for the 67 genera to help in the identification of the woods from this region.

We would like to acknowledge the valuable contributions of some of our colleagues during the preparation of this book. We thank Ali Kavgacı for his help during sampling in the Mediterranean Region of Turkey, and Emine Gümüs and Hatice Yılmaz for their help during the laboratory work. We are also grateful to the following colleagues who helped us in collecting some wood samples: Saime Basaran and M. Ali Basaran at the South-Western Anatolia Forest Research Institute. In preparation of this book, we have been greatly encouraged by Dr. Norbert Kessel, Kessel Publishing House. We thank him for the generous support.

We hope that this book will be useful and make a contribution to wood anatomy in the eastern Mediterranean Basin.

Ünal Akkemik
Barbaros Yaman

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Introduction

Wood anatomy is an important research field for various disciplines such as botany, ecology, forestry, forest industry, archaeology, paleobotany and architecture. This important discipline also has a long history. Theophrast classified plants into trees, shrubs, perennial herbs and herbs. This was the most important study until the beginning of modern wood anatomy (Kisser, 1967). Baas (1982) stated that the history of plant anatomy goes back to Hook (1665)'s famous book "Micrographia" in the seventeenth century. Malpighi (1628-1694), Grew (1641-1712) and Leeuwenhoek (1632-1723) are accepted as the true founders of plant anatomy. Wood anatomy continued to develop much faster during the nineteenth and twentieth centuries than it had in the past. Hartig (1859), v. Wiesner (1873, 1900, 1914), Moeller (1876), De Bary (1877), Russow (1883), Hartig (1885), and many other scientists performed important studies in the field of plant anatomy (Kisser, 1967).

As a result of increasing wood anatomy studies, valuable wood anatomy books have been published during the last century and at present (e.g. Schmidt, 1941; Metcalfe and Chalk, 1950; Huber and Rouschal, 1954; Greguss, 1955; Jacquiot, 1955; Jane, 1956; Esau, 1963; Barefoot and Hankins, 1982; Fahn et al., 1986; Carlquist, 1988; Schweingruber, 1988; Schweingruber et al., 2011).

B. Aytug and A. Berkel are pioneers of the field and have made significant contributions to the field of wood anatomy in Turkey. Many books, papers and theses have been published since their initial efforts (e.g. Aytug, 1959, 1961; Berkel and Bozkurt, 1961; Bozkurt, 1967a, b, 1971a, b; Yaltirik, 1971; Eliçin, 1977; Merev, 1982, 1998a, b, 2003; Şanli, 1978; Erdin, 1983; Efe, 1987; Saribaş, 1988; Akkemik,1995a, b; Çinar-Yilmaz, 1998a; Bozkurt and Erdin, 2000; Yaman, 2002; Serdar, 2003; Bak, 2006; Doğu, 2007; Akkemik et al., 2007; Cihan, 2010).

Wood anatomical features of woody plants serve to identify woods from different mediums such as archaeological excavations, historical buildings, burned areas, wooden charcoals and fossil forests. For that reason, the wood features of trees and shrubs must be studied and demonstrated.

Wood usage has a very long history in the eastern Mediterranean Basin. Woods from different forests and from different species have been used in construction and for different purposes. Identification of woods from different archaeological sites showed important results. Kayacik and Aytug (1968) and Aytug (1970) studied the woods from the Gordion King Tombs and identified *Cedrus libani* A. Rich., *Pinus sylvestris* L., and *Juniperus foetidissima* Bieb. Sanli (1988 and 1989) also identified many woods from different archaeological excavations such as *Cupressus sempervirens* L., *Pinus nigra* Arn., *Taxus baccata* L., *Abies nordmanniana* Spach., *Quercus robur* L., *Juglans regia* L., *Alnus glutinosa* (L.) Gaertn. and *Cornus mas* L. Yaman (2011) identified evergreen oaks and pines from the Bronze age of Gökceada, which is an Aegean island. Recently, Doğu et al. (2011) also identified some woods such as *Castanea sativa* L., *Quercus ithaburensis* Decne, *Quercus pontica* L. and *Cupressus sempervirens* L. from Yenikapi archaeological excavations. Akkemik and Metin (2011) identified *Juniperus foetidissima* from Juliopolis Necropolis (Ankara), whose age is about 2000 years old. Furthermore, we collected thousands of wood types from 27 Byzantine ships excavated from Yenikapı (Istanbul) and we identified mainly oak, chestnut, plane and Spanish broom species.

Having a long history of wood usage, a wood anatomy atlas for the eastern Mediterranean Basin would be an important reference for identifying different woods. Several wood anatomical books have been published in the aforementioned region. Huber and Rouschal (1954) published a wood anatomy atlas for Mediterranean species; Fahn et al (1986) published a book on Israel and its adjacent region. An atlas covering a much wider region for European woods was published by Schweingruber (1988). These books cover many species and are extremely valuable for the region.

This wood anatomy atlas for eastern Mediterranean species includes woody species collected mainly from the natural distribution areas in Turkey. Most of the species included in this book are also common for the entire Mediterranean Basin and have also been published in some wood anatomy books (e.g. Schmidt, 1941; Huber and Rouschal, 1954; Fahn et al., 1986; Schweingruber, 1988; Bozkurt and Erdin, 2000; Merev, 2003). This book covers many new and endemic woody plants and shrubs. In addition, some dimensions of the wood features are provided. Finally, wood features of some woody plants are provided for the first time in English in this book. This information can be useful for the identification of the woods and ecological aspects of wood formation.

Basic Microscopic Features of Woods

The two main groups of woody plants, gymnosperms and angiosperms, can also be classified based on their wood anatomical features. Their wood elements are different and therefore can easily be recognized using a magnifying glass or through naked eye.

Gymnosperm woods

Gymnosperm woods are rather simple and composed of only two main elements which can be seen in all gymnosperm woods: tracheids in the axial direction and rays in the horizontal direction within growth rings. The other wood elements are resin canals, ray tracheids, and axial parenchyma cells. These wood elements can be seen in the woods of some conifers. Basic microscopic features of these elements such as growth rings, resin canals, tracheids, ray tracheids, rays, and axial parenchyma cells in gymnosperm woods are given below.

GROWTH RINGS

Growth rings of the gymnosperm woods in the eastern Mediterranean Basin mostly have a distinct border between the rings (Figure 1.1, 1.2, 1.3). This feature can also be visible to the naked eye and/or through a magnifying glass. Woods of the Pinaceae and Taxaceae families have very distinct and stable growth rings; by contrast, woods of the Cupressaceae family, such as *Cupressus* and *Juniperus* mostly have growth rings which have intra-annual fluctuations, discontinuous and false rings (Figure 1.3).

RESIN CANALS

In some woods in the eastern Mediterranean Basin such as *Pinus* and *Picea*, longitudinal resin canals are mostly present in the transition zones from earlywood to latewood, and within the latewood (Figure 1.2, 1.4). Except these normal resin canals, in the woods of *Abies* and *Cedrus* traumatic resin canals can be seen. These traumatic resin canals may be produced after wounding, freezing, etc. Horizontal resin canals are also present inside the rays in these woods. Furthermore, the wood of *Cedrus* also has horizontal resin canals within very wide rays.

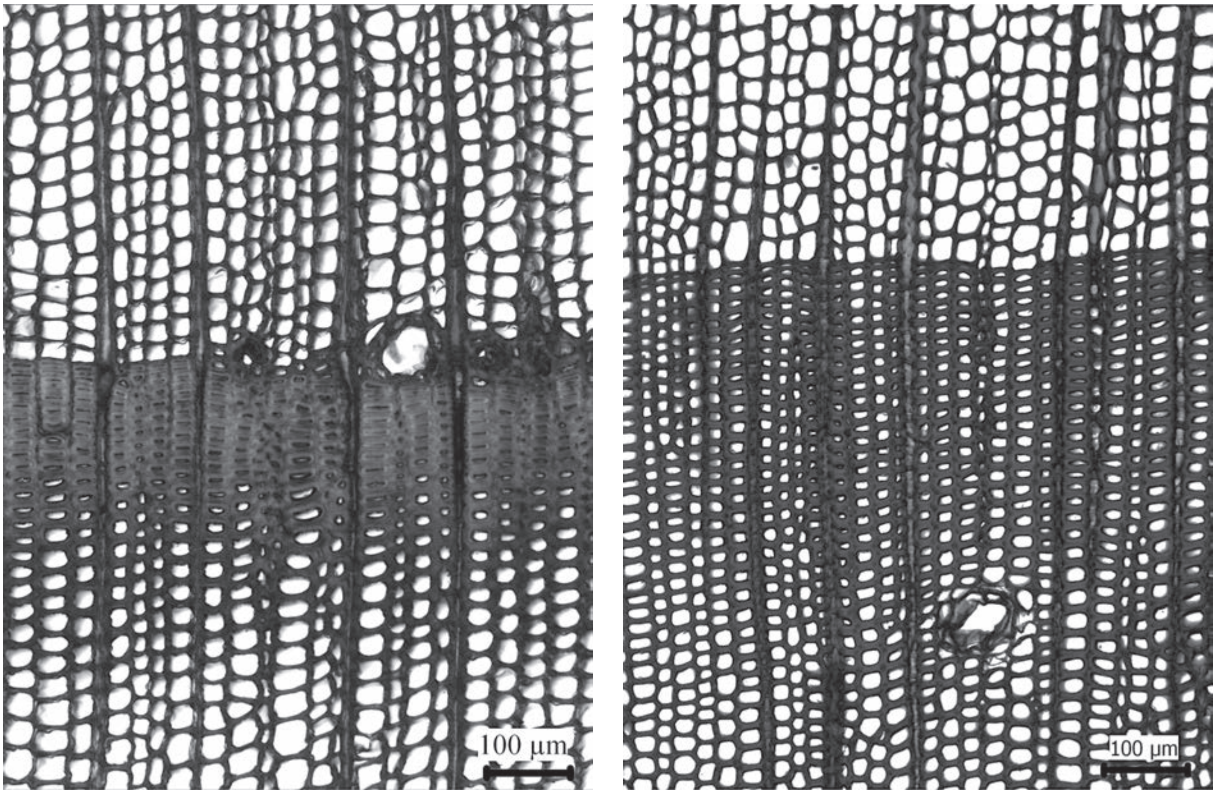
TRACHEIDS

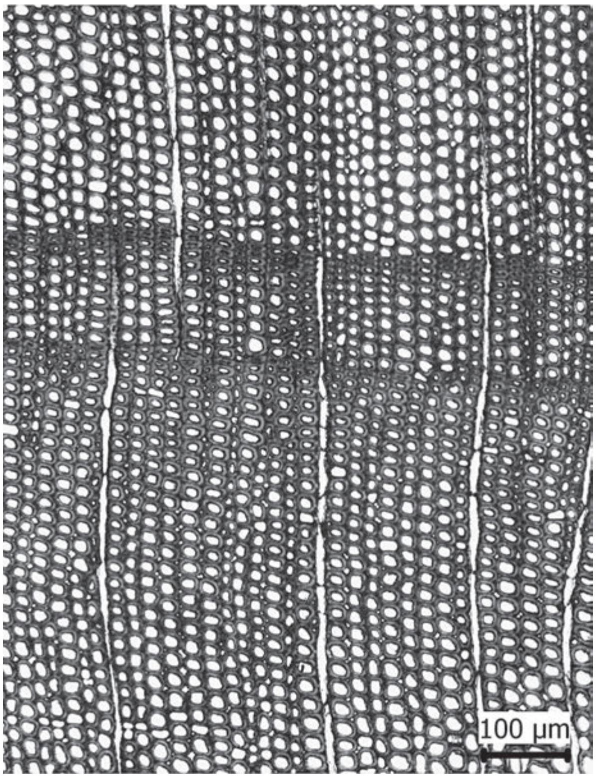
Tracheids are the main axial elements in the gymnosperm woods. Their lengths are generally 1-3 mm in modern woods and up to 9 mm in fossil woods (*Sequoioxylon* from Late Oligocene) (Akkemik et al., 2006), and diameters up to 80 µm. They are dead longitudinal cells and have bordered pits on their mainly radial surfaces and near the tips.

One of the important features in some gymnosperm woods is having intercellular spaces throughout the wood, which can be seen in the cross sections. This feature is very common in most species of the genus *Juniperus* (Figure 1.3).

Tracheids in the genus *Taxus* have helical thickening, which is important in identification. Helical thickening is present throughout the growth ring and widely spaced in the genus *Taxus* (Figure 2.3, 3.3).

Most gymnosperm woods of the Mediterranean Basin mainly have tracheids, which have predominantly uniseriate bordered pits. Such genera as *Abies*, *Cedrus*, and *Larix* also have biseriate bordered pits. This feature is common in *Larix* and *Cedrus*. Arrangement of the biseriate bordered pits is mostly opposite. In some genera such as *Juniperus* and *Cupressus* bordered pits can also be seen on tangential surfaces.





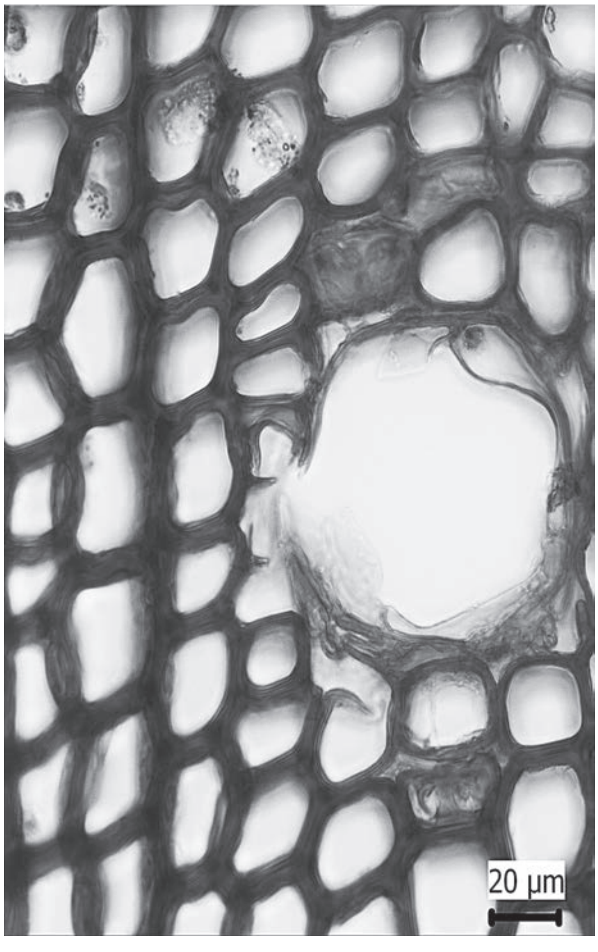


Figure 1. Transversal sections of some gymnosperms. -1) Transversal section of *Abies cilicica* with trauamatic resin canals. -2) Transversal section of *Pinus nigra* with resin canal. -3) False ring in *Juniperus phoenicea*. -4) Resin canal in *Pinus nigra*.

RAY TRACHEIDS

In the woods of the eastern Mediterranean Basin ray tracheid is a common feature in the woods which have longitudinal resin canals (*Pinus* and *Picea*), and *Cedrus* trees, which have traumatic resin canals. It is very rare in the genus *Abies*. The height of ray tracheids is very changeable from one to three-four rows. They are mostly located in the upper and lower borders of rays. However, they can be seen in the inner parts and/or only on one side of the rays. Their walls are extremely important in identification. They can be smooth (*Pinus pinea*, *Picea*, and *Cedrus*) or dentate (*Pinus nigra*, *Pinus brutia*, and *Pinus halepensis;* Figure 2.1, 2.4).

RAYS

Rays are predominantly uniseriate in all conifer woods in the eastern Mediterranean Basin. They are sometimes multiseriate in rays with horizontal resin canals (Figure 3.1). Rays are mostly composed of only ray cells, which are called homogeneous. In some genera mentioned above rays are composed of ray cells, horizontal resin canals and ray tracheids, which are called heterogeneous (Figure 2.1, 2.4). Ray heights are also different and a useful feature in identification. It is very low in *Juniperus* (Figure 3.2) and high in *Abies*, *Picea*, *Cedrus* and *Taxus* (Figure 3.3).

One of the most important features in gymnosperm woods are cross-field pits on the radial surface of ray cells. Five main types can be easily recognized: window-like, pinoid, taxodioid, cupressoid and piceoid types (Figure 2.1, 2.2, 2.4). In *Pinus* woods, two types of cross-field pit, the pinoid type (*Pinus brutia*, *Pinus halepensis* and *Pinus pinea*) and the window-like type (*Pinus nigra*) are common. The other common type of cross-field pit is the cupressoid type, and common in *Cupressus*, *Juniperus*, *Abies*, *Cedrus* and *Taxus*. The piceoid type is seen in *Picea*.

The end and horizontal walls of ray cells are smooth and/or pitted in gymnosperms. This feature is very important in the identification of some genera such as *Abies*, *Juniperus* and *Cupressus* (Figure 2.4).

AXIAL PARENCHYMA

Another important element in some gymnosperm woods such as *Juniperus* and *Cupressus* in the eastern Mediterranean Basin is axial parenchyma. This is a common feature in the Cupressaceae family and is lacking in Taxaceae. In the Pinaceae family it is not common. In *Juniperus* and *Cupressus* they are located mostly in the transitional zone from earlywood to the latewood and/or in latewood. They diffuse and tangentially zonate within latewood or at the end of the growth ring.

The end walls of axial parenchyma cells are smooth (generally in *Cupressus*) or pitted (in *Juniperus*) (Figure 3.4).

CRYSTALS

Crystals are not a common feature in the gymnosperm woods of he eastern Mediterranean Basin. Crystals can be seen in the upper and lower marginal cells of rays in the genus *Cedrus*, and rarely in *Abies*.

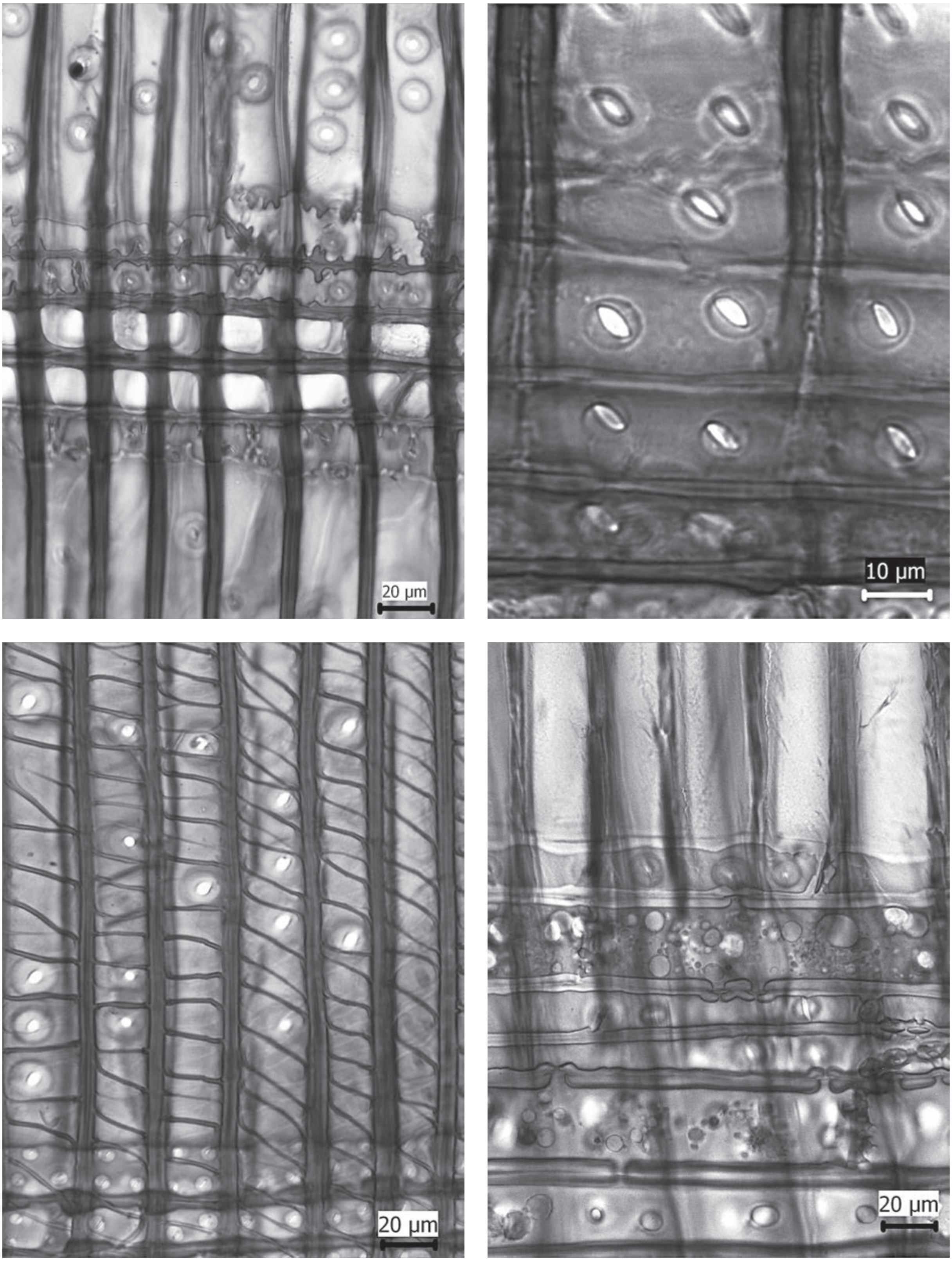


Figure 2. Radial sections of some gymnosperms. -1) Rays with fenestriform pits and ray tracheids with dentate walls in *Pinus nigra*. -2) Cupressoid type cross-field pits in *Cupressus sempervirens*. -3) Helical thickening in *Taxus baccata*. -4) Pinoid type cross-field pits and smooth walled ray tracheids in *Pinus pinea*.

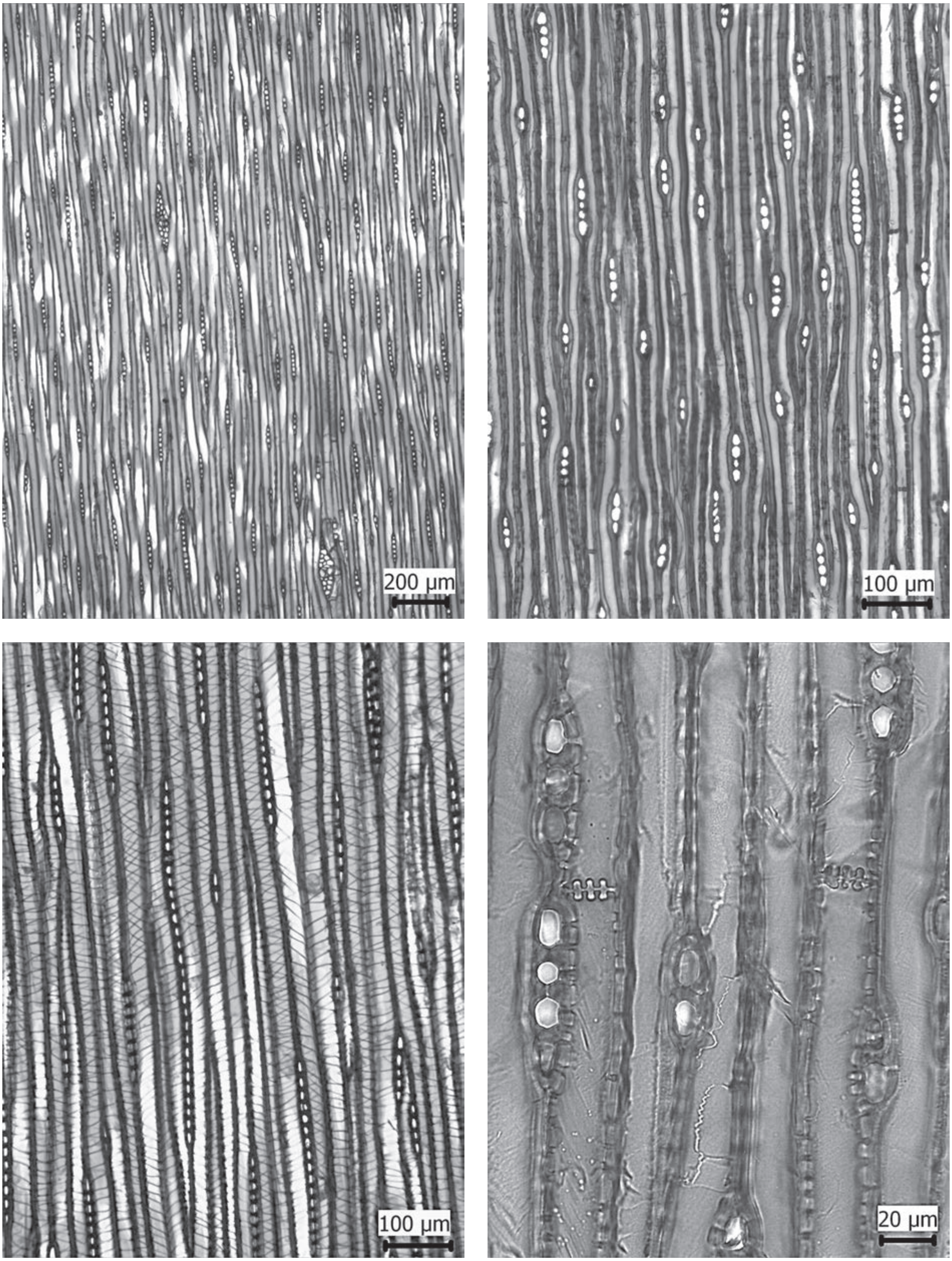


Figure 3. Tangential sections of some gymnosperms. -1) Tangential section with horizontal resin canals in *Pinus nigra*. -2) Rays with 1-7 cells in *Juniperus phoenicea*. -3) Helical thickening in *Taxus baccata*. -4) Axial parenchyma cells with dentate end walls in *Juniperus excelsa.*

Angiosperm woods

Angiosperm woods are mostly more complex than gymnosperm woods. Axial elements in their woods are vessels, fibers, tracheids and axial parenchyma, and horizontal elements are rays.

GROWTH RINGS

The angiosperm woods of the eastern Mediterranean Basin mostly have distinct boundaries. In some woods growth ring boundaries are indistinct. Growth ring boundaries are more distinct in the woods which are ring-porous (Figure 4, 5) or semi-ring porous.

VESSELS

Vessels are the main axial elements of the woods. Their diameter and porosity are very changeable from one genus to another, and therefore this feature is one of the main characters for identification. The angiosperm woods in the eastern Mediterranean Basin have three types of porosity: (1) Ring porous (for example *Quercus*, *Fraxinus*, *Ulmus*, *Rosa* etc.) (Figure 4), (2) Semi-ring porous (*Juglans*) (Figure 6.4), and (3) Diffuse porous (*Fagus*, *Carpinus*, *Corylus*, *Liquidambar*, etc.) (Figure 5). Arrangement of vessel can be a diffuse, tangential, radial, diagonal or dendritic pattern (Figure 5, 6). Vessels are solitary, in radial multiples or clusters (Figure 4-6).

Vessels have different types of perforation plates. These types are mainly simple, scalariform and reticulate. In the angiosperm woods of the eastern Mediterranean Basin, woods mainly have simple perforation plates and rarely scalariform (Figure 7).

Arrangements of bordered pits are also different in different genera. Mostly alternate and opposite types may be seen and rarely scalariform. Helical thickening is common in some species.

Vessel element length is generally ≤350 µm, in some species it is 350-800 µm. Diameter of vessels ranges from 15-20 µm to 400 µm. All these vessel characteristics are crucially important in the identification of the woods.

FIBRES AND TRACHEIDS

Fibers are the main ground tissue elements. Their length, wall thickness and some features may have importance in identification. Some woods such as *Ulmus minor* have septate fibers, and this can be a useful feature in identification. In the *Pyrus* species fibres have distinctly-bordered pits in both radial and tangential sections.

Vascular tracheids are an important feature in the woods of the Mediterranean Basin. The woods generally show xeric characteristics in this region and vascular tracheids are common. They have an important role in water transportation in xeric conditions, and are common especially in brushes.

AXIAL PARENCHYMA

Axial parenchyma cells in the woods of angiosperms are more common than in the gymnosperm woods. They may be diffuse, diffuse-in-aggregate, narrowly banded, scanty paratracheal, vasicentric or aliform. Diffuse and scanty paratracheal types of axial parenchyma are common in the woods of the eastern Mediterranean Basin (Figure 4.3). Generally 2-3 cells, 2-4 cells or 5-8 cells are present per parenchyma strand.

RAYS

Rays are generally composed of only ray cells. Many different types and arrangements of ray cells are important identification characters. Ray widths are uniseriate (*Castanea*, *Paliurus*, *Populus*, *Salix*) (Figure 8.1), biseriate (*Pyrus*, *Fraxinus*) (Figure 8.2), larger rays 4-10 seriate (*Rosa*, *Celtis*) and higher than 10 seriate (*Quercus*, *Fagus*) (Figure 8.3). In some species two distinct sizes of rays are common (*Acer monspessulanum*, *Quercus*) (Figure 8.3, 9.4). Aggregate rays are also seen in *Corylus* and *Alnus* (Figure 9.3). Ray heights range from 2-3 cells to the numerous (up to 5 mm) (Figure 8, 9). Ray length is more than 1 mm (*Quercus*, *Rosa*).

Ray cellular composition is one of the important features to identify angiosperm woods. All rays may be procumbent (*Quercus*, *Ulmus*) or with upright/square marginal cells. Perforated ray cells may be seen (for example *Rhamnus pyrellus*). Perforation type in perforated ray cells is the same as the main perforation in the wood. For example in *Styrax officinalis*, perforation is scalariform and that is the same in the perforation ray cells.

STORIED STRUCTURE

Storied structure may be seen in vessel elements and parenchyma in the eastern Mediterranean Basin. In some species such as *Spartium junceum*, *Calycotome villosa* and *Tamarix smyrnensis* this is a common feature and their woods can also be identified by using this feature (Figure 7.1).

CRYSTALS

Crystals are common in most of the Mediterranean species. In some species such as *Pyrus serikensis* and *Acer monspessulanum* crystals are common in chambered axial parenchyma cells as chains (Figure 8.2). In some other species such as *Rhamnus* species they are common in ray cells. Different types and densities of crystals may be used in descriptions of the species.

Ecological trends in angiosperm woods

As it is well known, the plant life in a region is affected by seasonally separated climatic stresses such as summer drought and winter cold stress (Mitrakos, 1980; Larcher, 2000). In the eastern Mediterranean Basin summer drought is one of the most important stresses in wood formations. Studies have revealed that environmental factors such as water availability, temperature, altitude, latitude from south to north affect the anatomical characteristics of woods.

The concept of ecological wood anatomy is based on Carlquist (1966), Baas (1973), and Graaff and Baas (1974). In the last quarter of 20th century and the last decade, many ecological wood anatomy studies have been performed in the World. In Turkey history of ecological wood anatomy goes back to the year of 1968. Yaltirik (1968) studied anatomical and morphological characteristics of Turkish maples wood with relation to the humidity of the sites. Şanli (1978) examined anatomical features of beech woods related to altitude in the different regions of Turkey. Later, wood structures of *Ostrya carpinifolia* (Gercek et al., 1998), *Rhododendron* sp. (Merev and Yavuz, 2000), Salicaceae (Serdar, 2003), *Populus tremula* (Yaman and Saribas, 2004), Oleaceae (Erşen Bak, 2006), *Cerasus avium* (Yaman, 2006) and *Juglans regia* (Yaman, 2008) were studied with regard to ecological perspective.

Akkemik et al. (2007) showed that endemic *Rhamnus* species had very low mesomorphy ratio ranges 11-23, and adapted to xeric conditions. Cihan (2010) studied the ecological wood anatomy of five macchie elements from typical Mediterranean and Black Sea Regions. Mesomorphy ratio in the Mediterranean specimens of *L. nobilis* was 103, and it was 255 in its Black Sea specimens. This value is higher than the limit value of mesomorphy. In the other species (*Arbutus andrachne* L., *Myrtus communis* L., *Phillyrea latifolia* L., *Spartium junceum* L.), this value is lower than the limit value of 75.

Altitudinal and regional comparisons revealed that mesomorphy ratio increases from the Mediterranean Region to the Black Sea Region and from higher altitude to lower.

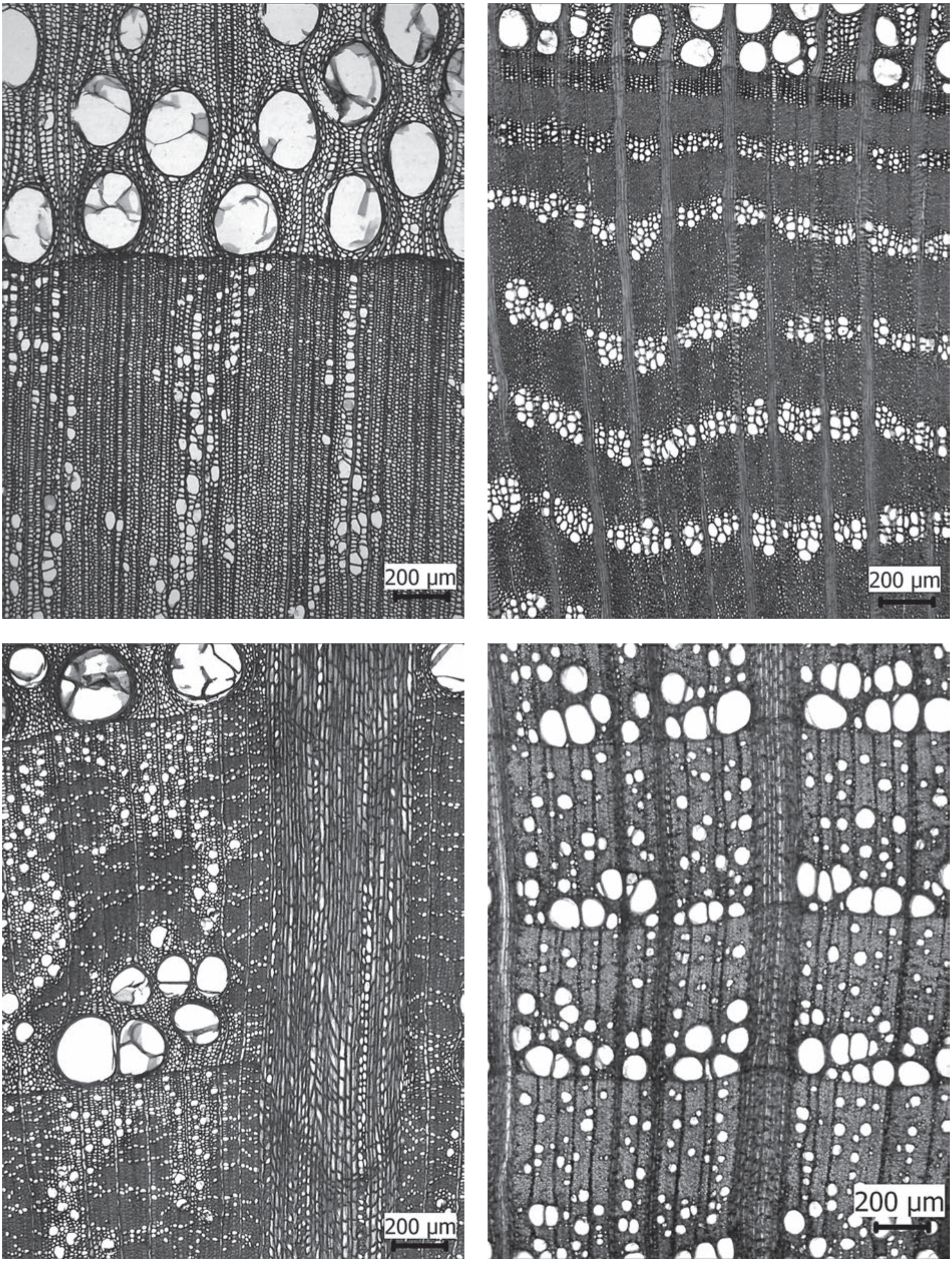


Figure 4. Transversal sections of some angiosperms. -1) Wood ring porous in *Castanea sativa*. -2) Wood ring porous with tangential bands in latewood in *Ulmus minor*. -3) Ring porous and very wide rays in *Quercus infectoria* subsp. *boissieri*. -4) Ring porous and wide rays in *Rosa dumalis*.

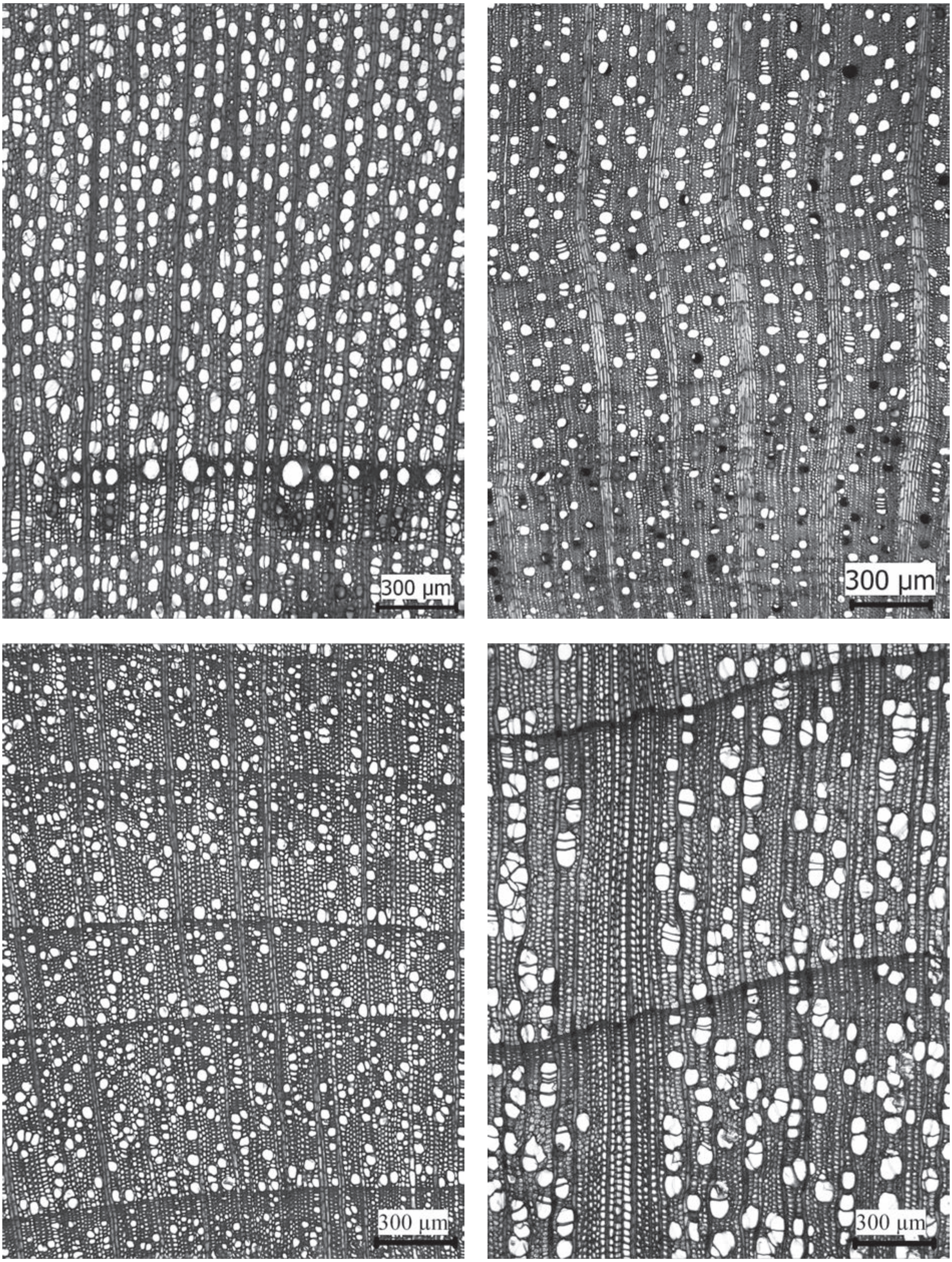


Figure 5. Transversal sections of some angiosperms. -1) Diffuse porous in *Liquidambar orientalis.* -2) Diffuse porous in *Acer monspessulanum*. -3) Transversal section with diffuse porous of *Myrtus communis*. -4) Diffuse porous with radial multiples of vessels in *Alnus orientalis*.

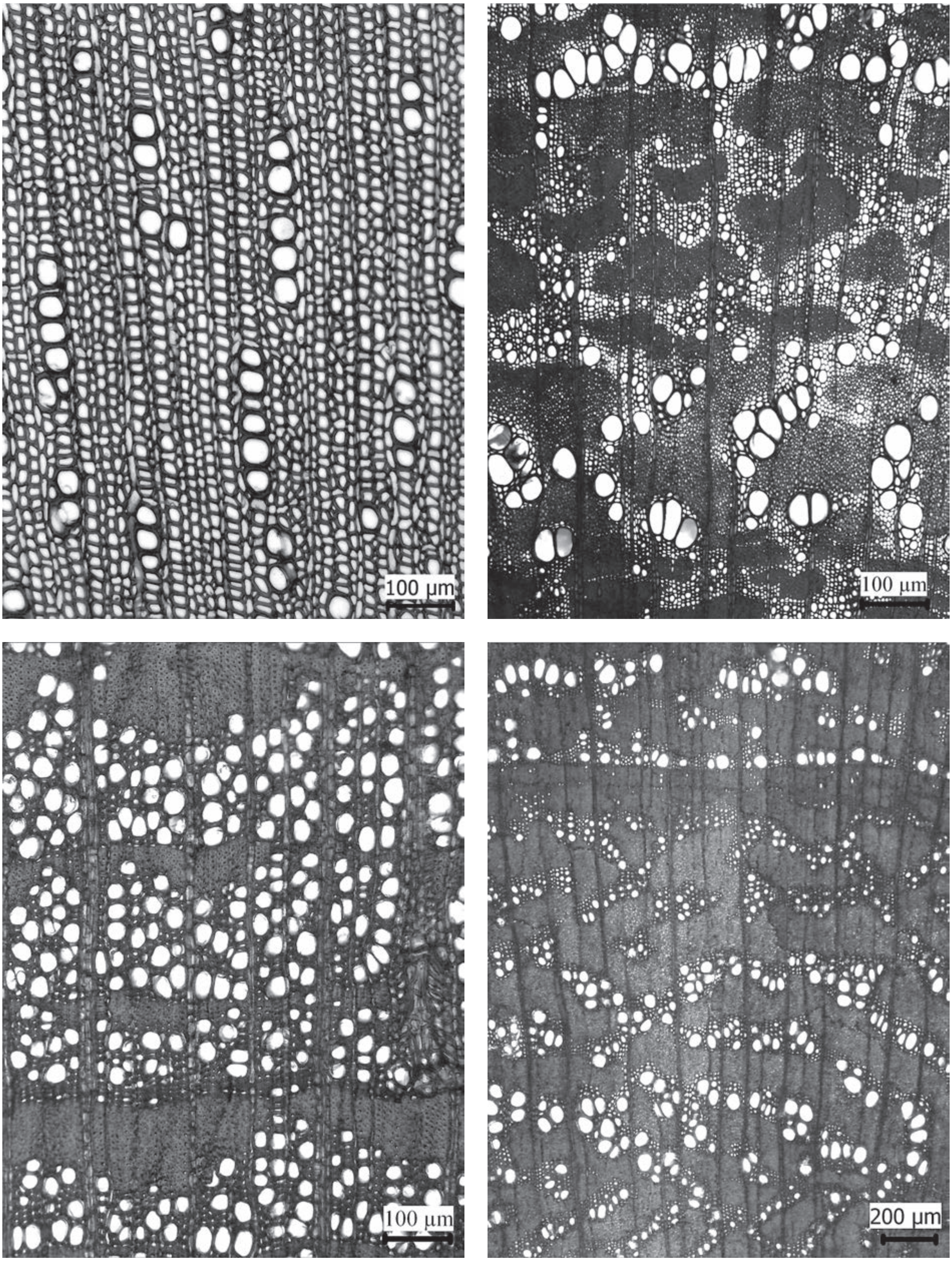


Figure 6. Transversal sections of some angiosperms. -1) Vessels in radial multiples in *Nerium oleander*. -2) Wood semi-ring porous and vessels in dendritic pattern in *Spartium junceum*. -3) Vessels in dendritic pattern in *Rhamnus nitidus*. -4) Wood semi-ring porous and vessels in dendritic pattern in *Calycotome villosa*.

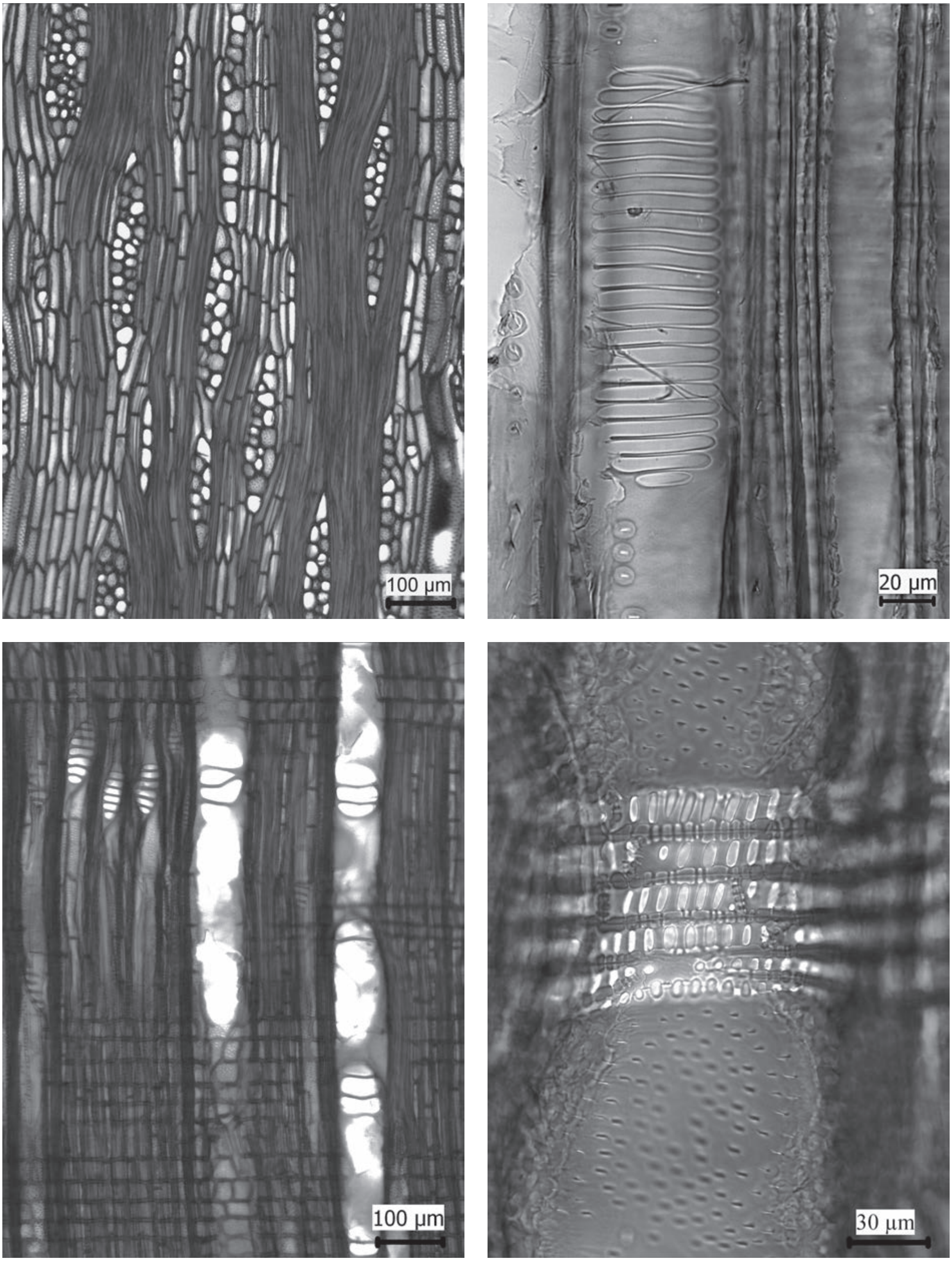


Figure 7. Radial sections of some angiosperms. -1) Storied structure in vessel elements of *Anagyris foetida*. -2) Scalariform perforation plates in *Liquidambar orientalis*. -3) Scalariform perforation plates with low bar number in *Styrax officinalis*. -4) Vertical (palisade) vessel-ray pitting in *Quercus aucheri*.

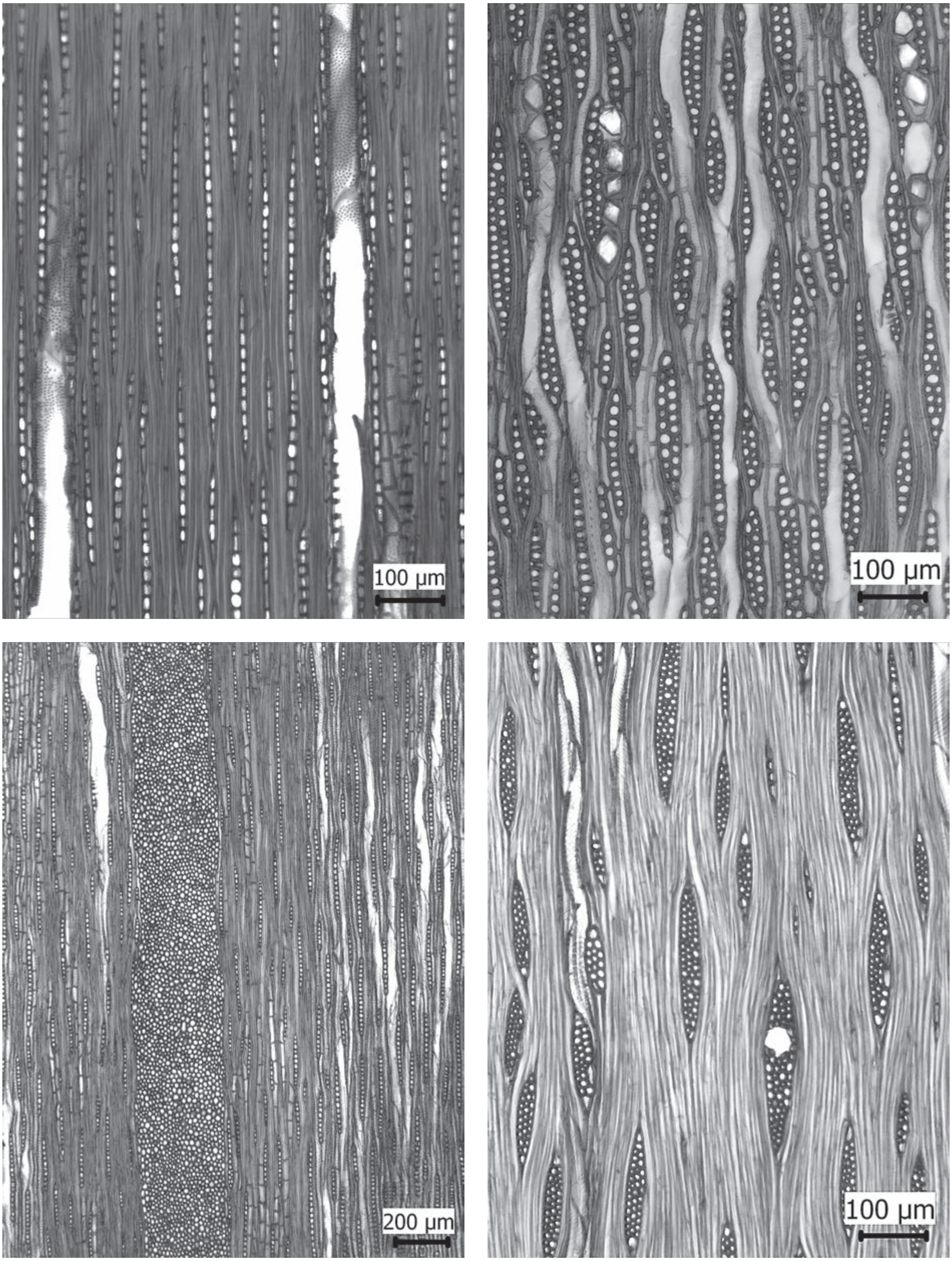


Figure 8. Tangential sections of some angiosperms. -1) Uniseriate rays in *Paliurus spina-christii*. -2) Biseriate rays and axial parenchyma cells with crystals in *Pyrus syriaca*. -3) Uniseriate and very wide multiseriate rays in *Quercus petraea* subsp. *pinnatiloba*. -4) Ray with latex tube (Laticifers) in *Pistacia terebinthus*.

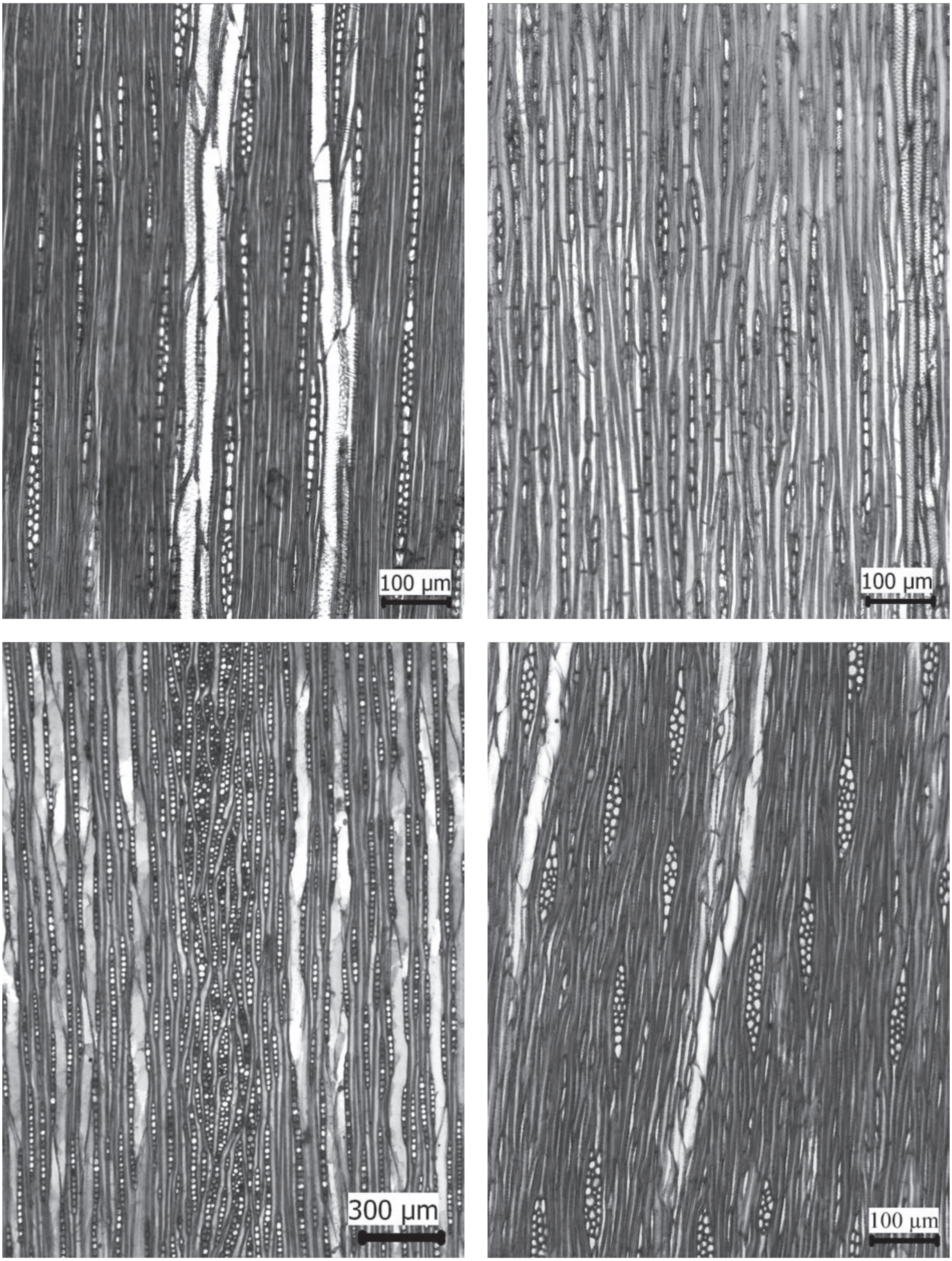


Figure 9. Tangential sections of some angiosperms. -1) Uniseriate and partly biseriate rays in *Cotynus coggyria*. -2) Uniseriate rays with upright cells in *Euphorbia hierosolymitana*. -3) Aggregate rays in *Alnus orientalis*. -4) Two distinct sizes of rays in *Erica bocquetti*. Uniseriate and bi-to-triseriate. Uniseriate ones are upright cells.

Juniperus foetidissima from the eastern Mediterranean Basin (Photo: Ali Kaya)

Gymnosperm woods of Eastern Mediterranean

Pinaceae

Abies cilicica (Ant. & Kotschy) Carr. — Cilician fir

Distribution:
Main distribution area is Taurus Mountains of Turkey, and localy Syria and Lebanon

IAWA Index:
40, 43, 44, 51, 55, 56, 75, 80, 86, 88, 93, 98, 103, 104, 107, 111

Growth rings. Growth ring boundaries distinct. Transition from earlywood to latewood mostly gradual. No resin canal.

Tracheids. Tracheid pitting in radial walls in earlywood predominantly uniseriate. No organic deposits. Average tracheid lenght medium[1]. Intercellular spaces throughout the wood in transversal section not observed. Latewood tracheids thick-walled. Torus present. No helical thickening. Crassule formation common.

Axial parenchyma. Axial parenchyma rare and marginal in only growth ring boundary[1].

Rays. Rays exclusively uniseriate, rarely partly biseriate. Rays homogeneous, ray tracheids absent or very rare. End and horizontal walls of ray parenchyma cells distinctly pitted. Average ray height 1-26 cells [1]. Max ray height 45 cells[1].

Cross-field pitting cupressoid. Number of pits per cross-field 2 to 3[1] (mostly 2).

Intercellular canals. Intercellular canals absent. Traumatic resin canals common.

Storied structures. No storied structure.

Mineral inclusions. Rarely present in the marginal cells of rays.

Key Characteristics. Growth ring boundaries distinct. Transition from earlywood to latewood mostly gradual. No resin canal. No helical thickening. Rays homogeneous, uniseriate and its height 1-26 cells. Cross-field pitting cupressoid. Number of pits per cross-field 2 to 4 (mostly 2).

1 The following average values and features are given for *Abies cilicica*: Average tracheid lenght 2654 (1000-4200) µm, width of tracheids 34.1 (16-50) µm, axial parenchyma absent, and diameter of cupressoid pits 5 µm. Axial parenchyma rare and marginal in only growth ring boundary, and cross-field pitting cupressoid. Number of pits per cross-field 2 to 3 (Aytuğ, 1961). Average tracheid lenght 3995 µm, average diameter 40.6 µm. Wall thickness 6.6 µm and lumen diameter 27.5 µm. Diameter of bordered pits 13.2-19.0 µm, porus 4.8-6.6 µm. Tracheid number per mm 1200 (918-1398). Diameter of cross-field pits 6.6-11.4 µm. Ray heights 1-26 (max.45) cells (Bozkurt, 1971b).

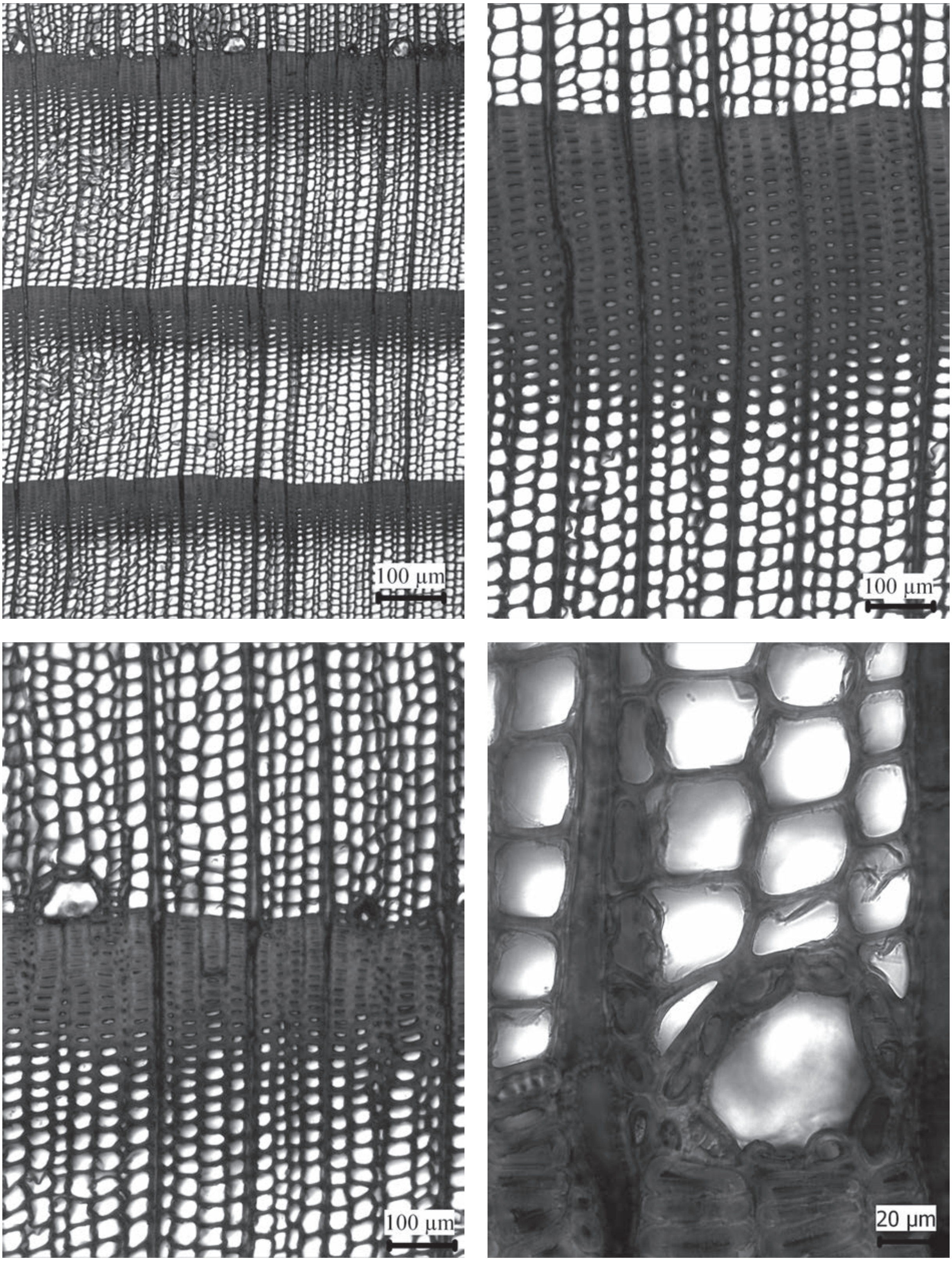


Figure 10. -1-4) Transversal sections of *Abies cilicica*. -1, 3, 4) Transversal sections with traumatic resin canals.

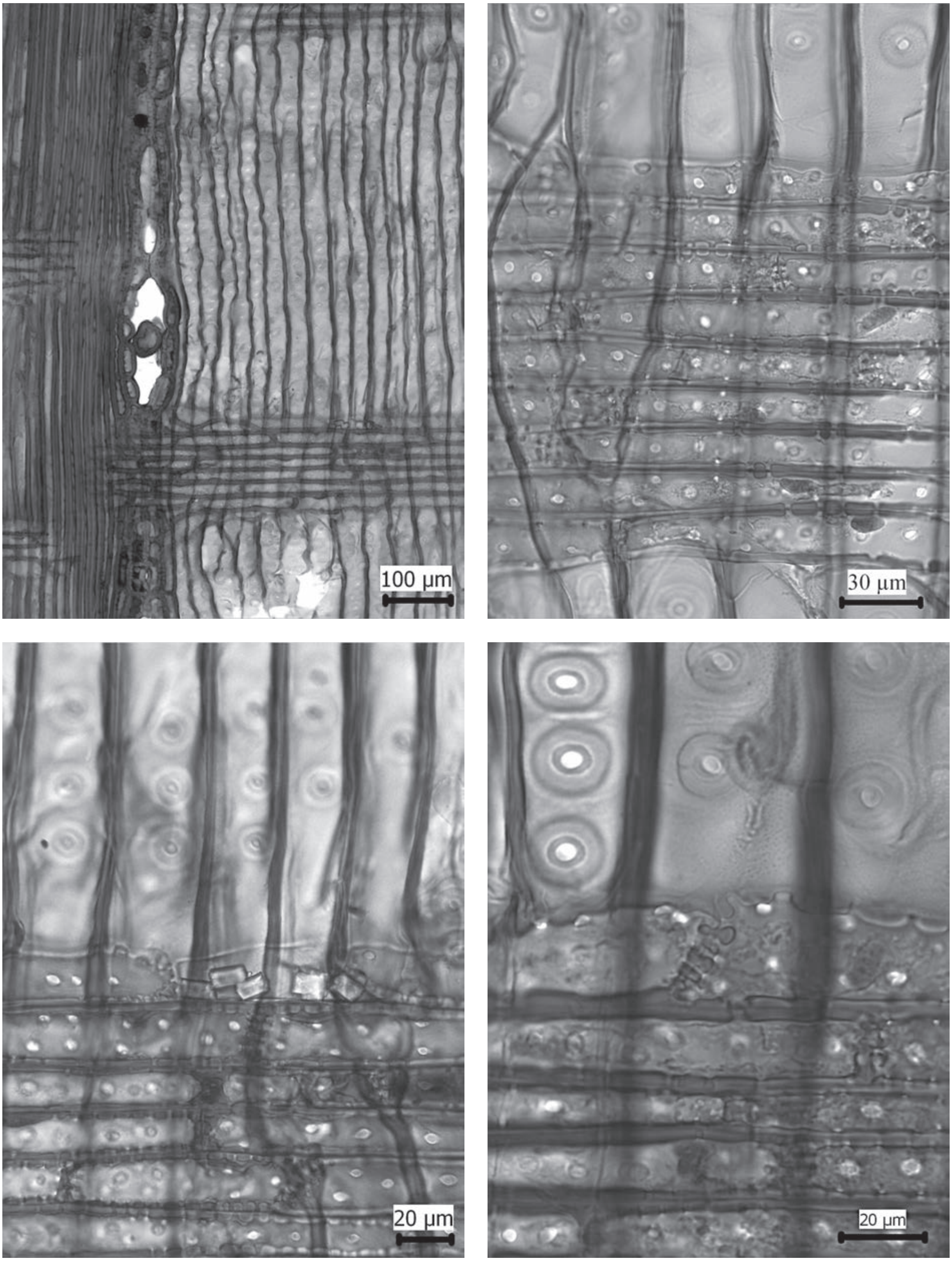


Figure 11. Radial sections of *Abies cilicica*. -1) Traumatic resin canal in radial section. -, 2, 4) Homogeneous rays with cupressoid pits. End and horizontal walls pitted. -3) Crystals in marginal cells of rays.