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Epidermal Cellular Characteristics of Selected Livestock-Poisoning Plants in North America

with special reference to Texas

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Contents

Foreword

Poisonous plants cause very serious economic losses to the livestock industry in North America. Veterinarians, animal scientists, rangeland scientists, and ranchers utilize an array of skills and tools for diagnosing the causes of livestock death or intoxication, but often need a practical method for determining if poisonous plants have been ingested by affected animals. The microhistological analysis method presented herein, along with general descriptive terminology and photomicrographic prints of the epidermal cellular characteristics of 109 North American poisonous plant taxa, provide a valuable diagnostic tool to determine the presence of poisonous plants in the ingesta or feces of affected animals.

The taxonomic terminology has been defined in the glossary, and the photomicrographs depict the major epidermal cellular characteristics of each taxon. A dichotomous key is included to aid the user in identifying a poisonous plant in a fecal or ingesta sample. Microhistological analysis will be most useful subsequent to evaluation of the clinical symptoms of the affected animal(s), post-mortem examinations, and/or field surveys to determine if suspected poisonous plants were a potential food item of the affected animal(s).

We have emphasized the poisonous plants in Texas herein, because that is where we work, but most of the taxa have large geographical ranges so the information provided has application throughout North America.

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Summary

The epidermal cellular characteristics of 109 of the major plant taxa known to be toxic to livestock in Texas are presented and described as a diagnostic tool to aid veterinarians and diagnosticians in determining specific plants responsible for livestock intoxication. Although the microhistological technique described has several limitations, information gained from its use, coupled with other diagnostic tools (study of symptoms, pathological examination of blood, tissues, etc.) should provide more rapid and conclusive diagnoses of poisonous plant problems. Often when intoxicated animals die under rangeland conditions, feeding by scavengers makes pathological examinations impossible and samples of ingesta may provide the only clues to potential causal factors. In many instances information obtained from examination of an intoxicated animal, post mortem examinations, or pathological studies of tissues will present a set of potential causative plants, some of which may be rapidly eliminated or suspected by knowledge of the normal geographical distribution of the plants, or knowledge of the local flora in the area where the intoxicated animal grazed. The photographs, descriptions, keys, etc. presented will be most useful when used as the final step in the diagnostic process, i.e. to confirm that a suspected toxic plant was actually consumed by an intoxicated animal. Ingesta may be sampled from various parts of the gastrointestinal tract during post mortem examination or fecal samples may be utilized in the microhistological technique described. A key is provided to depict some of the major morphological and anatomical features of plant epidermal tissues that are utilized for identifying specific plant fragments in an ingesta sample. Instructions are provided on how to sample and preserve ingesta and how to prepare microscope slides from ingesta samples.

Introduction

A poisonous or toxic plant is one which induces biochemical or physiological disturbances when grazed by animals. The effects of ingestion of toxic plants include reduced livestock performance (reproduction efficiency, growth, milk production, wool or mohair production), increased maintenance requirements, and death loss (Sperry et al. 1977, Bailey 1978). This very broad definition suggests great difficulty would be encountered in providing an accurate estimate of economic losses resulting from ingestion of toxic plants by livestock. However, estimates of losses to the livestock industry in Texas alone may approach 100 million dollars annually (Sperry et al. 1977).

Almost 200 plant taxa in Texas are known or suspected to cause livestock poisoning but fewer than 80 taxa are thought to cause economically important losses (Sperry et al. 1977). The remaining taxa produce only isolated cases of poisonings or have caused losses in other states. Sperry et al. (1977) described about 80 toxic plants and presented information on their distributions in Texas, species of animals poisoned, clinical signs, poisonous principles, and suggestions for management and treatment.

Diagnosing specific plant-induced toxicities is a major obstacle to management of toxic plant problems. Determination of the presence or absence of a specific plant-induced intoxication requires evidence that the plant has been grazed by the affected animal and identification of plant material in rumen, stomach contents, or feces upon autopsy. Additional clues are an adequate history of grazing management, number of animals involved, presence of syndrome and/or clinical signs, and post mortem lesions (Bailey 1978).

Epidermal cellular characteristics have been used to identify plants in the ingesta of herbivores for about 45 years (Dusi 1949), and numerous refinements have been made since early work (Sparks and Malacheck 1968, Williams 1969, Dearden et al. 1975). This technique, often termed microhistological analysis, involves examination of plant fragments under high power (80 to 200X) magnification. Epidermal cellular characteristics that are most useful for identification include: cell wall patterns; morphology, abundance, and arrangement of stomata; and presence, morphology, and abundance of crystal idioblasts, secretory cells (glands), and trichomes. The relative size of these structures is also useful in differentiation of species. Several references have detailed epidermal cellular characteristics of specific plants (Hansen 1971, Howard and Samuel 1979, Riegert and Singh 1982, Awad et al. 1983). The objective of this study was to describe the epidermal cellular characteristics of selected plant species which cause livestock poisonings to aid veterinarians and diagnosticians in diagnosing plant-induced toxicities in livestock.

Materials and Methods

Most of our reference plant specimens came from the University Herbarium at Angelo State University, San Angelo, Texas or from collections made by The Texas Veterinary Medical Diagnostic Laboratory. Two microscope slides were prepared for each part of each plant. Whole plant parts (leaves, stems, or flowers) were placed in a blender to which enough hot water to cover the cutting blades was added. Dilute household bleach was added unless the tissue was frail (i.e. flower parts, narrow or semi-succulent leaves). The material was blended for 20 to 60 seconds, then thoroughly rinsed over a 200-mesh sieve. A small amount of blended material was then transferred to appropriately labeled 75 by 25-mm microscope slides. If the tissue was not sufficiently cleared by the bleach, two drops of Hertwigs' clearing solution was thoroughly mixed with the sample then evaporated slowly over an alcohol lamp, taking care not to scorch the material. Hoyer's mounting medium was then thoroughly mixed with the sample and 22 by 40-mm glass coverslips were affixed to produce semi-permanent slides.

Reference slides were examined under 20 to 160X magnification on a standard, bi-ocular light microscope using either phase contrast or dark field illumination. Epidermal cellular characteristics for each taxa were described using terms of Harrington and Durrell (1957) for morphology of trichomes and glands, Gould (1968) for anatomy of grasses, and Fraceschi and Horner (1980) for morphology of crystal idioblasts. Descriptive features of dicots were detailed using terminology adopted from Storr (1961).

Black and white photomicrographs were taken with an automatic 35-mm camera attached to the microscope at 20, 80, or 160X. Magnifications of the photomicrographs when printed were approximately 45, 180, and 260X. All photomicrographs contain a micrometer index to provide a quantitative measurement of size. Magnifications shown are approximate because it was impossible to duplicate magnifications exactly from one roll of film to another in the printing process. Ten micrometer divisions on photographs shown as 260X equal 0.077 mm actual size. Ten divisions on photographs shown as 180X and 45X equal 0.120 and 0.480 mm, respectively.

The relative size of structures provides useful clues for identification of plant species. The following is provided as a guide to interpret the relative sizes given in the descriptions below:

Structure	Relative Size		
	Small	Medium	Large
	(μm)		
Cells	< 36	36 - 72	> 72
Stomata	< 24	24 - 48	> 48
Trichomes/glands	< 60	60 - 180	> 180
Crystal idioblasts	< 24	24 - 60	> 60

These are not absolute measurements. Standard magnifications used are typically 80 to 125X for identification of plants in fragmentary condition. The importance of relative size for identification becomes apparent as experience is gained in the microscope technique.

The general format for descriptions of epidermal characteristics given in the figure captions are as follows:

Scientific name and authority, common name, number of species in the genus that occur in Texas, number of varieties of the species that occur in Texas: Cell pattern, cell wall morphology, relative size of cells; size of stomata in relation to cells or relative size, number of companion cells of the stomata, arrangement or distinctness, number reduced; trichome type(s), relative size, type of attachments, abundance; gland type(s), relative size, abundance; crystal idioblast type(s), morphology, abundance. Distribution[1] in Texas and elsewhere. Magnification of each photomicrograph.

This format was slightly modified for description of four grass species since these plants differed for diagnostic features.

A dichotomous key to the taxa based on prominent characteristics is presented in Appendix A. The key is useful to identify an unknown plant found in fragmentary condition. Epidermal characteristics of all taxa are summarized to identify or eliminate potential plants suspected of causing animal poisonings in Appendix B. A glossary of terms used in the text and figure captions is presented in Appendix D.

Plant descriptions are presented in alphabetical order by families. The genera and the species within genera are also alphabetized within classification rank. Taxonomic nomenclature and authorities follow U.S.D.A. (1982), and common names follow Gould (1975) or Correll and Johnston (1970).

[1]Primary references for distributions were Lundell et al. (1961, 1966, 1969), Correll and Johnston (1970), Gould (1975a,b), Elias (1980), U.S.D.A. (1982), and McGregor and Barkley (1986).

Results

AMARANTHACEAE (Amaranth family)

Figure 1. *Amaranthus retroflexus* L., redroot amaranth (pigweed), 23 species in Texas: Regular, smooth cell walls, medium size (a,b,d); small stomata, companion cells three or four, not distinct (a,b); trichome/glands multicelled, complex attachments, unicelled globose distal segment, rare (c); dimorphous crystal idioblasts, abundant medium-to-large clusters of extremely fine crystals throughout tissue (d), and small-to-medium size, subcrystalline druses in stem tissue (c). Distribution: Plains Country to south central Texas and the Trans-Pecos; central and eastern U.S. and adjacent regions of southeast Canada and northeast Mexico, spread to Near East, North Africa and Asia. Photographs a,c, and d 180X, b 260X.

AMARYLLIDACEAE (Amaryllis family)

Figure 2. *Agave lecheguilla* Torr., lechuguilla, 12 species in Texas: Sublinear, thick luminescent cell walls, six-sided (often four-sided) cells, resembling an elongated hexagon, medium size (a); large sunken stomata common in leaf tissue (a); trichomes and glands not apparent; polymorphic crystal idioblasts, (1) large styloid crystals in bundles of one to several, common in leaf material (b,c,d), (2) small-to-medium size raphides (b,c,e), many sizes of styloid crystals and raphides common in flower parts (b,c), and (3) very large clusters of amorphous crystals, common, often visible underneath epidermis (a,d,e). Distribution: West Texas; from southern New Mexico southeast across the Mexican highland to the State of Mexico. All photographs 180X.

APOCYNACEAE (Dogbane family)

Figure 3. *Apocynum sibiricum* Jacq., prairie (willow) dogbane, five species and two varieties of *A. sibiricum* in Texas: Regular, smooth cell walls, small (a to d,f,g); small stomata, not conspicuous (c,d); trichomes/glands small luminescent bumps on epidermis, abundant (e to h); small-to-medium size, irregularly

shaped amorphous druses appearing bright red in reference slides, common (a to d,f,g,h). Distribution: North central Texas, the Edwards Plateau, Plains Country and Trans-Pecos; throughout most of North America. All photographs 260X.

Figure 4. *Nerium oleander* L., common oleander (oleander), a monotypic genus in Texas: Regular, smooth cell walls, small (a,c), sublinear over veins and around "stomatal crypts" (b,c); stomata hidden, not observed; small unicellular trichomes radially arranged pointing inward around crypts (b,c,d), and similar trichomes occasionally over veins, common, superficial attachments; glands not observed; small-to-medium size subcrystalline druses (c), common, and small rhomboid crystals (e,f), rare in veins. Distribution: Central, southern and far eastern Texas; native of the Mediterranean region and Orient, cultivated and widely naturalized in North America. All photographs 180X.

ASCLEPIADACEAE (Milkweed family)

Figure 5. *Asclepias asperula* (Decaisne) Woodson, spider antelopehorn, Gould (1975a) lists var. *decumbens*, 36 species in Texas, we describe four: Regular, smooth cell walls, medium size (a); conspicuous stomata, medium size, usually with two distinct companion cells, both reduced (a); trichomes absent; medium-size two-to-three celled glands with a frail, unicelled, globose distal segment, and complex attachments, common (b,c); medium-size subcrystalline druses rare in stem tissue. Distribution: North, west, central and east central Texas; Kansas and Oklahoma south to Texas. All photographs 180X.

Figure 6. *Asclepias latifolia* (Torr.) Raf., broadleaf milkweed: Regular, smooth cell walls, small (a,b); conspicuous stomata, medium size, equal to or exceeding the size of most epidermal cells, numerous small companion cells radially arranged about stomata (a); trichomes absent; glands/gland bases appearing as small luminescent dots, abundant on leaf epidermis (a); medium-size crystalline druses common (b). Distribution: West and northwest Texas; from southwest Nebraska and Texas west to southern Utah and southeast California. All photographs 180X.

Figure 7. *Asclepias subverticillata* (Gray) Vail, poison (horsetail) milkweed: Regular, smooth cell walls, medium size (a); conspicuous stomata, medium size, usually with two distinct companion cells, both reduced (a); trichomes large, one-to-five celled, superficial or complex attachments, rare to common (b); glands with multicelled stalk and elongated, muticous distal segment which is often slightly inflated, rare (c); small-to-medium size subcrystalline to crystalline druses, common throughout tissue (d,e,f); epidermal characteristics of this species vary. Distribution: Western half of Texas, especially in the Trans-Pecos; from Texas west to Utah, Colorado, Arizona and New Mexico. All photographs 180X.

Figure 8. *Asclepias verticillata* L., (eastern) whorled milkweed: Regular, smooth cell walls, medium size (a); conspicuous stomata, medium size, usually with two distinct companion cells, both reduced (a); multicellular trichomes medium-to-large size, uniformly tapered, complex attachments, rare (b,c,d); glands absent; medium-size crystalline druses, similar to *A. subverticillata* (Fig. 7), common in stem tissue, rare otherwise. Distribution: East half of Texas; east Canada, south to Florida and west to North Dakota and Texas. All photographs 180X.

CAMPANULACEAE (Bellflower family)

Figure 9. *Lobelia berlandieri* A.DC., Berlandier lobelia, eight species and two varieties of *L. berlandieri* in Texas: Dimorphic cells, regular, thin, undulate cell walls, small-to-medium size (a,b,c), and sublinear, thin, smooth cell walls, large (d); medium-size stomata restricted to regular cells, companion cells three-to-five (often four), not distinct (a,b,c); small to very large unicellular trichomes, soft, ensiform, broad at base, apiculate tip, superficial attachments, restricted to sublinear cells, common (d,e,f); glands and crystal idoblasts absent. Distribution: The var. *berlandieri* occurs in the Rio Grande Plains of south Texas and south into Mexico and var. *brachypoda* occurs in the Edwards Plateau and Trans-Pecos. Photographs b and c 260X, a,d,e, and f 180X.

CARYOPHYLLACEAE (Pink family)

Figure 10. *Drymaria pachyphylla* Woot. & Standl., thickleaf drymary, four species in Texas:

Regular, smooth to slightly undulate cell walls, medium to large, tissue very frail (a,b); medium-size stomata, companion cells three or four, one often reduced (a,b); large, stiff, unicellular trichomes, often vaginate, complex attachments, rare (c,d); glands not apparent; dimorphous crystal idioblasts, small to moderately large, globose subcrystalline druses, and clusters of crystal sand, clusters large and elongated especially in veins, both types abundant (e,f). Distribution: Trans-Pecos of Texas; in western U.S. and northern Mexico. All photographs 180X.

CHENOPODIACEAE (Goosefoot family)

Figure 11. *Kochia scoparia* (L.) Schrad., belvedere summercypress (fireweed, mexican fireweed), two species in Texas: Regular (blocky- sublinear in stem tissue), smooth cell walls, small (a,b); small stomata, companion cells often four with two often reduced (a,b); long, thin, stiff, multicellular trichomes, slightly swollen at joints, abundant, complex attachments, distal cell-of-attachment usually luminescent, conspicuous (c,d,e); glands absent; small-to-medium size subcrystalline druses, abundant (c,f,g). Distribution: Common statewide in Texas; a native of Europe, escaped from cultivation and now naturalized in many parts of the U.S. Photograph d 45X, a,b,c,e,f, and g 180X.

COMPOSITAE (Asteraceae) (Sunflower family)

Figure 12. *Baileya multiradiata* Harvey & Gray, desert baileya, a monotypic genus in Texas: Regular, unduate cell walls, small (a); small stomata, faint, companion cells usually four, not distinct (a); multicelled trichomes (b to e), tape-like, swollen at joints, abundant, superficial attachments (a); bicellular glands ("footballs"), rare (e); crystal idioblasts absent. Distribution: Abundant in the Trans-Pecos deserts, rare in the Edwards Plateau; occurs in California, Utah, Nevada, New Mexico, Arizona, and Texas, and in Chihuahua and Coahuila, Mexico. Photograph a 260X, b to e 180X.

Figure 13. *Conyza coulteri* Gray, Coulter conyza, six species in Texas: Regular, undulate cell walls, medium size (a,b); small stomata, companion cells usually four, one often reduced (a); trichomes three-to-six celled, rapidly tapering, medium size, common, apiculate distal segment, complex attachments (c,d,e); glands many celled, stalk divided bilaterally, globose two-to-five celled distal segment, common (c,e); crystal idioblasts absent. Distribution: Frequent in the Trans-Pecos, less common in the Edwards Plateau, and rare in the Rio Grande Plains; southwestern U.S. and Mexico. Photograph a 260X, b to e 180X.

Figure 14. *Eupatorium rugosum* Houtt., white snakeroot, 25 species in Texas: Regular, smooth to undulate cell walls, medium size (a to d); medium-size stomata, companion cells usually four, not distinct (a,b,d); trichomes 6-to-l0 celled, medium to large, muticous distal segment, complex attachments, common (e to h); glands and crystal idioblasts absent. Distribution: East, southeast and north central Texas and Edwards Plateau; most of eastern North America. All photographs 180X.

Figure 15. *Flourensia cernua* DC., tarbush (blackbrush), a monotypic genus in Texas: Regular, smooth cell walls, medium size (a,b); medium-size stomata, often equal to or exceeding the size of most epidermal cells, companion-cell-number variable, not distinct (a,b); medium-to-large trichomes, appressed, two or three cells, luminescent, many large attachment cells arranged around base of trichome (=complex attachments), common (c,d); multicelled clavate glands, similar to *Xanthocephalum* spp. (Figs. 27 and 28), rare on stem tissue; crystal idioblasts absent. Distribution: Very abundant in the Trans-Pecos deserts, rare in east to western part of the Plains Country of Texas; Texas, New Mexico, and Arizona, and in Sonora, Chihuahua, Coahuila, Nuevo Leon, Durango, and Zacatecas, Mexico. All photographs 180X.

Figure 16. *Helenium autumnale* L., common (fall) sneezeweed, Gould (1975a) lists var. *canaliculatum* T.&G., 11 species occurring statewide in Texas, we describe three: Regular (sublinear over veins and on stem tissue), smooth to undulate cell walls, medium size (a,b,d); small-to-medium size stomata, companion-cell-number variable,

often three or four, not distinct (a,b); trichomes three-to-five celled, appressed, basal segment inflated, often greatly, muticous or apiculate distal segment, common, multicelled (complex) attachments on stem tissue, superficial on leaf tissue (c,d); bicellular glands ("footballs") common (e); crystal idioblasts absent. Distribution: North central and east Texas, Edwards Plateau and Plains Country; widespread in temperate North America. All photographs 180X.

Figure 17. *Helenium badium* (Gray) Greene, basin (bitter) sneezeweed: Cells vary greatly, sublinear to regular, smooth to undulate walls, medium size, faint (a,b,d,e); medium-size stomata, faint, companion-cell-number variable, not distinct (b); trichomes two-to-six celled, uniform in width over much of their length, muticous distal segment, basal segment slightly enlarged, common, complex attachments (c,d,e); bicellular glands ("footballs") rare (a,e); crystal idioblasts absent. Distribution: Edwards Plateau, Plains Country and Trans-Pecos, infrequent farther east in Texas; also occurs in southwestern Oklahoma. All photographs 180X.

Figure 18. *Helenium microcephalum* DC., smallhead (littlehead) sneezeweed: Regular, smooth cell walls, medium size, faint (a,b,c); medium-size stomata, faint, companion cells three or four, not distinct (a,b); trichomes three-to-six celled, slightly tapered, muticous distal segment, complex attachments, rare (c,d); bicellular glands ("footballs") abundant (c); crystal idioblasts absent. Distribution: Western half of Texas, infrequently east to Brazos and San Patricio counties, Texas; Texas, southern New Mexico, and in Tamaulipas, Nuevo Leon, and Coahuila, Mexico. All photographs 180X.

Figure 19. *Hymenoxys odorata* DC., western bitterweed, two species in Texas: Regular, generally sinuate cell walls (a), sublinear with smooth cell walls over veins and on stem tissue (b), medium size, cell walls thin, tissue very frail; small stomata, often luminescent, companion cells often four, not distinct (a,b); frail multicelled trichomes, complex attachments, rare (c); bicellular glands ("footballs") common (d); crystal idioblasts absent. Distribution: Abundant in the Edwards Plateau and Trans-Pecos, frequent in northwest Texas, east and south to Wilbarger, Robertson and Starr counties, Texas; Kansas, Colorado, New Mexico, Arizona, California, Texas, and Oklahoma, and in Sonora, Chihuahua, Coahuila, Nuevo Leon and Tamaulipas, Mexico. All photographs 180X.

Figure 20. *Isocoma wrightii* (Gray) Rydb., jimmyweed (rayless goldenrod), four species in Texas: Regular, thick, luminescent, smooth cell walls, cells varying in size, generally small (a,b); small stomata, companion-cell-number variable, one or more usually reduced (a,b); multicelled trichomes varying in size, common, complex attachments (c,d,e); glands abundant, bowl shaped in side view (f,g), appearing as clusters of luminescent dots from above (a), located in fovae of the epidermis; small-to-medium size subcrystalline druses common (h). Distribution: Trans-Pecos and Plains Country of Texas; Arizona, New Mexico, Texas, and probably southeastern Colorado, and in Chihuahua and Sonora, Mexico. All photographs 180X.

Figure 21. *Psilostrophe gnaphaloides* DC., cudweed paperflower, three species in Texas, all are poisonous to livestock and are described: Regular (sublinear around veins), smooth cell walls, medium size (a,b); medium-size stomata, companion cells often three, one usually reduced (a,b); lanate multicelled trichomes, superficial attachments, basal segment slightly inflated, swollen at joints, apiculate distal segment, abundant (c,d,e); bicellular glands ("footballs") rare (e); small amorphous druses rare. Distribution: Frequent in Trans-Pecos, Rio Grande Plains and extreme western end of the Edwards Plateau, very rare farther east in Texas; Texas, and in Chihuahua, Coahuila, Durango, Nuevo Leon, San Luis Potosi, Sonora, Tamaulipas and Zacatecas, Mexico. Photograph d 45X, a,b,c, and e 180X.

Figure 22. *Psilostrophe tagetina* (Nutt.) Greene, woolly paperflower, three varieties in Texas: Regular (sublinear near veins), smooth to undulate cell walls, medium size (a,b); medium-size stomata, companion cells often three, one usually reduced (a); lanate multicellular trichomes, superficial attachments, basal segment usually slightly

inflated, swollen at joints, apiculate distal segment, abundant (a,b,c); bicellular glands ("footballs"), similar to *P. gnaphaloides* (Fig. 21), rare; small amorphous druses rare. Distribution: Frequent in the Trans-Pecos, infrequent in southern part of the Plains Country and rare in western part of the Edwards Plateau; Arizona, New Mexico, Texas and Utah, and in Chihuahua and Coahuila, Mexico. Photographs a and b 180X, c 45X.

Figure 23. *Psilostrophe villosa* Rydb., hairy paperflower: Regular (sublinear near veins), smooth cell walls, medium size (a,b); medium-size stomata, companion cells three or four, one often reduced (a,b); lanate multicellular trichomes, superficial attachments, basal segment usually slightly inflated, swollen at joints, apiculate distal segment, abundant (a,b); bicellular glands ("footballs"), similar to *P. gnaphaloides* (Fig. 21), rare; crystal idioblasts not observed. Distribution: Frequent in the Plains Country, infrequent in the Trans-Pecos and Rio Grande Plains, very rare farther east in Texas; Kansas, Oklahoma, Texas and New Mexico. Both photographs 180X.

Figure 24. *Senecio longilobus* Benth., threadleaf groundsel, 14 species in Texas, two are described: Regular, smooth cell walls, large (a); moderately large stomata, companion cells usually four, one often reduced (a); arachnoid trichomes appearing unicellular, several attachment cells, muticous distal segment, superficial attachments, abundant (b,c); glands and crystal idioblasts not observed. Distribution: Abundant in western half of Texas, east rarely to the Rio Grande Plains; widespread in driest parts of western U.S. and northern Mexico. All photographs 180X.

Figure 25. *Senecio spartioides* T.&G. (*S. riddellii* T.&G.), broom (Riddell) groundsel, Gould (1975a) lists var. *fremontii* (T.&G.) Greenm. in Texas: Regular-hexagonal (sublinear near veins and on stem tissue), smooth cell walls, large (a,b); large stomata, companion cells three or four, one often reduced (a,b); multicelled trichomes, three-to-five celled, rarely more, uniformly tapered, muticous distal segment, common on stem tissue, rare on leaf tissue, complex attachments (c to f); glands not observed; crystal sand rare in stem tissue (g). Distribution: Western half of Texas and also in coastal part of Rio Grande Plains; widespread in western U.S. and northern Mexico. All photographs 180X.

Figure 26. *Xanthium* sp., cocklebur, six species in Texas, photomicrographs are of an unknown species collected near San Angelo, Texas at the five leaf stage: Regular, smooth to undulate cell walls, small and faint (a,b); small stomata, faint, companion-cell-number variable, not distinct (a,b); multicelled trichomes, three-to-five celled, rarely more, rapidly tapering, basal segment greatly inflated, apiculate distal segment, complex attachments, attachment cells often inflated, abundant (c,d); bicellular glands ("footballs") faint, common (e); small-to-medium size subcrystalline druses abundant (f,g). Distribution: Some species statewide in Texas; widespread in the warmer, drier parts of the world. Photographs a,b, and e 260X, c,d,f, and g 180X.

Figure 27. *Xanthocephalum microcephalum* (DC.) Shinners, threadleaf snakeweed (broomweed), 10 species in Texas, two are described: Regular, smooth cell walls, varying in size, shape, and arrangement, generally small (a,b); medium-size stomata, appearing large relative to and often exceeding the size of the epidermal cells, companion cells three to five, not distinct (a,b); multicelled trichomes, antrorse, three or four celled, luminescent, complex attachments, most common on stem tissue, generally rare (c,d,e); dimorphous glands, multicellular clavate glands with tapering, whip-like distal segment, common, and bicellular glands ("footballs") rare (e,f); crystal idioblasts not observed. Distribution: Locally abundant in the Trans-Pecos, rarely east to the western part of the Edwards Plateau and the Plains Country; California, Utah, Colorado, Arizona, New Mexico and Texas, and in Sonora, Chihuahua and Coahuila, Mexico. Photographs a to e 180X, f 260X.

Figure 28. *Xanthocephalum sarothrae* (Pursh) Shinners, broom snakeweed (perennial broomweed): Regular, smooth cell walls, varying in size, shape, and arrangement, generally small (a); small stomata, appearing large relative to and often exceeding the size of the epi-

dermal cells, companion cells four or five, not distinct; multicelled trichomes, antrorse, three or four celled, luminescent, complex attachments, common (b to e); multicellular clavate glands with tapering, whip-like distal segment, rare (e), bicellular glands not observed; crystal idioblasts not observed. Distribution: Locally abundant in the Trans-Pecos, Rio Grande Plains and Plains Country, rarely east to north central Texas and southern part of southeast Texas; Manitoba, Saskatchewan and Alberta, Canada south to Chihuahua, Nuevo Leon and Tamaulipas, Mexico, and west to Washington and California. All photographs 180X.

EUPHORBIACEAE (Spurge family)

Figure 29. *Euphorbia marginata* Pursh, snow-on-the-mountain, 62 species in Texas: Regular, smooth cell walls, medium size in leaf tissue, very small in stem tissue (a,b,d); small-to-medium size stomata, companion cells two to five, not distinct (a,b); long multicellular trichomes (c) very rare, epidermal cells radially arranged about superficial attachments (d); glands not observed; small subcrystalline druses in stem tissue (f). Distribution: Locally abundant in the western half of Texas, rarely in the Rio Grande Plains and Trans-Pecos; Montana and Minnesota south to Texas and New Mexico. All photographs 180X.

Figure 30. *Jatropha cathartica* Teran & Berl., Berlandier nettlespurge, three species in Texas, two are described: Regular, smooth cell walls, medium size, faint, leaf tissue very frail (a,b); medium-size stomata, faint, companion cells often two, both reduced (a,b); dimorphous trichomes, appearing unicellular, long, spiralled, smaller type common (c), larger type morphologically similar but less common (d); glands not observed; polymorphous crystal idioblasts, (1) large crystalline bodies in veins (e,f), (2) small-to-medium size subcrystalline druses (e,f,g), and (3) small-to-medium size crystalline druses (e,f,g). Distribution: Scattered in the Rio Grande Plains of Texas; Texas and Tamaulipas, Nuevo Leon and Coahuila, Mexico. All photographs 180X.

Figure 31. *Jatropha dioica* Sesse ex Cerv., leatherstem (leatherweed, sangre de drago), Gould (1975a) lists two varieties in Texas: Regular, smooth cell walls, medium size, faint, leaf tissue very frail (a); medium-size stomata, faint, companion cells often two, both reduced (a); dimorphic trichomes, unicellular spiralled trichomes abundant (b,c), and small-to-medium size unicellular trichomes rare (d,e); glands not observed; polymorphic crystal idioblasts, (1) long crystalline bodies, similar to *J. cathartica* (Fig. 30), in vein tissue, (2) small-to-medium size irregularly shaped amorphous druses (a), and (3) small-to-large crystalline druses (f). Distribution: Var. *dioica* frequent in the Rio Grande Plains northwest to Val Verde County, Texas and north to Bexar, Blanco and Uvalde counties; Oaxaca northwest to Durango, Mexico and Texas. Var. *graminea* frequent in the Chihuahuan desert of Brewster and Jeff Davis counties, Texas and in the Trans-Pecos; Texas and in Zacatecas, Coahuila and Chihuahua, Mexico. All photographs 180X.

Figure 32. *Phyllanthus abnormis* Baill., Drummond leafflower, seven species in Texas: Regular (blocky-sublinear in stem tissue), smooth to sinuate cell walls, medium size (a to e); small stomata, companion cells usually three, one reduced (c,d); trichomes/glands one-celled bumps, larger on stem tissue (f), smaller and appear to be luminescent dots on leaf tissue (a,b), common; small-to-medium size subcrystalline druses rare in stem tissue (g). Distribution: West Texas to east central Texas; Oklahoma and Texas extending into northern Mexico (Tamaulipas) and with a disjunct population in peninsular Florida. Photographs a to d, f, and g 180X, e 260X.

Figure 33. *Ricinus communis* L., castorbean, a monotypic genus in Texas: Regular, generally smooth cell walls, medium size, faint (a,b,c); small stomata, distinctly two companion cells, one reduced (b); trichomes and glands absent; small to large crystalline druses common in stem tissue (d). Distribution: Cultivated and rarely escaped, more commonly in the southern part of Texas; probably a native of Africa but now widely distributed in the warmer parts of the world. All photographs 180X.

Figure 34. *Stillingia sylvatica* L., queensdelight (queens-root), three species in Texas, all are poisonous to livestock and are described: Regular grading to sublinear, smooth cell walls, large; medium to moderately large stomata, distinctly two companion cells, one reduced; trichomes absent; nondescript glandular areas, similar to *S. texana* and *S. treculiana* (Figs. 35 and 36), rare on leaf margins; small subcrystalline druses rare in vein tissue. Distribution: Frequent over most of Texas east of the Trans-Pecos; Virginia to Florida, west to Louisiana and Texas, and north to Kansas and New Mexico. Photograph 180X.

Figure 35. *Stillingia texana* I.M. Johnston, Texas stillingia: Regular grading to sublinear, smooth cell walls, moderately large (a,b,c); medium to moderately large stomata, distinctly two companion cells, one or both reduced (a); trichomes absent; nondescript glandular areas on leaf margins, common (b); medium-size subcrystalline druses rare in vein tissue (c). Distribution: Edwards Plateau and north central Texas, west to Val Verde County; Oklahoma and Texas, and in Coahuila, Mexico. All photographs 180X.

Figure 36. *Stillingia treculiana* (Muell. Arg.) I.M. Johnston, trecul stillingia: Regular grading to sublinear, smooth cell walls (a), medium size, smaller than *S. sylvatica* or *S. texana* (Figs. 34 and 35); small stomata, usually two companion cells, one often reduced (a); trichomes absent; nondescript glandular areas on leaf margins common (b) and clavate glands common on flower parts (c); irregularly shaped amorphous druses rare (d). Distribution: Rio Grande Plains and Edwards Plateau, north to Tom Green County, and west to Crockett and Val Verde counties, Texas; Texas and in Tamaulipas, Coahuila and Nuevo Leon, Mexico. All photographs 180X.

FAGACEAE (Oak family)

Figure 37. *Quercus havardii* Rydb., Havard (sand shinnery) oak, 35 species in Texas, two are described: Regular, smooth cell walls, dimorphic, medium-size cells lacking stomata (a), small cells with stomata (b,c); small-to-medium size stomata, luminescent ends on guard cells, companion-cell-number variable, not distinct (a); stellate trichomes with about eight arms, center attaching directly to tissue, common (a,c,d); glands and crystal idioblasts absent. Distribution: Southern Panhandle plains of Texas; from eastern Oklahoma, west to southeast New Mexico, northeastern Arizona and southeastern Utah. All photographs 180X.

Figure 38. *Quercus virginiana* Mill., live oak: Regular, smooth cell walls, dimorphic, small cells lacking stomata (b), and very small cells with stomata (a,d); small stomata, luminescent ends on guard cells, companion-cell-number variable, not distinct (a,d); stellate trichomes with about 16 arms, center attaching directly to tissue (b,c); two-celled glands rare; rhomboid crystals rare in vein tissue (d). Distrbution: Including coastal and inland races, central and southeastern Texas; southeastern Virginia to southern Florida then west in coastal areas to Texas, and in Tamaulipas, Nuevo Leon and Coahuila, Mexico. Photograph a 260X, b,c, and d 180X.

GENTIANACEAE (Gentain family)

Figure 39. *Centaurium beyrichii* (T.&G.) C.L. Robinson, rock centaury (mountain pink), three species in Texas, two are described: Regular (sublinear near veins), deeply dentate ("zippered"), to deeply sinuate, to undulate, thin and usually faint cell walls, medium-size cells, tissue very frail (a,b); small-to-medium size stomata, companion cells two or three, not distinct (a,b); trichomes and glands absent; small irregularly shaped crystals rare (c). Distribution: North central to west Texas; Texas and Arkansas. All photographs 180X.

Figure 40. *Centaurium calycosum* (Buckl.) Fern., Buckley centaury, Gould (1975a) lists two varieties in Texas: Regular (sublinear near veins), deeply dentate ("zippered"), to deeply sinuate, to undulate, thin and usually faint cell walls, medium-to-large size cells, tissue very frail (a to d); medium to moderately large stomata, companion cells two or three, not distinct (b,c,d); trichomes and glands absent; small irregularly shaped crystals common (e). Distribution: Central and west Texas; from Texas to Missouri west to Utah, Nevada and Arizona, and northern Mexico. All photographs 180X.

HIPPOCASTANACEAE (Buckeye family)

Figure 41. *Aesculus arguta* Buckl. [A. *glabra* Willd. var. *arguta* (Buchl.) B.L. Robinson], white buckeye, Correll and Johnston (1970) list this plant as a separate species whereas Gould (1975a) lists it as a variety of *A. glabra*. There are three species in Texas, two are described: Dimorphic cells, regular, undulate cell walls, medium-size lacking stomata, and regular, smooth cell walls, small with stomata (a,b); stomata, when present, small, companion cells numerous, radially arranged about stomata (b); trichomes/glands usually two-to-six celled, muticous distal segment, common, superficial attachments (c,d,e); small rhomboid crystals grading to small subcrystalline druses common in vein tissue (d,e,f). Distribution: Northeast and central Texas; southeastern Nebraska, the eastern half of Kansas, and Missouri south to central Texas. All photographs 180X.

Figure 42. *Aesculus pavia* var. *flavescens* (Sarg.) Correll, yellow buckeye, Correll and Johnston (1970) list two varieties, both are described: Regular, smooth cell walls, small (a,d); medium-size stomata, generally equal to or exceeding the average size of most epidermal cells, companion cells numerous, radially arranged about stomata (a,d); trichomes/glands with three to ten or more cells, muticous distal segment, rare, superficial attachments (b,c); small rhomboid crystals grading to small subcrystalline druses common in vein tissue (d). Distribution: See var. *pavia*, this yellow-flowered variety is apparently restricted to the Edwards Plateau in Texas where it intergrades with var. *pavia* on the eastern edge of its range; distribution elsewhere unknown. All photographs 180X.

Figure 43. *Aesculus pavia* var. *pavia* L., red buckeye: Regular, smooth to undulate cell walls, small (a); small-to-medium size stomata, generally exceeding the average size of the epidermal cells, companion cells numerous, radially arranged about stomata (a); multicellular trichomes/glands, large, often flattened, muticous distal segment, rare, superficial attachments (b); small rhomboid crystals grading to small subcrystalline druses common in vein tissue (c,d). Distribution: Eastern half of Texas; from eastern North Carolina, south to northern Florida, and west to southern Illinois, also southeastern Missouri, Arkansas, and Texas. All photographs 180X.

LABIATAE (Lamiaceae) (Mint Family)

Figure 44. *Perilla frutescens* (L.) Britt., beef-steak-plant, a monotypic genus in Texas: Regular, deeply sinuate to sinuate cell walls, small-to-medium size (a,b,e); small stomata, companion cells often two, one usually reduced (a,b); medium-to-large multicellular trichomes, three to five cells, often four-celled, basal segment sometimes inflated but usually not greatly, sharp-pointed distal segment, common, epidermal cells radially arranged about superficial attachments (c,d,e); glands and crystal idioblasts absent. Distribution: A native of India, along streams and seepage areas in east Texas; from Florida to Texas, north to New England, New York, Ohio, Indiana, Missouri and eastern Oklahoma and Kansas. All photographs 180X.

LEGUMINOSAE (Fabaceae) (Legume family)

Figure 45. *Acacia berlandieri* Benth., guajillo, 13 species in Texas: Regular (sublinear on stem tissue), undulate cell walls, small (a,d); small stomata, companion cells two or three, one usually reduced (a); unicelled trichomes, stiff, luminescent, superficial attachments, abundant on stem tissue, rare on leaf tissue (b); glands not observed; medium-size rhomboid crystals common in veins, some vaginate and appearing rounded (c,d). Distribution: Exceedingly abundant on ridges and shallow soils in the Rio Grande Plain and northeast to eastern Brewster County, in the Trans-Pecos and southern part of the Edwards Plateau, Texas; Texas to Queretaro, San Luis Potosi and Hidalgo, Mexico. Photograph a 260X, b,c, and d 180X.

Figure 46. *Astragalus emoryanus* (Rydb.) Cory, Emory milkvetch (red-stemmed peavine, Emory loco), Gould (1975a) lists 26 species and two varieties of *A. emoryanus*, three species are described: Regular, undulate cell walls, medium size (a); small stomata, companion-cell-number variable, not distinct (a); unicelled trichomes with a single, often luminescent attachment cell, trichomes with finely serrate margins, long and thin,

abundant, cells radially arranged about superficial attachments (b,c); glands and crystal idioblasts absent. Distribution: Var. *emoryanus* frequent in the Trans-Pecos and near the Rio Grande in the Rio Grande Plains, occasional in south central Texas; Arizona, New Mexico and Texas, and in Chihuahua and Nuevo Leon, Mexico. Var. *terlinguensis* known only in Texas in Brewster, Presidio, Culbertson and Hudspeth counties in the Trans-Pecos; also in Coahuila, Mexico. All photographs 180X.

Figure 47. *Astragalus mollissimus* Torr. var. *coryi* Tidestr. (*A. argillophilus* Cory), yellow-flowered loco (Cory loco), Gould (1975a) lists five varieties of *A. mollissimus* in Texas, three are described: Regular, smooth cell walls, small-to-medium size, faint; small stomata, companion-cell-number variable, not distinct; unicelled trichomes with a single, often luminescent attachment cell, long and thin, abundant, epidermal cells radially arranged about superficial attachments; glands and crystal idioblasts absent. Distribution: Abundant on the western part of Edwards Plateau from Crockett County north to Martin County; endemic to Texas. Photograph 180X.

Figure 48. *Astragalus mollissimus* Torr. var. *earlei* (Green ex Rydb.) Tidestr. (*A. earlei* Greene ex Rydb.), early loco: Regular, smooth to undulate cell walls, medium size (a,b); small stomata, companion-cell-number variable, not distinct (a,b); unicellular trichome with a single, often luminescent attachment cell (d), long and thin, abundant (c), epidermal cells radially arranged about superficial attachments (a,b); glands and crystal idioblasts absent. Distribution: Abundant in the Trans-Pecos, Texas; Texas, and in Chihuahua and Coahuila, Mexico. All photographs 180X.

Figure 49. *Astragalus mollissimus* var. *mollissimus* Torr., wooly loco: Regular (sublinear on stem tissue), smooth cell walls, medium size (a,b); small stomata, companion-cell-number variable, not distinct (a); unicelled trichomes with a single, often luminescent attachment cell, long and thin, abundant (d), epidermal cells radially arranged about superficial attachments (c); glands and crystal idioblasts absent. Distribution: Plains Country, one record from Culbertson County in the Trans-Pecos; distribution outside of Texas unknown. Photographs a and b 180X, c 260X, and d 45X.

Figure 50. *Astragalus wootonii* Sheldon, Wooton loco (garbancillo): Regular, smooth cell walls, medium size (a); small stomata, companion- cell-number variable, not distinct (a); unicelled trichomes with a single, sometimes luminescent attachment cell, generally long but shorter and thicker (cigar-shaped) than the other *Astragalus* spp. (see Figs. 46 to 49)(a,b), verrucose, abundant, epidermal cells radially arranged about superficial attachments (a); glands and crystal idioblasts absent. Distribution: Frequent in the Trans-Pecos and reportedly rare near the Canadian River in the Panhandle of Texas; California, Arizona and New Mexico southeast to Michoacan and Puebla, Mexico. Both photographs 180X.

Figure 51. *Cassia lindheimeriana* Scheele, Lindheimer senna, 17 species in Texas, four are described: Regular-blocky, smooth cell walls, varying in size but generally small (a); small stomata, appearing large relative to and often exceeding the average size of the epidermal cells, companion cells two-to-four (usually four), one usually reduced (a); unicelled trichomes, stiff, often geniculate near base, luminescent, epidermal cells radially arranged about superficial attachments, abundant (b,c); glands absent; small rhomboid crystals common in veins. Distribution: Edwards Plateau from Travis, Bexar and Dimmit counties west through the Trans-Pecos; New Mexico and southeastern Arizona south to Chihuahua and Tamaulipas, Mexico. Photographs a and b 180X, c 45X.

Figure 52. *Cassia obtusifolia* L., sicklepod senna: Regular (sublinear near veins), smooth cell walls, varying in size but generally medium (a); small stomata, companion cells two, one usually reduced (a); unicelled or multicelled (two to five cells) trichomes, muticous distal segment, cells radially arranged about superficial attachments, most common over veins but generally rare (b,c); glands and crystal idioblasts not observed. Distribution: East Texas west to Dallas and Gonzales counties; east and

north to Pennsylvania, Indiana and Missouri, south through the American tropics and in the Old World. All photographs 180X.

Figure 53. *Cassia occidentalis* L., coffee senna (stypicweed): Regular, undulate to smooth cell walls, dimorphic but both types morphologically similar, undulate walls most common on small cells (a), smooth walls most common on moderately large cells (b); generally small stomata with distinctly two companion cells, one usually reduced (a,b); unicelled trichomes, polymorphic, (1) large, rapidly tapering, rare (c), (2) medium-to-large, uniformly tappered, common (d), and (3) small-to-medium size with very little taper except at tip, common in flower parts (e), types 1 and 2 with complex attachments, type 3 with epidermal cells radially arranged about superficial attachments; nondescript glandular areas on epidermis; small rhomboid crystals in veins (f). Distribution: Gulf coast and inland north and northeast to Cherokee, Robertson, Travis and Comal counties, Texas; in southeastern U.S. and the tropics and subtropics of the New World and Old World. All photographs 180X.

Figure 54. *Cassia roemeriana* Scheele, twoleaf senna: Regular, smooth cell walls, medium (a) and small sizes, both morphologically similar; medium-size stomata with distinctly two companion cells, one usually reduced (a); unicelled trichomes, stiff, appressed, medium to large, epidermal cells radially arranged about superficial attachments, common (b); nondescript glandular areas on epidermis (a); small-to-medium size rhomboid crystals common in veins (c). Distribution: Central and west Texas from Ellis and Navarro counties south to the Rio Grande and west to Bailey, Gaines, Culbertson and Presidio counties; also in southwestern Oklahoma and New Mexico south to Nuevo Leon and Coahuila, Mexico. All photographs 180X.

Figure 55. *Melilotus alba* Medik., white sweetclover, three species in Texas, two are described: Regular (sublinear in stem tissue), sinuate or smooth cell walls, corresponding to top and bottom leaf surfaces, small-to-medium size (a,b,d); small stomata, faint, companion cells two to five, not distinct (b); unicelled trichomes, frail, medium size, one or two (usually one) often luminescent attachment cells (c), epidermal cells radially arranged about superficial attachments (d), most abundant on stem tissue, common on leaf tissue; glands not observed; rhomboid crystals rare in vein tissue (e). Distribution: Statewide in Texas; native of Eurasia now widely introduced. All photographs 180X.

Figure 56. *Melilotus officinalis* (L.) Lam., yellow sweetclover (yellow meliot): Regular (sublinear in stem tissue), sinuate or smooth cell walls, corresponding to top and bottom leaf surfaces (a,b), small-to-medium size; small-to-medium size stomata, companion cells two to five, not distinct (a,b); unicelled trichomes, frail, medium sized, one or two (usually one) often luminescent attachment cells, epidermal cells radially arranged about superficial attachments, abundant on stem tissue, rare on leaf tissue (c); glands not observed; rhomboid crystals rare in vein tissue (d). Distribution: Frequent in north central Texas and scattered elsewhere; native of Eurasia now widely introduced. All photographs 180X.

Figure 57. *Oxytropis lambertii* Pursh, Lambert crazyweed (white loco, locoweed), a monotypic genus in Texas: Regular, smooth cell walls, medium size (a,b); medium-size stomata, companion cells two to four (often three), one or two often reduced (a,b); unicelled trichomes, attached 1/8 to 1/4 the way up the side, brightly luminescent, abundant, one attachment cell, epidermal cells radially arranged about superficial attachments, very conspicuous (a,b,c); glands and crystal idioblasts not observed. Distribution: Plains Country and north central Texas south to Tarrant and Dallas counties, rare south to Comanche and Travis counties; Saskatchewan and Manitoba south and southwest to Arizona, New Mexico and Texas. Photographs a and b 180X, c 45X.

Figure 58. *Parkinsonia aculeata* L., retama (Mexican paloverde, horse bean), a monotypic genus in Texas: Regular grading to sublinear, smooth to undulate cell walls, small (a,b); small-to-medium size stomata, equal to or exceeding the average size of the epidermal cells, companion-cell-number variable, not distinct (a,b); unicelled trichomes, frail, one slightly luminescent attachment cell

(c,d), epidermal cells radially arranged about superficial attachments (e), common; glands not observed; small subcrystalline druses abundant (f). Distribution: Frequent in Rio Grande Plains, north at least to Williamson County, Texas; widespread in America, perhaps a native of South America. Photographs a,b,c, and f 180X, d and e 260X.

Figure 59. *Prosopis glandulosa* var. *glandulosa* Torr., honey mesquite, Gould (1975a) lists four species and three varieties of *P. glandulosa* in Texas: Regular-blocky grading to sublinear, smooth cell walls (a to d), varying somewhat in size, mature leaves with a conspicuous, thick, luminescent, waxy coating (a,b), medium size; medium-size stomata, often equal to or exceeding the size of most epidermal cells, companion cells distinctly two thin cells with their long axis parallel to the guard cells (a,b); unicelled trichomes with a single, usually luminescent attachment cell, superficial attachments, rare (c,d); glands not observed; rhomboid-to-sand type crystals common in vein tissue (e). Distribution: Abundant in the Rio Grande Plains, parts of north central and southeastern Texas, Plains Country, Trans-Pecos, east Texas, and the Edwards Plateau; Kansas, Oklahoma, and eastern New Mexico south to Tamaulipas, Nuevo Leon and Coahuila, Mexico. All photographs 180X.

Figure 60. *Sesbania drummondii* (Rydb) Cory, Drummond sesbania, four species in Texas, three are described: Regular, smooth to undulate cell walls, small-to-medium size (a,b); small stomata, companion cells three or four, one or two often reduced (a,b); unicelled trichomes with one or two attachment cells, distal attachment cell usually luminescent, common (c,d), epidermal cells radially arranged about superficial attachments; glands not observed; dimorphous crystal idioblasts, amorphous druses appearing globose from above, cylindrical in cross section, these always bright red in reference slides (e), and larger irregularly shaped crystals, generally with a reddish tinge but not as bright red as amorphous druses (f), both types common. Distribution: Coastal Plain inland to Denton, Williamson, Travis, Comal, Wilson, McMullen and Starr counties, Texas; Coastal states, Florida to Veracruz and inland to San Luis Potosi. Photograph b 260X, a,c,d,e, and f 180X.

Figure 61. *Sesbania macrocarpa* Muhl. *[S. exaltata* (Raf.) Cory], coffeebean (Colorado river-hemp): Dimorphous cells, regular, smooth walled, and regular, undulate walled, both types medium size with stomata (a,b,c); small stomata, companion cells three or four (usually three), one conspicuously reduced (a,b,c); trichomes and glands absent; dimorphous crystal idioblasts, amorphous druses appearing globose from above, cylindrical in cross section, these always bright red in reference slides (d), and larger, irregularly-shaped crystals, usually arranged in a lattice-type pattern, often reddish colored but not as bright red as amorphous druses (e), both types common. Distribution: Eastern third of Texas, west to Denton, Tarrant, Travis, Hays, Comal, San Patricio and Cameron counties; Virginia, Illinois, Missouri, southeastern Kansas, and Oklahoma south to Georgia, Florida, and Texas, and rare in northeastern U.S. All photographs 180X.

Figure 62. *Sesbania vesicaria* (Jacq.) Ell. [*Glottidium vesicarium* (Jacq.) Desv.], bagpod sesbania: Dimorphous cells, large and small types, both with regular, smooth to slightly undulate cell walls and small stomata (a,b,c); companion cells three or four (usually three), one reduced (a,b,c); unicelled trichomes, similar to those of *S. drummondii* (Fig. 60), rare (d); glands absent; polymorphic crystal idioblasts, amorphous druses (e) and irregularly shaped crystals in lattice-type pattern (f), similar to those of *S. macrocarpa* (Fig. 6l), plus elongated crystals in vein tissue, all types common and bright red to reddish in color in reference slides. Distribution: Frequent in the eastern third of Texas west to Palo Pinto, Erath, Bastrop, Gonzales, Karnes and San Patricio counties; central states, North Carolina to Texas, also West Indies. All photographs 180X.

Figure 63. *Sophora nuttalliana* B.L. Turner (*S. sericea* Nutt.), white loco (silky sophora), five species in Texas, two are described: Regular, smooth cell walls, medium size, faint (a); medium-size stomata, companion cell number variable, not distinct (a); stiff, unicelled trichomes with a single, inflated and luminescent attachment cell (a,b,c),

epidermal cells radially arranged about superficial attachments (a,e), abundant; glands absent; irregular-to-globose shaped, small-to-medium size, amorphous-to-sand type crystals, common (d,e). Distribution: Higher elevations of the Plains Country, the Trans-Pecos mountains, and the High Plains; South Dakota and eastern Wyoming south to Kansas, Oklahoma, Texas, New Mexico and Arizona. All photographs 180X.

Figure 64. *Sophora secundiflora* (Ortega) DC., mescalbean (frijolito, Texas mountainlaurel): Dimorphous cells, regular, smooth cell walls, medium size without stomata (c), and regular-blocky to sublinear, smooth cell walls, varying in size, with stomata (a,b); stomata, when present, medium size, exceeding the size of most epidermal cells, companion cells numerous, radially arranged about stomata (a,b); trichomes absent; gland bases conspicuous, luminescent, very common in tissue without stomata (c), rare in tissue with stomata (a,b), glands small, two-celled structures (d); rhomboid crystals, small size common in both tissue types, medium size common in vein tissue (e). Distribution: Southern edge of the Edwards Plateau north to Travis County, shallow soils of the Rio Grande Plains, and occasional in the western part of the Edwards Plateau and Trans-Pecos, and Cameron County, Texas; Texas and New Mexico south in the mountains to San Luis Potosi, Mexico. Photograph d and e 260X, a,b, and c 180X.

LILIACEAE (Lily family)

Figure 65. *Nolina texana* S. Wats., sacahuista, seven species in Texas: All epidermal cells in a definite sublinear pattern, generally two-to-four times longer than wide, with thick, luminescent, and smooth cell walls, medium size; sunken stomata with four usually equal companion cells; luminescent bumps common on epidermis (typical trichomes, glands, and crystal idioblasts are absent from leaf material). Distribution: Rocky soils from central Texas to the upper Rio Grande Plains and Trans-Pecos, and Garza County; Oklahoma and New Mexico south to Texas, and in northern Mexico. Photograph 180X.

Figure 66. *Zigadenus nuttallii* (Gray), S. Wats., Nuttall (poison) deathcamus, five species in Texas: All epidermal cells in a definite sublinear to linear pattern, the long axis generally more than two and as much as five times the length of the short axis, smooth, thin, and usually faint cell walls (a,b); medium to moderately large stomata with guard cells parallel to the long axis of the epidermal cells, located between two cells in alternate rows of epidermal cells, usually faint (a,b); trichomes and glands absent; dimorphous raphides, large bundles with relatively few crystals per bundle and smaller bundles with many crystals per bundle, both types common (c,d). Distribution: Eastern third of Texas; Tennessee to Kansas and south to Texas. All photographs 180X.

MELIACEAE (Mahogany family)

Figure 67. *Melia azedarach* L., Chinaberry (pride-of-India), monotypic of the Meliaceae in Texas: Dimorphous cells, medium size, regular, smooth cell walls, relatively uniform in size without stomata (a), and small, regular (grading to sublinear over veins), smooth cell walls, cells vary in size, stomata present (b,c), both types common and correspond to the top and bottom leaf surfaces; stomata, when present, small but generally equal to or exceeding the size of most epidermal cells, numerous small companion cells radially arranged about stomata (b,c); unicellular trichomes, most common on stem tissue but generally rare, superficial attachments (d,e); glands not observed; dimorphous crystal idioblasts, small-to-medium size subcrystalline druses throughout both tissue types, and irregularly shaped crystal sand occurring mostly in veins (f,g,h). Distribution: Eastern half of Texas; native of Asia but cultivated and escaped as far north as southeastern Virginia in the U.S. All photographs 180X.

PAPAVERACEAE (Poppy family)

Figure 68. *Argemone albiflora* Hornem. (*A. alba* Lestib.), white pricklypoppy, Gould (1975a) lists subsp. *texana* G.B. Ownbey [var. *texana* (Ownbey) Shinners] in Texas. There are eight commonly occurring species in Texas, we describe three plus an unknown species collected near San Angelo, Texas: Regular, four-to-eight (often six) sided

cells, medium size, lateral walls often visible which gives the cells a three-dimensional appearance (a,b); small stomata, companion cells four or five (usually four), one or two often reduced (a,b); finely dissected macroscopic spines present (see Fig. 69), but typical trichomes, glands, and crystal idioblasts are absent. Distribution: State-wide in Texas; northern Arkansas and southern Missouri to Texas. Both photographs 180X.

Figure 69. *Argemone aurantiaca* G.B. Ownbey, pricklypoppy: Regular, four-to-eight (usually six) sided cells, medium size, lateral walls often visible which gives the cells a three-dimensional appearance (a,b); medium-size stomata, companion cells four or five (usually four), one or two often reduced (a,b); finely dissected macroscopic spines (c) present, but typical trichomes, glands, and crystal idioblasts are absent. Distribution: South central Texas; endemic in Texas. Photographs a and b 180X, c 45X.

Figure 70. *Argemone polyanthemos* (Fedde) G. B. Ownbey, (broadleaf) pricklypoppy: Regular, four-to-eight (often six) sided cells, medium size, lateral walls often visible which gives the cells a three-dimensional appearance (a); medium-size stomata, often faint, companion cells four or five (usually four), one or two sometimes reduced (a); finely dissected macroscopic spines (b) present but typical trichomes, glands, and crystal idioblasts absent. Distribution: Northern half of Texas; western North Dakota and eastern Montana south to Texas and eastern New Mexico. Photograph a 180X, b 45X.

Figure 71. *Argemone* sp., an unknown species collected near San Angelo, Texas: Regular, four-to-eight (often six) sided cells, large, lateral walls often visible which gives the cells a three-dimensional appearance; medium to moderately large stomata, companion cells four or five (usually four), one or two sometimes reduced; finely dissected macroscopic spines present (see Figs. 69 and 70), but typical trichomes, glands, and crystal idioblasts are absent. Distribution: Some species state-wide in Texas; widespread in the Americas. Photograph 180X.

Figure 72. *Corydalis aurea* Willd. [*Capnoides aureum* (Willd.) Ktze.], golden corydalis (scrambled eggs), Gould (1975a) lists five species and two varieties of *C. aurea* in Texas, we describe var. *occidentalis* (this plant is listed in the FUMARIACEAE family in some references): Regular, smooth cell walls, medium size, epidermis often rugulose (a,b); small-to-medium size stomata, companion cells four to six, not distinct (a,b); small bumps present on epidermis (c), giving the rugulose appearance, but typical trichomes and glands are absent; small-to-medium size amorphous druses common (d,e). Distribution: Western half of Texas; southwestern South Dakota south to central Texas, west to Utah, southern Nevada and Arizona, also in northern Mexico. All photographs 180X.

PHYTOLACCACEAE (Pokeweed family)

Figure 73. *Phytolacca americana* L., common pokeberry (pokeweed, polk), a monotypic genus in Texas: Dimorphous cells, corresponding to the top and bottom leaf surfaces, large, four-to-six (usually six) sided cells (a) and regular, undulate cell walls, medium size (b), both types with medium-size stomata; companion cells three or four (usually four) with one or two (usually one) reduced in "hexagonal" cells, and four to six, not distinct in undulate-walled cells (a,b); trichomes/glands medium sized bumps on epidermis, common (c,d); dimorphous crystal idioblasts, large clusters of sand-type crystals, and needle-like crystals in loose bundles, lacking typical structure associated with raphides (e to h). Distribution: Through-out most of Texas; Florida to Texas, north to New England, southern Quebec, New York and southern Ontario. All photographs 180X.

POACEAE (Gramineae) (Grass family)

Figure 74. *Panicum antidotale* Retz., blue panicum, 35 species in Texas: Linear, smooth to undulate cell walls (a to d); round stomata, guard cells often exceeding the subsidiary cells, in single rows, common (a,b,c); silica-suberose "couples" usually absent; bone-shaped silica cells vary morphologically, in one to five rows over veins, abundant (a to d); bicellular microhairs with long, thin,

and pointed distal segment (d), basal segment long, tube-shaped, rare; prickle hairs rare on leaf margins. Distribution: Gould (1975) lists this species statewide except in far eastern Texas and the Trans-Pecos but these authors have observed this plant along irrigation canals near Pecos, Texas in the Trans-Pecos; native of India, cultivated by state experiment stations in Mississippi, Texas, Oklahoma, Arizona and California and spreading. Photographs a,b, and c 180X, d 260X.

Figure 75. *Sorghum almum* Parodi, Sorghum almum, three species in Texas, all are poisonous to livestock under certain conditions and are described: Linear, undulate to sinuate cell walls (a,c,d); oval-to-diamond shaped stomata, in single or alternating rows, abundant (a,c,d); silica-suberose "couples" tall and thin, silica cell irregularly shaped, between cells of rows without stomata, common (a,c,d); bone-shaped silica cells, most of which are uniform in shape, in three to five rows over veins, abundant (b); bicellular microhairs with cone-shaped basal segment and hemispherical distal segment, costal and intercostal, common (c,d): prickle hairs rare on leaf margins. Distribution: Planted in the Edwards Plateau and South Texas Plains and likely elsewhere in the state; native of Argentina, planted extensively as a forage crop in the warmer regions of the Americas. Photographs a and b 180X, c and d 260X.

Figure 76. *Sorghum bicolor* (L.) Moench. (*S. vulgare* Pers.), grain sorghum: Linear, undulate to sinuate cell walls (a); oval-to-diamond shaped stomata, in single or alternating rows, common (a); silica-suberose "couples" tall and thin, silica cell irregularly shaped, mostly between cells of rows without stomata, common (a); bone-shaped silica cells rather uniform in shape but not usually in continuous rows, abundant (b); bicellular microhairs with cone-shaped basal segment and hemispherical distal segment, costal and intercostal, common; prickle hairs rare on leaf margins. Distribution: Planted state-wide in Texas; widely cultivated in the world. Both photographs 180X.

Figure 77. *Sorghum halepense* (L.) Pers., Johnsongrass: Linear, undulate cell walls (a,b); stomata generally diamond-shaped, in single or alternating rows, common (a,b); silica-suberose "couples" tall and thin, silica cell irregularly shaped, mostly between cells of rows without stomata, common (a,b); bone-shaped silica cells, largely uniform in shape, in one to three rows over veins, abundant (c); bicellular microhairs with cone-shaped basal segment and hemispherical distal segment, costal and intercostal, common (not shown in Fig. 77); macrohairs vary from prickle hairs to large, thin hairs, common (d). Distribution: Statewide in Texas; native of the Mediterranean region but in tropical and warmer regions of the World. In the U.S., Massachusetts to Iowa and Kansas, south to Florida and Texas and west to southern California. All photographs 180X.

POLYGONACEAE (Knotweed family)

Figure 78. *Persicaria hydropiperoides* (Michx.) Small (*Polygonum hydropiperoides* Michx.), swamp smartweed (mild water pepper), Correll and Johnston (1970) list 11 species and two varieties of *P. hydropiperoides* in Texas: Regular, smooth grading to undulate cell walls, medium size (a,b,c); medium-size stomata, companion cells two, one or both conspicuously reduced (b,c); finely dissected trichomes, appressed, luminescent, complex attachments, common (d); glands absent; irregularly shaped amorphous druses throughout tissue (e). Distribution: Wet areas throughout Texas; throughout North America. Photographs a,b,d, and e 180X, c 260X.

POLYPODIACEAE (True fern family)

Figure 79. *Notholaena sinuata* (Lagasca) Kaulf. var. *cochisensis* (Goodding) Weatherby, jimmyfern, ten species and three varieties of *N. sinuata* in Texas: Regular, deeply sinuate cell walls, medium size (a); large stomata, usually with a luminescent "bar" at the union of the guard cells, companion-cell-number variable, not distinct (a); large, dissected trichomes, many appendages, complex attachments, abundant (b,c); glands and crystal idioblasts absent. Distribution: Trans-Pecos northeast to Motley County in the Plains Country and east to Sterling and Edwards counties on the Edwards Plateau of Texas; Texas west to California, and in Mexico. Photographs a and b 180X, c 45X.

Figure 80. *Pteridium aquilinum* (L.) Kuhn var. *pseudocaudatum* (Clute) Heller, western bracken (bracken-fern), a monotypic genus in Texas, with two varieties of *P. aquilinum* reported: Regular, deeply sinuate, often thick and luminescent cell walls, large (a,b); large stomata with a luminescent "bar" at the union of the guard cells, companion-cell-number variable, not distinct (b); trichomes, glands, and crystal idioblasts absent. Distribution: Timber Belt of east Texas and in the southern half of the Blackland prairies, southwest to Wilson County; Massachusetts west to Ohio, Missouri and southeastern Kansas, and south to Florida and Texas. Both photographs 180X.

RANUNCULACEAE (Crowfoot family)

Figure 81. *Delphinium virescens* Nutt., plains (white) larkspur, three species and four varieties of *D. virescens* in Texas: Regular (sublinear near veins), smooth and faint cell walls, large (a,b); large stomata, companion-cell-number variable, not distinct (a,b); unicellular trichomes with serrate margins, medium size, slightly swollen at base producing a sucker-like superficial attachment, abundant (b,c); glands and crystal idioblasts absent. Distribution: Some varieties throughout most of Texas; the species as a whole occurs widely in North America. All photographs 180X.

RESEDACEAE (Mignonette family)

Figure 82. *Oligomeris linifolia* (Vahl) Macbr (*Dipetalis subulata* O. Ktze.), desert spike, monotypic of the Resedaceae in Texas: Regular (sublinear near veins), undulate to sinuate cell walls, thin, epidermis often rugose, medium-size cells (a,b); small-to-medium size stomata, companion cells often four, not distinct (a,b); trichomes absent; punctate glands rare (c); crystal idioblasts absent. Distribution: Rio Grande Valley and the Trans-Pecos of Texas; Texas to California and northern Mexico. Photograph a 180X, b and c 260X.

RHAMNACEAE (Buckthorn family)

Figure 83. *Colubrina texensis* (T.&G.) Gray, Texas colubrina (hog-plum), two species in Texas: Dimorphous cells, corresponding to the top and bottom leaf surfaces, regular, smooth cell walls, medium size without stomata (a,b), and regular, undulate-to-sinuate walled, small with stomata (c,d); small stomata, companion-cell-number variable, not distinct (c,d); unicelled trichomes, stiff and luminescent, often geniculate, abundant, slightly swollen at base producing a sucker-like superficial attachment, occurring mainly over veins (e,f); glands absent; small crystalline druses common in vein tissue, rare otherwise (f). Distribution: Locally abundant in the Rio Grande Plains, infrequent north to the southern part of north central Texas and the southern part of the Plains Country, rare in the eastern part of the Trans-Pecos; Texas south to Coahuila, Nuevo Leon and Tamaulipas, Mexico. Photographs a,b, and f 180X, c,d, and e 260X.

Figure 84. *Karwinskia humboldtiana* (J.A. Schultes) Zucc., coyotillo, a monotypic genus in Texas: Dimorphous cells, regular, smooth and thick cell walls, medium size, lacking stomata (a), and regular, smooth and thin cell walls, small, often faint, stomata present (b,c), the first type most common in reference slides; very small and faint stomata, companion-cell-number variable, radially arranged, distinct (b,c); trichomes and glands absent; dimorphous crystal idioblasts, small subcrystalline druses grading to small rhomboid crystals (d,e,f), and large rhomboid crystals (d,e), both types common. Distribution: Frequent in the Rio Grande Plains, north to the southern part of southeast Texas and the Edwards Plateau, and the extreme southeastern part of the Trans-Pecos; Texas, and in Baja California, Sonora, Chihuahua, Tamaulipas, Nuevo Leon, Coahuila, San Luis Potosi, Veracruz, Queretaro, Guanajuato, Hidalgo, Jalisco, Mexico, Guerrero, Puebla and Oaxaca, Mexico. Photographs a,d,e, and f 180X, b and c 260X.

ROSACEAE (Rose family)

Figure 85. *Prunus gracilis* Engelm. & Gray. [*P. normalis* (T.&G.) Small], Oklahoma (sand) plum, 14 species in Texas, two are described: Dimorphous cells, small, regular-blocky, smooth cell walls, lacking stomata (a,c), and smaller, regular-blocky, smooth cell walls, with stomata (b,d); small stomata, when present, larger than all epidermal

cells, companion cells very small and numerous, radially arranged about stomata, all reduced (b,d); stiff, unicellular trichomes, bases rounded, superficial attachments, medium-to-large, common (e,f); nondescript glandular areas; very small subcrystalline druses infrequent in vein tissue. Distribution: East Texas and the Panhandle; Texas, Oklahoma, Arkansas and eastern New Mexico. Photographs a and b 260X, c to f 180X.

Figure 86. *Prunus virginiana* L., common chokecherry (chokecherry): Regular (sublinear near veins), undulate cell walls, small (a); medium-size stomata, generally exceeding the average size of most epidermal cells, companion cells numerous, radially arranged about stomata (a); unicelled trichomes, similar to those of *P. gracilis* (Fig. 85), infrequent on stem tissue; glands not observed; irregularly shaped crystals grading to druses common in stem tissue (b,c). Distribution: East Texas, the Panhandle, and the Trans-Pecos; Newfoundland to Saskatchewan, south to North Carolina, Tennessee, Missouri, Kansas, Oklahoma, New Mexico and Texas, and west to California, also in Baja California. All photographs 180X.

RUBIACEAE (Madder family)

Figure 87. *Cephalanthus occidentalis* L., common buttonbush, two species in Texas: Dimorphous cells, regular (sublinear near veins), smooth cell walls, medium sized, lacking stomata (a), and regular (sublinear near veins), smooth cell walls, small-to-medium size, with stomata (b,c,d,g); medium-size stomata, companion cells usually four, cells above and below stomata conspicuously reduced (b,c,d,g); unicelled trichomes, stiff, rapidly tapering from base to about 1/3 the way up the trichome, uniformly tappered to a sharp point over the distal 2/3, superficial or complex attachments, rare (f); glands not observed; dimorphous crystal idioblasts, small-to-medium size amorphous druses, sometimes forming large clusters (a to e), and elongated crystals in veins (d,g), both types common and appear reddish-orange in reference slides. Distribution: Wet areas throughout the state of Texas; from Florida to Mexico, north to eastern Canada, New York, and west to California. All photographs 180X.

RUTACEAE (Citrus family)

Figure 88. *Thamnosma texana* (Gray) Torr., Texas desertrue (Dutchmans britches), a monotypic genus in Texas: Trimorphous cells, (1) regular, smooth cell walls, medium size without stomata (a), (2) regular, undulate cell walls, small with stomata (b), and (3) predominately sublinear type on stems, small-to-medium size cells with stomata (c); medium-size stomata on stems with numerous small companion cells radially arranged (c), small stomata in undulate-walled cells with companion-cell-number variable, not distinct (b); trichomes absent; punctate glands common on leaf tissue (d), and elevated glandular areas common on stem tissue (c,e); small irregularly shaped amorphous druses common (f). Distribution: Frequent in the Rio Grande Plains, southern and western parts of the Edwards Plateau, the Trans-Pecos and southern parts of the Plains Country; Texas, New Mexico and Arizona, and in northern Mexico. Photographs a,c,d,e, and f 180X, b 260X.

SOLANACEAE (Potato or Nightshade family)

Figure 89. *Datura inoxia* Mill., Indianapple, Correll and Johnston (1970) list four species in Texas, all are described: Regular-hexagonal, smooth cell walls, medium size, similar to *D. wrightii* (Fig. 92); medium-size stomata, companion cells two-to-four (often three), one usually reduced; trichomes one-to-four (usually two) celled, soft, basal segment often slightly swollen, apiculate distal segment, common, conspicuous superficial attachments (a); glands not observed; small-to-medium size subcrystalline druses often forming large clusters, common (b,c). Distribution: Edwards Plateau, Rio Grande Plains, and the Trans-Pecos, Texas; southwest Oklahoma, west Texas and New Mexico west to California, and south to central Mexico. All photographs 180X.

Figure 90. *Datura quercifolia* H.B.K., oakleaf datura (thornapple): Regular-hexagonal, smooth cell walls, medium size (a,b); medium-size stomata, companion cells two-to-four

(often three), one usually reduced (a); trichomes one-to-four (usually two) celled, soft, basal segment often slightly swollen, apiculate distal segment, common (a,b,c), conspicuous superficial attachments (a,b); glands not observed; small subcrystalline druses common throughout tissue. Distribution: Panhandle and Trans-Pecos of Texas; from southwestern Kansas, western Oklahoma and western Texas through southern New Mexico, and adjacent areas of northern Mexico. All photographs 180X.

Figure 91. *Datura stramonium* L., jimsonweed (stramonium): Regular-hexagonal, smooth cell walls, medium size (a); medium-size stomata, companion cells two-to-four (usually three), one often reduced (a); trichomes, similar to *D. inoxia* (Fig. 89), very small and rare; glands not observed; medium size subcrystalline druses common throughout tissue (b). Distribution: Statewide in Texas; widely distributed in the temperate and tropical regions of the World. Both photographs 180X.

Figure 92. *Datura wrightii* Regel (*D. meteloides* DC.), Indianapple (sacred datura): Regular-hexagonal, small-to-medium size, smooth cell walls (undulate cell walls on young, expanding tissue), cells relatively smaller than the other *Datura* spp. (Figs. 89 to 91) (a,b,c); small stomata, companion cells two-to-four (often three), one usually reduced (a,b,c); trichomes one-to-four (often three) celled, soft, basal segment often slightly inflated, distal segment apiculate, some segments often flattened laterally, abundant (d,e), conspicuous superficial attachments (a,b); glands not observed; small-to-medium size subcrystalline druses abundant, sometimes forming large clusters in veins (f,g). Distribution: East Texas to the Trans-Pecos; from Texas west to California and northern Mexico. Photographs a,b,e,f, and g 180X, c and d 260X.

Figure 93. *Nicotiana glauca* Graham, tree tobacco (mustard tree), four species in Texas, three are described: Regular (grading to sublinear near veins), smooth cell walls, medium size (a,b); medium-size stomata, companion cells three or four, one or two reduced (a,b); trichomes absent; short-stalked glands rare; medium-to-large clusters of extremely fine crystals abundant (c). Distribution: Along the coast and extreme southern Texas west to the Trans-Pecos; native of South America that has become naturalized northwestward to Texas and California. All photographs 180X.

Figure 94. *Nicotiana repanda* Willd., fiddleleaf (wild) tobacco: Regular, undulate to sinuate cell walls, large (a,b,c); medium-size stomata, companion-cell-number variable, not distinct (b,c); multicelled trichomes abundant, uniformly tappered, muticous distal segment, other segments rarely flattened laterally (d), superficial attachments (a); glands morphologically similar to trichomes but with a globose distal segment, abundant (e,f); small-to-large clusters of extremely fine crystals abundant (g). Distribution: Edwards Plateau and south Texas; Texas and adjacent areas of Mexico. Photographs a,d,e, and g 180X, b,c, and f 260X.

Figure 95. *Nicotiana trigonophylla* Dunal, desert tobacco: Regular, smooth to undulate cell walls, medium size (a,b); medium-size stomata, companion cells three or four, one often reduced (a); trichomes absent; large glands with multicellular stalk and multicelled, globose distal segment, gland stalk sometimes forked once, rarely twice, superficial attachments covering several epidermal cells (c to f); dimorphous crystal idioblasts, small-to-medium size subcrystalline druses, and medium-to-large clusters of extremely fine crystals, both types abundant (g). Distribution: Mesas and mountains in the Rio Grande Plains, South Plains and Trans-Pecos, Texas; from Texas west to California and northern Mexico. All photographs 180X.

Figure 96. *Solanum americanum* Mill. (*S. nigrum* L. of others), blueflower buffalobur, 21 species in Texas, five are described: Regular, undulate cell walls, small-to-medium size (a,b); medium-size stomata, companion cells three or four, one usually reduced (b); trichomes two-to-five celled, soft, apiculate distal segment, basal segment inflated or rarely flattened laterally, common, complex attachments occurring over veins (c); glands not observed; dimorphous crystal idioblasts, small-to-medium size, subcrystalline-to-crystalline druses, and medium-to-large clusters of extremely fine crystals, both types abundant (d,e). Distribution:

Statewide in Texas; New England to North Dakota south to Florida, Louisiana and Texas. All photographs 180X.

Figure 97. *Solanum dimidiatum* Raf., western horsenettle: Regular, undulate cell walls, medium size (a); medium-size stomata, companion cells three or four, one usually reduced (a); large stellate trichomes (b), common (d), trichome branches (except for two) generally lie within a single plain, dissected attachment arm (c), complex attachments; glands absent; medium-to-large clusters of extremely fine crystals common (e). Distribution: Throughout Texas except in the extreme east and west; South Carolina to Florida, west to Missouri, Kansas, and Texas. Photographs a,b,c, and e 180X, d 45X.

Figure 98. *Solanum elaeagnifolium* Cav., silverleaf nightshade (white horsenettle, bullnettle): Epidermis obscured by a dense covering of trichomes, rarely visible in reference slides, cell pattern and stomata similar to *S. rostratum* (Fig. 99) with regular, smooth cell walls, small cells and stomata; abundant stellate trichomes (c), trichome branches (except for two) generally lie within a single plain (a,b), dissected attachment arm (b), complex attachments; glands absent; small-to-large clusters of extremely fine crystals common (d). Distribution: Throughout most of Texas; from Missouri and Kansas south to Louisiana, Texas, Arizona and adjacent Mexico. Photographs a,b, and d 180X, c 45X.

Figure 99. *Solanum rostratum* Dunal, buffalobur (Kansas-thistle): Regular, smooth to undulate cell walls, small (a); small stomata, companion cells three or four, one usually reduced (a); large stellate trichomes, the arms of which do not generally lie within a single plain (b,c), intact trichomes generally with seven to ten arms, common, dissected attachment arm, complex attachments, and large finely dissected macroscopic spines, common (d); glands absent; dimorphous crystal idioblasts, medium-to-large clusters of extremely fine crystals common (e), and small-to-medium size subcrystalline druses common (a). Distribution: Throughout Texas; originally restricted to the Great Plains but now widely distributed in the U.S. and Mexico. Photographs a,c, and e 180X, b and d 45X.

Figure 100. *Solanum triquetrum* Cav., Texas nightshade: Regular (blocky sublinear on stem tissue), smooth to undulate cell walls, medium and moderately large (a,b,c), top and bottom of leaf correspond to different cell sizes; medium-size stomata, companion cells three or four, one often reduced (a,c); trichomes three-to-five celled, stiff and luminescent, medium size, common, complex attachments (d,e); glands not observed; medium-to-large clusters of extremely fine crystals abundant (f). Distribution: Central, southern and west Texas; Texas and adjacent Mexico. All photographs 180X.

UMBELLIFERAE (Apiaceae) (Parsley family)

Figure 101. *Cicuta maculata* L., spotted (cowbane) waterhemlock (musquash-root), two species in Texas: Dimorphous cells, corresponding to the top and bottom leaf surfaces, regular, undulate cell walls, medium size without stomata (a), and regular, smooth to undulate cell walls, small with stomata (b); small stomata, when present, generally with three or four companion cells, one often reduced (b); bumps on epidermis (c), similar to those of Conium maculatum (Fig. 102), rare, otherwise typical trichomes, glands, and crystal idioblasts absent. Distribution: Wet places in east, central and north Texas; throughout eastern U.S. and Canada, south to Georgia and Louisiana, and west to the Dakotas and Texas. All photographs 180X.

Figure 102. *Conium maculatum* L., poison hemlock, a monotypic genus in Texas: Dimorphous cells, corresponding to the top and bottom leaf surfaces, regular, undulate cell walls, medium size lacking stomata (a), and regular, smooth cell walls, small with stomata (b); medium-size stomata, when present, large relative to adjacent epidermal cells, companion-cell-number variable, not distinct (b); unicelled trichomes, resembling the protruberance of a mammary gland, complex attachments, common (c,d); epidermis often pustulose, with the elevated areas often luminescent (e); crystal idioblasts absent. Distribution: Wet places in the southern half of Texas; a Eurasian species widely introduced and naturalized throughout the temperate regions of the World. Photographs a,b, and e 260X, c and d 180X.

VERBENACEAE (Vervain family)

Figure 103. *Aloysia lycioides* Cham. [*A. gratissima* (Gill. & Hook.) Troncoso], whitebrush (bee bush), three species and two varieties of *A. lycioides* in Texas: Dimorphous cells, regular, smooth cell walls, small lacking stomata (a,c), and smaller, regular, smooth cell walls, with very small stomata; stomata usually obscured by a dense covering of trichomes; dimorphous trichomes, medium-size unicellular trichomes with complex and usually luminescent attachments, swollen at base, restricted to larger cells (a,c,e), and small unicellular trichomes with superficial and sometimes luminescent attachments, restricted to smaller cells (b,d) both types abundant; unicellular clavate glands restricted to tissue with smaller cells and trichomes, common (b,d); crystal idioblasts not observed. Distribution: Throughout Texas except the Plains Country; Texas and New Mexico, also in Mexico and southern South America. Photographs a,b, and e 180X, c and d 260X.

Figure 104. *Lantana horrida* H.B.K., common lantana (hierba de cristo, calico bush, buncheberry), four species in Texas: Regular, undulate to sinuate cell walls, medium size (a,b,e); medium-size stomata, luminescent, companion-cell-number variable, not distinct (a,b,e); unicellular trichomes, medium-to-large size, luminescent, swollen at base, complex attachments, common (c), attachments and surrounding epidermal cells brightly luminescent (a to e); glands and crystal idioblasts not observed. Distribution: Throughout most of Texas except the northwest; cultivated and in New Mexico, Arizona, California, and northern Mexico, and introduced in North Carolina and Mississippi. All photographs 180X.

ZYGOPHYLLACEAE (Caltrop family)

Figure 105. *Kallstroemia hirsutissima* Vail ex Small, hairy caltrop, six species in Texas, two are described: Regular, smooth cell walls, medium size (a,b); small stomata, companion cells three to six, not distinct (a,b); dimorphous trichomes, large, stiff, luminescent unicellular trichomes with complex attachments, attachment and surrounding epidermal cells luminescent (c,d,e), and smaller, morphologically similar trichomes with superficial attachments, rounded at base (f,g), both types common; glands absent; dimorphous crystal idioblasts, medium-to-large irregularly shaped rhomboid-type crystals, rare (h to k), and small-to-medium size subcrystalline druses, common (g). Distribution: Rio Grande Plains from Cameron County to Kinney and Bexar counties, in Kerr County on the Edwards Plateau, and in the Trans-Pecos in Jeff Davis, Pecos, and Brewster counties, Texas; from southeastern Arizona and southern New Mexico to Texas, and through Chihuahua, Coahuila, Nuevo Leon and Tamaulipas to San Luis Potosi, Mexico. Photographs a,b, and d to k 180X, c 45X.

Figure 106. *Kallstroemia parviflora* J.S.B. Norton, warty caltrop: Regular, smooth to slightly undulate cell walls, medium size (a,b); medium-size stomata, companion cells three to five, one often reduced (a,b); dimorphous trichomes, similar to *K. hirsutissima* (Fig. 105), large, stiff, luminescent unicellular trichomes, undulate margins, complex attachments, attachment and adjacent epidermal cells luminescent (c,d), and smaller morphologically similar trichomes but with superficial attachments, rounded at base (e,f), both types common; glands absent; small subcrystalline to crystalline druses rare. Distribution: Common everywhere in Texas except the east and southeast, High Plains and southernmost Rio Grande Plains; Texas west through New Mexico, Colorado, Arizona, and southern Nevada to southeastern California, north through Oklahoma, Kansas and Missouri to Illinois and Mississippi, also in Mexico from Sonora through Chihuahua, Coahuila, Nuevo Leon, Durango, Zacatecas, Aguascalientes and San Luis Potosi to Guanajuato, Queratero and Hidalgo. Photographs a,b,c,e, and f 180X, d 45X.

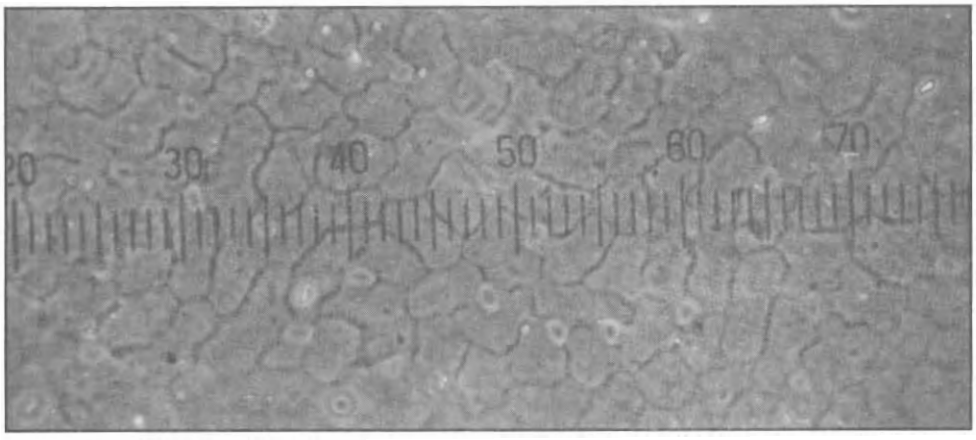
Figure 107. *Peganum harmala* L., harmal peganum (African rue), two species in Texas, both are described: Regular grading to sublinear, often rugose, smooth cell walls, medium size (a,b); medium-size stomata, often luminescent, companion-cell-num-

ber variable, not distinct (a,b); trichomes absent; multicellular clavate glands, multicelled stalk and distal segment, common (c,d); small, short, needle-like crystals in clusters that vary in size, not in typical raphide-type bundles, common in stem tissue (e,f,g). Distribution: Scattered across the Trans-Pecos in Hudspeth, Reeves, Presidio and Pecos counties, in Edwards County on the Edwards Plateau, and in Garza County in the Plains Country of Texas; and introduced weed of the Great Palaearctic Desert, spreading from an introduction in Luna County, New Mexico in the 1930s, also known from Arizona and Nevada. Photographs a,b,c,e and f 180X, d and g 260X.

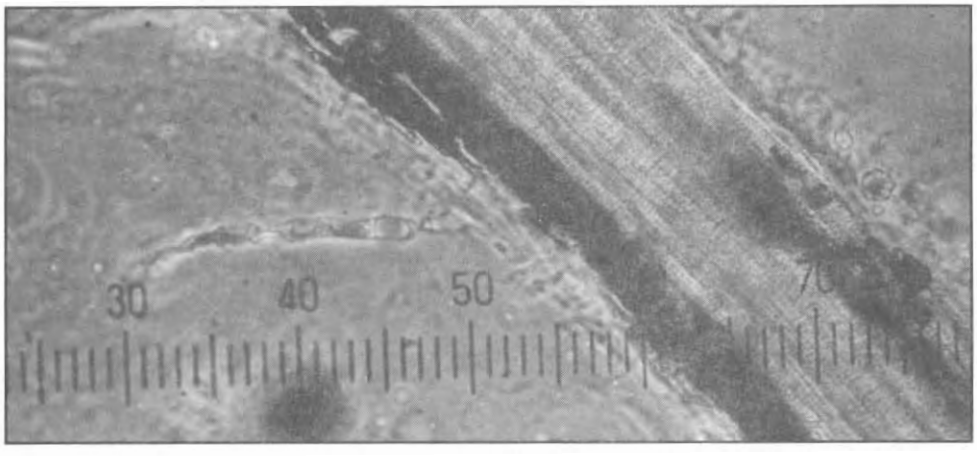
Figure 108. *Peganum mexicanum* Gray, Mexican peganum: Regular grading to sublinear, smooth cell walls, sometimes rugose, medium size (a,b,c); medium-size stomata, often luminescent, companion-cell-number variable, not distinct (a,b,c); small unicellular trichomes, complex attachments, rare (d); glands not observed; polymorphous crystal idioblasts, (1) large globous druses composed of many fine needle-like crystals, common (e,f), (2) medium-size raphides abundant (g), and (3) irregularly shaped crystal sand, common (h,i). Distribution: In the U.S. known only in Hudspeth County, Texas in the Trans-Pecos; from Texas south through Sonora, Chihuahua, Coahuila, Nuevo Leon and Tamaulipas to Zacatecas and San Luis Potosi, Mexico. Photographs a,c,e,g,h, and i 180X, b,d, and f 260X.

Figure 109. *Tribulus terrestris* L., puncturevine (bullhead, goathead), a monotypic genus in Texas: Regular-hexagonal, smooth cell walls, medium size (a,c,e); small stomata, companion cells four or five, one or two reduced (a); many different sizes of unicelled trichomes, all morphologically similar, stiff, luminescent, undulate margins, rounded at base, epidermal cells radially arranged about superficial attachments, common (b,c,d); glands not observed; medium-to-large subcrystalline druses rare (e). Distribution: Throughout Texas except on the Gulf Coast and extreme eastern portion; a native of the Mediterranean region, now widely distributed throughout the warm temperate regions of the World. Photograph a 260X, b and d 45X, c and e 180X.

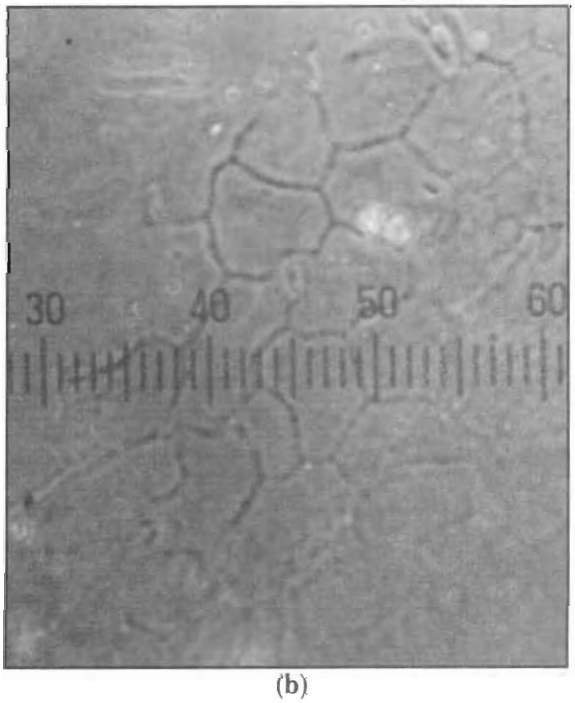
Figure 110. Photomicrographs of rumen contents from a cow suspected of being poisoned in western Tom Green County, Texas. Stellate trichomes (a) are a *Solanum* sp. (see Figs. 97, 98, 99) and unicellular trichomes (b) are a *Cassia* sp. (see Fig. 54).



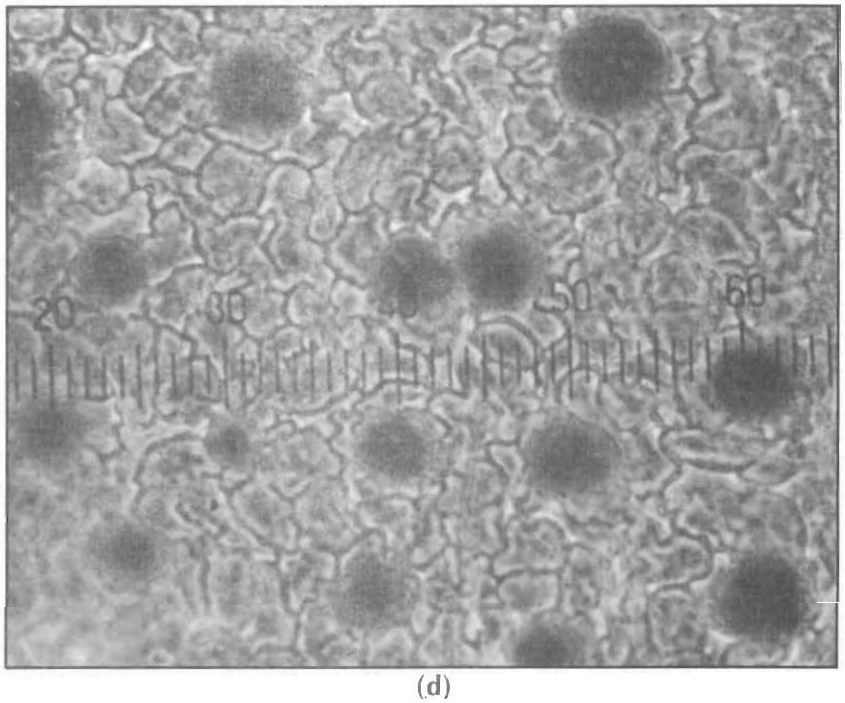
(a)



(c)

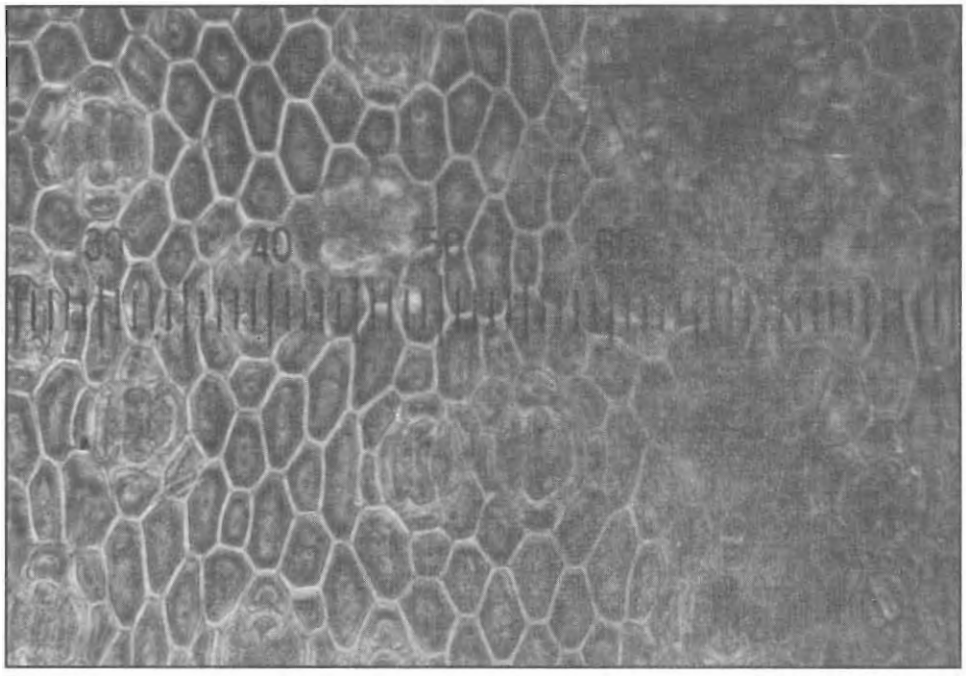


(b)



(d)

Figure 1. ***Amaranthus retroflexus***



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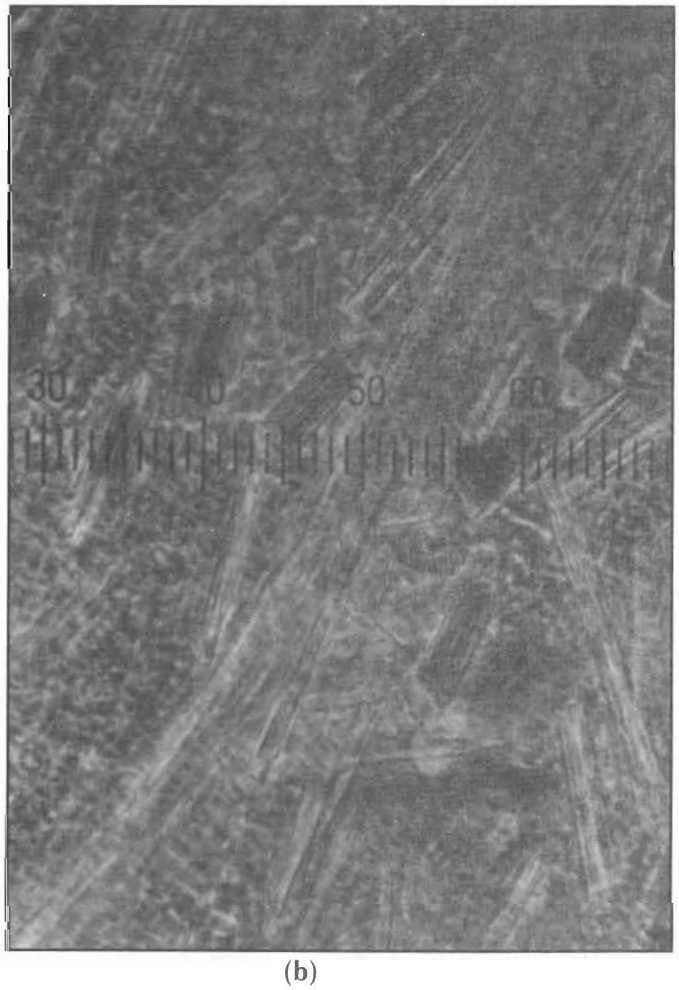

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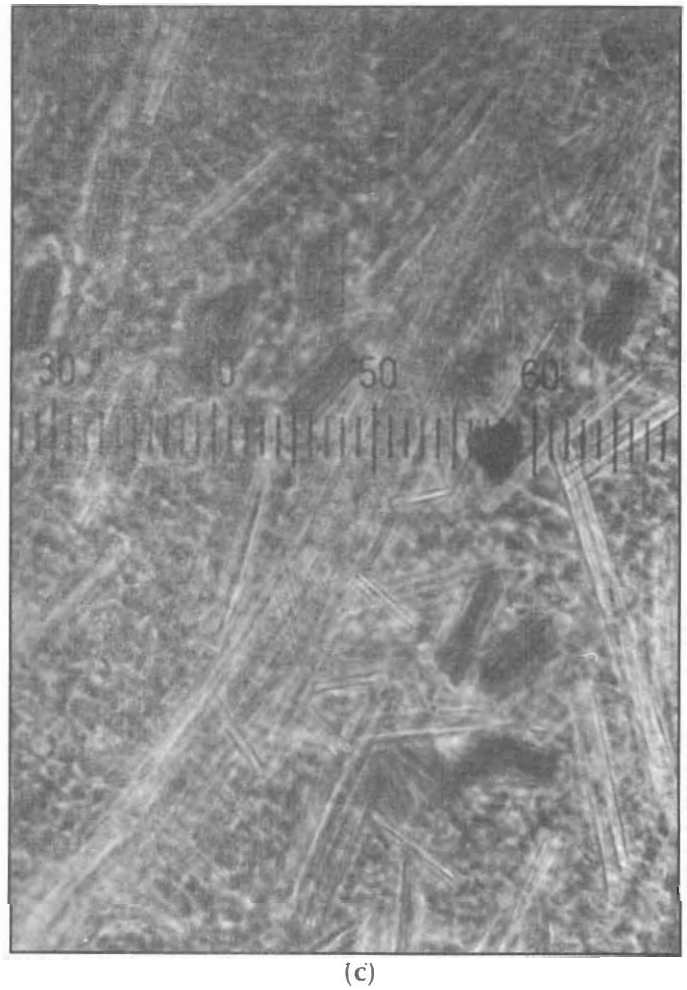
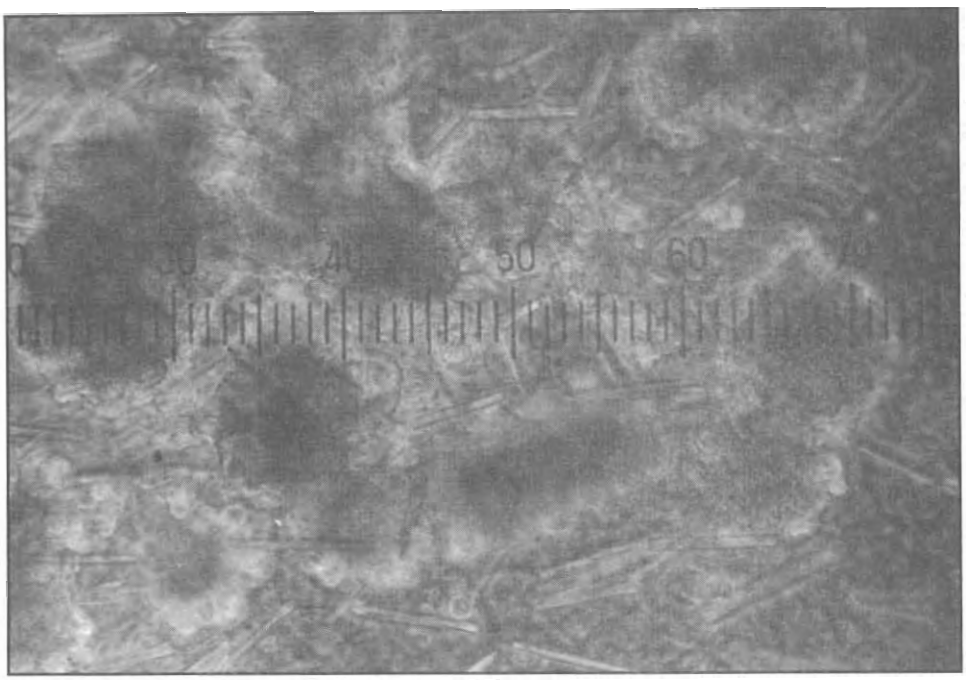


(c)

Figure 2. *Agave lechegüilla*



(d)

(e)

Figure 2. (continued)

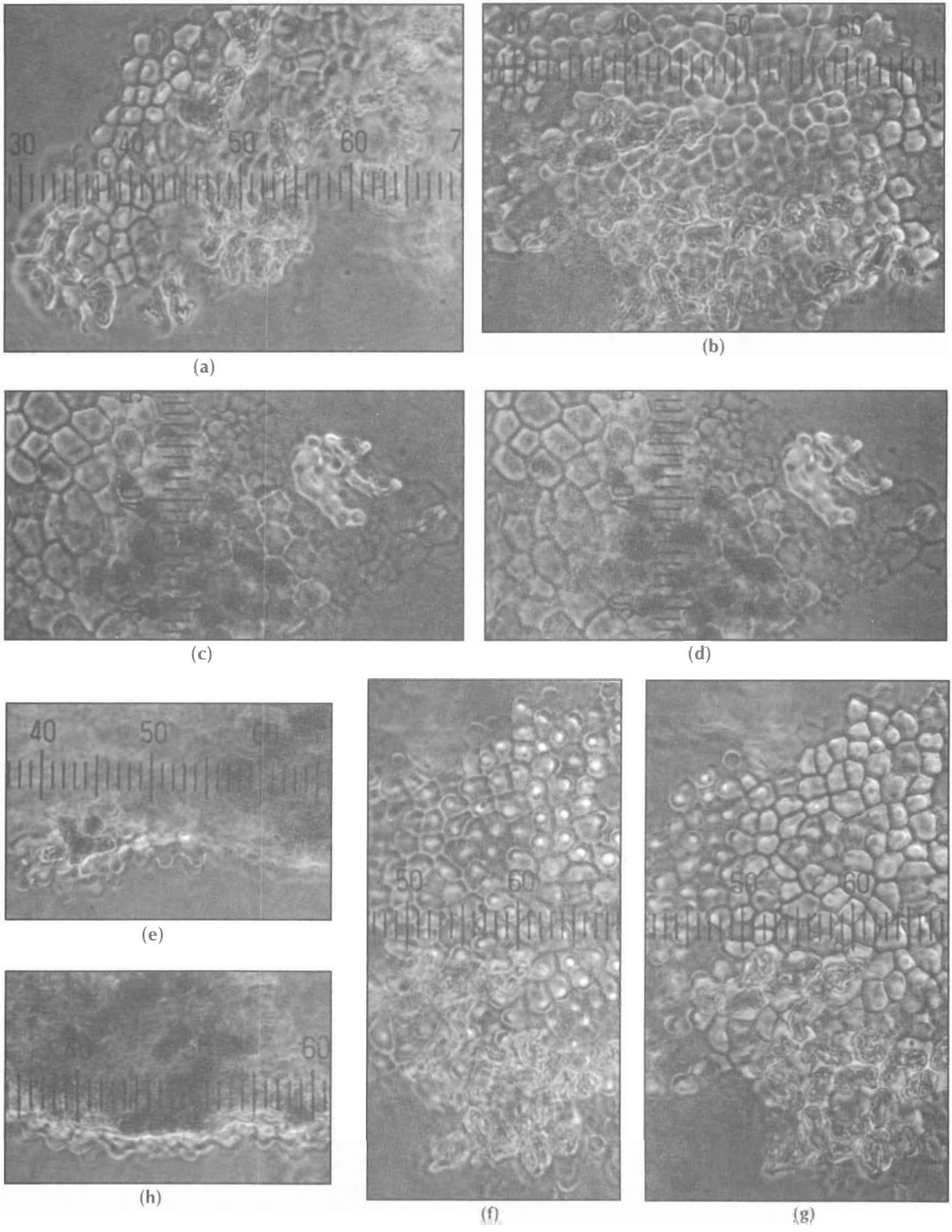
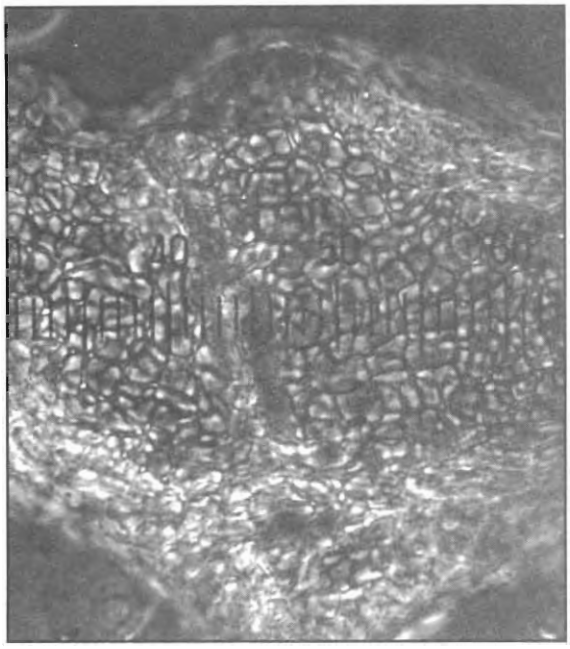


Figure 3. *Apocynum sibiricum*



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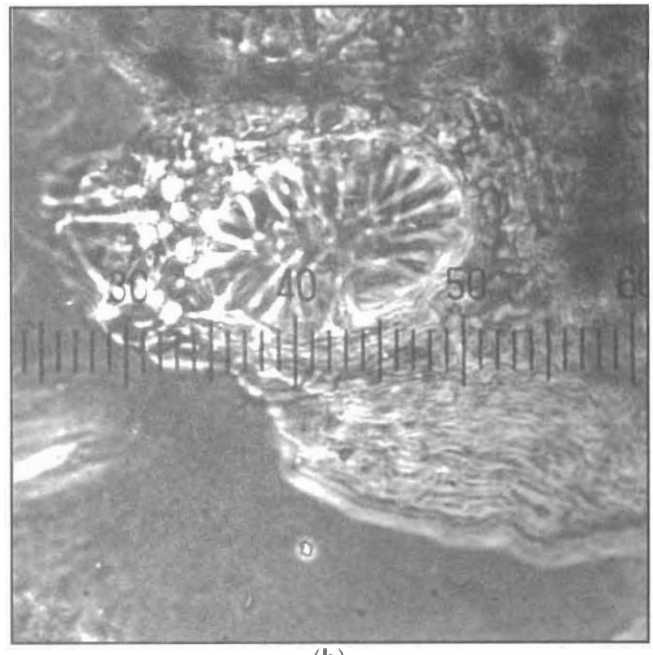

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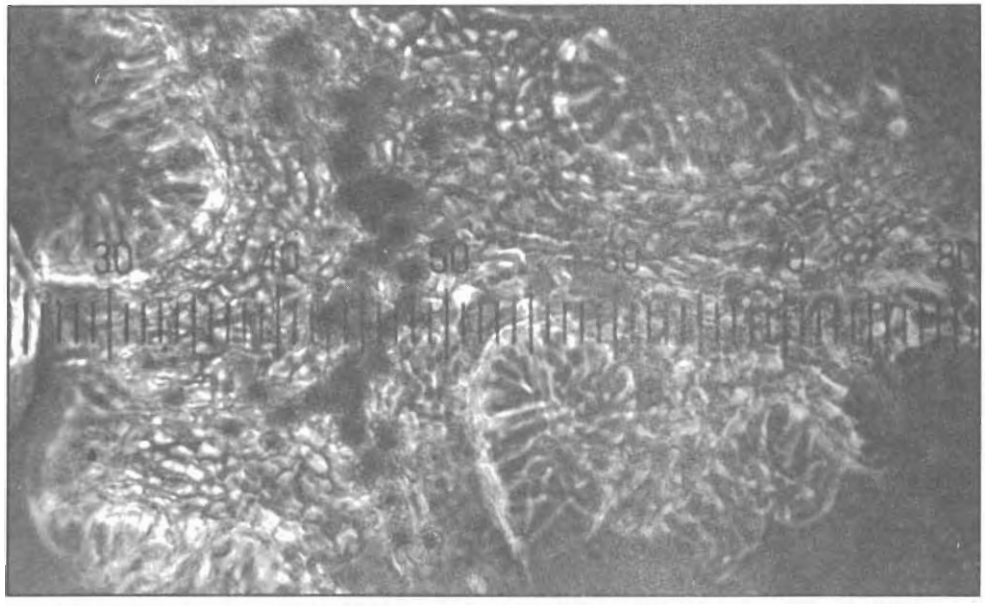

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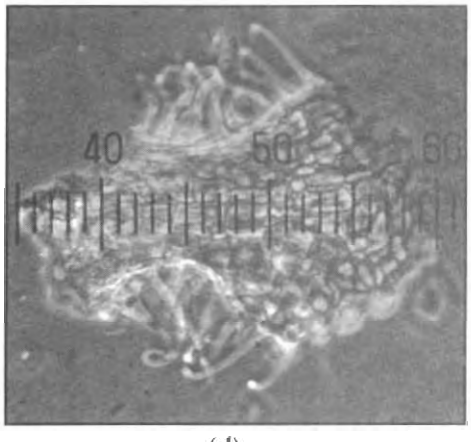

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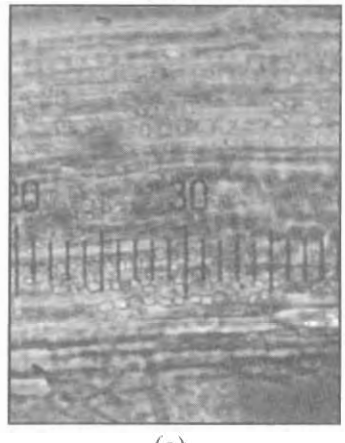

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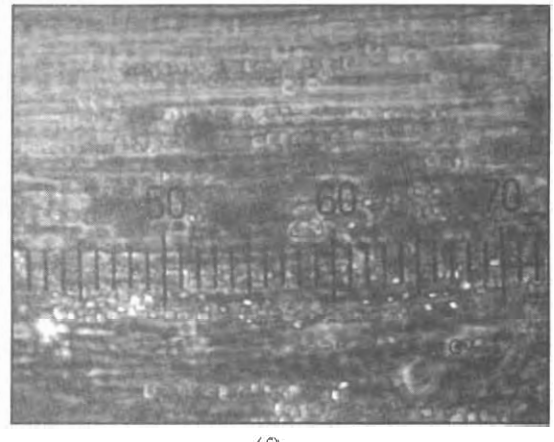

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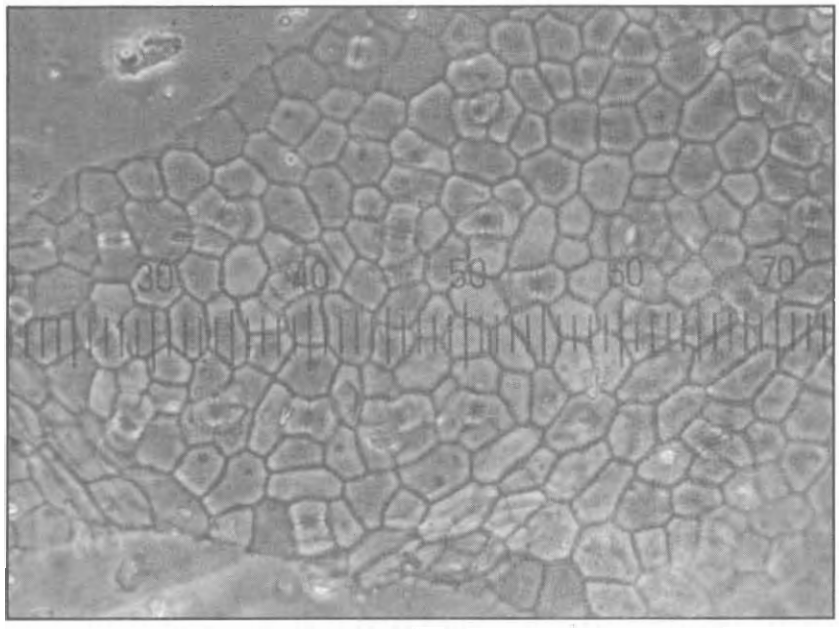
Figure 4. *Nerium oleander*



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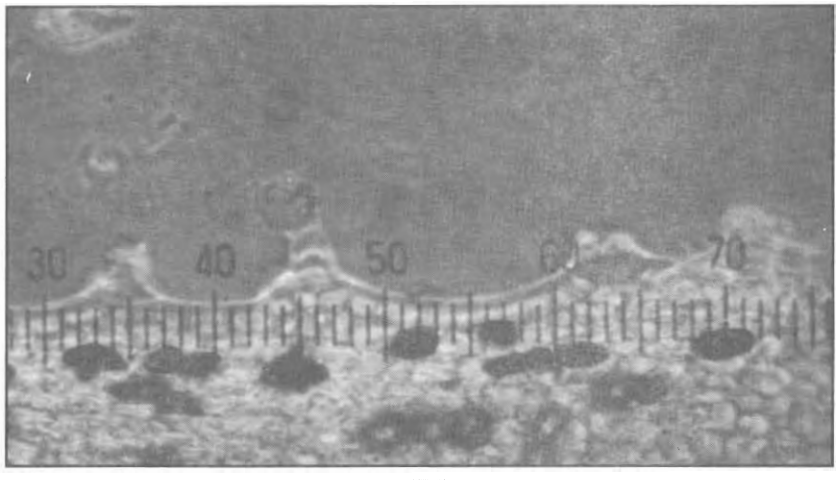

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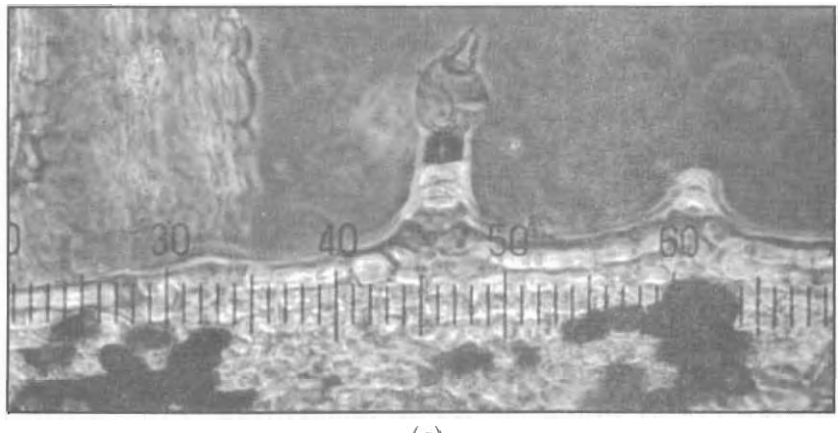
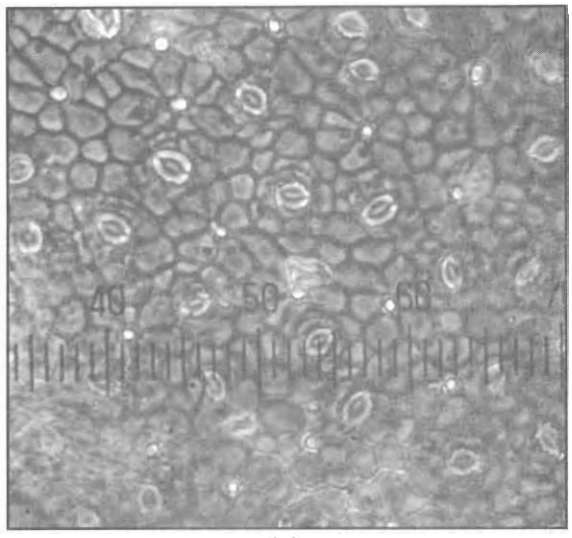


(c)

Figure 5. *Asclepias asperula*



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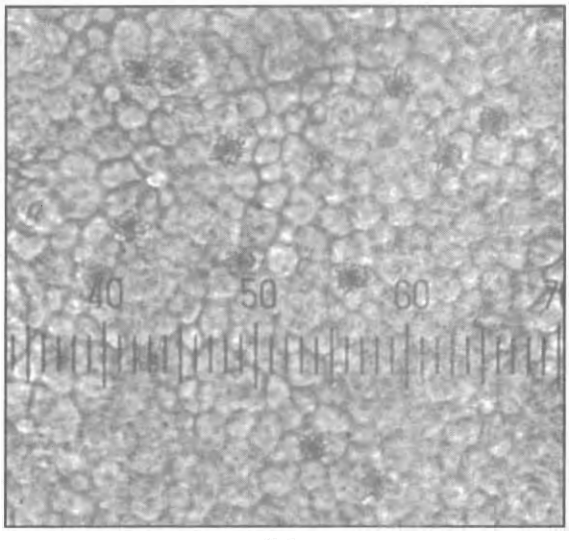


(b)

Figure 6. ***Asclepias latifolia***

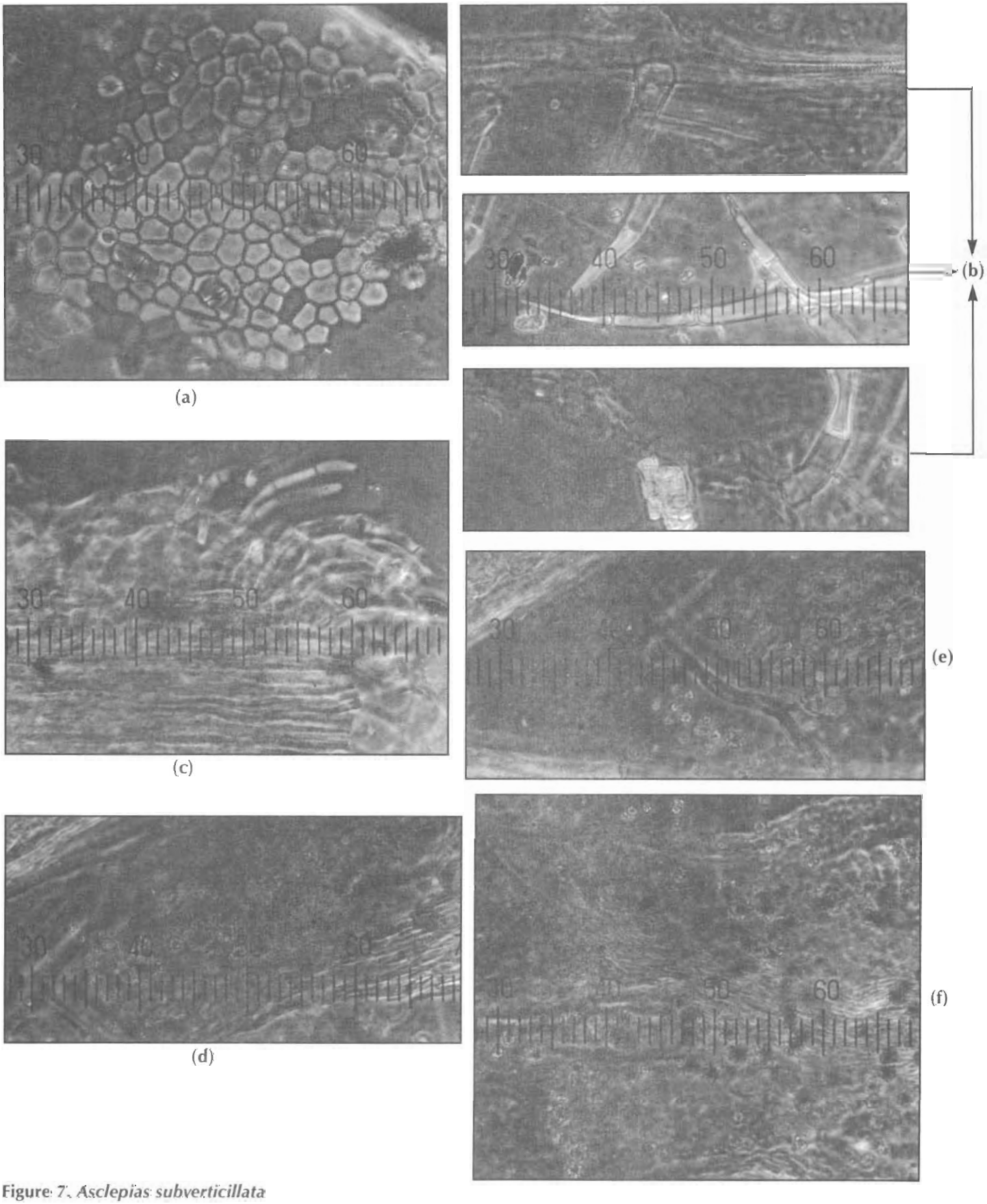
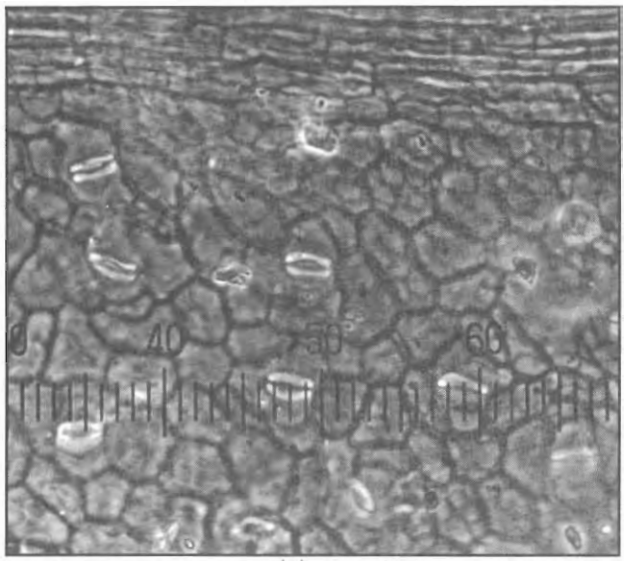


Figure 7. *Asclepias subverticillata*



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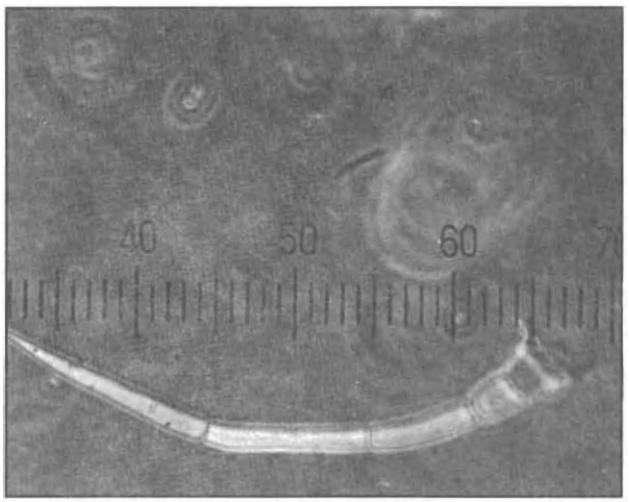

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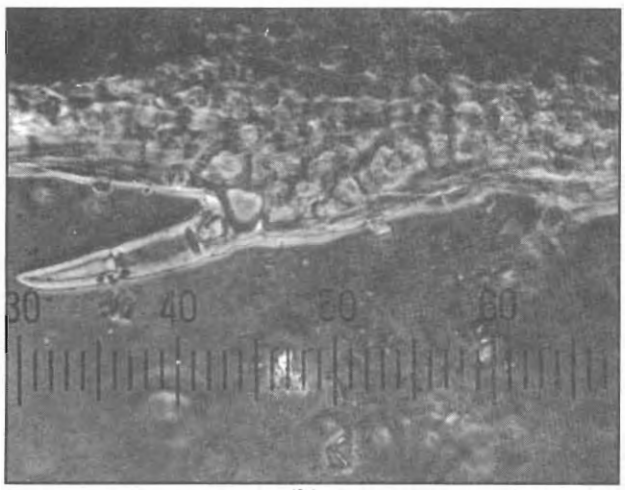

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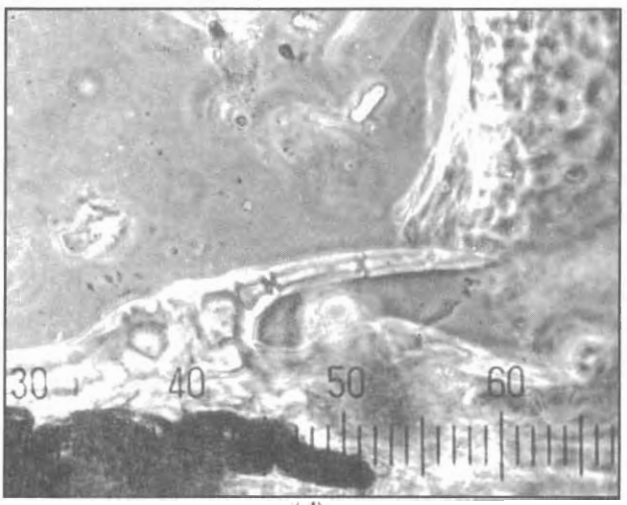

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Figure 8. *Asclepias verticillata*

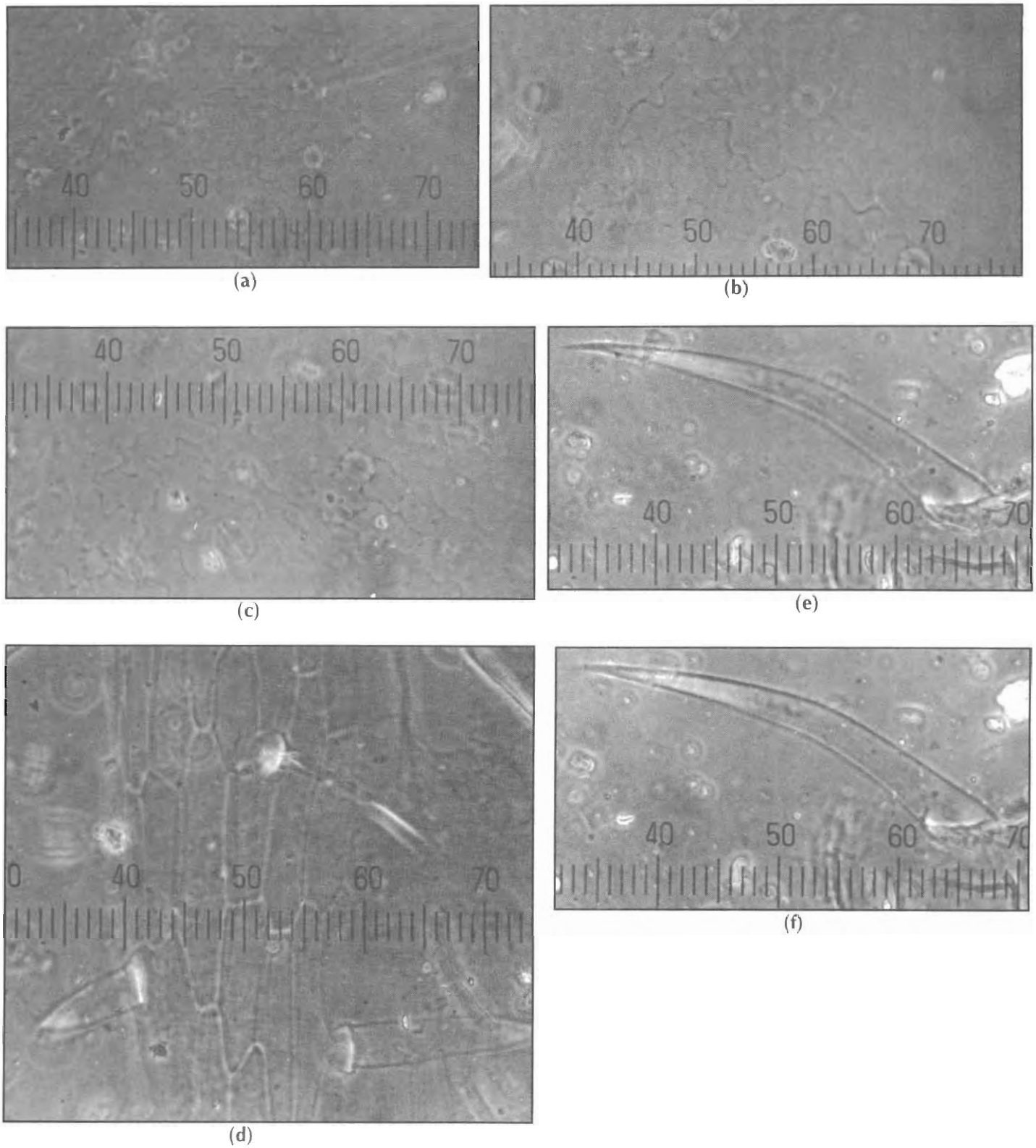
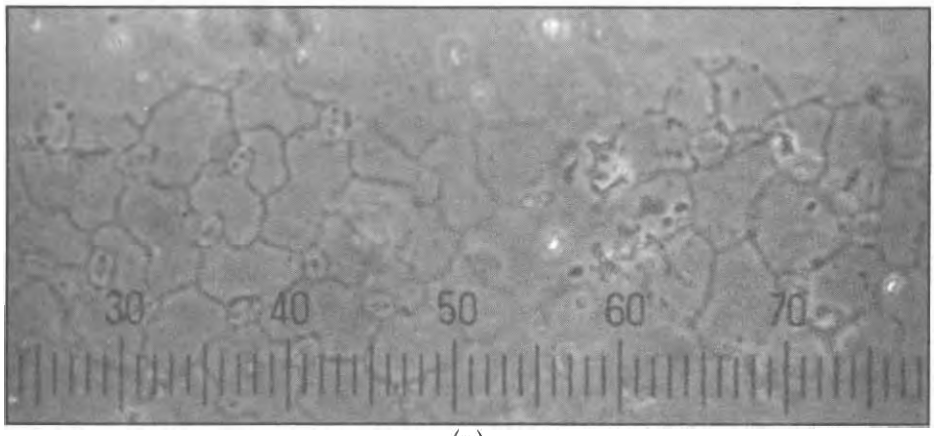


Figure 9. *Lobelia berlandieri*



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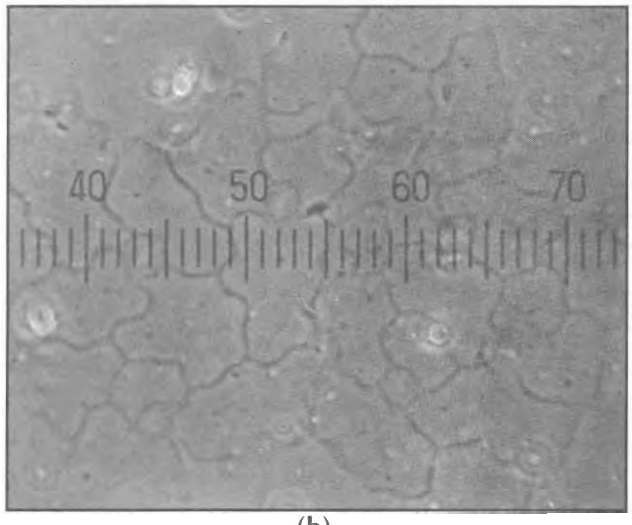

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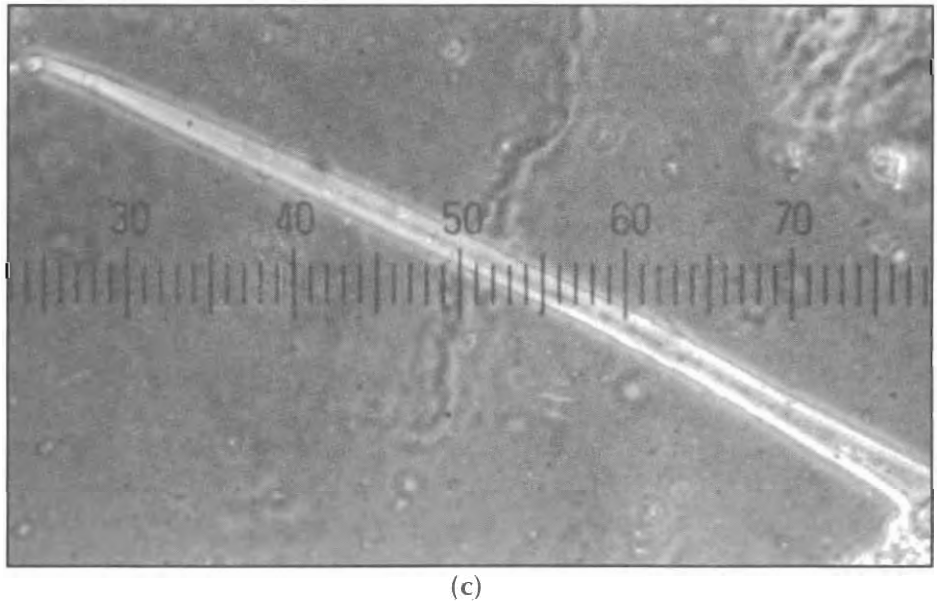
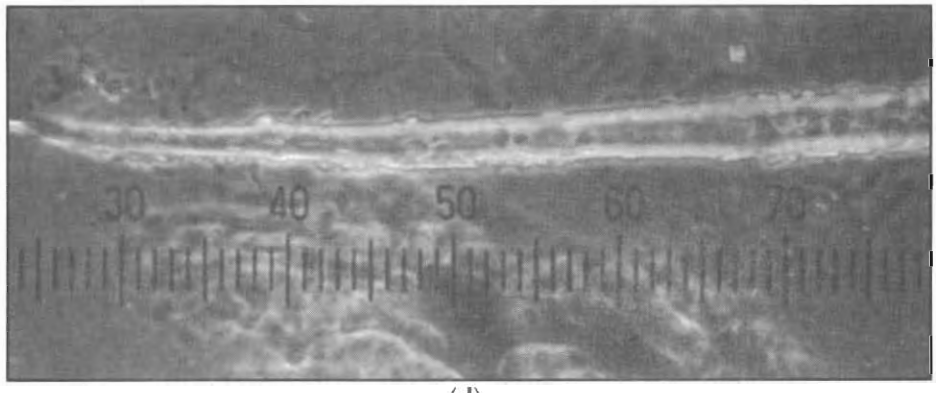


(c)

Figure 10. ***Drymaria pachyphylla***



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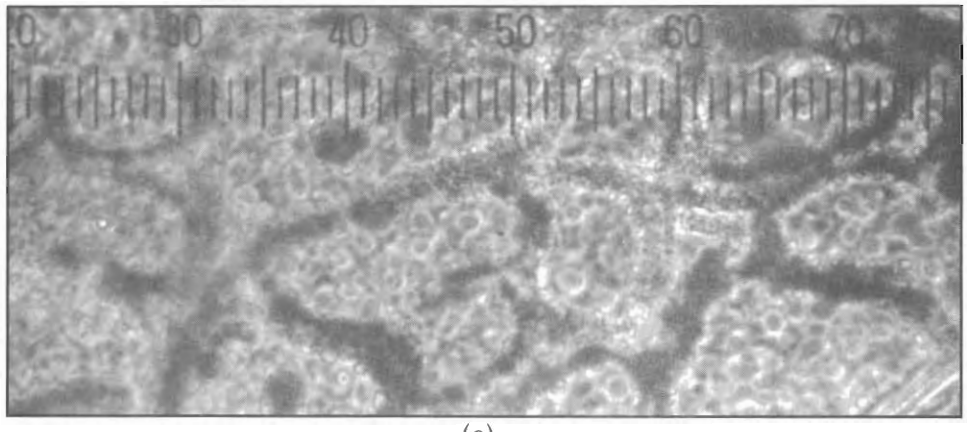

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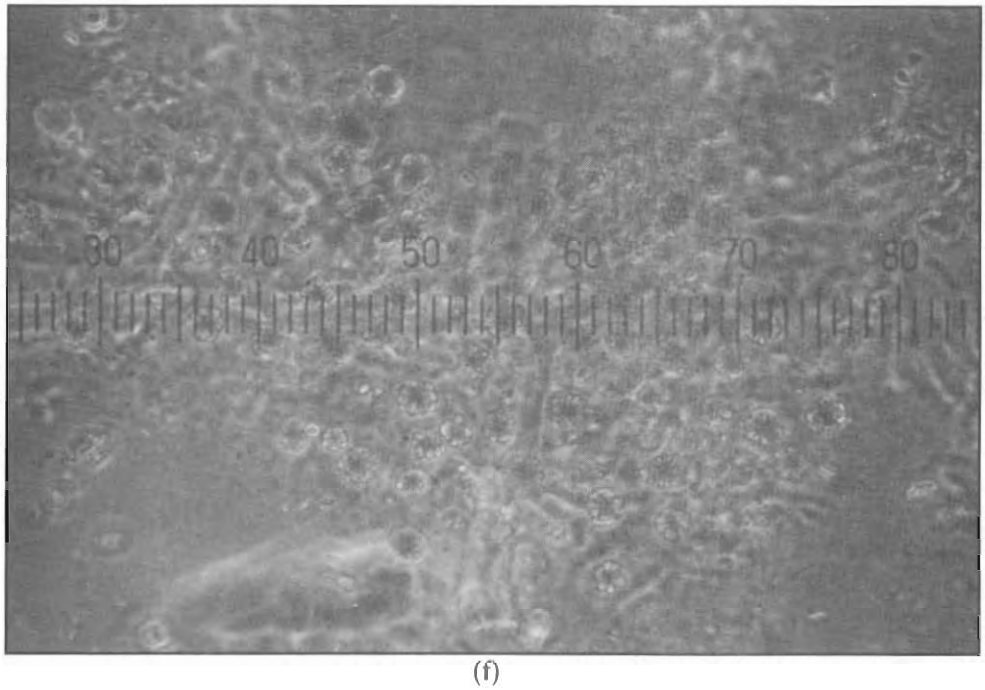

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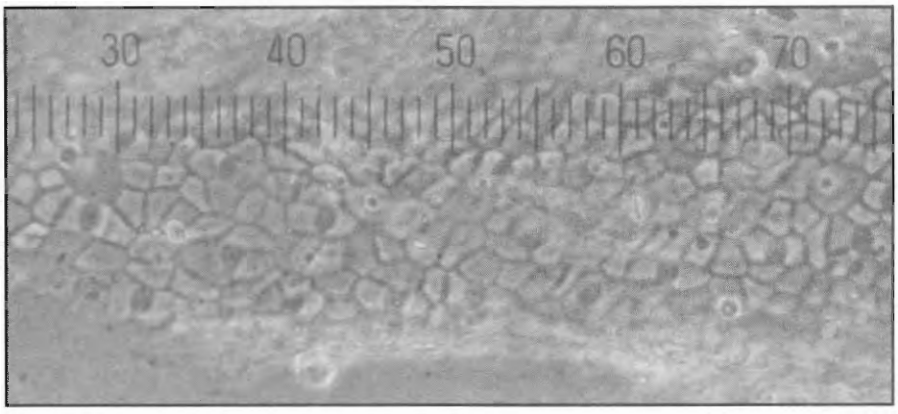

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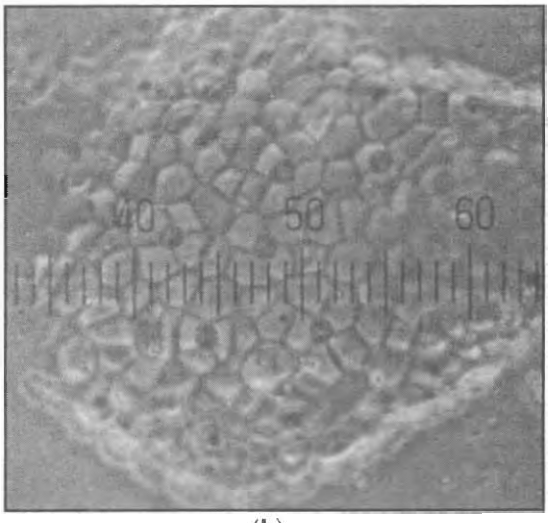

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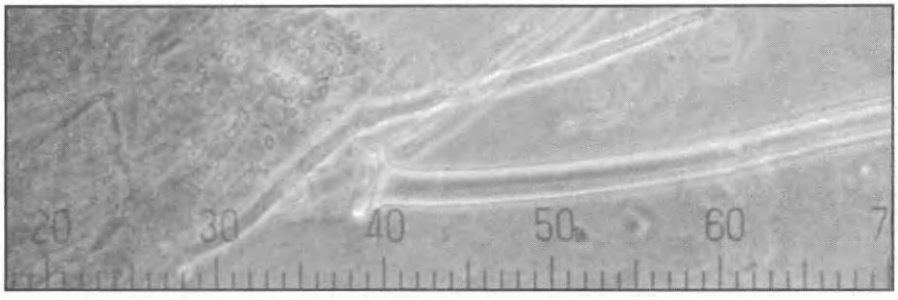

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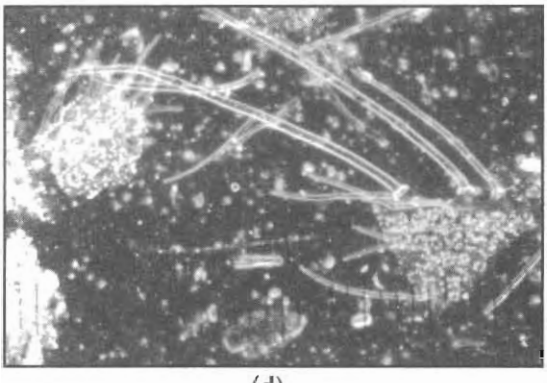

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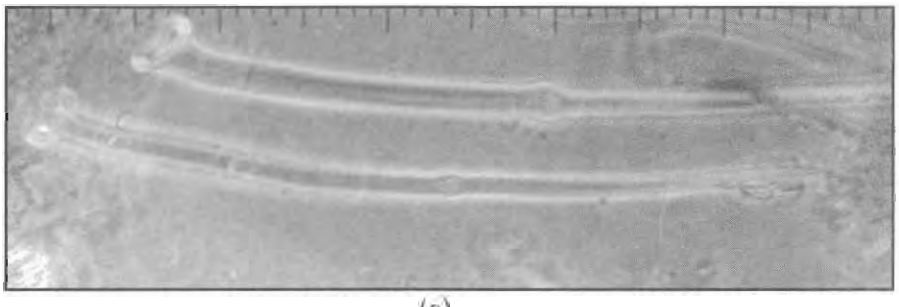

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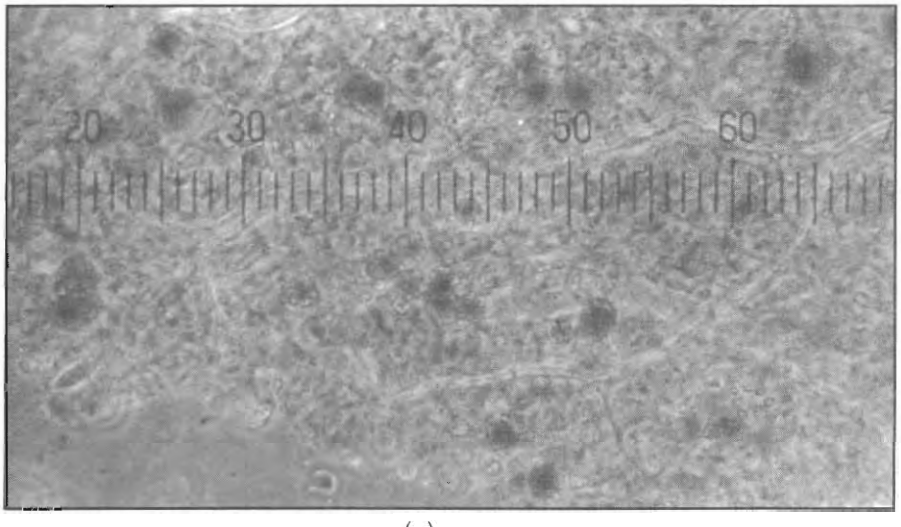

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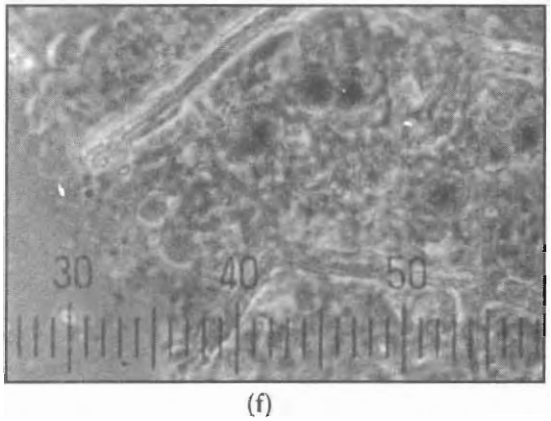
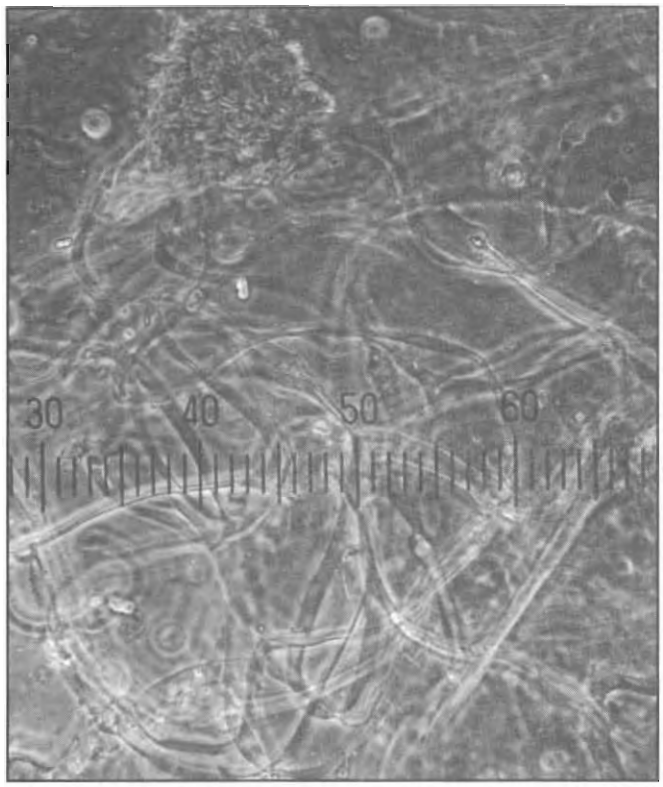


(f)

Figure 11. *Kochia scoparia*



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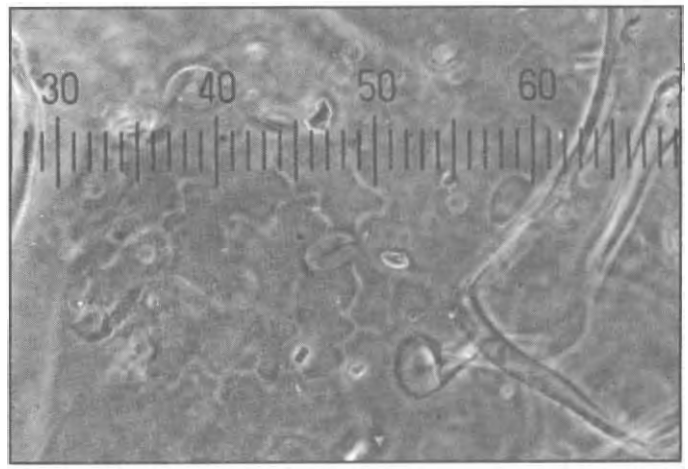

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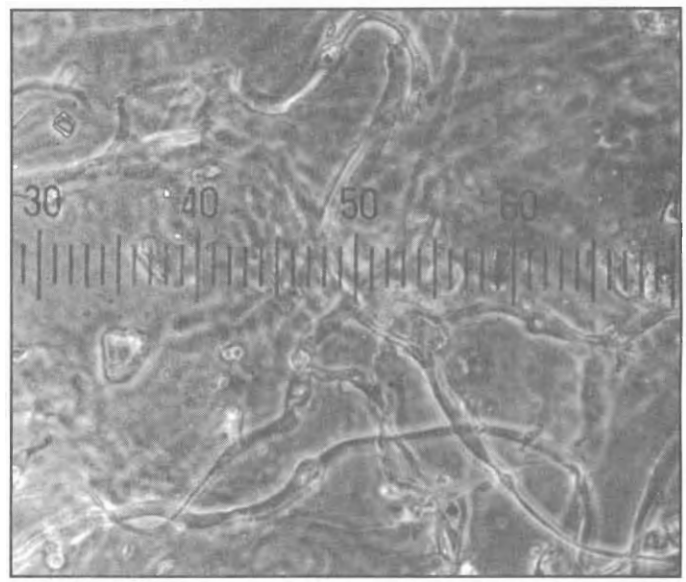

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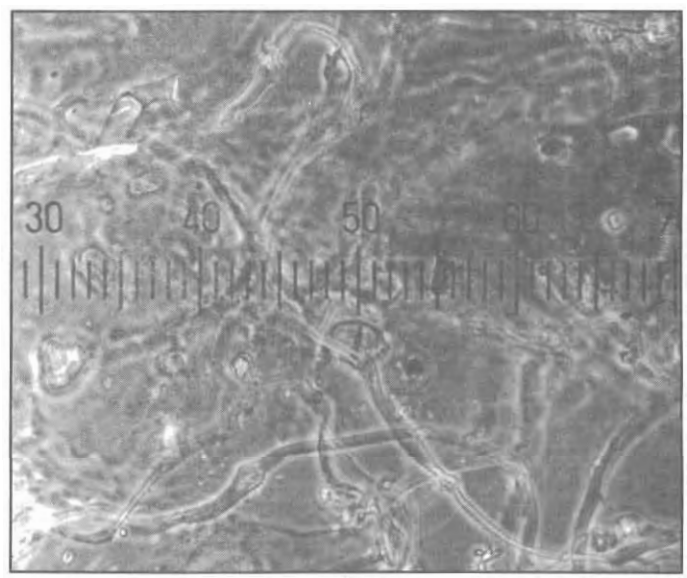
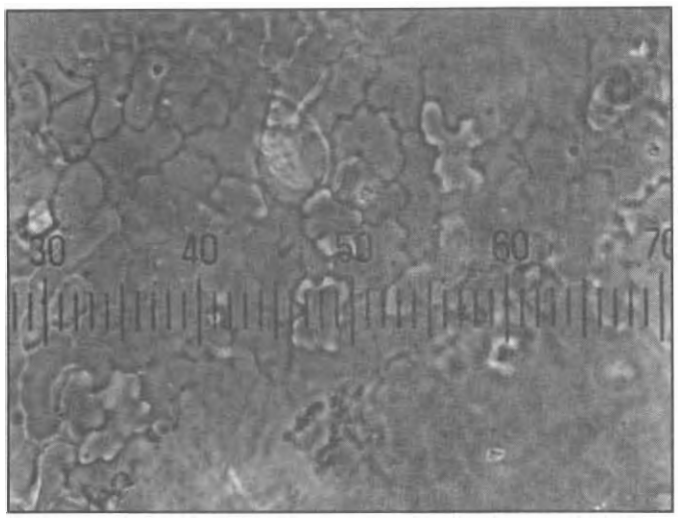


(e)

Figure 12. ***Baileya multiradiata***



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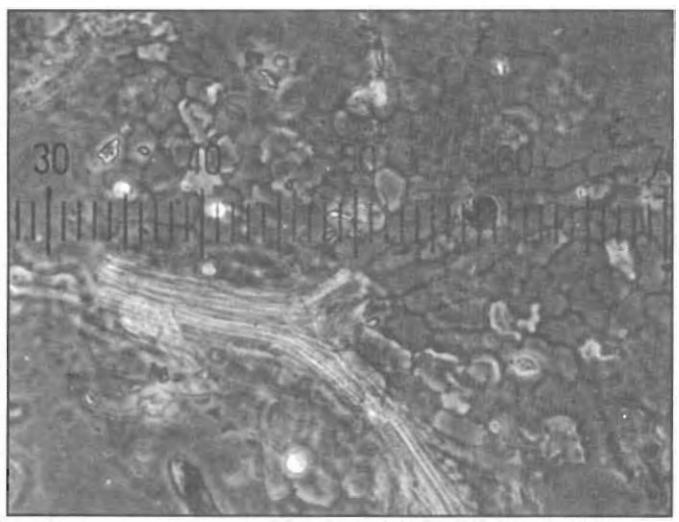

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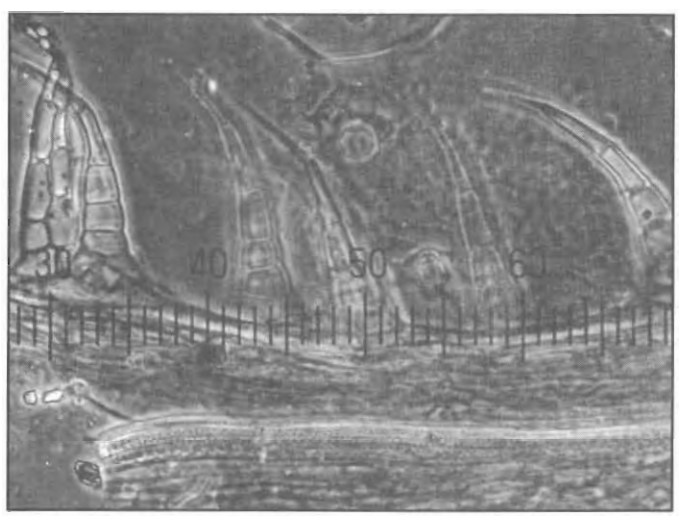

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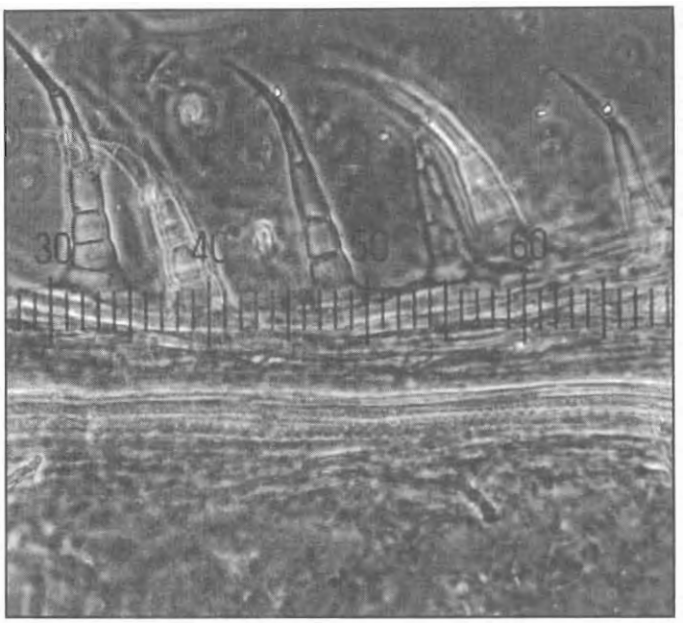

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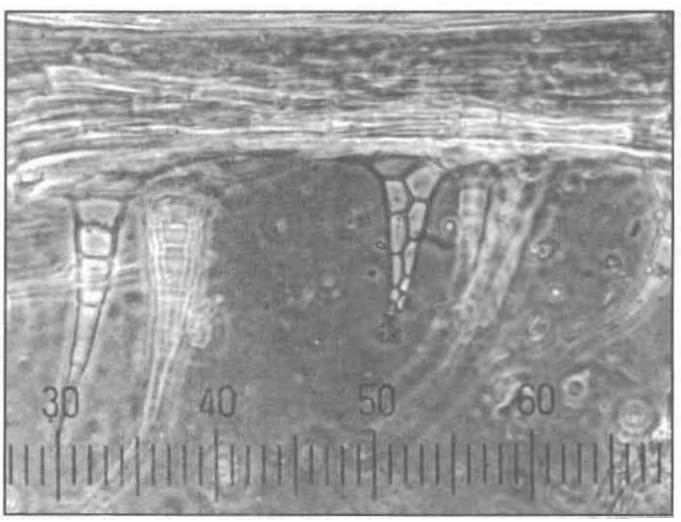
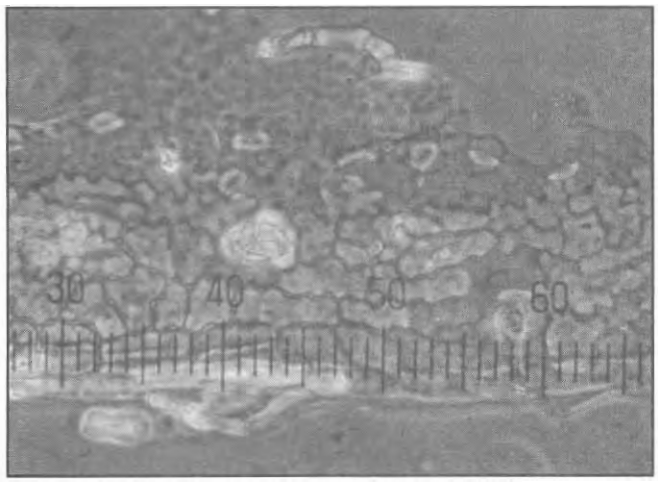


(e)

Figure 13. *Conyza coulteri*



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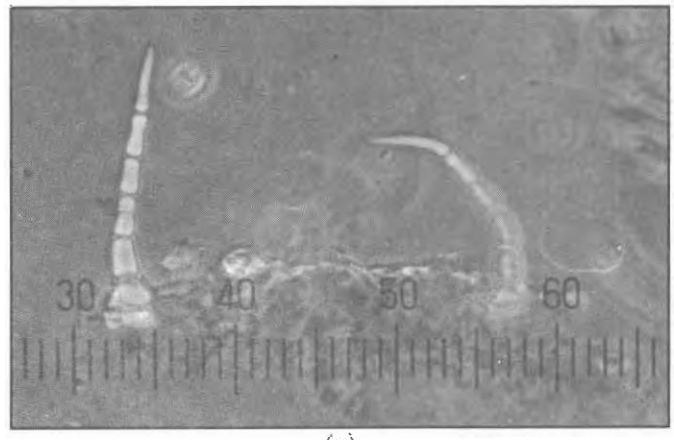

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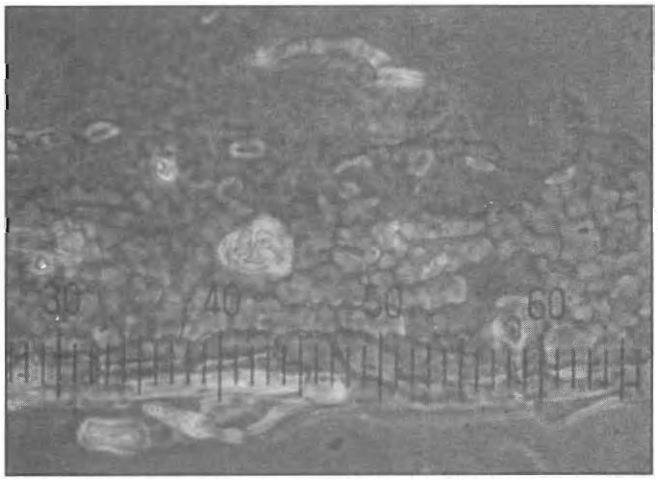

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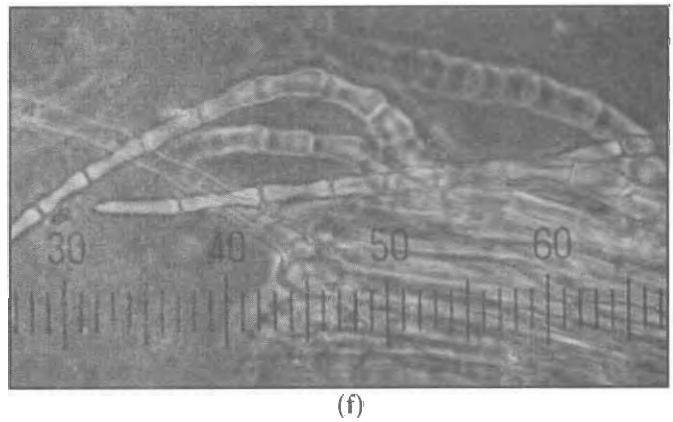

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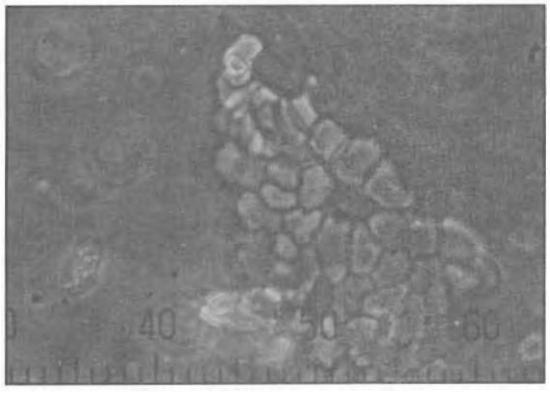

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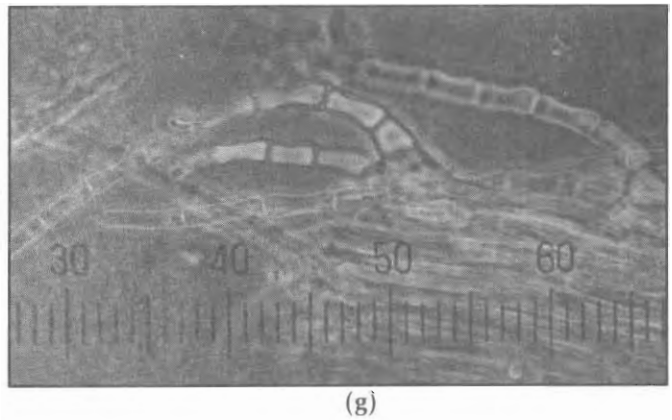

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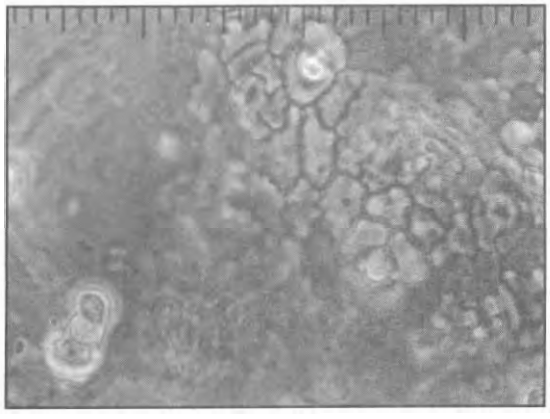

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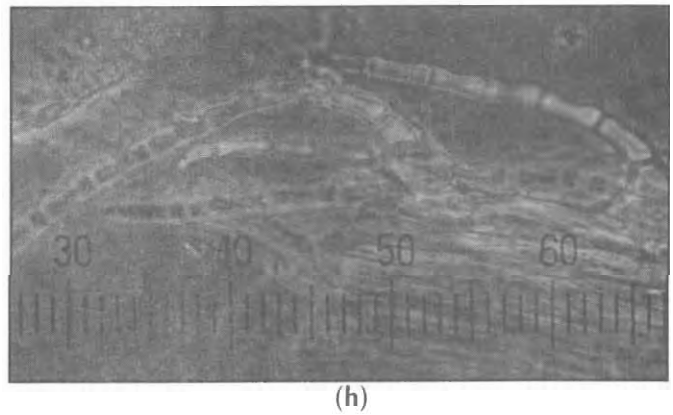
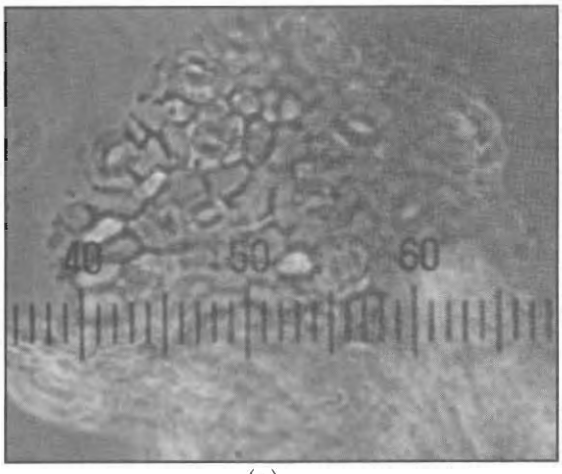


(h)

Figure 14. *Eupatorium rugosum*



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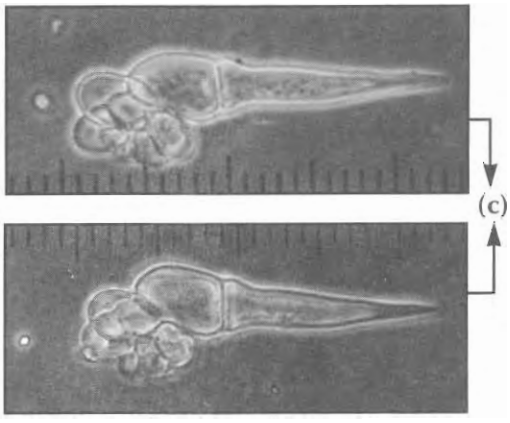
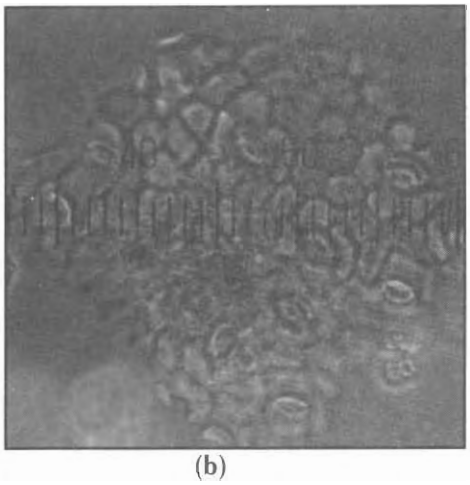
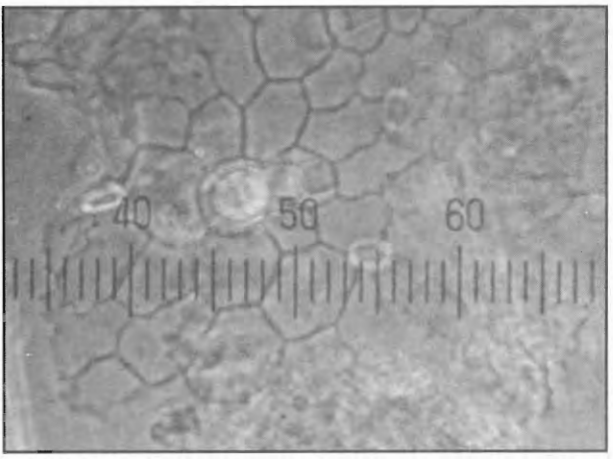




(b)

(d)

Figure 15. *Flourensia cernua*



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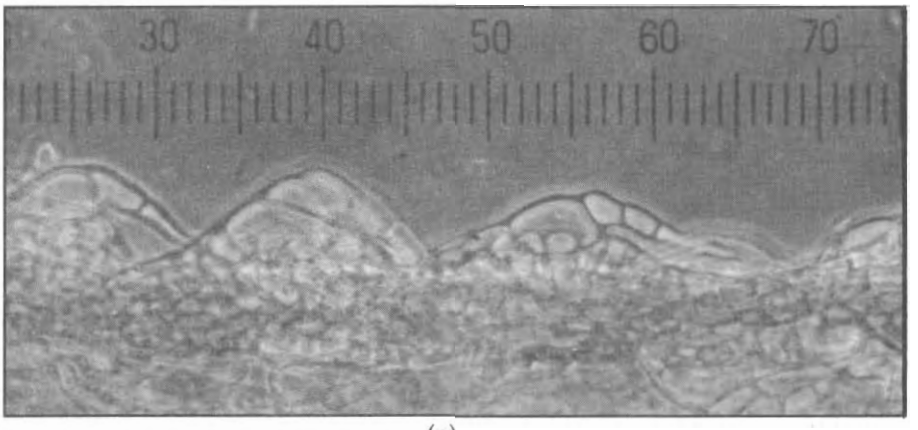

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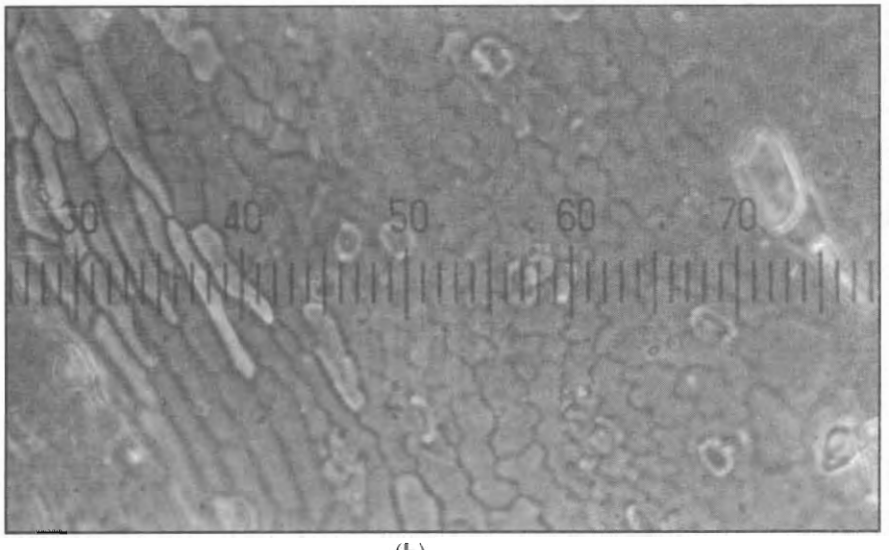
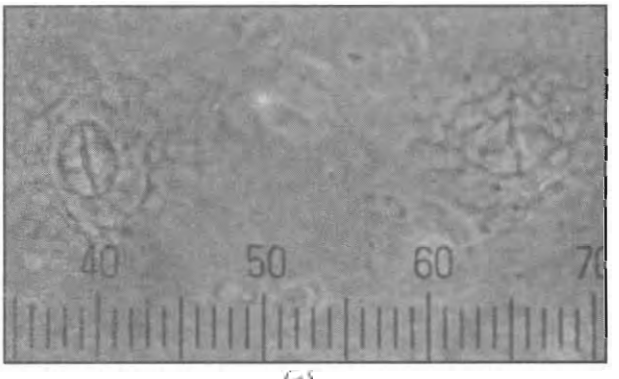
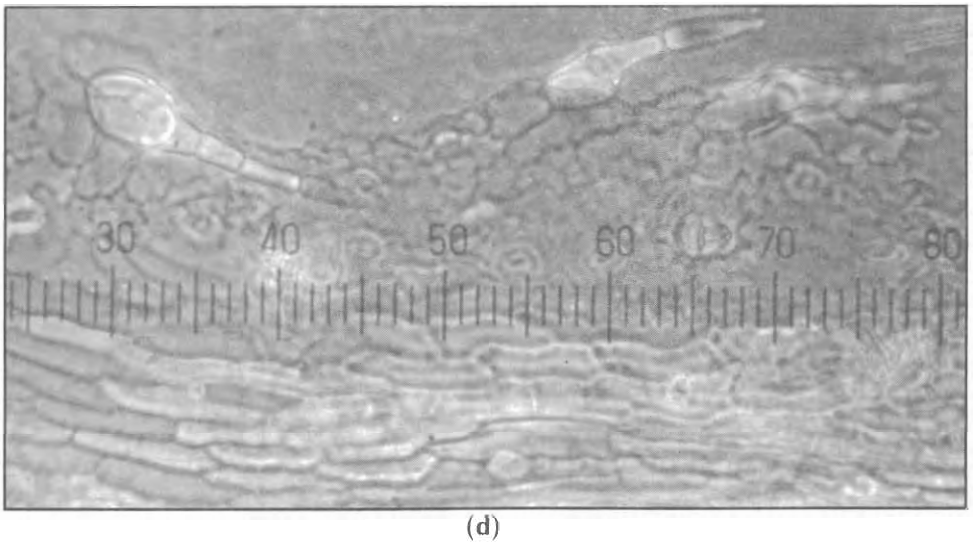


(b)

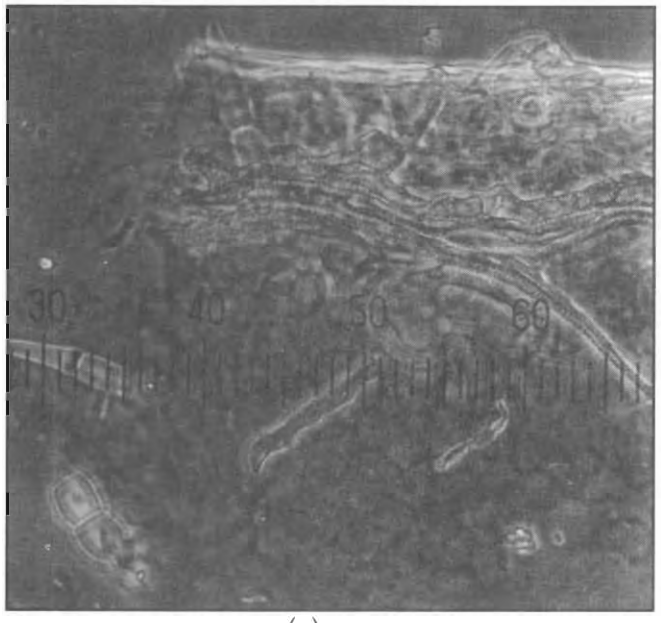


(e)

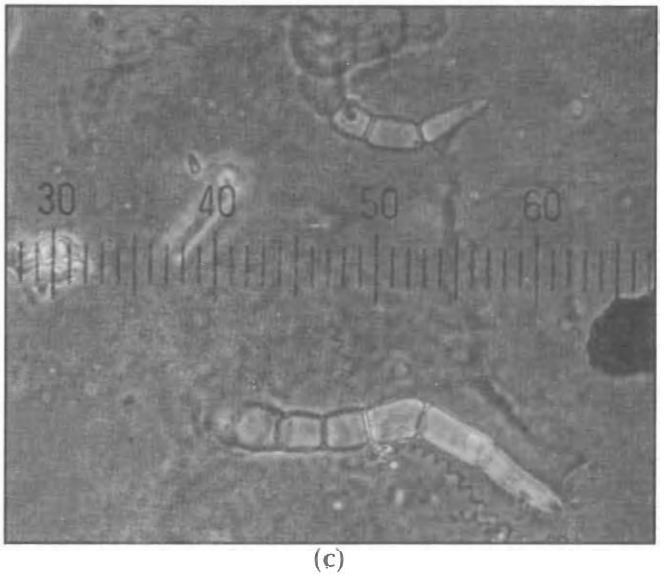


(d)

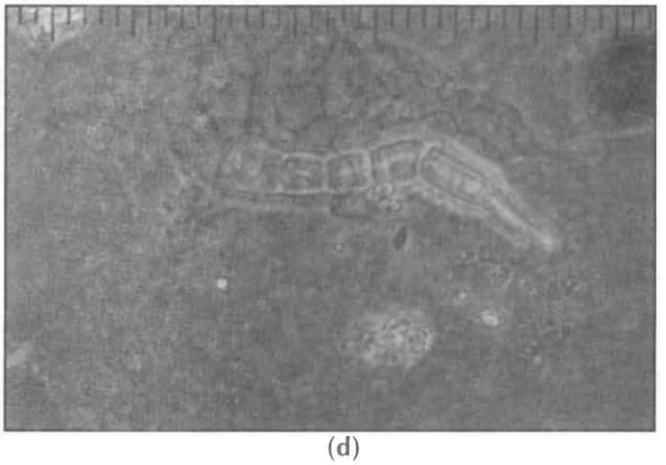
Figure 16. ***Helenium autumnale***



(a)



(c)



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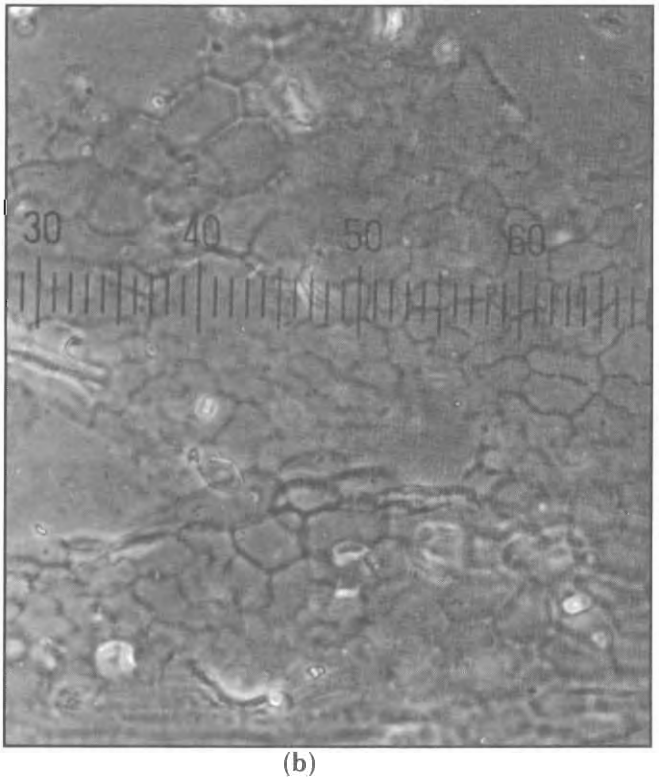

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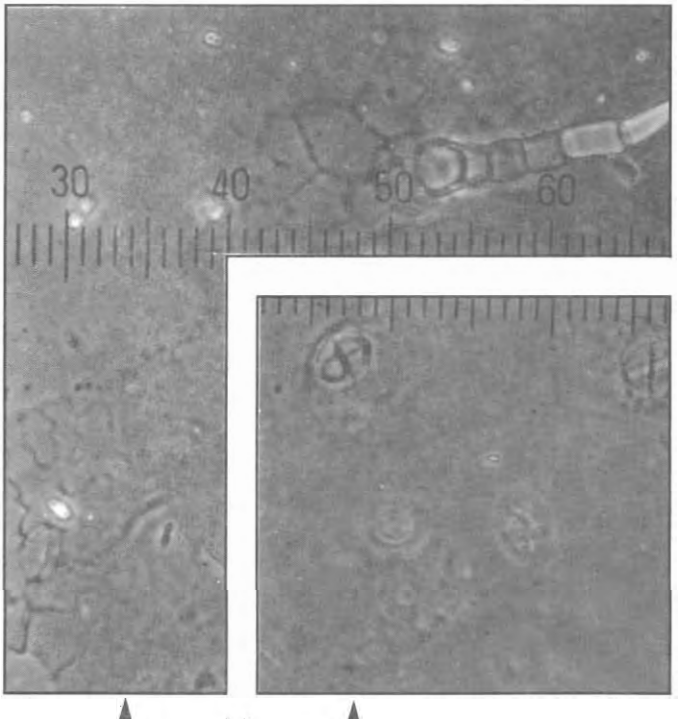
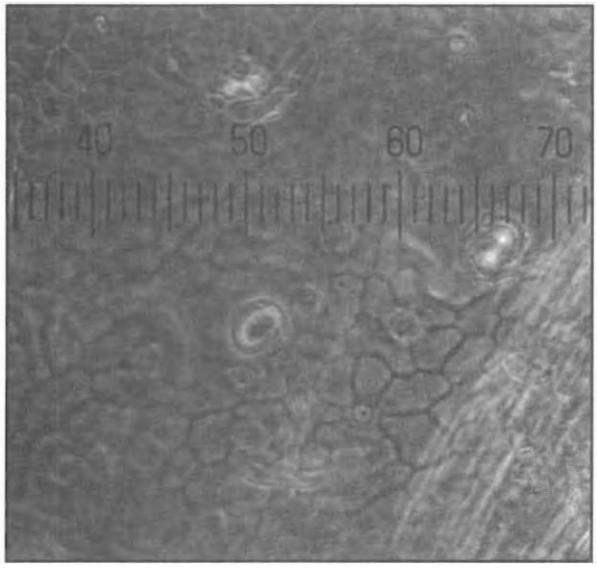


(e)

Figure 17. *Helenium badium*



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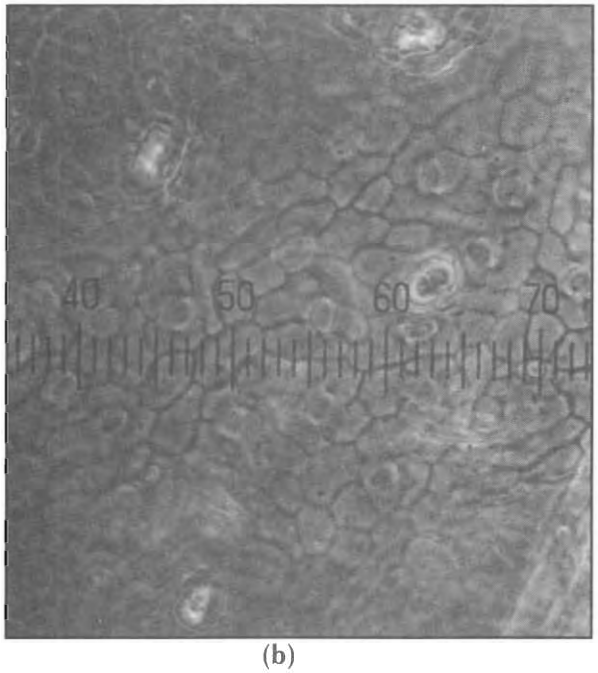

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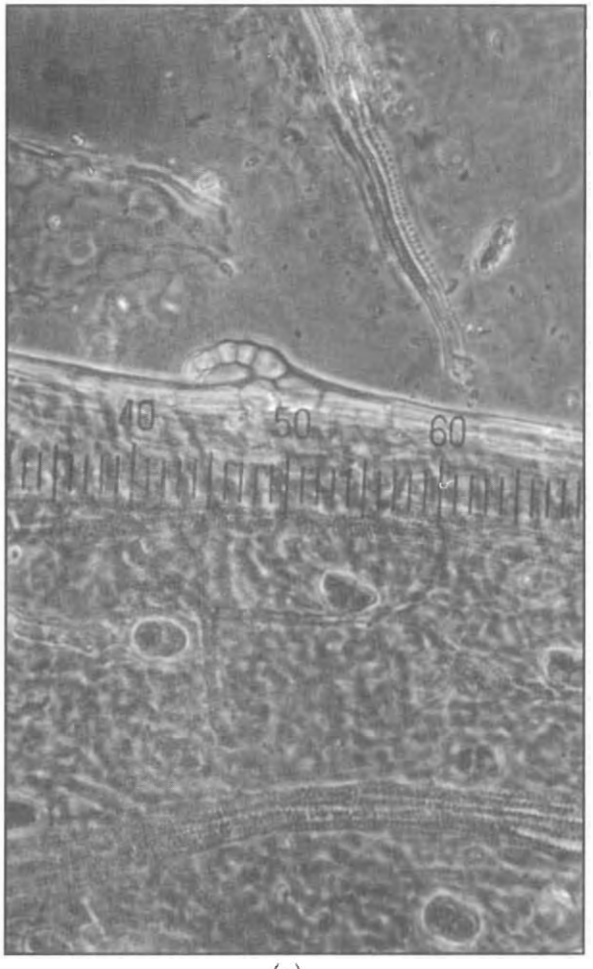

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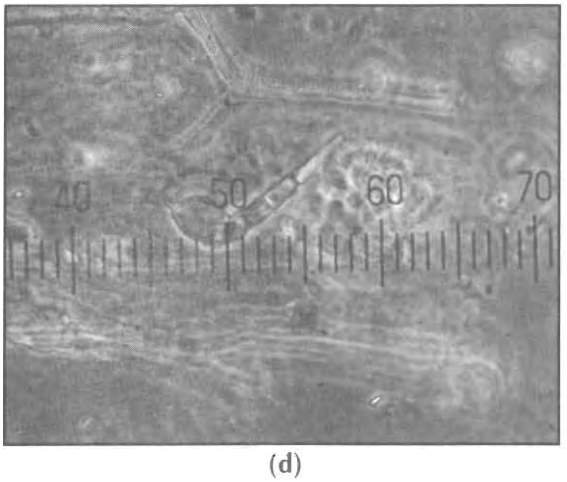


(d)

Figure 18. ***Helenium microcephalum***

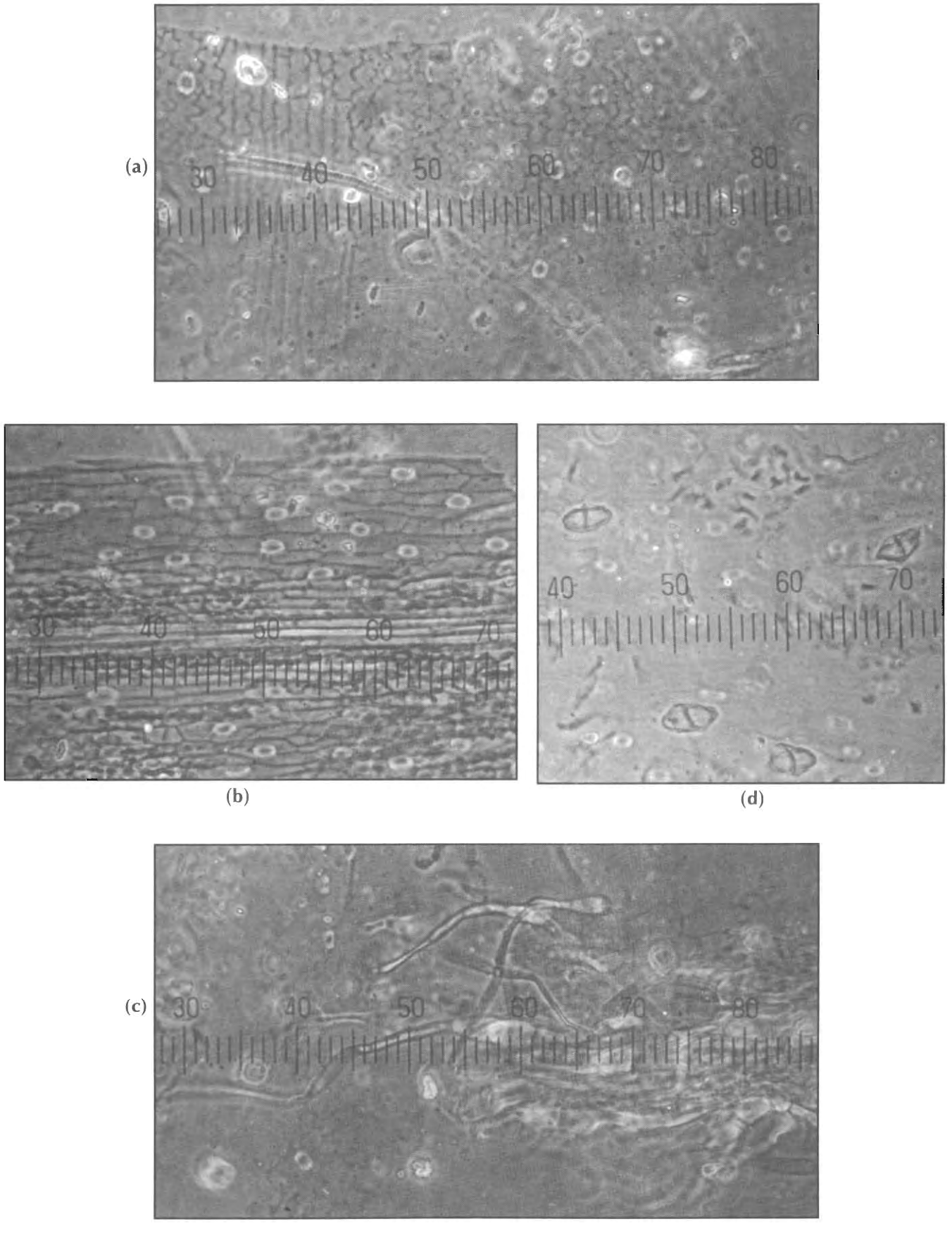


Figure 19. *Hymenoxys odorata*

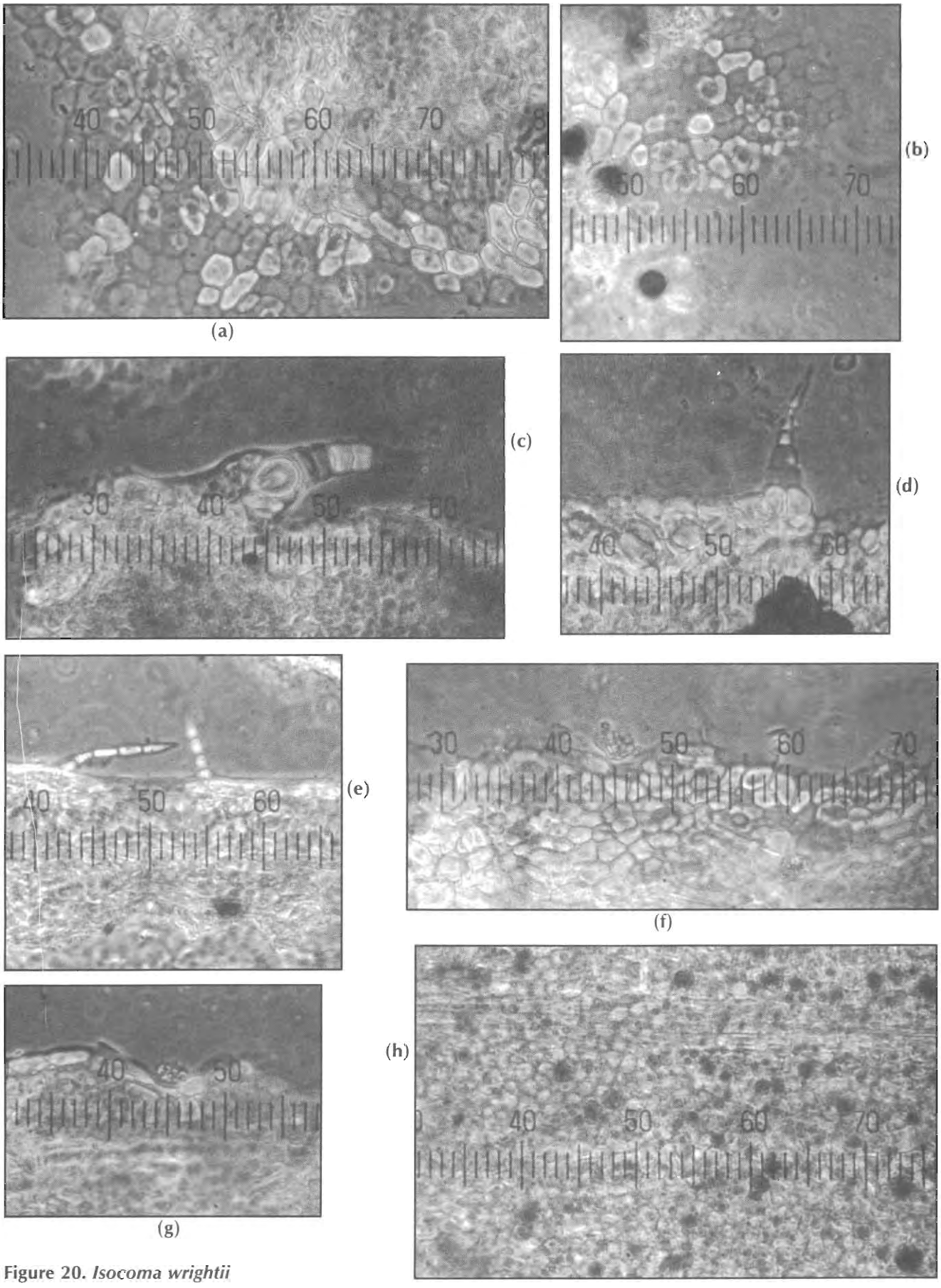
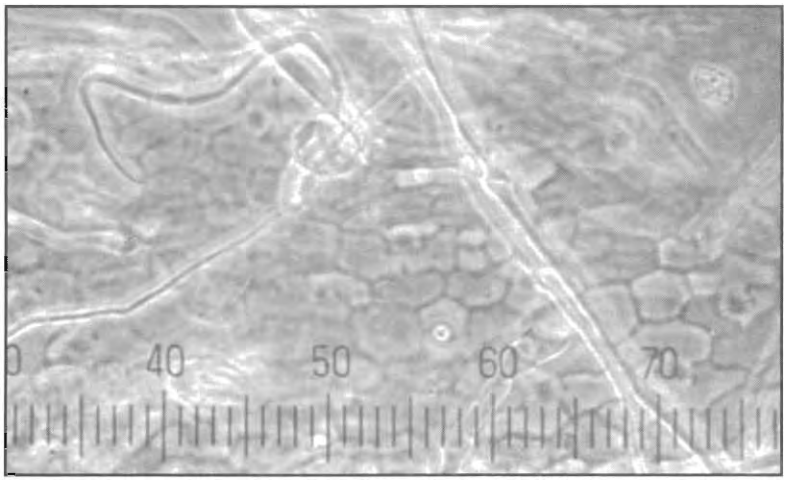
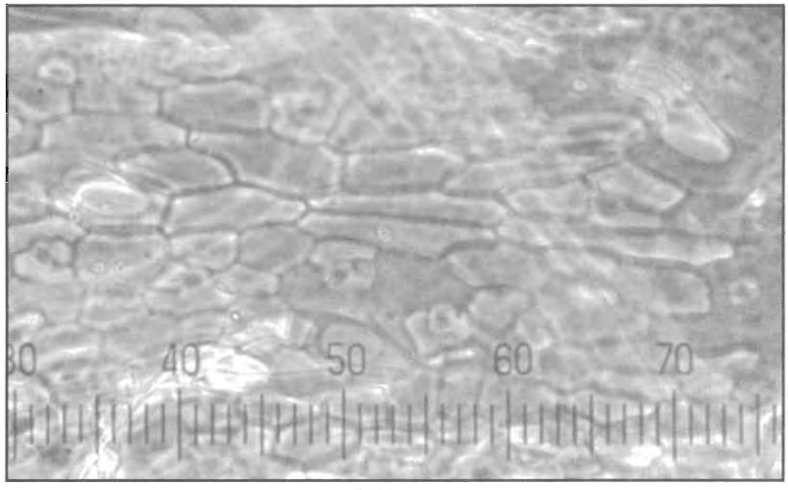


Figure 20. ***Isocoma wrightii***



(a)



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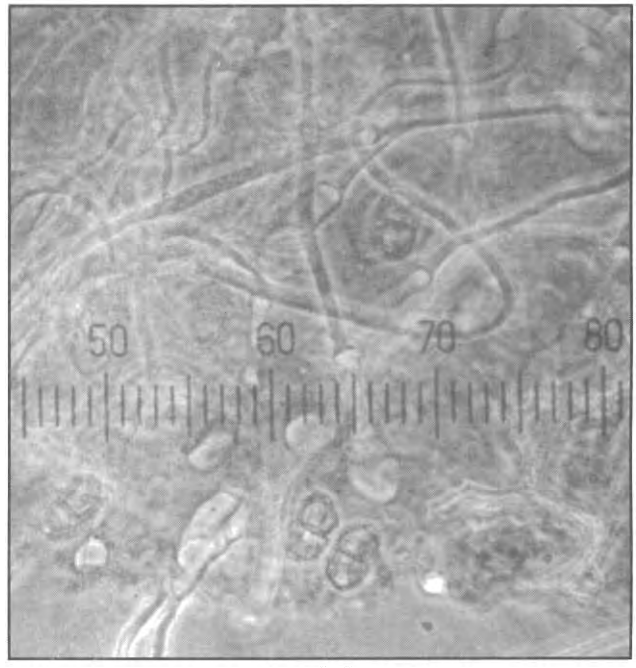

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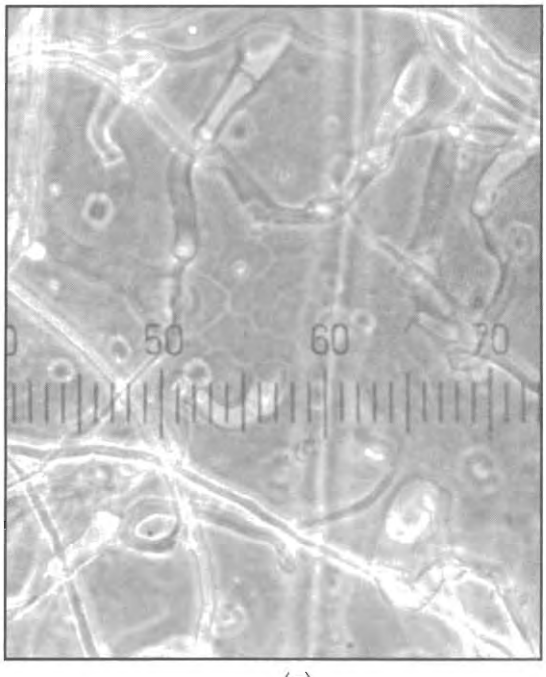

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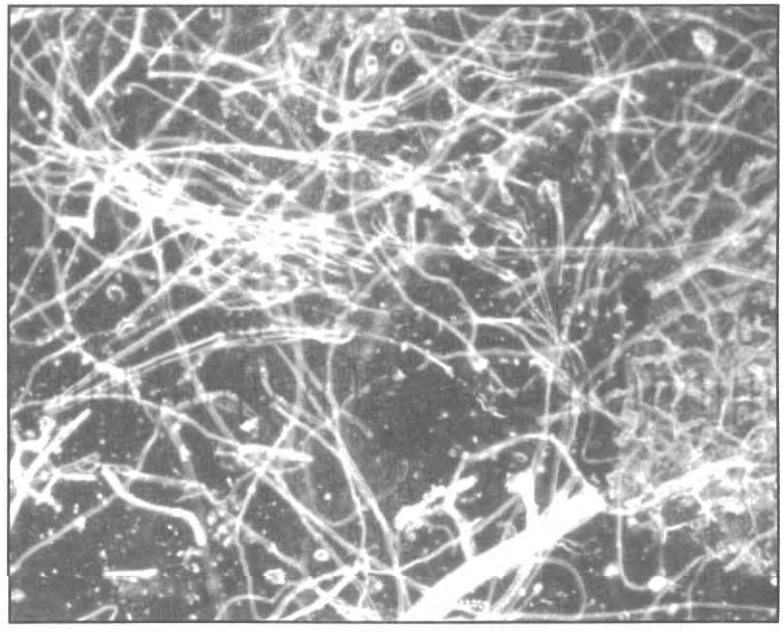
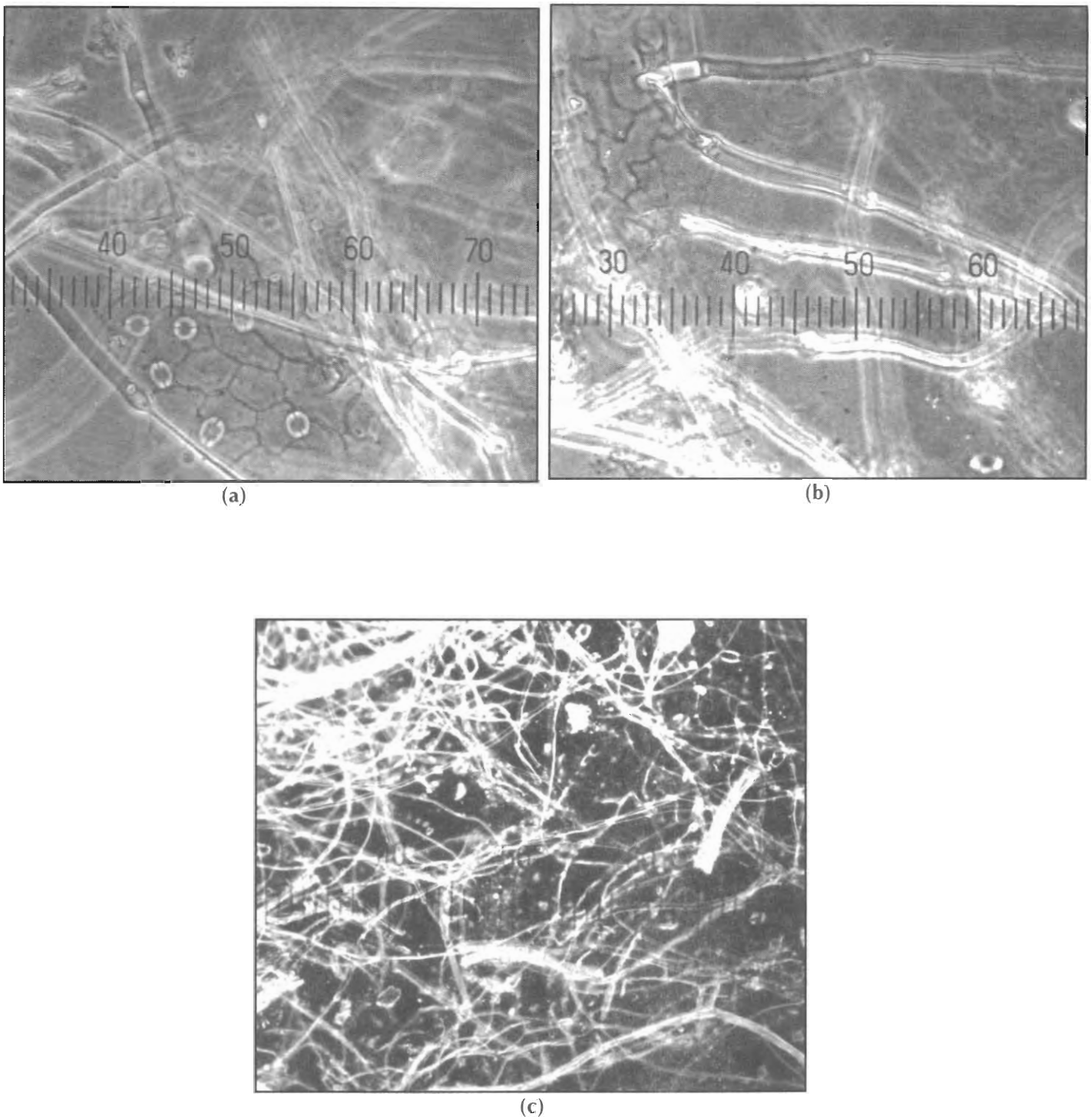


(d)

Figure 21. *Psilostrophe gnaphaloides*

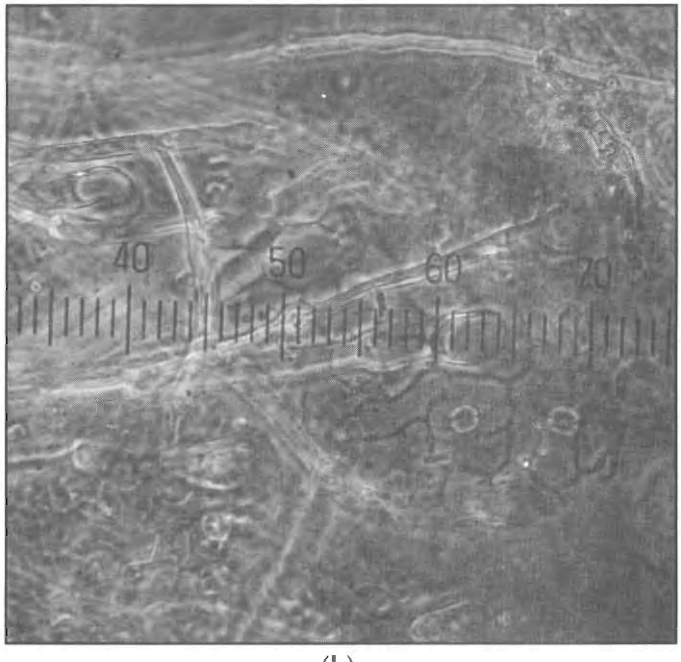


(a) (b)

(c)

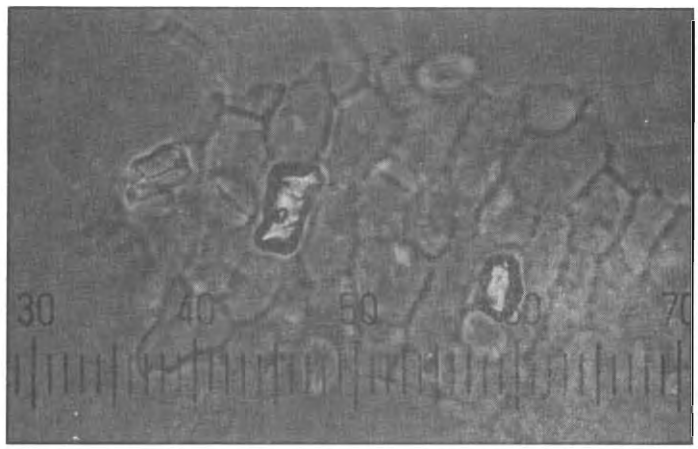
Figure 22. *Psilostrophe tagetina*

(a)

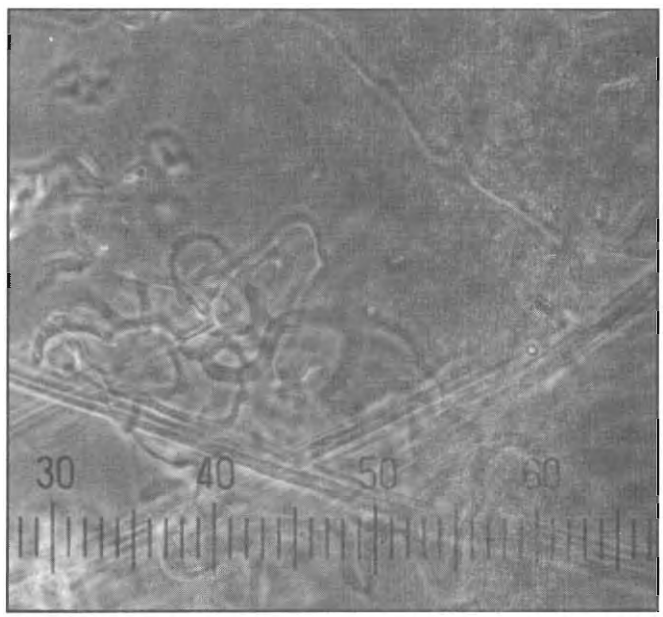


(b)

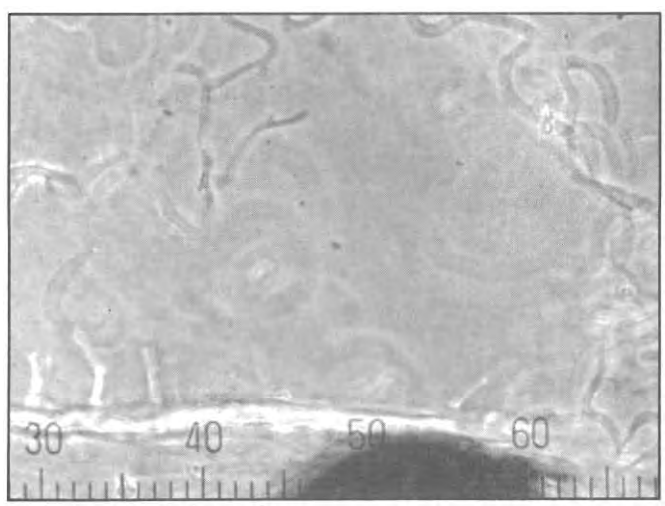
Figure 23. ***Psilostrophe villosa***



(a)

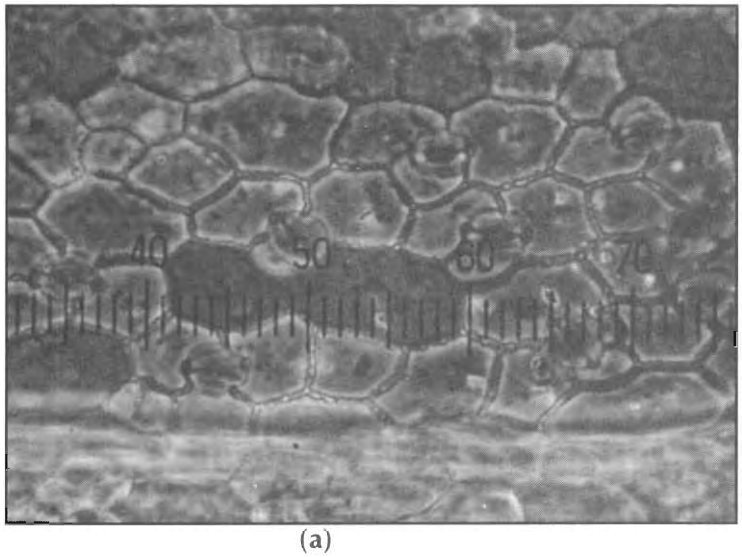


(b)

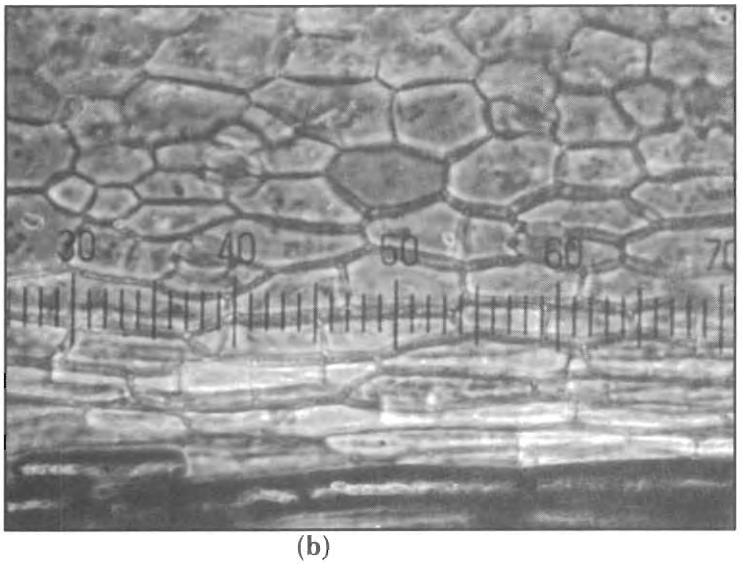


(c)

Figure 24. ***Senecio longilobus***



(a)



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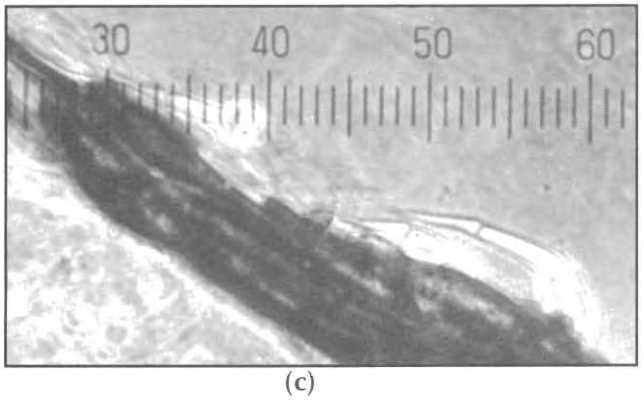

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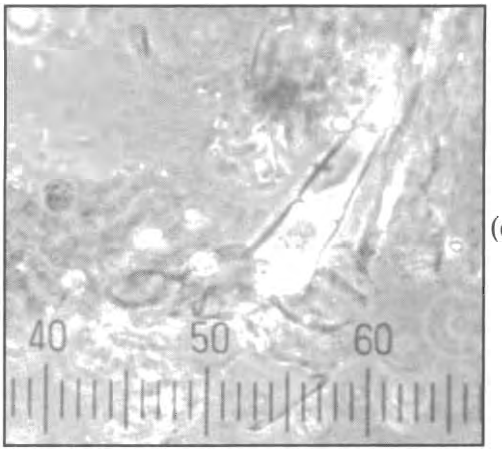
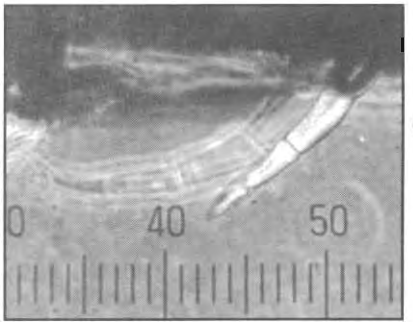
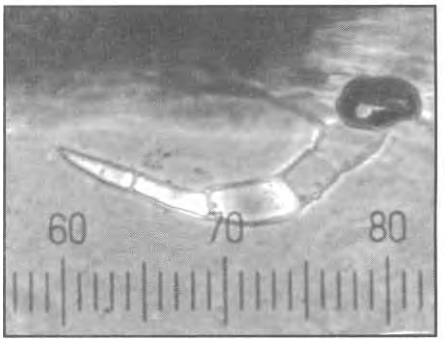


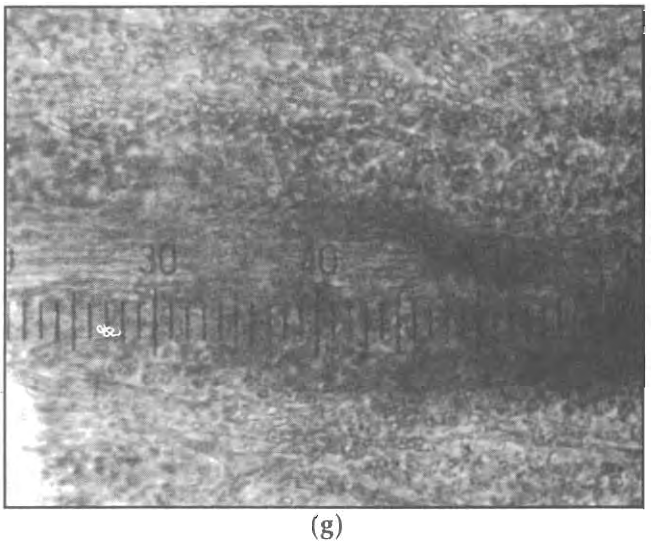
(d)



(e)



(f)



(g)

Figure 25. ***Senecio spartioides***

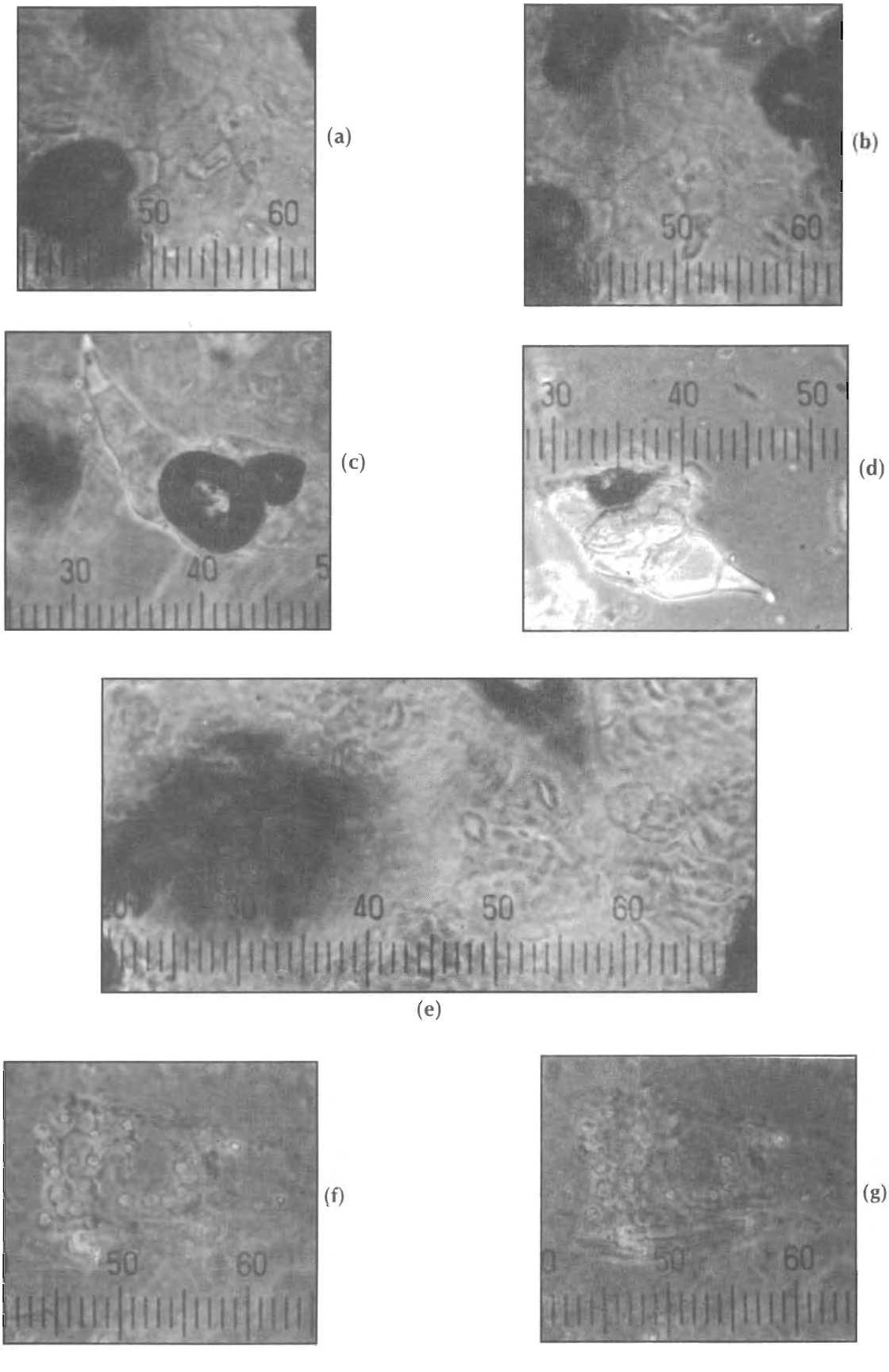
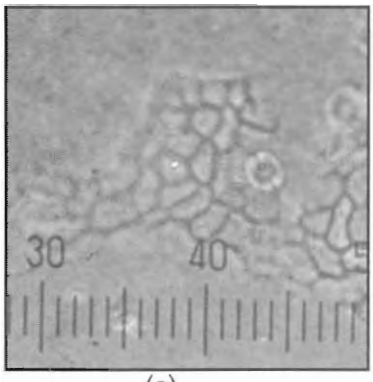
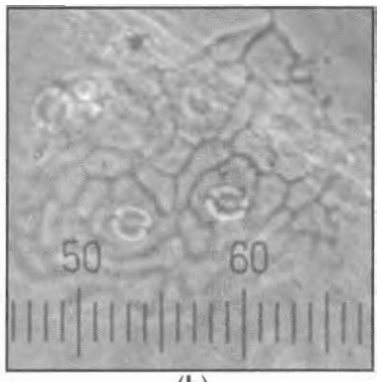


Figure 26. ***Xanthium*** **sp.**



(a)



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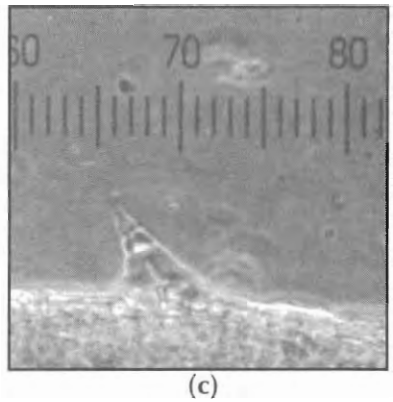

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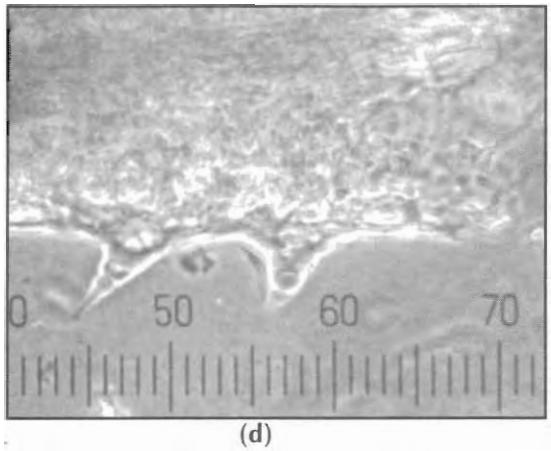

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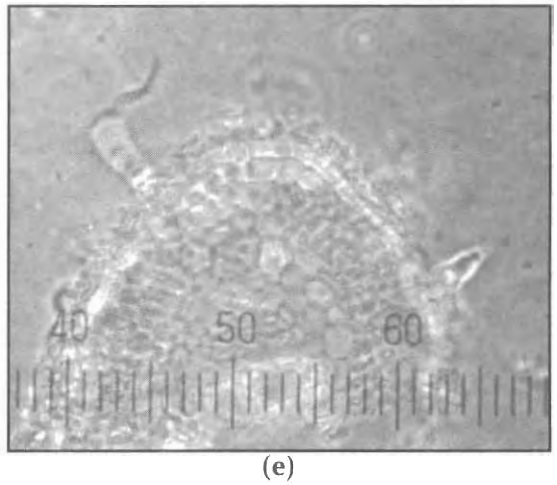

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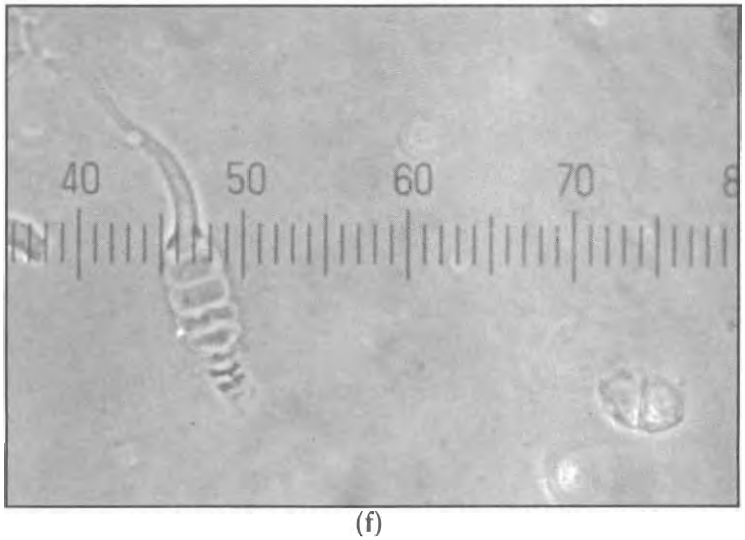
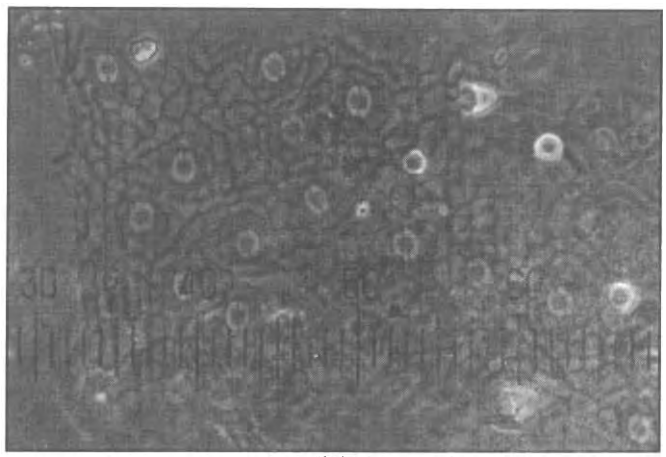
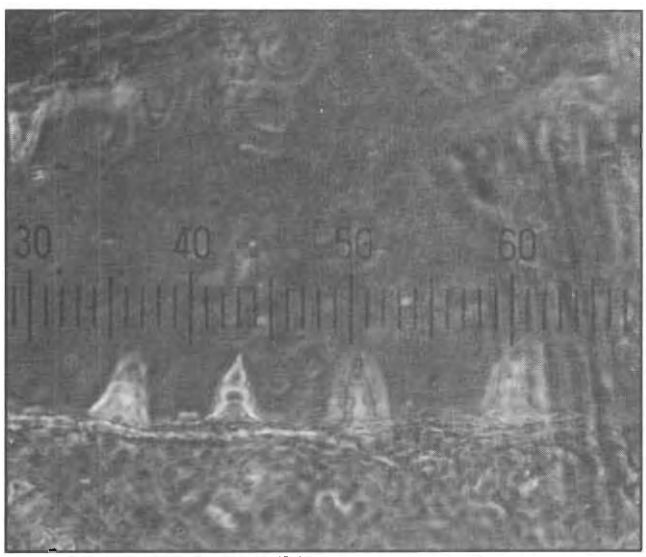


(f)

Figure 27. ***Xanthocephalum microcephalum***



(a)



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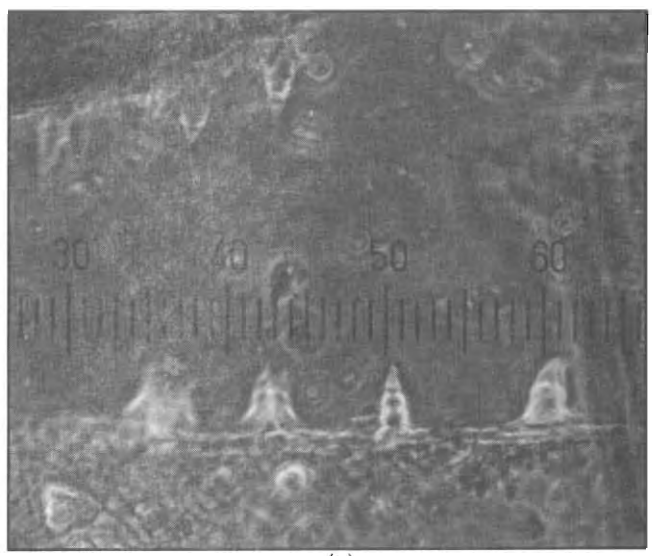

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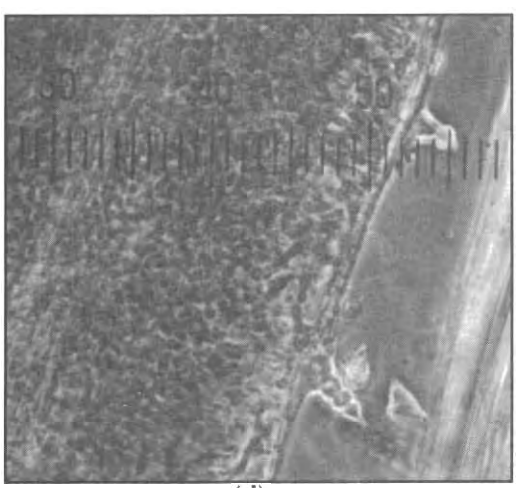
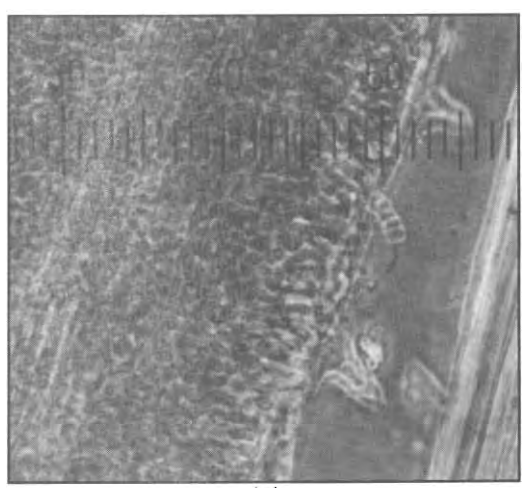


(d)



(e)

Figure 28. ***Xanthocephalum sarothrae***

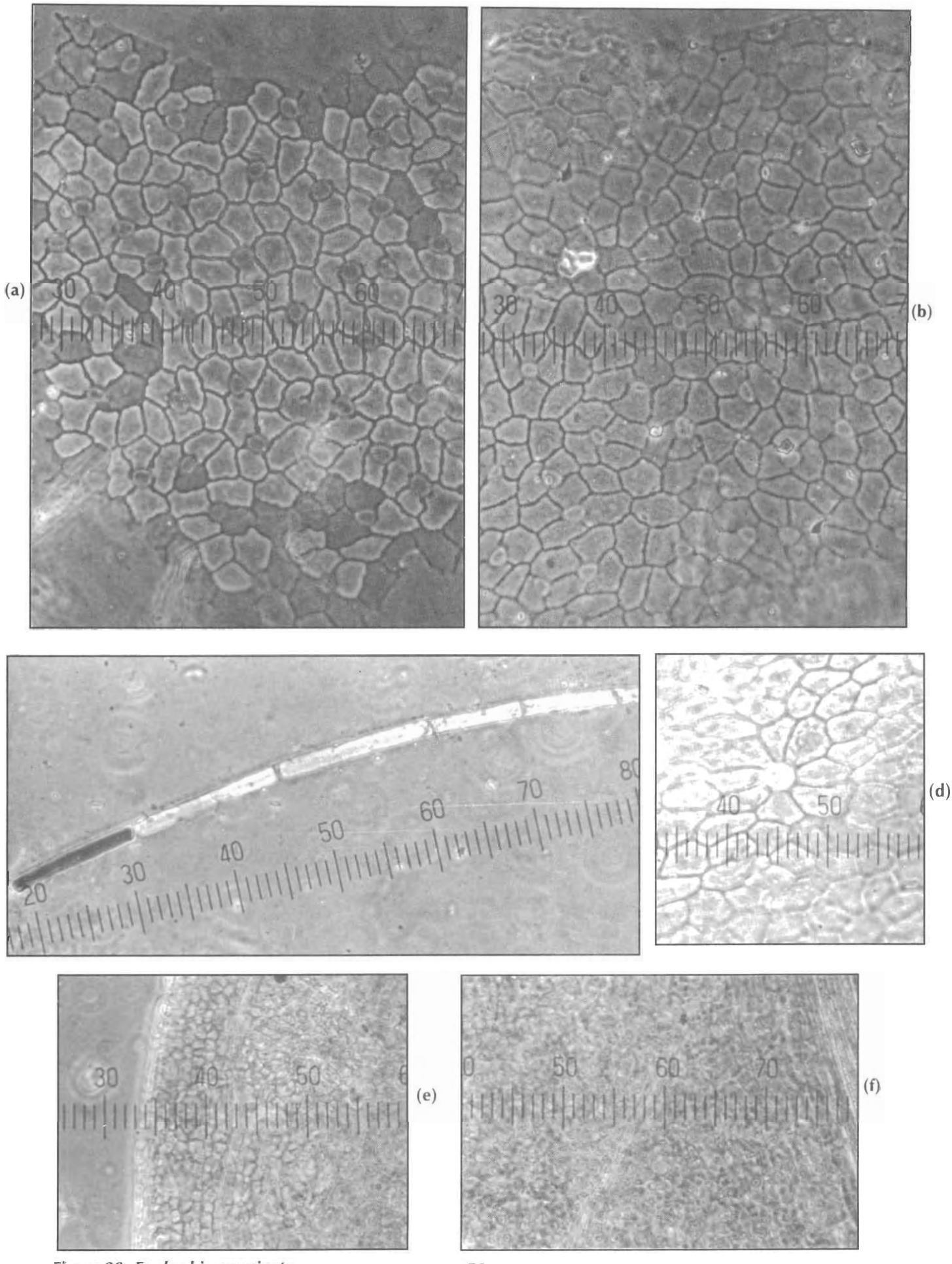
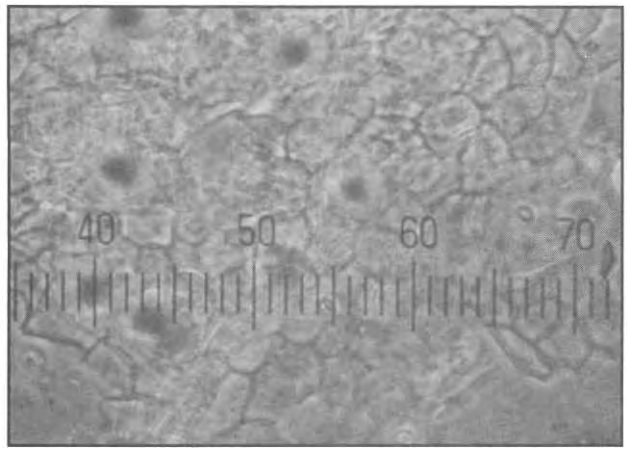
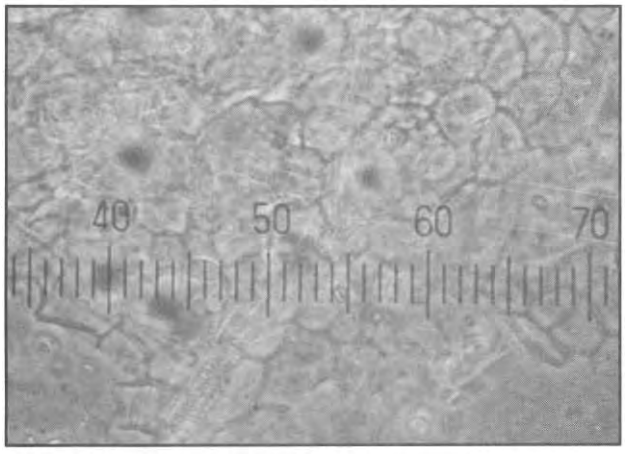


Figure 29. ***Euphorbia marginata***



(a)



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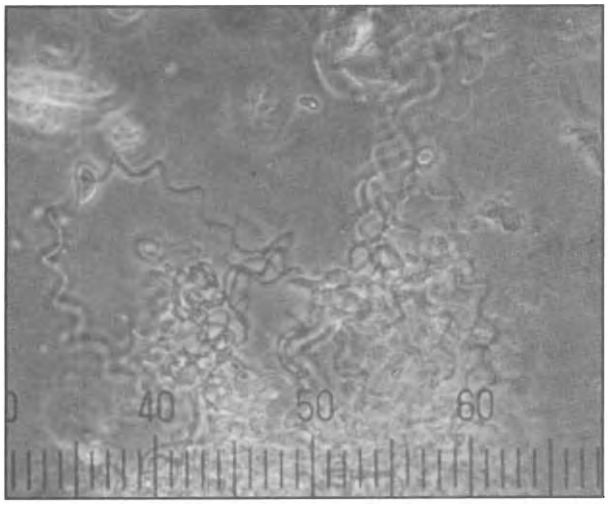

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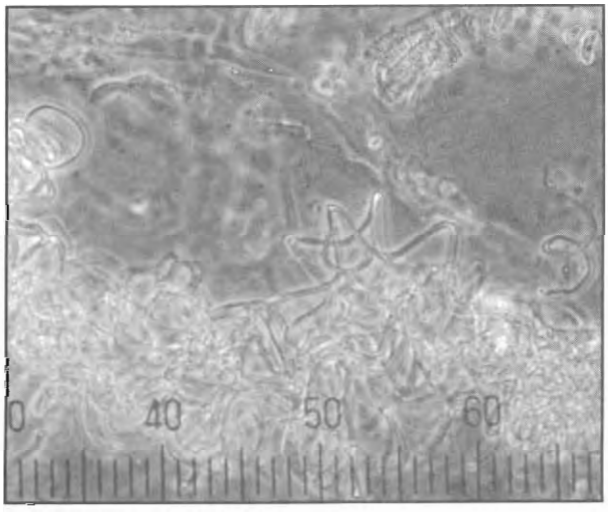

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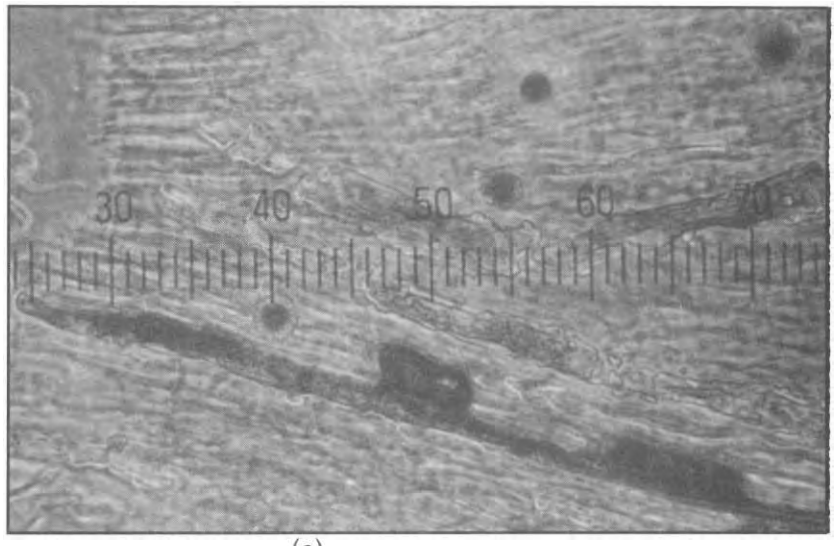

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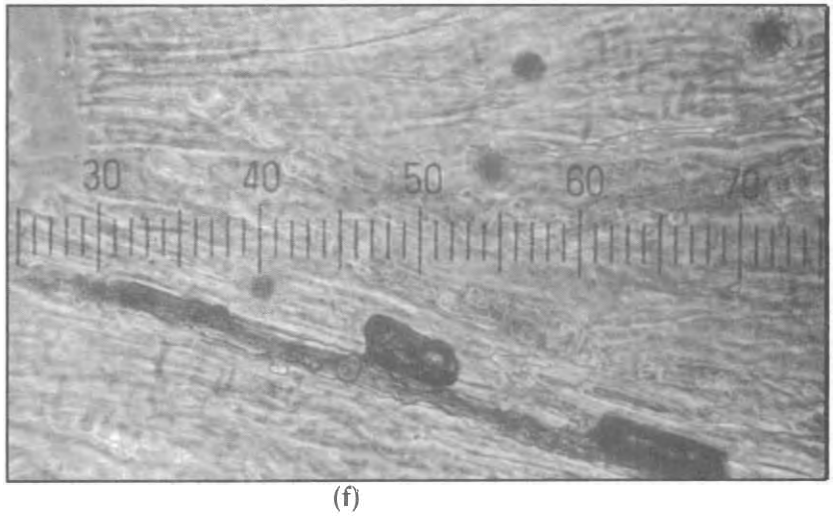

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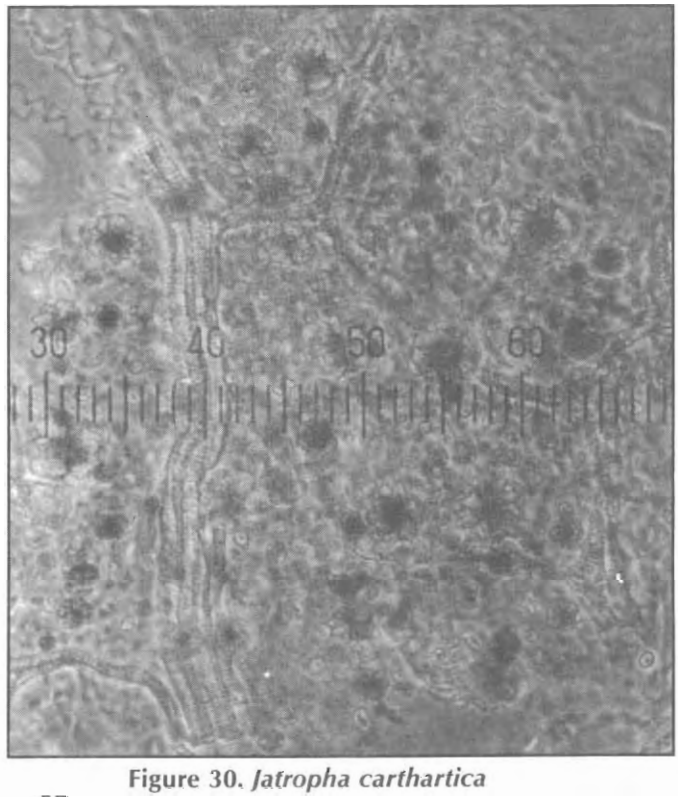
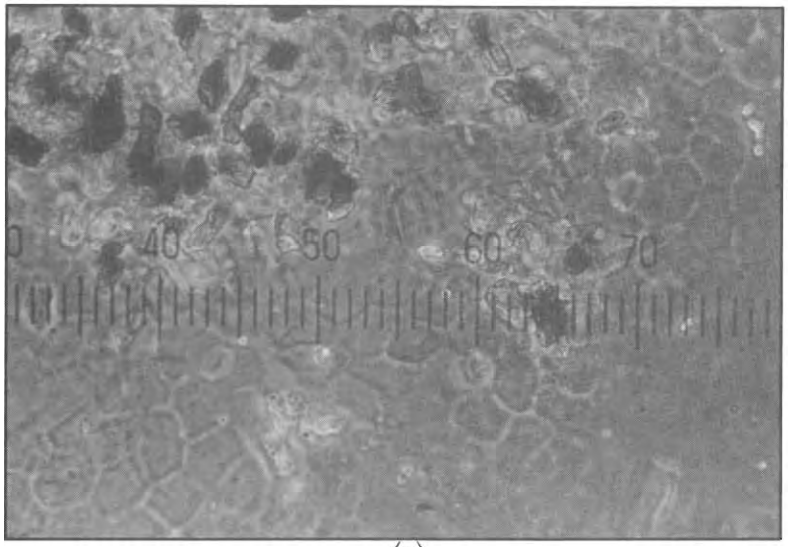
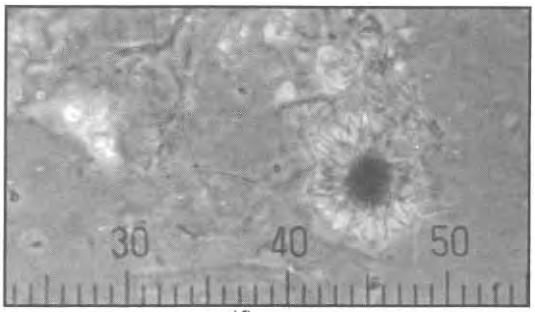


(g)

Figure 30. ***Jatropha carthartica***



(a)



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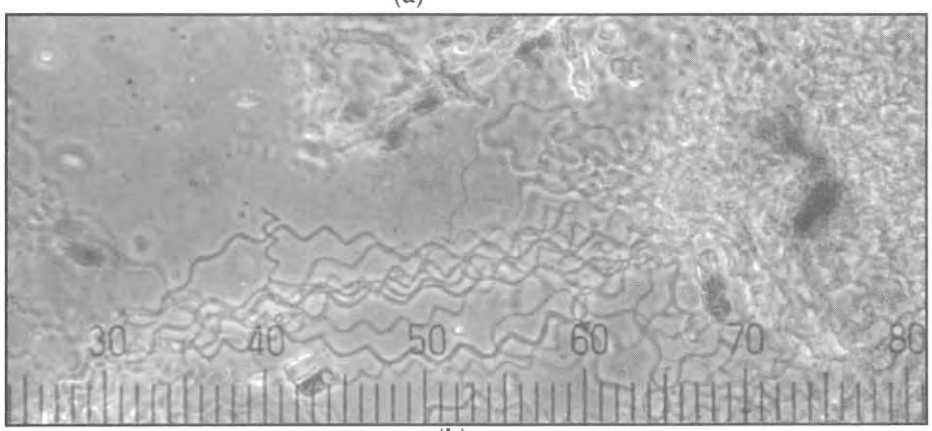

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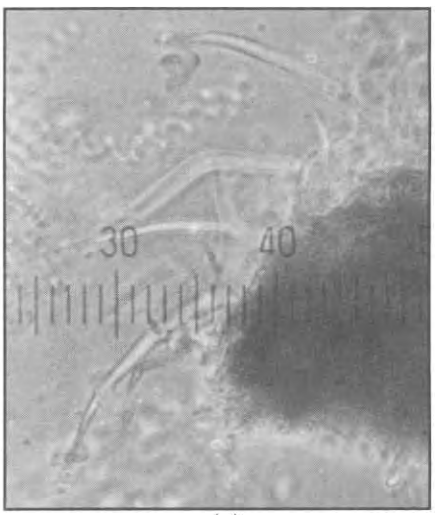

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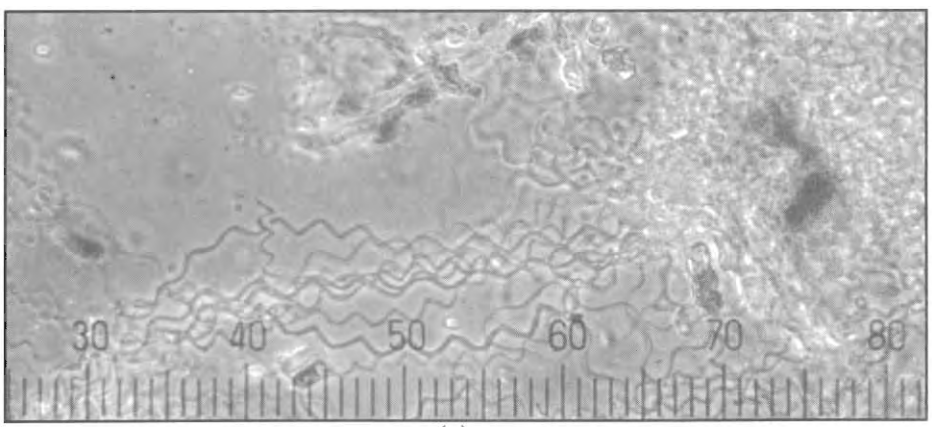

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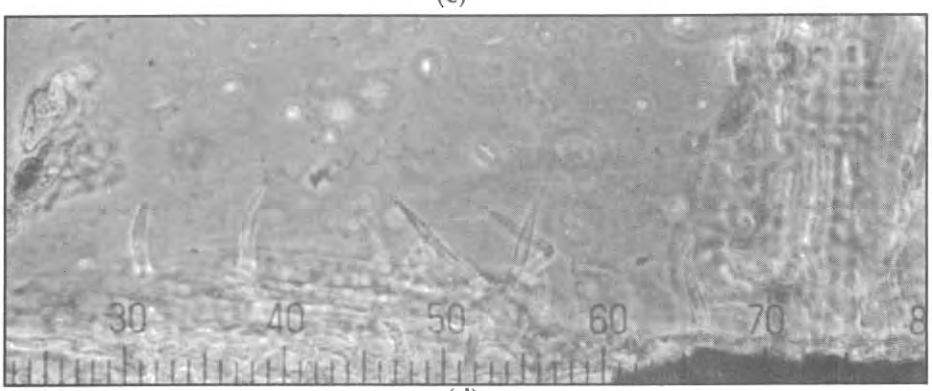
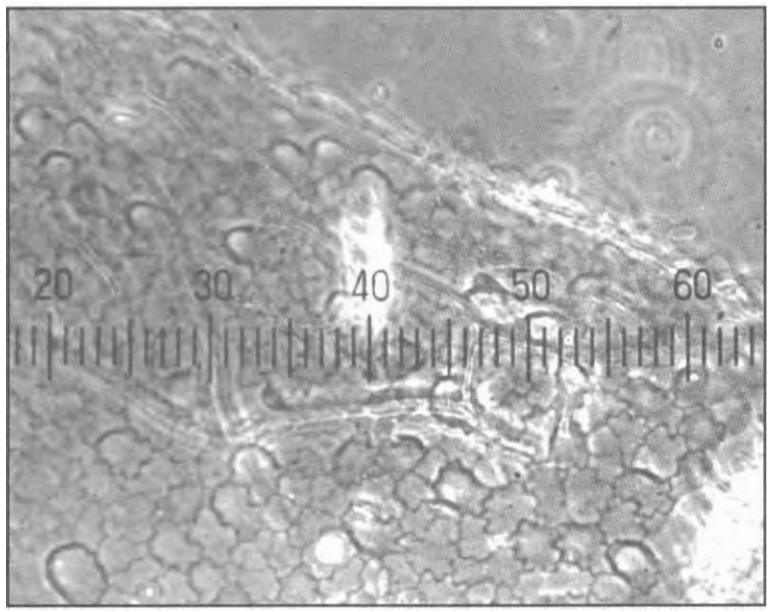
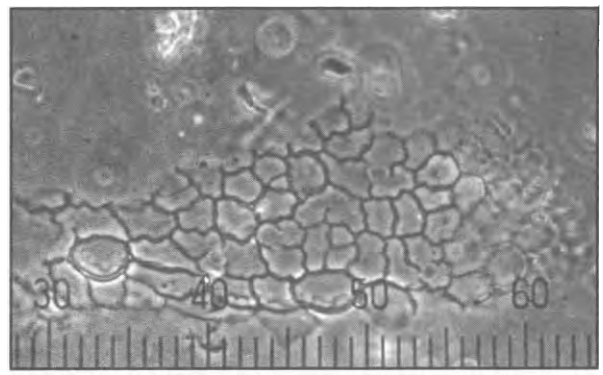


(d)

Figure 31. *Jatropha dioica*



(a)



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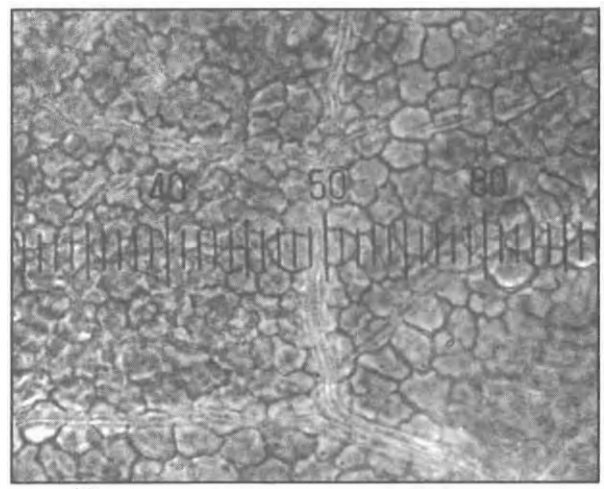

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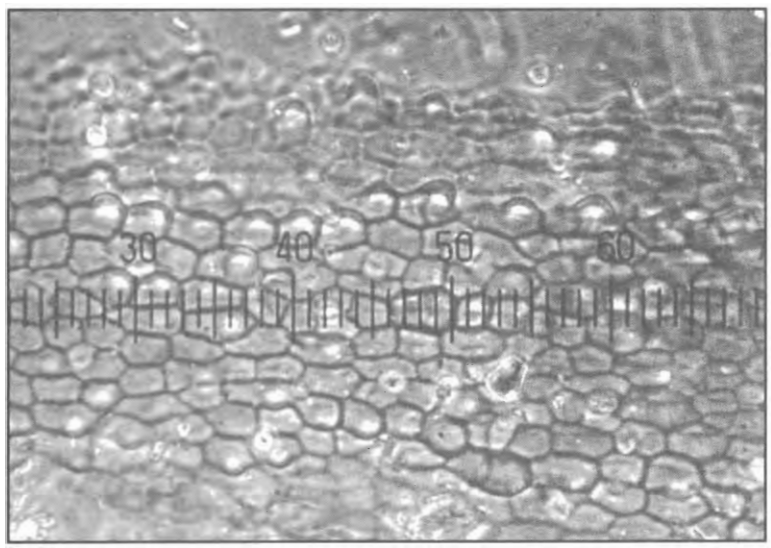

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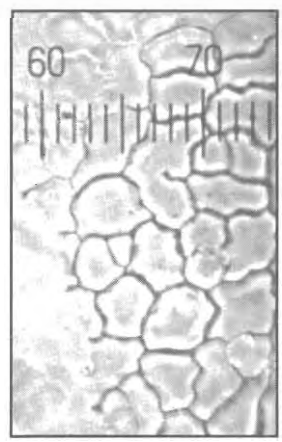
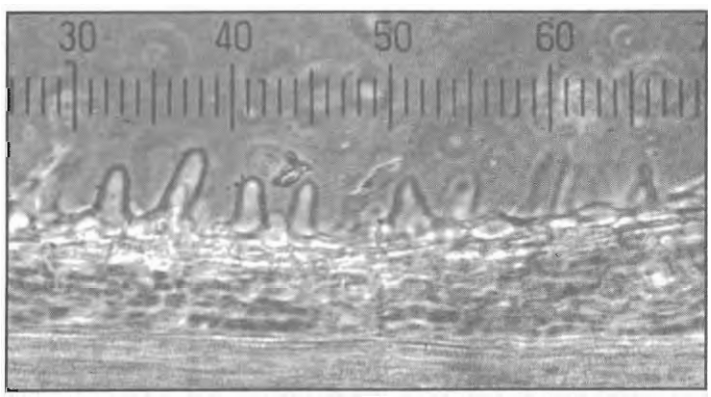


(e)



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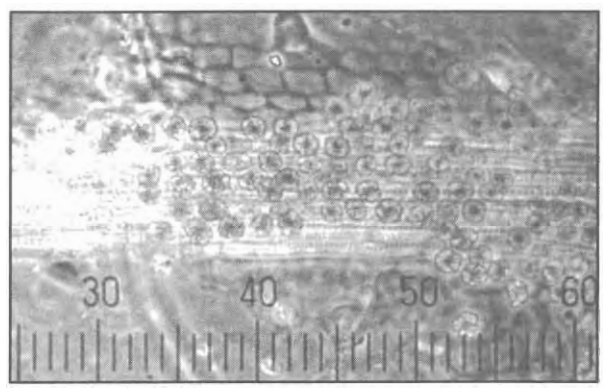
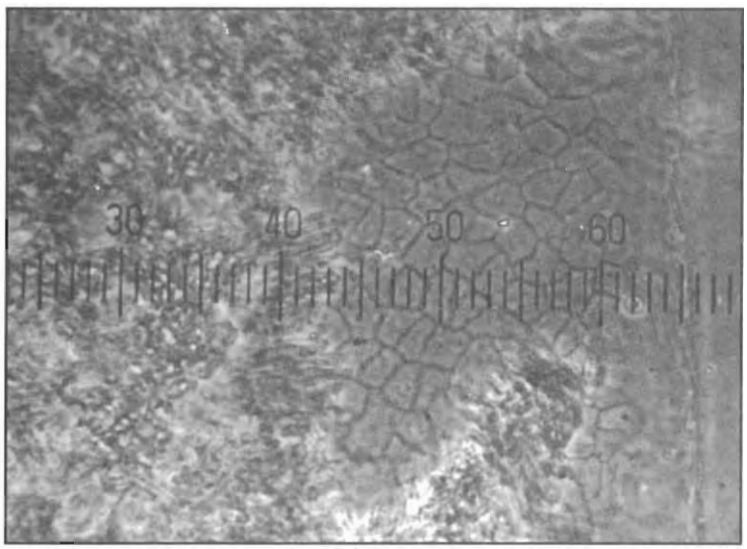
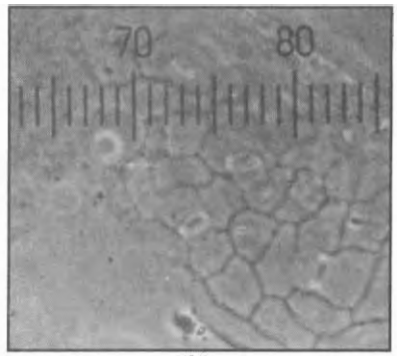


(g)

Figure 32. ***Phyllanthus abnormalis***



(a)



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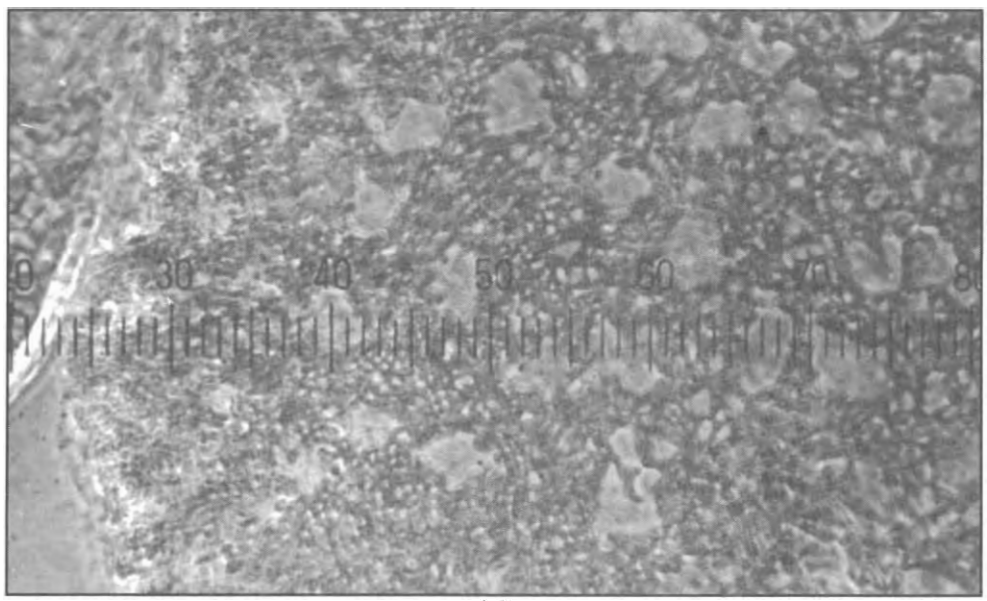

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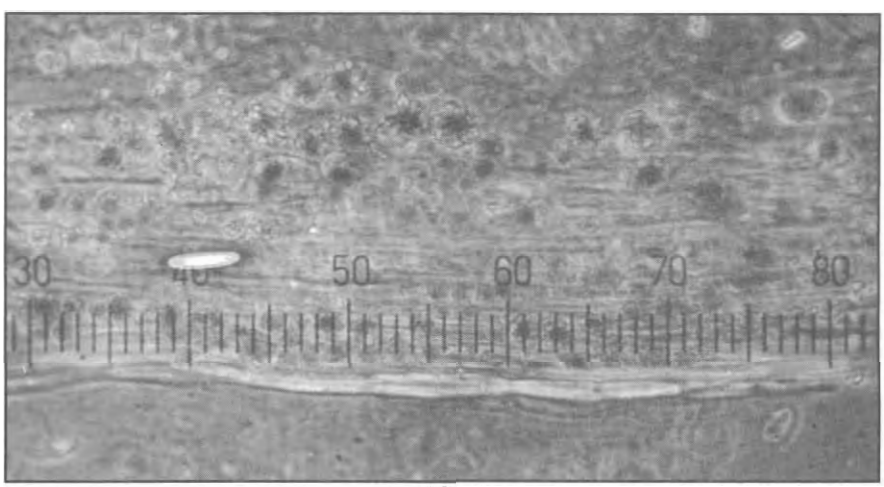
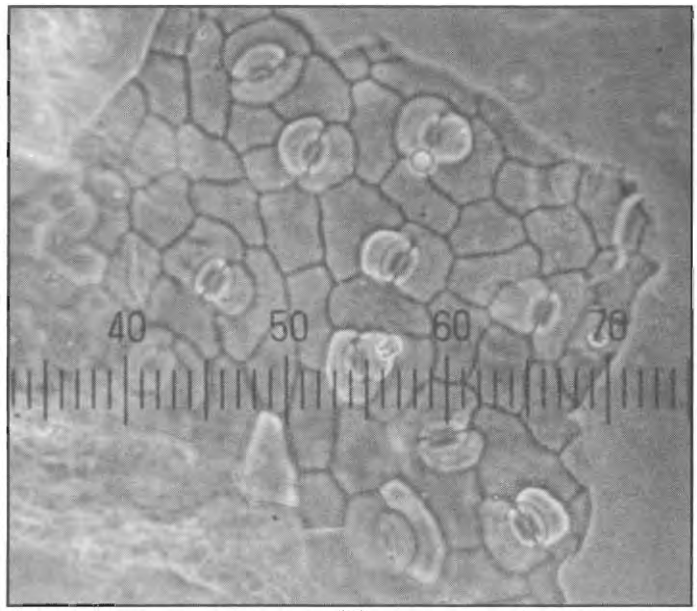


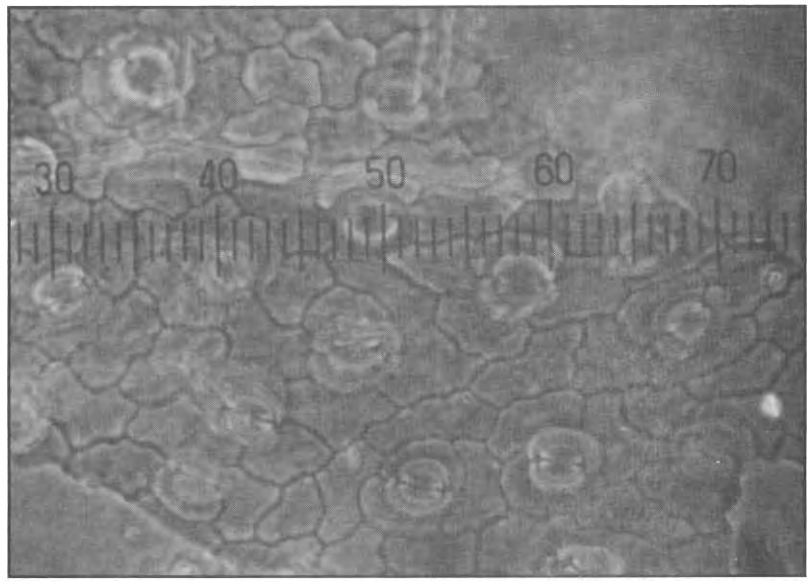
(d)

Figure 33. *Ricinus communis*

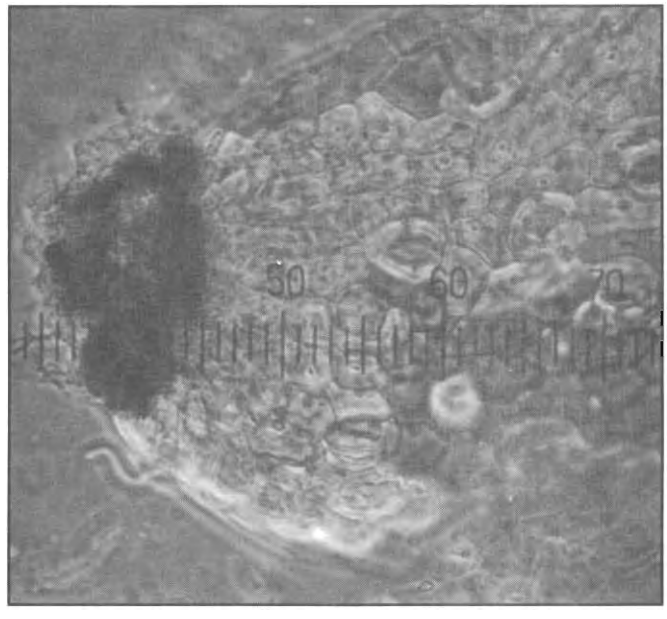


(a)

Figure 34. ***Stillingia sylvatica***



(a)



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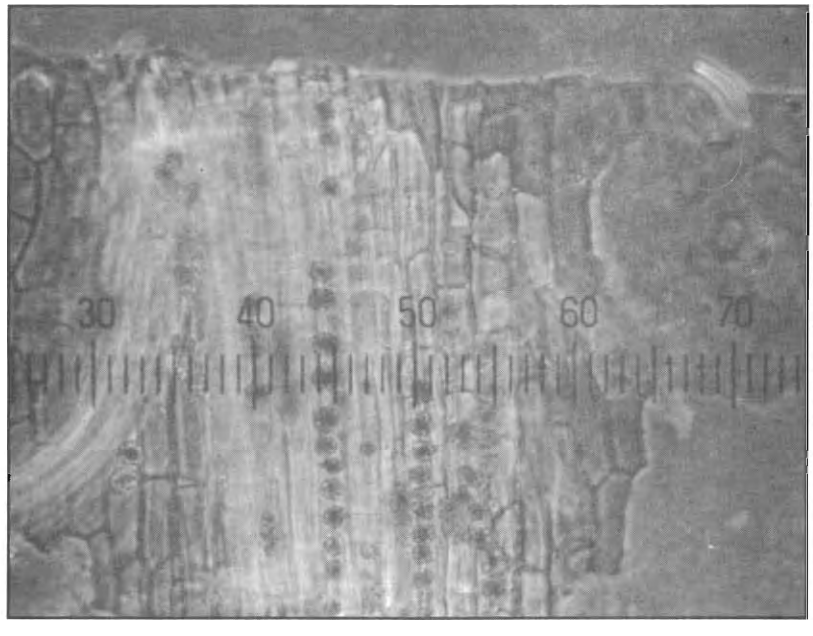


(c)

Figure 35. *Stillingia texana*

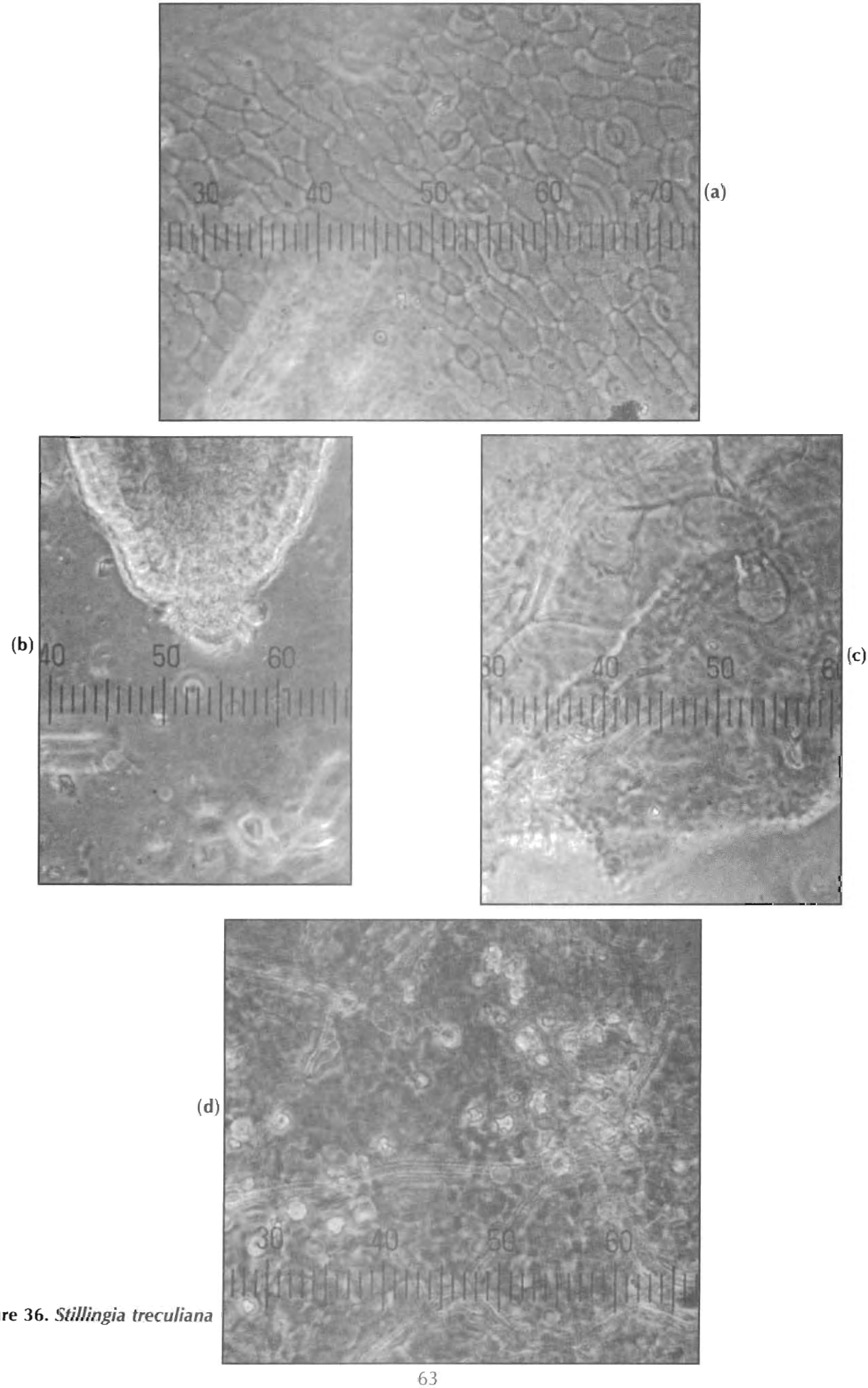
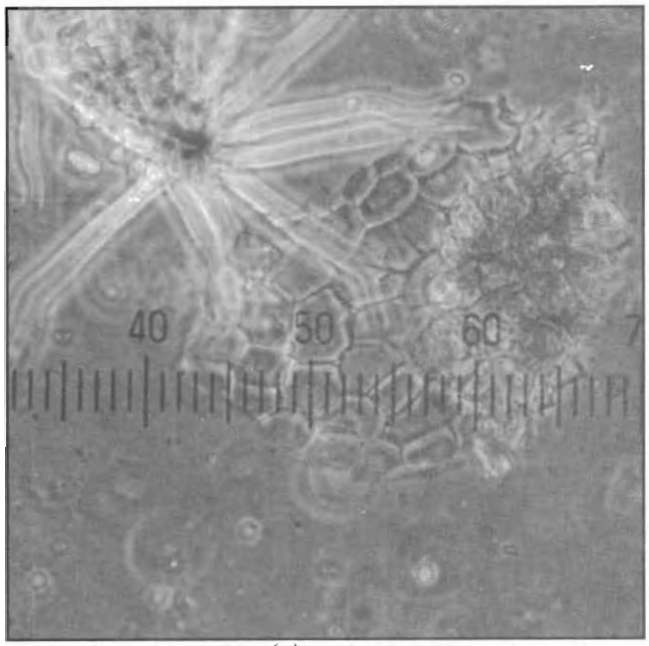
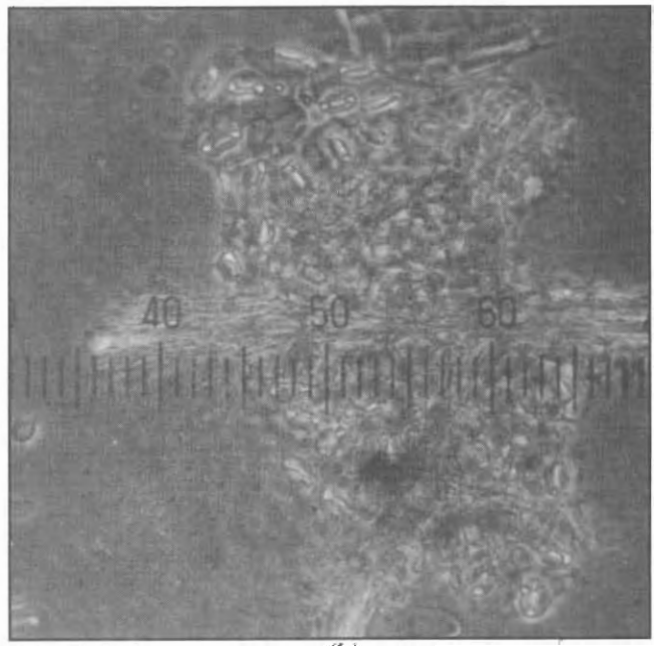


Figure 36. *Stillingia treculiana*



(a)



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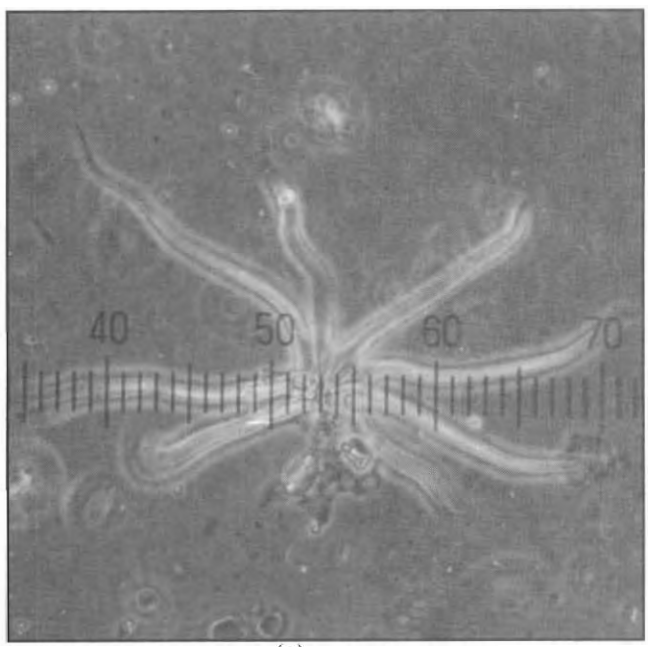

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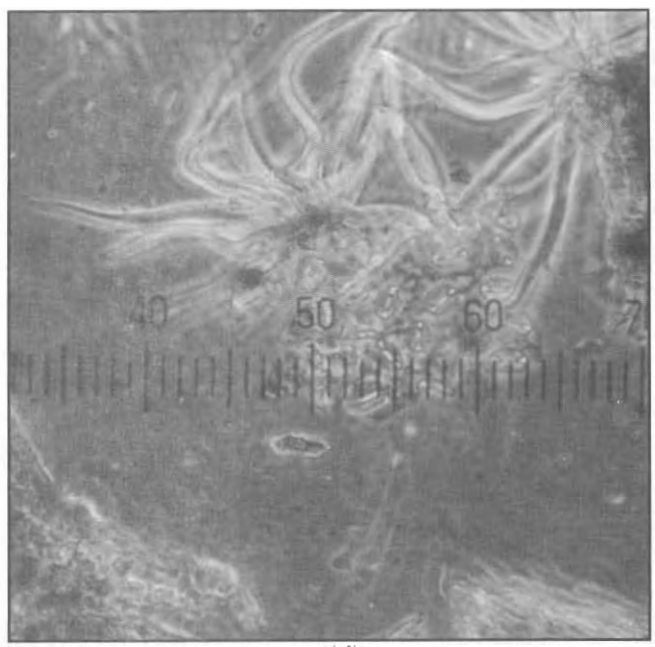
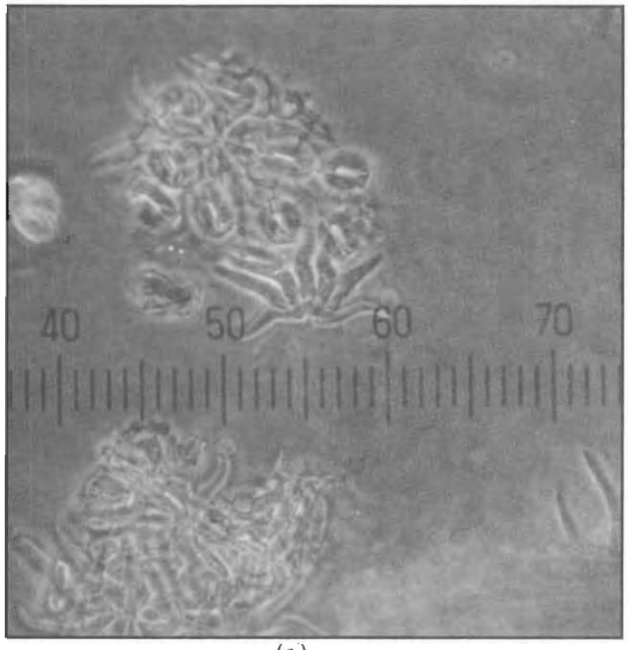
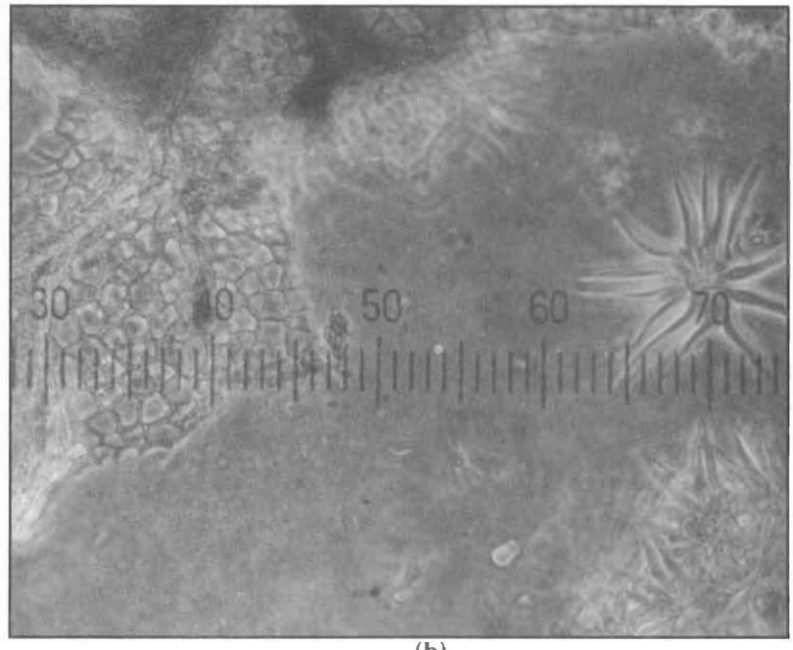


(d)

Figure 37. *Quercus havardii*



(a)



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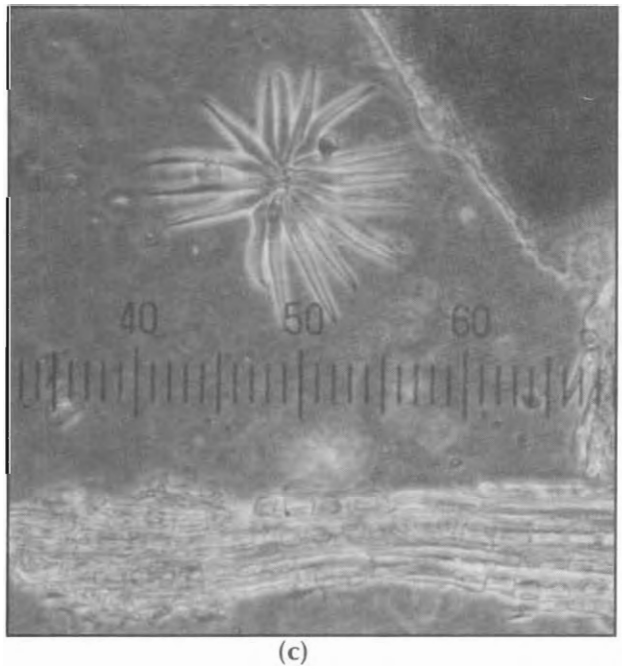

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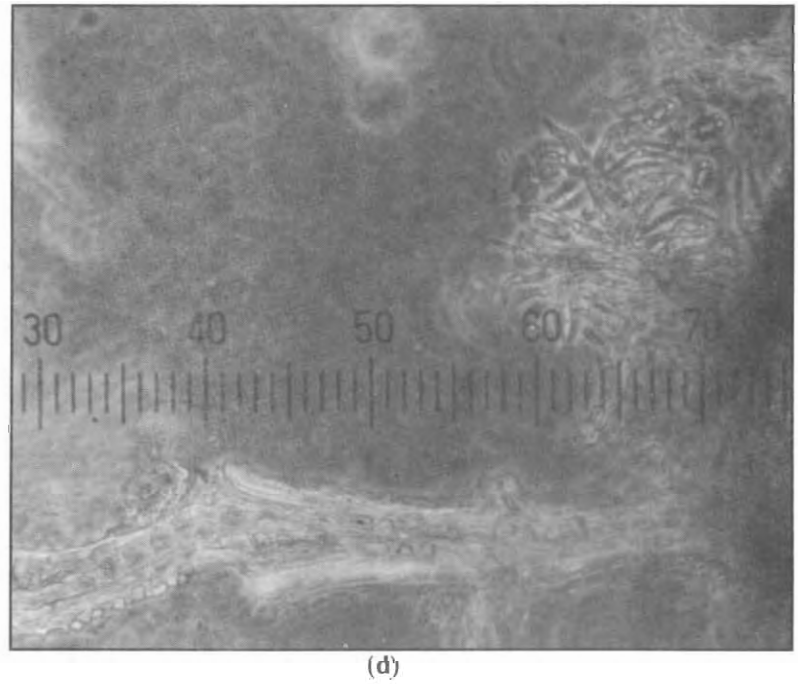
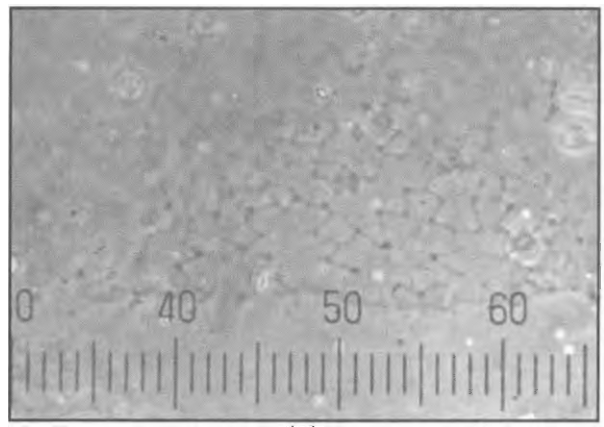
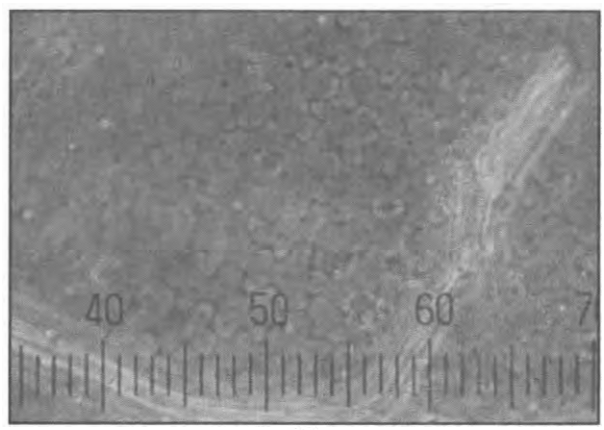


(d)

Figure 38. *Quercus virginiana*



(a)



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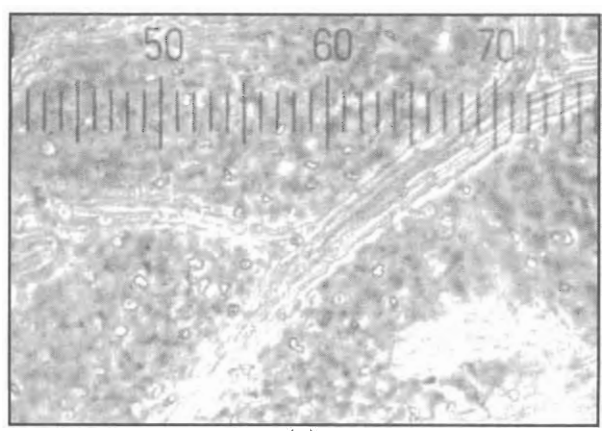
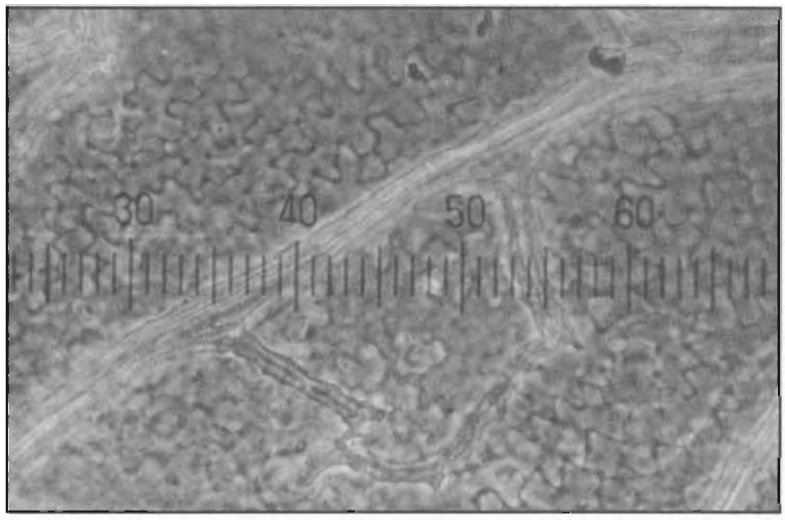
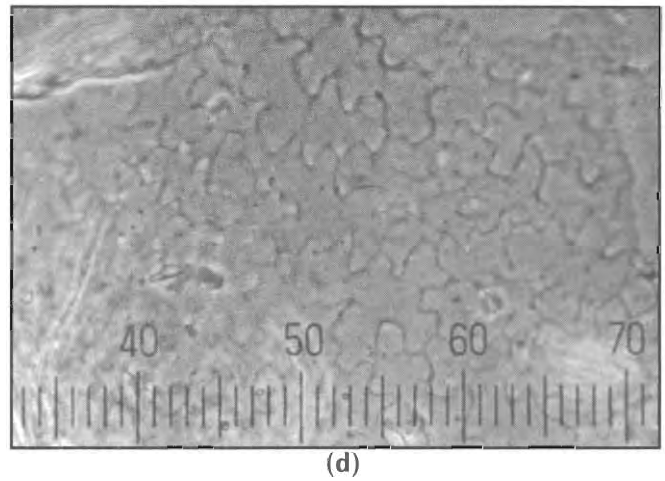


(c)

Figure 39. *Centaurium beyrichii*



(a)



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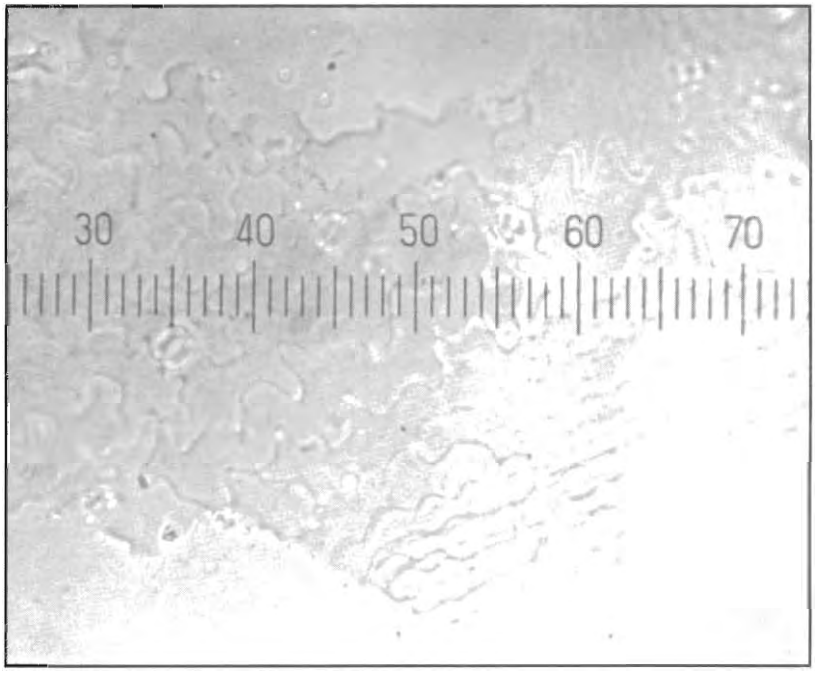

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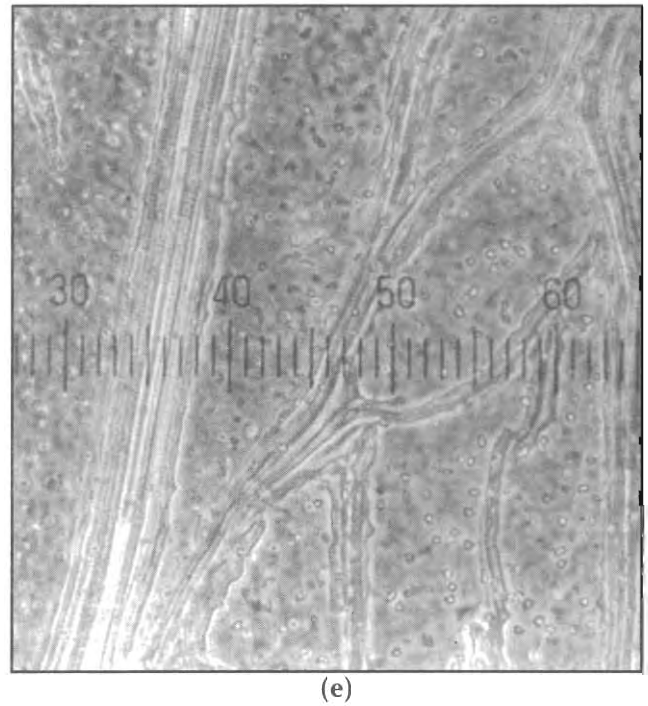
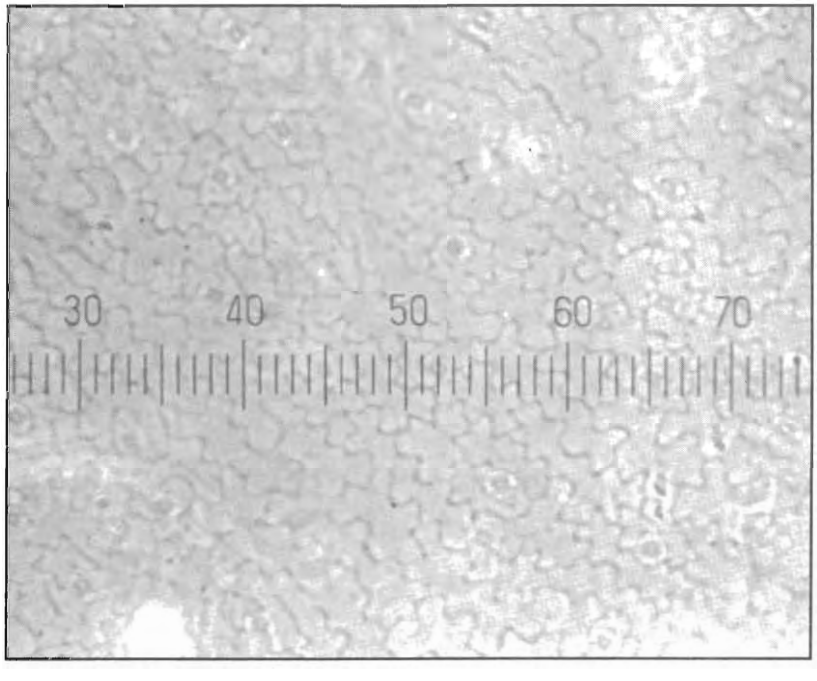
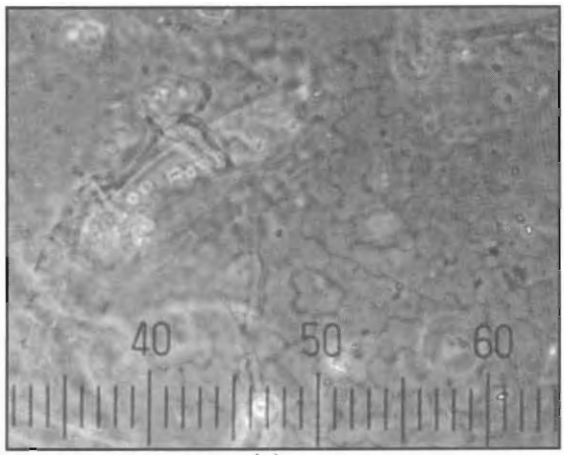


(e)

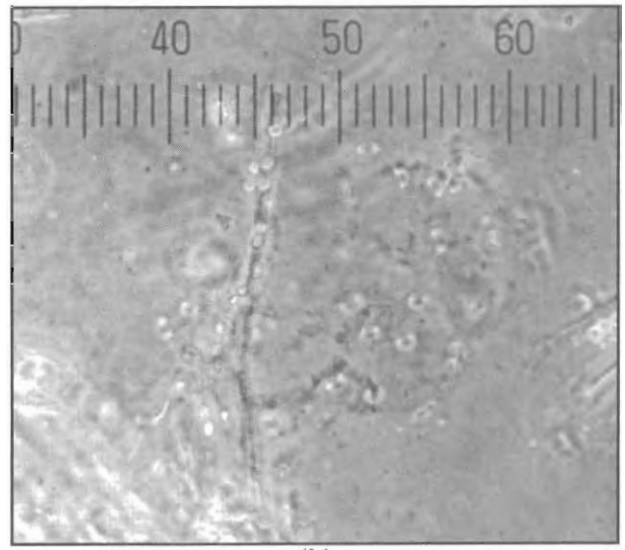


(c)

Figure 40. ***Centaurium calycosum***



(a)



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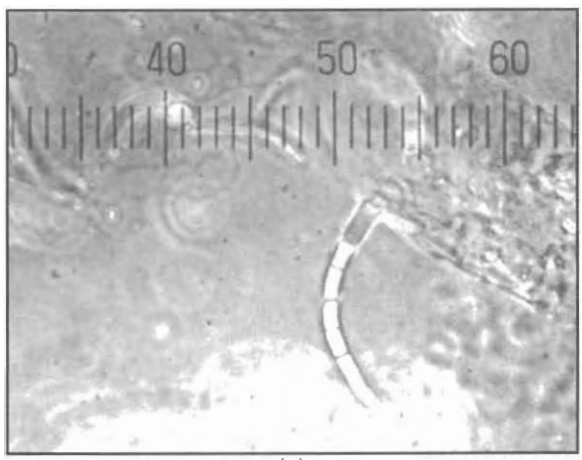

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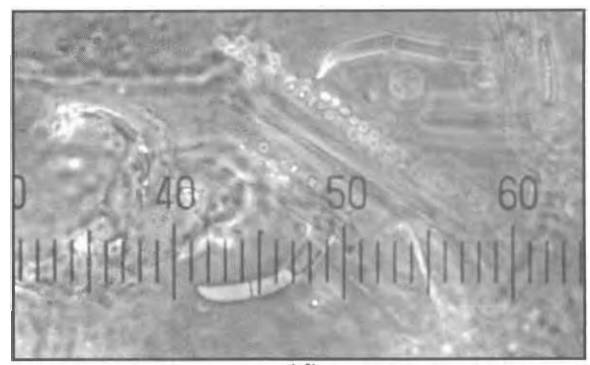
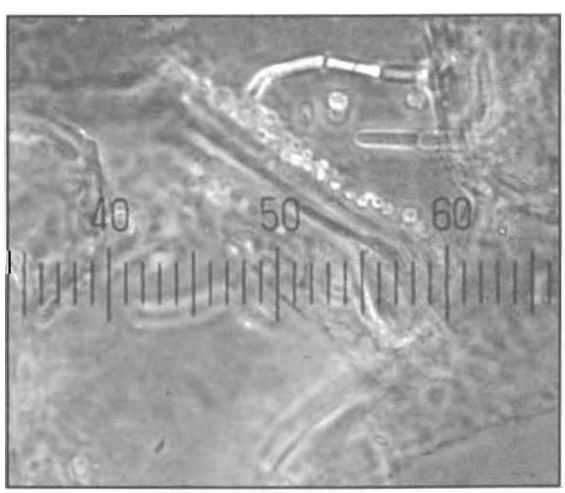


(d)



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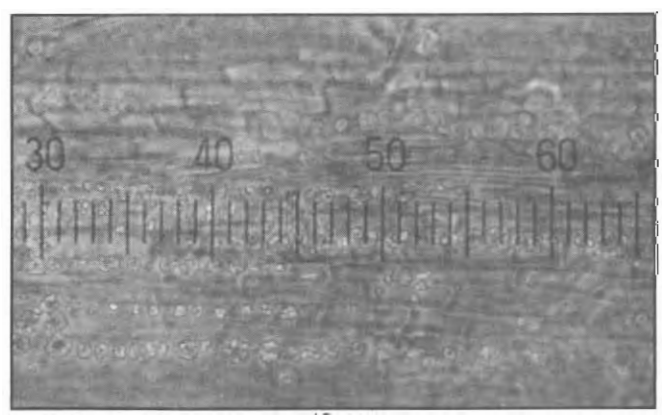
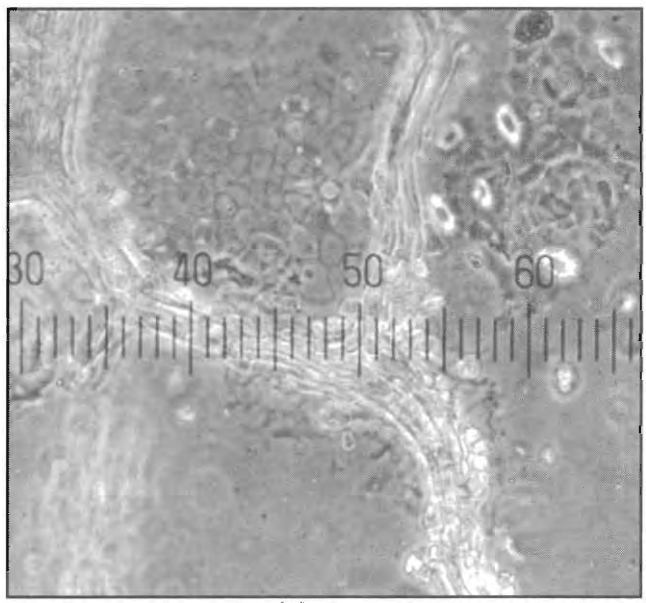
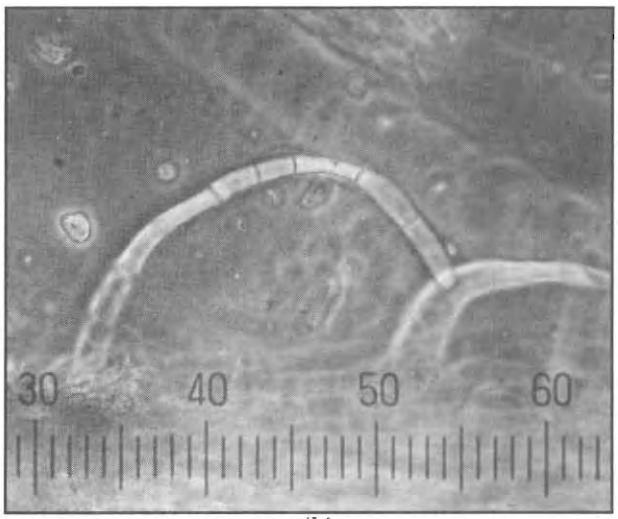


(f)

Figure 41. *Aesculus arguta*



(a)



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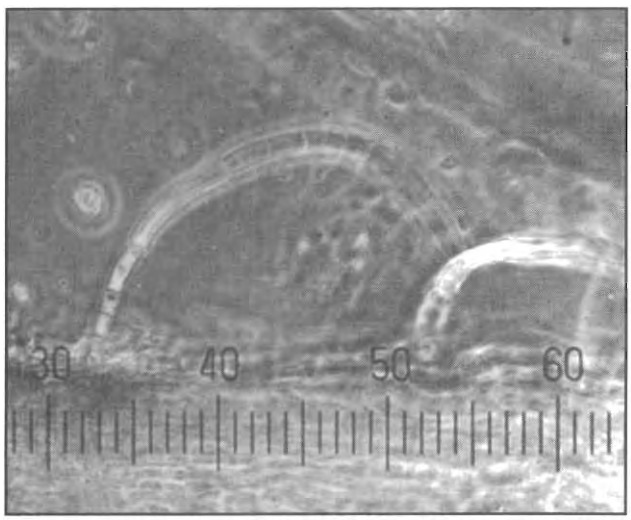

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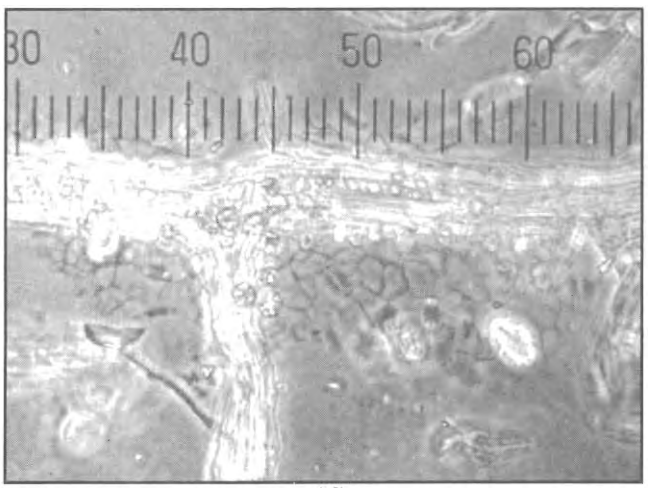
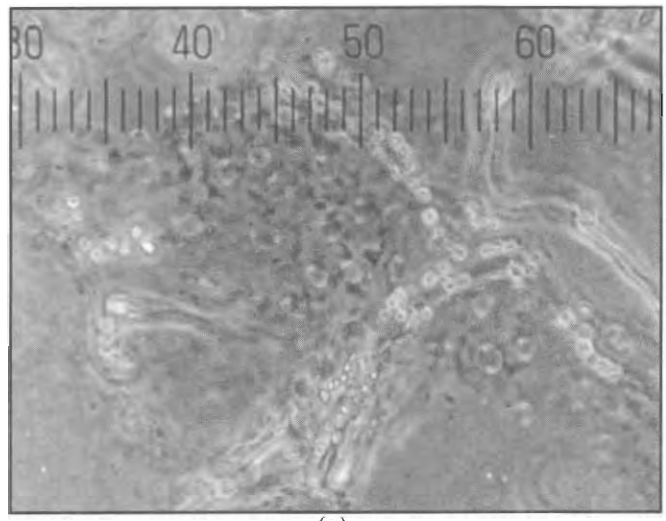
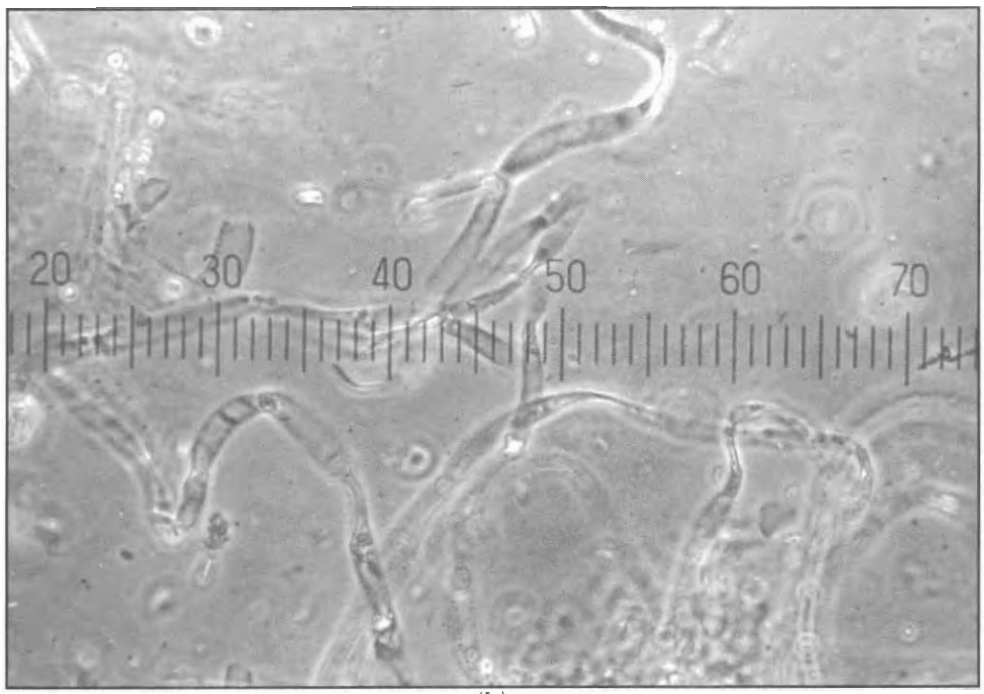


(d)

Figure 42. ***Aescula pavia*** **var.** ***flavescens***



(a)



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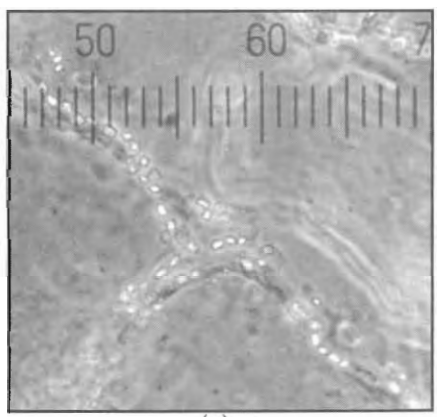

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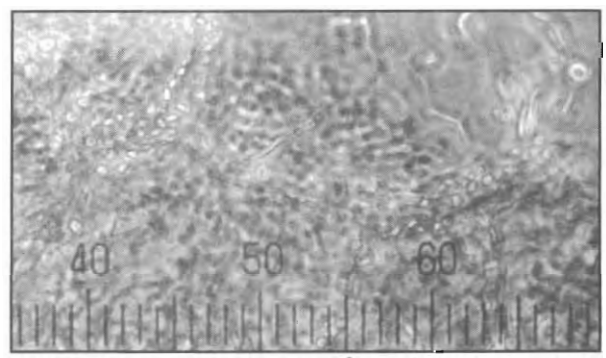
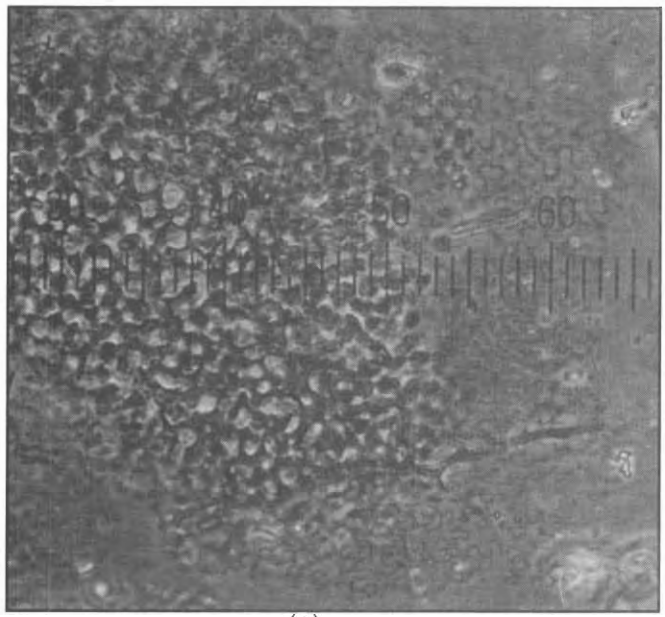
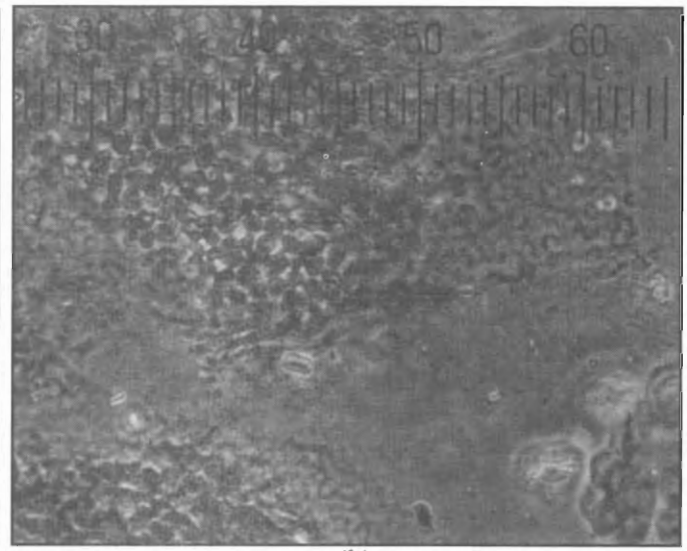


(d)

Figure 43. *Aesculus pavia* var. *pavia*



(a)



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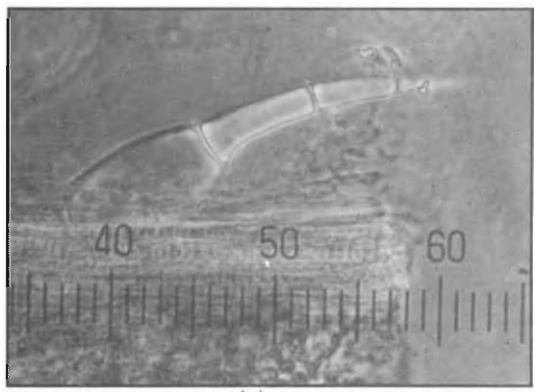

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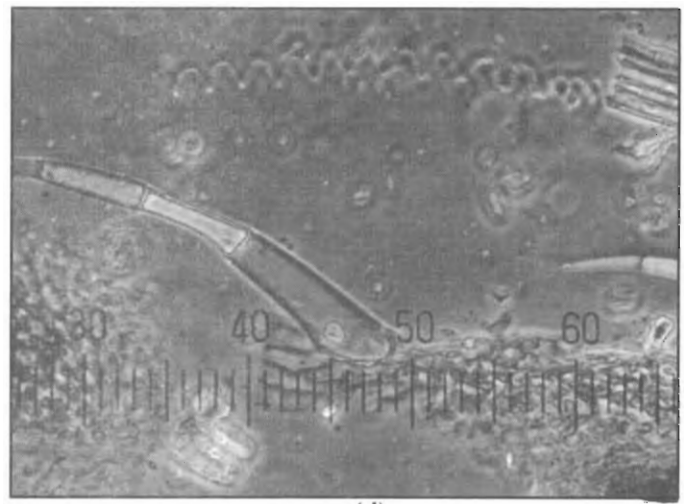

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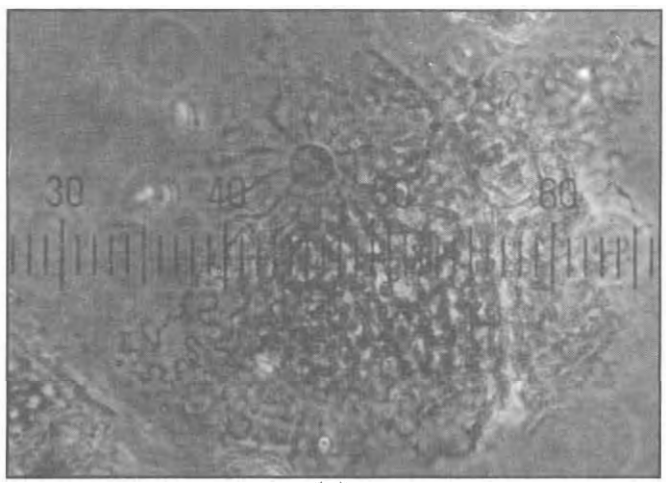


(e)

Figure 44. ***Perilla frutescens***

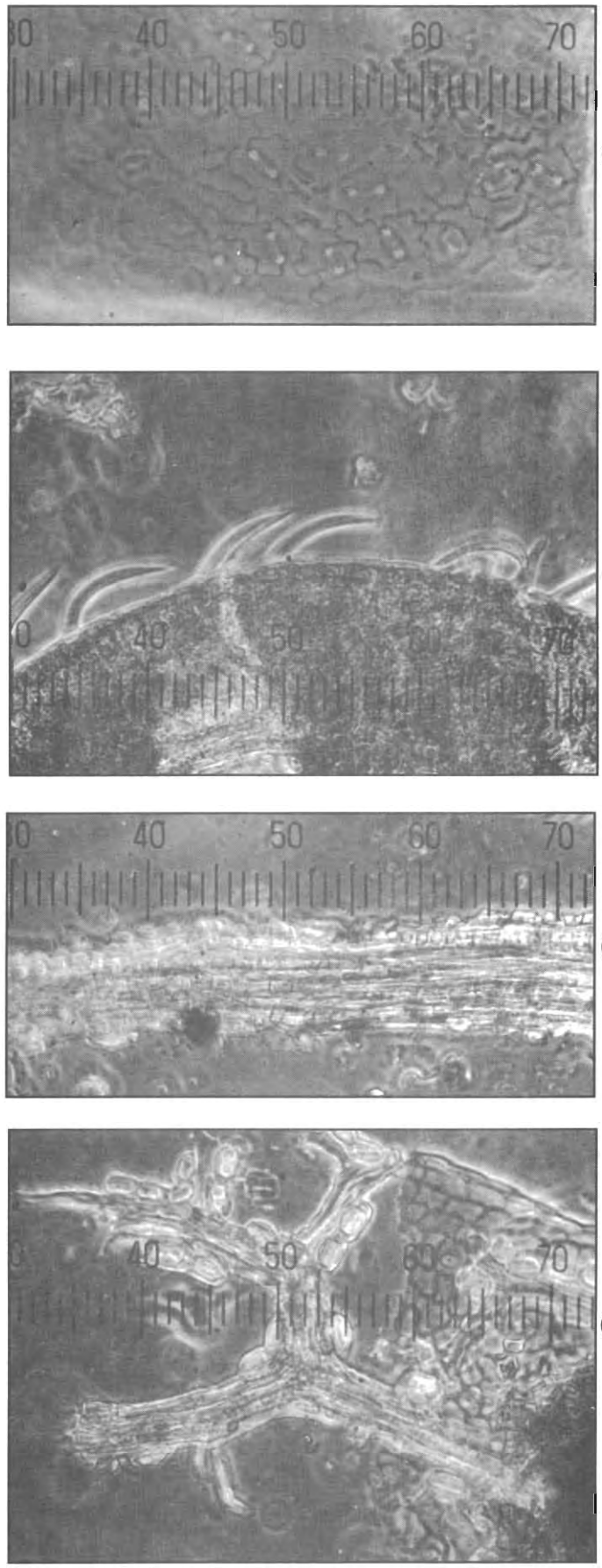


Figure 45. ***Acacia berlandieri***

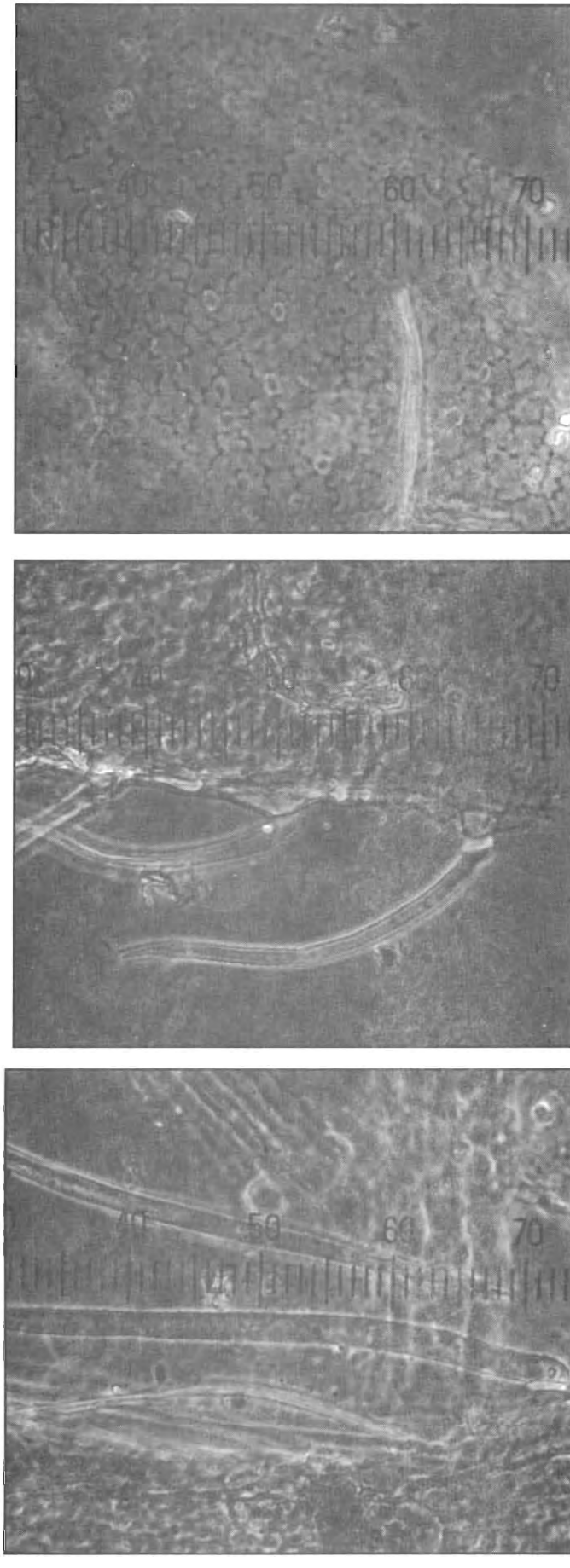


Figure 46. *Astragalus emoryanus*

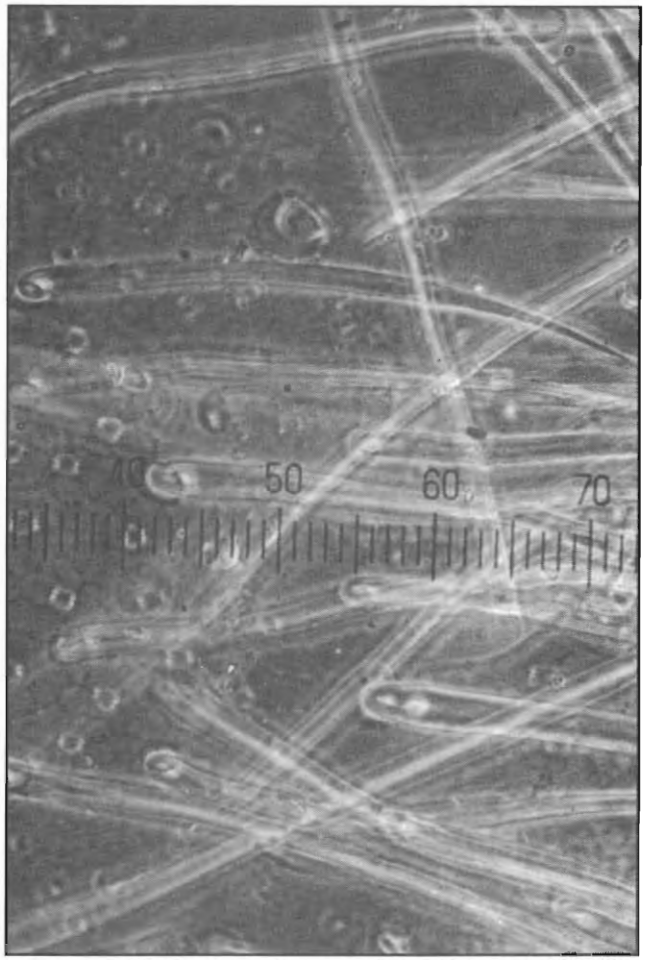


Figure 47. *Astragalus mollissimus* var. *coryi*

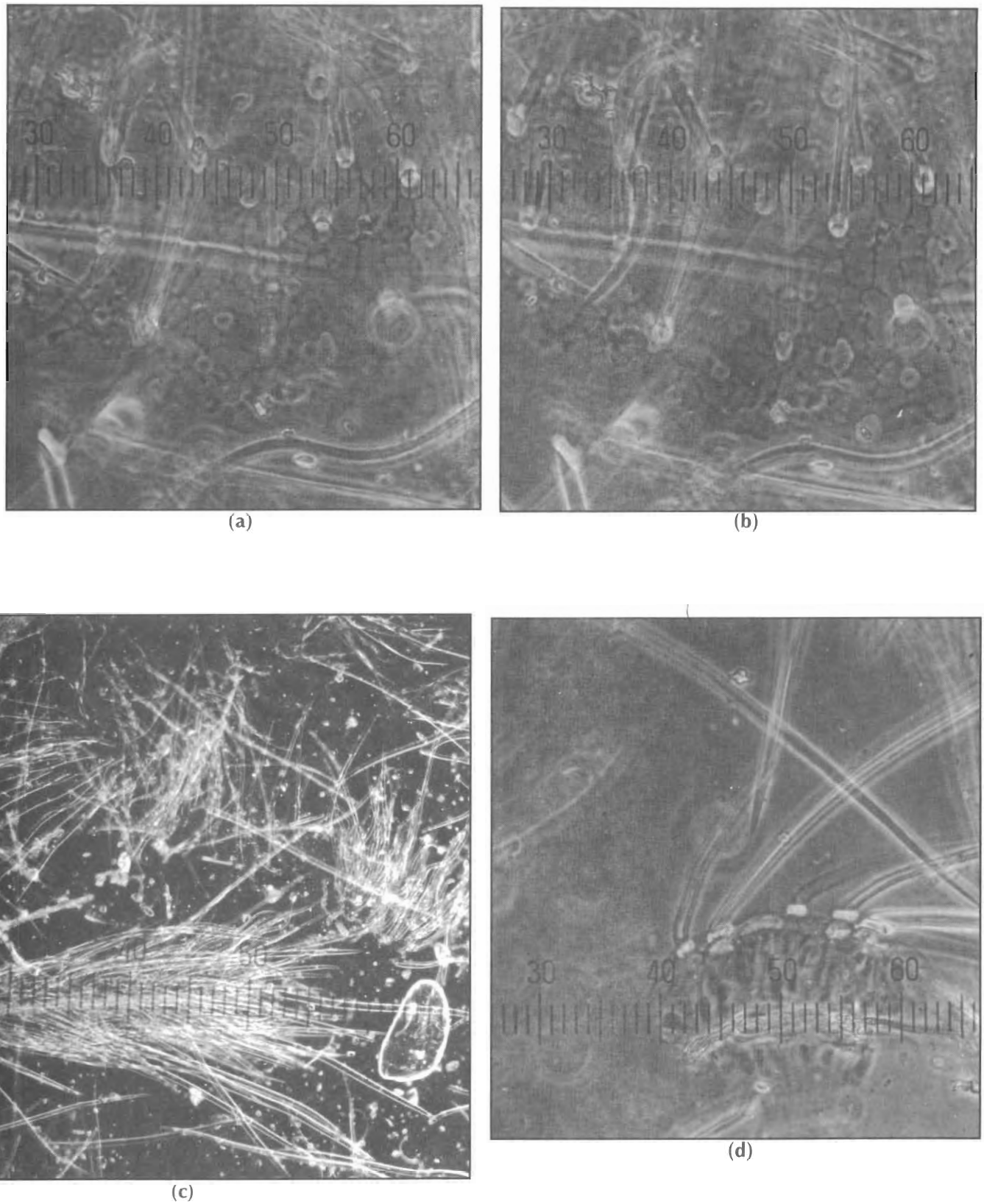
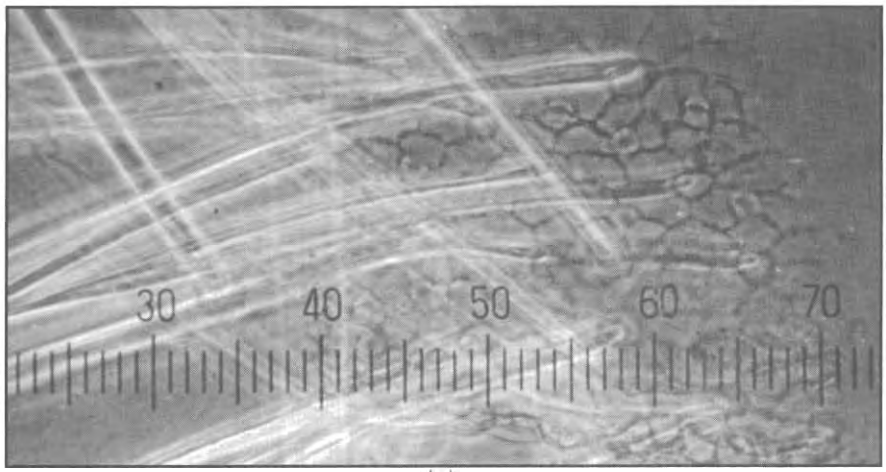
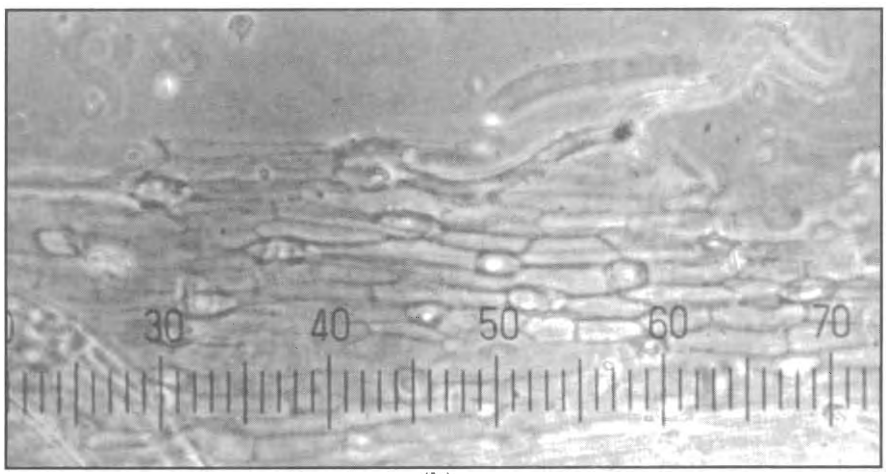


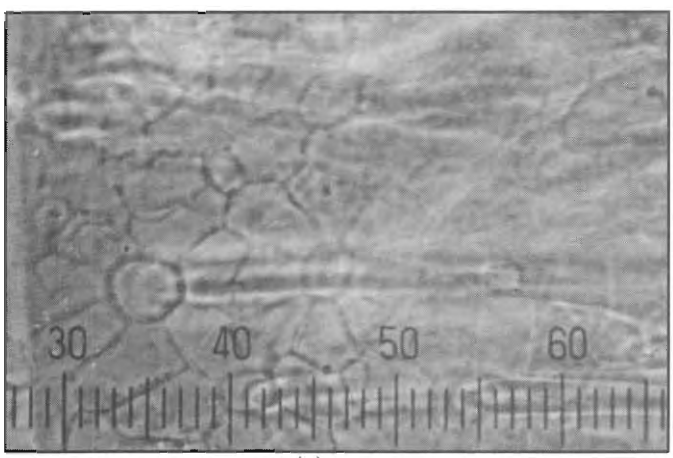
Figure 48. *Astragalus mollissimus* **var.** *earli*



(a)



(b)



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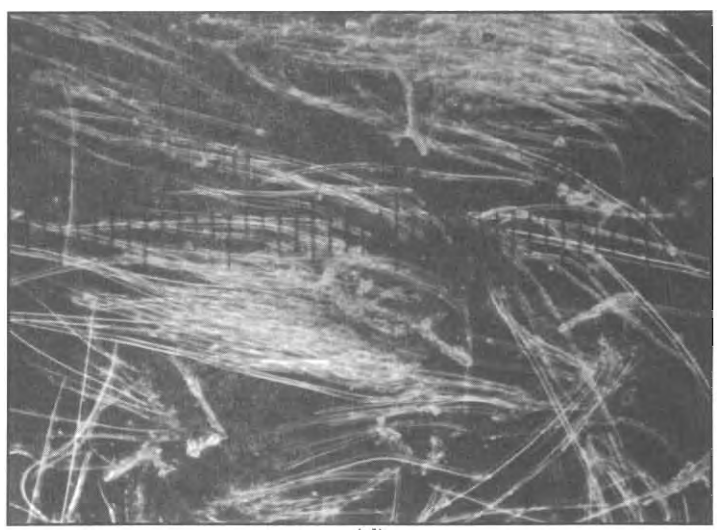
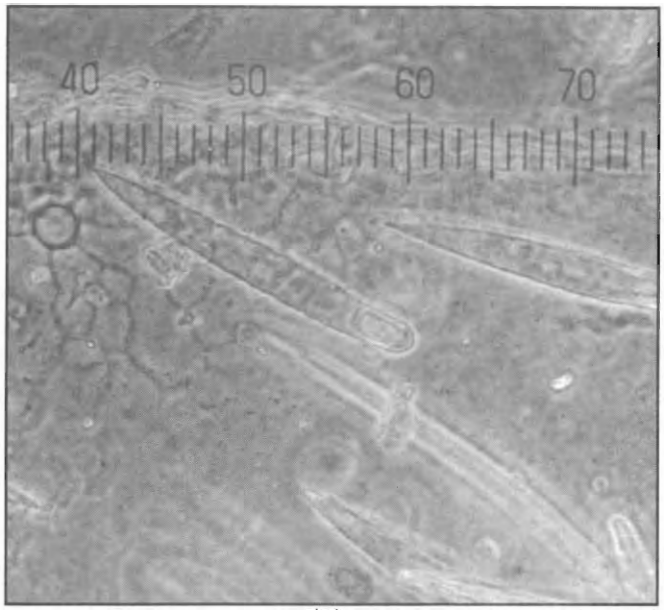


(d)

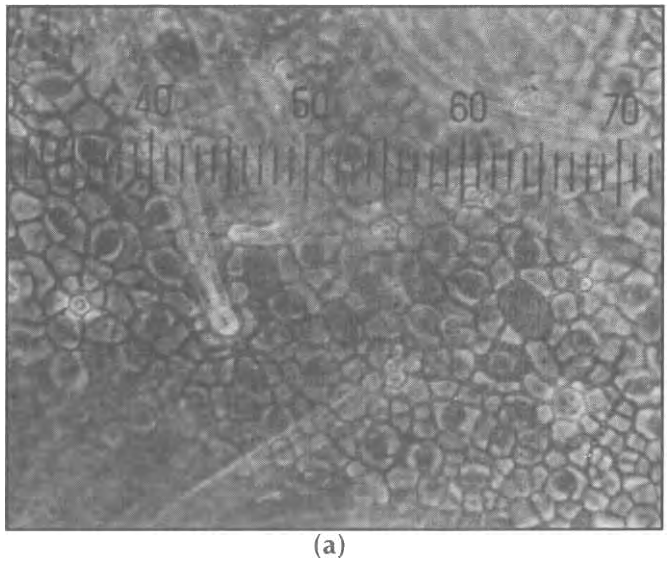
Figure 49. ***Astragalus mollissimus*** **var.** ***mollissimus***



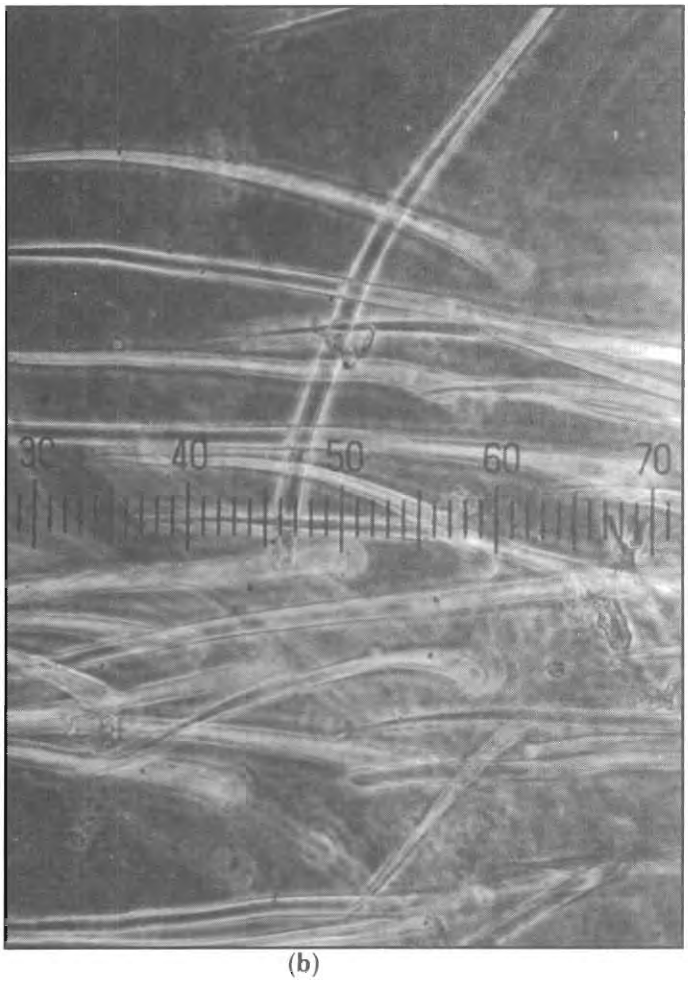
(a)

(b)

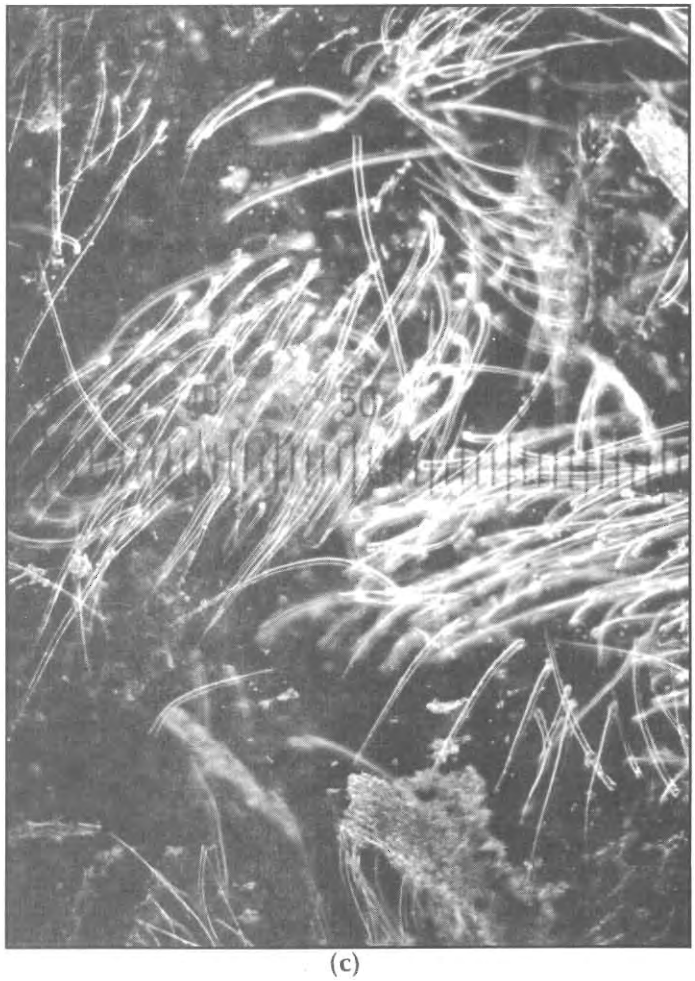
Figure 50. *Astragalus wootonii*



(a)

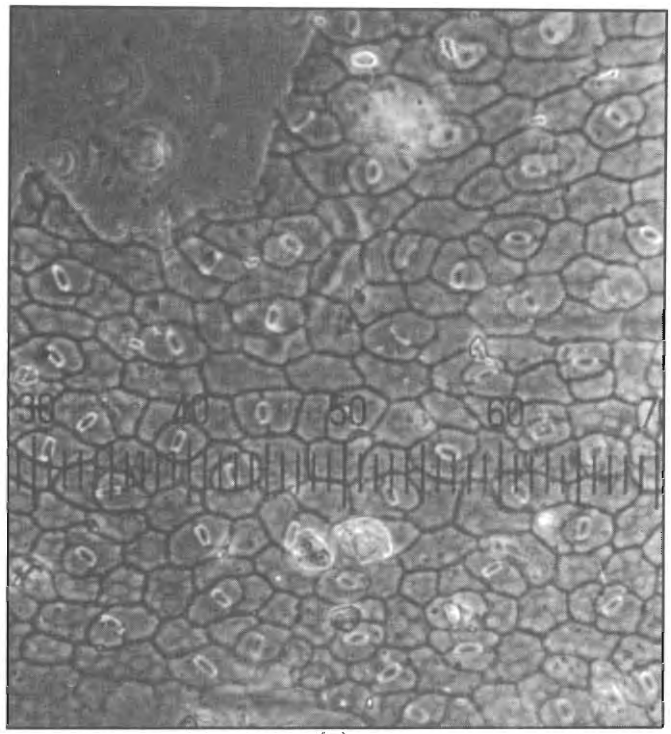


(b)

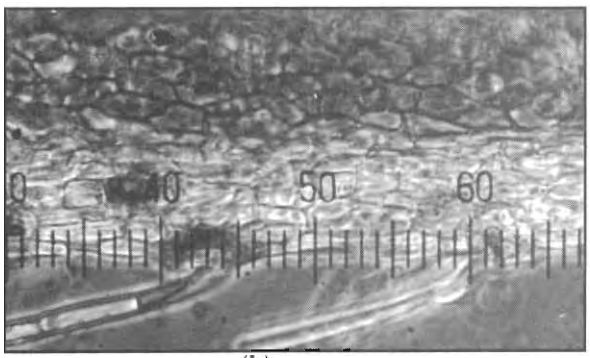


(c)

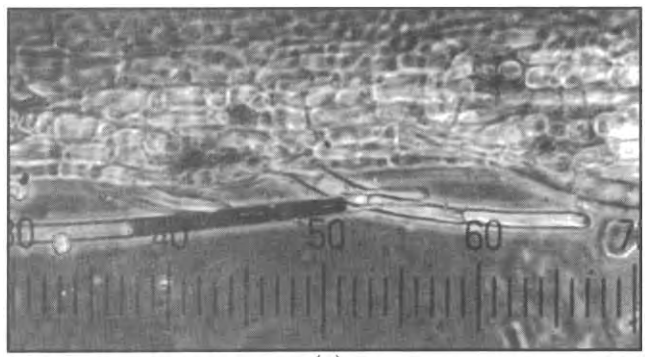
Figure 51. *Cassia lindheimeriana*



(a)



(b)



(c)

Figure 52. ***Cassia obtusifolia***

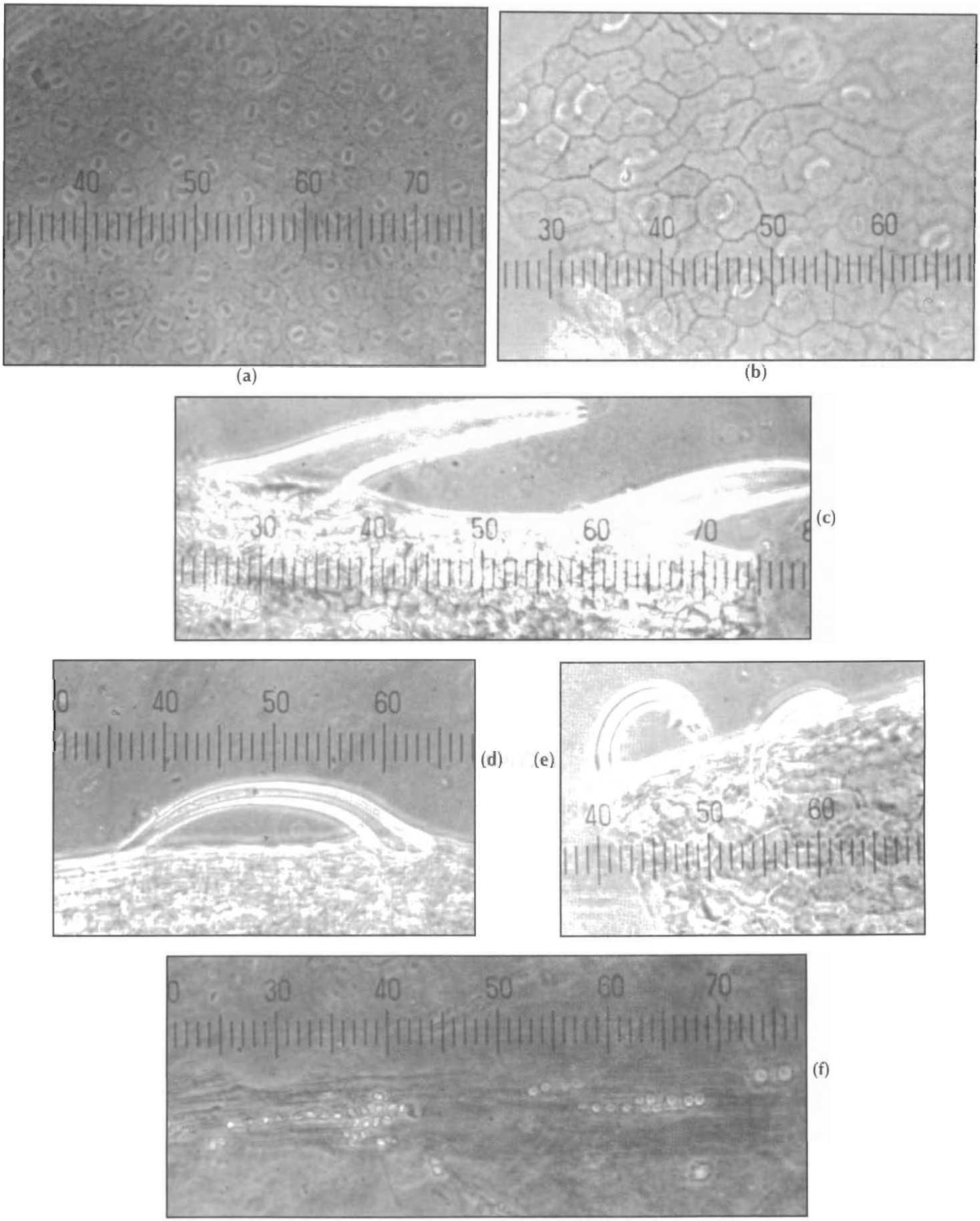
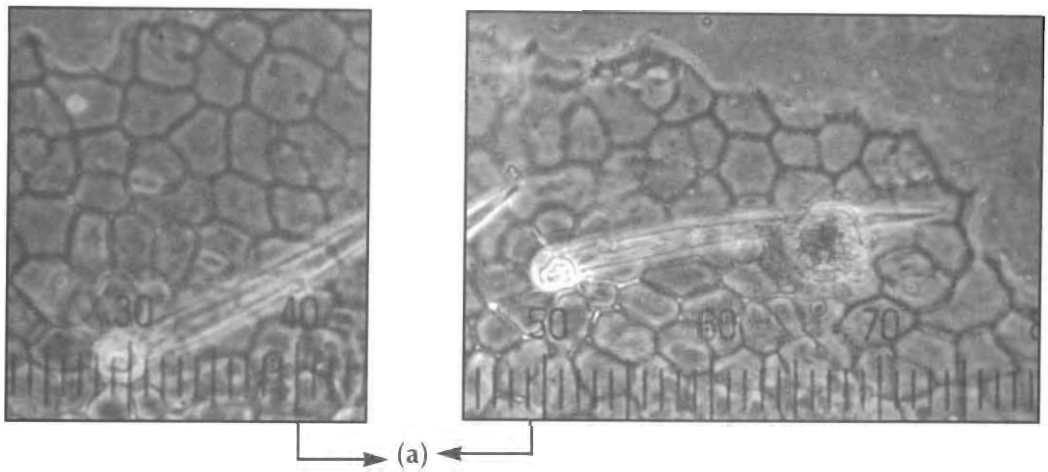
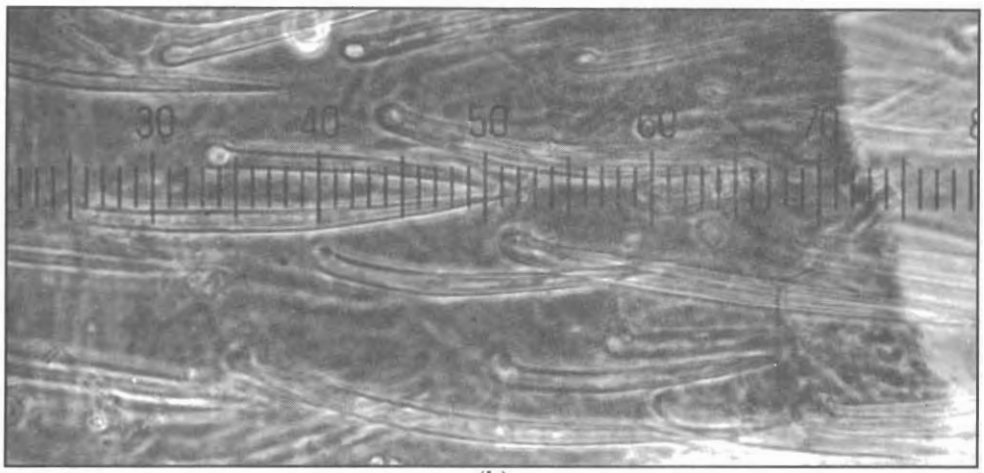


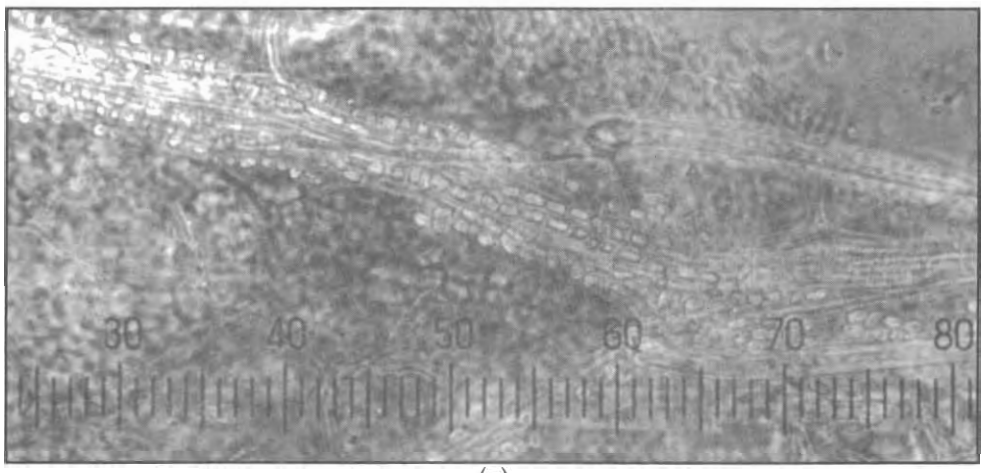
Figure 53. *Cassia occidentalis*



(a)

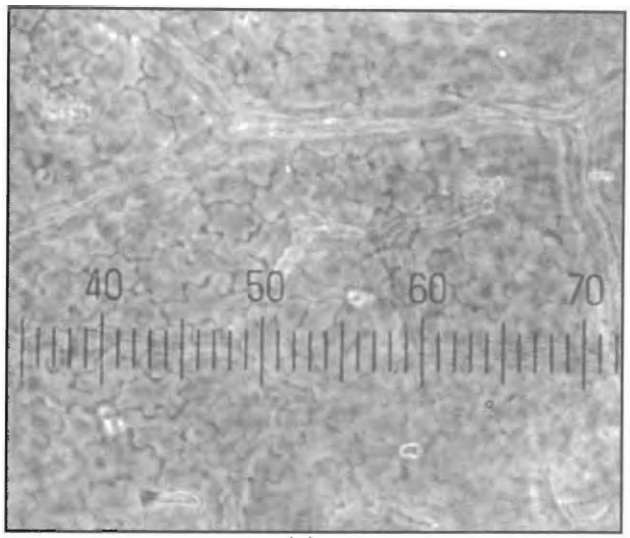


(b)

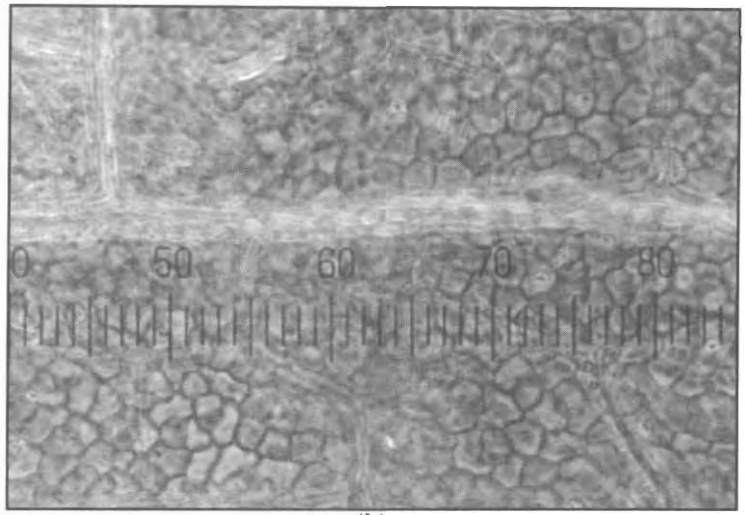


(c)

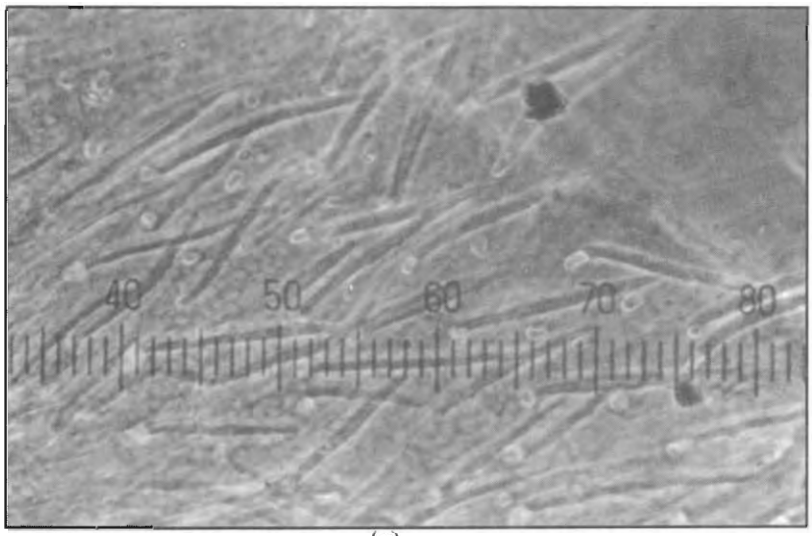
Figure 54. *Cassia roemeriana*



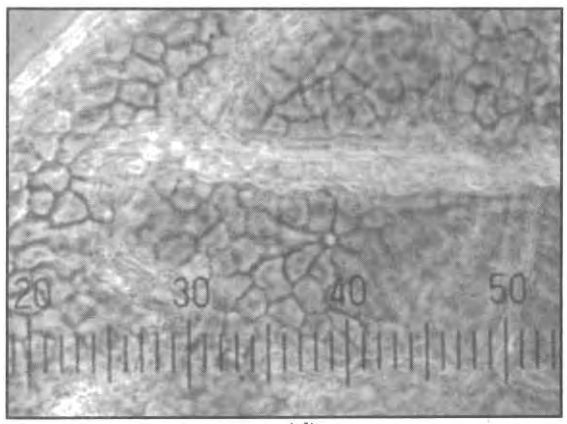
(a)



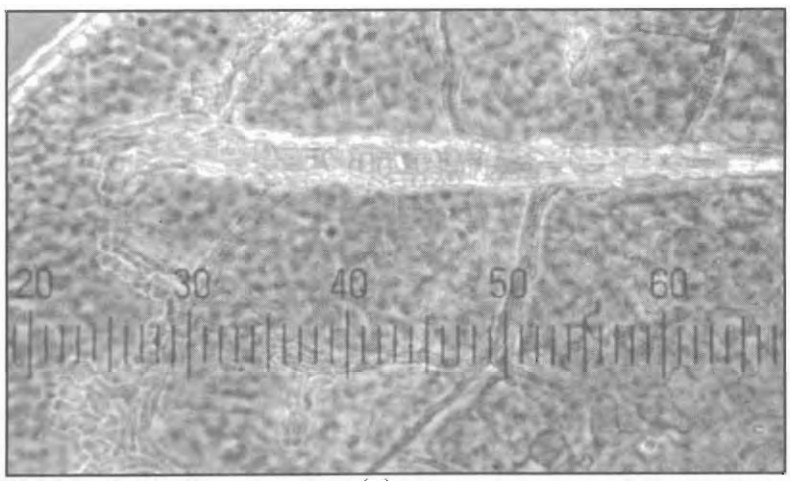
(b)



(c)

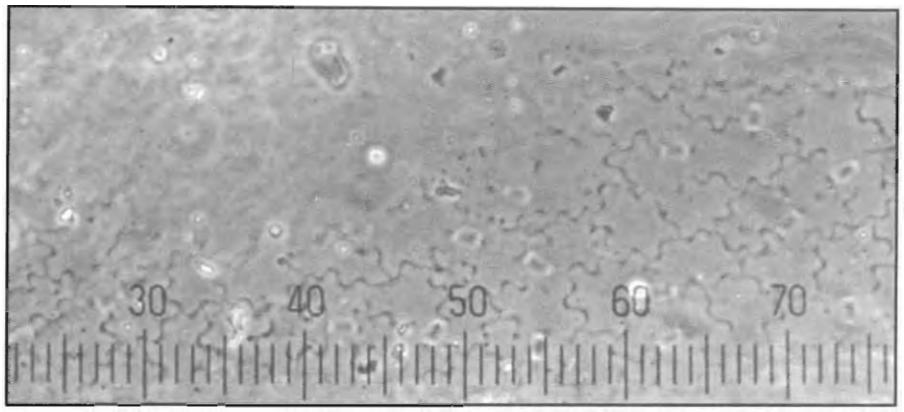


(d)

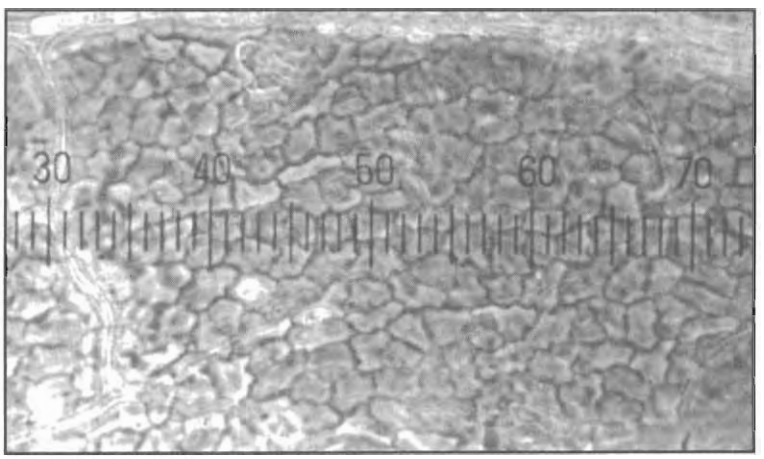


(e)

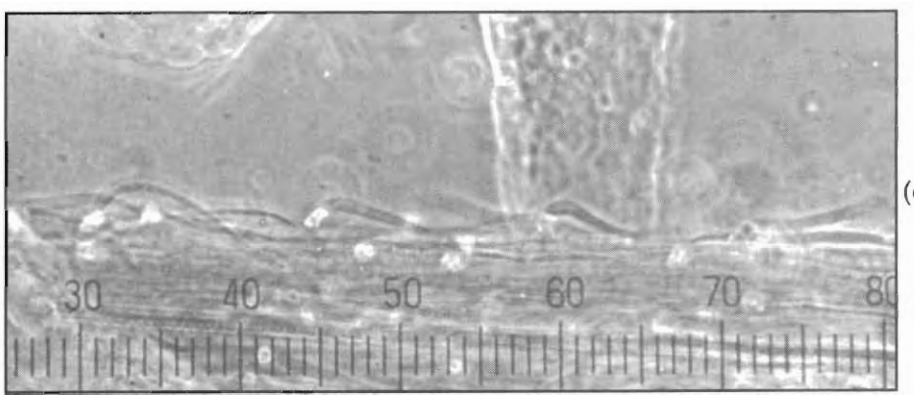
Figure 55. ***Melilotus alba***



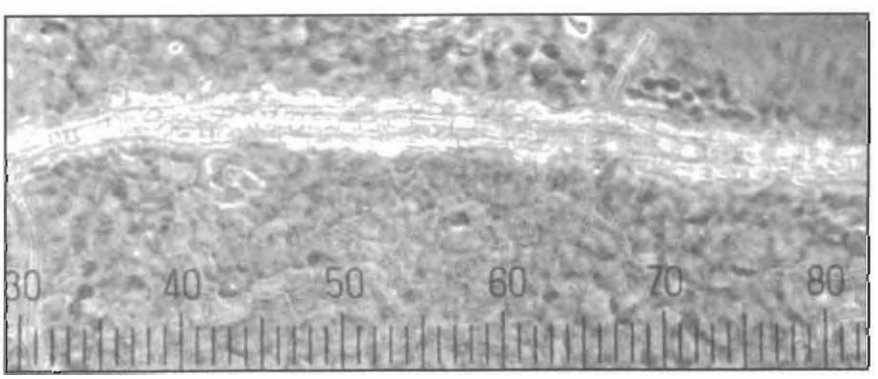
(a)



(b)

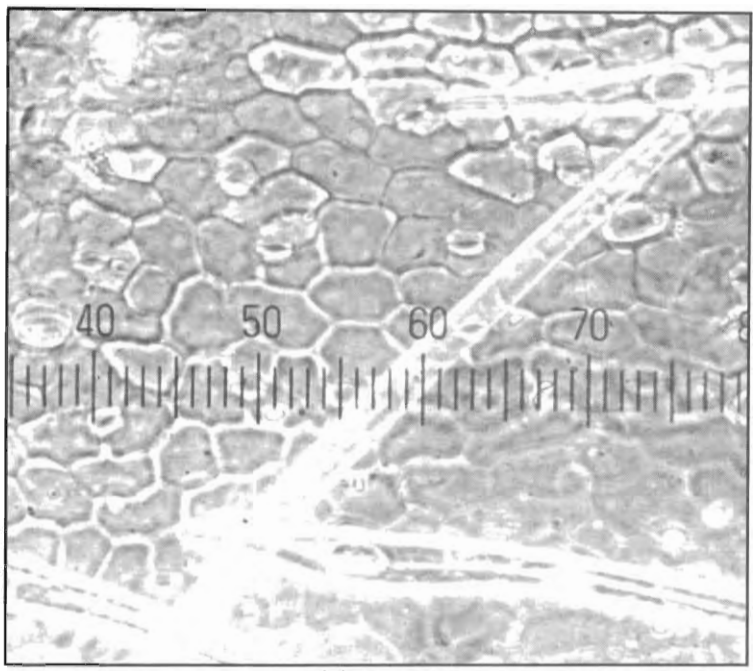


(c)

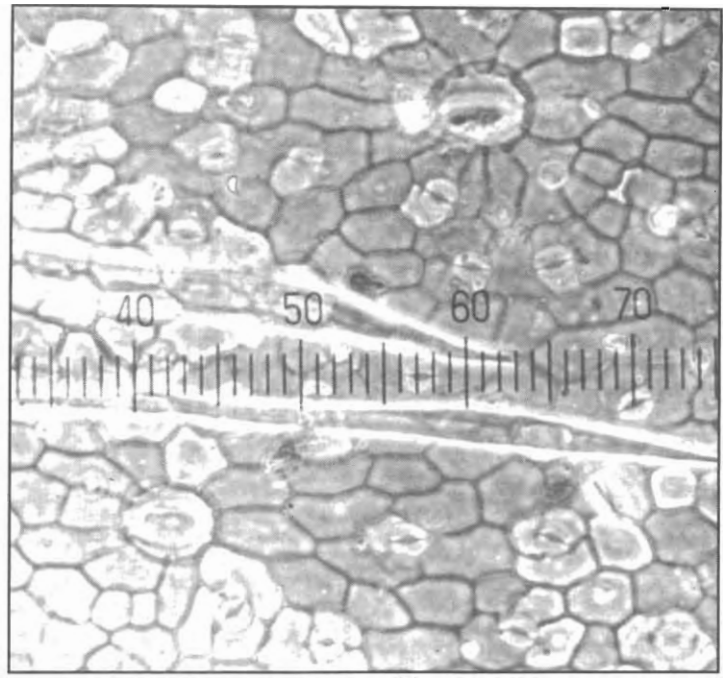


(d)

Figure 56. *Melilotus officinalis*



(a)



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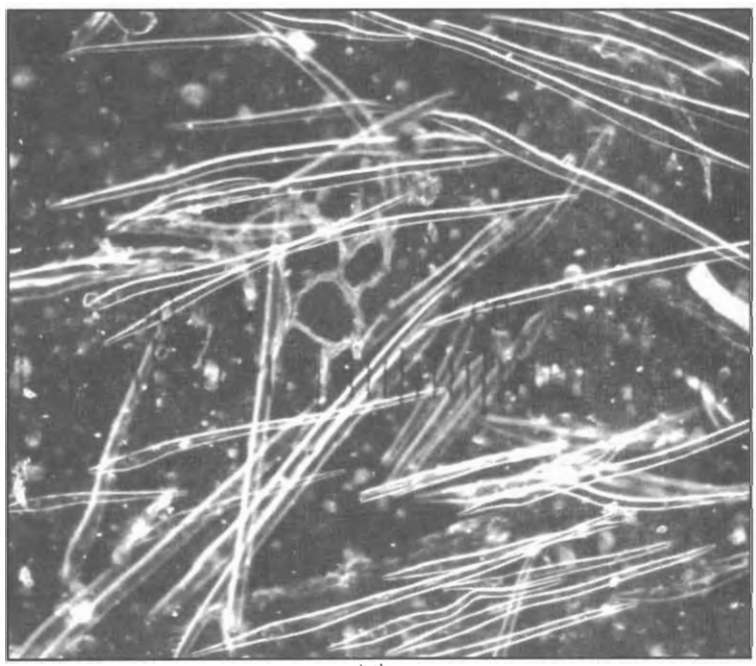
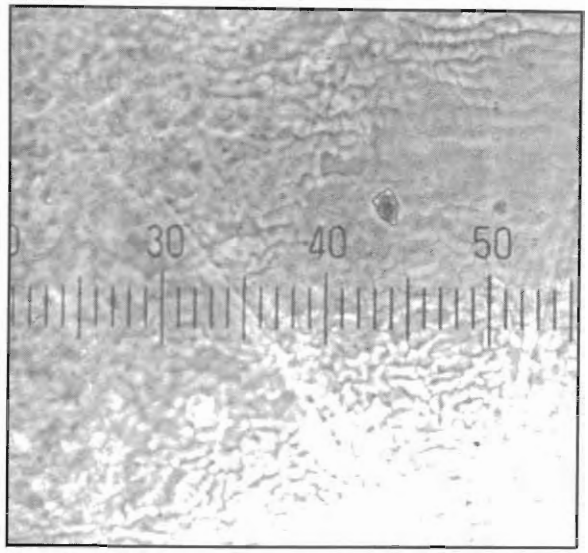
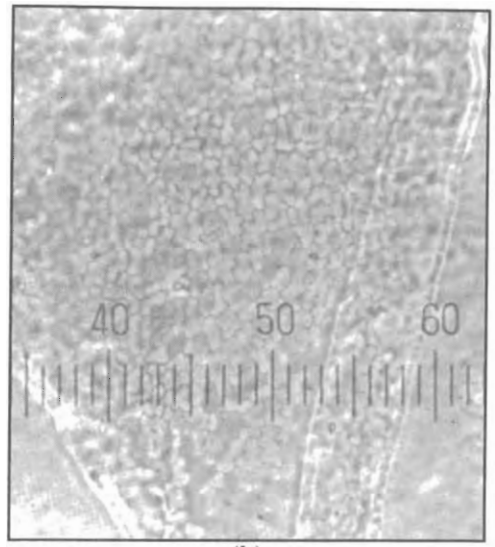


(c)

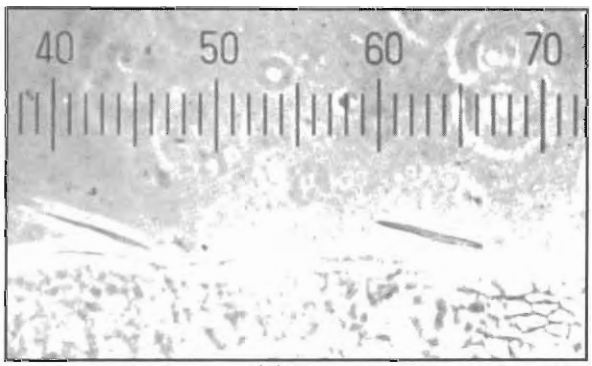
Figure 57. *Oxytropis lambertii*



(a)



(b)



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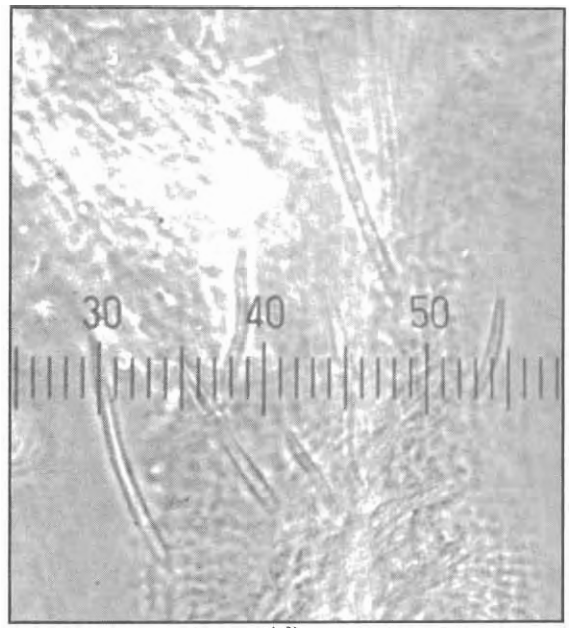
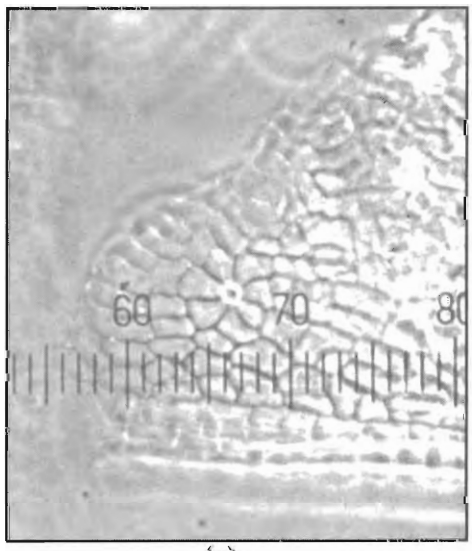
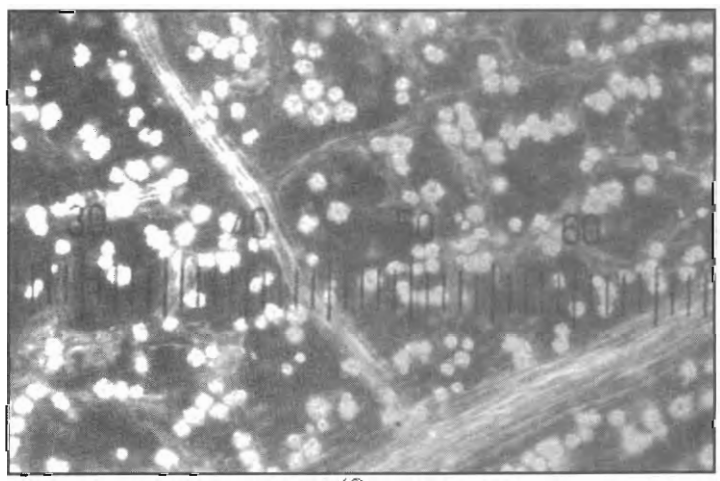


(d)

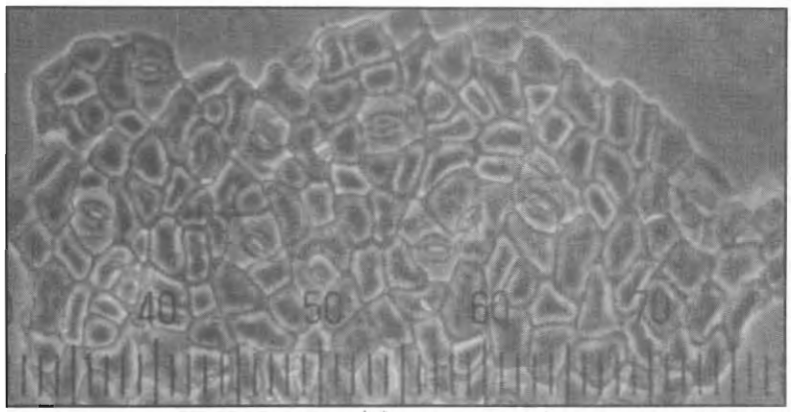


(e)

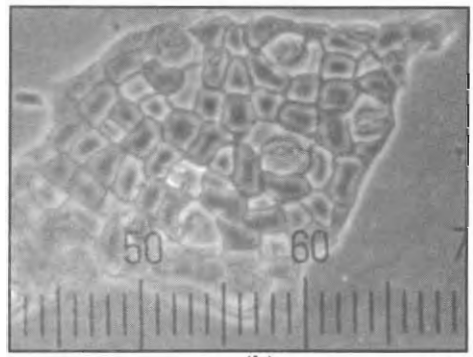


(f)

Figure 58. *Parkinsonia aculeata*



(a)



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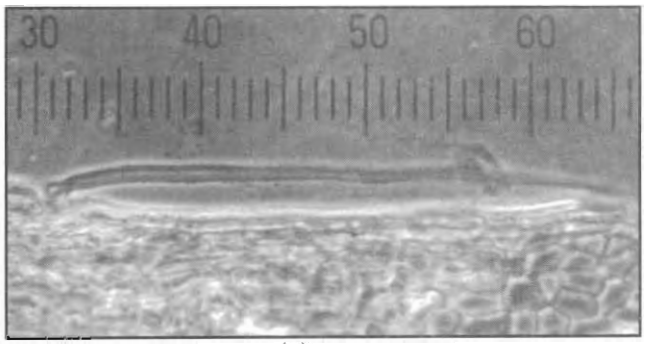

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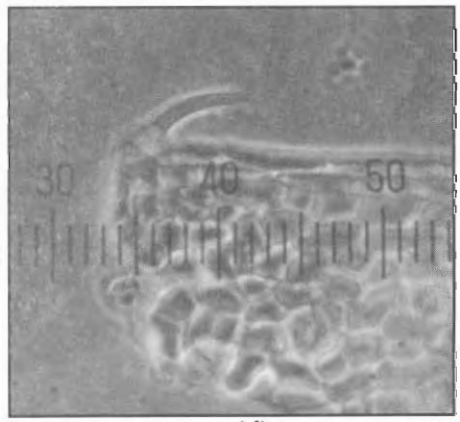
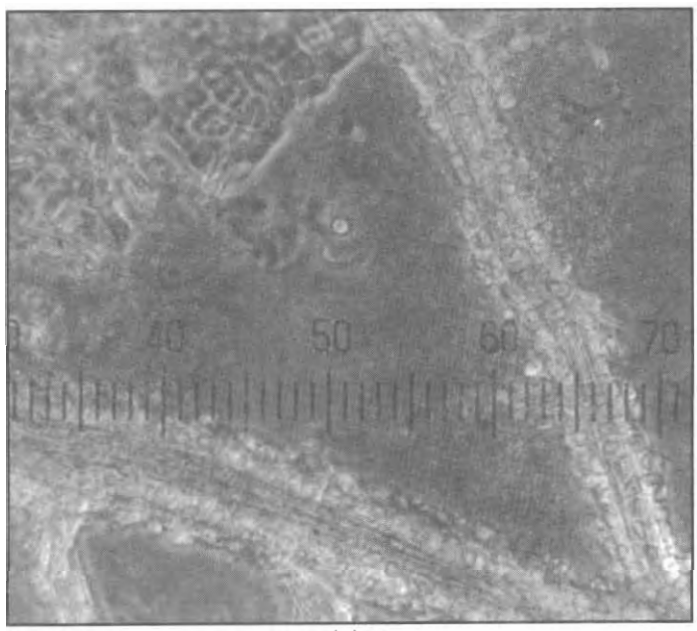
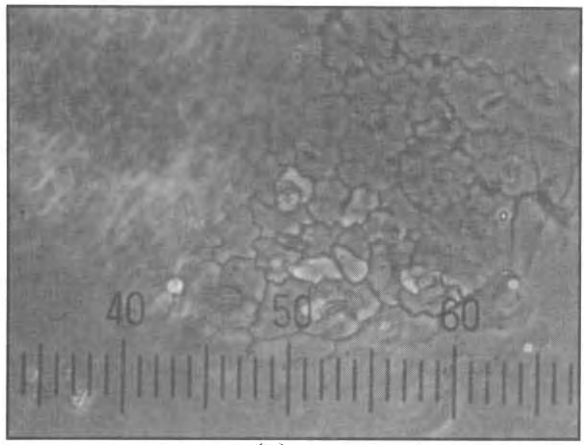


(d)



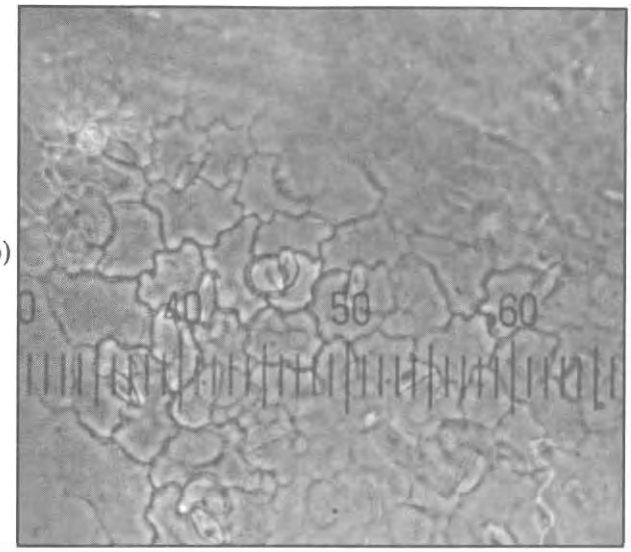
(e)

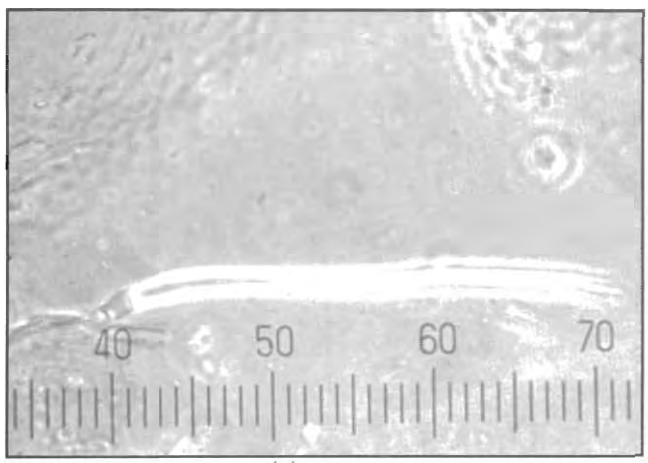
Figure 59. ***Prosopis glandulosa*** **var.** ***glandulosa***



(a)

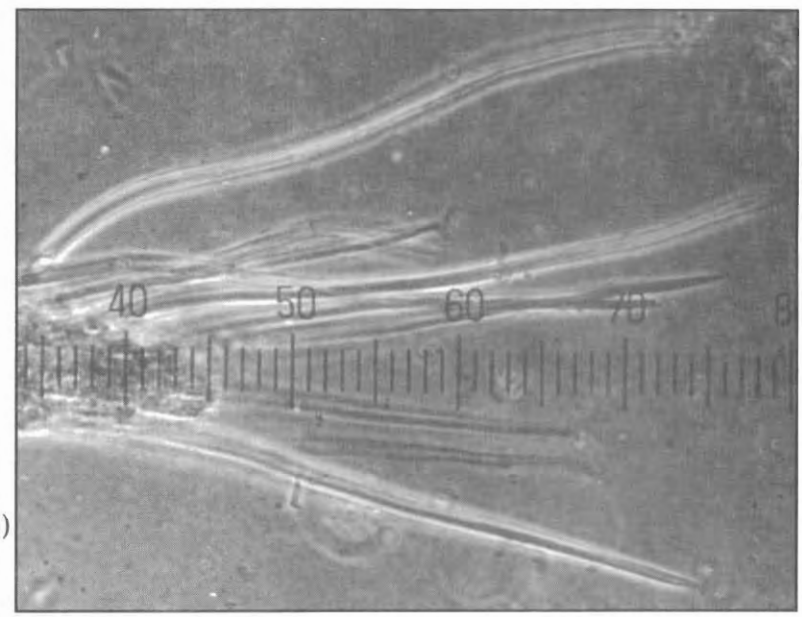
(b)

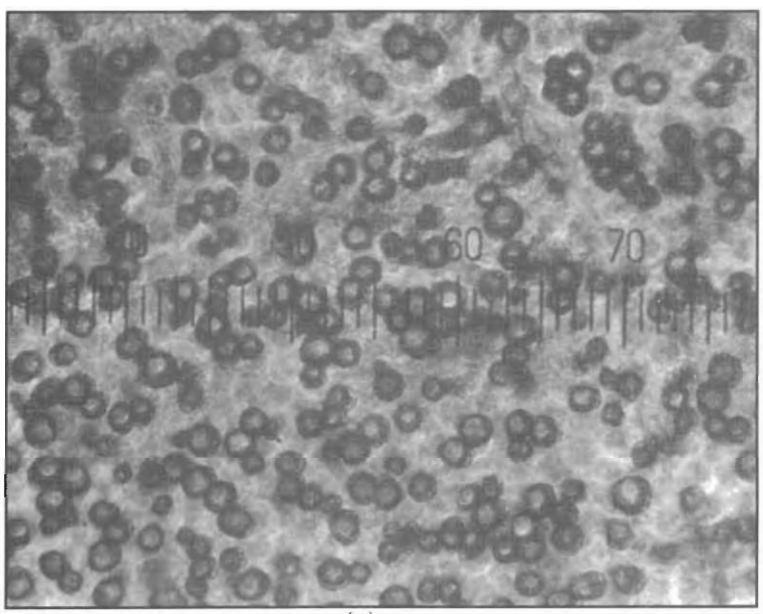




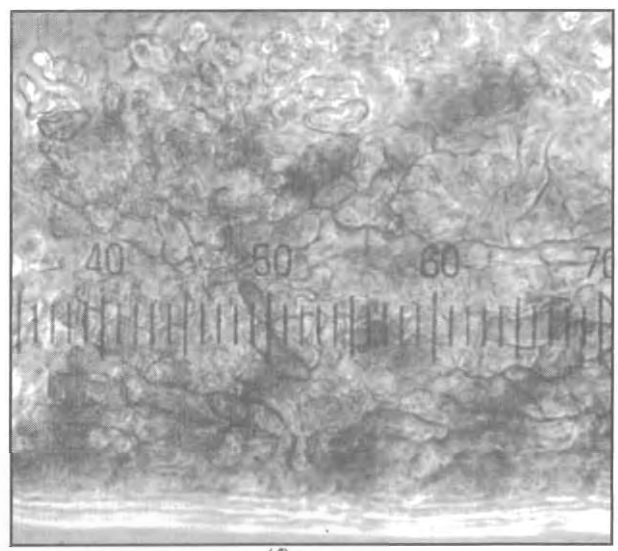
(c)

(d)



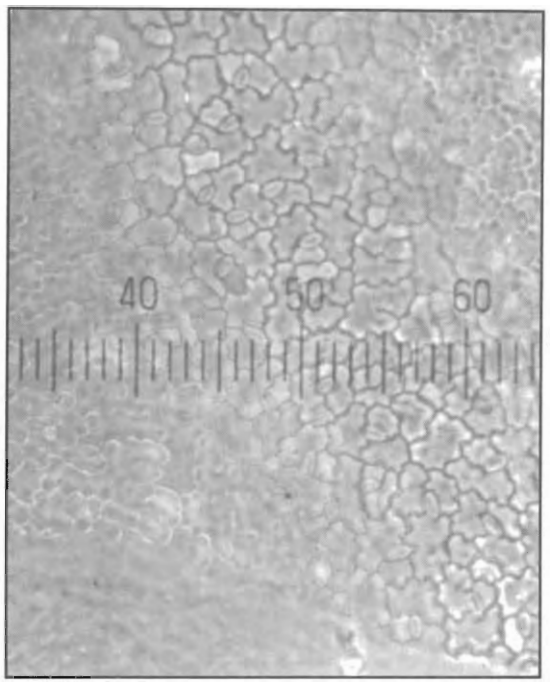


(e)

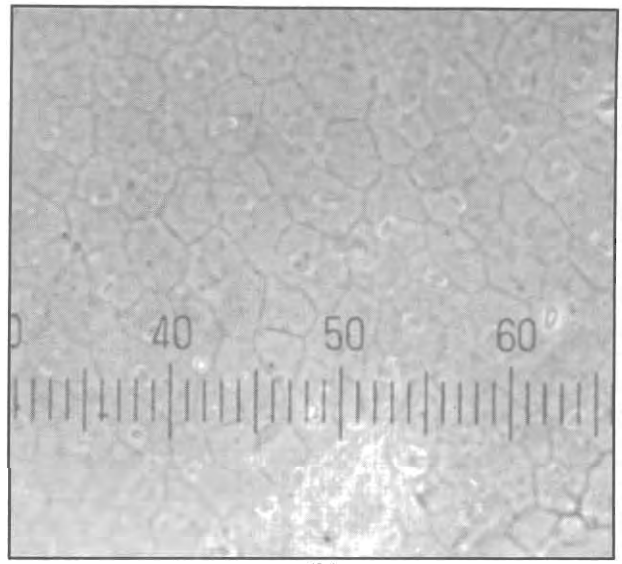


(f)

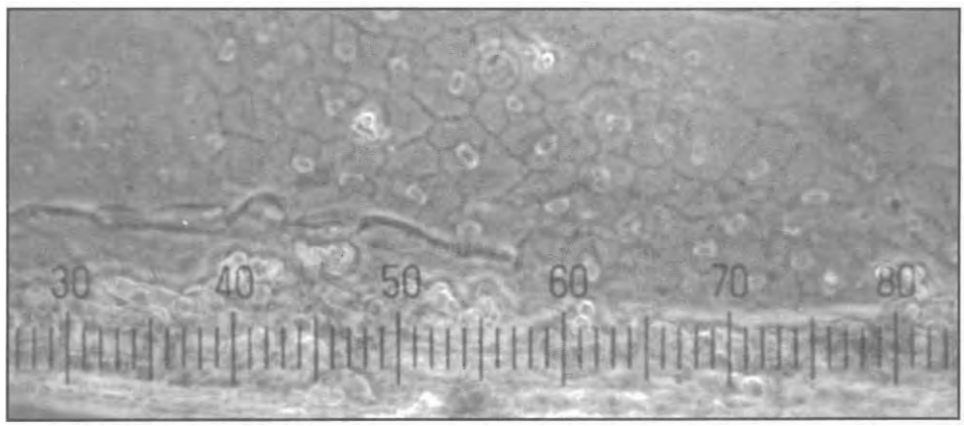
Figure 60. ***Sesbania drummondii***



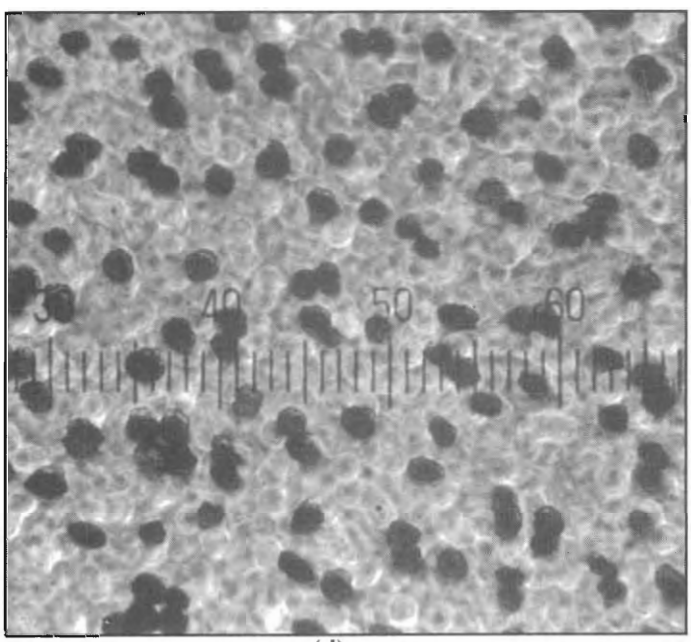
(a)



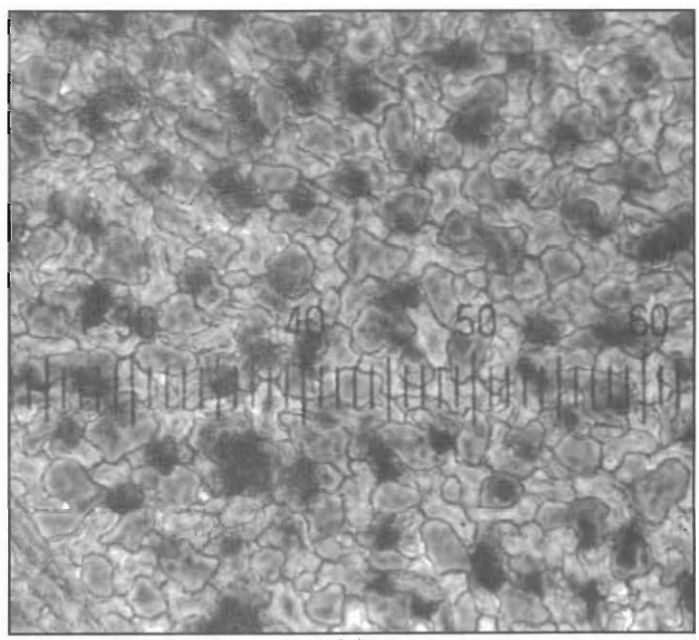
(b)



(c)

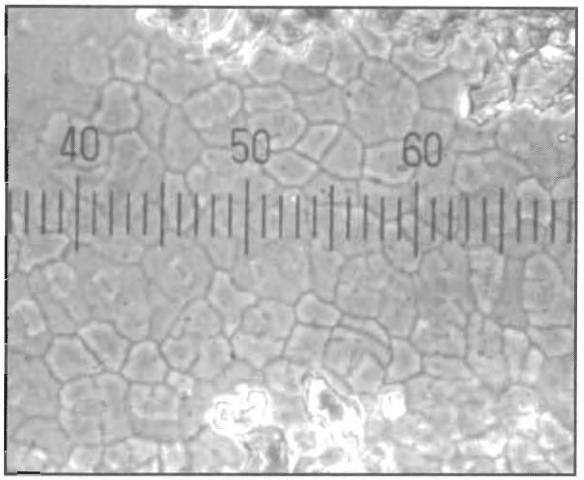


(d)

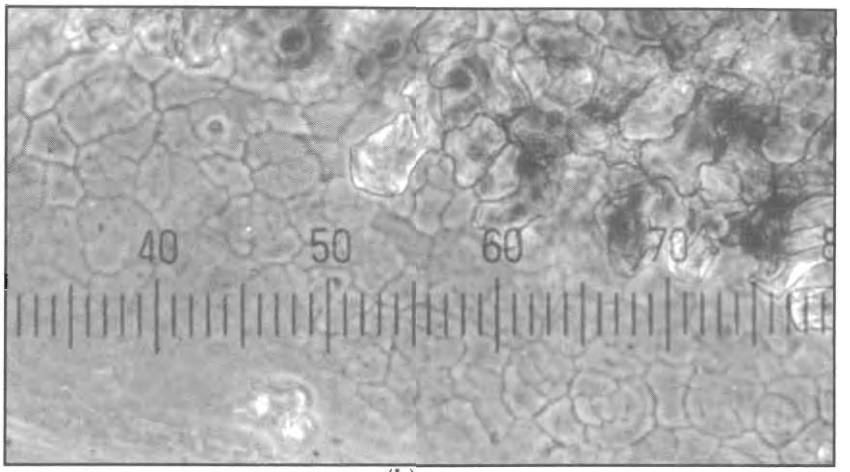


(e)

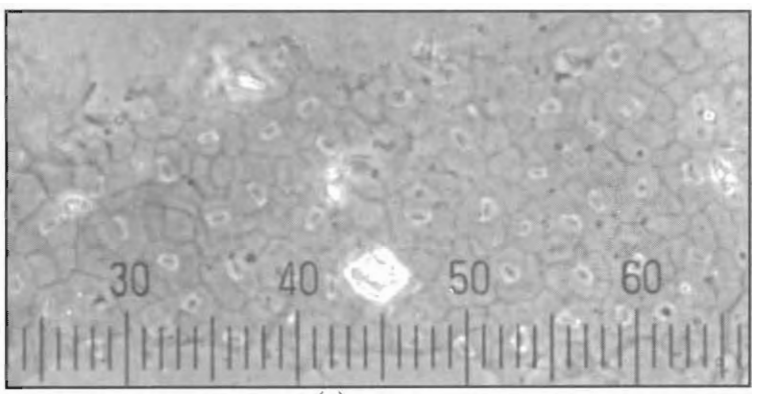
Figure 61. ***Sesbania macrocarpa***



(a)



(b)



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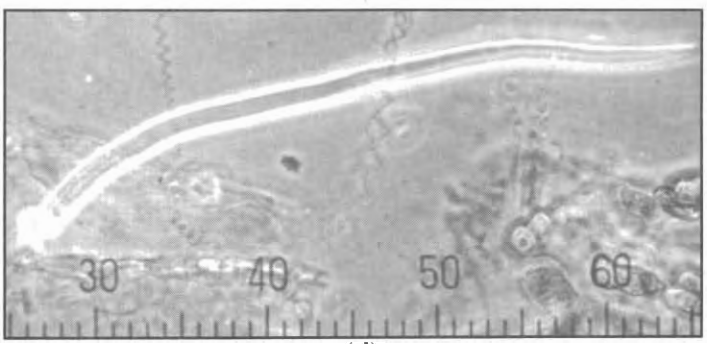
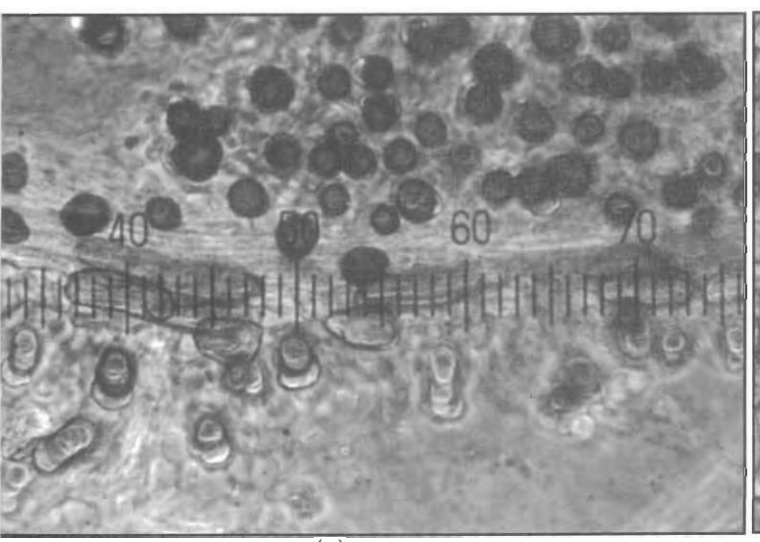
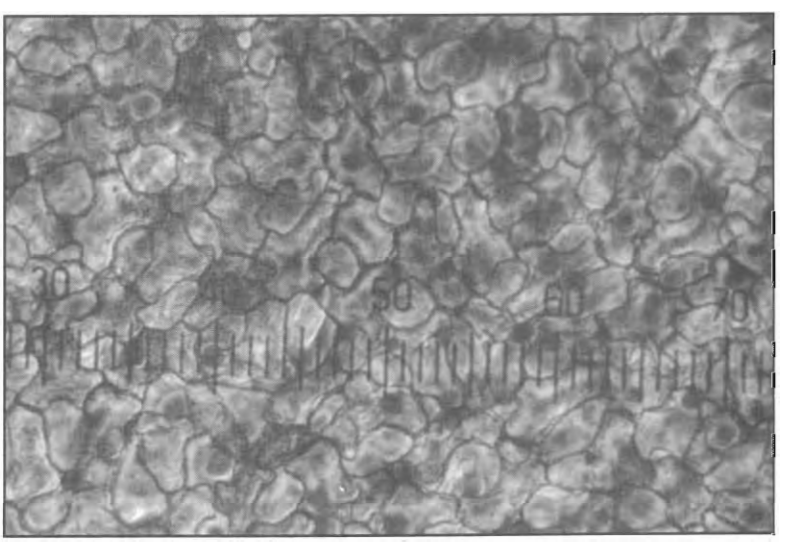


(d)

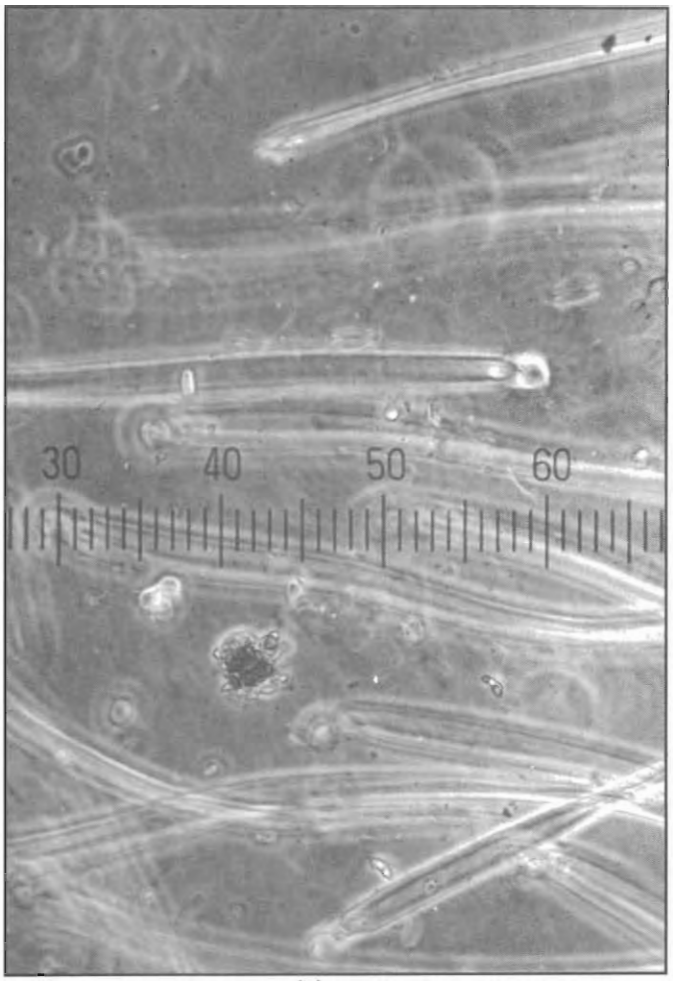


(e)

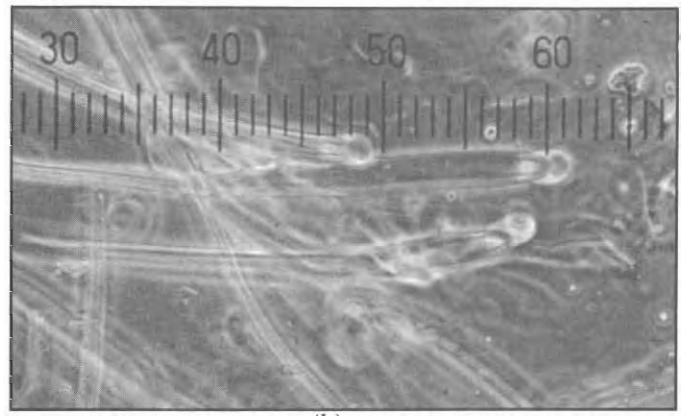


(f)

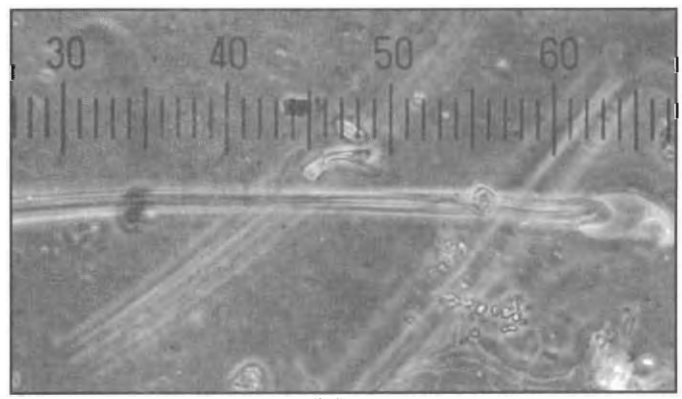
Figure 62. ***Sesbania vesicaria***



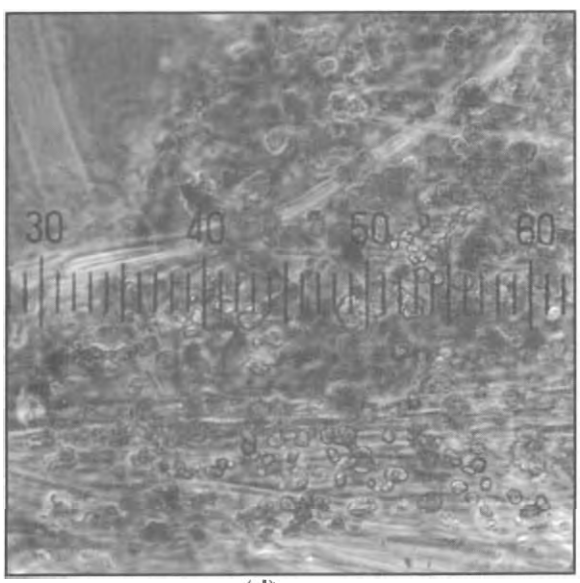
(a)



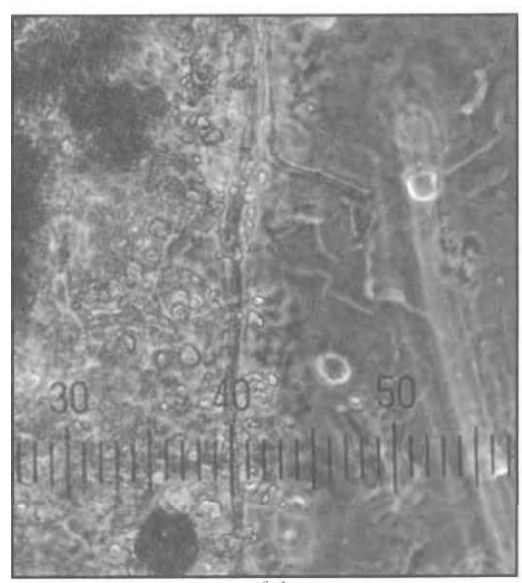
(b)



(c)



(d)



(e)

Figure 63. *Sophora nuttalliana*

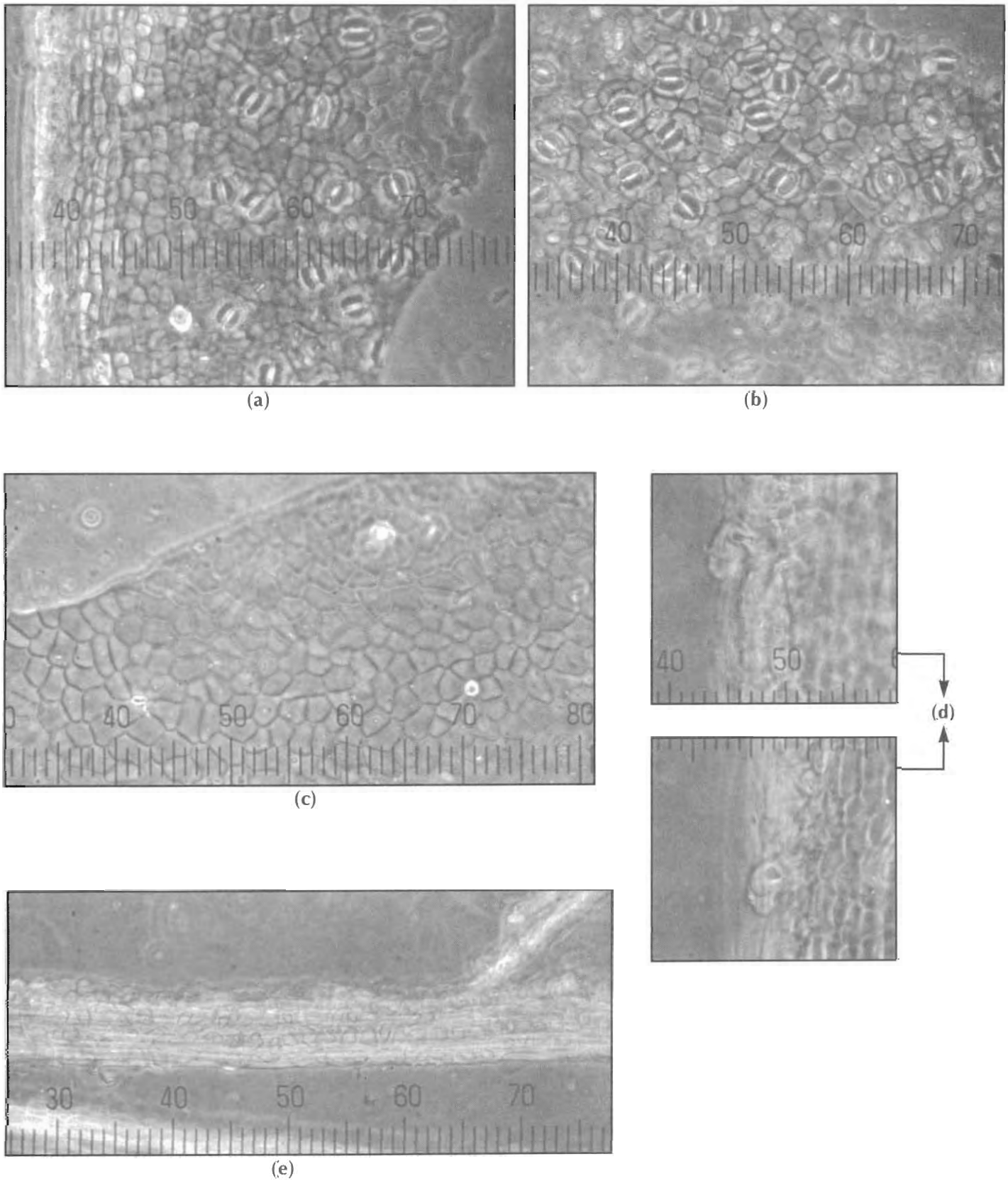


Figure 64. *Sophora secundiflora*

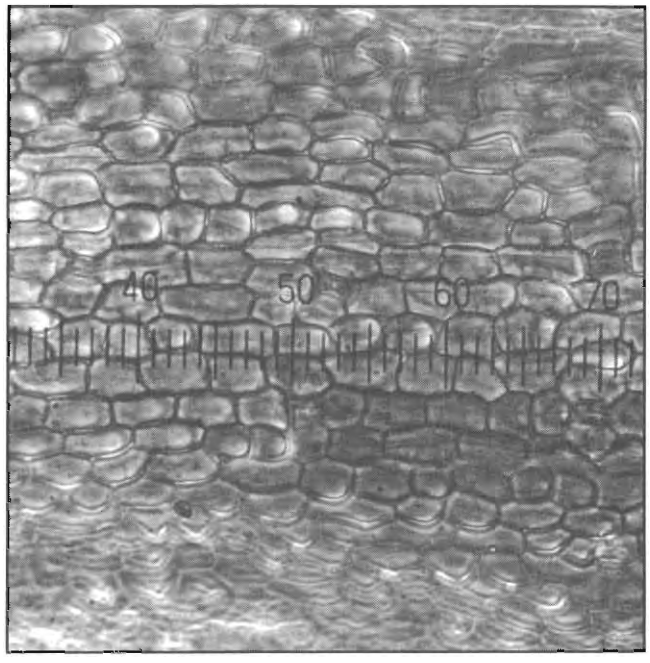
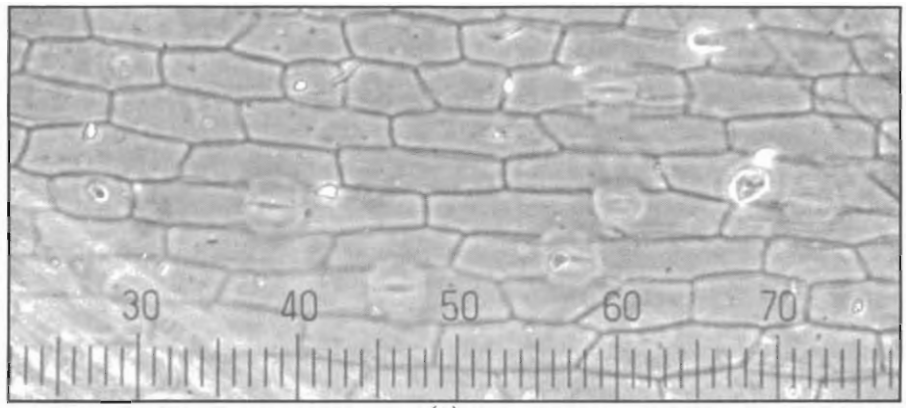
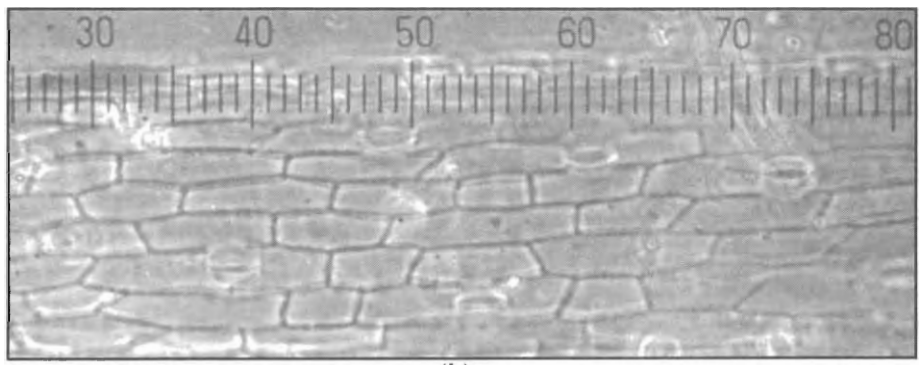


Figure 65. ***Nolina texana***



(a)



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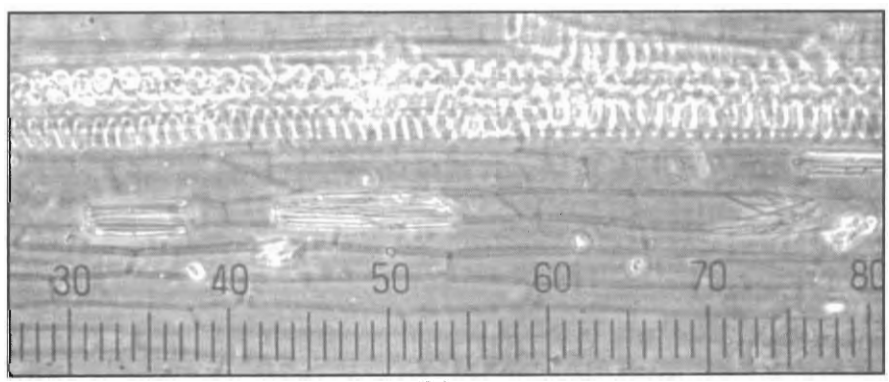

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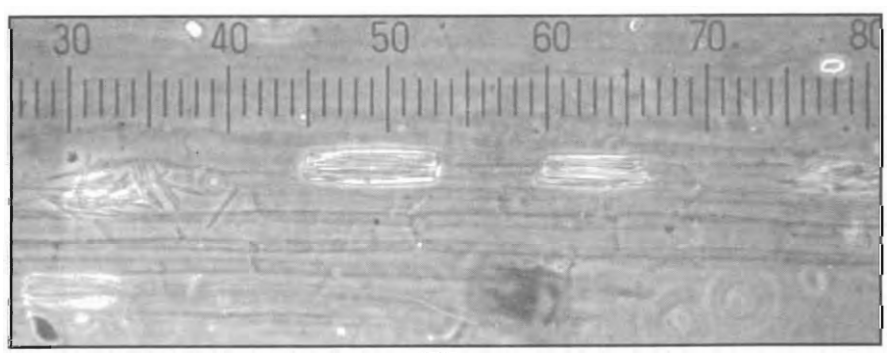
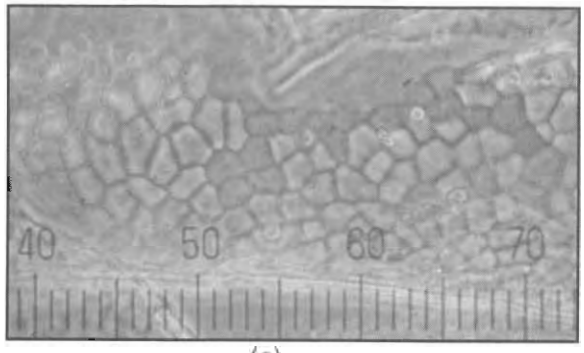
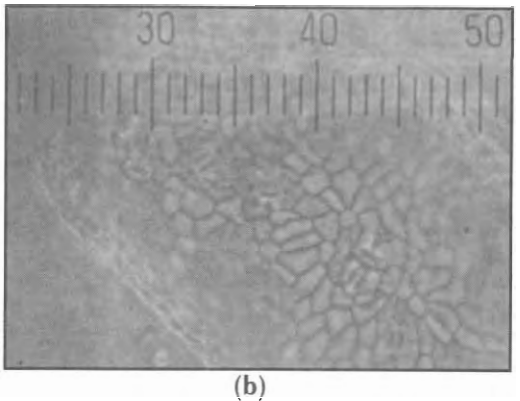


(d)

Figure 66. *Zigadenus nuttallii*



(a)



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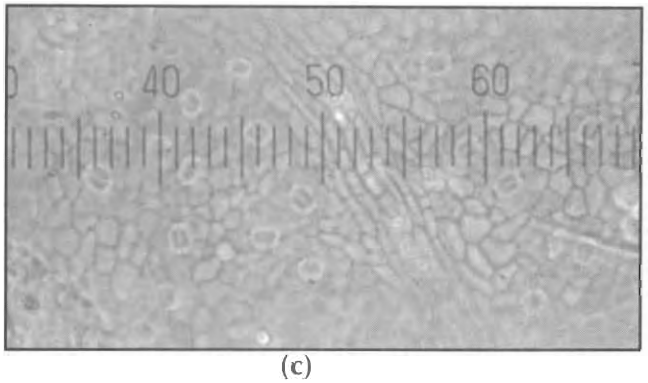

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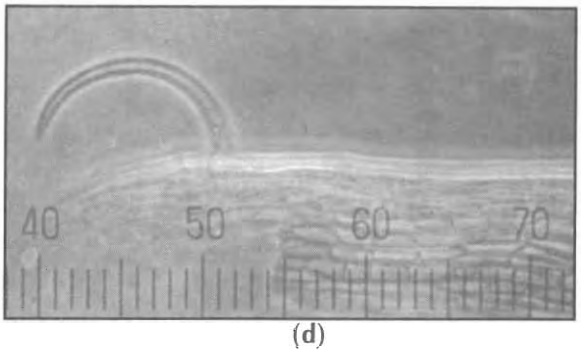

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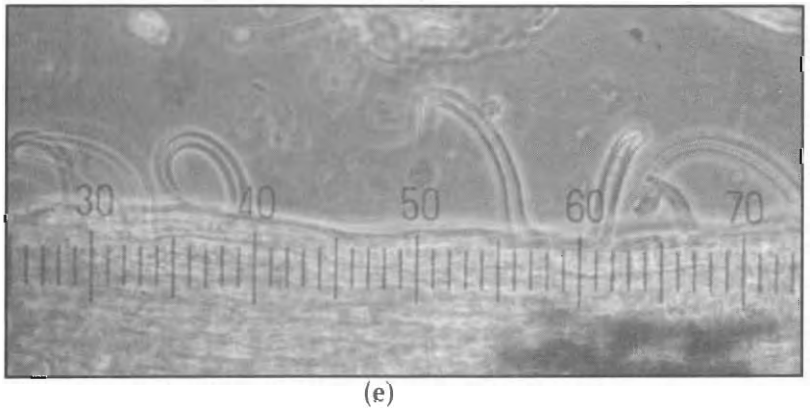

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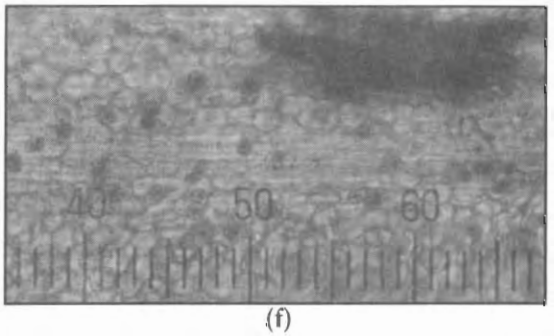
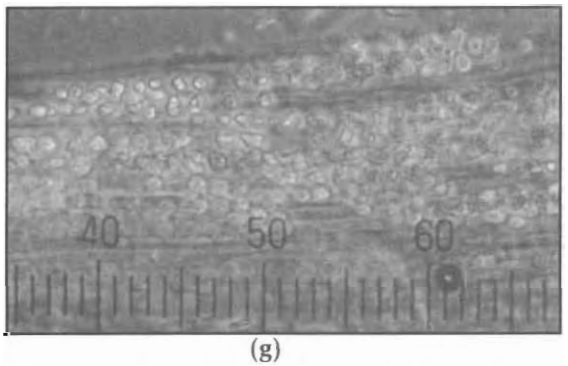


(f)



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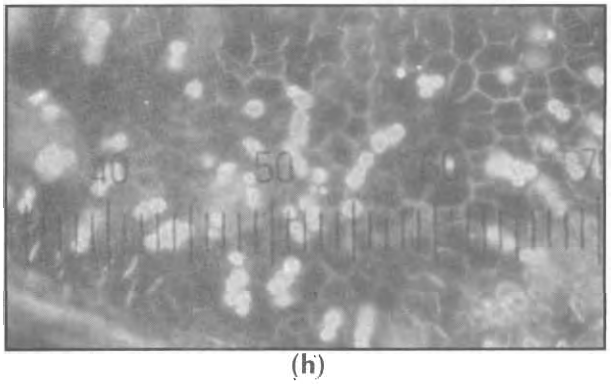
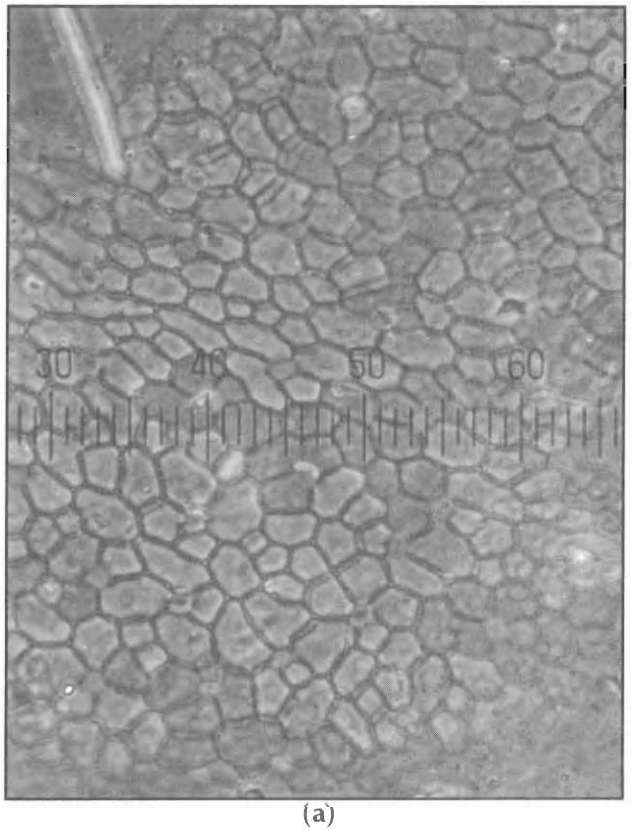


(h)

Figure 67. *Melia azedarach*



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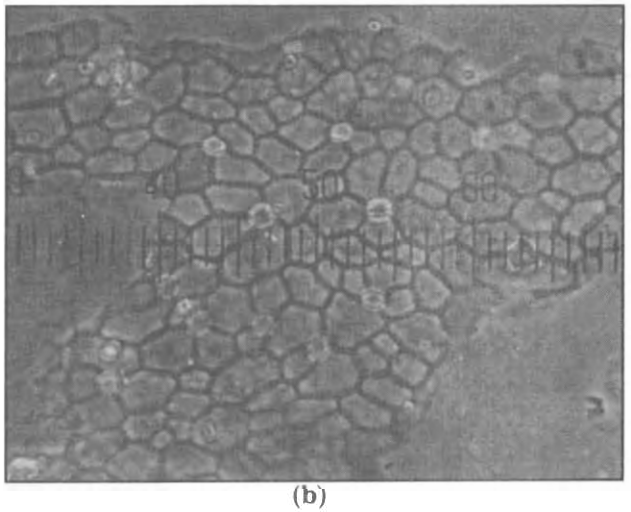
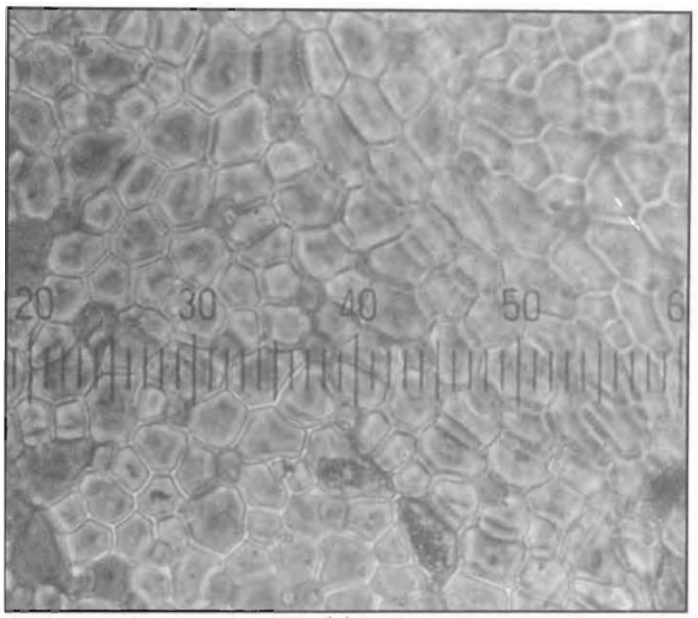
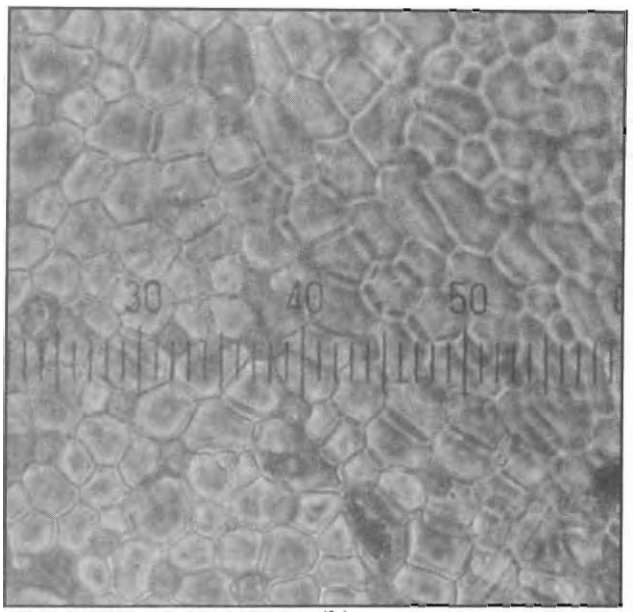


(b)

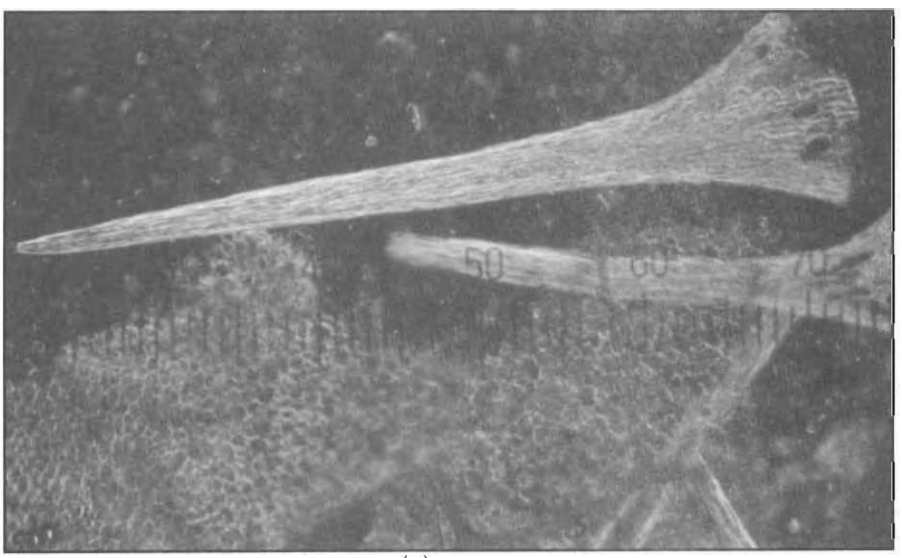
Figure 68. ***Argemone albiflora***



(a)

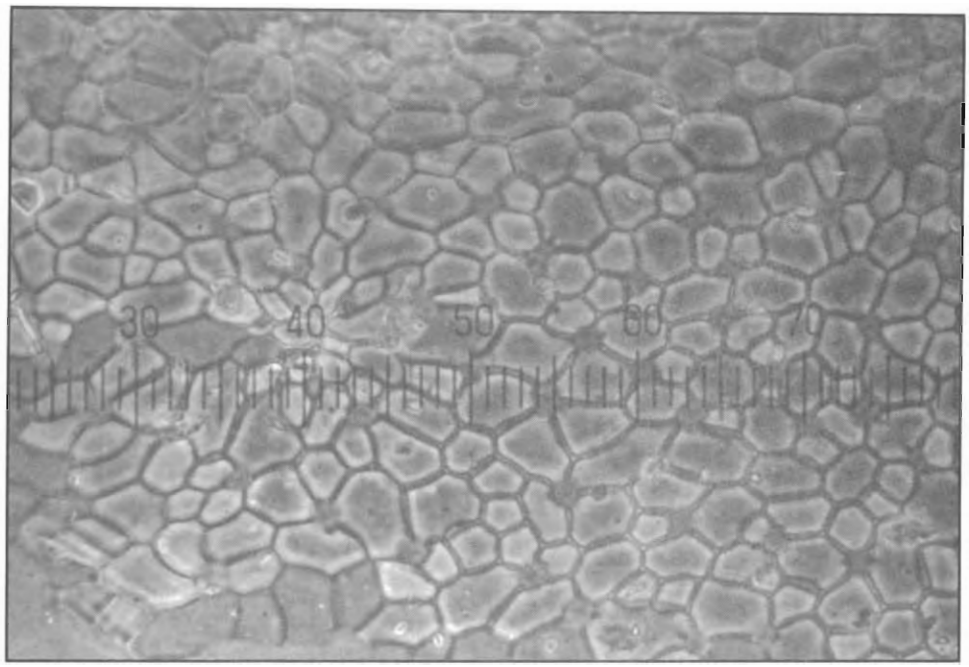


(b)

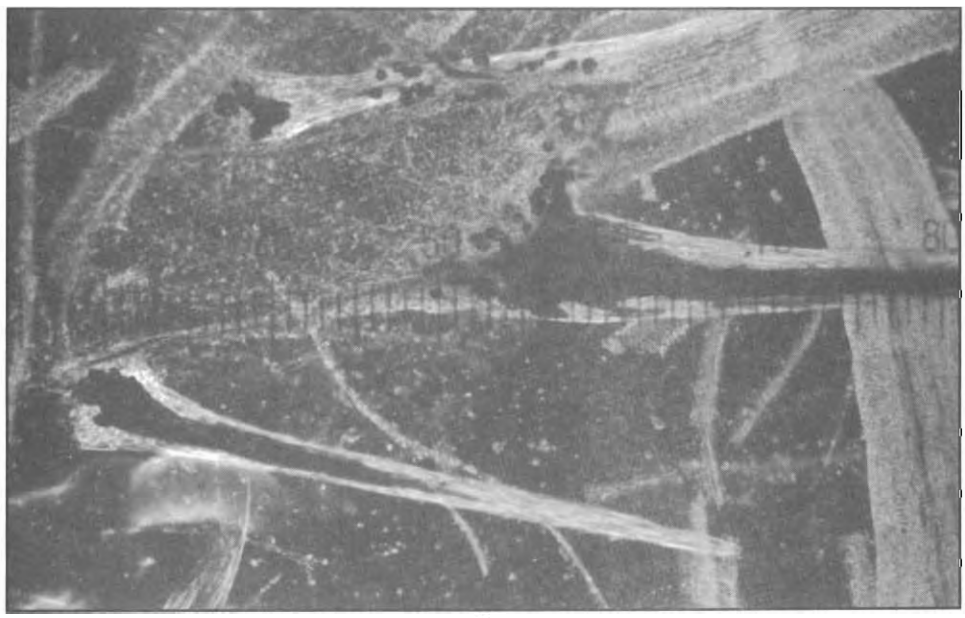


(c)

Figure 69. *Argemone aurantiaca*



(a)



(b)

Figure 70. *Argemone polyanthemos*

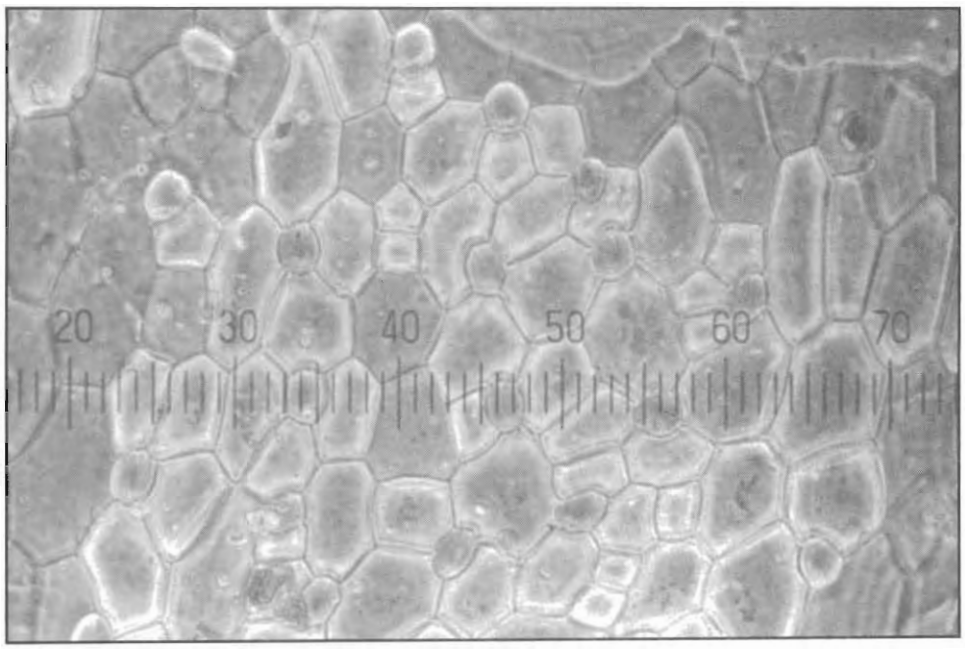


Figure 71. *Argemone* **sp.**

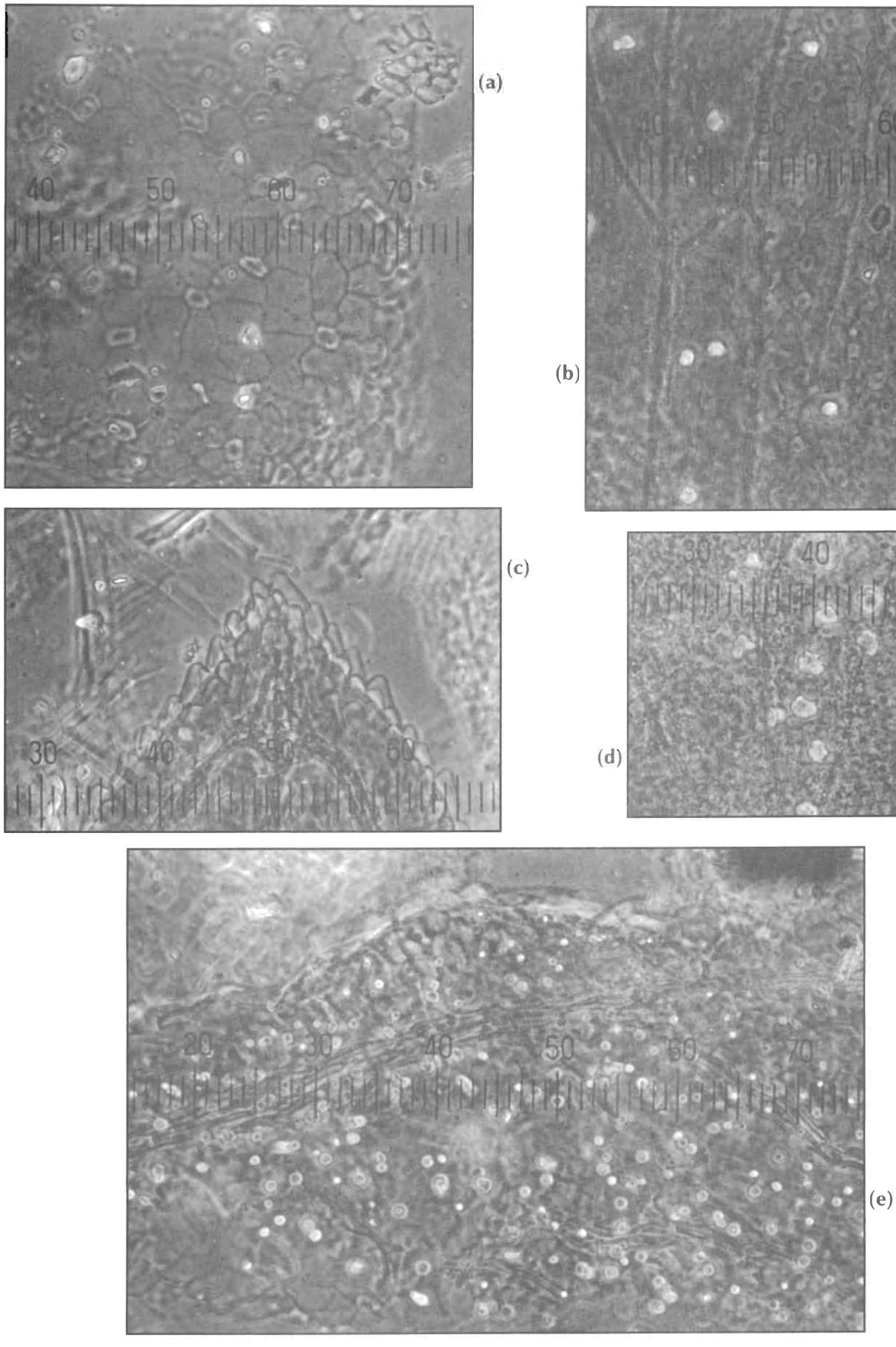
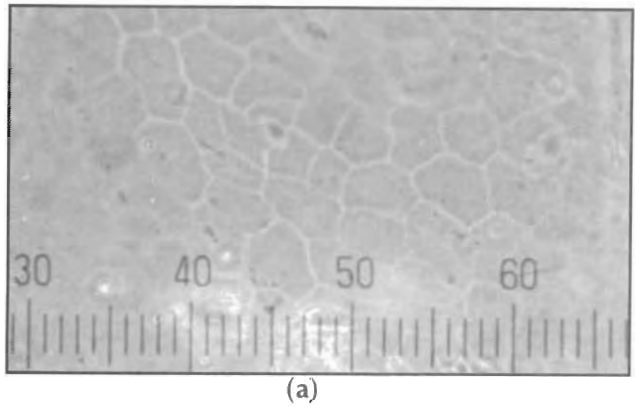
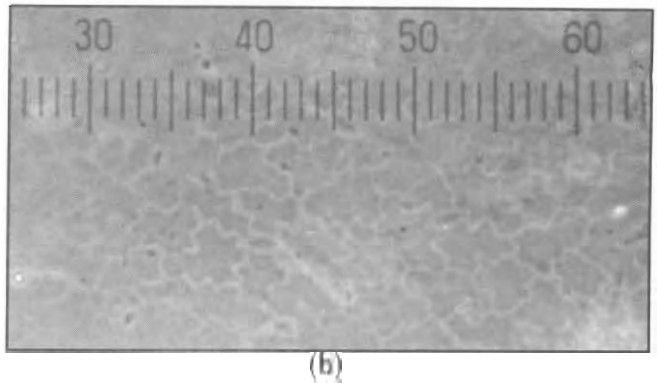


Figure 72. *Corydalis aurea*



(a)



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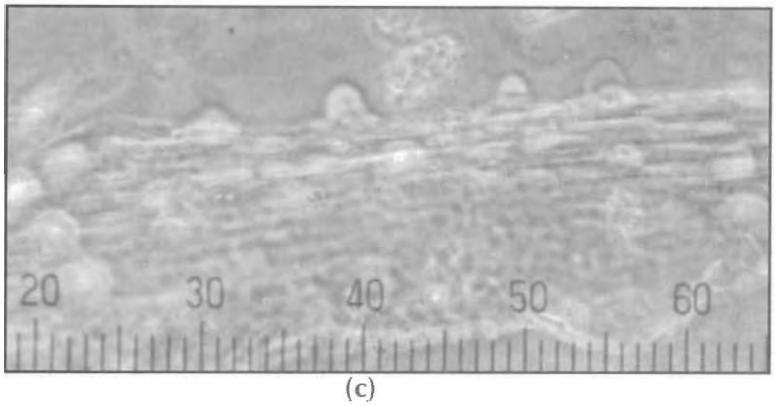

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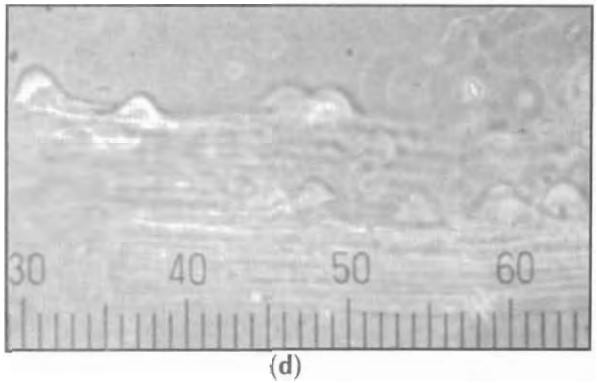
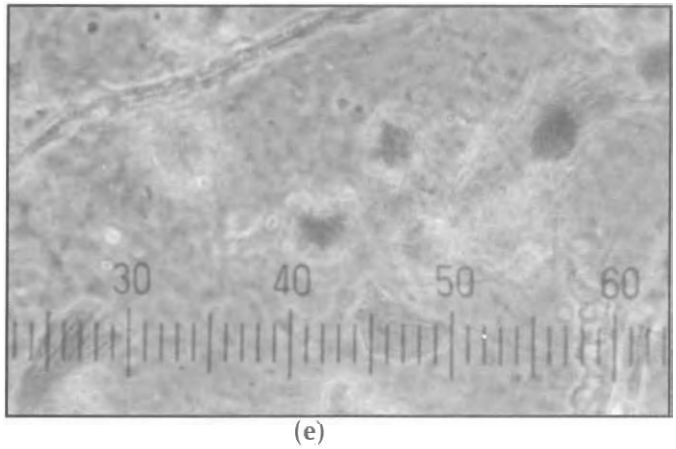
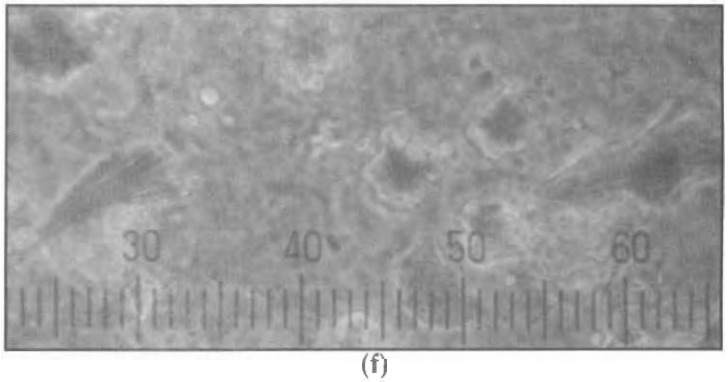


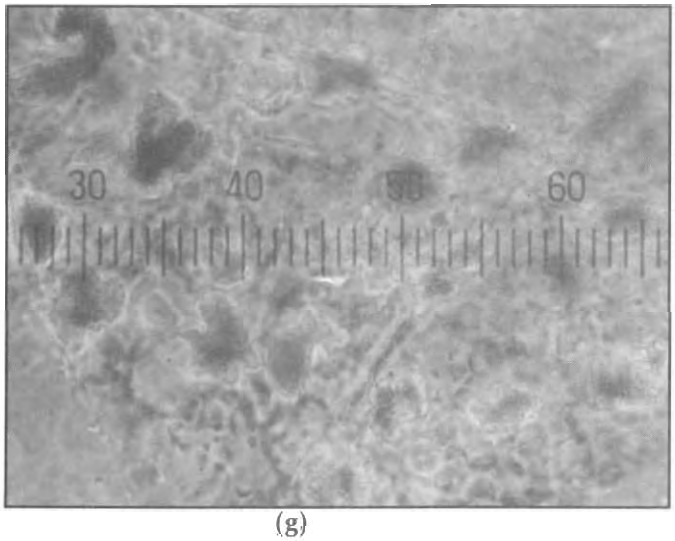
(d)



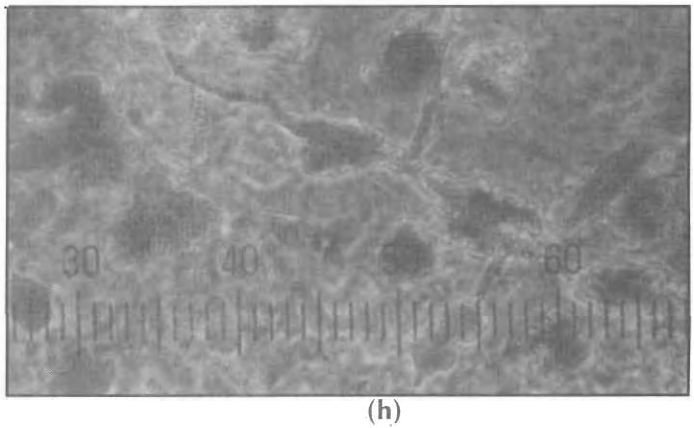
(e)



(f)

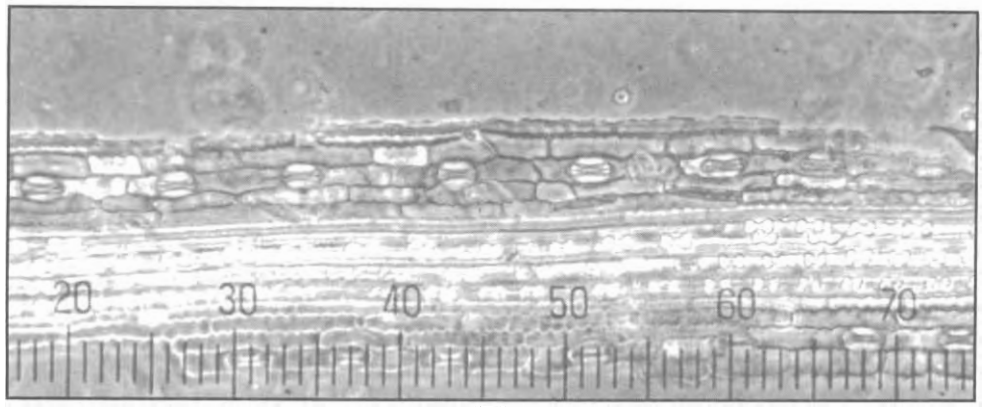


(g)

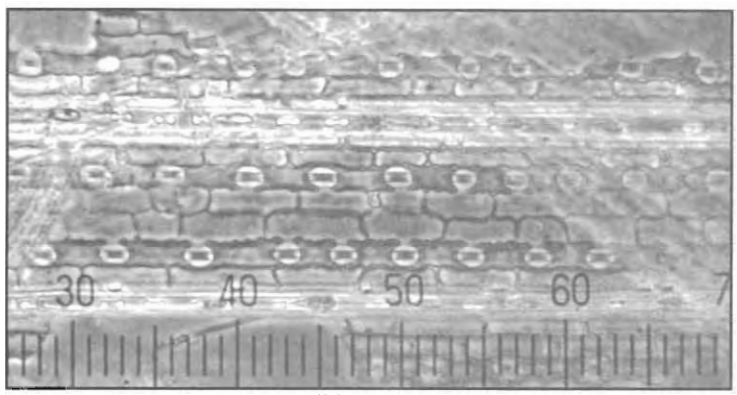


(h)

Figure 73. *Phytolacca americana*



(a)



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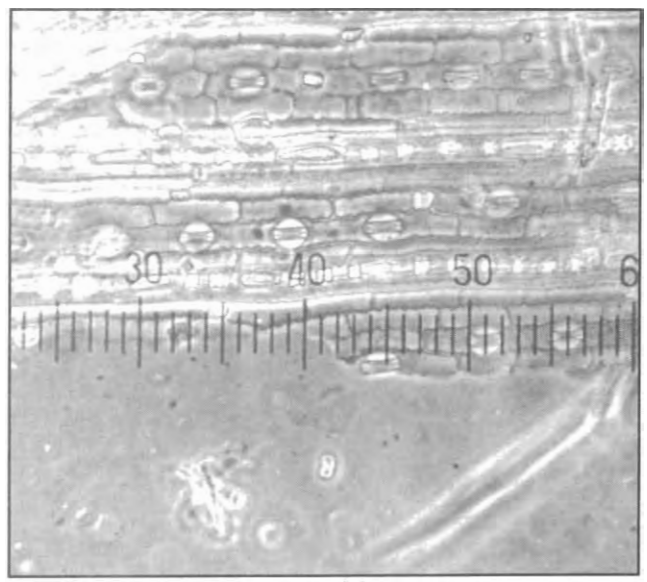

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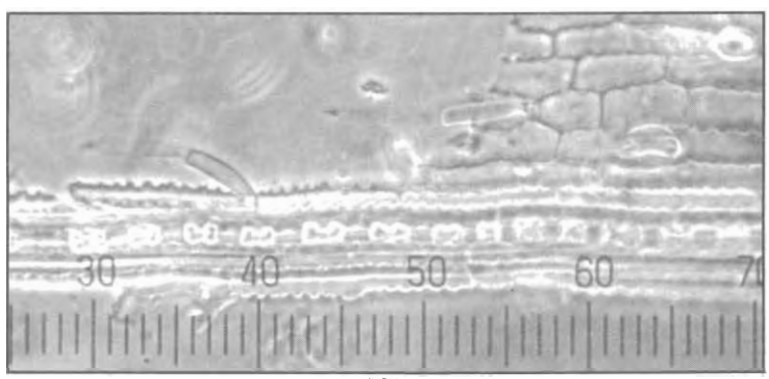
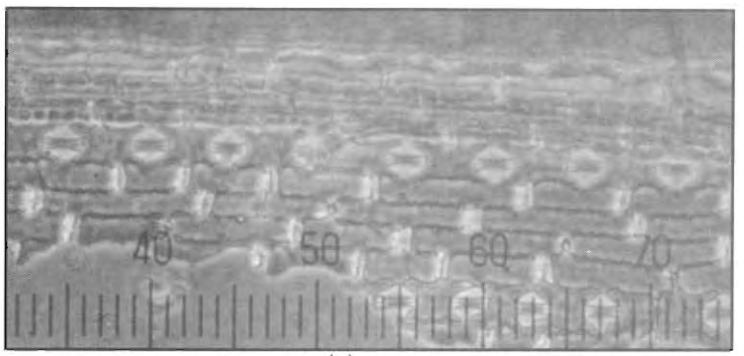
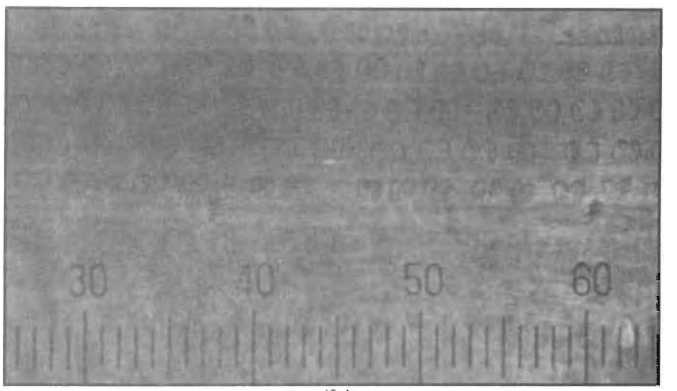


(d)

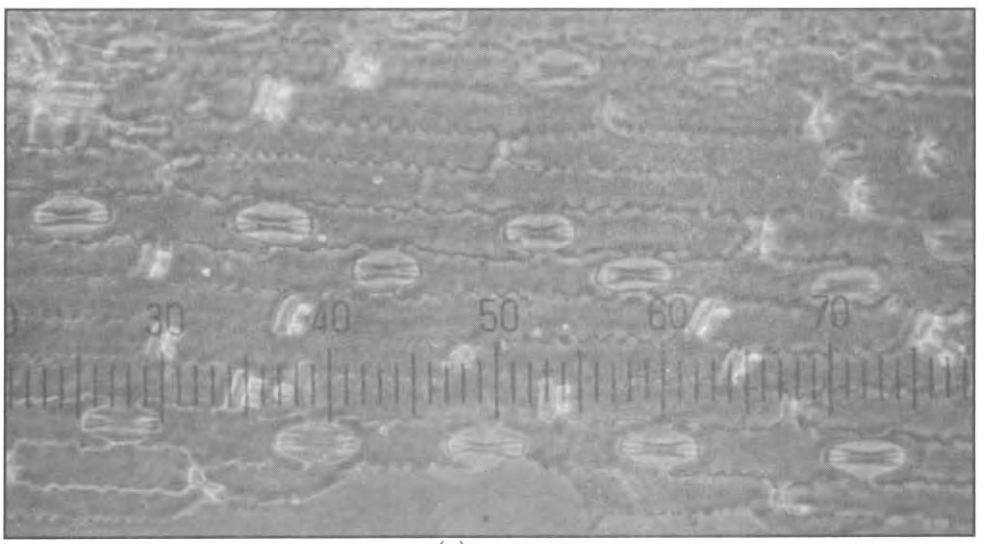
Figure 74. ***Panicum antidotale***



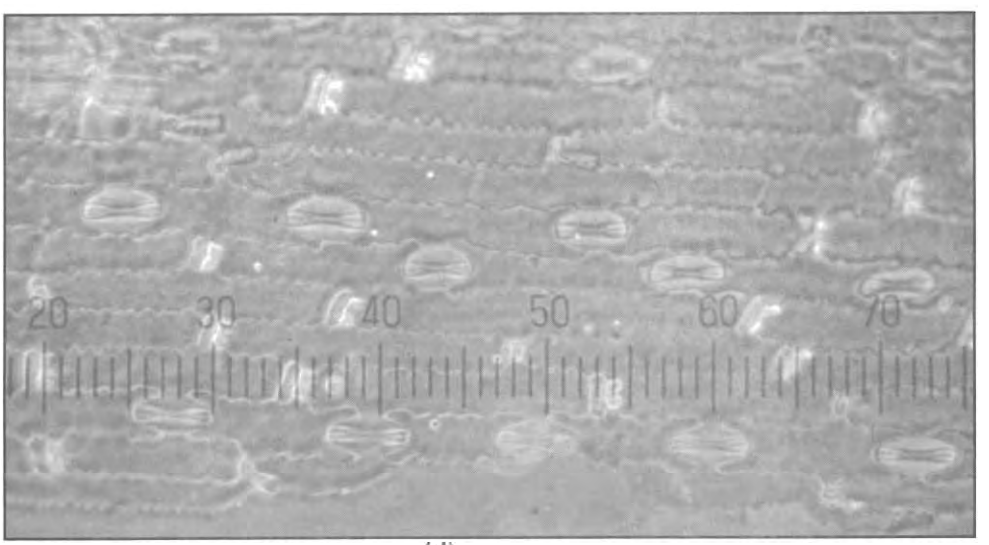
(a)



(b)

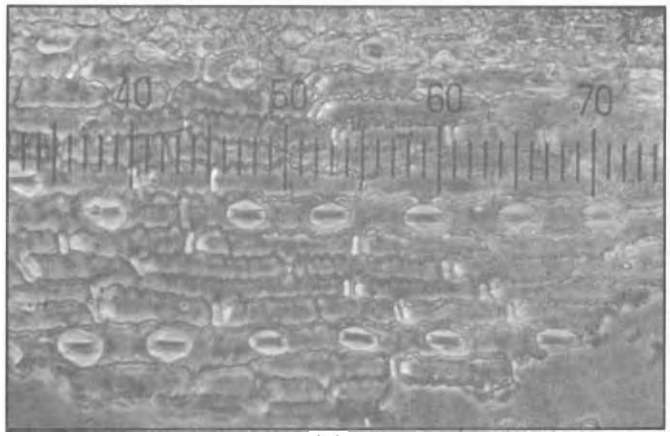


(c)

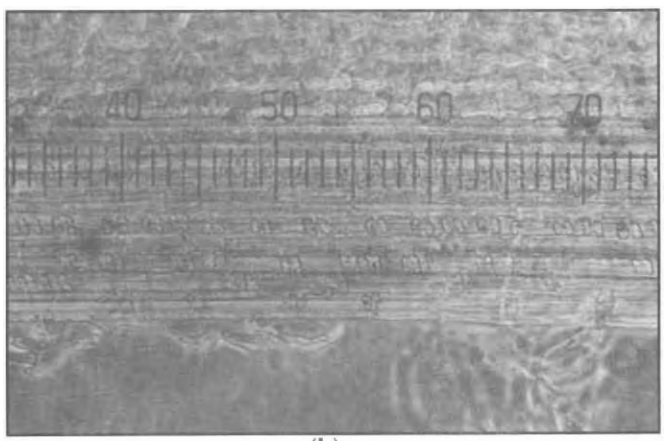


(d)

Figure 75. ***Sorghum almum***



(a)



(b)

Figure 76. ***Sorghum bicolor***

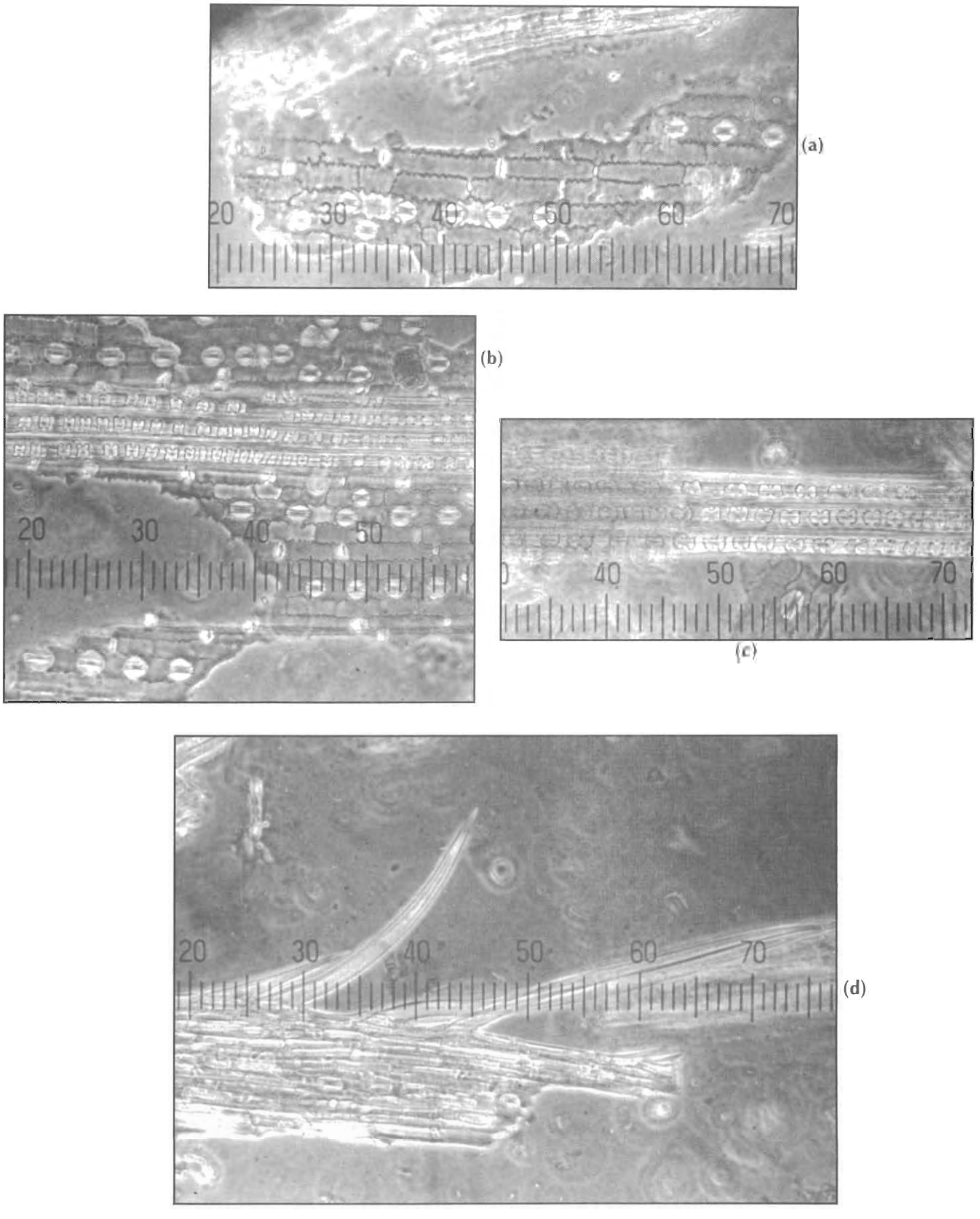
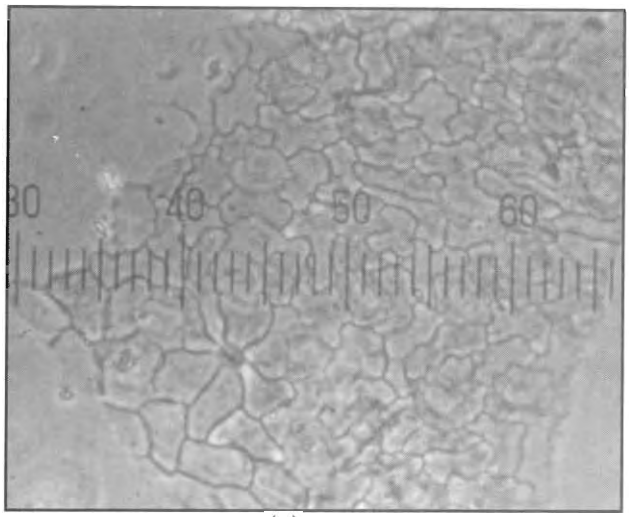
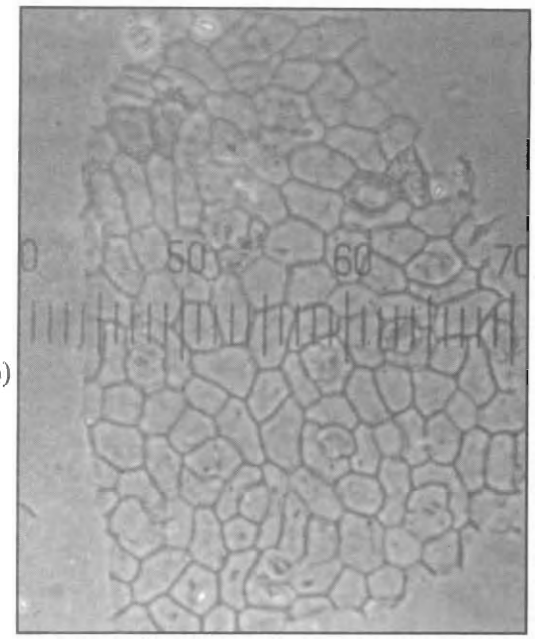


Figure 77. ***Sorghum halepense***



(a)



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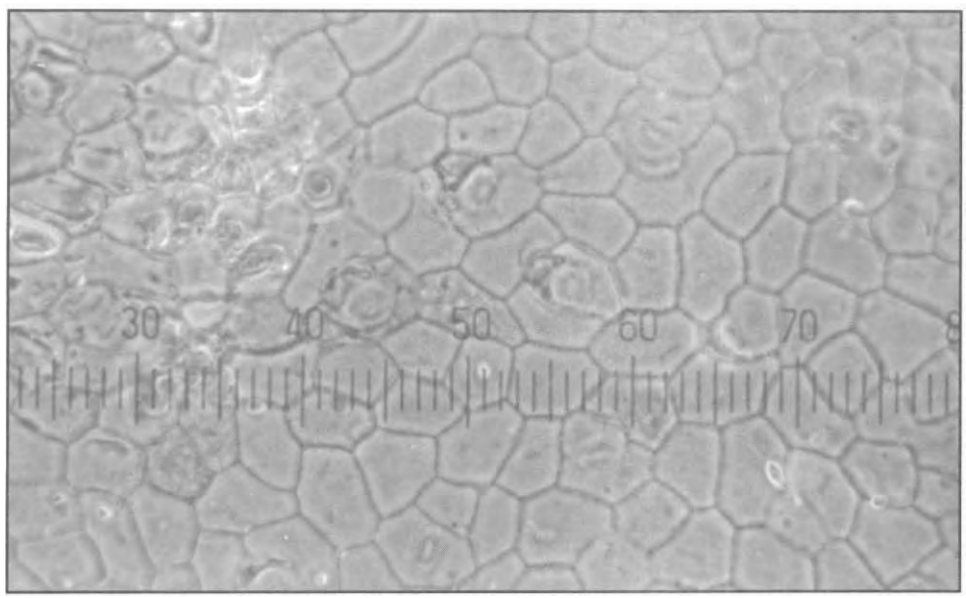
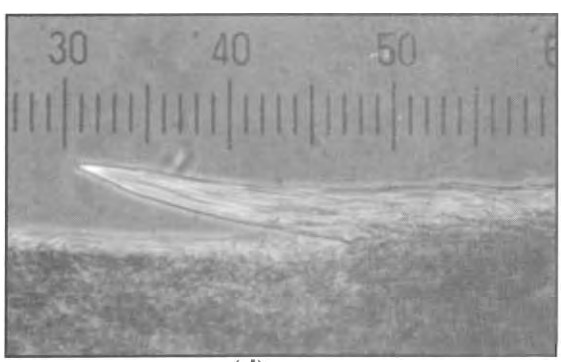


(c)



(d)

(e)

Figure 78. ***Persicaria hydropiperoides***

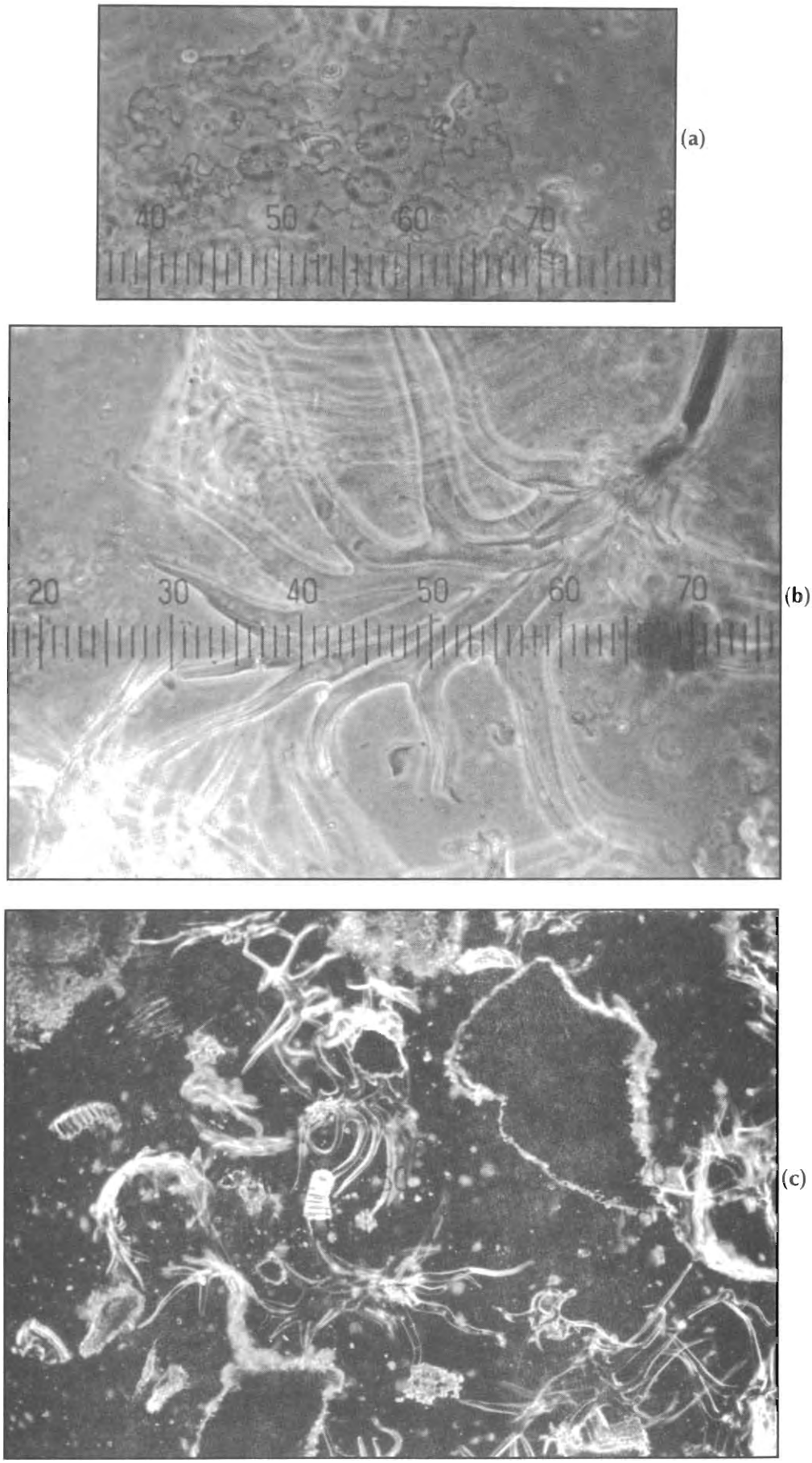
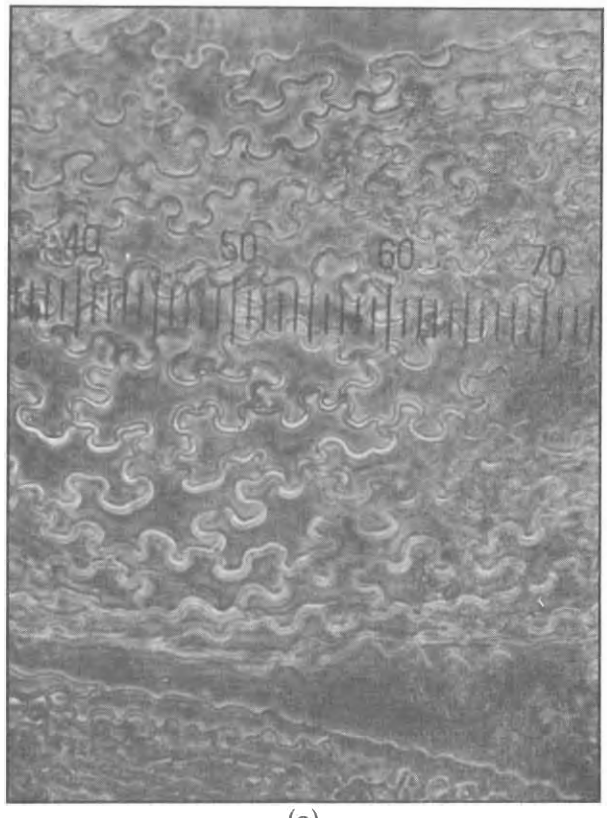
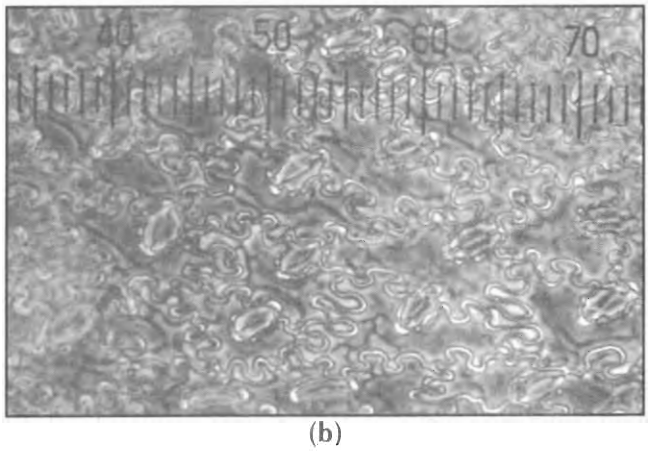


Figure 79. *Notholaena sinuata*

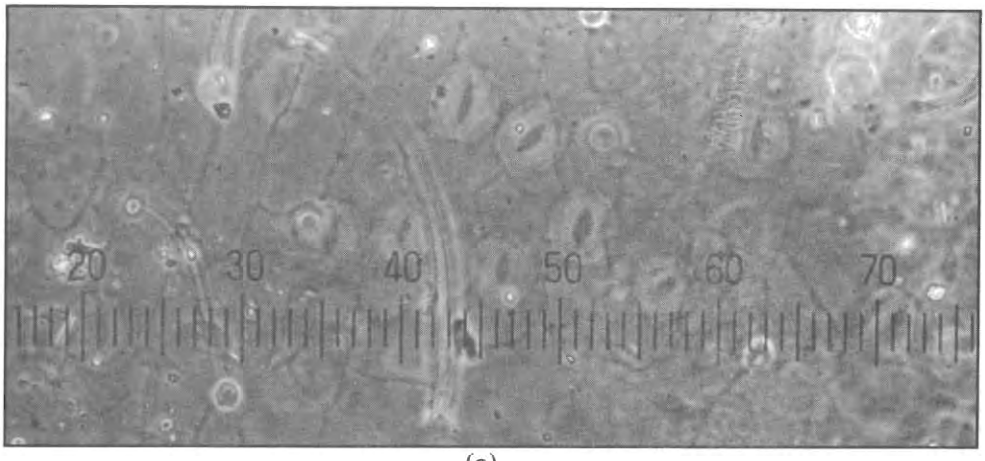


(a)

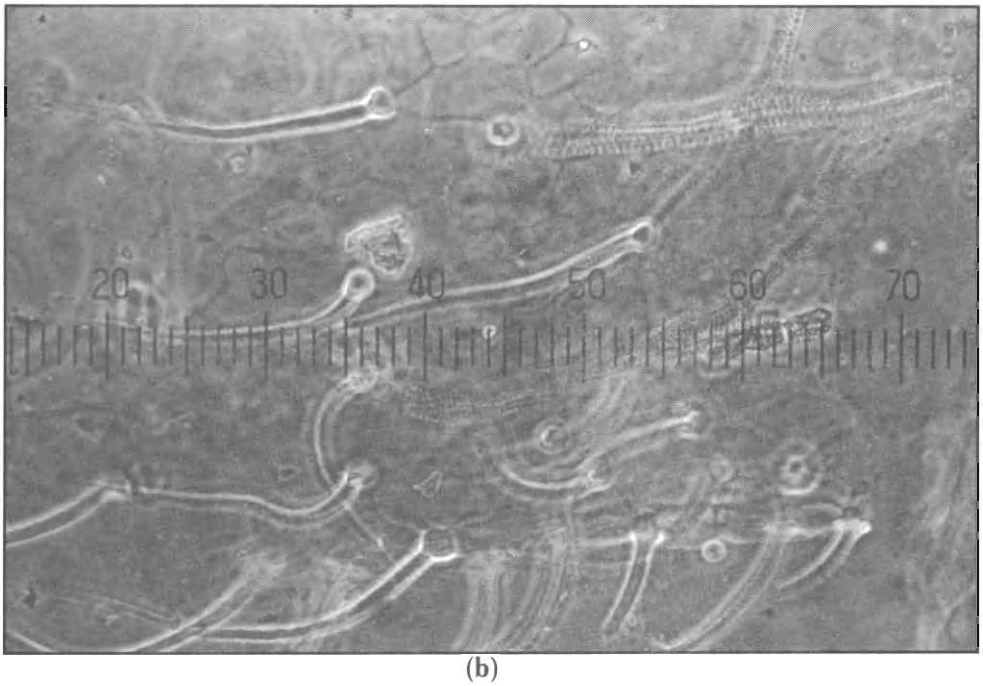


(b)

Figure 80. ***Pteridium aquilinum***



(a)



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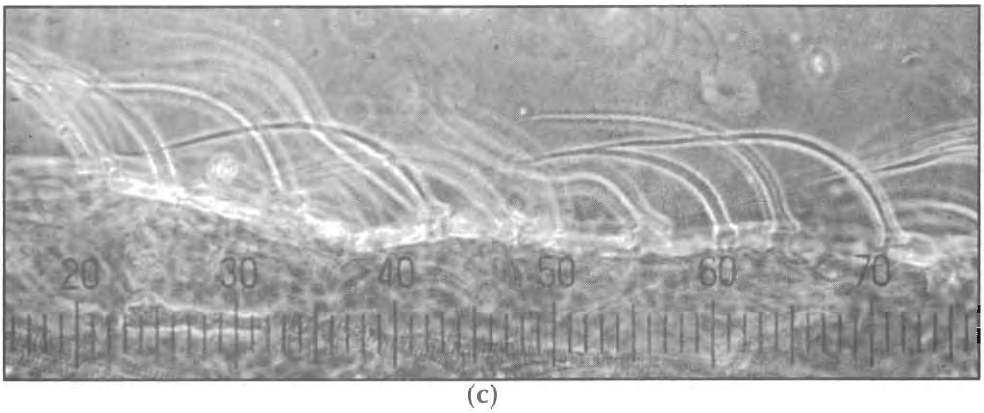
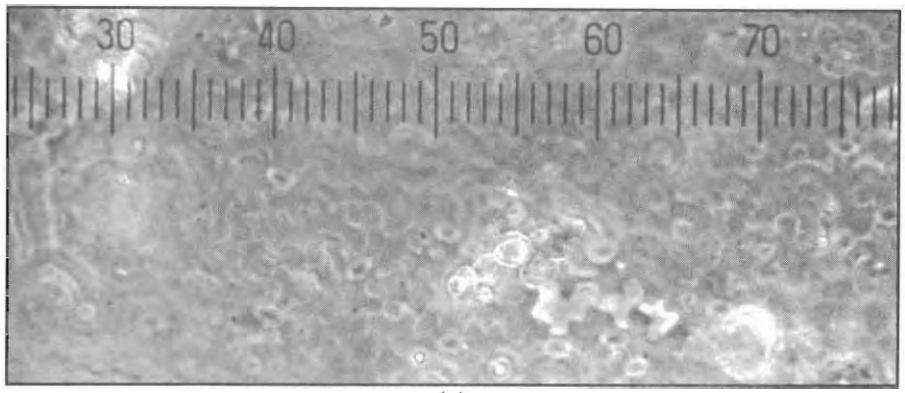
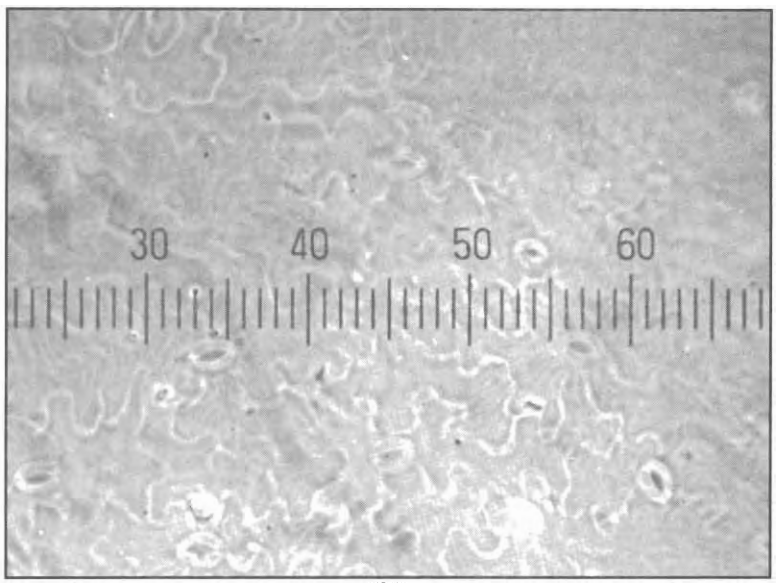


(c)

Figure 81. ***Delphinium virescens***



(a)



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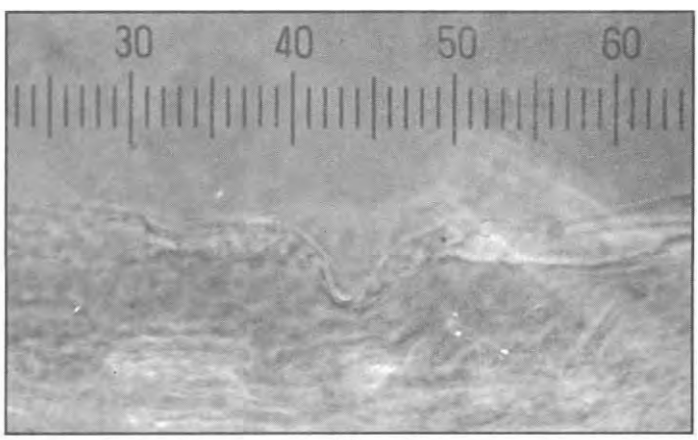
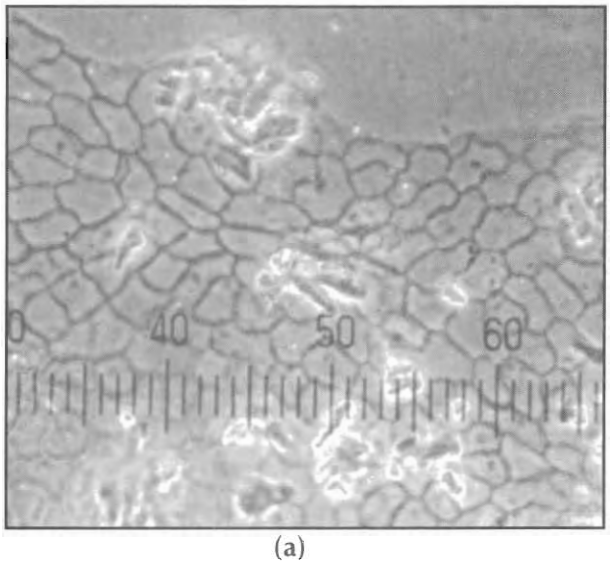
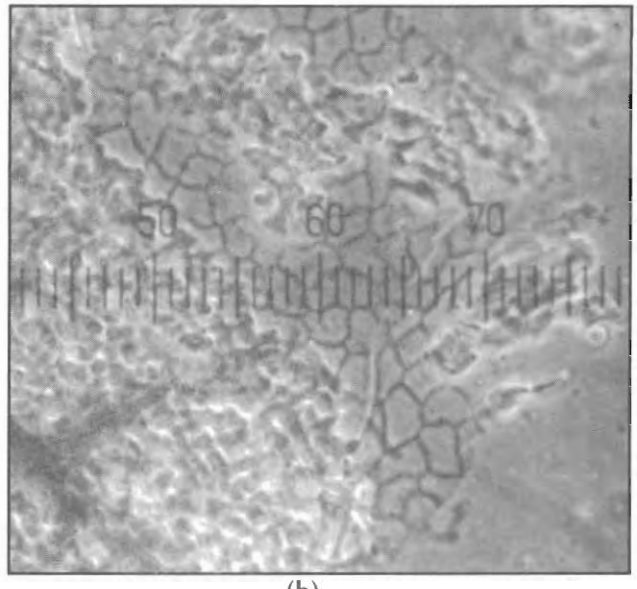


(c)

Figure 82. *Oligomeris linifolia*



(a)



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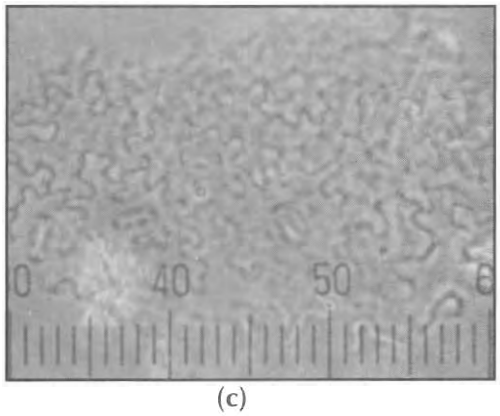

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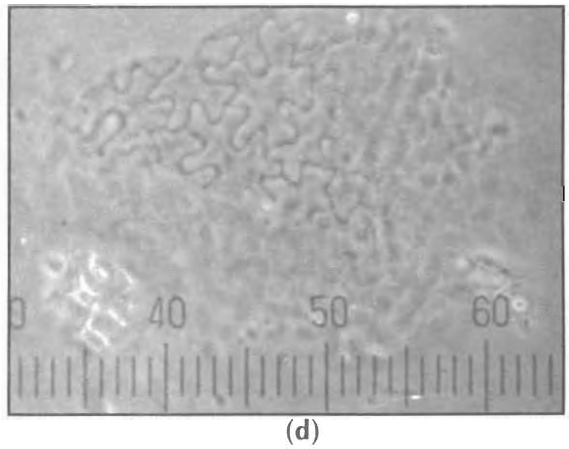

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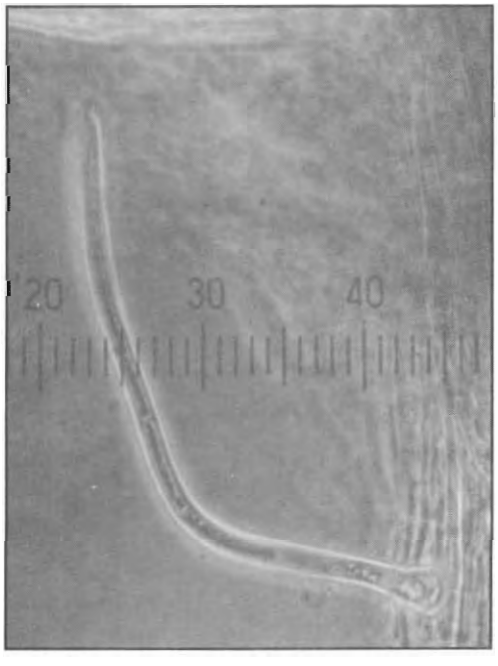
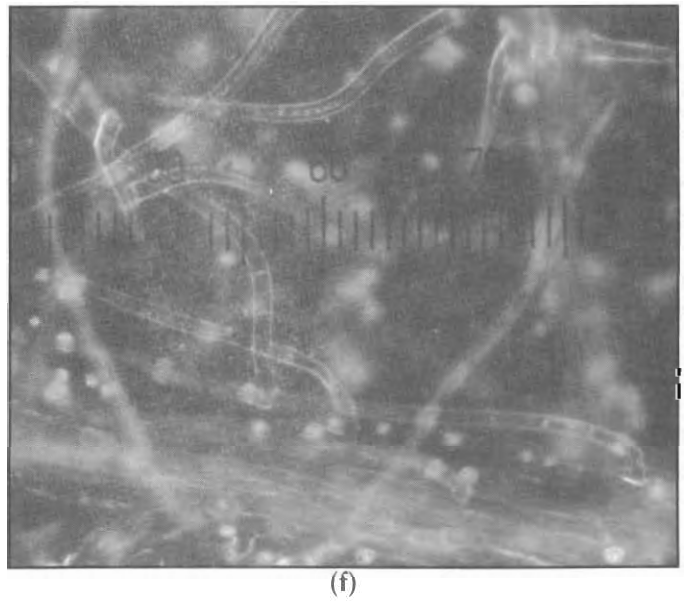
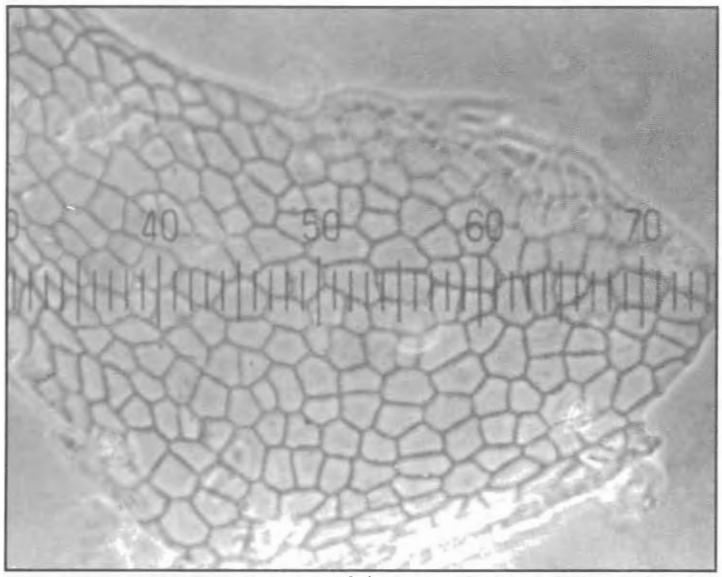


(e)

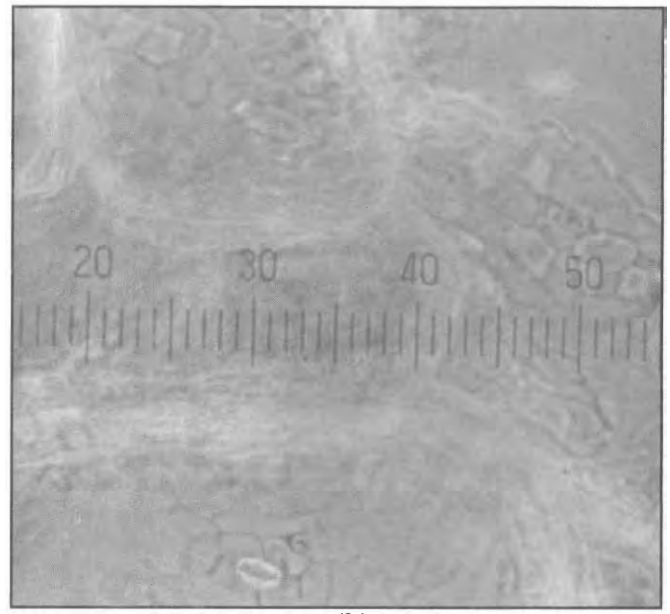


(f)

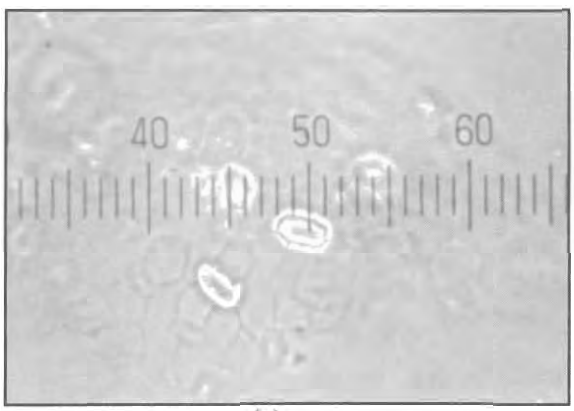
Figure 83. *Colubrina texensis*



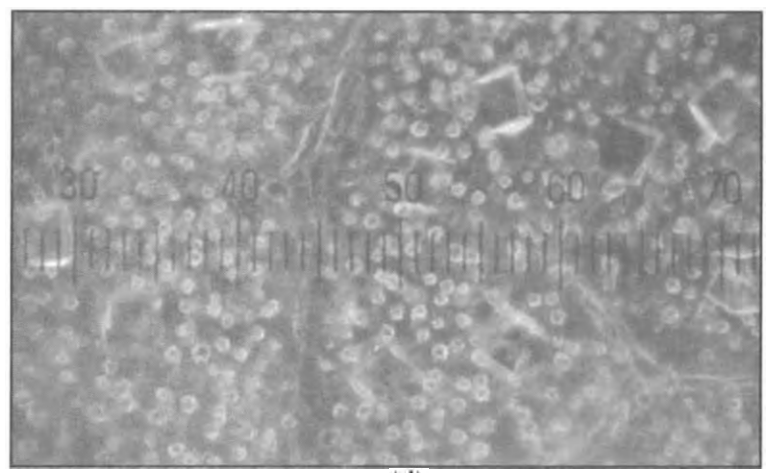
(a)



(b)



(c)



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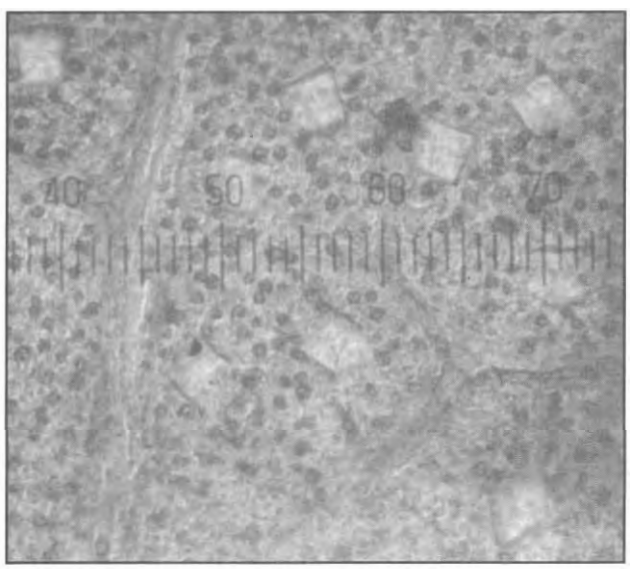
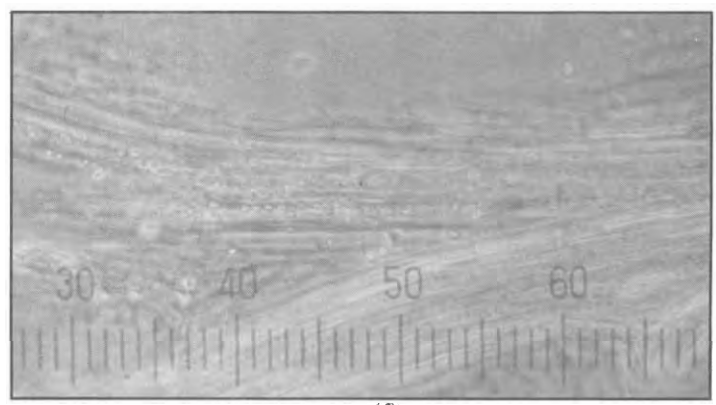
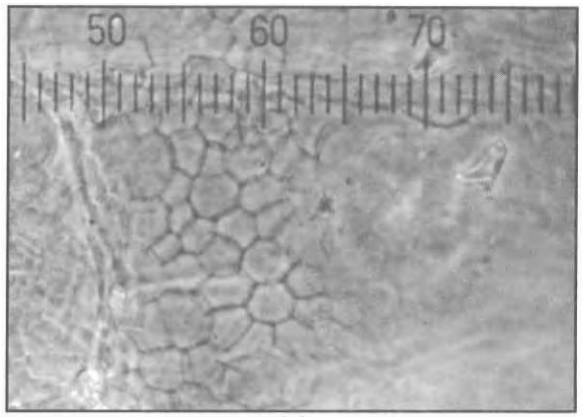


(e)

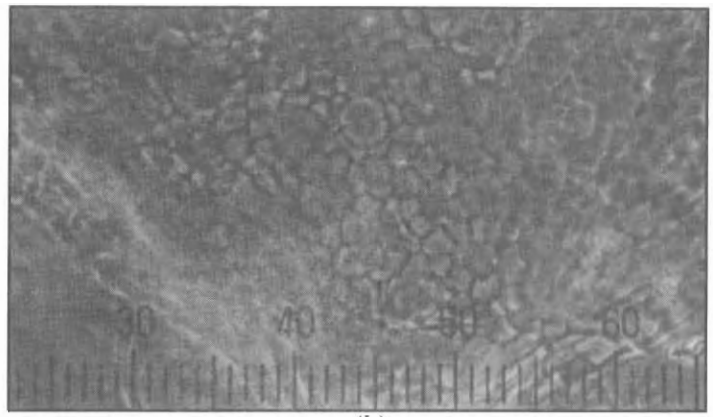


(f)

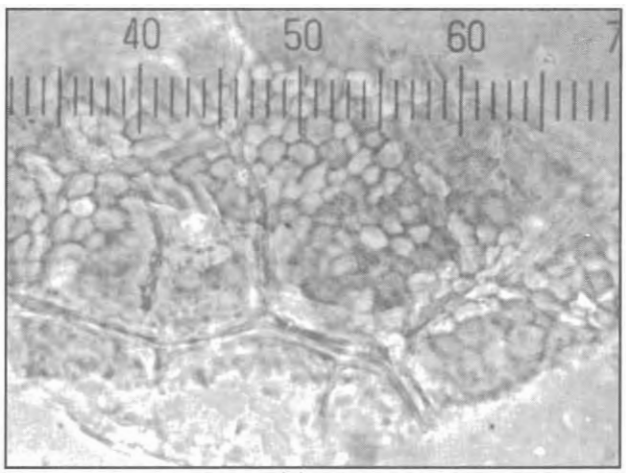
Figure 84. ***Karwinskia humboldtiana***



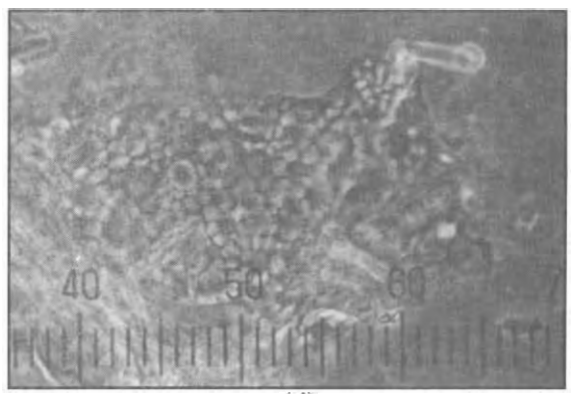
(a)



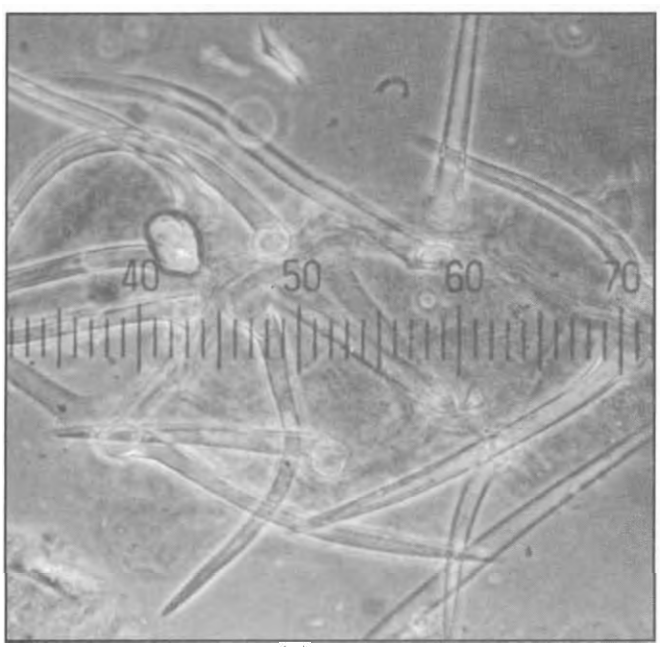
(b)



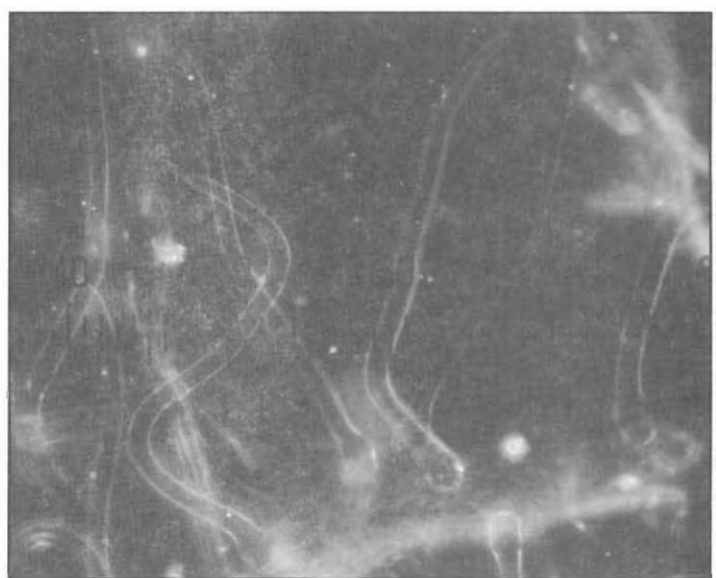
(c)



(d)

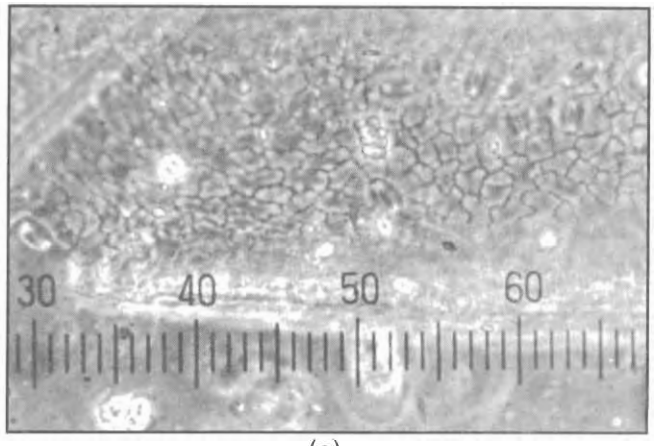


(e)

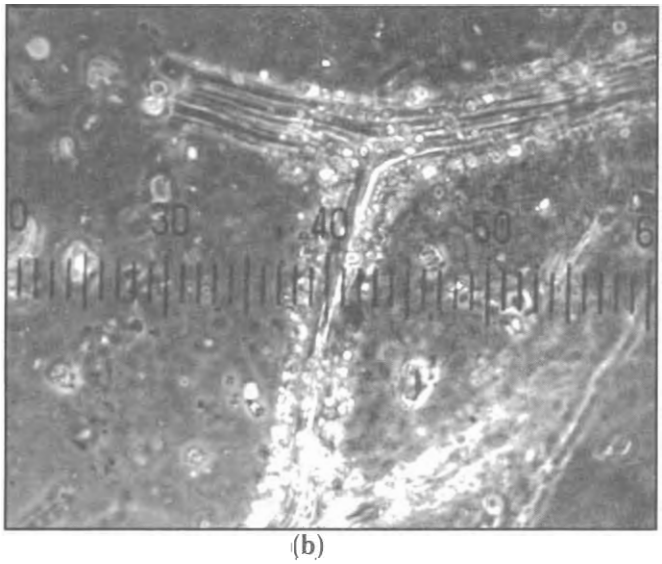


(f)

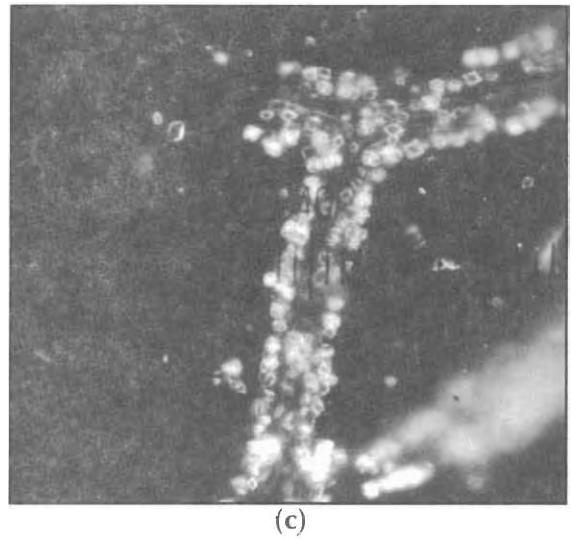
Figure 85. *Prunus gracilis*



(a)



(b)



(c)

Figure 86. *Prunus virginiana*

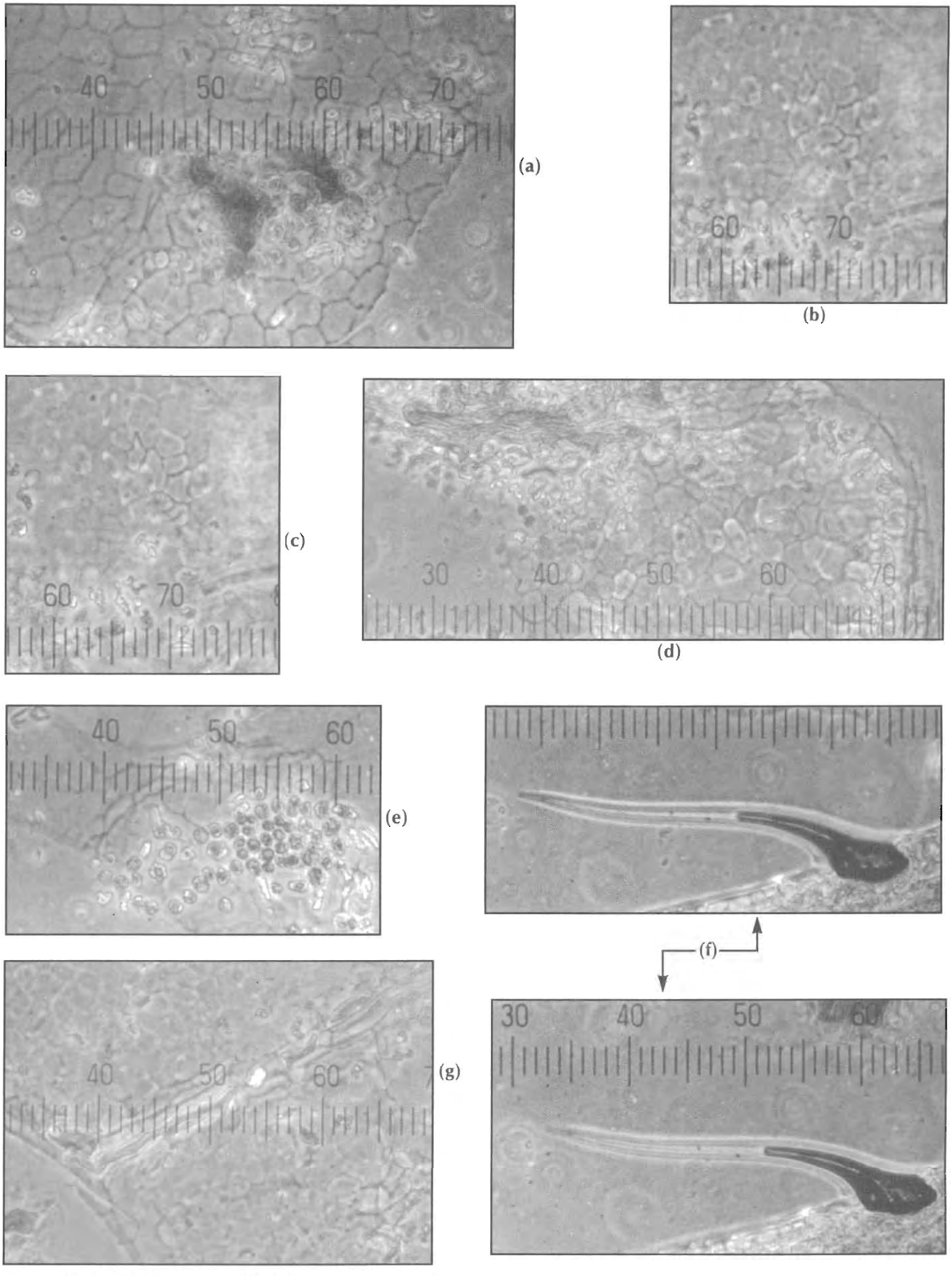
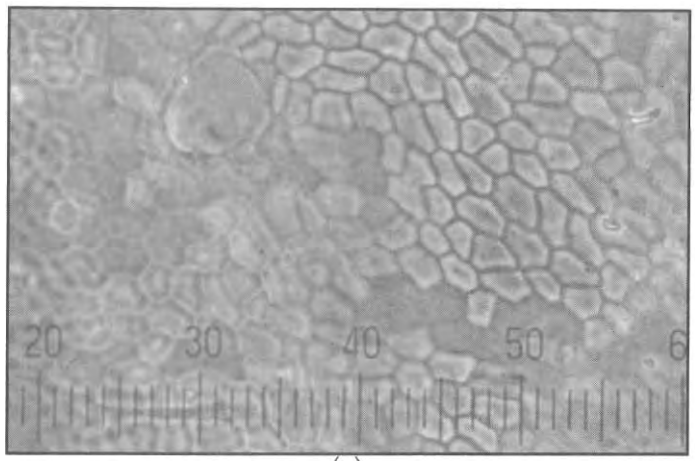
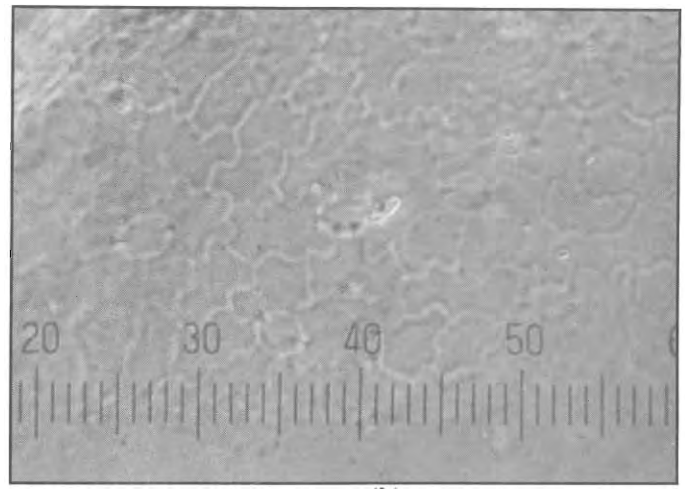


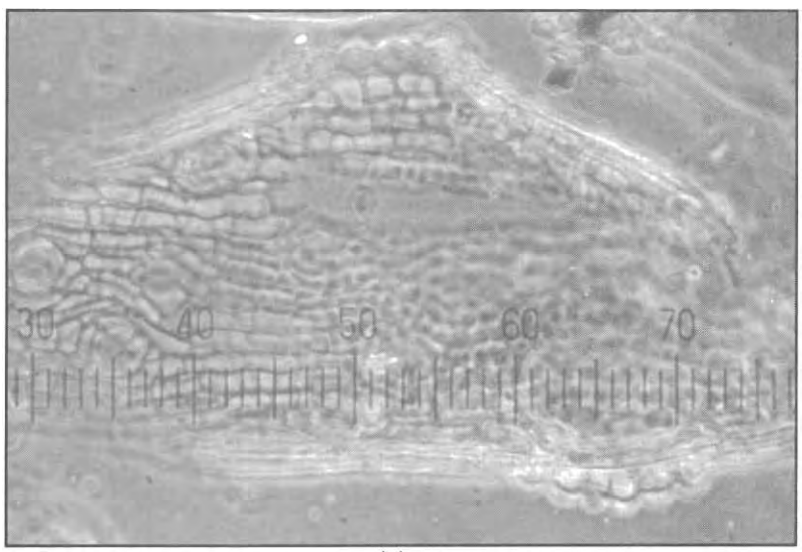
Figure 87. ***Cephalanthus occidentalis***



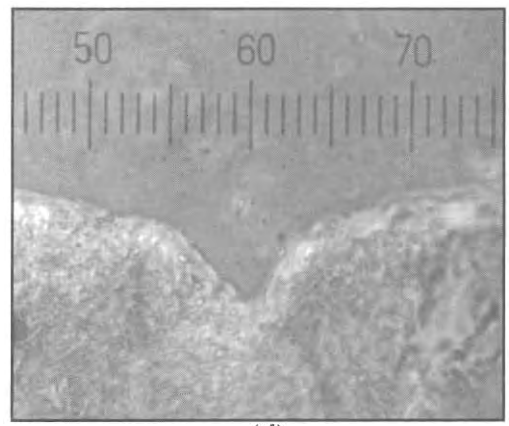
(a)



(b)



(c)



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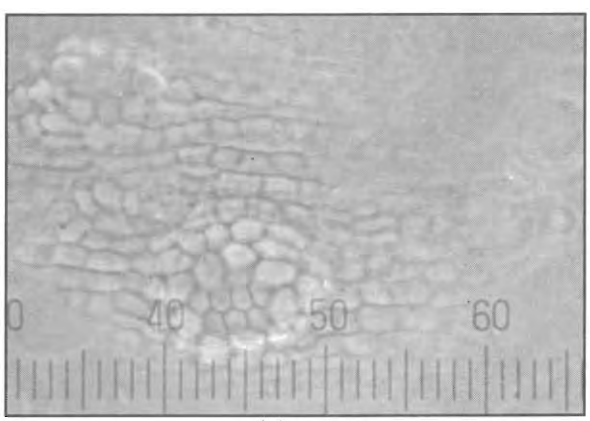
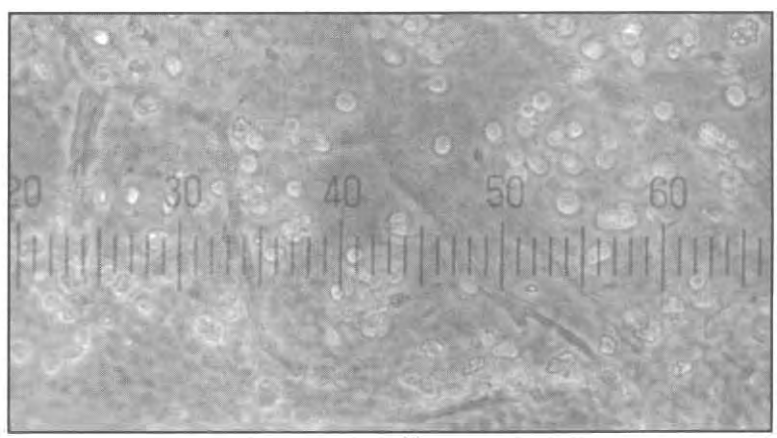
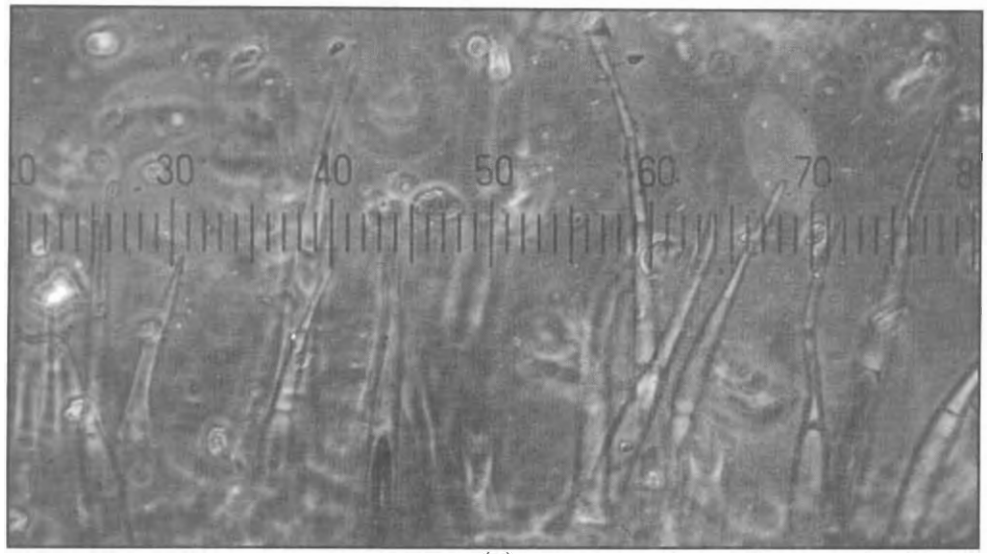


(e)

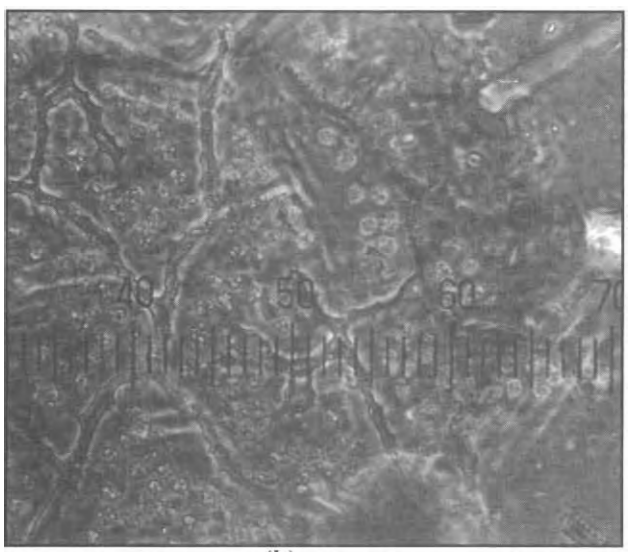


(f)

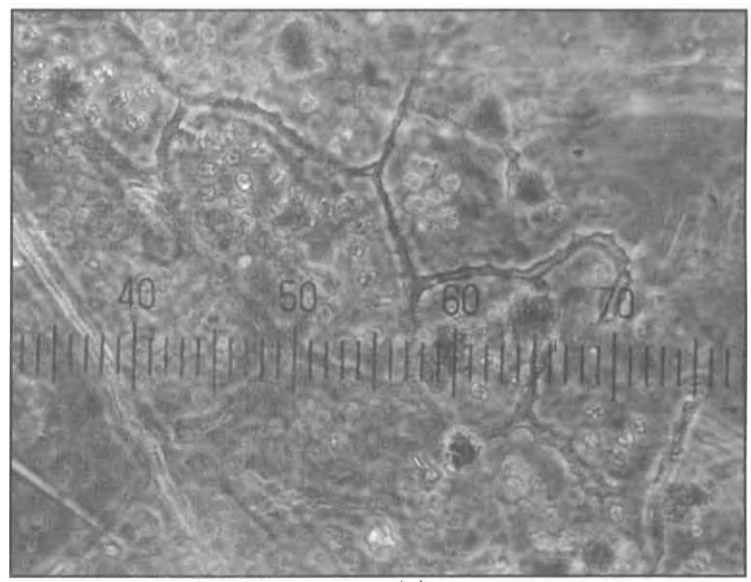
Figure 88. ***Thamnosma texana***



(a)

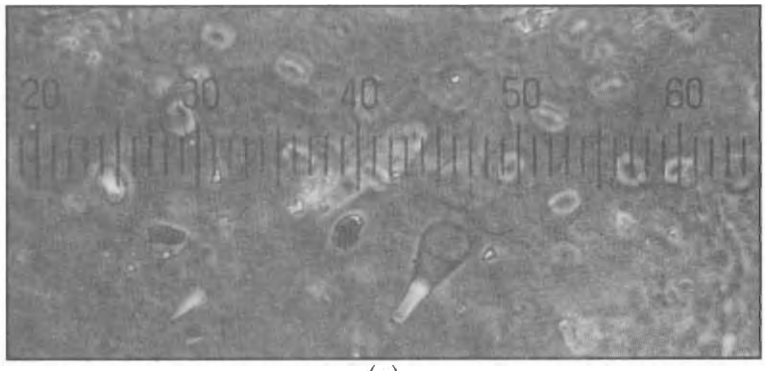


(b)

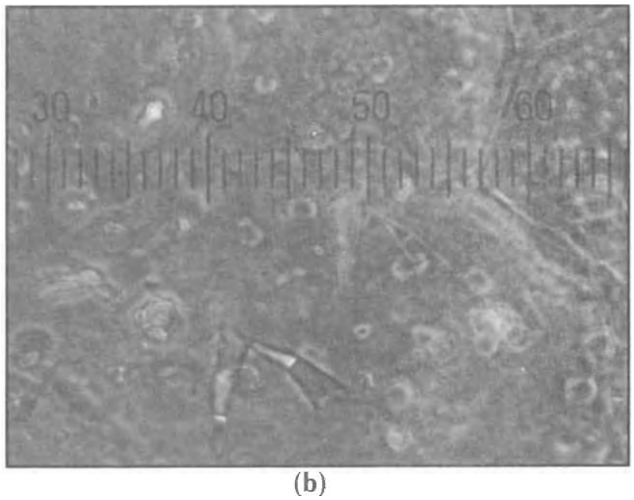


(c)

Figure 89. *Datura inoxia*



(a)



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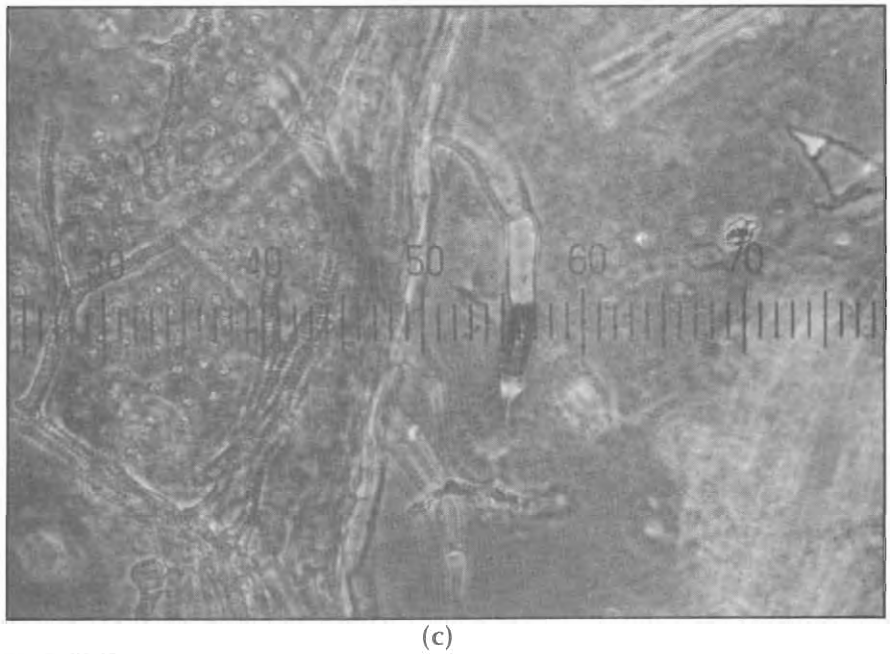
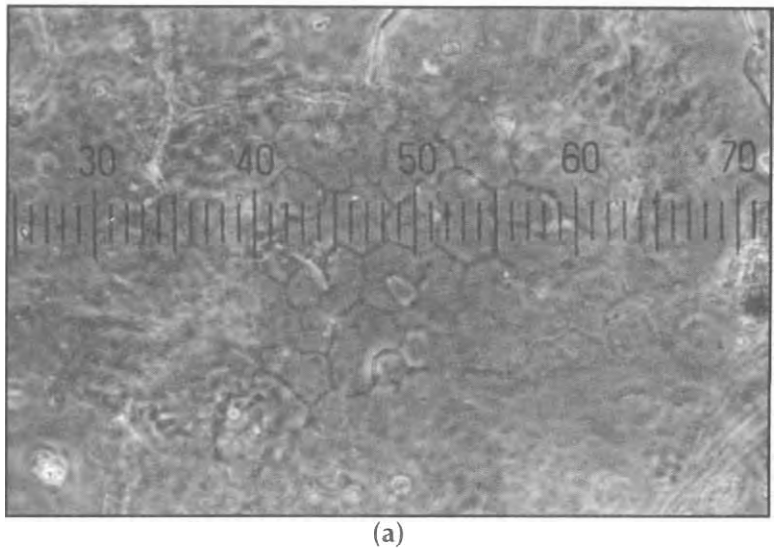
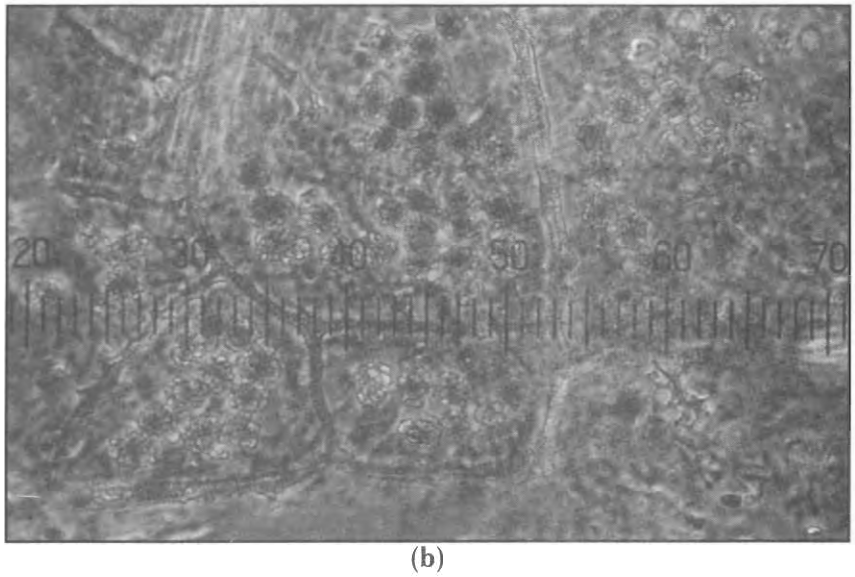


(c)

Figure 90. *Datura quercifolia*

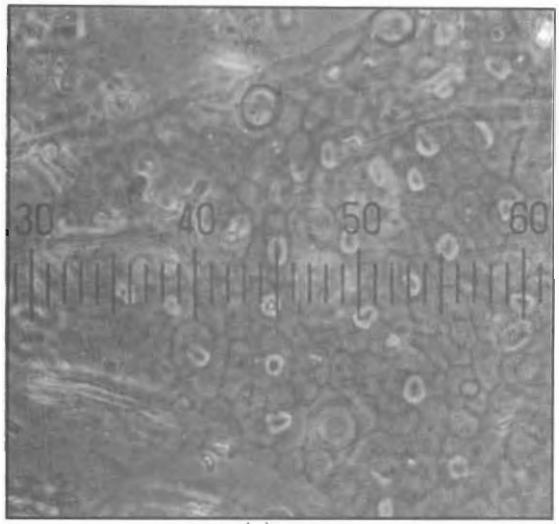


(a)

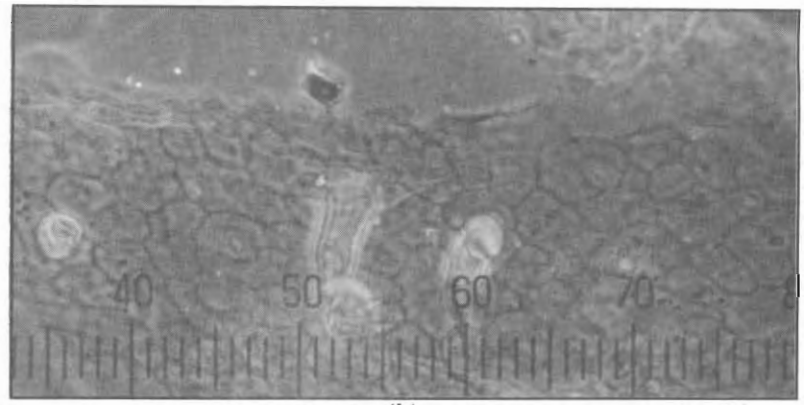


(b)

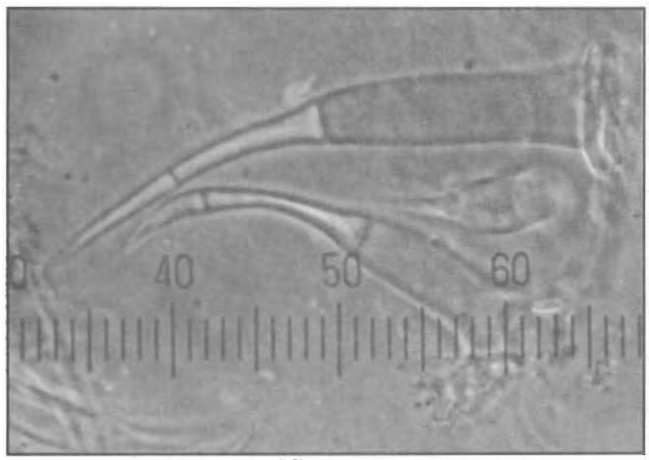
Figure 91. ***Datura stramonium***



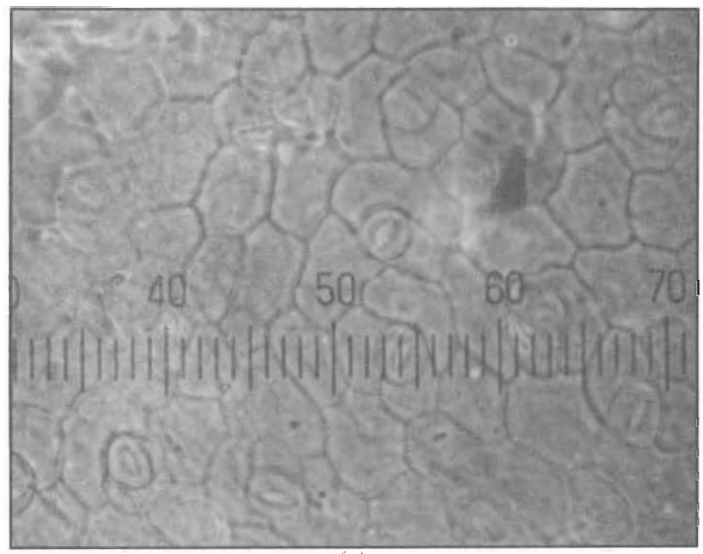
(a)



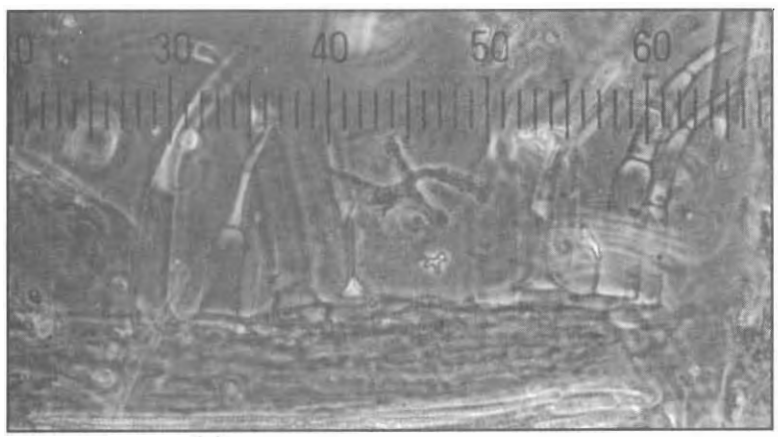
(b)



(d)

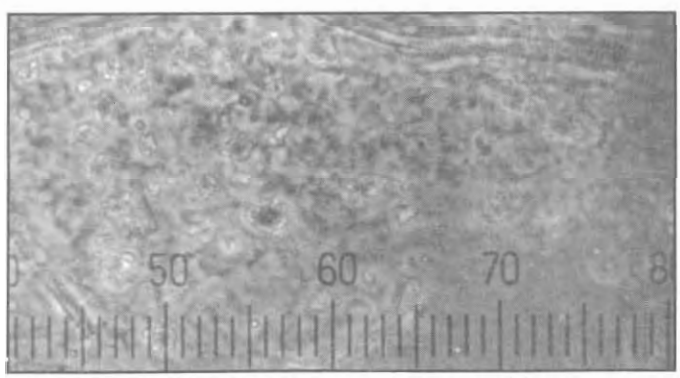


(c)



(e)

(f)



(g)

Figure 92.. *Datura wrightii*

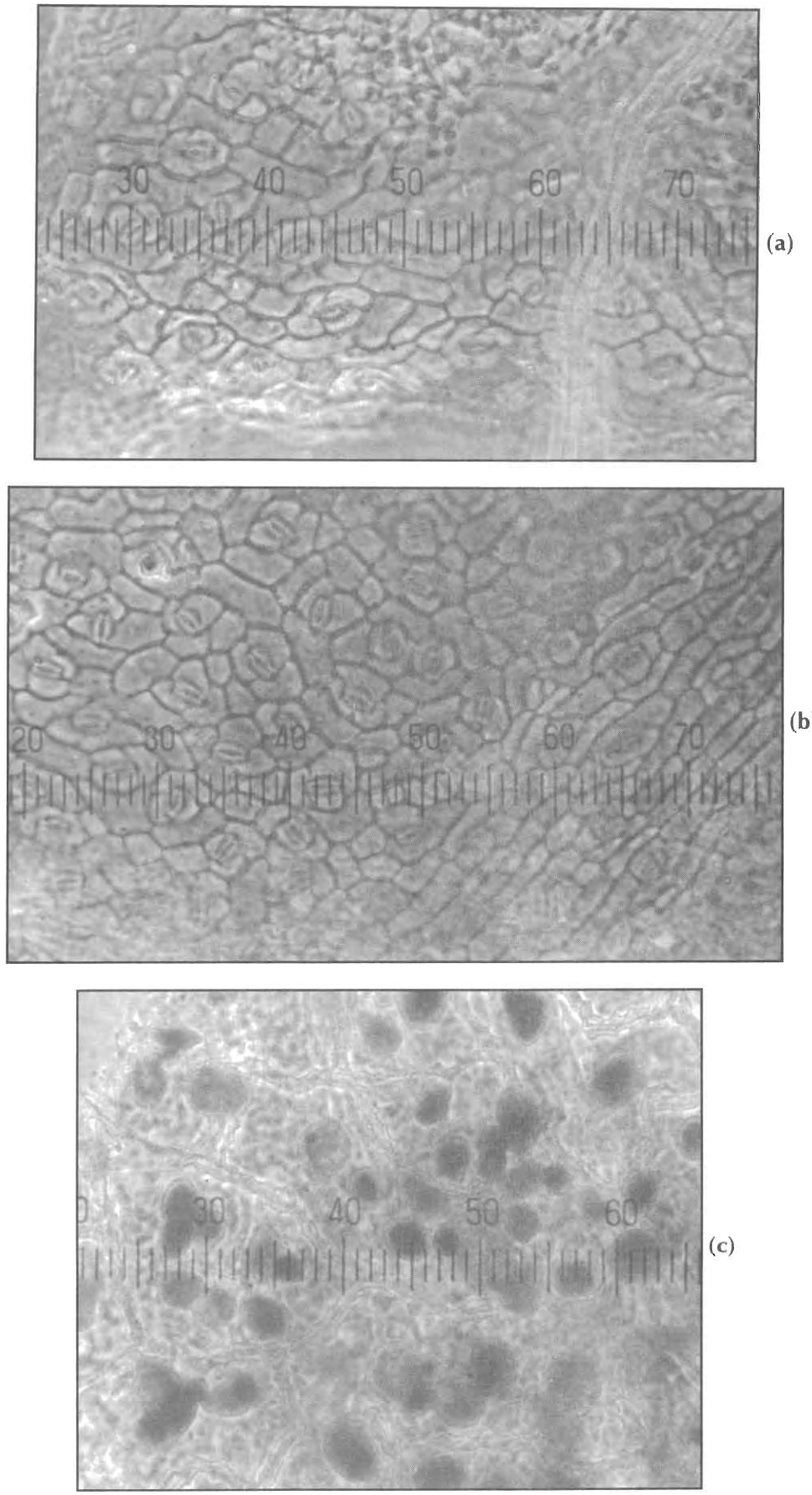
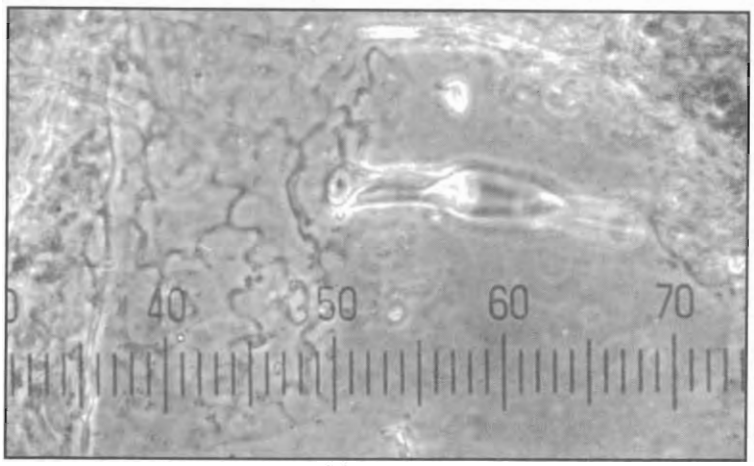
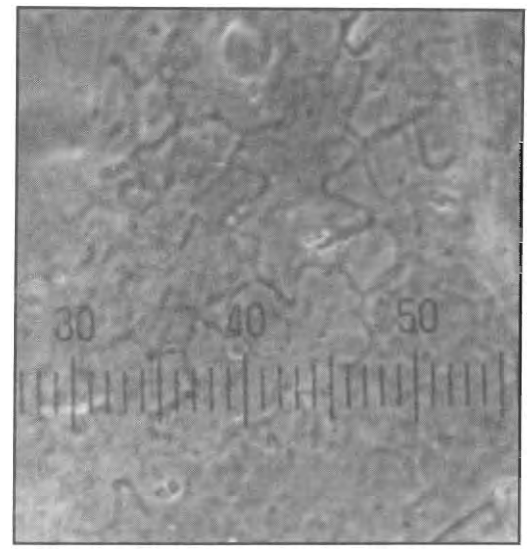


Figure 93. *Nicotiana glauca*



(a)



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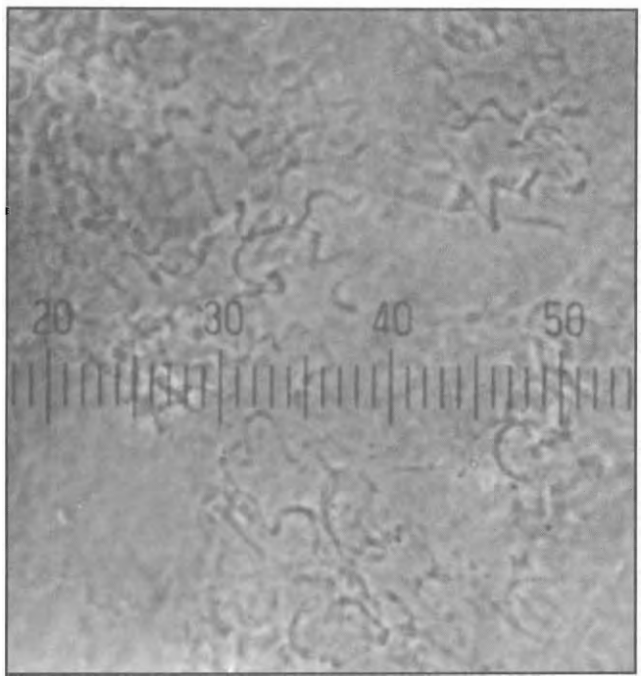
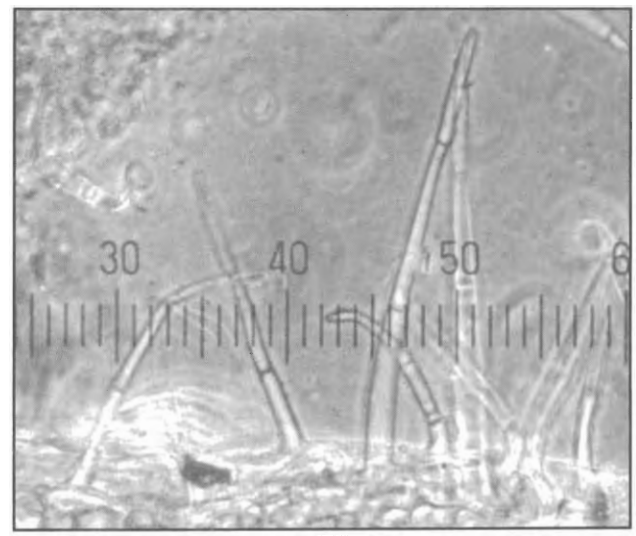
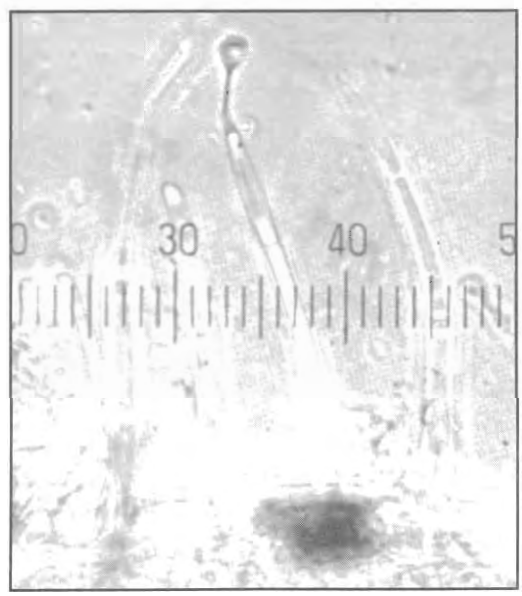


(c)

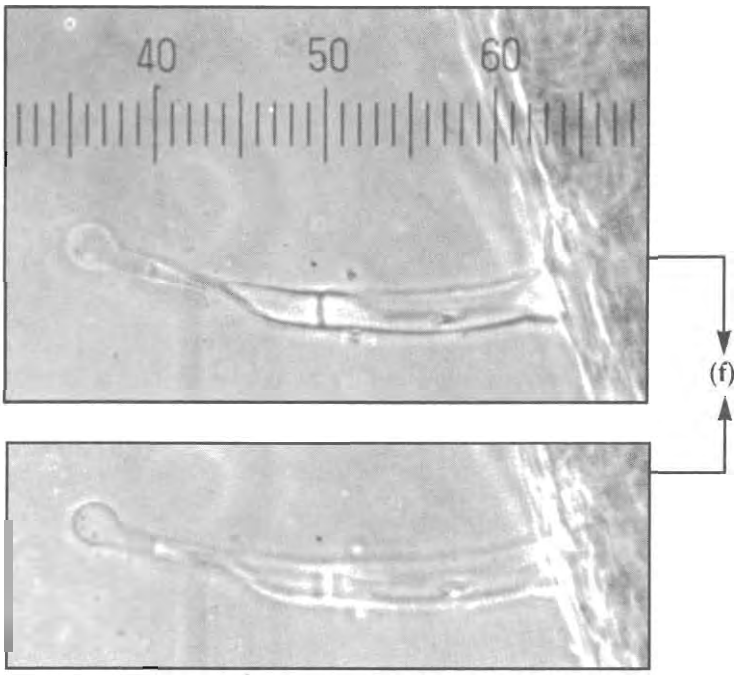


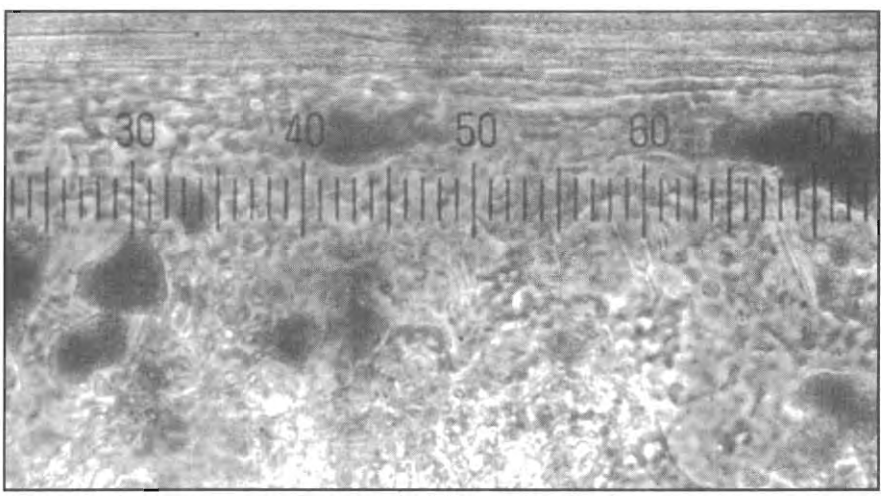
(d)



(e)

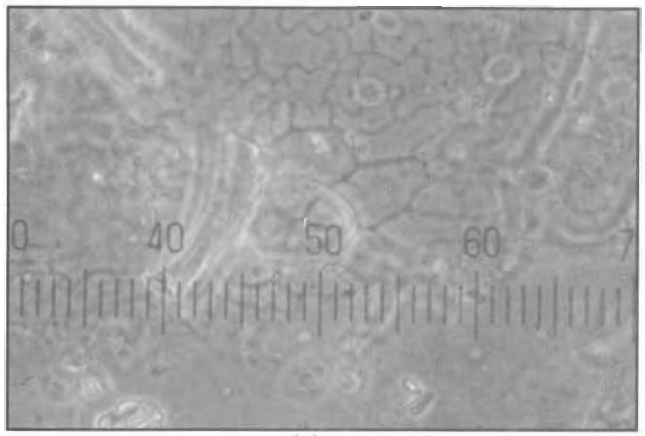
Figure 94. *Nicotiana repanda*



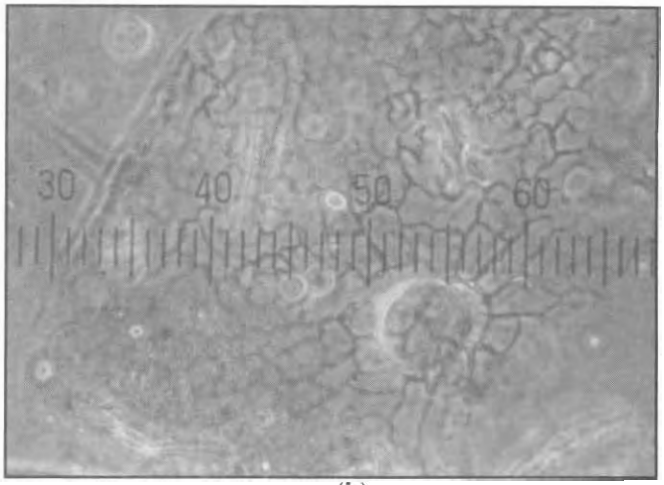


(g)

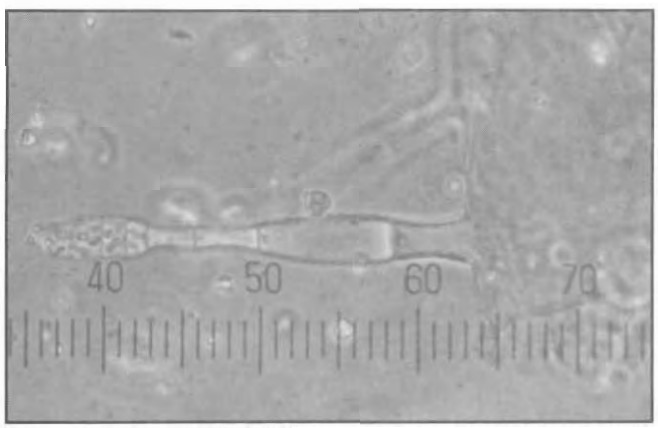
Figure 94. (continued)



(a)



(b)



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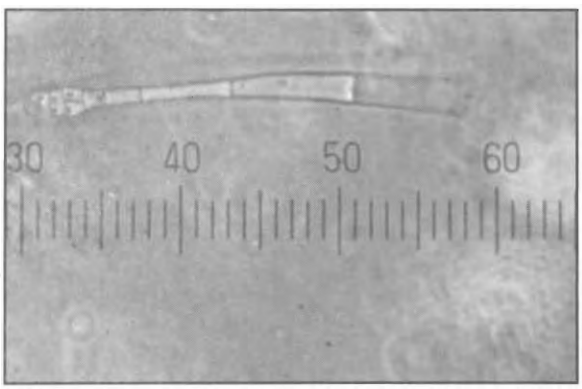

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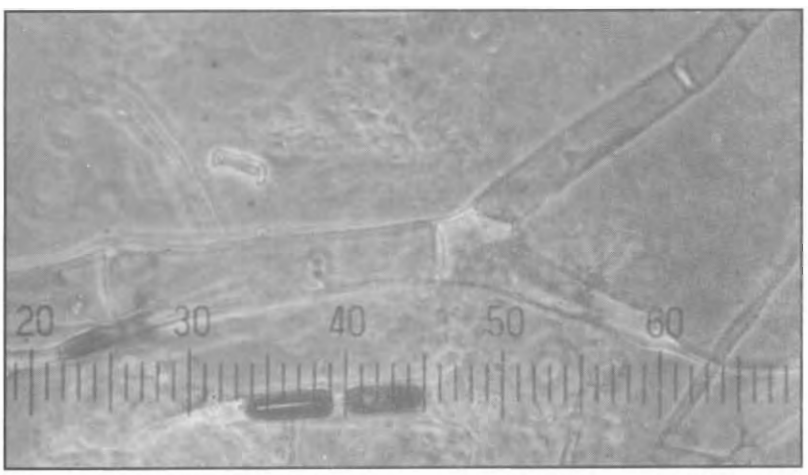
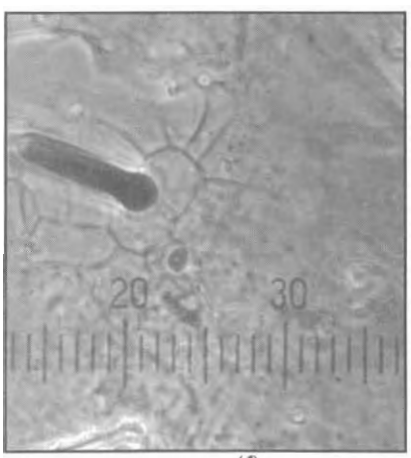
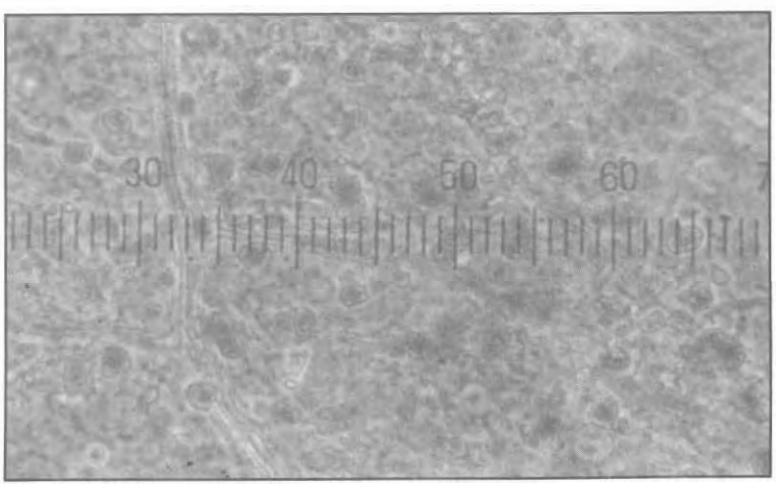


(e)

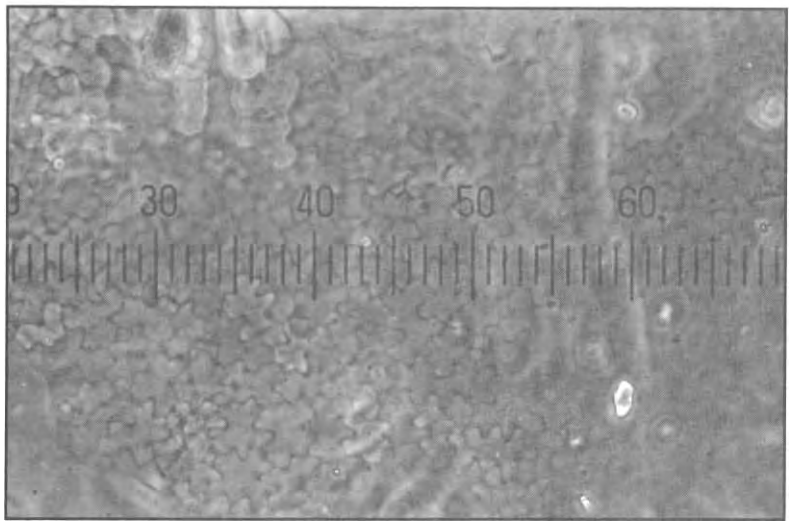


(f)

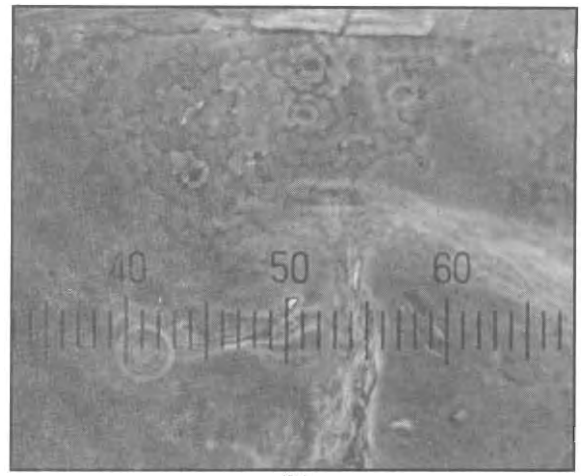


(g)

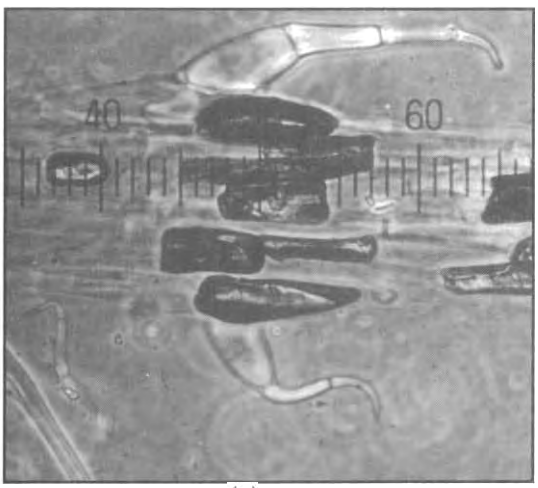
Figure 95. *Nicotiana trigonophylla*



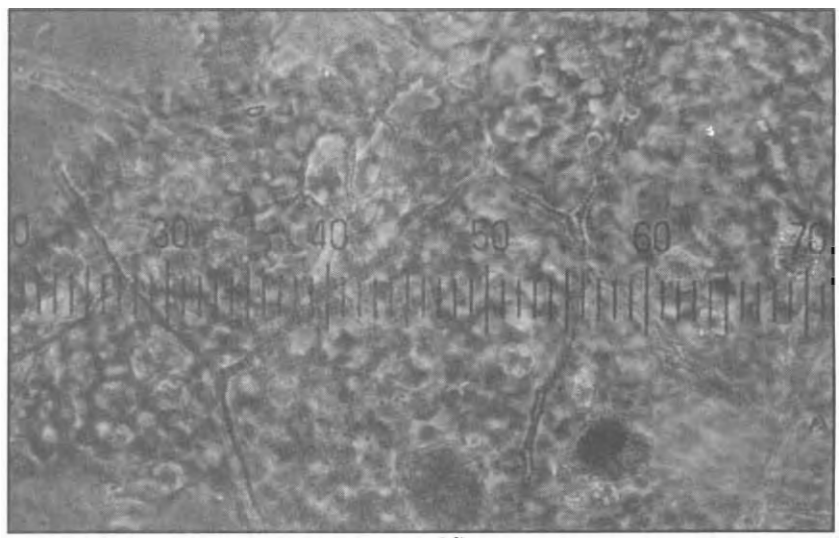
(a)



(b)



(c)



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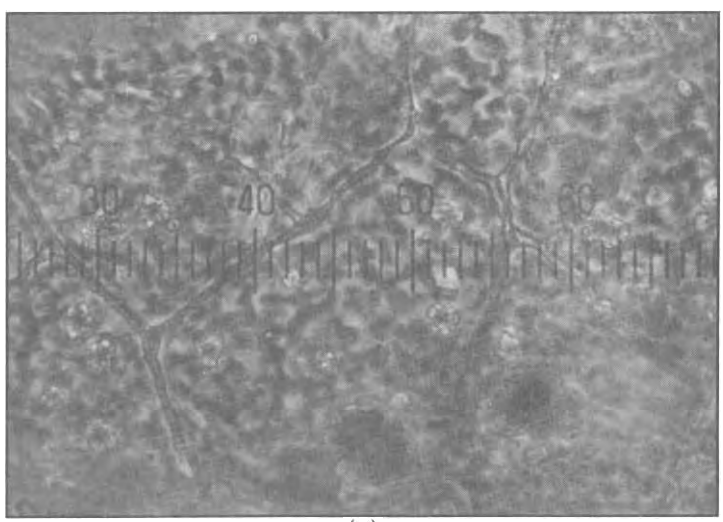
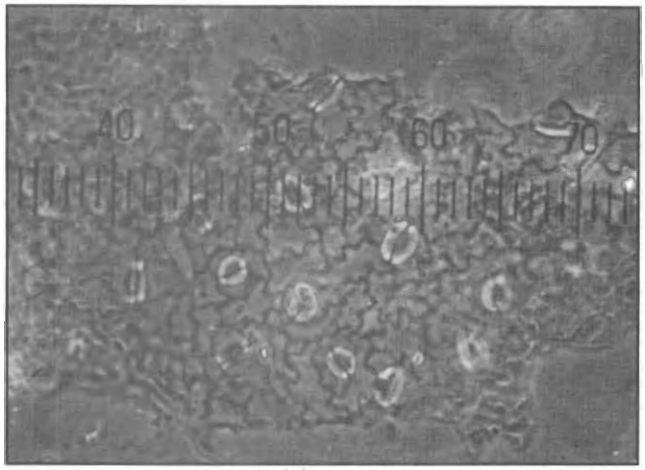
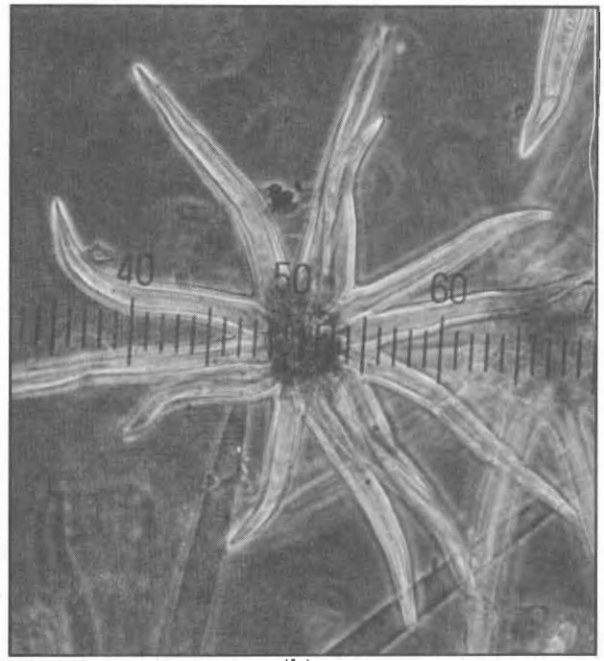


(e)

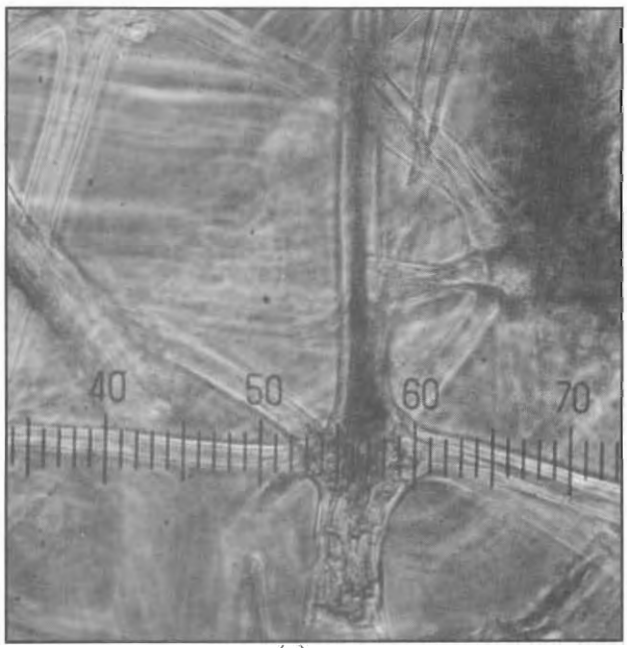
Figure 96. ***Solanum americanum***



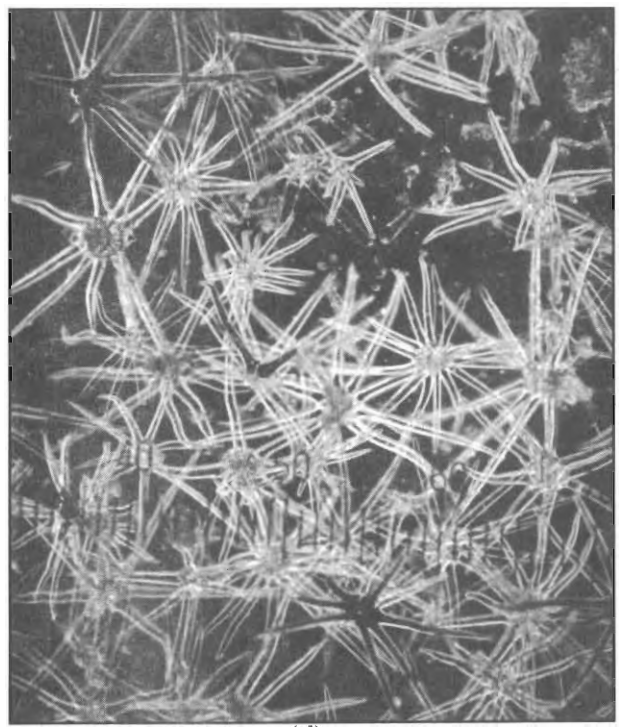
(a)



(b)



(c)



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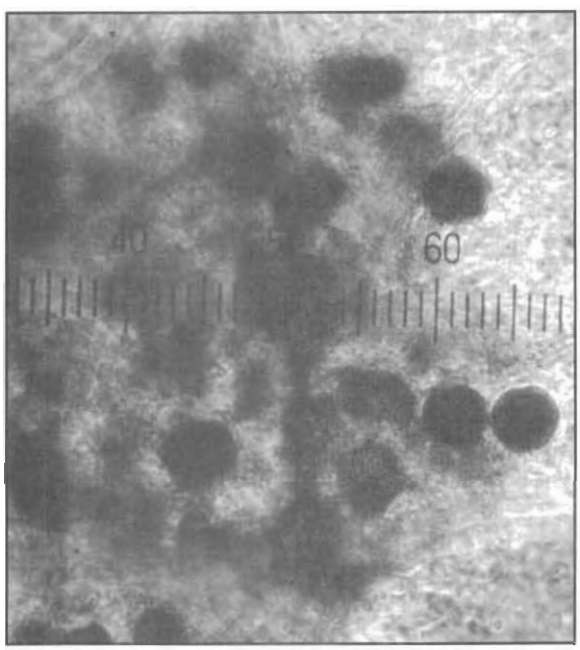


(e)

Figure 97. ***Solanum dimidiatum***

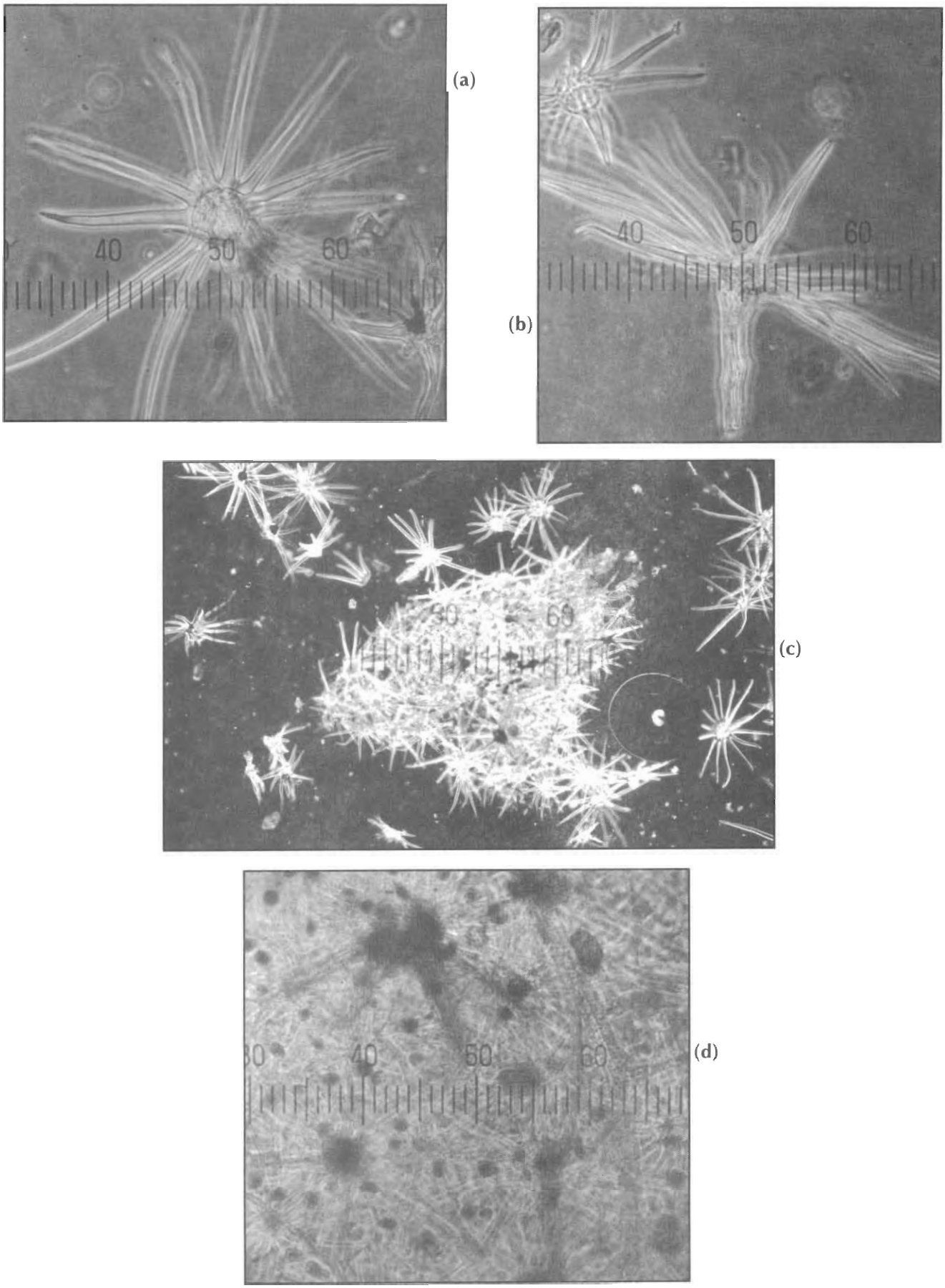
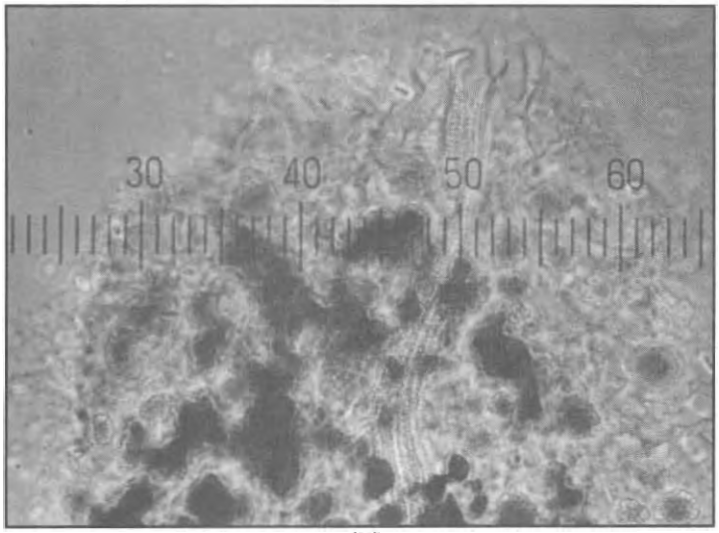
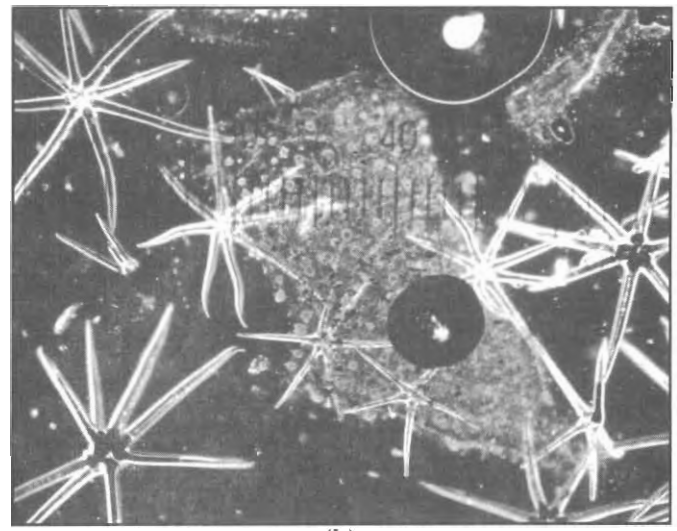


Figure 98. *Solanum elaeagnifolium*



(a)



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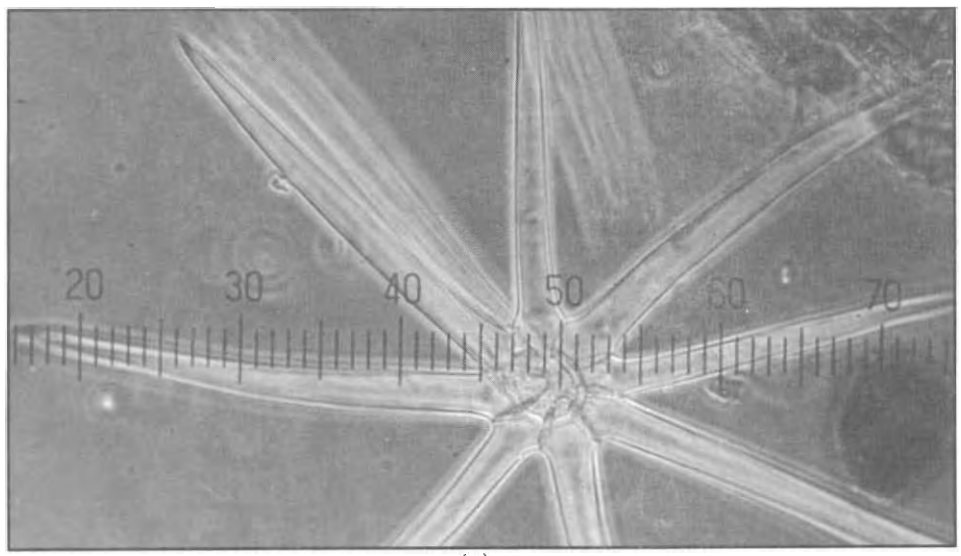

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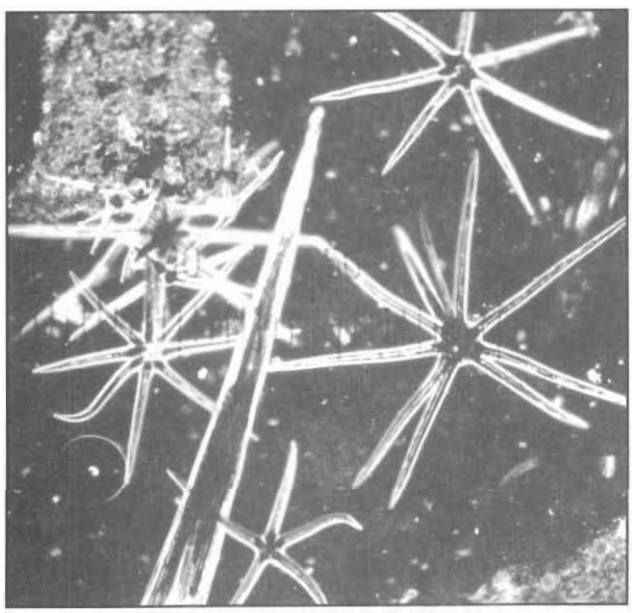

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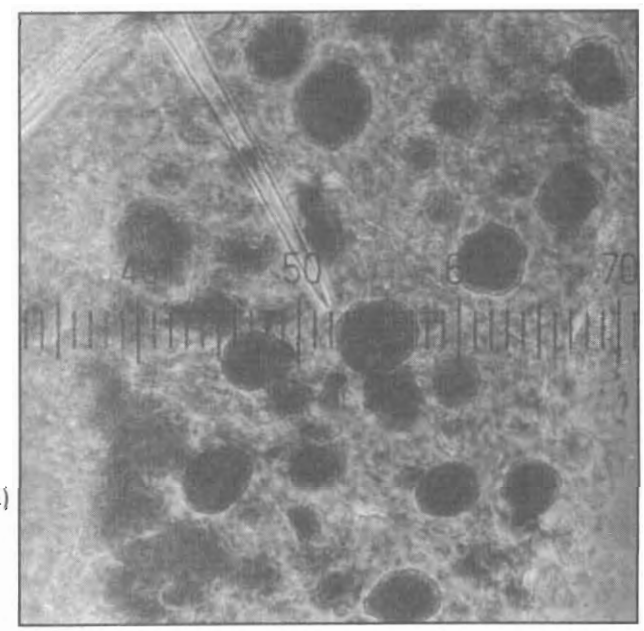
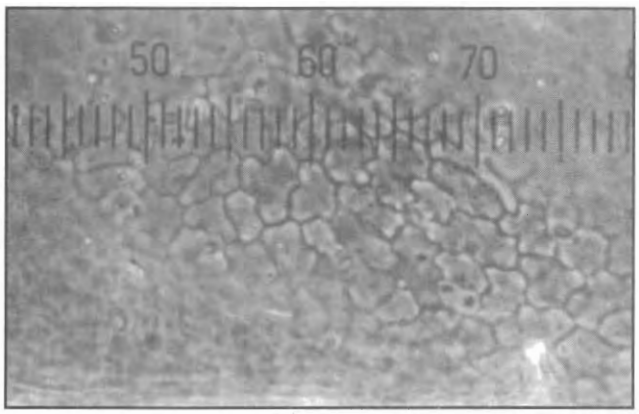
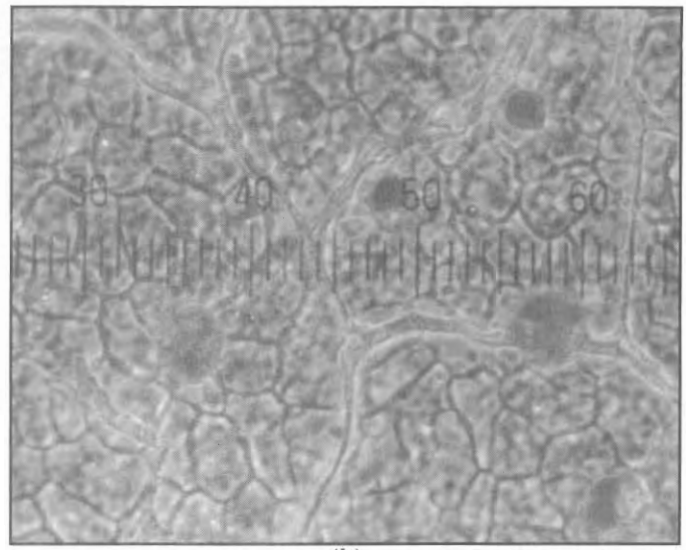


(e)

Figure 99. *Solanum rostratum*



(a)



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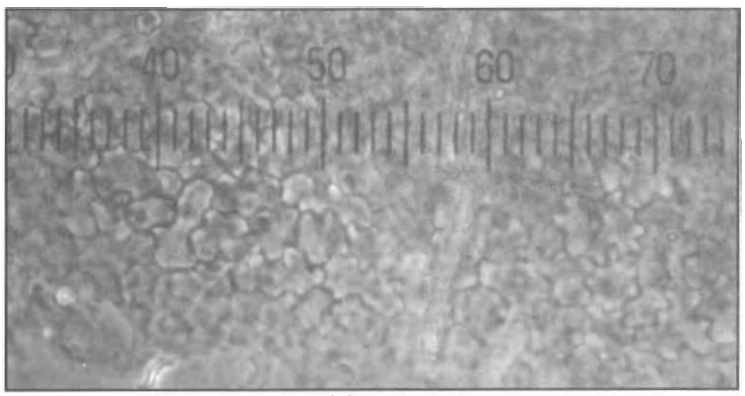

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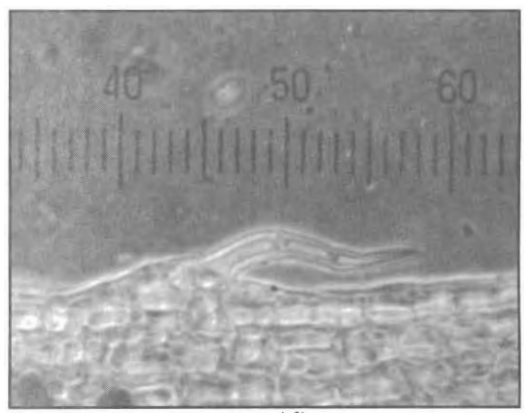

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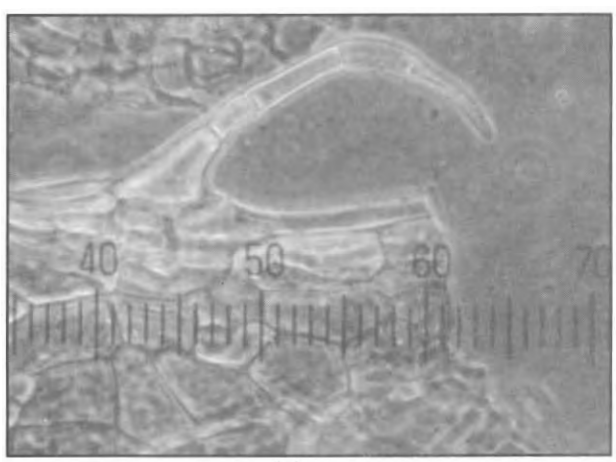

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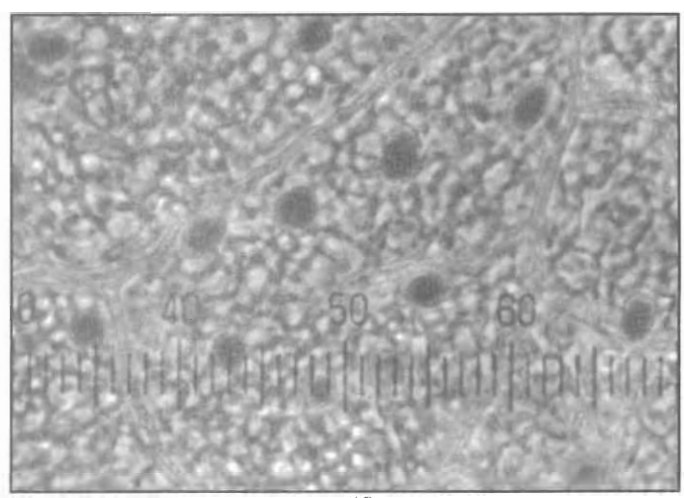
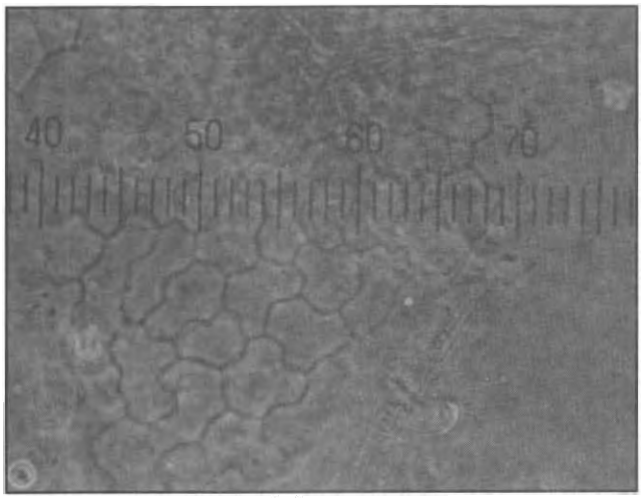
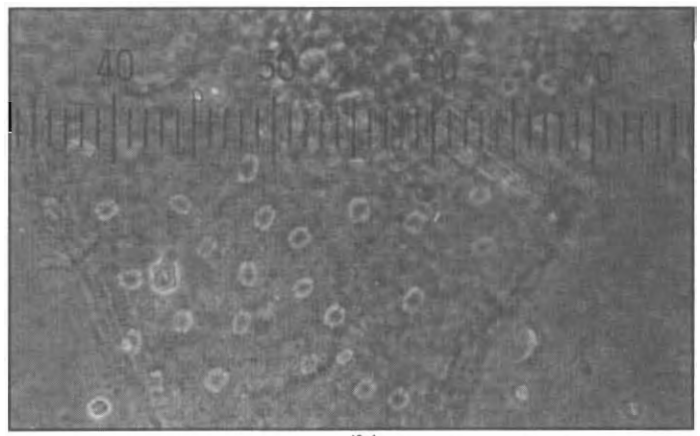


(f)

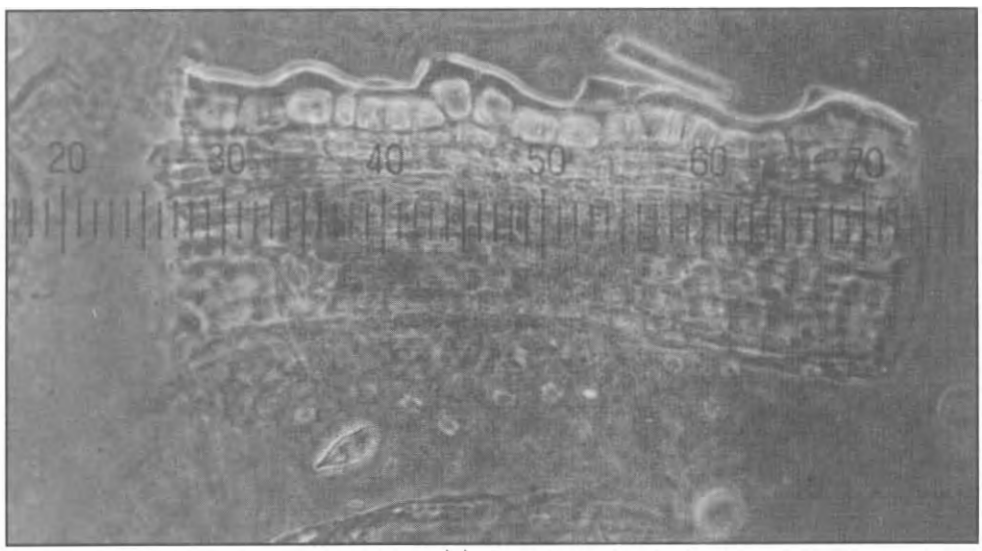
Figure 100. ***Solanum triquetrum***



(a)

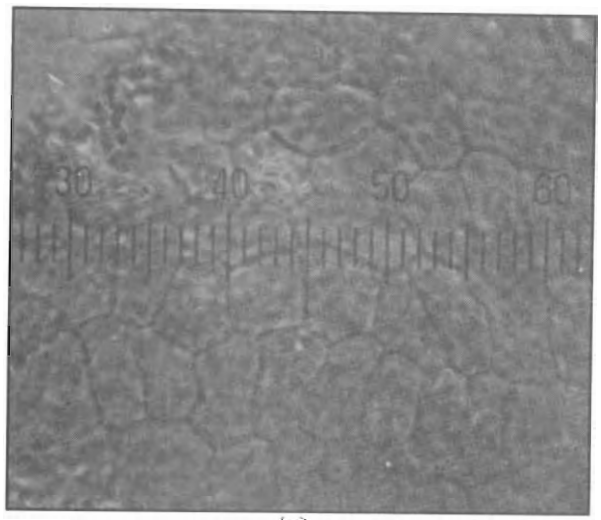


(b)

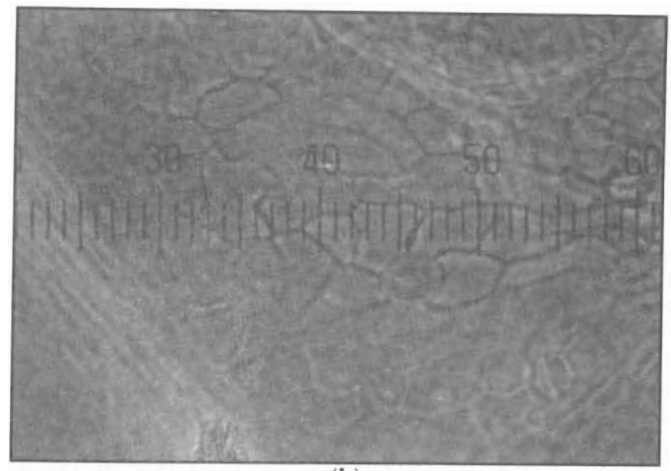


(c)

Figure 101. *Cicuta maculata*



(a)



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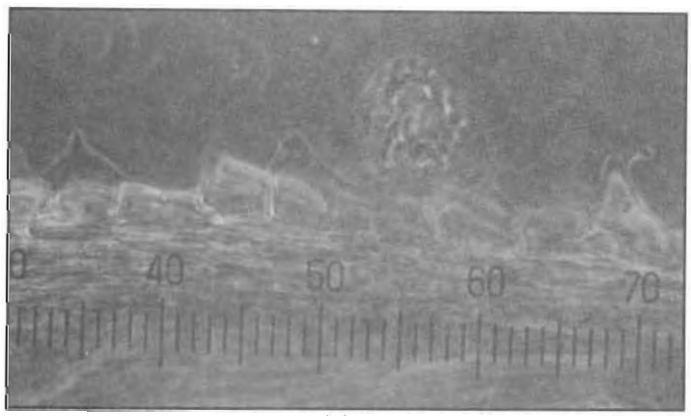
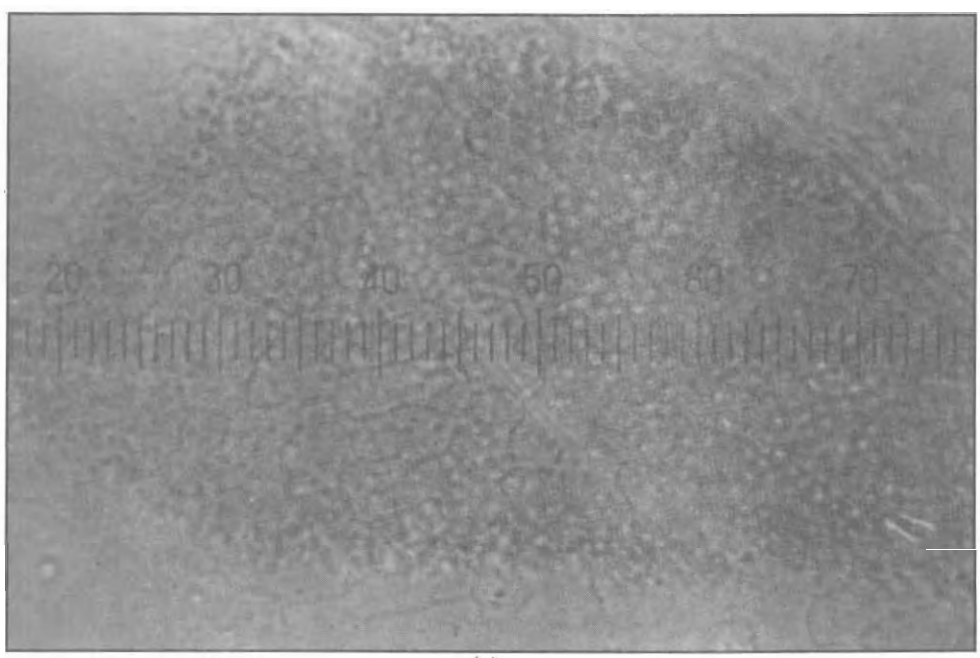


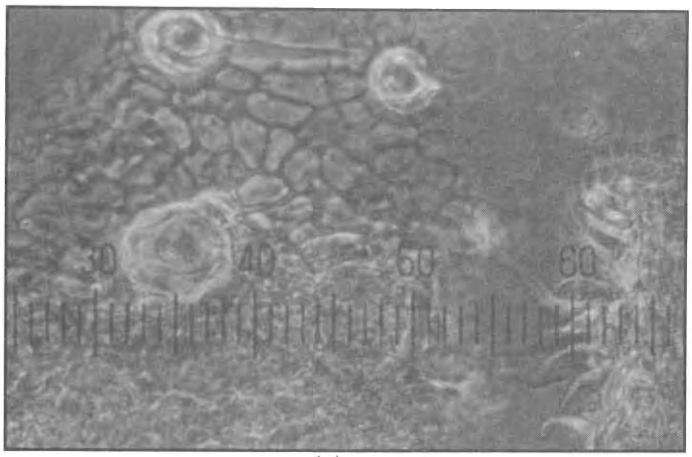
(c)

(d)

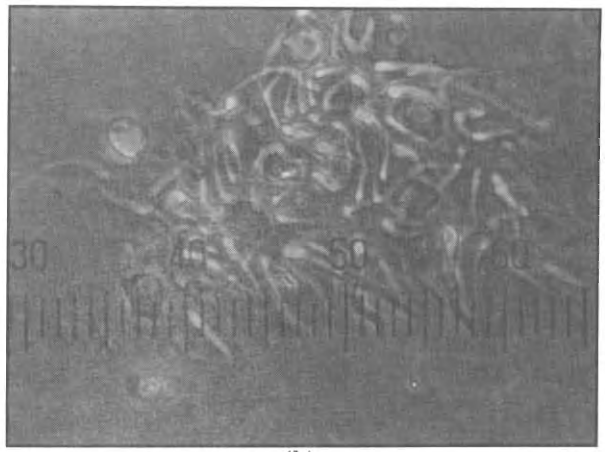


(e)

Figure 102. *Conium maculatum*



(a)



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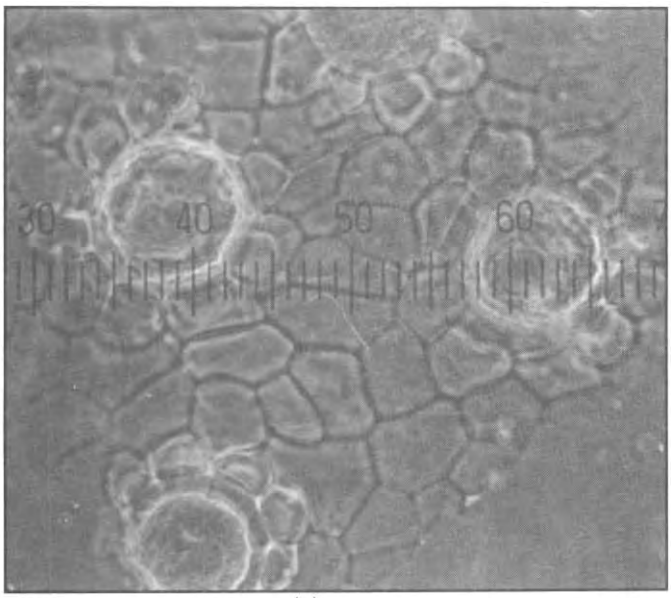

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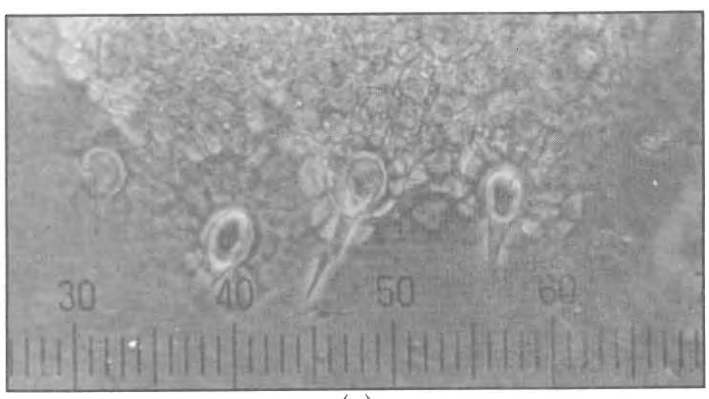
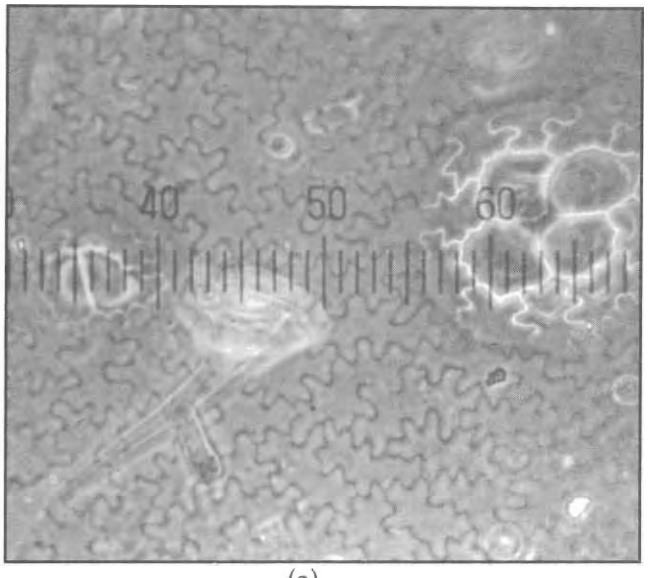
(d)



(e)

Figure 103. *Aloysia lycioides*



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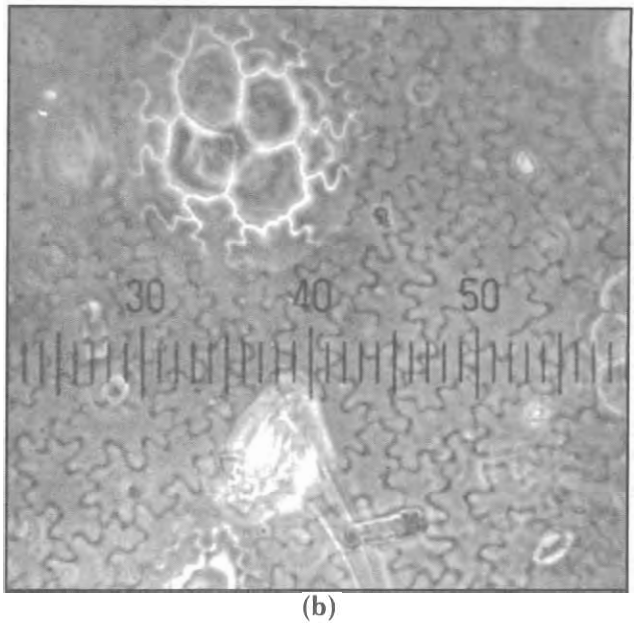

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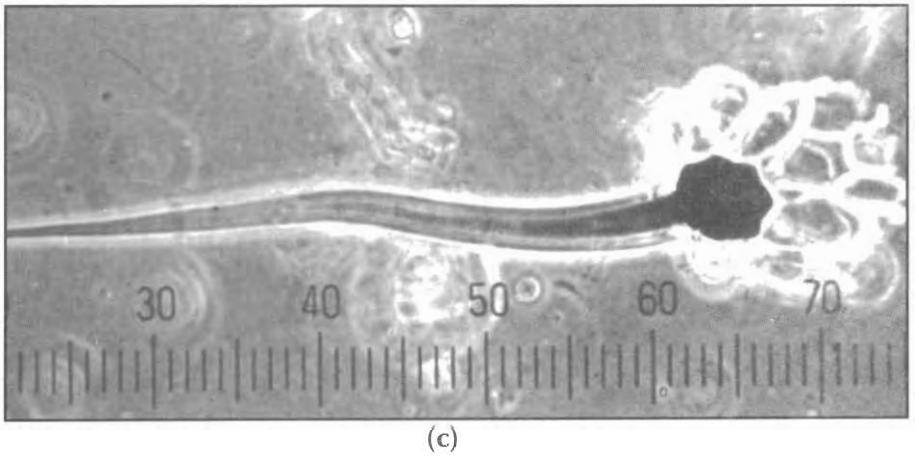

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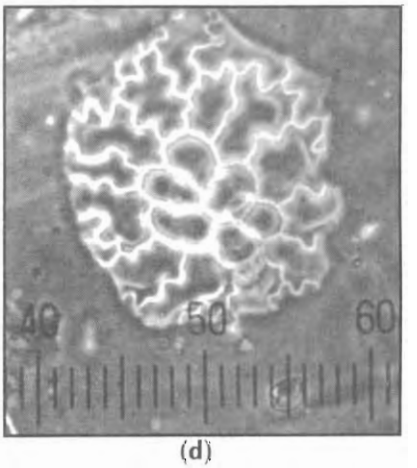

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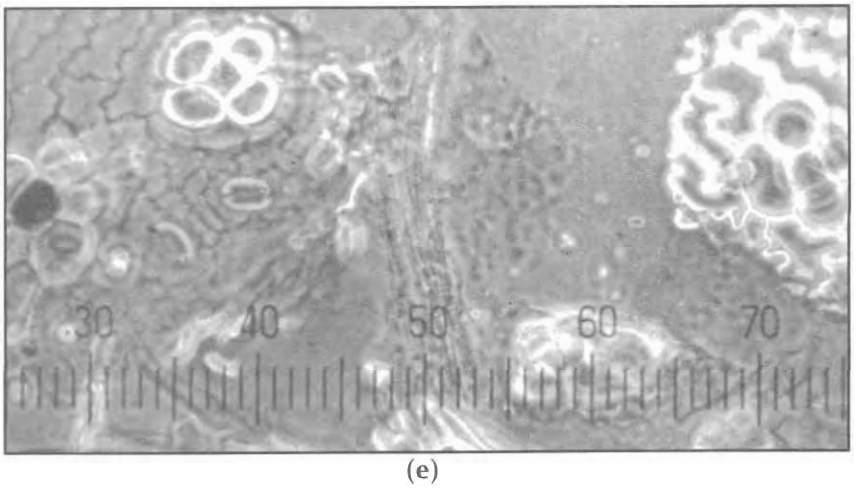
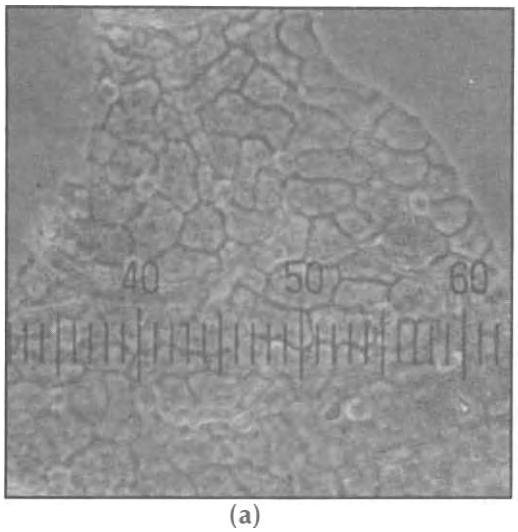


(e)

Figure 104. *Lantana horrida*



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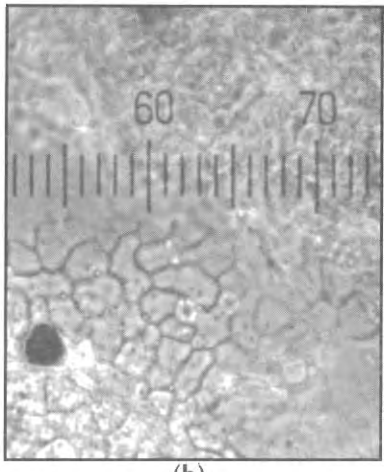

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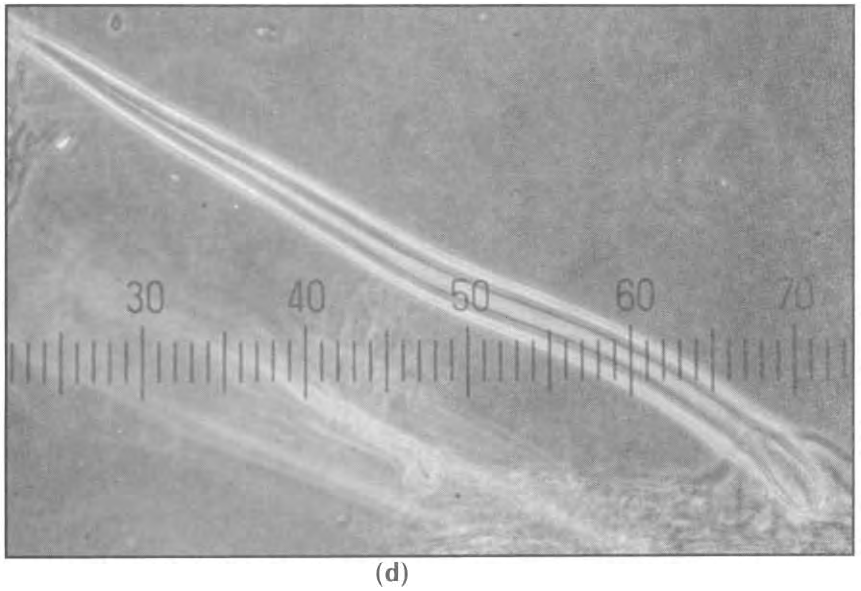
(c)



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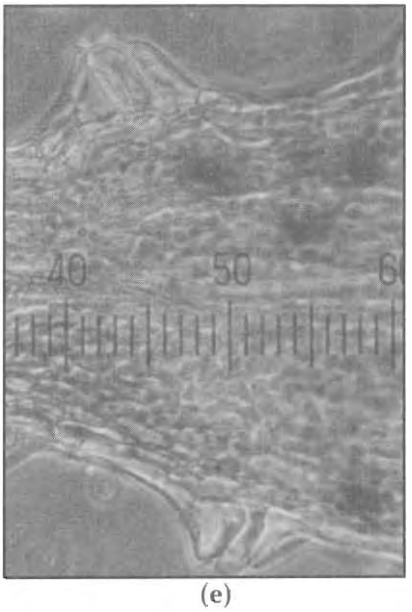

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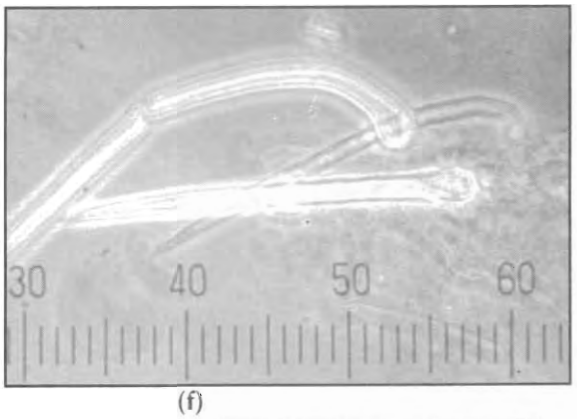

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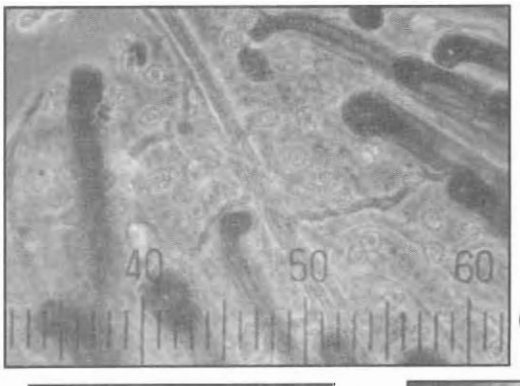
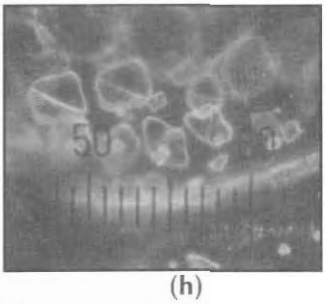


(g)



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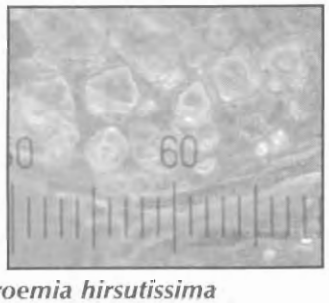
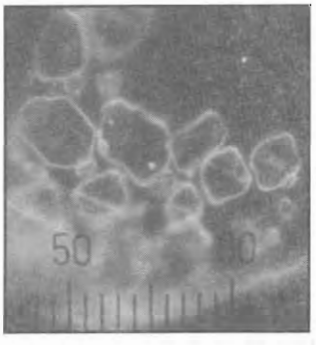
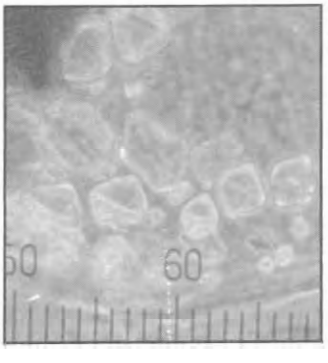


(i)

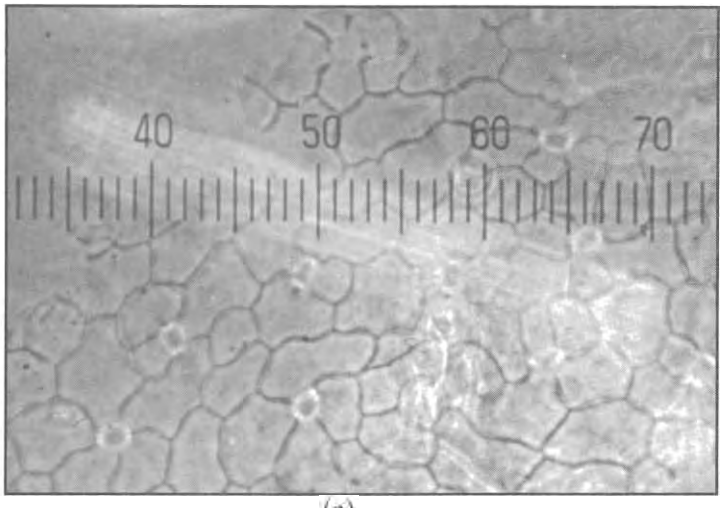


(j)

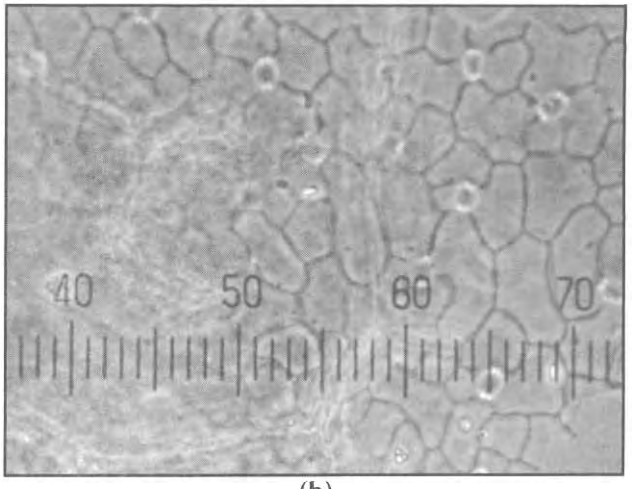


(k)

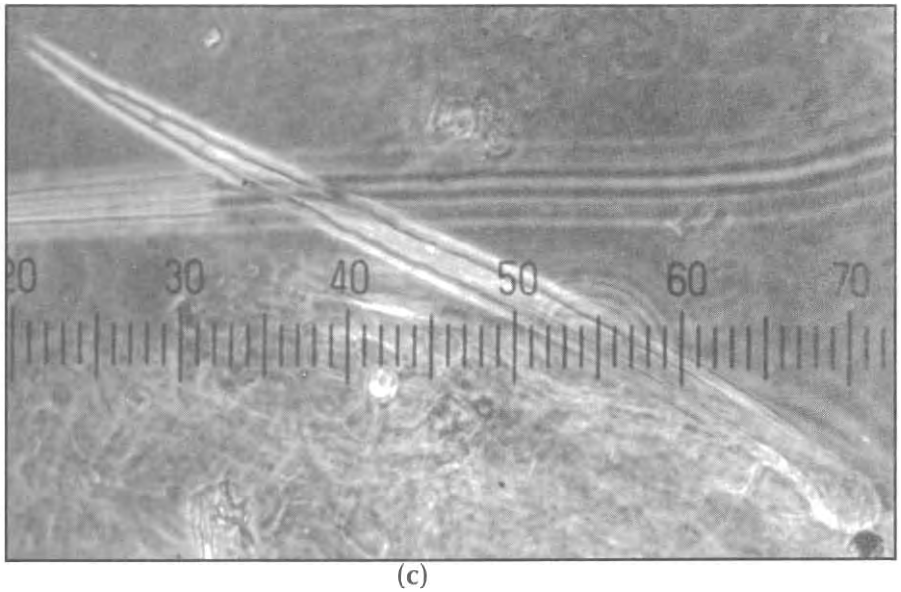
Figure 105. ***Kallstroemia hirsutissima***



(a)



(b)



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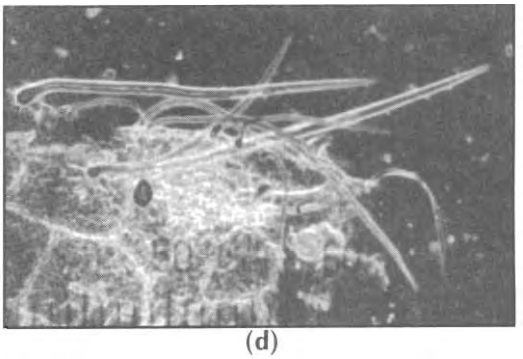

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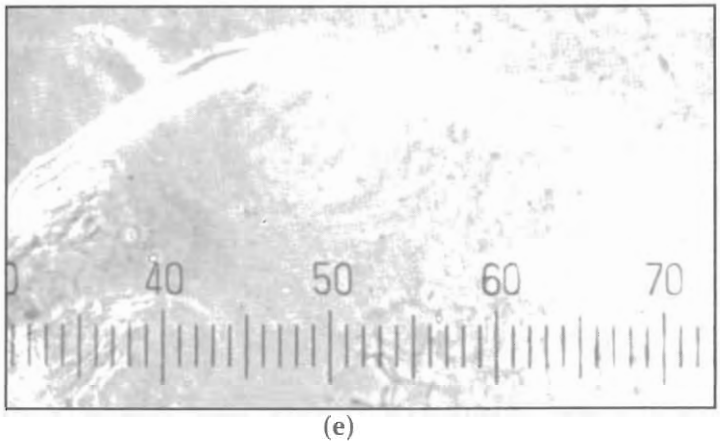
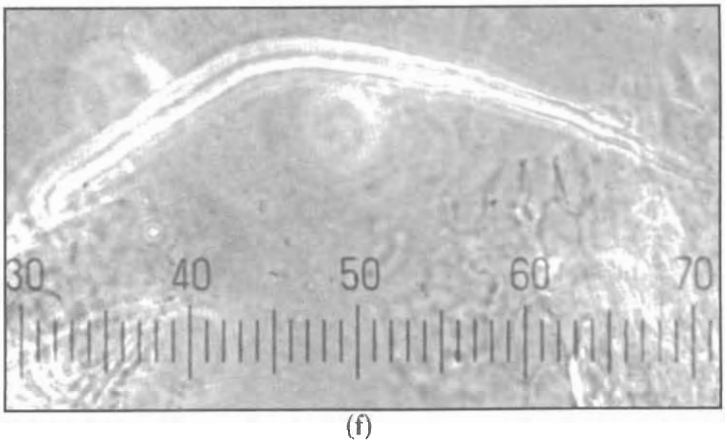
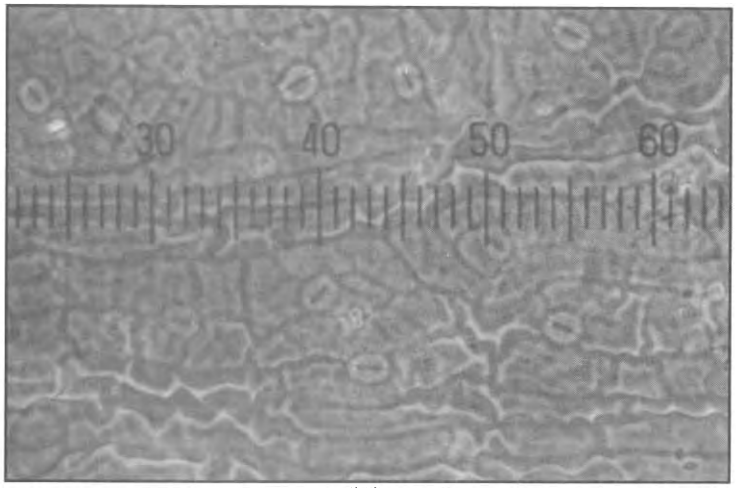


(e)

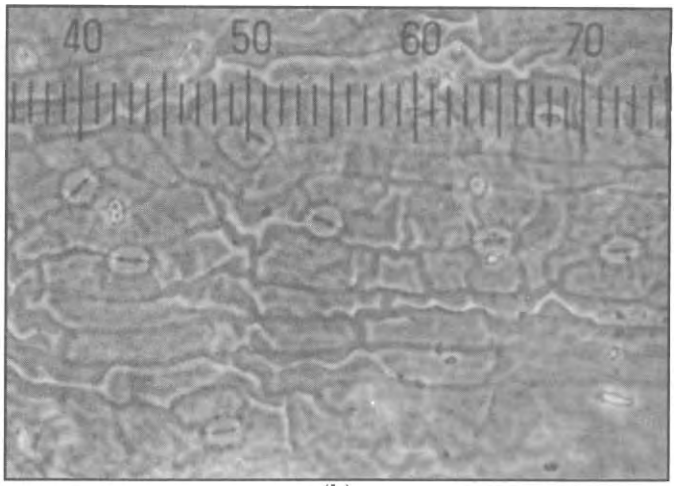


(f)

Figure 106. ***Kallstroemia parviflora***



(a)



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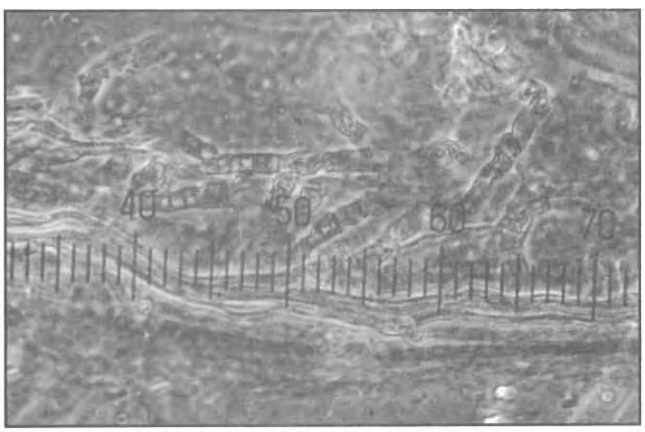

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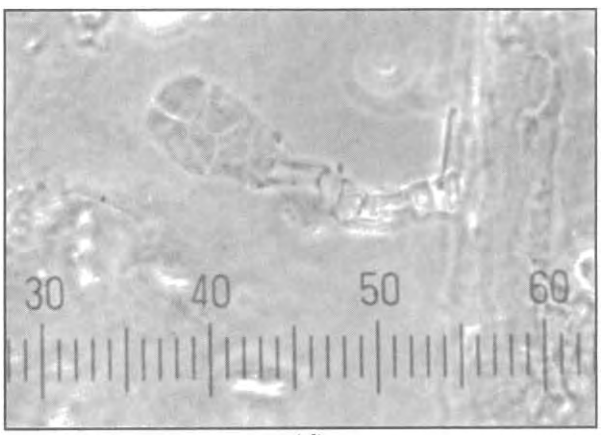

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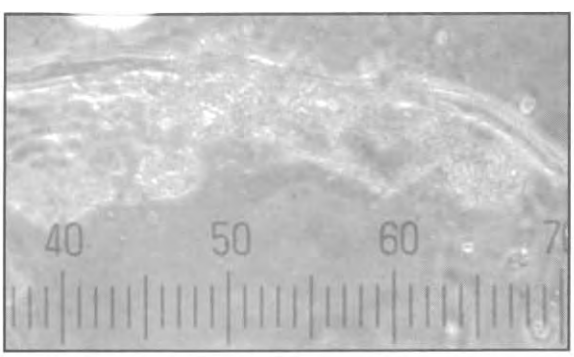

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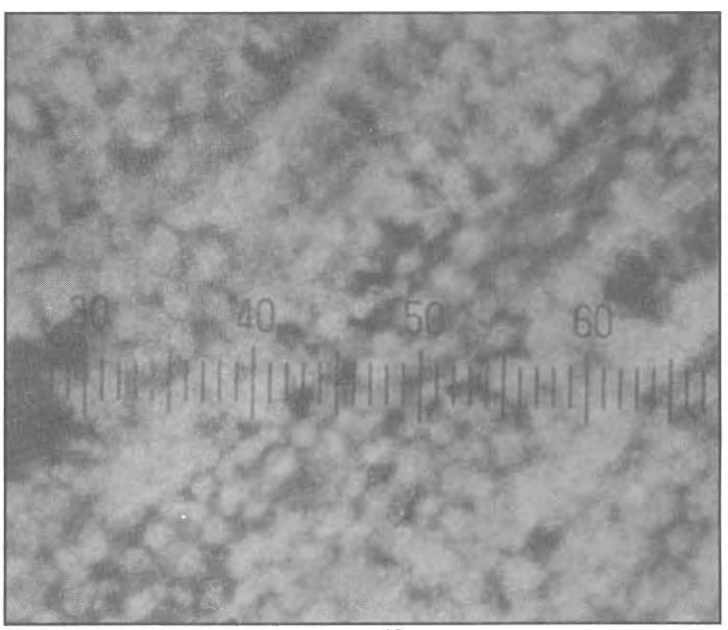

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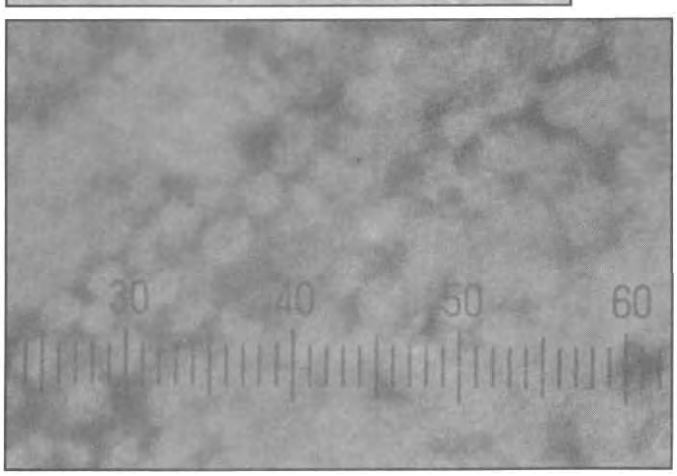
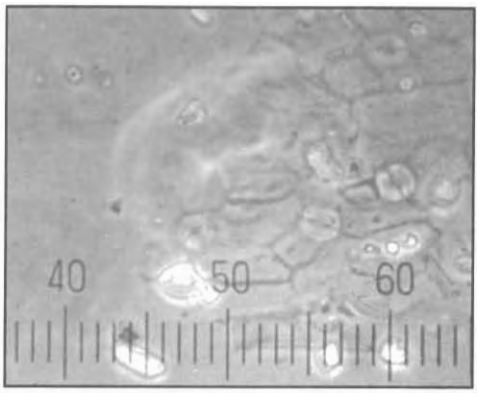
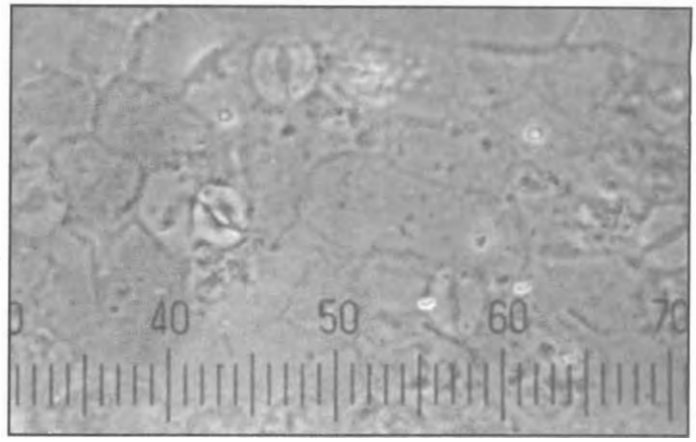


(g)

Figure 107. ***Peganum harmala***



(a)



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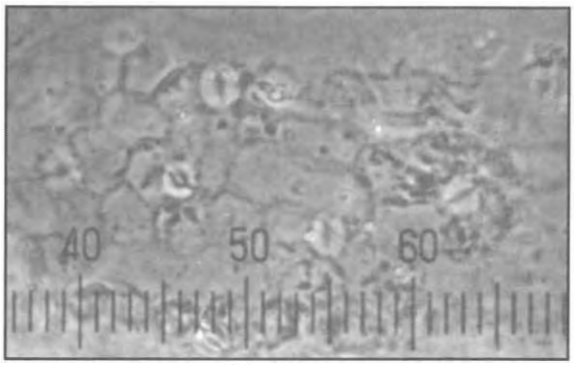

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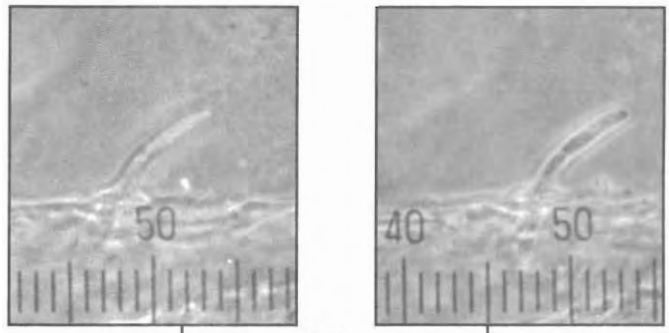

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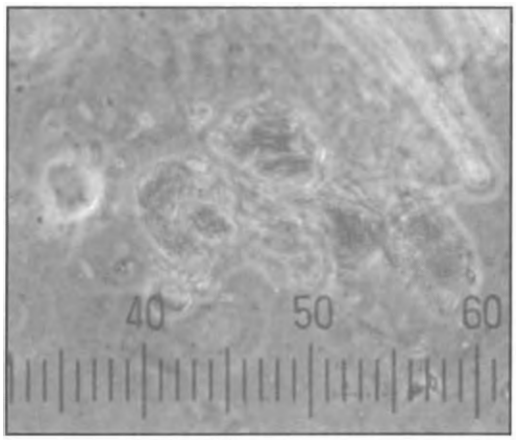

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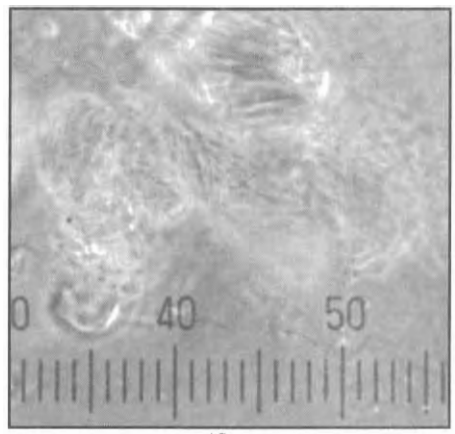
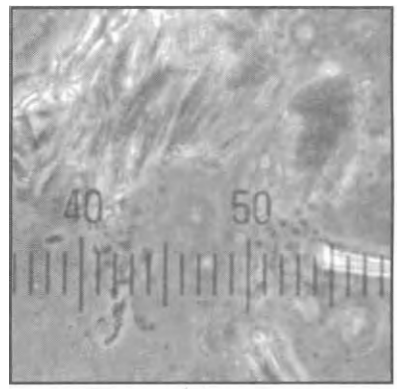
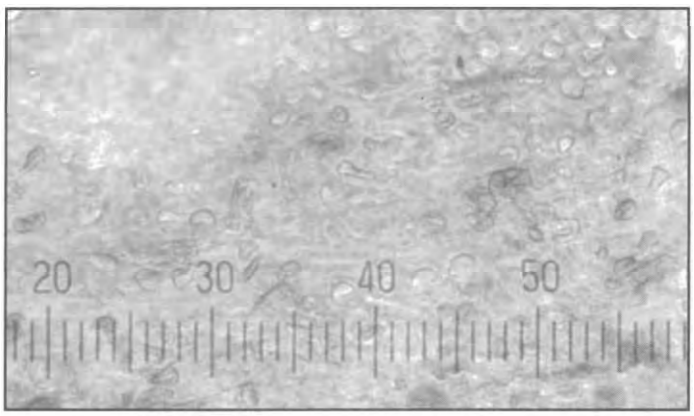


(f)



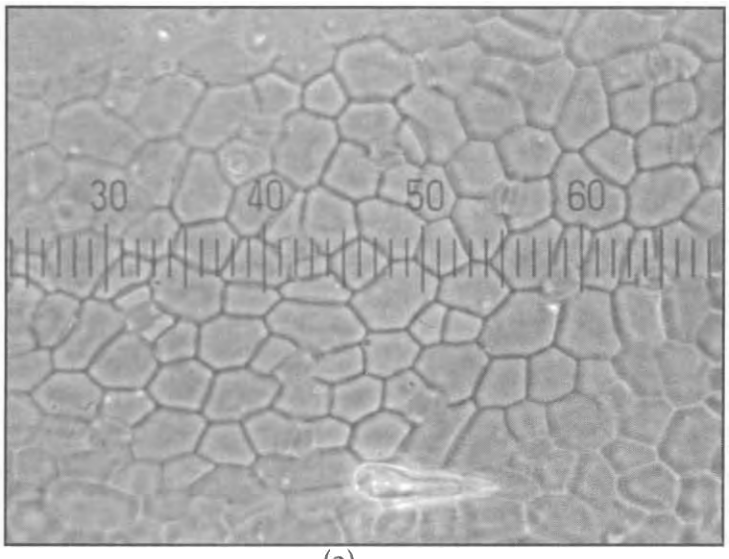
(g)



(h)

(i)

Figure 108. ***Peganum mexicanum***



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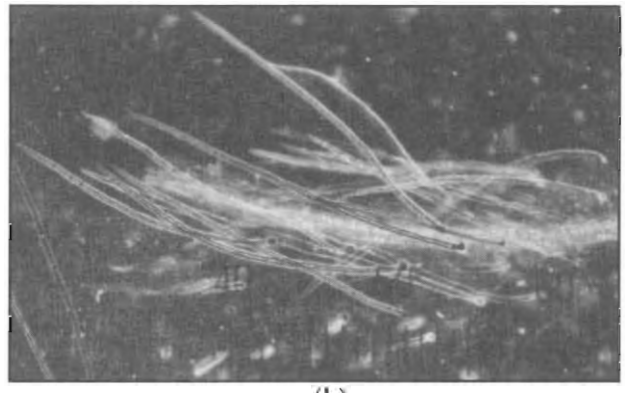

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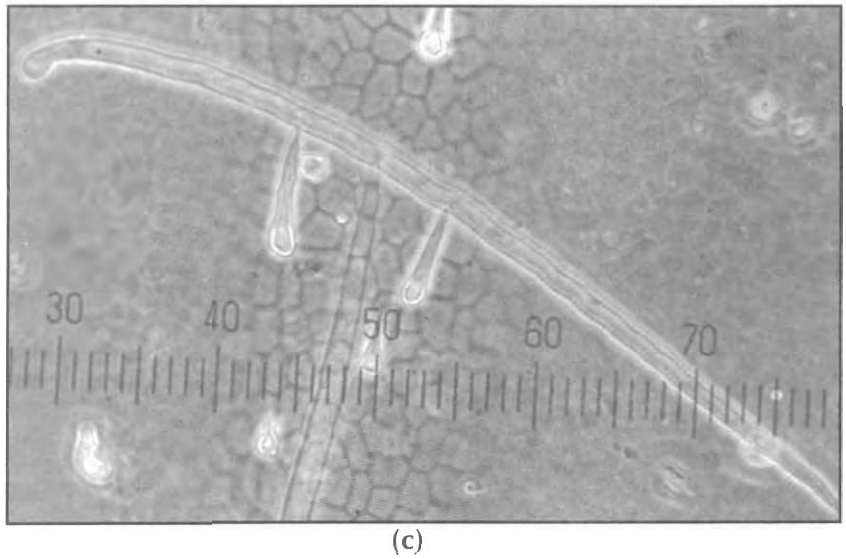

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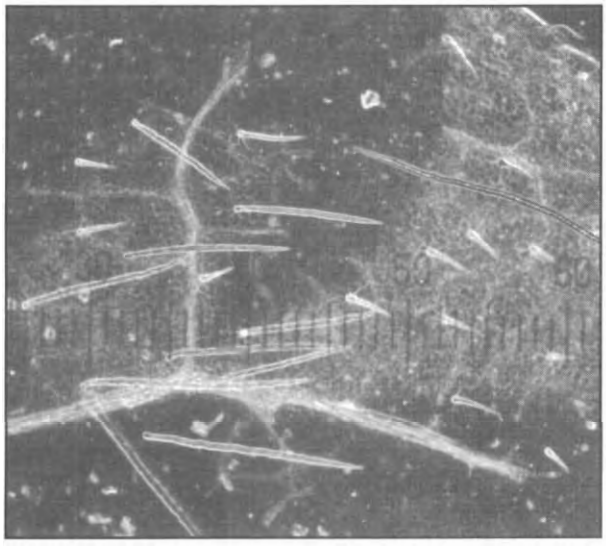

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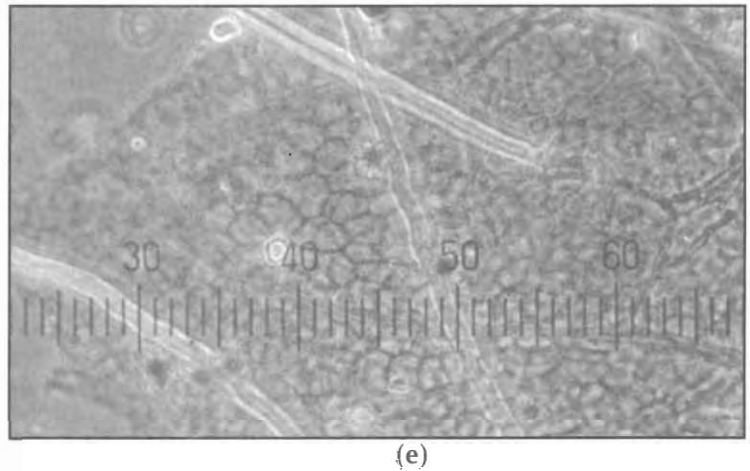
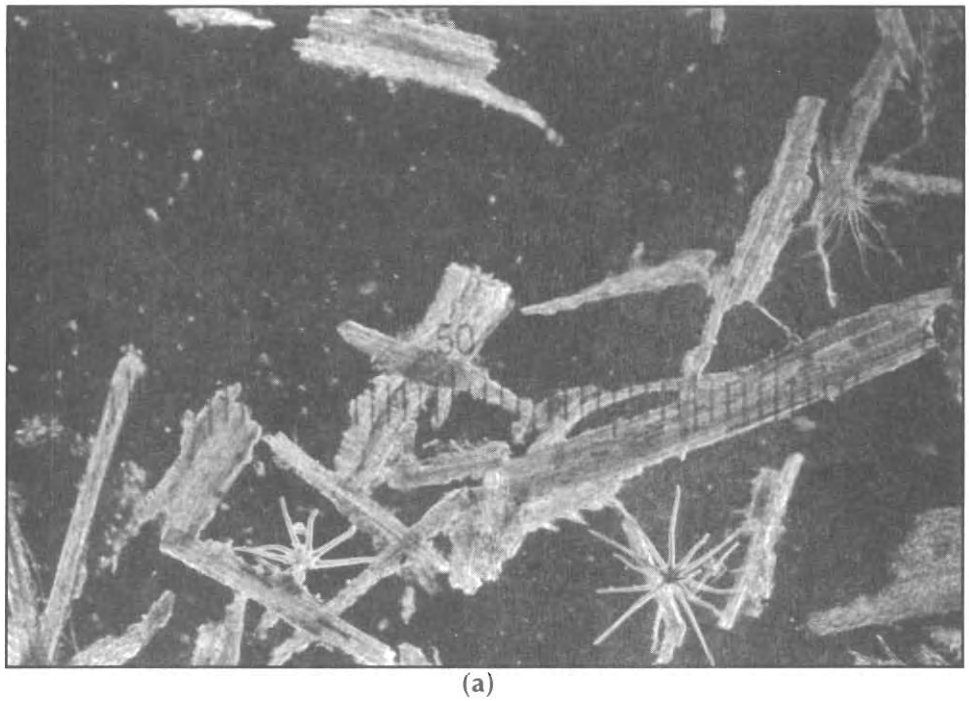
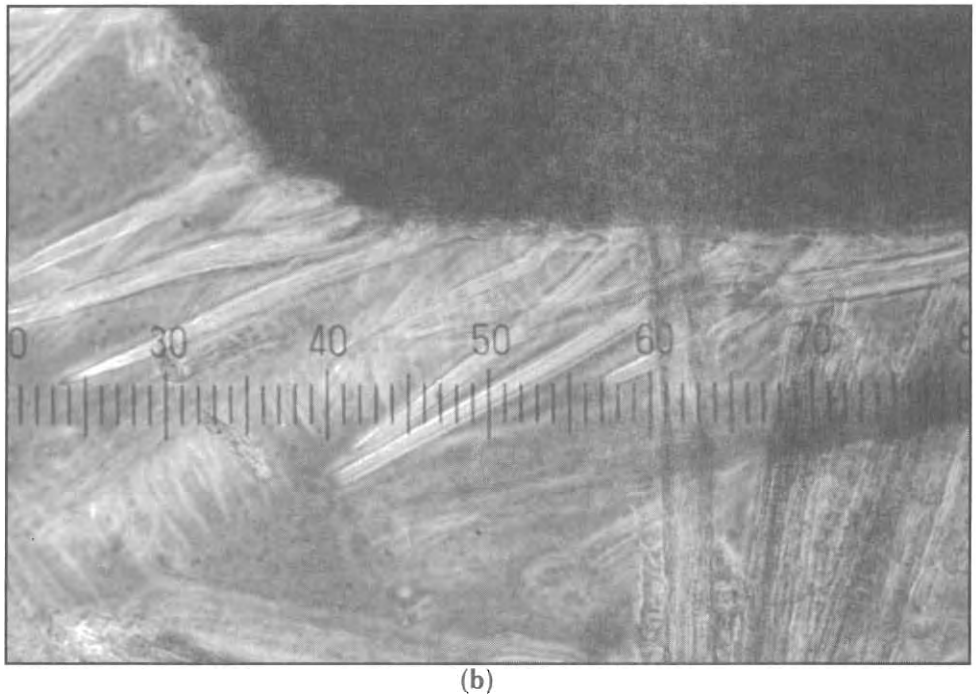


(e)

Figure 109. ***Tribulus terrestris***



(a)



(b)

Figure 110. Photo micrographs of rumen contents from a cow.
(a) stellate trichomes of *Solanum* sp.
(b) unicellular trichomes of *Cassia* sp.

Discussion

Epidermal cellular characteristics of 109 taxa in 65 genera spanning 31 families were described. Five families (Compositae, Euphorbiaceae, Leguminosae, Solanaceae, and Zygophyllaceae) contain five or more taxa and collectively about 48% of the genera and 57% of the species. Two families contain four taxa each and eight families contain three taxa each. The remaining 15 families contain only a single taxa. Five taxa (*Amaranthus, Argemone, Prunus, Quercus,* and *Xanthium*) constitute an entire genera for which all or an unknown number of species are thought to be toxic to livestock. One to several representative species are described for each of these taxa.

There are limitations of the microhistological technique for diagnosing plant toxicities. Plants causing acute toxicity (larkspur, chokecherry, poison hemlock, waterhemlock, wild tobacco, deathcamus, cocklebur, and others) may only be present in small amounts (0.1 to 5%) in ingesta, thus exhaustive and extensive examination of microscope slides may be necessary to detect fragments of the toxic plant. Livestock, with few exceptions, are not likely to consume an exclusive diet of a poisonous plant. Therefore, non-poisonous plants which have epidermal cellular characteristics similar to that of a poisonous taxa could be contained in the ingesta. Positive identification of a poisonous taxa may be restricted without knowledge of the cellular characteristics of all plants contained in the ingesta. An example of this would be the large genus *Astragalus* which contains important poisonous taxa as well as valuable forage herbs. Many of the *Astragalus* species are indistinguishable based on epidermal cellular characteristics. Also, the technique, as it is currently employed to quantify botanical composition of diets, requires that each identifiable fragment on slides be categorized. Therefore, non-poisonous taxa must also be categorized to quantify the relative amount of a poisonous taxa contained within ingesta. This would not, however, restrict specific identification of poisonous plants which possess unique epidermal cellular characteristics in the ingesta of an intoxicated animal.

Extensive research has demonstrated that certain plants fragment differently when passing through the gastrointestinal tract of herbivores, thus creating biases when feces is used to estimate diet composition (Anthony and Smith 1974, Westoby et al. 1976, Vavra et al. 1978, Holochek et al. 1982). The absolute percentages of grasses are often overestimated while that of many forbs are often underestimated. However, dietary trends and the relative importance of forage plants in diet samples are accurate when using feces to estimate diets (Vavra et al. 1978). In the authors' opinion, microscopic examination of fecal material or ingesta within the gastrointestinal tract of intoxicated animals will be adequate for determining if toxic plants have been consumed.

Other plants represent special problems. Threadleaf groundsel usually produces chronic toxicity from consumption during winter but symptoms and death losses occur several months after animals stop eating the plant. Examination of dry feces from infested pastures could prove consumption had occurred but direct evidence of the plant in the ingesta of a sick animal or upon autopsy may not be possible.

Two types of cell patterns are often present within a single taxa because the top and bottom leaf surfaces differ in anatomical features. Also, young tissue may have sinuate cell walls (expanding) while mature, fully developed tissue may exhibit regular, smooth-walled cells. Different plant parts may exhibit different cell patterns as well as different trichome types.

In practice, the microtechnique is more an art than a science. Readers unfamiliar with the technique are warned that identification of taxa based solely on a single characteristic may often be in error.

Reference slides should only be made from vouchered plant specimens. Extreme caution should be taken to avoid cross contamination between plant species when reference slides are made. When examining or studying reference slides, ignore rare characteristics as these would probably not be useful for diagnostic purposes or may even be cross contamination. Generally, only the predominant characteristics of a plant will be useful for identification.

Characteristics observed in reference slides may differ from those in slides made from ingesta or feces to varying degrees. Most of the epidermis of plants is undigestable cellulose, hemicellulose, and cutin. However, the physical effect of ingestion may alter the distinctness of some characteristics.

Some plants have very frail tissue and epidermal characteristics of these plants are observable in only the most carefully prepared reference slides. This suggests that these plants would also be difficult to identify in ingesta or fecal material when found in fragmentary condition. These plants are often those with small and/or semi-succulent to succulent leaves and include: *Centaurium calycosum, Centaurium beyrichii, Drymaria pachyphylla, Hymenoxys odorata, Jatropha cathartica, Jatropha dioica, Peganum harmala, Peganum mexicanum,* and *Perilla frutescens*. Sometimes these plants possess other characteristics, such as distinctive trichomes, which facilitate identification.

Diagnosis of Animal Poisonings

Material from the digestive tract should be frozen, freeze dried, air dried, mixed with an equal volume of granular salt, or preserved in chloroform or formaldehyde to prevent microbial decomposition. Slides of fecal material or ingesta can be prepared by the same procedures described for making reference slides. Ingesta from an intoxicated animal should be thoroughly subsampled and mixed to insure the material is representative. Dried material should be ground to pass a l-mm screen or blended with water, then thoroughly washed over a 200-mesh screen prior to mounting on microscope slides. Grinding is important when composition of the material is to be quantified.

Photomicrographs of rumen contents from a cow suspected of being poisoned in western Tom Green County, Texas are shown in Figure 110. The sample contained a *Cassia* sp. (either Lindheimer or twoleaf senna) and a *Solanum* sp. (either buffalobur or silverleaf nightshade). The stellate trichomes most closely resembled silverleaf nightshade and this plant was abundant in the pasture where the poisoning occurred. The cow died suddenly in August 1984 following a severe summer drought.

Acknowledgments

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APPENDIX A

Dichotomous key to plant taxa described in the Results section based on epidermal cellular characteristics.

1. (a) Most cells in a definite linear pattern, grasslike. 2
   (b) Most cells in a regular (net) pattern, not as above. 6
2. (a) Silica-suberose couples absent. 3
   (b) Silica-suberose couples present. *Sorghum* spp.
   Fig. 75. *S. almum*
   Fig. 76. *S. bicolor*
   Fig. 77. *S. halapense*
3. (a) Raphides present. 4
   (b) Raphides absent. 5
4. (a) Stomata sunken, cell walls thick and luminescent.
   Fig. 2. *Agave lecheguilla*
   (b) Stomata not sunken, cell walls thin.
   Fig. 66. *Zigadenus nuttallii*
5. (a) Stomata sunken.
   Fig. 65. *Nolina texana*
   (b) Stomata not sunken, bone shaped silica cells in vein tissue.
   Fig. 74. *Panicum antidotale*
6. (a) Trichomes absent or rare. 7
   (b) Trichomes present (rare, common, or abundant). 47
7. (a) Glandular trichomes or structures present. 8
   (b) Glandular trichomes or structures rare or absent. 24
8. (a) Glands or gland bases luminescent bumps or dots, nondescript glandular areas, or punctate. 9
   (b) Glands bicellular or multicelled structures, distinctly different from epidermal cells. 14
9. (a) Glands punctate. 10
   (b) Glands luminescent bumps or dots, or nondescript glandular areas. 11
10. (a) Epidermis rugulose, crystal idioblasts absent.
    Fig. 82. *Oligomeris linifolia*
    (b) Epidermis not rugulose, small irregularly shaped amorphous druses common.
    Fig. 88. *Thamnosma texana*
11. (a) Stomata equal to or exceeding the size of most epidermal cells, glands or gland bases luminescent dots, not bumps that project from the epidermis. 12
    (b) Stomata smaller than most epidermal cells, glands luminescent bumps or nondescript areas. 13

12. (a) Crystalline druses present, rhomboid crystals absent.

    Fig. 6. *Asclepias latifolia*

    (b) Crystalline druses absent, rhomboid crystals common in vein tissue.

    Fig. 64. *Sophora secundiflora*

13. (a) Glands luminescent bumps which project from the epidermal cells, companion cells three or four, not distinct.

    Fig. 3. *Apocynum sibiricum*

    (b) Glands nondescript areas on leaf tips or margins, two distinct companion cells of the stomata.

    Fig. 34. *Stillingia sylvatica*

    Fig. 35. *S. texana*

    Fig. 36. *S. treculiana*

14. (a) Glands without a distinct multicelled stalk. 15

    (b) Glands with a distinct multicelled stalk. 18

15. (a) Crystal idioblasts absent, glands bicellular ("footballs"). 16

    (b) Crystal idioblasts present, glands rare. 17

16. (a) Cell walls undulate (sublinear cells over veins and on stem tissue may have smooth cell walls).

    Fig. 19. *Hymenoxys odorata*

    (b) Cell walls smooth, never with undulate cell walls.

    Fig. 18. *Helenium microcephalum*

17. (a) Crystal idioblasts medium sized clusters of extremely fine crystals, glands rare.

    Fig. 93. *Nicotiana glauca*

    (b) Crystal idioblasts rhomboid crystals restricted to vein tissue, glands rare.

    Fig. 64. *Sophora secundiflora*

18. (a) Distal segment of stalked glands whip-like, bicellular glands ("footballs") also present but rare.

    Fig. 27. *Xanthocephalum microcephalum*

    (b) Distal segment of glands globose, multicellular, or slightly inflated, but not whip-like, bicellular glands absent. 19

19. (a) Distal segment of glands multicellular. 20

    (b) Distal segment of glands unicellular. 21

20. (a) Crystal idioblasts subcrystalline druses, epidermis not rugose, stalk of glands often forked.

    Fig. 95. *Nicotiana trigonophylla*

    (b) Crystal idioblasts small, short, needle-like crystals clustered in vein tissue, epidermis often rugose, glands clavate.

    Fig. 107. *Peganum harmala*

21. (a) Distal segment of glands globose. 22

    (b) Distal segment of glands inflated, not globose. 23

22. (a) Crystal idioblasts large clusters of extremely fine crystals, gland stalks long and thin.

Fig. 1. *Amaranthus retroflexus*

(b) Crystal idioblasts absent, gland stalks short and thick.

Fig. 5. *Asclepias asperula*

23. (a) Crystal idioblasts subcrystalline druses.

Fig. 7. *Asclepias subverticillata*

(b) Crystal idioblasts small rhomboid crystals restricted to vein tissue.

Fig. 42. *Aesculus pavia var. flavescens*

Fig. 43. *A. pavia var. pavia*

24. (a) Cell walls smooth. 25

(b) Cell walls undulate or sinuate. 40

25. (a) Crystal idioblasts absent. 26

(b) Crystal idioblasts present (may be rare in some plants). 28

26. (a) Macroscopic spines present and finely dissected.

Fig. 68. *Argemone albiflora*

Fig. 69. *A. auratiaca*

Fig. 70. *A. polyanthemos*

Fig. 71. *A.* sp.

(b) Macroscopic spines absent. 27

27. (a) Stomates equal to or exceeding the size of most other epidermal cells.

Fig. 27. *Xanthocephalum microcephalum*

(b) Stomates much smaller than most other epidermal cells.

Fig. 52. *Cassia obtusifolia*

Fig. 101. *Cicuta maculata*

28. (a) Companion cells of the stomata distinctly two. 29

(b) Companion cells of the stomata (1) numerous, distinct and radially arranged, (2) two, three or four, with one or two reduced, or (3) not distinct. 31

29. (a) Crystalline druses present.

Fig. 7. *Asclepias subverticillata*

Fig. 8. *A. verticillata*

Fig. 33. *Ricinus communis*

(b) Crystalline druses absent. 30

30. (a) Cells with a conspicuous waxy coating.

Fig. 59. *Prosopis glandulosa* var. *glandulosa*

(b) Cells without a conspicuous waxy coating.

Fig. 34. *Stillingia sylvatica*

31. (a) Companion cells of the stomata variable (numerous), distinct, radially arranged. 32

    (b) Companion cells of the stomata two, three, or four, with one or two reduced, or not distinct. 33

32. (a) Crystal idioblasts large rhomboid crystals, not restricted to vein tissue.

    Fig. 84. *Karwinskia humboldtiana*

    (b) Crystal idioblasts rhomboid crystals but not large, restricted to vein tissue.

    Fig. 42. *Aesculus pavia* var. *flavescens*

    Fig. 43. *A. pavia* var. *pavia*

    Fig. 64. *Sophora secundiflora*

    Fig. 67. *Melia azedarach*

33. (a) Companion cells of the stomata two, three, or four, with one or two reduced. 34

    (b) Companion cells of the stomata not distinct (= none reduced). 37

34. (a) Lattice-type crystal idioblasts present, reddish, and bright red amorphous druses, both types common.

    Fig. 61. *Sesbania macrocarpa*

    Fig. 62. *S. vesicaria*

    (b) Lattice-type crystal idioblasts absent, druses (but not bright red) or irregularly shaped crystals present. 35

35. (a) Crystal idioblasts moderately large druses composed of extremely fine crystals.

    Fig. 93. *Nicotiana glauca*

    (b) Crystal idioblasts subcrystalline druses or irregularly shaped crystals. 36

36. (a) Crystal idioblasts subcrystalline druses, throughout tissue.

    Fig. 10. *Drymaria pachyphylla*

    Fig. 91. *Datura stramonium*

    (b) Crystal idioblasts irregularly shaped, elongated in vein tissue, sometimes in large clusters.

    Fig. 87. *Cephalanthus occidentalis*

37. (a) Raphides present.

    Fig. 108. *Peganum mexicanum*

    (b) Raphides absent. 38

38. (a) Crystal idioblasts moderately large to very large druses composed of extremely fine crystals.

    Fig. 1. *Amaranthus retroflexus*

    (b) Crystal idioblasts very small druses or irregularly shaped. 39

39. (a) Crystal idioblasts very small druses restricted to stem tissue.

    Fig. 29. *Euphorbia marginata*

    (b) Crystal idioblasts irregularly shaped, throughout tissue.

    Fig. 72. *Corydalis aurea*

40. (a) Crystal idioblasts absent. 41

    (b) Crystal idioblasts present. 43

41. (a) Cell walls deeply sinuate. 42

(b) Cell walls undulate.

Fig. 101. *Cicuta maculata*

42. (a) Epidermis rugulose, cell walls thin, not luminescent.

Fig. 82. *Oligomeris linifolia*

(b) Epidermis not rugulose, cell walls brightly luminescent.

Fig. 80. *Pteridium aquilinum* var. *pseudocaudatum*

43. (a) Companion cells of the stomata three or four, one often reduced. 44

(b) Companion cells two or three, or numerous and radially arranged. 45

44. (a) Lattice-type crystal idioblasts present.

Fig. 61. *Sesbania macrocarpa*

Fig. 62. *S. vesicaria*

(b) Lattice-type crystal idioblasts absent, druses and crystal sand abundant.

Fig. 10. *Drymaria pachyphylla*

45. (a) Companion cells of the stomata numerous, radially arranged.

Fig. 43. *Aesculus pavia* var. *pavia*

Fig. 86. *Prunus virginiana*

(b) Companion cells of the stomata two or three. 46

46. (a) Companion cells distinct.

Fig. 33. *Ricinus communis*

(b) Companion cells not distinct (= none reduced).

Fig. 39. *Centaurium beyrichii*

Fig. 40. *C. calycosum*

47. (a) Trichomes stellate.

Fig. 37. *Quercus havardii*

Fig. 38. *Q. virginiana*

Fig. 97. *Solanum dimidiatum*

Fig. 98. *S. elaeagnifolium*

Fig. 99. *S. rostratum*

(b) Trichomes not stellate. 48

48. (a) Trichomes small unicellular bumps or protrusions from the epidermis.

Fig. 32. *Phyllanthus abnormis*

Fig. 72. *Corydalis aurea*

Fig. 73. *Phytolacca americana*

Fig. 101. *Cicuta maculata*

Fig. 102. *Conium maculatum*

(b) Trichomes distinctly different from other epidermal cells, not small unicellular bumps or protrusions from the epidermis. 49

49. (a) Some trichomes long, tangled spirals that appear unicellular, attachments not conspicuous.

Fig. 30. *Jatropha cathartica*

Fig. 31. *J. dioica*

(b) Trichomes unicellular or multicellular, but not long, tangled spirals. 50

50. (a) Trichomes of more than one type (some specimens may have predominantly homomorphous trichomes). 51

(b) Trichomes of only one type. 60

51. (a) Trichome attachments complex. 52

(b) Trichome attachments superficial. 55

52. (a) Crystal idioblasts absent.

Fig. 103. *Aloysia lycioides*

(b) Crystal idioblasts present. 53

53. (a) Trichomes unicellular, stiff, luminescent, often with wavy margins. 54

(b) Trichomes, at least some, multicellular (some specimens may have predominantly unicellular trichomes, characteristics of this plant can vary).

Fig. 7. *Asclepias subverticillata*

54. (a) Trichomes long and thin, uniform in width over most of their length.

Fig. 105. *Kallstroemia hirsutissima*

Fig. 106. *K. parviflora*

(b) Trichomes much broader near base, tapering toward the tip.

Fig. 53. *Cassia occidentalis*

Fig. 87. *Cephalanthus occidentalis*

55. (a) Trichomes predominantly unicellular. 56

(b) Trichomes predominantly multicellular. 59

56. (a) Trichomes long and thin, uniform in width over much of their length.

Fig. 105. *Kallstroemia hirsutissima*

Fig. 106. *K. parviflora*

Fig. 109. *Tribulus terrestris*

(b) Trichomes with a conspicuous taper or swollen at base. 57

57. (a) Crystal idioblasts absent.

Fig. 103. *Aloysia lycioides*

(b) Crystal idioblasts present. 58

58. (a) Druses absent, small rhomboid crystals in veins.

Fig. 53. *Cassia occidentalis*

(b) Druses present, characteristics of this plant can vary.

Fig. 7. *Asclepias subverticillata*

59. (a) Distal segment of trichomes muticous (= blunt tipped).

Fig. 52. *Cassia obtusifolia*

Fig. 7. *Asclepias subverticillata*

(b) Distal segment of trichomes apiculate.

Fig. 7. *Asclepias subverticillata*

Fig. 89. *Datura inoxia*

Fig. 90. *D. quercifolia*

Fig. 91. *D. stramonium*

Fig. 92. *D. wrightii*

60. (a) Trichomes unicellular (may have one or two small cells-of-attachment). 61

(b Trichomes multicellular. 86

61. (a) Trichome attachments complex. 62

(b) Trichome attachments superficial. 65

62. (a) Cell walls smooth. 63

(b) Cell walls undulate or sinuate. 64

63. (a) Companion cells of the stomata three or four, one often reduced.

Fig. 10. *Drymaria pachyphylla*

Fig. 87. *Cephalanthus occidentalis*

(b) Companion cells of the stomata variable in number, not distinct (= none reduced).

Fig. 108. *Peganum mexicanum*

64. (a) Companion cells of the stomata three or four, one often reduced.

Fig. 10. *Drymaria pachyphylla*

(b) Companion cells of the stomata variable in number, not distinct (= none reduced).

Fig. 104. *Lantana horrida*

65. (a) Cell walls smooth. 66

(b) Cell walls undulate or sinuate. 80

66. (a) Stomata hidden in crypts, trichomes radially arranged pointed inward along edges of stomatal crypts.

Fig. 4. *Nerium oleander*

(b) Stomata not hidden in crypts, trichomes attached to epidermis. 67

67. (a) Stomata generally equal to or greater in size than most epidermal cells. 68

(b) Stomata relatively much smaller in size than most epidermal cells. 72

68. (a) Cells with a conspicuous waxy coating.

Fig. 59. *Prosopis glandulosa* var. *glandulosa*

(b) Cells without a conspicuous waxy coating. 69

69. (a) Druses present, abundant. 70

(b) Druses absent or rare (rhomboid crystals present). 71

70. (a) Trichomes thin walled, frail, with an additional usually luminescent attachment cell.

Fig. 58. *Parkinsonia aculeata*

(b) Trichomes thick walled, luminescent, usually curved and attached over veins.

Fig. 67. *Melia azedarach*

71. (a) Stomata size roughly equal to the size of most epidermal cells, trichomes abundant.

Fig. 51. *Cassia lindheimeriana*

(b) Stomata, when present, greatly exceeding the size of the epidermal cells, trichomes common but not abundant.

Fig. 85. *Prunus gracilis*

72. (a) Companion cells of the stomata two, three, or four, one or two reduced. 73

(b) Companion cells of the stomata variable in number, not distinct (= none reduced). 76

73. (a) Trichomes attached on the side.

Fig. 57. *Oxytropis lambertii*

(b) Trichomes attached at one end. 74

74. (a) Crystal idioblasts irregularly shaped lattice-type crystals, common.

Fig. 60. *Sesbania drummondii*

Fig. 62. *S. vesicaria*

(b) Crystal idioblasts amorphous druses, or rhomboid or elongated crystals, lattice-type crystals absent. 75

75. (a) Trichomes uniform in width over much of their length, not greatly broader near base.

Fig. 54. *Cassia roemeriana*

(b) Trichomes not uniform in width over much of their length but broader near base, rapidly tapered over the basal one-third.

Fig. 87. *Cephalanthus occidentalis*

76. (a) Trichomes with an additional, usually luminescent cell-of-attachment. 77

(b) Trichomes without any additional attachment cells, slightly swollen at base, producing a sucker-like attachment.

Fig. 81. *Delphinium virescens*

Fig. 83. *Colubrina texensis*

77. (a) Trichomes small and frail, not luminescent, crystal idioblasts small rhomboid crystals common in vein tissue.

Fig. 55. *Melilotus albus*

Fig. 56. *M. officinalis*

(b) Trichomes medium-to-large size, luminescent, crystal idioblasts small amorphous druses or absent. 78

78. (a) Crystal idioblasts present, cell-of-attachment often inflated.

Fig. 63. *Sophora nuttalliana*

(b) Crystal idioblasts absent, cell-of-attachment often luminescent. 79

79. (a) Trichomes broad, cigar-shaped.

Fig. 50. *Astragalus wootonii*

(b) Trichomes long and thin, abundant.

Fig. 47. *Astragalus mollissimus* var. *coryi*

Fig. 48. *A. mollissimus* var. *earlei*

Fig. 49. *A. mollissimus* var. *mollissimus*

80. (a) Trichomes with one or two additional, usually luminescent cells-of-attachment. 81

(b) Trichomes without additional cells-of-attachment. 84

81. (a) Trichomes small and frail, not luminescent. 82

(b) Trichomes large or luminescent. 83

82. (a) Crystal idioblasts small crystalline druses throughout tissue, rhomboid crystals absent.

Fig. 58. *Parkinsonia aculeata*

(b) Crystal idioblasts small rhomboid crystals common in vein tissue, druses absent.

Fig. 55. *Melilotus albus*

Fig. 56. *M. officinalis*

83. (a) Crystal idioblasts red amorphous druses and irregularly shaped lattice-type crystals, common.

Fig. 60. *Sesbania drummondii*

Fig. 62. *S. vesicaria*

(b) Crystal idioblasts absent.

Fig. 46. *Astragalus emoryanus*

Fig. 48. *A. mollissimus* var. *earlei*

84. (a) Trichomes moderately large, slightly swollen at base producing a sucker-like attachment.

Fig. 83. *Colubrina texensis*

Fig. 85. *Prunus gracilis*

Fig. 86. *P. virginiana*

(b) Trichomes small to large, ensiform or curved, not conspicuously swollen at base. 85

85. (a) Crystal idioblasts present and distinctive rhomboid crystals enclosed within a sheath, common in vein tissue, trichomes small, curved, brightly luminescent.

Fig. 45. *Acacia berlandieri*

(b) Crystal idioblasts absent, trichomes soft, ensiform.

Fig. 9. *Lobelia berlandieri*

86. (a) Trichome attachments complex. 87

(b) Trichome attachments superficial. 100

87. (a) Bicellular glands ("footballs") common. 88

(b) Bicellular glands absent or rare. 89

88. (a) Basal segment of trichomes greatly inflated.

Fig. 16. *Helenium autumnale*

Fig. 26. *Xanthium* sp.

(b) Basal segment of trichome not greatly inflated.

Fig. 17. *Helenium badium*

Fig. 18. *H. microcephalum*

Fig. 19. *Hymenoxys odorata*

89. (a) Basal segments of some trichomes greatly inflated. 90

(b) Basal segments of trichomes not inflated. 92

90. (a) Crystal idioblasts absent.

Fig. 15. *Flourensia cernua*

(b) Crystal idioblasts present. 91

91. (a) Cell walls smooth and thick.

Fig. 20. *Isocoma wrightii*

(b) Cell walls undulate and thin.

Fig. 96. *Solanum americanum*

92. (a) Trichomes small, three to four or fewer cells, rapidly tapered.

Fig. 27. *Xanthocephalum microcephalum*

Fig. 28. *X. sarothrae*

(b) Trichomes medium to large, dissected or many celled. 93

93. (a) Trichomes dissected. 94

(b) Trichomes not dissected. 95

94. (a) Trichomes with many lobes or appendages.

Fig. 79. *Notholaena sinuata* var. *cochisensis*

(b) Trichomes not lobed, appressed.

Fig. 78. *Persicaria hydropiperoides*

95. (a) Crystal idioblasts absent. 96

(b) Crystal idioblasts present. 97

96. (a) Distal segments of trichomes usually muticous.

Fig. 14. *Eupatorium rugosum*

(b) Distal segments of trichomes apiculate, gland stalks dissected bilaterally.

Fig. 13. *Conyza coulteri*

97. (a) Trichomes slightly swollen at joints.

Fig. 11. *Kochia scoparia*

(b) Trichomes not swollen at joints. 98

98. (a) Crystal idioblasts clusters of many extremely fine crystals.

Fig. 100. *Solanum triquetrum*

(b) Crystal idioblasts subcrystalline druses. 99

99. (a) Complex attachments many celled.

Fig. 8. *Asclepias verticillata*

(b) Complex attachments few celled.

Fig. 25. *Senecio spartioides*

100. (a) Cell walls smooth. 101

(b) Cell walls undulate or sinuate. 105

101. (a) Crystal idioblasts absent (rare in some taxa). 102

(b) Crystal idioblasts present. 104

102. (a) Trichomes long and thin. 103

(b) Trichomes tapered, three-to-five celled, basal segment inflated.

Fig. 16. *Helenium autumnale*

103. (a) Trichomes tape-like, not swollen at joints.

Fig. 24. *Senecio longilobus*

(b) Trichomes not tape-like, swollen at joints.

Fig. 21. *Psilostrophe gnaphaloides*

Fig. 22. *P. tagetina*

Fig. 23. *P. villosa*

104. (a) Crystal idioblasts small rhomboid crystals restricted to vein tissue, druses absent.

Fig. 41. *Aesculus arguta*

Fig. 42. *A. pavia* var. *flavescens*

Fig. 43. *A. pavia* var. *pavia*

(b) Crystal idioblasts small subcrystalline druses in stem tissue, rhomboid crystals absent.

Fig. 29. *Euphorbia marginata*

105. (a) Crystal idioblasts absent. 106

(b) Crystal idioblasts present. 108

106. (a) Trichomes long and thin, swollen at joints.

Fig. 12. *Baileya multiradiata*

Fig. 22. *Psilostrophe tagetina*

(b) Trichomes with conspicuous taper over most of their length, joints not swollen but basal segment may be inflated. 107

107. (a) Bicellular glands ("footballs") present.

Fig. 16. *Helenium autumnale*

(b) Bicellular glands absent.

Fig. 44. *Perilla frutescens*

108. (a) Crystal idioblasts clusters of many fine crystals.

Fig. 94. *Nicotiana repanda*

(b) Crystal idioblasts small rhomboid crystals restricted to vein tissue.

Fig. 41. *Aesculus arguta*

Fig. 43. *A. pavia* var. *pavia*

APPENDIX B

Checklist of epidermal cellular characteristics and distributions by resource areas of Texas excluding plants in the Poaceae family.[1]

Taxon	Cell Size	Stomata Size	Trichomes: Present	Trichomes: Homomorphous	Trichomes: Polymorphous	Trichomes: Type(s)	Trichomes: Abundance	Trichomes: Attachment Type	Glands	Crystal Idioblasts	Distribution
AMARANTHACEAE											
Amaranthus retroflexus	m	s	y	✓		mc	r	cx	pr	Cl,Dr	2345678910
AMARYLLIDACEAE											
Agave lecheguilla	m	l,su	n						ab	Sty,Rp,Cl	7 10
APOCYNACEAE											
Apocynum sibiricum	s	s	y	✓		bu	a		pr	Dr	5 78 10
Nerium oleander	s	no	y	✓		uc	a	sf	ab	Dr,Rh	12 67
ASCLEPIADACEAE											
Asclepias asperula	m	m	n						pr	Dr	45 78910
A. latifolia	s	m	n						pr	Dr	78910
A. subverticillata	m	m	y		✓	uc/mc	r/c	sf/cx	pr	Dr	2 6 8910
A. verticillata	m	m	y	✓		mc	r	cx	ab	Dr	1234567 10
CAMPANULACEAE											
Lobelia berlandieri	s/m	m	y	✓		uc	c	sf	ab	ab	2 678 10
CARYOPHYLLACEAE											
Drymaria pachyphylla	m/l	m	y	✓		uc	r	cx	ab	Dr,Cs	10
CHENOPODIACEAE											
Kochia scoparia	s	s	y	✓		mc	a	cx	ab	Dr	2 89
COMPOSITAE											
Baileya multiradiata	s	s	y	✓		mc	a	sf	pr	ab	6 10
Conyza coulteri	m	s	y	✓		mc	c	cx	pr	ab	2 7 10
Eupatorium rugosum	m	m	y	✓		mc	c	cx	ab	ab	12 7
Flourensia cernua	m	m	y	✓		mc	c	cx	pr	ab	7 10
Helenium autumnale	m	s/m	y	✓		mc	c	sf/cx	pr	ab	5 78
H. badium	m	m	y	✓		mc	c	cx	pr	ab	345 78910
H. microcephalum	m	m	y	✓		mc	r	cx	pr	ab	345678910
Hymenoxys odorata	m	s	y	✓		mc	r	cx	pr	ab	678910
Isocoma wrightii	s	s	y	✓		mc	c	cx	pr	Dr	8 10
Psilostrophe gnaphaloides	m	m	y	✓		mc	a	sf	pr	Dr	2 67
P. tagetina	m	m	y	✓		mc	a	sf	pr	Dr	678910
P. villosa	m	m	y	✓		mc	a	sf	pr	ab	23 678910

Taxon	Cell Size	Stomata Size	Trichomes: Present	Trichomes: Homomorphous	Trichomes: Polymorphous	Trichomes: Type(s)	Trichomes: Abundance	Trichomes: Attachment Type	Glands	Crystal Idioblasts	Distribution
Senecio longilobus	l	l	y	✓		uc	a	sf	ab	ab	78910
S. spartioides	l	l	y	✓		mc	c	cx	ab	Cs	78910
Xanthium sp.	s	s	y	✓		mc	a	cx	pr	Dr	Statewide
Xanthocephalum microcephalum	s	m	y	✓		mc	r	cx	pr	ab	10
X. sarothrae	s	s	y	✓		mc	c	cx	pr	ab	2 5 78910
EUPHORBIACEAE											
Euphorbia marginata	m	s/m	y	✓		mc	r	sf	ab	Dr	5 78910
Jatropha cathartica	m	m	y		✓	sp	c		ab	Cb,Dr	2 6
J. dioica	m	m	y		✓	sp/uc	a	cx	ab	Cb,Dr	2 67
Phyllanthus abnormis	m	s	y	✓		bu	c		pr	Dr	2345678 10
Ricinus communis	m	s	n						ab	Dr	12 6
Stillingia sylvatica	l	m	n						pr	Dr	123456 8 10
S. texana	l	m	n						pr	Dr	5 7
S. treculiana	m	s	n						pr	Dr	2 67 10
FAGACEAE											
Quercus havardii	s/m	s	y	✓		st	c	cx	ab	ab	78910
Q. virginiana	s	s	y	✓		st	c	cx	pr	Rh	23 67
GENTIANACEAE											
Centaurium beyrichii	m	s/m	n						ab	Cs	5 78
C. calycosum	m/l	m/l	n						ab	Cs	2 678 10
HIPPOCASTANACEAE											
Aesculus arguta	s/m	s	y	✓		mc	c	sf	pr	Rh,Dr	1 345 7
A. pavia var. *flavescens*	s	m	y	✓		mc	r	sf	pr	Rh,Dr	7
A. pavia var. *pavia*	s	s/m	y	✓		mc	r	sf	pr	Rh,Dr	1234 78
LABIATAE											
Perilla frutescens	s/m	s	y	✓		mc	c	sf	ab	ab	12
LEGUMINOSAE											
Acacia berlandieri	s	s	y	✓		uc	a	sf	ab	Rh	2 67
Astragalus emoryanus	m	s	y	✓		uc	a	sf	ab	ab	10
A. mollissimus var. *coryi*	s/m	s	y	✓		uc	a	sf	ab	ab	7
A. mollissimus var. *earlei*	m	s	y	✓		uc	a	sf	ab	ab	78910
A. mollissimus var. *mollissimus*	m	s	y	✓		uc	a	sf	ab	ab	8910

Taxon	Cell Size	Stomata Size	Trichomes: Present	Homomorphous	Polymorphous	Type(s)	Abundance	Attachment Type	Glands	Crystal Idioblasts	Distribution
A. wootonii	m	s	y	✓		uc	a	sf	ab	ab	10
Cassia lindheimeriana	s	s	y	✓		uc	a	sf	ab	Rh	67 10
C. obtusifolia	m	s	y		✓	uc/mc	r	sf	ab	ab	1 34 6
C. occidentalis	s/l	s	y		✓	uc	c	sf/cx	pr	Rh	123 6
C. roemeriana	s/m	m	y	✓		uc	c	sf	pr	Rh	45 78 10
Melilotus albus	s/m	s	y	✓		uc	c	sf	ab	Rh	2345678910
M. officinalis	s/m	s/m	y	✓		uc	c	sf	ab	Rh	345 8910
Oxytropis lambertii	m	m	y	✓		uc	a	sf	ab	ab	45 8
Parkinsonia aculeata	s	s/m	y	✓		uc	c	sf	ab	Dr	234567 10
Prosopis glandulosa var. *glandulosa*	m	m	y	✓		uc	r	sf	ab	Rh,Cs	2345678910
Sesbania drummondii	s/m	s	y	✓		uc	c	sf	ab	Dr,Cb	1234 6
S. macrocarpa	m	s	n						ab	Dr,Cb	123456
S. vesicaria	s/l	s	y	✓		uc	r	sf	ab	Dr,Cb	123456
Sophora nuttalliana	m	m	y	✓		uc	a	sf	ab	Dr,Cs	78910
S. secundiflora	m	m	n						pr	Rh	2 4 67 10
LILIACEAE											
Nolina texana	m	su	n						ab	ab	5678 10
Zigadenus nuttallii	m	m	n						ab	Rh	1 345 7
MELIACEAE											
Melia azedarach	s/m	s	y	✓		uc	r	sf	ab	Dr,Cs	234
PAPAVERACEAE											
Argemone albiflora	m	s	n						ab	ab	1234567
A. auratiaca	m	m	n						ab	ab	34 678
A. polyanthemos	m	m	n						ab	ab	1 45 78910
A. sp	l	m/l	n						ab	ab	
Corydalis aurea	m	s/m	n						ab	ab	5 78910
PHYTOLACCACEAE											
Phytolacca americana	m/l	m	y	✓		bu	c		pr	Cs,Rp-like	12345678
POLYGONACEAE											
Persicaria hydropiperoides	m	m	y	✓		mc	c	cx	ab	Dr	12345678
POLYPODIACEAE											
Notholaena sinuata var. *cochisensis*	m	l	y	✓		mc	a	cx	ab	ab	78910
Pteridium aquilinum var. *pseudocaudatum*	l	l	n						ab	ab	1234

Taxon	Cell Size	Stomata Size	Trichomes: Present	Trichomes: Homomorphous	Trichomes: Polymorphous	Trichomes: Type(s)	Trichomes: Abundance	Trichomes: Attachment Type	Glands	Crystal Idioblasts	Distribution
RANUNCULACEAE											
Delphinium virescens	l	l	y	✓		uc	a	sf	ab	ab	2345678910
RESEDACEAE											
Oligomeris linifolia	m	s/m	n						pr	ab	67 10
RHAMNACEAE											
Colubrina texensis	s/m	s	y	✓		uc	a	sf	ab	Dr	2 567
Karwinskia humboldtiana	s/m	s	n						ab	Dr,Rh	2 67 10
ROSACEAE											
Prunus gracilis	s	s	y	✓		uc	c	sf	pr	Dr	1 345 789
P. virginiana	s	m	y	✓		uc	r	sf	ab	Cs,Dr	8910
RUBIACEAE											
Cephalanthus occidentalis	s/m	m	y	✓		uc	r	sf/cx	ab	Dr	Statewide
RUTACEAE											
Thamnosma texana	s/m	s/m	n						pr	Dr	678910
SOLANACEAE											
Datura inoxia	m	m	y		✓	uc/mc	c	sf	ab	Dr	67 10
D. quercifolia	m	m	y		✓	uc/mc	c	sf	ab	Dr	910
D. stramonium	m	m	y		✓	uc/mc	r	sf	ab	Dr	123 5 78910
D. wrightii	s/m	s	y		✓	uc/mc	a	sf	ab	Dr	67 10
Nicotiana glauca	m	m	n						pr	Cl	2 67 10
N. repanda	l	m	y	✓		mc	a	sf	pr	Cl	2 67
N. trigonophylla	m	m	n						pr	Cl	2 678 10
Solanum americanum	s/m	m	y	✓		mc	c	cx	ab	Cl,Dr	Statewide
S. dimidiatum	m	m	y	✓		st	c	cx	ab	Cl	2345678
S. elaeagnifolium	s	s	y	✓		st	a	cx	ab	Cl	Statewide
S. rostratum	s	s	y	✓		st	c	cx	ab	Cl,Dr	Statewide
S. triquetrum	m/l	m	y	✓		mc	c	cx	ab	Cl	1234567 10
UMBELLIFERAE											
Cicuta maculata	s/m	s	y	✓		bu	r		ab	ab	34 78
Conium maculatum	s/m	m	y	✓		uc/bu	c		pr	ab	2 4 7 10
VERBENACEAE											
Aloysia lycioides	s	s	y		✓	uc	a	cx/sf	pr	ab	2 45678 10
Lantana horrida	m	m	y	✓		uc	c	cx	ab	ab	1234567

Taxon	Cell Size	Stomata Size	Trichomes: Present	Trichomes: Homomorphous	Trichomes: Polymorphous	Trichomes: Type(s)	Trichomes: Abundance	Trichomes: Attachment Type	Glands	Crystal Idioblasts	Distribution
ZYGOPHYLLACEAE											
Kallstroemia hirsutissima	m	s	y		✓	uc	c	cx/sf	ab	Rh,Dr	2345678 10
K. parviflora	m	m	y		✓	uc	c	cx/sf	ab	Dr	2 45 78 10
Peganum harmala	m	m	n						pr	Rp-like	78 10
P. mexicanum	m	m	y	✓		uc	r	cx	ab	Dr,Rp,Cs	10
Tribulus terrestris	m	s	y		✓	uc	c	sf	ab	Dr	2345678910

[1]Abbreviations used in checklist: a = abundant, ab = absent, bu = bumps (= papilla), c = common, cb = crystalline bodies, Cl = clusters, Cs = crystal sand, cx = complex, Dr = druses, l = large, m = medium, mc = multicellular, n = no, no = not observed, pr = present, r = rare, Rh = rhomboid, Rp = raphides, s = small, sf = superficial, sp = spirals, st = stellate, sty = styloid, su = sunken, uc = unicellular, y = yes, 1 = Pineywoods, 2 = Gulf Prairies and Marshes, 3 = Post Oak Savannah, 4 = Blackland Prairies, 5 = Cross Timbers and Prairies, 6 = South Texas Plains, 7 = Edwards Plateau, 8 = Rolling Plains, 9 = High Plains, l0 = Trans-Pecos, Mountains and Basins

APPENDIX C

Other plants occurring in Texas which reportedly cause livestock poisonings.

REFERENCE[1]	SCIENTIFIC NAME	COMMON NAME
(4)	*Agrostemma githago* L.	Common corncockle
(4)	*Allium* spp.	Onion
(4)	*Amanita* spp.	Mushrooms
(1)	*Anemone* spp.	Anemone
(1)	*Arceuthobium* spp.	Dwarf Mistletoe
(4)	*Argemone mexicana* L.	Yellow pricklypoppy
(4)	*Arisaema triphyllum* (L.) Schott.	Indian jack-in-the-pulpit
(4)	*Baptisia* spp.	Wildindigo
(4)	*Batis maritima* L.	Maritime saltwort
(4)	*Berberis repens* Lindl.	Creeping barberry
(4)	*Celastrus scandens* L.	American bittersweet
(1)	*Cercocarpus montanus* Raf.	True montainmahogany
(4)	*Chenopodium* spp.	Goosefoot
(1)	*Chrysothamnus nauseosus* (Pall.) Britton	Rubber rabbitbrush
(1)	*Clematis* spp.	Clematis
(1)	*Corydalis* spp.	Corydalis
(4)	*Crotalaria* spp.	Crotalaria
(4)	*Croton* spp.	Croton
(4)	*Cyanophyta* spp.	Blue-green algae
(3)	*Cynodon dactylon* (L.) Pers.	Bermudagrass
(4)	*Cypripedium calceolus* L.	Yellow ladyslipper
(1)	*Delphinium* spp.	Larkspur
(1)	*Descurainia pinnata* (Walt.) Britt.	Pinnate tansymustard
(1)	*Equisetum* spp.	Horsetail
(1)	*Euphorbia* spp.	Euphorbia
(4)	*Festuca arundinacea* Schreb. (*F. elatior* L.)	Tall fescue
(4)	*Gelsemium sempervirens* (L.) Ait.	Carolina jessamine
(4)	*Gossypium hirsutum* L.	Upland cotton
(4)	*Gymnocladus dioica* (L.) Koch	Kentucky coffeetree
(1)	*Helenium amarum* (Raf.) H. Rock (*H. tenuifolium* Nutt.)	Sneezeweed
(1)	*Hymenoxys richardsonii* (Hook.) Cockerell	Pingue bitterweed
(4)	*Ilex* spp.	Holly
(4)	*Iris* spp.	Iris
(4)	*Lactuca* spp.	Lettuce
(1)	*Lactuca serriola* L.	Prickly lettuce

REFERENCE[1]	SCIENTIFIC NAME	COMMON NAME
(4)	*Leucaena glauca* (L.) Benth.	White popinac leadtree
(1)	*Linum* spp.	Flax
(4)	*Lolium temulentum* L.	Darnel ryegrass
(1)	*Lupinus* spp.	Lupine, bluebonnet
(4)	*Lyonia ligustrina* (L.) DC.	He-huckleberry
(4)	*Maclura pomifera* (Raf.) Schn.	Osage orange
(1)	*Malva parviflora* L.	Little mallow
(4)	*Melanthium virginicum* L.	Bunchflower
(1)	*Nolina* spp.	Beargrass
(4)	*Onoclea sensibilis* L.	Sensitivefern
(3)	*Panicum coloratum* L.	Kleingrass
(4)	*Papaver somniferum* L.	Opium poppy
(3)	*Paspalum dilatatum* Poir.	Dallisgrass
(4)	*Physalis* spp.	Groundcherry
(4)	*Pinus* spp.	Pine
(2)	*Pinus ponderosa* Laws	Ponderosa pine
(4)	*Podophyllum peltatum* L.	Common mayapple
(4)	*Psoralea tenuiflora* Pursh.	Slimleaf scurfpea
(1)	*Ranunculus* spp.	Buttercup
(1)	*Reverchonia arenaria* Gray	Sand reverchonia
(4)	*Rhus toxicodendron* L.	Poison ivy, poison oak
(4)	*Rhododendron* spp.	Azalea
(1)	*Robinia pseudo-acacia* L.	Black locust
(4)	*Rumex* spp.	Dock
(1)	*Salsola kali* L.	Russianthistle
(4)	*Salvia coccinea* Juss. ex Murr.	Tropical sage
(1)	*Salvia reflexa* Hornem. (*S. lanceafolia* Poir.)	Lanceleaf sage
(4)	*Sanguinaria canadensis* L.	Bloodroot
(1)	*Sarcobatus vermiculatus* (Hook.) Torr.	Greasewood
(4)	*Sartwellia flaveriae* Gray	Threadleaf sartwellia
(4)	*Solidago* spp.	Goldenrod
(4)	*Spigelia marylandica* L.	Woodland pinkroot
(1)	*Suckleya suckleyana* (Torr.) Rydb.	Poison suckleya

[1]1 = Rowell (undated), 2 = James et al. (1980), 3 = Bailey (1978), and 4 = Sperry et al. (1977).

APPENDIX D

GLOSSARY OF TERMS

Amorphous	Lacking crystalline structure.
Antrorse	Directed forward or upward.
Apiculate	Ending in an abrupt slender tip which is not stiff.
Appressed	Lying flat or close against something.
Arachnoid	Beset with cobwebby or entangled hairs.
Cell	A microscopic structural unit of a plant.
Cell-of-attachment	A cell that adjoins two structures.
Clavate	Club-shaped and widest near the apex.
Companion cell	Cells adjoining the stomata.
Complex attachment	Epidermal cells at base of trichome elevated or otherwise differ greatly from other adjacent epidermal cells.
Costal	The region over the nerves (veins) of the grass leaf.
Crystal idioblasts	Cell which produces calcium oxalate crystals.
Crystal sand	Small, usually six-sided crystals.
Crystalline	Composed of many smaller crystals.
Dimorphic	In two forms.
Dimorphous	With two forms.
Dissected	Cut or divided into numerous and usually narrow segments, too varied to draw.
Distal	The end opposite the point of attachment.
Druse	Spherical aggregate of crystals.
Ensiform	Shaped like a sword, as the leaf of *Iris*.
Epidermis	The outer layer of cells.
Faint	May require higher power magnifications (128-200X) to be visible. Also indicates cells have thin walls.
Fovae	Small depression or pit.
Geniculate	Abruptly bent, as at the elbow or knee joint.
Gland	A secreting structure or surface, or an appendage having the general appearance of such an organ.
Glandular trichome	Unicellular or multicellular trichome consisting of a stalk and a unicellular or multicellular distal segment.
Globose	Shaped like a globe, like a model of the earth.
Hexagonal	Cells with roughly six sides.
Homomorphous	Of only one form or kind.
Idioblast	(see crystal idioblast)

Intercostal	The area between the vascular bundles or nerves of a leaf.
Lanate	With long, tangled, woolly hairs.
Linear	A narrow flat shape with parallel sides, the length is over four times the width.
Luminescent	Appearing bright when viewed under phase contrast or dark field illumination which often indicates thick cell walls or thick-walled trichomes.
Macrohairs	Long, mostly one-celled trichomes which are usually visible to the naked eye.
Microhairs	Much smaller than macrohairs and usually two-celled.
Multicellular	Consisting of 3 or more cells or small compartments.
Muticous	Blunt and without a point.
Polymorphic	Having several forms.
Polymorphous	With several forms.
Punctate	Marked with dots, pits or translucent glands.
Pustulose	Beset with pimple-like elevated areas.
Raphides	Long, needle-shaped crystals which are pointed at both ends and aggregated in bundles.
Reduced	Smaller, i.e., as with companion cells of the stomata, one or several smaller than others.
Rhomboid	Roughly square crystals.
Rugose	With wrinkled or creased surface.
Rugulose	Minutely rugose.
Serrate	Having angled tooth-like protrusions along margins.
Silica cell	Short epidermal cells of the grass leaf that contain silica bodies of various shapes, sometimes adjacent to suberose cells.
Silica-suberose couple	(see silica cell and suberose cell).
Sinuate	Strongly wavy margins or cell walls.
Smooth	Without undulations, entire as used to describe leaf margins.
Stellate	Star-shaped or branched trichomes with slender arms radiating out from a common center.
Stomate (pl. stomata)	A small opening on the surface of a leaf through which gaseous exchange takes place, sometimes written stoma. Here, refers to guard cells and stoma collectively.
Styloid	Long, needle-like crystal which is blunt at both ends and sometimes aggregated into bundles.
Subcrystalline	Intermediate in structure between amorphous and crystalline.
Suberose cell	Cork cells, usually adjacent to silica cells of the grass leaf.
Superficial attachment	Epidermal cells at base of trichome not greatly different than other epidermal cells.
Taxon (pl. taxa)	Any taxonomic group or entity.

Trichome	A hair-like outgrowth of the epidermis.
Undulate	A gently wavy margin or cell wall.
Unicellular	One-celled.
Vaginate	Provided with or surrounded by a sheath.
Vein	Threads of vascular tissue in a leaf.
Verrucose	Covered with wart-like elevations.
Vouchered plant specimens	Plant specimens or samples that have been positively identified by comparison to known or type specimens by a regional or national herbarium.

APPENDIX E

INDEX TO COMMON AND SCIENTIFIC NAMES

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