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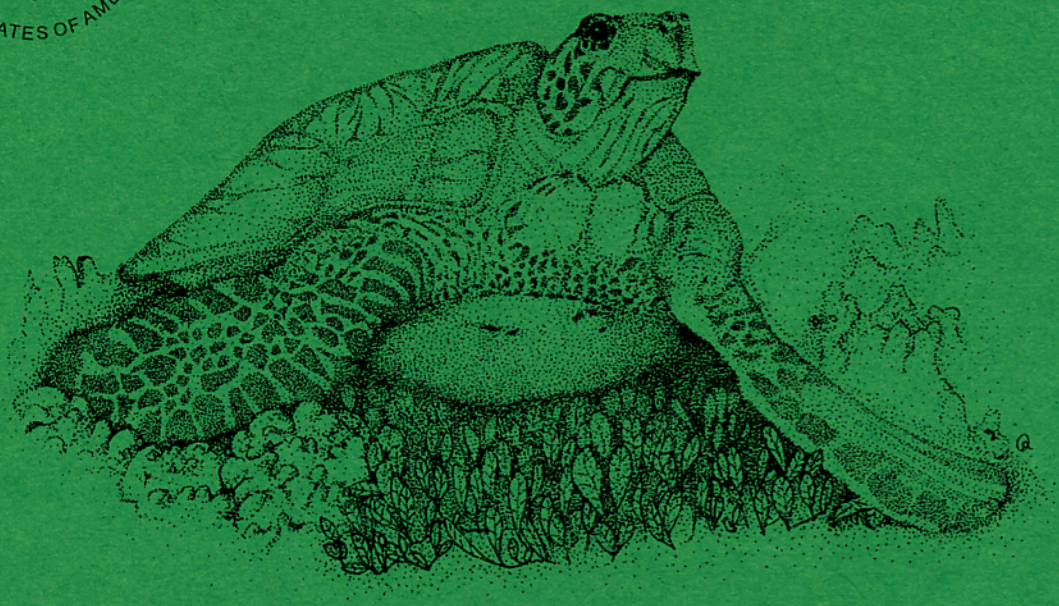

IDENTIFICATION MANUAL FOR DIETARY VEGETATION OF THE HAWAIIAN GREEN TURTLE *Chelonia mydas*

Dennis J. Russell and George H. Balazs

NOAA-TM-NMFS-SWFSC-294

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

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JUNE 2000

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Introduction

This manual is designed to assist sea turtle biologists and other non-phycologists in the identification of the food items contained in the gastrointestinal tract of green turtles (*Chelonia mydas*) sampled from the Hawaiian Islands. The manual contains many of the most common algal species found in crop/stomach samples taken from Hawaiian green turtles. During this study, which began in 1976, we have documented over 275 species of Chlorophyta (green algae), Anthophyta (sea grass), Phaeophyta (brown algae), Rhodophyta (red algae) and Cyanophyta (blue-green algae or blue-green bacteria) in or on green turtles. Green turtles are the most common sea turtle present in Hawaii and are primarily herbivorous, feeding on a variety of marine algae, a single sea grass, invertebrate animals, plus a few freshwater species. The purpose of this manual is to begin with the most common green turtle food species and then to expand this effort at a later time to include the less common algae, animals, and incidental items found in gut samples taken over the past 20 years. Lists of species, locations, quantities and ecological discussions can be found in prior publications (Balazs, 1980; 1983; 1984; 1985, Balazs et al., 1987; Russell, 1994; Russell and Balazs, 1994).

Studies involving foraging ecology, growth, and health status of sea turtles require identification of crop/stomach contents. High priority objectives are 1) to identify the primary food items of the green turtle, 2) to determine the relative amounts of each species eaten by the turtles, 3) to ascertain different feeding habits in different local populations of turtles, 4) to evaluate changes in their diets over time, 5) to assess the effects of introduced algae on their diets, 6) to help determine any connections between diet items and the prevalence of fibropapilloma tumors (Balazs and Pooley, 1991; Landsberg et al., 1999), and lastly, 7) to detect the ingestion of unusual items related to pollution of the oceans, which could be deleterious to their health.

Green turtles feed mostly on marine algae in selected grazing areas by removing numerous small nips of algae with their beaks, pressing the water out of the food on the roof of their mouth, and swallowing after forming a bolus. The bolus enters the crop, a pouch located at the end of the esophagus, where it is stored and digestion begins before entering the stomach. Hawaiian green turtles have a prominent, well-developed crop filled with fresh algal food material located in the posterior region of the esophagus just prior to the stomach. Australian green turtles also have a crop, but in contrast the green turtles from Florida have no structure like this (Balazs et al., 1997; Rainey, 1981). Food in the crop is very compact and stratified with distinctly different colors and textures. During a necropsy different species of algae can be seen as different colors, with the freshest food items in the esophageal crop closer to the esophagus and the older, previously ingested items in the posterior stomach where a lower pH (higher acidity) exists and the food undergoes a change in color. The food enters the small intestines where more digestion and absorption occurs. The food then enters the large intestine and cloaca where microbial breakdown of cellulose and other polysaccharides occurs before being discharged as fecal pellets (Bjorndal, 1979, 1985; Fenchel et al., 1979).

Sampling procedure

During the past 20 years algae samples have been taken from the foraging, feeding, and fecal elimination process. Samples were collected from green turtles on the reef where they were feeding: from their mouths (when captured alive while actively foraging), from stomach lavage,

from the crop/stomach, from intestines and fecal pellets of dead turtles, and from fecal pellets found on the beach. The majority of samples were taken from crops of turtles during necropsies. These turtles had died from illegal killings, forced submergence in fishing nets, being hit by boats, and fibropapilloma disease. Their carcasses were salvaged for research purposes as part of a sea turtle stranding program conducted by the Southwest Fisheries Science Center, Honolulu Laboratory, National Marine Fisheries Service (see Murakawa et al., In Press).

The drawings and descriptions in this manual were based mostly on what a person would normally find in the crop/stomach samples. Algae from the fresher samples in the crop/stomach have been torn into small pieces by the turtle and have undergone some degradation. It is much more difficult and sometimes impossible to identify algae to the species level when it is found further along the digestive tract because most of the key taxonomic features are digested and have disappeared.

Samples of algae were taken directly from observed green turtle feeding areas on the reef to ensure that undamaged and fresh food material could be compared to the fragmented and partly digested algae taken from the crop/stomach. Samples of fresh reef algae were preserved in 5-10% formalin/seawater and compared to crop/stomach samples preserved in the same manner.

During the necropsy the crop/stomach was dissected, opened, and examined. At this time it was possible to see the stratified layers of different algae that had been eaten, the general amounts of each, and the order in which they had been eaten; i.e., the last food eaten was closest to the esophagus. Algae from each stratum was sampled, and approximately 50 ml was preserved in 5-10% formalin/seawater, sealed, and packaged for further analysis. A dissecting microscope (7x-30x) was used to identify the majority of the algae present. Clean forceps and pipettes were used to remove numerous smaller pieces of algae from throughout the 13mm deep, 140mm diameter petri plate, placed on slides, and examined under 100x or more with a compound microscope. The bulk of algae material, which obstructs the view of smaller species, was then removed, placed back into the original sample tube, and the remaining liquid and small scraps in the petri plate were examined until no additional species were found.

Fecal pellets, as found washed-up along a shoreline (Balazs et al., 1993), were often lumpy and needed to be broken, hydrated, and spread out with forceps. The pellets were examined and sorted in the same way as samples from the crop/stomach. Mouth samples and stomach flush samples were examined in the same manner as crop/stomach samples.

Identification of major algal species from Hawaiian green turtles was based on the best knowledge of the algae available in the literature at the time the sample was taken. Some of the references used for this manual are listed in the bibliography, while other references were from unpublished papers and notes. Many taxonomic changes have occurred between 1976 and 1999, and one important purpose of this manual is to supply enough descriptive information to assure consistency of naming over time and to avoid false assumptions of changes in the green turtle's diet.

Taxonomic organization

Algae are traditionally organized according to Divisions, which are based on their general colors: Chlorophyta (green algae), Phaeophyta (brown algae), Rhodophyta (red algae),

Cyanophyta (blue-green algae or bacteria), and others. Each Division also has other characteristics that they share in common besides color, and with practice a person can identify the Division in which a specimen belongs by its vegetative structure even when the colors are missing or have been altered significantly by the digestion process.

The manual is organized according to the major phyla or Divisions of algae, plus Anthophyta (sea grass). All of the larger macroalgae are listed in alphabetical order in the first part and all of the mostly microscopic Cyanophyta are grouped together in the second part. The macroalgae are the first species recognized during the identification process and are usually quickly and easily identified based on the appearances of the individual fragments.

The figures for each species are arranged with the most common and definitive fragments located in the center of the diagram, the peripheral parts near the outside, cross-sections to the lower left; larger whole branches, branching patterns, and entire thalli are located at the bottom and lower right corners. The measure bars represent different size approximations of the figures they reflect. On the side of each figure is an explanation of the colors involved, the definitive characteristics, what samples normally look like in crop/stomach samples, and a note about the ecology of the species. The reader is encouraged to seek comprehensive works on tropical marine algae to further verify identifications, especially when dealing with less common species not covered in this brief manual.

Cyanophyta species are included in this manual, not because they are dominant food items, but because they represent a large group of commonly encountered species and some are known to produce toxins.

Freshwater and terrestrial plant species

It is common to find freshwater and terrestrial algae in green turtle samples. Some green turtles venture into estuaries, streams and mixohaline or brackish ponds, where they feed on water weeds, green algae and blue-green algae/bacteria that have accumulated on the bottom. Terrestrial algae are also sometimes washed off the land into estuaries and into nearshore ocean waters and accumulate among unattached drift seaweed in low spots in the sand underwater. For example, it is common for sea turtles to feed among large masses of drifting sea weeds just offshore in sandy troughs in Kailua Bay, Oahu. Leaves from grass and trees, twigs of the ironwood tree (*Casuarina equisetifolia*), and moss have been found in crop/stomach samples from areas like Kailua Bay.

Animal species

The purpose of this manual is not to identify the various animal species found in turtle samples. However, some colonial animals form dark firm lumps (ascidians and anthozoans) that resemble the green alga *Codium arabicum* and are commonly found in crop/stomach samples. Coarse pieces of various sponge species filled with spicules are often seen, as well as the remains of various kinds of molluscs, crustacea, jellyfish, worms, and insects. Examples of animal species we have found will be included in later editions of this manual as it expands in scope.

Future plans for expanding this manual

Plans are being made to expand the coverage presented in this manual to include additional pages describing more of the primary marine food species as they appear in green turtle crop/stomach samples, along with a summary of the percentages they represent as food for green turtles, locations where green turtles are grazing, and dates. An additional section will be included describing the freshwater and marine algae identified from scrapings taken from sea turtle skin and identification tags affixed to the flippers.

Acknowledgments

We would like to acknowledge the help and cooperation of Dr. I.A. Abbott and Dr. Celia Smith, Botany Department, University of Hawaii, Dr. George Antonelis, Barbara Schroeder and Judy Kendig for their many useful suggestions and corrections during the writing of this manual. During recent years the following individuals made special contributions to this work: Shawn K.K. Murakawa, Denise M. Parker, Shandell Eames, Dr. Thierry Work, Dr. Robert Morris (Makai Animal Clinic), Dr. A. Alonso Aguirre, Marc Rice (Hawaii Preparatory Academy), Leon Hallacher, Walter Dudley, John Coney, Skippy Hau, Bill Puleloa, Don Heacock and Pete Hendricks. We also thank Christine Wyatt for setting up and editing the manual through its multiple drafts.

Chlorophyta (green algae)

Bryopsis pennata Lamouroux

Distinguishing characteristics: Two varieties are both placed under this one species. It has very soft, delicate feather-like erect branches (pinnae), either flat or curled to one side. There are no inward extensions of cell wall (no trabeculae). It is not made up of cells, but is tubular (coenocytic).

B. pennata occurs in fresh green turtle samples as dark green tubular fragments, but is more often a colorless thread-like mass. Positive identification comes from the feather-like ramulae without trabeculae and with black spots in terminal extensions. Erect ramulae rise up from prostrate portions with root-like extensions.

Ecology: *B. pennata* occurs near shore in calmer waters or in harbors. Thallus branches are erect to 4 cm tall and have a very delicate form.

Related species: Some *Caulerpa* species appear similar to *Bryopsis*, but *Caulerpa* has trabeculae and *Bryopsis* does not.

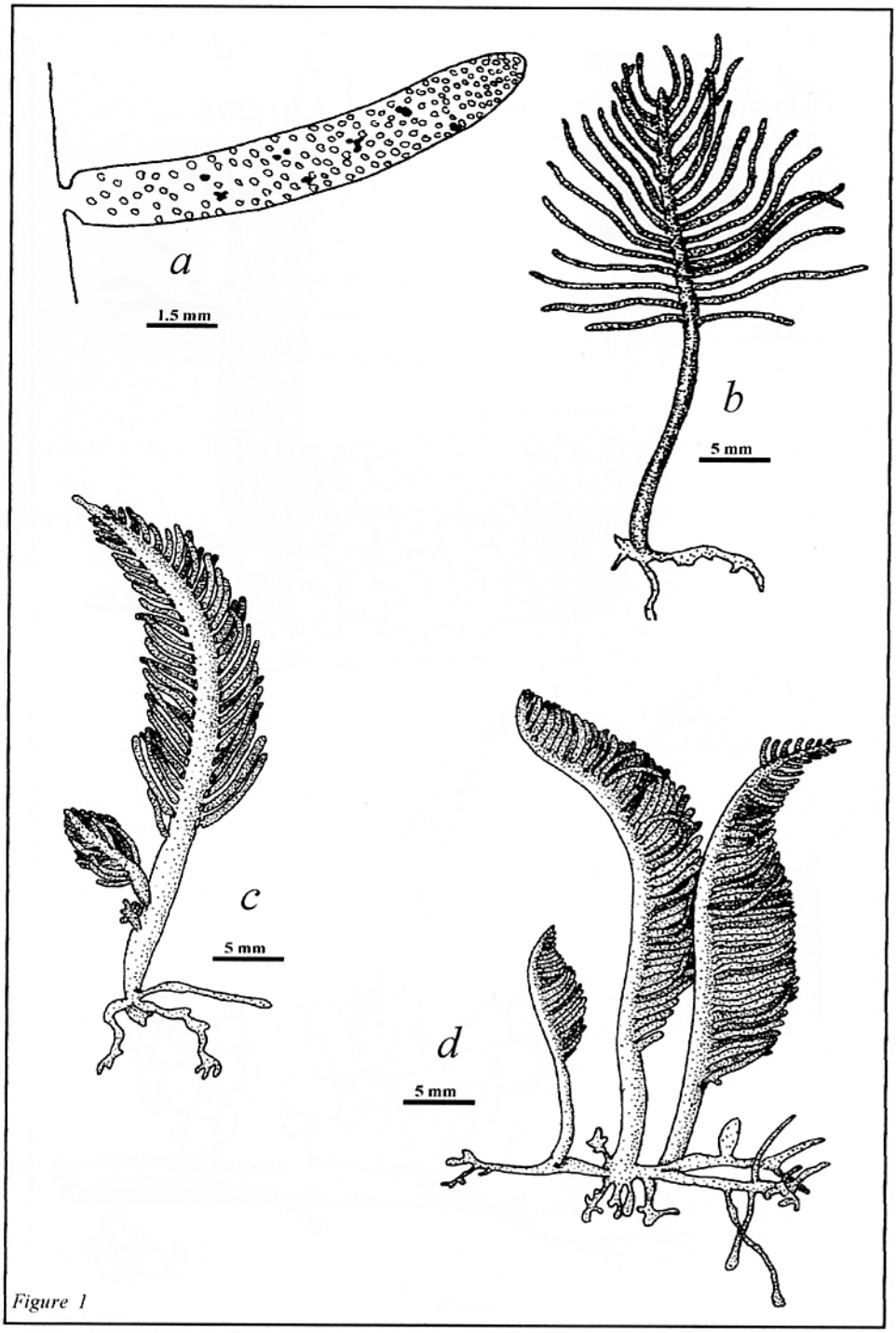

Figure 1

Key to figure 1: ***a.*** detail of ramulus branch showing black spots and chloroplasts ***b.*** one thin branch ***c.*** branch of *Bryopsis pennata* var. *pennata* ***d.*** branch of *Bryopsis pennata* var. *secunda*

Chlorophyta (green algae)

Caulerpa racemosa (Forsskal) J. Ag.

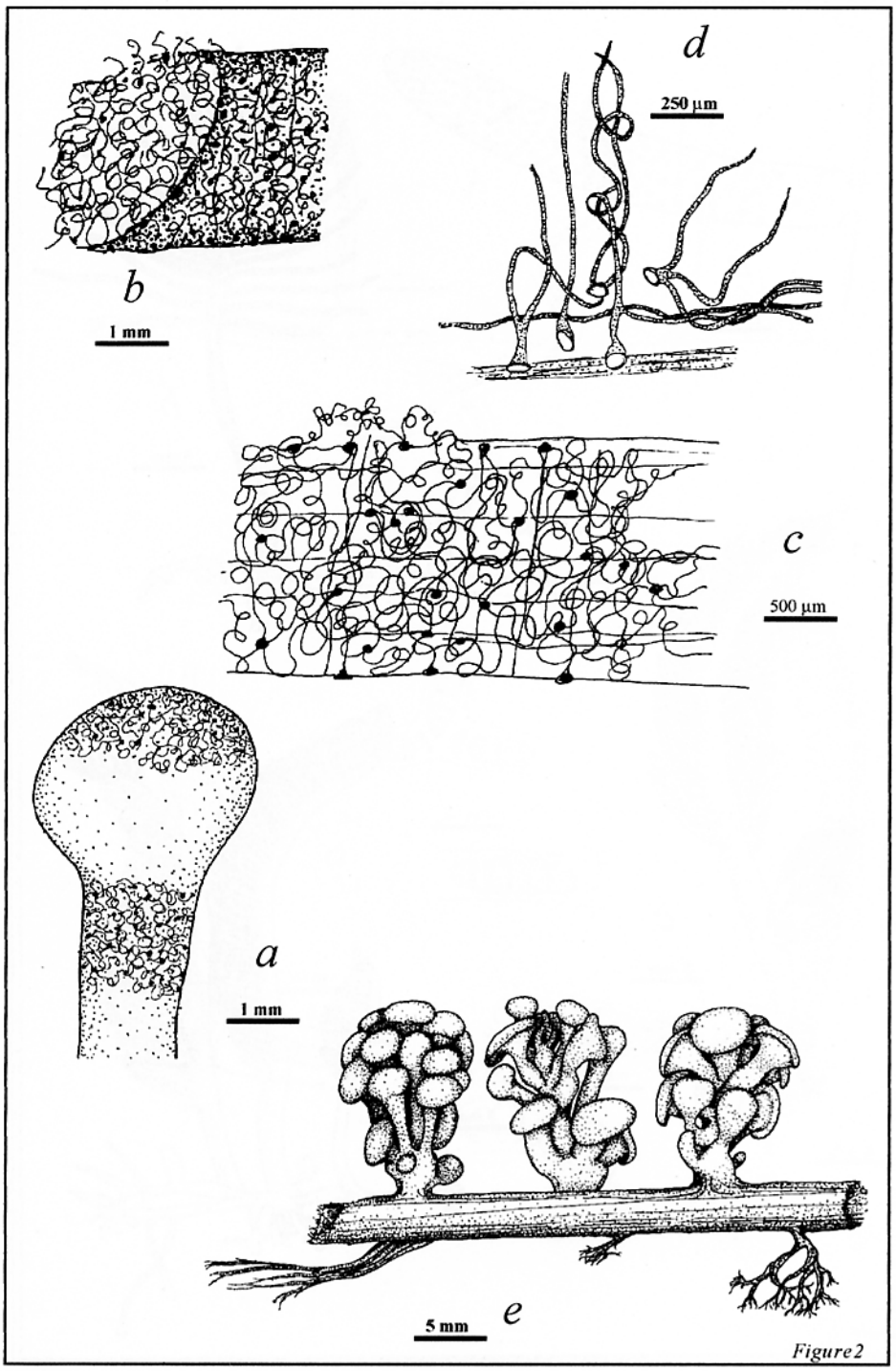

Figure 2

Distinguishing characteristics: At least six varieties of this species are recognized based on the various shapes of the erect branches (ramulae). Ramulae vary from a single disc on a stalk to clusters of disc-like, grape-like, or club-shaped branches. Ramulae arise from prostrate branches that look like they are "rooted" in soft substrate. The entire alga is tubular, coenocytic, with wiry curls of reinforcing trabecular cell wall material.

C. racemosa occurs in green turtle samples as green or yellowish fragments, that for certain identification include parts of the ramulae with trabeculae inside. There are no surface cells. *Caulerpa* species are known to contain toxins.

Ecology: *C. racemosa* occurs on the upper surface of coral rock or is "rooted" in calm sandy patches in shallow water or in deeper water in strong currents.

Related species: *C. racemosa* is a highly variable species, but easily distinguished in all its variations from other *Caulerpa* species found in Hawaii because it never has blades nor is it feather shaped or curled with spines.

Key to figure 2: ***a.*** fragment of a branch tip ***b.*** cut-section of the rhizome, ***c.*** rhizome showing trabeculae ***d.*** detail of trabeculae ***e.*** portion of thallus with erect ramulae and root-like rhizoids.

Chlorophyta (green algae)

Cladophora sericea (Huds.) Kuetz.

Distinguishing characteristics: *C. sericea* is a delicate pale green filamentous alga with main axes 50-70 µm diameter, cells 4-8x longer than wide containing reticulated chloroplasts. The main axis branches dichotomously and has lateral branches that are shorter, narrower (20-40 µm diameter), arranged alternately, opposite or on one side. Lateral branches near the tip often have shorter branches between longer branches.

Ecology: *C. sericea* occurs in small amounts with other algae or in abundant loose strands (10-100 cm long). It became exceedingly abundant on leeward reefs in Maui 10 years ago and sporadic blooms are common. *C. sericea* is now more common in green turtle samples than in the past. *Cladophora* species tolerate nutrient pollution, but its abundant presence is an indication that no heavy metal pollution is there.

Related species: Similar *Cladophora* species grow in dense tufts, are coarser, and have branch cells of equal diameter to the axis. *Cladophora* is an ill-defined genus, and its species will probably be changed.

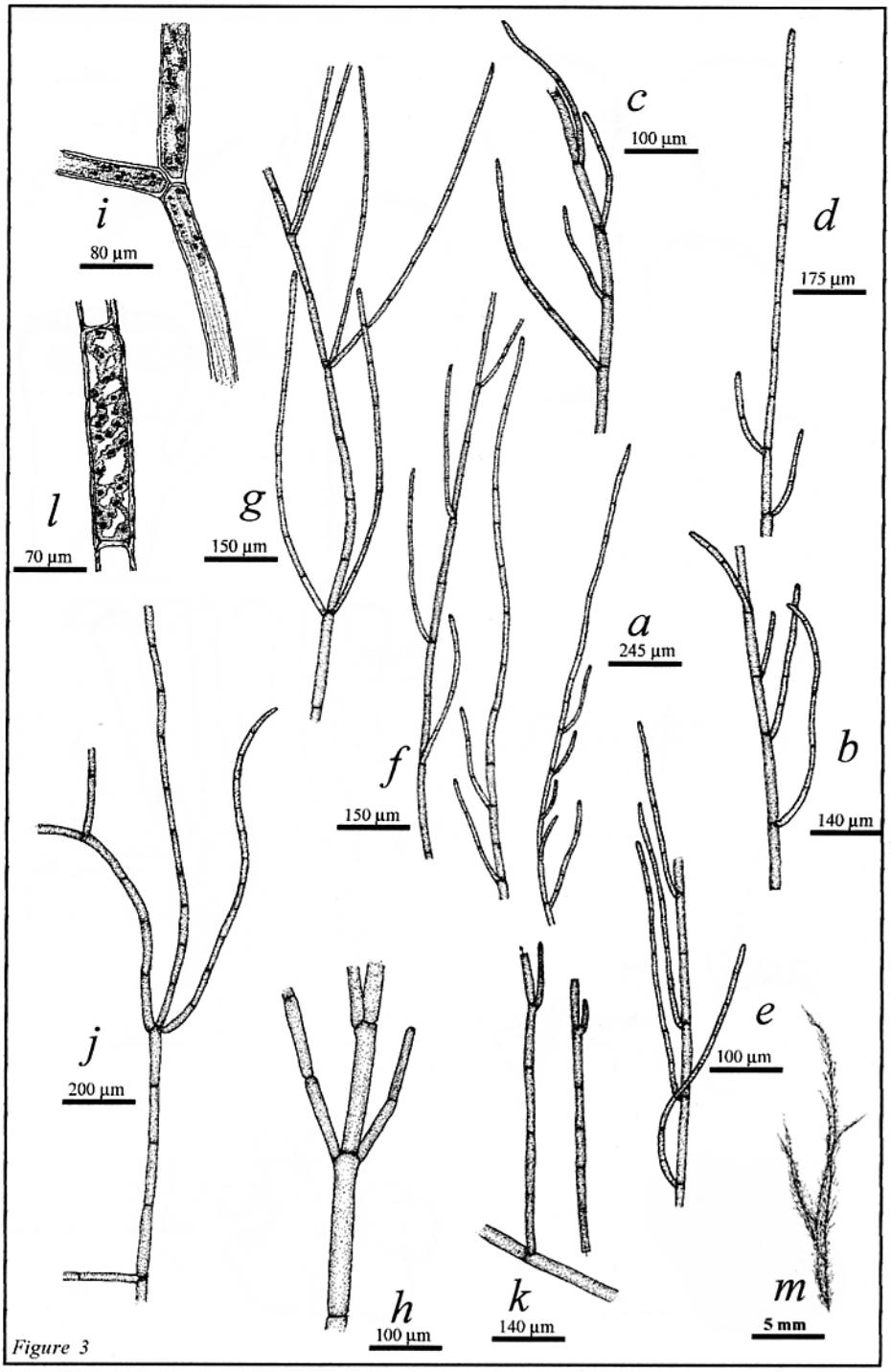

Figure 3

Key to figure 3: ***a.-d.*** thallus tips with 6-16 cells before the first lateral branch and shorter branches between longer branches ***e.-f.*** arrangement of equal length branches ***g.- h.*** opposite branching ***i.*** dichotomous branching of the main cells ***j.*** dichotomous and opposite branching of the main filament with lateral branches ***k.*** a lateral branch with short branchlets ***l.*** cellular detail, reticulated chloroplast with dark pyrenoids ***m*** entire thallus as it appears on the reef.

Codium arabicum Silva

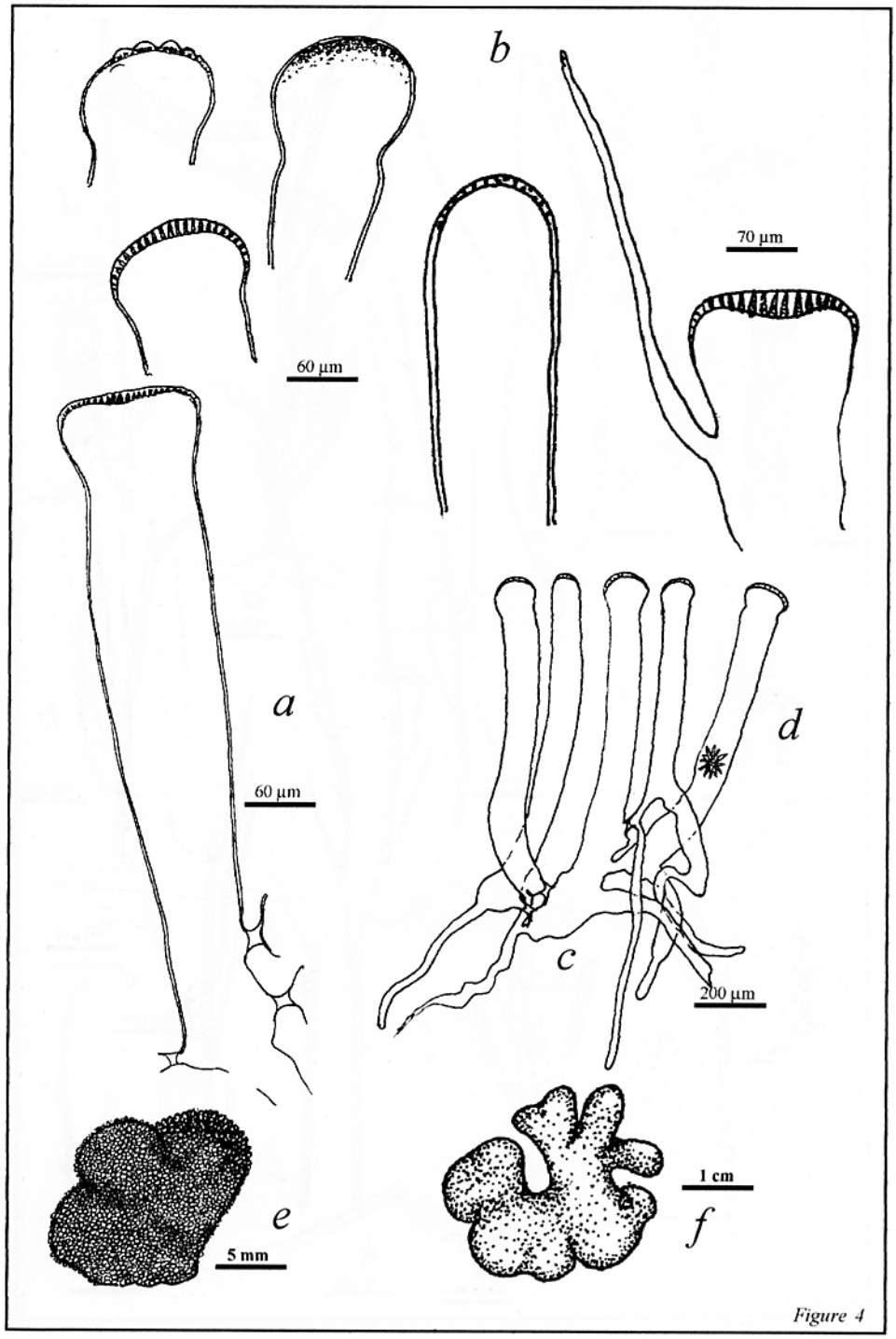

Figure 4

Distinguishing characteristics: The utricles are tall (500 µm) and narrow (50 µm) with a distinct wall thickening at the apex, with many small striations. The utricles usually have no hairs attached.

C. arabicum occurs in green turtle samples as dark green lumps with little or no branching. Sometimes very short, sessile dichotomous branches occur, or the lumps have a suggestion of dichotomy to them. Some utricles may have only small clusters of spots decorating the apex. Often small clusters of crystals are found inside the utricles. Digestion erodes the distinguishing utricle tip features.

Ecology: *C. arabicum* typically occurs on mid-portions of the reef, as a cushion in well lighted places, in water 0.5-2.0 m deep.

Related species: *Codium edule* fragments may look like *C. arabicum*, but *C. edule* has larger utricles without sculptured tips characteristic of *C. arabicum*.

Key to figure 4: ***a.*** utricle ***b.*** utricle tip variation ***c.*** utricles attached in a series ***d.*** utricle with a crystal bundle inside ***e.*** detail of fragment ***f.*** entire plant as it appears on the reef

Chlorophyta (green algae)

Codium edule Silva

Distinguishing characteristics: The utricles are tall (500-1200 µm) and wide (200-500 µm) with no distinct wall thickening at the apex, and usually have 1-2 hairs attached near the apex or scars where the hairs had been.

C. edule occurs in green turtle samples as 5 mm diameter sections with dichotomous branching. The utricles can be easily seen with a dissecting scope and appear clear with a dark green spot at the apex due to cytoplasmic coagulation.

Ecology:
C. edule typically occurs on the mid-portion of the reef. Thallus branches are not erect, but lie on top of each other as a mat. It is found in well lighted places, in water 0.5-2.0 m deep.

Related species:
Codium arabicum fragments may look similar but they have smaller utricles, swollen tips with a thickened apical wall that is sculptured with striations or small dots. The larger *C. edule* utricles have hairscars, which are seldom seen in *C. arabicum*.

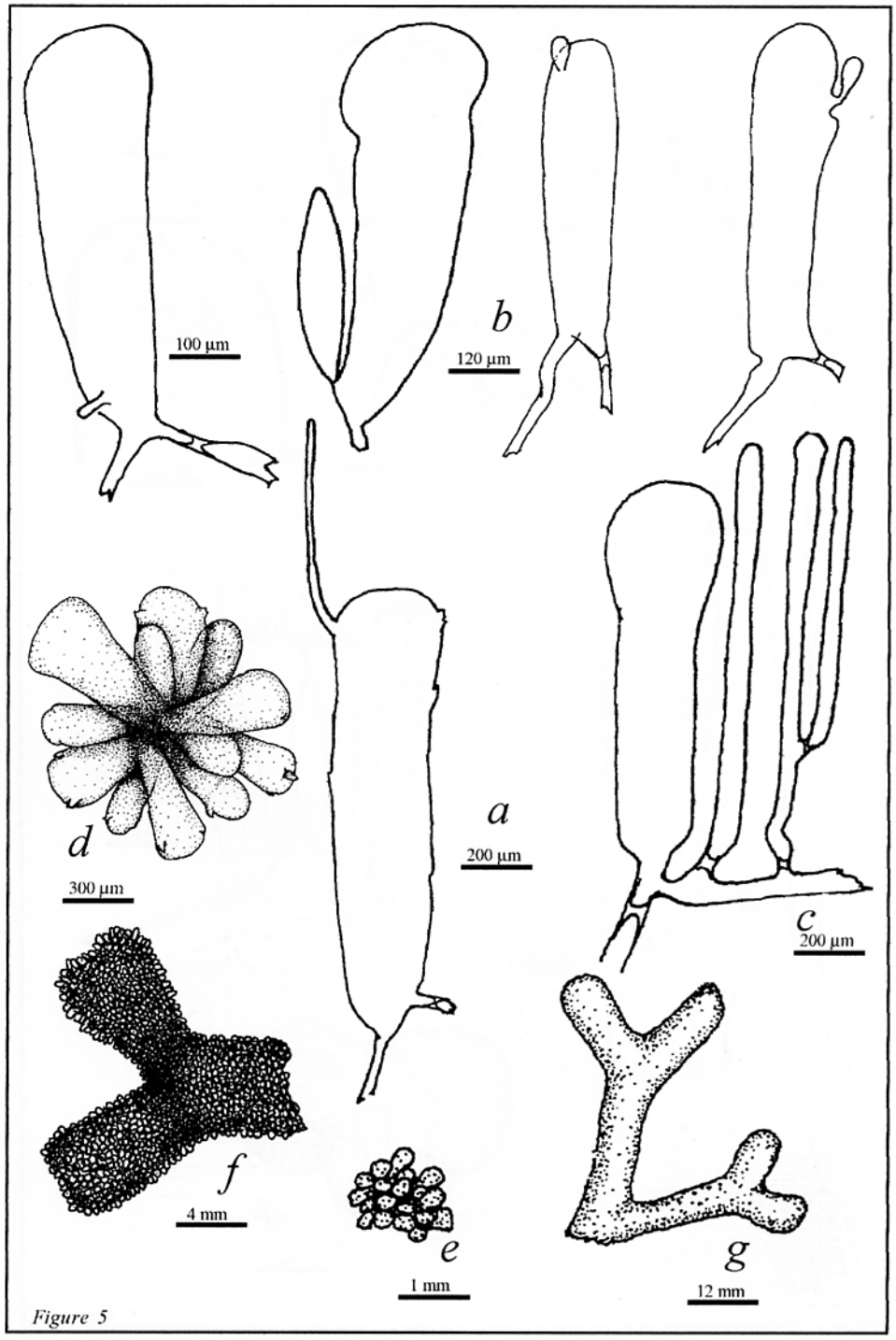

Figure 5

Key to figure 5: ***a.*** utricle ***b.*** utricle variation ***c.*** utricles attached in a series ***d.*** cluster of utricles ***e.*** surface view of a cluster of utricles ***f.*** detail of fragment ***g.*** branching pattern

Codium phasmaticum Silva

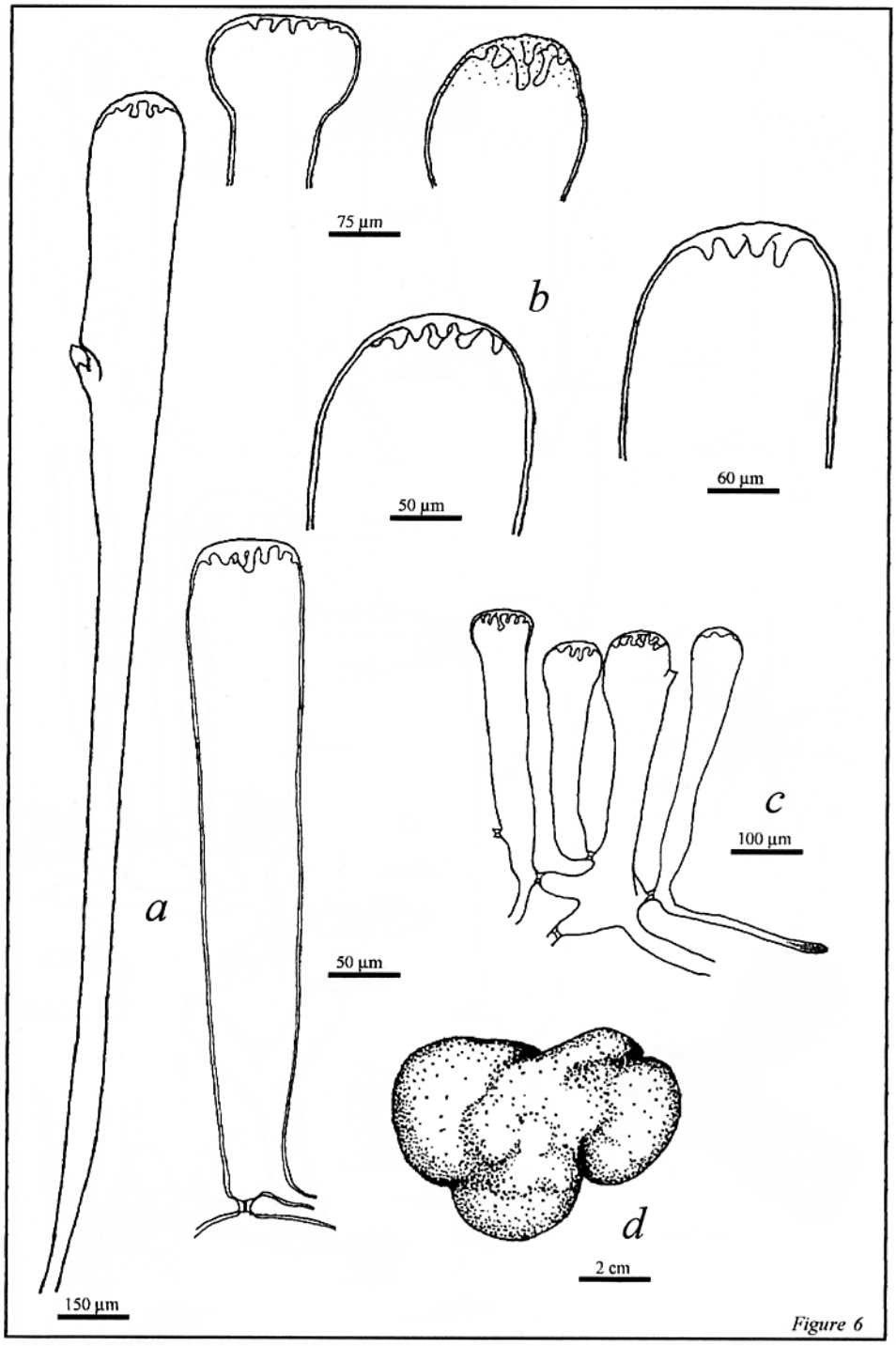

Figure 6

Distinguishing characteristics: The utricles are very tall (500-2000 µm) and narrow (50-80 µm) with nearly every utricle apex thickened with distinct inward extensions that look like stalactites, and most of the utricles do not have hairs attached.

C. phasmaticum occurs in green turtle samples as soft light green cushions with no branching. Utricles are pale and difficult to distinguish with a dissecting scope.

Ecology: *C. phasmaticum* occurs on the mid-portion of the reef, as velvet lumps in well lighted places in water 0.5-2.0 m deep. It grows with *C. arabicum* and *C. edule*.

Related species: *C. phasmaticum* is difficult to distinguish from *C. arabicum,* but the latter is darker green, utricles can be seen with a dissecting scope, and the thallus is tougher. *C. phasmaticum* utricles are much longer, pale yellow to pale green and more easily torn apart with dissecting needles.

Key to figure 6: ***a.*** utricles ***b.*** utricle tip variation ***c.*** utricles attached in a series ***d.*** entire plant as it appears on the reef

Chlorophyta (green algae)

Codium reediae Silva

Distinguishing characteristics: The utricles are tall (400-1000 µm) and wide (150-400 µm), many are conical-shaped with a thickened apex wall, these utricles usually have a short bulbous hair or extremely long (2500µm) hairs attached, with a darkened swollen tip. Many utricles contain large clusters of distinct feathery crystals.

C. reediae occurs in green turtle samples as 10 mm diameter sections with uneven dichotomous branching, flattened where the branches join. Utricles can be seen with the dissecting scope and branch tips often have long fine hairs. Fragments are usually dark green.

Ecology: *C. reediae* occurs near the shore or mid-reef. Thallus branches are erect to 10 cm tall, unevenly dichotomously branched, and flat. *C. reediae* is attached to the substratum by a single tough fibrous holdfast.

Related species: *C. edule* fragments look similar but its utricles are larger in diameter, do not have a thickened apex, very long hairs or crystals as in *C. reediae*.

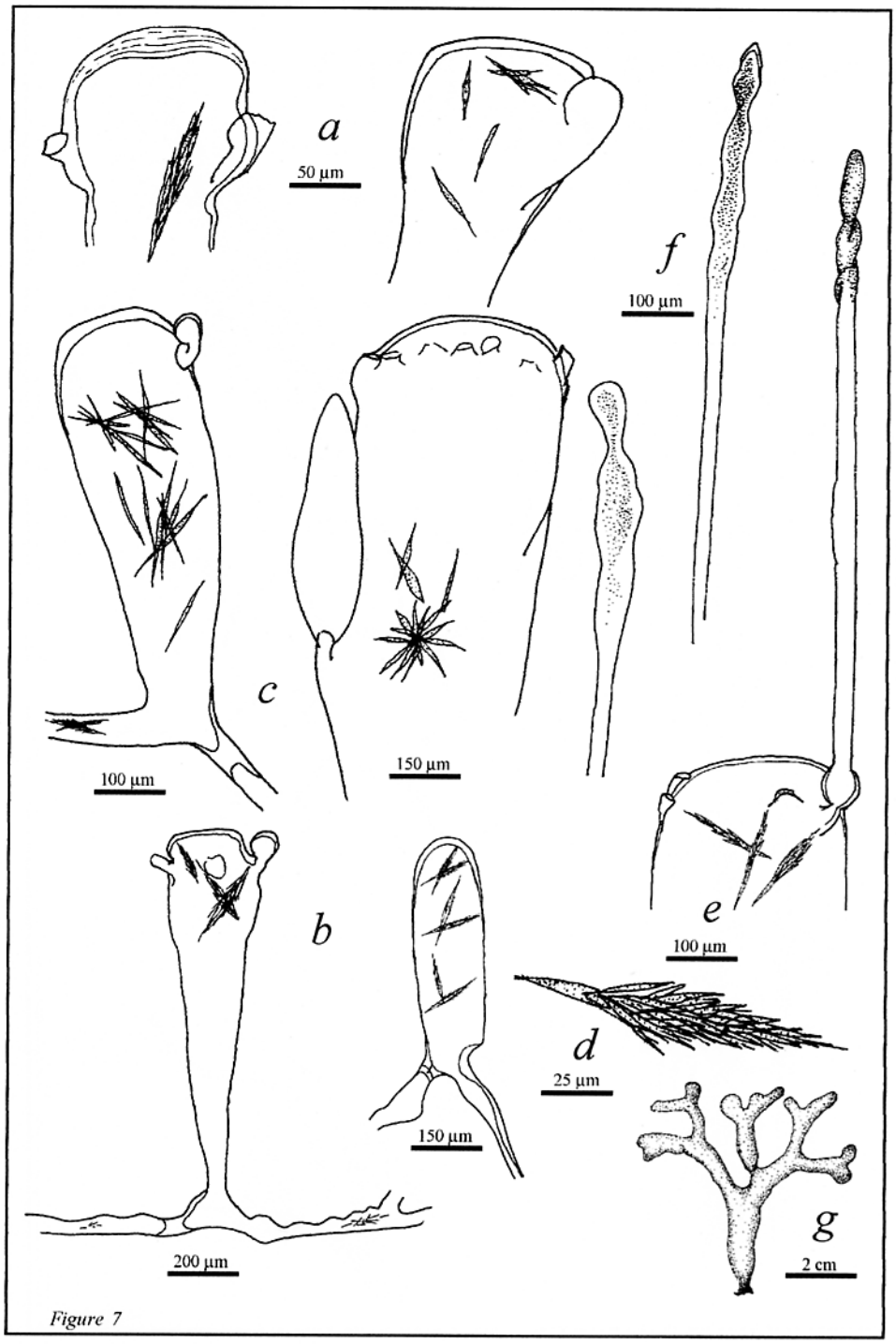

Figure 7

Key to figure 7: ***a.*** utricles with short bulbous hairs ***b.*** utricle variation ***c.*** utricle with sporangium and crystals ***d.*** detail of crystal ***e.*** utricle with long hair ***f.*** hair tip detail ***g.*** entire plant as it appears on the reef.

Dictyosphaeria cavernosa (Forsskal) Boerg.

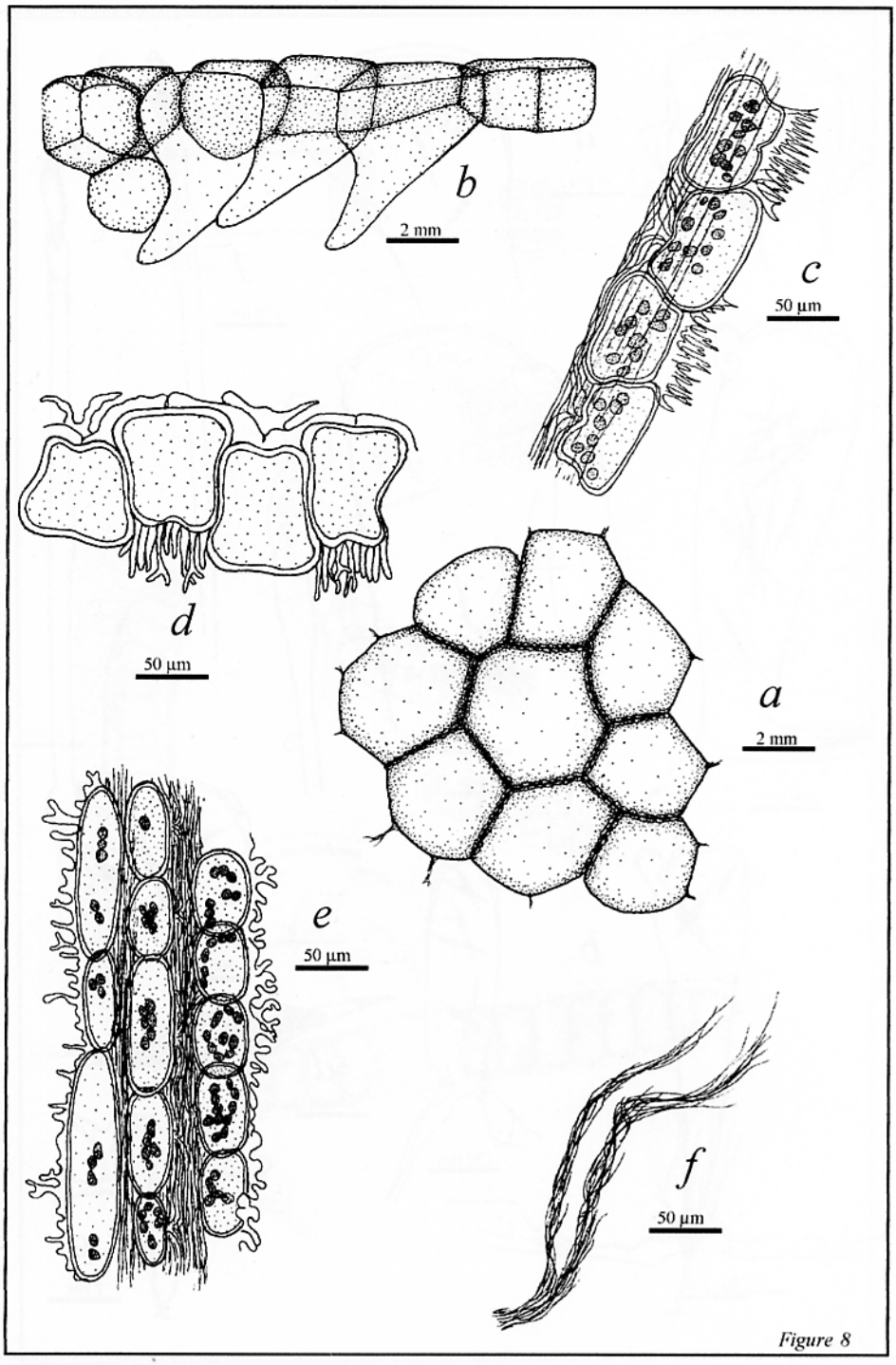

Figure 8

Distinguishing characteristics: ***D. cavernosa*** has large bubble-shaped cells or segments (3-4 mm diameter). Its cell walls do not form trabecular extensions into them, and the smaller cells along cell walls are trapezoidal and have finger-like extensions that attach to the larger cells.

D. cavernosa occurs in green turtle samples as white colorless chunks that are one cell thick, soft, but tough to tear. Certain identification includes the occurrence of large cells without trabeculae.

Ecology: *D. cavernosa* occurs in calm bays, on coral rock often where there is nitrogen available from terrestrial or sediment sources. It has a bubbly appearance and intertidal populations often trap air inside the domed light green thallus.

Related species: *D. versluysii* looks like *D. cavernosa,* but *D. versluysii* is several cells thick, with cells that have trabeculae and the thalli are hard. *D. cavernosa* thalli are not hard and are easily crushed.

Key to figure 8: ***a.*** large lens-shaped cells, surface view, with a few smaller cells shown along cell walls ***b.*** cross-section of the thallus ***c.*** detail of smaller cells between the larger cells ***d.*** detail of smaller cells ***e.*** smaller cells along a thick cell wall ***f.*** fragments of cell wall material (fibers).

Chlorophyta (green algae)

Dictyosphaeria versluysii Weber van Bosse

Distinguishing characteristics: It has large bubble-shaped cells or segments (1-2 mm diameter). The cell walls form trabecular extensions into them, and the small cells along cell walls are semi-circular and have short fringe-like extensions that attach to the larger cells.

D. versluysii occurs in green turtle samples as white colorless chunks that are several cells thick, soft, but tough to tear -- like plastic film. Certain identification includes the occurrence of large cells with trabeculae and strap-like cellulose cell wall fibers.

Ecology: *D. versluysii* occurs on coral reefs in strong wave action or in bays with currents. It is hard and firmly attached, a translucent light green, and difficult to crush.

Related species: *D. cavernosa* looks like *D. versluysii* but is not a solid mass several cells thick. Cells of *D. cavernosa* do not have trabeculae.

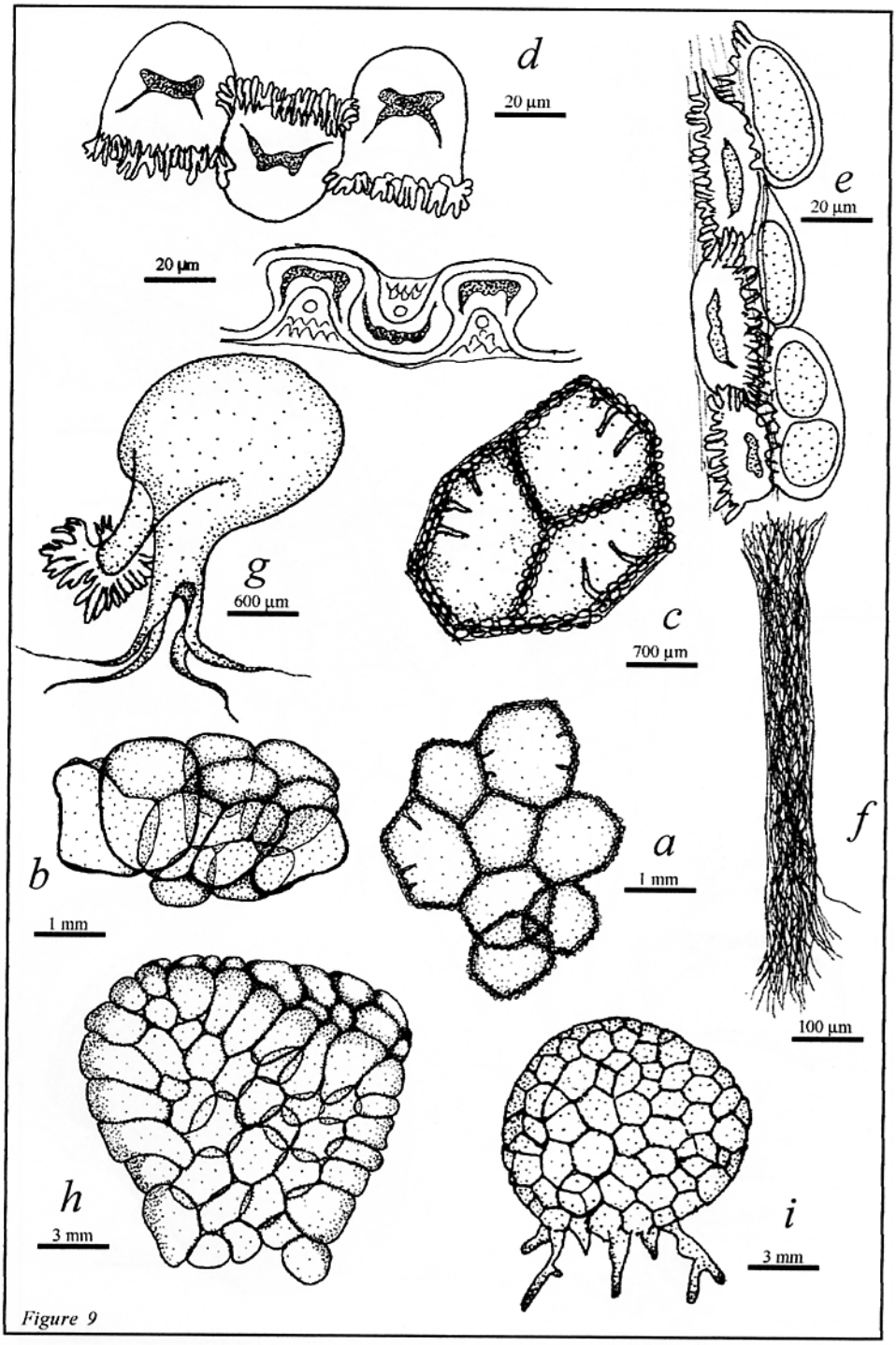

Figure 9

Key to figure 9: ***a.*** large lens-shaped cells, surface view, with trabeculae and smaller cells shown along cell walls ***b.*** thallus fragment ***c.*** detail of smaller cells between the larger cells ***d.*** detail of smaller cells ***e.*** smaller cells along a thick cell wall ***f.*** fragment of strap-shaped cell wall fibers ***g.*** rhizoidal cell ***h.*** cross-section of the thallus ***i.*** entire plant as it appears on the reef

Microdictyon setchellianum Howe

Chlorophyta (green algae)

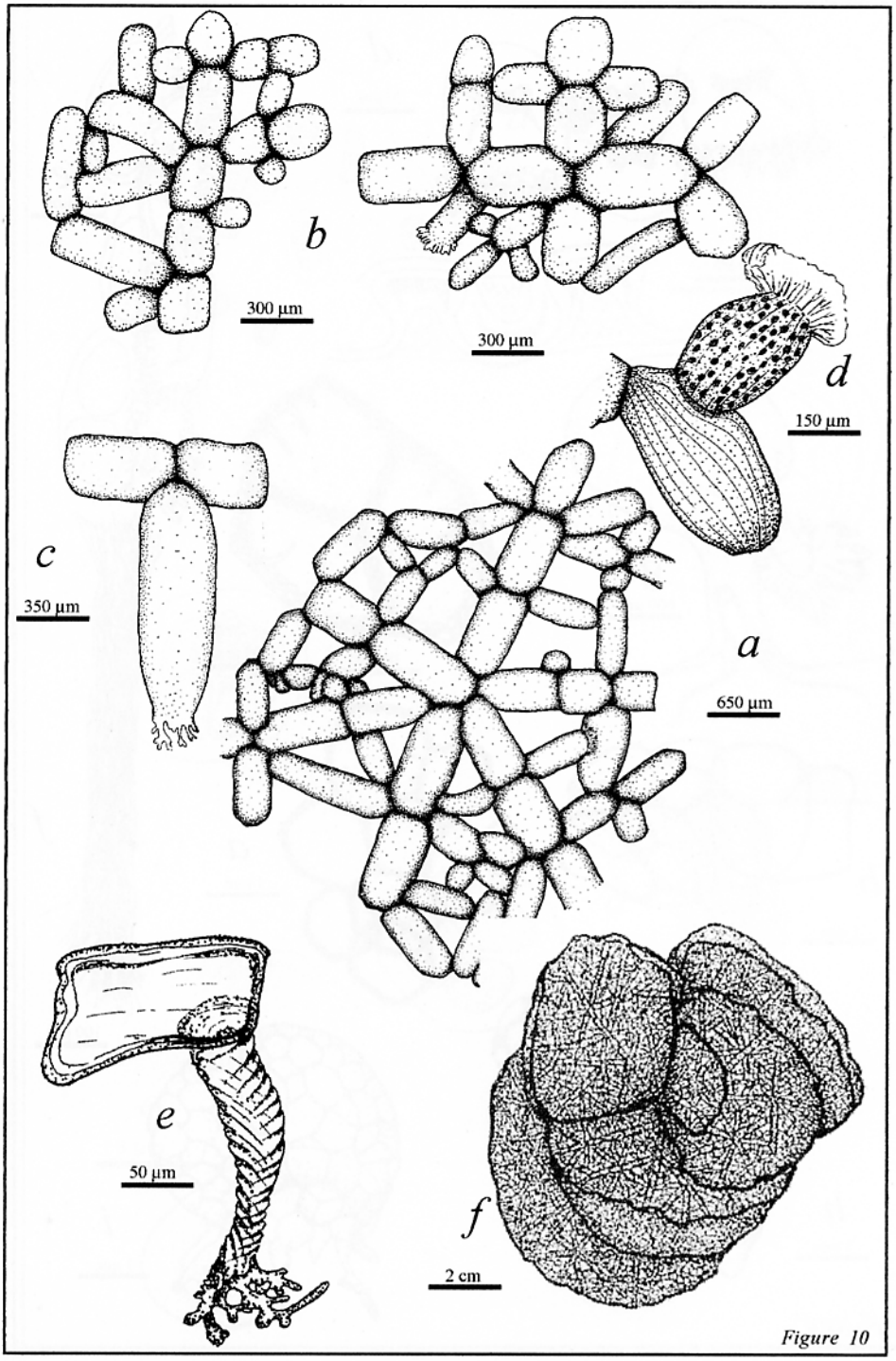

Figure 10

Distinguishing characteristics: It is a flat, tight network of large cells (200-400 µm wide, 400-1000 µm long) forming ruffled sheets only one cell thick. Cells fasten to each other by short projections of the cell walls.

M. setchellianum occurs in green turtle samples as small colorless fragments of mesh forming cells and the rhizoids from the lower sides of some cells are funnel-shaped with visible bias fibers in the cell walls.

Ecology:
M. setchellianum grows from a stalk-less center from which arise several semicircular, fragile, dark green blades forming a rosette. *M.setchellianum* grows on reef rock, near sandy areas, and in strong currents.

Related species:
Microdictyon japonicum is similar but has much finer cells and mesh than *M. setchellianum.*

Key to figure 10: ***a.*** large fragment showing the cell arrangement ***b.*** small fragments of the thallus ***c.*** detail of a cell with attaching extensions of cell wall ***d.*** cell with pad-like attachment and striations in the cell wall ***e.*** detail of cell with rhizoidal extension ***f.*** entire plant as it appears on the reef.

Chlorophyta (green algae)

Rhizoclonium grande Boerg.

Distinguishing characteristics: This alga appears as long (10-15 mm) filaments that are usually not branched, and when they are the branches are short. They have long cells (200 – 400 µm) that are slightly arched and that contain a single netted chloroplast. The filament attaches by a single basal cell that is flared and sometimes lobed.

R. grande occurs in green turtle samples as entangled hair-like masses, often colorless or pale green and mixed in with other algae.

Ecology: *R. grande* is most often found growing as masses of long green strands entangled among the branches of other algae or as part of green algal mats formed by *Valonia aegagropila* and *Cladophoropsis luxurians*.

Related species: *Rhizoclonium grande* is the largest (200 µm wide) of the three species (*R. riparium* and *R. africanum* are less than 100 µm wide). All three species can have unilateral short rhizoidal branches, when on mud or sand and one basal holdfast cell. Species of *Cladophora* and *Cladophoropsis* are similar but have many distinct long branches.

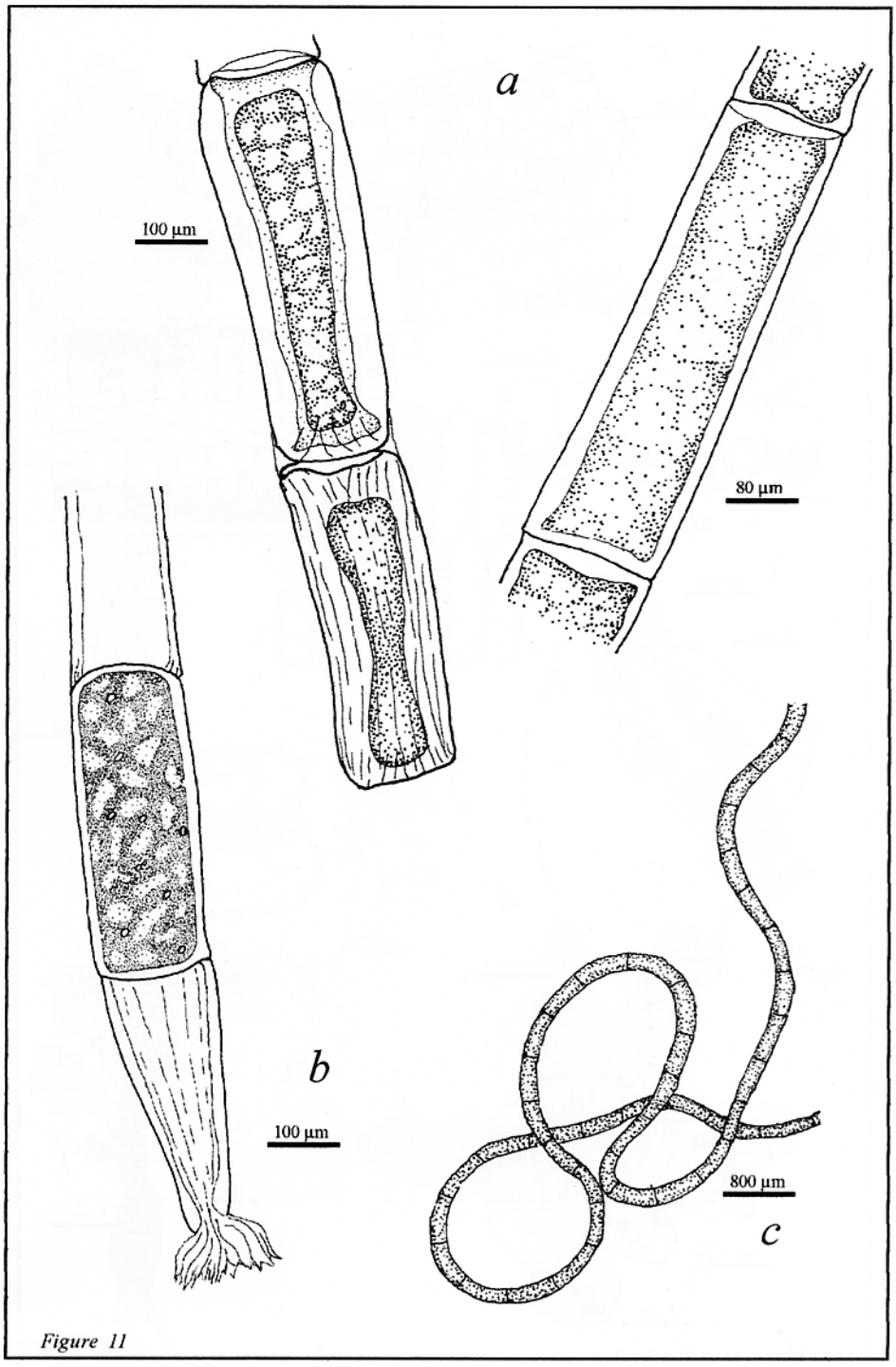

Figure 11

Key to figure 11: ***a.*** filament cells with reticulated chloroplasts ***b.*** basal holdfast cell ***c.*** unbranched filament

Ulva fasciata Delile

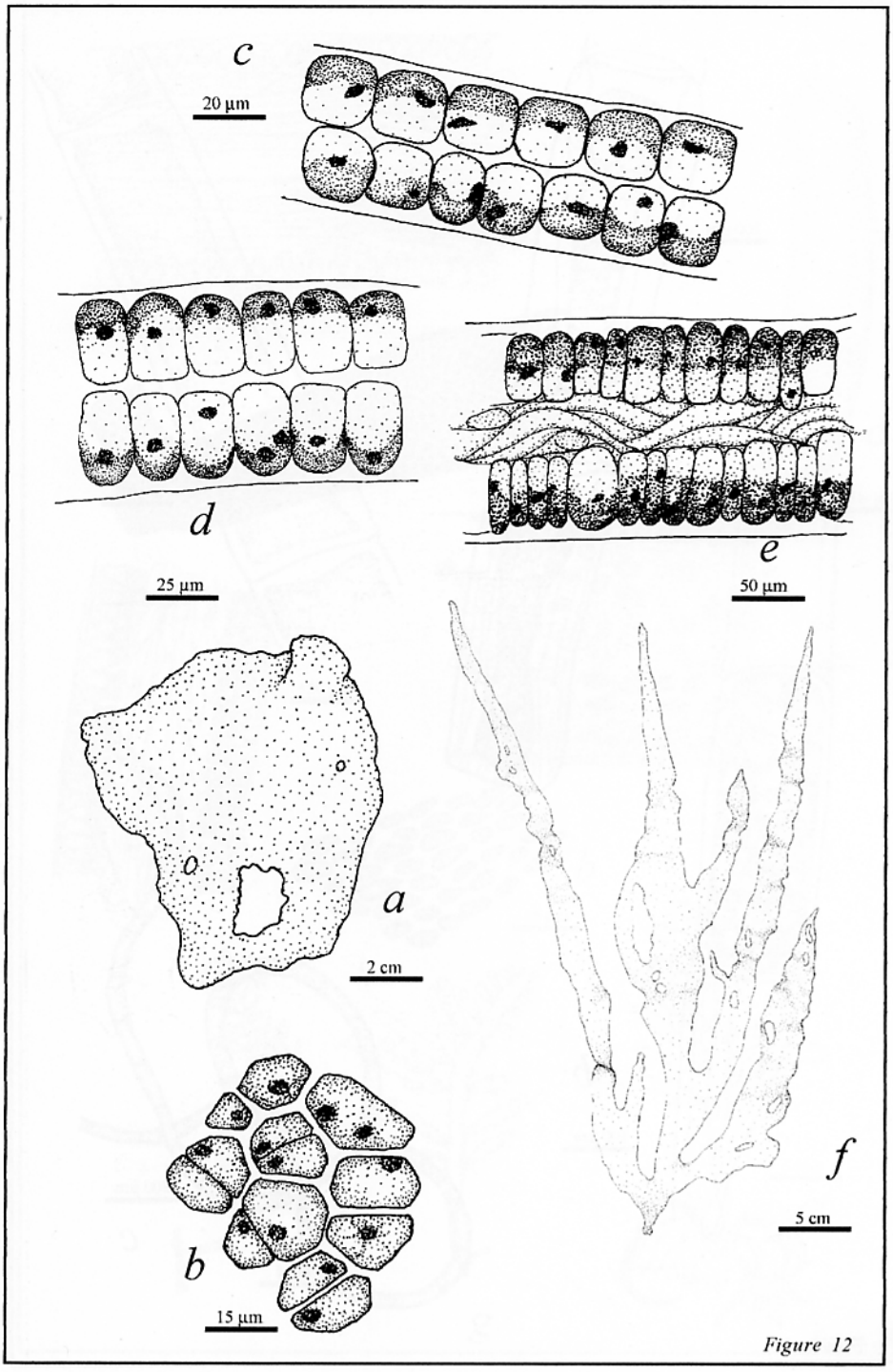

Figure 12

Distinguishing characteristics: They are dark green to colorless sheets two cells thick (20-50 µm). The cells are usually just as tall as wide but taller near the center or base, with little or no space between the two sheets. The surface cells are different sizes, irregular, and angular, and the holdfast is small without dark rhizoids.

U. fasciata occurs in green turtle samples as fragments that for certain identification include square cells in cross-section, no rhizoids, and a blade with few or no irregular holes. The two layers do not separate easily into single cell layers.

Ecology: *U. fasciata* occurs more often near shore with freshwater influence. Thalli are in dense tufts with blades that attain 20 cm or more length.

Related species: *Ulva rigida* is similar but has rhizoids, tall cells, and its thallus separates easily into two layers. *Ulva reticula* is much thinner and filled with numerous holes.

Key to figure 12: ***a.*** blade fragment ***b.*** detail of surface cell shape and arrangement ***c.*** cross-section near thallus edge ***d.*** near thallus center ***e.*** near the holdfast ***f.*** shape of a plant as it appears on the reef.

Chlorophyta (green algae)

Ulva reticulata Forsskal

Distinguishing characteristics: They are pale green to colorless sheets two cells thick (20-30 µm). Cells are just as tall as wide with no clear space between the two sheets. Usually there is no holdfast. The thallus is twisted, curled, and is full of large irregular holes.

U. reticulata occurs in green turtle samples as fragments that for certain identification include finding a network of holes and thallus in tangled, twisted, two cell layered thin sheets. The two layers do not easily separate. Unlike *U. rigida* the surface cells of *U. reticulata* have a thicker outer wall, are tightly packed, and are not in groups of two or four.

Ecology: *U. reticulata* occurs as an epiphyte tangled in the branches of other algae, on all parts of the reef shoreward of the breakers.

Related species: *U. reticulata* has a distinctive netted thin thallus that is similar to *U. fasciata,* but the latter is slightly thicker, darker green, has fewer holes, and is not as twisted.

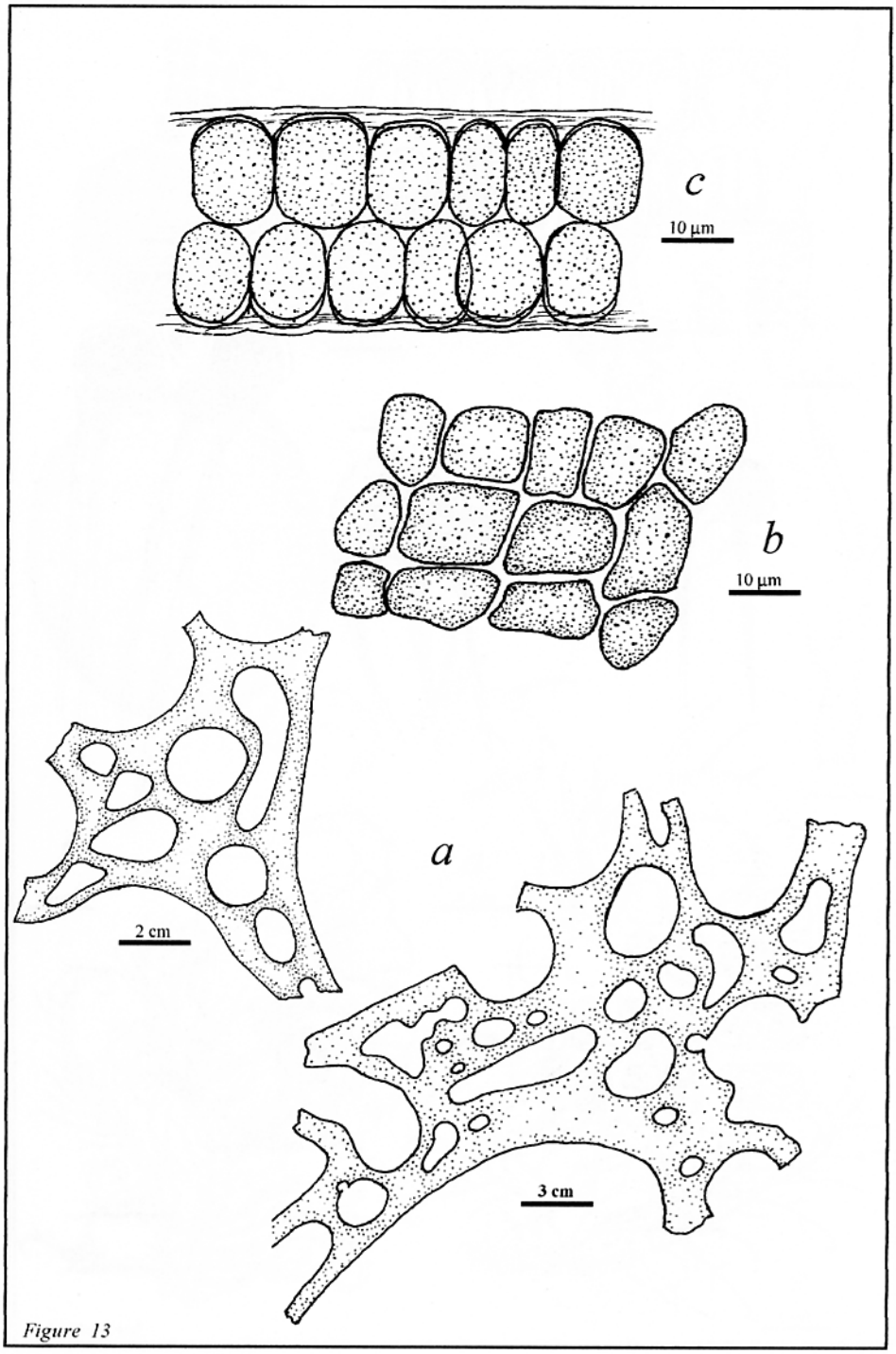

Figure 13

Key to figure 13: ***a.*** flattened fragments of the thallus ***b.*** detail of the surface cells ***c.*** cross-section of the blade

Ulva rigida C. Ag.

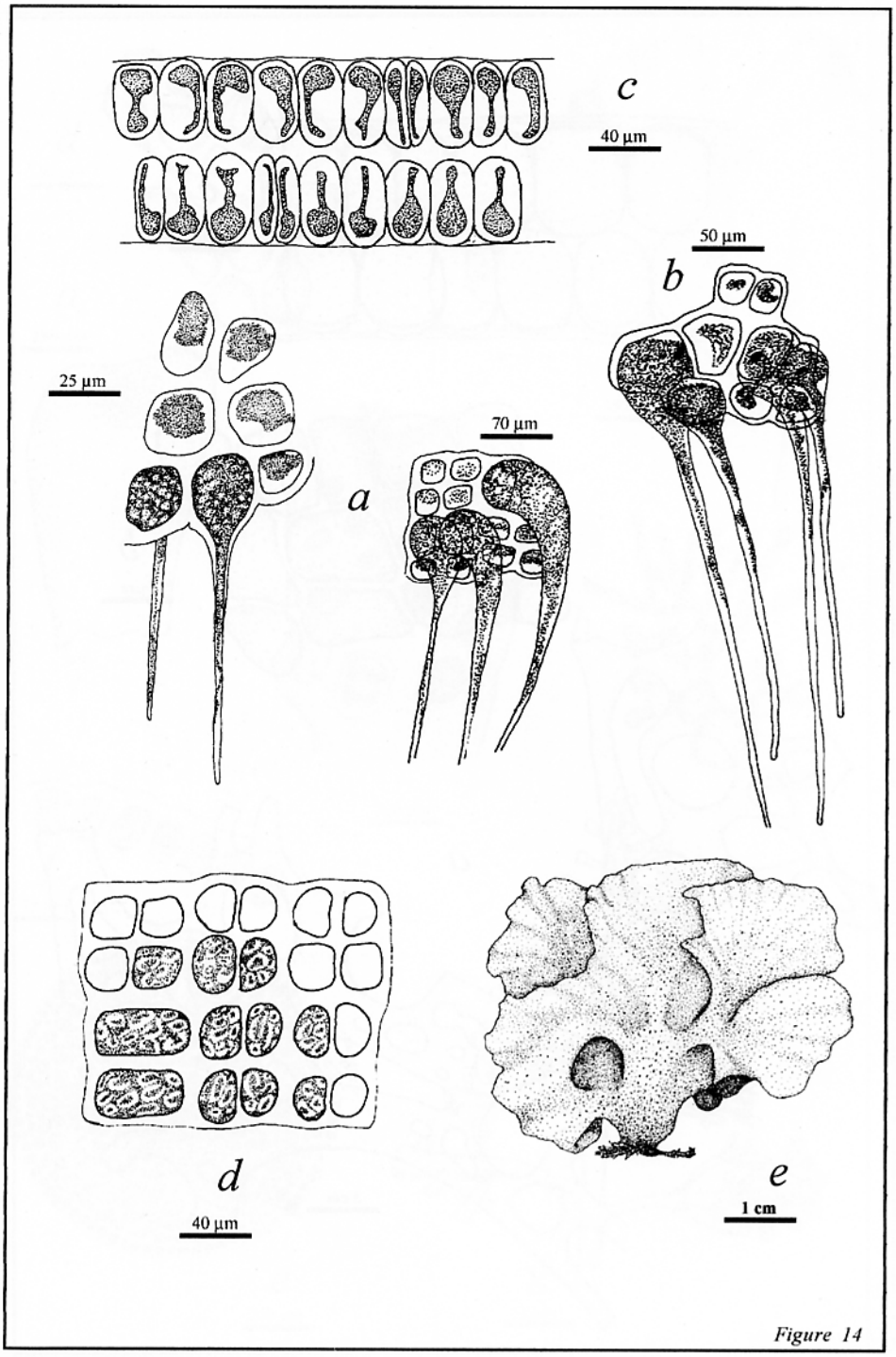

Figure 14

Distinguishing characteristics: They are dark green to colorless sheets, two cells thick (90-100 µm) with small teeth on the margins. Cells are taller than wide with a clear space between the two sheets. The holdfast is very tough and full of dark green rhizoids. Sometimes all cell structure is digested away and only the holdfast fibers remain and look like a triangular piece of gray fabric.

U. rigida occurs in green turtle samples as fragments that for certain identification include finding a strong rhizoidal mass, and a distinct space between the two layers of cells. The two layers easily separate into single cell layers or plies.

Ecology: *U. rigida* occurs near shore in areas with freshwater influence. Thalli are in small dense tufts (1-2 cm tall) or broad blades that attain 10 cm height and are strongly attached.

Related species: *U. fasciata* is similar but has few or no rhizoids, has square cells, and does not separate easily into two plies.

Key to figure 14: ***a.*** rhizoids from lower blade cells ***b.*** detail of rhizoids with black spots in them ***c.*** cross-section of blade ***d.*** detail of surface cell arrangement in groups of two and four ***e.*** entire plant as it appears on the reef.

Anthophyta (sea grass)

Halophila hawaiiana Doty and Stone

Distinguishing characteristics: They have thin, feather-veined leaves with one main vein down the center, two veins running down the inside edge, connected by parallel pinnate veins. Stems have a distinct thicker core, joined at thickened nodes.

H. hawaiiana occurs in green turtle samples as fragments of leaves, stems, and roots, usually pale green, white or colorless. Identification is from leaf fragments with parallel veins. Leaf cells contain a black spot. Stem cells are long with elliptical or lens-shaped cross-walls. Two leaves occur at each node, flower buds may be present and the true roots may have hairs.

Ecology: *H. hawaiiana* occurs rooted in clean sand in shallow protected water, well inside the breaker zone. Delicate stems run along the surface of the sand or are slightly buried.

Related species: *Ruppia maritima* is similar but is found in brackish water, and has long dark green narrow leaves (0.5 mm). It too has stems, roots, and flowers.

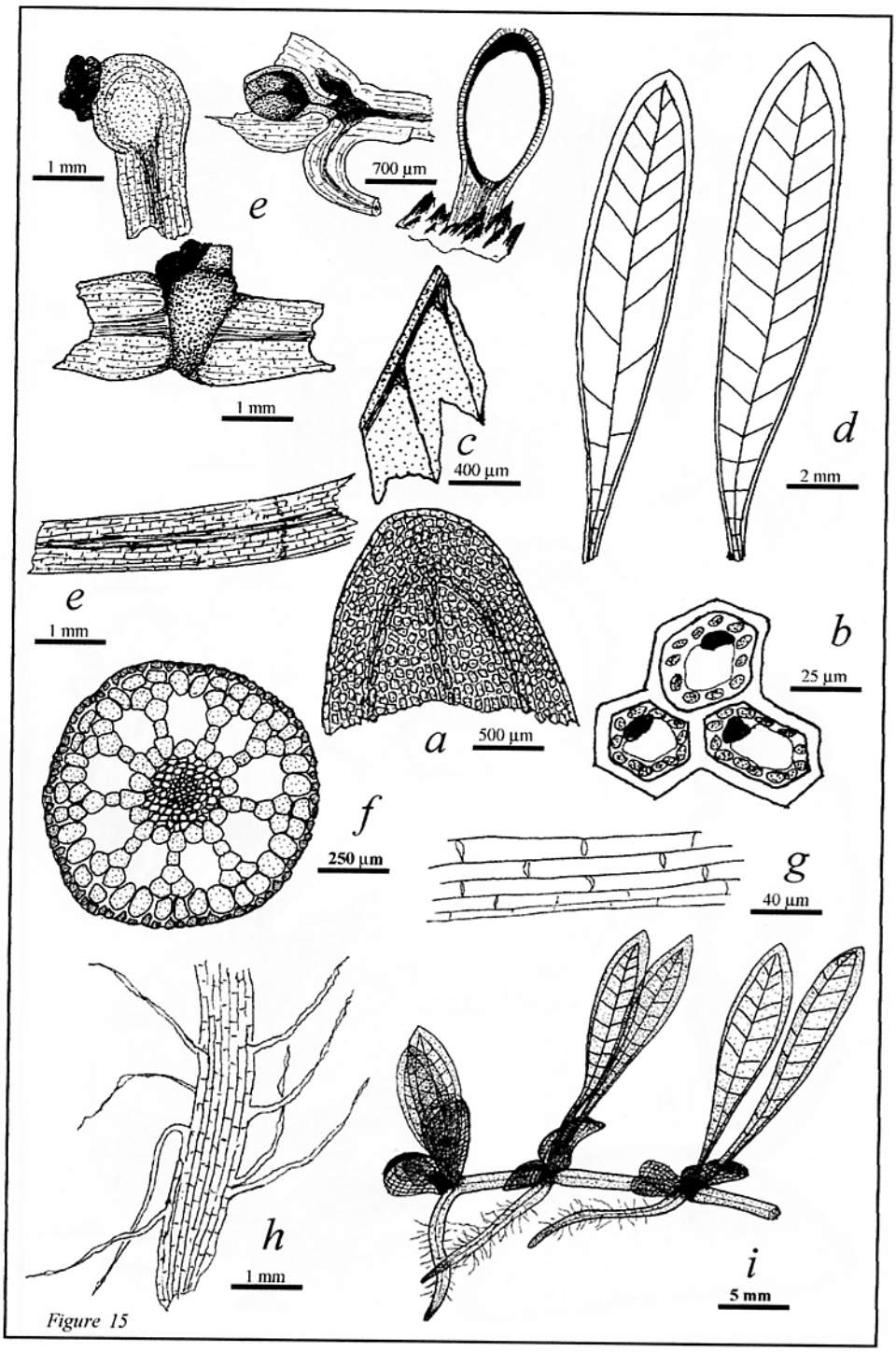

Figure 15

Key to figure15: ***a.*** leaf tip ***b.*** leaf cell detail ***c.*** leaf edge piece ***d.*** leaves ***e.*** stem pieces, nodes and buds ***f.*** stem cross-section ***g.*** stem cell detail ***h.*** root with root hairs ***i.*** entire plant as it appears on the reef.

Sargassum echinocarpum J. Ag.

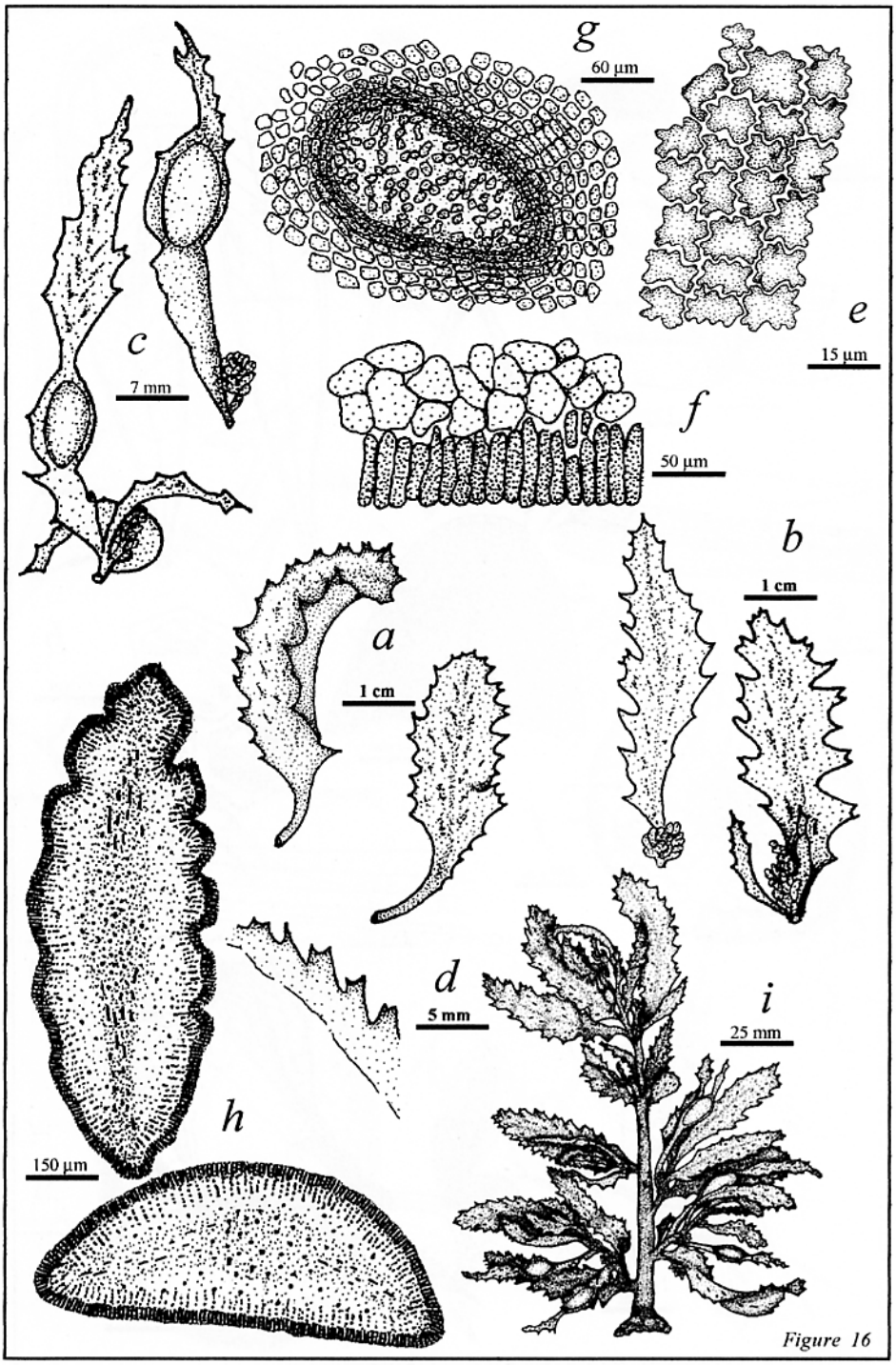

Figure 16

Distinguishing characteristics: *S. echinacarpum* has wide dark brown to yellow spiny "leaves" or lamina, the spines commonly have two small teeth followed by a deep notch and another sharp tooth with a single or double tip. Leaves have dark splotches in two rows near the middle, and some have hollow floats.

S. echinocarpum occurs in green turtle samples as dark brown-yellow fragments that for certain identification include coarse teeth along the margins. Surface cells have a distinct square shape to them with spine-shaped walls. Small brown dots are under the surface, and there are no holes to the surface. Floats have a flag-like extension at the top and dense clusters of small reproductive structures are in the axils of the "leaves."

Ecology: *S. echinocarpum* is a large bushy alga (0.5 m tall) occurring in regions of strong wave action on most Hawaiian reefs.

Related species: *Sargassum obtussifolium* and *Sargassum polyphyllum* are similar but have narrow more densely arranged leaves.

Key to figure 16: ***a.*** leaf shapes ***b.*** leaves with reproductive structures ***c.*** floats with reproductive structures at the base ***d.*** detail of leave toothed edge ***e.*** surface cell detail ***f.*** cross-section of cortex ***g.*** surface pit detail ***h.*** cross-section of lower and upper stems ***i.*** entire plant as it appears on the reef.

Phaeophyta (brown algae)

Turbinaria ornata (Turner) J. Ag.

Distinguishing characteristics: *T. ornata* are thick, yellow-brown and spiny fragments with small dark brown spots on the surface. Some are shallow funnel-shaped or peltate pieces 1-2 cm across, with a rim of coarse sharp spines.

T. ornata occurs in green turtle samples as fragments that for certain identification include parts of the peltate branches. The surface cells have a distinct pattern to them that resemble the horned branches. The small brown dots on the surface are round to oval holes in the surface and are lined with cells that protrude into the center. A cross-section of the thallus has a sandwiched appearance with a dark line in the center of colorless cells.

Ecology: *T. ornata* grows on the outer portions of the reef, in strong surge or currents.

Related species: *S. echinocarpum* fragments are similar but this alga has much thinner blades, and there are no funnel-shaped branches or crown-like surface cells.

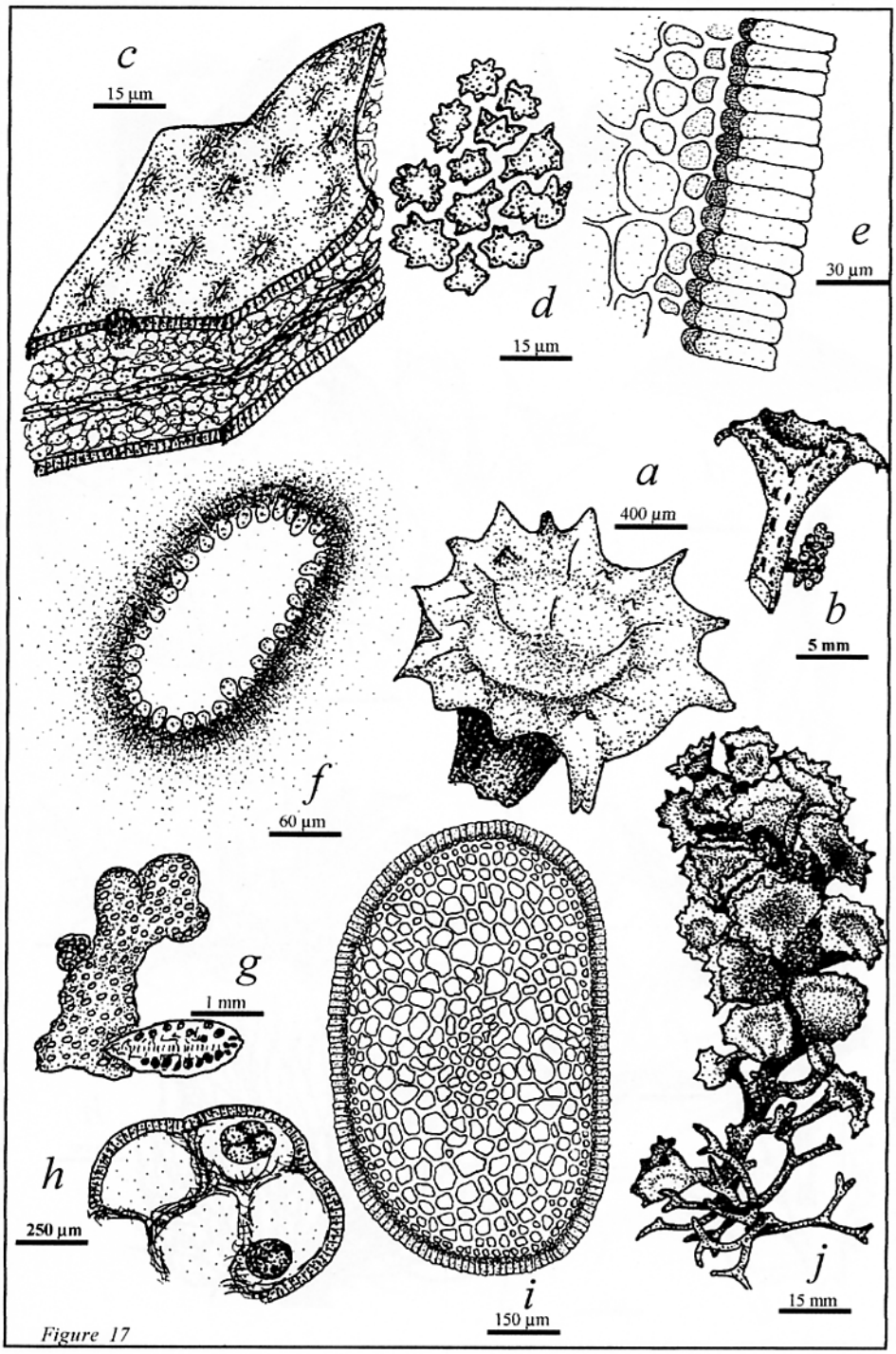

Figure 17

Key to figure 17: ***a.*** branch tip ***b.*** branch tip with receptacles ***c.*** fragment of a thallus branch ***d.*** detail of the surface cells ***e.*** cross-section of surface cell layer ***f.*** detail of a brown spot, surface opening ***g.*** conceptacle portion, with spores inside ***h.*** cross-section of conceptacles ***i.*** cross-section of a rhizoid ***j.*** entire plant as it appears on the reef.

Acanthophora spicifera (Vahl) Boerg.

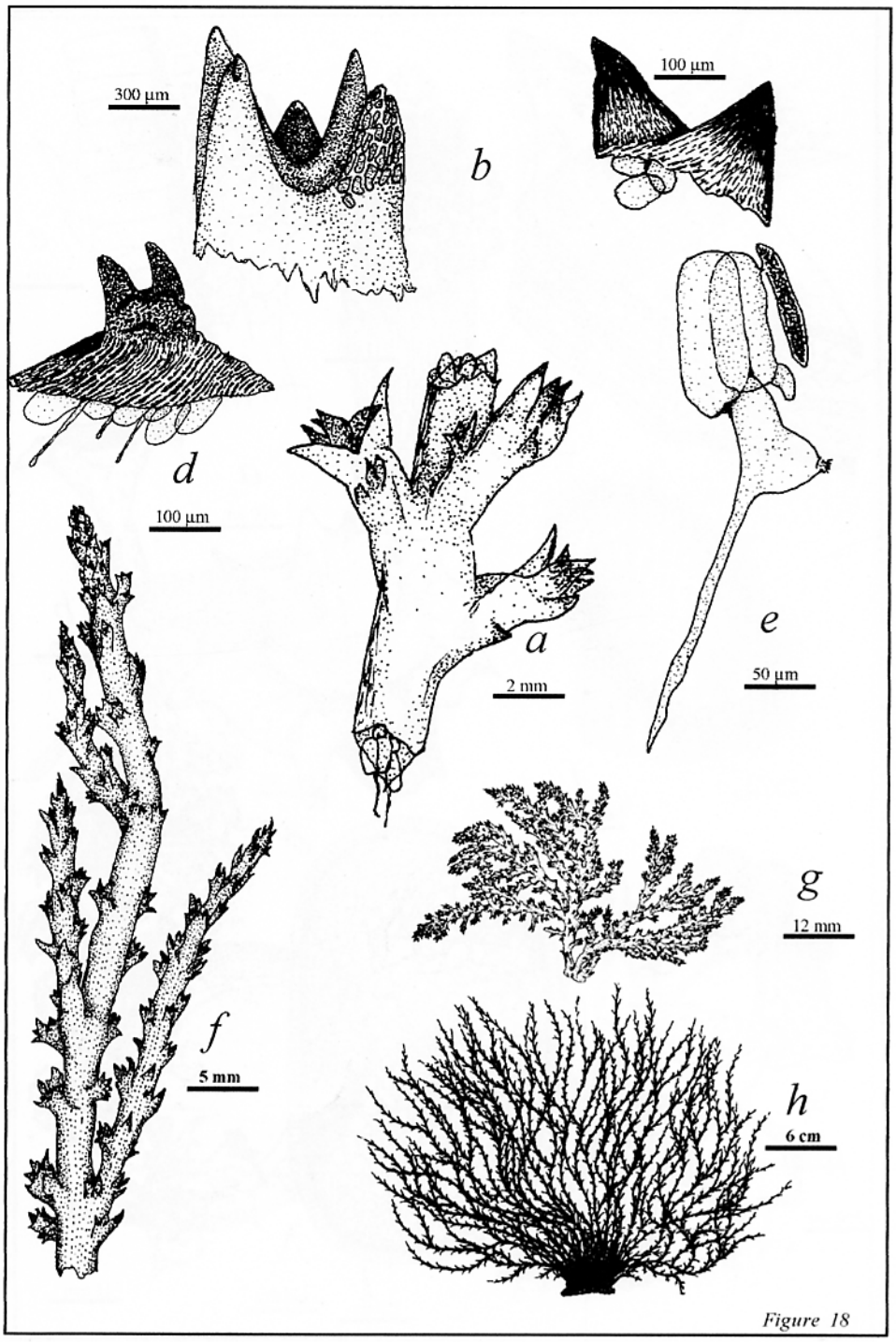

Figure 18

Distinguishing characteristics: The many short spiny fragments and many short fragile branches are diagnostic for this species. The branches have crown-shaped tips with tight clusters of pointed projections.

A. spicifera occurs in green turtle samples as colorless fragments, round in cross-section, very soft and small (3-5 mm long, 1-3 mm wide) often with black branch tip cells packed with starch. The surface layer cells are small, elongated, and appear as darker streaks, in rows that follow the contour. These cells are attached to large colorless cells inside, which often have elongated, thin-walled extensions.

Ecology: *A. spicifera* occurs in large (10-20 cm) loose clusters of wiry, spiny thread-like branches. They attach to objects in the sand water 0.2-1.0 m deep. This alga was introduced to Hawaii from Guam in 1950-1952.

Related species: No similar species like this has been found in green turtle samples.

Key to figure 18: ***a.*** short branches with spiny tips ***b.*** tip detail ***c.*** two spines with large colorless inner cells showing ***d.*** branch tip with rows of darker surface cells, colorless inner cells ***e.*** inner cells attached to outer cell ***f.*** detail of spine arrangement ***g.*** branching pattern ***h.*** entire plant as it appears on the reef.

Rhodophyta (red algae)

Ahnfeltiopsis concinna (J. Ag.) Silva and DeCero

(formerly *Ahnfeltia concinna)*

Distinguishing characteristics: *A. concinna* usually has many v-shaped forked blunt branch tips with one side slightly longer than the other. Surface cells are very small and dense. A cross-section shows thick-walled central cells that have a star-like appearance. The outer cortex often cracks or peels off and is made up of small densely packed red cells.

A. concinna occurs in green turtle samples as slightly flattened or cylindrical pieces with a peeling skin and blunt forked tips. Fresh samples are tough, but those from stomach samples are very soft.

Ecology: *A. concinna* occurs on solid substrata, intertidal basaltic rocks, in high wave action. Thallus branches are straight erect to 10 cm tall, stiff, wiry in texture, sometimes highly branched with curved branches, dark-red to yellow-red. They form dense stiff growths in strong currents and waves.

Related species: It may appear similar to *Gracilaria* species, but *A. concinna* has smaller densely packed cells in the center, where species of *Gracilaria* have large loose thin-walled cells.

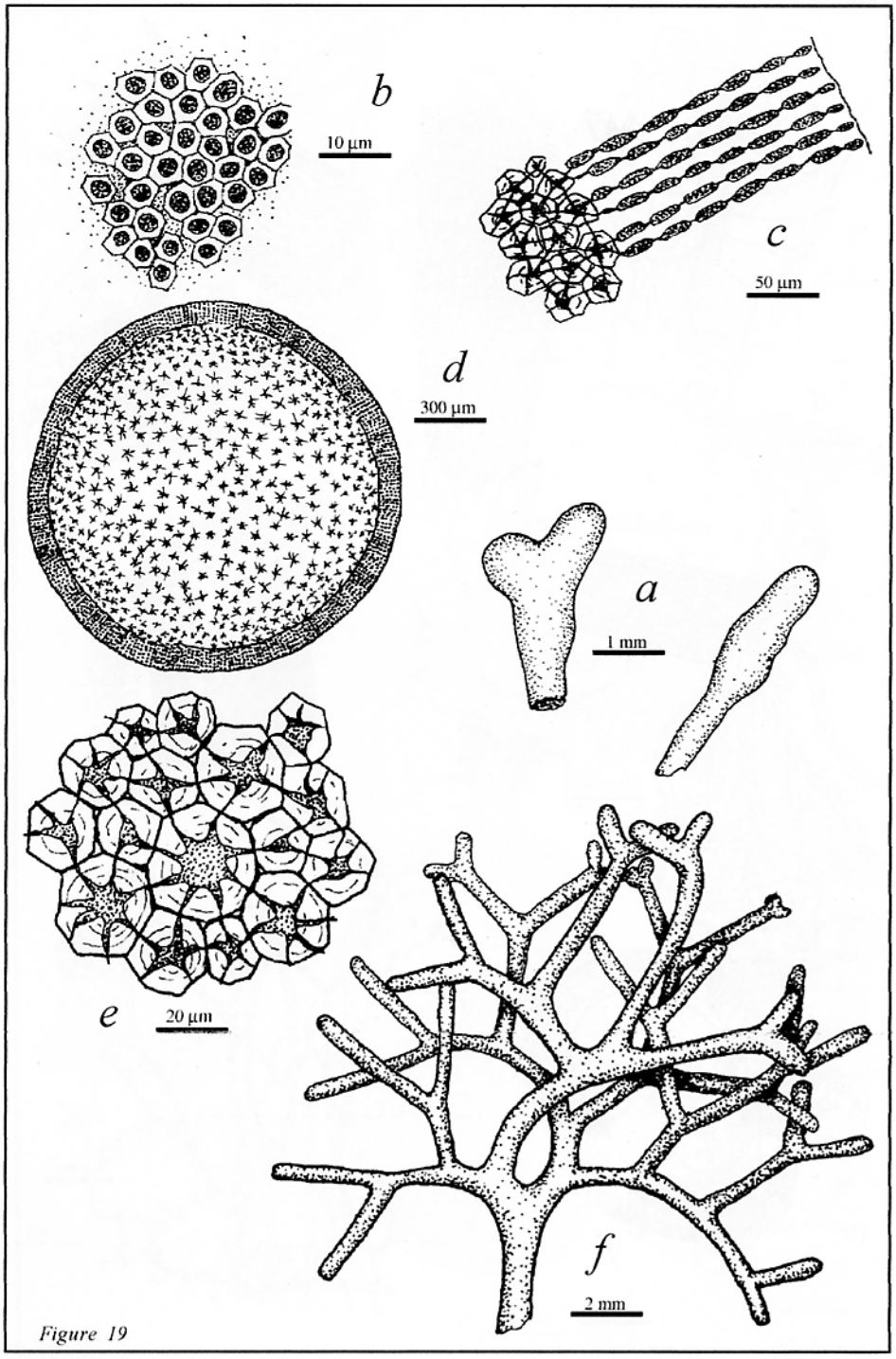

Figure 19

Key to figure 19: ***a*** .branch tips ***b.*** surface cells with cracks occurring ***c*** .detail of cortex ***d.*** cross section of a branch ***e.*** central thick walled medullary cells ***f.*** branching pattern

Centroceros clavulatum (C. Ag.) Montagne

Rhodophyta (red algae)

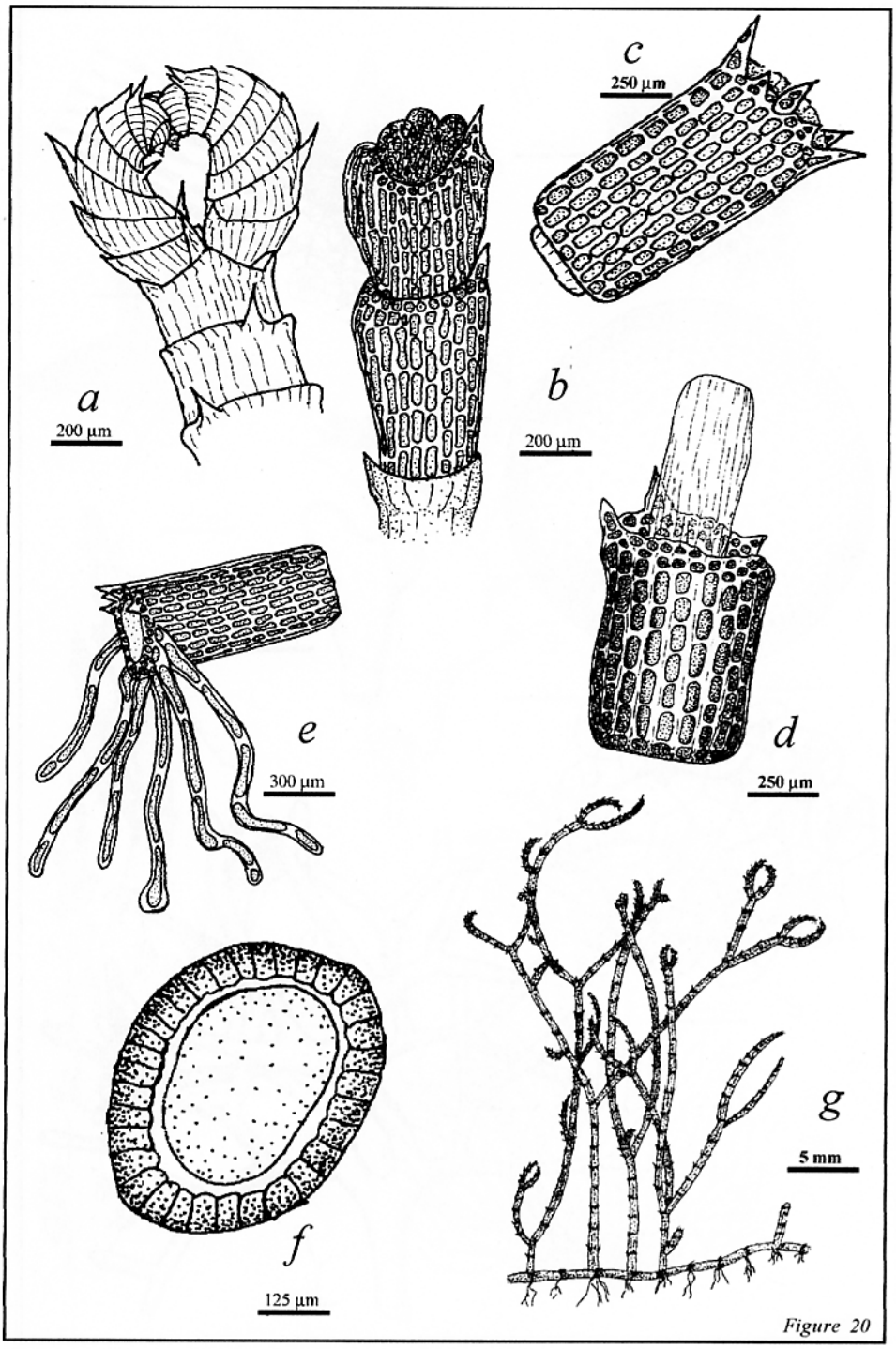

Figure 20

Distinguishing characteristics: The cylindrical portions of *C. clavulatum* thalli have two celled thorns on the upper side. The thallus easily fragments into many short crown-topped sections, covered with many smaller elongated cells in rows. There is one large cell protruding in the center.

C. clavulatum occurs in green turtle samples as crown topped sections. More complete pieces are dichotomously branched, with incurved forcep-shaped tips.

Ecology: *C. clavulatum* occurs as tall (4 cm) thalli in loose monospecific tufts or mixed with other algae in dense deep, red mats or turf (2 cm), in shallow water and moderate wave action.

Related species: *C. clavulatum* looks similar to species of *Polysiphonia* but is easily distinguished by its many small cortical cells and spines at the tops of each section, which *Polysiphonia* species do not have.

Key to figure 20: ***a.*** forcep shaped branch tip ***b.*** branch tip ***c.*** single section with two-celled spines ***d.*** section with spines and central cell ***e.*** section of prostrate branch with rhizoids ***f.*** cross section of a branch, single layer of cells around one large central cell ***g.*** entire plant as it appears on the reef.

Rhodophyta (red algae)

Gracilaria salicornia (C. Ag.) Dawson

Distinguishing characteristics: *G. salicornia* is a yellow to red alga, 2-3 mm diameter, translucent, cylindrical, and constricted at regular intervals. Tips are inflated at the uppermost end with a dent on the top, sometimes containing a small terminal section.

G. salicornia occurs in green turtle samples as fragments that for certain identification include typical pear-shaped sections. In cross-section there are large (100 µm) colorless medullary cells with thick cell walls (2-6 µm) that typically blend into a tangled mass. Cells are smaller toward the cortex, and large gland cells are just beneath the surface.

Ecology: *G. salicornia* was introduced from an unknown source location to Hilo and then to Waikiki in 1972 and to Kaneohe Bay in 1978. It grows well in the shallow, calmer parts of reef flats.

Related species: *Gracilaria coronopifolia* and *Gracilaria parvispora* look similar but do not have a constricted thallus, fragile branches, or prostrate growth habit.

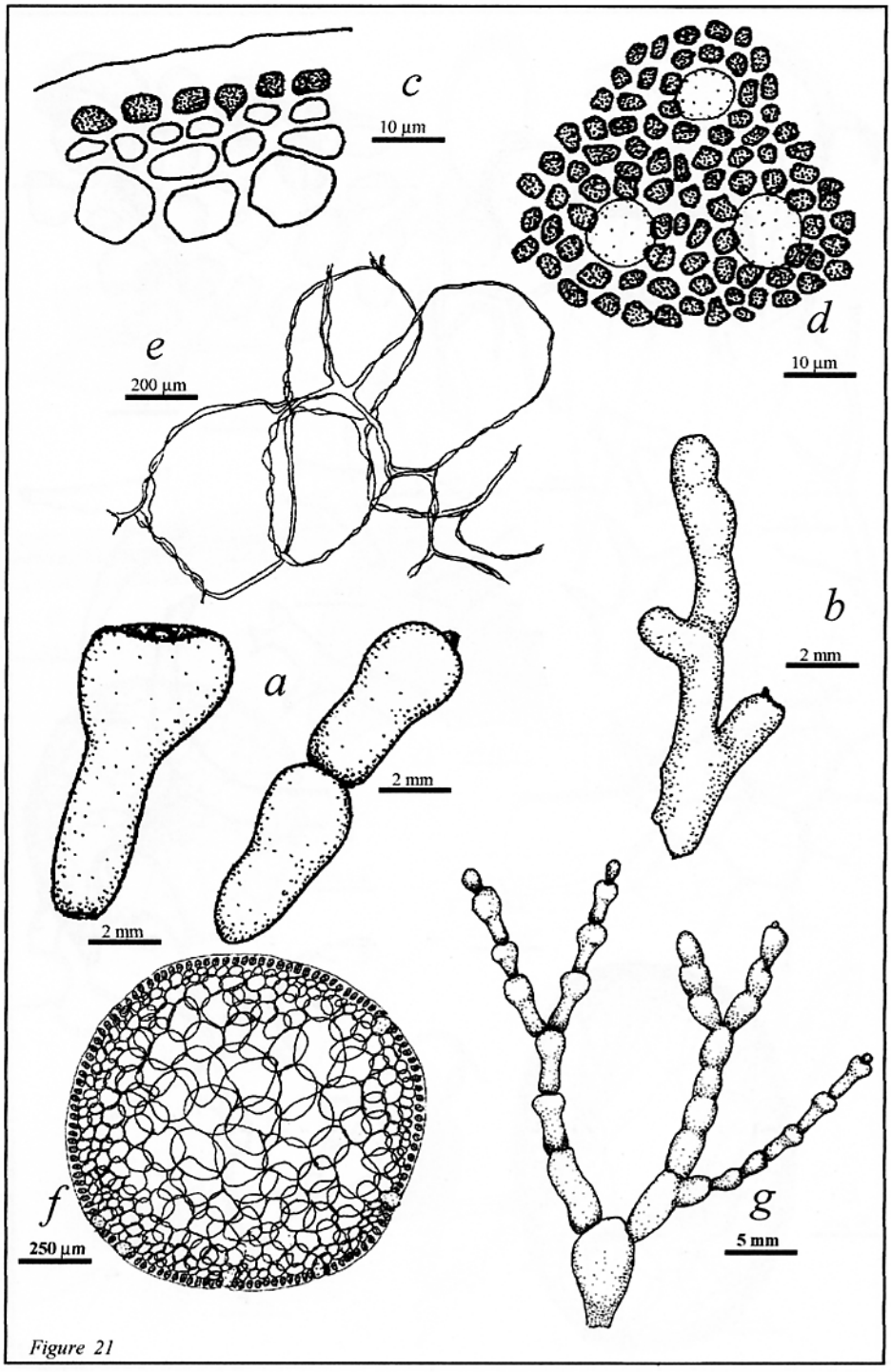

Figure 21

Key to figure 21: ***a.*** branch tip form, with small apex and indented tip ***b.*** branch tip variation ***c.*** detail of cells near the cortex ***d.*** surface view with larger, clear gland cells ***e.*** medullary cells ***f.*** cross-section of the thallus ***g.*** branching pattern

Gracilaria tikvahiae McLachlan

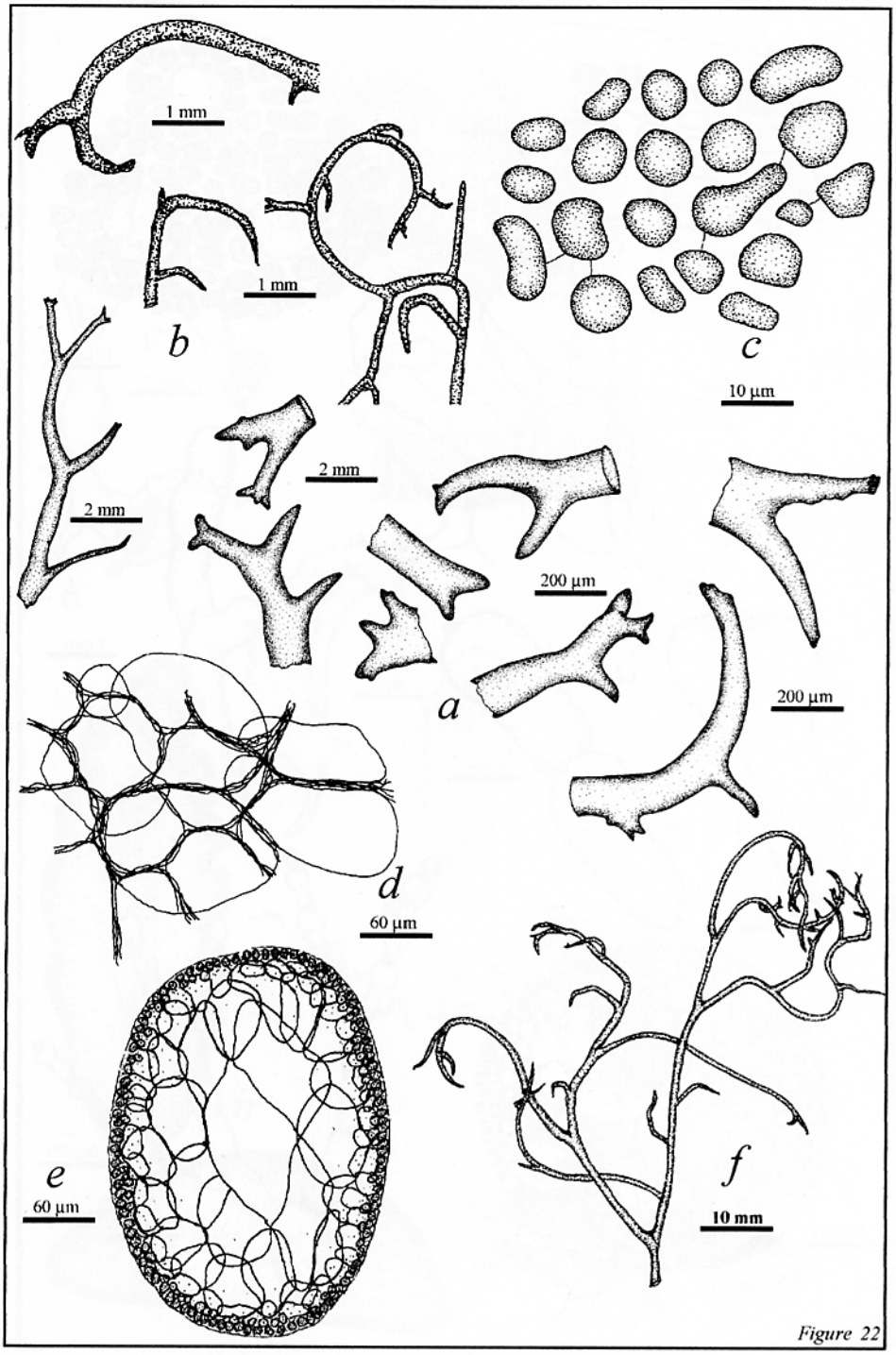

Figure 22

Distinguishing characteristics: *G. tikvahiae* has branched, fine (1 mm wide) red to brown fragments. Branches are slightly flattened with lumpy margins, but are not constricted. The branching is curved, with wide dichotomies. Tips of the branches are unevenly forked with one side longer and wider.

G. tikvahiae occurs in green turtle samples as fragments, (4-10 mm long) brown or nearly white. Surface cells are small (10-12 µm) with a few secondary pit connections. The cross-section is oval, filled with large (400 µm) colorless cells with thick entangling walls. Cells are smaller toward the cortex.

Ecology: *G. tikvahiae* was introduced to Hawaii in 1976 and spread into Kaneohe Bay and other places where it grows in calm enriched water near shore.

Related species: *Grateloupia filicina* looks similar but is flat, has many short fringing blades, a medulla crossed by colorless filaments, and star-shaped cells near the cortex. None of these features are seen in *G. tikvahiae*.

Key to figure 22: ***a.*** small fragments of branch tips ***b.*** large fragments with curved branches ***c.*** surface view with secondary pit connections ***d.*** detail of the entwining tangle of medullary cell walls ***e.*** cross-section of the thallus ***f.*** branching pattern

Rhodophyta (red algae)

Hypnea musciformis (Wulfen) Lamouroux

Distinguishing characteristics: *H. musciformis* have a deep red, highly branched thallus, with fringed swollen hooks at the tips. The branches are 1 mm wide with hooks 3 mm across. Branch tips are acute, with a smaller branch proximal from the tip. Surface cells are very small and in pairs or fours. Subsurface cells are large and colorless.

H. musciformis occurs in green turtle samples as small red to colorless fragments, seldom more than 10 mm long. It is associated with other algae to which it readily attaches. A certain identification requires seeing swollen hook fragments.

Ecology: *H. musciformis* usually occurs as an epiphyte on other algae in shallow water across the reef, attaching by means of its hooks. It was introduced to Hawaii from Florida in 1974. It sometimes forms massive algal blooms on Maui.

Related species: *Hypnea cervicornis* and *Hypnea valentiae*, are similar but lack the abundant swollen hooks. If they do have hooks, they are few and not swollen.

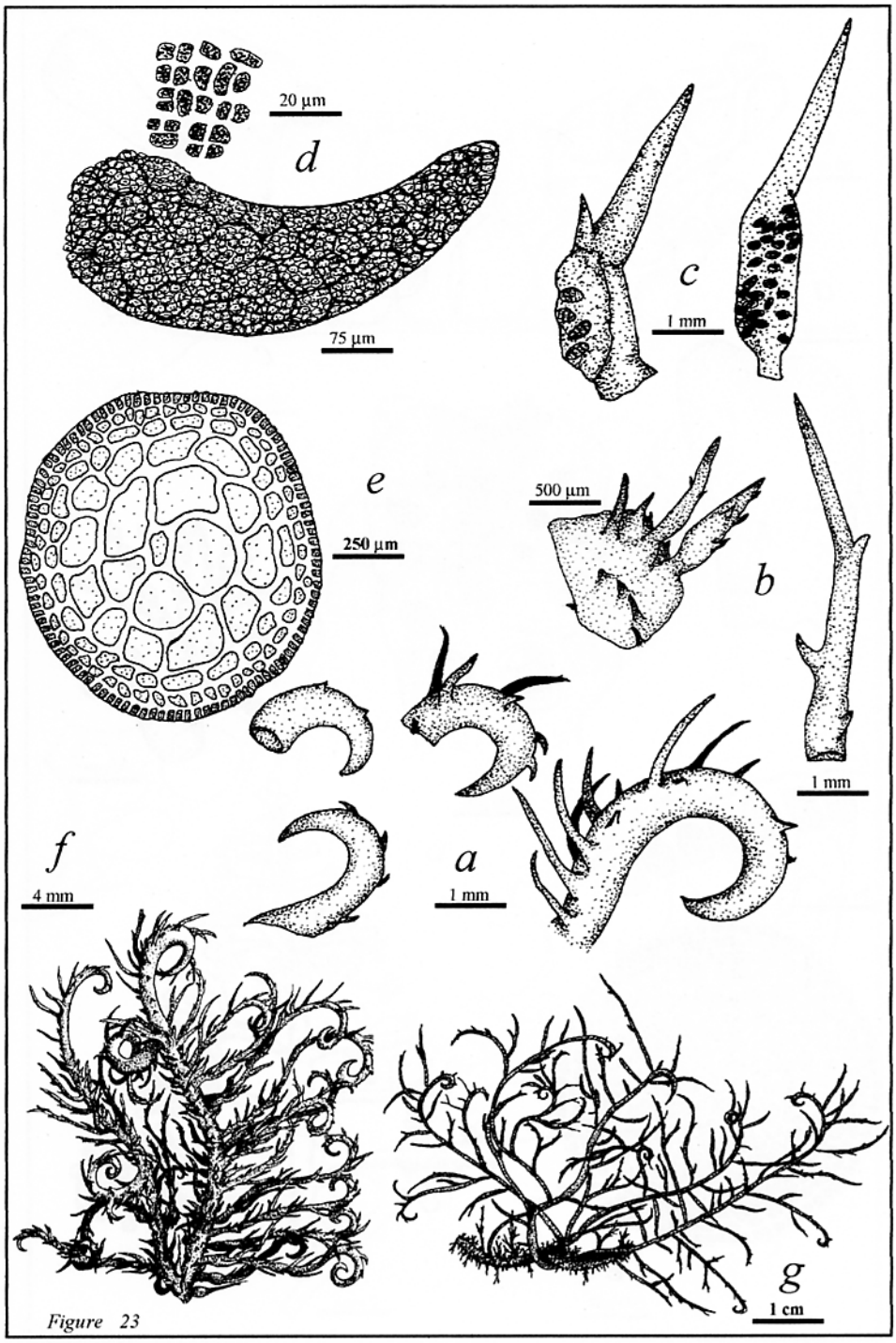

Figure 23

Key to figure 23: ***a.*** swollen hook fragments ***b.*** branch tip ***c.*** branches with tetrasporangia ***d.*** surface detail of branch tip ***e.*** cross-section ***f.*** robust branching pattern ***g.*** average plant as it appears on the reef.

Laurencia nidifica J. Ag.

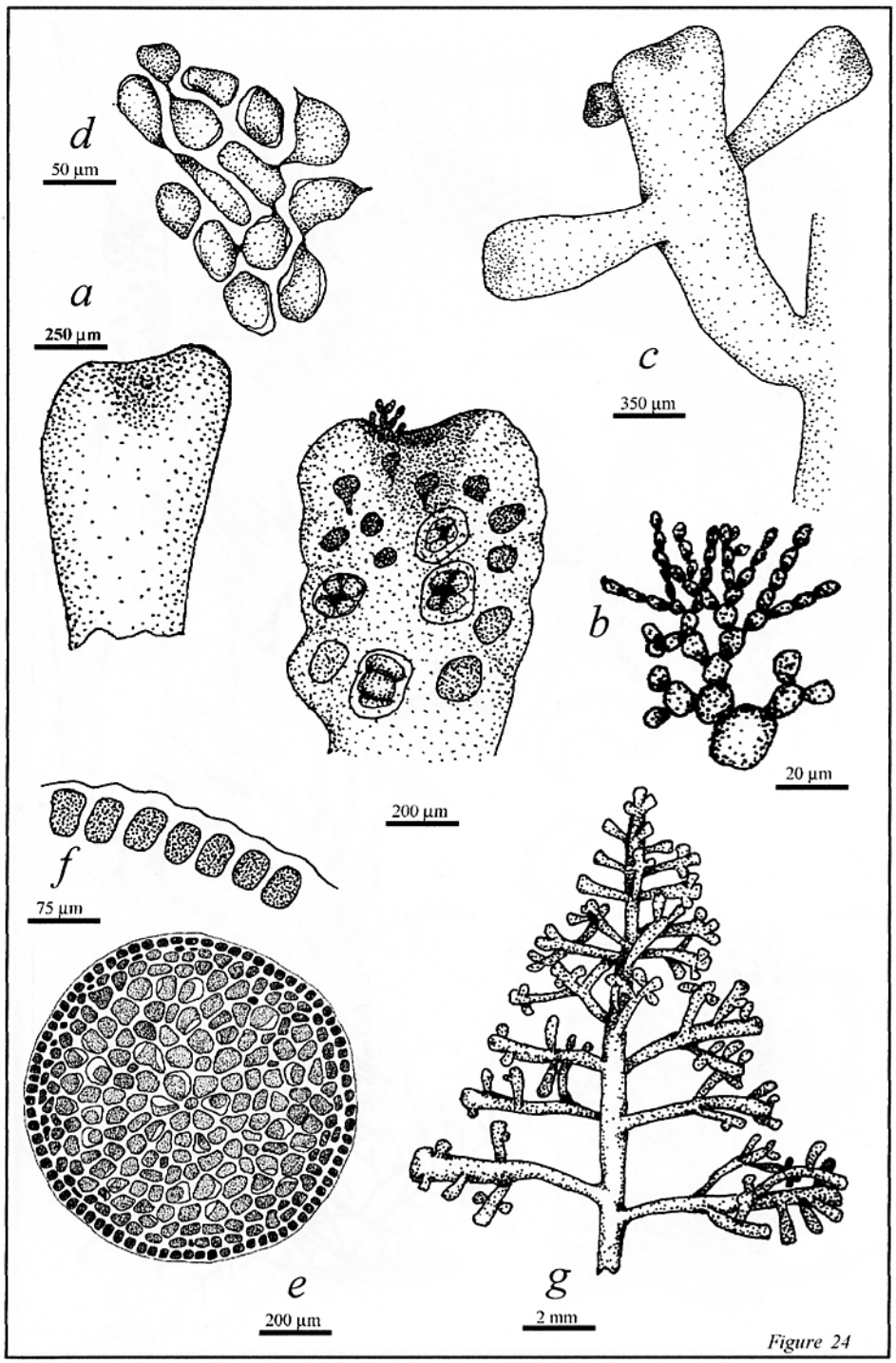

Figure 24

Distinguishing characteristics: Most often *L. nidifica* are colorless or slightly pink fragments with abundant short branches with blunt, indented tips. Surface cells have secondary pit connections, and the medullary cells have lens-shaped wall thickenings.

L. nidifica occurs in green turtle samples as fragments that for certain identification include short, blunt, indented branches without an obvious tuft of hair. Surface cells do not protrude and have wall thickenings.

Ecology: *L. nidifica* occurs on the inner portions of the reef, often with *A.spicifera* in moderate surge or currents.

Related species: There are several other species of *Laurencia* in Hawaii , but *L. nidifica* is the most common species in green turtle samples.

Key to figure 24: ***a.*** fragment of a branch tip ***b.*** detail of a branch tip with lenticular tetraspores and minute branches (trichoblasts) ***c.*** detail of a side branch ***d.*** surface cells with secondary pit connections and cell wall thickenings ***e.*** cross-section of a branch, cells with lenticular thickened cell walls ***f.*** surface cells not protruding ***g.*** complete plant branch as it appears on the reef.

Rhodophyta (red algae)

Melanamansia glomerata (C. Ag.) R. Norris

(formerly *Amansia glomerata)*

Distinguishing characteristics: Cells of nearly the entire thallus are arranged in a characteristic series, like narrow rectangular bricks arranged in rows in a wall.

M. glomerata occurs in green turtle samples as fragments of leaf-like fronds (two cells thick) with curled margins and remnants of the thicker, tougher stipe and frond midribs. The color is usually dark red, deep burnt-orange, or red-black. The cells inside the main branches are colorless and filled with starch grains.

Ecology: *M. glomerata* occurs as globular masses on the mid - to outer portions of the reef, under overhanging coral rock, in shaded, dark places, in deeper water (1-4 m depth).

Related species: *M. glomerata* was formerly called *Amansia glomerata*.

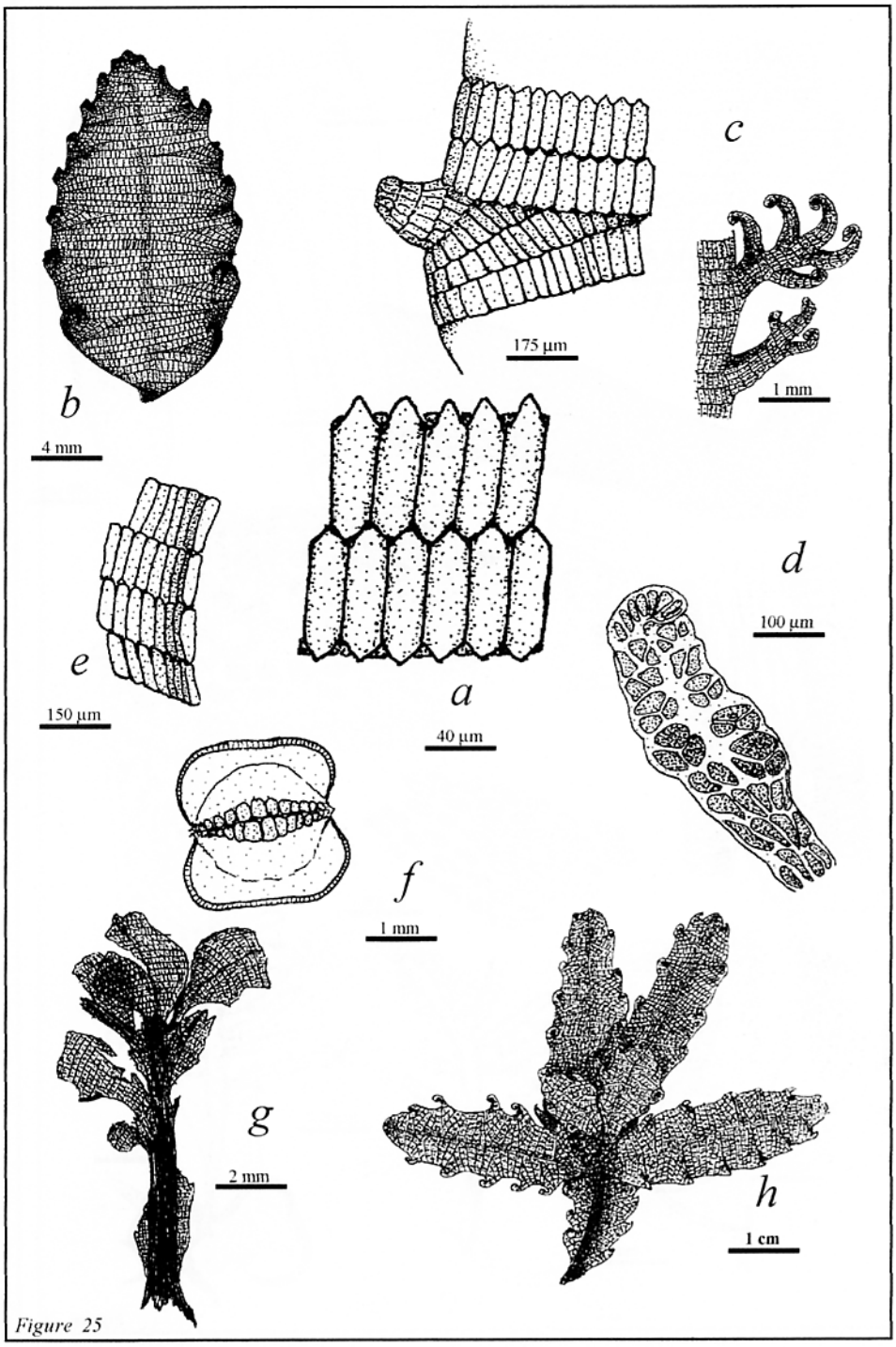

Figure 25

Key to figure 25: ***a.*** single series of frond cells ***b.*** complete leaflike frond ***c.*** detail of frond fragments ***d.*** frond margin with tetraspores ***e.*** section and surface of a frond fragment ***f.*** cross-section of the stalk ***g.*** stalk with fronds attached ***h.*** intact branch tip

Pterocladiella capillacea (S. Gmelin) Santelices and Hommersand

(formerly *Pterocladia capillacea)*

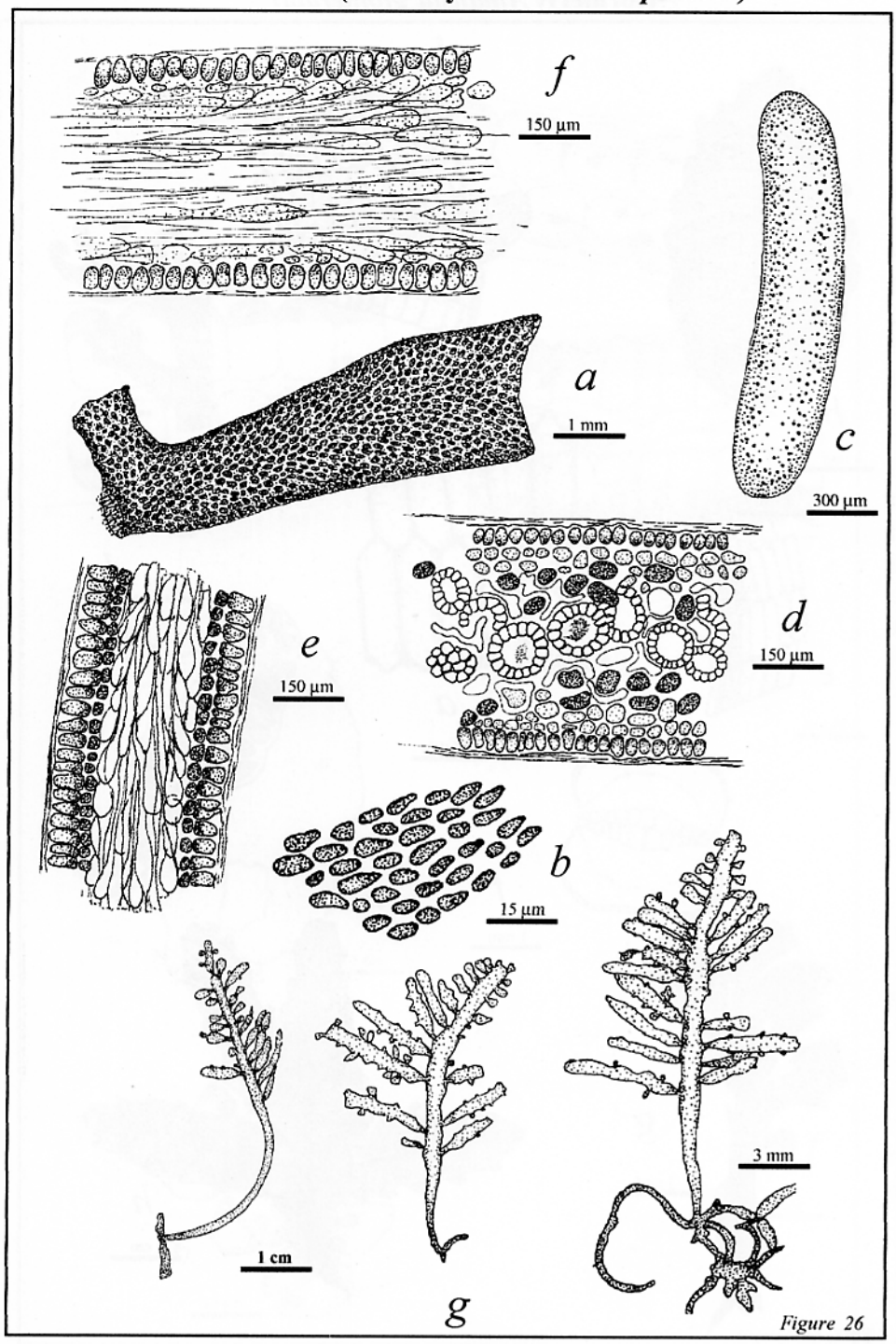

Figure 26

Distinguishing characteristics: *P. capillacea* has flattened thalli with pinnate branching and blunt tips. Sections through the blades reveal the center filled with tough filaments.

P. capillacea occurs in green turtle samples as distinctly red flat pinnately-branched fragments with small surface cells that are arranged in v-shaped rows that appear to converge near the middle of the blade.

Ecology: *P. capillacea* occurs in dense patches on rock and other solid substrate in strong surf or currents. In some places it grows tall (20 cm) and at other places it forms a dense short (2 cm) red turf.

Related species: Species of *Gelidium* are nearly identical but have biloculate cystocarps with two or more ostioles; *Pterocladiella* is uniloculate with one ostiole. This feature is seldom seen in green turtle samples, and blades with cystocarps are quickly digested to form one large vacant hole. *Pterocladiella capillacea* was formerly called *Pterocladia capillacea.*

Key to figure 26: ***a.*** fragment of a frond ***b.*** detail of surface cells ***c.*** cross-section of the main axis ***d.*** cross-section of the main axis with fiber cells ***e.*** longitudinal section of the frond ***f.*** longitudinal section of the main axis ***g.*** thallus morphology

Rhodophyta (red algae)

Spyridia filamentosa (Wulfen) Harvey

Distinguishing characteristics:
S. filamentosa appears as drum-shaped sections with a distinctive pattern of cells on the surface. It is a very fine thallus, with 0.5 mm diameter main branches, covered with fine unbranching filamentous hair-like branches.

S. filamentosa occurs in green turtle samples in a completely dismantled way, the hairs are not attached, branching is not evident, and often the surface cells are digested and appear as white streaks. Certain identification is from the drum-shaped segments.

Ecology: *S. filamentosa* occurs near shore in the warmer shallow portions of the reef. When collected it is a pale pink, fuzzy, entangled, finely branched mass, often with a lot of epiphytic diatoms on it (which adds a light brown tone).

Related species:
S. filamentosa is not easily confused with other species.

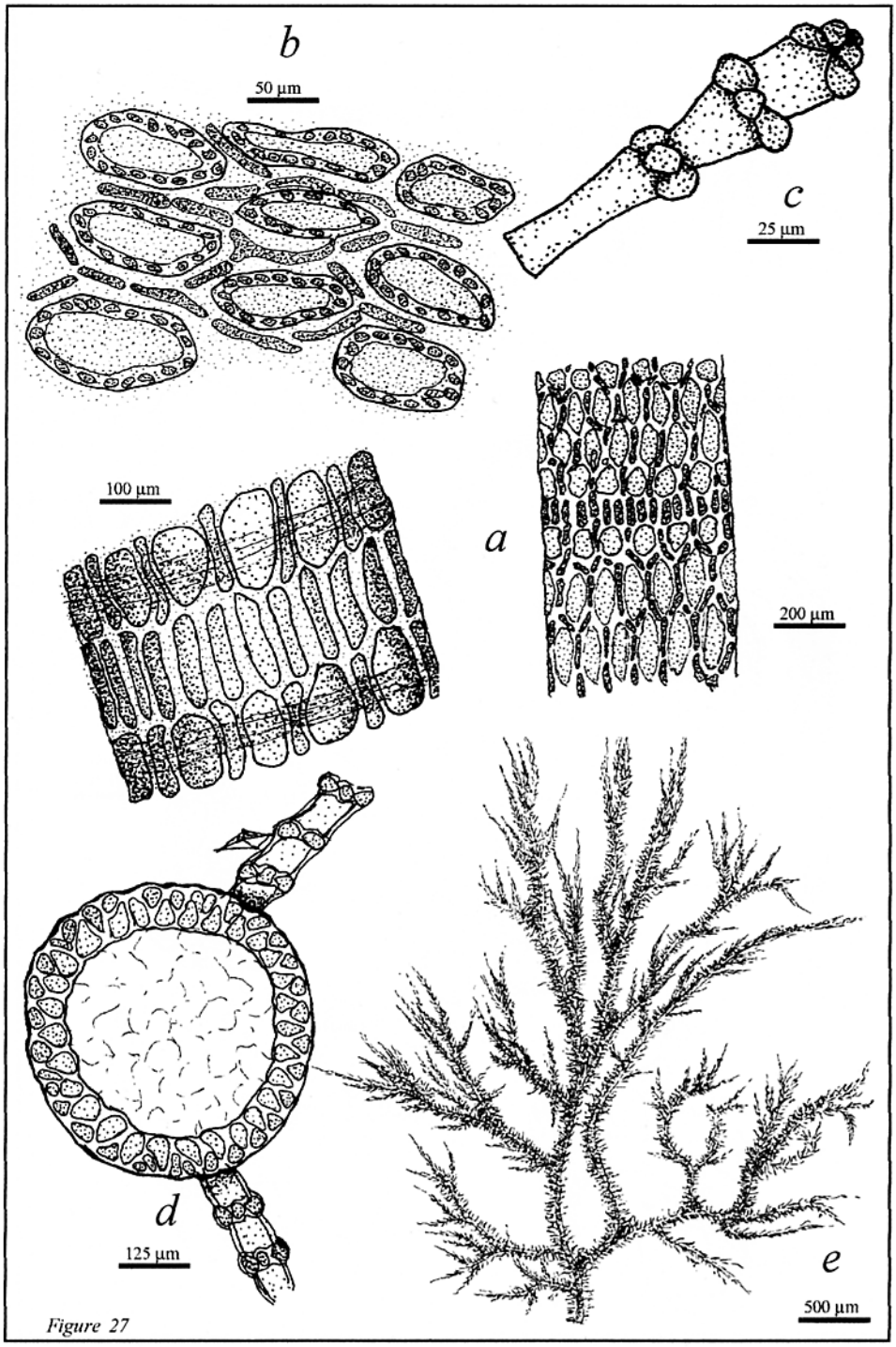

Figure 27

Key to figure 27: ***a.*** drum-shaped section of the main thallus axis ***b.*** detail of the surface cells ***c.*** a filamentous branch tip ***d.*** cross-section of the main axis with surface cells surrounding the large central cell with cell wall markings ***e.*** branching pattern

Cyanophyta

(blue-green algae)

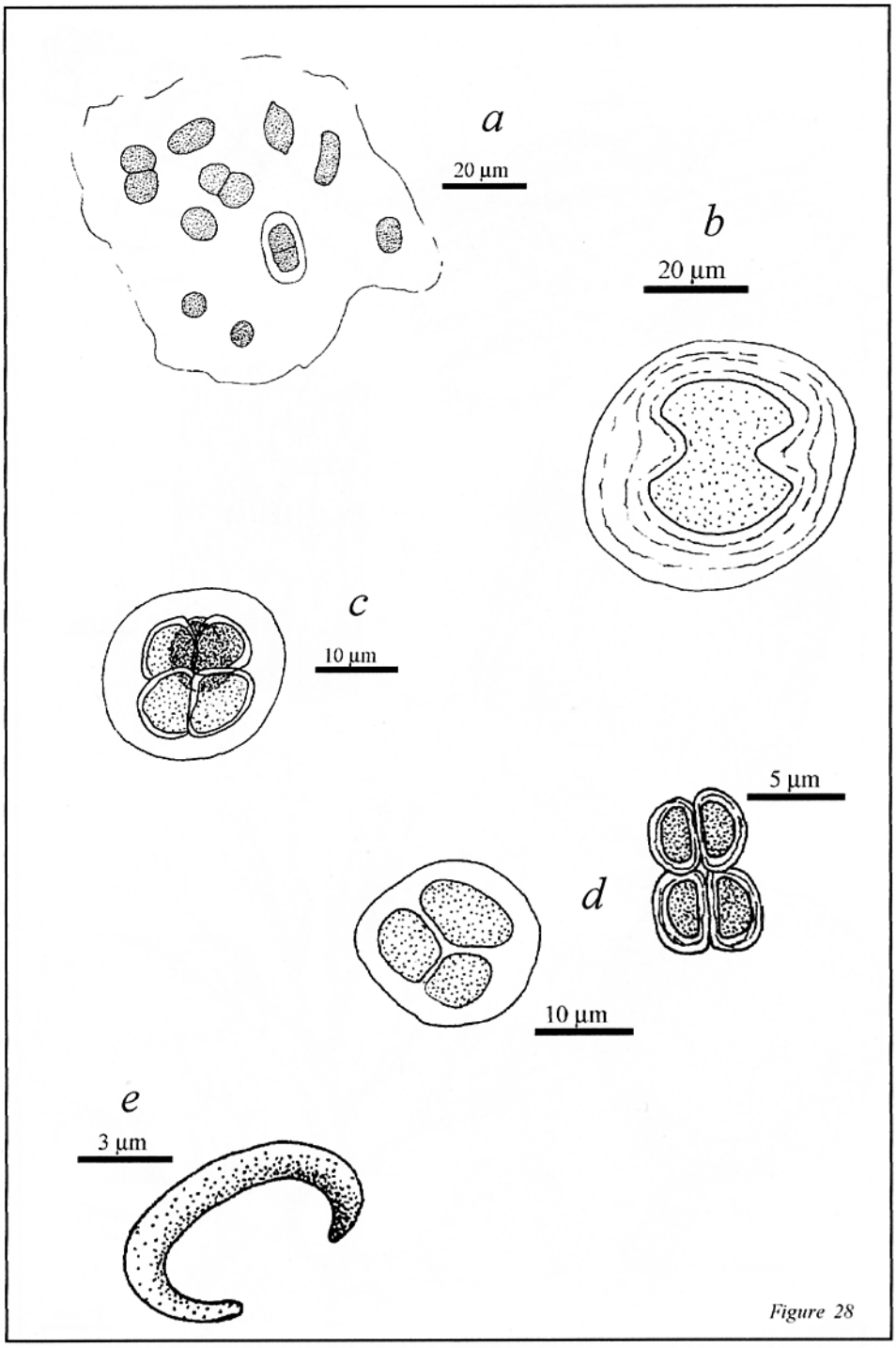

Figure 28

Family Chroococcaceae: These blue-green bacteria are unicellular irregular or discrete colonies of cells, never filaments. The cells are round, spherical to ellipsoidal but may be long, blunt, or tapered at both ends. Colonies are most often formed in a loose gel or surrounded by a distinct gel sheath.

Aphanocapsa (Fig. 28a) species are many spherical cells arranged loosely in irregular colonies with no distinct sheath around each cell; sometimes a thin indistinct envelope can be seen around some cells. They form small (1-20 mm diameter) gelatinous spheres or lumps on other algae.

Chroococcus (Fig. 28b-d) species are spherical cells forming groups of 3-4 cells (rarely single) in a gel sheath that is either not lamellated or weakly so. Groups of cells (3-80 µm with sheath) are flattened where they touch each other in a non-homogenous sheath.

Dactylococcopsis (Fig. 28e) species have cells with tapering ends, that are individual or in small loose colonies or bundles of cells twisted together. No sheath is present. The cells are either spindle-shaped, or sickle- or S-shaped (1-3 µm broad, 8-50 µm long).

Key to figure 28: ***a.*** *Aphanocapsa biformis* A. Br. ***b.*** *Chroococcus macrococcus* (Kuetz.) Rabenh. ***c.*** *Chroococcus minor* (Kuetz.) Nag. ***d.*** *Chroococcus sp.* ***e.*** *Dactylococcopsis raphidioides* Hansg.

(blue-green algae)

Cyanophyta

Family Chroococcaceae: (continued)

Gloeocapsa (Fig. 29a) species are spherical cells within a distinctly lamellated thick sheath. Distinct layered envelopes (4-20 µm diameter) surround each cell or group of 4-8 cells (each cell 2-11 µm diameter). Cell division occurs in three directions and forms small irregular colonies.

Synechocystis (Fig 29b) species are usually found as single spherical cells (3-6 µm diameter), with no envelopes surrounding them.

Microcystis (Fig 29c-d) species form small (30-60 µm diameter) discrete round, ellipsoidal or irregular colonies of tightly packed spherical cells (3-5 µm diameter) that have no individual envelopes and that are not arranged into regular groups. *Microcystis litoralis* is often found growing on marine algae.

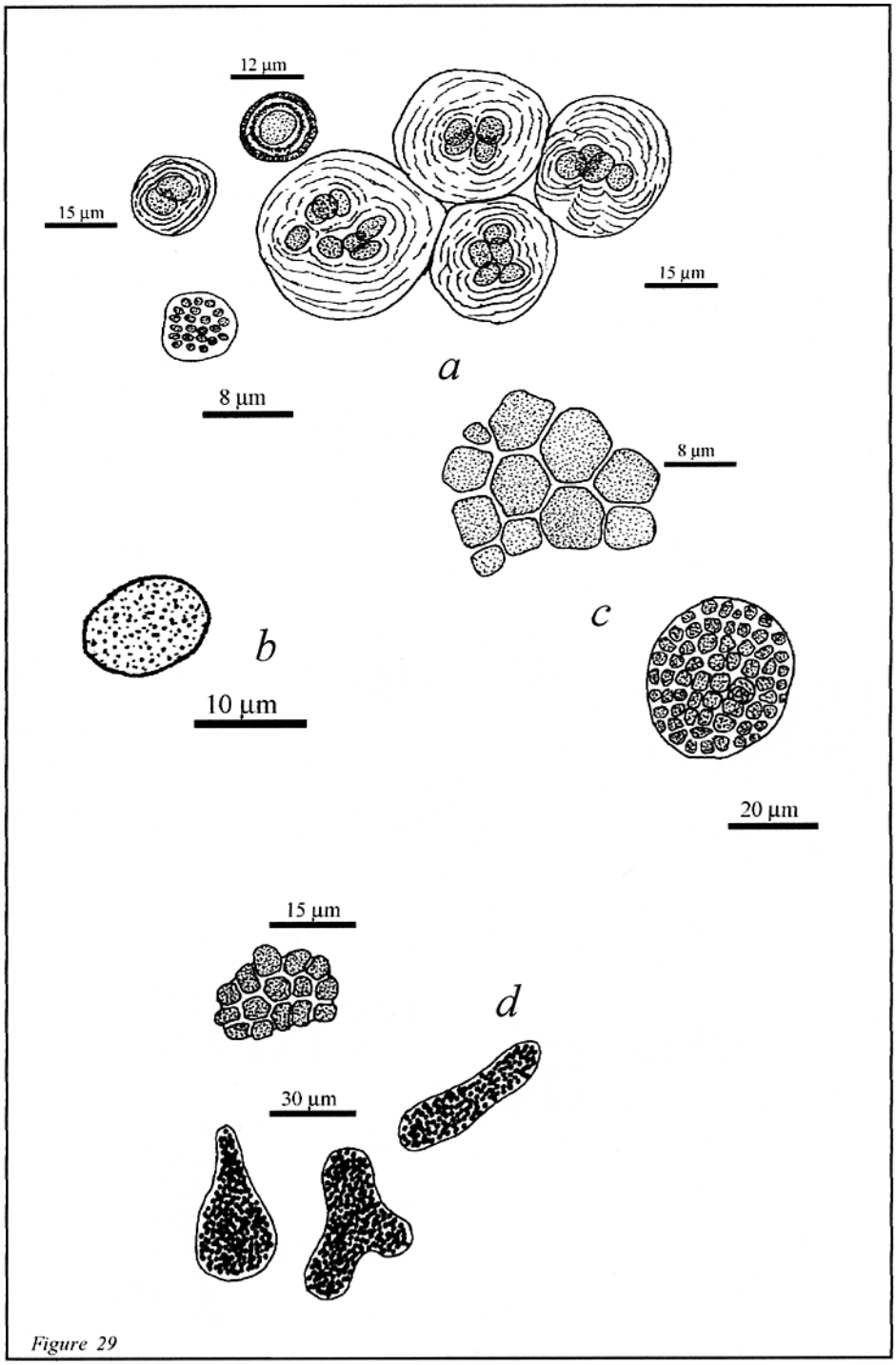

Figure 29

Key to figure 29: ***a.*** *Gloeocapsa decorticans* (A. Br.) Richter, with nannocytes **b.** *Synechocystis aquatilis* Sauv. ***c.*** *Microcystis litoralis* (Hansg.) Forti. ***d.*** *Microcystis sp.*

Cyanophyta

(blue-green algae)

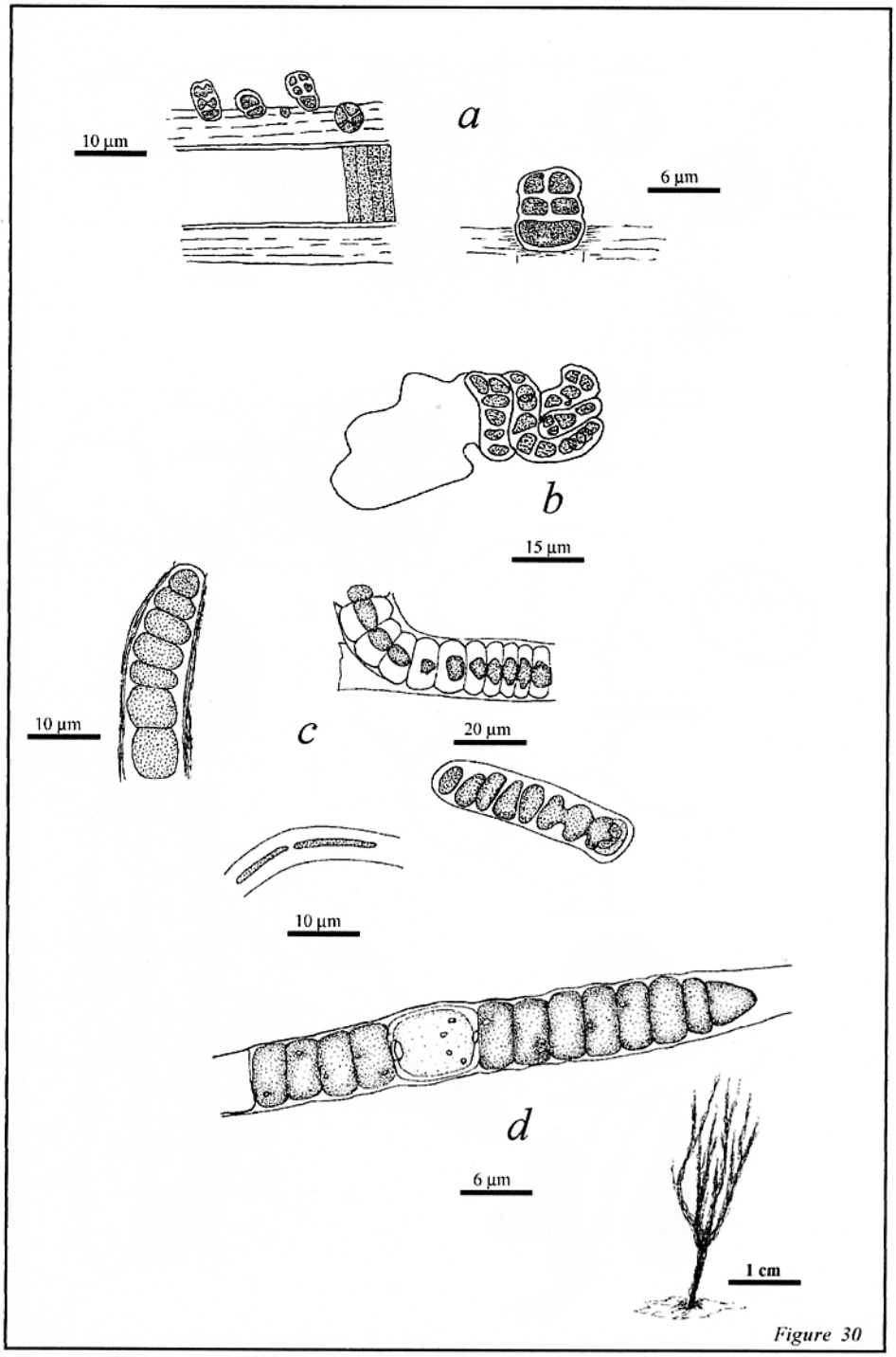

Figure 30

Family Dermocarpaceae: *Dermocarpa* (Fig. 30a) species are discrete small thalli within a lamellated sheath. They are attached to other algae by a larger basal cell and disc. Upper cells form 8-32 endospores.

Family Entophysalidaceae: They are small attached thalli with spherical, ellipsoidal cells that form false filaments. *Chlorogloea* (Fig. 30b) species are irregularly lobed thalli in a firm homogenous gel, with cells arranged in several distinct radial rows.

Family Hyellaceae: They are heterotrichous filaments in a firm gel. The long prostrate filaments have long thin cells, while the short erect filaments have short thick cells. No heterocysts or hormogones are formed, but endospores are produced. *Hyella* (Fig. 30c) species are mostly prostrate with short erect filaments.

Family Nostocaceae: Trichomes are either free or in a gel sheath. Hormogones and heterocysts are common. *Hormothamnion* (Fig. 30d) species grows on marine algae and form prostrate and erect thalli (1-5 cm tall). They have one trichome in a sheath in upper parts of the thalli and several per sheath in the lower parts. The blue-green branches are rope-like, soft and agglutinated.

Key to figure 30: ***a.*** *Dermocarpa spherica* Setchell and Gardner ***b.*** *Chlorogloea fritschii* Mitra ***c.*** *Hyella caespitosa* Born. et Flah. ***d.*** *Hormothamnion enteromorphoides* Grunow

(blue-green algae)

Cyanophyta

Family Oscillatoriaceae:

Members of this family have single rows of cells or trichomes that are of uniform width either with no sheath around them or with a conspicuous sheath. They are unbranched filaments which may be spiraled but do not have heterocysts or spores and do not end with a hair. Some move by oscillating or gliding, when alive.

Crinalium (Fig. 31a) species are the only members in this family that have a distinctly flat, ribbon-shaped filament. They often bend back on themselves, folding and twisting.

Lyngbya (Fig. 31b-d) species are trichomes that have a distinct sheath around them that is open at the ends. The sheath is often very thick and may be colored yellow, brown, dark blue or black. It can occur in tangled masses, is often found on other algae, but it never forms distinct bundles of filaments.

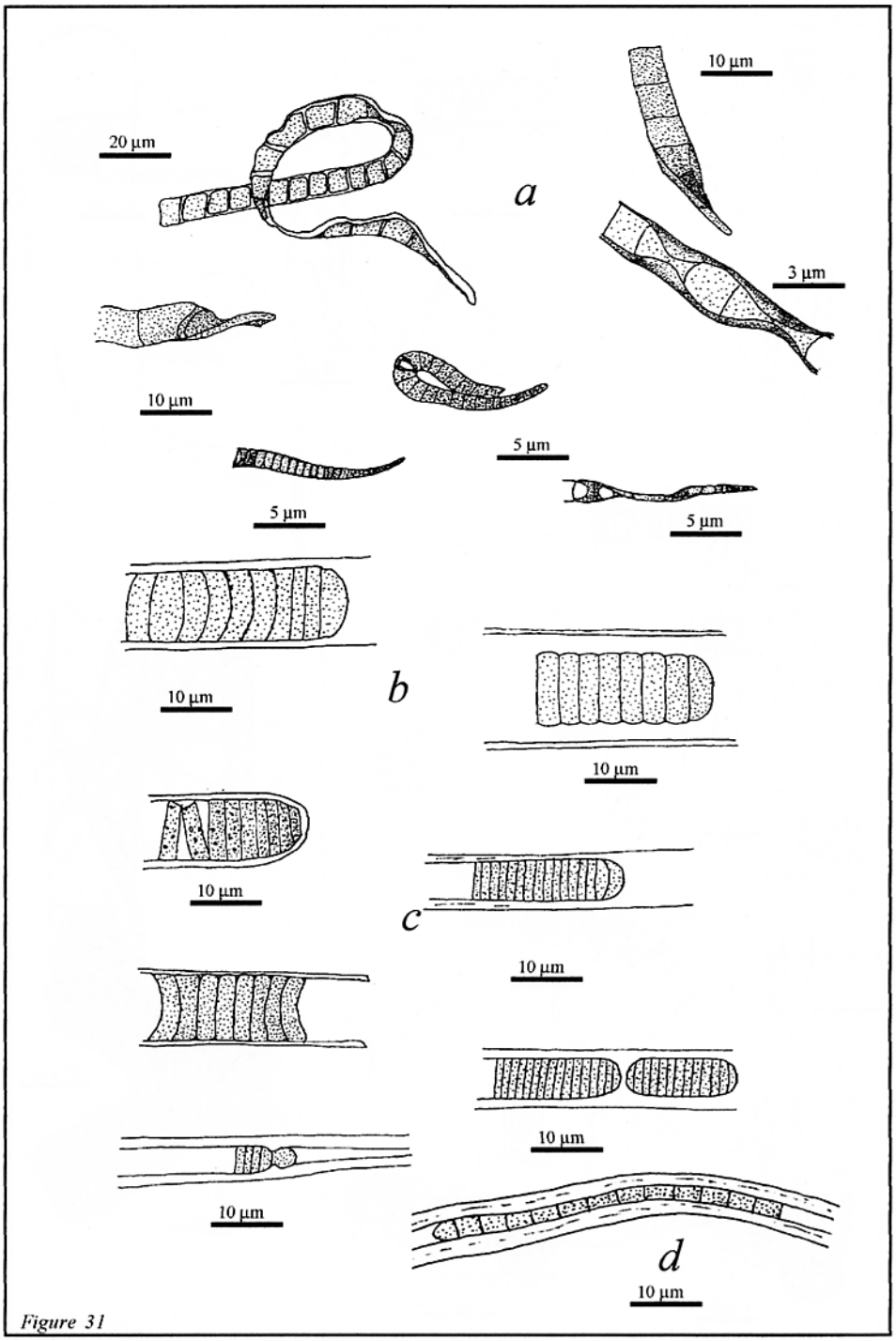

Figure 31

Key to figure 31: ***a.*** *Crinalium sp.* ***b.*** *Lyngbya cinerescens* Kuetz. ***c.*** *Lyngbya confervoides* Ag. ***d.*** *Lyngbya kuestzingiana* Kirchner

Cyanophyta

(blue-green algae)

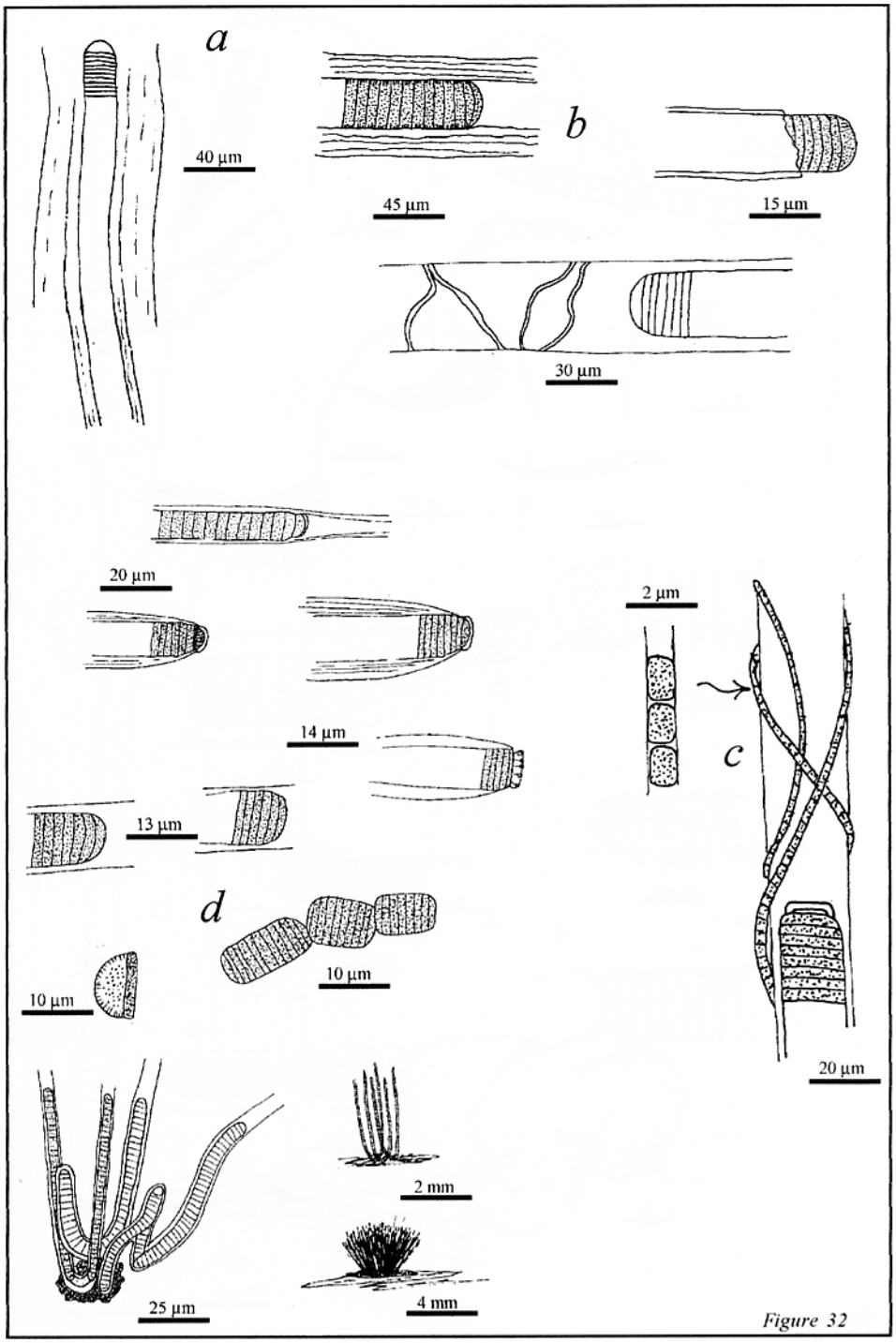

Figure 32

Family Oscillatoriaceae: (continued)

Lyngbya majuscula (Fig. 32a-b) is very common in green turtle samples and it can form large tangled black hair-like masses (2-6 cm) on other algae. It is up to 80 µm wide and has a lamellated sheath, with almost black trichomes inside, which end with rounded tips that have no calyptra.

Lyngbya porphyrosiphonis (Fig. 32c) is a small (1-2 µm diameter) species most often seen growing on and spiraling around other filamentous algae.

Lyngbya semiplena (Fig. 32d) grows in dense yellow-green tufts (2-3 cm tall) attached by the mid-portions of the trichomes. The tips of the trichomes usually have a calyptra.

Key to figure 32: ***a.*** *Lyngbya major* Menegh. ***b.*** *Lyngbya majuscula* Harvey ***c.*** *Lyngbya porphyrosiphonis* Fremy ***d.*** *Lyngbya semiplena* (C.Ag.) J. Ag.

(blue-green algae)

Cyanophyta

Family Oscillatoriaceae: (continued)

Microcoleus (Fig. 33a-c) species are easily recognized because many trichomes are twisted together in bundles within a common loose surrounding sheath. The trichomes are usually tapered at each end.

Oscillatoria (Fig. 33e-j) species are commonly found as traces in green turtle samples. Members of this genus are single or grouped trichomes without a sheath or within a very thin delicate sheath. Trichomes are usually straight and stiff, but can be curved and coiled near the ends.

Phormidium (Fig. 34a) species form a tan to olive-green thallus, often with dark red tones or streaks. The thallus is made from trichomes in confluent mucilaginous sheaths and may be prostrate or erect 4-10 cm tall. The trichome apices are either blunt or attenuated with or without a calyptra or with small hairs.

Spirulina (Fig 34b-c) species trichomes are distinctly and evenly tight or loose coils of cells that are extremely small and usually visible only under high magnification.

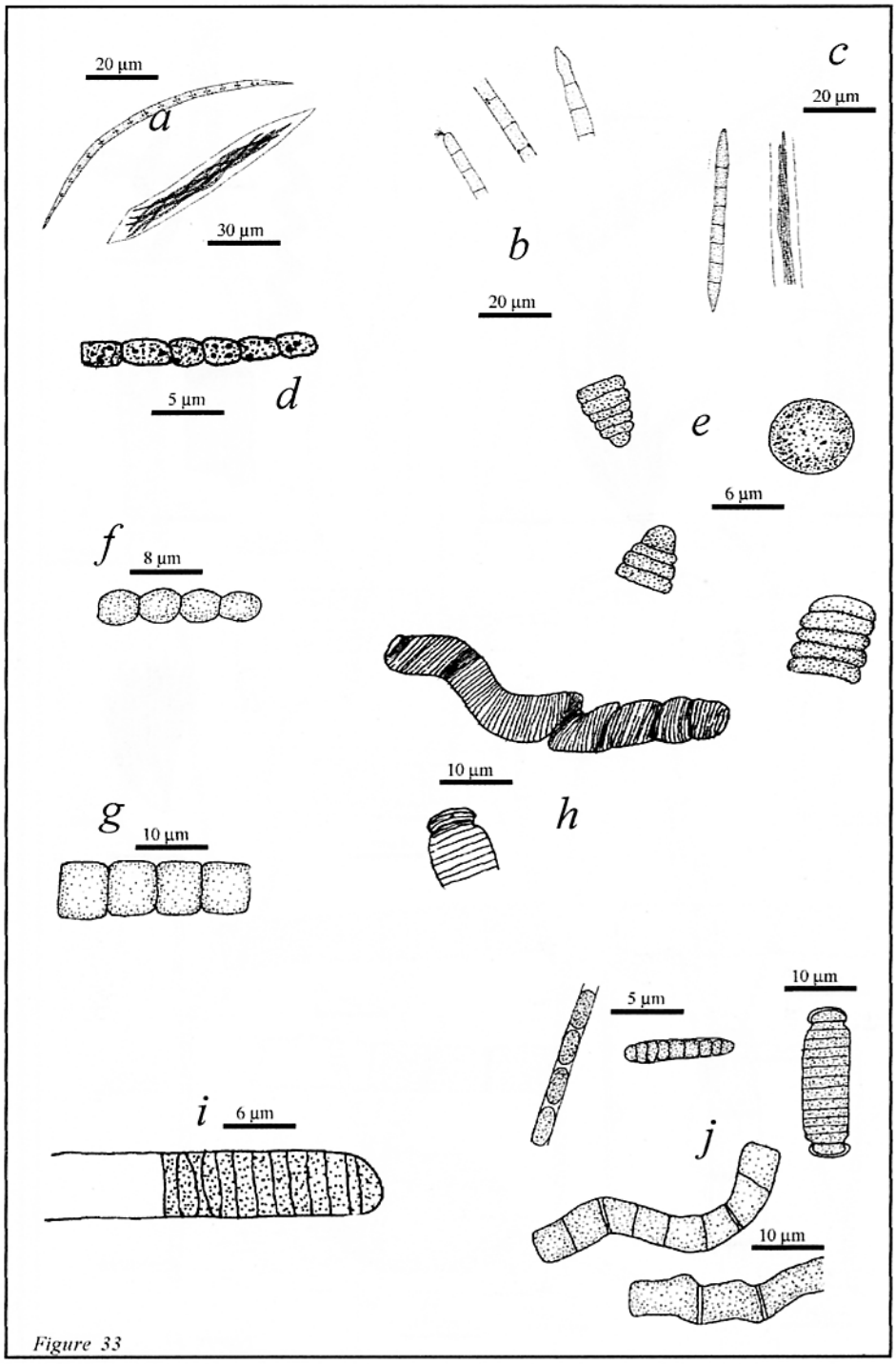

Figure 33

Key to figure 33: ***a.*** *Microcoleus acutissimus* Gardner ***b.*** *Microcoleus vaginatus* (Vaucher) Gomont ***c.*** *Microcoleus sp.* ***d.*** *Oscillatoria amphigranulate* Van Goor ***e.*** *Oscillatoria anna* Van Goor ***f.*** *Oscillatoria foreaui* Fremy ***g.*** *Oscillatoria hamelli* Fremy ***h.*** *Oscillatoria nigro-viridis* Thwaites ***i.*** *Oscillatoria subbrevis* Schmidle ***j.*** *Oscillatoria sp.*

Cyanophyta

(blue-green algae)

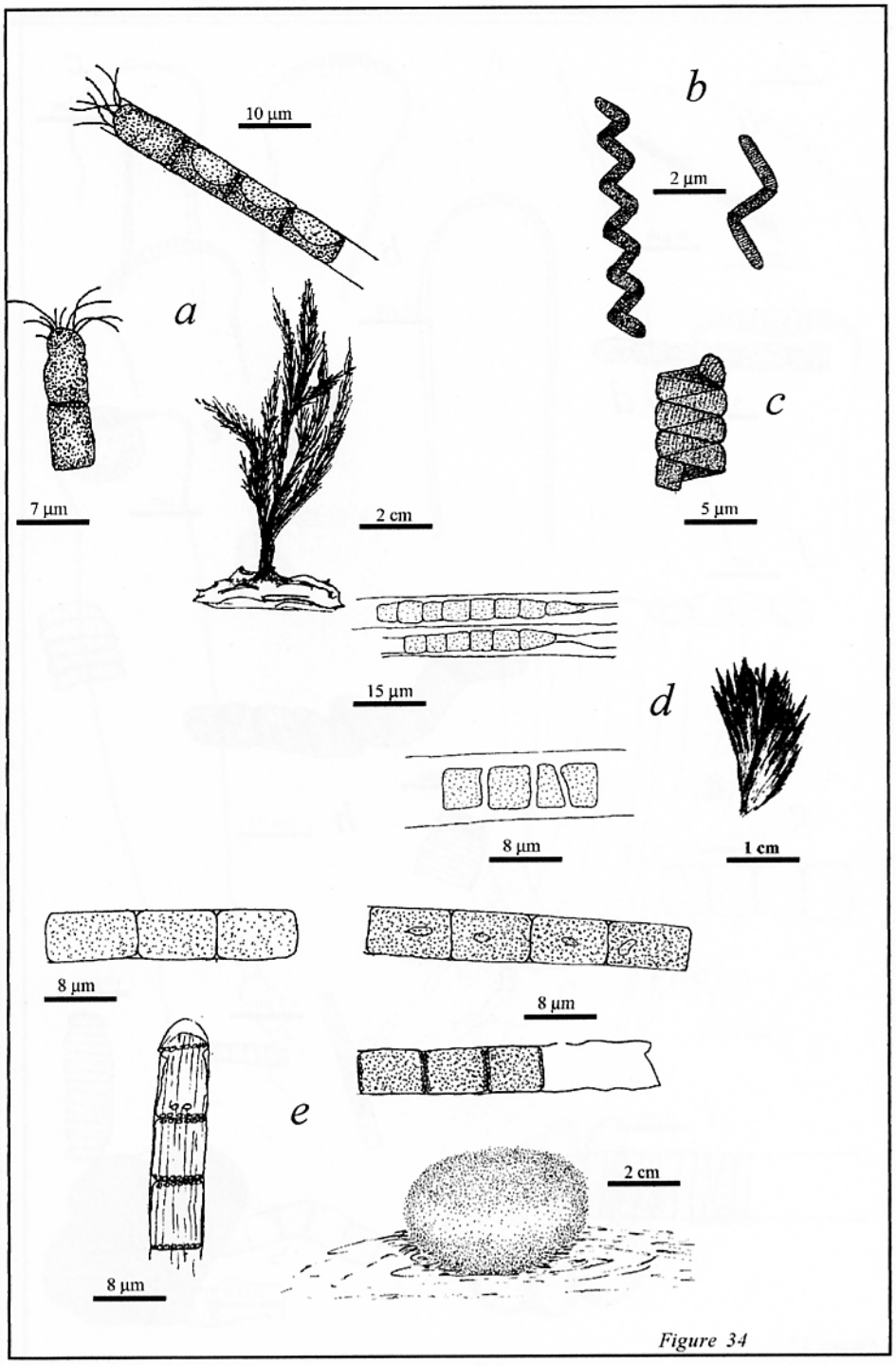

Figure 34

Family Oscillatoriaceae: (continued)

Spirulina (continued) Trichomes are not in a sheath, are single, or form thin sheets or loosely organized masses covering the substratum.

Symploca (Fig. 34d) species form erect tufted and calcified thalli (1-3 cm tall) from bundles of densely packed trichomes (6-8 µm diameter) in a firm, thick sheath, one trichome per sheath. The cells are irregularly square and end with a tapered cell. Thalli in sea turtle samples are usually entirely gray ragged tufts, but are gray-white when alive, with red-violet streaks near the top.

Schizothrix (Fig 34e) species consist of many trichomes (3-60 µm diameter) that are richly branched, have no clayptra and loosely arranged in a shared sheath. Colonies are often large cottony, round cushions (2-4 cm diameter) that are white, lightly calcarious, with a pink, light blue-gray, or yellow-brown top. A prostrate sheet of filaments can form on the substratum rather than a cushion. Cells in the trichome usually have no granules at the cross-walls. The terminal cell is conical or slightly tapered.

Key to figure 34: ***a.*** *Phormidium sp.* ***b.*** *Spirulina subtillissima* Kuetz. ***c.*** *Spirulina subsalsa* Oerst. ***d.*** *Symploca hydnoides* Kuetz. ***e.*** *Schizothrix calcicola* (Ag.) Gomont

(blue-green algae)

Cyanophyta

Family Rivulariaceae:

Members of this family form single rows of cells that taper to a point and end with a terminal hair.

Rivularia (Fig. 35a-b) species form dense tufts on algae or hard substrate that attaches by a broader basal cell or heterocyst. Individual trichomes are not branched and are often covered by a clear sheath, which often has a shredded appearance.

Calothrix (not illustrated) species are similar but have a spore above the heterocyst, can have false-branching, and grow as a continuous carpet rather than in tufts.

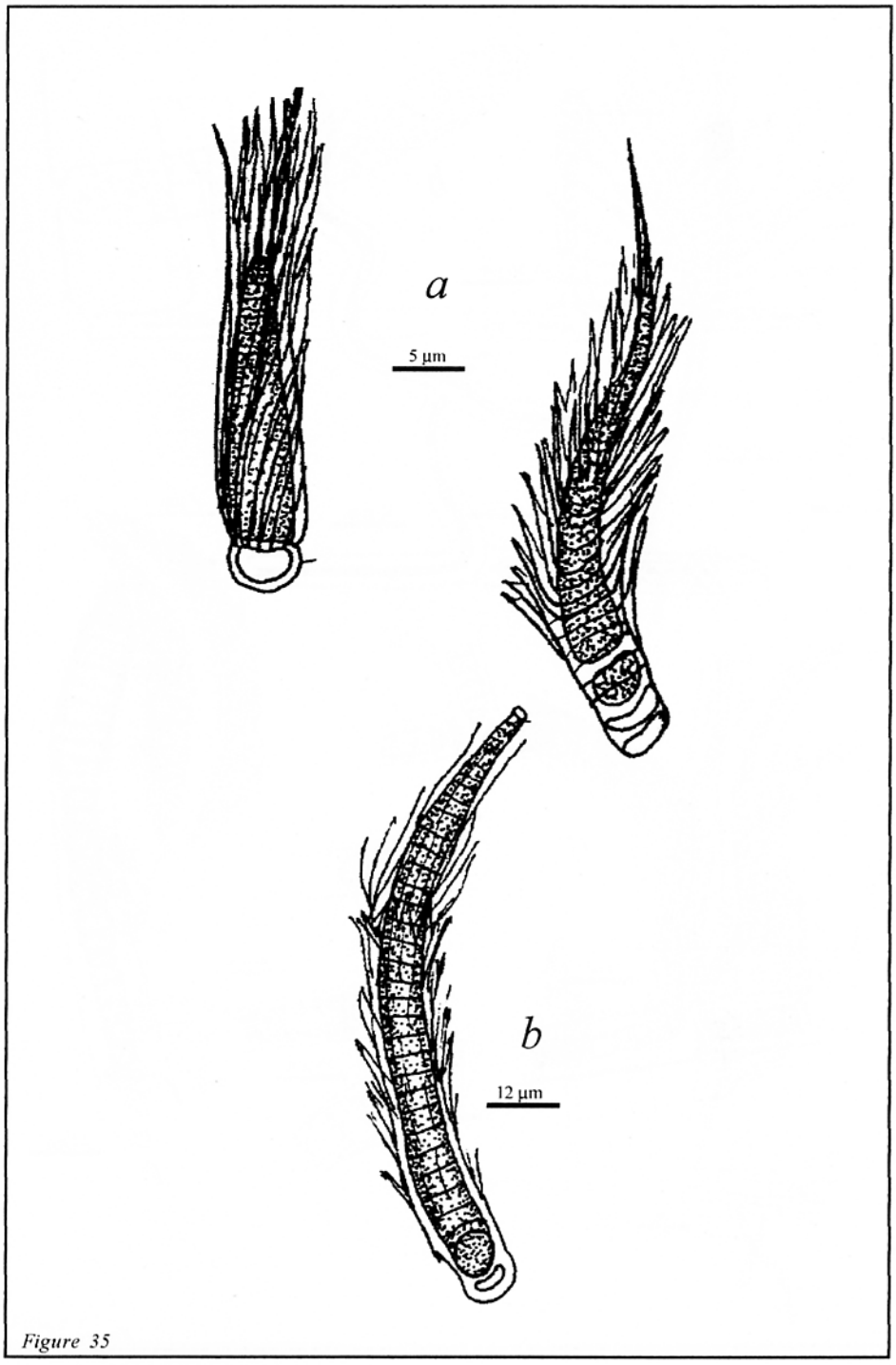

Figure 35

Key to figure 35: ***a.*** *Rivularia mangihii* Fremy ***b.*** *Rivularia* sp.

Cyanophyta

(blue-green algae)

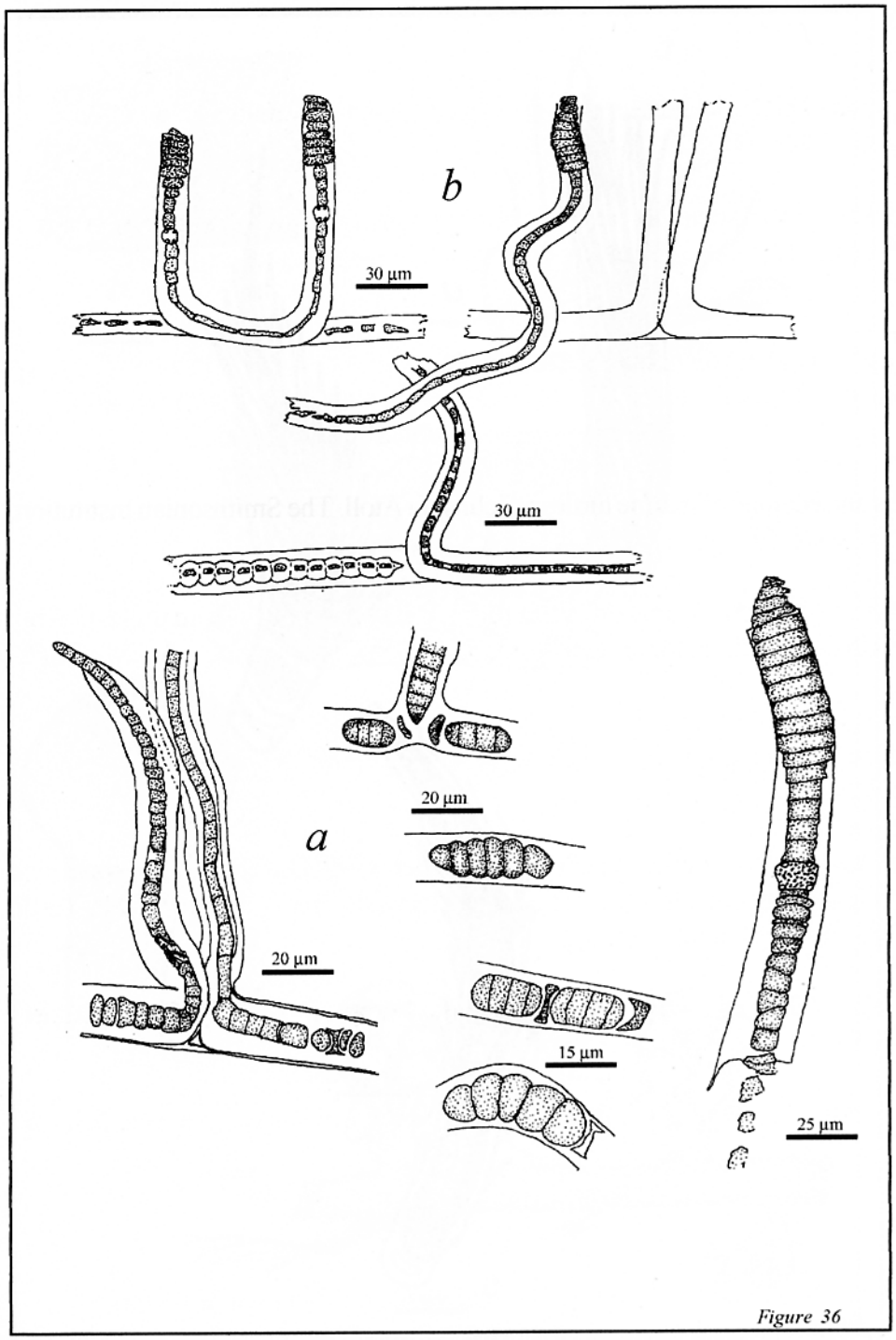

Figure 36

Family Scytonemataceae:

This family has intercalary heterocysts with 2 pores at the end walls, hormogones, geminate false-branching, and single trichomes in a prominent sheath.

Scytonema pascheri (Fig. 36a-b) forms brownish thalli with trichomes about 20 µm wide. The trichomes are narrow and have elongated cells in the prostrate portions and are broader with short cells in the erect portions. It is usually a terrestrial species.

Key to figure 36: *Scytonema pascheri* Bharadwaja ***a.*** double branching ***b.*** intercalary heterocyts

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GLOSSARY OF TERMS

Agglutinate To unite by a glue or other tenacious substance.

Algae Seaweeds and simple freshwater photosynthetic plant-like organisms that do not produce flowers or seeds.

Anthozoa A group of invertebrate animals that include the corals and sea anemones.

Anthophyta The Division which contains flowering plants, in the Kingdom Plantae.

Ascidia A group of invertebrate animals that include the sea squirts.

Calyptra A covering over the tip of a filament, a hat, cap or hood of material.

Chlorophyta The Division of algae that are usually green.

Cnidaria A group of invertebrate animals that include corals, jellyfish, and sea anemones.

Coenocytic Hollow or tubular rather than made up of distinct individual cells.

Cortex The external tissue, the outer rind or skin of a seaweed.

Crop A food containing storage pouch at the base of the esophagus (crop/stomach) in some populations of green turtles.

Crustacea A group of invertebrate animals that include crabs, shrimps, lobsters and other aquatic animals with a calcified jointed exoskeleton.

Cyanophyta The Division of algae/bacteria that are usually blue-green.

Cystocarps Swollen parts of some female red algae, usually darker in color and containing sexually produced reproductive spores.

Cytoplasm The living material found inside of cells.

Dichotomous Branching in two equal parts, an equally forked paired branching pattern.

Division The botanical classification level below Kingdom and above Class, the same level as Phylum in other classification systems. Presently the levels of classification are Domain, Kingdom, Division (=Phylum), Class, Order, Family, Genus, Species.

Endospores Spores that are formed inside of another cell.

Exoskeleton The outside skeleton or shell found in crabs, shrimp, and insects.

False-branching A situation in filamentous blue-green algae in which a trichome breaks free of its sheath and grows to the side like a branch. This is in contrast to true branching that occurs directly from cells which divide in a new direction, to the side, and form a branch.

Family The taxonomic unit above a Genus and below an Order. Family names of algae and plants end consistently with the letters — aceae.

Filament A series of cells in the Division Cyanophyta that consist of the trichome and the sheath, if present.

Floats Hollow, gas-filled portions of some algae, usually brown algae, that cause the thallus to float erect while attached to the substratum.

Forcep Pincher-shaped, forked, and curved inward like pliers.

Hair scar A scar or blemish left behind on a thallus after a hair has dropped off.

Heterocyst A specialized cell found in filamentous blue-green algae that is usually larger than the other cells, colorless and with a thick wall. It is associated with nitrogen fixation.

Holdfast The portion of a seaweed that attaches to the surface or substratum.

Hormogone A specialized cell found in some filamentous blue-green algae, such cells are larger and darker than the vegetative cells.

Intercalary The position in which cells are situated between cells located in a series or within continuous tissues, rather than being located at the tip of a filament or branch.

Lamellated Material which is formed from layers of material laid upon each other like pages in a book.

Lamina The part of some algae that have a leaf-like appearance.

Lenticular Lens-shaped, thin at the edges, and thick in the middle.

Medulla The center core tissue portion of a seaweed.

Mixohaline A mixture of freshwater and saltwater resulting in brackish water.

Mollusc A group of soft-bodied invertebrate animals that includes snails and clams.

Monospecific Consisting entirely of only one species.

Mucilaginous A substance or texture that is mucus-like, thick, and slippery.

Nannocyte A very small, minute cell.

Ostiole An opening or a hole.

Phaeophyta The Division of algae that are usually brown.

Phycology The formal scientific study of algae.

Phycologist A person who studies algae.

Phylum The classification or group of organisms, below the level of Kingdom and above the level of Class.

Pinnate The general shape or appearance of a feather.

Pit connection A plugged cytoplasmic connection between the cells of some red algae, visible with a microscope.

Pyriform Shaped like a pear, narrow at one end and broader at the other end.

Ramulus Any secondary branch, especially like the erect branches found in *Bryopsis* and *Caulerpa*.

Receptacles Special portions of some brown algae that contain the reproductive structures. They form small branched masses in the axils or near the base of the "leaves" in *Sargassum* and *Turbinaria*.

Rhizoid Root-like unicellular extensions of the thallus that anchor some seaweeds to a solid or sandy surface.

Rhodophyta The Division of algae that are usually red.

Sessile Attached and usually unable to move.

Sporangium A structure in seaweeds that contain spores, reproductive cells.

Stipe The stem-like structure seen in some algae.

Striations Stripes or long grooves or lines.

Substratum The solid substance to which a seaweed or sea grass is anchored.

Terrestrial Pertaining to the earth or land, not usually associated with the marine environment.

Thallus The general body of a seaweed.

Trabeculae Cell wall thickenings that extend into the cell cytoplasm as horn-like or thread-shaped extensions.

Trapezoidal Having the geometric shape of a trapezoid, two parallel and two nonparallel sides.

Trichoblast A hair-like row of cells or tuft of filaments.

Trichome A hair-like filament or row of cells formed by some species of blue-green algae, sometimes surrounded by a sheath. See filament.

Uniloculate Consisting of one small discrete container or space.

Utricles The swollen part of the tubular thallus filaments of *Codium* that makeup the outer portion or cortex.

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