ON THE MODE OF GROWTH OF THE SKELETON IN FUNGID CORALS*

By G. MATTHAI, Sc.D. (Cantab.)†

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[Plates 3 to 14]

Work on this paper was carried on, during a year of leave (1938–9), in the Zoological Laboratory at Cambridge, but was interrupted by the outbreak of war. I then had the benefit of discussing the work with the late Professor J. Stanley Gardiner, F.R.S., at whose suggestion its completion was postponed till my return to Cambridge after the termination of the war. The present paper, based on his Fungid coral material from the Indo-Pacific region (Gardiner 1898, 1905, 1909), the late Dr Cyril Crossland's collections from Tahiti and the Red Sea and mine from the Bermudas and Tortugas, is supplementary to a previous one (Matthai 1940), in which the mode of growth in Astraeid corals was considered.

My thanks are due to the late Professor J. Stanley Gardiner, F.R.S., for help rendered in various ways, to Professor J. Gray, F.R.S., and Mr F. R. Parrington, M.A., for facilities in the Department of Zoology and for accommodation in the Museum, to the Royal Society for financial aid and to the Governing Body of Emmanuel College, Cambridge, for hospitality during a year of residence.

From a study of skeletal growth forms it appears that colonial Fungid corals are descended from solitary ancestors represented by the recent genus *Fungia*. Asexual reproduction by means of budding, continued without loss of organic connexion among the buds, has resulted in different forms among colonial Fungids. Budding has taken place in the region of the oral disk, unaccompanied by the appearance of directive couples or of hexameral arrangement of mesenteries. This process is, therefore, comparable to intratentacular budding in Astraeid corals, although tentacles in colonial Fungids may be scattered, rudimentary or even absent, the edge zone never normally giving rise to buds. In other words, extratentacular budding that takes place in certain Astraeid genera does not appear to have played any role in colony formation among Fungid corals. Hence, in the latter, true corallite walls and peritheca can hardly be said to be present.

The capacity for formation of sudsidiary calicinal centres exists within the genus *Fungia*, as seen in several specimens among Professor Gardiner's collections from the Indo-Pacific region and Dr Crossland's collection from the Red Sea (also Döderlein 1902, plate 3, figure 1; plate 4, figure 9; plate 7, figure 5; plate 8, figure 1; plate 9, figure 3; plate 21,

* The specific names employed in this paper are provisional.

† The author died while the MS. of this paper was in the hands of the printer. The proofs have been seen through the press by R. B. Seymour Sewell, F.R.S.

figure 3; plate 23, figures 1 and 2; plate 24, figure 2; Klunzinger 1879, plate 7, figures 1 to 3). This capacity becomes more manifest under abnormal conditions.* Within the genus *Fungia* there is also a wide range of variation in the shape of the corallum, from almost flat to highly convexo-concave, i.e. the upper calicinal surface highly convex and the lower non-calicinal surface correspondingly concave, as shown by several specimens in Professor Gardiner's collection (also Döderlein 1902, plate 4, figures 6 to 9; plate 5, figure 5; plate 9, figure 3; plate 11, figures 1 and 1*a*; plate 14, figure 1; plate 19, figure 2; plate 22, figure 3 (showing very highly convex calicinal surface) and plate 23, figures 1 and 2; Matthai 1924, plate 9, figure 3).

Elongated forms of *Fungia*, with an axial furrow of varying length, make an easy transition to the condition of *Herpetolitha simplex* Gard. (Döderlein 1902, plate 7, figures 1 to 5; Vaughan 1901, plates 8, 10; Vaughan 1907, plates 31, 35, 36).†

Polyphyllia‡ is derivable from *Herpetolitha*. The corallum has essentially the same shape, being convexo-concave and much longer than broad. There is usually an axial row of calicinal areas. Surrounding the axial row are subsidiary calicinal areas somewhat scattered or arranged in more or less concentric drawn-out ovals (Bedot 1907, plate 34, figure 174; plate 35, figures 177 to 179; Gardiner 1909, plate 36, figure 13; plate 38, figure 19; plate 39, figure 26; Thiel 1932, plate 12, figure 2). The axial calicinal areas are usually larger than the surrounding ones and have radiating septa, the middle calicinal area of the axial row being the earliest and the largest. The specimens referred by Gardiner to different species of *Herpetolitha* form an intermediate series from the *Fungia* to the *Polyphyllia* condition (Gardiner 1905, plate 91, figure 13; Gardiner 1909, plate 36, figure 15; plate 38, figures 21 to 23; plate 39, figure 24; also Bedot 1907, plate 33, figures 169 to 173; Faustino 1927, plate 64, figure 1; Klunzinger 1879, plate 8, figure 5; Vaughan 1918, plate 53, figure 1; plate 54, figure 1).

The condition of subsidiary calicinal areas, represented in certain species of *Fungia* by columellar centres with associated septa, becomes definite in *Döderleinia* in which these areas, though comparatively few, nevertheless tend to get arranged in successive concentric rows around the primary calicinal area (Bedot 1907, plate 32, figures 165 to 168; Gardiner 1898, plate 43, figure 1; Gardiner 1909, plate 39, figure 28; Horst 1921, plate 3, figure 4; plate 4, figure 1). A condition similar to that of *Döderleinia* is also noticeable in

* The specimen figured under *Fungia fungites* (Linn.) by Boschma (Boschma 1925, plate 7, figure 73), with several subsidiary calicinal areas around the primary calicinal centre, seems to belong to *Döderleinia* or *Halomitra* rather than to *Fungia*, whereas such definite areas are not seen in the specimens figured by Studer and Faustino under *Halomitra fungites* Studer (Studer 1901, plate 24, figures 2 and 3; Faustino 1927, plate 60, figures 4 and 5). Those specimens would, therefore, come under *Fungia* owing to their resemblance to some of the specimens figured by Döderlein under *F. fungites* (Linn.) (e.g. Döderlein 1902, plate 24, figure 4).

† Boschma (1925, p. 226) regards *Herpolitha* (*Herpetolitha*) *weberi* (Horst 1921, plate 1, figure 5) as intermediate between *H. simplex* Gard. and *H. foliosa* (Ehrb.). This author, like van der Horst (Horst 1921, pp. 15 and 16), brings all recorded species of *Herpetolitha*, including *H. stricta* Dana (Vaughan 1918, plate 51, figures 3 to 3*b* of Dana's type), but excepting *H. simplex* Gard. and *H. weberi* (Horst), under the synonymy of *Herpolitha* (*Herpetolitha*) *limax* (Esper).

‡ With regard to *Polyphyllia*, Gardiner remarks: 'The genus contains only two undoubted species, *P. talpina* (syn. *P. pelvis*) and *P. novae-hiberniae*—*P. substellata*, *P. leptophylla*, *P. pileiformis* and *P. Galeriformis* are not recognizable from their original descriptions or from M. Ed. and H's great work' (Gardiner 1909, p. 287). Boschma (1925, p. 232) regards *P. producta* Folkeson (1919) as synonymous with *P. talpina* (Lam.).

Zoopilus echinatus Dana in which the calicinal centres appear to be even fewer (Boschma 1925, plate 11, figure 135).

Halomitra, which is probably descended from a *Döderleinia*-like ancestor, shows the cyclical arrangement of subsidiary calicinal areas in successive concentric rows around the primary calicinal area (plate 3, figure 1; also Studer 1901, plates 23, 25, 26, and 27).*

The corallum, in all species of *Halomitra*,† is much more convexo-concave than in *Polyphyllia*, the calicinal surface being highly convex, the non-calicinal surface correspondingly concave.

Podabacia‡ represents a further stage in skeletal evolution from the *Döderleinia* stem. Here the cyclical arrangement of subsidiary calicinal areas in successive concentric rows becomes more definite. The primary calicinal area, which is usually larger in size, tends to be somewhat excentric owing to greater growth on one side (plate 3, figure 2 and plate 4, figure 4). Even in a large colony from Tahiti the primary calicinal area can be easily recognized (plate 3, figure 3). The corallum of *Podabacia* is thinner than that of *Halomitra*; the calicinal surface in *Podabacia* is concave, the corallum, unlike that of *Halomitra*, being concavo-convex, usually with a scar of attachment on the convex non-calicinal surface, opposite the original calicinal centre (Bedot 1907, plate 32, figures 161 to 164; Faustino 1927, plate 68, figures 1 and 2). Thus, in appearance, *Podabacia* is like a *Halomitra* turned outside in, but the corallum is less coarse. In both *Halomitra* and *Podabacia* the calicinal surface is more extensive than in *Döderleinia*.

In the above-mentioned genera, secondary columellar centres show progressive development from the stage represented by the incipient subsidiary calicinal centres of certain species of *Fungia* to the condition in *Herpetolitha*, *Polyphyllia*, *Döderleinia*, *Halomitra* and *Podabacia*, but in all cases formed by twisted septal trabeculae. The septa, which in Fungid genera are, as a rule, alternately thick and thin—the alternation varying from slight to very marked in the different genera—also show progressive adjustment around the columellar centres. In the early stages, as seen in certain species of *Fungia* and *Herpetolitha*, the septocostae appear to be incised or vertically split in places where subsidiary calicinal centres are formed; otherwise there is hardly any deviation in their course towards the periphery of the corallum. In *Döderleinia*, *Polyphyllia*, *Halomitra* and *Podabacia*, however, definite calicinal areas are formed around the primary centre, and two septo-costae (one distal and the other proximal) converge, on each side, towards each columellar centre, this being the initial stage in a readjustment of septo-costae around each subsidiary columellar centre. In *Polyphyllia talpina* (Lamk.), septo-costae in the axial row of calicinal centres have been rearranged to radiate around each columellar centre; this is seen even at a comparatively early stage represented by the smaller of the two specimens from Singapore figured by Gardiner (Gardiner 1909, plate 38, figure 19).

* Boschma (1925) brings all three species of *Döderleinia* under the name *Halomitra robusta* (Quelch) (p. 242), *Zoopilus echinata* Dana under *Halomitra echinata* (Dana) (p. 235), and all four species of *Halomitra* described by Studer, as well as *H. louwinae* Horst, under *H. philippinensis* Studer (p. 237).

† In *Herpetolitha*, *Polyphyllia*, *Döderleinia* and *Halomitra*, particularly in the last two genera, the corallum has a coarse appearance.

‡ Of the five species of *Podabacia* described so far, viz. *P. crustacea* (Pallas), *P. dispar* Verrill, *P. involuta* Horst, *P. lobata* Horst and *P. elegans* M. Ed. & H. (Horst 1921, pp. 26–29), there does not seem to be any doubt with regard to the specific identity of *P. crustacea* (Pallas).

*Echinophyllia** resembles *Podabacia* in general growth form of corallum; explanate, concavo-convex, the upper concave surface being calicinal, the lower convex surface non-calicinal. The primary calicinal area is larger than the subsidiary ones, and situated towards the hinder or proximal part of the corallum. Subsidiary calicinal areas are arranged in concentric rows which, however, are not regular (plate 11, figure 44). These concentric rows are comparatively wide apart, although calicinal areas may get approximated here and there in the same row. As in *Döderleinia*, *Halomitra* and *Podabacia*, septo-costae can be seen to extend from the edge of the corallum to the primary calicinal centre, becoming incised or split where subsidiary calicinal areas are formed. As in *Podabacia*, new septo-costae make their appearance with the formation of fresh calicinal centres, intercalated among existing septo-costae. In *Echinophyllia aspera* (Ell. & Sol.) the corallum is of the same thickness as in *Podabacia* but is more extensive, much rougher and has a coarse spiny appearance owing to the presence of marginal teeth on the septo-costae, particularly conspicuous in calicinal areas. The corallum has thus some resemblance to that of the Astraeid genus *Echinopora*. In *Echinophyllia* the septo-costae have a sinuous appearance in the inter-calicinal regions, and columellar centres are comparatively feebly developed. In both genera, the non-calicinal surface is free except where attachment may be effected excentrically, with or without a very short peduncle, almost opposite the primary calicinal area. The corallum in *Echinophyllia* may sometimes get folded, the edges of the two flaps thus formed secondarily fusing and giving a false appearance of both surfaces being calicinal; when such a corallum is split across, the non-calicinal surface becomes visible.

Echinophyllia is probably descended from a *Podabacia*-like ancestor. Both genera have a similar concavo-convex growth form, almost the same thickness of corallum and septa, and excentrically placed primary calicinal area distinguishable by its larger size, opposite to which on the convex non-calicinal surface is the excentric area or short stalk of attachment. The corallum is rougher in *Echinophyllia* than in *Podabacia*.

A distinct line of advance in skeletal evolution shown by *Echinophyllia* is in the elevation of septo-costae around columellar centres, giving a star-shaped appearance to the calicinal areas. This is unaccompanied by the upraising of the corallum to form corallite walls, or by the formation of concentric ridges. But the thickening of the elevated portions of the septo-costae around columellar centres may be carried to such an extent that they may secondarily fuse to form corallite walls which are sometimes incomplete as they occur only on the proximal side, when the calicinal areas appear to be oblique. With the elevation of the septo-costae in the calicinal areas, columellar centres also tend to rise above the surface of the corallum. As in other colonial Fungid genera, a pair of septo-costae from opposite directions converge to each columellar centre, the convergence being more marked than in *Halomitra* and *Podabacia*.

In *Echinophyllia*, while concentric ridges are not formed, radial ridges may appear by the raising up of septo-costae at comparatively wide intervals (plate 11, figure 45). Such ridges are usually discontinuous, and, when high, the intervening spaces appear like radial valleys —a facies that is reminiscent of the condition so pronounced in *Tridacophyllia*, and therefore suggestive of parallel evolution.

* Of the two recorded species of *Echinophyllia*, *E. aspera* (Ell. & Sol.) and *E. lacera* (Verrill), the latter is not specifically different from the former. *Oxypora contorta* Quelch seems also to be synonymous with *Echinophyllia aspera* (Ell. & Sol.).

In *Pavona* the cyclic arrangement of subsidiary calicinal areas to form concentric rows is well seen, the areas being comparatively smaller, more numerous and more closely arranged in each row, than in *Podabacia* (plate 7, figure 28). The concentric rows are also more closely approximated and almost equidistant. Growth is greater distally, and the primary calicinal area becomes excentric and ultimately indistinguishable. There are also low, somewhat oblique, ridges along the proximal sides of the corallite areas (plate 7, figure 29). Between such ridges are shallow valleys in which additional calicinal areas may appear beside the original median row. The columellar centres are compact and ridged above, around which a readjustment of septo-costae takes place as in *Podabacia*. In *Pavona* the corallum, in its simplest condition, is thin, foliate, concavo-convex, the upper surface being calicinal and the lower surface non-calicinal. In this, as in all Fungid genera, growth is primarily cyclic, as shown by the concentric arrangement of subsidiary calicinal areas.

A further stage in skeletal evolution in *Pavona* is the appearance of ridges that radiate from the base of the folia towards the periphery, at varying distances apart, giving the corallum a fan-like appearance as in the Astraeid *Merulina* (plate 12, figure 46). These ridges are continuous, more often discontinuous, and when present, are better developed and more conspicuous than the concentric ridges connecting the proximal sides of the subsidiary calicinal areas. New calicinal areas are formed on both sides of these radial crests, as also when parts of concentric ridges rise to any height. The vertical growth of radial or concentric ridges from the calicinal surface results in secondary thin foliae, with incomplete concentric rows of calicinal areas on both sides of each vertical plate. Less frequently, horizontal laminae, concavo-convex, similar to the original folia, make their appearance, when the concentric rows (usually incomplete) of calicinal areas are restricted to their upper surface. The secondary foliae, both vertical and horizontal, vary in thickness, resembling the primary folia in the concentric arrangement of calicinal areas. This is the condition in *Pavona cactus* (Forsk.).

A later modification is when the secondary vertical plates become numerous, decrease in width, more closely and somewhat irregularly arranged, secondarily branching and connexions often taking place between plates or their branches. Thus the formation of secondary foliae leads on to a wide range of skeletal variation. Indeed, all species under 'corallum frondose or ramose' in Vaughan's synopsis of *Pavona* (Vaughan 1918, pp. 134 and 135) seem to be only variants of *P. cactus* (Forsk.).*

Another line of modification is towards the condition of *P. varians* (Verrill) by the thickening of the primary lamina till ultimately a massive corallum is formed. The concentric ridges often rise up to assume the appearance of definite collines. Valleys between them become discontinuous when, as usually happens, discontinuous radial ridges cut across concentric collines. By such intersection, short valleys and even distinct corallites may be formed. Thus, an appearance of sinuous valleys not infrequently becomes characteristic of *P. varians* (Verrill), and represents the Astraeid *Coeloria* stage in skeletal

* Viz. *P. divaricata* Lamk., *P. frondifera* Lamk., *P. praetorta* Dana, *P. formosa* Dana, *P. venusta* (Dana), *P. decussata* Dana, *P. lata* Dana, *P. crassa* Dana, *P. knorri* (M. Ed. & H.), *P. muelleri* (M. Ed. & H.), *P. danai* (M. Ed. & H.), *P. complanata* Verrill, *P. foliosa* Verrill, *P. angularis* Klunz., *P. laxa* Klunz. (not seen in Klunzinger's list, 1879), *P. prismatica* Brügg, *P. minor* Brügg, *P. seriata* Brügg, also perhaps *P. cristata* (Ell. & Sol.), *Heteropora palmata* Ehrbg., *Lophoseris percarinata* (Ridl.), *Haloseris crispa* (Ehrbg.), *Trichoseris angulosa* Ortmann, *Pavona gardineri* Horst.

evolution within the genus *Pavona*.* In a valley there is usually more than one row of calicinal areas, a condition whose initial appearance is seen in *P. cactus* (Forsk.), and, as has already been noted, subsidiary calicinal areas may also appear on the sides of collines.

Both concentric and radial ridges may become discontinuous, more often the latter, the former remaining inconspicuous. From such a *Merulina* condition of the corallum the Astraeid *Hydrophora* facies, with monticules of varying length, is soon reached (plate 5, figure 15). When monticules are comparatively long, the appearance is comparable to that of *Hydnophora contignatio* (Forsk.) (plate 5, figures 13 and 14). By shortening of monticules the facies of *H. exesa* (Pallas) results (plate 5, figure 16) and finally the extreme condition of conical monticules of *H. microconos* (Lamk.) (plate 5, figure 17).

All species under 'corallum primarily incrusting, subsequently may become massive' in Vaughan's synopsis of *Pavona* (1920, p. 135) are probably variants of *P. varians* (Verrill).†

In parts of some colonies of *P. varians* (Verrill) there is a return to the original condition of calicinal areas with neither ridges (concentric or radial) nor incomplete corallite-walls—a condition that is characteristic of *Podabacia* and *Halomitra*.

The condition in *Pavona ponderosa* (Gard.) seems to have been reached in evolution by the formation of radial ridges in addition to concentric collines having been carried farther than in *P. varians* (Verrill) till the former cut across the latter at narrower intervals, both systems of ridges being of about the same height. Such close intersection of two systems of ridges will result in very short discontinuous valleys (plate 6, figures 21 and 23) and distinct corallites (plate 6, figures 18, 19, 22 and 24), both systems taking part in the formation of their walls. This condition has become permanent in *P. ponderosa* (Gard.). In the early stages of colonies of *P. ponderosa* (Gard.), in which the corallum is explanate, both systems of ridges—concentric and radial—can be well seen, arranged fairly close to one another. It is also seen that their intersection results in short valleys and distinct corallites.‡

In a specimen from the Maldives, short discontinuous valleys are as numerous as distinct corallites. In the case of short valleys, up to six columellar centres are present in a valley, arranged more usually in groups or in double rows, rather than in a single linear row; but soon transverse partitions arise, which are at first lower than the original walls, indicating a tendency towards formation of distinct corallites. On one side of this specimen, parts of the original concentric and radial ridges are noticeable, whilst on the opposite side there are distinct corallites.

The corallite walls of *P. ponderosa* (Gard.) are flat-sided, usually pentagonal, less frequently six- or four-sided.

In marked contrast to the condition in *P. ponderosa* (Gard.) the distinct corallites in *P. maldivensis* (Gard.) are oval or circular, the corallum being raised up around each calicinal

* In Astraeid corals the meandroid condition seems to have been evolved in a reverse manner. The first mother corallite had definite corallite walls within which, by continued intracalicinal (intratentacular) budding valleys are formed. Valleys become discontinuous if transverse partitions are formed in places, otherwise remain continuous (Matthai 1940).

† Viz. *P. explanulata* Lamk.; *P. diffluens* (Lamk.), *P. ehrenbergi* (M. Ed. & H.), *P. repens* Brügg, *P. intermedia* Gard. and *P. calicifera* Gard., also perhaps *Tichoseris obtusata* Quelch (Quelch 1886, p. 114, plate 5, figures 3, 3*a* to *c*).

‡ *Coeloseris mayeri* Vaughan (1918, plate 58, figures 1*a*, 1*b*, 2, 3, 3*a*) appears to be only a skeletal variant of *Pavona ponderosa* (Gard.).

area. In this species there has also been considerable thickening of the corallum, with the result that the latter has become more massive and heavier than in *P. varians* (Verrill) or in any other colonial Fungid, and the upper calicinal surface is more or less evenly convex, the lower surface is non-calicinal and entirely attached to the substratum.

In colonies of *P. ponderosa* (Gard.) growth takes place by intracalicinal budding, usually one or two, rarely three, bud calices appearing on the sides of corallite walls. When two bud calices are formed, they are arranged one on each side of the parent calyx in a linear row, or triangularly disposed with reference to the parent calyx. When there are three buds they have usually a quadrangular arrangement in relation to the parent calyx. As in other species of *Pavona*, columellar centres invariably remain distinct.

The condition of the corallum of *P. maldivensis* (Gard.) would be reached by considerable thickening of the vertical foliae of *P. cactus* (Forsk.) so as to form humps of varying height on the original horizontal plate which usually thickens to form a massive corallum. The humps vary in width, may be branching, anastomosis being rare or absent, and, as in *P. cactus* (Forsk.), are almost invariably broader towards their free ends than at their bases. In this condition ridges are rarely present on the comparatively flat regions at the base of the corallum, but corallite walls, incomplete and oblique, may be present (plate 6, figure 20), or the corallum is raised up around individual calicinal centres so as to form low but complete corallite walls which are usually somewhat oval, sometimes circular (plate 12, figure 47). Both conditions occur in the incrusting regions of the corallum, whilst on the humps the margins of the calicinal areas are almost level with the surface of the corallum, except for the exsert ends of the septo-costae. The latter are definitely orientated around each columellar centre to form septal cycles, a stage that is more advanced than that of *P. cactus* (Forsk.). Calicinal areas are closely aggregated on the humps and on constricted regions between humps, but are never flat-sided. Septo-costae are clearly seen between calicinal areas, and pursue a somewhat wavy course on comparatively wide intercalicinal regions.

Four species* under 'corallum massive' in Vaughan's synopsis of species of *Pavona* appear to be variants of *P. maldivensis* (Gard.).

The condition of distinct corallites—four- to six-sided in *P. ponderosa* (Gard.), oval or circular in *P. maldivensis* (Gard.)—represents the Astraeid *Favia-Goniastrea* stage in skeletal evolution. The growth facies of *Pavona maldivensis* (Gard.)—with massive corallum rising into humps, somewhat constricted at their bases, covered with small oval or circular corallites projecting slightly above the general surface and having septa arranged starwise around distinct columellar centres—simulates the characteristic appearance of the corallum of *Favia acropora* (Linn.).

Thus in *Pavona* evolution has taken place from the single foliate condition of the corallum along four lines, viz. (1) the multiple foliate condition of *P. cactus* (Forsk.), with concentric rows of calicinal areas, (2) the massive condition of *P. varians* Verrill, with sinuous valleys, usually discontinuous, (3) the condition of *P. ponderosa* (Gard.) with very massive corallum bearing distinct corallites four- to six-sided as well as very short valleys, (4) the condition of *P. maldivensis* (Gard.), with massive corallum bearing humps of varying height covered with

* Viz. *P. clavus* Dana, *P. gigantea* Verrill, *P. clivosa* Verrill and *P. duerdeni* Vaughan (Vaughan 1918, p. 135); also perhaps *Siderastrea sphaeroidalis* Ortmann and *S. lilacea* Klunz.

distinct corallites oval or circular. In (1) and (2), as has already been seen, there is a further range of variation to branching and anastomosing of foliae as in *P. cactus* (Forsk.), and to the assumption of the *Merulina* and *Hydnophora* facies as in *Pavona varians* Verrill.

From the early single foliate condition of *Pavona* the appearance that is so distinctive of *Pachyseris* can be reached by the development of ridges along the proximal sides of the concentric rows of calicinal areas so as to form definite collines of more or less even height, enclosing comparatively deep valleys between them, and by the axial row of columellar centres fusingto form a continuous median trabecular plate simulating the appearance of the columellar plate in the Astraeids *Coeloria* and *Platygyra* (plate 13, figures 48 and 49). The valleys are of even width, and there is only one such columellar plate which invariably runs along the middle of each valley. In *Pachyseris* the concentric ridges or collines are comparatively close to each other and almost equidistant, becoming somewhat sinuous in places. Since the columella is continuous, composed of closely twisted trabeculae, the convergence of pairs of septa has disappeared, the septa passing straight from colline to columellar plate. The growth form of the corallum in *Pachyseris* is that of a concavo-convex basal folia which is comparatively thin, the concave upper surface being calicinal, the convex lower surface non-calicinal, but is much more extensive than the basal folia of any colony of *Pavona cactus* (Forsk.). Secondary growths may arise on the upper calicinal surface, giving rise to eminences, or secondary foliae may be formed, concavo-convex like the primary basal folia, with collines and valleys restricted to the upper surface (plate 13, figure 48).*

The collines in *Pachyseris* are the concentric ridges formed along the proximal sides of the calicinal rows. An initial stage in their evolution was noticed in *Podabacia* (p. 179) and a subsequent stage in *Pavona* (p. 181), the ridges at both these stages being oblique, i.e. vertical on the distal side and sloping on the proximal side of each row. In *Pachyseris* collines are oblique towards the edge of the corallum where they are seen at a comparatively early stage in their formation, and tend to become vertical in the central or older part of the corallum.

Skeletal variation in *Pachyseris*† is mainly in regard to (1) height of collines and consequent depth of valleys: in parts of the corallum, under abnormal conditions of growth, collines are low or absent and valleys shallow or unrecognizable, the radial course of the septo-costae being then broken only by the concentric columellar plates, as in van der Horst's figures of *P. involuta* Studer (Horst 1921, plate 3, figure 6) and *P. carinata* Brügg (Horst 1921, plate 5, figure 3), also in *P. leircollis* (Dana) judging from Dana's figure (1848, plate 22, figure 2); (2) extent of collines: in parts of the corallum broken so as to form discontinuous collines or monticules of varying length (plate 13, figure 49), as in van der Horst's figures of *P. valenciennesi* M. Ed. & H. and *P. rugosa* (Lamk.) (Horst 1921, plate 5, figure 2 and plate 6, figure 2), to a less extent in Vaughan's figures of Dana's type of *P. speciosa* (Dana) and *P. torresiana* Vaughan (1918, plate 54, figures 3 and 3*a*; plate 55, figures 1, 1*a*); this

* A specimen from Tahiti actually shows this condition.

† The corallum in *Pachyseris speciosa* (Dana) and *P. rugosa* (Lamk.) may be regarded as approximating to the condition typical of the genus. According to van der Horst, *Agaricia speciosa* Dana is synonymous with *Pachyseris speciosa* M. Ed. & H., and therefore the name *P. halmei* Quelch = *P. speciosa* M. Ed. & H. is to be dropped (Horst 1921, p. 35).

Vaughan (1918, p. 131) regards *P. monticulosa* Verrill = *P. valenciennesi* M. Ed. & H.; the latter probably = *P. rugosa* (Dana), since collines are discontinuous in Dana's figure (1848, plate 22, figure 1).

condition, however, never becomes so general as in the Hydnophoroid coralla of *Pavona varians* (Verrill); (3) alternation of septa: this is a general feature of Fungid corals, less noticeable in *Pachyseris*, and in parts of the corallum septa may be of even width and thickness, without any appearance of alternation, e.g. *P. speciosa* (Dana) (Vaughan 1918, plate 54, figures 3*a* and 4*a*); (4) extent of columellar plate: tending to get broken in parts of certain coralla. All these variations may be seen in a large-sized corallum; it appears that there is only one species in *Pachyseris*, all others being only variants of *P. speciosa* (Dana).

Radial ridges have not so far been seen in any of the coralla from Tahiti, nor are transverse partitions present across valleys. Hence the concentric valleys retain their continuity. Secondary plates when formed are horizontal, concavo-convex like the primary plate.

The genus *Leptoseris* is derivable from a primitive *Fungia patella* (Ell. & Sol.)-like ancestor, with comparatively thin closely arranged septa, by the formation of subsidiary calicinal areas around the primary centre. Such calicinal areas are, at first, comparatively few and somewhat scattered, as in *Leptoseris fragilis* M. Ed. & H. (plate 4, figures 5, 7 and 8; also Gardiner 1905, plate 92, figure 24), although tending to be cyclically arranged, as in *L. incrustans* Gard. (Gardiner 1905, plate 92, figure 25) around the primary centre which, by uneven growth of the corallum, becomes excentric in position. The corallum is comparatively thin, and its rim may get turned up or down, i.e. may become concavo-convex or convexo-concave. Columellar centres are distinctly seen, being formed of closely twisted septal trabeculae, and provided with short paliform processes, two septo-costae on each side converging from opposite directions towards each columellar centre as in *Podabacia*. Incomplete corallite walls are formed mainly by the raising up of the calicinal surface, on the proximal side, i.e. the side facing the primary centre, aided by the fusion of the outer parts of the septo-costae and the synapticulae. Such incomplete corallite walls on the proximal side give an oblique appearance to the subsidiary calicinal areas (plate 4, figures 9 and 10). When calices are not circular, their longer diameter is across the direction of the septo-costae. The walls tend to become continuous along the proximal side of each concentric row, so as to form inconspicuous oblique ridges or incipient collines; hence, there is an appearance of intervening shallow valleys, the columellar centres being distinct and arranged along the middle of each valley (plate 4, figure 11).

Among the recorded species (about fourteen) of *Leptoseris* there are three main growth forms, viz. (1) corallum concavo-convex, tending to be bowl- or vase-shaped, with entire margin, or slightly interrupted, and a scar or short stalk of attachment at the centre of the lower non-calicinal surface as in *L. fragilis* M. Ed. & H. (plate 4, figure 6, also Gardiner 1905, plate 92, figure 24; Matthai 1924, plate 10, figure 1), *L. hawaiiensis* Vaughan (1907, plates 39 and 40; Horst 1922, plate 32, figure 1) and *L. scabra* Vaughan (1907, plate 41, figures 1 and 2), and perhaps the three species described by Quelch under his new genus *Domoseris*, viz. *D. porosa*, *D. solida* and *D. regularis* (Quelch 1886, plate 5, figures 4, 4*a*, 5, 5*a*, 6) as well as *Leptoseris edwardsi* M. Ed. & H.; (2) corallum branched, leaf-like, as in *L. papyracea* (Dana) (Gardiner 1905, plate 92, figure 23; Horst 1921, plate 5, figure 7), or digitiform with secondary branching, as in *L. digitata* Vaughan (1907, plate 42, figures 1 and 2; Matthai 1924, plate 11, figures 5 and 7); *L. tubulifera* Vaughan also seems to belong to this type, as the tubular growths are perhaps due to the fusion of folded lobes (Vaughan 1901, plate 42, figure 3; plate 43, figure 1); (3) corallum incrusting by means of the entire non-calicinal surface as in *L. incrustans** (Gardiner 1905, plate 92, figure 25) and *L. tenuis* Horst (1921, plate 5, figures 9 and 10), the latter being not essentially different from the former species.

Coscinaraea† is obviously descended from a *Leptoseris*-like ancestor. The appearance and arrangement of septo-costae and of the columellar centres are similar in both genera. In an early stage of a colony of *Coscinaraea* the corallum is more or less circular (plate 8, figures 30 and 31), comparatively thin, tending to be convexo-concave—a tendency so pronounced in *Halomitra*—the upper convex surface being calicinal and the lower concave surface non-calicinal. The primary calicinal centre becomes excentric in position but to a less degree than in *Leptoseris*, around which subsidiary calicinal areas are arranged in more or less concentric rows (plate 8, figures 32, 33, 34, 35 and 36). Concentric oblique ridges are formed, as in *Pavona* and *Agaricia*, along the proximal sides of the bases of calicinal areas, with somewhat oblique shallow valleys between the ridges. Radial ridges, mostly discontinuous, also appear, cutting across the concentric ridges. Thus, the original continuous valleys running cyclically are divided into discontinuous valleys of varying length; and in places distinct corallites are also formed by the intersection of the two systems of ridges. Such distinct corallites tend to be flat-sided, with four to six sides, but not sharply defined as in *Pavona ponderosa* (Gard.). In *Coscinaraea* concentric ridges tend to become wavy in places, as in certain colonies of *Pachyseris*. When radial ridges cut across such wavy parts of the concentric ridges, the walls of resultant short valleys are also somewhat wavy, being curved in the case of distinct corallites (plate 9, figures 37 and 38).

With growth, the primary calicinal area becomes almost indistinguishable, the corallum thickens, becomes heavy and dome-shaped. The condition of the calicinal surface also becomes mainly that of distinct corallites, or of corallites with two or three columellar centres. When short valleys are formed, the tendency is towards the further formation of transverse partitions which are at first lower than the collines. Since the wavy condition of the concentric ridges is more pronounced in older colonies, the walls of distinct corallites and collines of short valleys, in such colonies, appear curved. In colonies that have reached the stage of short valleys and distinct corallites, intracalicinal budding takes place, buds tending to arise on the sides of walls rather than at the calicinal base. In every case, columellar centres are well formed, of closely twisted septal trabeculae, and are distinct, or may become continuous. In large colonies, valleys and corallites are comparatively deep.

In *Coscinaraea* the septal sides are well provided with spines which, in the case of adjacent septa, tend to meet and form synapticulae. The narrower septa curve towards and often meet the sides of the neighbouring broader septa. There is, thus, already a tendency towards cutting off of spaces in the peripheral region of calicinal areas, which, as will be seen below, becomes a permanent and generic feature in *Psammocora*.

The following stages in the growth of *Coscinaraea* are represented by actual colonies in the collections studied: (1) *Leptoseris stage*: foliate, with calicinal areas arranged in con-

* The specimens figured by van der Horst (1922, plate 32, figures 3 and 4) under *Leptoseris incrustans* (Quelch) = *Cylloseris incrustans* Quelch may probably be young forms of *Coscinaraea monile* (Forsk.).

† The typical condition of the corallum in *Coscinaraea* is represented by *C. monile* (Forsk.). The remaining recorded species of the genus, viz. *C. columna* (Dana), *C. meandrina* M. Ed. & H., *C. savigniensis* (Gard.), *C. donnani* Gard. and *C. ostreaeformis* Horst are probably only skeletal variants of *C. monile* (Forsk.). *Siderastrea savignyana* M. Ed. & H. may be a second species of *Coscinaraea*.

centric rows around the primary calicinal area, concentric ridges tending to be formed along the proximal sides of bases of the subsidiary areas, seen in *Sealark* specimens (also Marenzeller 1907, plate 24, figure 83); (2) *Merulina stage*: foliate, with radial ridges (inconspicuous and somewhat irregular) across concentric ridges, consequently discontinuous valleys are formed that vary in length and tend to become sinuous, seen in *Sealark* specimens; (3) *Coeloria stage*: massive, highly convex calicinal surface, with comparatively wide deep valleys, of varying length, usually comparatively short and sinuous, seen in Maldive and Red Sea specimens; (4) *Favia stage*: convex, but not heavy, rising at places into eminences, with distinct corallites and short valleys, both being comparatively narrow and shallow, seen in Maldive specimens.

It will, therefore, be seen that within the genus *Coscinaraea*, are represented all evolutionary stages (except the Hydnophoroid stage) noticed in *Pavona*. In *Coscinaraea*, however, the calicinal surface never rises to form vertical or horizontal foliae as in *Pavona cactus* (Forsk.).

Psammocora, which is derivable from a *Coscinaraea*-like ancestor, undergoes nearly all types of skeletal modification seen in *Pavona*, and may, therefore, be regarded as having followed an analogous line of evolution. The specimens collected by the 'John Murray' Expedition are somewhat disk-shaped and convexo-concave, with calicinal areas restricted to the upper slightly convex surface. Although the calicinal areas are shallow, the pentagonal or hexagonal outlines of their walls are already discernible. This might indicate an early appearance of evenly thin inconspicuous radial ridges across equally faint concentric ridges (plate 14, figure 50). In the *Merulina* facies the radial ridges are well formed, usually discontinuous, with subsidiary calicinal areas appearing on both sides of such ridges (plate 10, figure 43). When ridges grow up into vertical plates or foliae covered with subsidiary calicinal areas on both sides, the condition of *Psammocora contigua* (Esper.)* results (plate 10, figures 41, 42 and 43) which is comparable to *Pavona cactus* (Forsk.). As in the latter species, the vertical foliae become narrow towards the base (plate 14, figure 51) and undergo an equally wide range of variation in regard to breadth, thickness, number, branching and anastomosis. Horizontal foliae, which are sometimes formed in *P. cactus* (Forsk.), have not been seen in *Psammocora contigua* (Esper.). Radial ridges can be seen on both sides of vertical foliae, passing from the base fanwise towards the periphery. When vertical plates arise from a horizontal basal folia and are comparatively narrow and crowded, with well developed continuous radial ridges, as seen in certain Tahiti examples, the appearance simulates the facies of *Merulina ampliata* (Ell. & Sol.) (Vaughan 1907, plate 52, figures 1 and 1*b*; Marenzeller 1907, plate 5, figure 5).

Psammocora haimiana M. Ed. & H.,† in which the corallum becomes massive, with calicinal surface highly convex, often uneven, and discontinuous valleys of varying length and sinuosity, formed by the intersection of radial ridges at comparatively wide intervals,

* All other recorded species of *Psammocora*, with branching corallum, are probably skeletal forms of *P. contigua* (Esper.), viz. *P. plicata* (Lamk.), *P. obtusangula* (Lamk.), *P. columna* Dana, *P. planipora* M. Ed. & H., *P. digitata* M. Ed. & H., *P. gonagra* Klunz., *P. ramosa* Quelch, *P. parvistella* Verrill, *P. frondosa* Verrill, *P. divaricata* Gard., as well as *Stephanaria stellata* Verrill and *S. brighami* Vaughan.

† The remaining species of *Psammocora*, with incrusting or massive corallum, seem to be only skeletal variants of *P. haimiana* M. Ed. & H.; viz. *P. exesa* Dana, *P. fossata* Dana, *P. superficialis* Gard., *P. profundacella* Gard., *P. verrilli* Vaughan, *P. merstrazi* Horst., *P. explanulata* Horst and *P. samoensis* Hoffmeister.

simulates the appearance of *Pavona varians* (Verrill) and represents the *Coeloria* stage in skeletal evolution within the genus *Psammocora*. More than one row of calicinal areas, somewhat irregularly arranged, may occur within the same valley. Colonies of *P. haimiana* M. Ed. & H. also exhibit the Hydnophoroid facies, of all stages, by discontinuity in radial ridges resulting in monticules of varying length, viz. of *Hydnophora contignatio* (Forsk.), *H. exesa* (Pallas) and *H. microconos* (Lamk.). The condition of *H. rigida* (Dana), with anastomosing cylindrical branches and conical monticules arranged in rows, which is not found in *Pavona varians* (Verrill), is also represented within *Psammocora haimiana* M. Ed. & H. by certain Tahiti examples. The *Favia* stage, with distinct corallites, or corallites with not more than two or three columellar centres, is reached within *Psammocora haimiana* M. Ed. & H., when the radial ridges intersecting concentric ridges are fairly close to each other and more or less equidistant, the corallite-walls being flat-sided as in *Pavona ponderosa* (Gard.). Corallites, when present in *Psammocora haimiana* M. Ed. & H., are smaller than in *Coscinaraea monile* (Forsk.). At all stages of skeletal evolution *Psammocora*, like *Pavona*, retains the condition of distinct columellar centres.

Psammocora agrees with *Coscinaraea* in columellar centres being well developed, composed of closely twisted septal trabeculae and more or less circular in outline when viewed from above, septa having very rough sides and thickened towards the periphery, narrower septa meeting sides of neighbouring broader septa, thus cutting off interseptal spaces peripherally. This process of partitioning off peripheral interseptal spaces is enhanced by flattened synapticulae between septa, an initial stage of which, as has already been pointed out on p. 186, is seen in certain colonies of *Coscinaraea*. In *Psammocora* subsidiary couples of mesenteries lie in these disconnected spaces, a feature that has been ascertained by study of polyp sections and which plays an important rôle in budding that leads to colony formation and growth.

The Atlantic genus *Agaricia** (plate 7, figure 25) has followed a line of evolution parallel to that of the Indo-Pacific *Pavona*, in several respects, having evolved independently from the *Fungia* stem. In the simpler forms the corallum is explanate, concavo-convex, the upper concave surface being calicinal and the lower convex surface non-calicinal. Columellar centres are invariably distinct. Definite more or less concentric oblique ridges or collines have appeared connecting the proximal sides of bases of the calicinal areas (Verrill 1901, plate 26, figures 1*a* and 1*c*; plate 27, figure 2; plate 28, figure 1). These ridges are usually continuous, sometimes discontinuous, approximated towards each other, more or less equidistant, between which are comparatively narrow shallow valleys. The first calicinal area is excentric in position, owing to the greater growth of the corallum distally. A pair of septo-costae, one distal and the other proximal, converge on each side towards each columellar centre. New calicinal areas sometimes appear in valleys beside the median calicinal row, as well as on the sides of the concentric ridges. In some forms radial ridges, continuous or more usually discontinuous, also appear intersecting the concentric ridges (plate 7, figure 27)—a process which results in the formation of discontinuous short valleys and distinct corallites whose walls are flat sided (Verrill 1901, plate 27, figures 1, 1*a*, 2, 2*a*, 5,

* The typical condition of *Agaricia* seems to be represented by *A. agaricites* (Linn.), of which *A. fragilis* Dana, *A. crassa* Verrill, *A. purpurea* (Les.), *A. nobilis* Verrill, *A. elephantotus* (Pallas), *A. cailleti* (Duch. and Mich.), *A. frondosa* (Duch.) and *A. regularis* Quelch seem to be only variants.

6, 6*a*, 7, 7*a*; plate 30, figure 6; plate 34, figure 2; plate 27, figure 4*a*). In some colonies of *A. agaricites* secondary foliae arise from the primary folia, usually horizontal, concavo-convex, with calicinal areas restricted to the concave upper surface. In all these respects, evolution has followed the same line in *Agaricia* as in *Pavona* and as in *Pachyseris*. Secondary vertical foliae which form a distinctive feature of *Pavona cactus* (Forsk.) seem to be rare or absent in *Agaricia*, nor do colonies of the latter ever attain to such great size as in *Pavona*. Ridges occasionally may become discontinuous, but the Hydnophoroid condition so characteristic of some coralla of *Pavona varians* Verrill is hardly ever seen in *Agaricia*. The corallum also never becomes massive, nor do valleys assume a sinuous appearance as in some colonies of *Pavona varians* Verrill.

It would appear, therefore, that within the Atlantic genus *Agaricia* evolution has been much less prolific than in the Indo-Pacific *Pavona*—neither the characteristic growth form of *P. cactus* (Forsk.), with numerous vertical foliae, branching and anastomosing, the condition of *P. varians* Verrill, with massive coralla and sinuous valleys and Hydnophoroid facies, nor that of *P. maldivensis* (Gard.) with massive corallum and distinct oval or circular corallites having appeared. The maximum growth-size of colonies is also much less than in *Pavona*.

The condition of *P. ponderosa* (Gard.) is represented in the Atlantic region by *Siderastrea radians* (Pallas)* in which the corallum is massive and comparatively heavy, and attachment, when effected, is by the entire lower non-calicinal surface, the calicinal surface is more or less evenly convex, with flat-sided single corallites, usually pentagonal, sometimes six- or four-sided, forming the permanent feature (Vaughan 1901, plate XIV, figures 1, 2; plate XV; plate XVI, figures 1, 2). The maximum growth size of the corallum in *Siderastrea radians* (Pallas) is, however, much less than in the Indo-Pacific *Pavona ponderosa* (Gard.), being in this respect comparable to *Agaricia agaricites* (Linn.). Whilst in *Pavona ponderosa* (Gard.) very short valleys are occasionally present, such are never seen in *Siderastrea radians* (Pallas). The single corallite condition seems to be the final stage in the intersection of two systems of ridges—concentric and radial. The stage of *Agaricia purpurea* (Les.), with thickened corallum and flat-sided distinct corallites, seems to be intermediate between the two extreme conditions represented by *A. agaricites* (Linn.), with thin coralla and continuous valleys, and *Siderastrea radians* (Pallas) with massive coralla and distinct corallites.

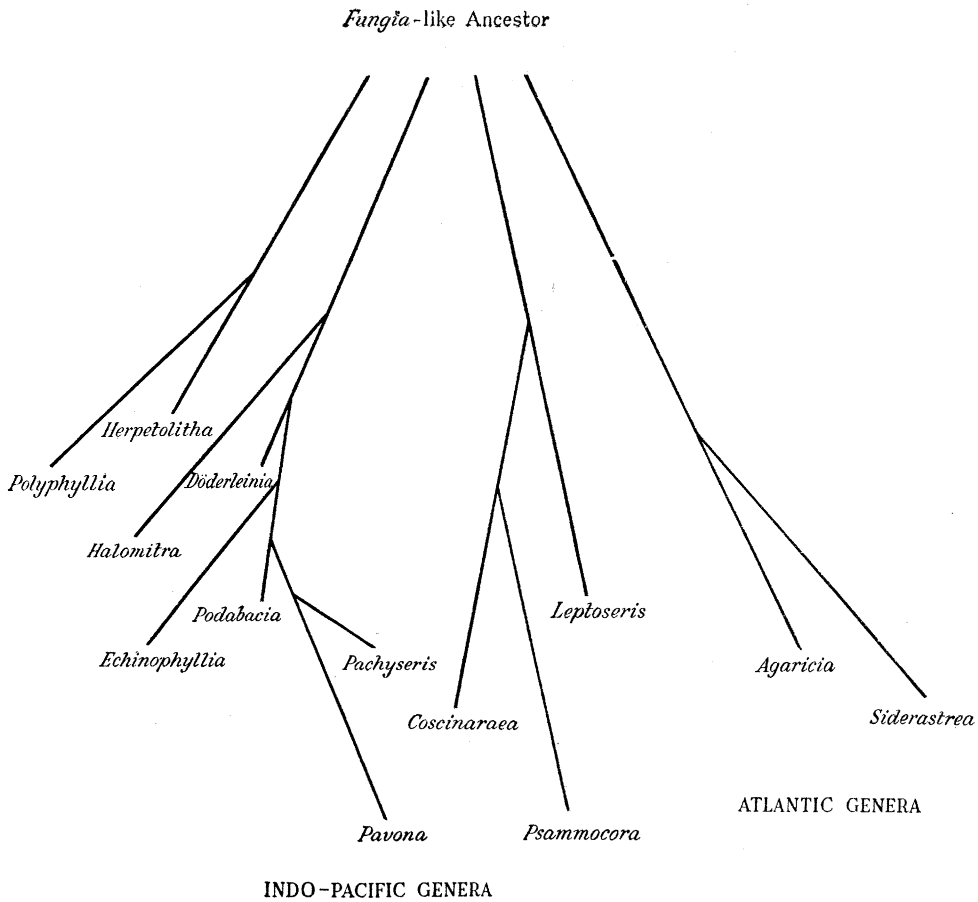
From the foregoing account it will be seen that growth is cyclic in colonial Fungid genera. Consequently the corallum tends towards the explanate type, becoming either concavo-convex or convexo-concave, with the primary calicinal area shifted to an excentric position, and thinning outwards and becoming somewhat fragile at the periphery. In *Leptoseris*, *Pavona*, *Agaricia* and *Echinophyllia*, the concentric rows of subsidiary calicinal centres tend to become incomplete on the side (proximal) towards which the primary calicinal area becomes somewhat shifted.

Further, in these genera, the condition of distinct corallites bounded by corallite walls becomes the final stage in skeletal evolution, whilst in Astraeids the distinct corallite condition is the initial stage in skeletal evolution, which by continued intracalicinal budding leads on to the meandroid condition and sinuous valleys (Matthai, 1940). Whilst colonial

* The remaining three recorded species of *Siderastrea*, viz. *S. siderea* (Ell. & Sol), *S. stellata* Verrill and *S. galaxea* (Ell. & Sol.) seem to be only skeletal variants of *S. radians* (Pallas).

Astraeids possessing distinct corallites, such as *Favia* and *Goniastrea*, represent ancestral stages in the evolution of Meandroid Astraeids, colonial Fungids with distinct corallites such as *Pavona ponderosa* (Gard.), *P. maldivensis* (Gard.) and *Siderastrea radians* (Pallas) represent final stages in skeletal evolution within their respective genera.

The above considerations suggest the appended evolutionary tree.



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Explanation of plates 3 to 14*

Plate 3

Figure 1. *Halomitra philippinensis* Studer. View of convex calicinal surface with primary calicinal area in the centre and somewhat smaller subsidiary calicinal areas arranged in concentric circles. Non-calicinal surface concave, with central scar of attachment opposite primary calicinal area from which closely arranged echinulate striations radiate outwards. Height 5·5 cm., diameters 16 × 16 cm. From Long Island, Reef, Seychelles. Nat. size.

Figure 2. *Podabacia crustacea* (Pallas). View of somewhat concave calicinal surface with primary calicinal area almost central and smaller subsidiary calicinal areas arranged in concentric circles. Non-calicinal surface somewhat convex with a short central stalk of attachment opposite primary calicinal area and concentric markings. Length 10·5 cm., breadth 7 cm., thickness 0·7 cm. From Minikoi. Nat. size.

Figure 3. *Podabacia crustacea*. View of deeply concave calicinal surface, showing somewhat excentric primary calicinal area and concentric circles of smaller subsidiary calicinal areas. Non-calicinal surface highly convex, with an excentric scar of attachment opposite primary calicinal area and concentric markings. Depth from rim to primary calicinal area 18 cm., diameters 30 × 26 cm. From Tekepotu Atoll, Tuamotus, Tahiti. Nat. size.

* The photographs in these plates were prepared by Mr W. Tams.

PLATE 4

FIGURE 4. *Podabacia crustacea* (Pallas). View of somewhat convex calicinal surface, showing primary calicinal area shifted to one side beyond which are smaller subsidiary calicinal areas arranged in more or less concentric rows. Non-calicinal surface somewhat concave, with a short stalk of attachment opposite primary calicinal area. Length 6·8 cm., breadth 4·5 cm. From Maldives. Nat. size.

FIGURE 5. *Leptoseris fragilis* Milne Edwards and Haime. View of concave calicinal surface of a young corallum, showing slightly excentric primary calcinal area and a few smaller subsidiary calicinal areas somewhat scattered. Depth from rim to primary calicinal area 1·5 cm., diameters 6 cm. × 5·5 cm. From North Male, Maldives, 20 fathoms. Nat. size.

FIGURE 6. *Leptoseris fragilis* Milne Edwards and Haime. View of convex non-calicinal surface of above, showing short stalk of attachment, 1·5 cm. in height, opposite primary calicinal area. Nat size.

FIGURE 7. *Leptoseris incrustans* Gardiner. Enlarged view of calicinal surface of a young incrusting corallum, smaller than above, showing excentric primary calicinal area and a few incipient subsidiary calicinal areas without definite arrangement. Diameters 2·7 × 2·3 cm. From South Nilandu, Maldives, 19 × $3\frac{1}{2}$ fathoms.

FIGURE 8. *Leptoseris fragilis* Milne Edwards and Haime. Enlarged view of the concave calicinal surface of a young incrusting corallum, showing excentric primary calicinal area and a few scattered subsidiary calicinal areas. Depth from rim to primary calicinal area 1 cm. Diameters 2·5 × 2 cm. From Suvadiva, Maldives, 38 fathoms. × $3\frac{1}{3}$.

FIGURE 9. *Leptoseris hawaiiensis* Vaughan. Enlarged view of part of concave calicinal surface, showing oblique low corallites and septo-costae. Non-calicinal surface convex, with excentric short stalk of attachment. Depth from rim to bottom 8 cm., diameters 22 × 22 cm. From outside Galawa Reef, Red Sea, 25 fathoms. × 2.

FIGURE 10. *Leptoseris hawaiiensis* Vaughan. Reduced view of part of calicinal surface of above, showing low oblique corallites and faint concentric ridges. × $\frac{1}{2}$.

FIGURE 11. *Leptoseris scabra* Vaughan. View of calicinal surface of a piece of corallum broken towards the edge, showing concentric rows of oblique corallites and discontinuous concentric ridges. Diameters 10 × 10 cm. From Abu Shaar, Ghardaqa, Red Sea, 20 fathoms. Nat. size.

PLATE 5

FIGURE 12. *Pavona varians* (Verrill). View of calicinal surface of corallum, rising in groups of low narrow vertical foliae, between which calicinal surface is even, simulating growth facies of *P. cactus* (Forskål). Height 10 cm., length 11·5 cm., breadth 10 cm. From Tahiti. Nat. size.

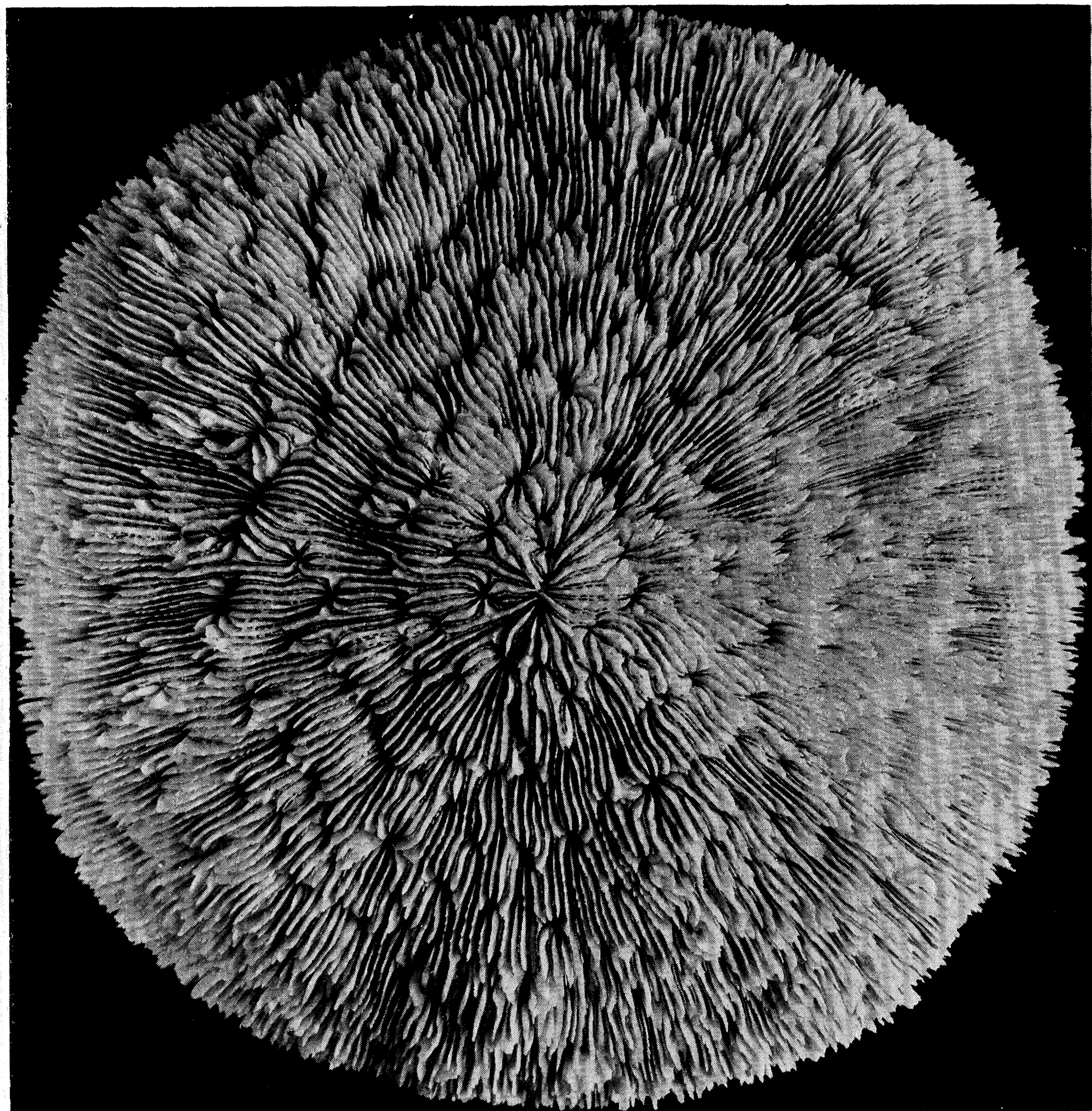
FIGURE 13. *Pavona varians* (Verrill). View of part of calicinal surface of corallum, showing discontinuous crests. Height 17 cm., length 13·5 cm., breadth 10 cm. Probably from Tahiti. Nat. size.

FIGURE 14. *Pavona varians* (Verrill). View of part of calicinal surface of corallum showing sinuous valleys on humpy regions and *Hydnophora contignatio* and *H. exesa* facies in intervening regions, with discontinuous collines. Height 10 cm., length 17 cm., breadth 12·5 cm. Probably from Tahiti. Nat. size.

FIGURE 15. *Pavona varians* (Verrill). View of part of uneven calicinal surface of corallum showing *Hydnophora exesa* and *H. microconos* facies, with discontinuous collines, on one side with incipient foliae (one of which 2 cm. high and 2 cm. broad) and concentric arrangement of calices showing commencement of *Pavona cactus* facies. Length 14 cm., breadth 12·5 cm. From Tahiti. Nat. size.

FIGURE 16. *Pavona varians* (Verrill). View of part of uneven calicinal surface, showing *Hydnophora exesa* facies. Height 11 cm., length 15 cm., breadth 11 cm. From Pa'ea, Tahiti. Nat. size.

FIGURE 17. *Pavona varians* (Verrill). View of part of calicinal surface of above, showing *Hydnophora microconos* facies. Nat. size.



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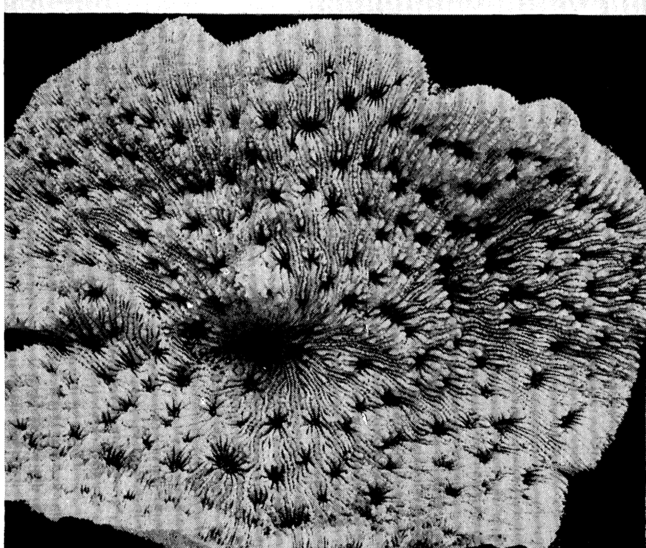

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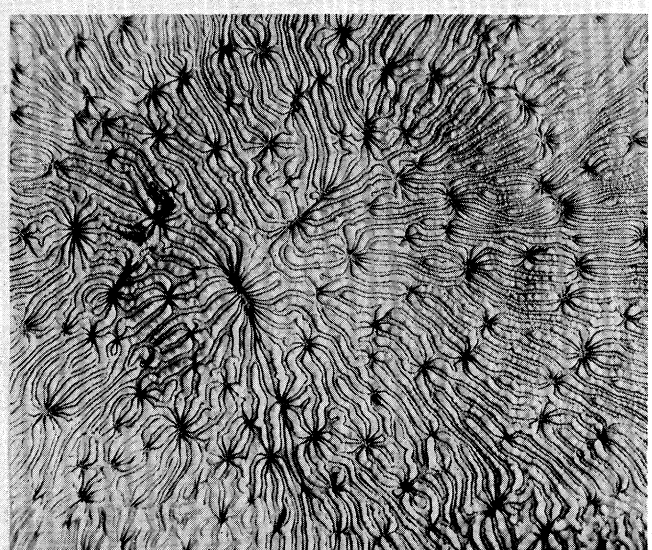

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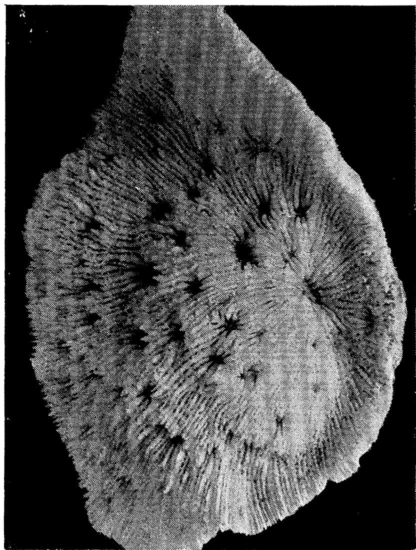
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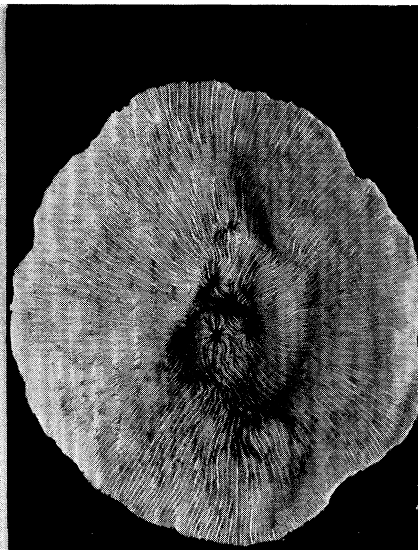
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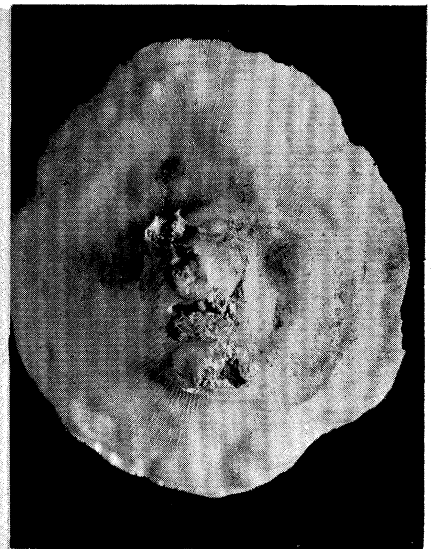
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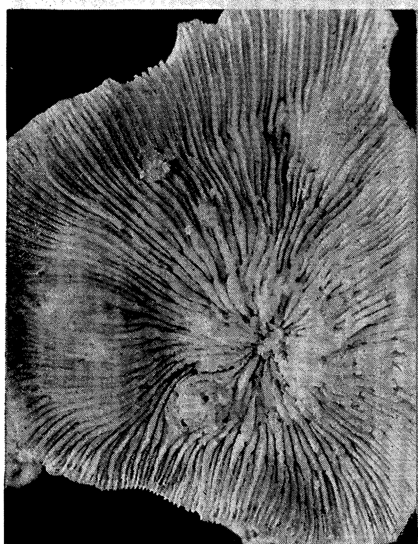
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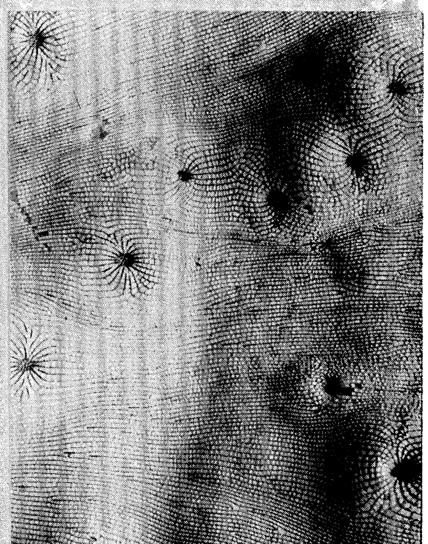
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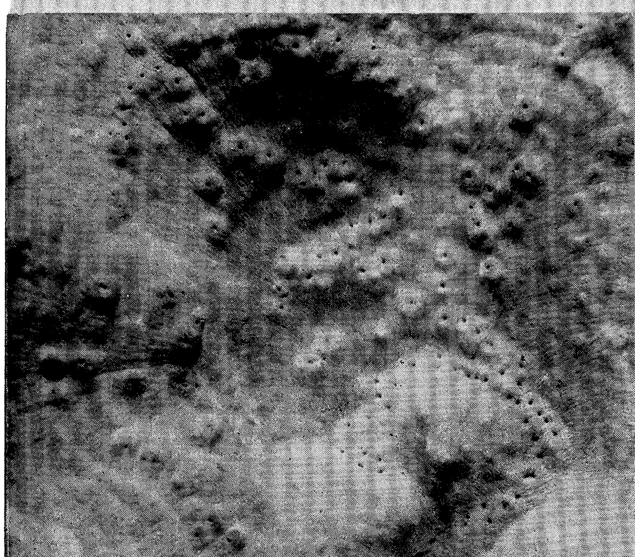
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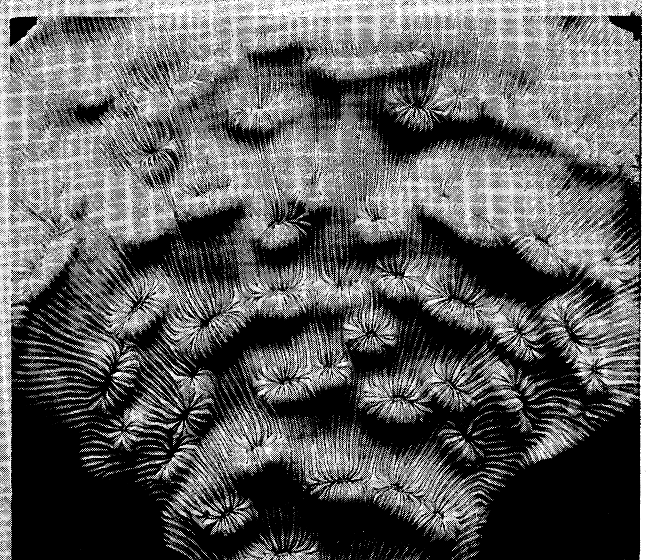
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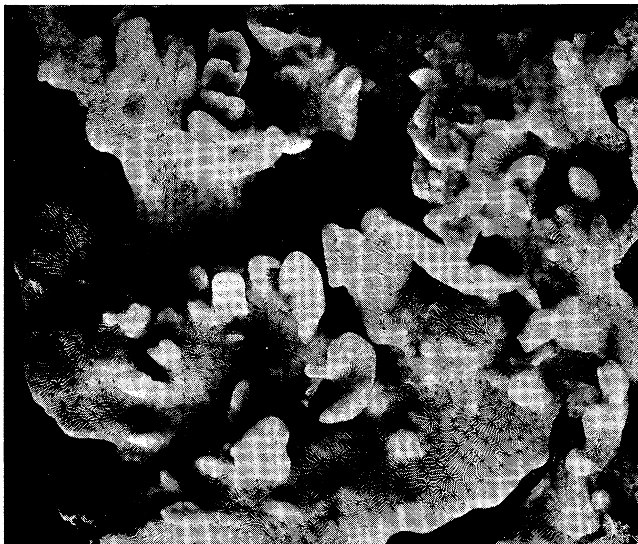

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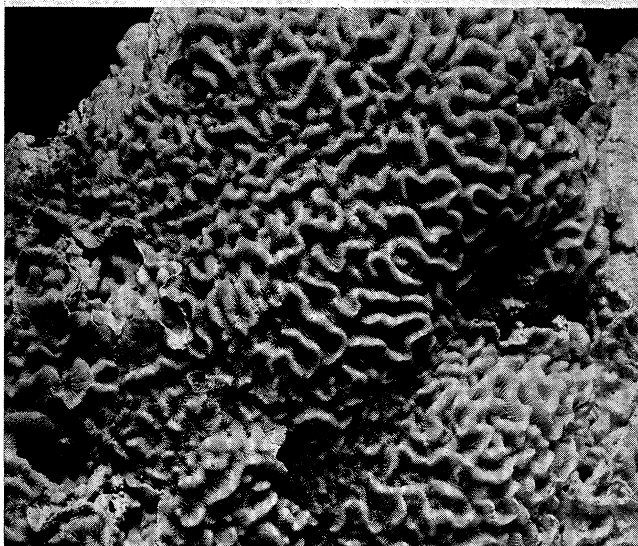

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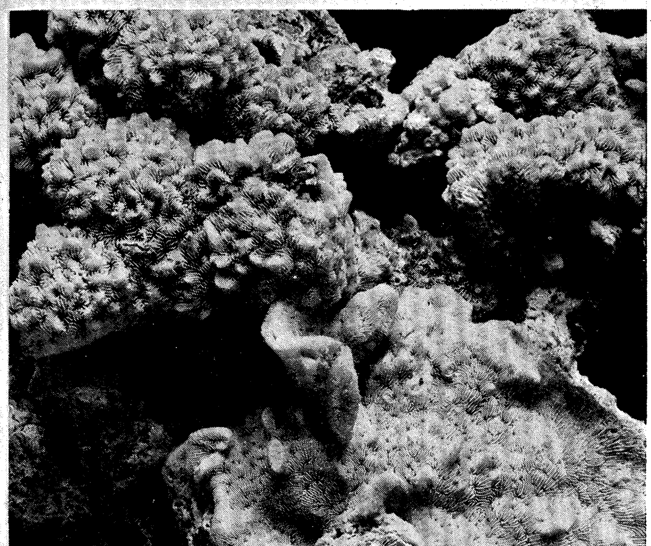

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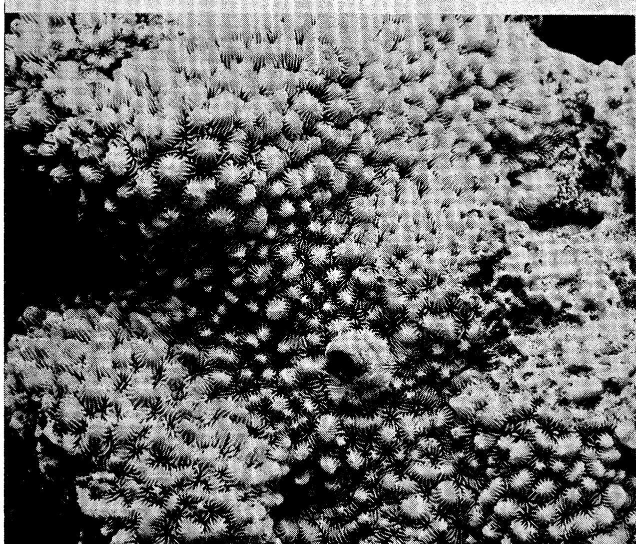

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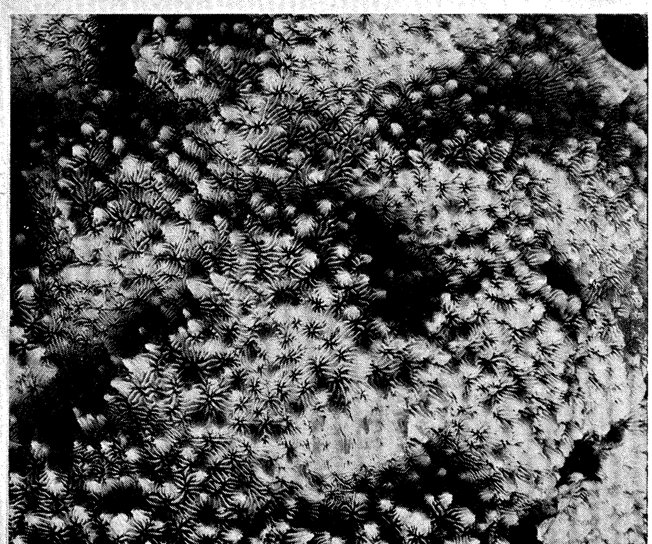

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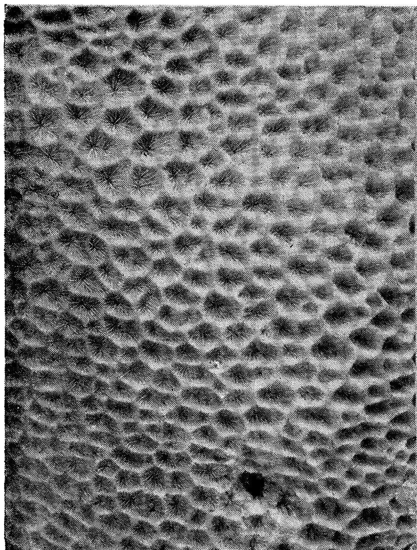

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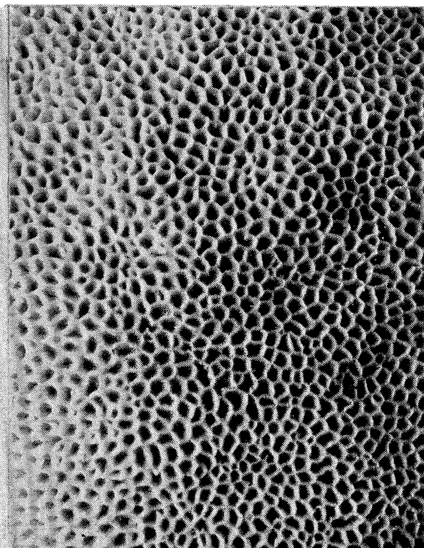

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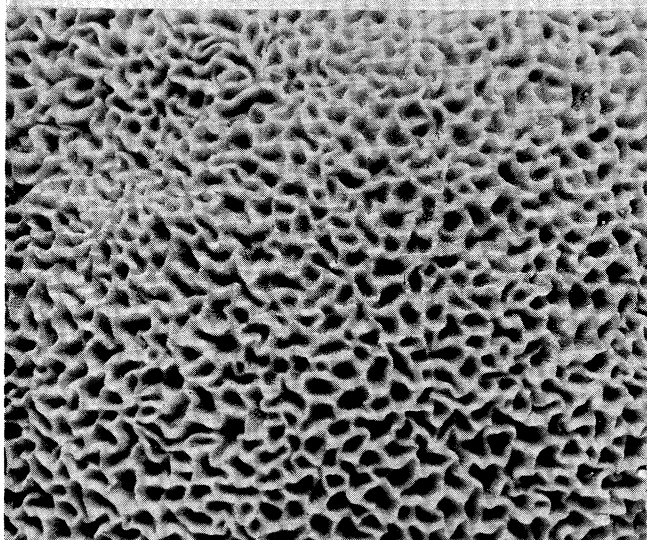

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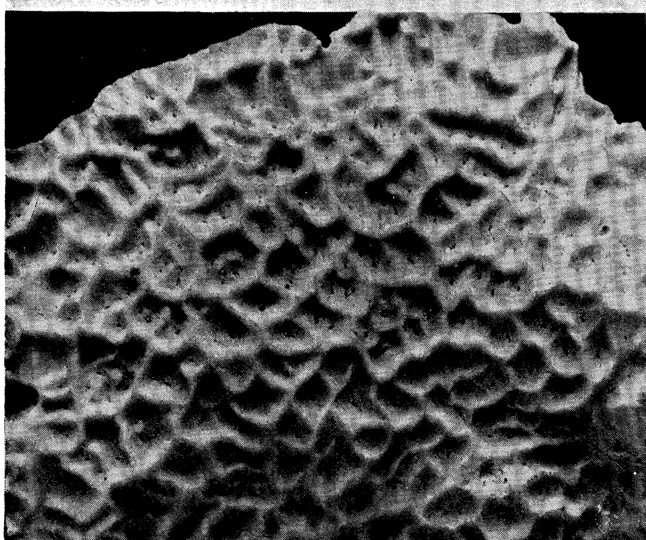

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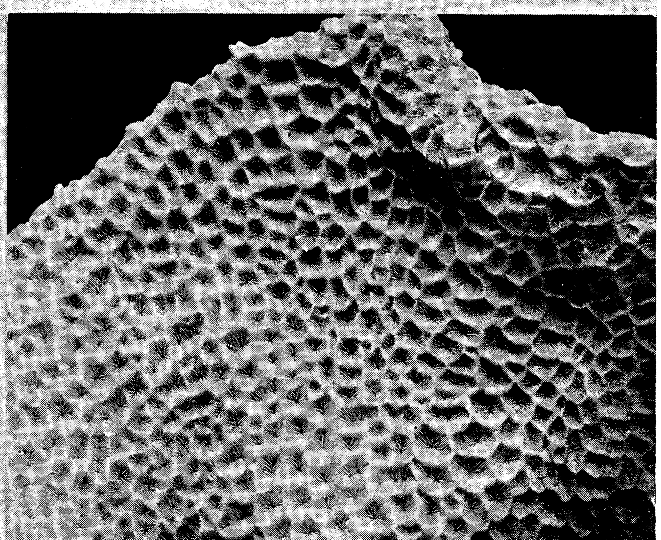

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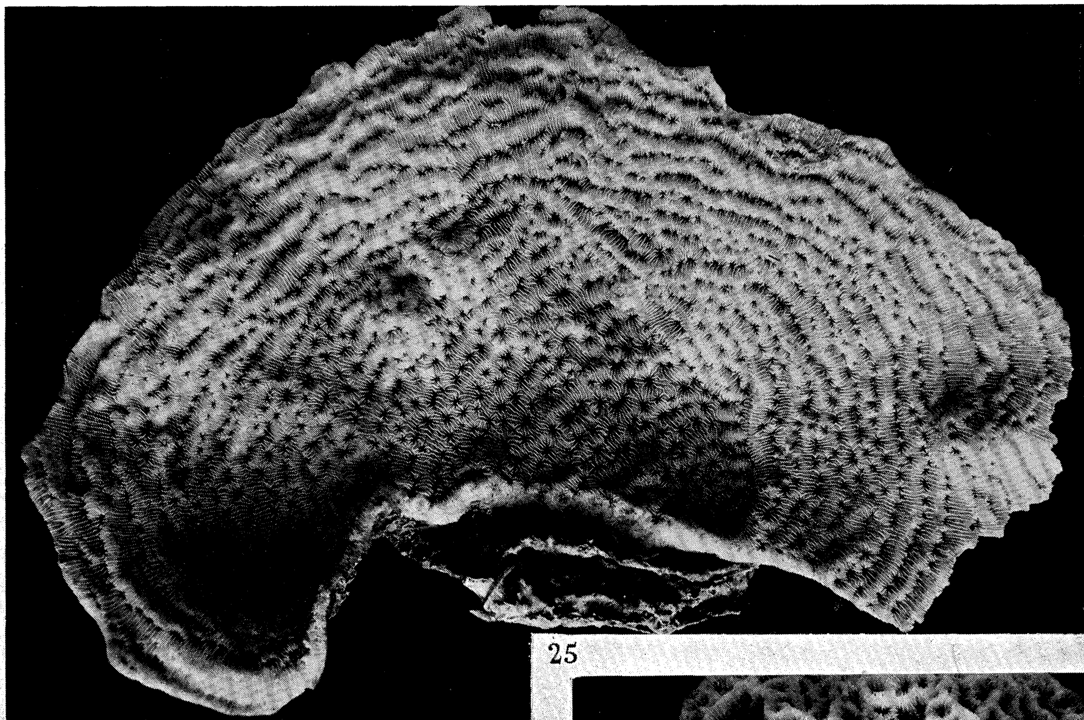

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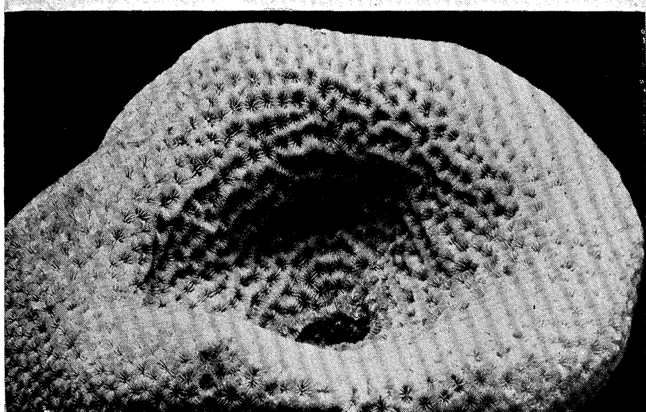

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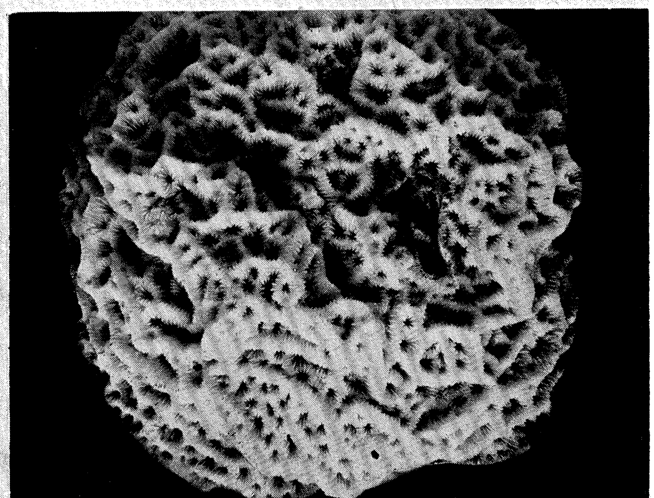

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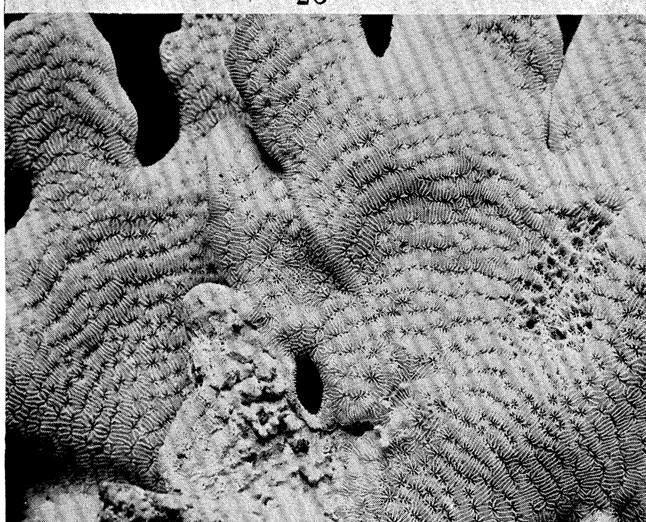

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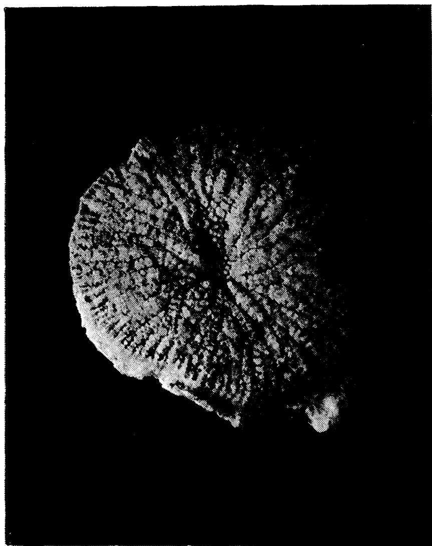
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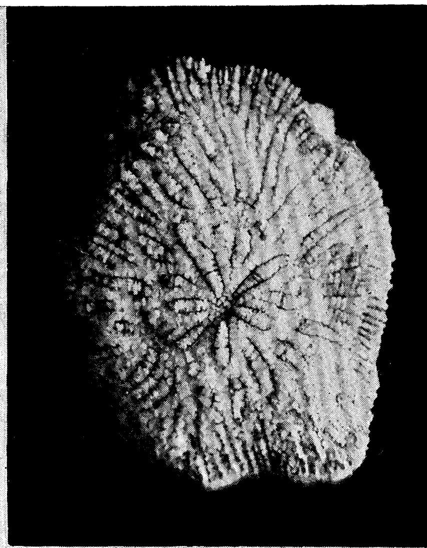
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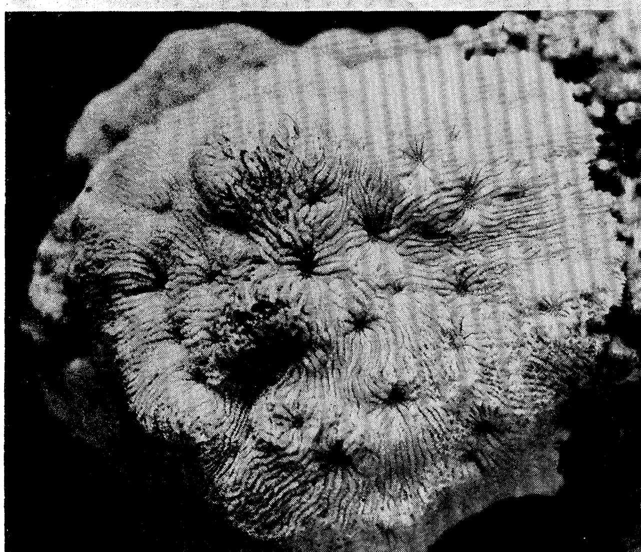
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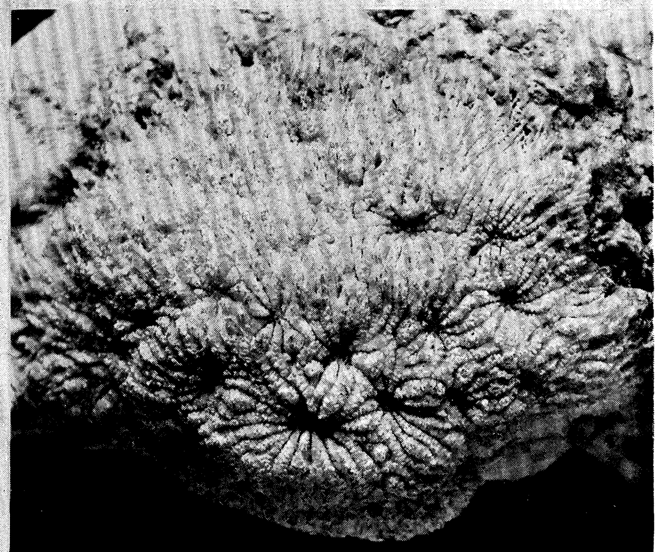
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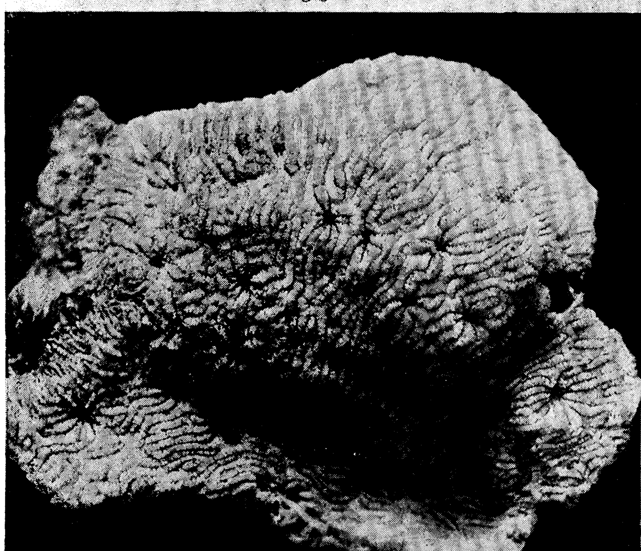
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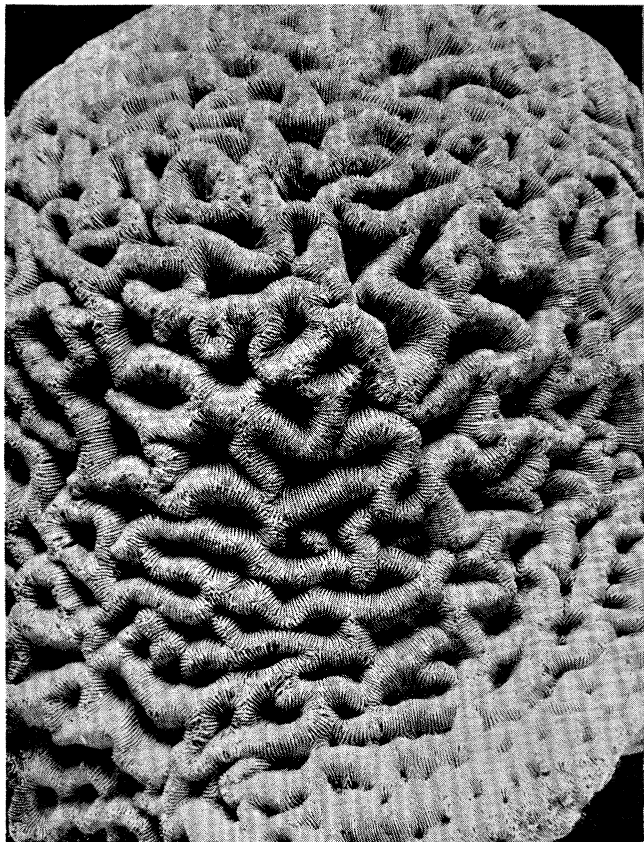

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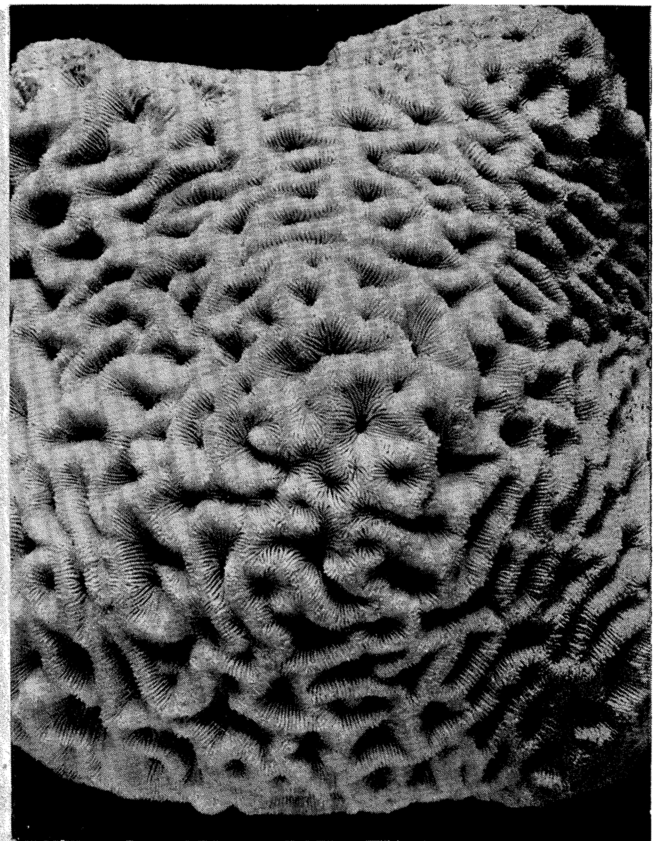

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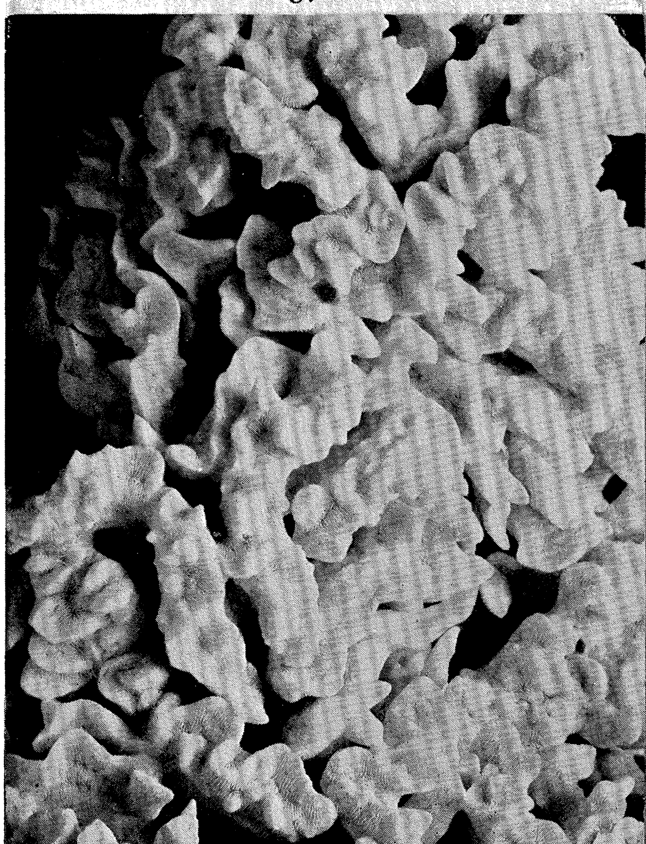

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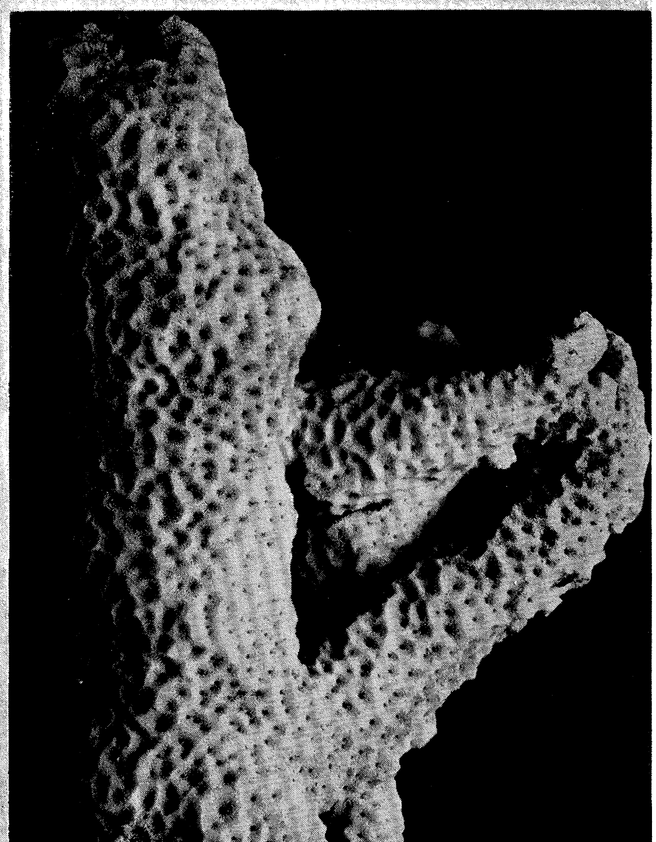

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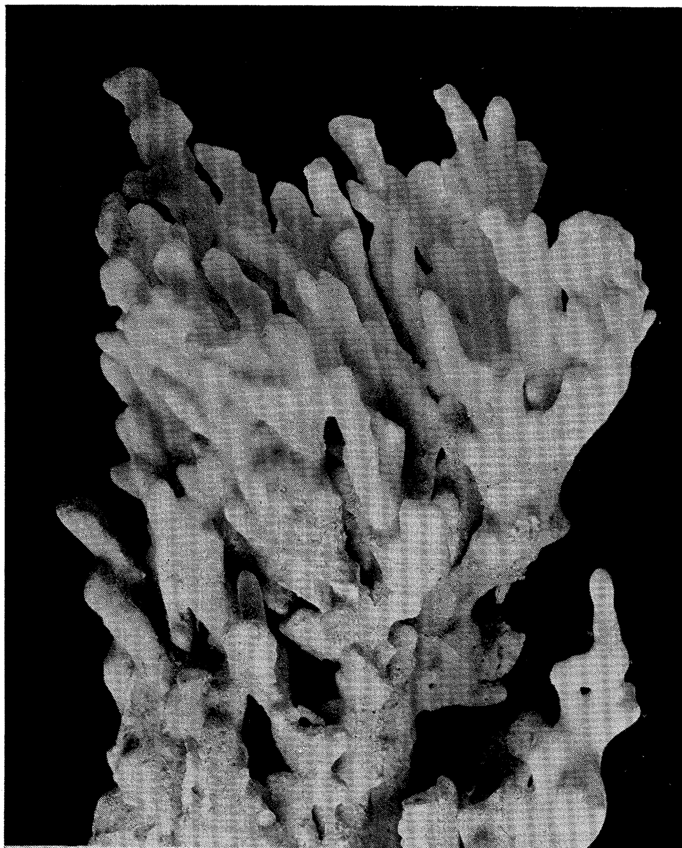

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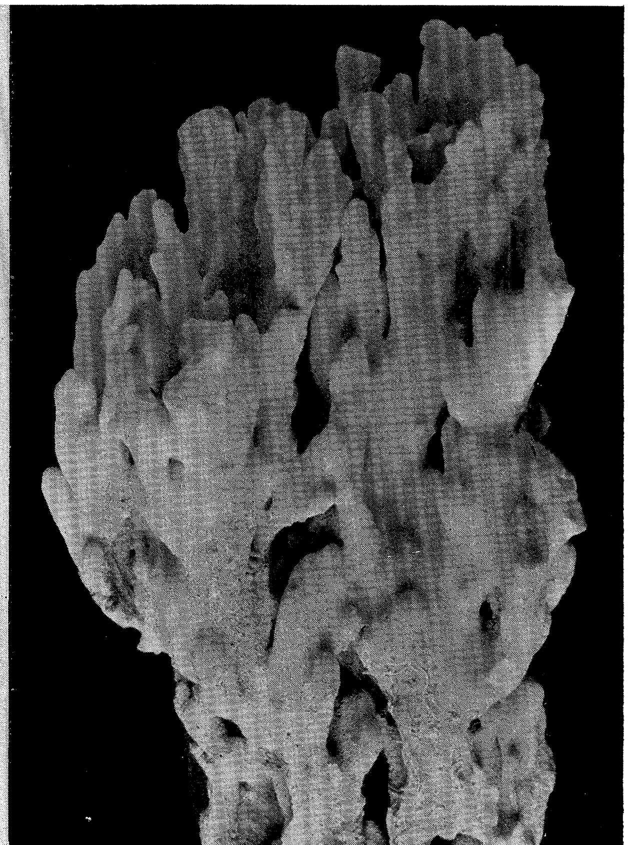

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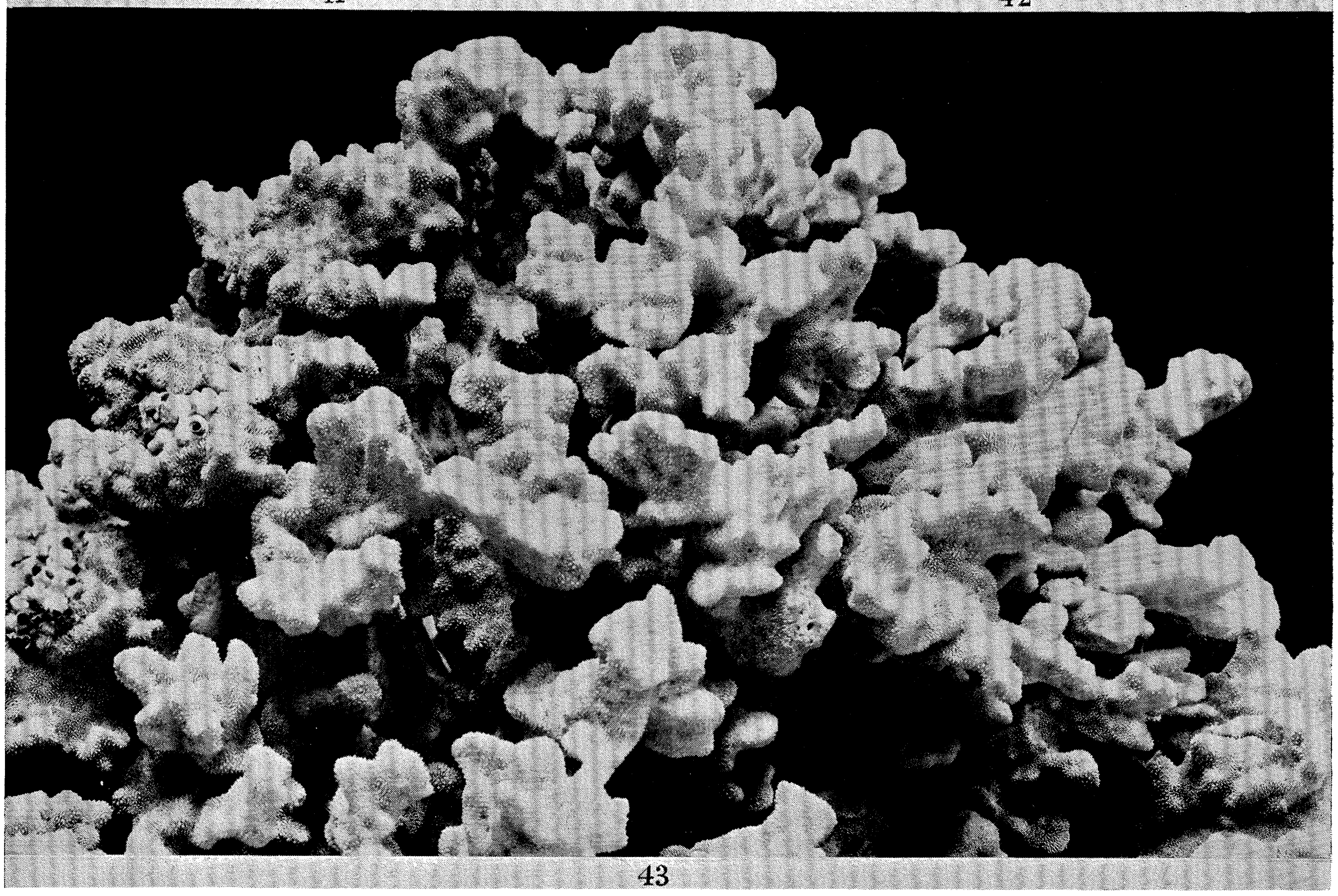

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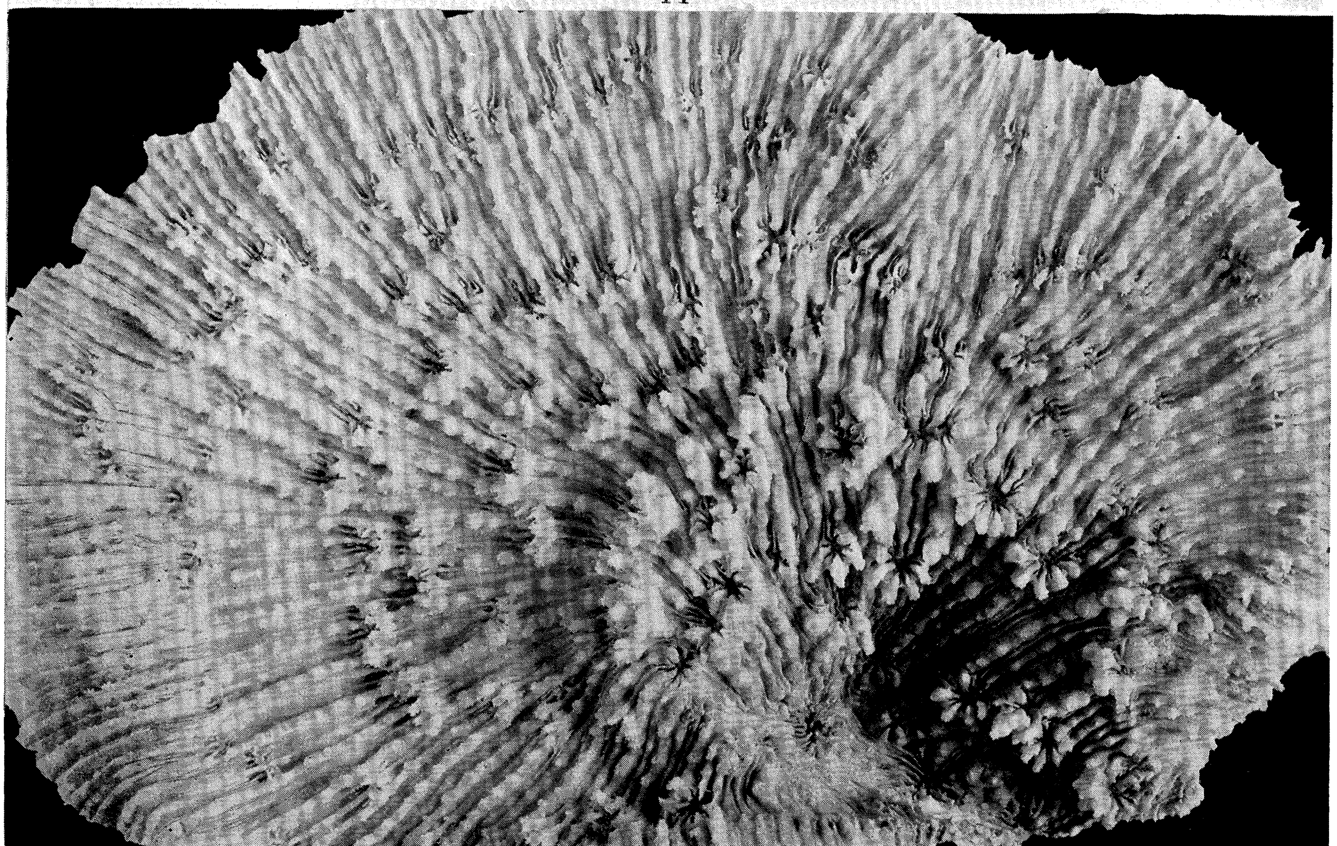

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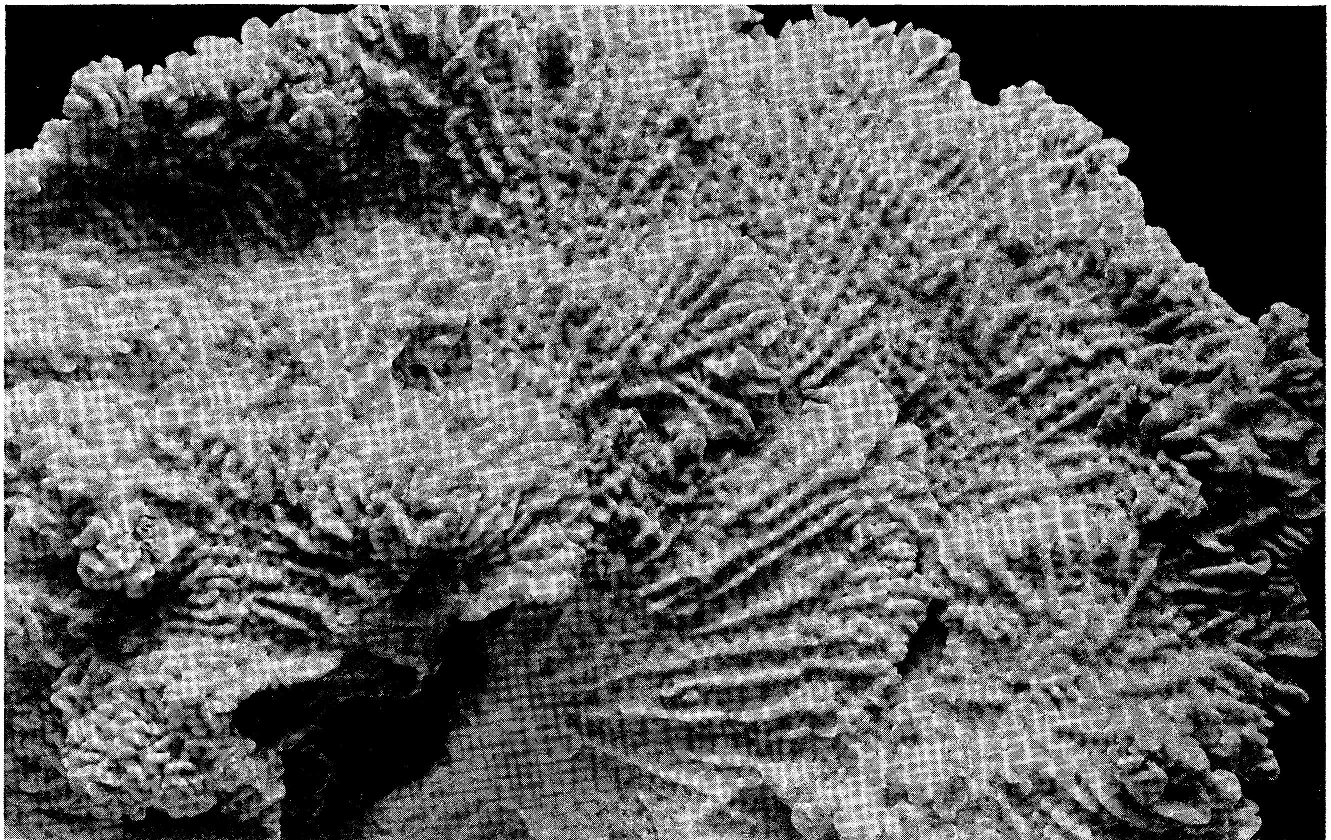

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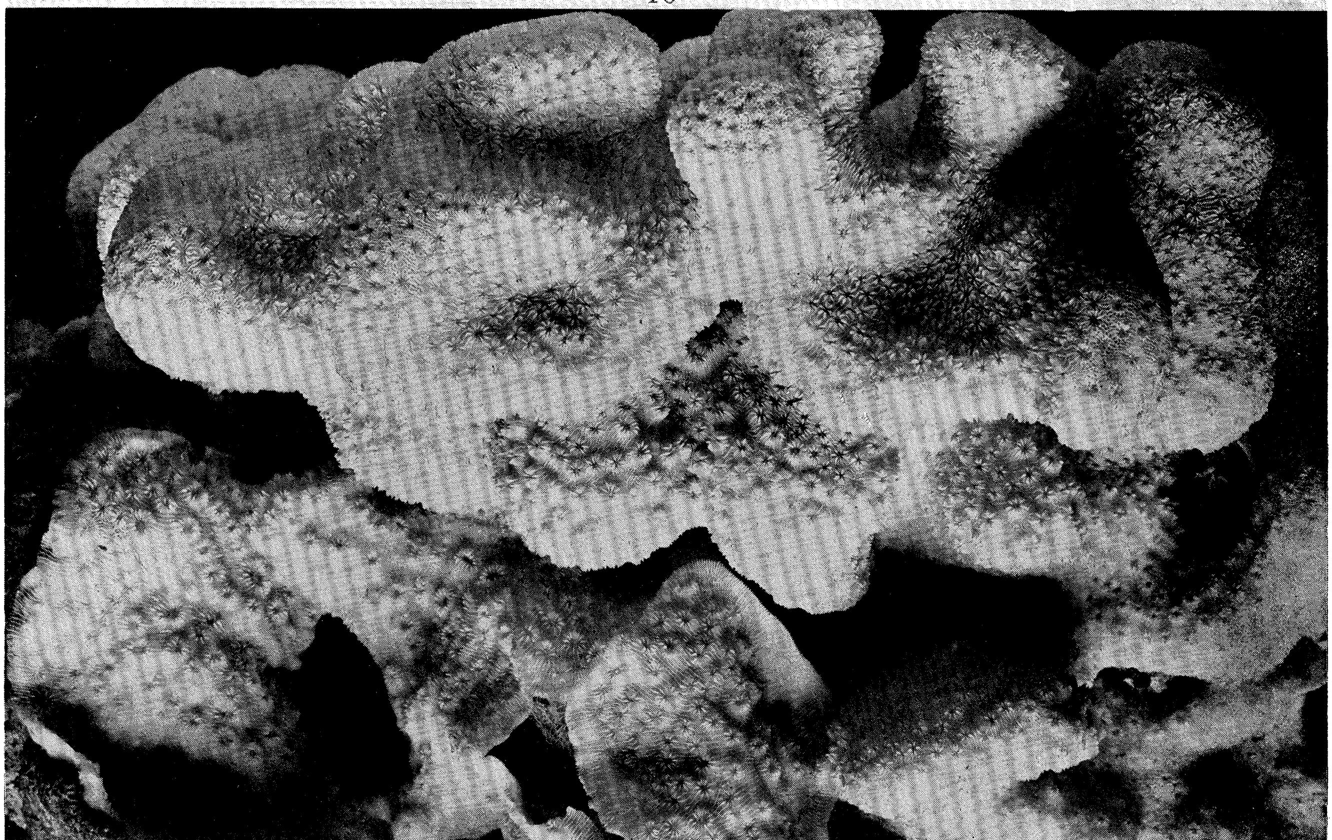

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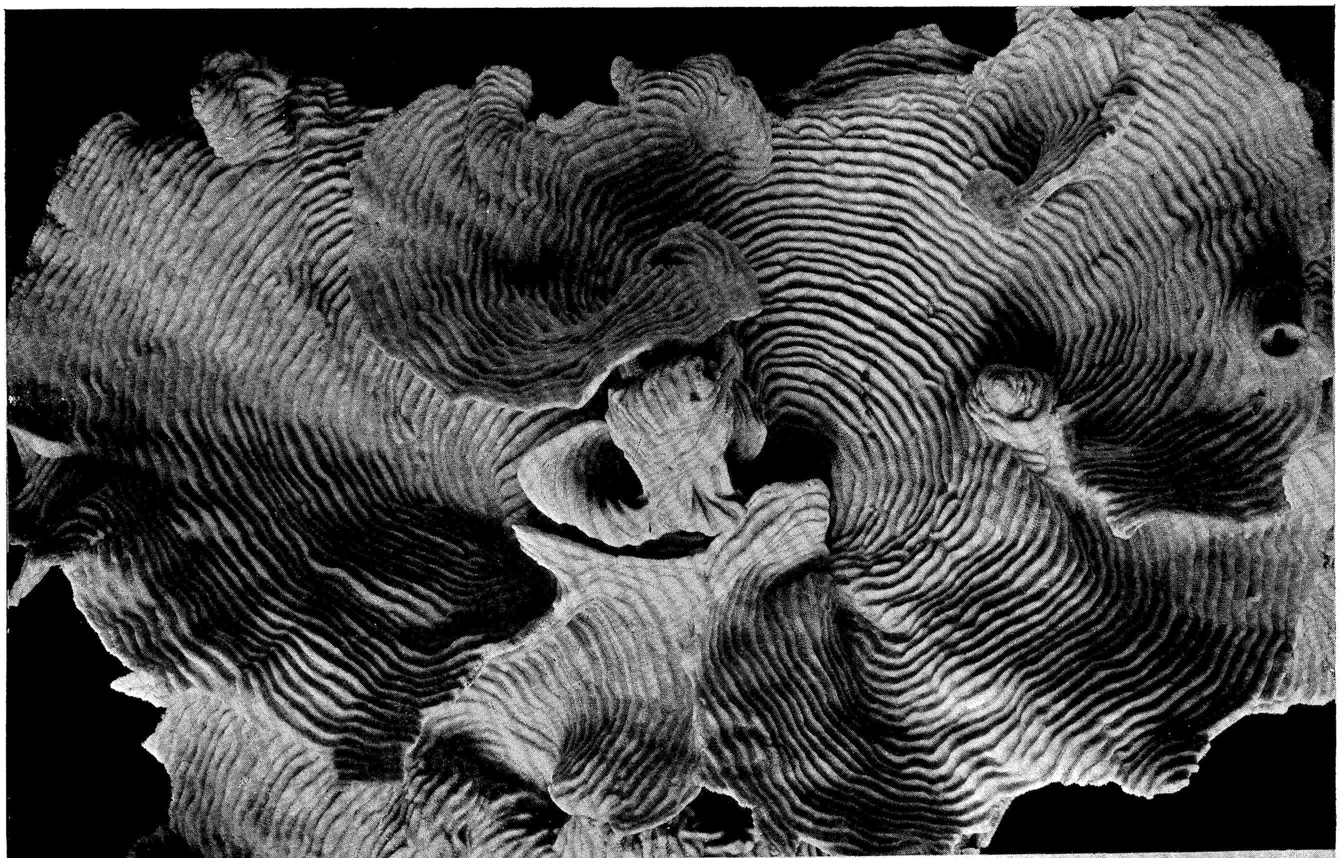

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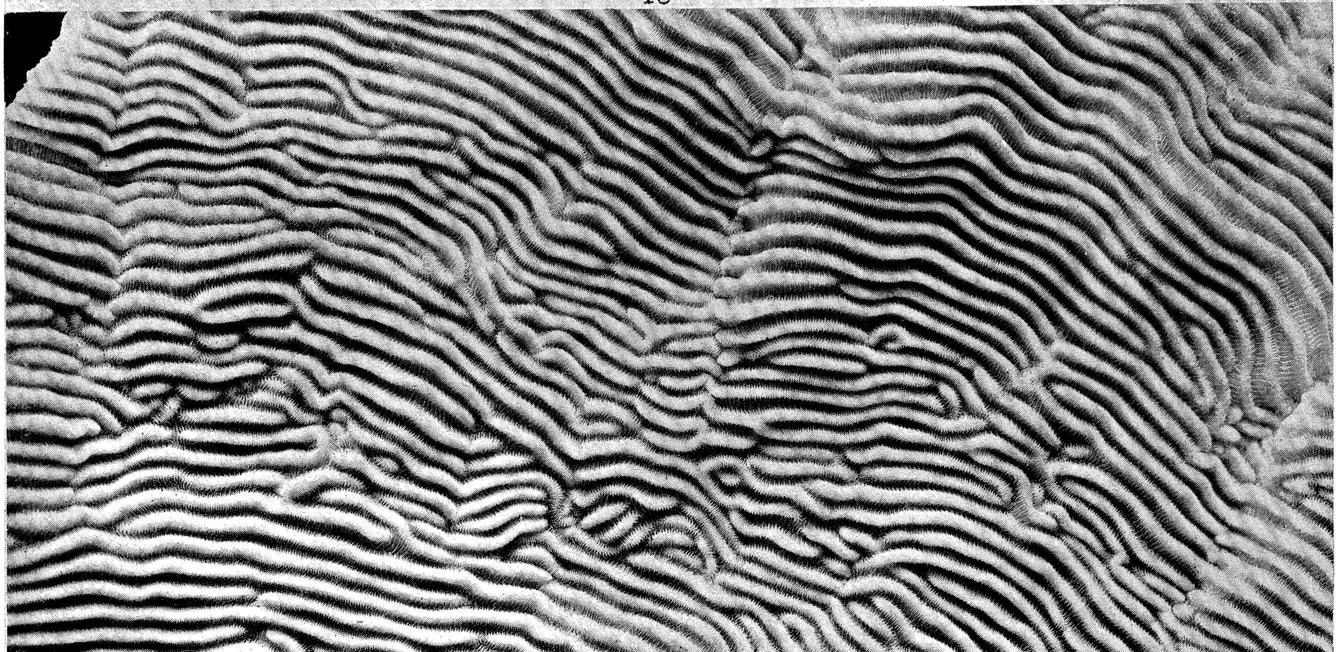

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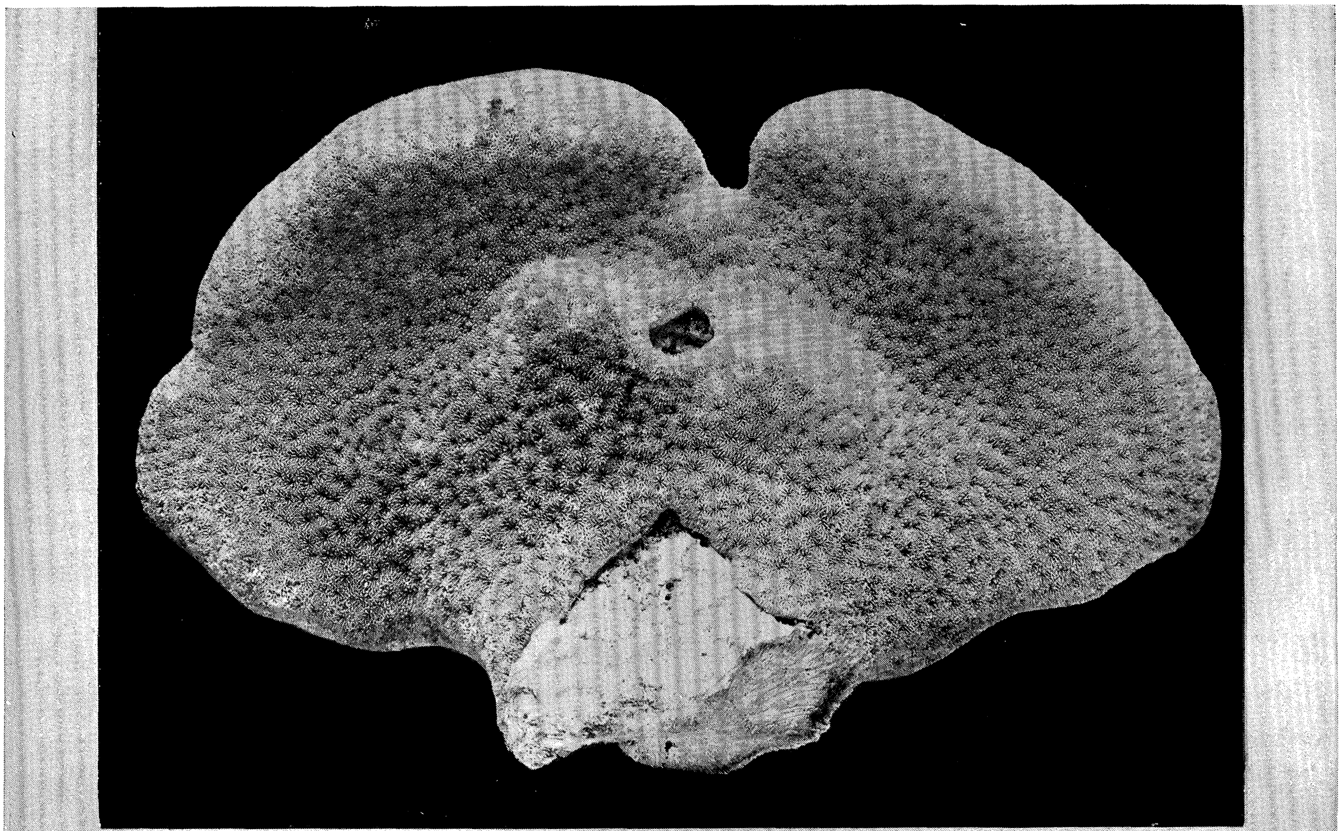

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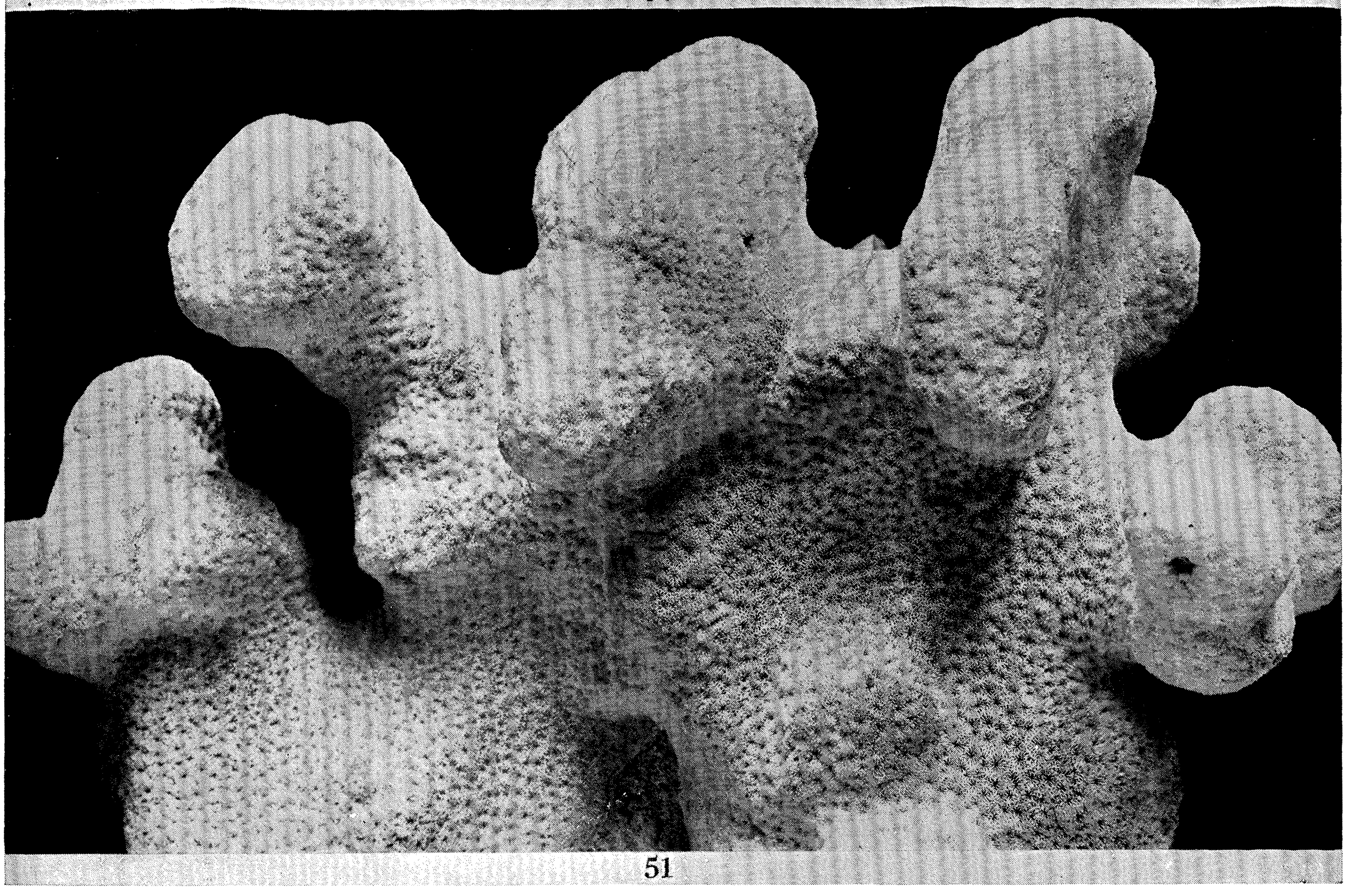

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Plate 6

Figure 18. *Pavona ponderosa* (Gardiner). View of a side of highly convex calicinal surface of an entire heavy corallum showing comparatively large calicinal areas. Height 12 cm., length 15 cm., breadth 12 cm. From Tahiti. Nat. size.

Figure 19. *Pavona ponderosa* (Gardiner). View of upper part of above, showing small calicinal areas. Nat. size.

Figure 20. *Pavona maldivensis* (Gardiner). View of part of calicinal surface of incrusting corallum, with oblique corallite-walls. Length 9 cm., breadth 3·5 cm. From Tahiti. Nat. size.

Figure 21. *Pavona ponderosa* (Gardiner). View of one side of calicinal surface of a heavy massive corallum, showing short sinuous valleys. Height 16·5 cm., length 32 cm., breadth 21 cm. From Tahiti. Nat. size.

Figure 22. *Pavona ponderosa* (Gardiner). View of another side of calicinal surface of above, showing distinct corallites. Nat. size.

Figure 23. *Pavona ponderosa* (Gardiner). View of part of convex somewhat uneven calicinal surface of a comparatively thin entire corallum, being type of *Agaricia ponderosa* Gardiner. Very short valleys or single calicinal areas formed by intersection of radial and concentric ridges. Concentric arrangement of calicinal areas better seen towards periphery. Non-calicinal surface concave with an excentric scar of attachment. Length 11·5 cm., breadth 8·5 cm. From Minikoi. Nat. size.

Figure 24. *Pavona ponderosa* (Gardiner). View of part of calicinal surface of comparatively thin corallum. Single calicinal areas, formed by intersection of radial and concentric ridges, smaller than in above. Length 12 cm., breadth 9 cm. Tahiti. Nat. size.

Plate 7

Figure 25. *Agaricia agaricites* (Linnaeus). View of somewhat concave calicinal surface of a comparatively thin semicircular corallum, showing concentric arrangement of subsidiary calicinal areas, with concentric ridges connecting proximal sides of their bases. Length 13·5 cm., breadth 9·5 cm. From Bermudas. Nat. size.

Figure 26. *Pavona maldivensis* (Gardiner). View of upper part of calicinal surface with depression about 3 cm. deep, showing single calicinal areas formed by intersection of concentric and radial ridges and concentrically arranged. Height 9·5 cm., length 8 cm., breadth 6 cm. From Hulule, Maldives. Nat. size.

Figure 27. *Agaricia agaricites* (Linnaeus) var. *purpurea*. View of somewhat convex calicinal surface of corallum, with radial ridges intersecting concentric ridges, thus forming single corallites and short valleys. Non-calicinal surface somewhat concave, with central scar of attachment. Height 2 cm. length 6·5 cm., breadth 6 cm. From Tortugas. Nat. size.

Figure 28. *Pavona cactus* (Forskål). View of calicinal surface, on one side, of two broad comparatively thick vertical fronds, showing calicinal areas arranged in concentric rows, without concentric or radial ridges. Height 12 cm., length 12 cm., breadth 5 cm. From Faar Flats, Tahiti. Nat. size.

Figure 29. *Pavona cactus* (Forskål). View of calicinal surface, on one side, of vertical fronds, showing concentric ridges at proximal sides of calicinal rows, parts of two or three concentric ridges rising into low crests, and commencement of faint radial ridges at bases of fronds. Height 9 cm., length 13 cm., breadth 6 cm. From Pa'ea, Tahiti. Nat. size.

PLATE 8

Enlarged views of calicinal surface of successive growth-stages of *Coscinaraea monile* (Forskål).

FIGURE 30. Slightly convex calicinal surface, with only the primary calicinal area. Non-calicinal surface somewhat concave, with central scar of attachment. Diameters 1 × 1 cm. From Felidu, Maldives, 20 to 25 fathoms. × 4.

FIGURE 31. Somewhat convex calicinal surface, showing slightly excentric primary calicinal area, surrounded by incipient subsidiary calicinal areas. Non-calicinal surface somewhat concave, with a scar of attachment opposite primary calicinal area. Diameters 1·5 × 1·1 cm. From Mahlos. × 4.

FIGURE 32. Convex calicinal surface, with excentric primary calicinal area surrounded by a few subsidiary calicinal areas. Non-calicinal surface more or less concave. Diameters 1·7 × 1·4 cm. From Felidu, Maldives. × 4.

FIGURE 33. Convex calicinal surface of incrusting corallum, with almost central primary calicinal area surrounded by three concentric circles of somewhat smaller subsidiary calicinal areas. Diameters 3 × 3 cm. From Amirante, < 25 fathoms. × 2.

FIGURE 34. Convex calicinal surface of incrusting corallum, with greater distal growth. Corallum slightly but evenly upraised around primary calicinal area, subsidiary calicinal areas arranged concentrically, a few subsidiary calicinal areas appearing to be somewhat oblique owing to slight upraising of corallum on their proximal side. Diameters 2·5 × 1·8 cm. From Suvadiva. × $3\frac{1}{2}$.

FIGURE 35. Unevenly convex calicinal surface, with inconspicuous primary calicinal area and subsidiary calicinal areas arranged more or less concentrically. Non-calicinal surface concave, without stalk of attachment. Diameters 3·5 × 2·9 cm. From S. Male. × $2\frac{1}{2}$.

FIGURE 36. Somewhat concave calicinal surface of comparatively thin corallum, with greater distal growth, inconspicuous primary calicinal area, calicinal areas arranged more or less concentrically, a few calicinal areas appearing to be oblique owing to slight upraising of corallum on their proximal side. Non-calicinal surface with a short excentric stalk of attachment. Diameters 4·7 × 4 cm. From Suvadiva. × 2.

PLATE 9

FIGURE 37. *Coscinaraea monile* (Forskål). View of calicinal surface on one side of dome-shaped heavy corallum, with short sinuous comparatively deep valleys and a few single corallites. Concentric arrangement noticeable only at periphery. Height 9 cm., length 18 cm., breadth 16 cm. From Donganab, Red Sea. Nat. size.

FIGURE 38. *Coscinaraea monile* (Forskål). View of convex calicinal surface on top of heavy corallum, with short sinuous valleys and single corallites somewhat concentrically arranged. Height 6 cm., length 14 cm., breadth 12 cm. From Harbour Reef, Ghardaqa, Red Sea. Nat. size.

FIGURE 39. *Pavona cactus* (Forskål). View of part of heavy foliate corallum, with a somewhat unique appearance owing to foliae being sinuous, grooved above and fusing in places, and carinae towards the periphery. Height 12 cm., length 26 cm., breadth 15·5 cm. From Papeari, Tahiti. Nat. size.

FIGURE 40. *Psammocora haimiana* Milne Edwards and Haime. View of part of incrusting corallum on another branching dead corallum, with numerous five- to six-sided single corallites, simulating *Pavona ponderosa* facies, and very few short valleys. Length 19 cm., breadth 7 cm. From Shore Reef edge, Papeari, Tahiti. Nat. size.

PLATE 10

FIGURES 41 and 42. *Psammocora contigua* (Esper.). Side views of two coralla composed of narrow vertical branching foliae crowded together with secondary fusions. Height 14 cm., breadth 7 cm. Both from a hole about 3 ft. deep in Shore reef, Pa'ea, Tahiti. Nat. size.

FIGURE 43. *Psammocora contigua* (Esper.). General view of large corallum composed of vertical foliae, broader than in figures 41 and 42, with secondary fusions here and there, and Hydnophoroid facies occurring in parts. Height 16 cm., length 21 cm., breadth 17 cm. From Inshore coral beds, Pa'ea, Tahiti. Nat. size.

PLATE 11

FIGURE 44. *Echinophyllia aspera* (Ellis and Solander). View of concave calicinal surface of thin corallum, with excentric primary calicinal area situated proximally, and smaller subsidiary calicinal areas arranged almost concentrically. Non-calicinal surface convex, with excentric short stalk of attachment opposite primary calicinal area. Depth from rim to primary calicinal area 5 cm. Diameters 22 × 21 cm. From Abu Shaar, Ghardaqa, Red Sea, 15 fathoms. Nat. size.

FIGURE 45. *Echinophyllia aspera* (Ellis and Solander). View of slightly concave calicinal surface of thin corallum, much rougher than above, with excentric primary calicinal area situated proximally, and smaller subsidiary calicinal areas arranged more or less concentrically, some of the subsidiary calices appearing to be oblique by union or raised parts of septo-costae on their proximal side, some septo-costae raised into crests. Non-calicinal surface with very excentric short stalk of attachment. Depth from rim to primary calicinal area 5 cm., diameters 18 × 14·5 cm. Nat. size.

PLATE 12

FIGURE 46. *Pavona varians* (Verrill). View of uneven calicinal surface of corallum composed of a thin basal folia rising into low hillocks with *Merulina ampliata* facies, both continuous and discontinuous radial ridges, extending fan-wise towards periphery across concentric rows of subsidiary calicinal areas, breaking up into monticules in depressions of calicinal surface. Non-calicinal surface uneven, with radial grooves corresponding to radial ridges on calcinal surface. Diameters 21 × 16 cm. From Shore reef, Papeari, Tahiti, 1 fathom.

FIGURE 47. *Pavona maldivensis* (Gardiner). General view of large heavy corallum, rising into basally constricted hillocks up to 4 cm. in height, simulating growth form of *Favia acropora* (Linnaeus). Height 16 cm., length 23 cm., breadth 22 cm. From submerged flat, Tahiti. Nat. size.

PLATE 13

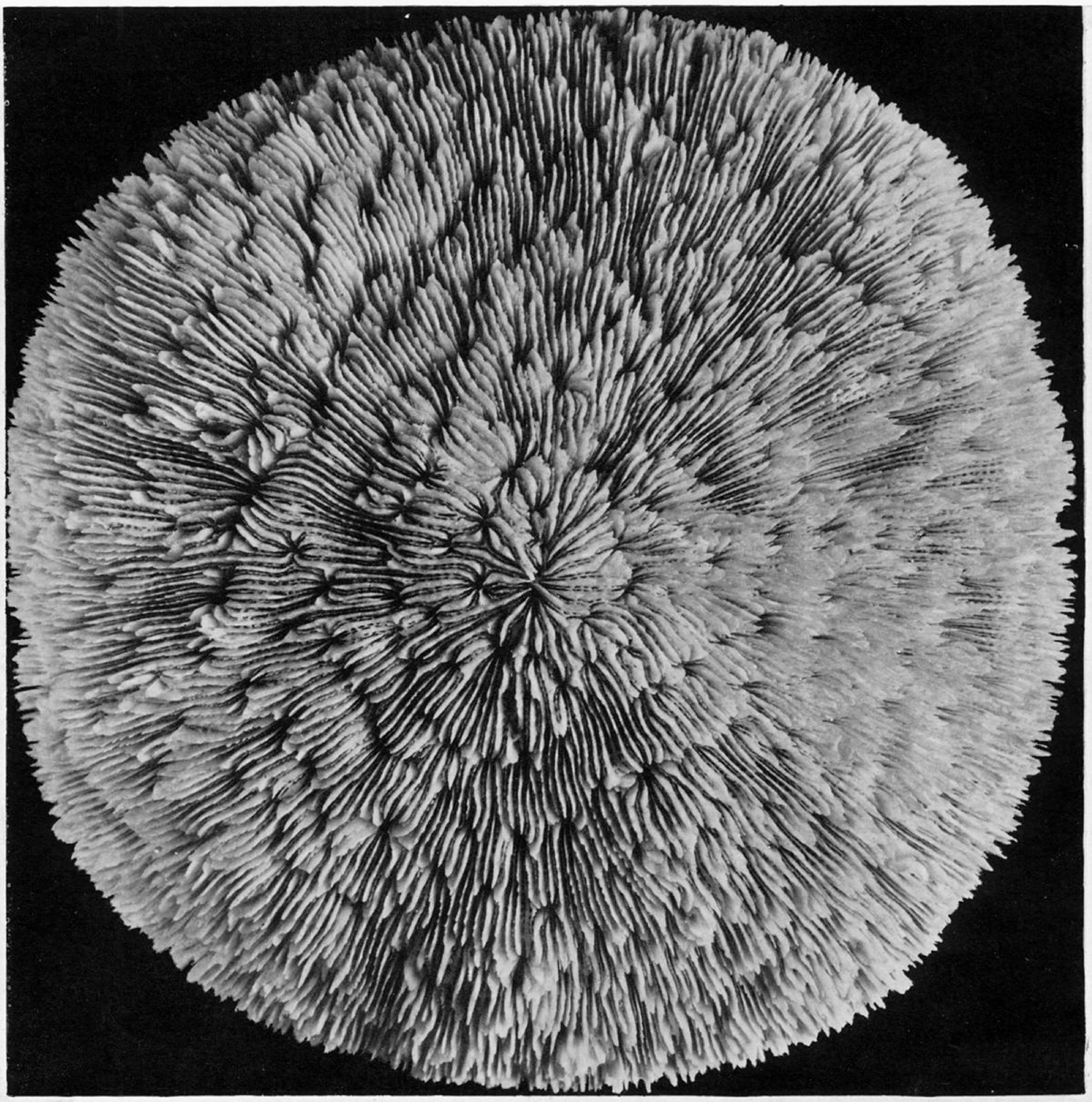
FIGURE 48. *Pachyseris speciosa* (Dana). General view of large corallum, with several horizontal concavo-convex foliae, valleys arranged concentrically, becoming shallow to almost flat in lowest folia, collines becoming oblique towards periphery, lower surface of foliae non-calicinal. Depth 15 cm., diameters 40 × 27 cm. From Tahiti. $\times \frac{1}{2}$.

FIGURE 49. *Pachyseris speciosa* (Dana). View of part of slightly concave calicinal surface of a horizontal folia, with collines breaking up in places into monticules of varying length, lower surface of folia non-calicinal. Diameters 28·5 × 20 cm. Probably from Tahiti. Nat. size.

PLATE 14

FIGURE 50. *Psammocora haimiana* Milne Edwards and Haime. Side view of a bifurcated corallum (previously named *Psammocora exesa* Dana) showing concentric arrangement of calicinal areas. Thickness 3·5 cm., length 14 cm., breadth 8·5 cm. From Hulule, Maldives. Nat. size.

FIGURE 51. *Psammocora haimiana* Milne Edwards and Haime. Side view of part of corallum showing humps up to 5 cm. in height, the larger ones compressed laterally and broadening towards distal end, simulating growth facies of *Favia acropora* (Linnaeus). Length 27·5 cm., breadth 20·5 cm., thickness 5 cm. From Neru, Hulule, Maldives. Nat. size.



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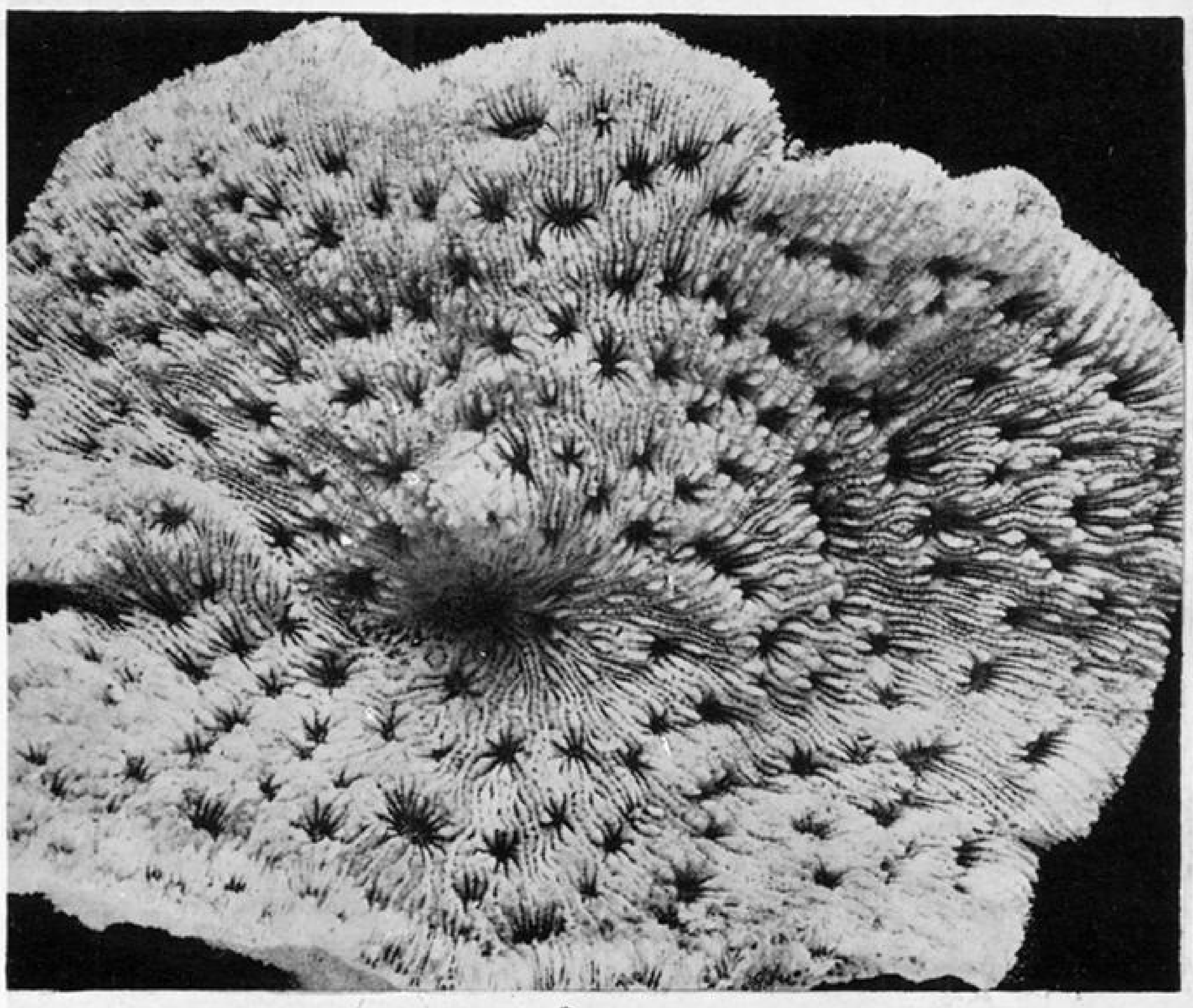

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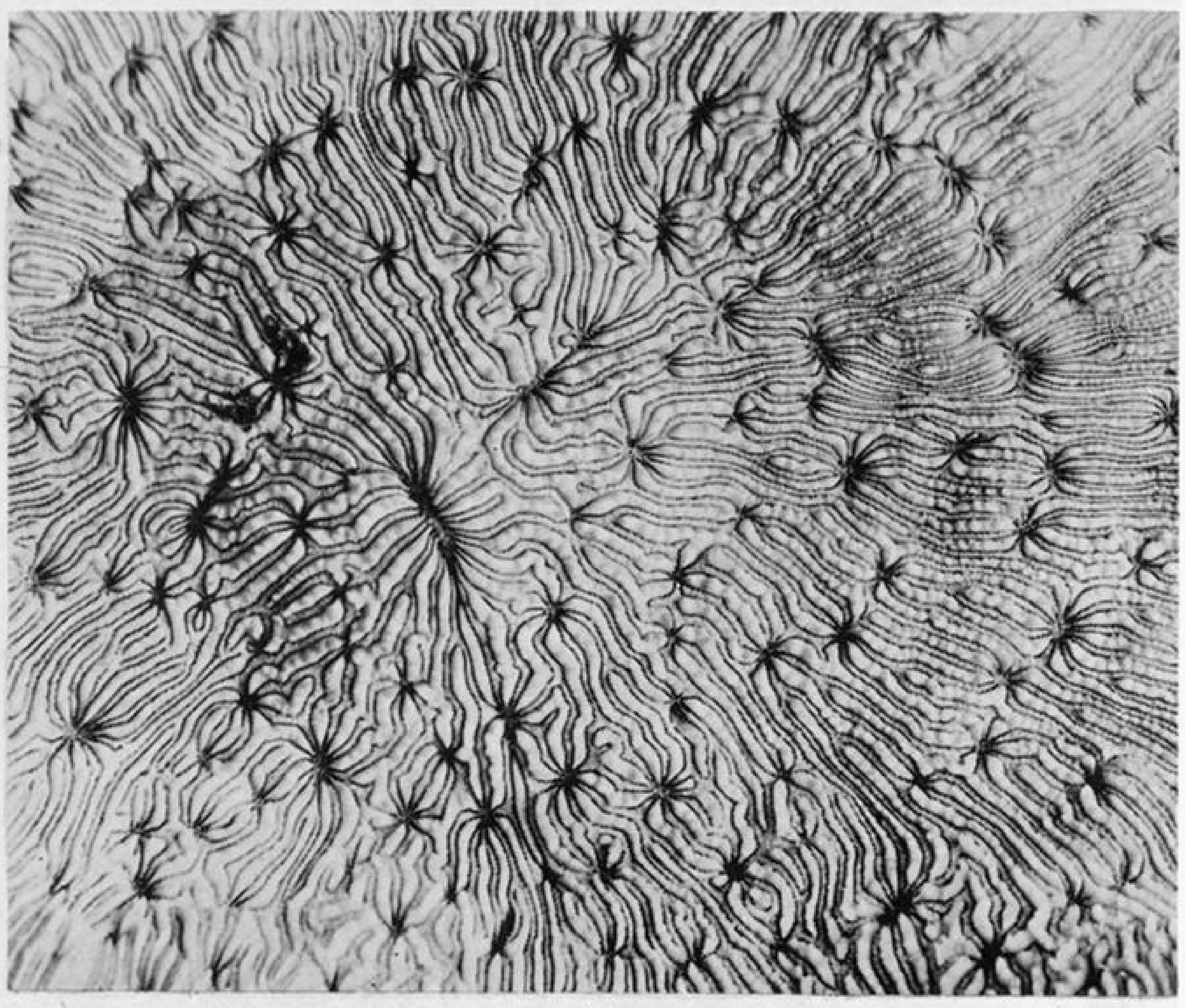

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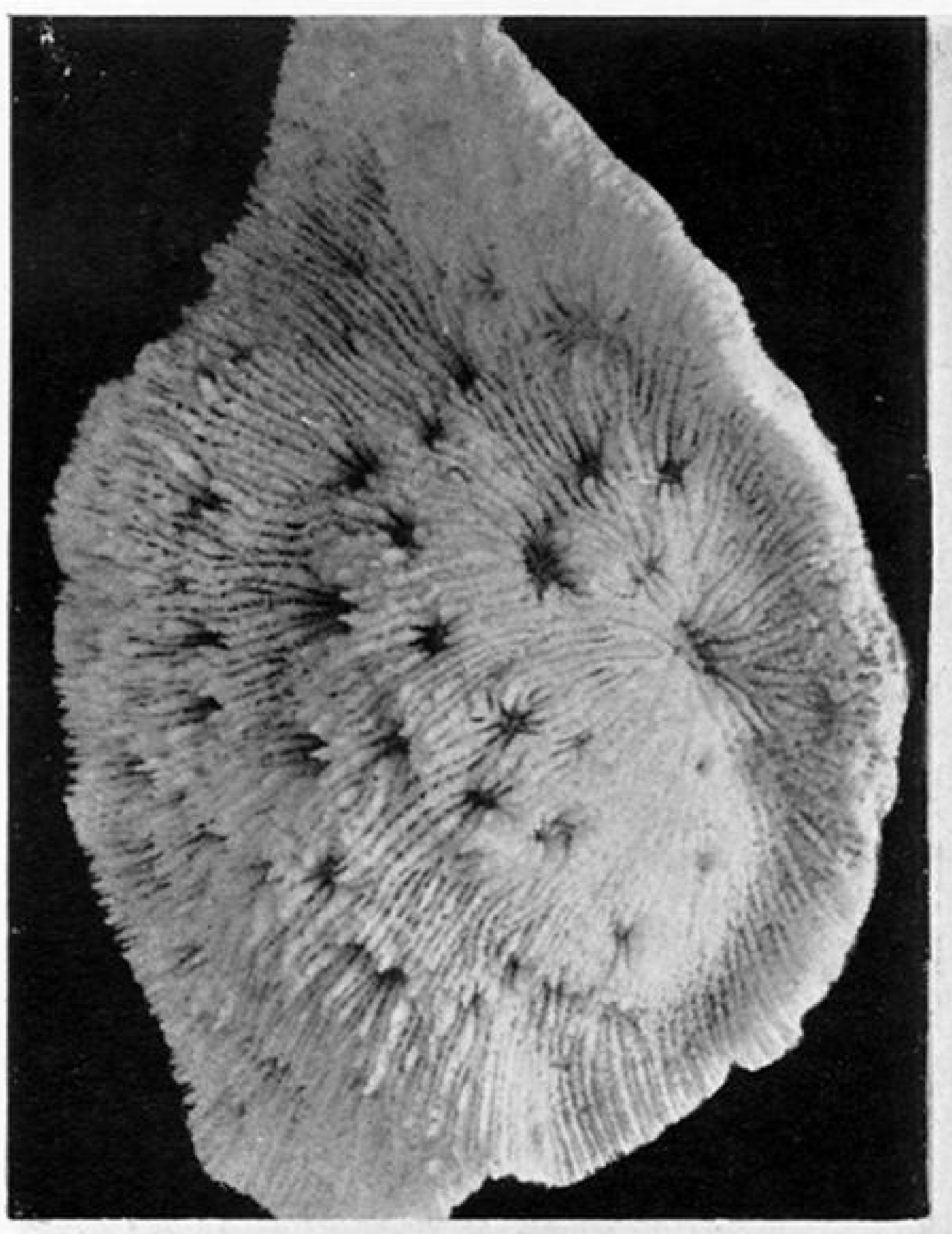
PLATE 3

FIGURE 1. *Halomitra philippinensis* Studer. View of convex calicinal surface with primary calicinal area in the centre and somewhat smaller subsidiary calicinal areas arranged in concentric circles. Non-calicinal surface concave, with central scar of attachment opposite primary calicinal area from which closely arranged echinulate striations radiate outwards. Height 5·5 cm., diameters 16 × 16 cm. From Long Island, Reef, Seychelles. Nat. size.

FIGURE 2. *Podabacia crustacea* (Pallas). View of somewhat concave calicinal surface with primary calicinal area almost central and smaller subsidiary calicinal areas arranged in concentric circles. Non-calicinal surface somewhat convex with a short central stalk of attachment opposite primary calicinal area and concentric markings. Length 10·5 cm., breadth 7 cm., thickness 0·7 cm. From Minikoi. Nat. size.

FIGURE 3. *Podabacia crustacea*. View of deeply concave calicinal surface, showing somewhat excentric primary calicinal area and concentric circles of smaller subsidiary calicinal areas. Non-calicinal surface highly convex, with an excentric scar of attachment opposite primary calicinal area and concentric markings. Depth from rim to primary calicinal area 18 cm., diameters 30 × 26 cm. From Tekepotu Atoll, Tuamotus, Tahiti. Nat. size.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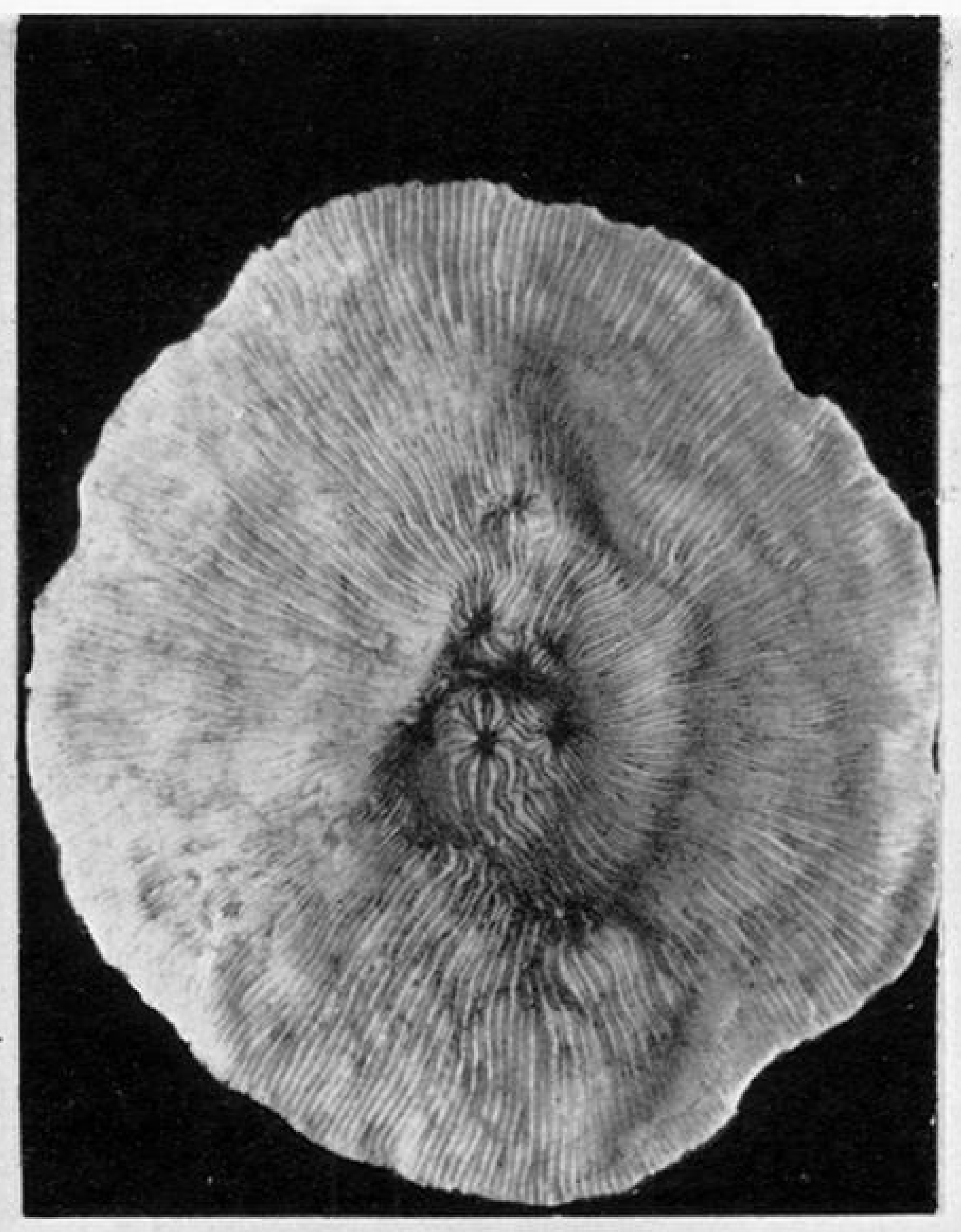
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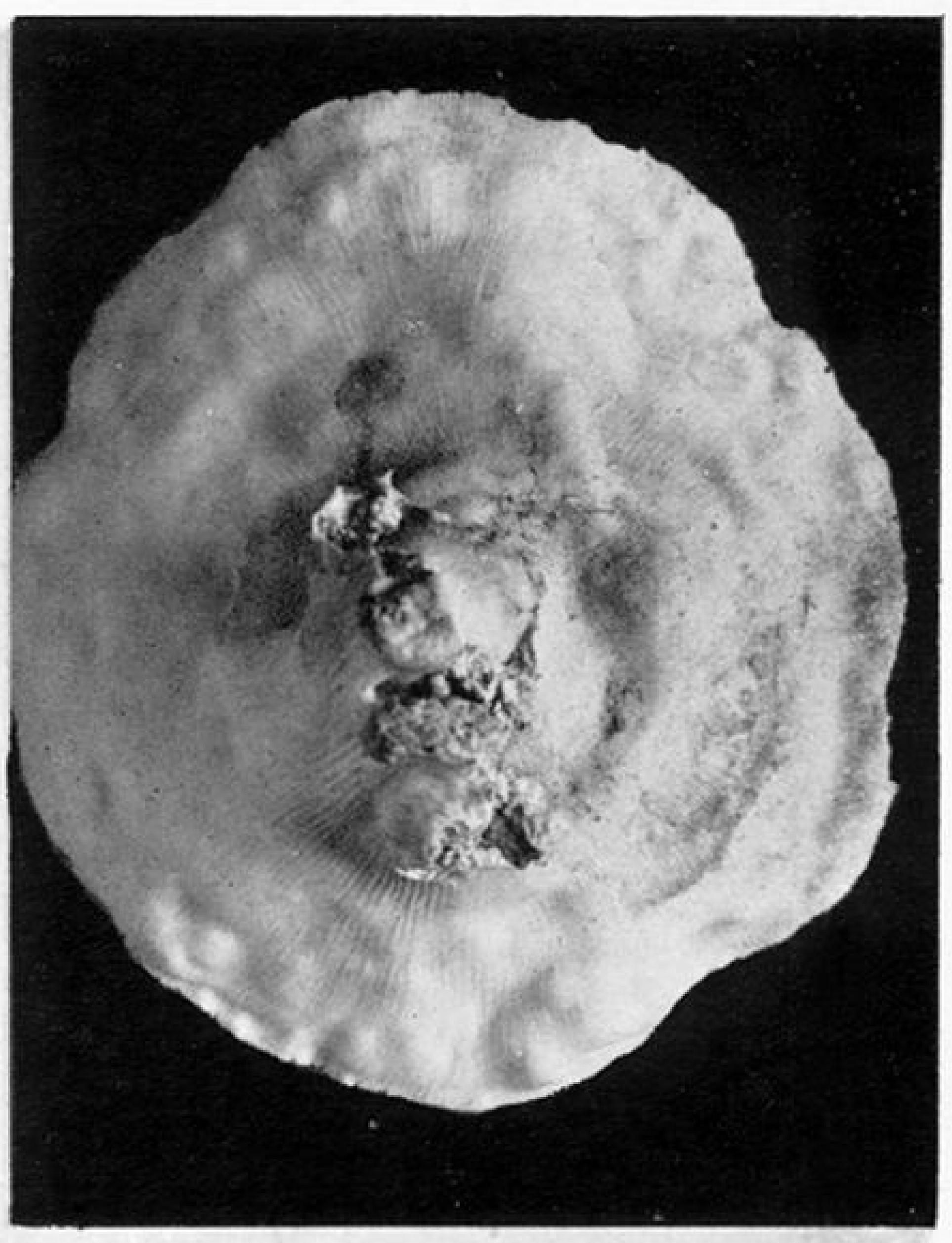
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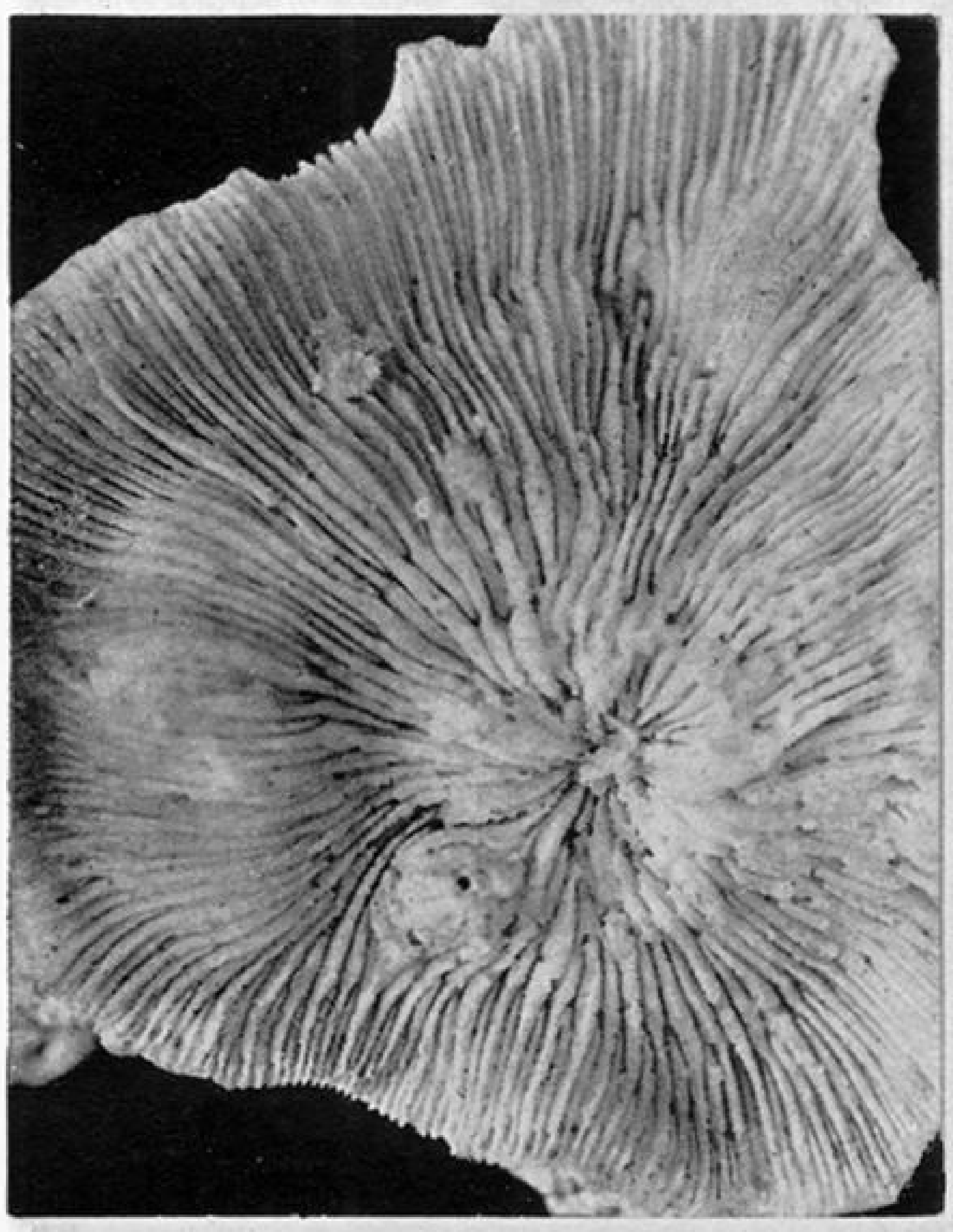
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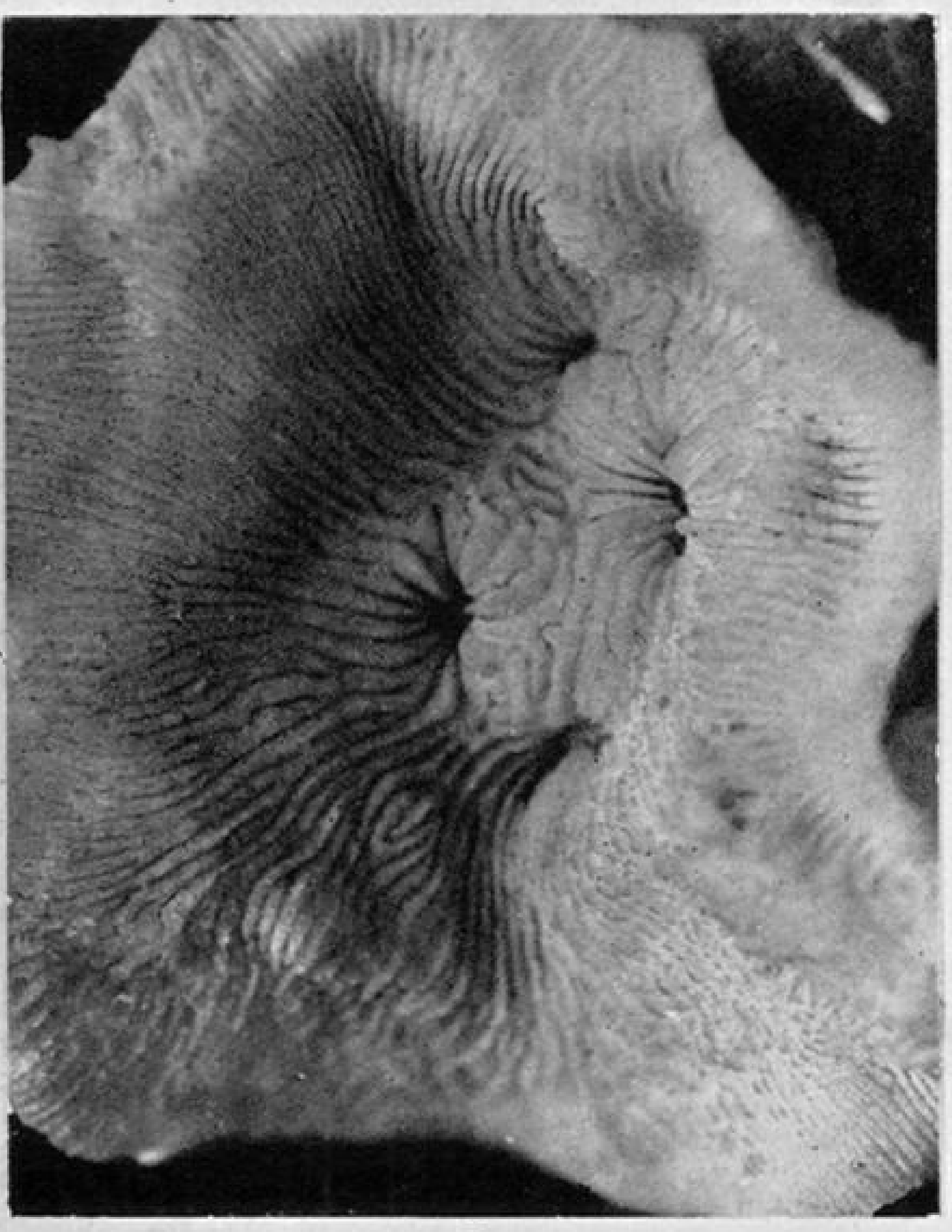
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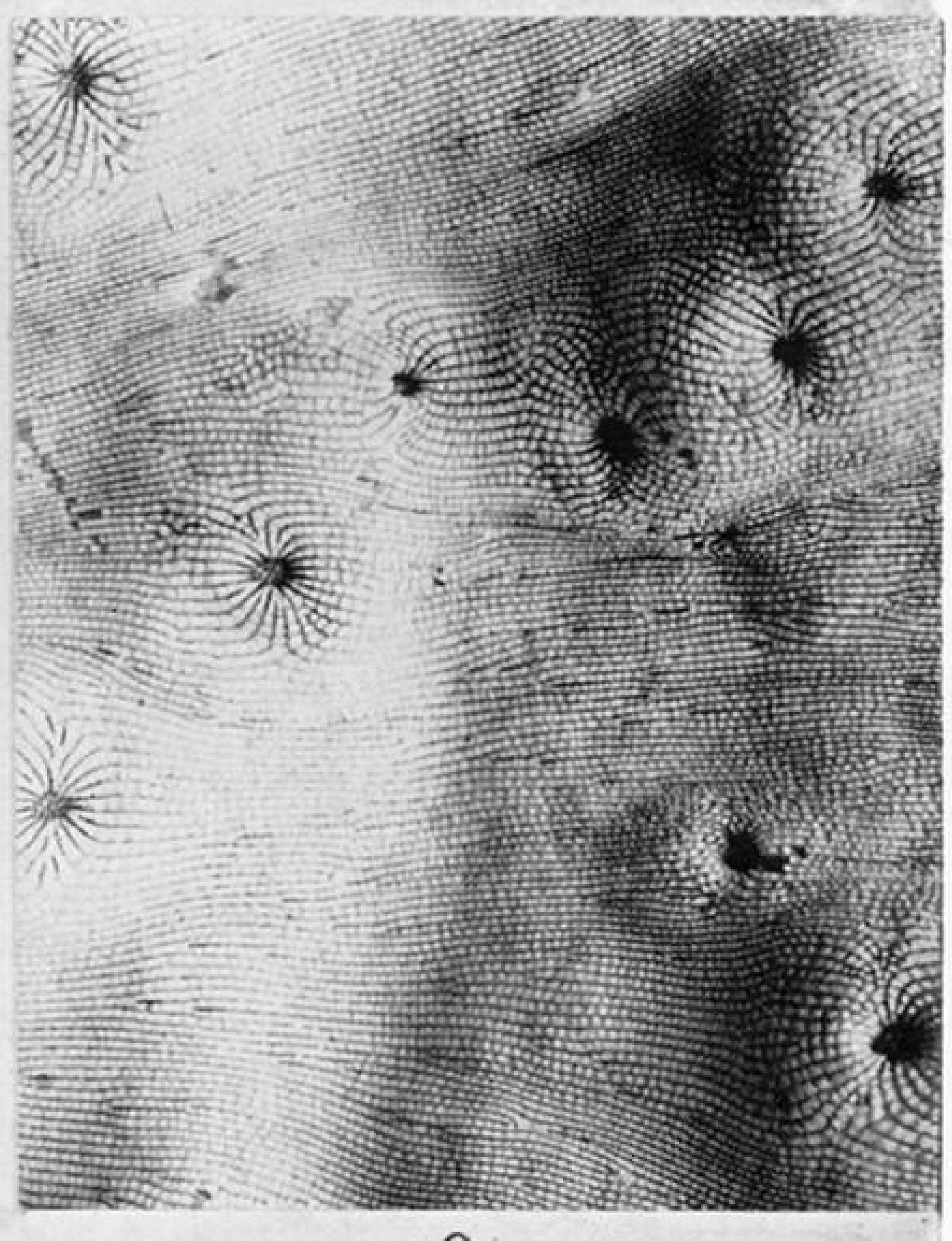
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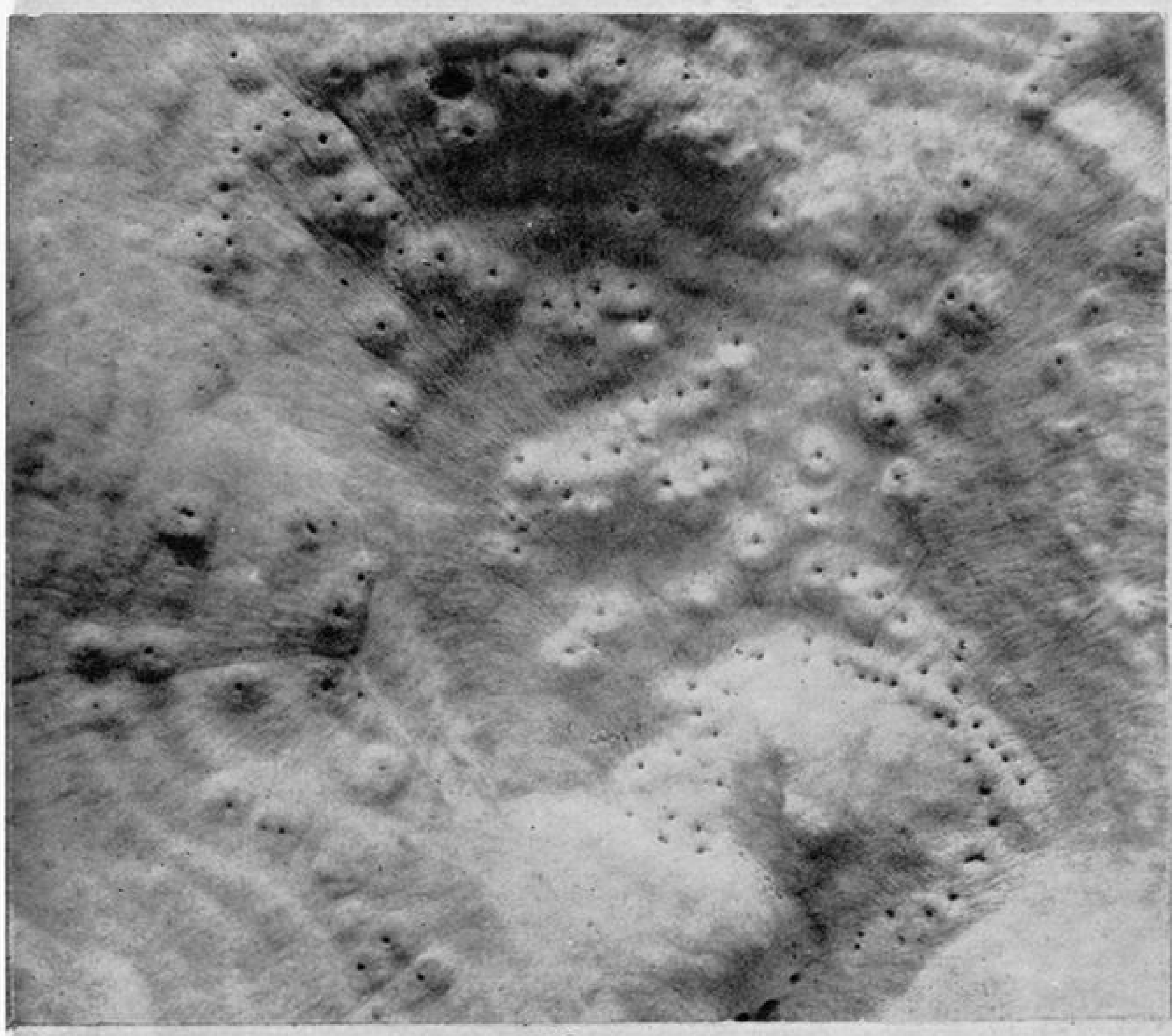
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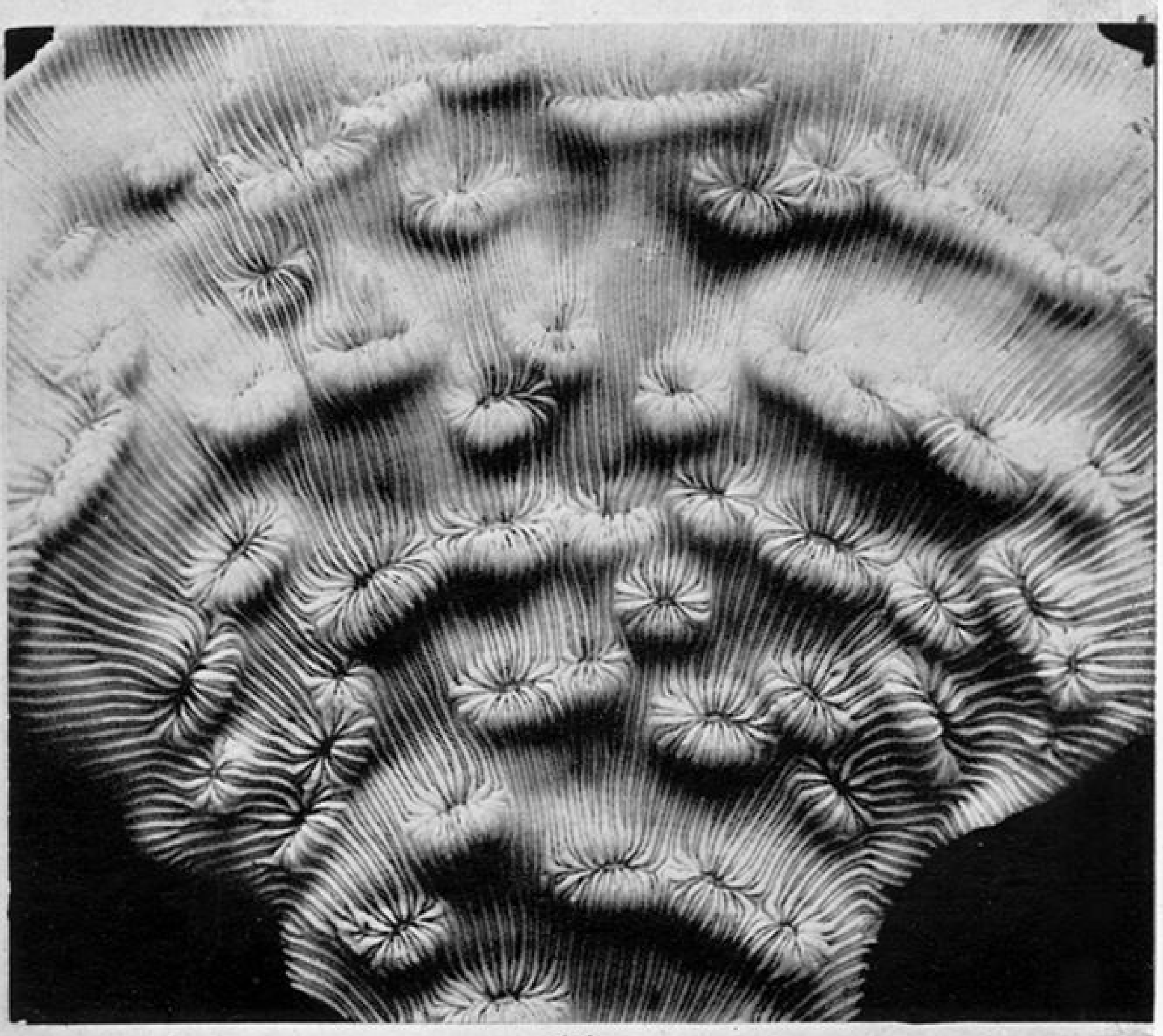
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PLATE 4

FIGURE 4. *Podabacia crustacea* (Pallas). View of somewhat convex calicinal surface, showing primary calicinal area shifted to one side beyond which are smaller subsidiary calicinal areas arranged in more or less concentric rows. Non-calicinal surface somewhat concave, with a short stalk of attachment opposite primary calicinal area. Length 6·8 cm., breadth 4·5 cm. From Maldives. Nat. size.

FIGURE 5. *Leptoseris fragilis* Milne Edwards and Haime. View of concave calicinal surface of a young corallum, showing slightly excentric primary calcinal area and a few smaller subsidiary calicinal areas somewhat scattered. Depth from rim to primary calicinal area 1·5 cm., diameters 6 cm. × 5·5 cm. From North Male, Maldives, 20 fathoms. Nat. size.

FIGURE 6. *Leptoseris fragilis* Milne Edwards and Haime. View of convex non-calicinal surface of above, showing short stalk of attachment, 1·5 cm. in height, opposite primary calicinal area. Nat size.

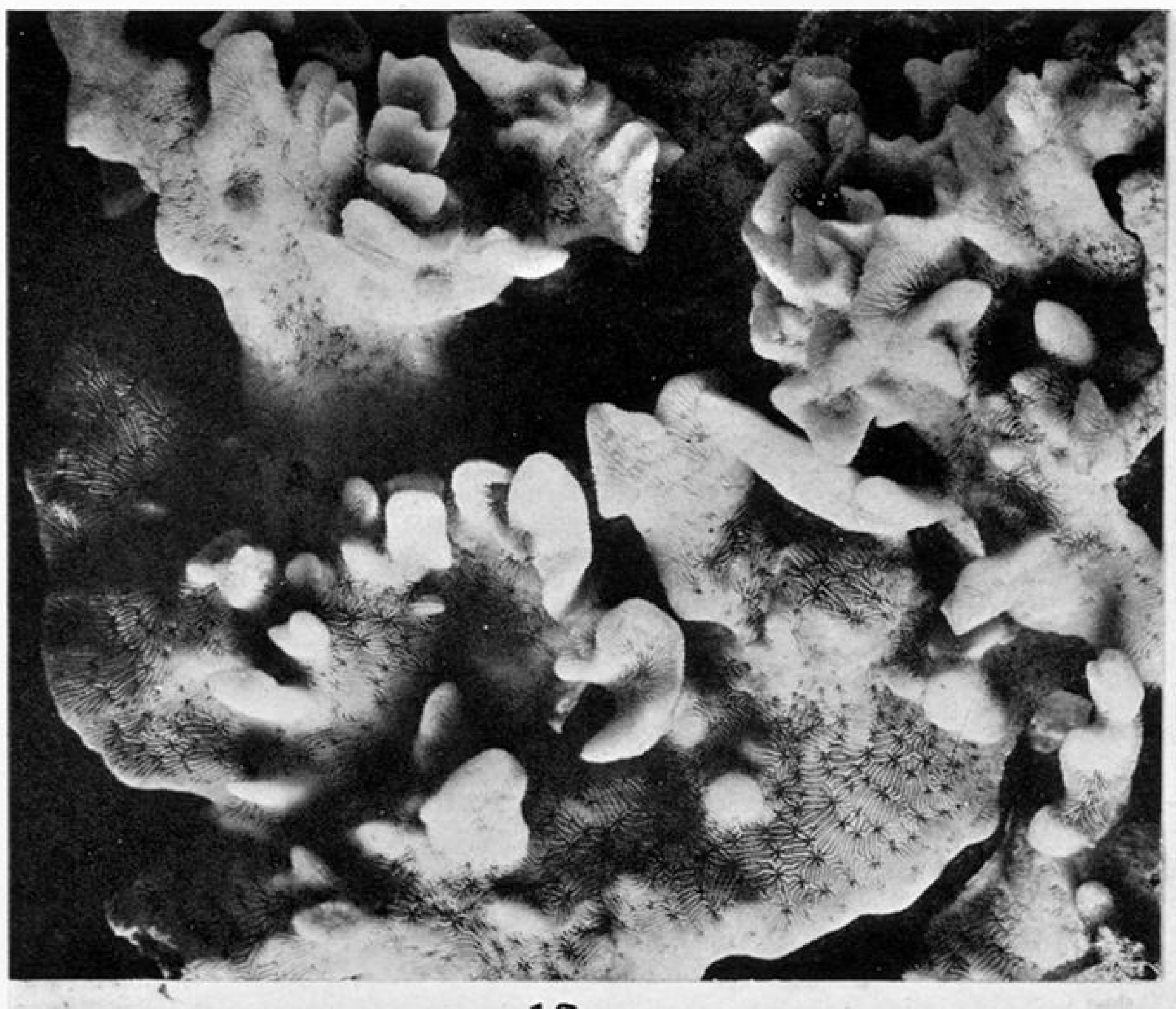
FIGURE 7. *Leptoseris incrustans* Gardiner. Enlarged view of calicinal surface of a young incrusting corallum, smaller than above, showing excentric primary calicinal area and a few incipient subsidiary calicinal areas without definite arrangement. Diameters 2·7 × 2·3 cm. From South Nilandu, Maldives, $19 \times 3\frac{1}{2}$ fathoms.

FIGURE 8. *Leptoseris fragilis* Milne Edwards and Haime. Enlarged view of the concave calicinal surface of a young incrusting corallum, showing excentric primary calicinal area and a few scattered subsidiary calicinal areas. Depth from rim to primary calicinal area 1 cm. Diameters 2·5 × 2 cm. From Suvadiva, Maldives, 38 fathoms. $\times 3\frac{1}{3}$.

FIGURE 9. *Leptoseris hawaiiensis* Vaughan. Enlarged view of part of concave calicinal surface, showing oblique low corallites and septo-costae. Non-calicinal surface convex, with excentric short stalk of attachment. Depth from rim to bottom 8 cm., diameters 22 × 22 cm. From outside Galawa Reef, Red Sea, 25 fathoms. × 2.

FIGURE 10. *Leptoseris hawaiiensis* Vaughan. Reduced view of part of calicinal surface of above, showing low oblique corallites and faint concentric ridges. $\times \frac{1}{2}$.

FIGURE 11. *Leptoseris scabra* Vaughan. View of calicinal surface of a piece of corallum broken towards the edge, showing concentric rows of oblique corallites and discontinuous concentric ridges. Diameters 10 × 10 cm. From Abu Shaar, Ghardaqa, Red Sea, 20 fathoms. Nat. size.



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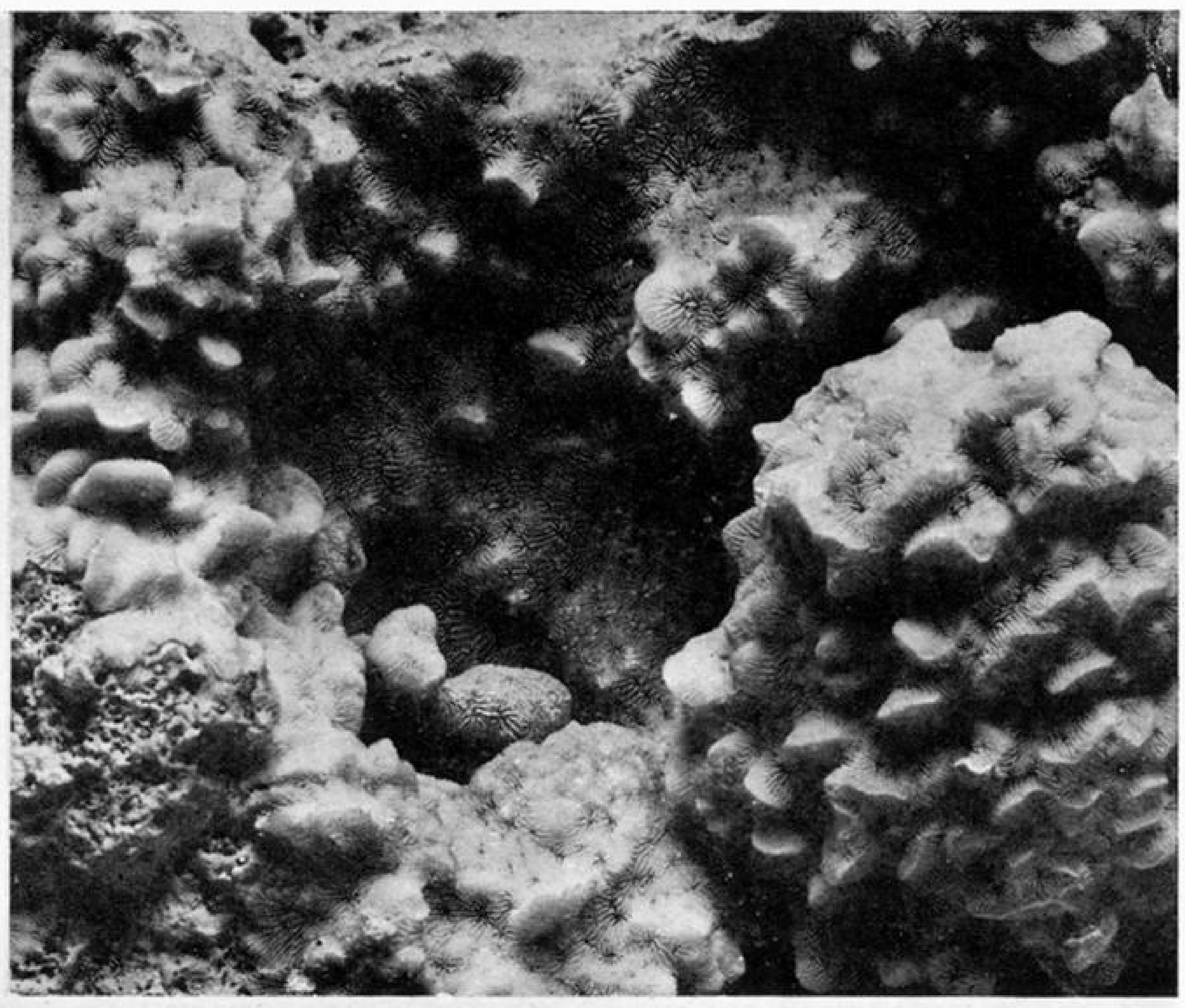

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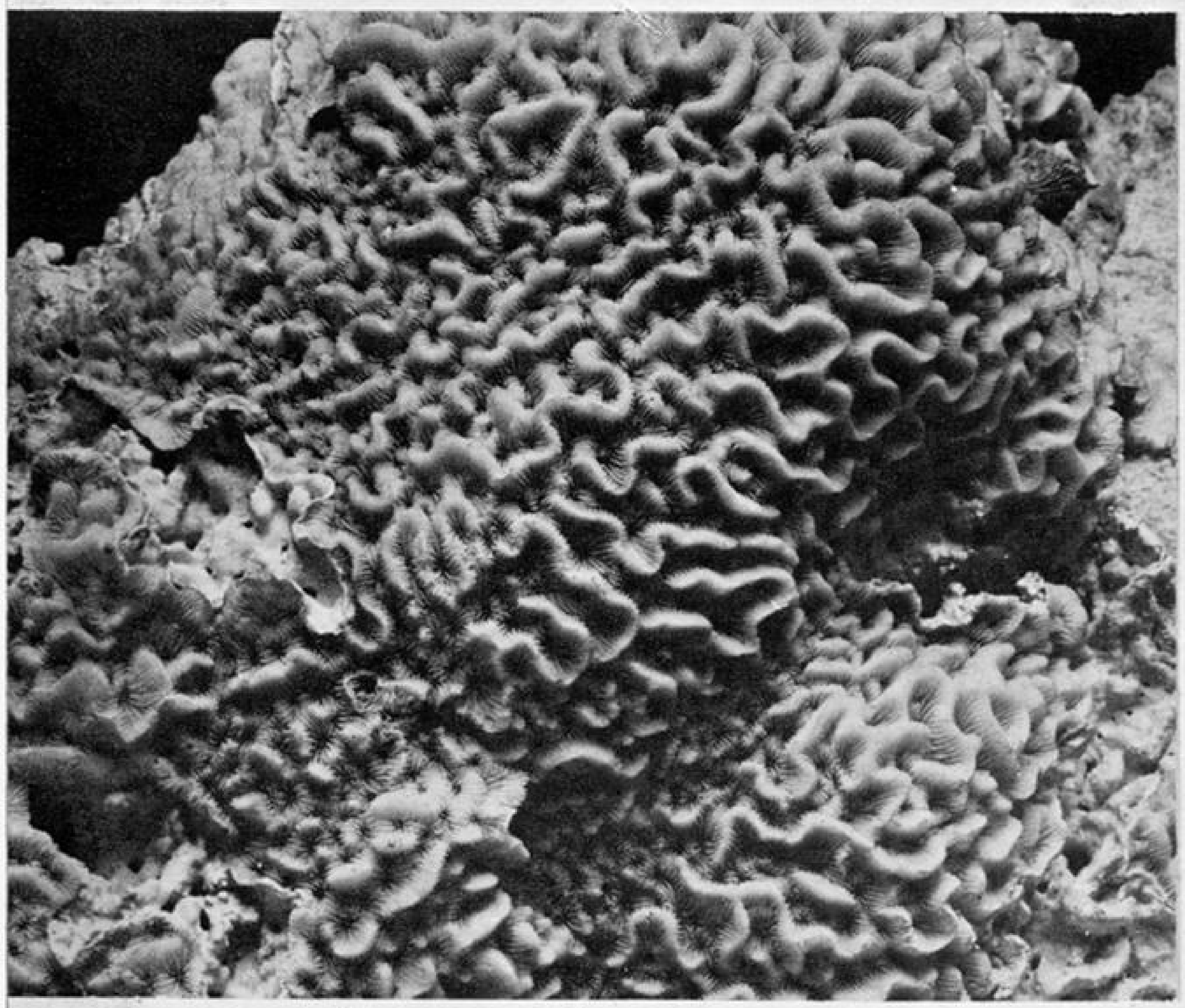

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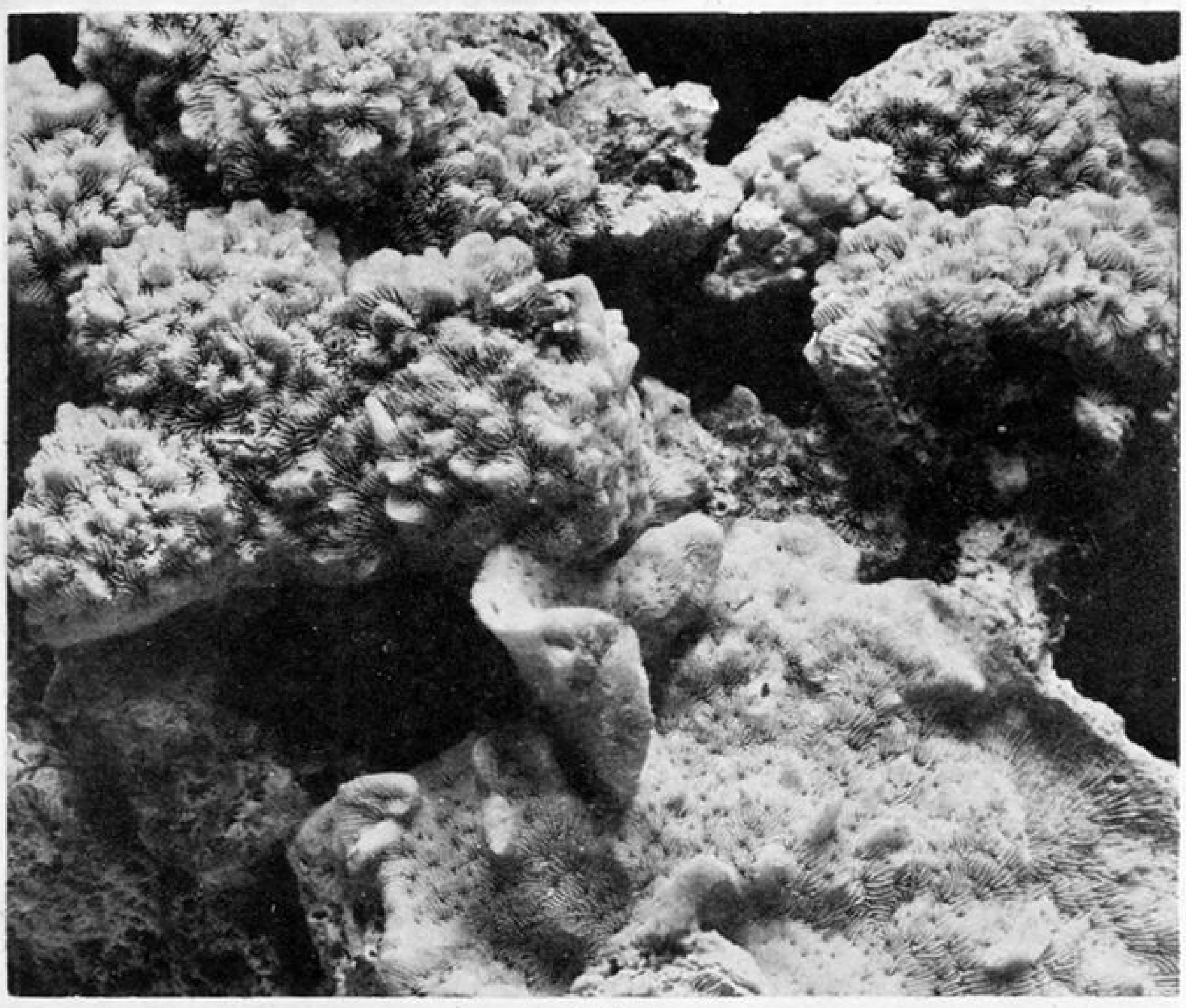

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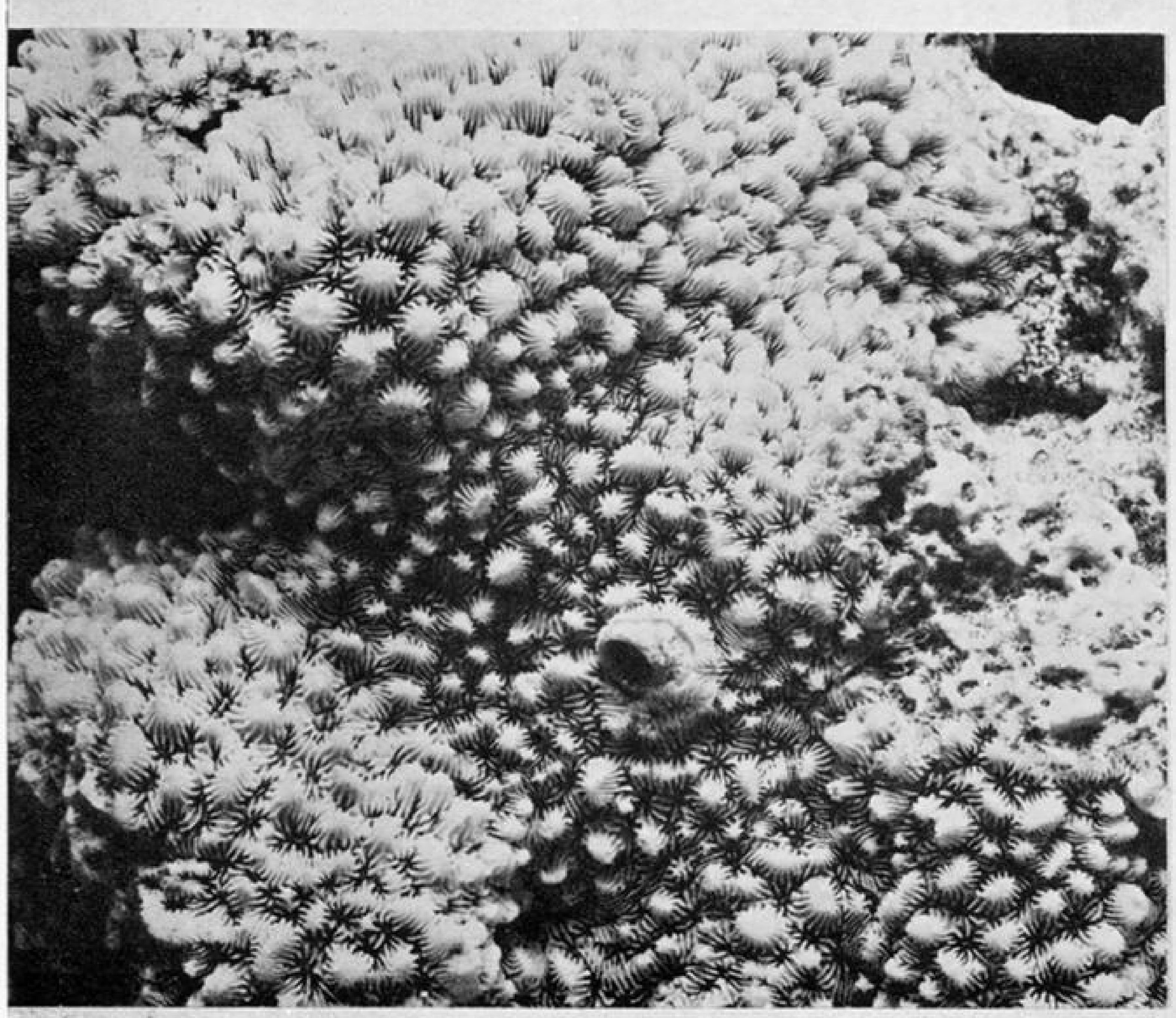

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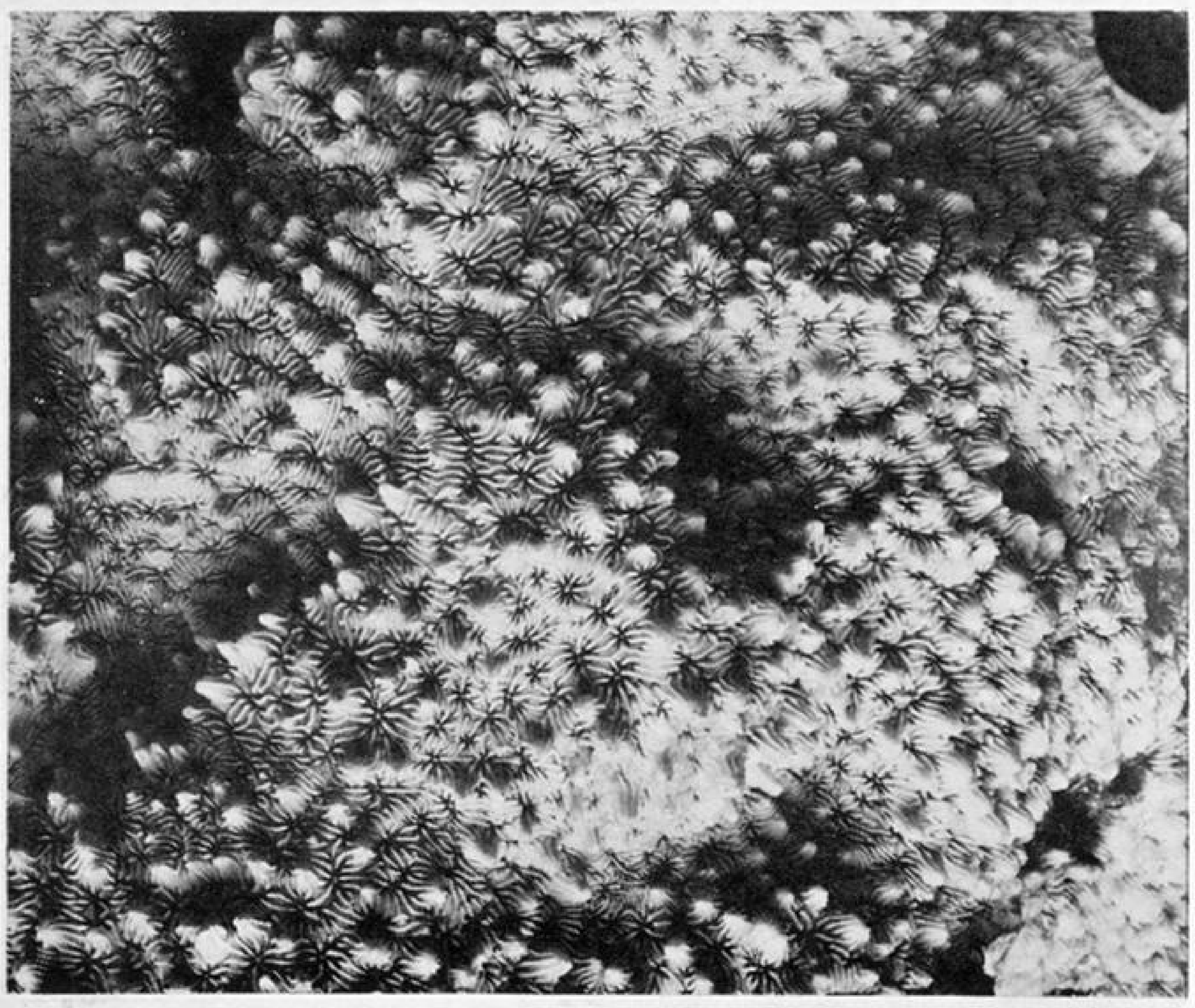

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PLATE 5

FIGURE 12. *Pavona varians* (Verrill). View of calicinal surface of corallum, rising in groups of low narrow vertical foliae, between which calicinal surface is even, simulating growth facies of *P. cactus* (Forskål). Height 10 cm., length 11·5 cm., breadth 10 cm. From Tahiti. Nat. size.

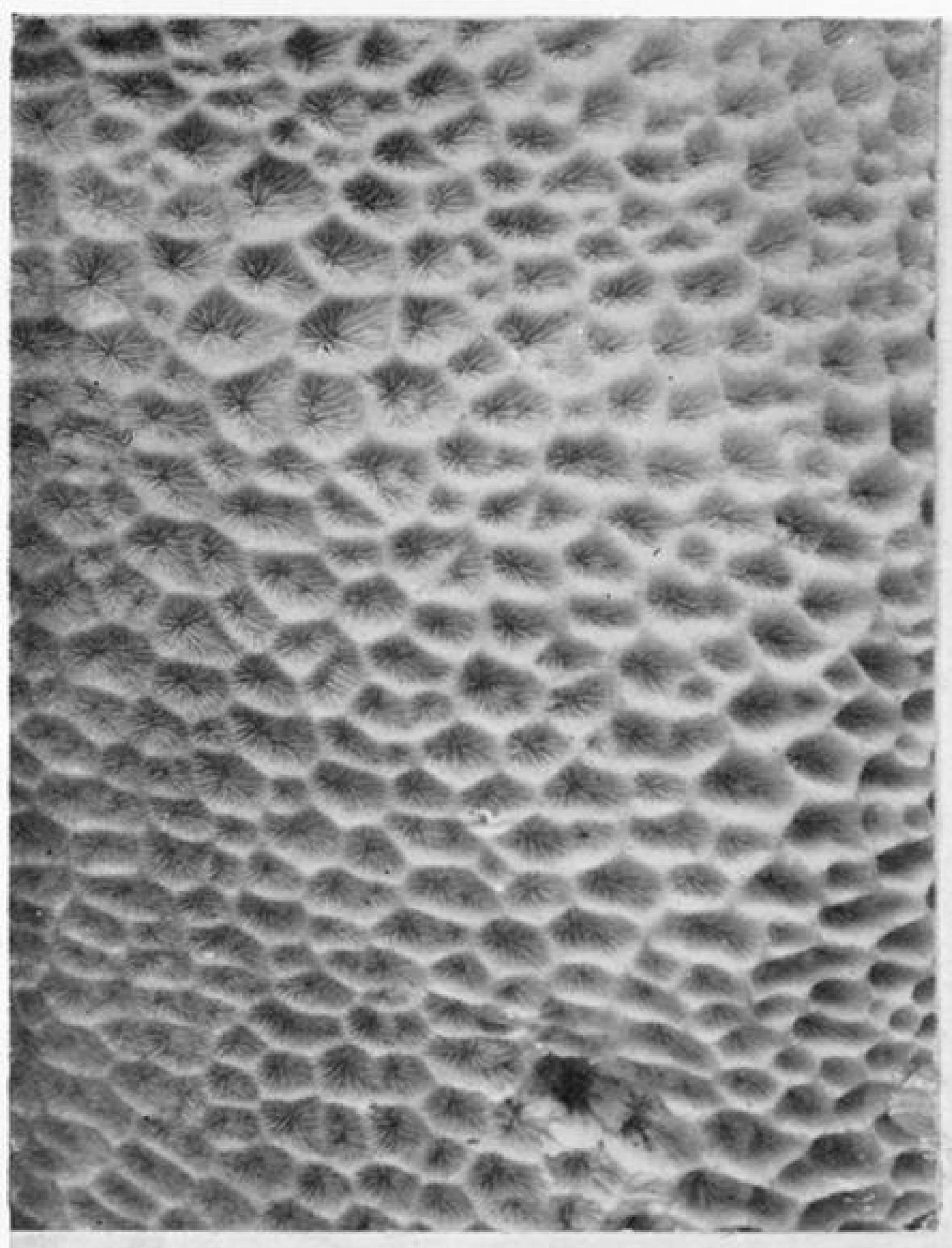
FIGURE 13. *Pavona varians* (Verrill). View of part of calicinal surface of corallum, showing discontinuous crests. Height 17 cm., length 13·5 cm., breadth 10 cm. Probably from Tahiti. Nat. size.

FIGURE 14. *Pavona varians* (Verrill). View of part of calicinal surface of corallum showing sinuous valleys on humpy regions and *Hydnophora contignatio* and *H. exesa* facies in intervening regions, with discontinuous collines. Height 10 cm., length 17 cm., breadth 12·5 cm. Probably from Tahiti. Nat. size.

FIGURE 15. *Pavona varians* (Verrill). View of part of uneven calicinal surface of corallum showing *Hydnophora exesa* and *H. microconos* facies, with discontinuous collines, on one side with incipient foliae (one of which 2 cm. high and 2 cm. broad) and concentric arrangement of calices showing commencement of *Pavona cactus* facies. Length 14 cm., breadth 12·5 cm. From Tahiti. Nat. size.

FIGURE 16. *Pavona varians* (Verrill). View of part of uneven calicinal surface, showing *Hydnophora exesa* facies. Height 11 cm., length 15 cm., breadth 11 cm. From Pa'ea, Tahiti. Nat. size.

FIGURE 17. *Pavona varians* (Verrill). View of part of calicinal surface of above, showing *Hydnophora microconos* facies. Nat. size.



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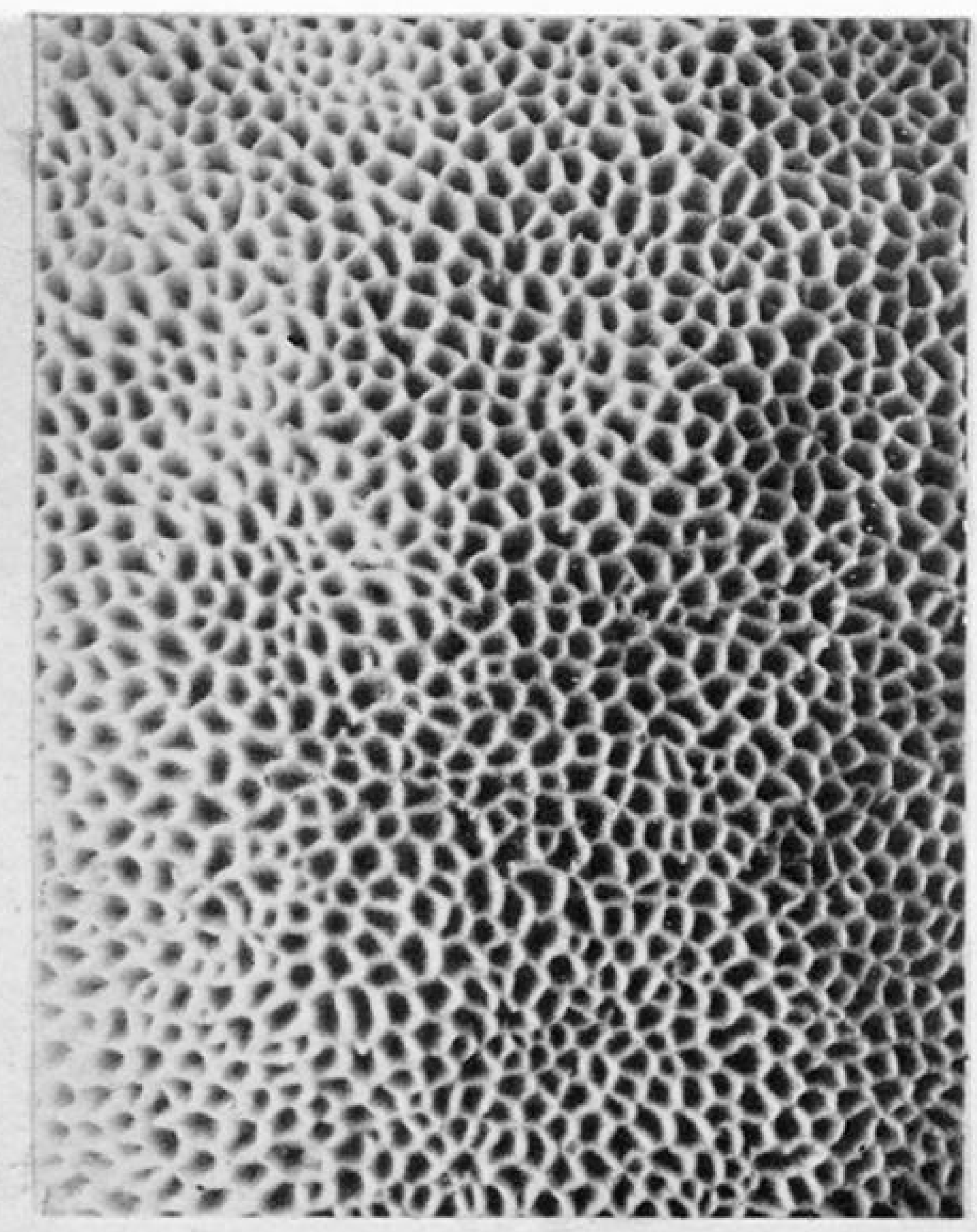

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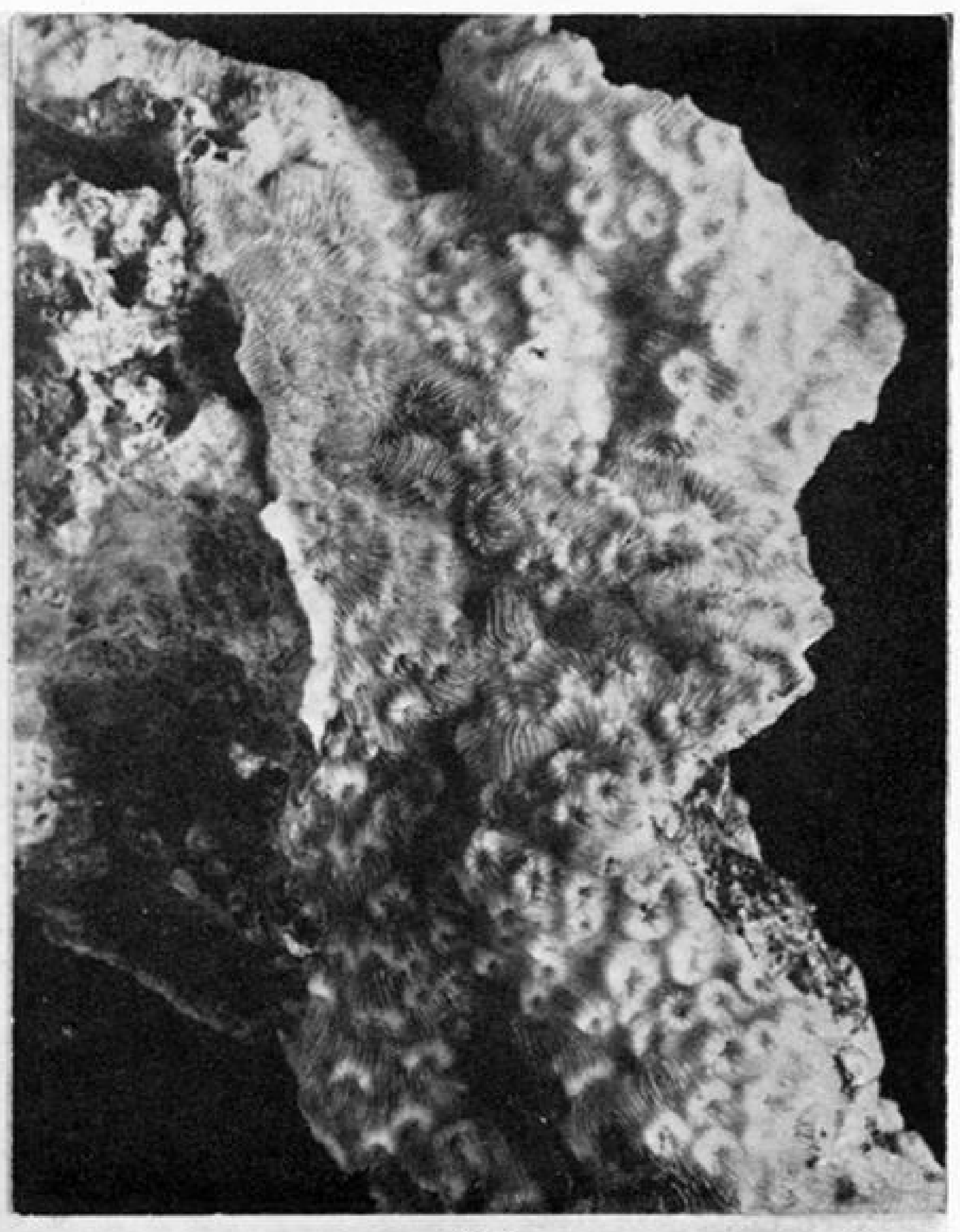

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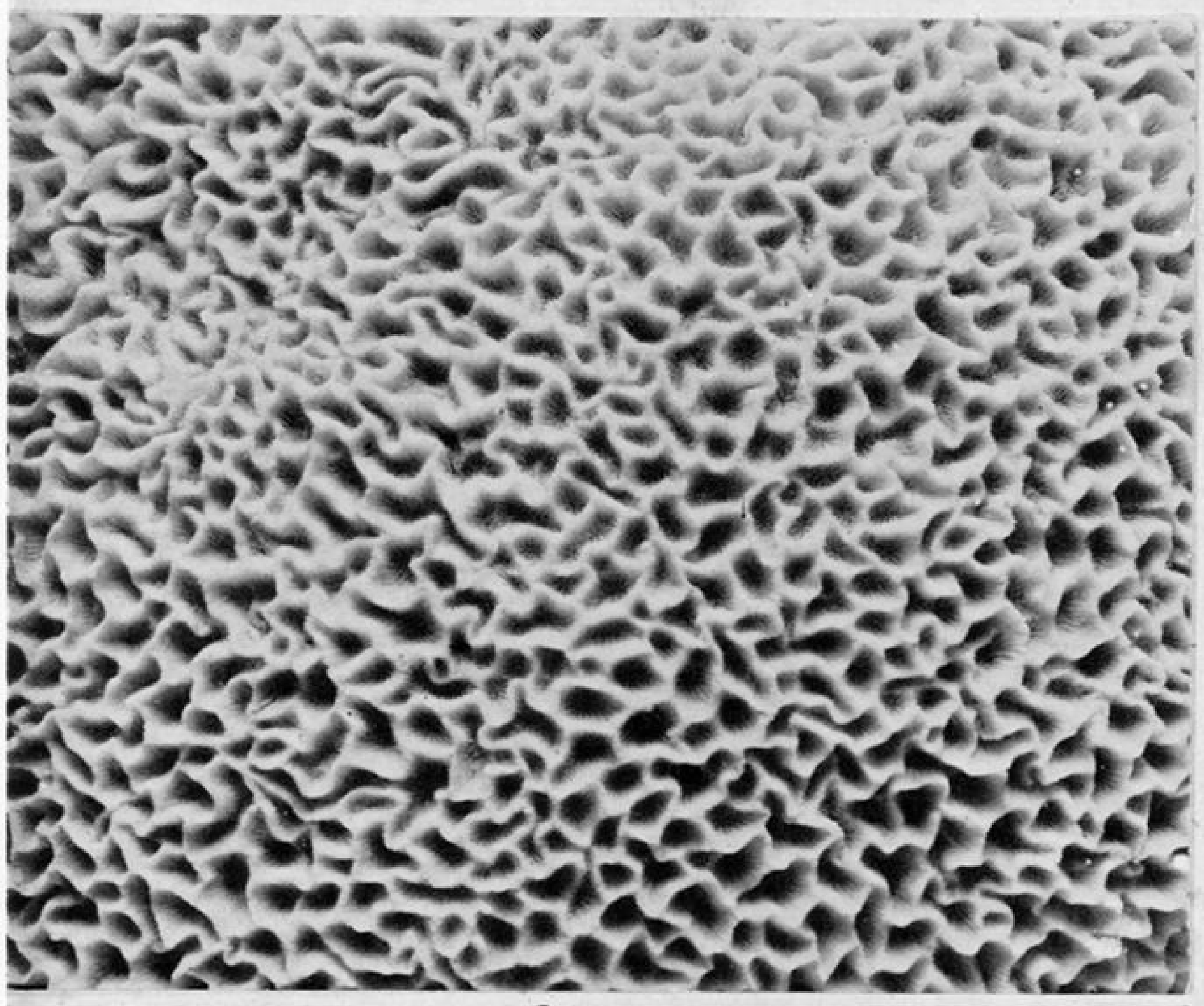

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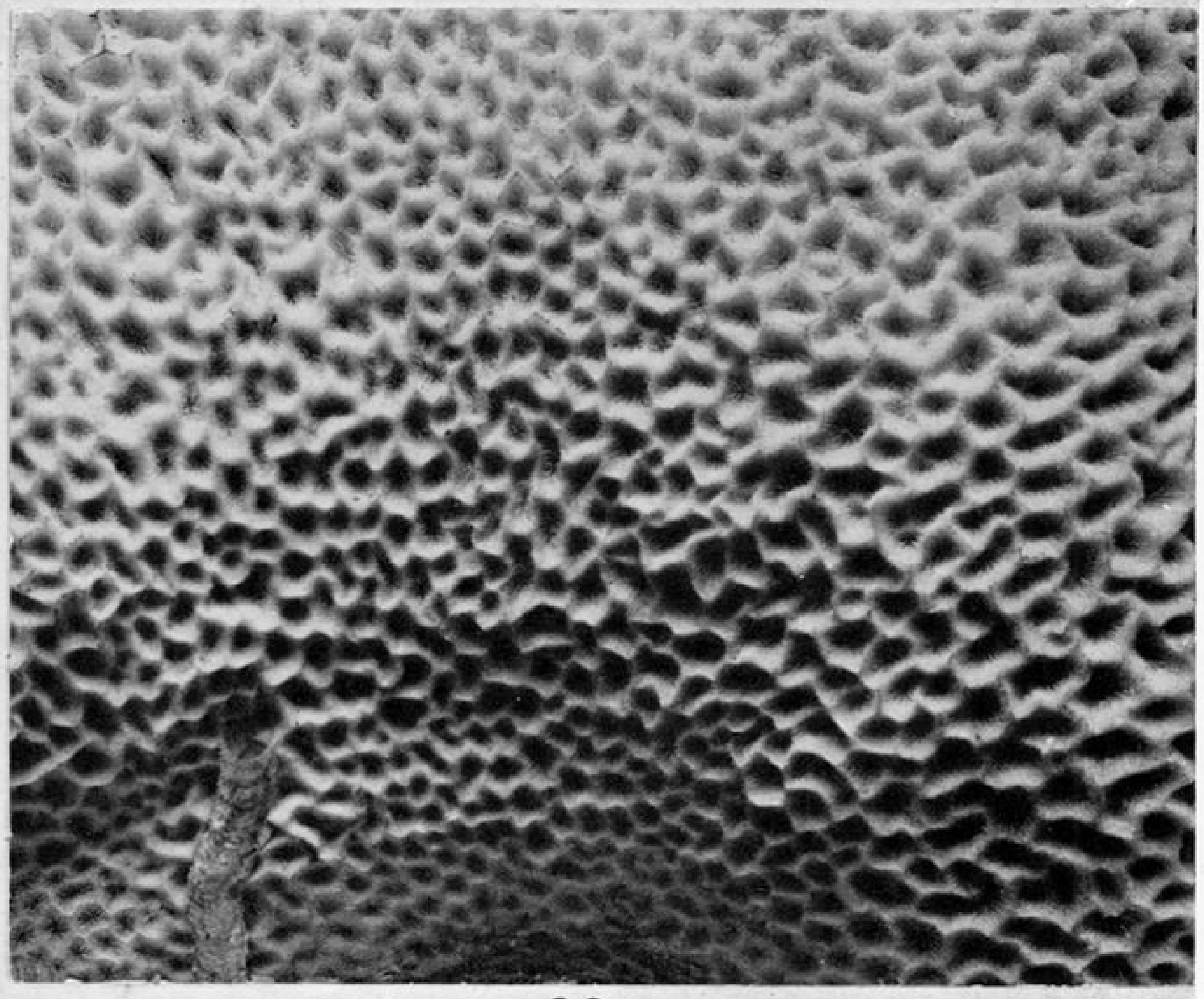

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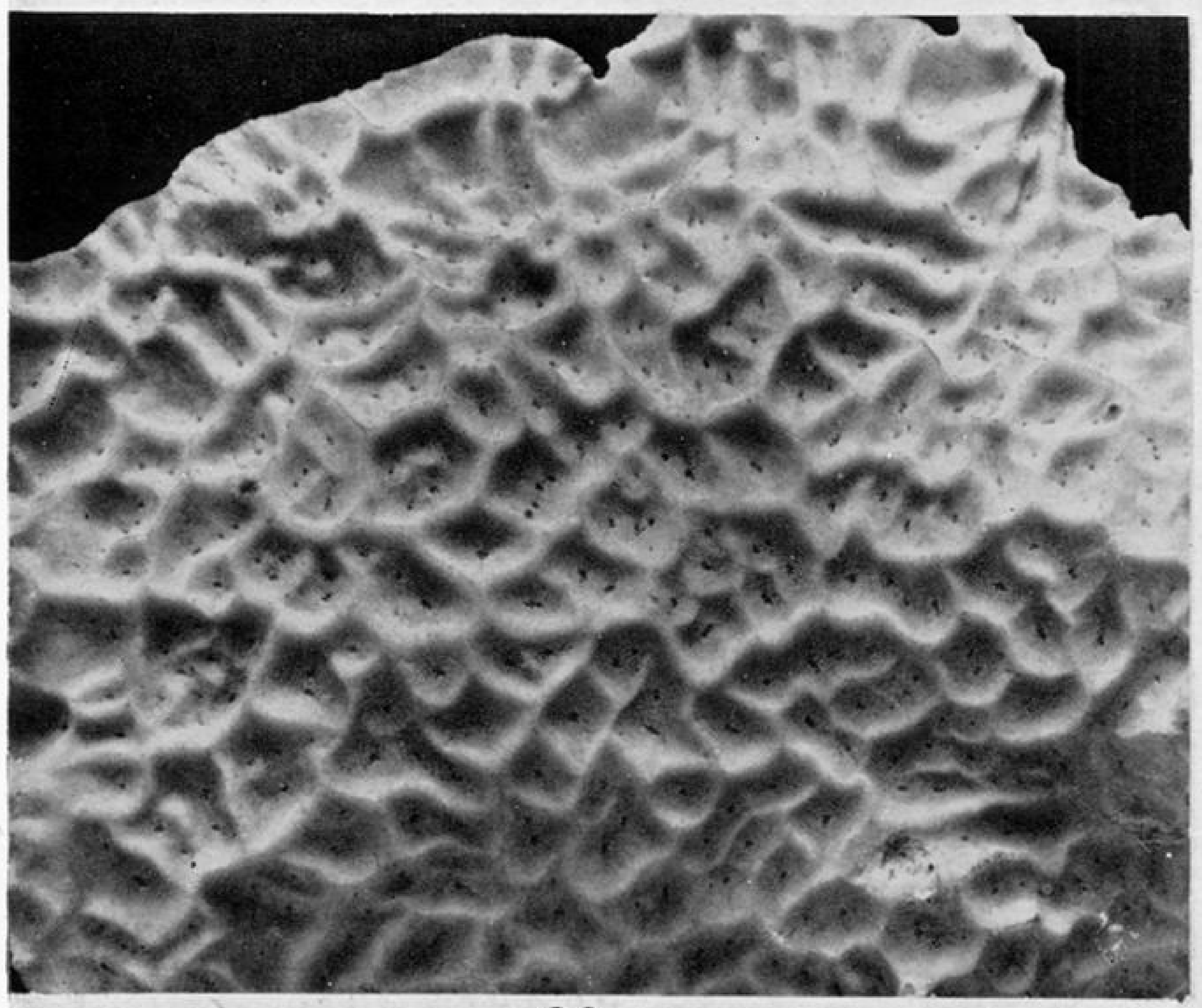

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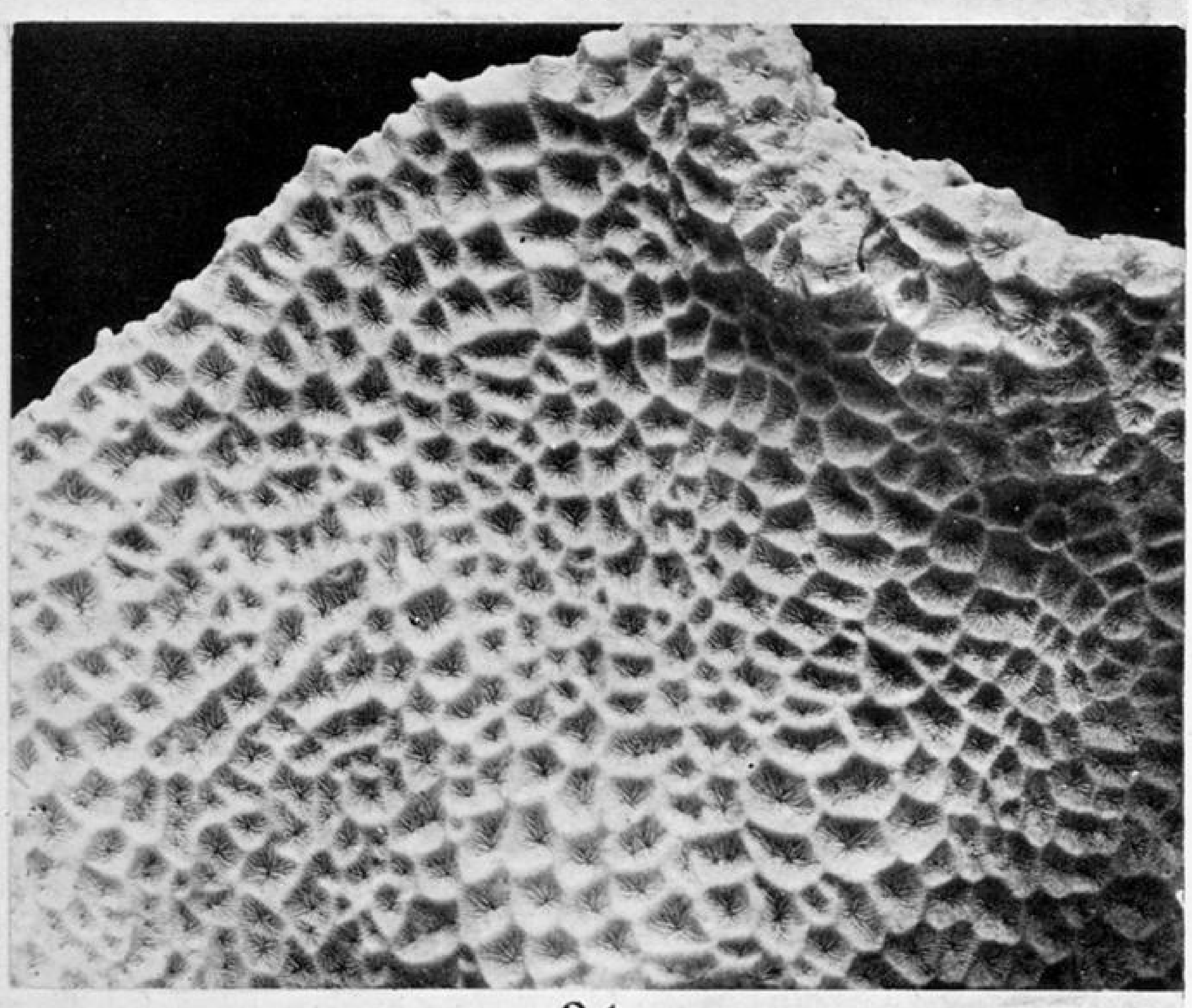

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PLATE 6

FIGURE 18. *Pavona ponderosa* (Gardiner). View of a side of highly convex calicinal surface of an entire heavy corallum showing comparatively large calicinal areas. Height 12 cm., length 15 cm., breadth 12 cm. From Tahiti. Nat. size.

FIGURE 19. *Pavona ponderosa* (Gardiner). View of upper part of above, showing small calicinal areas. Nat. size.

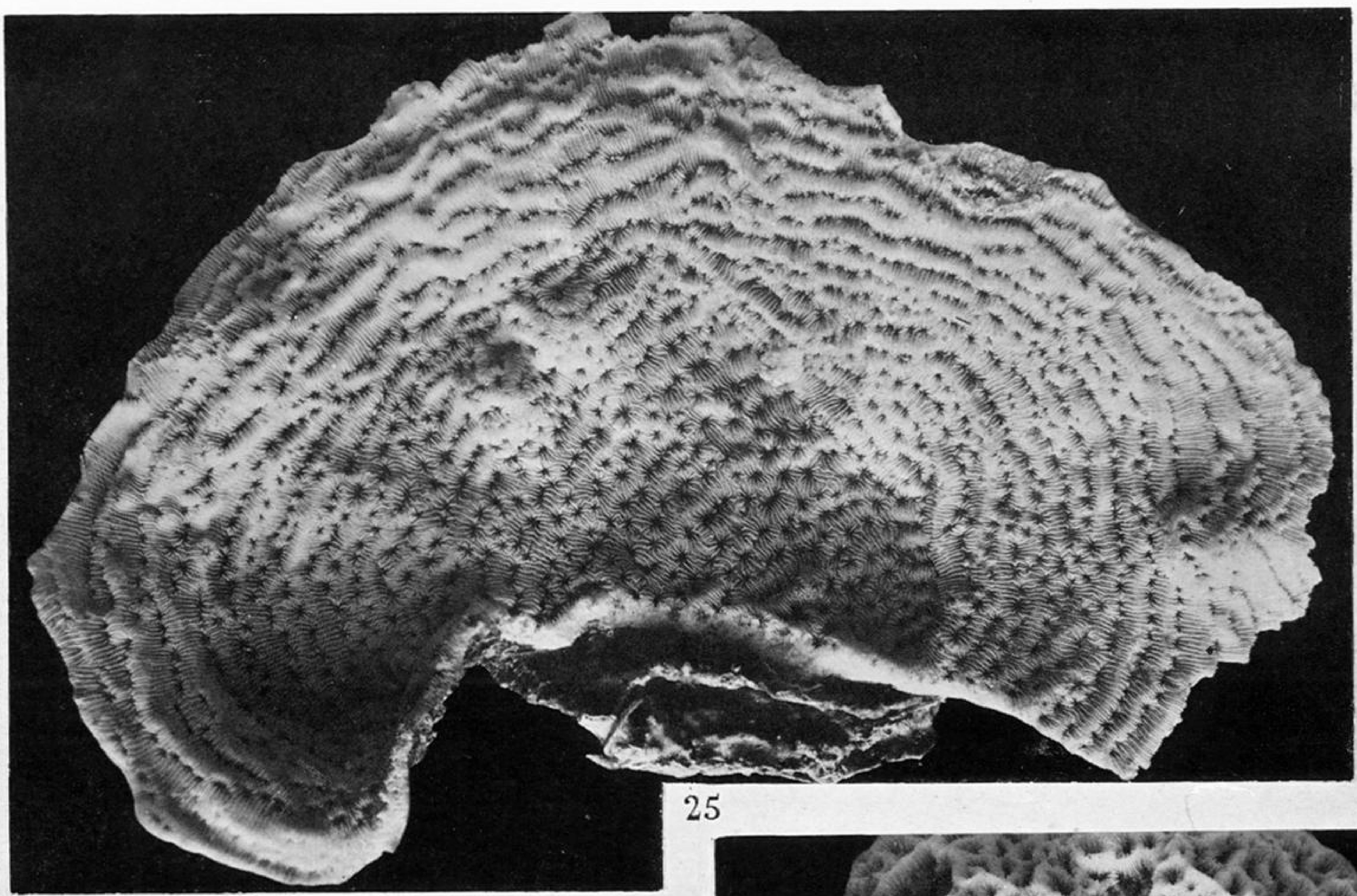
FIGURE 20. *Pavona maldivensis* (Gardiner). View of part of calicinal surface of incrusting corallum, with oblique corallite-walls. Length 9 cm., breadth 3·5 cm. From Tahiti. Nat. size.

FIGURE 21. *Pavona ponderosa* (Gardiner). View of one side of calicinal surface of a heavy massive corallum, showing short sinuous valleys. Height 16·5 cm., length 32 cm., breadth 21 cm. From Tahiti. Nat. size.

FIGURE 22. *Pavona ponderosa* (Gardiner). View of another side of calicinal surface of above, showing distinct corallites. Nat. size.

FIGURE 23. *Pavona ponderosa* (Gardiner). View of part of convex somewhat uneven calicinal surface of a comparatively thin entire corallum, being type of *Agaricia ponderosa* Gardiner. Very short valleys or single calicinal areas formed by intersection of radial and concentric ridges. Concentric arrangement of calicinal areas better seen towards periphery. Non-calicinal surface concave with an excentric scar of attachment. Length 11·5 cm., breadth 8·5 cm. From Minikoi. Nat. size.

FIGURE 24. *Pavona ponderosa* (Gardiner). View of part of calicinal surface of comparatively thin corallum. Single calicinal areas, formed by intersection of radial and concentric ridges, smaller than in above. Length 12 cm., breadth 9 cm. Tahiti. Nat. size.



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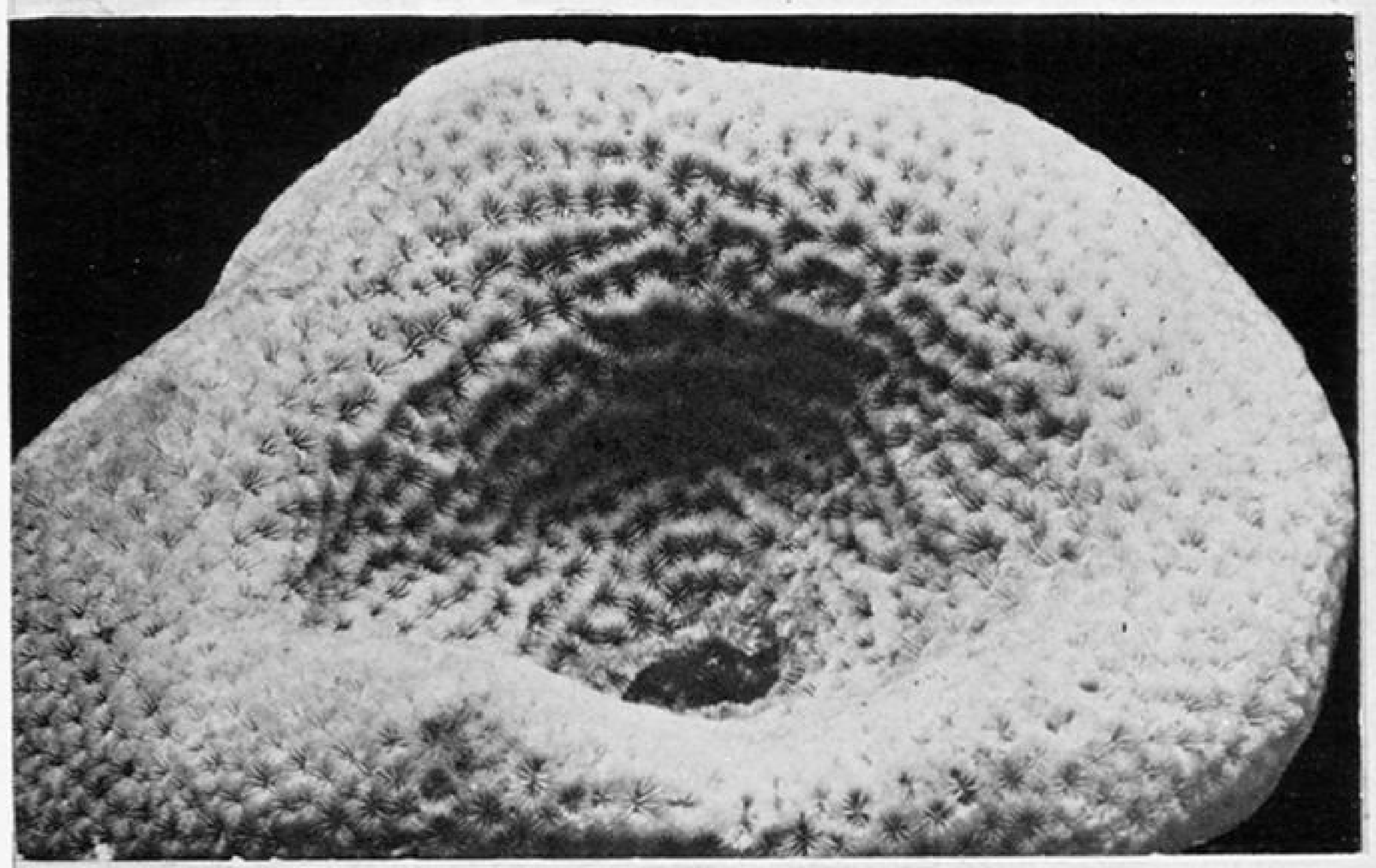

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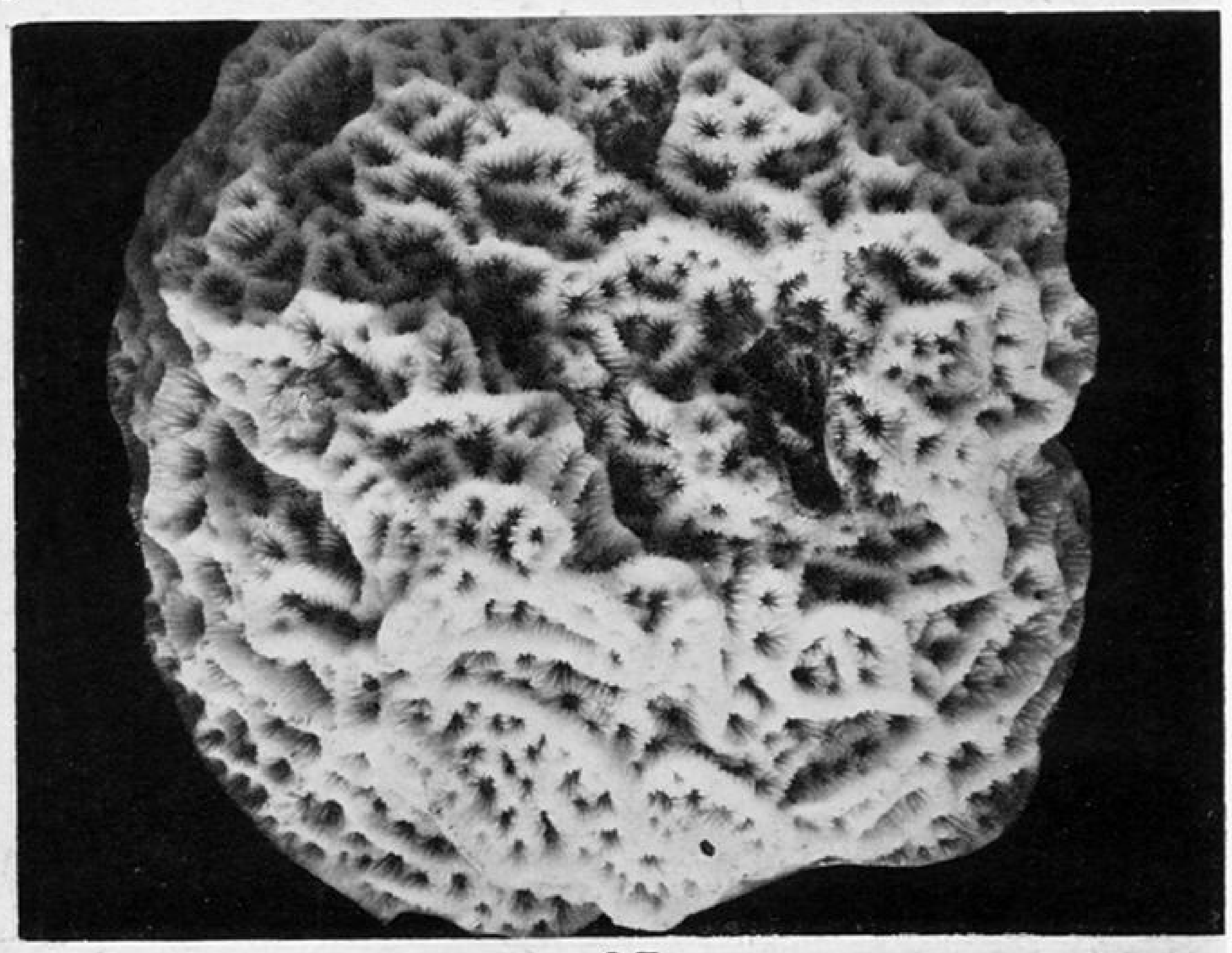

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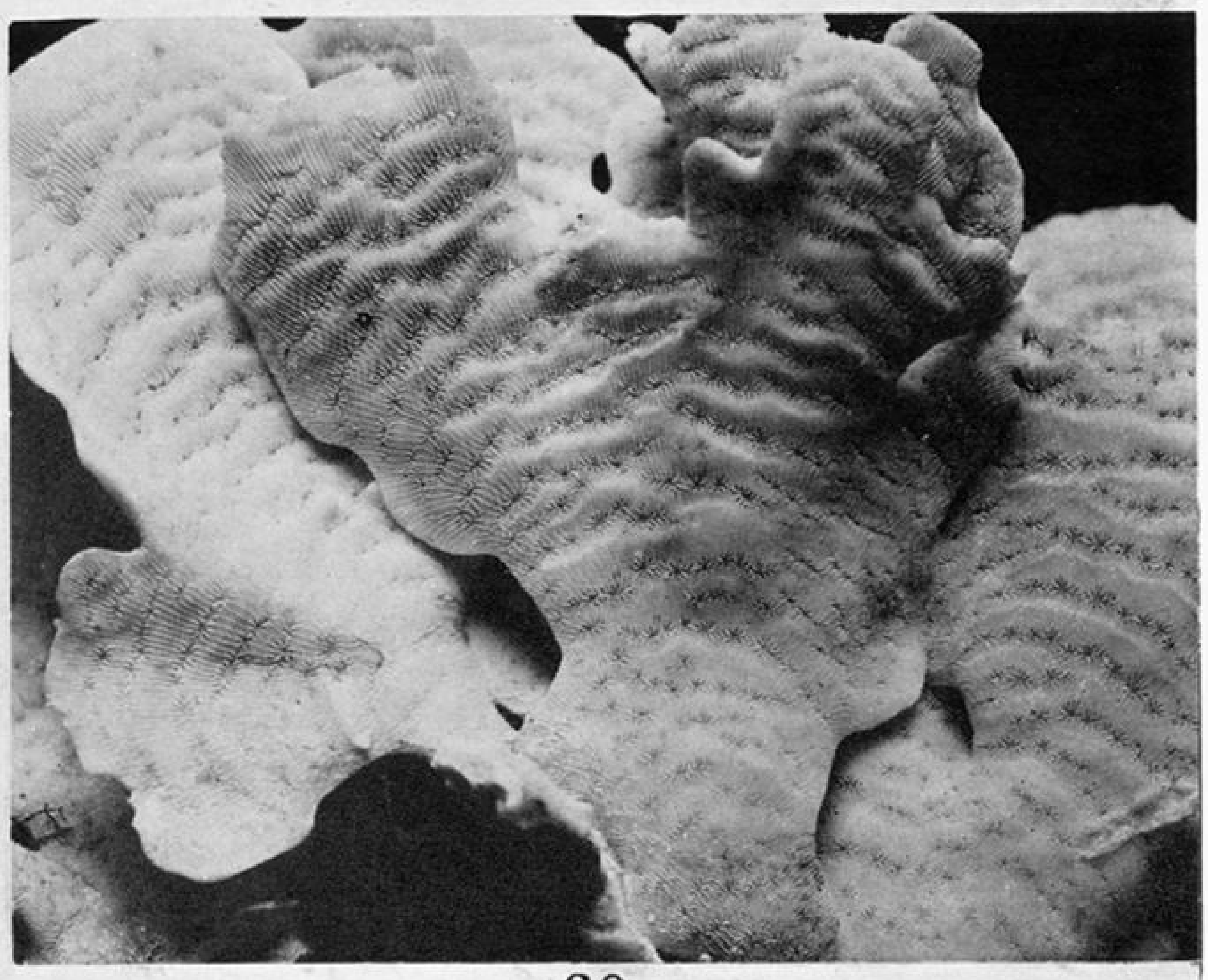

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PLATE 7

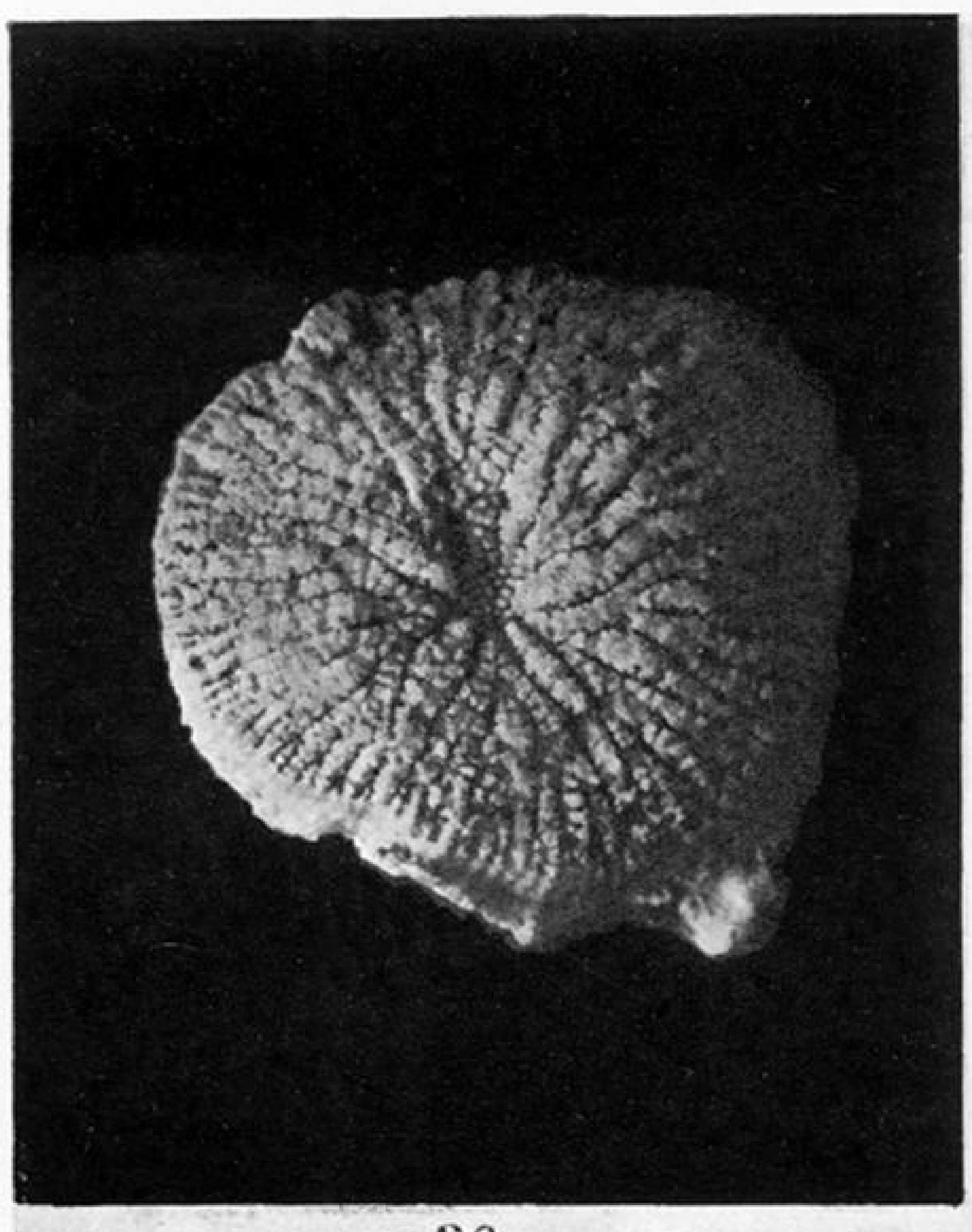
FIGURE 25. *Agaricia agaricites* (Linnaeus). View of somewhat concave calicinal surface of a comparatively thin semicircular corallum, showing concentric arrangement of subsidiary calicinal areas, with concentric ridges connecting proximal sides of their bases. Length 13·5 cm., breadth 9·5 cm. From Bermudas. Nat. size.

FIGURE 26. *Pavona maldivensis* (Gardiner). View of upper part of calicinal surface with depression about 3 cm. deep, showing single calicinal areas formed by intersection of concentric and radial ridges and concentrically arranged. Height 9·5 cm., length 8 cm., breadth 6 cm. From Hulule, Maldives. Nat. size.

FIGURE 27. *Agaricia agaricites* (Linnaeus) var. *purpurea*. View of somewhat convex calicinal surface of corallum, with radial ridges intersecting concentric ridges, thus forming single corallites and short valleys. Non-calicinal surface somewhat concave, with central scar of attachment. Height 2 cm. length 6·5 cm., breadth 6 cm. From Tortugas. Nat. size.

FIGURE 28. *Pavona cactus* (Forskål). View of calicinal surface, on one side, of two broad comparatively thick vertical fronds, showing calicinal areas arranged in concentric rows, without concentric or radial ridges. Height 12 cm., length 12 cm., breadth 5 cm. From Faar Flats, Tahiti. Nat. size.

FIGURE 29. *Pavona cactus* (Forskål). View of calicinal surface, on one side, of vertical fronds, showing concentric ridges at proximal sides of calicinal rows, parts of two or three concentric ridges rising into low crests, and commencement of faint radial ridges at bases of fronds. Height 9 cm., length 13 cm., breadth 6 cm. From Pa'ea, Tahiti. Nat. size.



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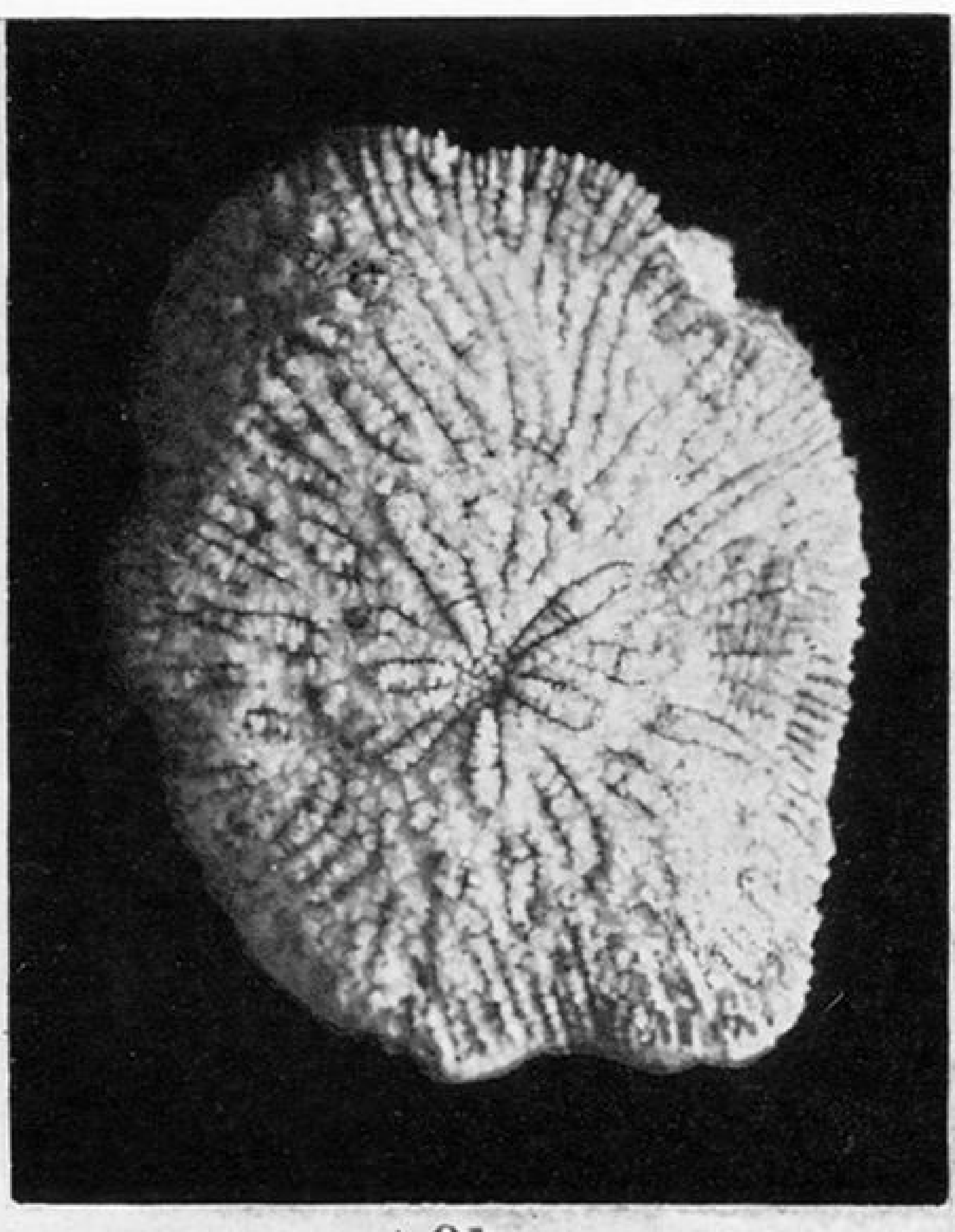

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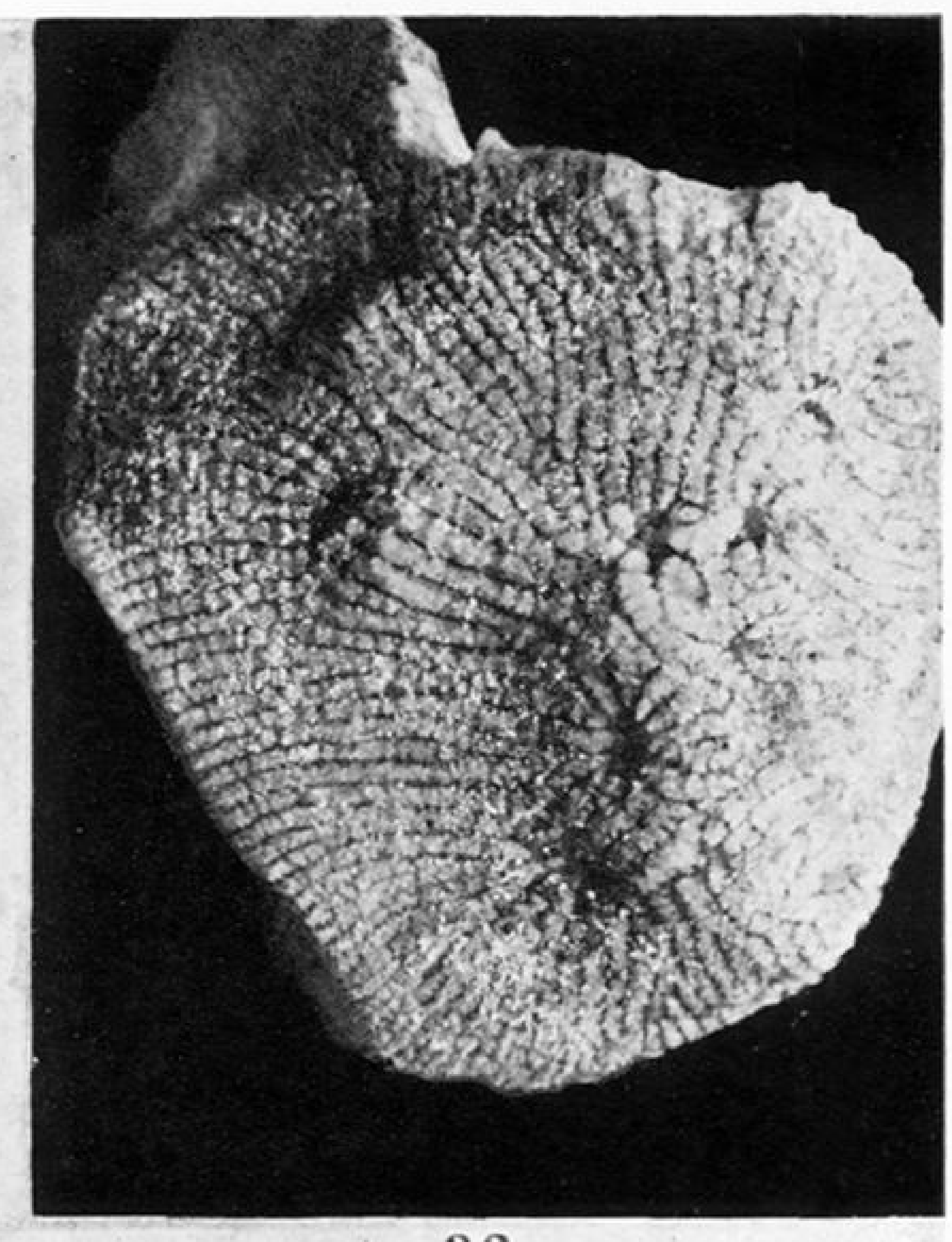

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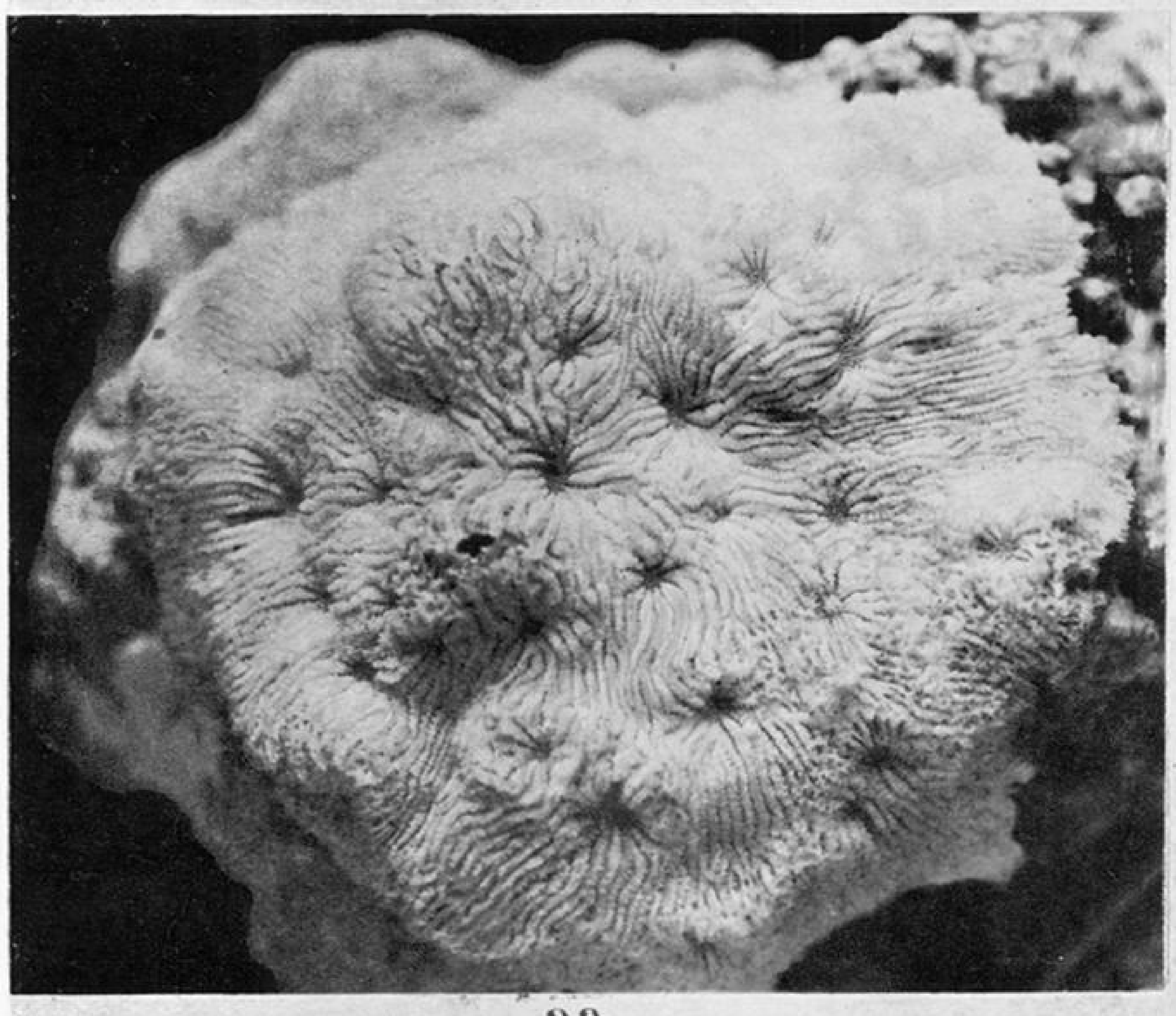

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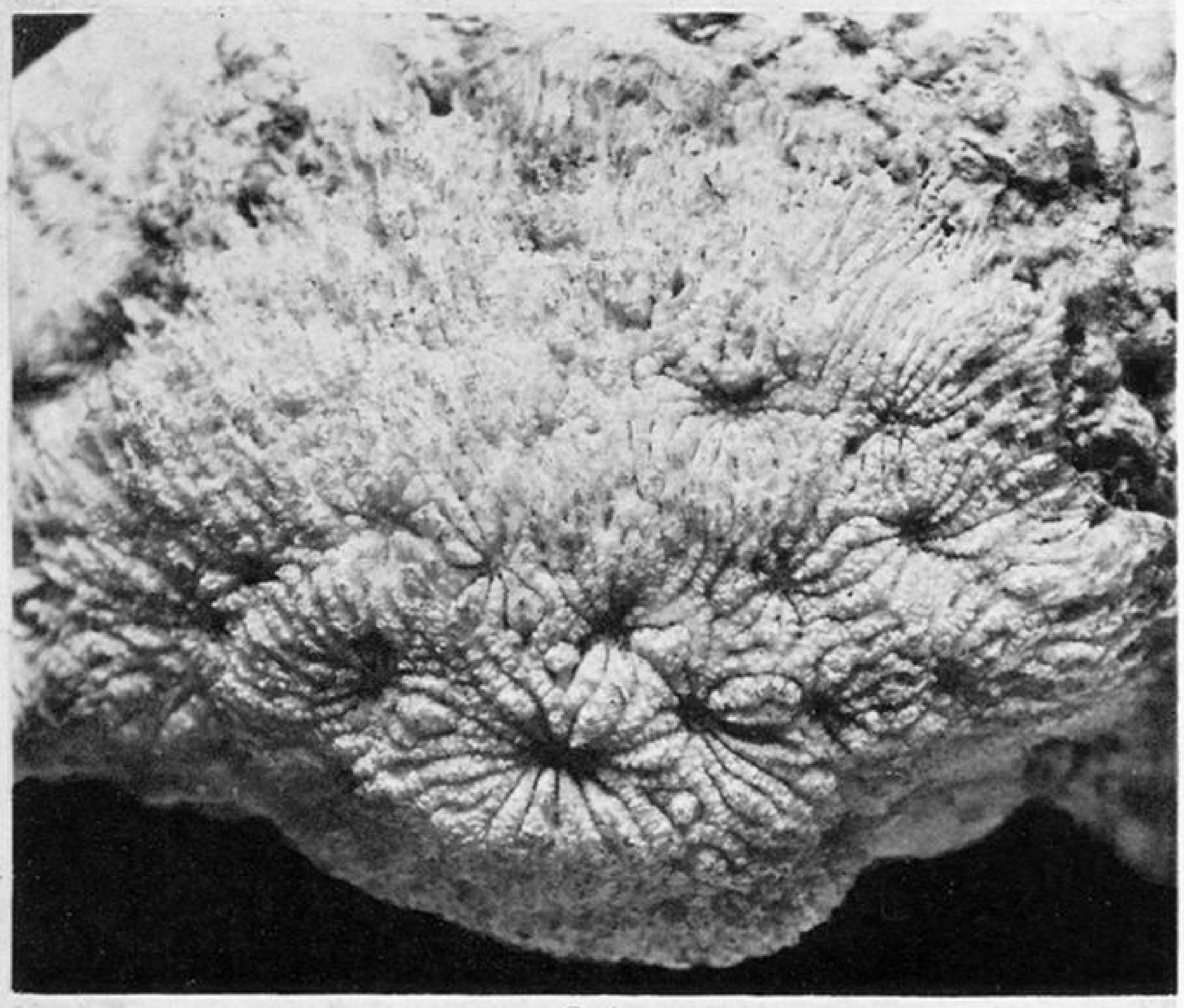

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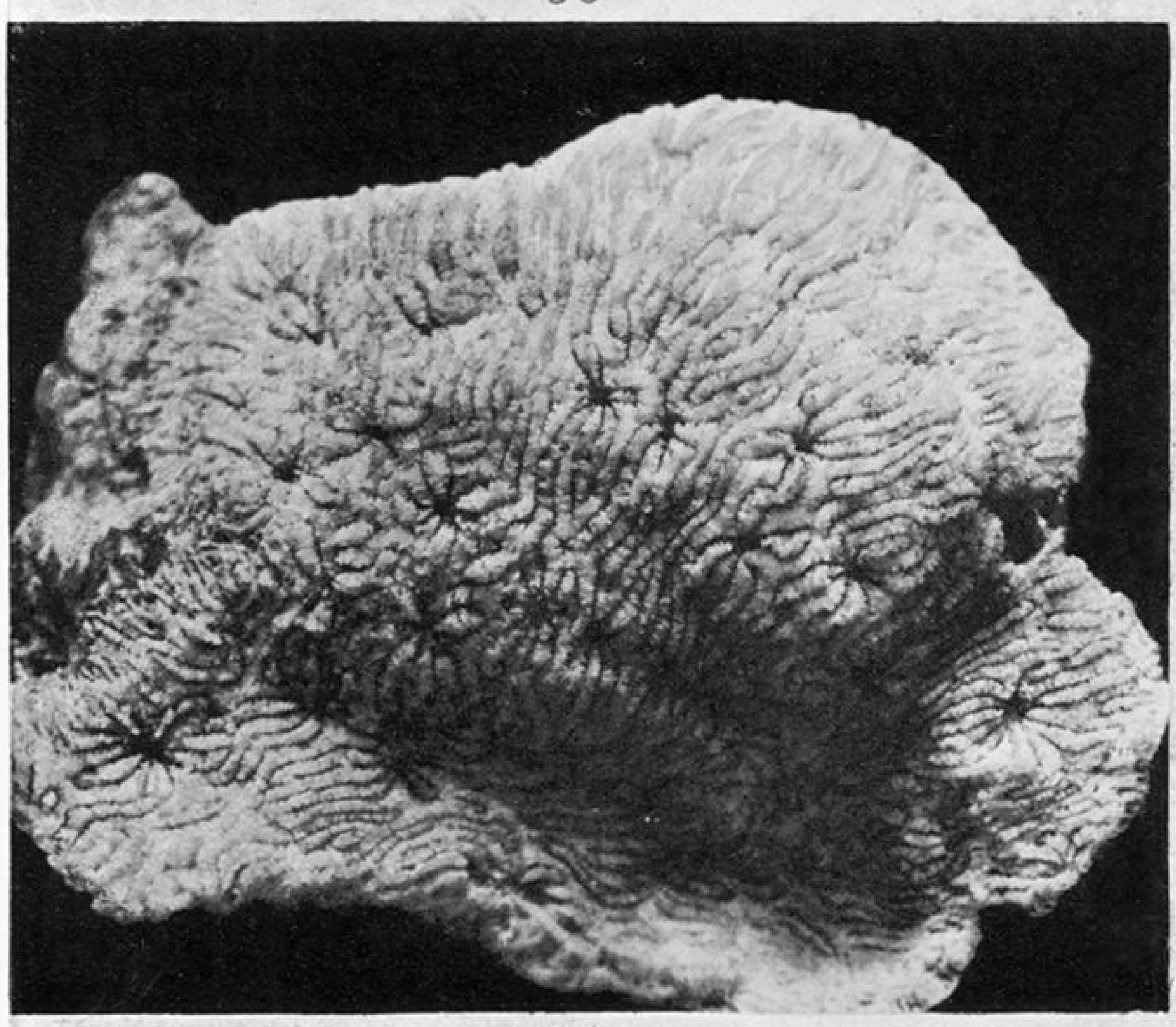

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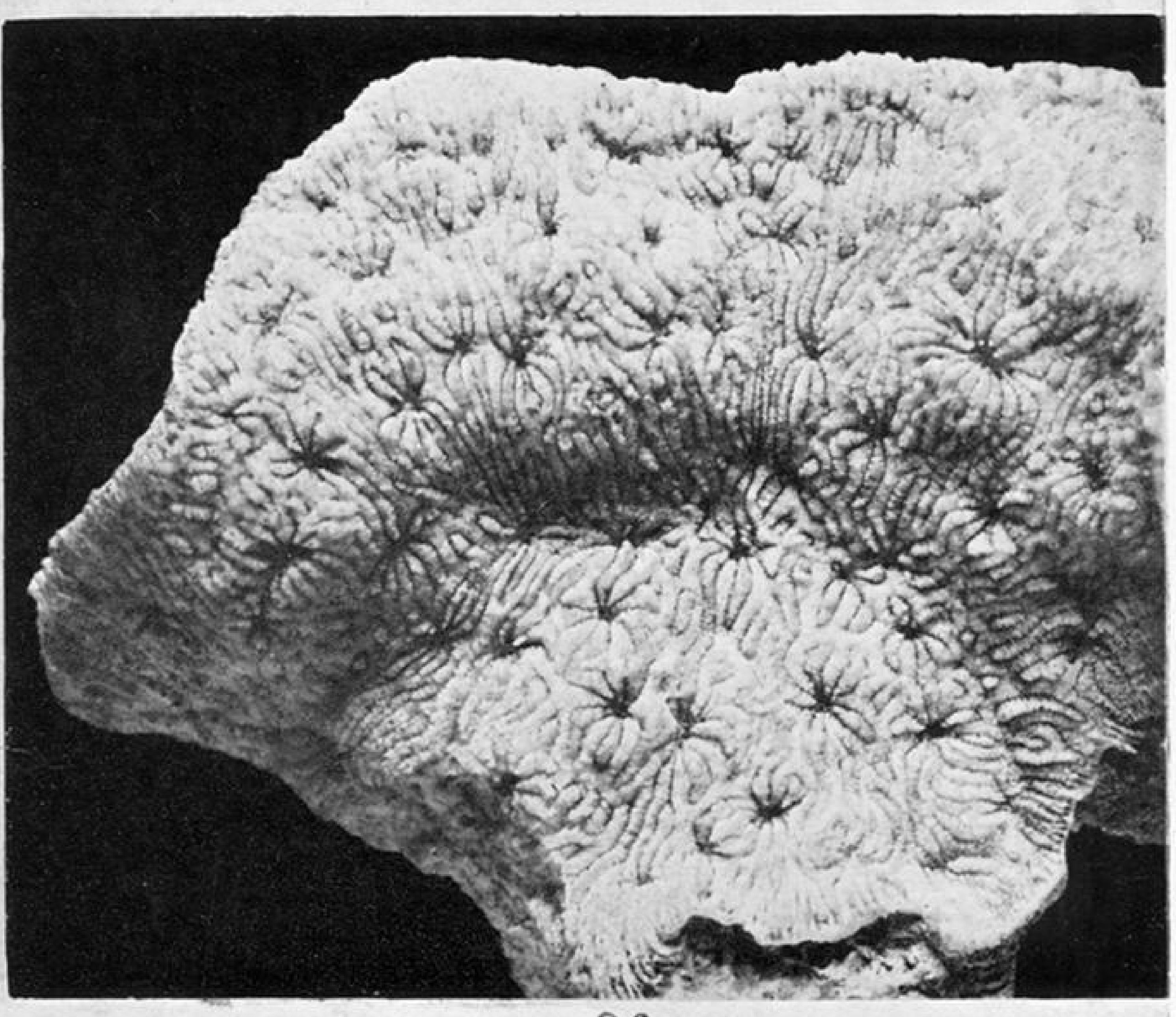

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PLATE 8

Enlarged views of calicinal surface of successive growth-stages of *Coscinaraea monile* (Forskål).

FIGURE 30. Slightly convex calicinal surface, with only the primary calicinal area. Non-calicinal surface somewhat concave, with central scar of attachment. Diameters 1 × 1 cm. From Felidu, Maldives, 20 to 25 fathoms. × 4.

FIGURE 31. Somewhat convex calicinal surface, showing slightly excentric primary calicinal area, surrounded by incipient subsidiary calicinal areas. Non-calicinal surface somewhat concave, with a scar of attachment opposite primary calicinal area. Diameters 1·5 × 1·1 cm. From Mahlos. × 4.

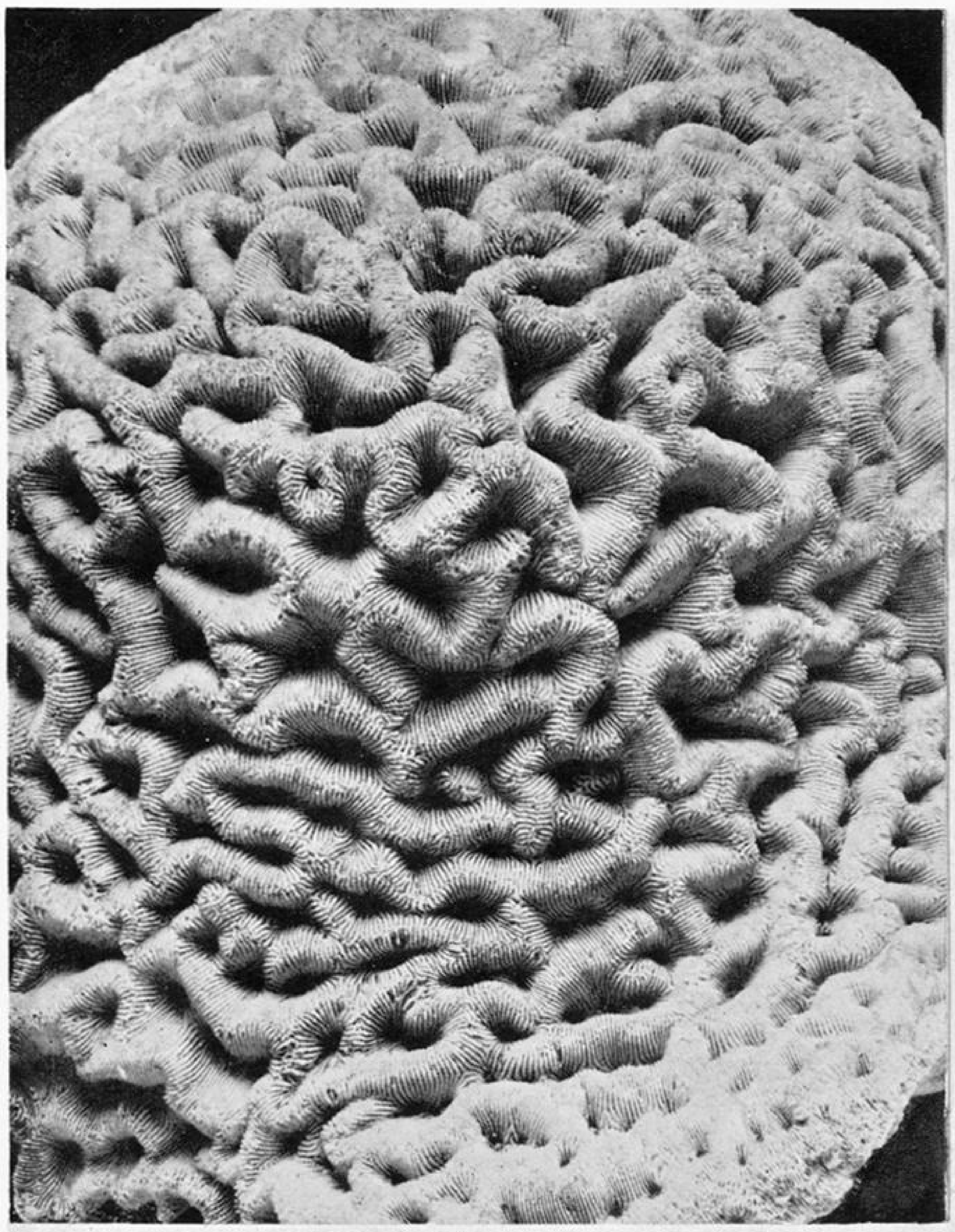
FIGURE 32. Convex calicinal surface, with excentric primary calicinal area surrounded by a few subsidiary calicinal areas. Non-calicinal surface more or less concave. Diameters 1·7 × 1·4 cm. From Felidu, Maldives. × 4.

FIGURE 33. Convex calicinal surface of incrusting corallum, with almost central primary calicinal area surrounded by three concentric circles of somewhat smaller subsidiary calicinal areas. Diameters 3 × 3 cm. From Amirante, < 25 fathoms. × 2.

FIGURE 34. Convex calicinal surface of incrusting corallum, with greater distal growth. Corallum slightly but evenly upraised around primary calicinal area, subsidiary calicinal areas arranged concentrically, a few subsidiary calicinal areas appearing to be somewhat oblique owing to slight upraising of corallum on their proximal side. Diameters 2·5 × 1·8 cm. From Suvadiva. × $3\frac{1}{2}$.

FIGURE 35. Unevenly convex calicinal surface, with inconspicuous primary calicinal area and subsidiary calicinal areas arranged more or less concentrically. Non-calicinal surface concave, without stalk of attachment. Diameters 3·5 × 2·9 cm. From S. Male. × $2\frac{1}{2}$.

FIGURE 36. Somewhat concave calicinal surface of comparatively thin corallum, with greater distal growth, inconspicuous primary calicinal area, calicinal areas arranged more or less concentrically, a few calicinal areas appearing to be oblique owing to slight upraising of corallum on their proximal side. Non-calicinal surface with a short excentric stalk of attachment. Diameters 4·7 × 4 cm. From Suvadiva. × 2.



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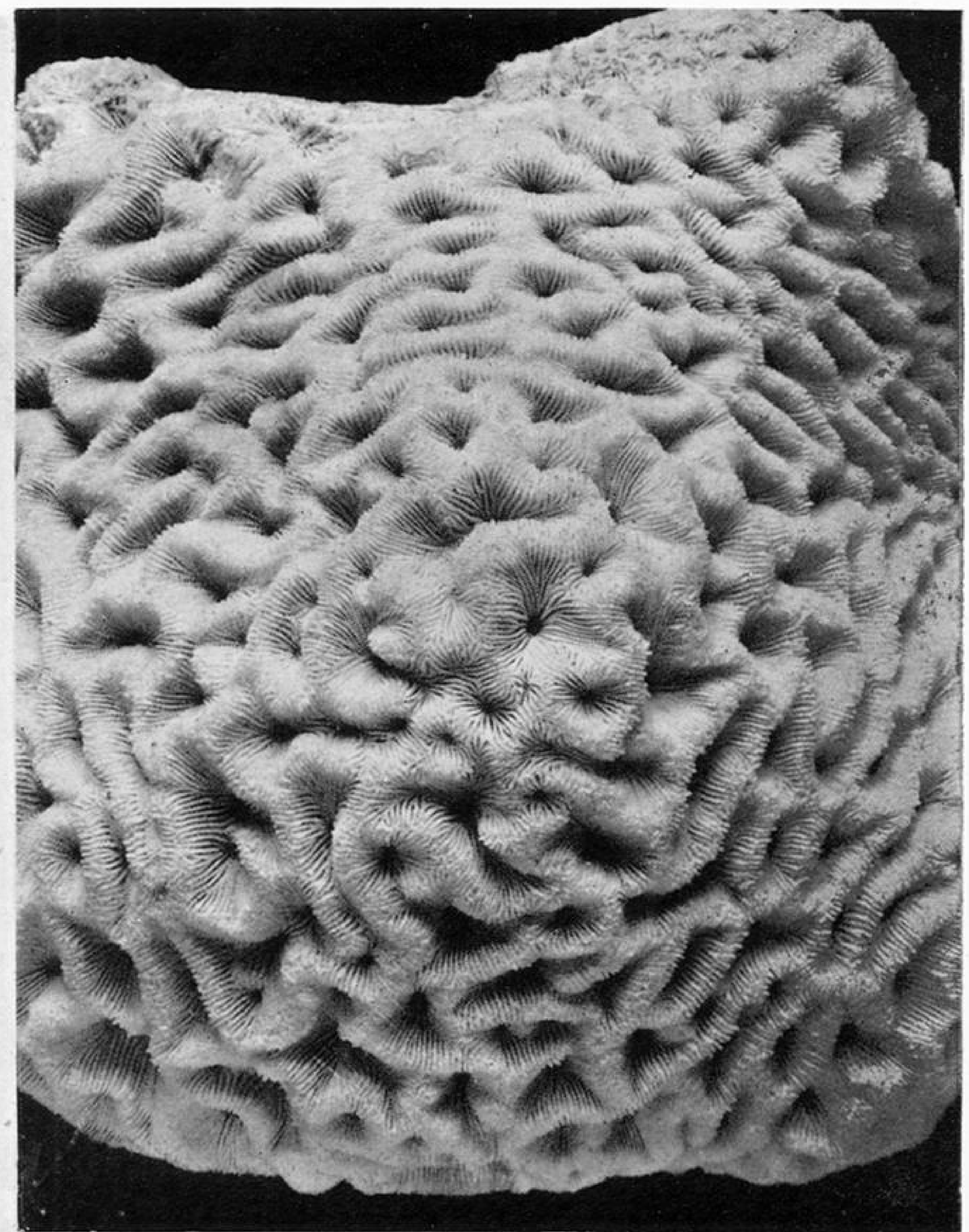

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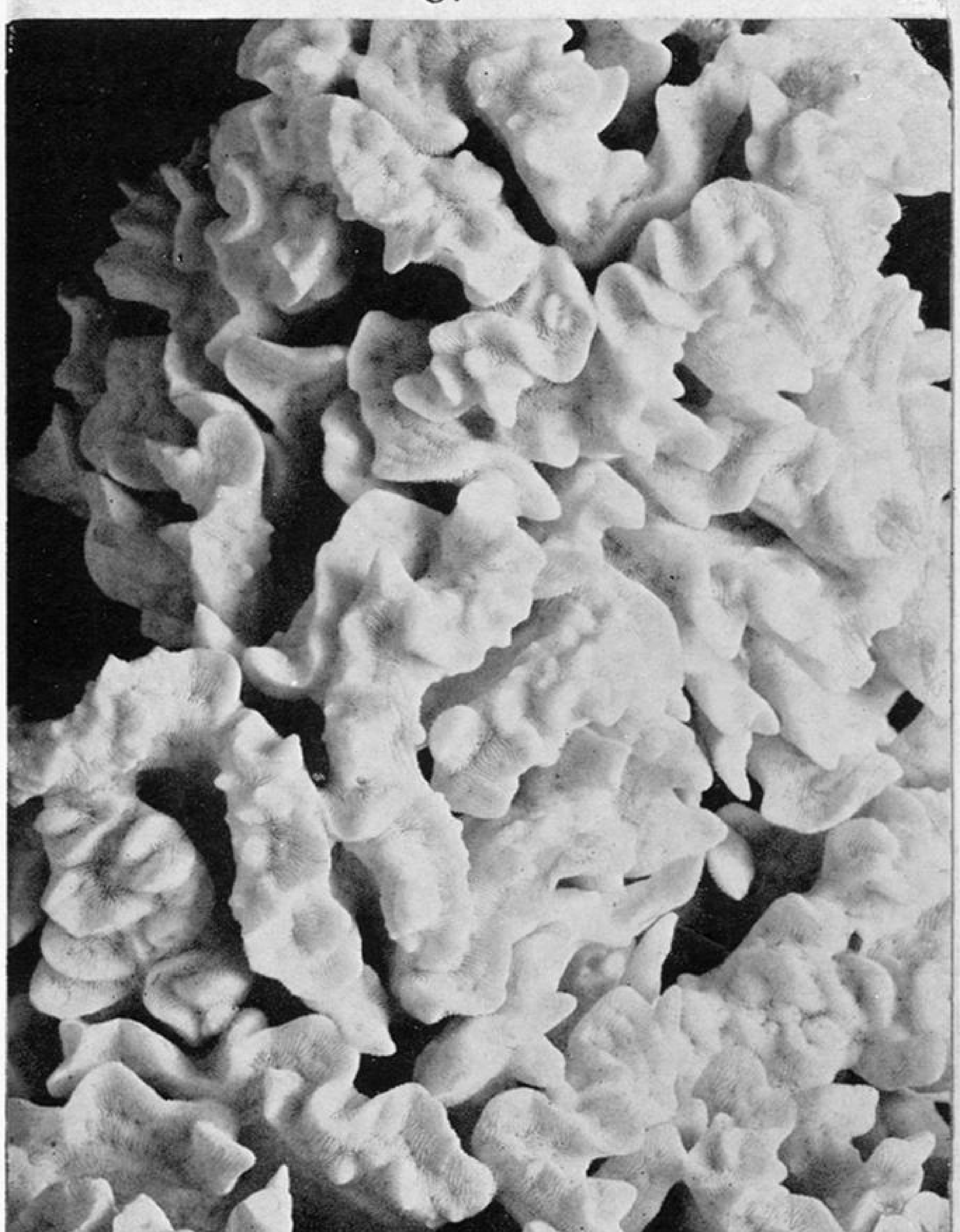

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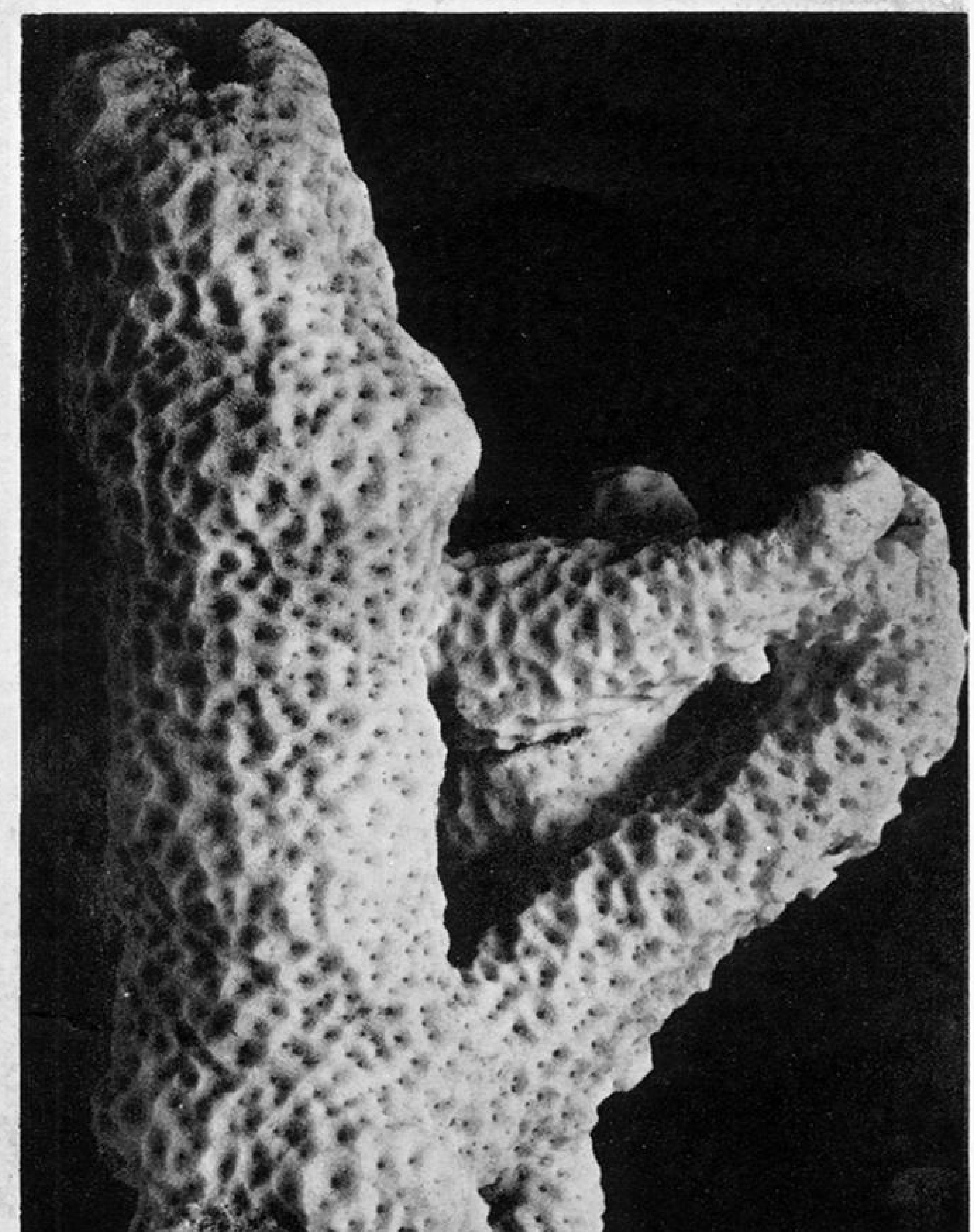

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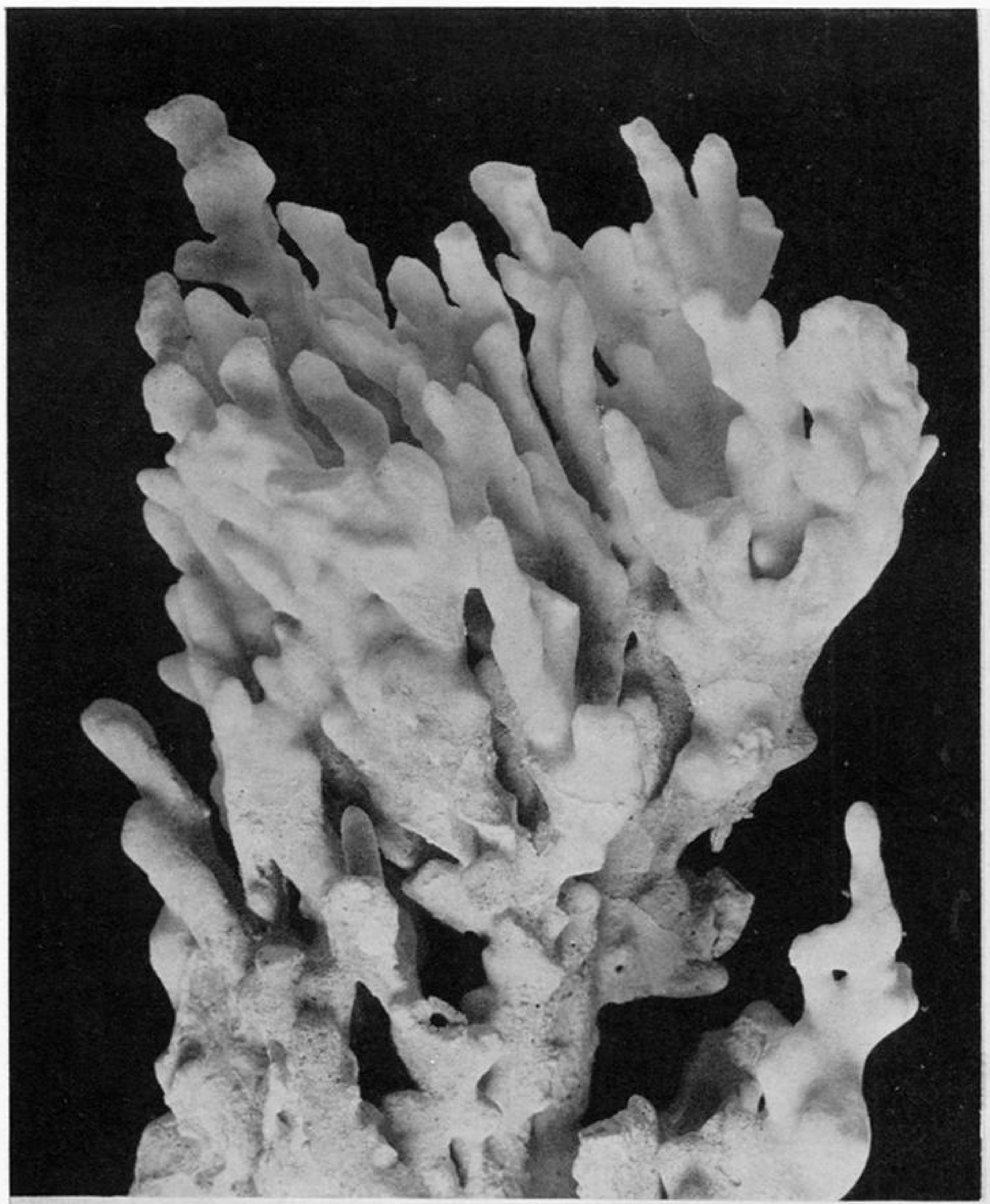
PLATE 9

FIGURE 37. *Coscinaraea monile* (Forskål). View of calicinal surface on one side of dome-shaped heavy corallum, with short sinuous comparatively deep valleys and a few single corallites. Concentric arrangement noticeable only at periphery. Height 9 cm., length 18 cm., breadth 16 cm. From Donganab, Red Sea. Nat. size.

FIGURE 38. *Coscinaraea monile* (Forskål). View of convex calicinal surface on top of heavy corallum, with short sinuous valleys and single corallites somewhat concentrically arranged. Height 6 cm., length 14 cm., breadth 12 cm. From Harbour Reef, Ghardaqa, Red Sea. Nat. size.

FIGURE 39. *Pavona cactus* (Forskål). View of part of heavy foliate corallum, with a somewhat unique appearance owing to foliae being sinuous, grooved above and fusing in places, and carinae towards the periphery. Height 12 cm., length 26 cm., breadth 15·5 cm. From Papeari, Tahiti. Nat. size.

FIGURE 40. *Psammocora haimiana* Milne Edwards and Haime. View of part of incrusting corallum on another branching dead corallum, with numerous five- to six-sided single corallites, simulating *Pavona ponderosa* facies, and very few short valleys. Length 19 cm., breadth 7 cm. From Shore Reef edge, Papeari, Tahiti. Nat. size.



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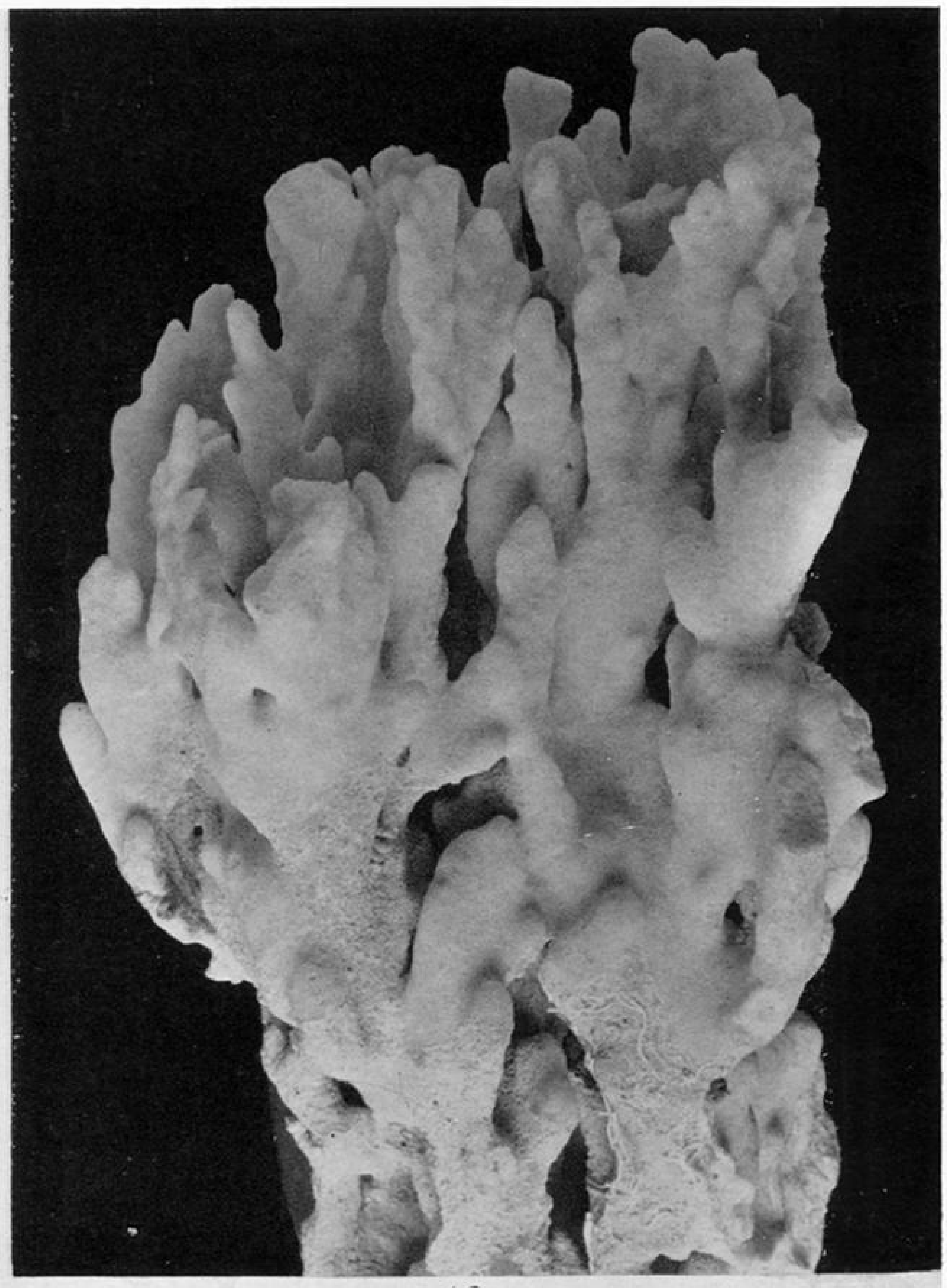

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PLATE 10

FIGURES 41 and 42. *Psammocora contigua* (Esper.). Side views of two coralla composed of narrow vertical branching foliae crowded together with secondary fusions. Height 14 cm., breadth 7 cm. Both from a hole about 3 ft. deep in Shore reef, Pa'ea, Tahiti. Nat. size.

FIGURE 43. *Psammocora contigua* (Esper.). General view of large corallum composed of vertical foliae, broader than in figures 41 and 42, with secondary fusions here and there, and Hydnophoroid facies occurring in parts. Height 16 cm., length 21 cm., breadth 17 cm. From Inshore coral beds, Pa'ea, Tahiti. Nat. size.

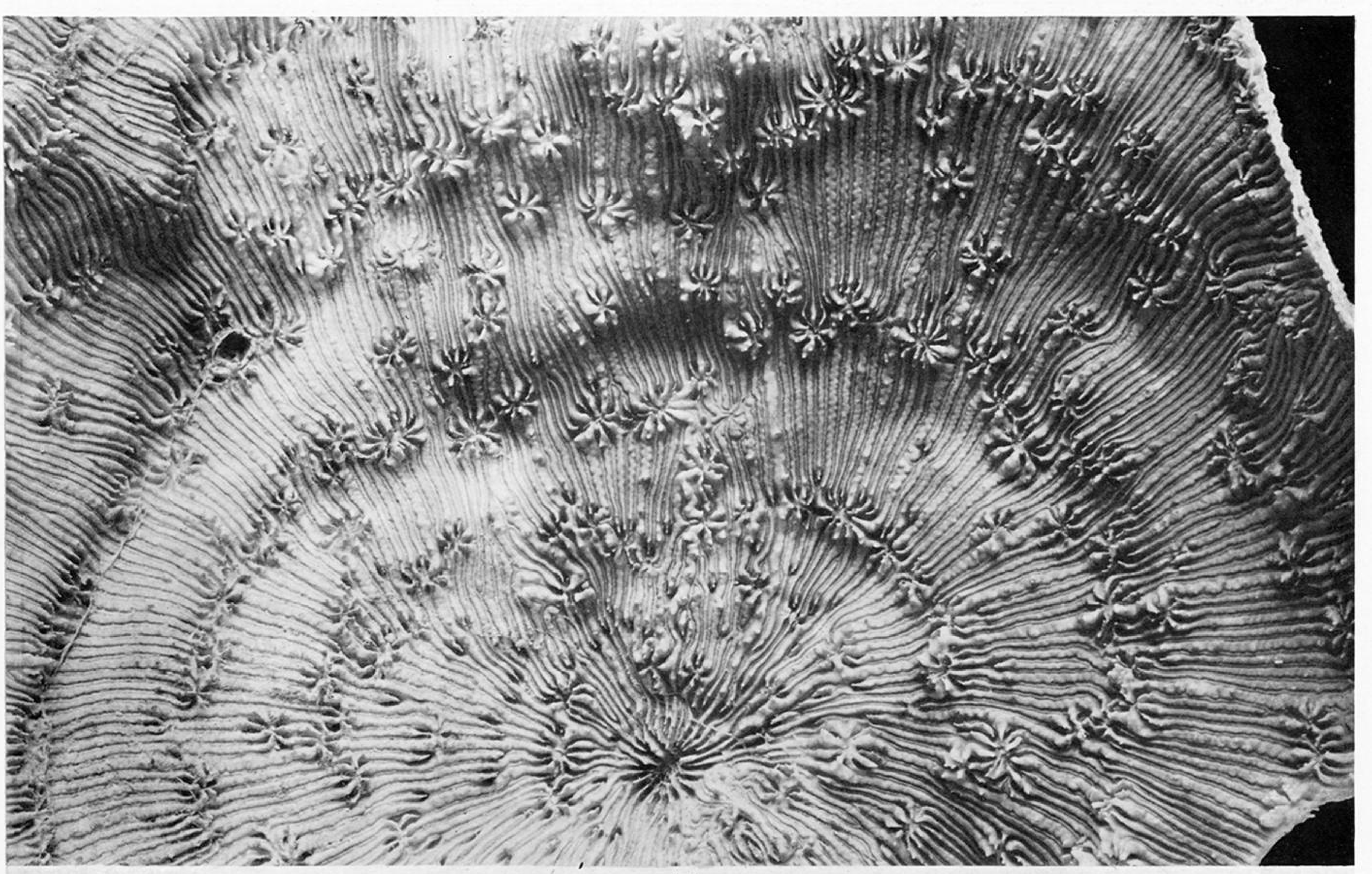

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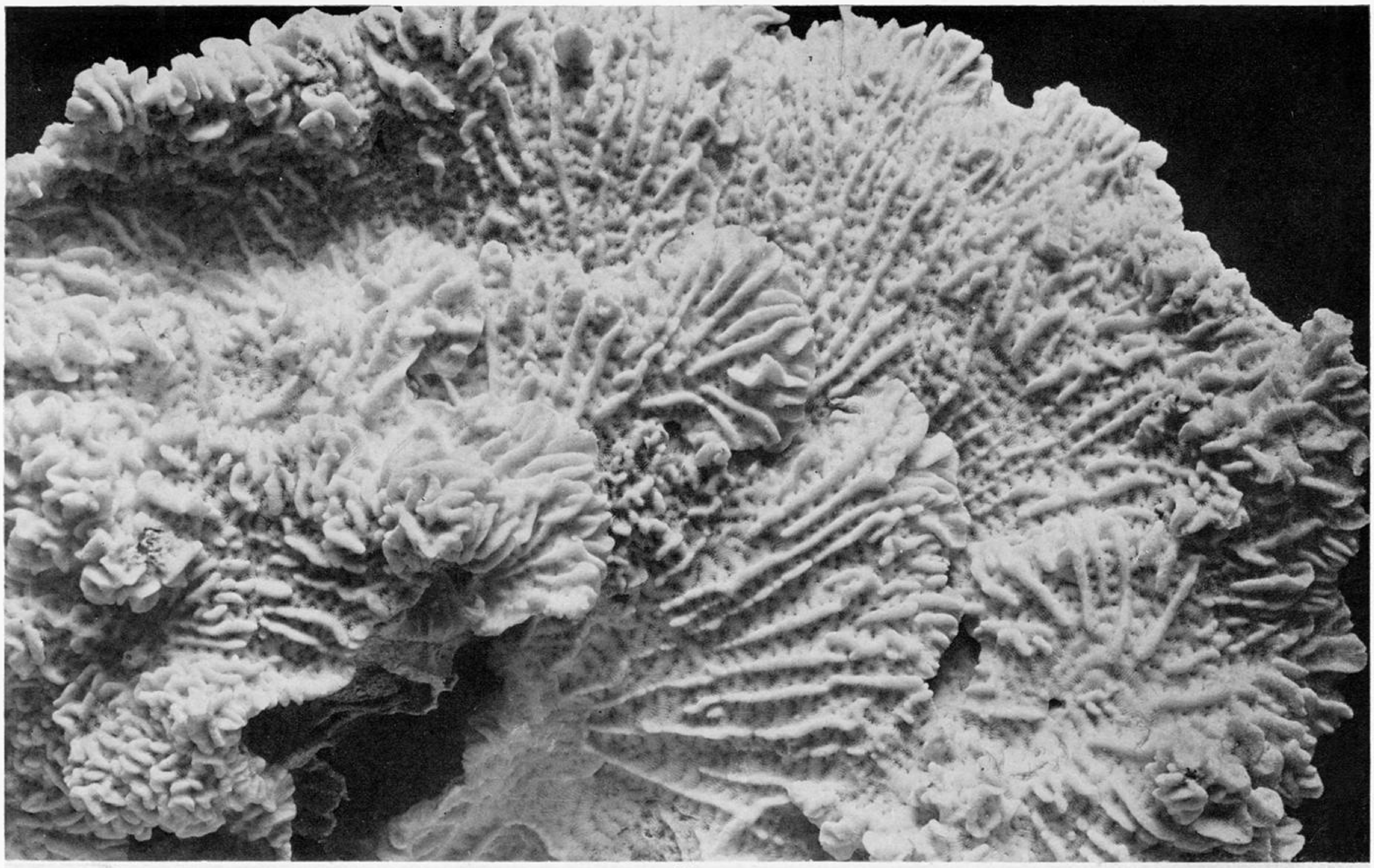
PLATE 11

FIGURE 44. *Echinophyllia aspera* (Ellis and Solander). View of concave calicinal surface of thin corallum, with excentric primary calicinal area situated proximally, and smaller subsidiary calicinal areas arranged almost concentrically. Non-calicinal surface convex, with excentric short stalk of attachment opposite primary calicinal area. Depth from rim to primary calicinal area 5 cm. Diameters 22 × 21 cm. From Abu Shaar, Ghardaqa, Red Sea, 15 fathoms. Nat. size.

FIGURE 45. *Echinophyllia aspera* (Ellis and Solander). View of slightly concave calicinal surface of thin corallum, much rougher than above, with excentric primary calicinal area situated proximally, and smaller subsidiary calicinal areas arranged more or less concentrically, some of the subsidiary calices appearing to be oblique by union or raised parts of septo-costae on their proximal side, some septo-costae raised into crests. Non-calicinal surface with very excentric short stalk of attachment. Depth from rim to primary calicinal area 5 cm., diameters 18 × 14·5 cm. Nat. size.



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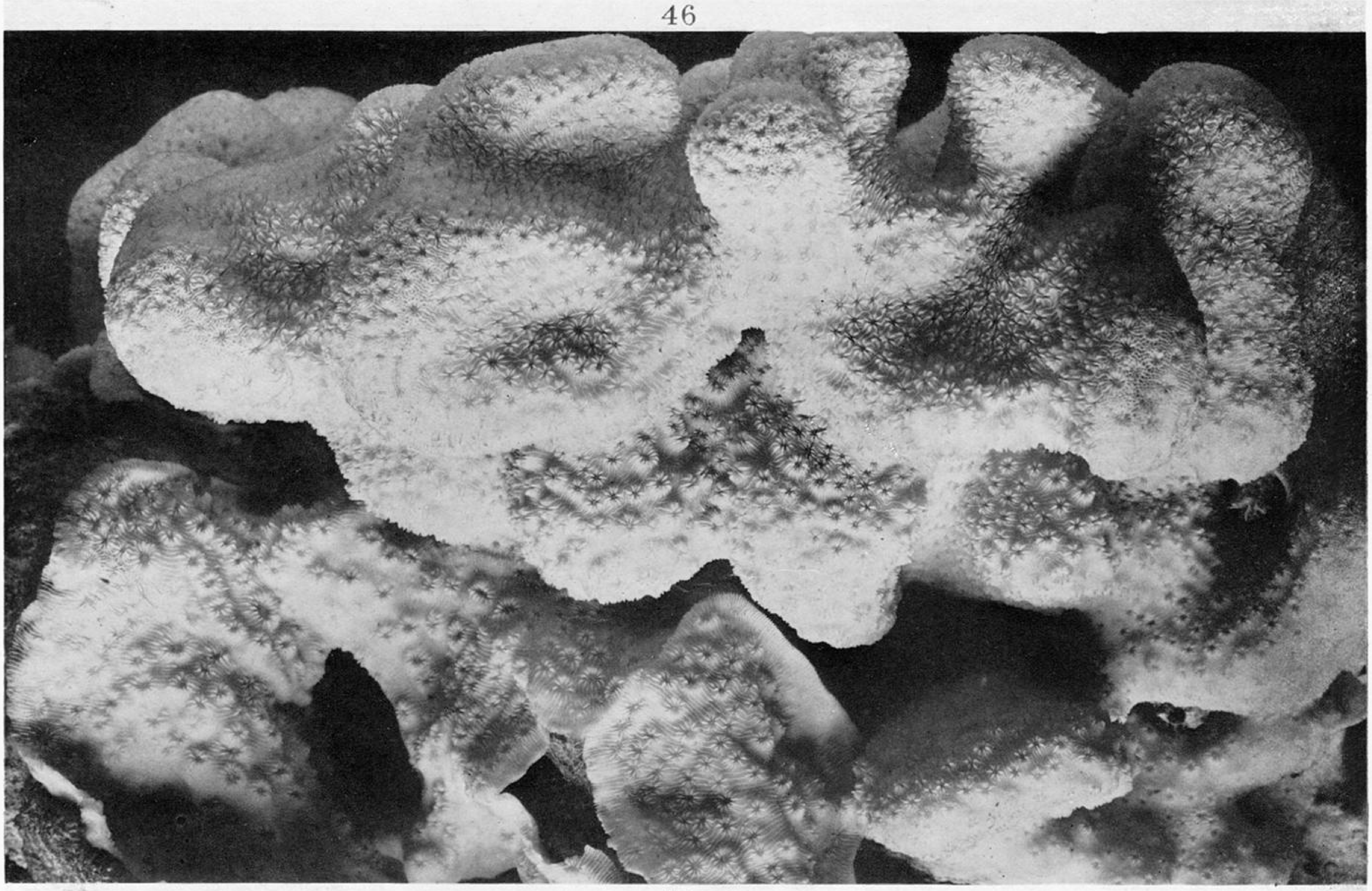

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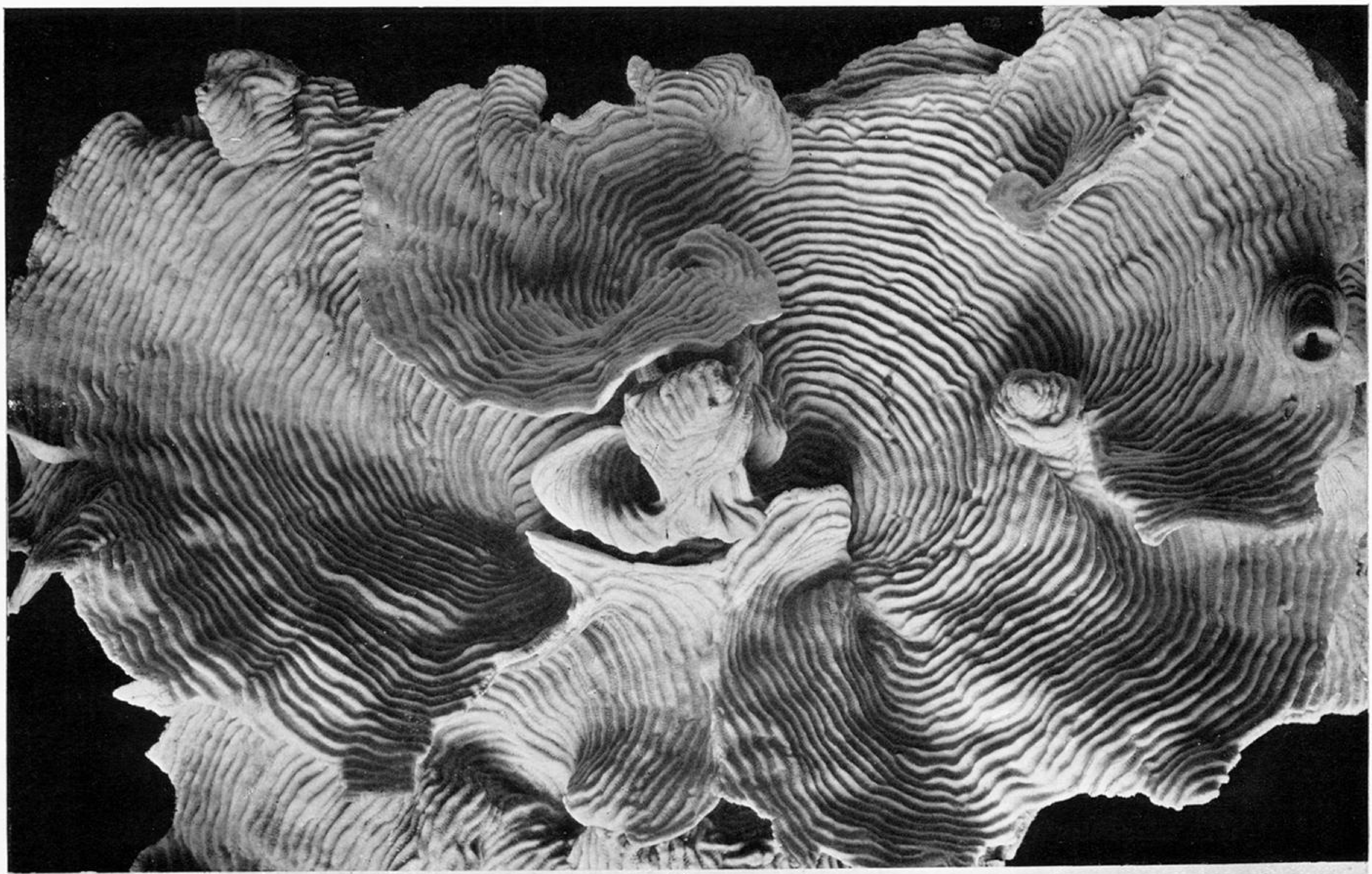
PLATE 12

FIGURE 46. *Pavona varians* (Verrill). View of uneven calicinal surface of corallum composed of a thin basal folia rising into low hillocks with *Merulina ampliata* facies, both continuous and discontinuous radial ridges, extending fan-wise towards periphery across concentric rows of subsidiary calicinal areas, breaking up into monticules in depressions of calicinal surface. Non-calicinal surface uneven, with radial grooves corresponding to radial ridges on calcinal surface. Diameters 21 × 16 cm. From Shore reef, Papeari, Tahiti, 1 fathom.

FIGURE 47. *Pavona maldivensis* (Gardiner). General view of large heavy corallum, rising into basally constricted hillocks up to 4 cm. in height, simulating growth form of *Favia acropora* (Linnaeus). Height 16 cm., length 23 cm., breadth 22 cm. From submerged flat, Tahiti. Nat. size.



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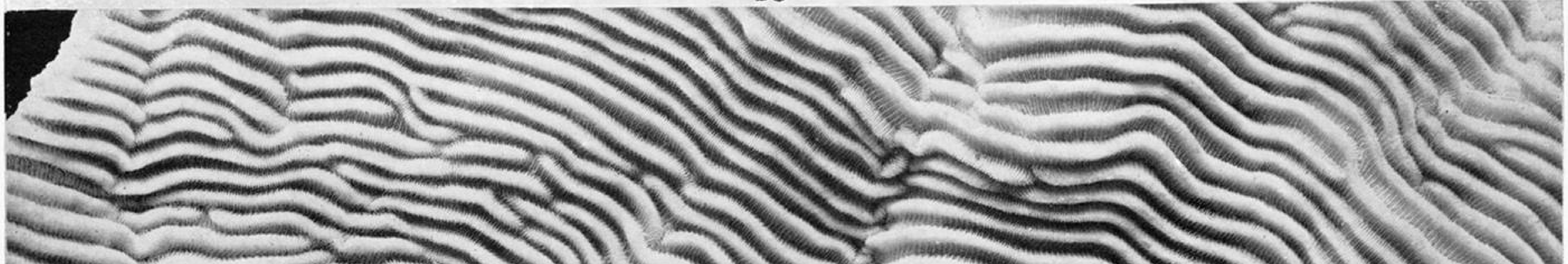

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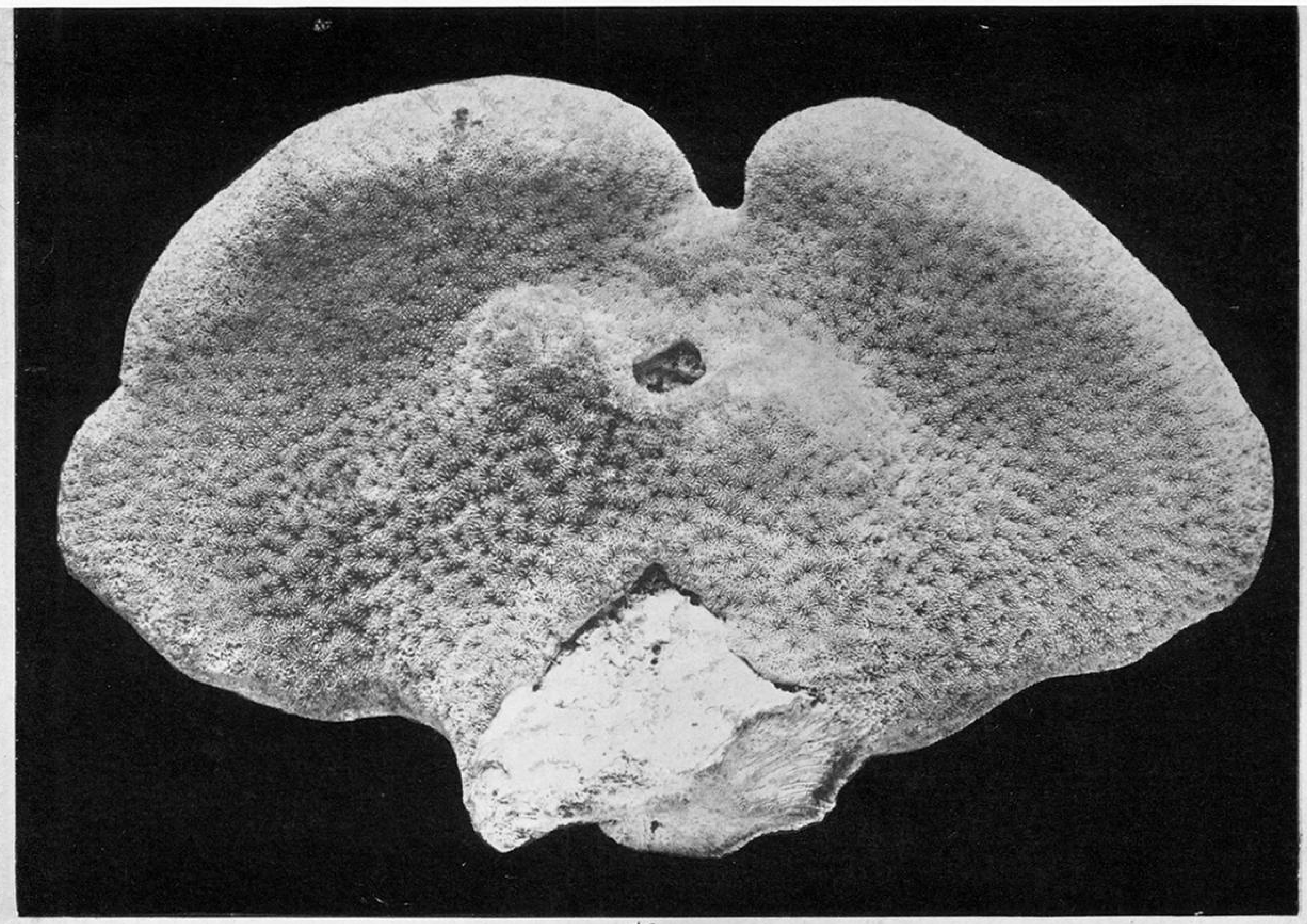
PLATE 13

FIGURE 48. *Pachyseris speciosa* (Dana). General view of large corallum, with several horizontal concavo-convex foliae, valleys arranged concentrically, becoming shallow to almost flat in lowest folia, collines becoming oblique towards periphery, lower surface of foliae non-calicinal. Depth 15 cm., diameters 40 × 27 cm. From Tahiti. × $\frac{1}{2}$.

FIGURE 49. *Pachyseris speciosa* (Dana). View of part of slightly concave calicinal surface of a horizontal folia, with collines breaking up in places into monticules of varying length, lower surface of folia non-calicinal. Diameters 28·5 × 20 cm. Probably from Tahiti. Nat. size.



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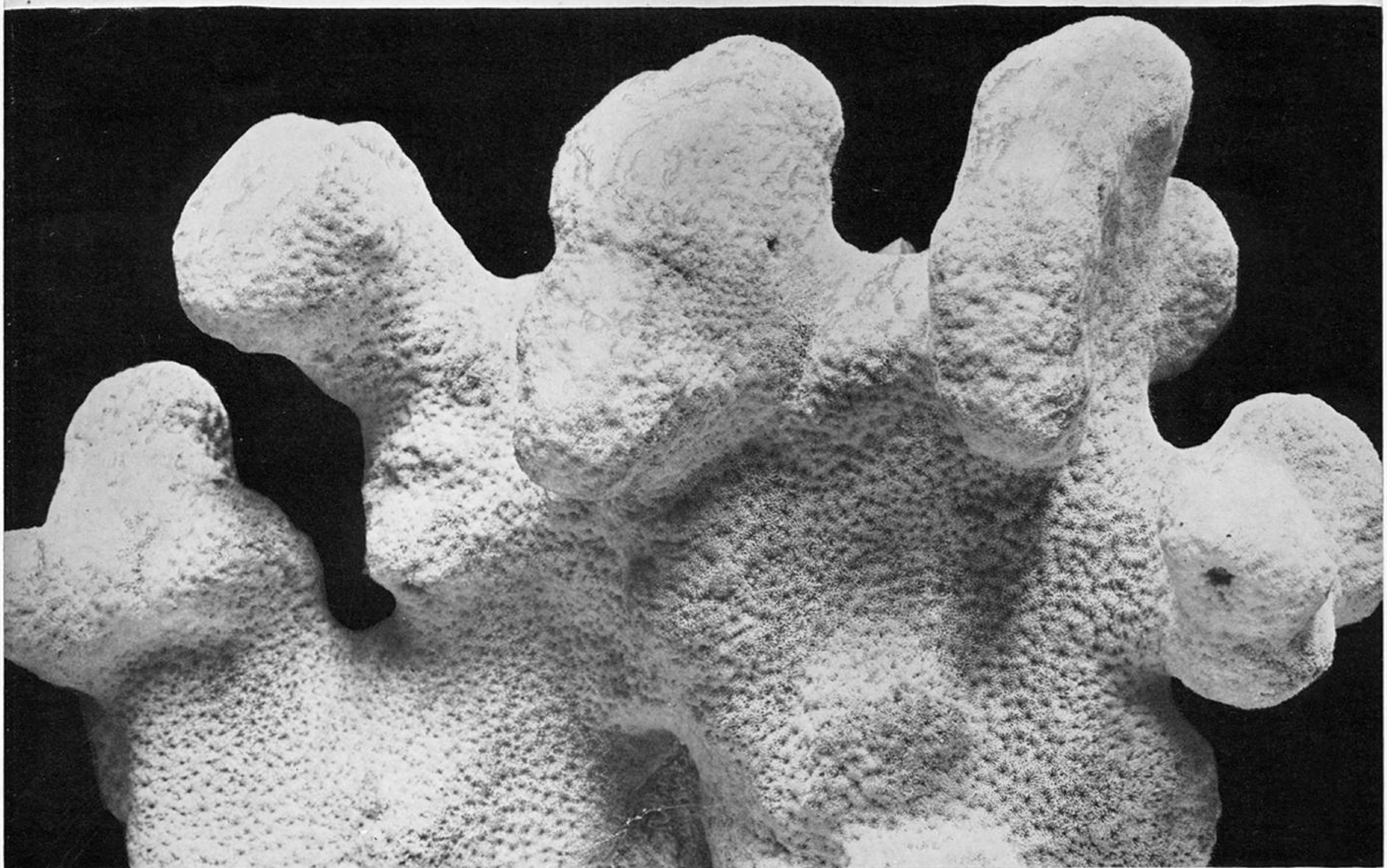

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PLATE 14

FIGURE 50. *Psammocora haimiana* Milne Edwards and Haime. Side view of a bifurcated corallum (previously named *Psammocora exesa* Dana) showing concentric arrangement of calicinal areas. Thickness 3·5 cm., length 14 cm., breadth 8·5 cm. From Hulule, Maldives. Nat. size.

FIGURE 51. *Psammocora haimiana* Milne Edwards and Haime. Side view of part of corallum showing humps up to 5 cm. in height, the larger ones compressed laterally and broadening towards distal end, simulating growth facies of *Favia acropora* (Linnaeus). Length 27·5 cm., breadth 20·5 cm., thickness 5 cm. From Neru, Hulule, Maldives. Nat. size.