Lystrosaurus Zone (Triassic) Fauna from Antarctica

Abstract. *Tetrapod skeletons recently found in the Fremouw Formation in the Shackleton Glacier area, Transantarctic Mountains, include several forms that closely compare to South African species. Faunal similarities that confirm a close connection between Antarctica and Africa during the Triassic Period lend further support to the concept of Gondwanaland and continental drift.*

The discovery at Coalsack Bluff in 1969 of fossil bones of *Lystrosaurus* (*1*) was a significant addition to the evidence for continental drift. The occurrence of this form in now-isolated Antarctica is not explainable except in terms of the existence during the Triassic of a former supercontinent, Gondwanaland, which later split into the present southern continents and peninsular India. The bones at Coalsack Bluff, recovered from stream channel deposits, were disarticulated, and this made difficult the precise identification of many constituents of the fauna. However, unmistakable bones of *Lystrosaurus* unequivocally tie it to the Lower Triassic *Lystrosaurus* Zone in the Middle Stage of the Beaufort Series in South Africa (*2*).

The continuing program of geological investigation in the Transantarctic Mountains by the Institute of Polar Studies at Ohio State University included part of a field season for 1970–71 based on the McGregor Glacier (85°08'S, 174°50'W), a small tributary to the Shackleton Glacier in the Queen Maud Mountains (Fig. 1) (*3*). On the first day of fieldwork a major fossil locality with articulated skeletons was discovered in Thrinaxodon Col on the northeast flank of Mt. Kenyon. This and other fossil localities (Fig. 1), including Collinson Ridge, Shenk Peak, and Kitching Ridge, proved to be far richer in well-preserved fossils than localities on Coalsack Bluff. The lower part of the Fremouw Formation on Graphite Peak (Fig. 1), site of Antarctica's first tetrapod discovery by Barrett (*4*), was also found to contain abundant fossils of the *Lystrosaurus* fauna.

The regional geology in the Queen Maud Mountains is similar to that of the Queen Alexandra Range and Coalsack Bluff, 225 km northwest. Nearly horizontal beds of the Beacon Supergroup (*5*) rest on a pre-Devonian erosion surface that was cut across a metasedimentary and metavolcanic basement intruded by Ordovician granitic rocks. The Beacon Supergroup is predominantly a continental sequence and ranges in age from Devonian to Triassic (Table 1). It is intruded by diabase and overlain by basalt flows that crop out beyond the head of the Shackleton Glacier. Beacon stratigraphy of this region was described by La Prade (*6*), who proposed the name Mt. Kenyon Formation for Triassic strata. On the basis of regional mapping, it will be recommended that Mt. Kenyon Formation be dropped in favor of extending into this area the earlier named Fremouw and Falla formations as defined by Barrett (*7*). Barrett's terminology is used in this report.

All fossil bone localities in the Shackleton Glacier area are in the lower 200 m of the more than 700-m-thick Fremouw Formation (Fig. 2) (*7*). At Coalsack Bluff, bones were found as far as 120 m above the base of the formation in similar rocks (*1*). From the Queen Alexandra Range to the Queen Maud Mountains the lower part of the Fremouw Formation is a cyclic unit consisting of one to several fining-upward cycles typical of fluvial deposition (Fig. 2). A cycle begins at the base with a coarse channel sandstone that contains intraformational conglomerate. At some localities these intraformational conglomerates contain disarticulated bones. Most clasts are the same mudstone as the beds beneath the erosion surface into which the channel

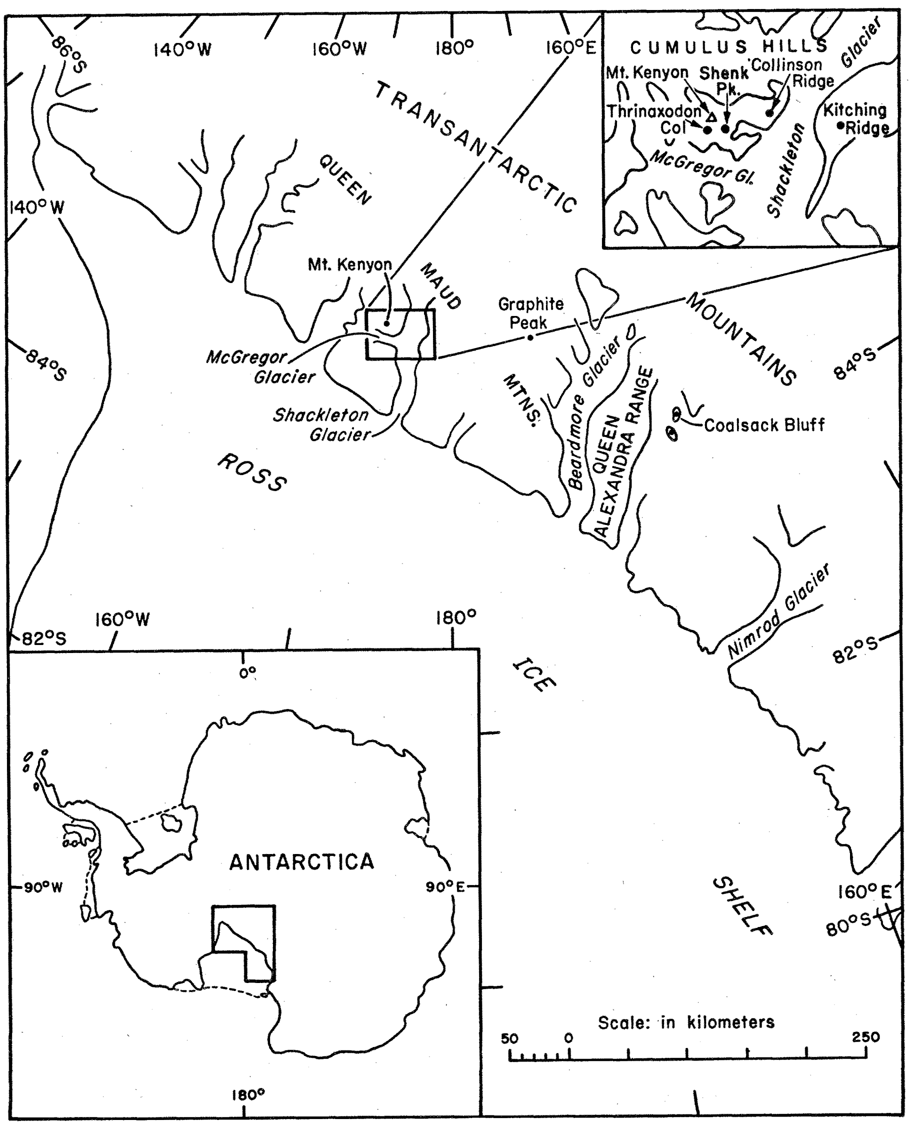

Fig. 1. Locality map of the central Transantarctic Mountains.

Table 1. Post-Ordovician stratigraphy of the Shackleton Glacier area.

Age	Group	Formation	Description	Approximate thickness (m)
		Falla	Sandstone, shale; *Dicroidium*	200+
Triassic		Fremouw	Arkosic sandstone, green-gray mudstone; *Lystrosaurus* fauna near base; logs, coal seams near top	700+
---------	Victoria Group of the Beacon Supergroup	Buckley	Arkosic and volcanic sandstone, dark gray shale, coal; *Glossopteris*	450
		Fairchild	Massive arkosic sandstone	200
Permian		Mackellar	Dark shale, fine-grained sandstone	160
		Pagoda	Tillite, sandstone	4–190
---------	-------------------------		REGIONAL UNCONFORMITY	
Ordovician-Precambrian			Basement metasedimentary and metavolcanic complex intruded by granitic rocks	

is cut. They are presumed to have been derived from older, fine-grained floodplain deposits. Each cycle grades upward to medium and fine sandstone, then to green-gray mudstone in which skeletal material is found. This part of the Fremouw Formation is readily recognized by its thick, resistant sandstone ledges, which contrast with the nonresistant, predominantly mudstone beds of the middle part of the Fremouw Formation and with the slope-forming carbonaceous beds of the underlying Permian Buckley Formation.

As a result of collecting carried on at McGregor Glacier during November and December 1970, which supplemented the work at Coalsack Bluff of the preceding field season, we can now say that the fossils so far recovered from Antarctica represent a fauna that may be equated closely with the Lower Triassic *Lystrosaurus* fauna of South Africa. Additional materials collected during the last field season confirm the somewhat tenuous evidence from the fossils collected a year ago, which indicated that *Lystrosaurus murrayi,* the type species of the genus and the most common form found in Africa, is also the Antarctic species. However, at presently known localities in Antarctica *Lystrosaurus* is not as abundant as in some parts of the Karroo basin; the frequency of its occurrence in the region of McGregor Glacier is generally comparable to its abundance in Natal, along the southern edge of Africa.

Among the materials collected this season, which augment the original collection from Coalsack Bluff, a small dicynodont was found that appears to be a new element in the *Lystrosaurus* fauna.

The discovery in Antarctica during

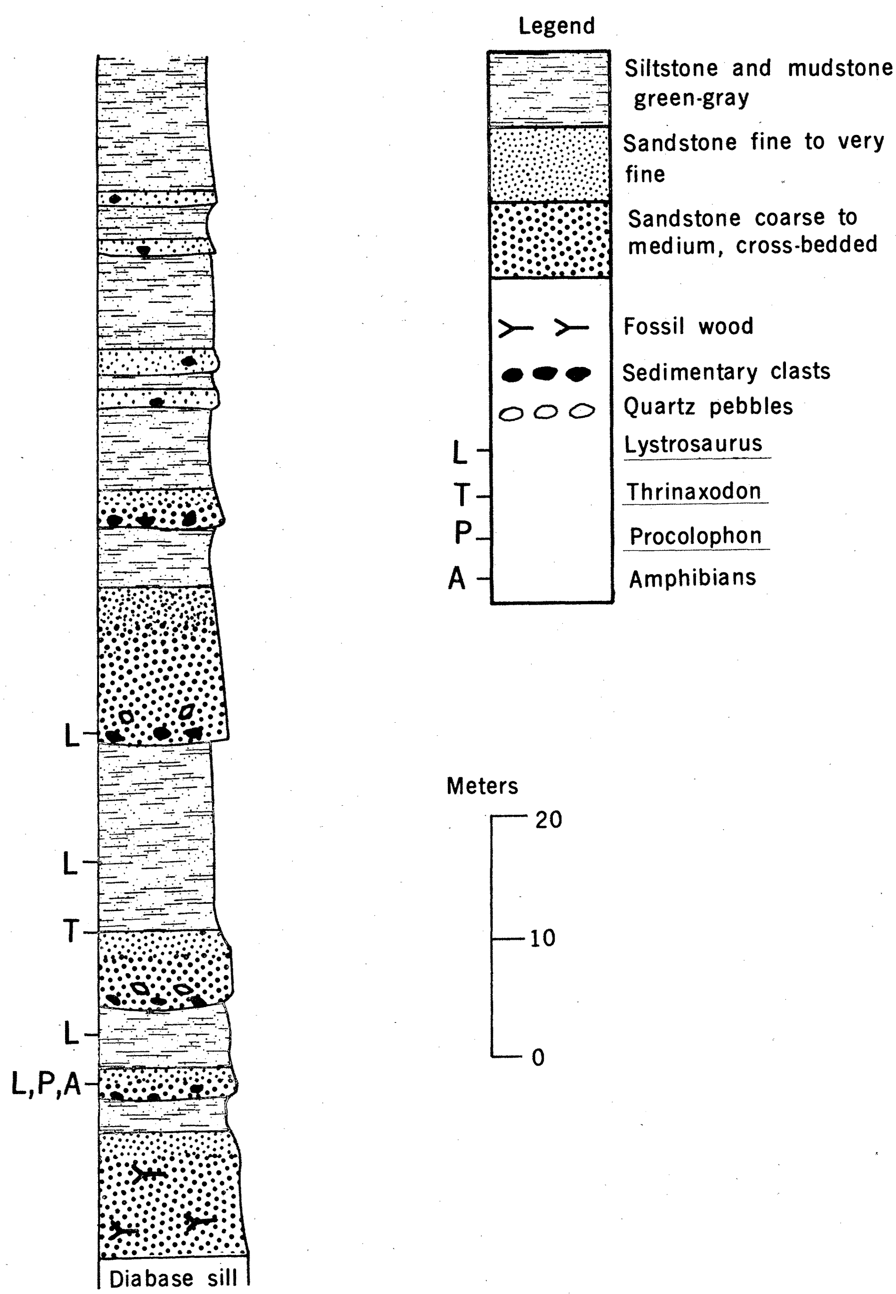

Fig. 2. Stratigraphic section of bone-bearing strata of the basal 100 m of the Fremouw Formation at Thrinaxodon Col.

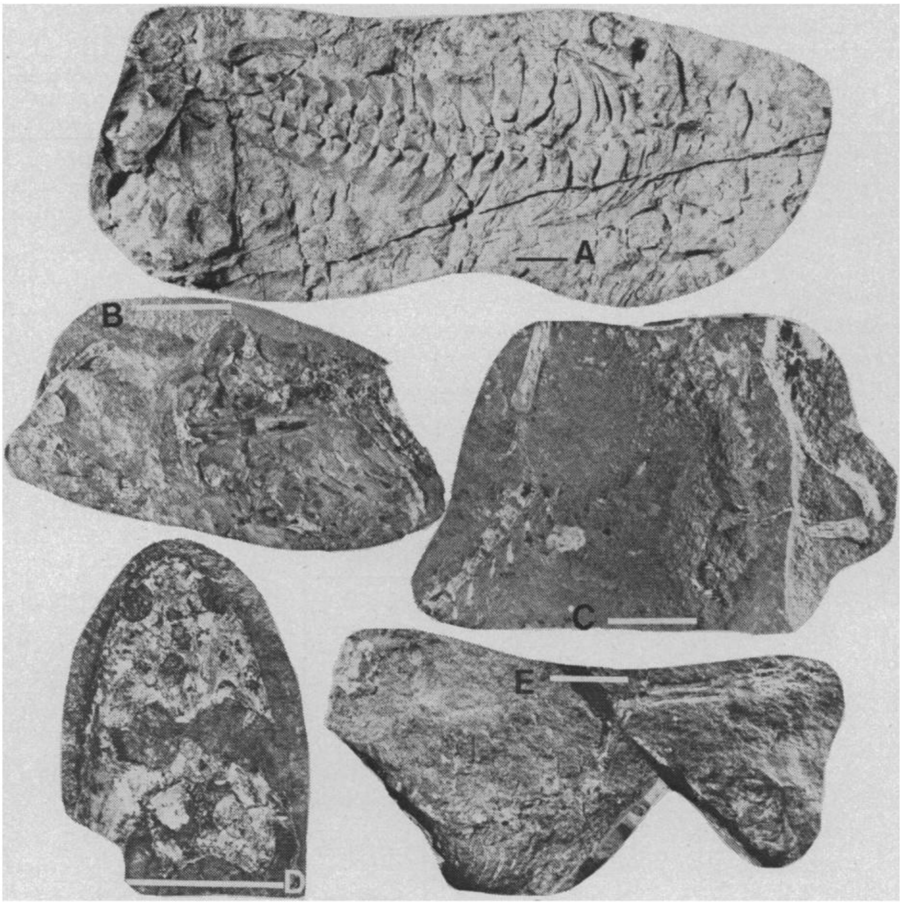

Fig. 3. Tetrapods from the Lower Triassic Fremouw Formation, collected in the vicinity of McGregor Glacier, Transantarctic Mountains, Antarctica. (A) *Thrinaxodon*, American Museum of Natural History (AMNH) specimen No. 9500, almost complete impression of a skull and skeleton in the rock. (B) *Procolophon*, AMNH No. 9501, skull (not visible in this view) and anterior portion of skeleton. (C) Small thecodont, AMNH No. 9502, partial skeleton. (D) Small amphibian, AMNH No. 9503, skull. (E) Eosuchian, AMNH No. 9504, skeleton. The scale for each specimen is 20 mm.

the past field season of several skeletons of *Thrinaxodon* that seem to be identical with those of the South African *Thrinaxodon liorhinus* is of prime importance, for it provides additional evidence for the ligation of Africa and Antarctica at the beginning of the Mesozoic. Several specimens of *Thrinaxodon* were discovered in the McGregor Glacier area, and their mode of occurrence was quite similar to that in the Karroo basin. In both Africa and Antarctica this small theriodont occurs in groups, with several individuals preserved in close proximity to each other.

Another significant Antarctic discovery is that of the cotylosaurian genus *Procolophon*, apparently *Procolophon trigoniceps*, the same species found in Africa. The Antarctic *Procolophon* is particularly significant because it is closely associated with representatives of *Lystrosaurus murrayi* in the Fremouw Formation.

For many years *Procolophon* in the Karroo basin has been assigned to a separate stratigraphic zone, thought to be intermediate between the *Lystrosaurus* Zone below and the *Cynognathus* Zone above. In 1964 a well-preserved specimen of *Procolophon cf. P. trigoniceps* was found within the same horizon as *Lystrosaurus murrayi* in Lootsberg Pass, Graaff-Reinet district, South Africa (*8*). Since then, *Procolophon* skulls have been found within the *Lystrosaurus* Zone at other South African localities. The association of *Procolophon* and *Lystrosaurus* in Antarctica further supports the contention of one of the present authors (J.W.K.) that rocks containing *Procolophon* in South Africa are correlative with those of the *Lystrosaurus* Zone (*2*).

Thecodont reptiles, not yet generically identified, were found during the 1969–70 field season at Coalsack Bluff and during the past field season at McGregor Glacier. All the thecodont remains discovered in Antarctica to date are of small reptiles; nothing has yet been identified that might be equated with *Proterosuchus (Chasmatosaurus)*, the characteristic (although rare) thecodont of the *Lystrosaurus* Zone in Africa. This thecodont occurs with *Lystrosaurus* also in India and China.

If the Fremouw Formation is presently unique among *Lystrosaurus*-bearing beds because of the absence of *Proterosuchus*, it is outstanding for the relative abundance of small prolacertid eosuchians, which are relatively rare in the *Lystrosaurus* Zone of South Africa.

Some labyrinthodont amphibians collected from the Fremouw Formation are small; others are of considerable size. This parallels the situation in South Africa, where the small genus *Lydekkerina* is common in the *Lystrosaurus* Zone, and the rather large *Uranocentrodon* (*Rhinesuchus*) also occurs but is rare. Further study will be required in order to determine whether the amphibians of the Fremouw Formation can be equated with the above-named African genera.

The abundant occurrence in Antarctica of fossils representing the *Lystrosaurus* fauna confirms the close connection between Antarctica and Africa in early Triassic time. Moreover, the fact that the *Lystrosaurus* fauna was nearly complete in Antarctica suggests that the Triassic connection between the two continents was probably a broad one, rather than an isthmian link over which the effects of faunal filtering would be more evident. In short, the *Lystrosaurus* fauna as it is now known in Antarctica and in southern Africa constitutes one of the strongest lines of evidence as yet adduced in support of Gondwanaland and, correlatively, of continental drift.

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References and Notes

1. D. H. Elliot, E. H. Colbert, W. J. Breed, J. A. Jensen, J. S. Powell, *Science* **169**, 1197 (1970).
2. J. W. Kitching, in Proceedings of the Second Symposium on the Stratigraphy and Paleontology of the Gondwana System, Cape Town and Johannesburg, South Africa (1970).
3. One of us (J.W.K.) joined the field party as the South African exchange scientist with the U.S. Antarctic Research Program.
4. P. J. Barrett, R. J. Baillie, E H. Colbert, *Science* **161**, 460 (1968).
5. P. J. Barrett, in Proceedings of the Second Symposium on the Stratigraphy and Paleontology of the Gondwana System, Cape Town and Johannesburg, South Africa (1970).
6. K. E. La Prade, *Geol. Soc. Amer. Bull.* **81**, 1403 (1970).
7. P J. Barrett, *Institute of Polar Studies Report No. 34* (Institute of Polar Studies, Ohio State University, Columbus, 1969); J. W. Collinson and D. H. Elliot, in preparation; ———, P. A. Mayewski, E. Stump, in preparation.
8. J. W. Kitching, *Palaeontol. Afr.* **11**, 61 (1968).
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Inductive Interactions between Human Dermis and Chick Chorionic Epithelium

Abstract. *In a study of specificity in mesenchymal-epithelial interactions, human embryonic dermis has been recombined with chick chorionic epithelium and cultured for 7 days on a host chick chorioallantoic membrane. Dermis from the sole of the foot or palm of the hand induces chick chorionic epithelium to form an epidermis that resembles chick rather than human epidermis. Chick epithelium, though it has the capacity to respond to a human dermal stimulus, is limited to forming chick-type tissue. The human dermis was modified in its turn by culture in combination with chick epithelium.*

That differentiation of embryonic skin and the other specialized derivatives of the integument is based on specific interactions between dermal and epidermal components is well established (*1–3*). Similarly, maintenance of epidermal specificity in adult skin is dependent on the presence of dermis (*4*). Maintenance alone may not, however, require a specific dermis, for Briggaman and Wheeler, using chorioallantoic membrane grafting, reported that adult human epidermis is maintained in recombinations prepared from either human or guinea pig dermis (*5*).

Opportunities to investigate dermal-epidermal interactions were expanded by the elegant demonstration (*2, 6*) of the potentialities of the chick chorionic epithelium (CE) as a responding tissue in combinations with different dermal inducers.

A schematic representation of the methods used in isolating, recombining, and grafting of human and chick tissue on the chick chorioallantoic membrane (CAM) is shown in Fig. 1. Isolated dermis was obtained from either 14- or 15-week-old human or 16-day-old chick embryonic skin. In both cases dermis was easily separated from its epidermis after about an hour in a solution of double-strength calcium- and magnesium-free Tyrode's solution with 0.25 percent disodium ethylenediaminetetraacetate dihydrate (EDTA) at 37°C. Samples of each type of isolated dermis were fixed in Bouin's solution before histological comparison. Samples for experimental recombination were kept in cold Tyrode's solution for about 30 minutes and then wrapped in freshly isolated chick chorionic epithelium obtained from 8-day-old embryos. Isolated epithelium was obtained by rinsing the chorioallantoic membrane in cold Tyrode's solution and then placing it also in the EDTA solution. After 20 minutes at 4°C, the epithelium was easily separated as a continuous sheet (*2*). The recombinants were transplanted onto the chorioallantoic membrane of 11-day-old chick embryos and grown for 7 days.

Two types of control cultures were prepared. Both naked human sole or palm dermis and chick anterior shank dermis were grown for 7 days in Millipore filter chambers on the chorioallantoic membrane. Use of these chambers prevents interaction of the graft with the chorionic epithelium of the host, which ordinarily migrates over naked dermis and undergoes transformation (*7*). Intact skin (dermis and epidermis) from both human and chick were cultured for 7 days directly on the membrane.

Histological comparison of embryonic chick and human skin at explantation showed that the skins are easily distinguishable (Fig. 2, A and B). Cells of the intermediate layers of the epidermis differ; those of the chick have a denser staining cytoplasm. The distinctive subperidermal and peridermal layers characteristic of chick epidermis were not present in the human skin. Swollen cells were commonly seen at the surface of the human epidermis. In both, the basal cell layer was columnar. Human dermis had a denser accumulation of fibers positive to either aniline blue or eosin than chick dermis, and distinctive cells with dark-staining nuclei were present.

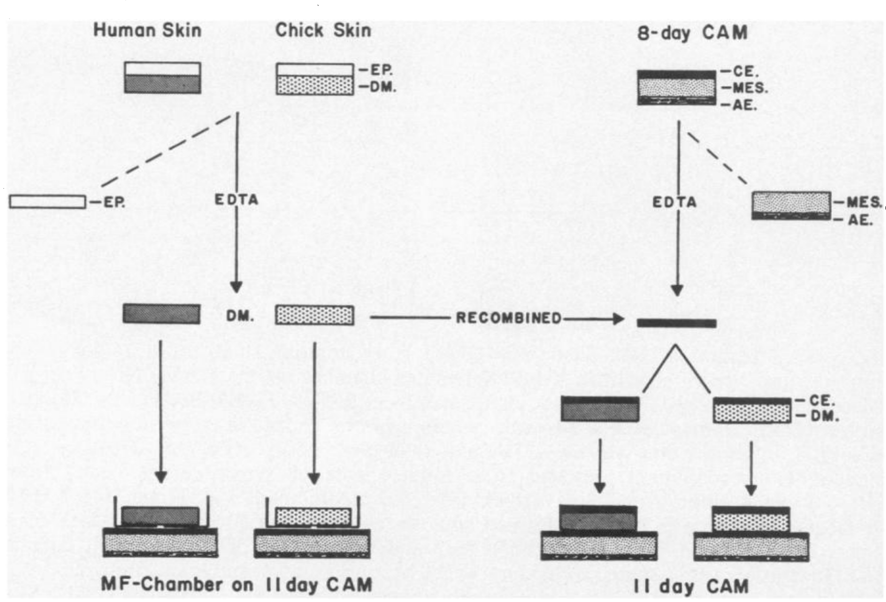

Fig. 1. Methods of preparing tissue recombinants for CAM grafting. *AE*, allantoic epithelium; *CAM*, chorioallantoic membrane; *CE*, chorionic epithelium; *DM*, dermis; *EDTA*, disodium ethylenediaminetetraacetate; *EP*, epidermis; *MES*, mesenchyme; *MF*, Millipore filter.