The shell structure groups

cess, but simply of unequal secretion over the previous surface. These sources of unequal secretion must move relatively outwards and inwards from the periphery, all the time dividing further. Finally, as in *Semele decisa,* the outer edge of the irregularly distributed denticles is elevated above the general level of the outer surface of the shell. The resulting external ornamentation consists of a very peculiar and irregular nodulation with only vague traces of radial arrangement (Pl. IV, fig. 7). The denticles in the inner ectostracum are eventually covered by the mesostracum.

It must be noted that the fibers within each fan radiate as do the fans. It is thus likely that the secreting sources move continually from the center region of the denticles to the denticular margins, even as these denticles themselves move away from the periphery.

Panopeidae

In *Panope generosa* the ribbing much resembles that of *Semele decisa.* The outer ribbing here is also beaded, but may in addition show a scattering of small ribs, irregular in trend and sometimes even crossing (Pl. II, fig. 8).

Shell structure groups

On the basis of their structures the shells studied could be fitted into three major groups (see table of microstructures). Two of the present groups seem to have a basic structural plan which shows up in many Recent forms. In the other (the foliated group) no basic structural plan could be detected in Recent forms, but such a plan appears to have existed in Paleozoic ancestors of these Recent forms.

The first group is here termed the n a c r o - p r i s m a t i c g r o u p and appears to have basically a nacreous mesendostracum and prismatic ectostracum. It is typified by the Unionidae. This structure and its variants occur not only in primitive pelecypods such as *Nucula,* but also in primitive gastropods such as *Pleurotomaria* and *Haliotis,* and with certain modifications in the tebrabranchiate cephalopods such as *Nautilus.* This nacro-prismatic structure appears thus to represent the primitive structure for the mollusks as a whole, or at least an important common structural stage for most mollusk groupings.

The second group is termed the foliated group and includes all Recent monomyarian pelecypods. These late representatives of this group are characterized by folia, which are always present though in differing amounts. Foliated structure, however, involves different portions of the shell in the diverse monomyarian families and probably developed independently in several closely related stocks. Thus the shell structure of any one family is not clearly derivable from that of any other family. Distribution of crossed-lamellae and prisms is also quite variable in this group. NEWELL's (1937) studies indicate that none of the presumed late Paleozoic ancestors of the Recent monomyarians had folia. Their structure, when not nacro-prismatic, was characterized as in *Aviculopecten* by a crossed-lamellar mesendostracum, and the ectostracum was prismatic in the right valve and homogeneous in the left.

There remains, however, one serious objection to *Aviculopecten* or a related genus as the immediate ancestral form of the foliated group. In these Paleozoic genera, the endostracal crossed-lamellae are arranged radially, whereas those of modern monomyarians are absent or are arranged concentrically as in *Plicatula* and *Pododesmus*. Thus the ancestor of the present monomyarians probably would have to have acquired concentric crossed-lamellae in the endostracum before the various families were structurally differentiated.

The third or *complex-lamellar group* has basically a complex endostracum and a crossed-lamellar mesectostracum, and is exemplified by the Arcidae. This group includes most isomyarians as well as the family Dreissenidae among the anisomyarians.

The general structural pattern of the various families within each structural group is rather similar, and modifications from typical structure are not very great. The following are the main types of structural modifications:

In the nacro-prismatic group, the endostracum and mesostracum may one or both tend to be prismatic, although no shell was found in which both were fully prismatic. The ectostracum may be gránular. All layers may be more or less homogeneous.

In the foliated group, the endostracum and mesostracum may either one or both be partially or wholly crossed-lamellar. The endostracum may be partly or wholly prismatic. The ectostracum may be more or less prismatic, at least in the right valve.

In the complex-lamellar group, the ectostracum and sometimes the upper mesostracum may be fibrillar. The mesostracum, especially its lower portion, and the endostracum often tend to become homogeneous. The endostracum in some cases tends to be prismatic or radial crossed-lamellar.

The exact phylogenetic significance of these structural groups is as yet uncertain. It is theoretically possible that shells of very different origins may have acquired a more or less similar structure through convergence. This appears not to be the case for the nacro-prismatic and foliated groups, and for the heterodonts in the complex-lamellar group; if DOUVILLÉ's phylogenies (as shown in DAVIES, p. 127) are valid, however, it would appear that complex-lamellar structure may have been acquired by other pelecypod groups independently from that of the heterodonts (e.g., also by the Dreissenidae, Arcacea, Myacea, Adesmacea).

Some previous attempts at classifying pelecypods by shell structure are:

HATCHETT (1799) divided sea-shells into porcellaneous and nacreous types, although his inclusion of oysters in the latter category would seem to indicate a broader usage of this term than that of most later authors. This division was accepted by GRAY (1833) and emphasized by DOUVILLÉ (1912).

CARPENTER (1844) and CAYEUX (1915) failed to classify pelecypods on the basis of shell structure, but listed the types of structure they observed.

ROSE's (1858) mineralogical classification distinguishes between purely calcitic shells, those with both calcite and aragonite, and those composed entirely of aragonite.

BOGGILD (1930) pointed out that almost all of the anisomyaria are partly or totally calcitic and almost all isomyaria are aragonitic and that the shell structure of these two major groups is almost entirely distinct.

Comparison of Pelecypoda with other Mollusca

The three calcareous palliostracal layers of the pelecypods are usually rather clearly recognizable in the other classes of mollusks (fig. 3 A—E).

The layer distribution in uncoiled or little coiled gastropod genera such as *Haliotis* appears to represent the simplest possible arrangement of the calcareous layers of the palliostracum, with all three present and