

some domes may be non-ciliated. These papillae usually occur in clusters, each having between two and three, up to 10 and 15 papillae per group. Those on the lateral aspect and around the suckers tend to be more numerous and larger in size, as well as having more papillae per cluster. The dorsal surface exhibits similar surface features, but the spines and papillae appear less numerous and having smaller sizes, and the invagination is less extensive than on the ventral aspect.

When observed under the transmission electron microscope, the tegument can be divided into four layers based on the ultrastructural characteristics. The first or surface layer is the cross-sections of ridges and pits. Its cytoplasmic matrix is the most densely packed and contains numerous discoid membranous granules (G_2) whose size is about 20-40 x 135-250 nm, and fewer ovoid granules (G_1) with dense matrix whose size is about 70-90 x 170-210 nm. Both G_1 and G_2 granules are joined with the surface membrane, which is a trilaminar structure about 4 nm thick. The membrane is underlied by the dense lamina of cytoplasm about 15 nm thick, and coated externally by the glycocalyx. The glycocalyx has two layers: the thin dense homogeneous layer about 9-14 nm in width closely apposed to the membrane, and to external fibrillar layer about 50-280 nm in width. The glycocalyx is intensely stained by the positive colloidal iron and ruthenium red which indicates that it is highly negatively charged. It, however, shows very little and spotty staining with the negative colloidal iron. Ruthenium red stains glycocalyx as well as some G_1 granules close to the surface. It is, therefore, suggested that G_2 granules are the major contribute to the synthesis of the new surface membrane, while G_1 granules contribute the

formation of the glycocalyx. The second layer of the tegument is a thin zone of cytoplasm whose matrix is also densely packed, and the most prominent characteristic is the accumulation of G_1 , G_2 and some G_3 granules. The last is a light, ovoid granule about 50-75 x 130-180 nm in size that contains moderately dense but mottled matrix. In addition, there are a high number of lysosomes that are evenly distributed throughout this layer. The third layer occupies the middle portion of the tegument and is the widest. Its cytoplasmic matrix is less tightly packed than in the upper two layers, and contains numerous mitochondria which are evenly distributed throughout. All types of granules are present but G_1 and G_2 granules are much fewer than in the first and second layers and most are of smaller size. G_3 granules are evenly distributed and some dissolve their membranes so that their fibrous matrix joins up with the network of microtrabeculae which constitute the main body of the cytoplasmic matrix. The fourth layer is the lowest zone that rests on the basal lamina. Its cytoplasmic matrix is the loosest and contains numerous infoldings of the basal membrane which have mitochondria in close association. It contains fairly large number of G_1 granules but few of other kinds of granules. There are one type of tegumental cell lying underneath the muscle layers that can synthesize all three kinds of tegumental granules, but the G_2 granules predominate. The cells send their granules into the tegument via the cells processes which contain bundles of microtubules.

The filamentous cytoskeletal system constitutes the body of the tegumental cytoplasmic matrix. The cytoskeleton is composed of four components, namely, (1) the dense lamina underlining the surface membrane,

(2) the bundles of fortifying fibrils lying under the dense lamina, (3) the microtrabeculae, and (4) the microtubules. The dense lamina is about 15 nm in width, which may help to strengthen the membrane and glycocalyx. The bundles of fortifying fibrils contain parallel straight fibers, each about 7-11 nm in width, which may help to stabilize the upper part of the tegument, and the surface membrane. The microtrabeculae are the highly cross-linked network of knobby fibers that form the major part of the cytoskeleton. In the upper part of the tegument the fibers are so tightly packed that their knobby parts appear as closely aggregated dots in cross section. The dot or knobby part is about 8-12 nm in diameter, while the fibrous part is about 4-6 nm in width. When subjected to the extraction by Triton X-100 and DTT, the knobby fibers are unraveled to assume a cobweb of thin and straight fibers about 1-4 nm in width, which could represent the primary level organization. Microtubules are confined to the tegumental cell processes and the basal layer of the tegument and may be involved in the transport of the granules from the tegumental cells' bodies to the tegument.

Immunocytochemical staining of the tegument by monoclonal antibodies (MAB) against vertebrate's actin shows that this protein is widely distributed throughout the tegument of the microtrabeculae. MAB against vertebrate's cytokeratin, an intermediate filament protein, exhibits staining as row dense spots in the upper layer of the tegument which may correspond to the position of fortifying fibrils. MAB against tubulin shows staining in the tegumental cells' processes and the basal layer of the tegument which correspond to the position of microtubules.