definitions should facilitate discrimination between meanings. Howard Freeman (Brandeis) indicated that a sophisticated and authoritative thesaurus could have application beyond that of MEDLARS. The meeting accomplished its twofold purpose of bringing together a few of those who generate and use information in biomedical behavioral sciences and those who convey it, and of formulating guidelines toward developing a useful and imaginative communication tool. The five members of the task force are hopeful that their colleagues will communicate to them any comments or suggestions for improving biomedical literature analysis in behavioral sciences.

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Structure of Cell Membranes at the Molecular Level

At the City of Hope Medical Center, Duarte, California, 9–11 December 1965, about 60 scientists from the Los Angeles–San Diego–San Francisco area met at a conference held by the Center's Institute for Advanced Learning in the Medical Sciences. The conference featured three formal presentations by F. A. Vandenheuval (Canadian Department of Agriculture) on "Lipid constituents of membranes"; D. T. Warner (Institute Fellow at the City of Hope, on leave from The Upjohn Company) on "Proposed structures for the protein components of membranes"; and O. Hechter (Worcester Foundation for Experimental Biology) on "The lipoprotein arrangements of mitochondrial membranes." These formal presentations were followed by open discussions and short presentations by other participants, including Lars Elfvin (U.C.L.A.), T. Kakefuda (City of Hope), Sidney Fleischer (Vanderbilt University), and D. Branton and R. Park (University of California, Berkeley).

F. A. Vandenheuvel reported on his study of the lipid constituents of cell membranes by the use of molecular models. Most of this work was done by making projection photographs of the appropriate Dreiding stereomodels and then drawing in the space-filling characteristics of the various atoms using full Vander Waal's radii. In this way he has examined in considerable detail the space-filling shape and volume of various lipid components and their possible arrangement in a lipid layer or bilayer. The average cross-sectional size and length of each of the most common components have been determined with accuracy by his procedure. These dimensions have then been compared with the known measurements for lipid layers as determined by x-ray methods or electron microscopy. The organization of the polar groups of lipid components with relation to a water lattice or inserted ionic components in such a lattice was also illustrated with projection photographs of the Dreiding stereomodels. Vandenheuvel has extended the studies to the proteins, examining again the space-filling characteristics for the side chains of the individual peptide moieties of a hypothetical primary sequence based on the approximate amino acid composition of the myelin sheath. He also presented an actual model (Dreiding set) of a portion of the sequence fitted onto a water lattice, and demonstrated with this model the contact of the various polar groups and some of the peptide oxygens with the oxygen positions in water. In his concept a so-called layer of protein would be a single peptide chain in thickness. As the chain coils around a central origin the peptide oxygens lie either above or below the plane which is generated by the coil. This would constitute the primary layer of structural protein. Molecules of functional protein, such as enzymes, attached to this primary layer would then constitute the membrane superstructure. Arguments for the existence of unit lipoprotein particles in membranes were presented, and the forces governing membrane stability and lipid turnover were discussed.

D. T. Warner presented a proposed conformation for the membrane proteins based on studies with molecular models, beginning with simple antibiotics and ending with a suggested model of the entire cytochrome *C* sequence. This proposed conformation, designated for simplicity as the "hexagonal conformation," has the peptide chain so arranged that the peptide carbonyl oxygens lie in a uniform hexagonal array. Thus a cyclic hexapeptide forms one hexagon of peptide oxygens, a cyclic decapeptide forms two fused hexagons, and a continuous protein subunit chain generates an expanding spiral of peptide oxygens whose continuing hexagonal pattern builds a honeycomb network. An intriguing property of this peptide network is its similarity to the hexagonal "second neighbor" oxygen pattern of the ice lattice; this similarity introduces the possibility of a precise collinear hydrogen bond contact between a water layer and a peptide layer. This lamination could introduce stabilizing features as well as proton transfer properties into the system. Individual protein subunits in the "hexagonal" conformation could also conceivably interact with each other through their respective hydrophobic (that is, side chain) surfaces to form peptide bilayers. Fundamentally such a peptide bilayer would be like a lipid bilayer, but the protein analogue would have a thickness of about 6.9 angstroms compared with 45 angstroms for the usual lipid bilayer. The outer surfaces of such a protein bilayer in this model would both be coated with water. Under suitable conditions of temperature and *p*H, Warner suggested the possibility that the water could serve as a cement between the various bilayers, producing rods as in the case of protein from tobacco mosaic virus or layers in membrane structures.

O. Hechter outlined the development of a conceptual model for biological membranes, starting from the idea that one protein coat of a membrane must serve as the fundamental scaffold in membrane construction, which dictates the arrangement of the lipids and water structures. Using principles for packing protein subunits and lipids developed in the first two discussions, Hechter considered the protein scaffold to be built of modular protein subunits in hexagonal conformation, interlocked equatorially primarily as hexamers, but including some pentamers as well. The protein subunits are interlocked at "hydrophobic" surfaces, forming a protein bilayer or "sandwich." The hydrophobic surfaces of the subunits of the "sandwich" arrangement are considered to have complimentary surfaces; non-covalent and covalent bonding interactions between complimentary groups are invoked to provide stability to the interdigitated assembly of protein subunits.

In the hexameric regions of the interlocked "sandwich," all of the non-polar groups except those at the edges of the disc would be buried in the interior and only the polar amide groups of hexagonal discs would project outside to the aqueous environment; in the region of the pentamers, a pattern of amino acid residues of an underlying peptide unit would be exposed and these discontinuities in the coat might serve as "receptor sites." The hydrophilic surface of the interdigitated hexameric discs serves to bond water in a hexagonal ice-like structure. These bonded water layers are used to "cement" one or more equatorially interlocked sandwich layers together, forming the protein coat. Water bonded to the protein coat also serves to "fix" the hydrophilic groups of lipids into position, forming a bimolecular lipid leaflet. Hechter applied these considerations to the inner membrane of the mitochondria, where information is available concerning some of the protein components. All of the known proteins in this membrane have molecular weights which are multiples of about 12,500 (approximately 112 amino acid residues). Hechter discussed certain aspects of mitochondrial membrane structure and function in terms of a model where the "base pieces" are built of "hexagonal" protein subunits (molecular weight 12,500) arranged primarily as hexameric discs. He considers the individual subunits in hexagonal conformation not to be stable as monomers, and invoked an energized template mechanism to provide for assembly of unstable subunits into a system of interlocked hexamers, rather than a spontaneous self-assembly process where the order of subunits is dictated solely by the primary amino acid sequence. Other theoretical difficulties inherent in the "hexagonal" protein model, such as non-planarity of amides and *cis* and *trans* amide forms, were discussed briefly.

Lars Elfvin discussed electron micrographs of various membranes, emphasizing that although the electron micrograph may not depict membranes as they really are, the differences which show up in the pictures of different membranes may still be significant and often characteristic of that particular membrane. Electron micrographs of plasma membranes, mitochondrial membranes, and various cytoplasmic membranes were shown and discussed. The plasma membrane usually appears as an asymmetric triple-layered structure. Differences in the structure of plasma membrane can be observed in intestinal epithelial cells of starved animals and animals fed a diet of corn oil. Moreover, in capillary endothelium the outer dense portion of the plasma membrane is continuous with a single-layered membrane that bridges the fenestrations of the cells. These findings indicate that it is now possible, to a certain extent, to study successfully various functional states of the plasma membrane by means of electron microscopy. In contrast to the plasma membrane, mitochondrial membranes and certain cytomembranes usually appear symmetrical. Furthermore, after suitable fixation a substructure can be demonstrated indicating that these membranes consist of globular components separated by stained septa. Experiments on the calcium-transporting membranes of the sarcoplasmic reticulum indicate that these membranes, although in other respects structurally different from the plasma membrane, also are asymmetrical. In these experiments it has been possible to label with an electron-dense ferritin compound the SH-groups associated with the active sites of the adenosine triphosphatase involved in the calcium transport.

T. Kakefuda described his work on membrane-like structure prepared with lecithin and other lipid components. The lecithin-type bilayers are produced from dispersions of lecithin in aqueous media, and these preparations are examined after phosphotungstate staining. These electron micrographs were compared with pictures made from the myelin sheath membrane of the spinal cord of a mouse. From these comparisons it could be seen that some of the same fundamental spacings appear in the respective electron micrographs. Additional features such as possible cross bridgings between layers could be seen in both artificial membrane and the myelin sheath. Electron micrograph studies of cholesterol-lecithin complexes also showed spacings characteristic of lipid bilayers. However, when saponin was added to a lecithin-cholesterol complex a different type of lipid arrangement resulted. This arrangement was characterized by a circular pattern of "ring-and-hole" structures. The ring was composed of several subunit particles. Attempts to produce this "ring-and-hole" structure with lecithin and saponin alone were not successful.

Sidney Fleischer described his studies with mitochondrial membranes; he showed that removal of lipid from mitochondria leads to loss of enzymic (electron transport) activity. Mitochondrial lipids, when added in the form of micelles, are spontaneously rebound. The amount of mitochondrial lipid which can be rebound is equal to that which was originally present and complete activation of enzymic activity is obtained. Although the number of sites for the binding of lipid by mitochondria is constant, any of several purified phospholipids can be rebound. Specificity of phospholipids, thus, appears to be manifest for functional rather than structural considerations. Physically, phospholipids seem to impart plasticity to mitochondrial membranes as well. The removal of the lipid from mitochondria does not markedly alter the gross morphology as viewed in the electron microscope. The outer membrane is lost in these lipid-free mitochondria, but the trilaminar "unit membrane" arrangement is still present. The retention of the trilaminar arrangement in lipid-free membranes suggests that cross bridges between membrane layers are important in the maintenance of membrane integrity. Structural protein constitutes about 50 percent of the mitochondrial mass. It has been isolated and complexed successfully with mitochondrial lipids as well as with purified phospholipids. The properties of these lipid-protein complexes can thus be studied with this purified system.

D. Branton and R. Park have used freeze-etching techniques in preparing membrane structures for electron microscopy. Cells are quick-frozen and then cleaved at −100°C in a vacuum with a steel microtome knife cooled to liquid nitrogen temperatures. Under these conditions the knife does not actually cut the tissue but fractures it along lines or planes of inherent least resistance, yielding a three-dimensional break. This fresh surface is then etched briefly by continuing the vacuum, thus subliming water from the interstices of whatever molecules are present there. The surface is then replicated and examined with the electron microscope. Electron micrographs of onion root tips along such a cleavage plane show particles about 75 angstroms in diameter. The particle arrangement seems to be characteristic of the material examined. The particles seem to be "in" and not "on" the membrane, suggesting that the knife action splits the membrane in half. Chloroplasts yield a number of different type faces with both large and small particles. Quantosomes were studied in even greater detail. In these studies the surfaces were examined before and after two kinds of enzyme treatment, looking for surface alterations as well as changes in physicochemical properties. Both lipase-galactosidase and pronase alter the photochemical activity of the system, but only pronase influences the absorption spectrum. Pronase alters the surface characteristics by reducing the size of the particles in the cleavage surface without altering the smooth surface areas. However, galactosidase-lipase roughens the smooth areas without markedly altering the size of particles present. These results were interpreted to mean that membranes are composed of subunits and that the number, arrangement, and chemical composition of these subunits vary in different membranes.

The meeting was held under informal circumstances, and no publication is planned. In addition to the staff of the City of Hope and the speakers, interested scientists from California Institute of Technology; University of California at Los Angeles, La Jolla, and Berkeley; and the University of Southern California attended the meeting.

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Marine Geotechnique

Description of the physical, chemical, and mechanical properties of the gas-fluid-solid system of the sea floor, together with an understanding of the response of the system to applied static and dynamic forces, falls within the broad province of marine geotechnologists. This relatively young field of research was the subject of the first International Research Conference on Marine Geotechnique, held 1–4 May 1966, at the University of Illinois' Allerton House conference center near Monticello. Twenty-eight scientists and engineers attended; seven were from foreign countries.

Areal studies of the mass physical and chemical properties of estuarine and marine sediments were emphasized. C. R. Kolb (Waterways Experiment Station, Vicksburg) and B. McClelland (McClelland Engineers, Houston) discussed the geotechnical properties of interdistributary, prodelta, and offshore clays of the Mississippi delta region. Kolb's x-ray radiography of clay specimens has revealed flowage, fractures, and other inhomogeneities in otherwise massive-appearing clays. McClelland at the same time showed that some of the clays exhibited excess pore-water pressures that probably have not dissipated in the 500 years that have elapsed since clay deposition. He also pointed out that values of the compression index (C_c) often increase with increasing values of the liquid limit and that void ratio generally correlates well with liquid limit.

Shear strength, bearing capacity, gas content, and general mass properties of Chesapeake Bay sediments were discussed by A. G. Altschaeffl (Purdue University), A. M. Richardson (University of Pittsburgh), and Wyman Harrison. The c/p ratio for silts with a high content of clay shows values that are quite different from those obtained from the usual correlation between c/p and plasticity index. At the same time, an average gas content of these sediments approximates 10 percent. Plate-load tests (similar to ASTM Test D 1196-57) on Chesapeake Bay sands revealed a decrease in the settlement of a plate under a given load as the diameter of the plate increased. Higher ultimate carrying capacities were obtained than would have been predicted by Terzaghi's equation for bearing capacity.

W. R. Bryant (Texas A & M University) performed consolidation testing of Gulf of Mexico cores in which the Anteus back pressure apparatus was used. Samples from the abyssal plains yield e-log p curves that show the foraminiferal oozes to be "underconsolidated." This fact contrasts with data from deep-sea clays and oozes presented by Richards and E. L. Hamilton for Atlantic, Pacific, and Mediterranean core samples. R. F. Scott (Caltech) and N. Morgenstern (Imperial College, London) questioned the meaning of values for the "preconsolidation" pressure P_c obtained from the upper few meters of recent marine sediments.

E. L. Hamilton and R. F. Dill (Naval Electronics Laboratory, San Diego) reviewed NEL's comprehensive program in marine geotechnique. Hamilton's group will continue studies of sound velocity in marine sediments, especially the determination of the shear wave in situ. Dill described the results of explosive loading of shallow sands off California and Jamaica and the use by SCUBA divers of a torque "screwdriver" to make shear vane tests of marine sands. Explosion of charges of black powder leads to densification of the sands. While the in situ vane shear test may give relative estimates of sand density from place to place, conference members engaged in soil mechanics research felt that information on the distribution of normal stress in the mass being sheared would be needed before such values could be used in slope stability analyses.

Turning to areal studies in European waters, A. Jerbo (State Railways Board, Stockholm) summarized the geotechnical properties of nearly 3000 samples from the Gulf of Bothnia and the Baltic. He noted the relatively high content of natural gas in the fine-grained sediments and stressed the fact that the shearing resistance of clayey sediments stored in cores is markedly affected by the addition of gas produced by microbes. Richards reviewed his work with the Norwegian Geotechnical Institute (NGI) on the geotechnical properties of sediments from the Oslofjord. The NGI gas-operated sampler was used for incremental sampling of the bottom and subbottom; high-resolution, echo sounding techniques were employed to determine the sediment levels actually sampled. This method of investigation, directed toward other areas of the sea floor, is being continued at Illinois.

F. C. Kögler (University at Kiel, Germany) is concerned mainly with the effects of diagenesis on sediment strength and consolidation. Cohesion of Baltic and Persian Gulf sediments—as measured with the Swedish fall-cone penetrometer—were described. Gerhard Einsele (University at Tubingen, Germany) discussed his shear strength measurements on cores from the Nile Delta, where anomalous profiles of cohesion versus sample depth can be used to determine approximate amounts of erosion of overlying sediments. G. Almagor (Geological Survey of Israel, Jerusalem) reported on the cohesion and consolidation of shelf sediments off Israel.

Laboratory work on the consolidation mechanics of artificially sedimented clays was reported by Altschaeffl, Einsele, and Scott. Altschaeffl's laboratory clays indicate they could be sedimented so as to duplicate the c/p values found in natural clays of similar