for a full discussion of the later periods. Civilization, after all, is cumulative and the nearer the archeologist approaches to the historical period the more extensive his material becomes and the more numerous and vital are the problems which he must endeavor to solve.

"Human Origins" is the most useful manual of prehistory available to readers of English. It surpasses the work of Déchelette in its superior grasp of problems of physical anthropology. The illustrations of MacCurdy's work are also more numerous and better. The classical French work is, however, better balanced. The scant notice accorded to the archeology of the Eastern Mediterranean area is less excusable in a general manual of prehistory than in a work primarily concerned with the archeology of France. But, without a doubt, students of prehistory are to be congratulated upon the publication of this scholarly treatise which is the work of no amateur but of a dependable authority.

E. A. HOOTON

HARVARD UNIVERSITY

## SPECIAL ARTICLES

### ELECTRIC TRANSPORT OF FLUID ACROSS MAMMALIAN SEROUS MEMBRANES

EXPERIMENTS performed during the past year have shown that the serosae of mammals are amphoteric membranes. If the membrane is bathed in dilute blood or buffer more alkaline than a certain critical hydrogen-ion concentration and traversed by an electric current, the liquid streams through the membrane toward the cathode. With buffers more acid than the reversal point, streaming is toward the anode. A reversal in sign of the electrokinetic potential difference[1] between the membrane pore walls and the liquid in the pores is thus indicated.

The mesenteries of anesthetized living dogs, cats and rabbits, the mesenteries and parietal pericardia and pleurae of the same species, post-mortem, and two human pericardia, post-mortem, have thus far been tested. These membranes are essentially sheets of connective tissue, bearing blood vessels, lymphatics and nerves, and in some instances, fat cells, lined on each surface by a single layer of pavement mesothelial cells. Intercellular fibers form the major bulk of the lean membranes; these are predominantly collagenous except in the pleural sheet between pericardium and diaphragm where elastin fibers may be present in large proportion.

The reversal point of a complex, amphoteric membrane may be defined as that concentration of H-ions in a given solution within the pores of the membrane, traversed by an electric current, at which the total electroendosmotic current through the membrane is zero.

The mean values of the reversal points with citrate-phosphate buffers for all tissues studied have been between pH = 4.3 and pH = 5.3. By using buffers alternately more acid or alkaline than the reversal point the direction of liquid flow across any given membrane site may be reversed an indefinite number of times. The time interval required is only that taken for the requisite manipulation in changing buffers and making the runs.

The buffers used have been dilutions of McIlvaine's[2] citric acid-sodium phosphate mixture and certain isotonic, physiologically balanced buffers. The latter were citrate-phosphate mixtures containing Na, K and Ca in the proportion of Ringer's solution, and made isotonic by the addition of glucose or of glycerin. The glycerin buffer was found preferable.

The mean values of the reversal points for the several membranes when bathed in the hyptonic unbalanced buffer and in the isotonic, physiologically balanced buffers showed only small and inconstant differences.

The fat and lean membranes in each category similarly showed small if any difference in the positions of the mean reversal points.

The apparent reversal points for the mesenteries of living animals proved to be lower than those for the mesenteries post-mortem. This low value in the animals with functioning circulation has been interpreted as essentially due to admixture with the buffers of buffer salts from the blood. Distinct differences have not been detected between the reversal points of the membranes in the first compared with later hours or days post-mortem, with the possible exception of a small shift toward the acid range of the fat pericardia reversal points when tested several days post-mortem.

The approximate mean reversal points found with the citrate-phosphate buffers were as follows: for mesenteries of living animals, pH = 4.4; for pleurae, post-mortem, pH = 4.6; for mesenteries, post-mortem, pH = 4.8; for lean and fat pericardia, post-mortem, pH = 5.1. The mean reversal point estimated for the human pericardia was about pH = 5.0. The concentration of hydrogen-ions requisite for reversal of the membranes with these buffers containing polyvalent anions is greater than with an acetate buffer.

The ready reversibility of the membranes would seem to indicate that their charging, *i.e.*, electrokinetic p. d., is ultimately dependent largely upon the dis-

[1] Freundlich, H., and Gyemant, A., *Ztschr. f. physik. Chem.*, 1922, c, 182.

[2] McIlvaine, T. C., *J. Biol. Chem.*, 1921, xlix, 183.

sociation state of certain amphoteric components of the membranes. The position and sharpness of the reversal points is strongly suggestive of these ampholytes being proteins. The conclusion seems warranted that proteins probably constitute an important part at least of the material of which the membrane cell surfaces are composed.

STUART MUDD

ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH

## SELACHIAN "DENTICLES" IN THE CAT[1]

IT is now well known that the human lips at birth possess an inner zone beset with "long, soft, villus-like outgrowths." In a few weeks, these villi largely disappear, though the zone itself remains more or less distinctly marked throughout life. Denuded of their epithelium, Ruysch figured them as "papillae," in 1707. Luschka (1863) was the first to describe them with modern precision, and since then they have been the subject of important studies by Neustätter, Stieda, Ramm and others. The portion of the lip which bears the villi is clearly distinguishable to the naked eye, and the individual projections, with their vascular cores, may be seen on low magnification. Neustätter, in 1895, remarked that so far as his investigations showed, human lips alone are provided with this double zone—the outer of which is smooth, and the inner, villous—and he rather fantastically ascribed the condition to the shortness of the nipples and flatness of the central area of the breasts in women. Thus human infants require a special "Greifapparat" for an airtight contact!

Rejecting this interpretation—of "non-skid" lips, as his assistant called them—and after reviewing the literature in the way here outlined, Dr. F. T. Lewis proposed a different interpretation (Buffalo meeting of the American Association of Anatomists, April 16, 1924). He showed photographs of the labial "villi" in man, and others of the teeth of the skate, both intact and in sections, and proposed to regard them as homologous structures. That is to say, he considered the human labial villi, notwithstanding their small size, their tendency to point outward and their lack of dentine, as actual denticles or potential selachian teeth. In the human oral region, then, in addition to the gill clefts, there would be another striking suggestion of the ichthyoid plan of development.

The present account is intended to report the finding of bilaterally arranged papilliform structures on the inner surface of the upper lip in the newborn kitten. These are very clearly the equivalents of the villi or denticles of the human lip, though the inner zone which they form is not exposed at the oral margin; they are wholly within the lips.

On the upper lip of the kitten they are arranged in three groups in the specimens studied—a median group, and on either side, a lateral group.

The median group consists of a single row of four large incisor-like papillae, which might possibly be mistaken for teeth, but the well-defined dental ridge is further within the mouth, and these papillae have no connection with it. Of these four papillae those next the midline are the largest and measure 1.0 mm in height by 0.75 mm in width at the base. They are flattened in the same plane as the human incisors. Their free margins are somewhat rounded and are without serrations. The lateral members of this group are very similar though a little smaller.

On either side of the median group is a lateral group of from twenty to thirty smaller papillae, bluntly conical in shape and arranged in poorly defined rows. Those in one row may partially overlap the units in the next row. These papillae do not stand erect, but their tips are turned somewhat forward and toward the median line. Beyond the lateral groups, in the direction of the corners of the mouth, a portion of the lip is quite smooth.

The papillae in all the groups consist of connective tissue cores covered with a very thick epithelium, much thicker than the epidermis. In these respects they are like the papillae of the human lips, but they are neither so slender nor so vascular. No dentine has been observed.

The location of the villi would seem to preclude the possibility of their serving to strengthen the animal's grasp upon the nipple. Without assigning to these rather remarkable structures any function, I would regard them, provisionally at least, as "denticles," for superficially their resemblance to selachian teeth is very striking.

During the month that this report has been in press, 130 kittens and cats have been examined, and although the villi early disappear in man, in the cat they are found to be retained throughout life. Their number diminishes, and those of the median group become merely moundlike masses limited by furrows. In the lateral groups, however, the loss in number is accompanied by an increase in size, and the acquisition of a more definitely pointed character, in those which remain. They may attain a length of 2.75 mm. and a breadth of 1.25 mm. In general they point downward and outward, but instances are not rare in

[1] A study conducted as Medical Fellow of the National Research Council.