cm H_2O (mean ± S.E.) in 12 measurements. Simultaneously measured cardinal vein pressure was approximately zero. The effect on filtration rate of varying filtration (perfusion) pressure and cardinal vein pressure is set out in the table.

TABLE 1

Afferent arteriolar Pressure (cm H_2O)	Single Nephron Filtration Rate ($\times 10^{-6}$ ml·min^{-1})	
	CVP = 0	CVP = 4.8 - 5.3
5.0 - 6.2	23.0 + 6.6 (4)	306.3 + 49 (4)
8.0 - 9.5	120.9 + 17.6 (12)	484.6 + 39 (14)
12.0 - 12.5	139.1 + 11.1 (22)	—
14.5 - 17.0	159.0 + 13.6 (12)	—

CVP = Cardinal venous pressure (cm H_2O)

At normal cardinal vein pressure and at perfusion pressure corresponding to normal aortic pressure single nephron filtration rate was $23.0 \pm 5.65 \cdot 10^{-6}$ ml · min^{-1}. The largest increment in filtration for a pressure increase is found in the initial elevation from normal to 8.0 - 9.5 cm H_2O. Lesser increments in flow attend subsequent increases in perfusion pressure. The system is most sensitive to pressure changes in the normal range at higher pressures arteriolar resistance effects a degree of autoregulation of filtration rate. This is demonstrated in the striking increase in filtration consequent to a modest elevation of the cardinal venous pressure (final column of table). Retrograde pressure is not subject to reduction by resistance through the afferent limb and effective filtration pressure is apparently distributed over a greater capillary surface. The inulin tubular fluid to perfusion fluid ratio remained near unity for all collection periods, showing no net reabsorption from capsule, neck segment or early duct during perfusion of single glomeruli. Supported by DFG-Sto 71-3 and NIH grant AM-14424 to J.W. Boylan. Dr. Eisenbach was a Fellow the the National Kidney Foundation.

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FLUID REABSORPTION IN THE NEPHRON OF THE SKATE *Raja erinacea* AND ITS POSSIBLE RELATIONSHIP TO PASSIVE UREA TRANSPORT

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A model for passive urea reabsorption in the elasmobranch kidney has been proposed (Comp.

Biochem. Physiol. 40B:666, 1972) based on micropuncture observations by Thurau (Bull. MDIBL 9:60, 1969) in the dogfish and reinforced by the first detailed description of the skate nephron by Deetjen and Antkowiak (Bull. MDIBL 10:5, 1970). In this model the final low urea concentration of urine is accomplished by diffusion from the terminal thin-walled segment of the nephron into a low-urea environment created by more proximal adjacent loops.

More recently Schmidt-Nielsen and Patel have suggested that the bulk of filtered urea may be reabsorbed passively as a consequence of active sodium transport and that the final low-urea concentration results from secretion of a urea-poor fluid into the terminal segment (Bull. MDIBL 12:94-98, 1972). There is firm biological precedent for both of these processes.

The present study supports the Schmidt-Nielsen hypothesis in that it is shown 1) fractional filtrate reabsorption is large enough to account for the bulk movement of urea, and 2) dye-stuff and inulin are diluted in a final coiled segment of the nephron.

Fluid reabsorption in proximal segments was studied in six male and female skates weighing 500 - 1200 gm. The animals were anesthetized with 0.5 mg/kg BW sodium pentothal and 0.5 mg/kg BW curare via the median tail vein. The fish were prepared for micropuncture as described by Deetjen *et. al.*, (Bull. MDIBL 10:5-7, 1970). Sharpened glass capillaries ground to a tip diameter of 10-16 micron were filled with castor oil stained with sudan black. Surface segments with the largest diameter were selected. This part of the nephron corresponds to segment III in the description of Deetjen and Antkowiak (Bull. MDIBL 10:5-7, 1970). A drop of castor oil was injected into the tubule large enough to block the flow of tubular fluid. The downstream movement of this block was observed and another oil block was injected subsequently in such a way that a part of the tubular fluid was included between the oil blocks. Removal of the puncture pipette permitted the exit of tubular fluid from newly-formed filtrate. The radius and length of the confined droplet were measured with an eyepiece-micrometer at one to two minute intervals.

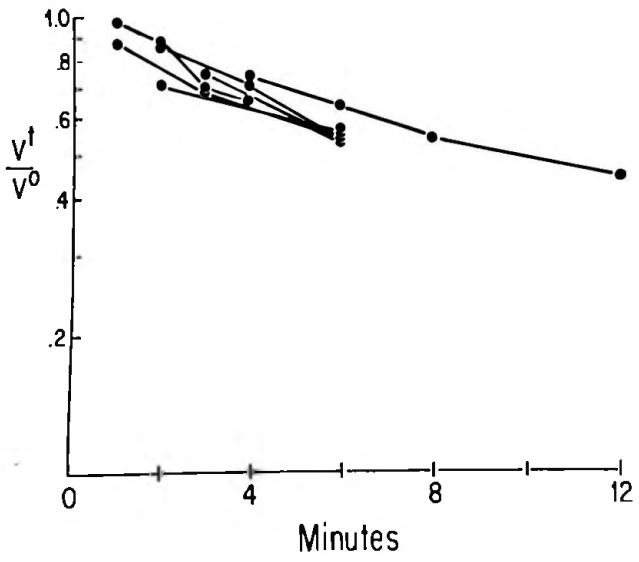

Figure 1: Fractional decrease of droplet volume vs. contact time. (semi-logarithmic)

Figure 2: Microphotography of the countercurrent concentration-dilution system in the skate nephron. The loops are filled with a perfusion solution containing .1 percent Lissamine green. The perfusion pipette was inserted in segment three of this nephron.

Figure 1 shows the fractional decrease of the droplet volume as a function of time on a semi-logarithmic scale. The volume shrinkage was calculated by the equation: $v^t/v^o = (1^t + 2/3\ r) / (1^o + 2/3\ r)$ where 1^t and 1^o are droplet lengths at time zero and time t respectively. This formula contains a correction for the hemispherical menisci of the oil columns. The semilog regression analysis showed a significant regression coefficient of .88. The half time of volume reabsorption is 8.3 minutes.

In a second series of three animals microperfusion experiments were performed. The perfusion solution had a total osmolarity of 993 mOsm/l (NaCl 270 mMol/l and urea 443 mM/l). The solution contained 100 percent lissamine green and Inulin C^{14} in an amount suitable for liquid scintillation determination. The same nephron segments used as in the reabsorptive half-time determination were selected for the perfusion studies. In all microperfusion experiments it was uniformly observed that the colored perfusate disappeared shortly after its introduction at the puncture site and reappeared in a coiled arrangement of loops. The loops were arranged in such a way that a loop with a concentrated (darker) dye solution lay countercurrent to a loop containing (bright) diluted dye solution. The difference between the two dye concentrations is very obvious. These loops correspond to segment VI in Deetjen's nomenclature and possibly to the diluting segment described by Thurau *et. al.* in the dogfish. (Bull. MDIBL 9:60-63, 1969).

Figure 2 shows a typical view of this arrangement photographed with a Polaroid land camera. These pictures were taken at 10-minute intervals after removal of the perfusion capillary. Distal to the coiled segment the nephron again disappears from the kidney surface and then reappears, forming a thin straight segment which empties into a collecting duct. A schematic drawing of the area in which the perfused segment lies is given by Figure 3.

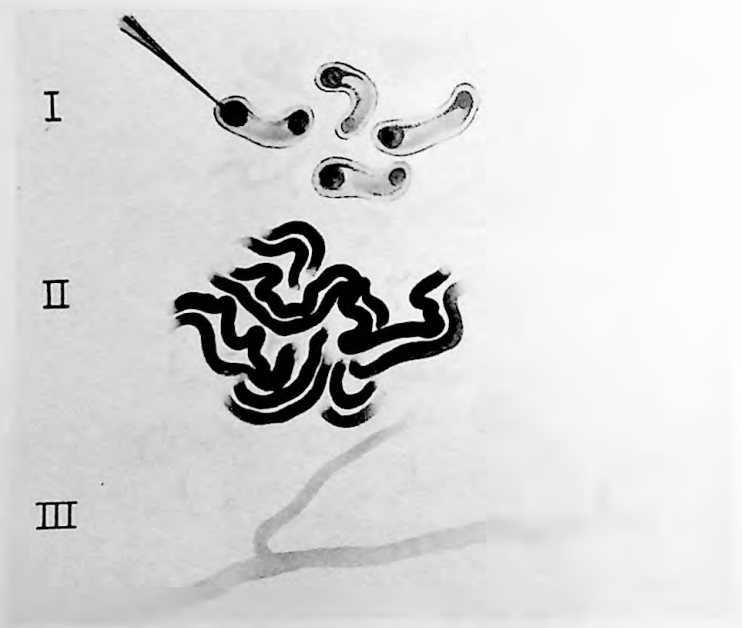

Figure 3. Schematic drawing of the perfusion situation showing the three different structures visible during microperfusion. Phase I: segment III. Phase II: Countercurrent system. Phase III: Collecting duct.

The average time elapsed between phase I and II was 24.5 minutes and between II and III, eight minutes at an initial perfusion rate of 14/nl/min. Four samples of perfusion fluid from the dye-diluted sections of the coiled segments were collected. The average inulin C^{14} concentration was 54 percent of the perfusate concentration indicating a dilution between the two puncture sites. Because of possible contamination with interstitial fluid this figure is only suggestive. A more direct assessment of the amount of dilution is necessary.

The relationship between passage time and half-time of reabsorption determines the fractional fluid reabsorption in the segment under consideration. Deetjen *et. al.* (Bull. MDIBL 10:5-7, 1970) found a passage time through segments III-VI (which correspond to phase I and II in our study) of 17 minutes. With a perfusion rate of 14 nl/min we have found a passage time of 24.5 minutes. This figure in combination with the half-time value of 8.3 minutes indicate a reabsorption of 75-87.5 percent of the filtered fluid. Micropuncture studies of Stolte *et. al.* (Bull. MDIBL 11:91-93) have shown that in segments III and V the tubular fluid osmolarity is equal to the plasma value. This leads to the conclusion that urea permeability is high and allows a rapid transport rate in comparison with the passage time of tubular fluid. Fractional urea reabsorption may therefore be of the same order of magnitude as fluid reabsorption and is in good agreement with the urea excretion rates found in clearance studies. The observed countercurrent concentration-dilution system (Figure 2) may be the site of net fluid secretion into the tubular fluid. Another possibility is that the concentration of the dye is reduced by a passive inward movement of water due to high water permeability in this part of the coiled segment. There is at present no experimental evidence favoring one or the other of these two possibilities. The localization of the 'diluting' segment near the end of the nephron is in good agreement with a hypothetical net fluid secretion into tubular urine and could account for a final U/P urea <1 without active transport of this substance. Supported by NIH grant 5R01-AM-14424. Dr. von Baeyer is a Fellow of the National Kidney Foundation and of the Henry C. and Bertha H. Buswell Endowment.

1973 #50

ELECTROMECHANICAL STUDIES IN THE SINGLE CELL LAYERED HEART OF *Boltenia ovifera*

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The heart of the tunicate *Boltenia ovifera* consists of a straight one-cell layer thick tube which propels blood through the circulatory system by means of peristaltic contractions. In the MDIBL Bulletin of 1972 we reported on some of the contractile properties of this singular myocardium. In this report we are concerned with electrical as well as mechanical characteristics of this heart.

The excised heart was cannulated at both ends (see Figure 1). The cannulae were in turn fixed to two micromanipulators adjusted to hold the heart at constant length in a tissue bath. Through the cannulae the luminal surface of the heart could be perfused with different solutions in quick succession at constant pressure. The extraluminal surface of the heart was also perfused with different solutions through an arrangement of holes in the side of the chamber. The standard intra- and