85%). Similar results were reported earlier (Wiebel, Leutz, Diamond, and Gelboin, Arch. Biochem. Biophys. 144:78, 1971) for 3-methylcholanthrene (3-MC) pretreated and control rats. In rats the response is due to the differential effects of ANF on cytochrome P-450 (control) or cytochrome P-448 (3-MC treated) catalyzed AHH activities; cytochrome P-450-dependent AHH is stimulated by higher concentrations of ANF, whereas cytochrome P-448-dependent AHH is inhibited (Wiebel and Gelboin, Biochem. Pharmacol. 24:1511, 1975).

This is interesting in respect to AHH activity in the little skate since DBA and 3-MC treatment do not induce the apparent formation of cytochrome P-448 in hepatic microsomes (Pohl, Fouts, and Bend, Bull. MDIBL, 15: in press). However, it is possible that an altered form of cytochrome P-450 is synthesized in skate liver in response to type II inducers, as evidenced by the inhibition of AHH activity by ANF, but that this hemoprotein cannot be distinguished spectrally from the cytochrome P-450 present in hepatic microsomes of untreated fish. The hepatic microsomal mixed-function oxidase system from DBA-induced skates is currently being separated into cytochrome P-450, NADPH-cytochrome c reductase and lipid fractions, as described previously for untreated skates (Bend, Pohl, Arinc, and Philpot, Proc. Third Inter. Symp. on Microsomes and Drug Oxidatives, Pergamon Press, in press), in order to investigate this question in more detail.

This investigation has demonstrated that AHH activity in hepatic microsomes from control and DBA-induced little skates can be differentiated by carrying out the incubations in the presence of ANF (as well as by the much higher AHH activities in the induced skates). We are interested in the potential utilization of data such as this in monitoring for polycyclic aromatic hydrocarbon or TCDD pollution (potent type II inducers) in the marine environment since fish are able to accumulate these lipophilic compounds in their livers. Many pollutants of this type are toxic to humans.

RENAL EFFECTS OF ANGIOTENSIN II IN *Lophius americanus*

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The direct effects of angiotensin II on urine flow and sodium excretion rates in mammals are exceedingly variable. As a first general rule, diuresis and natriuresis result when the dose administered is relatively large (or when the dose is small, but endogenous levels are presumed to be high, e.g., during sodium depletion). Explanations for these effects fall into two main categories: hemodynamic and tubular. Hemodynamic. Angiotensin II is a potent vasoconstrictor. Changes in urine flow and sodium excretion are often directly related to changes in blood pressure, independently of changes in whole kidney glomerular filtration rate. Further, whole kidney glomerular filtration rate can be modified by angiotensin, the direction of change being determined by the site--afferent or efferent arteriolar--where angiotensin's vasoconstrictor effect predominates. Still further, the distribution of glomerular filtration between different populations of nephrons might be affected by angiotensin II. Tubular. Stop flow experiments in dogs and some micropuncture experiments in rats suggest that angiotensin directly inhibits the reabsorption of filtered sodium. As a second general rule, smaller doses of angiotensin cause antidiuresis and sodium retention. Because of the relatively short time-lag, aldosterone is thought not to be the mediator of these effects, although its secretion rate is stimulated by angiotensin II. The same sorts of explanations

are offered for these opposite effects: an overall decrease in glomerular filtration rate, an altered intrarenal distribution of filtration, a direct stimulatory effect on sodium reabsorption. The experiments done to clarify answers to seemingly simple questions (e.g., does angiotensin II have an effect on sodium transport of isolated frog skin or toad bladder?) have produced contradictory results (F. Gross and J. Mohring. Ann Rev. Pharmacol. 13:57-90, 1973; H. Sokabe. Kidney Intern. 6:263-271, 1974; J. Capelli L.Wesson, and G. Aponte. Am. J. Physiol. 218:1171-1178, 1970).

We decided to study the renal effects of angiotensin II in goosefish, primarily because it seemed that the interpretation of any effects of angiotensin on urine flow or sodium excretion would not be complicated by possible hemodynamic changes. To our knowledge this is the first report of the renal effects of this agent in any fish.

METHODS. The goosefish used in this study were captured by otter trawl and kept in tanks filled with rapidly running aerated sea water. A total of 9 fish of both sexes was used. Body weight ranged from 0.8 to 11.7 Kg and averaged 3.3 ± 1.2 Kg. A small ventral incision was made on restrained fish, exposing both ureters. These were catheterized with polyethylene tubing as close as possible to the kidneys. The hepatic vein and celiac artery were also catheterized with polyethylene tubing. The arterial catheter was attached to a U-tube "water manometer" and except when blood samples were drawn from the catheter, arterial blood pressure was continuously monitored. An intravenous infusion was begun (300 mOs/Kg H_2O of NaCl, at 0.1083 mg/minute) and approximately 60 minutes later, the first of two consecutive "control" urine collection periods (45-90 minutes duration) was begun. Following the control periods, enough angiotensin II (Hypertension, CIBA) was added to the intravenous infusion to deliver between 10 and 100 ng/Kg body weight/minute (average dose was 44 ± 9 ng/Kg/minute). Approximately 30 minutes later, one or two "experimental" urine collections were obtained. Then the intravenous infusion was changed back to saline alone, and 30 minutes later, one or two "recovery" urine collections were obtained. Arterial blood was drawn (0.2 ml, approximately) at the beginning and the end of each urine collection period. Plasma and urine were frozen until analyzed for sodium (IL flame photometer) and osmolality (Advanced Osmometer). Urine flow rate was normalized per Kg body weight, and the following were calculated: plasma sodium concentration and osmolality, urine sodium concentration and osmolality, and sodium excretion rate and clearance. Averages of these parameters were calculated for each fish for control, experimental and recovery periods, and these averages were then averaged for presentation in the next section. The paired t test was used to assess the significance of any of the observed changes.

RESULTS. Angiotensin II had a pressor effect in all fish. The averages of blood pressure ± SEM (in cm H_2O) were: control, 22.4 ± 2.4; angiotensin, 26.9 ± 2.7; recovery, 19.6 ± 2.4. These changes were significant, with at most $p = 0.004$. A representative response is shown in Figure 1.* In contrast with the usual response in mammals, the pressor effect persisted for some time after angiotensin administration ceased. In the fish of Figure 1, some 45 minutes elapsed before blood pressure returned to the control level.

Other results are summarized in Table 1. Plasma sodium and osmolality tended to increase over time, the increases achieving significance only between the angiotensin and recovery periods. The explanation for these increases is not clear; they were not predicted on the bases of urine and intravenous fluid compositions and flow rates; urine osmolality exceeded plasma osmolality, which in turn exceeded the osmolality of the fluid administered, and urine flow rate approximated the fluid administration rate. Evaporative water loss is a possibility.

*Figure 1 is shown on page xx.

TABLE 1

EFFECTS OF ANGIOTENSIN II IN GOOSEFISH

	CONTROL		EXPERIMENTAL		RECOVERY
Plasma Na, mEq/liter	190 ± 3 (9)	NS	193 ± 4 (9)	0.008	200 ± 5 (8)
Plasma Osmolality, mOs/Kg H_2O	374 ± 7 (9)	NS	378 ± 7 (9)	0.01	390 ± 9 (8)
Urine Flow, µl/hr/Kg body wt	634 ± 70 (18)	0.006	714 ± 69 (17)	0.04	619 ± 80 (14)
Urine Na, mEq/liter	55 ± 6 (18)	NS	62 ± 5 (17)	0.05	86 ± 14 (16)
Na Excretion, mEq/hr/Kg body wt	34 ± 4 (18)	0.00001	47 ± 6 (17)	NS	43 ± 7 (14)
Na Clearance, µl/hr/Kg body wt	180 ± 23 (18)	0.00002	236 ± 30 (17)	0.05	213 ± 32 (14)
Urine Osmolality, mOs/Kg H_2O	368 ± 10 (18)	NS	378 ± 9 (17)	0.04	407 ± 16 (16)

Angiotensin II (Hypertensin, CIBA) was infused intravenously during the experimental period at doses ranging from 10 to 100 ng/Kg body wt/minute (average, 44 ± 9 ng/Kg/minute). "Isotonic" NaCl (300 mOs/Kg H_2O) was infused intravenously throughout all periods at 0.1083 ml/minute. Values in tables are means ± SEM with numbers of observations in parentheses. P values between columns were calculated using the paired t test.

Urine flow increased during angiotensin administration, then fell below control level during the recovery period. Although urine sodium concentration increased progressively, sodium excretion increased during angiotensin infusion, and fell toward control level during the recovery period. Sodium clearances in individual experiments are plotted in Figure 2. Both the average increase during angiotensin and the average decrease during recovery are statistically significant.

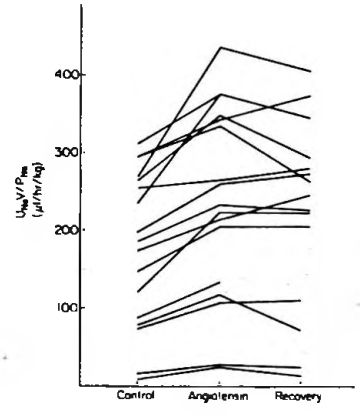

Figure 2. Effect of intravenous angiotensin II administration on sodium clearance ($U_{Na}V/P_{Na}$) of goosefish. Saline (300 mOs/Kg H_2O) was infused at 0.1083 ml/minute throughout all three periods; angiotensin II (Hypertensin, CIBA) was infused at an average rate of 44 ± 9 ng/Kg body wt/minute.

DISCUSSION. It is not as easy as we had anticipated to interpret our results in the context of the possible explanations cited in the introduction. Our observations seem to support a direct inhibitory effect of angiotensin II on sodium transport in the reabsorptive direction, in accord with previous results by others: stop-flow in dogs (Vander. Am. J. Physiol. 205:133-138, 1963) micropuncture in rats (Lowitz, Stumpe, and Ochwadt. Nephron 6:173-187, 1969). However, this conclusion is valid only if angiotensin did not increase the rate at which sodium entered the aglomerular tubules, and this

could have happened either by a direct effect on tubular transport or as a consequence of the pressor effect of angiotensin. Brull et al. (J. Marine Biol. Assoc. U.K. 32:329-336, 1953) and Brull and Cuypers (J. Marine Biol. Assoc. U.K. 33:733-738, 1954) have described a "pressure diuresis" (sodium excretion was not measured) in isolated perfused goosefish kidneys. Although the kidney in goosefish is perfused by venous blood, portal venous pressure might have increased along with systemic arterial blood pressure when angiotensin II was infused.

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THE SARCOMERE LENGTH TENSION RELATION OF THE SINGLE CELL LAYERED HEART OF "SEA POTATO."

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The tubular heart of the "sea potato" (*Boltenia ovifera*) consists of a single layer of spindle shaped cells. The length-tension relation of this myocardium was measured under conditions where servo-control was applied to keep a small segment of the wall isometric (MDIBL Bulletin Vol. 15). The servo-control system was improved and a laser diffraction technique was used in the present study to measure the sarcomere length-tension relation.

The sea potato heart was removed from the animal and after cannulation opened along the raphe to form a sheet of muscular tissue. The tissue was placed over an elongated opening (1.3 mm x 4.5 mm) and tied down along the perimeter of a slightly larger (1.8 mm x 5 mm) circumscribed rectangle, thereby blocking the passage of fluid through the opening from the closed lower section of the chamber to the open upper section. Nylon strings were used to snare down the preparation into two grooves corresponding to the long sides of the rectangle, and the shorter ends were pressed down with two rubber bands. With the pressure of the lower chamber slightly increased, the tissue would bulge up thereby approximating a semicircular cylindrical surface over the central portion of the opening. Both sides of the preparation were perfused with cold filtered seawater. Transepithelial current was applied to elicit contraction.

The experimental set-up is represented schematically in Figure 1. The semicircular arch labeled "muscle" represents a cross section through the bulge shaped preparation. A partially blocked blue light beam is used to measure the height of the bulge, h, and the sarcomere length is estimated from the angular distribution of light diffracted from a red light beam passing through the center of the preparation. Sodium fluorescein (0.2 mM) was added to the solution perfusing the lower chamber. This solution absorbs strongly around 490 nm, thereby effectively blocking the passage of blue light through the bulge, but lets the red light beam through with negligible attenuation. The blue light beam originates from an incandescent lamp equipped with a 488 nm interference filter. The condensed blue light is passed through a rectangular aperture the image of which is focused in a slit (2 mm long and 0.5 mm wide) onto the preparation. The light not blocked by the bulge is measured by a photodiode detector. A second blue interference filter is placed in front of the photodiode in order to block scattered red light and to decrease the effect of varying room light. A second detector measures directly the blue light emitted by the lamp and an amplifier which balances the signals from the two detectors is used to minimize the effect of small variations in the light output from the lamp.

The monochromatic red light (λ = 633 nm) is generated by a 3 watt He-Ne laser and is focused on the muscle in a spot (diameter, 0.4 mm). The diffracted light diverging from the muscle is converted