malities, all animals seemed to have been normal, and no difference in the amount of internal fat was apparent.

Two trials for nitrogen balance were conducted during days 5 to 10 and days 16 to 23. Urine and feces, collected separately for each trial, were blended, sampled, and analyzed. The animals were in positive nitrogen balance at all times; the amount of nitrogen retained was higher during period I (60 percent) than during period II (50 percent). The digestion coefficient for nitrogen was 90 percent in period I, but it was slightly lower in period II. The animals on the diet containing plankton, as well as the control animals, seemed to utilize nitrogen during both periods. Palatability of the red tide was not a problem at any time despite marine odor and high salinity.

Our analyses of the nutrient composition of *G. polyedra* indicate its potential as a source of food. Exploratory feeding trials showed that the rats had good early growth and no toxicity during that period. Factors determining the occurrence, size, and variety of organisms of plankton blooms in the open ocean are not well known, and *G. polyedra* is not one of the more common varieties. However, controlled farming of plankton could become an integral part of the recovery (by atomic energy) of potable water and chemicals from seawater. In many arid coastal regions of the world, drying of plankton may be practical because of climates of high heat and low humidity.

STUART PATTON
P. T. CHANDLER
Division of Food Science, Pennsylvania State University, University Park
E. B. KALAN
Eastern Regional Research Laboratory, Philadelphia, Pennsylvania
A. R. LOEBLICH III, G. FULLER
A. A. BENSON
Scripps Institution of Oceanography, University of California, San Diego, La Jolla

References and Notes

1. J. Schradie and C. A. Bliss, *Lloydia* **25**, 214 (1962); E. J. Schantz, J. M. Lynch, G. Vayvada, T. Matsumato, H. Rapoport, *Biochemistry* **5**, 1191 (1966).
2. W. M. Chapman, *Food Technol.* **20**, 45 (1966).
3. S. Patton, G. Fuller, A. R. Loeblich III, A. A. Benson, *Biochim. Biophys. Acta* **116**, 577 (1966).
4. *G. polyedra* is a unicellular, photosynthetic, marine dinoflagellate averaging about 40 μ in diameter [see F. T. Haxo, in *Comparative Biochemistry of Photoreactive Systems*, M. B. Allen, Ed. (Academic Press, New York, 1960), p. 345].
5. Minor modifications of the culturing method of Schradie and Bliss (*1*) were used.
6. K. A. Piez and L. Morris, *Anal. Biochem.* **1**, 187 (1960).
7. W. G. Gordon and E. O. Whittier, in *Fundamentals of Dairy Chemistry*, B. H. Webb and A. H. Johnson, Eds. (Avi Publishing Co., Westport, Conn., 1966), p. 60.
8. J. R. Spies, *Anal. Chem.* **39**, 1412 (1967). We thank him for the tryptophan analyses.
9. Composition (in percentage) of the control and red-tide diets, respectively, for each ingredient was: casein, 20 and 16; red tide, 0 and 17.89; cornstarch, 64 and 47.61; corn oil, 10 and 12.5; minerals, 4 and 4; and vitamins, 2 and 2.
10. We are grateful to A. E. Branding for technical assistance. Supported in part by PHS grant HE 03632. Paper No. 3271 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

10 August 1967

5-Hydroxytryptamine in the Carotid Body of the Cat

Abstract. *Glomus cells, at least in the carotid body of cats, contain catechol and indolamines. Cells containing adrenaline, noradrenaline, and 5-hydroxytryptamine were identified.*

Catecholamines are present in the carotid body of some species. Using histochemical methods, Muratori and Battaglia (*1*) demonstrated the presence of catecholamines in the carotid body of the pig; Muscholl *et al.* (*2*) obtained similar results in calves. The presence of noradrenaline in the carotid body of calves and pigs was confirmed by Rahn (*3*). With Falck's (*4*) technique, Niemi and Ojala (*5*) found that the human carotid body fluoresces, and they attribute this to catecholamines. Using biochemical and histochemical methods, we found various amounts of dopamine, noradrenaline, and adrenaline, with dopamine comprising more than half of the total catecholamine content of the carotid body. The glutaraldehyde-silver technique enabled us to identify cells containing adrenaline and noradrenaline (*6*). At the same time, Fillenz and Woods (*7*) reported the presence of dopamine in the carotid body of the rabbit.

The only available information on the presence of indolamines in normal carotid bodies was reported by Hamberger, Ritzén, and Wersäll (*8*) who examined human carotid bodies with a fluorescence method for histochemical visualization of certain monoamines. They found cells with a green to yellow-green fluorescence, presumably norepinephrine, and yellow fluorescent cells containing 5-hydroxytryptamine (5-HT). Using a fluorescence microspectrographic method, they established the presence of both monoamines in human carotid bodies.

During our study of the carotid body with the glutaraldehyde-silver technique, we noticed that there was more than one type of silver-reducing cell. Cannata *et al.* showed that this technique permits the differentiation of noradrenaline from cells containing 5-HT. After glutaraldehyde fixation, the cells containing noradrenaline reduce the silver immediately, whereas the cells containing 5-HT need a longer period of silver treatment (*9*). Therefore, the study of the 5-HT content in the cat's carotid bodies was undertaken. Once we had proved the presence of this indolamine, we identified the cells containing 5-HT. The carotid bodies were removed from adult cats anesthetized with Nembutal (40 mg/kg), dissected, immediately immersed in 5 percent trichloroacetic acid, and assayed for 5-HT by the technique of Bogdansky *et al.* (*10*). In each of ten experiments, four carotid bodies were assayed. For the assay of catecholamines, the same number of carotid bodies was dissected and distributed in ten experiments. The carotid bodies were weighed and immersed in 0.4*M* perchloric acid. The extraction was performed by the method of Bertler *et al.* (*11*). Adrenaline and noradrenaline were assayed with the technique of Donoso *et al.* (*12*), whereas for the assay of dopamine the method of Carlsson and Waldeck was used (*13*). For histochemical studies by electron microscopy, the carotid bodies were fixed in 6.5 percent glutaraldehyde solution in Millonig buffer at *p*H 7.2, 4°C, for 6 hours. The glutaraldehyde-silver technique (*14*) was used after a careful wash in distilled water. Silver treatment was applied at various times (2, 5, 15, and 30 minutes).

The biochemical assays showed that 5-HT was present in a large amount (6.9 ± 0.27 μg/g); the amount of noradrenaline was 2.4 ± 0.37 μg/g, that of adrenaline was 0.4 ± 0.08 μg/g, that of dopamine was 4.4 ± 0.41 μg/g. Extracts of carotid bodies prepared for 5-HT assays excited at 295 mμ showed that the fluorescence spectrum obtained with an Aminco Bowman spectrofluorometer was the same as that obtained with pure 5-HT. Both showed a fluorescence maximum at 575 mμ (uncorrected).

Electron microscopy with the glutaraldehyde-silver technique revealed three different types of cells. The first type, distributed irregularly, contains large, polymorphic granules; with 1 or 2 minutes of treatment with silver, a positive glutaraldehyde-silver reaction

was observed. These cells were identified as containing noradrenaline. The second type of glomus cell contains granules smaller in size than the first type and gives a negative reaction with 2 minutes of silver treatment; when treated 15 minutes or longer, it gives a positive reaction (Figs. 1–3). These cells, the most numerous of all, store 5-hydroxytryptamine. The third type of cell, which is very scarce and is characterized by the presence of small, round granules, gives a negative reaction even with more than 30 minutes of treatment with silver. This type contains adrenaline.

These findings explain the results of Costero and Barroso Moguel (*15*) and Pryse-Davies *et al.* (*16*) who found 5-hydroxytryptamine in tumors of the carotid body. It is difficult to explain the function of the high amount of 5-hydroxytryptamine in the carotid body. Two hypotheses should be considered: either indolamine acts as a transmitter in the initiation of chemoreceptive impulse, or else 5-HT can be discharged into the bloodstream and acts at a distance.

Although it was claimed (*17*) that 5-hydroxytryptamine increases the discharge of afferents from the carotid body and confirmed (*18*) that in the dog this effect appears with a short latency, Lever and Lewis (*19*) refused to consider this substance as a candidate for transmitter. 5-Hydroxytryptamine may, on rare occasions, excite the superfused carotid body (*20*). Our study shows that the glomus cells in the carotid body of cats contain catechol and indolamines. At the same time, various cells types were identified as containing noradrenaline, adrenaline, and 5-hydroxytryptamine.

SARA R. CHIOCCHIO
ANA MARIA BISCARDI
JUAN H. TRAMEZZANI
Instituto de Biología y Medicina Experimental, Obligado 2490
Buenos Aires, Argentina

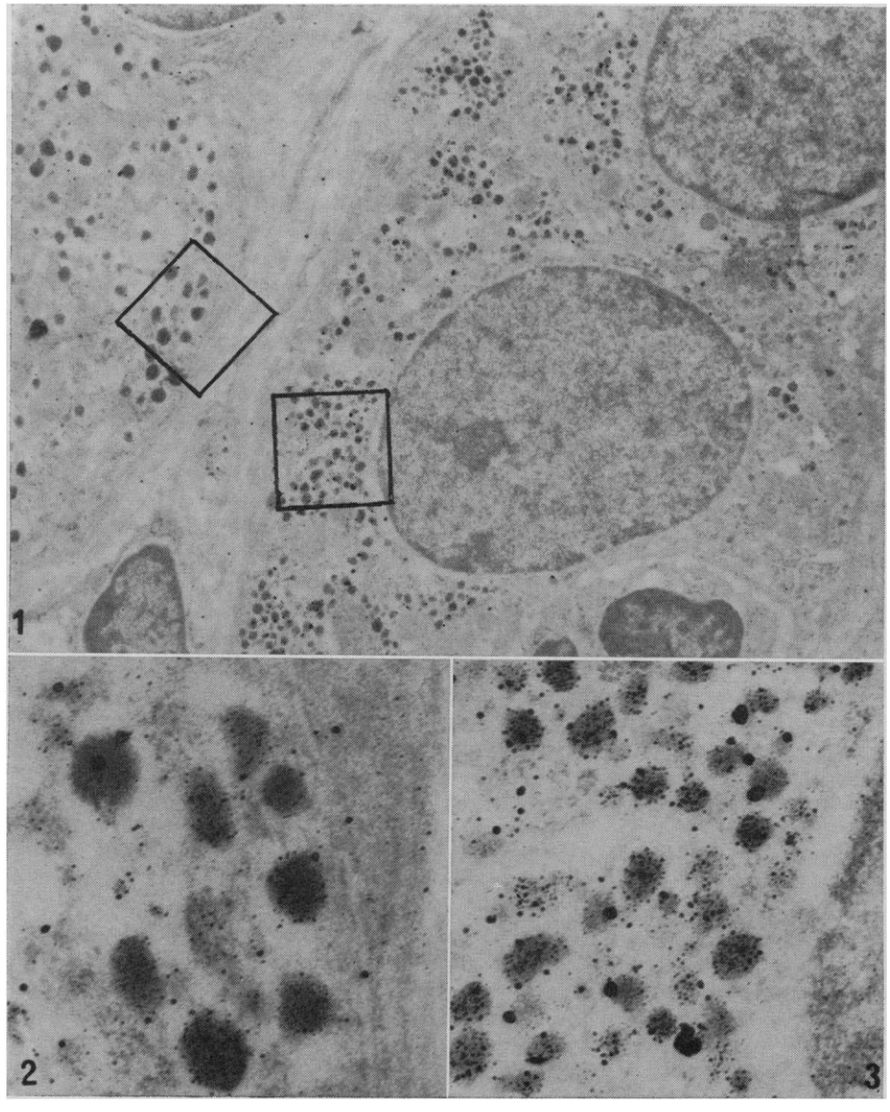

Fig. 1. Carotid body of cat. Glutaraldehyde-silver technique with 30 minutes of silver treatment (× 12,000). Figs. 2 and 3. Selected areas of Fig. 1 at higher magnification show a positive reaction in the two types of cells (× 54,000). The cell on the left, with larger granules, contains noradrenaline; cells on the right with smaller granules contain 5-HT.

References

1. G. Muratori and G. Battaglia, *Boll. Soc. Ital. Biol. Sperim.* **36**, 402 (1960).
2. E. Muscholl, K. H. Rahn, M. Watzka, *Naturwissenschaften* **47**, 325 (1960).
3. K. H. Rahn, *Anat. Anz.* **110**, 140 (1961).
4. B. Falk, *Acta Physiol. Scand.* **56**, Suppl. 197 (1962).
5. M. Niemi and K. Ojala, *Nature* **203**, 539 (1964).
6. S. R. Chiocchio, A. M. Biscardi, J. H. Tramezzani, *ibid.* **212**, 834 (1966).
7. M. Fillenz and R. I. Woods, *J. Physiol.*, Proc. Physiol. Soc. Oxford Meeting (1966).
8. B. Hamberger, M. Ritzén, J. Wersäll, *J. Pharmacol. Exp. Therap.* **152**, 197 (1966).
9. M. A. Cannata, S. R. Chiocchio, J. H. Tramezzani, *Histochemie*, in press.
10. D. F. Bogdanski, A. Pletscher, B. B. Brodie, S. Udenfriend, *J. Pharmacol. Exp. Therap.* **117**, 82 (1956).
11. A. Bertler, A. Carlsson, E. Rosengren, *Acta Physiol. Scand.* **44**, 273 (1958).
12. A. O. Donoso, A. Biscardi, G. F. Wassermann, *Medicina* **25**, 169 (1965).
13. A. Carlsson, and B. Waldeck, *Acta Physiol. Scand.* **44**, 293 (1958).
14. J. H. Tramezzani, S. R. Chiocchio, G. F. Wassermann, *J. Histochem. Cytochem.* **12**, 890 (1964).
15. I. Costero and R. Barroso Moguel, *Amer. J. Pathol.* **38**, 127 (1961).
16. J. Pryse-Davies, I. M. P. Dawson, G. Westbury, *Cancer* **17**, 185 (1964).
17. W. W. Douglas and J. Toh, *J. Physiol.* **117**, 71P (1952).
18. J. W. McCubbin, J. H. Greene, G. C. Salmoiraghi, J. H. Page, *J. Pharmacol. Exp. Therap.* **116**, 191 (1956).
19. J. D. Lever and P. R. Lewis, *J. Physiol.* **149**, 26P (1959).
20. C. Eyzaguirre and H. Koyano, *ibid.* **178**, 410 (1965).

5 September 1967

Induction of Coiling in Tendrils by Auxin and Carbon Dioxide

Abstract. *Symmetric application of indole-3-acetic acid, CO_2, or, to a lesser extent, ethylene can substitute for the contact stimulus in inducing coiling in the tendrils of* Marah fabaceus. *In the case of auxin, treatment of the apical few millimeters results in strong, permanent coiling throughout the length of the tendril. The speed of the response to CO_2 is comparable to that to tactile stimuli. A possible mechanism for thigmotropism is outlined.*

Accumulated experimental evidence (*1*) suggests that, when a tendril receives a contact stimulus, the growth rate of the stimulated side falls while that of the opposite side rises sharply.