values when gamma globulin and other serum protein measurements are made.

HOWARD M. RAWNSLEY*
VIRGINIA L. YONAN
JOHN G. REINHOLD
William Pepper Laboratory of Clinical Medicine, Hospital of the University of Pennsylvania, Philadelphia

References and Notes

1. J. H. Lewis, *The Biology of the Negro* (Univ. of Chicago Press, Chicago, Ill., 1942).
2. L. Arens and J. F. Brock, *S. African J. Clin. Sci.* 5, 20 (1954).
3. J. S. Garrow, *West Indian Med. J.* 3, 104 (1954).
4. D. F. Milam, *J. Lab. Clin. Med.* 31, 285 (1946).
5. J. G. Reinhold, L. G. Tourigny, V. L. Yonan, *Am. J. Clin. Path.* 23, 645 (1953).
6. J. G. Reinhold, H. M. Rawnsley, V. L. Yonan, *Résumés des Commun.* 3e Congrès Int. Biochem. (Bruxelles, 1955), p. 142.
7. These studies were supported by the Office of the Surgeon General, U.S. Department of the Army.
8. J. S. Simmons and C. J. Gentzkow, *Medical and Public Health Laboratory Methods* (Lea and Febiger, Philadelphia, ed. 2, 1955).
9. H. G. Kunkel, *Proc. Soc. Exptl. Biol. Med.* 66, 217 (1947).
10. J. de la Huerga and H. Popper, *J. Lab. Clin. Med.* 35, 459 (1950).
11. We wish to thank Mrs. C. A. J. Goldberg, Shirley Matis, and Harry Bass for kindly doing the electrophoretic studies.

* Woodward fellow in Physiological Chemistry.

14 December 1955

Green Crabs and the Redistribution of Quahogs

In a recent report, Dow and Wallace commented on the effects of winter storms in redistributing populations of the quahog, *Venus mercenaria* L. (*1*). The probable effect of water currents in accumulating masses of young quahogs has been indicated elsewhere (*2*). Recently it has come to light that crabs also constitute a factor in the redistribution of a quahog population.

The green crab, *Carcinides maenas* (L.), is a voracious predator upon clam and quahog populations in northern New England waters (*3, 4*). Although other factors are also involved, its progressive increase in the Gulf of Maine has roughly paralleled a serious depletion of the soft-shelled clam, *Mya arenaria* L. (*5*), and the crab is an important factor in the reduction of seedbeds of the quahog (*4*). Data obtained during the fall of 1955 indicate that, in addition to its importance as a shellfish predator, the green crab plays a minor but appreciable role in redistributing quahogs in an area where crabs and quahogs occur together.

On 16 Sept. 1955, while repairing a fence impeding the entrance of crabs into Brickyard Cove, Sebascodegan Island, Me., we collected a green crab that was moving about with a 1-in. quahog pinched onto the tip of one of its walking legs. When the crab was lifted from the water, the quahog pinched down more tightly on the crab's leg, thus removing the tip of the terminal segment. The same action left a small circular nick, marking the two valves symmetrically, at the edge of the quahog shell. It was then noted that several quahogs lay exposed on screening that had been placed on the bottom behind the fence to reduce tidal erosion and on which the crab with the attached quahog had been collected. Of a sample of 32 of these exposed quahogs, 26 were living, and in 24 of these the edges of the valves were scarred by nicks similar to that described. In the other two living specimens, growth had continued after scarring so that each valve was marked near the edge by a semicircular scar, and its concavity was filled in by new growth.

It is assumed that the quahogs found on the flat screening had been transported there by the movements of crabs and that once over the screening the quahogs had either been shaken off or had amputated the tips of the crab legs, thus freeing themselves. It is further assumed that a quahog becomes attached to a crab's leg when a crab inadvertently places a leg tip between the open valves of a quahog in the region of the pallial sinus as the latter rests upright in the mud.

These assumptions are strengthened by the following observations. Small quahogs are frequently collected about the periphery of Quahog Bay, of which Brickyard Cove is an arm, each with a small circular nick in the edge of the shell in the region of the pallial sinus. When a quahog is opened immediately after it has pinched off the tip of a crab leg, it is found that the tip lies between the valves near a circular nick at the edge of the shell. Green crabs with missing leg tips occur frequently in the area. Robert L. Dow and Dana E. Wallace of the Maine Department of Sea and Shore Fisheries have observed a horseshoe crab, *Limulus polyphemus* L., at the moment that it picked up a quahog passenger in the manner postulated for the green crab; they have photographed the specimens involved.

After the observations of 16 Sept., we collected a random sample of 1000 quahogs, all under 5 cm and more than 1.5 cm, in Brickyard Cove. Of these specimens, 29, or 2.9 percent, demonstrated a circular nick at the edge of the shell, or a shell bilaterally marked by semicircular scars that had been filled in by subsequent growth. Of the specimens thus far examined, the smallest in which the nick, either peripheral or elsewhere, has been detected has been 2 cm in length; the largest, 3.7 cm.

The role of the green crab in redistributing the quahog may not be especially important to the whole ecology of either, but it may be that something of a beneficial effect is introduced by the green crab in thinning crowded populations, since it would be in such areas that the walking legs would seem most likely to enter the valves. On the other hand, the breaks introduced may allow entrance to foreign invaders or to the action of green crab pincers, thus increasing the susceptibility of the quahog to destruction. However, a sample of several empty scarred valves that were collected showed that the nick was in a peripheral position in but one case.

One value of the observations reported here may lie in a possible correlation between frequency of the scar reported and the relative populations of green crabs and quahogs. On the other hand, the frequency of missing leg tips of the green crab in a quahog area might reasonably be presumed to be related to the density of small quahogs in the feeding zone.

JAMES M. MOULTON
ALTON H. GUSTAFSON
Department of Biology, Bowdoin College, Brunswick, Maine

References

1. R. L. Dow and D. E. Wallace, *Science* 122, 641 (1955).
2. J. M. Moulton and G. W. Coffin, *Research Bull. No. 17* (Maine Department of Sea and Shore Fisheries, Augusta, 1954).
3. O. R. Smith, J. P. Baptist, E. Chin, *Comm. Fisheries Rev.* 17, No. 6 (1955).
4. A. H. Gustafson, in *Fifth Conference on Clam Research, Boothbay Harbor, Maine* (Fish and Wildlife Service, Clam Investigations, Boothbay Harbor, Me., 1955).
5. R. L. Dow and D. E. Wallace, *Fisheries Circ. No. 8* (Maine Department of Sea and Shore Fisheries, Augusta, 1952).

22 December 1955

Serotonin-Releasing Activity Limited to Rauwolfia Alkaloids with Tranquilizing Action

Previous findings (*1, 2*) have led us to postulate that the clinical effects of reserpine are mediated through serotonin (5-hydroxytryptamine), a substance that is normally present in the brain, and that serotonin may have a role in brain function. This concept is based in part on the observation that reserpine liberates serotonin from its body depots. The evidence presented in this paper strengthens the concept by showing that of a number of centrally acting drugs only *Rauwolfia* alkaloids exerting a tranquilizing action effect the liberation of brain serotonin.

Rabbits received the various drugs intravenously and were killed 4 hours later. Their brains were removed as rapidly as possible, and serotonin was determined fluorometrically (*3*).

In Table 1 is shown the effect of a

Table 1. Serotonin concentration in rabbit brain 4 hours after administration of various *Rauwolfia* alkaloids. Rabbits received 2 mg/kg of alkaloid intravenously (25 mg of each compound was dissolved in a few drops of glacial acetic acid and diluted with 0.7 ml ethanol, 0.7 ml propylene glycol, and 3.6 ml water.)

Alkaloid	No. of animals	Sedative action	Serotonin content (μg/g)
None	9		0.57 ± 0.08
Reserpine	2	Active	0.05, 0.07
Deserpidine (recanescine)	2	Active	0.06, 0.13
Rescinnamine	2	Active	0.09, 0.12
Isoreserpine	2	Inactive	0.42, 0.54
Methyl reserpate	2	Inactive	0.43, 0.45
Reserpic acid	2	Inactive	0.48, 0.55
Reserpinine	1	Inactive	0.49
Serpentine	2	Inactive	0.43, 0.46
Ajmaline	1	Inactive	0.44
Ajmalacine	2	Inactive	0.52, 0.58
p-Toluene sulfonyl methyl reserpate	1	Inactive	0.49
Yohimbine	1	Inactive	0.48

Table 2. Serotonin concentration in rabbit brain 4 hours after intravenous administration of various drugs that act on the central nervous system.

Drug	Dose (mg/kg)	Central effect	Serotonin content (μg/g)
None			0.57 (avg.)
Phenobarbital	100	Hypnosis	0.51
Barbital	200 (divided doses)	Hypnosis	0.51, 0.48
Morphine	20	Sedation	0.43, 0.57
Scopolamine	50	Light sedation	0.50
D-Amphetamine	70 (divided doses)	Convulsions	0.55
Diphenhydramine	35 (divided doses)	Convulsions	0.54
Cortisone	26 (divided doses)	Convulsions	0.49

Table 3. Serotonin concentration in rabbit brain 4 hours after intravenous administration of various hallucinogenic and psychotherapeutic drugs.

Drug	Dose (mg/kg)	Central effect	Serotonin content (μg/g)
None			0.57 (avg.)
LSD	0.12	Excitement	0.47, 0.49
Mescaline	75	Excitement	0.46, 0.50
Chlorpromazine	10	Sedation	0.52, 0.49
Frenquel	75 (divided doses)	Convulsions	0.53, 0.59

number of *Rauwolfia* alkaloids on brain serotonin. Only reserpine, rescinnamine, and deserpidine (recanescine) induced sedation and caused a significant alteration in brain-serotonin levels. Methyl reserpate, an inactive hydrolytic product of reserpine, did not release serotonin. Other alkaloids that are structurally related to reserpine had neither a sedating action nor an effect on brain serotonin. The failure of isoreserpine to release serotonin or to produce an observable sedative effect was of particular interest, since this compound differs from reserpine only in steric configuration (*4*).

Table 2 shows the effect on brain serotonin of other centrally acting drugs that are structurally unrelated to reserpine. It can be seen that a variety of hypnotics, narcotic analgesics, and central nervous system stimulants had no effect on brain serotonin.

The effect of a number of hallucinogenic agents and synthetic psychotherapeutic drugs is shown in Table 3. None of the compounds studied changed significantly the serotonin content of brain tissue. Since previous studies have shown that the hallucinogenic agent, lysergic acid diethylamide (LSD), antagonizes a central action of reserpine (*1*), it seemed possible that pretreatment with LSD would prevent the release of serotonin by reserpine. It was found, however, that LSD did not block this release,which indicates that LSD inhibits reserpine centrally by blocking the action of liberated serotonin, as previously suggested (*5*).

Of special interest was the inability of chlorpromazine to release serotonin, since, like reserpine, chlorpromazine exerts tranquilizing effects, potentiates hypnotics, and is useful in the treatment of psychiatric disorders. Presumably, therefore, the central actions of chlorpromazine are not mediated through the release of serotonin. This is in accord with our observation that LSD blocks the reserpine-induced potentiation of hypnotics but not that induced by chlorpromazine (*6*). It thus seems likely that chlorpromazine acts directly on receptor sites in the brain. This is in contrast to reserpine, which acts through serotonin. Frenquel, a new drug that is currently under investigation for the treatment of psychiatric disorders, also failed to release serotonin in brain tissue.

The experiments described here show that, of a wide variety of drugs that act on the central nervous system, only the *Rauwolfia* alkaloids that cause sedation can affect brain serotonin. They offer further evidence that the beneficial clinical effects of these drugs are mediated through the action of serotonin.

BERNARD A. BRODIE
PARKHURST A. SHORE
A. PLETSCHER*
Laboratory of Chemical Pharmacology, National Heart Institute, National Institutes of Health, U.S. Public Health Service, Bethesda, Maryland

References and Notes

1. P. A. Shore, S. L. Silver, B. B. Brodie, *Science* 122, 284 (1955).
2. A. Pletscher, P. A. Shore, B. B. Brodie, *ibid.* 122, 374 (1955) and *J. Pharmacol. Exptl. Therap.* 116, 84 (1956); B. B. Brodie, A. Pletscher, P. A. Shore, *Science* 122, 968 (1955).
3. D. Bogdanski *et al.*, *J. Pharmacol. Exptl. Therap.*, in press.
4. C. F. Huebner *et al.*, *Experientia* 11, 303 (1955).
5. P. A. Shore, S. L. Silver, B. B. Brodie, *ibid.* 11, 272 (1955).
6. P. A. Shore and B. B. Brodie, unpublished observation.
* Guest worker from Hoffmann-La Roche, Inc., Basel, Switzerland.

2 December 1955

Chemistry has been termed by the physicist the messy part of physics, but that is no reason why the physicists should be permitted to make a mess of chemistry when they invade it.—FREDERICK SODDY.