Table 3. Crystallographic parameters.

c (Å)	a (Å)	c/a	V_p/V_0	$\Delta V/V_p$ (%)	$\Delta d/d$ (%)
		Silicon			
2.585	4.686	0.554	0.918	22.7	+6.3
		Germanium			
2.692	4.884	.551	.875	20.7	+8.6
		Tin			
3.182	5.831	.546		20.9	+7.5

peared. Patterns taken over a 3-day period at constant pressure revealed a change in the added pattern until ultimately that given in Table 2 appeared. Of particular note was the appearance of $l \neq 0$ lines for a white tin tetragonal indexing such as 101, 301, 112, and 312, while diffraction peaks previously indexable as 400 and 420 shifted positions, indicating now unresolved lines with additions of 321 and 411. The line indexing 220, which had been strong, was too faint to measure in the background between 1.713 Å (labeled X) and 211 (tin) which blended with 311 (diamond). A glance at Table 2 reveals that two further lines appeared, at 2.613 Å and 1.713 Å. Neither of these fit a white tin structure. When the pressure was lowered, all lines indexable as white tin disappeared, while these two lines persisted, indicating that they belonged to a separate phase. The nature of this phase, as well as its relationship to the now reasonably-well proved white tin structure for Si at high pressure, is not known. Such an indexing is given in Table 2. The collected crystallographic data for Ge and Si are given in Table 3, together with those of Sn (*11*) at zero pressure for comparison (d is interatomic distance).

It now becomes possible to discuss the mode of transition of Ge and Si under the stress conditions of the x-ray experiments. It must be remembered that the samples are encased in confined boron which will apparently support quite high shearing stresses. Musgrave and Pople (*12*) have suggested that the mode of transition of a diamond structure to a white-tin structure can be a mechanical one, namely a compression along any one of the cubic axes and an expansion along the direction (110). This means that in the pressure experiments on the average, the c axis of the new phase will be normal to the piston faces, while the a axes will be parallel. Hence the diffraction pattern will consist of intensified a reflections and diminished c until recrystallization with lateral relief of the sample can occur. This makes it difficult to say precisely what the pressure of transition (in Si especially) is. If the V_p/V_0 for Si from Table 3 is plotted on a graph containing Bridgman's curve for V_p/V_0 vs. pressure to 10^5 kg/cm^2 (*6*), it seems to correspond to a pressure of about 160 kb or so rather than Minomura and Drickamer's figure of 195 to 200 kb (*7*). However, Minomura and Drickamer also reported that some Si samples, confined in pyrophyllite, showed exceedingly low resistivities starting as low as 135 to 150 kb, while samples confined in the low-shear-strength material AgCl consistently transformed at 195-to-200 kb. The present study is mechanically more analogous to their study of the pyrophyllite cell. Hence, on the basis of the x-ray study, it does not seem inappropriate to suggest that the Si transition is actually displaced by a nonhydrostatic stress system. Such a displacement is metastable, for with time the system relaxes by recrystallization to a more "hydrostatic" condition. This in turn suggests that in studies of polymorphic transitions at high pressures with solid pressure-transmitting media, transition pressures *lower* than those of hydrostatic equilibrium may be reported. This is contrary to what would be expected from the thermodynamics of the hydrostatic case in which a reported pressure of transition must be equal to or above the true equilibrium pressure on increasing pressure.

JOHN C. JAMIESON
Department of Geophysical Sciences, University of Chicago, Chicago, Illinois

References and Notes

1. J. C. Jamieson and A. W. Lawson, *J. Appl. Phys.* **33**, 776 (1962).
2. A portion of this work was presented at the Houston meeting of the Geological Society of America, November 1962. This work has been supported by grant G19744 from the National Science Foundation and also by a grant from the Petroleum Research Fund of the American Chemical Society.
3. A report on the group III–V compounds is in press (*Science*). A report on tin is in preparation.
4. North American Philips Co. collimator for their 114.58 mm powder camera.
5. I thank Prof. N. H. Nachtrieb for the Ge, Prof. J. V. Smith for the Si.
6. P. W. Bridgman, *Proc. Am. Acad. Arts Sci.* **76**, 55 (1948).
7. S. Minomura and H. G. Drickamer, *J. Phys. Chem. Solids* **23**, 451 (1962).
8. A. Jayaraman, R. C. Newton, G. C. Kennedy, *Nature* **191**, 1288 (1961).
9. P. L. Smith and J. E. Martin, *ibid.* **196**, 762 (1962).
10. J. S. Kasper, private communication.
11. H. E. Swanson and E. Tatge, *Natl. Bur. Std. U.S., Circ. 539* (1953), vol. 1.
12. M. J. P. Musgrave and J. A. Pople, *J. Phys. Chem. Solids* **23**, 321 (1962).

18 January 1963

Tremoctopus violaceus Uses Physalia Tentacles as Weapons

Abstract. *Immature octopods* (Tremoctopus violaceus) *have been found with numerous fragments of tentacles of the coelenterate* Physalia *attached to the suckers of their dorsal arms. The probable method of acquisition, the evidence of adaptation for holding the tentacles, and the possibility that the octopod uses these coelenterate tentacles as offensive and defensive weapons are discussed.*

Several workers (*1, 2*) have reported the occurrence of portions of unidentified coelenterate tentacles on the arms of young *Tremoctopus violaceus* Delle Chiaje (Cephalopoda: Tremoctopodidae), a pelagic octopod. Naef (*2*) was unable to determine whether this association was the accidental result of an encounter with the coelenterate or an advantageous behavior pattern whereby the stinging cells could be used as weapons by the octopod. He proposed that the latter was probably the case.

This report presents some similar observations in which the coelenterate fragments are identified, and Naef's hypothesis of an advantageous behavior pattern is supported.

During cruise No. 38 of the Bureau of Commercial Fisheries' research vessel *Hugh M. Smith* in February 1957, night-light stations were conducted in the vicinity of latitude 13°S, longitude 110° to 112°W. Among the frequent visitors to the submerged light were a number of immature female octopods, *Tremoctopus violaceus*. I dip-netted one of these from the water and lifted it by hand out of the net. I experienced sudden and severe pain and involuntarily threw the octopod back into the water. To determine the mechanism responsible for this sensation 10 or 12 small (40 to 72 mm total length) octopods were captured and I purposely placed each one on the tender areas of my hands. The severe pain occurred each time, but careful observation indicated that I was not being bitten by the octopod. The pain and the resulting swelling and inflammation, which lasted several days, resembled the stings of the coelenterate *Physalia*, the Portuguese man-of-war, which was quite abundant in the area.

Subsequent examination of one of these female octopods, 72 mm long, which had been preserved, revealed fragments of *Physalia* tentacles attached in an orderly fashion to each row of suckers of each of its four dorsal arms (Fig. 1*a*). No tentacles were found on any of the four ventral arms.

About 75 percent of the suckers of each dorsal arm carried *Physalia* fragments. The unoccupied suckers were, for the most part, those near the base and the distal tips of the arms. This degree of occupation of the suckers would render these arms nonfunctional as conventional grasping organs.

Although each fragment was grasped by several suckers in such a manner that there was a minimum of contact between it and the tissue of the octopod, microscopic examination indicated that a number of discharged nematocysts had their tubes embedded in the tissue of the octopod suckers. Thus it appears that *Tremoctopus* is either immune to the toxin of *Physalia* or is able to confine it to insensitive tissue. That such immunity is possible is supported by at least three records of animals that eat *Physalia*. These are the loggerhead turtle (*3*), the marlin (*4*), and the Portuguese man-of-war fish (*5*). However, examination of the stomach contents of a 40-mm female octopod which carried tentacle fragments on its arms revealed no coelenterate material.

There is evidence that the structure of the suckers of the arms of *Tremoctopus* is adapted for holding coelenterate fragments. A diagrammatic lateral view of the suckers of the ventral arm shows that they are cylindrical with an elongate capsule cavity, an unconstricted opening, and a large distal surface apparently suitable for adhesion to a plane surface (Fig. 1*b*). The capsule of the sucker of the dorsal arm is similar to a small bulb, rounded, with a very small opening and with no flat distal surface (Fig. 1*c*). The manner of grasping the *Physalia* fragments by the suckers of these dorsal arms is indicated in Fig. 1*d*, which shows a fragment which has been teased loose from three suckers. The tissue of this fragment shows that it was drawn out by suction into three small pedunculate diverticula which just filled the capsule cavities.

While from experience, I can personally testify to the efficacy of the coelenterate fragments on the octopod's arms as a means of defense, there is some evidence that defense is not the only function of these stinging tissues. The suckers of cephalopods are generally used as offensive weapons, that is, for capturing food, and some species have well-developed chitinous teeth or hooks in the sucker rings which add to the animal's ability to catch and hold its prey. Defensive behavior in cephalopods usually involves color changes, the use of ink as a decoy or screen, and agility in jumping and jetting. With these considerations in mind, it appears quite possible that *Tremoctopus* may utilize *Physalia* tentacles as offensive weapons. Berry's illustrations of the female *Tremoctopus violaceus* (*6*) suggest that the four dorsal arms with their connecting web may form a coarse straining mechanism. With every row of suckers of such a mechanism armed with tissue capable of stinging, the entire arrangement could be quite effective in capturing plankton or small fish. The tentacles of *Physalia*, with their stinging cells, are quite adhesive and the action of these stings on fish quickly renders them quiet and helpless (*7*).

It is interesting to speculate on the method *Tremoctopus* might use in obtaining the tentacle fragments. Unless the octopod is immune to *Physalia* toxin, the approach to the coelenterate must be made quite cautiously, and one can only imagine the pickpocket type of dexterity which would be required to obtain enough tentacle fragments to cover eight rows of suckers. The arrangement in single-file rows of the tentacle fragments on the arms suggests that the oral surface of a dorsal arm of the octopod is moved to a position parallel with an extended *Physalia* tentacle and then the small suckers are attached to a long section of the tentacle. It appears from their rounded ends that the fragmentation of the tentacles may have been the result of autotomy.

Certain observed behavior patterns in *Tremoctopus* and *Argonauta* octopods may explain the origin of carrying *Physalia* fragments by the former. During the same cruise on which the specimen shown in Fig. 1*a* was collected, several small specimens of *Tremoctopus* were kept in an aquarium containing circulating sea water. They were frequently observed attached to the sides or bottom of the vessel or crawling about in a manner similar to that of more conventional benthic octopuses.

A small mature female *Argonauta hians* Solander with a brood shell was also observed for a period of nearly a month and it spent considerable time attached to the sides or the bottom of the aquarium. This argonaut was

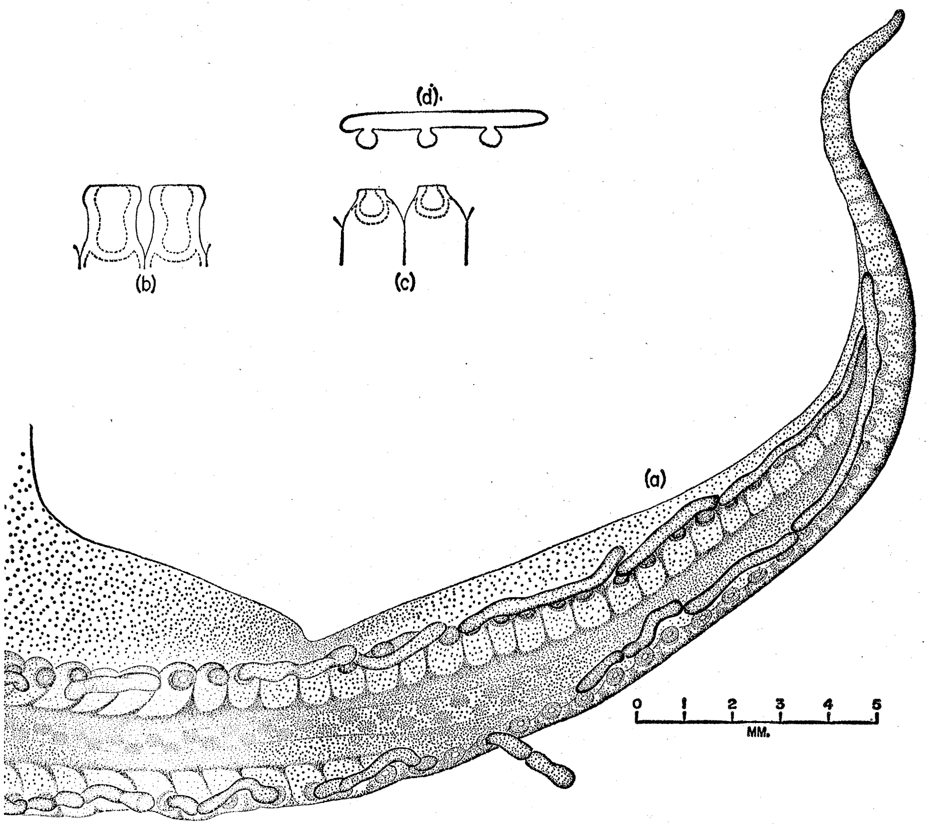

Fig. 1. (*a*) Dorsal arm of *Tremoctopus*, with *Physalia* fragments; (*b*) diagrammatic lateral view of a sucker of a ventral arm; (*c*) diagrammatic lateral view of a sucker of a dorsal arm; (*d*) *Physalia* fragment showing diverticula.

captured while it was attached to a floating siphonophore, *Velella*. E. L. Nakamura (*8*) in 1952 captured three small female argonauts, each of which was attached to the exumbrella of a medusa (*Pelagia placenta* Haeckel) which was drifting near the surface of the water. Bruun *et al.* (*9*) reported similar observations from the Indian Ocean. These reports suggest that pelagic octopods of the families Tremoctopodidae and Argonautidae are not strong swimmers and rest by attaching themselves to buoyant coelenterates. Such close association might lead to immunity from the coelenterate toxin and to the acquisition of the tentacle fragments by *Tremoctopus*. No coelenterate fragments were found, however, on a number of argonauts which were examined.

The behavior of holding *Physalia* fragments has been observed only in young *Tremoctopus*, and it is not known whether it persists in the adult. Voss (*10*) has stated that *T. violaceus* may exceed 5 feet in total length and in his collection he has (*11*) a preserved 4-foot egg-bearing female. These reports of large-sized specimens indicate that a female of 72 mm total length is almost certainly immature. Two immature males, 30 mm in total length, with the hectocotylized arm still within a sac, are in the collection of the Biological Laboratory, Honolulu, and each is carrying *Physalia* fragments on its dorsal arms.

Various other marine animals are known to employ coelenterates or their stinging cells as defensive weapons. Among these are hermit crabs; brachyuran crabs, which carry an anemone in each cheliped; and flatworms and nudibranchs, which carry coelenterate nematocysts in their dorsal filaments. *Tremoctopus* appears to be unique in its use of such potent tissue as the nematocysts of *Physalia* and, if my hypothesis is correct, in employing such tissue as an offensive as well as defensive weapon. It is perhaps unique also in its use of only parts of coelenterates as weapons. This may imply an ability to determine when replacement is necessary.

EVERET C. JONES

U.S. Bureau of Commercial Fisheries,
Biological Laboratory,
Honolulu, Hawaii

References

1. H. Troschel, *Arch. Naturgesch.* **32**, No. 1, 41 (1857); L. Joubin, *Ann. Inst. Oceanogr. Paris* **7**, Fasc. 1 (1929).
2. A. Naef, *Fauna e Flora del Golfo di Napoli, 35 Monogr. 1 Th., Bd. 1, lief. 2* (1923).
3. E. D. Wangersky and C. E. Lane, *Nature* **185**, 330 (1960).
4. C. L. Hubbs and R. L. Wisner, *Calif. Fish Game* **39**, 127 (1953).
5. K. Kato, *Proc. Imp. Acad. Tokyo* **9** (1933).
6. S. S. Berry, *Bull. U.S. Bur. Fish.* **32**, 282, Figs. 8 and 9 (1912).
7. P. A. Zahl, *Natl. Geograph.* **101**, 185 (1952).
8. E. L. Nakamura, personal communication.
9. A. F. Bruun *et al.* Eds., *The Galathea Deep Sea Expedition, 1950–1952.* (Macmillan, New York, 1956).
10. G. L. Voss, *Bull. Marine Sci. Gulf Caribbean* **6**, 85 (1956).
11. ———, personal communication.

19 November 1962

Racial Differences in Skin Resistance

Abstract. *In two laboratories utilizing different age subjects and recording techniques, Negro subjects had higher skin resistance than a comparable white population. There was no difference in other autonomic variables or autonomic reactivity. Reasons for this racial difference may offer a better physiological explanation for galvanic skin resistance.*

In the course of investigating other problems, we noted, separately, that the basal skin resistance of Negro subjects is uniformly higher than that of comparable white subjects. Though a much younger sample was studied in St. Louis, and different type electrodes, electrode paste, and electrode placements were employed, the consistency of the results obtained in the two laboratories suggested that a more detailed analysis of possible racial difference should be made and a joint report submitted. The results from the St. Louis study are presented first.

One hundred seventy-four children (65 white boys, 22 Negro boys, 55 white girls, 32 Negro girls) between the ages of 83 and 92 months of age (most within 1 month of their seventh birthday) from the 7-year anoxia follow-up study were used (*1*). Each child was brought into the laboratory and asked to rest in bed. Recording electrodes were attached to the first and third fingers of the right hand. These electrodes were made of zinc, approximately 15 mm in diameter, backed with dental cement, and were taped over corn pads filled with zinc sulfate electrode jelly. This method was adapted from one recommended by Lykken (*2*). The recorder utilized a Wheatstone bridge with 50-μa current supplied through the electrode. The output of the bridge was recorded on a Grass polygraph.

Levels of skin resistance were taken at the end of each 2 minutes during a 10-minute resting period. The average of the five measures taken during the resting period is the measure used in this analysis.

The mean and standard deviations of the resting resistance levels are presented in Table 1. Test for significance was by analysis of variance. The F ratio for race was 34.26, df = 1/170, $P < .001$; for sex the F was 5.51, df = 1/170, significant at the .025 level. The race by sex interaction was not significant.

In San Diego, 42 subjects (16 Negro men, 5 Negro women, mean age 23.05; 16 white men, 5 white women, mean age 22.90) were examined. The white subjects were selected to be comparable in age to the Negro subjects. The age range was from 18 to 39.

All variables were recorded simultaneously on a 12-channel Offner Type R Dynograph at a paper speed of 25 mm/sec. The equipment was instrumented for the recording of six channels of the electroencephalographic trace (EEG), one channel each of heart rate, respiration rate, skin and room temperatures, and skin resistance. Skin and room temperatures were recorded on the same channel. The remaining two channels were used for recording stimulus onset and subject response.

The EEG, galvanic skin response (GSR), skin temperature and respiration instrumentation and recording procedures were similar to those used and reported in detail by Wenger (*3*) and Johnson (*4*). Zinc electrodes, 2 cm in diameter, encased in a plastic cup, were used for GSR. Palm-to-palm recordings were made and contact with the skin was made with an agar zinc sulfate electrode paste. A current of 40 μa was impressed through the electrodes. The gain of the Wheatstone bridge was calibrated so that 1 mm equaled a 1000-ohm resistance change.

Resting skin resistance, EEG amplitude, heart rate, respiration rate, and skin temperature were recorded after a 15-minute pre-experimental period. Spontaneous GSR activity was measured over a 10-minute period at the beginning of the record. A spontaneous GSR response was recorded if a 1-mm,