Individual Differences

Inspection of these amplitude-time graphs shows some differences between the whistles of these two animals. The male tends to become silent briefly between his pairs of whistles (*M*1 through 8 and 12 and 13). The female tends to "fill in" between what correspond to his pairs of whistles with sound. He builds his average intensity to a fast peak and drops it to a lower level in the last half of the record. A male may have one or more fast notches and fast peaks in his record. A female also does this (other records); she may often start at a lower level, rise suddenly to a higher one, and drop back to the lower one (Fig. 2, *F*6 and 7). She also may have one or more deep fast notches and peaks in the amplitude record.

In analyzing these sounds for their frequency, these amplitude variations can be correlated with the frequencies emitted. Figure 3 shows sonograms of frequency versus time for emissions *M*7 and 8 (top traces), *F*2 and 3 (middle traces), and *M*9 (bottom traces). In general all of the time pattern of the fundamental (frequency *f*) is shown; the second harmonic (2*f*) and third harmonic (3*f*) sometimes do not show because of their low intensity. At other times all the harmonics up to the sixth (6*f*) have sufficient intensity to be recorded. (Almost all of the frequencies are integral multiples of the fundamental.)

Inspection of the traces of the male show that, in general, the recorded harmonics are enhanced during his amplitude peaks—that is, when the amplitude is high the harmonic content is high (*M*8, *M*9). The traces of the female show in general that her high amplitudes correspond to her highest frequencies of the fundamental. The harmonic content of the female's emissions tends to be more constant than that of the male during a given emission. The frequencies covered by his fundamental are from 6 to 15 kcy/sec; her fundamental varies from 3.5 to 11 kcy/sec. Some of her low-frequency and her low-amplitude emissions correspond to his short silences between pairs of whistles (Figs. 2 and 3, *F*2 to *F*3).

The separation of the emissions of whistles into countable integral units is based on measurements of occurrences and durations and on graphical records of isolated single whistles, on repetitions of similar (but not necessarily identical) patterns of frequency variation in pairs and triplets, and on the qualities of their total effect as heard (slowed down) by experienced observers. When the female whistles, she emphasizes the relatively flat, high-frequency portion and deemphasizes the low-frequency "slump," somewhat the way some people fill in between words with a low-intensity "aaaah." (Listening to records obviously does not give us the same acoustical experience that the dolphins have; the dolphins have a much wider hearing range than we do and they may have special resonators in the hearing side as well as on the transmitting side which may make the hearing experience of sounds an entirely different kind of experience for them than for us.)

Usually, but not always, the duration of the whistles is of the order of 0.2 to 0.4 second (see Fig. 2). Under special conditions yet to be thoroughly determined, extremely short (0.1 second) or extremely long (2 to 3 seconds) whistles, or both, occur. Most whistle transmissions are in the middle range.

Trains of clicks cover the full range of duration of the whistles and sometimes continue as long as 15 seconds without pause. The most frequently observed durations for click trains are close to those of the longer whistles (0.5 to 1 second).

The amplitudes of the middle-frequency components (less than 40 kcy/sec) of each click are varied by the dolphin in systematic ways. Sonograms and detailed high-speed oscillograph recordings show each click to be a complex train of sine waves whose components vary in frequency and in amplitude with time within the train. From click to click there is more controlled variation in the middle and low range of frequencies (1 to 20 kcy/sec) than in the high range (20 kcy/sec to apparatus limits at 64 kcy/sec). The clicks are not "white noise" in the range below 20 kcy/sec. The lower-frequency portion of the train lasts up to 5 msec and can have mean frequencies as low and as high as the whistle frequencies, with variations ranging from ½ to 2 times the mean value. The high-frequency portion of the train (above 20 kcy/sec) is very brief (0.1 msec) and may, with certain kinds of frequency analyzers, appear to be white noise (*4*).

If one listens to slowed tape recordings (slowed to 1/16 of normal speed) the complex tonal variations can be perceived within each click, from one click to the next, and from animal to animal. The clicks of "creakings" (Table 1) are higher pitched, shorter, and "harder-sounding" than those of exchanges (*4*). The "sonar" click is usually one of high frequency; the exchange click, one of lower frequency.

Conclusion

In this report (*5*) we have presented something of what dolphins transmit in their exchanges—signals plus noise. A few tentative, simple "meanings" have been found ("distress," "attention," "irritation," and so on); however, most of the exchanges are not yet understood.

Note added in proof: Since this report was submitted we found that dolphins can emit ultrasonic clicks independently of sonic clicks and vice versa.

References and Notes

1. J. C. Lilly and A. M. Miller, *Science* **133**, 1689 (1961).
2. J. C. Lilly, *Psychiat. Research Repts.*, **5**, 1 (1956).
3. ——— and J. T. Shurley, *Psychophysiological Aspects of Space Flight* (Columbia Univ. Press, New York, 1960).
4. W. Schevill and B. Lawrence, *J. Exptl. Zool.* **124**, 147 (1953); *Breviora* **53**, 1 (1956); W. N. Kellogg, R. Kohler, H. N. Morris, *Science* **117**, 239 (1953); W. N. Kellogg, *ibid.* **128**, 982 (1958); ———, *J. Acoust. Soc. Am.* **31**, 1 (1959).

5. This research has received support from the Air Force Office of Scientific Research. the Coyle Foundation, the U.S. Department of Defense, the National Institute of Mental Health, the National Institute of Neurological Diseases and Blindness, and the Office of Naval Research. We thank K. N. Stevens of the Massachusetts Institute of Technology for the use of a Kay Sonograph, J. C. Steinberg of the University of Miami for the use of a hydrophone set, and Herbert Gentry of Orlando, Fla., for the use of a Precision Company wide pass-band tape recorder.

6. The sonograms were made with a Kay Electric Company Sonograph.

13 April 1961

Cutaneous Molt Induced by Calciphylaxis in the Rat

Abstract. A molt, conducive to the loss and subsequent replacement of all cutaneous layers, can be induced by topical "calciphylaxis" in the rat. This is accomplished by sensitization with dihydrotachysterol followed by challenge with egg white or ferric dextran.

Calciphylaxis is a condition of induced systemic hypersensitivity in which, during a "critical period" after sensitization by a systemic calcifying factor (for example, vitamin-D compounds, parathyroid hormone, sodium sulfathiazole), treatment with certain challengers (for example, metallic salts, albumen) causes an acute local calcification, followed by inflammation and sclerosis. The term was coined in analogy with such designations as "anaphylaxis" or "tachyphylaxis" that likewise refer to induced systemic alterations in the body's responsiveness to certain challenging agents. Apparently, calciphylaxis is a fundamentally adaptive (phylactic) response, that leads to defensive inflammation and sclerosis, through the selective deposition of calcium in the challenged area. However, like many other basically defensive reactions (for example, serologic immunity), it can also become the cause of morbid lesions (*1, 2*).

The skin is particularly predisposed to the induction of massive calcium deposition through topical calciphylaxis. We have recently developed a technique in which, following sensitization by dihydrotachysterol (DHT), a single subcutaneous injection of egg white or a ferric dextran (Fe-Dex) causes acute massive petrification with subsequent exuviation of all cutaneous layers in the rat.

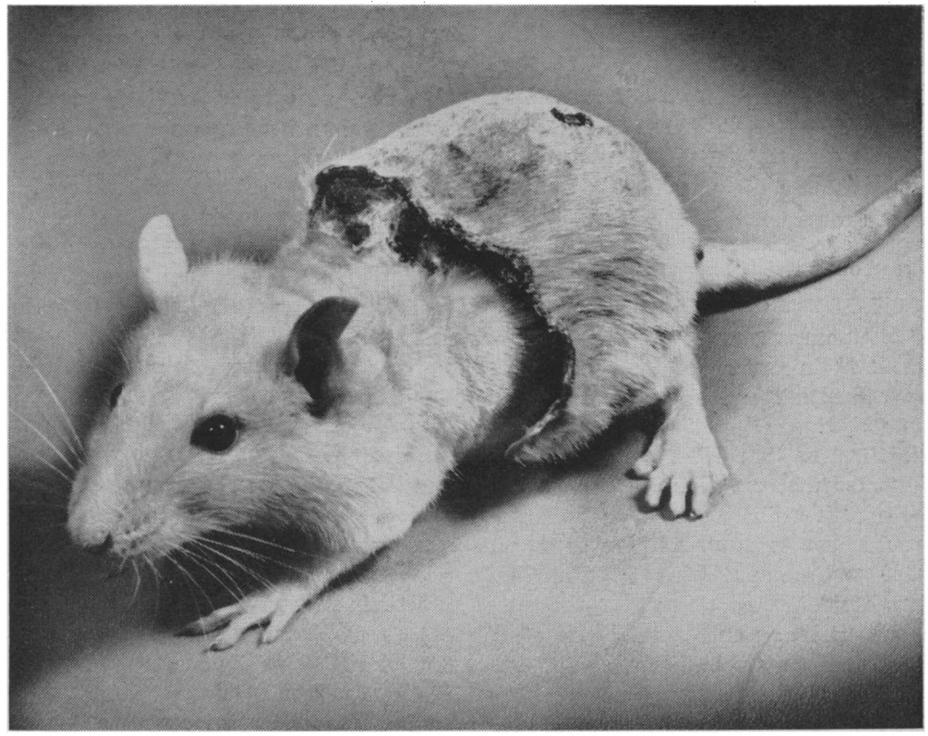

Fig. 1. Rat 3 weeks after sensitization with DHT followed by challenge with egg white. The petrified old skin is almost fully detached and ready to be cast off. Both the old and the new skin are hair bearing. Curiously, the animal does not appear to be particularly damaged by this extensive molt.

Sixty female Holtzman rats with a mean initial body weight of 98 g (range, 95 to 100 g) were subdivided into five equal groups and treated as follows: group 1, DHT; group 2, egg white; group 3, Fe-Dex; group 4, egg white plus DHT; and group 5, Fe-Dex plus DHT.

Dihydrotachysterol (*3*) was given on the first day at the dose of 1 mg in 0.5 ml of corn oil by a stomach tube once. Egg white (50-percent aqueous solution of domestic fowl albumen) and ferric dextran (*4*) (diluted with water to contain 10 mg of metallic iron per 10 ml) were both administered once on the second day, at a dose of 10 ml, by subcutaneous infiltration of the entire body surface, except the head, anogenital region, and extremities, in order not to interfere with food ingestion, excretion, and locomotion. The calcific nature of the cutaneous deposits was verified histochemically (by means of the von Kóssa technique).

No cutaneous lesions were produced by treatment with DHT alone, while Fe-Dex and egg white alone produced only a transitory edema which subsided within about 48 hours. By contrast, the rats sensitized with DHT and subsequently challenged by the subcutaneous injection of either egg white or Fe-Dex developed a massive cutaneous calcification which transformed the entire challenged skin area into a hard exoskeleton-like tight-fitting shield. In the course of the next 3 weeks the calcified skin began to detach itself along its borders. During the fourth week large cracks appeared in this "carapace," usually along its ventral surface, while a fine lanugo-bearing new skin was formed underneath. A few days later, the old calcified, and still hair-bearing, skin was cast off and the rats crept out of their exuviae with a new cutaneous covering (Fig. 1).

During the first few days, while cutaneous calcium deposition was in progress, the skin appeared to be painful to touch, but after the first week the animals showed no evidence of discomfort and rapidly gained in weight. Interestingly, several of the rats which, owing to previous accidental injuries, happened to have scars, cast these off together with their old skin and developed no comparable lesions in the newly formed derma.

In general, the cutaneous tissue, like the skeletal connective tissue, possesses a particular ability to store calcium and other metals, but only a few animal species form a shield-like calcified carapace or exoskeleton (for example, lobster, armadillo). The biochemical mechanisms responsible for the physiologic development and periodic exuviation of calcified skin structures is not known. It remains to be seen whether there is any relationship between these normally occurring cutaneous changes and calciphylaxis. It is noteworthy, however, that even treatment with normal body constituents can produce cutaneous calcinosis with subsequent shedding of the affected skin. This was accomplished, for example, by treatment with parathyroid hormone as a sensitizer and iron ($FeCl_3$) as a challenger in the rat (*2, 5*).

HANS SELYE
G. GENTILE*
P. PRIORESCHI†
Institut de Médecine et de Chirurgie expérimentales, Université de Montréal, Montreal, Quebec

References and Notes

1. H. Selye, P. Jean, R. Veilleux, *Proc. Soc. Exptl. Biol. Med.* **104**, 409 (1960); H. Selye and K. Nielsen, *Acta Morphol. Acad. Sci. Hung.* **10**, 327 (1961); H. Selye, S. Grasso, J. M. Dieudonné, *Rev. Allergy and Appl. Immunol.* **15**, 461 (1961).
2. H. Selye, G. Gentile, P. Jean, *Can. Med. Assoc. J.* **85**, 770 (1961).
3. Dihydrotachysterol (Calcamin, Wander Co., Berne, Switzerland).
4. Ferric dextran (Imferon, Benger Labs, Toronto, Canada).
5. This work was supported by the Gustavus and Louise Pfeiffer Research Foundation and by the Office of the Surgeon General, U.S. Army Medical and Research Command, contract No. DA-49-193-MD-2039.
* Fellow of the Gustavus and Louise Pfeiffer Research Foundation.
† Fellow of the Life Insurance Medical Research Fund.

24 July 1961