in addition, suggest that the effect of radiation on the medium, while closely related to synthetic processes and to mRNA, is not related to the degradation of DNA. Thus two aspects of the action of ionizing radiation on simple cells can be studied separately.

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## Itch and Vibration

Abstract. *Itch produced by application of cowage to the wrist was reduced in intensity by vibration of the stimulated area. Application of vibration to the opposite wrist also reduced intensity. The results may be attributed to physiological activities occurring at the early stages of information transmission.*

Itch is relieved by scratching, but when the scratching has ceased it often returns with increasing intensity, sometimes changing to frank pain (*1*). Two theories have been proposed to account for these facts. According to traditional specificity theory (*2*) itch is the result of weak stimulation of pain receptors; and interactions between inputs from scratching and the itch-producing stimulus occur at the thalamus or cortex. These propositions are based on the assumption that each modality is carried by direct-line pathways from receptors to a brain center that registers a specific sensation. According to the pattern theory (*3, 4*), itch perceptions are subserved by unique spatial and temporal patterns of nerve impulses, and these afferent patterns can be modified by interaction with tactile inputs beginning at the earliest stages of information transmission.

Physiological and behavioral evidence (*4*) lends strong support to pattern theory. Wall and Cronly-Dillon (*5*) showed that the first central cell of the spinal cord responded with characteristic firing patterns to various skin stimuli. They observed that the high-frequency bursts of impulses recorded when itch powder was applied to the skin were abolished by simultaneous vibration of the surrounding skin. Their data suggest that the vibratory input exerts an inhibitory effect on the afferent pattern produced by pruritogenic substances. Although vibration raises (*5*) thresholds for tactile, thermal, and noxious stimuli, there are no comparable psychological data for itch. We have therefore examined the effects of vibration applied to different parts of the body on the intensity of perceived itch.

Our subjects were 34 male and 16 female university students assigned at random to one of five groups containing ten subjects each. Itch was produced by applying small amounts of cowage (*Mucuna pruriens* spicules) to the flexor surface of one of the wrists until the subjects reported a desire to scratch. A few subjects who failed to experience itch were not tested further. After the subjects reported the desire to scratch, a small patch of adhesive tape was placed over the wrist (to hold the cowage spicules in place), and one of four skin areas was vibrated by lowering onto the subject's skin a 60-cy/sec vibrator fitted with a rubber disc 5.7 mm in diameter and mounted on a retort stand. Vibration was applied to the itch-stimulated wrist (group I), to the flexor surface of the same arm half-way between the elbow and the wrist (group II), to the opposite wrist (group III), and to the flexor surface of the opposite arm (group IV). A control group (group V) received no vibration, although the inactivated vibrator was placed on the itch-stimulated skin.

All five groups received identical instruction. The subjects were told to report *0* when they felt no itch, *1* when itch was just perceptible and without annoying effect, *3* when itch was bothersome or annoying, *5* when the itch was at its worst and produced an intense desire to scratch, *2* and *4* being appropriate intermediates. The subjects were also instructed to report the scale numbers (which were presented on a card) continuously throughout the experiment, starting a few seconds after cowage was applied, until they were told to stop. When each subject reported a constant itch intensity at *3* or higher, the vibrator was placed on the skin for 100 seconds and then removed.

A decrease in itch intensity of two scale units or more was the criterion for effective reduction of itch. Itch was reduced significantly ($p = .05$ or better, Fisher tables, *6*) by application of vibration to the same wrist (group I) beginning at 10 seconds, to the opposite wrist (group III) at 20 and 30 seconds, to the same lower arm (group II) at 30 seconds, and to the opposite lower arm (group IV) at 50, 90, and 100 seconds.

The reduction of itch intensity and its subsequent return toward initial intensity during vibration is shown in Fig. 1. Since the control group exhibited a slow, rhythmic, spontaneous decrease in itch intensity in the absence of vibration, the values on the curves for the experimental groups in Fig. 1 have been corrected by subtracting the corresponding values of the control group.

Except for an occasional increase, vibration generally decreased itch intensity. The occasional increase appeared to depend, in part, on the original intensity of the itch. Three subjects who, at first, felt severe, almost painful itch reported that the vibration immediately transformed the itch into frank pain. Others reported a decrease in intensity and a subsequent "overshoot" to greater intensity. Most subjects in groups I and III reported that after cessation of vibration itching returned, and that it was sometimes more intense than before vibration.

The results show that vibration effectively reduces the intensity of moderate degrees of itching. The long delays of the effect of vibration experienced in groups II, III, and IV, compared with the rapid and more marked effect in group I, indicate that the reduction in intensity cannot be attributed simply to distraction or to implicit suggestion. Rather, it appears to be due to an interaction of the two

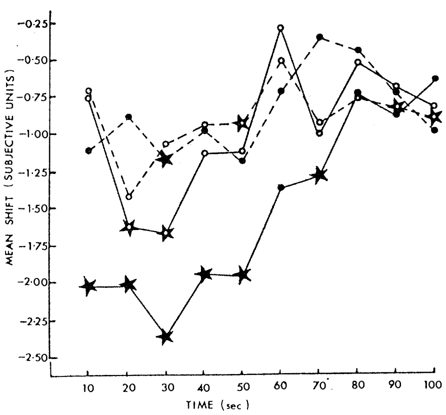


Fig. 1. Mean shift in itch intensity from initial level produced by vibrator application at different body sites. The value at each point is corrected for the slow, spontaneous decrease in itch intensity in the absence of vibration observed in the control group. ●——●, Group I, same wrist; ●- - - -●, group II, same lower arm; ○——○, group III, opposite wrist; ○- - - -○, group IV, opposite lower arm. *Star*, associated $p \leq .05$

inputs during afferent transmission (*7*).

An explanation of this interaction may be that the light tactile stimulation produced by vibration, like that produced by scratching, triggers impulses in the large A "touch" fibers which inhibit the C-fiber "itch" impulses at the thalamus or cortex (*8*). However, there is no physiological evidence for this mechanism. Moreover, this mechanism does not account for the enhancement of itch intensity after vibration or prolonged scratching.

The results may be explained more satisfactorily as being due to physiological activities occurring at the early stages of information transmission. Mendell and Wall (*9*) have shown that the largest A fibers produce activity in the substantia gelatinosa and that this activity inhibits subsequent transmission of nerve impulses from peripheral sensory fibers to the first central cell. Conversely, C fibers facilitate transmission of sensory input. Since light tactile stimulation produces firing in some C fibers (*10*) as well as in the largest A fibers (*11*), vibration would have opposing inhibitory and facilitatory effects on the input evoked by cowage. However, the number of active C fibers would be small compared with the large number of low-threshold A fibers that would be fired by the vibrator (*11*); thus the overall effect would be inhibitory. This mechanism could account for the decrease in itch intensity produced by vibration.

After cessation of vibration, the balance would shift in favor of a greater after-discharge in C fibers than in A fibers. After-discharge is unlikely to continue more than a few milliseconds in A fibers (*11*) but has been observed to persist in C fibers for as long as 10 seconds after brief stimulation of the skin (*12*). This facilitation of the afferent pattern by the C-fiber after-discharge could therefore account for the enhancement of itch intensity that frequently occurs after scratching or vibration. The transformation of severe itch into frank pain by vibration observed in three subjects is comparable to the observation (*7*) that vibration enhances perception of intense, painful shock although it masks low-intensity shock. At high itch intensities the massive C-fiber input evoked by the itch-producing substance apparently combines with the C-fiber input activated by vibration (and overcomes the inhibitory A-fiber effect) to produce an increased frequency in central firing that gives rise to pain rather than itch.

That the intensity of itch felt at the wrist is decreased significantly by vibration applied to the opposite wrist is also consistent with this hypothesis. Activity in the substantia gelatinosa is influenced by fibers from both sides in the body, so that vibration of either wrist should have comparable effects (*13*).


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## Trained Porpoise Released in the Open Sea


Abstract. *A Pacific bottlenose porpoise,* Tursiops gilli, *was trained for a period of 10 weeks to swim at high speed on command and return to an underwater speaker when a specific sound cue was played. This animal was released in the open sea off Oahu, Hawaii, and worked each day for 7 days. At night it was held in an anchored floating pen. The trainer's control over the animal was probably associated with the controlled feeding of the porpoise, the development of social ties between the porpoise and trainer, and the animal's fear of unknown situations.*


On 23 August 1964, near Coconut Island, Kaneohe Bay, Oahu, Hawaii, a trained subadult male Pacific bottlenose porpoise (*Tursiops gilli*) was escorted into the open sea and its movements controlled by use of underwater sound signals (*1*). A week later the same animal was placed in a floating chain-link cage, 9.3 by 9.3 by 3.1 m, anchored in the open sea in the lee of Manana Island, 1.5 km off the Oahu coast. Daily releases of the unfettered animal were made for 7 days in the course of attempts to determine its top swimming speed (*2*). The animal could be controlled easily by the use of the sound signals and standard food rewards.

The experimental porpoise, named Keiki (Hawaiian for "child"), was caught on 24 March 1964 on Penguin Bank 45 km from the Oahu coast. The animal was taken from a school of approximately 80 animals, including at least four other young.

When the porpoise was feeding well, after a few days of captivity at the Oceanic Institute, trainers established the sound of a police whistle as a conditioned reinforcing stimulus by pairing the stimulus with the presentation of food. The conditioned stimulus, followed by food, was used to establish some simple conditioned behavior, including stopping in front of the trainer. No further training was undertaken until 15 June 1964, when a variety of trained behaviors related to the projected speed tests were shaped by standard conditioned-response techniques. Throughout the tests behavior desired by the experimenter was reinforced first by the use of a police