range in number from many to one, in arrangement from spiral to whorled, and in morphology from simple to complex. Nevertheless, insofar as known, each carpel is a complete unit derived from a single sporophyll with a self-contained vascular system consisting most commonly of a dorsal carpellary bundle and two ventral carpellary bundles. The pistillate papaya carpel does not conform to the concept of development from a single sporophyll.

Unisexual flowers resulting from transmutation of stamens into carpels or carpels into stamens have been reported in many species of plants (*5*). Generally, such flowers have been regarded as abnormal or teratological forms resulting from the influence of external factors upon the physiology of the plant and as having no real evolutionary significance.

In the derivation of the pistillate papaya flower, however, sterile carpelloid stamens have replaced fertile stamens and become part of the ovary with retention of epipetaly. The flower is visualized as an interesting morphological anomaly, therefore, with the greater part of its ovary consisting of sterile carpels and its ventral vascular system inherited without modification from a previously existing whorl of carpels farther up on the receptacle. Evidence of several intervening cycles of organs between the dorsal and ventral vascular systems which disappeared phylogenetically persists in the form of vestigial traces in the internal anatomy of the ovary. The morphological structure described has become fixed genetically in the pistillate papaya tree. Unlike hermaphroditic trees among which sex reversal in response to physiological influences is commonplace, the pistillate tree is virtually unknown to undergo any change of sex.

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Shark Pit Organs: Response to Chemicals

Abstract. *Nerve fibers from pit organs and canal neuromasts are distinguished by the nature of their electrophysiological response to mechanical and chemical stimulation. Pit organs respond to touch but have a relatively high threshold compared with canal neuromasts. They respond readily to sodium and potassium chloride solutions, the rate of discharge increasing with the concentration of the solution. Order of effectiveness with 1 molar solutions of monovalent cations is as follows: potassium, rubidium > sodium, ammonium > cesium, lithium. Anions are ineffective. Divalent cations such as calcium and magnesium are inhibitory. Responses to acid, sugar, and quinine are either very slight or inhibitory.*

Two hypotheses regarding the function of pit organs (Fig. 1) in sharks are that (i) they serve as external taste buds (*1*) and (ii) they are free neuromasts serving as mechanoreceptors for mediating water displacements (*2*). With electrophysiological techniques, we have studied the responses of pit organs to acid, sugar, quinine, mechanical stimulation, and solutions of monovalent cations.

Small nurse sharks (*Ginglymostoma cirratum*) (40 to 70 cm) shipped from Florida to Hawaii were used because this species can survive for several hours on the operating table. Sharks were secured to boards and covered, except for the head and tail, by gauze irrigated with seawater. During all experiments, seawater containing 0.02 g of anesthesia (MS222) per liter was introduced into the mouth by way of a plastic mouthpiece and was allowed to flow out the opercula.

Activity was recorded from the lateralis nerve where it approaches the dermis on the caudal peduncle. This nerve receives fibers from canal neuromasts of the lateral line and from a row of pit organs along the dorsolateral margin of the caudal fin (*3*). The nerve was exposed and cut, and the end of the posterior segment was separated into small bundles which were looped over a silver-wire electrode (*4*). The nerve response was recorded on a tape recorder through a conventional RC coupled high-gain amplifier, and later displayed on an oscilloscope screen and photographed if necessary. Recordings were also made from the external mandibular nerve which receives fibers from the mandibluar canal and mandibular row of pit organs on the lateral and ventral surface of the head (*2*). In all, recordings were made of 76 pit organ fibers in 29 sharks.

Fibers from canal organs were distinguished from those from pit organs by the nature of the response. The former responded readily with increased discharge rate to light touch on the denticles of the skin, whereas the pit organ fibers had a higher threshold, responding only to pressure on them. Although both showed spontaneous activity, the spikes were relatively larger in the pit organ fibers (about 1 to 3 mv) than in the canal organ fibers (less than 1 mv) and the activity was maintained for a longer period of time (2 or 3 hours as compared to ½ hour). When the tail area was flooded with seawater or salt solutions, the discharge rate of the canal organ fiber did not change.

Table 1. Effectiveness of various 1*M* salt solutions on the pit organ. Spike number in 5 seconds of the response plateau shown by: +++, more than 70; ++, between 70 and 40; and +, less than 40.

Sodium salts	Spike No.	Chloride salts	Spike No.
NaCl	++	NaCl	++
$NaNO_3$	++	KCl	+++
$NaHCO_3$	+	LiCl	+
Na_2SO_4	++	RbCl	+++
Na-glutamate	++	CsCl	+
Na-propionate	++	NH_4Cl	++
$NaCH_3SO_4$	+	Choline-Cl	—
$NaC_2H_5SO_4$	+		

Seawater sometimes produced a slightly increased discharge rate in pit organ fibers. The rate of discharge progressively decreased in pit organ fibers when the seawater was progressively diluted with distilled water and reached zero in distilled water. When the skin was flooded with seawater, normal activity of the pit organ fiber was restored. When the area of the pit organ was flooded with salt solutions—for example, 1*M* NaCl or KCl in distilled water—the discharge rate after several seconds slowly increased to a maximum; the rate remained at a plateau for periods ranging from about 50 to 100 seconds and then decreased slowly. Latency, maximum discharge rate, plateau value, and rate of increase and decrease of the discharges all depended on the concentration of the salt solution.

The following results, relative to the spontaneous discharge rate in normal seawater, were obtained with solutions which would be expected to stimulate taste buds (*5*): 0.06*N* hydrochloric acid in seawater did not affect discharge rate; 0.06*N* hydrochloric acid in distilled water reduced discharge rate; 0.083*N* acetic acid in distilled water reduced discharge rate; a solution of 1*M* sucrose plus 1*M* sodium chloride did not reduce or only slightly reduced discharge rate; 1*M* sucrose in distilled water completely inhibited discharges; and 0.005 to 0.003*M* quinine sulfate in seawater reduced discharge rate. These responses were reversible, the original discharge rate being regained within a few minutes after flooding of the area with seawater. Acid, sugar, and quinine had either no effect or an inhibitory one. Thus pit organs did not give responses typical of mammalian taste buds.

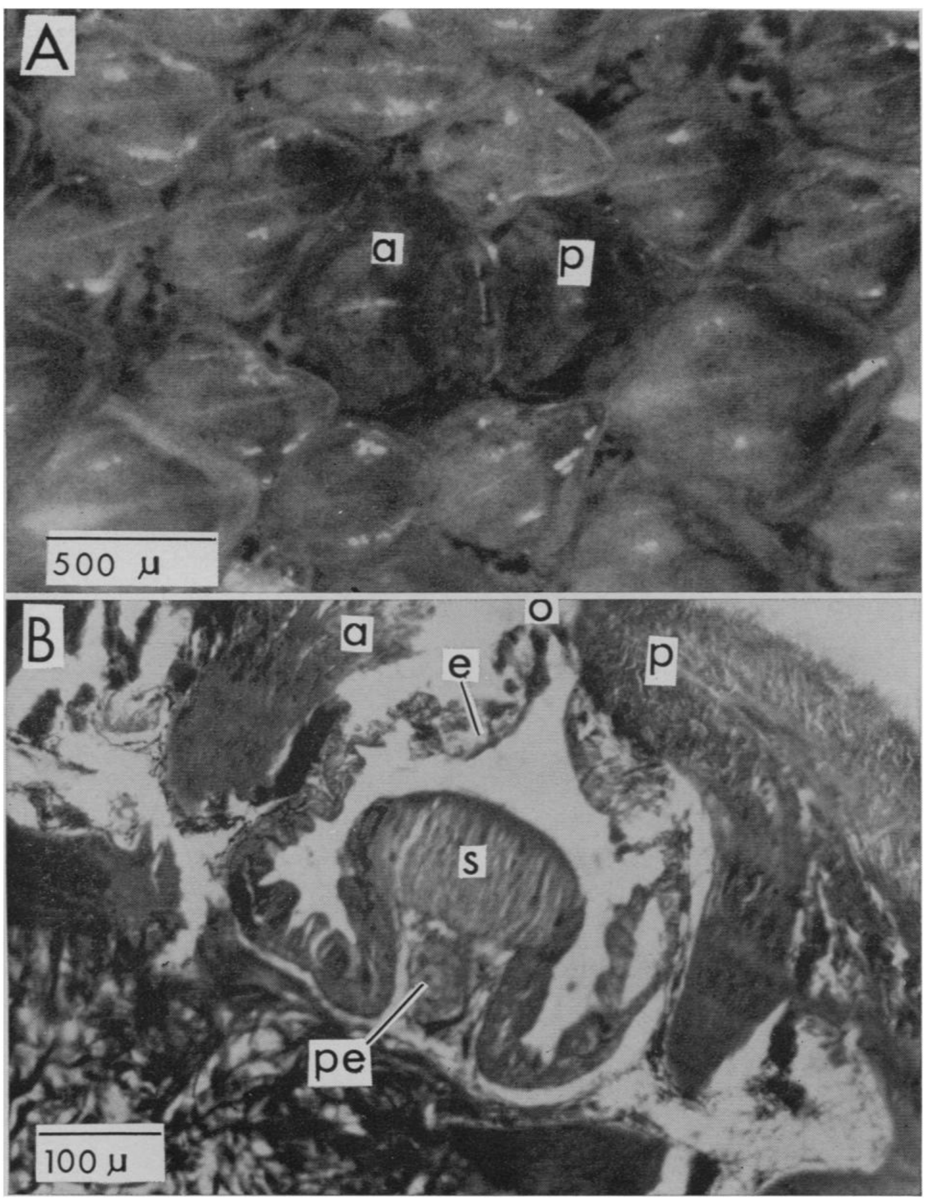

Fig. 1. Pit organ of a 45-cm nurse shark. (A) Anterior (*a*) and posterior (*p*) modified scales which overlap to cover the pit organ cavity. (B) Longitudinal section showing opening (*o*), epithelium (*e*) torn from scale surface, and the sensory organ (*s*) resting on the pedicel (*pe*). The pedicel has been found only in the nurse shark.

Pit organ fibers did not display nerve discharge in distilled water. The rates of discharge increased with application of increasing concentrations of NaCl and KCl. The curves for such responses presumably would start to flatten at concentrations above 1 mole/liter and become S-shaped (Fig. 2). The rate of change of the discharge rate begins to increase markedly at 0.5*M* NaCl, so it approximates that of seawater. The response to potassium chloride was consistently greater than that to sodium chloride.

Next tested were 1*M* solutions of various sodium salts including the nitrate, carbonate, sulfate, glutamate, propionate, methylsulfonate, and ethylsulfonate. All, including the last two with anions of large molecular size, produced nerve discharges, although there were differences in effectiveness (Table 1). Because choline choride was ineffective, we conclude that the cation, rather than the anion, is the primary cause of excitation. Rate of discharge was high in 1*M* solutions of KCl and RbCl, medium in 1*M* NaCl and NH_4Cl, and low in 1*M* CsCl and LiCl, although still much higher than the discharge rate in seawater (Table 1). Chlorides of the divalent cations, calcium and magnesium, particularly the former, inhibited activity.

Seawater containing a small amount of blood or meat extract of shark was very effective on the pit fibers, perhaps as a result of the specific actions of various ions in the extracts.

That the sensory cells rather than the nerve endings respond to monovalent cations is shown by the fact that 10 percent cocaine solution applied to pit organ and to lateralis nerve fibers has no effect on the former and completely inhibits the latter.

The changes in discharge rate are not due to changes in osmotic pressure. Both 0.50*M* NaCl and 1*M* sucrose in distilled water are approximately isotonic with seawater, yet one produced little or no change in response and the other completely inhibited the response.

The pit organ (Fig. 1), composed of hair cells, supporting cells, mantle cells, and mucous covering resembling a cupula (*6*), is practically identical to

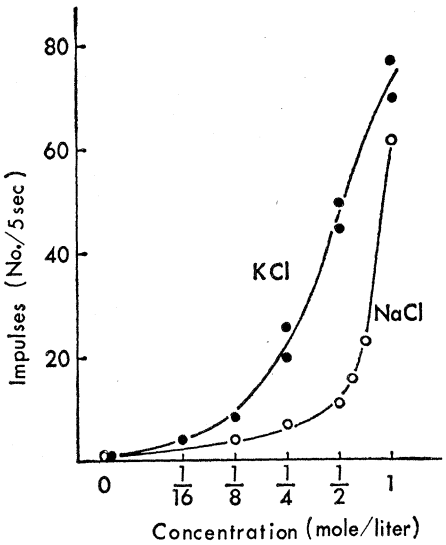

Fig. 2. Relation between rate of discharge (5 seconds in plateau) and concentration of sodium and potassium chloride.

the canal neuromast. However, the threshold of the pit organ fiber to touch on the skin surface is strikingly higher than that of the canal organ fiber, and there is no sign that the canal organ responded to various salt solutions introduced into the lateral line canal.

Thus the pit organ of the shark, unlike the canal neuromast, will respond to salinity changes in the environment. However, it is uncertain whether, under natural conditions, it serves as a salinity detector.

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Normal Incidence of Brain Hernia in the Mouse

Anomalies appear in births of both mice and men, and their origin may be genetic or congenital. Some 5 percent of all human births carry some congenital anomaly, and although most of these are tolerable in that they do not contribute to the shortening of life, they emphasize the fact that normality does not infer 100 percent perfection.

Flynn (*1*) singles out the anomaly of brain hernia, or exencephaly, and states that 12.2 percent of 90 litters of mice contained exencephalous fetuses. The 12.2 percent does not indicate the incidence of this anomaly. When all fetuses were counted (1056) some 1.04 percent were exencephalous. This figure does not differ radically from our own. The mouse used was the CF1 white strain, and the data were derived from several generations from an original stock.

When one counts only the firstborn which appear to be perfectly normal, it has been shown (*2*) that virgins of 3 to 5 months produce 83.03 percent normals; older virgins of 7 to 9 months have 81.57 percent normals; multiparas of 7 to 9 months show 83.70 percent normals; and ex-breeders of 10 to 12 months had 73.65 percent normals. Thus if one wishes to downgrade any mouse stock it is possible to show that about 20 percent are "not normal." This includes those that are stunted (less than 1 g at 18 days), are resorbed *in utero*, or possess various anomalies such as multiple digits, crooked tails, persistent amnions, extruded gut, and other abnormalities. However, if among those classified as anomalous we count *only* mice with definite brain hernias (exencephalia) we find in 150 litters of 1530 CF1 mice that there was an incidence of only 0.17 percent of exencephalia. In 328 litters of CF1-S mice at one time only 0.68 percent, and at another time 365 litters with 0.43 percent of the fetuses had such brain hernias. Thus, we admit freely that this anomaly does occur in normal and presumably healthy stock, but not in great numbers, never (in our experience) exceeding 0.68 percent. Since x-irradiation does in fact increase the incidence of this anomaly (*3*) the increase above the normal incidence may be attributed to the effects of ionizing radiations, providing, of course, there are statistically adequate numbers. We have examined over 300,000 mouse fetuses at 18 days (about one-third of these were unirradiated controls) and have never found the normal incidence of this anomaly to exceed 0.68 percent. The fact that it does occur spontaneously makes it a good test object for the study of the effects of x-irradiation, which dramatically increases the incidence of exencephaly.

There is some evidence of a genetic predisposition to exencephalia. Some males that sired litters with different females produced offspring showing more than a normal incidence of exencephalia. In fact, such litters may sometimes have more than a single exencephalous fetus. One cannot rule out genetic considerations, and this area merits further investigation.

Possibly the low incidence of exencephalia that we found was due to the fact that most of our litters are primipara, derived from mice received directly from Carworth Farms. The offspring therefore do not represent a common ancestry but a very wide sampling, thus reducing any inherent genetic predisposition to exencephalia. Flynn reported on first, second, and third generation descendents of an original and limited stock, which means that any unrecognized but inherent tendency to develop exencephaly would be exaggerated. Although the percentage reported by Flynn could be misleading (12.2 percent of the litters with exencephaly rather than 12.2 percent incidence) we concur that brain hernias do occur spontaneously, whatever their origin, and must be considered in light of increased incidence when the developing fetus also receives x-irradiation. The higher incidence (1.04 percent above our 0.68 percent) reported by Flynn cannot have statistical significance.

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