traction and the incompleteness of relaxation) we attribute to the release of such vasoactive substances at the onset of contraction. Part of these substances diffuses into the bathing solution. Therefore, changing the bathing solution results in a loss of vasoactive substances. These can be actually identified in the bathing solution by biological tests and paper chromatography. When α-blockers are added to the bath, the contraction due to electrical stimulation is decreased and relaxation favoured. The presence of β-blockers, on the other hand, gives rise to the opposite effect. Furthermore α-blockers will, as shown in Figure 2, intensify the action of potassium much in the same way as adrenalin. All kinds of stimuli, indeed also those which produce contraction such as serotonin, hypertensin, histamin, are influenced by α-blockers which cancel their action. The action of adrenalin on the coronary vessel of the horse is not influenced either by α- nor by β-blockers.

On one side, the ATPase activity of the tonoactomyosin from coronary arteries, as well as from other vessels we have investigated, can be activated by the substance stimulating contraction and this activation hindered by α-blockers. On the other hand, the ATPase activity can be hindered by the substance favouring relaxation, the action of which can be recovered by β-blockers.

On the basis of our investigations, in particular the fact that one of our vasoactive substances is inhibited by α-blockers and the other one by β-blockers, we are led to suggest that these substances might be identical with the α- and β-receptors.

*Zusammenfassung.* Es werden die Besonderheiten der am isolierten Koronargefäss von Rind und Pferd nach elektrischer Reizung, Verabreichung von Adrenalin oder Kalium registrierten Mechanogramme beschrieben. Es wird darauf hingewiesen, dass die Kontraktilität der Muskelzellen des Rinderkoronargefässes von zwei Stoffen abhängig ist, wovon der eine die Kontraktion und der andere die Erschlaffung fördert.

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## The Response of Frog Taste Cells (*Rana nigromaculata* and *Rana catesbeana*)

In frog as well as in mammals, it has been established that gustatory nerve fibres respond to more than 1 of 4 basic taste solutions applied to the tongue[1]. A recent investigation on the sensory innervation of the frog tongue[2] has suggested that 1 gustatory fibre innervates about 30 receptor cells which are on the average distributed among 6 fungiform papillae. In order to determine whether the multiple sensitivity of one gustatory fibre derives from the multiple sensitivity of individual receptor cells or whether it is due to convergence of receptor cells sensitive to different taste stimuli, in the present study intracellular recordings were obtained from the frog taste cells. These experiments indicated that taste cells exhibit sensitivity to the 4 basic taste qualities. These observations confirm the only previous intracellular recording by KIMURA and BEIDLER[3] on rat or hamster taste cells.

The tongue isolated from the frogs (*Rana nigromaculata* and *R. catesbeana*) was used in this study. Glass capillary microelectrodes filled with 2 *M* KCl (50–150 *MΩ*) were inserted into single taste cells of the fungiform papillae with the aid of a special jolting apparatus designed by TOMITA[4]. NaCl, acetic acid, sucrose and quinine hydrochloride were used as 4 basic taste stimuli. The last 3 substances were dissolved in 0.1 *M* NaCl to exclude the interference of the so-called 'water response'. A small amount of each taste solution was applied very gently to the tongue via a microsyringe to avoid mechanical disturbances. Following each test solution the tongue was always rinsed with Ringer solution.

At a depth of 20–30 μ from the surface of the papilla, the microelectrode tip penetrated a cell of the taste cell layer as signified by a negative resting potential of 10–35 mV. When the resting potential changed with taste stimuli applied to the surface of the tongue, such a cell was assumed to be a taste cell. No cells penetrated at other depths responded at all to taste stimuli. The potential changes to the taste solutions were slow depolarizing potentials: never spike potentials (Figure 1). When the electrode was withdrawn to a just extracellular position, the same taste stimuli elicited no detectable potential change. Therefore, the intracellular recorded slow potential was not simply a physicochemical potential occurring at the fluid interphase, but it was an electrophysiological potential across the cell membrane which will henceforth be referred to as the receptor potential. The amplitude of the receptor potential became larger as the concentration of the taste solution was increased as shown in Figure 2. The 2 curves were obtained from different NaCl-sensitive cells.

It was very difficult to obtain stable intracellular recordings from the taste cells for long periods, because the flask-shaped taste cell is very small with a diameter of about 7 μ in the thickest part. The period of the electrode penetration varied from a few seconds to 10 min. Therefore, in order to complete the sensitivity test to different solutions within a short time, 4 basic taste solutions could be examined only at constant concentrations, e.g. *M*/2 NaCl, *M*/64 acetic acid, *M*/4 sucrose and *M*/256 quinine hydrochloride. These concentrations were 5–10 times threshold for minimal discharges in the whole gustatory nerve, but were lower than the concentrations for maximal discharges.

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It was a general finding that each taste cell responded to more than 1 of the 4 taste solutions, as can be seen in Figure 1. Note that in this cell slow depolarizations were produced by all 4 test solutions as well as water. Detectable hyperpolarization was not produced in any of the cells. Figure 3 illustrates the responses to the 4 taste stimuli found in 10 taste cells (A–J). Even though the resting potentials varied in different cells, an approximately linear relation was found between the amplitude of the receptor potentials and that of the resting potentials. Thus, the size of receptor potentials in this figure was expressed as a percentage of the resting potential allowing for comparison of the sizes of responses obtained with different recording conditions. Note that all the taste cells investigated responded to more than 2 qualities of taste solutions. The cells could be divided into 3 groups (I, II, III) by the number of effective solutions; Group I, cells sensitive to 2 qualities (F in Figure 3), Group II, cells sensitive to 3 (D, E, H, I) and Group III, cells sensitive to 4 (A, B, C) qualities. The pattern of sensitivity to different solutions, in terms of relative size of depolarizations, varied with the individual cells. The first 2 groups (I, II) could be further subdivided into several types according to different combinations of taste qualities to which they responded (see Figure 3). When a correlation coefficient was calculated between the amplitudes of receptor potentials to each pair of 4 taste stimuli used, no apparent correlation could be found in any pairs. When a correlation does not exist between the discharge rates of gustatory units to some pair of taste stimuli, PFAFFMANN[5] has suggested that the 2 taste substances may produce different tastes as revealed by a behavioural test. This leads to a possibility that at the taste cell level the frog already discriminates the 4 primary taste qualities.

Multiple sensitivity of single gustatory fibres has been reported in various species of animals including the frog[1]. The present finding accounts for this as due to multiple sensitivity of individual taste cells rather than due to the convergence of cells specifically sensitive to different taste stimuli[6].

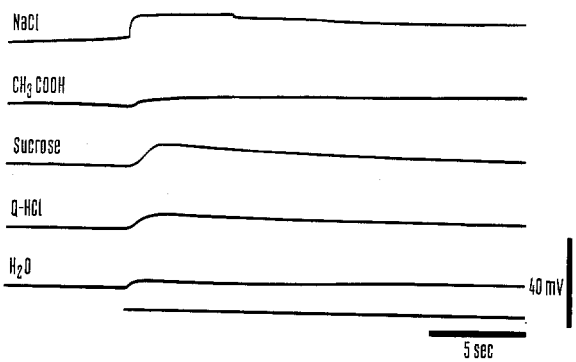


Fig. 1. Receptor potentials of 1 taste cell to application of 4 basic solutions and water to the tongue. Solutions: *M*/2 NaCl, *M*/64 acetic acid, *M*/4 sucrose, *M*/256 quinine hydrochloride, and deionized water. Duration of taste stimuli is shown by a horizontal line just above the time calibration. *R. nigromaculata* was used in this experiment.

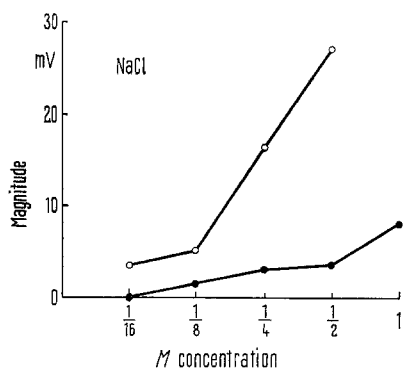


Fig. 2. Magnitude of receptor potentials of 2 different taste cells as a function of molar concentration of NaCl. *R. catesbeana* was used in this experiment.

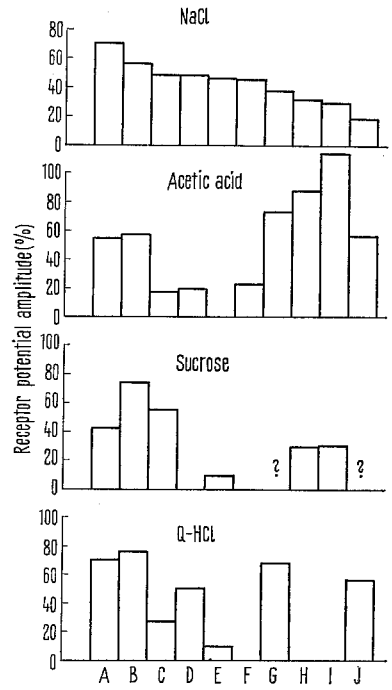


Fig. 3. Histogram showing the amplitude of receptor potentials of 10 taste cells (A–J) to 4 basic taste solutions, *M*/2 NaCl, *M*/64 acetic acid, *M*/4 sucrose, and *M*/256 quinine hydrochloride. The amplitude of receptor potentials was represented as percentage of the amplitude of resting potentials. 2 question marks indicate a failure of recording potentials. *R. nigromaculata* was used in this series of experiments.

*Zusammenfassung.* Die Registrierung der Rezeptorpotentiale einzelner Geschmackszellen von Raniden (*R. nigromaculata* und *R. catesbeana*) bei Reizung mit 4 Grundgeschmacksarten mittels Glasmikroelektrode ergibt: Ruhepotential der Rezeptorzellen 10–35 mV (innen negativ). Die einzelnen Geschmackszellen antworten auf mehr als 2 Geschmacksarten und zeigen im Hinblick auf ihre Antwortmuster zellcharakteristisches Verhalten.

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