could maintain a near-neutral pH at the epithelial surface. Bicarbonate thus still has a vital role to play in adjusting mucus pH, but the combined defence provided by mucus and bicarbonate is likely to work by restricting proton diffusion and minimising the buffer shuttle, rather than by generating an unstirred layer within which a complete neutralization takes place.

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2 Heatley, N.G., Gastroenterology *37* (1959) 313.
3 Williams, S.E., and Turnberg, L.A., Gastroenterology *79* (1980) 299.
4 Pfeiffer, C.J., Am. J. Physiol. *240* (1981) G176.
5 Williams, S.E., and Turnberg, L.A., Gut *22* (1981) 94.
6 Ross, I.N., Bahari, H.M.M., and Turnberg, L.A., Gastroenterology *81* (1981) 713.
7 Bahari, H.M.M., Ross, I.N., and Turnberg, L.A., Gut *23* (1982) 513.
8 Allen, A., and Garner, A., Gut *21* (1980) 249.
9 Montalvo, J.G., and Guilbault, G.G., Analyt. Chem. *41* (1969) 1897.
10 Carr, P.W., Analyt. Chem. *49* (1977) 799.
11 Ross, J.W., Riseman, J.H., and Krueger, J.A., Pure appl. Chem. *36* (1973) 473.
12 Vadgama, P.M., Alberti, K.G.M.M., and Covington, A.K., Analytica chim. Acta *136* (1982) 403.
13 Guilbault, G.G., Meth. Enzym. *44* (1976) 597.
14 Müller, R.H., Analyt. Chem. *41* (1969) 113A.
15 Engasser, J.M., and Horvath, C., Biochim. biophys. Acta *358* (1974) 178.
16 Engasser, J.M., and Wilhelm-Despres, A.M., Chem. Engng Sci. *35* (1980) 669.
17 Grossman, M.I., 21st Int. Congress of Physiological Sciences, Buenos Aires 1959, p.226.
18 Makhlouf, G.M., McManus, J.P.A., and Card, W.I., Gastroenterology *51* (1966) 149.
19 Makhlouf, G.M., in: Physiology of the gastrointestinal tract, p.551. Ed. L.R. Johnson. Raven Press, New York 1981.

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The effect of weak electrical potential gradients on the transport of water in broad bean plants under stress

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Summary. Adequate moisture was transported by an electrical potential gradient of 1 V/cm of the correct polarity to maintain the turgid state of broad-bean plants subjected to severe stress conditions.

The effect on growth of plants of small direct currents, driven by low voltage gradients has been reviewed by several authors[2-4]. Studies on the transportation of water in plants by low voltage gradients in relation to the movement and metabolism of plant hormones have also been reported[5-7]. In a communication[8] which dealt with transmission of viruses to plants by small currents driven by low voltage gradients, several preliminary control experiments were conducted to confirm the observations of the previous authors[5-7].
In these experiments[8] use was made of 9 V dry cell batteries, either singly, or, as 2 batteries connected in series. The poles of the batteries were connected to the plants via short pieces of platinum (Pt) wire inserted in their stems and the opposite poles via Pt wires to the soil in the vicinity of the roots. A voltage gradient of 1 V/cm was used. Young bean plants (*Phaseolus vulgaris* cv. van Zyls) could be dehydrated, or wilted, in 20 h by connecting their stems at positions 9 cm from the soil to the positive ('positive plants') and the soil to the negative pole ('negative soil') of a 9 V battery. The wilting or, dehydration of the plants, judging from their appearance compared to control plants, kept under the same conditions of temperature (22 °C) and relative humidity (approximately 50%), occurred despite adequate water in the soil. Using bean plants in which the polarities were reversed ('negative plants') no dehydration occurred as witnessed by their turgidity after 20 h.
The dehydration of the plants, 'positive plant' 'negative soil' could be counteracted by slicing off the tips of bean plants, immersing the damaged leaves into weak buffer, 10 mM phosphate, pH 7.5, and passing a current of approximately 1 V/cm for 20 h through the plants having the plant positive and the soil 'negative'. Having confirmed the effect of weak direct currents on plants the effect of weak potential gradients on plants subjected to severe stress conditions was investigated.
Seeds from broad beans (*Vicia faba* cv. aqualdulce) were germinated and grown in autoclaved sandy loam soil in plastic pots of 150 cm diameter. Four pots, each with 2 plants were used in the experiment. When the seedlings emerged from the soil the pots were transferred to a glass house. The containers with the plants were watered daily to saturation. The glass house was fully exposed to the sun and the internal temperature fluctuated between 25 °C at 06.00 h to 40 °C at 14.00. When the plants reached a height of approximately 10 cm they were subjected to the 'voltage gradient' experiment. One of 2 plants in 1 container was made 'negative' and its soil 'positive' (gradient 1 V/cm). The 2nd plant was the control. In a 2nd pot, 1 plant was made 'positive' and its soil 'negative'. The 2nd plant served as control. The 4 plants in the remaining 2 containers were additional controls.
The plants were well watered at the start of the experiment, but, it must be emphasized that the pots received no water during the next 4 days. The plants were examined daily and their conditions noted.
After 1 day the 'positive plant' (soil negative) was severely wilted, while the control in the same pot and the additional controls were slightly dehydrated. In contrast, the 'negative' plant (soil 'positive') was turgid. On the 4th day the 'positive' plant (soil negative) was dark brown and dry. At this stage the 6 control plants were wilted to such a degree that when watering was resumed on the same day they did not recover, despite daily watering to saturation. They were dry and brown on the 6th day.
From this experiment it was concluded that residual moisture in the soil of the 4 pots on the 4th day could not be mobilized for maintenance of the 6 control plants; the

small voltage gradient, 1 V/cm across the stem of the 'negative' plant could transport adequate water for maintenance of the plant from the soil. The soil at this stage appeared dry and hard. In the case of the 'positive' plant, (soil 'negative'), the moisture was transferred from the plant to the soil, hence the plants 'complete' dehydration on the 4th day of the 'voltage gradient' experiment. The 'voltage gradient' experiment on the broad beans was performed 3 times with identical results during 2 years, at times when the atmospheric conditions were considered right for producing stress conditions in plants.
No measurements were made of the amount of moisture transported in the broad bean plants. The reason being that the high transportation rate of the plants, subjected to the very arid conditions in the glass house, 23–40 °C and relative humidity which fluctuated between 40 and 20%, made such measurements meaningless.
Measurements were made on the influence of a weak potential gradient on the transportation of fluid in vine plants during the dormant period, June 1981 (winter in the southern hemisphere). Three plants of the cultivar Pinotage were used in the experiment. The plants were approximately similar in size and were grown in plastic pots in sandy loam soil and kept in the glass house, the temperature fluctuated between 10 and 20 °C. The stems were cut off 18 cm from the soil and 2 pairs of 9 V batteries connected in series to supply 18 V, connected to the soil and the stems of the plants. In 1 instance the plant was 'positive'; the Pt wire was inserted in the stem at the position where it was cut; the soil was 'negative'. In a 2nd instance the plant was made 'negative' and the soil 'positive'. The 3rd plant was the control. The plants were watered daily for 3 weeks. After 24 h exposure to the gradient, the 'negative' plant (soil 'positive') started to emit fluid from the 'wound'. A chute was made of 'Bostic' gum to direct the exuded fluid into a plastic centrifuge tube attached to the stem. 30 ml were collected in 48 h. The experiment was terminated after 21 days. At that stage the 'positive' plant was dry and never became viable again. The 'negative' plant started to bud while the control plant was still dormant. On the assumption that stationary ionizable acidic, viz. carboxyl and, or basic, viz. imino and amino groups are present in the plant tissues, the transport of moisture by a weak potential gradient may be due to electro-endosmosis; the direction of migration of the fluid being dependant upon the net charge density.

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2 Lund, F.J., Bioelectric fields and growth. University of Texas Press, Austin 1947.
3 Schrank, A.R., in: Encyclopedia of plant physiology. Ed. W. Rhuland. Springer, Berlin/Göttingen/Heidelberg 1953.
4 Ellis, H.W., and Turner, E.R., Sci. Prog. Oxford *65* (1978) 393.
5 Black, J.D., Forsyth, F.R., Fensom, D.S., and Ros, R.B., Can. J. Bot *49* (1971) 1809.
6 Bratton, B.O., and Henry, E.W., J. exp. Bot. *28* (1977) 338.
7 Morris, D.A., Planta *150* (1980) 431.
8 Polson, A., and von Wechmar, M.B., J. gen. Virol. *51* (1980) 179.

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Relaxation of isolated rabbit veins mediated by latent histamine H_2-receptors

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Summary. Isolated rabbit veins preconstricted by either norepinephrine, methoxamine or potassium were relaxed by histamine in the presence of mepyramine, a histamine H_1-antagonist. The relaxation was not antagonized by atropine, propranolol and indomethacin but by an H_2-antagonist cimetidine. It is likely that histamine relaxes the rabbit veins through H_2-receptors.

It is now well established that the effect of histamine on the cardiovascular system, including the heart and arterial side, is mediated by 2 distinct specific receptors H_1 and H_2[2-4]. However, there is little information regarding the mechanism of histamine action, especially about H_2-receptors, on the venous side. The current study reports the existence of H_2-receptors in veins and the relaxation mediated by the receptors.
Male Japanese white rabbits weighing 2–3 kg were killed by a blow on the head and rapid exsanguination. The saphenous, cephalic, ear, facial, external jugular, azygos, pulmonary, portal, splenic and renal veins and posterior vena cava were removed and ring segments (4 mm in length) were prepared under a dissecting microscope. A ring segment preparation[5] was suspended in an organ bath containing 50 ml of modified Krebs-bicarbonate solution which was aerated with 95% O_2 + 5% CO_2 and maintained at 37 °C. The composition of the modified Krebs-bicarbonate solution was: NaCl 119, KCl 4.7, $CaCl_2$ 2.5, KH_2PO_4 1.18, $MgSO_4$ 1.17, $NaHCO_3$ 24.9 and glucose 11.7 (all mM). A passive load of 0.5 g was applied for large veins with an OD of 1.5 mm or more, and 0.3 g for smaller veins. Isometric contraction and relaxation were recorded on an ink-writing oscillograph (Nihon Kohden Kogyo, Tokyo, Japan) by means of force displacement transducers (Nihon Kohden Kogyo). During the equilibration period of 2 h, submaximal contractions were elicited twice by histamine 10 µM, and bathing media were renewed approximately every 20 min before the experiment on drug effects.
Drugs used were histamine dihydrochloride, l-norepinephrine bitartrate, methoxamine hydrochloride, mepyramine maleate, cimetidine[6], atropine sulfate, dl-propranolol hydrochloride and indomethacin.
Histamine induced contractions in all veins studied. As shown in figure 1, the histamine concentration-response curve was shifted êö , tlel to the right, dose-dependently, by mepyramine, a selective H_1-receptor antagonist. pA_2-Values[7] were around 9 in most veins, the values comparing well with those obtained with the guinea-pig ileum[7].
On the other hand, an H_2-receptor antagonist cimetidine 10 µM hardly affected the contractile responses of veins to histamine (data not shown). The result was in accordance