Elektrode C2 befindet. Die Zahlenangaben der Äquipotentiallinien entsprechen Stufen von 120 μV. Nach dieser Darstellung wird die positive Welle im EEG durch einen annähernd konzentrischen, relativ steilen Potentialberg gebildet, während die negative Senke einem flachen, nierenförmigen Trog entspricht.

Die zeitliche Verschiebung der positiven und negativen Potentialmaxima für eine Welle wurde in 2 msec-Intervallen, mit den entsprechenden Amplituden als Ordinaten räumlich dargestellt, auf der linken Seite von Figur 1 wiedergegeben. Sowohl das negative als auch das positive Potentialmaximum verschieben sich innerhalb einer Welle im Gegensinn des Uhrzeigers; diese Bewegungsrichtung bleibt konstant, solange sich die EEG-Tätigkeit nicht ändert. Dabei ist die topographische Verteilung der positiven und der negativen Maxima ungleich: Während sich die Höhe des negativen Potentialmaximums während seiner Kreisbahn nur wenig ändert, zeigen die positiven Feldgipfel Maxima über den anterioren Elektroden des Ableitequadrates und Minima posterior. Die Geschwindigkeit ist nicht gleichförmig. Sie beträgt im Durchschnitt 7.2 cm/sec. An einigen Orten bleibt das Potentialmaximum stationär oder verschiebt sich nur sehr langsam; an anderen wieder kommt es zu relativ raschen Verschiebungen (63 cm/sec), wobei jedoch die aufeinanderfolgenden Äquipotentialbilder eindeutig zeigen, dass es sich nicht um eine kontinuierliche Verschiebung handeln kann, sondern um die Anregung eines zweites Potentialfeldes handelt. Solche Diskontinuitäten in der Ausbreitung sind besonders deutlich zu sehen, wenn sich der Gipfel des positiven Feldes von Elektrode B2 nach C2 und von C3 nach B3 verschiebt.

Dieser Befund gewährt einen Einblick in den Mechanismus der Synchronisierung der EEG-Tätigkeit im epileptischen Anfall. Einerseits zeigt er, dass der regelmässigen EEG-Tätigkeit auch ein regelmässiges, spatiotemporales Verhalten von Potentialfeldern entspricht, ferner, dass dabei mehrere und relativ umschriebene Felder (der Durchmesser der positiven Felder beträgt 3 mm) sowohl stationär bleiben, als auch sich kontinuierlich verschieben («travelling waves») oder andere Potentialfelder zur Entstehung anregen können; die Gestalt der positiven Felder weicht von denen der negativen ab, und auch die topographische Amplitudenverteilung beider Felder ist nicht identisch (eine weitere Bestätigung für die bereits mehrmals geäusserte Vermutung, positiven und negativen Phasen des EEGs entsprechen verschiedene physiologische Phänomene)[7].

Nach diesem Befund dürften bei der Synchronisierung selbst so regelmässiger Anfallsformen wie der tonischen Muster in morphologisch einheitlichen Strukturen komplexe Mechanismen zusammenwirken.

Summary. The circular movement of cortical potential fields during epileptic seizures of the rabbit, evoked by intracortical application of penicillin, is described.

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[7] J. CALVET, M. C. CALVET und J. SCHERRER, Electroenceph. clin. Neurophysiol. *17*, 109 (1964).

The Effects of Lithium and Methacholine on the Intracellular Ionic Composition of Goose Salt Gland Slices: Relation to Sodium and Chloride Transport

The salt glands of euryhaline birds produce a hypertonic solution consisting mainly of sodium chloride. During secretion sodium is actively transported from the inside of the secretory cell across the apical cell membrane into the lumen of the tubule; chloride probably follows passively[1,2]. The entry of Na^+ and Cl^- into the secretory cell across the baso-lateral membrane may not be by a process of simple diffusion but rather by carrier-mediated exchanges of Na^+ for H^+ and Cl^- for HCO_3^-[2]. If this is in fact the mechanism, then Na^+ and Cl^- influx would depend on the production of carbon dioxide and a close link between cellular respiration and Na^+ and Cl^- entry would be expected. Low concentrations of Li^+ stimulate respiration of salt-gland slices in vitro[3] but do not stimulate salt-gland secretion when infused i.v. in anaesthetized geese, which infers that Li^+ does not stimulate the sodium pump on the luminal membrane of the cell. Therefore the presence of Li^+ appears to dissociate cellular respiration from secretory activity and, under such conditions, changes in Na^+ and Cl^- movements into the cell might be evident; this we have found to be the case. Since secretion is induced by cholinergic nerves, the effects of the cholinomimetic drug methacholine also have been studied in slices incubated with low concentrations of Li^+ in the medium.

The methods used for studying the intracellular composition of salt-gland slices in vitro have been described previously[1]. Slices of salt gland from each goose were divided into two batches and incubated separately. All were pre-incubated for 15 min in Krebs-bicarbonate medium at 41 °C and then ^{14}C-sucrose was added for the determination of extracellular space[1]. 20 min later (sufficient time for the labelled sucrose to reach equilibrium in the slices[1]) LiCl was added to achieve a concentration of 10 m*M* in the medium. In one series of experiments the tissue was exposed to Li^+ for 10 min, and to one of each pair of tubes methacholine (0.33 m*M*[4]) was added at the same time as the LiCl. In the other series methacholine was added 10 min after the LiCl and incubation continued for a further 10 min. After incubation the tissue was treated and analysed as described previously[1,5].

With 10 m*M*-LiCl in the medium, intracellular [Na], [K] and [Cl] were all increased, the change being significant for [Na] and [Cl] but not significant for [K]. When methacholine was also present, intracellular [Na] and [Cl] were not significantly different compared with control slices incubated without LiCl (Table). In other words methacholine reversed the effect of the added LiCl. The changes observed with LiCl were not obtained with an addionalit 10 mmoles/l NaCl in the medium. The mean differences for both intracellular [Na] and [Cl] between slices incubated in LiCl and LiCl plus methacholine

[1] M. PEAKER, J. Physiol., Lond. *213*, 399 (1971).
[2] M. PEAKER, Phil. Trans. R. Soc., B *262*, 289 (1971).
[3] A. BORUT and K. SCHMIDT-NIELSEN, Am. J. Physiol., *204*, 573 (1963).
[4] G. D. V. VAN ROSSUM, Biochim. biophys. Acta *126*, 338 (1966).
[5] M. PEAKER and S. J. STOCKLEY, Nature, Lond. *243*, 297 (1973).

Effects of LiCl and LiCl plus methacholine on the intracellular composition of goose salt-gland slices

		Tissue			
		A Incubated control	B Incubated + 10 m*M* LiCl	C Incubated + 10 m*M* LiCl + 0.33 m*M* methacholine	*P* value for paired *t*-test between B and C
		(11)	(7)	(7)	
Water content (ml/100 g tissue)		76.7 ± 0.9	77.6 ± 0.9	78.0 ± 1.2	NS
^{14}C-sucrose space (ml/100 ml tissue water)		57.3 ± 2.1	57.8 ± 1.9	54.8 ± 2.8	NS
Calculated intracellular concentration	Na	58.3 ± 1.9	78.8 ± 7.0 $p < 0.01$	62.8 ± 6.5	< 0.05 (MD = 16)
(mmoles/l intracellular water)	K	112.0 ± 9.4	127.0 ± 2.0	124.9 ± 8.2	NS
	Cl	63.4 ± 4.8	84.9 ± 10.2 $P < 0.05$	68.8 ± 10.9	< 0.05 (MD = 16)
	Li	—	11.7 ± 1.5	12.0 ± 2.1	NS

Lithium (10 m*M*) and methacholine (0.33 m*M*) were added for the final 10 or 20 min of incubation as described in the text. Data from both times of incubation have been bulked since there was no apparent difference between them. Mean ± S.E.
Number of determinations in parentheses. The *P* values below the figures in the columns are for a *t*-test between the data in B or C compared with the control data in A. NS = not significant (only shown for the paired *t*-test). MD = mean difference.

were identical (16 mmoles/l). This finding implies that, under these conditions, Na^+ and Cl^- movements were affected equally while intracellular [K] remained unchanged. There was no significant difference in intracellular [Li] between the two groups incubated with LiCl or LiCl plus methacholine, and no significant correlation was apparent between intracellular [Li] and [Na] in the slices incubated with 10 m*M*-LiCl.

The increases in intracellular [Na] and [Cl] with LiCl can be interpreted as providing further evidence for the hypothesis that, during secretory activity, Na^+ and Cl^- are transported into the cell across the basal and lateral membranes in exchange for H^+ and HCO_3^-. The 20% increase in cell respiration with Li^+[3] (which we confirm) would lead to more CO_2 (and therefore H^+ and HCO_3^-) being available for these exchanges to occur; the mechanism by which Li^+ exerts its effect on respiration is not known. The equimolar decrease in intracellular [Na] and [Cl] which occurred when methacholine was also present implies that this cholinomimetic activates the sodium pump on the luminal membrane which then extrudes the additional Na^+ and Cl^- entering the cell under the influence of Li^+. In other words methacholine restored the balance between influx and efflux across the two poles of the secretory cell. It would also seem unlikely that a rise in intracellular [Na^+] is the means by which the luminal sodium pump is activated because, when Li^+ was present, intracellular [Na^+] was increased and yet methacholine still appeared to stimulate the luminal pump. A similar suggestion, that a raised intracellular [Na^+] is not responsible for the activation of the luminal pump in the cat submandibular gland, has been made recently[6]. If this interpretation is correct, the question arises, how does acetylcholine, released from the secretory nerve terminals at the basal side of the cell, stimulate the pump on the opposite (i.e. luminal) side of the cell?

While these findings on the effect of Li^+ provide useful information on the secretory mechanism in the salt gland, the implications may be of wider interest. It is possible that Na^+ and Cl^- movements could be affected by Li^+, acting to alter cell respiration, in epithelial tissues with Na^+/H^+ and Cl^-/HCO_3^- exchange mechanisms on one border of the cells. Since such tissues apparently exist in mammals as well as in other vertebrates[7] and, with the current interest in lithium as an agent for use in the treatment of psychological disorders and in any side effects it may have, such a possible mechanism of action should not be overlooked.

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A.R.C. Institute of Animal Physiology, Babraham, Cambridge CB2 4AT (England), 9 August 1973.

[6] J. H. Poulsen, Acta physiol. scand. *87*, 51A (1973).
[7] R. D. Keynes, Q. Rev. Biophys. *2*, 177 (1969).
[8] During this work S. J. S. was a 'sandwich course' student at Trent Polytechnic.

Effect of a Chelating Ion Exchange Resin (Chelex 100) on Impedance and Evoked Potentials

Both raising and lowering calcium levels in the environment of nervous tissue has long been known to alter its excitability[1-5]. Changes in impedance of cerebral cortex after topical application of calcium and magnesium solutions were previously reported[6-8]. Topical application of ion chelating gels produced inversion of the transcortical DC gradient, EEG flattening, and seizure activity[9].

In the present note we report the effects of a chelating ion exchange resin Chelex 100 (Bio Rad Laboratories) on flash evoked potentials and impedance. Chelex 100 is a styrene divinylbenzene copolymer containing imminodiacetate functional groups. It is structurally classed with the weak acid cation exchangers by virtue of its carboxylic acid groups. Its high affinity for calcium and magnesium makes it suitable for studying effects of removal of these ions from nervous tissue.

The study was performed in 32 alert cats with chronically implanted cannulae and bipolar concentric electro-