appears capable of alkalinizing its contents, which may serve a protective function in vivo. The alkalinization process appears to be electrically neutral and distinct from that responsible for I_{SC}, and to function at a faster rate on the basis of chemical equivalents.

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2 E.A. Barnard, in: Comparative Animal Physiology chapter 4, p. 133, 3rd edn. Ed. C.L. Prosser. W.B. Saunders, Philadelphia 1973.
3 D.W. Powell, S.J. Malawer and G.R. Plotkin, Am. J. Physiol. *215*, 1226 (1968).
4 H.H. Ussing and B. Andersen, Proc. 3rd int. Congr. Biochem. 1955.
5 T.H. Wilson and L. Kazyak, Biochim. biophys. Acta *24*, 124 (1957).
6 M.J. Jackson and B.N. Morgan, Am. J. Physiol. *228*, 482 (1975).
7 N.J. Carlisky and V.L. Lew, J. Physiol. *206*, 529 (1970).
8 T.W. Clarkson and S.R. Toole, Am. J. Physiol. *206*, 658 (1964).
9 G. Lonnerholm, Acta physiol. scand. *99*, 53 (1977).
10 R.A. Frizzell, M.J. Koch and S.G. Schultz, J. Membrane Biol. *27*, 297 (1976).
11 H.J. Binder and C.J. Rawlins, Am. J. Physiol. *225*, 1232 (1973).
12 K.A. Hubel, Am. J. Physiol. *217*, 40 (1969).
13 D.W. Powell, H.J. Binder and P.F. Curran, Am. J. Physiol. *223*, 531 (1972).
14 H.J. Binder, in: Int. Rev. Physiol., vol. 12, chapter 9, p. 285. Ed. R.K. Crane. University Park Press, Baltimore 1977.

Stimulus-response function at several levels of background luminance, in the cat visual areas 17 and 18

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Summary. Stimulus-response curves of simple cells of the visual cortex were obtained by using 500-msec stationary stimuli. Background influence on single unit responses was studied. The contrast sensitivity of simple cells increases as a function of background luminance. The resolution power of these cortical cells for detecting differences in stimulus contrast decreases at background levels above 0.09 cd/m^2.

In a previous paper[2], we described the stimulus-response function of single neurons in visual areas 17 and 18 of the cat. Discrete stimuli were positioned on the neuron receptive field and series of 500-msec flashes of increasing intensities were presented on a background of constant luminance. Curves were constructed by plotting the response magnitude versus the logarithm of stimulus intensity. For all cortical neurons studied under these conditions, the stimulus-response relation was described by a S-shaped curve. We also observed that if the level of background illumination was changed, similar stimulus-response functions were obtained but the curves were shifted along the abscissa (log luminance) by an amount equal to the amount of change in background luminance; therefore, the plotting of the above responses versus the contrast between stimulus and background illumination eliminates the abscissa shift and superimposition of curves occurs. In this investigation we describe results concerning the influence of background illumination on the stimulus-response relation of cortical neurons. A similar study was conducted by Sakmann and Creutzfeldt[3] on the ganglion cells of the retina and by Virsu et al.[4] on the neurons of the lateral geniculate nucleus in the cat; they described changes in response sensitivity at different background levels.

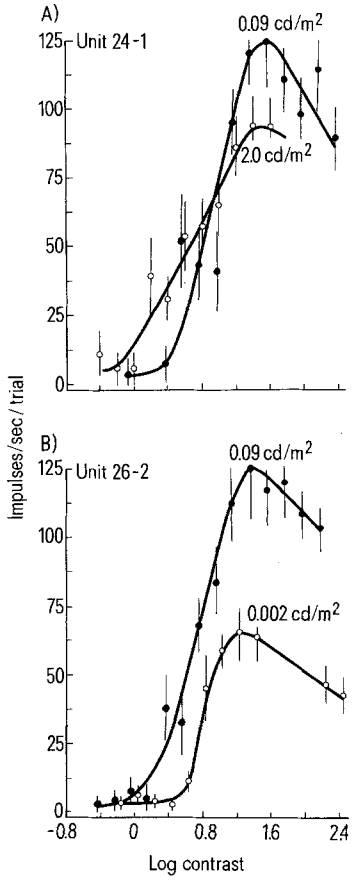
Material and methods. Experiments were carried out on locally anaesthetized cats, paralyzed with Flaxedil and artificially ventilated. The closed chamber technique[5,6] was used to record impulse activity from an extracellular position by means of tungsten microelectrodes. Sequences of impulses were recorded on magnetic tape and subsequently analyzed with a digital computer (Honeywell, mod. 316). The cat eyes were covered by contact lenses with an artificial pupil 5 mm in diameter. Focal visual stimuli, appropriate in shape and size according to the receptive field, were projected on a tangent milky screen which was 1 m in front of the animal; the luminance of the screen was between 2×10^{-3} and 2×10^{0} cd/m^2 or, expressed as retinal illumination, between 3×10^{-2} and 3×10^{1} effective trolands. The light intensity of the stimuli was randomly changed by using neutral density filters in order to test neurons from threshold to saturation responses; 10 repetitions of each stimulus intensity were carried out in a random order.

The conditions of stimulations were defined in terms of contrast (that is I-B/B, where I is the intensity of the focal stimulus and B the background luminance). When the level of background luminance was changed, some 40–50 min were allowed for retinal adaptation[7]. Anatomical controls were routinely carried out; as reported elsewhere[8] we found, in area 18, neurons of the simple type according to Hubel and Wiesel's definition[9]. This finding was also reported by other authors[10,11].

Results and discussion. Results were obtained from 41 neurons, 31 of which histologically identified in area 17 and 10 in area 18; all were simple cells. Stimulus-response curves were constructed by plotting the response magnitude (mean frequency of discharge) versus the logarithm of stimulus contrast. The mean frequency of discharge was calculated by dividing the total number of spikes for each response by the duration of the response; when present, the spontaneous activity was subtracted. Each stimulus-response curve shows a minimal (threshold) and a maximal value at the extremes of a nearly straight portion. The plots in the figure (A and B) examplify our results; changes in background illumination were accompanied by several changes in the stimulus-response function of cortical neurons. In fact, a) an increase in background luminance caused a decrease in contrast threshold which was dependent on the amount of background increase (note in the figure A, the shift to the left of the curve obtained with background luminance of 2 cd/m^2, and in B a similar shift for the curve obtained with 0.09 cd/m^2); b) at all levels of background luminance explored, maximal responses were always obtained with log contrast +1.3, +1.4; c) as a

consequence of the effects described in a) and b), whenever the background luminance was raised, the contrast range over which the stimulus-response relation was obtained became wider; d) the magnitude (impulses/sec) of the maximal response was small at low background luminance (0.002 cd/m^2) and increased with background luminance levels up to 0.09 cd/m^2. Beyond this background level, the maximal response magnitude decreased progressively as luminance increased, at least within the range we explored (the highest background luminance tested was 2 cd/m^2); e) at background levels higher than 0.09 cd/m^2 the stimulus-response curves had a lower positive slope.

These results suggest the following comments. 1. The range of contrast which can be recognized by cortical neurons increases as a function of background luminance, at least within those background levels explored by us (0.002–2 cd/m^2). 2. Since the widening of the contrast range is due only to a shift to the left – that is to a lowering – of the threshold, the sensitivity of cortical visual neurons increases as a function of the background luminance. 3. Since at background levels higher than 0.09 cd/m^2 the stimulus-response curves had a lower positive slope, the resolution power for detecting differences in stimulus contrast decreases from this level (0.09 cd/m^2) up to the highest background we explored (2 cd/m^2). In conclusion, background changes can markedly modify important characteristics of the visual information process such as threshold and resolution power.



Stimulus-response function at different levels of background luminance. In *A* and *B* the levels of diffuse luminance of the tangent screen expressed in cd/m^2 are reported on the top of each curve. The unit in *A* was isolated in area 17, classified as simple cell and activated by 500-msec stationary flashes of light of variable contrast. The unit in *B* was isolated in area 18, classified as simple cell[8] and activated by 500-msec stationary 'negative' flashes of light of variable contrast; 'negative' flashes were obtained by switching off for 500 msec the light of the focal stimulus. In this case the contrast of the stimulus was again I-B/B where I was the light intensity of the focal stimulus before the switching off and B the background luminance. Each data point of the curves represents the mean ±SD of 10 random trials.

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2 E. Riva Sanseverino, C. Galletti and M.G. Maioli, Electroenceph. clin. Neurophysiol. *34*, 739 (1973).
3 B. Sakmann and O.D. Creutzfeldt, Pflügers Arch. ges. Physiol. *313*, 168 (1969).
4 V. Virsu, B.B. Lee and O.D. Creutzfeldt, Exp. Brain Res. *27*, 35 (1977).
5 G.F. Poggio, F.H. Baker, Y. Lamarre and E. Riva Sanseverino, J. Neurophysiol. *32*, 892 (1969).
6 E. Riva Sanseverino, C. Galletti and M.G. Maioli, Brain Res. *54*, 225 (1973).
7 E. Riva Sanseverino, C. Galletti and M.G. Maioli, Brain Res. *124*, 251 (1977).
8 E. Riva Sanseverino, C. Galletti and M.G. Maioli, Arch Sci. biol. (Bologna) *58*, 1 (1974).
9 D.H. Hubel and T.N. Wiesel, J. Physiol. (Lond.) *160*, 106 (1962).
10 B. Dreher and L.J. Cottee, J. Neurophysiol. *38*, 735 (1975).
11 G.A. Orban, M. Callens and J. Colle, Brain Res. *90*, 205 (1975).

Effects of hypothalamic injections of 5,6-dihydroxytryptamine on thermoregulation in rats[1]

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Summary. 5,6-Dihydroxytryptamine, a serotonin depletor, infused directly into the anterior hypothalamus of rat's brain, produced an increase in both heat production and heat loss (as indicated by changes in peripheral circulation) at temperatures of 8, 15 and 22 °C. The rectal temperature of these treated rats remained constant.

Recently, a number of attempts to assess the thermoregulatory effects of a lowered content of 5-hydroxytryptamine (5-HT; serotonin) in the brain have produced conflicting results. For example, in rats in which brain 5-HT had been depleted by systemic administration of p-chlorophenylalanine, the rise in rectal temperature when exposed to the acute heat stress (38 °C) was reduced[2]. Both rats and monkeys treated with intrahypothalamic injection of 5,6-dihydroxytryptamine (5,6-DHT), a specific 5-HT depletor, were unable to maintain body temperature in the cold but recovered from the heat deficit[3,4]. On the other hand, the destruction of brain 5-HT neurons by pretreatment with intraventricular administration of 5,7-DHT, which lowered the brain 5-HT content, did not disrupt the thermal balance in rabbits[5,6]. Unfortunately, most of the experiments performed in studying the relation between brain 5-HT and thermoregulation have relied on measurements of rectal temperature solely. This makes it difficult properly to assess the action of brain 5-HT depletion on particular functions such as metabolic heat production, respiratory evaporative heat loss and vasomotor activity. This study was attempted to quantify any changes in the thermoregulatory outputs induced by the direct administration of 5,6-DHT into the preoptic anterior hypothalamus (POAH), in