potential differences, short-circuit currents, and potassium fluxes are obtained with or without sodium.

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THE EFFECT OF BRANCHING AT C-1 ON THE BIOLOGICAL ACTIVITY OF ALCOHOLS

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Recently, Gudjónsdóttir and Burström[2] described some stimulating effects of low-molecular-weight alcohols on excised wheat roots. Among the possible explanations for differences noted among alcohols, effects on the cell membrane were discussed. Differential effects of primary and secondary alcohols were also noted by Levan,[3] who found that the secondary isomers were always more toxic. He also observed increase in toxicity with increasing molecular weight.

During a study of beet-root tissue permeability, it was observed that the leakage of red pigment was induced by certain alcohols and not by their C_1-branched isomers, and that these differences correlated with the effects of these alcohols on germination. This work suggests that the toxicity (but not necessarily the stimulatory effects) of alcohols is in fact a membrane phenomenon as will be indicated here.

Experimental.—Following the procedure previously described,[5] groups of 20 beet-root cubes were placed in 6 ml of $M/15$ phosphate buffer pH 6.6 or buffered 1.5 M alcohols, and initial readings taken on the Klett colorimeter with a no. 54
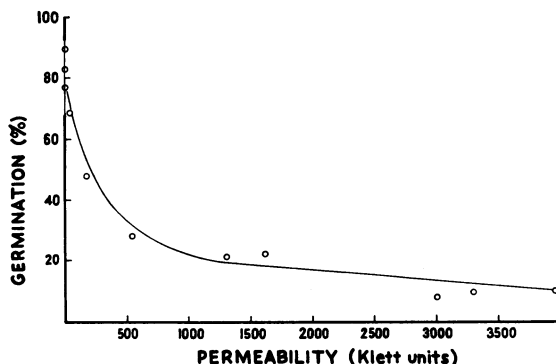
Fig. 1.—Relation between the effects of alcohols at 1.5 M on permeability of beet membrane and at 0.015 M on rye germination.

filter. Triplicate vessels were set up for each treatment. After 5, 10, and 20 min at 25°C, readings were taken on the aqueous phase. Dilutions were made when necessary for off-scale densities. Incubation periods much in excess of 20 min led to very dense solutions requiring large dilutions and hence were avoided. For convenience, 20 min was selected as a good reference time.

Germination tests with winter rye were carried out in darkness at 25°C. Groups of seeds were in water or various concentrations of the alcohols. Germination percentages were based upon triplicates of 50 seeds each. Counts were made after 24 hr when water controls had reached their maximum of 80 ± 5 per cent germination.

Results and Discussion.—The effects of the alcohols on permeability and germination are generally closely related (Fig. 1). Moreover, upon examination of the effects of the various alcohols, a structural relationship was also noted.

Methanol in the concentration used has no apparent effect on the beet cell membrane, ethanol a marginal one, and the higher *n*-homologues are progressively more active (Table 1). A methyl group at C-1 abolishes lytic effects in the propanols, whereas with the longer carbon chain of the butanols one C-1 methyl reduces activity markedly but incompletely, whereas two C-1 methyl groups (*tert*-butanol) again eliminate all effects. That branching *per se* does not prevent activity is indicated among the pentanols. A C-3 or C-2 methyl has at most only a minor effect, whereas one at C-1 reduces markedly but does not abolish the lytic effect. Two C-1 methyl groups leave only a small residual effect.

In 0.15 M concentrations, all alcohols other than methanol were toxic. At 0.03 M, selectivity is evident, but not as defined as it is at 0.015 M. At this concentration, the reciprocal relationship between the two biological responses is clearly delineated.

These results confirm the differential toxicity of primary alcohols and their C-1 branched isomers, and give strong support to a mechanism based upon injury to the cell membrane. It is, of course, possible that the differential oxidation of the alcohols leads to products differing in lytic activity. This explanation could be applied to some but not all of the compounds. It would, for example, fail to account for the loss of activity in secondary alcohols as the methyl ketones formed from them—acetone, for example—are known to be effective lytic agents.

TABLE 1

THE RELATION BETWEEN ALCOHOL STRUCTURE AND ITS EFFECTS ON PERMEABILITY AND GERMINATION

C	Alcohol Skeleton	Permeability (Klett units) 1.5 M	Germination of Winter Rye (%)		
			0.015 M	0.03 M	0.15 M
1	C—OH	0	89	85	79
2	C—C—OH	4	76	58	0
3	C—C—C—OH	164	48	4	0
3	C—C—OH (C branch)	0	83	73	0
4	C—C—C—C—OH (C branch)	1,605	22	4	0
4	C—C—C—OH (C branch)	535	28	5	0
4	C—C—OH (C branch)	0	75	11	0
5	C—C—C—C—C—OH (C branch)	3,958	10	0	0
5	C—C—C—C—OH (C branch)	3,305	10	0	0
5	C—C—C—C—OH (C branch)	3,000	8	0	0
5	C—C—C—C—OH (C branch)	1,298	21	4	0
5	C—C—C—OH (C branch)	38	64	8	0

Some alcohols are known to increase phenol oxidations,[4] but it is difficult to see how this property can be related to the present case.

Additional evidence that the effect is at the membrane level is in the rapidity of the response and in its reversal by Ca-ion, a "classical" membrane stabilizer:[1]

Solution	Klett readings (15 min)
Control	0
1.5 M n-propanol	385
$+ 5 \times 10^{-4} M$ CaCl$_2$	183
$+ 5 \times 10^{-3} M$ CaCl$_2$	15

Summary.—(1) The effects of 12 alcohols upon beet-root tissue permeability and winter rye germination were studied. (2) Alcohol-induced increases in permeability (leakage of red pigment) were correlated with suppression of rye germination. (3) Permeability is increased regularly with length of C-chain from C$_1$ to C$_5$, in normal alcohols. (4) In a typical case (n-propanol), Ca-ion reverses injury. (5) Branching on the alcoholic carbon (C-1) abolishes or reduces injury to beet cell membranes and reduces inhibition of rye germination. Branching elsewhere (in the isomeric amyl alcohols) has little or no effect on the activity of the alcohol in the test systems.

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EXTENSION OF QUASICONFORMAL MAPPINGS FROM TWO TO THREE DIMENSIONS*

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1. It was proved by F. Gehring[1] that a quasiconformal mapping from one 3-dimensional halfspace to another induces a quasiconformal homeomorphism of the boundary planes. The question arises whether the converse is true, that is, whether a quasiconformal mapping from one plane to another can always be raised to a quasiconformal mapping of the half space. The corresponding problem for the half plane had been settled in the affirmative by A. Beurling together with the writer.[2] It was natural to try to generalize the construction used in this case by imitation of the formulas, but after several fruitless attempts I was forced to abandon this approach. In our discussions of the problem, Beurling made the elementary but important observation that a quasiconformal mapping with sufficiently small dilatation can be approximated by piecewise affine mappings. This suggests a discrete approach, which turns out to be successful.

It is typical of the discrete method that it can be applied only when the maximal dilatation is sufficiently small. When going from two to three dimensions this is no restriction, for it is known that a 2-dimensional quasiconformal mapping can be composed by a finite number of mappings with arbitrarily small dilatations. For higher dimensions this theorem is not known, and the method fails.

2. The following lemma will be used in an essential manner:

LEMMA. *For any $\epsilon > 0$ there exists $k_0 > 0$ with the following property: If φ is a quasiconformal mapping of the z-plane onto itself, normalized by $\varphi(0) = 0$, $\varphi(1) = 1$, $\varphi(\infty) = \infty$, and with dilatation coefficient $k \leq k_0$, then $\left| \varphi(z) - z \right| \leq \epsilon$ for $\left| z \right| \leq 2$.*

As usual, $k = (K - 1)/(K + 1)$ where K is the maximal dilatation. The proof is by an obvious compactness argument.

Suppose that we keep only the normalization $\varphi(0) = 0$, $\varphi(\infty) = \infty$. If $a \neq 0$, the lemma is applicable to $\varphi(az)/\varphi(a)$, and on replacing z by z/a we obtain

$$\left| \varphi(z) - z\varphi(a)/a \right| \leq \epsilon \left| \varphi(a) \right| \quad \text{for} \quad \left| z \right| \leq 2 \left| a \right|. \tag{1}$$

This is the form in which the lemma will be used.

3. Let φ be a quasiconformal mapping of the plane onto itself, normalized by $\varphi(0) = 0$, $\varphi(\infty) = \infty$. When more convenient, we shall also use the real notation $z = (x_1, x_2)$, $\varphi = (\varphi_1, \varphi_2)$. The extension problem is to find a quasiconformal mapping $f(x_1, x_2, x_3)$ of the halfspace $x_3 \geq 0$ onto itself, such that $f = (\varphi_1, \varphi_2, 0)$ for $x_3 = 0$. The discrete problem is to find a piecewise affine quasiconformal mapping which agrees with φ at the lattice points $(m_1, m_2, 0)$ with integral coordinates.