quite surprised to find that the crater has a diameter of only 70 feet and a depth of only 10½ feet.

The crater had been reported originally by E. S. Simpson in 1938. Simpson's report was based upon a description given him by a former manager of the Dalgaranga sheep station, who reported finding several meteorite fragments around the crater in 1923. Simpson did not go to see the crater. His erroneous report was the basis of the incorrect measurements which were incorporated in the recent British Museum Catalog of Meteorites and which have been given in numerous other publications.

A survey, including a description of the meteorite fragments that were recovered at the site during the recent visit to the crater, is being prepared by the museum.

H. H. NININGER
American Meteorite Museum, Sedona, Arizona

15 September 1959

Effect of Chlorine Dioxide on Lignin Content and Cellulose Digestibility of Forages

A significant negative correlation exists between the percentage of lignin in a forage and the digestibility of the dry matter and the crude fiber. Lignin is susceptible to decomposition by chlorine and its oxides. The removal of lignin from plant material by sodium chlorite in aqueous acid solutions is part of the procedure for the preparation of holocellulose. Holocelluloses prepared from wood have been found to have digestion coefficients of 80 to 90 (*1*), which are higher than those of cellulose in untreated wood. The treatment of forages to remove lignin should lead to an improved utilization of the fibrous constituents of forages. Various treatments of forages or low-grade feeds have been carried out with delignifying agents; an example is the work of Prianishnikov and Tomme (*2*). They treated straw with aqueous ClO_2 and then with aqueous sulfite; however, a loss in soluble constituents resulted, even though the digestibility of the crude fiber was increased. So far as we know, no observations on the effect of ClO_2 gas in the dry state on the digestibility of forage have been made.

Experiments were carried out on a laboratory scale to degrade the lignin without loss of soluble constituents of forage. Three forages were treated as follows: Air was bubbled through a solution of sodium chlorite, sodium acetate, and acetic anhydride and then passed through a glass tube containing 5 to 10 gm of finely ground roughage in an air-dry state for 4 to 24 hours. The sample, still apparently air-dry, had an acid odor which could be removed by exposure to air, by vacuum treatment, or by a short aeration with air containing ammonia. The product was analyzed for acid-insoluble lignin (*3*), and the digestion coefficient of its cellulose was determined by an artificial-rumen technique developed at the Pennsylvania Agricultural Experiment Station (*4*). The results appear in Table 1. The dry treatment of dried and ground grass and straw with ClO_2 resulted in a marked decrease in the acid-insoluble lignin content as determined by chemical analysis and in a significant increase in the digestibility of the cellulose as indicated by the artificial-rumen technique. The changes were related to the amount of sodium chlorite that was used (*5*).

Table 1. Lignin content and cellulose digestibility of forages treated with ClO_2 gas.

Treatment	Hygroscopic moisture (%)	Acid-insoluble lignin (%)	Digestion coefficient of cellulose
Orchard grass, flowering, treated in 10-gm lots			
No treatment	5.6	5.3	36.9
0.2 gm $NaClO_2$	6.2	5.3	39.2
2.4 gm $NaClO_2$	5.7	3.9	48.0
3.0 gm $NaClO_2$	6.2	3.6	46.3
Reed canary grass, late dough, sample previously extracted with benzene-alcohol, treated in 5-gm lots			
No treatment	5.2	5.5*	30.9
1.2 gm $NaClO_2$	6.2	3.7*	40.0
3.0 gm $NaClO_2$	7.2	2.0*	46.9
Wheat straw, treated in 8-gm lots			
No treatment		6.7	22.8
2.5 gm $NaClO_2$†		2.8	36.2
3.0 gm $NaClO_2$		3.9	24.0
3.2 gm $NaClO_2$		1.85	52.2

* Percentage of original grass. † Final aeration with vapor from ammonium carbonate solution.

J. T. SULLIVAN
Agricultural Research Service, U.S. Department of Agriculture, University Park, Pennsylvania

T. V. HERSHBERGER
Agricultural Experiment Station, University Park, Pennsylvania

References and Notes

1. W. Klauditz and M. Becker, *Holzforschung* **6**, 103 (1952); *Chem. Abstr.* **47**, abstr. 8927f (1953).
2. N. D. Prianishnikov and M. F. Tomme, *Biedermanns Zentr. B. Tierernähr.* **8**, 104 (1936).
3. J. T. Sullivan, *J. Animal Sci.*, in press.
4. T. V. Hershberger, T. A. Long, E. W. Hartsook, R. W. Swift, *ibid.* **18**, 770 (1959).
5. This report is contribution No. 173 of the U.S. Regional Pasture Research Laboratory, Crops Research Division, U.S. Agricultural Research Service, in cooperation with the 12 northeastern states and authorized for publication 10 July 1959, as paper No. 2385, Journal Series, Pennsylvania Agricultural Experiment Station.

15 July 1959

Sodium- and Potassium-Sensitive Glass Electrodes for Biological Use

Abstract. Continuous, accurate recording in circulating fluids from a sodium and a potassium electrode is described. The Na electrode is capable of discriminating $\triangle[Na^+]$ of less than 1 meq/lit. in 140 meq/lit., and the K electrode is capable of discriminating $\triangle[K^+]$ of less than 1 meq/lit. in the range of 1 to 10 meq/lit. with good reproducibility. The electrodes may be used singly or in pairs with a common reference calomel electrode for simultaneous monitoring of $\triangle[Na^+]$ and $\triangle[K^+]$ in mixed solutions. Problems of streaming potential dependent on flow rate and electrode shape, as well as transient K^+ response by the Na electrode, are discussed.

Eisenman, Rudin, and Casby have elegantly demonstrated that the ternary glass system, Na_2O-Al_2O_3-SiO_2, may be systematically varied to produce electrodes with high selective affinity for individual cations (*1*). They reported that NAS_{11-18} glass (Na_2O, 11 moles percent; Al_2O_3, 18 moles percent; SiO_2, 71 moles percent) was a particularly effective Na electrode and that effective K electrodes might also be prepared. Since then, working in cooperation with Eisenman *et al.*, we have been able to adapt NAS_{11-18} glass for practical use in biological systems by using metal-connected electrodes to overcome problems inherent in the nature of the glass (*2*). The present report (*3*) is concerned with the limits of precision of the Na electrode operating alone or paired in a two-electrode system with a K-selective electrode.

Tests of precision and reproducibility were carried out with a continuous flow system at constant rate. The electrode was mounted in a shielded cage, and the inflow and outflow tubes were interrupted by an air gap to reduce stray electrical interference. In such a system, solutions flowing past the electrode membrane can be changed only gradually and, theoretically, never completely. Pockets of solution in the line may also produce erratic mixing. The reproducibility of potentials is, nevertheless, limited only by the drift rate of the electrometer which, for short intervals, is negligible (Fig. 1*A*). Precision is limited mainly by the accuracy of the standards and the ± 20 μv noise level of the Cary electrometer (equivalent to less than 0.2 meq/lit. on a base of 140). Recovery of Na added to plasma can be equally good.

As in the case of the H^+ electrode the streaming potential of the Na^+ electrode is affected by flow rate, particularly in unbuffered solutions. The response is a function peculiar to each electrode but, in general, for electrodes with a capacity of less than 1 ml, the response decreases as flow increases and becomes unimportant above approximately 35 ml/min. The curvature of the glass membrane is unimportant in inducing the effect, since potentials picked off 3-mm disks at various parts of an eccentric electrode did not differ. On the other hand, shape is important, as was determined in studies in which several shapes, from spherical to constricted tubes, were used. The effect of shape is shown in Fig. 1*B* (upper traces) which compares the fusiform electrode previously described (*2*) with a parallel-sided, simple tube constricted from 3 to approximately 1.5 mm diameter in the membrane area. In part, the observed reduction in streaming potential depends, of course, on volume. In part, however, it must also depend on the type of flow it produces or favors (for example, turbulent, laminar) since electrodes which are parallel-sided throughout and not constricted at the thinned-out membrane area seem to give even less response to varying flow than constricted tubes. Such electrodes are a trial to the glass blower but are much to be preferred.

Response time depends on the flow rate used during the change of solution. At a flow rate of 10 ml/min, the electrode responds fully in less than 10 seconds (Fig. 1*B*, lower trace). This time probably reflects the time taken to change the solution, and full change-over in such a flowing system is exponential in time. More detailed analyses of the electrode time constant are being undertaken with dip-type electrodes.

Two electrodes may be operated simultaneously, with two electrometers, one grounded and one isolated from ground. Both electrodes are placed in line with a single reference calomel electrode between them. The feasibility of this arrangement depends on the type of electrometer used. With Cary electrometers there is some beating due to asynchrony between the two vibrating reeds; this might be avoided by using a single reed driving a second slave reed. The beat is not objectionable, however, at amplifications of 100 mv or more, such as used in this work. Two Na electrodes can thus be used together to study, for example, arteriovenous differences. It is also possible to measure separately both the Na^+ and K^+ activities of an unknown mixture with the highly selective NAS_{11-18} electrode in conjunction with a K-preferring electrode, as predicted (*1*). Typical results are shown in Fig. 1*C* using the Na electrode together with a stable K glass prepared by us from an initial composition of Na_2CO_3 (45 moles percent), Al_2O_3 (4.5 moles percent), SiO_2 (47.3 moles percent), and CaO (3.2 moles percent). With a good

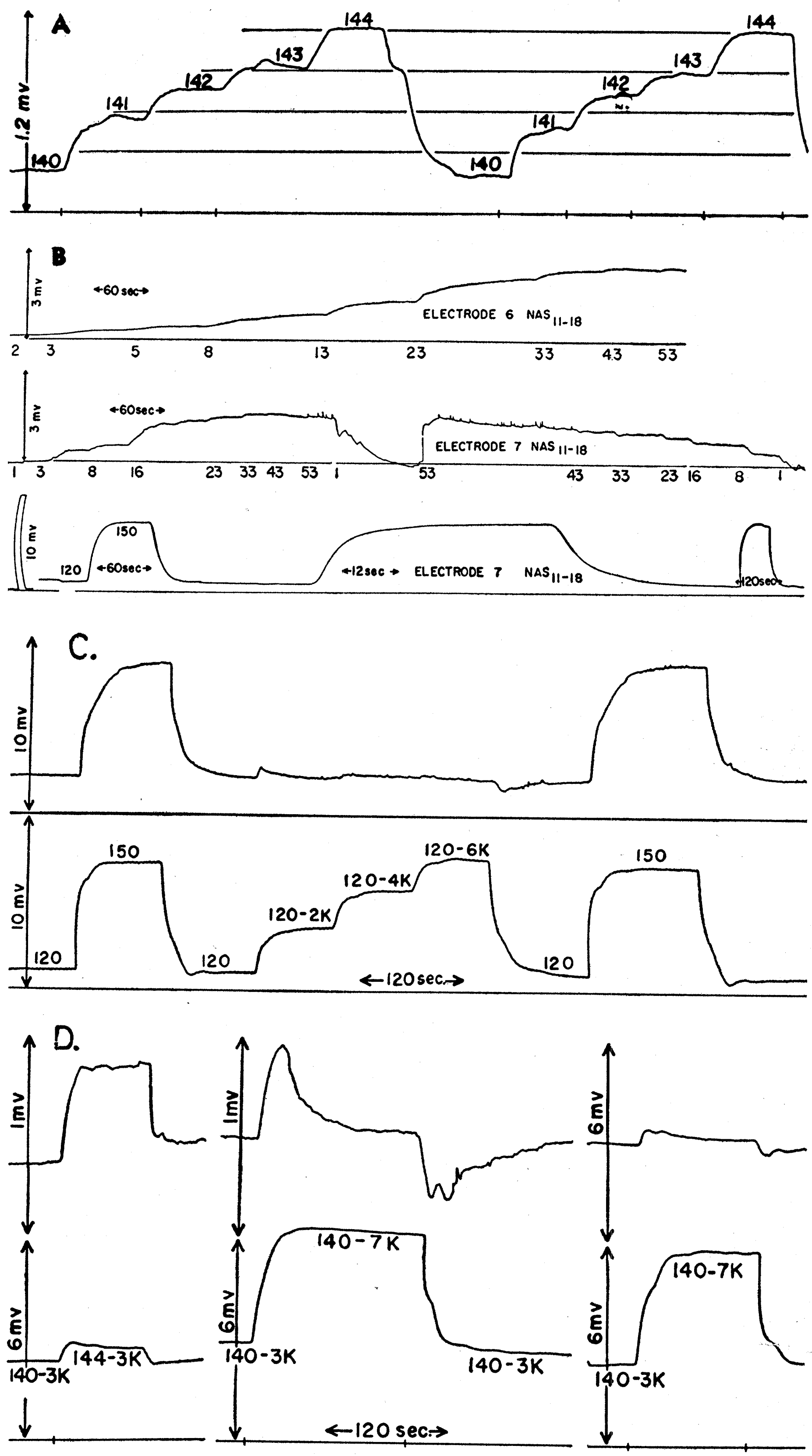

Fig. 1. (*A*) Response of an NAS_{11-18} electrode to changes in [Na^+] between 140 and 144 meq/lit. (*B*) Changes in flow rate between 1 and 53 ml/min and electrode potential in pure NaCl with musiform electrode (top trace) or parallel-sided, constricted electrode (middle trace). Response time to changes in concentration (120 to 150 meq of NaCl per liter) at a flow rate of 10 ml/min (lower trace). (*C*) Simultaneous responses of Na electrode (upper trace) and K electrode (lower trace) to changes in [Na^+] (120 to 150 meq/lit.) and [K^+] (0 to 6 meq/lit.). (*D*) Simultaneous responses of Na electrode (upper trace) and K electrode (lower trace) to small changes in [Na^+] (140 to 144 meq/lit.) and [K^+] (3 to 7 meq/lit.) at selective amplification. Note the transient potential developed by the Na electrode on changing [K^+] (middle pair).

K electrode in the pair, changes in Na^+ and K^+, as distinct from absolute values, can be monitored directly and continuously in biological fluids by taking advantage of their differing concentration ranges. Thus, for example, in the presence of a sodium concentration of 140 meq/lit., changes in potassium concentration between 1 and 10 meq/lit. can be accurately read with our electrode at a 6-mv full-scale amplification without change in the Na electrode equilibrium potential. Conversely, the K electrode responds only to large changes in Na at this amplification and background.

While it is true that a highly selective Na electrode is not affected by low K^+ activity, this statement should be modified by adding "at equilibrium." There is, in fact, a transient response to K^+ which may be as great as an equivalent Na^+ change, followed by a return to the basal electrode equilibrium potential in less than 1 minute (Fig. 1*D*). The response may be positive on addition of K^+ or negative on withdrawal. This transient cation potential, which has not previously been noted, is of considerable theoretical interest but should not be difficult to deal with in ordinary biological work.

SYDNEY M. FRIEDMAN
JAMES D. JAMIESON
MIYOSHI NAKASHIMA
CONSTANCE L. FRIEDMAN
Department of Anatomy, University of British Columbia, Vancouver, Canada

References and Notes

1. G. Eisenman, D. O. Rudin, J. U. Casby, *Science* **126**, 831 (1957).
2. S. M. Friedman, J. D. Jamieson, J. A. M. Hinke, C. L. Friedman, *Proc. Soc. Exptl. Biol. Med.* **99**, 727 (1958).
3. This work was supported by a grant from the Muscular Dystrophy Association of Canada.

15 July 1959

Bregmatic Bones in North American Lynx

Abstract. Anomalous bregmatic fontanelle bones were present in 279 of 1790 skulls of *Lynx rufus* examined, but with no apparent correlation with age, sex, or place of origin of the specimens. Examination of 472 skulls of *Lynx canadensis* disclosed only one possessing bregmatic bones.

Among the anomalous bones found in the mammalian skull is the fontanelle bone occurring in the bregmatic or anterior fontanelle at the junction of the coronal and sagittal sutures. In the 16th century this bone was noted in the human skull by Paracelsus, who named it the "ossiculum anti-epilepticum" from its supposed value as a cure for epilepsy. The presence of this bregmatic bone in various mammals was reported by Schultz (*1*), who found it quite common in some forms—for example, *Castor, Erethizon, Erinaceus,* and *Procyon cancrivorus.* However, among felids, Schultz found it in none of 62 specimens examined; he reported it as present in only one of 49 felids examined earlier by von Jhering.

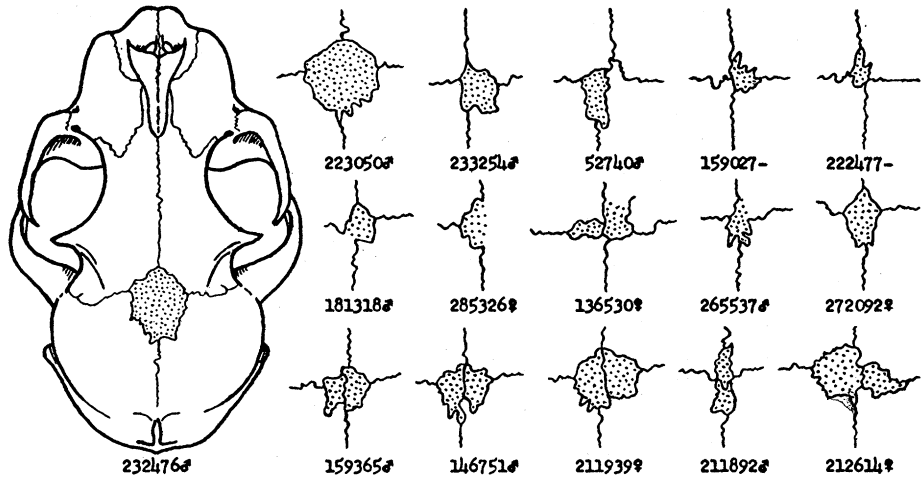

Fig. 1. Types of bregmatic bones observed in North American *Lynx* (No. 212614, *L. canadensis;* all others, *L. rufus*). All are similarly oriented and drawn to the same scale (about × ½).

In the course of examining a series of skulls of bobcats, *Lynx rufus,* from Oregon, bregmatic bones were found with surprising regularity—in 16.8 percent of 220 specimens. A further examination of all 1790 bobcat skulls in the U.S. National Museum (Biological Survey) collection disclosed bregmatic bones present as follows: in 141 of 957 adult males, in 116 of 653 adult females, in 17 of 155 adults of unknown sex, in 1 of 13 juvenile males, and in 4 of 12 juvenile females. Thus, bregmatic bones were present in 279 (15.5 percent) of the 1790 specimens examined. There was some geographic variation: the bone was present in 37.5 percent of 32 specimens from West Virginia and in 44.0 percent of 9 specimens from Mississippi, but in only 7.0 percent of 158 specimens from Texas and 14.6 percent of 123 specimens from Nevada. The bone was present in the southernmost of all specimens, a juvenile female from Amecameca, México, Mexico, but it was absent in all 11 specimens from British Columbia, New Brunswick, and Nova Scotia, as well as in 5 specimens from Alabama, 25 from Georgia, and 14 from South Dakota. It is probable that, as stated by Schultz, "it is never justifiable to ascribe any phylogenetic or atavistic significance" to these bones. They are present or absent with no regard to the age, sex, or geographic origin of the specimen.

These accessory, sutural bones, which form only in occasional cases, develop from one or more ossification centers in the membrane which closes the anterior fontanelle in fetal life. In the bobcat, they may be large or small in size, central or lateral in position, single or multiple in number, and they are almost always asymmetrical in shape. With advancing age, they coalesce with the frontal or parietal bones, and their original outlines may become obscured; this closure is only partially complete in many specimens. The variety of these bones is indicated in Fig. 1. In some forms (for example, *Homo*) it has been stated (*1, 2*) that they occur chiefly in males; this certainly is not the case in *Lynx rufus.*

Hall and Kelson (*3*), in their figures of skulls, indicate that this bone is present in *Lynx rufus* and absent in *L. canadensis.* In 472 specimens of the Canada lynx in the national collections, ranging from Alaska to Colorado and from Newfoundland to Oregon, readily identifiable bregmatic bones were present in only one specimen—an adult female (No. 212614) collected in 1916 in the Hoole Canyon of the Pelly River, Yukon Territory, Canada.

RICHARD H. MANVILLE
U.S. Fish and Wildlife Service, Washington, D.C.

References

1. A. H. Schultz, *J. Mammalogy* **4**, 65 (1923).
2. W. Gruber, *Arch. pathol. Anat. u. Physiol. Virchow's* **63**, 92 (1875).
3. E. R. Hall and K. R. Kelson, *The Mammals of North America* (Ronald, New York, 1959), vol. 2, pp. 967, 969.

16 July 1959