15) *Odontodactylus* Bigelow, 1893 (Class Crustacea, Order Stomatopoda), (pp. 86–87) (File 475).
16) All names for ''Petrificata'' in Vol. 3 of Linnaeus, 1768, *Systema Naturae* (ed. 12) and in corresponding portions of the following later editions of the above work: (*a*) Gmelin (J. F.), 1793, *Syst. Nat.* (ed. 13) Vol. 3; (*b*) Houttuyn (M.), 1785, *Natuurlyke Historie,* Vol. 3; (*c*) Turton (W.), 1806, *Gen. Syst. Nature,* Vol. 7 (p. 66) (File 418).
17) *Conchidium* Oehlert, 1887, and *Pentamerus* Sowerby (J.) 1813 (Class Brachiopoda), (pp. 89–96) (File 286).

(4) *Applications in Part 4*

18) *Ligia* Weber, 1795, *Ligia* Fabricius, 1798, and *Carcinus* Leach, 1814 (Class Crustacea, Order Decapoda), (pp. 99–102) (File 209).
19) *Capsus* Fabricius, 1803 (Class Insecta, Order Hemiptera), (pp. 103–104) (File 211).
20) The trivial names *quadratus* Fabricius, 1787, and *albicans* Bosc, 1801–1802, as alternative trivial names for the Sand Crab (Class Crustacea, Order Decapoda) (p. 105) (File 271).
21) *Tettigonia* and *Acrida*: proposed validation as from Linnaeus, 1758 (application submitted under *Opinion* 124), (pp. 106–118) (File 328).

2. The present notice is given in pursuance of decisions taken, on the recommendation of the International Commission on Zoological Nomenclature, by the Thirteenth International Congress of Zoology, Paris, July 1948 (*Bull. Zool. Nomenclature,* **4**, 51–56, 57–59 [1950]; *ibid.*, **5**, 5–13, 131).

3. Any specialist who may desire to comment on any of the foregoing applications is invited to do so in writing to the Secretary to the International Commission, 28 Park Village East, Regent's Park, London, N. W. 1, Eng., as soon as possible. Every such comment should be clearly marked with the commission's file number as given here.

4. If received in sufficient time before the commencement by the International Commission of voting on the applications in question, comments received in response to the present notice will be published in the *Bulletin of Zoological Nomenclature*; applications received too late to be so published will be brought to the attention of the International Commission at the time of the commencement of voting on the application in question.

5. Under the decision by the International Congress of Zoology specified in paragraph 2 above, the period within which comments on the applications covered by the present notice are receivable is a period of 6 calendar months calculated from the date of publication of the relevant part of the *Bulletin of Zoological Nomenclature.* The four parts now in question were published on April 20, 1951. In consequence, any comments on the applications published in those parts should reach the Secretariat of the International Commission at latest by October 20, 1951.

FRANCIS HEMMING
Secretary to the International Commission
on Zoological Nomenclature

Protochemical Cells

ELECTROCHEMICAL cells derive their energy in large part from oxidation-reduction reactions—that is, from electron exchanges. If, however, an oxidizing and a reducing substance are directly mixed, the resulting electron exchange yields no available electrical work. In order to obtain such work from these chemical reactions, it is necessary to separate spatially the site at which oxidation takes place, the anode, from the site at which reduction is occurring, the cathode, and also to provide means for electron transport at these sites by metallic conduction.

In living cells metabolic processes involving oxidation-reduction occur, but these cannot be immediate energy precursors for bioelectric phenomena because metallic conductors are not available for the required electron transport.

Can electrical work arise from proton exchanges in a manner analogous to electron exchanges? That is, can it arise from acid base rather than oxidation-reduction reactions? Electrical work should appear if the sites at which protons are released and at which they are accepted are separated, and if protonic conductors exist.

The conductance of water, hydrogen ions (H_3O^+), and hydroxyl ions (OH^-) is due largely to proton jumps, similar to the electron jumps that account for metallic conduction. The glass "electrode" provides a familiar example of a proton exchange site which affects the electrical potential of the cell of which it forms a part. It is well known that a glass membrane does not function as a hydrogen ion electrode until it is properly aged in water. The proton reaction at the glass-solution interface may be written as

$$H_2O + H^+ = H_3O^+$$

or

$$OH^- + H^+ = H_2O.$$

These reactions are evidently analogous to the iodine-iodide electrode process,

$$I + \varepsilon^- = I\varepsilon^-,$$

for example, which takes place on the surface of an inert electron conductor such as platinum. The platinum serves to bring in or take out electrons, and the glass performs a similar function with protons.

Let us consider an isothermal electrochemical cell (A), consisting of a (platinum) hydrogen electrode, a solution containing hydrogen ions and chloride ions, and a silver-silver chloride electrode:

$$(A)\qquad \begin{array}{ccccc} \text{(Pt) } H_2 & | & \text{solution} & | & AgCl, Ag \\ \text{(electrode)} & | & H_3O^+, Cl^-, \text{etc.} & | & \text{(electrode)} \\ & (a) & & (b) & \end{array}$$

At the surface (a) the reaction is

$$\tfrac{1}{2}H_2 + H_2O = H_3O^+ + \varepsilon^-$$

and at (b)

$$Ag^+Cl^- + \varepsilon^- = Ag^+\varepsilon^- + Cl^-.$$

The total potential of this cell depends on (a) the pressure of the hydrogen gas and the activity of the water and of the hydrogen ion constituent; (b) the

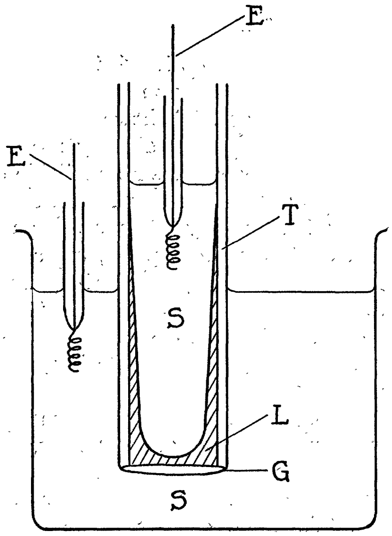

FIG. 1.

activity of the chloride ion constituent (silver chloride and silver, $Ag^{+}\varepsilon^{-}$, have constant activity since both are present in solid phase); and (*c*) the relative fugacities of the electrons (ε^{-}) from the platinum and from the silver.

A cell (*B*), involving proton rather than electron exchange, that I have studied, which is analogous to this electrochemical one, is the following:

$$\begin{array}{l|c|c} \text{Glass ``electrode''} & \text{Solution} & \text{Lauric acid (HL)} \\ (B) & H_3O^+,\ Ba^{++},\ Cl^- & \text{Barium laurate } (BaL_2) \\ \multicolumn{1}{r}{(a)} & \multicolumn{1}{r}{(b)} & \end{array}$$

At the surface (*a*) the reaction is

$$H_3O^+ = H_2O + H^+,$$

and at (*b*)

$$Ba^{++}L_2^{=} + 2H^+ = 2H^+L^- + Ba^{++}.$$

Here the total potential of the cell depends on (*a*) the activity of the water and of the hydrogen ion; (*b*) the activity of the barium ion (BaL_2 and HL, being relatively insoluble, are present in the solid phase so that their activities are constant); and (*c*) the relative fugacities of the protons (H^+) from the glass membrane and from lauric acid.

In the electrochemical cell (*A*), the metals at (*a*) and (*b*), where electron exchanges take place, are called electrodes. It may be well to call the glass at (*a*) and the lauric acid at (*b*) where proton exchanges take place in cell (*B*) *protodes,* and to call this type of cell a *protochemical* cell.

Since existing electrical measuring instruments are metallic, it is necessary to couple a protochemical cell such as just described to a metallic system. In the experiments to be described, this was accomplished with the aid of silver-silver chloride electrodes. The complete cell is shown in Fig. 1 and consists of a glass tube (*T*), on one end of which is fused a thin membrane (*G*) of .015 Corning glass. The inner surface of this membrane is coated with lauric acid and barium laurate (*L*), which extends along the inner wall of the tube. The solutions (*S*) of the same composition were buffered and contained barium chloride. Two silver-silver chloride electrodes (*E*), one placed in the beaker and the other within the tube, complete the cell:

$$\begin{array}{c|c|c|c|c|c} \text{Ag, AgCl} & \begin{matrix}\text{Solution}\\(S)\end{matrix} & \begin{matrix}.015\\\text{Glass}\end{matrix} & \begin{matrix}\text{HL}\\BaL_2\end{matrix} & \begin{matrix}\text{Solution}\\(S)\end{matrix} & \text{AgCl, Ag.} \\ \multicolumn{2}{r}{(a)} & \multicolumn{1}{r}{(c)} & \multicolumn{1}{r}{(b)} & & \end{array}$$

This is equivalent to cell (*B*), since the silver-silver chloride electrodes are both bathed by solutions of the same composition and therefore do not contribute to the cell potential.

The solutions used covered a concentration range between 1 and .005 molal in barium and a range of pH between about 1 and 8. If the mechanism described for (*B*) is correct, the potential of this protochemical cell should vary linearly, at constant pH, with the logarithm of the barium activity, log $m\gamma$, in which γ is the mean ionic activity coefficient at the barium concentration m. Results of one series of measurements at pH 4.66 are shown in Fig. 2 and indicate that such is actually the case. The straight line through the observed points has been drawn with the theoretical slope of $.0295 = \dfrac{2.3RT}{2F}$, two protons being involved in the protochemical reaction involving barium at surface (*b*).

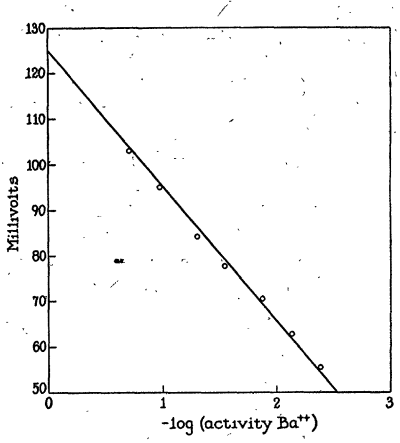

FIG. 2.

Similar results have been found at other values of pH, from 1 to 8, but with the theoretically expected change in the scale of ordinates due to the proton reaction at (*a*). We are evidently dealing here with a barium protode at (*b*) and the familiar hydrogen protode at (*a*). Preliminary measurements on a corresponding cell with calcium instead of barium also indicate calcium protode behavior.

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