

# The Symbol for $pH$

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## Question

What is the origin of the symbol  $pH$ ?

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## Answer

The  $pH$  concept was introduced by the Danish biochemist, Søren Peter Lauritz Sørensen (figure 1), in 1909 (1). Sørensen was investigating the use of a normal hydrogen electrode,  $H^+/Pt/H_2$  to measure the acidity of solutions. If the pressure of the  $H_2$  is fixed at 1 atmosphere, the potential of this electrode is given by the equation:

$$E = 2.3(RT/F)\log(1/[H^+]) = 0.0577\log(1/[H^+]) \quad [1]$$

thus making the potential of the overall cell proportional to  $-\log[H^+]$ . Consequently Sørensen found that it was convenient to use this term as an indirect measure of acidity in his work, the more so since most of the  $H^+$  concentrations he was working with were much smaller than 1 and could be written (1, 2):

*... in the form of a negative power of 10 ... [and] I will employ the name "hydrogen ion exponent" and the symbol  $p_{H^+}$  for the numerical value of the exponent of this power.*

In other words, Sørensen expressed his hydrogen ion concentrations in the form  $10^{-p}$  in which "p" represented the numerical *power* (English), *puissance* (French) or *potenz* (German) of the exponent. Variations on Sørensen's symbol soon appeared, including  $p_{H^+}$ ,  $P_h$  and  $pH$ , with the latter eventually gaining dominance, largely through its official adoption by the *Journal of Biological Chemistry* in the decade 1910-1919 (3).

Not everyone was pleased with Sørensen's proposal. W. Mansfield Clark, whose monograph, *The Determination of Hydrogen Ions*, was the major



Figure 1. Søren Peter Lauritz Sørensen (1868-1939).

American reference for Sørensen's work during the early decades of the 20th century, was certainly convinced of the importance of the  $H^+$  ion in biochemical phenomena, but was a good deal more ambivalent about the wisdom of using the  $pH$  concept to represent variations in its concentration (2):

*... both convenience and the nature of the physical facts invite us directly or indirectly to operate with some logarithmic function of  $[H^+]$ . It is unfortunate that a mode of expression so well adapted to the treatment of various relations should conflict with a mental habit.  $[H^+]$  represents the hydrogen ion concentration, the quantity usually thought of in conversation when we speak of increases or decreases in acidity.  $pH$  varies inversely as  $[H^+]$ . This is confusing.*

Nevertheless, Clark felt that he had to bow to the trends in the chemical literature, which showed a rapid increase in the use of the concept between 1910 and the appearance of the third the edition of his book in 1928. But even in his acquiescence he could not resist making the somewhat sarcastic observation that (2):

*Like the Greeks who personified the virtues, we, having embodied the acidic and basic properties, have lifted to our Olympus the hydrogen and hydroxyl ions ...*

#### Literature Cited

1. S. Sørensen, "Enzymstudien II: Über die Messung und die Bedeutung der Wasserstoffionenkonzentration bei enzymatischen Prozessen," *Biochem. Zeit.*, **1909**, *21*, 131-200. See especially p. 134.
2. W. M. Clark, *The Determination of Hydrogen Ions*, 3rd ed., Williams and Wilkins: Baltimore, MD, 1928, pp. x, 36, 38. In this source Clark gives a slightly different variation of the above quote, based on a French version of the paper published by Sørensen's Carlsberg laboratory.
3. W. M. Clark, *The Determination of Hydrogen Ions*, Williams and Wilkins: Baltimore, MD, 1920, footnote, p. 26.

*Do you have a question about the historical origins of a symbol, name, concept or experimental procedure used in your teaching? Address them to Dr. William B.*

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#### 2009 Update

Since publishing this column I have been made aware of a debunking literature which rather vociferously claims that Sørensen's choice of the letter *p* in *pH* was totally arbitrary. One of the bizarre arguments used to support this contention is that Sørensen wrote in German and French so *p* could not have stood for power. But of course the corresponding German and French words *potenz* and *puissance*, which Sørensen did use, also begin with *p* and this debunking claim is hard to reconcile with various explicit statements in Sørensen's original papers, such as the following on page 134 of reference 1 above:

*The magnitude of the hydrogen ion concentration will accordingly be represented by means of the normality factor with regard to the hydrogen ion, and this factor will be written in the form of a negative potenz (power) of 10. Since I refer to the above in a later section (see page 159), here I will mention only that I employ the name "hydrogen ion exponent" and the symbol pH for the numerical value of this potenz (power).*