Reports

Celsius versus Centigrade: The Nomenclature of the Temperature Scale of Science

Abstract. The temperature scale used by scientists in America has been called centigrade, while in many countries it was called Celsius for its inventor. In 1948 the 9th General Conference on Weights and Measures, representing 33 nations that subscribed to the Treaty of the Meter, adopted the name Celsius. This name, however, did not come into general use by scientists in America, partly because they were unaware of the official action of the conference and partly because some preferred the old name. At the 11th General Conference in 1960 the scale was defined in a way that makes the adjective centigrade inexact. The name Celsius is correct and its use by American scientists would help make the nomenclature of temperature uniform in all countries.

A three-paragraph note with the same title as that of this report appeared in the *Technical News Bulletin* of the National Bureau of Standards in September 1949. Its first paragraph states: "The Ninth General Conference on Weights and Measures, held in October 1948, adopted the name 'Celsius' for the scale of temperature that has more commonly been called 'Centigrade'. This action, which had not been proposed in advance of the Conference, arose from a question regarding preferred usage in French, the sole official language of the Conference. The decision therefore may be considered as applying strictly only to that language. In the interest of eventual uniformity of practice the use of Celsius appears desirable, but it is not practicable to impose this term on those who prefer Centigrade."

In the interval since this note was written, some circumstances have altered the viewpoint expressed in its last sentence (see below). Let us examine the background of this quotation in more detail to understand its significance.

Anders Celsius, a Swedish astronomer, is credited with having invented a thermometer, in 1742, whose scale had 100 degrees between the ice and steam points. The scale was known as the Celsius scale in Scandinavia, Russia, Japan, the Netherlands, and German-speaking countries. It was known in southern Europe and by scientists in English-speaking countries as the centigrade scale. Centigrade is defined in Webster's dictionary as: "Consisting of a hundred degrees: graduated into a hundred divisions or equal parts." The question regarding preferred usage in French arose because the French have a decimal system of angular measure in which the quadrant of a circle (90°) is divided into a hundred units called *grades*. To avoid the confusion resulting from using the same word both for degrees of temperature and degrees of angle, the French, in October 1948, were proffering the word *centésimale* for temperature. (The corresponding English word, centesimal, has essentially the same definition as centigrade.)

At its meeting in May 1948, the Advisory Committee on Thermometry agreed upon the text of a revision of the International Temperature Scale. During the meeting the word *centigrade* was used, and at no time was *centésimale* proposed. Some weeks later the Procès-Verbaux of this meeting were printed, including the text of the revision. In the printed text, however, *centigrade* had been changed to *centésimale* in five of the six places where the word *centigrade* had been used. Presumably the sixth one had been overlooked in this document. This document was proposed to the International Committee on Weights and Measures, meeting in October, and the International Committee recommended it to the 9th General Conference on Weights and Measures which followed.

At the conference itself one of the Belgian delegates asked whether the International Committee had decided to abandon the word *centigrade* for *centésimale*, or whether both words could be used interchangeably. He himself preferred a single word. In reply it was stated that the word *centigrade* leads to confusion; however, the International Committee had not deliberated on it. One of the Italian delegates, who was also a member of the International Committee, then proposed the adoption of the name *Celsius*. At this point the matter was referred back to the International Committee for its recommendation. At a brief session, just before the next and final session of the General Conference, the International Committee agreed to accept the name Celsius. The General Conference then voted to adopt it.

The General Conference on Weights and Measures is the official international body representing the nations that subscribe to the Treaty of the Meter (now 36 nations). Definitions and resolutions adopted at the General Conferences are intended to promote more uniform and accurate practices throughout the scientific world. The impromptu proposal and subsequent adoption of the name Celsius, therefore, had the merit that it would not only avoid the confusion in French but would also promote greater uniformity in the nomenclature of temperature. Another merit in the choice of the name Celsius for the temperature scale was mentioned in the third paragraph of the original note. This was that other scales are designated by the first letter of the inventor's name: F for Fahrenheit, R for Reaumur, K for Kelvin, and R for Rankine. It is more logical and consistent to consider that capital C designates the name of Celsius, who invented the scale, than that it designates the adjective centigrade, which describes the scale.

The word centigrade continues to be used by American scientists more gen-

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Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to contributors" [*Science* **125**, 16 (1957)].

erally than Celsius, in spite of the action of the General Conference in 1948. One reason for this is doubtless that they are not aware of the action taken at the 9th General Conference on Weights and Measures. Another reason may be that the end of the quotation from the note appeared to justify the retention of the name centigrade. Habits are not easy to break. On the other hand, the first part of the last sentence: "In the interest of eventual uniformity of practice the use of Celsius appears desirable," has prompted at least two American textbook writers to use Celsius.

Since 1948, two more actions have taken place at General Conferences that make the change to Celsius even more desirable than it was then. The first of these was in 1954 when the 10th General Conference on Weights and Measures redefined the Kelvin thermodynamic scale by assigning a value to the triple point of water. This redefinition takes the place of the old definition wherein the fundamental interval, between the ice and the steam points, was exactly 100 degrees. In 1854, when Kelvin proposed this thermodynamic scale, he said that it was convenient to define the scale by assigning 100 degrees to the fundamental interval in order to retain a connection with thermometry at that time. He said, however, that assigning a value to some definite temperature was the preferable way, and that this "must be adopted ultimately." The old definition of the Kelvin scale had made it strictly "centigrade" because the fundamental interval of that scale "consisted of a hundred degrees." The redefined Kelvin scale is not a centigrade scale because it has only one defined fixed point, which is the triple point of water at 273.16°K. (The zero of the scale is understood to be at the absolute zero of temperature.) The steam point, therefore, is no longer exactly 100 degrees above the ice point by definition, but whether it is more or less than 100 is not yet certain.

The other action came in 1960 when the 11th General Conference on Weights and Measures adopted the "International Practical Temperature Scale of 1948, Text Revision of 1960." All values of temperature on this scale were kept the same as in the 1948 definition within the experimental error of measurement. This scale, therefore, is not a revision of the scale of 1948 but merely a revision of the text. One of the changes in the text revision was in the list of defining fixed points of the scale where the ice point was replaced by the triple point of water with the value 0.01°C. One reason this was done is that the triple point of water is more reproducible than the ice point. Another reason is that it gives the International Practical Temperature Scale of 1948 one defining fixed point in common with the redefined Kelvin thermodynamic scale. The interval between two of the defining fixed points of the scale, triple point to steam point, is thus 99.99 degrees and not 100 degrees. By this definition, therefore, the international scale also has ceased to be a "centigrade" scale.

By these actions at the 10th and 11th General Conferences the concept of exactly 100 degrees for the fundamental interval has been abandoned as basic to either the thermodynamic or the international scale. It was a useful concept in the evolution of the scales, but more precise ways are available now to define them. The adjective centigrade, therefore, has become illogical to describe either scale. The thermodynamic scale is still a Kelvin scale, because it is defined in the way Kelvin said "must be adopted ultimately." The international scale is not strictly centigrade any more, but the name Celsius is as appropriate as ever.

Now the question is, what should be done? In those countries where centigrade was used, the replacement of Celsius is fortunate because the designation "C" remains the same. On many of its thermometer certificates since 1948, the National Bureau of Standards has used the name Celsius with the word centigrade added to parentheses, for example, 37 degrees Celsius (centigrade). This same practice has also been used in scientific papers, the parentheses being used following the first use of the name Celsius. This practice should be continued until the name Celsius, when used alone, is no longer unfamiliar. The editorial policy of the National Bureau of Standards is now to use the name Celsius in all of its scientific publications. If other journals and textbooks will also adopt the policy of using the name Celsius, much will be done to make the nomenclature of temperature uniform in all countries.

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Reversibility of the Reinforcement Relation

Abstract. Parameters were identified for the rat which both made drinking more probable than running and running more probable than drinking. In the same subjects, depending upon which parameters were used, running reinforced drinking and drinking reinforced running. This relationship suggests that a "reward" is simply any response that is independently more probable than another response.

Food or water are used customarily to reinforce the bar press or running, but it is not asked, Can this relation be reversed? Will the bar press or running reinforce eating or drinking? The traditional account of reinforcement does not generate this question, for it assumes categorical reinforcers, food and water being prime examples (*1*). Furthermore, the traditional account was not changed basically even by the finding that light and sound also reinforce (*2*). To incorporate these "new" reinforcers the reward category was simply enlarged, admitting unforeseen kinds of stimulation, and inferring additional drives and needs. The logic of the traditional account remains one that distinguishes between categories of positive and neutral events; only the events to which this logic is applied have changed.

We have proposed a model of positive reinforcement (*3*) whose major assumption is simply that, for any pair of responses, the independently more probable one will reinforce the less probable one. In this model the traditional vocabulary of drive, reward, and goal becomes either meaningless or misleading, for the model leads to the predictions that (i) the eating or drinking response is itself reinforcible (*4*) and, more important, (ii) the reinforcement relation is reversible.

Are there intervals of time in which eating or drinking are less probable than certain other responses, as well as other intervals in which the probabilities are reversed? Although the present model cannot make such predictions, but predicts only after the response probabilities are given, parameters were recently found in the rat that satisfy both conditions.

With free access to both food and an activity wheel, but access to water for only 1 hour per day, mean total drinking time for a group of six female rats was about 4 minutes, and mean total running time in the same period was only about 0.9 minute. With free ac-