The Calorie, the Joule

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ABSTRACT The joule is the unit for all forms of energy in *le Système international d'unités*, a coherent system founded on seven basic units of the metric system. In nutrition we consider energy manifested in three different ways, as heat, as static work, and as mechanical work; and we also must consider the potential energy of food. A calorie is the specific heat of water. Dissatisfaction with the use of this unit in calorimetry has been expressed among physical scientists. To be useful in kinetics, energy is expressed in terms of the joule. There is more reason to support the use of the joule as the unit of energy in nutrition. J. Nutr. *102:* 1553–1554, 1972.

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I would like to make some comments that have been prompted by the editorial paper by Dr. Max Kleiber (1) in a previous issue of this journal. In reply to a statement by Dr. S. R. Ames (2) that the joule is the unit of energy in the metric system, Dr. Kleiber justifiably said that the calorie is a valid unit in the metric system, being the unit of heat, therefore a unit of energy. If instead of "metric system" Dr. Ames had said "International System of Units," no argument could have been admitted. *Le Système international d'unités* (SI) is founded on seven basic units of the metric system (meter, kilogram, second, ampere, kelvin, candela, mole) in which all other metric units can be expressed. Some derived units have been retained in the SI for convenience, of which the newton ($1\ N = 1\ kg\ m\ s^{-2}$), the unit of force, and the joule ($1\ J = 1\ N\ m = 1\ kg\ m^2\ s^{-2}$), the unit of energy, are two. *La Conférence générale des poids et mesures* (3) in 1948 passed a resolution that the joule should be the unit for quantity of heat to correspond with the expression of other forms of energy. No argument could have been admitted to Dr. Ames's statement as it stands, therefore, if this recommendation had been universally followed, which, of course, it was not. It was at its meeting in 1960 that the conference (4) formally approved the SI (the mole was adopted later).

The metric system was established in France at the end of the 18th century to end the confusion that existed in methods and units of measurement. Its advantages, particularly for scientific work, were soon realized, and its use has extended both geographically and in magnitude with the growth of commerce and science. Just as a language changes when it is transported to a different part of the world, the metric system has been put to new uses and has had units grafted to it by almost every discipline that it serves. It has become the depository for many units, of which the calorie is one, that are used to express quantities that can be expressed in better defined and more applicable units. It is not as neat and orderly as it can and should be, and it is time that it was cleaned up. The SI shows a way of doing this. The SI is coherent, rational, and neat. It is the product of long and careful deliberation by experts in metrological science from many countries. It deserves more than passing notice.

A joule is the amount of work done when a force of 1 N produces a displacement of 1 m in the direction of the force. Dr. Thomas Moore (5) has pointed out that this kinetic entity is not a manifestation of static energy nor of heat, neither of which depends upon external motion. In this context it is ironical that the calorie does not describe the kinetic energy that the joule does but it is described in terms of the joule. One calorie is the specific heat of water, which varies with the temperature of the water. Why was this unit ever

adopted for biological work and potential biological work?

The calorie is not unreservedly respected among physical scientists, and dissatisfaction with it has been expressed in high places. One in a series of papers on calorimetry in Nature in 1895 was by Oliver Lodge (6) (he became Sir Oliver in 1902), who recommended adoption of the joule as the only fundamental unit of heat. James Clerk Maxwell was concerned with heat as a form of energy. In his *Theory of Heat* (7) he stated that any quantities in dynamics could be expressed in units derived from the three fundamental units of length, mass, and time; and that if quantities of heat were expressed in terms of length and mass, ambiguity and useless phraseology would be avoided.

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