# The Caloric Concept under a Frame-Theoretic Spotlight

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In this talk we conduct a frame-theoretic investigation of the respects in which the central concept of the caloric theory of heat has survived into modern accounts of thermodynamics despite the theory's demise in the latter half of the nineteenth century. We will first present a brief account of the development of the caloric theory as well as that of its competitor, the motion theory of heat. We will then compare the two theories' explanatory and predictive successes, paying particular attention to the role their central concepts played in facilitating those successes. The comparison will be performed to evaluate the epistemic and metaphysical claims made by traditional scientific realists and instrumentalists concerning whether or not (i) some parts of the caloric theory are in some sense approximately true and (ii) the term 'caloric' can be said to refer to a modern counterpart posit. We will test these claims against those stemming from our own structural realist conjecture. Ultimately, we hope this study of the caloric will give us a more complete picture of what happens to scientific concepts, classification systems and ontologies after a scientific revolution.

Although primitive versions of the two theories of heat go back to antiquity, it was not until the eighteenth century that the study of heat begun to flourish. Lavoisier developed the first sophisticated caloric theory of heat able to explain and predict phenomena. Caloric was conceived as special kind of substance responsible for heat phenomena. It was taken to be an imperceptible or at least hardly perceptible fluid that could only be measured indirectly via its intimate relation with temperature. More precisely, it was thought that the addition of caloric to a body raised its temperature, while its subtraction lowered it. At around the same time, a sophisticated version of the motion theory of heat was being developed. Heat, according to this theory, was simply a consequence of the motion of (ordinary matter) particles. Although both theories had their measure of success (and failure), it was the motion theory of heat that emerged victorious sometime in the latter half of the nineteenth century. Today the motion or 'kinetic theory' as it is better known lies at the heart of our best theory of thermal phenomena, i.e. statistical thermodynamics.

Is there some respect in which the caloric theory and its central concept survived into modern accounts of heat phenomena? Several answers have been proposed. Laudan (1977), for example, takes the caloric theory of heat to be a paradigmatic example of a genuinely successful theory that turned out to have no truth content and whose central theoretical term does not refer. Laudan suggests that this is a widespread phenomenon in the history of science and urges a pessimistic meta-induction: Since past explanatorily and predictively successful scientific theories have eventually been discarded, we have inductive evidence that our current theories will also be discarded one day. In reaction to the pessimistic meta-induction, traditional scientific realists attempt to show that only those theoretical components that are responsible for any success enjoyed by the rejected theories survive theory change. In other words, they attempt to show that the historical record provides grounds

for optimism. Most realists agree that certain parts of the caloric theory were indeed approximately true but they disagree on whether or not its central theoretical posit somehow refers to a modern day counterpart entity. For example, Psillos (1999) argues that the term caloric does not refer to anything because it was not genuinely central to the caloric theory's successes.

We plan to evaluate the claims made by Laudan and Psillos and compare them to our own structural realist conjecture. According to this conjecture there is a structural correspondence between certain parts of the caloric theory and statistical thermodynamics. This in effect means that certain aspects of the caloric theory survived theory change because they contain objective structural information about heat phenomena. To assist us in our task we will make use of a structural correspondence theorem found in Schurz (2009). Provided certain rather natural conditions are satisfied, the theorem establishes correspondence relations between the successes and truth-content of past theories and those of their successors. In so doing, the theorem also establishes an indirect reference relation between the relevant terms of successive theories. We conjecture that the relevant conditions are satisfied in the transition from the caloric theory to statistical thermodynamics and hence that a strong case can be made that some aspect of the caloric concept has survived theory change.

Frame theory is especially suited to reveal structural correspondence relations between scientific theories and hence to help us test the aforementioned conjectures. The main reason for this is that it explicates the central categories and concepts which underlie scientific theories in the form of recursive systems of attributes. In the case at hand, frame theory shall be used to model how those parts of the caloric theory that were responsible for its successes correspond to parts of statistical thermodynamics. Based on the chemical reaction frames developed in Schurz (2007) we will construct a frame for the description of thermodynamical reactions which is common to the caloric theory and the thermodynamic theory of heat, and which will hopefully throw some light on the extent to which the caloric concept corresponds to current concepts in statistical thermodynamics like kinetic energy. Drawing on Chen (2003) we will also study by frame-theoretic means the ontological transition from caloric as a substance concept to kinetic energy as a dynamical property concept. We hope that all of this will present clues as to how frame theory can be extended in order to accommodate the more dynamical aspects of scientific theory development.

**References:**


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