



Review

Urban metabolism and sustainability: Precedents, genesis and research perspectives

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ABSTRACT

Urban metabolism represents an area of study that is considered promising in interdisciplinary research of cities and sustainability. The term urban metabolism is a concept in which the city is analysed using the biological notion referring to the internal processes by which living organisms maintain a continuous exchange of matter and energy with their environment to enable operation, growth and reproduction. However, as a basis for understanding the deeper aspects of urban metabolism and its scope with regard to the analysis of cities in the context of sustainability, it is necessary to review the historical evolution of the concept and the theoretical foundations that structure it. This literature review discusses the origin and evolution of urban metabolism and its theoretical scope, including its relationship with the sustainability of cities in light of the technical-material paradigm proposed by urban ecology. Finally, the limitations of urban metabolism are analysed in relation to the concept of urban sustainability to address gaps and research needs in the metabolism of cities.

1. Introduction

Urban metabolism is a concept that evolved from the μεταβολικός (*metabolikós*) biological concept, which was coined in the nineteenth century by Theodor Schwann, and which has its historical origins in the economic theory of Karl Marx (Kennedy et al., 2011; Zhang, 2013). Urban metabolism refers to “the sum total of the technical and socio-economic processes that occur in cities, resulting in growth, production of energy, and elimination of waste” (Kennedy, 2007), that is, the operation of cities as metabolic bodies (Pengue, 2009).

Although its origin dates back to the nineteenth century, urban metabolism as a field of research required nearly a century of study before the academic community recognised its promising contributions in light of Abel Wolman’s approach to the concept (Holmes and Pincetl, 2012; Kennedy et al., 2011; Zhang, 2013). Today, urban metabolism is used for observing the natural and anthropic availability of resources and their use in attempts to preserve the current or future environment (Brunner and Rechberger, 2004). The importance of urban metabolism lies in its power to generate parameters in which experts can measure and assess the environmental impacts caused by cities (Kennedy et al., 2011). Urban metabolism thus enables the design of effective policies in urban planning, given that the relevant parameters satisfy the criteria of sustainability indicators in a manner that is scientifically valid, responsible, relevant for urban planners and residents, and based on data that are understandable, unambiguous, and comparable over time

(Kennedy et al., 2011; Pincetl et al., 2012).

Studies on urban metabolism have permeated direction, guidance and public opinion to achieve and ensure the sustainability of cities (Kennedy et al., 2011; Levine et al., 2008; Yang et al., 2014). Also they are conceived as a key for policy makers to develop plans that may positively influence the conservation of resources, the generation of waste, and the emissions of GHG. The decision support system for sustainable urban planning, developed within the framework of the BRIDGE project (sustainaBle uRban plannIng Decision support accountinG for urban mEtabolism) of the FP7, or indicators systems such as Eurostat are a good example of this type of applications (Chrysoulakis et al., 2013; Eurostat, 2001). Additionally, the study of urban metabolism is considered a fundamental dimension for projects that aim at urban sustainability in future cities by “which the city is re-inserted in nature and nature in the city” (Díaz Álvarez, 2014).

The theoretical basis of urban metabolism from its origin and evolution, as well as the limitations of the concept and current and future research prospects in this field of study are presented and developed in four sections of the text. The first explores the origin and evolution of urban metabolism, including the historical academic facts and the theoretical development of the concept. The second section addresses the theoretical considerations regarding metabolism in cities. This section focuses on explaining the form that urban metabolism concept takes today as well as the research limitations in the field.

The third section briefly addresses the issue of cities’ sustainability

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from the perspective of urban metabolism: it explains how urban metabolism is understood in the present and discusses the general aspects related to the limits of growth of cities and their importance in sustainability. Finally, the fourth section is a conclusion in terms of research perspectives of urban metabolism. This section presents the findings of the documentary research of this paper and presents guidelines for the most relevant aspects of the study of city metabolism.

2. Approach to the origin and evolution of urban metabolism concept

The first use of the term urban metabolism is attributed to Abel Wolman during the 1960s (Brunner and Rechberger, 2004; Garcia, 2013; Zhang, 2013) who defined it as “all the materials and commodities needed to sustain the city’s inhabitants at home, at work and at play” (Wolman, 1965). However, the first organismic metaphors of the city to consider human groups in relation to biological systems originated centuries ago (Sennett, 1996; Toledo, 2013). The first organic comparisons with the city were based on the medical advances of the seventeenth century, especially from the work on circulation and breathing developed by William Harvey and the studies developed for the nervous system by Thomas Willis and Albrecht von Haller (Fig. 1). All of them presented the interconnection and circulation of electrical impulses and blood as bases of health and the development of individual tissues. The paradigm shift in health generated by these new discoveries led to a new view of the body and the society based in flow, health and individuality (Sennett, 1996).

Parallel to the work of Harvey, Willis and von Haller in England, the Italian Santorio Santorio developed what would be the first investigation into the metabolism of humans. This work was published under the title *De Medicina Statica Aphorismi* (Fig. 1). In this work, Santorio Santorio presented the results of three decades of measurements of the mass ingested by a person in relation to its weight and the mass that is expelled as faeces and urine (Brunner and Rechberger, 2004; Levett and Agarwal, 1979). Santorio Santorio finally reached a similar conclusion to that of the English doctors, namely that health could not be estimated only under the static condition of the body (Brunner and

Rechberger, 2004). With advances in medicine in the seventeenth century, people began to have a new awareness of their bodies. This awareness was related to the fundamental role of personal hygiene and the use of lightweight materials in clothing to avoid clogging skin and the consequent arrest of the air flows toward the body and the secretion of toxic substances by perspiration (Sennett, 1996). It is not surprising, then, that urban planners incorporated these new findings into the design of the eighteenth century city with the objective that it “worked like a healthy body, flowing freely and enjoying a clean skin”. (The product of this comparison among the architects was a language based on the city-human body metaphor in which terms such as “vein” and “artery” are used to denote one-way roads and other expressions such as “urban heart” are used to differentiate the functional centre of the cities (Sennett, 1996).

The metaphor that emerged from the comparison between the city and the human body was not only presented as an analogy between the spatial configuration of urban systems and human anatomy, gradually functional and structural elements of the city were involved. One of the first to transcend this analogue nature of the metaphor was Adam Smith, an economist and Scottish philosopher who in the eighteenth century, following the discoveries of William Harvey, said that the labour market and goods work in a similar manner to blood circulation. According to Adam Smith, in terms of “good health” of the economy, the “movement of goods and money was more profitable than fixed and stable possession” (*metabolikós*) from the Greek expressions *μεταβολή* (*metábole*: change) and *ισμός* (*ismós*: process or state) to name these processes (Real Academia Española, 2014).

The emergence of the concept of metabolism reinforced the organic city-human body metaphor, giving an isomorphic character to what until the eighteenth century represented only an analogy between the spatial configuration of the city and how living beings operate. A couple of decades after the appearance of the neologism created by Schwann, Karl Marx spoke for the first time of social metabolism when he referred to the flows between the economic system and the natural world (Brunner and Rechberger, 2004; Martínez-Alier et al., 2010; Zhang, 2013) (Fig. 1). Marx’s social metabolism was mediated by the distinction between the use value and the exchange value of the goods, that is,

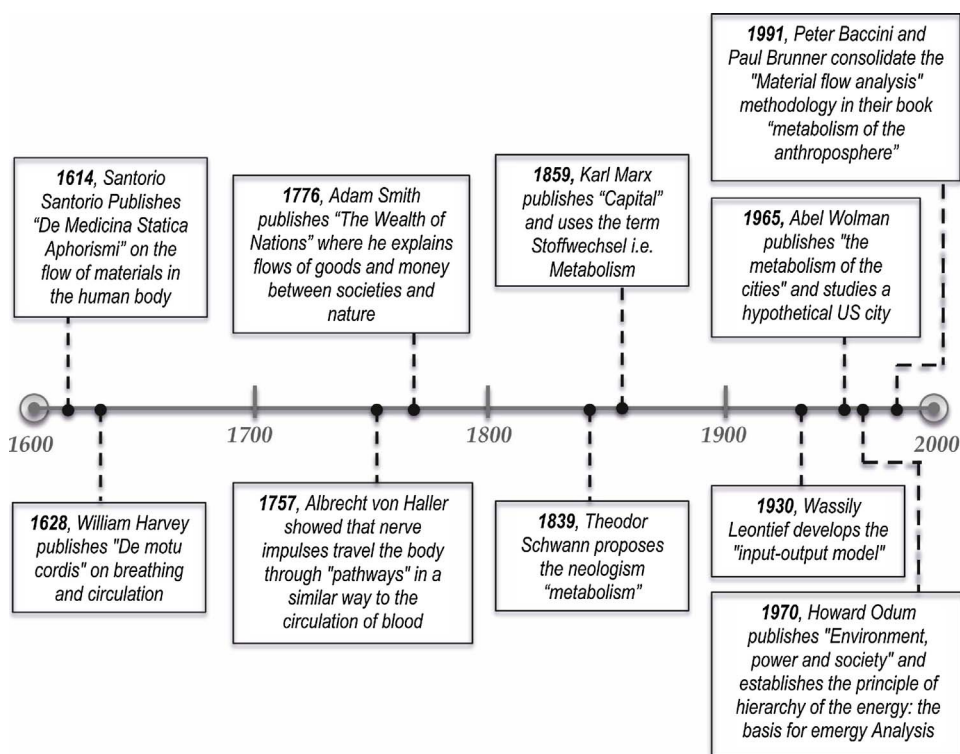


Fig. 1. Timeline of relevant events in the emergence of urban metabolism.

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