Scaling laws, evolutionary dynamics and imaging biomarkers in cancer: From the blackboard to the clinics and back

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Abstract

Many natural systems are complex systems composed of a large number of interacting elements. In spite of their complexity they often obey the so-called scaling laws that relate an observable quantity to a measure of the size of the system, such as its volume or mass [1]. I will describe data and facts supporting universal scaling laws in human cancers [2] and how they imply an increase of tumor aggressiveness with time that leads to an explosive growth as the disease progresses. The observations can be understood using different types of biologically-inspired mathematical models incorporating genetic evolutionary dynamics [2,3]. Most of the observed phenomena can be described using simplified models based on nonlocal partial differential equations. The mathematical approaches lead to the definition of different biomarkers of the disease aggressiveness that have been validated using cancers imaging data [4]. I will also discuss several open mathematical problems of relevance arising in the context of this research.
Finally, I will describe theoretically how non-genetic phenotypic variability may lead to selection processes that can lead to unexpected evolutionary dynamics with deep implications for tumor growth and treatment.

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