

Abstract

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Does Cancer “Think”? – Adaptive Behaviour in Tumour Evolution and Therapy Resistance

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ABSTRACT

Introduction: Cancer is traditionally defined as a genetic disease driven by mutation and uncontrolled proliferation. However, the tumours frequently exhibit adaptive behaviours such as therapy resistance, clonal selection, and recurrence that resemble decision-making processes. These observations suggest that tumour progression may be better understood within an evolutionary, systems-based framework that accounts for dynamic interactions between tumour cells and their microenvironment.

Methodology: A narrative literature review of 23 peer-reviewed studies published between 2008 and 2026 was conducted. Studies were selected based on relevance to tumour evolution, tumour heterogeneity, therapy-induced selection pressure, and resistance mechanisms. Evidence was drawn from experimental, computational, and clinical research. The included studies were thematically analysed to identify recurring adaptive patterns and synthesised into a conceptual framework describing tumour progression as an adaptive evolutionary system.

Results: Intra-tumour genetic and phenotypic heterogeneity was reported in 14 of 23 studies, supporting the presence of diverse subclonal populations capable of adaptation. Sixteen studies demonstrated that therapeutic interventions act as strong selective pressures, shaping clonal composition over time. Pre-existing resistant subclones were identified before treatment in 12 studies,

indicating that resistance is often selected rather than newly acquired. Convergent adaptive behaviours were observed in 10 studies across different cancer types or models, suggesting predictable evolutionary responses to similar selective pressures.

Conclusion: Although cancer cells lack cognition, evolutionary dynamics produce system-level behaviours that resemble decision-making. Conceptualising tumours as adaptive evolutionary systems provides a framework for improving combination and adaptive therapy strategies and for enhancing predictive modelling of treatment response and clinical outcomes.

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