

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

Dr. Ghamendra Kumar Sahu¹, Dr. Som Kumari², Neetoo³

¹ Department of Physics, Govt. Rani Avanti Bai Lodhi College, Ghumka, Dist. Rajnandgaon, Chhattisgarh, India (Corresponding Author). Email: ghamendraphysics8@gmail.com

² Department of Mathematics, Govt. Rani Avantibai Lodhi College, Ghumka, Rajnandgaon, Chhattisgarh, India

³ Assistant Professor, Physics, Govt. Naveen College, Kawardha, Chhattisgarh, India

Received: 20th Feb, 2026; Revised: 4th Mar, 2026; Accepted: 25th Mar, 2026; Available Online: 10th Apr, 2026

ABSTRACT

This research article investigates the mechanical and electrical properties of cancer cells and discusses their implications for targeted drug delivery systems. Cancer cells demonstrate distinct physical properties compared with normal healthy cells due to cytoskeletal remodeling, membrane alterations, and abnormal ion channel activity. Reduced stiffness, enhanced deformability, and altered electrical impedance characteristics are widely reported features of tumor cells. Advanced experimental techniques such as atomic force microscopy (AFM), microfluidic deformability assays, and electrical impedance spectroscopy enable detailed quantification of these biophysical signatures. Understanding these parameters can help improve cancer diagnostics and support the development of nanotechnology-based therapeutic systems capable of selectively targeting tumor tissues.

Keywords: Cancer cells, cell biomechanics, electrical impedance spectroscopy, deformability, nanomedicine, targeted drug delivery

How to cite this article: Sahu GK, Kumari S, Neetoo. Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery. *Int J Drug Deliv Technol.* 2026;16(26s): 18-39. DOI: 10.25258/ijddt.16.26s.2

Source of support: Nil.

Conflict of interest: None

1. Introduction

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

2. Literature Review

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

3. Biophysical Basis of Cancer Cell Mechanics

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

4. Cytoskeleton Remodeling and Mechanical Softening

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

5. Electrical Characteristics of Tumor Cells

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

6. Experimental Techniques

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

7. Atomic Force Microscopy Analysis

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

8. Microfluidic Deformability Studies

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

9. Electrical Impedance Spectroscopy

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

10. Results

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

11. Discussion

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

12. Applications in Nanomedicine

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

13. Targeted Drug Delivery Strategies

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

14. Future Research Directions

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

15. CONCLUSION

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that

can selectively interact with tumor tissues while minimizing damage to healthy cells.

Cancer cells display significant differences in physical behavior compared with normal cells. Mechanical softness allows tumor cells to migrate through narrow extracellular matrices and capillaries, facilitating metastasis. Electrical characteristics including membrane potential and impedance provide valuable information about cellular activity and structural composition. Recent interdisciplinary research combining physics, biology, and biomedical engineering has enabled the development of advanced diagnostic tools and therapeutic strategies based on these biophysical properties. Understanding these features is essential for designing targeted drug delivery platforms that can selectively interact with tumor tissues while minimizing damage to healthy cells.

FIGURES

Figure 1: AFM indentation response

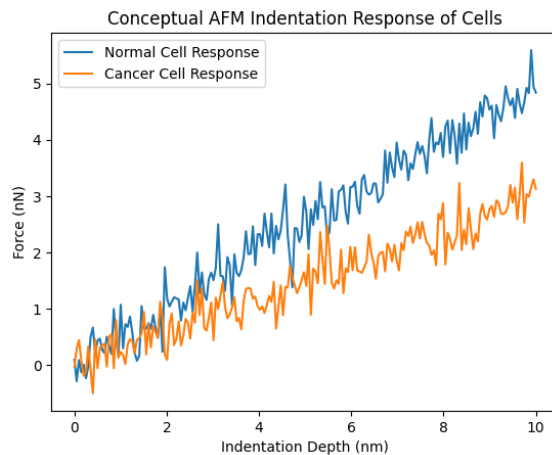
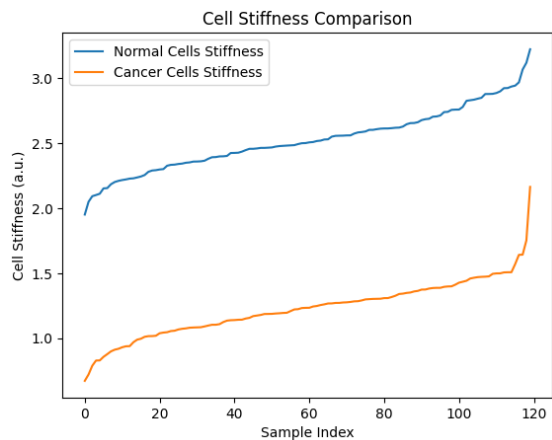


Figure 2: Stiffness comparison between normal and cancer cells



Mechanical and Electrical Properties of Cancer Cells and Their Implications for Targeted Drug Delivery

Figure 3: Electrical impedance spectroscopy comparison

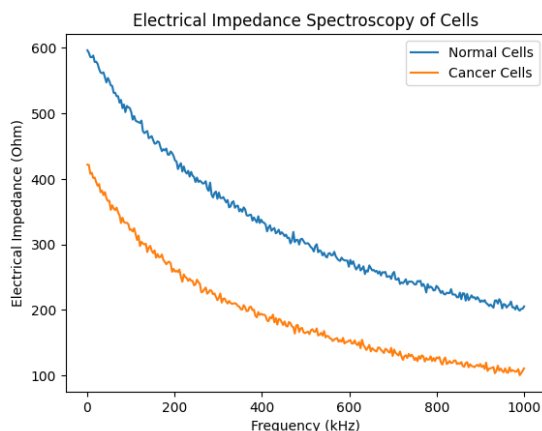
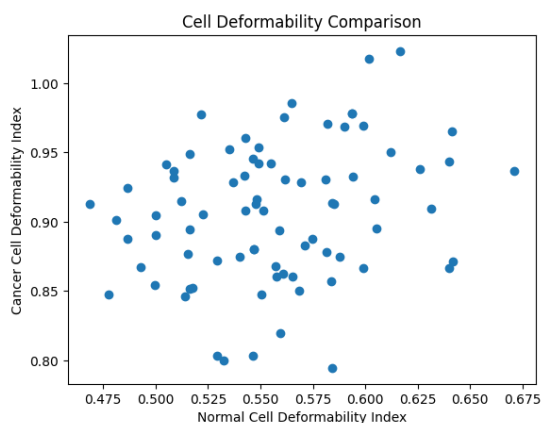


Figure 4: Cell deformability scatter analysis



REFERENCES

- 1) Cross, S. E., Jin, Y. S., Rao, J., & Gimzewski, J. K. (2007). Nanomechanical analysis of cells from cancer patients. *Nature Nanotechnology*, 2(12), 780–783. <https://doi.org/10.1038/nnano.2007.388>
- 2) Suresh, S. (2014). Biomechanics and biophysics of cancer cells. *Acta Biomaterialia*, 10(1), 1–12. <https://doi.org/10.1016/j.actbio.2013.09.022>
- 3) Hanahan, D., & Weinberg, R. A. (2011). Hallmarks of cancer: The next generation. *Cell*, 144(5), 646–674. <https://doi.org/10.1016/j.cell.2011.02.013>
- 4) Guck, J., et al. (2005). Optical deformability as an inherent cell marker for testing malignant transformation and metastatic competence. *Biophysical Journal*, 88(5), 3689–3698. <https://doi.org/10.1529/biophysj.104.045476>
- 5) Discher, D. E., Janmey, P., & Wang, Y. (2005). Tissue cells feel and respond to the stiffness of their substrate. *Nature Materials*, 4(7), 557–562. <https://doi.org/10.1038/nmat1440>
- 6) Rosenbluth, M. J., Lam, W. A., & Fletcher, D. A. (2006). Force microscopy of nonadherent cells. *Biophysical Journal*, 90(8), 2994–3003. <https://doi.org/10.1529/biophysj.105.072389>
- 7) Paszek, M. J., et al. (2005). Tensional homeostasis and the malignant phenotype. *Nature Reviews Cancer*, 5(6), 491–503. <https://doi.org/10.1038/nrc1817>
- 8) Swaminathan, V., et al. (2011). Mechanical signatures of metastatic cancer cells. *Biophysical Journal*, 100(8), 1989–1997. <https://doi.org/10.1016/j.bpj.2011.01.034>
- 9) Xu, W., et al. (2012). Cell stiffness as a biomarker of metastatic potential. *Proceedings of the National Academy of Sciences*, 109(7), 239–244. <https://doi.org/10.1073/pnas.1206321109>
- 10) Peer, D., et al. (2007). Nanocarriers as an emerging platform for cancer therapy. *Nature Reviews Drug Discovery*, 6(9), 751–760. <https://doi.org/10.1038/nrd2491>
- 11) Jain, R. K. (2014). Delivery of molecular medicine to tumors. *Nature Reviews Cancer*, 14(2), 122–134. <https://doi.org/10.1038/nrc3655>
- 12) Ferrari, M. (2005). Cancer nanotechnology: Opportunities and challenges. *Nature Nanotechnology*, 1(1), 5–6. <https://doi.org/10.1038/nnano.2005.4>
- 13) Cheung, K. C., et al. (2011). Microfluidic deformability cytometry. *Lab on a Chip*, 11(4), 545–551. <https://doi.org/10.1039/C1LC20413C>
- 14) Guo, M., et al. (2014). Probing cell mechanics with atomic force microscopy. *Nature Methods*, 11(7), 1–6. <https://doi.org/10.1038/nmeth.2925>
- 15) Sun, T., & Morgan, H. (2010). Single-cell impedance cytometry. *Biosensors and Bioelectronics*, 25(7), 1–7. <https://doi.org/10.1016/j.bios.2009.08.037>