Chapter 2
CRISPR-Cas9 Technology for Precision Cancer Medicine: Target Discovery, Disease Modeling, and Therapeutics

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ABSTRACT

CRISPR/Cas9 technology has emerged as a transformative tool in revolutionizing target discovery, disease modeling, and therapeutic interventions. Conventional CAR-T therapy achieves overall response rates of 70-85%, compared with 20-40% with standard chemotherapy. The technology shows particular promise in solid tumors including breast, lung, colorectal, hepatocellular, prostate, and pancreatic cancers. China, Asian nations have made substantial CRISPR contributions with mechanisms ranging from oncogene disruption to CAR-T cell enhancement. Critical

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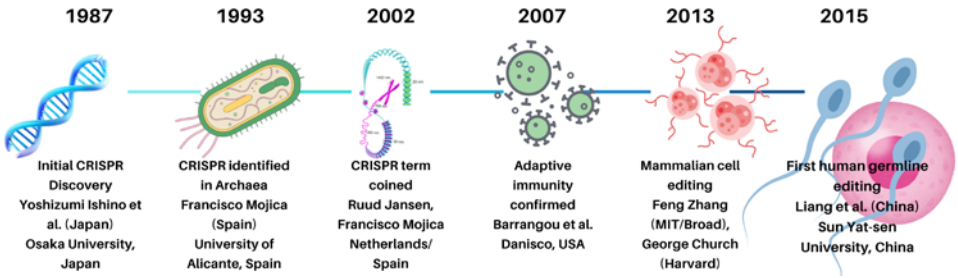
ethical frameworks addressing informed consent, germline editing, off-target effects, and global access equity have been established. The 2021 WHO framework provides a normative foundation but lacks enforcement mechanisms. The interdisciplinary convergence of CRISPR with artificial intelligence, multi-omics profiling, and systems biology promises next-generation precision oncology.

CRISPR/CAS9 TECHNOLOGY IN PRECISION CANCER MEDICINE

CRISPR/Cas9 represents a transformative genome editing technology that has revolutionized precision cancer medicine since its breakthrough demonstration in 2012. The advances of CRISPR/Cas9 in oncology have highlighted breast, lung, colorectal, hepatocellular, prostate, and pancreatic cancers (Qi et al., 2013). There are significant breakthroughs in cancer therapeutics, hematological malignancies, solid tumors, and immunotherapy. China has emerged as a global leader in clinical translation. The world's first human CRISPR trial in 2016 and clinical trials by 2017 is a promise in solid tumors treatment (Lu et al., 2017) (Figure 2). The mechanisms tested range from oncogene disruption to CAR-T cell enhancement and global access equity have been established by the WHO and national bodies. Critical ethical frameworks address informed consent, germline editing, off-target effects (Doudna, 2020).

Figure 1. Historical Beginnings of CRISPR-Cas9 technology



Clinical applications use the Cas9 protein and guide RNA (gRNA) for precise genome editing. CRISPR-Cas9 has enabled unprecedented accuracy in genetic modifications for cancer research and treatment. Maganti et al. (2022) analyzed 11 preclinical studies that revealed consistent improvements in anticancer efficacy. Across multiple cancer types, CRISPR/Cas9 with CAR-T therapy enhanced tumor reduction and survival outcomes compared to unedited controls. Notably, no adverse