CHAPTER

6

MOLECULAR MECHANISTIC PATHWAY IN CANCER THERAPY USING NANOMATERIALS

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6.1 INTRODUCTION

Cancer is a prevalent non-communicable disease known for uncontrolled cell proliferation and growth (Biganzoli et al., 2021). Global Cancer Observatory (GLOBOCAN) stated that cancer is the second leading cause of death globally, after cardiovascular diseases (Ferlay et al., 2021). The process of transforming healthy human cells into cancer cells is a complex and progressive event known as carcinogenesis. This process requires the gradual accumulation of numerous genetic and epigenetic abnormalities. Developing effective medications is challenging, considering the complex characteristics of cancer cells, the tumour microenvironment, and the similarities between cancer cells and normal cells. For over fifty years, the search for drugs to combat cancer has been driven by the knowledge that tumour cells proliferate more rapidly than healthy cells, with DNA being a key player in cell division. Consequently, DNA becomes a primary focus for anticancer medications, primarily by interfering with cell division, causing DNA damage, and encouraging cell death (Watanabe & Seki, 2024).

Advancements in genetics and molecular biology have improved our comprehension of the molecular mechanisms that play a role in cancer development, thus enabling the discovery of new treatment targets to combat cancer traits. Hanahan (2022) described ten biological capabilities acquired during cancer development as their hallmarks (Figure 6.1). These abilities include maintaining cell division signals, bypassing growth inhibitors, escaping immune attacks, allowing unlimited cell replication, stimulating inflammation related to tumours, resisting cell death, promoting blood vessel growth, encouraging genetic instability and mutations, disrupting cell metabolism, and initiating invasion and spread of cancer cells.

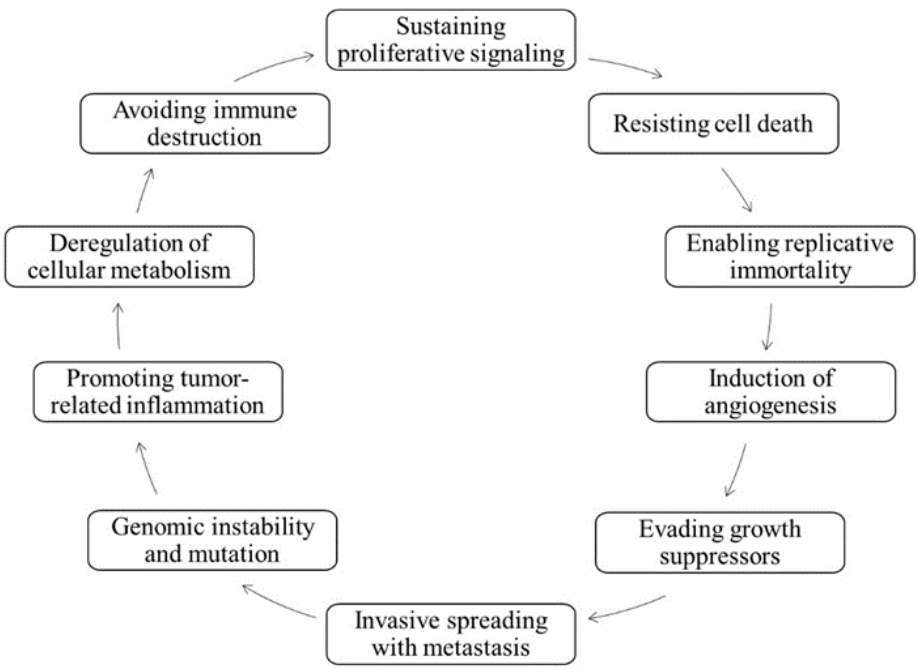

Figure 6.1 The hallmark of cancer (Source: Hanahan, 2022)

Presently, the treatment approaches used for treating cancer involve conventional modalities such as surgery, radiotherapy, and chemotherapy. Moreover, in cases of metastatic cancer, targeted therapy and immunotherapy are frequently employed as alternative approaches. However, it is important to recognise that these therapeutic modalities have

several limitations and disadvantages. At first, surgery has limited success in removing malignant tumours and is most effective when treating them before they spread or invade. Unfortunately, surgery is not an option for many cancer patients whose conditions are detected too late in the tumour's progression. Moreover, postoperative complications like infection, bleeding, biliary reflux, and lymphedema may arise. Additionally, individuals who undergo resection frequently experience metastasis and postoperative recurrence.

Postoperative adjuvant treatments for individuals with middle and advanced-stage cancer commonly involve chemotherapy and radiotherapy. However, the significant toxicity and negative impacts associated with these treatments remain a crucial concern. In contrast to chemotherapy, targeted therapy represents a newer therapeutic approach that seeks to modify specific molecular targets within cancer cells. Although targeted therapy presents numerous potential advantages, its primary drawbacks encompass side effects, lack of efficacy, and tumour recurrence attributable to drug resistance.

Recently, nanomaterials have become a subject of widespread interest in cancer treatment because of their distinct characteristics. Nanomaterials have been developed for various cancer therapies to enhance drug bioavailability and efficacy and to overcome the limitations of current treatment approaches. This chapter summarises the anticancer activities of nanomaterials and their molecular mechanism of action.

6.2 THE ANTICANCER EFFECT OF NANOMATERIAL IN VARIOUS CANCERS

The rapid progress in nanomaterials and nanotechnology over the last three decades has resulted in the development of numerous nanoparticulate-based systems. However, only a few have been successfully applied in biomedicine, with even fewer meet the stringent standards of the United States Food and Administration (U.S. FDA).

Several critical criteria for a biomaterial to effectively function in tumour or cancer therapy must be fulfilled to ensure both effectiveness