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Short Communication

Beyond Tumor Killing: Modern Anticancer Agents and the Evolving Landscape of Precision Oncology

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Abstract
Cancer therapy has evolved from broadly cytotoxic approaches toward increasingly selective strategies designed to exploit the molecular, cellular, and immunological characteristics of malignant disease. Anticancer agents currently encompass conventional chemotherapeutic drugs, targeted therapies, monoclonal antibodies, antibody–drug conjugates, immune checkpoint inhibitors, hormone therapies, cellular therapies, and emerging molecularly guided treatments. These agents act through diverse mechanisms, including disruption of DNA synthesis, inhibition of mitosis, blockade of oncogenic signaling pathways, modulation of hormonal signaling, induction of apoptosis, and activation of antitumor immunity. The development of molecular profiling and biomarker-driven treatment has enabled clinicians to select therapies according to specific genetic alterations and biological features of individual tumors. However, therapeutic resistance, tumor heterogeneity, adverse effects, and limited responses in certain malignancies remain important challenges. Recent advances in combination therapy, next-generation targeted agents, bispecific antibodies, antibody–drug conjugates, and personalized immunotherapy are expanding the possibilities for cancer treatment. This article reviews the major classes of anticancer agents, their mechanisms of action, therapeutic applications, benefits, limitations, and emerging developments. Understanding these therapeutic approaches is essential for improving treatment selection and moving toward more precise, effective, and individualized cancer care.

Introduction
Cancer represents a diverse group of diseases characterized by uncontrolled cellular proliferation, genomic instability, invasion, and the potential to metastasize to distant organs. Because malignant tumors differ substantially in their genetic and biological characteristics, cancer treatment has progressively shifted from a one-size-fits-all approach toward individualized therapeutic strategies

Anticancer agents are drugs or biological therapies used to prevent the growth, progression, or spread of malignant cells. Traditional chemotherapy remains an important component of treatment for many cancers, but its activity against rapidly dividing normal cells can produce significant toxicity. Advances in molecular biology have led to the development of targeted agents capable of interfering with specific proteins, receptors, enzymes, or signaling pathways that contribute to tumor development

Major Classes of Anticancer Agents

Cytotoxic Chemotherapeutic Agents

Conventional chemotherapy remains widely used in oncology. These drugs generally target cellular processes that are essential for proliferation.

Major groups include:

- **Alkylating agents:** Produce DNA damage that interferes with replication and transcription.
- **Antimetabolites:** Mimic normal cellular metabolites and interfere with DNA or RNA synthesis.

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- **Antitumor antibiotics:** Interact with DNA or cellular enzymes and may generate DNA damage.
- **Microtubule inhibitors:** Disrupt microtubule formation or function, thereby interfering with mitosis.
- **Topoisomerase inhibitors:** Interfere with enzymes required for DNA replication and repair

Chemotherapy may be administered as a primary treatment or combined with surgery, radiation therapy, immunotherapy, or targeted treatment

Hormonal and Endocrine Therapies

Certain malignancies depend on hormones for growth. Endocrine therapy is therefore particularly important in hormone-responsive cancers.

Examples include therapies that

- Block estrogen receptors.
- Reduce estrogen production.
- Inhibit androgen signaling.
- Suppress gonadal hormone production.
- Block hormone-dependent signaling pathways.

Molecularly Targeted Therapies

Targeted therapies are designed to interfere with molecular abnormalities that contribute to malignant transformation or tumor progression.

Important therapeutic targets include:

- Receptor tyrosine kinases
- Intracellular signaling proteins
- Angiogenic pathways
- DNA repair mechanisms
- Cell-cycle regulatory proteins
- Specific oncogenic mutations

Monoclonal Antibodies

Monoclonal antibodies are biological agents designed to recognize specific antigens or receptors associated with cancer.

They may work by:

1. Blocking growth-promoting receptors.
2. Inhibiting angiogenesis.
3. Recruiting immune cells against tumor cells.
4. Delivering therapeutic substances to malignant cells.
5. 5Altering signaling pathways involved in tumor survival

Mechanisms of Anticancer Activity

Anticancer agents can interfere with cancer biology at several levels. Common mechanisms include

DNA damage: Some drugs directly damage DNA or interfere with DNA repair.

Inhibition of DNA synthesis: Antimetabolites interfere with nucleotide metabolism and DNA replication.

Mitotic disruption: Microtubule-directed drugs prevent normal chromosome segregation.

Signal pathway inhibition: Targeted therapies suppress molecular pathways that promote proliferation and survival.

Apoptosis induction: Some agents activate programmed cell death pathways.

Angiogenesis inhibition: Certain therapies interfere with the formation of new blood vessels required for tumor growth.

Immune activation: Immunotherapies enhance the immune system's ability to identify and destroy malignant cells.

Because cancer cells can use multiple survival mechanisms simultaneously, combinations of agents with complementary mechanisms are frequently investigated

Conclusion

Anticancer therapy has progressed from predominantly nonspecific cytotoxic treatment toward a sophisticated therapeutic landscape that includes targeted drugs, monoclonal antibodies, antibody–drug conjugates, immunotherapies, hormonal therapies, and cellular treatments. Each class acts through distinct biological mechanisms and offers particular advantages and limitations. Precision oncology has strengthened the ability to select therapies according to tumor-specific characteristics, while advances in molecular biology continue to reveal new therapeutic targets.

Nevertheless, drug resistance, treatment-related toxicity, tumor heterogeneity, and unequal access remain important challenges. Continued development of biomarker-guided treatment, innovative drug-delivery systems, immune-based therapies, and rational treatment combinations may further improve cancer outcomes. The future of anticancer pharmacotherapy will increasingly depend on integrating molecular information with clinical

decision-making to provide safer, more effective, and more individualized treatment

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