

The Oncology Landscape: Molecular Pathophysiology, Diagnostics and Emerging Therapeutics

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Abstract: Cancer is a very complicated complex and diverse disease that affects millions around the world; it remains one of the leading causes of global toll even though there have been tremendous advancements in cancer research and development. The purpose of this paper is to provide a current overview of what we know about cancer and how it develops. We will discuss the etiology (cause), diagnosis and treatment methods for many common types of cancer including Breast, Gastric, Pancreatic, Oral, Prostate, Gallbladder, Colorectal, Thyroid and Ovarian Cancers. The progression of cancer is primarily due to a combination of genetic mutation(s), epigenetic changes, chronic inflammation and disrupted cell-to-cell adhesion. Of all these factors, inflammation is a significant contributor to both the development and spread of cancer and thus positions immunotherapy as a novel, state-of-the-art approach to treating cancer. In addition to traditional approaches to treating cancer (e.g., Surgery, Chemotherapy, Radiation Therapy), clinicians now have access to a variety of cutting-edge approaches such as Immunotherapy and Gene Therapy.

Keywords: Cancer, Breast Cancer, Radiation Therapy, Epigenetic Therapy, Nanotechnology.

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I. INTRODUCTION

Cancer is a complex genetic disease that develops due to progressive accumulation of genetic damage including both point mutations and structural changes during tumor progression. Cancer is an inherited disease with its initial phase being the onset of oncogenesis¹. The primary cause of damage in cancer is altered human cells that escape normal control mechanisms within cells; these altered cells become pathogenic components that form the base unit of the tumor².

In addition to the development of altered human cells, it is well-established that inflammation and the surrounding tissue microenvironment can also support tumor survival. Over the past 100 years there has been substantial progress made in our knowledge of cancer biology. This rapid advancement has occurred largely as a result of recent breakthroughs in technology and concepts³. The most significant advances in this area are largely due to advances in next generation high throughput sequencing technology, multi omic data integration, high resolution imaging technology, molecular immunology, flow cytometry, single cell analysis technology, advance cell culture techniques and the creation of new animal model⁴. The concept of personalized (or precision) medicine in oncology is based on the idea that every tumor is unique and therefore a patient's

response to treatment will depend on their specific genetics, lifestyle and environmental factors. Chronic inflammation is one of the main factors contributing to the development of many different types of malignancies such as colitis-associated colorectal cancer, H. pylori associated gastric cancer and hepatitis associated hepatocellular carcinoma. Chemotherapy resistance has limited the effectiveness of many cancer treatments and has contributed to repeated disease relapse and metastasis^{5,6}. Although cancer continues to represent a large global health burden for individuals at all economic levels throughout the world, Western Countries have been successful at reducing cancer-related mortality rates through early detection and screening programs, new therapeutic options and targeted reductions in risk factors⁷.

II. TYPES OF CANCER

➤ Breast Cancer:

Breast cancer is an aggressive form of cancer that significantly impacts women's health. The progression of breast cancer results from both intrinsic and extrinsic factors. In 1863, Rudolf Virchow was the first to propose the concept of an association between cancer and inflammation. He hypothesized that chronic inflammation could create a favorable environment for tumor development. Currently, there is substantial evidence

supporting the theory that inflammatory cells actively contribute to tumor progression via various cellular processes including leukocyte infiltration, tissue remodeling, neo-angiogenesis, and the production of specific cytokines (IL-1, TNF), and chemokines (CCL2, CXCL8). Tumor associated macrophages are a critical component in mediating the interactions between inflammation and cancer. Treatment strategies for breast cancer depend upon the presence or absence of specific molecular markers and subtypes. These subtypes include basal-like, Luminal A, Luminal B, and HER2-amplified tumors. When treating hormone receptor-positive (ER and/or PR positive) but HER2-negative cancers, hormonal therapy is often the initial treatment choice and often provides improved survival outcomes relative to hormone receptor-negative forms of breast cancer. There is no single chemotherapy option mandated by the American Society of Clinical Oncology for hormone receptor-positive breast cancer. However, commonly used chemotherapy regimens involve anthracyclines, taxanes, and platinum based drugs^{10,11}.

➤ *Gastric Carcinoma:*

The majority of all types of stomach cancer are gastric adenocarcinomas (GC), with the remaining being made up of various other types such as lymphomas, sarcomas, neuroendocrine tumors, and gastrointestinal stromal tumors. The complexity of this condition can be classified by where it develops. The development of GC is either in the proximal region of the stomach known as the cardia, or in the distal regions of the stomach referred to as non-cardia¹².

There are several key factors related to GC including:

- Risk factors: Alcohol use and smoking have been shown to increase a person's likelihood of developing stomach cancer.
- Primary treatment: The primary method for treating localized stomach cancer is through surgical removal of the tumor.
- Supporting treatments: In addition to the primary treatment there are additional supportive treatments available including chemotherapy, radiation therapy, targeted therapies and immunotherapies. Chemotherapy and radiation therapy are often administered prior to surgery (neoadjuvant) and/or after surgery (adjuvant) to help improve the overall effectiveness of the treatment plan¹³.

➤ *Pancreatic Cancer:*

The pancreatic cancer is a very aggressive type of cancer which, in most cases, will be found late in the course of the disease, and therefore will not respond well to many forms of standard therapy, leading to lower survival rates¹⁸. The worldwide rate of new cases of pancreatic cancer is increasing due to an aging population and increasing prevalence of major risk factors such as obesity and pancreatitis.

Although MASLD (metabolic dysfunction associated steatotic liver disease) is now the world's largest chronic liver disease, affecting approximately 68% of individuals

with type II diabetes, the relationship between MASLD and pancreatic inflammation/fat accumulation remains largely unknown²⁰. In general, a combination of lifestyle, medical and biological factors have been identified as raising the risk for developing pancreatic cancer; these include: Lifestyle choices: Smoking cigarettes and excessive use of alcoholic beverages.

Medical conditions: Type 2 diabetes mellitus and chronic or acute pancreatitis. Physical & biological factors: Being overweight/obese (high BMI), suffering from allergies, and the makeup of one's intestinal microflora^{20,21}.

➤ *Head and Neck Cancer:*

Head and neck cancers -- especially squamous cell carcinoma (SCC) -- are among the most common cancers found in the region of the head and neck, including the oral cavity, larynx, pharynx, lips, nasal and orbital cavities, and paranasal sinuses. One significant factor contributing to the rise of oral cancers is the presence of Human Papilloma Virus (HPV), which results in an oral HPV infection. The presence of symptoms associated with oral and oropharyngeal tumors has been observed and recorded by medical practitioners for centuries, starting with early clinical observations made by ancient healers through to today's highly advanced treatments. Individuals diagnosed with oral cancer in its early stages will typically have much greater chances of survival, better qualities of life, and more favorable prognoses¹⁸. However, because early-stage tumors rarely produce any symptoms and can easily be mistaken for non-harmful conditions, many individuals may put off getting medical attention. Therefore, regular screening is extremely important for detecting oral cancers at the earliest possible time. Oral cancer (OC) and other chronic health problems are having a very large effect on a person's quality of life²². The structures in a person's mouth are extremely important for performing many daily functions such as talking, eating, swallowing, and salivating. Thus, cancerous growths or their treatment methods may adversely affect these functions and may lead to noticeable alterations to a person's face. In the past, oral cancer was most frequently diagnosed in middle-aged men in their 50s and 60s who were heavy users of both alcohol and tobacco products²³. Recently, there has been a significant change, with the percentage of younger patients (less than 45 years old) being diagnosed with oral cancer increasing from only 3% to 5% several years ago to about 10% currently²⁴.

➤ *The Prostate Gland Cancer:*

It is an organ located beneath the bladder and surrounding the urethra in males. Its primary purpose is to produce fluid that will contribute to semen, aiding in ejaculation and maintaining viability of sperm. Most tumors found within the prostate gland develop in men during their middle-aged years or beyond. All races may be affected by prostate cancer; however, individuals of lower socioeconomic status tend to have higher mortality rates because they are often diagnosed late²³. There is increasing evidence that a man's genetic background may increase his likelihood of developing prostate cancer. Treatment for prostate cancer has evolved over time. In 1905, Hugh

Hampton Young reported on his radical prostatectomy performed via a perineal approach in the *Annals of Surgery*. Genetic History and Family Inheritance are significant risk factors for prostate cancer. This has been supported by long-term epidemiologic studies and twin studies. Fortunately, advances have occurred in diagnosing and treating prostate cancer. PSA blood testing and multiparametric MRI (mpMRI) have decreased the necessity of biopsies²⁴. A transperineal approach decreases the risk of post-procedural sepsis. PSMA PET/CT scanning is used to stage accurately and prevent patients from undergoing unnecessary local surgery or therapy²⁵. Active surveillance is an option for treating localized prostate cancer. It allows patients to avoid adverse effects associated with radiation cystitis, proctitis, erectile dysfunction, and urinary incontinence. Selection of the most appropriate treatment option for each patient is dependent upon the patient's individual lifestyle, comorbidities and symptoms²⁶.

Gallbladder Cancer is a serious problem for global health. The incidence of GBC is much greater in areas of the world where there are many people who have gallstones. Since most cases of GBC are detected at advanced stages, there is a very high death rate from this type of cancer. GBC belongs to the group of Biliary Tract Cancers (BTC), along with Intrahepatic Cholangiocarcinoma, Extrahepatic Cholangiocarcinoma, Klatskin Tumor (Perihilar Cholangiocarcinoma), and Distal Cholangiocarcinoma. Primary Care Physicians today treat a variety of illnesses that affect normal gallbladder functioning. There are a large number of articles on the internet regarding medical advice. Because of the conflict of information available on-line, global populations and specifically those in high-risk categories need to be provided with reliable and accurate methods to prevent cancer. Public Health Education Programs can help address this issue. Education programs can inform the public about known risk factors for developing GBC, including obesity, chronic inflammation of the gallbladder, and gallstones. Education programs can also educate the public about foods that increase mortality due to GBC (i.e. red meat consumption).

Colorectal cancer (CRC), which affects both the colon and rectum, is a significant global health issue. Globally, CRC ranks third among the most commonly diagnosed cancers and second among the leading causes of cancer-related deaths. Colon cancer is particularly aggressive and has a tendency to metastasize to other organs such as the liver, lungs, ovaries and additional parts of the gastrointestinal system. In contrast, treatment of rectal cancer presents a greater challenge because of the anatomical complexity of the pelvic region and a higher likelihood of local recurrence. According to statistics, men have a 25% greater incidence and mortality rate than women; furthermore, 5-year and 10-year survival rates are approximately 65% and 58%, respectively. There are also demographic differences in terms of CRC rates. For example, Non-Hispanic Black populations experience the highest rates of CRC incidence and mortality while Asian Americans and Pacific Islanders experience the lowest. Currently, carcinoembryonic antigen (CEA) is the main

serological marker used to detect CRC. CEA is produced during normal fetal development; however, it is also produced by various types of cancer cells. Therefore, healthy individuals produce less CEA than individuals with CRC, resulting in elevated blood CEA levels in individuals with CRC. Although CEA is elevated in individuals with CRC, it can also be elevated in individuals with non-cancerous conditions such as inflammation of the colon. As a result, CEA cannot be solely relied upon as a diagnostic tool. Nonetheless, CEA is an important clinical biomarker for monitoring disease progression and detecting cancer recurrence in individuals who have previously been diagnosed with CRC. Thyroid cancer is the most common endocrine malignancy.

➤ *Thyroid Cancer:*

It originates from either follicular epithelial cells or parafollicular cells. Cancers originating from follicular cells are classified into four distinct histological types: papillary thyroid cancer (PTC, accounting for 80-85% of cases), follicular thyroid cancer (FTC, 10-15%), poorly differentiated thyroid cancer (PDTC, <2%), and anaplastic thyroid cancer (ATC, <2%)³⁶. For the past several decades, the diagnostic and treatment strategies for follicular cell-derived thyroid cancers have undergone considerable change. These changes are largely due to a more accurate method of classifying patients according to their predicted clinical outcome and due to advancements in imaging technologies, laboratory diagnostic methods, molecular technologies and general medical knowledge³⁷. Although thyroid surgery, radioactive iodine therapy and TSH suppression remain the primary treatment modalities, the vast amount of new information regarding thyroid cancer has altered how physicians manage patients with thyroid cancer. Knowledge gained from this research has provided clinicians with the ability to reduce the intensity of treatment for patients with low risk, well-differentiated thyroid cancer; establish optimal treatment alternatives for patients with aggressive forms of the disease; and create individualized care plans for patients experiencing persistent or progressive thyroid cancer³⁸.

While several modifiable risk factors for thyroid cancer have been discovered, it remains unknown whether these factors are responsible for the increase in thyroid cancer incidence globally. The majority of known or suspected risk factors for thyroid cancer include patient age, biological sex, radiation exposure, nutritional status, exposure to environmental toxins/contaminants, ethnicity and family history³⁹.

➤ *Ovarian Cancer:*

The most frequently diagnosed type of gynecological cancer in the U.S. (uterine) affects about 3.1 percent of all women during their lives; however, ovarian cancer is less commonly diagnosed³⁹.

➤ *Pathophysiology of Cancer:*

Cancer development begins at the cellular level with changes to genetics and epigenetics. These changes may allow the affected cells to become able to spread to other

areas of the body. There are two primary ways for oncogenes (the genes responsible for causing cancer) to be turned on. One way is by a tumor-producing virus infecting a cell. The second way is when a proto-oncogene within a normal cell has been modified⁵.

In addition to changes in genetics and epigenetics, inflammation plays a critical role in the pathophysiology of cancer. Inflammation operates in a cycle. Chronic inflammation fuels the development of cancer. Tumors generate an inflammatory response³.

Although there is no adaptive immune response present in "immunologically cold" tumors, there are still

innate immune cells present in these types of tumors. Cell adhesion and metastasis also contribute significantly to the progression of cancer⁴⁰. Cell adhesion refers to the ability of cells to interact with each other. Cell adhesion molecules (CAMs) help cancer cells to adhere to the extracellular matrix (ECM). Constant interaction between the cells and the ECM will lead to increased local tumor growth and invasion of surrounding tissue. The ultimate result of this constant interaction is the preparation of the cancer cells to detach from the primary tumor site and travel to distant sites of the body. This process is called metastasis⁴¹.

➤ *Summary of Core Phases:*

Table 1 Summary of Core Phases

Phase	Primary Mechanism	Key Molecular Event	Clinical Outcome
Initiation	DNA Damage & Mutation	Activation of oncogenes; Inactivation of tumor suppressors	Genetically unstable, altered target cell
Promotion	Accelerated Proliferation	Evasion of cell cycle arrest and apoptosis pathways	Formation of a localized early tumour mass
Progression	Growth & Angiogenesis	Secretion of VEGF; recruitment of supportive tissue stroma	Structural expansion, tissue invasion, and local hypoxia
Metastasis	Systemic Dissemination	Cellular detachment and vascular/lymphatic intravasation	Secondary tumor colonization in distant target organs

III. EPIDEMIOLOGY

The study of how cancer occurs and is distributed among different groups of people is known as cancer epidemiology. Recent data from IARC/WHO shows that cancer continues to be one of the top causes of death around the world with approximately 20.6 million new cases each year and 9.8 million people dying from cancer each year. It is estimated that approximately 1 in 5 people will be diagnosed with cancer at some point in their lives, and approximately 1 in 9 men and 1 in 13 women will ultimately die from cancer⁴².

➤ *New Cases (Incidence):*

There are a few types of cancer that make up the overwhelming majority of new cases each year.

The top five most commonly diagnosed cancers for both males and females are⁴⁴:

- Pulmonary Carcinoma: 12.8% of all cases (about 2.63 million new diagnoses per year)
- Female Breast Carcinoma: 11.8% (about 2.43 million cases per year)
- Colorectal Cancer: 9.9% (about 2.04 million cases per year)
- Prostate Carcinoma: 7.5% (about 1.55 million cases per year)
- Gastric Cancer: 4.8% (about 0.98 million cases per year)

Cancer Mortality (Death) rates for different cancers vary greatly depending on how effective screening is, the biological characteristics of the particular cancer, and what treatment options exist.

The five most common types of cancer that cause the highest number of deaths each year include:

- Pulmonary carcinoma (19.1%) – Approximately 1.86 million people die from lung cancer every year.
- Colorectal Carcinoma (9.4%) – Approximately 918,000 people die from colorectal cancer every year.
- Hepatic Cancer (7.5%) – Approximately 732,000 people die from liver cancer every year.
- Breast Carcinoma (7.1%) in women – Approximately 694,000 women die from breast cancer every year⁵.
- Gastric Cancer (6.6%) – Approximately 642,000 people die from stomach cancer every year⁵.

➤ *Territorial Disparities and Emerging Pattern:*

There is a very clear and substantial economic difference in terms of the burden of cancer. Higher-income countries have higher incidence rates because they have longer average life spans and more effective screening systems (for example, Australia/New Zealand). However, in contrast, lower-income countries have much higher mortality-to-incidence ratios because of their inability to provide adequate access to healthcare, delayed diagnosis, and the fact that many of these cancers are caused by infections. As the result of an older population base and a shift toward less healthy lifestyles, the World Health Organization (WHO) has projected that global cancer incidence will rise to 34.4 million new cases by 2050 – a 67% increase over what was seen as the current baseline.

➤ *Causes:*

Despite a century of progress in medicine and a hopeful decrease in the rate at which people die from cancer over the past ten years, the disease still ranks second among

causes of death in America and around the world, trailing only heart disease. The World Health Organization estimates that about ten million people per year succumb to

cancer, therefore making it the reason for approximately 1 out of every 6 deaths across the globe.

➤ Milestone Timeline

Table 2 Milestone Timeline

Year	Discovery / Publication	Scientific Impact & Technology Used
1902	Theodor Boveri proposes that chromosomal damage causes uncontrollable cell division.	Foundation of Cancer Genetics: Laid the groundwork for understanding the internal causes of cancer.
1911	Peyton Rous discovers the Rous Sarcoma Virus (RSV) in chickens.	Birth of Tumor Virology: Proved for the first time that a micro-organism (an infectious virus) can cause cancer.
1915	Yamagiwa & Ichikawa induce skin tumors in rabbits using coal tar.	Chemical Carcinogenesis: First experimental proof that external chemical agents physically damage tissue to cause cancer.
1970	Varmus & Bishop isolate the src gene from RSV, discovering oncogenes.	Cellular Culture & Gene Isolation Technology: Proved that viral "cancer genes" are mutated copies of normal host genes (proto-oncogenes).
1983	Zur Hausen publishes the definitive link between Human Papillomavirus (HPV) and cervical cancer.	DNA Hybridization Technology: Isolated microbial DNA directly from human tumors, eventually leading to the preventive HPV vaccine.
1984	Marshall & Warren identify Helicobacter pylori and its connection to gastric ulcers and stomach cancer.	Microbiological Culture & Endoscopy: Transformed gastric cancer into a disease that could be mitigated via simple antibiotic therapy.
2000	Hanahan & Weinberg publish "The Hallmarks of Cancer" in Cell.	Systems Biology Framework: Synthesized decades of technology, oncology, and microbiology into unified rules of how tumors survive.
2014+	The Human Microbiome Project establishes how gut microflora modulate cancer therapies.	Next-Generation Sequencing (NGS): Enabled deep genomic tools to screen structural chemical scars left in human DNA by microbes and environmental carcinogens.

➤ Cellular and Genetic Origins :

Cancer, at its fundamental level, is caused by genetically abnormal cells which develop from previously normal, healthy cells into fast-growing cancerous tumors. Typically these abnormal cell developments are the result of one of three causes:

- **DNA Replication Errors:** Natural occurring errors made by a cell as it replicates its genetic material prior to cell division.
- **Environmental Pressures:** Carcinogenic substances (toxic chemicals) or radiation damage to cellular DNA.
- **Inherited Traits:** Genetic mutations passed from generation to generation that increase an individual's susceptibility to certain cancers.

Breast Cancer Risk Factors and Lifestyle Influences
Breast cancer is a result of an intricate interaction between genetic predispositions, lifestyle choices, and hormonal influences. The significant risk factors for breast cancer illustrate how societal changes and biological history contribute to changes in disease incidence:

- **Genetic Predisposition & Ionizing Radiation:** A history of breast cancer in a woman's immediate family dramatically increases her risk. Similarly, a history of exposure to ionizing radiation also significantly increases a woman's risk.
- **Nutrition and Lifestyle Shift:** With improvements in the overall quality of life and economic status of a population, there has been an improvement in the quality of nutrition available to that population. This has

contributed to increased obesity rates among populations. Additionally, the increasing consumption of saturated fat-rich diets combined with habits such as smoking and drinking alcoholic beverages further increase a woman's risk profile.

- **Reproductive/Hormonal History:** A woman's lifetime exposure to estrogen is a major determinant of her risk for developing breast cancer. Various reproductive/hormonal factors, including the age at which she begins menstruating (menarche), the age at which she stops menstruating (menopause), the number of times she becomes pregnant, and the length of time she nurses each child, all affect her hormone levels and ultimately her susceptibility to breast cancer.

Ageing Is The Primary Driving Force While genetics and lifestyle choices are important determinants of a person's risk for developing cancer, ageing is the most significant factor affecting a person's risk for developing cancer in humans and other multicellular animals. Organisms develop cancer through decades of cell proliferation. During this process, cells accumulate a lifetime's worth of unavoidable errors in DNA replication and environmental damage. In addition, as organisms age, their ability to repair damaged DNA and monitor for abnormal cells decreases. Together these two processes create the biological conditions necessary for cancer to occur.

➤ Treatment:

The prevention and treatment of cancer is based upon a combination of proactive life style modifications, new

surgical methods and sophisticated targeted treatments. Proactive strategies such as reducing tobacco use, increasing vaccinations, and pursuing early detection will help to prevent many forms of cancer⁵. Surgical removal of solid tumors was one of the first approaches to treating cancer which was developed during the early 1900's. This approach is still being used today. The use of biological markers has led to the development of "personalized medicine" where physicians tailor treatment plans based on a person's specific biological characteristics. A good example of this is a study that examined how a woman's biological makeup influenced her resistance to treatment for endometrial cancer⁶. In addition to our ability to develop personalized medicine through understanding a person's biological makeup, we also have access to numerous natural resources. Over 3000 different plant species are currently being studied in clinical trials to identify possible anti-cancer properties. These studies have identified approximately 30 naturally occurring anti-cancer agents^{45,46}.

➤ Immunotherapy:

The field of immunotherapy uses the patient's own immune system to specifically attack and eliminate malignant cell populations. Immunotherapy has recently gained popularity as an attractive alternative to CSC-based treatments due to its potential to treat and eradicate many types of cancer⁴⁷. While traditional immunotherapy has used viruses or bacteria to activate immune responses for close to a century now, the connection between cancer development and inflammation was first identified much earlier⁴⁸. In 1863, Rudolf Virchow made the initial discovery of a link between these two phenomena when he noted that there is often an influx of immune cells into neoplastic tissue⁴⁹.

- Multi-drug resistance: ALDH is a promising marker for identifying CSCs across various forms of cancer such as breast, bladder, lung, head-and-neck squamous cell carcinoma, and embryonal rhabdomyosarcoma⁴⁸.
- Gene Therapy: Gene therapy is another method to deliver therapeutics in oncology. Gene therapy involves using oncolytic viruses to specifically kill malignant cells, generate strong anti-tumor immune responses, and interrupt the survival mechanisms and micro-environment that support cancer cells⁴⁷.
- Biopsy: Histopathological biopsy is required to definitively diagnose breast cancer. The biopsy process includes removing cells and/or tissue from the breast area so that it can be evaluated by a pathologist in order to determine if there are any malignant cells present. There are two types of biopsies: a palpable mass biopsy and a non-palpable mass biopsy. A non-palpable mass biopsy will involve using an imaging method (such as mammogram and/or ultrasound) to guide the biopsy needle directly into the target area¹⁰.

➤ Natural Flavonoids:

Plants produce chemicals known as "naturally occurring flavonoids" which are derived from plant sources. These chemicals are structurally made up of a diphenyl propane (C6-C3-C6) backbone that includes an interior three-carbon ring and two outer aromatic rings. Flavonoids

are present in numerous food products and beverages including but not limited to: fruit and vegetable products, tea, coffee, wine, beer, and fruit juices. Flavonoids are thought to be associated with preventing heart disease, maintaining healthy bones, regulating hormones, and preventing cancer⁴⁵.

To overcome the difficulty of getting compounds into tumors, nanotechnology has developed new methods of drug delivery. Nanoparticles (NPs) are engineered particles, such as polymer-based particles (nanogels, nanofibers and liposomes), metal-based nanoparticles (gold, silver and calcium), carbon nanotubes, graphene, and quantum dots. All of these nanoparticles have specific surface charge properties, size characteristics and geometric shapes that allow them to be used effectively in treating cancer⁴⁹. Nanoparticles may be functionalized using ligands to bind to specific targets on cells. Ligands can include antibodies. Through the use of plasmon resonance, nanoparticles can detect cancer at its earliest stages and deliver drugs directly to individual cancer cells, reducing both the toxicity of chemotherapy and the cost of treatment⁵⁰.

➤ Epigenetic Therapy:

Epigenetics refers to the study of how gene expression is regulated by factors other than the genetic code itself. Researchers have learned about the epigenetic regulation of genes involved in cancer and have developed new drugs and treatments based upon this knowledge. One way to regulate gene expression via epigenetics is by reversing abnormal DNA methylation and histone acetylation patterns.

Another method is by adjusting the level of microRNAs (miRs) to the desired level. Some common epigenetic drugs are as follows:

- DNMTI – DNA Methyltransferase Inhibitors
- HDACIs – Histone Deacetylase Inhibitors; usually used in conjunction with DNMTIs
- Non-Coding RNA Based Treatments⁵¹

IV. CONCLUSION

Cancer is a very complex and multi-faceted disease that requires an integrated strategy to prevent, diagnose, and treat it. In the last few years, there have been some major breakthroughs in cancer research that have allowed us to understand the underlying causes and progression of cancer. New technologies, such as personalized medicine, immunotherapy, and nanomedicine, provide us with many opportunities to develop new ways to treat cancer. Flavonoids (a type of natural compound) and epigenetic therapy may offer some hope in preventing and treating cancer. Even though we are making great progress in understanding and treating cancer; however, this is still one of the biggest threats to world-wide public health. More research needs to be done to address the difficulties associated with treating cancer; namely, multi-drug resistance and the lack of better treatments that target specific areas. As we continue to learn more about the biological aspects of cancer, we can create more innovative

methods for treating cancer, which will help us improve patient care and reduce the impact of cancer on both individual patients and society.

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