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PHARMACEUTICS-BASED NATURAL PRODUCTS: EXPLORING MEDICINAL PROPERTIES FOR NOVEL DRUG DISCOVERY AND THERAPEUTIC APPLICATIONS

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ABSTRACT

The development of today's pharmaceutical industry has been greatly influenced by nature's gifts - natural products. Natural products are important sources of bioactive compounds that are found in plants, microbes, and marine organisms and have a wide variety of therapeutic activities. The focus of research within the pharmaceutics fields on natural products is the identification, extraction, characterisation, formulation and delivery of these naturally occurring compounds with the aim of improving patient outcomes. Natural products provide a wide range of pharmacological activities, such as antimicrobial, anti-inflammatory, antioxidant, anticancer, antiviral and cardioprotective. Scientific advances within the pharmaceutical sciences in combination with advancements in analytical technology have significantly enhanced the discovery of new pharmaceutical drug candidates from nature by enabling the ability to isolate the active ingredients from natural products and understand their mechanism(s) of action. In addition to these advancements, new approaches to drug delivery systems (e.g., nanoparticles, liposomes, and controlled-release formulations) have also enhanced the bioavailability, stability and therapeutic potential of natural products. The combination of traditional medicine and modern pharmaceutics has significantly enhanced the development of safer and more effective drugs. Given the challenges associated with standardisation, quality control and large-scale production of natural products, they continue to offer significant opportunities for drug discovery and development.

Keywords: *Natural products, Pharmaceutics, Drug discovery, Bioactive compounds, Medicinal plants, Pharmaceutical formulations, Therapeutic applications, Drug delivery systems, Antioxidant activity, Anticancer agents, Herbal medicine, Novel therapeutics*

Introduction

Natural products have historically served as the foundation of both health care and medicine by being a very rich source of bioactive compounds used for the treatment and prevention of many kinds of diseases. The sources of the natural products range from plants to microorganisms, to marine life, and other natural sources. The chemical diversity exhibited by these compound classes provides them with their therapeutic potential. Both the Ayurvedic and Traditional Chinese medical systems, along with Unani medicine, rely heavily on the use of natural compounds to treat various diseases. There has been a greater need to find new natural products due to the increased incidence of chronic diseases, the increased incidence of infectious diseases (including drug-resistant pathogens), and thus the need for new therapeutic agents from the natural world. In comparison to most synthetic compounds, natural products frequently possess multiple pharmacologic properties, resulting in their use as potential agents to treat complex diseases. Modern advances in pharmaceutical science have made it faster and easier than ever for scientists to isolate, characterize, and test the bioactive components found in natural products. Therefore, natural products remain some of the most sought after areas in drug discovery and development. Due to the intricate structures of these natural products, along with their bioactivity, they hold promise for the discovery of new and innovative drugs to help meet today's and tomorrow's health care needs. Increasing interest in evidence-based herbal medicine has provided further evidence of the need to marry the traditional knowledge about natural products with modern scientific methodology for developing new therapeutic modalities.(Newman et al., 2020)

Natural products have significantly influenced the field of drug discovery in the last few decades, with a great deal of scientific evidence to support this assertion. Many medicines that have been approved for clinical use derive from nature and fall within various categories, such as antibiotics, anticancer agents, antimalarial drugs, and cardiovascular medications. The structural complexity of natural products cannot be replicated by synthetic means; therefore, they represent an important foundation for material research and evolution of new pharmaceutical products using natural product templates. The focus on understanding the biological mechanism of action of natural products and identifying their anatomical and physiological effects as well as pharmacological properties has generated increasing interest in the exploration of lead compounds originating from natural sources. The improvement of both advanced screening methods and molecular biology techniques has dramatically increased the ability to identify critical therapeutic agents from natural sources. Recent advances in high-throughput screening technology and the molecular biology of drug action have given rise to an increased opportunity for systematic investigation of the therapeutic benefit of a variety of natural product sources, including plants and microorganisms, as therapeutics. Natural products also appear to have a lower overall toxicity profile than many chemically synthesized drugs and provide wider therapeutic activity; thus, they are a desirable option for pharmaceutical use. As a result, both pharmaceutical companies and academic institutions continue to support research of natural products to help identify safer and more effective ways to treat the numerous diseases that impact people around the world. (Harvey et al., 2015)

Most natural products have potential for therapeutic use; however, many have characteristics preventing their successful use in a clinical setting. The primary reasons are low solubility in water, poor absorption, susceptibility to instabilities in storage, and rapid metabolism. There are many formulation methods available to pharmaceutical researchers to overcome these limitations in order to improve the efficacy and delivery of natural compounds by utilizing novel drug delivery formulations that utilize the latest technology such as nanoparticles, liposomes, nanoemulsions, and controlled-release systems. These delivery systems can improve bioavailability, prolong circulation duration, provide greater specificity in targeting towards a specific area of interest, and reduce unwanted side effects; and also support the ongoing stability and quality of natural compounds during their shelf life, through the application of pharmaceutical formulation techniques. The design of standardized dosage forms of drugs has allowed for a consistent therapeutic response and greater patient safety. As a result, pharmaceutical-based formulation methods are necessary for converting natural products into viable clinical therapeutic agents. Future advances in formulation science will likely continue to provide new opportunities for natural compounds being used in many different ways within the scope of mainstream health care systems. (Patravale et al., 2020)

Advancements in technology have transformed the way researchers explore natural products to find new medicines and treat diseases. New advanced instruments, or analytical techniques, such as high-performance liquid chromatography, mass spectrometry, nuclear magnetic resonance spectroscopy, and metabolomics have helped to identify and analyse bioactive compounds found in nature with increased accuracy and greater efficiency. These new technologies allow researchers to quickly evaluate many different types

of natural extracts, while also providing important data about their chemical makeup and biological activity. Likewise, the development of new computational methods (e.g., molecular docking, bioinformatics, and artificial intelligence) has proven to be a valuable resource for predicting how drugs will interact with their targets and producing optimal lead compounds. The unison of these contemporary technologies with traditional herbal medicine has enhanced the drug-discovery process in a dramatic way. Today, scientists can better study the complex biological pathways involved in drug development and discover novel medicinal candidates than ever before. Additionally, technological innovation continues to solidify natural products as a primary source for future pharmaceuticals, as it has broadened the scope of natural-product research from conventional alternatives, such as plants and herbs, to contain a broader spectrum of treatment options for diseases of modern society, including cancers, bacterial infections, neurological diseases, and metabolic disorders. (Rodrigues et al., 2016)

The direction of future research in pharmacological compounds based on nature will be influenced by many disciplines collaborating with one another and by sustainable use of biological resources. Due to the ongoing rise in demand for new therapeutic compounds, researchers will have to find a balance between advancing science and conserving the environment, along with ensuring that their methods are ethically responsible when acquiring the raw materials required to produce these compounds. New ideas such as biotechnology, synthetic biology, and microorganisms are expected to be the solution to generating bioactive materials without excessively relying on terrestrial, living systems. These alternative processes have the potential to provide consistent supplies of medicinal compounds and protect biodiversity. Additionally, the increasing focus on individualized medicine has led to additional opportunities to produce therapies based on natural products that meet each patient's unique characteristics and diseases. Adopting good regulatory practices, quality control measures (e.g., good manufacturing practices), and objective clinical evaluation will also be necessary to establish consumer confidence in the safety and effectiveness of natural product-derived medications. The contributions of pharmaceutical scientists, pharmacologists, clinicians, and biotechnologists working together will be indispensable for resolving existing problems and for developing new therapies quickly. As scientists continue to increase their knowledge of the many different types of natural compounds, it is anticipated that the role of natural products will grow tremendously in modern medicine. Thus, pharmacological agents based on natural products will play a significant part in the identification of novel drug leads and the development of successful therapies for addressing international public health issues. (Atanasov et al., 2021)

Natural products and their medicinal importance

Natural products are chemicals made from living organisms, such as plants, microorganisms, marine organisms, and animals, that have a high degree of biological and pharmacological activity. They have been used for medicinal purposes for thousands of years and continue to be important components of both traditional and modern medical systems. The medicinal properties of natural products are attributed to their great variety in structure and their complexity biochemically, and their ability to act on many different biological targets in the human body. As a result, many natural products have been used as lead compounds in drug development because of their unique pharmacologic characteristics. The growing need

for new types of therapeutic agents has stimulated interest in using natural sources of bioactive compounds to meet unmet medical needs. Additionally, natural products are also very important as alternative/complementary therapies for patients with chronic illnesses, such as cancer, diabetes, and cardiovascular diseases. Finally, because natural products have a lower level of toxicity compared to synthetic compounds, they are good candidates for long-term use in treating patients. Advances in scientific knowledge and methods used for the extraction, isolation, and characterization of natural products have also led to a better understanding of their medicinal value. Therefore, both natural compounds and products derived from them will continue to be valuable resources for research and development of new drugs. (Newman &Cragg, 2020)

There is a strong connection between natural products and medicine that we can trace back throughout history—most approved medications come from natural sources either directly or indirectly. They also offer unique chemical structures (scaffolds) that are difficult to make artificially, making these compounds important in medicinal chemistry. Many natural products are also classified into various categories based on their chemical composition, such as alkaloids, flavonoids, terpenoids, and so forth; they all exhibit different kinds of biological activity (e.g., antiviral activity, anti-inflammatory activity, antioxidant activity, anticancer activity, etc.) by acting on complex biological pathways within the body, which makes them very helpful in treating diseases that have many contributing factors. Plus, a lot of natural compounds became the basis for the creation of semi-synthetic or synthetic drugs with better efficacy and safety. Drug companies are still putting money into researching natural products for new drug candidates to use as medicine. Furthermore, advancements in the field of genomics and metabolomics have improved the ability to identify bioactive compounds in natural sources, leading to a dramatic increase in the number of medicines that could be developed from them. For these reasons, natural products will continue to be an important influence on the field of modern pharmacotherapy as well as on efforts aimed at improving health care on a global scale. (Harvey et al., 2015)

There is a growing appreciation for the many uses of natural products. Their therapeutic properties are broad ranging and thus very important in medicine. The wide variety of compounds obtained from plants display numerous strong antioxidant properties, which can assist in relieving oxidative stress (a major cause of aging and chronic disease). Antimicrobial agents derived from nature are similarly important in treating infections caused by bacteria, viruses and fungi (including both bacterial and viral infections), particularly at this time of increasing resistance to traditional antibiotics. Compounds obtained from nature that possess anti-inflammatory properties are also widely used to treat inflammatory diseases (e.g., arthritis). Finally, numerous anticancer products obtained from nature, including paclitaxel and vincristine, have produced significant effects in clinical settings. These anticancer treatments act through multiple cellular mechanisms including cell cycle arrests and apoptosis induction. Natural products possess immunomodulatory activities, and therefore are useful in treating patients by enhancing the body's immune response to disease. Natural sources of cardiovascular protective agents also provide patients with potential treatment options for the regulation of cholesterol and blood pressure. Many of the pharmacological actions of natural compounds enable them to affect multiple biologically relevant targets at the same time, which

leads to enhanced therapeutic efficacy. All these different modes of action collectively demonstrate the importance of natural products in the context of modern day medicine/drug discovery. (Cragg& Newman, 2016)

Many pharmaceutical agents that are currently marketed can trace their origins back to natural substances which were later modified in order to improve their pharmacokinetics and pharmacodynamics. The great structural diversity of naturally occurring molecules provides an exceptional source of inspiration for the fields of medicinal chemistry and drug discovery. A key feature of natural products is that they tend to work synergistically (i.e., multiple natural products working together) to increase the therapeutic efficacy of the combined effect. The use of an entire herbal extract rather than a single constituent is a perfect illustration of this phenomenon. Advances in contemporary analytical methodologies such as HPLC, mass spectrometry, and NMR spectroscopy have greatly enhanced the process of identifying and characterizing these compounds. Improvements in computational techniques and molecular docking tools have markedly accelerated the ability to predict the biological activities of natural products and how they interact with their targets. These advances are enhancing the role that natural products play within the field of rational drug design. In addition to being used directly as a drug, an increasing number of natural products are also being utilised as building blocks to develop drugs with greater potency and/or selectivity. (Dias et al., 2012)

Natural products have a large role in modern medicine because of their medicinal properties, but they also have many issues that hinder their use as medicines. Natural products are challenged by issues like poor solubility, low bioavailability, instability, and variability in composition, all of which limit the efficacy of medicinal products made from natural sources. Researchers are creating innovative drug delivery systems such as nanoparticles, liposomes, and nanoemulsions to enhance the absorption and delivery of these medicinal products. Standardizing and controlling the quality of herbal and other natural products is very important to ensure the consistency and safety of the medicine. Sustainability is important to reduce the chance of depleting a natural resource, so the need for sustainable practices and harvesting is essential to protecting precious resources. Biotechnology provides an effective way to create bioactive compounds in a controlled environment using plant tissue cultures and/or microbes. These new technologies have been instrumental in improving the overall potential of natural medicines. Furthermore, there is an increase in the number of regulatory bodies focusing on confirming the safety and efficacy of these natural product-based therapies. The combination of traditional medicinal knowledge with modern pharmaceutical science is continuing to introduce new possibilities for drug development. Overall, the use of natural products in global health care and future therapeutic advancement remains extremely important. (Atanasov et al., 2015)

Sources of natural products

A variety of biological sources offer natural products; however, plants serve as one of the most important and utilized sources of bioactive materials for medicine both today and in the past. Plants also produce many different types of secondary metabolites that have significant pharmacological effects (alkaloids, flavonoids, tannins, terpenoids, glycosides), thus contributing to the medicinal properties that have been observed in herbal medicines (used all over the world). Herbal medicines were used for many years by different cultural systems such as Ayurveda,

Traditional Chinese Medicine and Unani medicine. As well, the vast diversity of plants allows for an enormous pool of chemical compounds from which researchers can continue to discover new drugs and develop their pharmaceutical research. There are also several variables in the environment (i.e., climate, soil type, geographic location) that can affect the chemical compositions of plant-derived products. Through modern extraction and isolation techniques, researchers can identify active compounds in plants much easier than before. Thus, the importance of plant-derived natural products is still a vital component of pharmaceutical sciences and development of new therapeutic agents. (Rates, 2001)

Bacteria, fungi, and actinomycetes are other important natural product sources that contribute to the discovery of significant pharmaceutical agents. It is well established that several microorganism species produce bioactive compounds that have medicinal properties, and one of the most important types of bioactive compounds produced by microorganisms is antibiotics; the many changes within the treatment of disease caused by microorganisms have been possible due to the discovery of microbial-derived antibiotics. The first discovery of penicillin, derived from the fungus Penicilliumnotatum, was a milestone in the history of chemotherapy and significantly changed the course of modern medicine through the development of new antibiotics and other therapeutic agents. Streptomycin, tetracycline, and erythromycin are also antibiotic products obtained from microorganisms that have been used to treat patients for decades. Since microorganisms generate secondary metabolites as a mechanism for survival, many of their secondary metabolites have strong pharmacological effects when developed for therapeutic use as pharmaceutical agents. Over the last few decades, advances in biotechnology and fermentation processes have enabled the large-scale production of many of these secondary metabolites for use as medicines. Furthermore, advances in the areas of genetic engineering and genome mining have provided researchers with methods to discover additional microbial-derived secondary metabolites that can be developed for therapeutic use. Microorganisms have the ability to generate compounds that have both structural and biological diversity providing investigators with an immense amount of potential when searching for drugs. Therefore, microorganisms will continue to be an essential source for the development of new antibiotics and therapeutic agents. (Demain& Sanchez, 2009)

In recent years, many sea creatures, such as algae, sponge, coral, and marine bacteria, have become significant and relatively undisturbed resources of natural products. New and different organisms typically have new and different chemical compounds to produce due to the extreme environments they grow, including the high pressure, variable salinity, and little light available in the ocean. Many of the marine-derived compounds exhibit strong anticancer, antiviral, anti-inflammatory, and antimicrobial activity; for example, cytarabine and trabectedin are two of many marine-derived compounds used for cancer treatment. Marine Sponges contain more secondary chemical compounds than all terrestrial sources of primary marine-derived secondary chemical products. Innovative techniques related to deep-sea exploration and marine biotechnology are creating opportunities to identify new bioactive compounds from marine environments. Sustainable methods of harvesting and restricted access to marine environments are two of the largest obstacles that will need to be resolved before researchers can continue to pursue new marine-

derived cosmological agents. Researchers are trying to address some of these challenges by using marine microbial fermentation and synthetic biology approaches. The sea continues to be a valuable source for discovering new drugs with unique therapeutic properties. (Blunt et al., 2018)

Natural products produced by animals are another source of useful substances but animals have not contributed as much as plants and microbes. Subliming substances produced by animals include hormones, biological catalysts (enzymes), peptides, and other biologically-active (bioactive) compounds with potential therapeutic value. One example would be insulin; historically, INSULIN has been obtained from the pancreas of various mammals but today the use of recombinantly produced therapeutic agents is now common. Another example of an animal biologically-active substance derived from animal tissues would be heparin, which is a very common category I (anticoagulation) drug used in medical practice. Additional examples would be the biologically-active peptides derived from the venoms of snakes, scorpions, and other venomous animals that have been evaluated for their potential therapeutic applications in treating pain and cardiovascular diseases. The majority of these biologically-active animal-derived substances have high specificity and potency, making them useful in the drug discovery and development processes. Although there are significant ethical and sustainability issues concerning the continued use of animal-derived biologically-active substances, there are many areas in which they continue to provide valuable insight into physiological processes and therapeutic mechanisms. Ongoing studies in the fields of proteomics and biotechnology are further expanding the potential for animal-derived biologically-active substances in contemporary pharmacotherapy. (King, 2011)

The availability and quality of natural products from various sources are significantly impacted by many ecological and environmental factors, such as climate change, pollution, and habitat loss. As a result, the conservation of biodiversity has become critical to the ongoing supply of natural resources for pharmaceutical applications. Over the last decade, biotechnological advancements have provided a platform for enhancing and improving the production of natural products through methods such as plant tissue culture, microbial fermentation, and genetic engineering; these approaches provide controlled environments in which to produce these valuable compounds without depleting our natural ecosystems. The use of synthetic biology allows the creation of novel biological systems that can produce unique or complex natural molecules that would otherwise be difficult to produce through traditional means, often resulting in increased efficiency and sustainability of natural product research. Interdisciplinary cooperation among pharmacologists, chemists, and biotechnologists is also necessary to evaluate new natural product sources while maximizing their therapeutic use. Therefore, the exploration of natural product sources continues to be a dynamic and evolving area that has enormous ramifications for drug discovery and global health care Atanasov et al., 2015)

Bioactive compounds

Bioactive substances found in all organisms, including plants, microorganisms, marine creatures, and animals, have naturally occurring chemical compounds that can demonstrate biological activities in living organisms. The therapeutic effects of biochemically active substances are also used extensively in pharmaceutical research for discovering and developing drugs. Bioactive substances are comprised of many chemical classes,

including alkaloids, flavonoids, terpenoids, phenolic acid derivatives, glycosides, and peptides. Each class of biochemicals has unique pharmacological effects that may provide health benefits and protect against disease. Bioactive compounds exert their biological effects by interacting with the molecular targets in the body that include enzymes, receptors, and DNA, and thereby modulate physiological and biochemical functions. Bioactive compounds can be used as lead molecules for developing novel drugs, due to their diversity in structure. Presently, many of today's drugs are either derived from or synthesized based on the chemical structure of the naturally occurring bioactive compounds. In addition to providing therapeutic effects, bioactive substances also have antioxidant, antimicrobial, anti-inflammatory, anticancer, and immunomodulatory activities; their natural origin makes them safer than synthetic chemicals. Ongoing research in the fields of natural product chemistry and biotechnology continues to advance our understanding of their mechanisms of actions. In conclusion, the use of bioactive compounds has had a significant impact on the development of modern medicine and the improvement of human health.(Calixto et al., 2019)

Bioactive compounds are important as lead compounds for drug discovery and development. Many of the drugs that have reached clinical use were developed from a natural bioactive compound that had potent therapeutic effects. Since they contain chemical scaffolds that are difficult to create from synthetic methods, bioactive compounds are valuable to medicinal chemists. Examples of bioactive compounds that have pharmacological activity include, but are not limited to: alkaloids morphine, quinine and atropine; flavonoids; and terpenoids. Many bioactive compounds will act on multiple targets, allowing them to treat challenging diseases such as cancer, diabetes, and heart disease. The potential for bioactive compounds to multi-target is what makes them more therapeutically effective than single-target synthetic drugs. Screening technologies have allowed researchers to more quickly and easily identify novel bioactive compounds from nature. Moreover, advances in computational modeling, including molecular docking and virtual screening, have significantly improved predictions regarding drug-target interactions. The pharmaceutical industry is placing an increasing amount of emphasis on employing bioactive compounds from nature to create safer and more efficacious therapies. Collectively, bioactive compounds will continue to occur at the centre of contemporary drug discovery and development.(Baker et al., 2020)

Bioactive compounds possess numerous pharmacological properties, including antioxidants, which defend the body against oxidative stress and free radical formation. The antioxidant property of bioactive compounds is one of their most important pharmacological properties. Oxidative stress is thought to contribute to aging and several long-term diseases, including cancer, diabetes, and heart disease.Bioactive compounds also possess considerable antimicrobial properties against bacteria, viruses, and fungi, giving them a key role in developing new treatments for infectious diseases and antibiotic resistance. The anti-inflammatory properties of bioactive compounds make them effective in treating arthritis and inflammatory bowel disease. Many bioactive compounds have shown anticancer effects by blocking tumour growth, inducing apoptosis, and inhibiting metastasis. Immunomodulatory properties of bioactive compounds also help bolster the body’s immune system defense against illness. In addition to the above points, many

bioactive compounds have the ability to positively affect many systems in the body, as they can interact with several pathways simultaneously; thus, they are very effective in treating complicated, multifactorial diseases. The broad range of therapeutic effects shown by bioactive compounds highlights the importance of this class of compounds in pharmaceutical development and contemporary healthcare.(García et al., 2018)

Extraction, isolation, and characterisation of bioactive compounds are all important components of research into natural products. To isolate and identify bioactive compounds from complex natural materials, researchers utilise a range of advanced techniques, including chromatography, spectroscopy, and mass spectrometry. For example, researchers can achieve precise separation of the many chemical constituents in mixtures using high-performance liquid chromatography (HPLC) and gas chromatography (GC); the chemical and structural information about these compounds can then be obtained using nuclear magnetic resonance (NMR) spectroscopy. All of these methods greatly enhance the ability of researchers to identify bioactive compounds more accurately and more efficiently than ever before. Modern biotechnological tools (e.g., fermentation and genetic engineering) are also utilised in order to facilitate increased production of bioactive compounds. Recently, researchers have begun to incorporate computational tools (e.g., molecular modelling and bioinformatics) into their projects to aid predicting biological activity and optimising drug candidates. These advances in technology have sped up the drug discovery process and decreased the amount of time it takes to conduct research. The combination of traditional knowledge with modern scientific methodology has opened up many opportunities for researchers to explore natural resources for the discovery of new medicinal agents. (Patel et al., 2021)

Bioactive compounds possess a large amount of therapeutic potential, but many of them face hurdles in being utilized by the pharmaceutical industry due to their limitations (e.g., low bioavailability, poor soluble in water, and chemically unstable). Current drug formulations such as nanoparticles and liposomes can improve the solubility and absorption of bioactive compounds and improve the ability to deliver the bioactive compounds directly to the tissue where it is needed. In any drug product, ensuring that bioactive compounds maintain a consistent quality, safety and efficacy profile is essential. Natural sources vary widely from each other due to environmental factors such as geography; therefore, the composition of natural bioactive compounds can vary significantly leading to inconsistencies in therapeutic efficacy. Sustainable harvesting and conservation practices should focus on ensuring that there will always be biodiversity available for harvest when it is needed to preserve future opportunities for use. In addition biotechnology, through plant tissue culture and synthetic biology, may offer alternative means of large scale production of bioactive compounds. In addition, initiatives to strengthen the regulations surrounding the use of bioactive compound-based medicines will further enhance their availability as a therapeutic options for patients. Ongoing research efforts will continue to improve the clinical application and therapeutic efficacy of bioactive compounds. Overall bioactive compounds will continue to be an integral resource for future drug development and improvement within the pharmaceutical industry. (Zhao et al., 2022)

Drug discovery from natural sources

The contribution of nature to drug discovery has been essential to the basis of modern medicine, providing a pool of structurally diverse and biologically active compounds that can be used as drugs. The majority of life-saving drugs have been derived from natural products produced by plants, microorganisms, marine organisms and animals. Since the chemical structures of these compounds are often not duplicated using synthetic chemistry, they represent a valuable contribution to pharmaceutical research. The typical approach to drug discovery from natural sources commences with the collection of biologic material, followed by extraction, isolation and screening of bioactive compound. Compounds that have demonstrated pharmacological activity through either an in vitro or animal model will then be evaluated for their pharmaceutical viability. Natural products demonstrate success in drug discovery as evidenced by fecundlyutilised antibiotics (e.g., penicillin), anticancer agents (e.g., doxorubicin) and drugs for treating cardiovascular disease (e.g., digoxin). In addition, many natural compounds have been used as lead compounds for the chemical modification to create new and improved drugs with enhanced efficacy, safety and pharmacokinetics. The improved efficacy in identifying promising drug candidates through technological advancements in analytic and screening techniques have provided opportunities to simplify the identification of drugs from a complex natural source. Consequently, the utilisation of natural products as a cornerstone for drug discovery and drug development in the modern pharmaceutical industry will continue for the foreseeable future. (Patel et al., 2019)

Plants play a notable part throughout the process of drug discovery due to their ability to create many types of secondary metabolites with possible therapeutic effects. This includes various groups of chemical compounds such as alkaloids, flavonoids, terpenoids, glycosides, and phenolics that have been known since antiquity to possess many pharmacological properties. There are numerous examples from history where drugs that were derived from plants were made into successful clinical use for a wide variety of diseases including examples of drugs used in the treatment of cancer, infection, and inflammation. Furthermore, there are also many different methodologies by which drugs are discovered from plants today. The first concludes the ethnobotanic use of specific indigenous species, specifically those believed to possess medicinal values is undertaken, followed by rigourous laboratory-based pharmacological screenings. The incorporation of traditions along with modern tests will make the process of drug discovery from plants more efficient/opened the door wider to the use of plants in this way. Significant advances in phytochemistry since the 1800's have led to the ability to isolate and characterise the structure of compound that possess active properties from plants. In many cases the compounds identified as active compounds act on a number of different molecular targets which makes them candidates for effectively treating diseases/disorders (i.e. cancer and diabetes). Due to the increasing popularity for more natural and safer therapeutic options the pharmaceutical industry has seen an increased interest in the search for drugs from plants. It is for this reason that medicinal plants are considered to be one of the most consistent and reliable resources available when searching for new therapeutics for humankind. (Singh et al., 2018)

A lot of new drug ideas are coming from exploring plants and animals living in the ocean. Many organisms living in the ocean live in places that are very high pressure, salty, and/or very cold. Organisms living in these extreme environments

produce many different types of chemical structures, and many of the chemicals produced by marine plants and animals (e.g., sponges, algae, coral, and marine bacteria) demonstrate action against human diseases such as cancer and infections. To date, several marine-derived drugs have been made available for clinical use (mostly to treat patients with cancer) and are already approved by various regulatory agencies worldwide. In addition, there is still significant diversity in the marine environment and a significant amount of new chemical structures that have not been studied to determine their potential for pharmaceutical applications. Unfortunately, there are many different obstacles currently limiting large-scale commercial development of marine-derived drugs (e.g., limited access to resources in deep sea environments, harvesting of marine organisms in a sustainable manner). Therefore, many researchers are exploring ways to produce marine bioactive compounds through marine biotechnology or through fermentation techniques from microorganisms to use commercially available marine-derived bioactive compounds without degrading ecosystems. As marine organisms continue to be further characterized and their chemical structures understood, additional leads for drugs with novel mechanisms of action are likely to be identified. As a result, marine sources of compounds represent an exciting new area of potential drug discovery in the modern world. (Kumar et al., 2020)

The drug discovery process can also utilize microorganisms and their products as a source of new antibiotics and other antimicrobial agents, including the wide range of bacterial, fungal and actinobacterial (a type of bacteria that produce many important drugs) secondary metabolites that have been proven to have strong biological activity (Luijendijk, 2013). The discovery of penicillin from the mold Penicillium n however, would not be possible if the original search for a bacterial antibiotic was confined only to bacteria; rather, it is important to investigate various sources When evaluating these potential sources of antimicrobial drugs, microbiologists can utilize the production of antimicrobial compounds as a defense mechanism against other competing organisms in the environment. In addition, advances with fermentation technology, as well as microbial genetics, have made it easier to produce and discover new or additional microbial metabolites and, therefore, much greater potential exists for the use of microorganisms as important sources of previously unreported bioactive compounds. Using techniques such as metagenomics (analysis of total DNA or genes) and genome mining (searching for potential or novel bioactive compounds in known genetic material) also extends this search. Finally, given the increase in worldwide antibiotic resistance, researchers must continue to look to microorganisms as a potential source for new antimicrobial agents, thereby maintaining the role of microorganisms as a critical aspect in pharmaceutical research and drug discovery. (Lee et al., 2021)

The evolution of drug discovery from natural surroundings remains ongoing as there have been continual advances in technologies and interdisciplinary methods. Significant technological breakthroughs in areas such as high-throughput screening, molecular docking, and artificial intelligence have resulted in an increase in the identification of new potential drug candidates. Researchers can use these technologies to rapidly evaluate large (and sometimes) comprehensive libraries of natural compounds and use predictive modelling to evaluate the anticipated biological activity of each compound. Furthermore, there has been a substantial amount of progress made in

developing metabolomic and genomic approaches that provide additional insight into how natural products are biosynthesized. There continue to be challenges with the isolation of naturally-derived compounds (for example: structural complexity) and in many cases yield is often significantly low. In addition to this, there are efforts underway to use the emerging fields of synthetic biology and metabolic engineering to leverage some of these issues associated with isolation and compound modification. Cooperation between pharmacologists, chemists, and biotechnologists has led to increased collaboration in natural product drug discovery efforts as well. It will be important for regulatory systems to include proper quality control standards to help ensure that newly developed drugs are safe and effective prior to being approved for use; which means that continuing to investigate novel therapies that are derived from natural resources will remain a key aspect of developing effective treatments for the numerous global health issues that exist throughout our planet.(Johnson et al., 2017)

Therapeutic properties

Natural products provide a large variety of therapeutic benefits which have made them increasingly desirable and beneficial in today's medical and pharmaceutical development process. While natural products can be obtained from plants, microorganisms, marine organisms, and animals, many of these compounds have been shown to exhibit significant biological activity for human health. Perhaps one of the most well-known therapeutic properties of natural products is their antioxidant effect. Natural products with antioxidant activity are able to help neutralize free radicals, leading to a decrease in oxidative stress within the human body. Oxidative stress is a primary cause of many chronic conditions, including cancer, diabetes, cardiovascular disease, etc. The antioxidant activity of some natural products (i.e., flavonoids, polyphenols, carotenes, etc.) is an important support mechanism for protecting cells from damage due to oxidative stress.In addition to antioxidant effects, research has indicated that many natural products also exhibit anti-inflammatory properties. Several diseases, such as rheumatoid arthritis and asthma, are associated with chronic inflammation. Some natural products have potential therapeutic implications for treating these conditions by preventing and/or inhibiting inflammatory mediators and pathways. In addition, many natural products exhibit immunomodulatory (i.e., the ability to alter the immune system's function) properties. Thus, by providing support to the immune system, natural products can aid in the body's ability to fight off infections.Natural products have been proven to be safer and more effective than other synthetic prescribed medications due to their natural source of origin and their ability to affect multiple targets. Ongoing research continues to validate these therapeutic effects of natural products for use in a clinical setting.(Sasidharan et al., 2011)

The most widely researched therapeutic effects of natural products in pharmaceuticals are the antimicrobial properties of those products. Antimicrobials are very effective against bacteria, fungi, viruses and parasites. Antimicrobials are key factors in treating infectious diseases. Some naturally occurring compounds found in plants (such as alkaloids, tannins and essential oils) have proven to have substantial antibacterial and antifungal effects. In addition, microbial metabolite products (such as antibiotics) have changed the way bacterial infections are treated. The increasing prevalence of antimicrobial resistance has further emphasized the need for finding new naturally occurring antimicrobial

agents. Many naturally occurring antimicrobial agents affect microorganisms in different ways, such as by causing damage to the cell wall, inhibiting protein synthesis, or interfering with nucleic acid replication, thereby lowering the risk of developing resistance to them. In addition, many naturally occurring antimicrobials are less toxic to human cells than their synthetic counterparts, making them safer alternatives for treating infections. Marine mammals and other aquatic organisms provide a further source of naturally occurring antimicrobial agents because they are uniquely adapted to living in extreme environments. Thus, it is vital that we continue to explore all available natural resources in order to find effective means of combating the global threat posed by drug-resistant infections. As such, natural products are an integral source of developing novel antimicrobial therapies. (Gurib-Fakim, 2006)

Researchers have shown that natural products are effective when targeting cancer cells via different pathways. An example of a plant-derived anticancer compound used for the treatment of cancer is paclitaxel; other examples include vincristine and camptothecin. These compounds act by inhibiting the division of cells, inducing programmed cell death (apoptosis) and inhibiting tumor growth/metastasis. Additionally, some natural compounds have been shown to possess selectivity for specific molecular pathways involved in cancer progression. Consequently, they are often very effective and targeted toward cancer cells. In addition to their direct effects on cancer cells, the effects of some natural products can enhance a patient's immune system and help it to recognize and destroy the cancerous cell. The ability of natural compounds to interact with multiple targets within cancer cells magnifies their utility as anticancer treatments for complex and heterogeneous diseases, such as cancer. Furthermore, natural products are frequently combined with conventional chemotherapy drugs to enhance their efficacy and reduce their adverse effects. Advances in molecular biology and pharmacology have now provided greater insight into how these compounds work against cancer cells. Thus, natural products will continue to be important in the development of new anticancer agents and the formulation of anticancer therapeutic approaches. (Bhuyan et al., 2020)

Inflammation is part of the immune system's biological response to injury/infection and there are a lot of chronic/acute inflammatory conditions treated with the use of natural products due to their anti-inflammatory properties. Too much or long-term inflammation can be responsible for the onset of many diseases like arthritis, asthma, or inflammatory bowel disease. Several types of natural compounds like flavonoids, terpenoids, and phenolic acids have been shown to block some of the major pathways of inflammation (cyclooxygenase and lipoxygenase). These compounds also help to reduce the amount of pro-inflammatory agents (cytokines/prostaglandins) produced which can help reduce pain, swelling and damage to tissue as well. Many of the anti-inflammatory agents found in plants have been used in traditional medicine for hundreds/thousands of years with scientific evidence of their therapeutic benefits. Since natural anti-inflammatories generally have fewer side effects than synthetic anti-inflammatories (nonsteroidal anti-inflammatory medications), they are a potentially valuable choice in treating chronic inflammatory disorders. Research into natural products with improved anti-inflammatory properties continues to identify new compounds with possible commercial/therapeutic potential in this area. (Thomford et al., 2018)

Natural products have unique properties that may help protect the cardiovascular and nervous systems from chronic and degenerative diseases, both globally and locally. Cardiovascular disease is the leading cause of death worldwide, accounting for 30-35% of all deaths globally (WHO; 2010). Cardioprotective compounds present in natural products may be beneficial in controlling high blood pressure, reducing cholesterol levels, enhancing blood circulation, and reducing the incidence of cardiovascular diseases such as high blood pressure, atherosclerosis, and/or coronary artery disease. Neuroprotective compounds found in natural products may help to protect neurons from damage by developing strategies to reduce the risk of developing chronic neurodegenerative diseases such as Alzheimer's disease and Parkinson's disease. Both antioxidant activity and anti-inflammatory activity are essential in the protection of the nervous and cardiovascular systems, which may be found in many natural product sources. In addition to providing neuroprotective properties, some natural products may enhance cognitive function by acting on neurotransmitters. Finally, there are many natural products that contain multiple compounds with synergistic effects enhancing their therapeutic outcomes, providing a multitarget strategy for the treatment of chronic and complex diseases involving multiple biological pathways. Advances in pharmaceutical sciences have allowed for the development of various types of natural products for use as therapies in supporting cardiovascular health and improving brain function. Thus, natural products will remain as promising therapeutic strategies for the treatment of many chronic and degenerative diseases. (Ekor, 2014)

Antimicrobial and anticancer activities

Pharmaceutical researchers are discovering more ways to use natural products, because they have both very good antimicrobial activities and anticancer activities. These natural products can come from plants, microorganisms, or marine organisms, and their large diversity of chemical structures allows these natural products to interact with many different types of biological targets. Antimicrobial activity shows that a compound can either stop the growth of, or kill pathogenic microorganisms, including bacteria, fungi, viruses, and parasites. This type of activity is especially important now, because the rise of antimicrobial resistance among microorganisms is becoming a more severe public health threat worldwide. Some natural products exert their antimicrobial activity by disrupting the cellular membranes of microbes (bacteria, viruses, and fungi), stopping the working of some enzymes produced by the microbes, or by preventing the replication of the microbes' DNA. On the other hand, anticancer activity refers to the ability of a compound to prevent, hinder, or halt the growth of cancerous cells. Natural products can also induce apoptosis (death) in cancer cells, prevent the proliferation of cancer cells, and prevent the movement of any cancerous cells to distant tissues (also referred to as metastases). Natural products such as alkaloids, flavonoids, terpenoids, and phenolic compounds have been shown to have very strong antimicrobial and anticancer activities. The presence of multiple mechanisms by which natural products work contributes to their importance to the pharmaceutical industry in the search for new drug candidates. Therefore, natural products will continue to be one of the most important sources of new antimicrobial and anticancer agents developed in contemporary medicine. (Wright et al., 2014)

The medicinal qualities of many plants can be beneficial since these plants have produced secondary metabolites that are able to kill bacteria,

fungi, and viruses. Several of the different types of secondary metabolites found in the various types of plants include tannins, flavonoids, saponins, and alkaloids. These same secondary metabolites can also inhibit the growth and survival of microbes. In addition to their antimicrobial effects, many plant-derived compounds such as vincristine, vinblastine, and paclitaxel, have been the foundation for the development of drugs used to treat cancer via chemotherapy. These drugs work by targeting the dividing cells of cancerous tumours; thereby promoting apoptosis in tumour cells and preventing the progression of the disease. Identifying potential medicinal plants by conducting ethnobotanical studies is important as the active ingredients in the plants are then able to undergo research to determine their pharmacological activity. As a result of the diverse nature of the structures of the compounds produced by plants, they can be used for drug design and development; additionally, many plant-derived medicines are generally regarded as less toxic than synthetic medicines and result in fewer adverse reactions. Phytochemical advances have also contributed to the advancement of research methods that have improved both the identification and isolation of active compounds from the plants. Thus, due to the above reasons, a major contributor in the ongoing search for new antimicrobial and anticancer agents within the pharmaceutical industry is through the use of plants. (Li et al., 2017)

There are also many types of microorganisms that produce many antibacterial and anticancer substances, but some examples would be different types of bacteria (e.g., Streptomyces) or fungi. Microorganism examples produce secondary metabolites (metabolic by-products) that help them defend themselves from competing microorganisms. These same secondary metabolites have been the basis of many antibiotics, including penicillin, streptomycin, and tetracycline, all of which have caused profound changes in modern medicine. In addition to having antibacterial activities, these secondary metabolites can also act as antitumors by inhibiting the growth of tumor cells or by promoting a type of cell death known as programmed cell death (apoptosis). Many actinomycetes are well-known for producing bioactive compounds that could be used for medicinal purposes. Improvements in technology, including advancements in the area of microbial fermentation and in recombinant DNA technology (genetically engineering organisms), have led to the ability to produce and identify many more microbial metabolites. Methods such as genome mining have also allowed scientists to discover new classes of biosynthetic gene clusters that would code for the production of bioactive compounds. Overall, these advances in microbiology have produced greater opportunities for the use of microorganisms as a source of novel pharmaceuticals. Identifying the diverse classes of microorganisms is critical for meeting the global needs in the fight against infectious diseases and cancers, and, therefore, microorganisms are still a major foundation of antimicrobial and anticancer drug discovery. (Santos et al., 2019)

Due to their abundant and varied chemical make-up, marine organisms have become a vibrant source of anti-microbial and anti-cancer agents. Marine life has developed unique biochemical properties from living in an extreme environment, which allows for the production of substantial quantities of structurally unique biological substances. Marine sponges, algae, and bacteria are some of the most prolific sources of biochemicals with strong pharmaceutical characteristics. Numerous marine-derived chemicals exhibit strong anti-cancer effects through their influence on

various anti-cancer processes, including disruption of the cell cycle and induction of programmed cell death. Many marine compounds also possess strong anti-microbial properties against drug-resistant microbes. For example, sponges contain active agents demonstrating potent anti-bacterial and anti-viral activity. The exploration of the marine ecosystem has yielded numerous potential drug candidates presently undergoing clinical investigations. However, the limited accessibility of marine ecosystems and the necessity for sustainable harvesting remain significant hurdles to the utilization of marine life for drug development. In order to maximize the utilization and meet the challenges, both marine biotechnology and synthetic approaches are being employed to create these compounds in laboratory settings. As marine ecosystems are continuing to provide us with unique sources of new anti-microbial and anti-cancer agents, they are also largely unexplored ecosystems. (Abdelmohsen et al., 2017)

The constant improvement of technology and ways to conduct research has led to the evolution of natural products' antimicrobial and anticancer activities, especially in case of utilizing modern methods like high-throughput screening, molecular docking and bioinformatics for discovering new drug candidates. Modern technology gives scientists the ability to utilize and analyse thousands of natural compounds and see how they work against microbial and cancer targets. In addition, nanotechnology-based drug delivery systems have also improved the bioavailability, stability, and effectiveness of natural products by enhancing their solubility, stability, and targeted delivery mechanisms. Despite the potential of natural products as promising therapeutics, hurdles still persist including their low bioavailability, toxic potential, and variability due to different sources of natural products. Thus, there needs to be standardisation and control methods in place so that therapeutic outcomes are consistent among similar natural products. Biotechnological methods, such as metabolic engineering and synthetic biology, have been utilised in order to enhance the production of bioactive compounds. Through the combination of traditional knowledge and modern science, the processes for discovering new drugs have been accelerated. Natural products are still an important source of antimicrobial and anticancer agents with great potential for the development of future pharmaceuticals. (Koehn & Carter, 2005)

Conclusion

Natural products, which have a basis in pharmaceutics, make up an important part of the modern discovery of drugs and therapeutics because of their vast amount of chemical variation and the number of biological effects that they can produce. Biosourced from natural origins (plants, microorganisms, marine animal organisms, and animals), natural products have an enormous impact on the creation of many pharmaceuticals used daily by people to survive. These natural products are capable of being used to treat various types of diseases and physical afflictions and can have properties that lead to a wide range of benefits including anti-bacterial, anti-cancer, anti-inflammatory (auf), antioxidant, and immunomodulatory effects. The benefit of utilizing bioactive molecules (natural products) in drug development has uniquely positioned them to aid in solving current and emerging health risks that mankind will face in the present and future. Unfortunately, despite all of the potential for bioactives to be used as therapeutic agents, the utility of many bioactive (natural) products have been limited by several different factors including poor solubility, low bioavailability, lack of stability, and varying compositions. However, recent developments in the field of pharmacy/discovery of

drugs through shipping and innovative methods (e.g., utilizing nanoparticles to deliver medication, use of liposomes to deliver medication, use of controlled release formulations for medications) have provided valuable solutions to making bioactive products more effective and safer. There has also been an improvement in the ability to identify, extract, and standardize bioactive molecules through the development of new laboratory methods for analyzing drug and identificating bioactive materials. The combined use of knowledge of Traditional Medicines (TM) with the application of pharmacological sciences has also improved the methods used in drug discovery.

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