Nature's Pharmacy: Biodiversity as a Source of Healing

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Abstract

The potential of biodiversity as a medicinal resource is boundless, and it is sometimes referred to as nature's pharmacy. For decades, people have utilized plants, animals, and microorganisms for therapeutic reasons; in fact, the raw materials for many modern drugs come from natural sources. Many biologically active substances found in the diversity of life on Earth might be used to develop new treatments for a range of diseases. This connection between healing and biodiversity emphasizes the need to promote sustainable behaviors and conserve ecosystems to ensure that these natural riches are available for future generations. Understanding biodiversity's role in medicine can help people appreciate nature and how it might improve human health by combining cutting-edge scientific research with traditional knowledge. Preserving biodiversity is therefore but also essential for public health, highlighting the significance of conservation efforts and sustainable practices to guarantee ongoing access to these therapeutic resources.

Keywords: Biodiversity, Healing, Natural resources, Medicinal research, Ethnobotany

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Introduction

Biodiversity is defined as a variety of plants, animals, and microorganisms living in an ecosystem that plays a critical role in the field of pharmacy. Natural compounds from plants, animals, and microorganisms are crucial sources of new drug candidates. Throughout human history, nature has been recognized as a wealth of resources for meeting a variety of human needs, including medical ones. From 1981 to 2010, around half of all medications approved by the US Food and Drug Administration came from pure extracts of natural products or their derivatives (Audah, 2019). Many of the modern medicines have their origins in traditional medicine. The relationship between society, nature, and environmental health to human health has recently been widely recognized. The loss of biodiversity has an indirect impact on human well-being. Overexploitation, pollution, invasive species, habitat loss and degradation, habitat fragmentation, and climate change are the main threats to biodiversity. Significant biodiversity losses and changes have resulted from the use and transformation of renewable and non-renewable natural resources to support the current global economic expansion, which has also created tensions between biodiversity conservation and development (Carranza et al., 2020). This chapter aims to emphasize the vital role of biodiversity in medical research and drug discovery, and to advocate for its conservation as a means of ensuring long-term access to natural therapeutic resources.

Historical use of Plants and Animals in Healing

Since at least 2600 BC, natural products have been utilized for medical reasons and have greatly influenced the creation of contemporary medicine, however many of the present empirical criteria and filters do not account for molecules with a diversity of characteristics. Natural products like alkaloids, which are basic, cyclic organic molecules with nitrogen in their ring structures, are especially affected by this. Plant-based classification is also employed, even though many alkaloids are categorized based on their molecular skeletons.

Unique lead compounds for medicine were supplied by alkaloids. Because of their basic characteristics, they dissolve in water in acidic environments and lipids in basic and neural environments. For membrane penetration in deprotonated form and dissolution in protonated form, this is particularly crucial. A wide range of chemical structures are produced by the biosynthesis of alkaloids, which are mostly extracted from plants. The nineteenth and twentieth centuries saw a sharp increase in the utilization of natural materials in pharmaceuticals, which enabled researchers to find active compounds in medicinal plants and animals (Heinrich et al., 2021).

Modern Pharmaceutical Products Derived from Nature

PLANT-DERIVED MEDICINES

Numerous natural compounds with diverse medicinal qualities can be found in plants, and these are constantly being investigated for the development of new medications. To cure a wide range of illnesses, traditional medicines have long relied on these natural compounds. Nowadays, the majority of pharmaceutical drugs are made from these natural ingredients. There are several bioactive chemicals found in natural products. Biological action against various disease-causing substances is imparted by these bioactive chemicals. Approximately 70,000 medicinal plants have been utilized, mostly in Asian remedies (Nasim et al., 2022; Jamil et al., 2024a).

Bioactive Phytochemicals

The third most common type of cancer, colon cancer, is brought on by a combination of environmental, genetic, and dietary factors. Delaying tumor development, controlling adverse effects from chemotherapy and radiation therapy, and acting at the molecular level are just a few of the well-known methods by which plant-based chemicals might regress colon cancer.

Medicinal plants contain numerous bioactive phytochemicals, including quercetin, luteOlin, kaempferol, lutein, glycosides, polysaccharides, carnosic acid, oleanolic acid, rosmarinic acid, catechins, caffeic acid, flavonoids, eugenol, curcumin (Jamil et al., 2024b), saponins, anthricin, and polyphenols, triterpenoids, alkaloids, and polyphenols. By activating initiator and executioner caspase, these bioactive substances can promote apoptosis and inhibit cell cycle checkpoints, among other processes, which can decrease the growth of tumor cells. Traditional medicines have been utilized to treat cancer throughout the world because of their anti-inflammatory, anti-cancer, anti-mutagenic, and anti-antigenic qualities (Esmeeta et al., 2022).

Aspirin

Acetylsalicylic acid, another name for aspirin, is a common prescription drug used to treat pain, fever, and inflammation. It functions by blocking mammalian cells' and tissues' production of thromboxane and prostaglandins. It is among the most often used pharmaceuticals that are chemically synthesized worldwide. Remarkably, aspirin's history dates back 3,500 years, when willow bark was used as an antipyretic and pain treatment (Montinari et al., 2021).

Paclitaxel

While paclitaxel has strong anticancer activity, its use is challenging due to its hydrophobic properties and low solubility in water paclitaxel, is a secondary metabolite produced by the genus Taxus, and was first isolated from the Pacific yew in 1971. Due to its strong anticancer activity, it was approved for use by the FDA in 1993 for the treatment of several malignancies, including lung, ovarian, and breast cancer. Disappointedly, plants in the genus Taxus grow slowly; a plant may take 200 years to achieve a respectable size, such as 40 feet in height (Gallego-Jara et al., 2020).

Morphine

When morphine, the first pure and natural plant-derived molecule, was isolated from Papaversomniferum in 1803, the drug discovery period officially began. It is used as a powerful analgesic (Li, 2022).

ANIMAL-DERIVED MEDICINE

The extensive therapeutic arsenal that animals and their byproducts offer has long been utilized in traditional medicine. In traditional medicine around the world, they also provide therapeutic compounds. These could be animal components like organs, glands, tissues, or hormones. Here are a few examples of medicines made from animals. In many parts of the world, animal-derived remedies are an essential component of folk medicine, especially for those who have little or no access to mainstream medical care. However, their contribution to healthcare has typically been disregarded in conversations about public health, faunistic resource conservation and management, and ecosystem preservation (Kinter *et al.,* 2021).

Insulin

Originally, it was obtained from pig and cow pancreas. Both the history of diabetes and medicine in general have seen significant advancements since the discovery of insulin. Historical scientific accomplishments that have saved and enhanced the lives of millions of people have characterized their evolution. Due to a persistent and extremely successful effort, a new insulin formulation has been made accessible roughly every 8 to 12 years for the previous 100 years.

Immediately following its discovery, insulin was the first hormone to be purified for human use, the first to have its amino acid sequence unraveled and synthesized using a DNA-recombinant process, and the first to have its amino acid sequence altered to alter its duration of action. Consequently, the discovery of insulin marks a turning moment in the history of medicine. To accurately replicate the changes in diurnal physiological plasma insulin, insulin's pharmacokinetic and pharmacodynamic characteristics have been refined since its inception (Falcetta et al., 2022).

Plasma-derived Hepatitis B Vaccine

Liver disorders that are extremely important to people in most parts of the world are caused by human hepatitis B virus (HBV) infections. A viral carrier state, which frequently develops into acute viral infection can cause severe sickness and sometimes death in a tiny percentage of infected persons, chronic liver disease with cirrhosis and hepatocarcinoma 15-30 years after the first infection has more catastrophic consequences. Hepatitis B vaccines that employ plasma from people who have recovered from HBV infection are known as plasma-derived vaccines. Because the plasma contains antibodies, the vaccinated person's immune system is stimulated, protecting them from infection in the future (Hilleman, 2024).

Hypothyroidism Treatment

Insufficient production of thyroid hormones by thyroid glands is known as hypothyroidism. In the US, one out of every 300 people have clinical hypothyroidism; the frequency is higher in older and female patients. Cold intolerance, exhaustion, weight gain, dry skin, constipation, and voice changes are frequent symptoms, which can range from minor to fatal (myxedema coma). Since the symptoms of thyroid dysfunction are ambiguous and nondiagnostic, particularly in the early stages of the disease, a diagnosis is made based on the levels of free thyroxin and thyroid-stimulating hormone in the blood. There is no proof that screening the population is helpful. Taking synthetic thyroid hormones to

replace the hormone that is lacking is the usual treatment for hypothyroidism. The initial dosage of levothyroxine replacement therapy is 1.5 to 1.8 mcg per kg per day, which relieves symptoms and returns thyroid-stimulating hormone levels to normal. Even in patients who have normal thyroid-stimulating hormone levels and ongoing symptoms, adding triiodothyronine is not advised. Less levothyroxine (12.5 to 50 mcg daily) should be administered to patients over 60 or who have known or suspected of ischemic heart disease. If a woman with hypothyroidism becomes pregnant, she should take one extra dose twice a week, increasing her weekly dosage by 30% to nine doses. She should then be evaluated and managed monthly. After receiving the recommended dosage of levothyroxine, patients who still experience symptoms should be evaluated for other reasons or referred. Myxedema coma must be identified early to receive proper care. For most individuals with subclinical hypothyroidism, treatment is unsuccessful unless the thyroid peroxidase antibody or thyroid-stimulating hormone level is elevated over 10 mIU/L (Wilson, 2021).

Microorganism Derived Medicines

Microorganism has been a rich source of medicines, and many life-saving drugs have been derived from it. They are used to develop vaccines that prevent infectious diseases.

Streptomycin

Streptomyces griseous is the source of the aminoglycoside antibiotic streptomycin. Before the development of more potent medications, streptomycin was first used to treat tuberculosis. The way streptomycin works is by attaching itself to the bacterial ribosome's 30S subunit and generating genetic code misreading. With cell-free ribosomal reaction mixes that can translate in vitro using a combination of radiolabeled and non-radiolabeled aminoacyl t-RNA, the frequency of codon misreading can be measured. The mechanisms behind streptomycin resistance include mutations in the S12 ribosomal subunit, streptomycin-inactivating enzymes, and multidrug efflux pumps (Nagarajan, 2024).

Tetracycline

A significant class of broad-spectrum antibiotics, tetracyclines stop bacteria from growing by preventing the creation of proteins. It is applied to several bacterial illnesses. Compounds in this broad family have bacteriostatic action and a variety of applications, ranging from intracellular organisms and protozoan parasite infections to Gram-positive and Gram-negative bacterial infections. Being the sole antibiotic in the tetracycline class with a restricted spectrum, sarecycline is special. The fundamental building block of tetracycline is a hydronaphtacene nucleus with four linearly condensed benzene rings (Ramachanderan, 2021).

Erythromycin

With significant internal and external therapeutic applications, ERY is a broad-spectrum antibiotic. The medication erythromycin (ERY), which was first discovered by McGuire et al. in 1939, is a member of the macrolide antibiotic class. After fermentation, it is produced by biosynthesis from species of the Gram-positive *Saccharopolyspora erythraea*, formerly *Streptomyces erythraeus*. There are several structural variations in the erythromycin group produced by bacterial strains, including ERY A, B, C, D, E, F, and G (Platon, 2022).

Success Stories of Some Natural Medicines

Artemisinin

The sweet Artemisia plant Artemisia annual L. yields Artemisinin (ARS), a natural sesquiterpene lactone that has been used for thousands of years in Chinese traditional medicine to treat chills and fevers. Artemisinin is an essential component of artemisiaannua, a traditional Chinese medicine that has been used for centuries to treat malaria in China. Artemisinin and its derivatives' anticancer qualities have also been documented in recent years. The study of artemisinin and its derivatives as anticancer drugs, including both synthetic and natural monomers and their dimers, has been included in this review. It further emphasizes the anticancer properties of artemisinin and its derivatives following site modification or conversion to a nano-delivery method. Further investigation into their possible mechanisms of action and the clinical trials of ARTs for cancer treatment have also been covered, which will help with the creation of new anticancer medications based on the artemisinin scaffold (Zeng et al., 2023).

Cortisol

Cortisol is a crucial glucocorticoid hormone that is produced by the adrenal glands and is necessary for several physiological processes. A complex neuroendocrine system responsible for stress response and homeostasis, the hypothalamic–pituitary–adrenal (HPA) axis, is triggered by the suprachiasmatic nucleus's meticulously regulated release, which also regulates the circadian cycle. Changes in cortisol regulation caused by disease, aging, and long-term stress have a big effect on many physiological systems. In large part, animal models have helped to clarify these complex cortisol changes during stress and shed light on the interplay of immunological, neuroendocrine, and physiological components in the stress response. Underscoring the importance of social factors in this process, these models have also shown how other pressures, such as social hierarchies, impact cortisol levels. Moreover, deregulation and excessive cortisol production are closely associated with chronic stress. The complex link between major depressive illness and cortisol dysregulation is typified by persistent inflammation and hyperactivity of the HPA axis. Lastly, chronic pain is associated with abnormal cortisol patterns that heighten pain sensitivity and susceptibility. Understanding these multifaceted mechanisms and their effects is essential, as they offer insights into potential interventions to mitigate the detrimental consequences of chronic stress and cortisol deregulation in these conditions (Knezevic et al., 2023).

Statins

Since statins are strong competitive inhibitors of 3-hydroxy-3-methyl-glutaryl-CoA (HMG-CoA) reeducates (HMGCR), they are often used as lipid-lowering drugs. Either food ingestion or cell-based de novo synthesis is the source of human plasma cholesterol. Statins reduce plasma

cholesterol levels by changing the expression of the low-density lipoprotein (LDL) receptor and reducing the generation of new cholesterol. Statins, being competitive inhibitors of HMG-CoA reductase (HMGCR), have pleiotropic effects that are distinct from their lipid-reducing effects, in addition to lowering cholesterol and improving cardiovascular risk.

Among these, statins' anti-cancer qualities have garnered a lot of interest and hinted at their potential as repurposed medications for cancer treatment. Numerous clinical and epidemiological research have detailed statins' anticancer qualities; nonetheless, there is conflicting evidence regarding their efficacy in preventing cancer. Perhaps some cancers are more susceptible to statin therapy than others due to their molecular subtypes. Research on statins' potential clinical anticancer effects is still ongoing. In the context of combination cancer therapy, statins should be taken into consideration because they seem to improve the effectiveness and resolve the drawbacks of traditional cancer treatments (Jiang *et al.*, 2021).

Ethnobotany

Ethnobotany is the study of how plants are used by humans from various cultures. For various purposes, such as food, medicine, clothing, and rituals. It combines aspects of anthropology, botany, and ecology to understand the relationships between humans and plants. Ethnobotanists explore how traditional knowledge about plants has been passed down through generations and how it shapes societies' interactions with the natural world (Leonti, 2022).

Ethnobotany of Medicinal Plants in the Surghar Range of Pakistan

To investigate and record the therapeutic plants utilized by the indigenous ethnic communities of Pakistan's Surghar Range, a thorough ethnobotanical study was conducted for the first time. The study region is next to the Salt Range, which is located in Pakistan's southernmost Himalayan Range. Although indigenous communities employ a wide variety of medicinal plants, their cultural history, and herbal medicines, there is no specific ethnobotanical research from this particular area because ethnobotany is still developing in Pakistan.

There are 417 plants in all, from 89 families, that are used ethnobotanically by ethnic groups. The majority of herbal treatments (33%) were made via decoction. Cardiovascular problems rated 0.7 on the ICF, followed by ENT illnesses (0.6). Species such as *Berberis lyceum*, *Forsskaolea tenacissima*, *Kickxia ramosissima*, *Momordica balsamina*, *Monotheca buxifolia*, *Pseudogaillonia hymenostephana*, *Rumex vesicarius*, *Ocimum americanum*, and *Schweinfurthia papilionacea* have shown potential pharmacological properties. It is recommended that *Viola cinerea* be studied further, as it presents an intriguing target for drug development.

The study found that the study region contains enough indigenous knowledge about the plants that the Aboriginal people employ as medicine. It is necessary to conserve their traditional knowledge of medicinal plants and confirm it by phytochemical and pharmacological screening to identify bioactive components (Rahim *et al.*, 2023).

Case Studies of Traditional Healing Practices

Traditional healing practices have been used for centuries across different cultures worldwide. Here are some case studies that provide insight into various approaches to healing, emphasizing the cultural significance and the methods employed:

TCM (traditional Chinese medicine)

TCM is a system of medicine that dates back over 2,000 years. It emphasizes the balance of the body's energy (Qi) and the use of acupuncture, herbal remedies, dietary therapy, and exercises like Tai Chi and Qigong.

A recent epidemic of the new coronavirus (SARS-CoV2) in over 200 countries resulted in highly contagious and dangerous viral pneumonia. TCM successfully offers ongoing prevention and therapy, and the Chinese government suggests that Western medication and Traditional Chinese medicine (TCM) be used in tandem to treat SARS-CoV2-induced pneumonia.

The use of TCM can help prevent COVID-19, and medical professionals can help avoid iatrogenic infections by making a decision based on the principles of TCM. As of March 13, 2020, new cases of COVID-19 in China have decreased in number to single digits. TCM's curative effect was outstanding, with a national participation rate of over 90%. More than 70,000 people were cured of COVID-19 and discharged from the hospital. Only approximately 10,000 Treatment for the patients is now underway, and it will take around two months in total (Wang *et al.*, 2021).

Traditional African Medicine - Herbal and Spiritual Healing

Traditional African medicine involves the use of herbal remedies, spiritual healing, and rituals performed by healers known as Sangomas (in Southern Africa) or Babalawos (in West Africa). This system of healing is deeply rooted in spirituality and ancestral connections.

In rural parts of South Africa, Sangomas have long-treated conditions such as tuberculosis, malaria, and HIV/AIDS. A case study from the University of KwaZulu-Natal showed that Sangomas' treatments, particularly those involving local plants like *Sutherlandiafrutescens*, helped manage symptoms of chronic diseases and enhanced the overall quality of life for patients (Tosam, 2021).

Shamanic Healing in the Amazon Rainforest

In the Amazon, shamans use ayahuasca, a psychoactive plant medicine, to facilitate healing. This practice involves spiritual journeys aimed at gaining insight, wisdom, and guidance. The study examined the use of ayahuasca in treating depression. This study found that individuals who underwent ayahuasca ceremonies experienced significant reductions in depressive symptoms, with many participants reporting long-term improvements in mental health (Montalvo, 2022).

The Decline of Biodiversity and its Implication for Medicines

The loss of biodiversity is a serious issue that has wide-ranging effects, especially in the medical area. Maintaining ecosystems and supplying resources for human health, including the creation of medications, depend on biodiversity, which is the variety of life on Earth. This is how medicine and healthcare might be affected if it were lost:

Loss of Medicinal Plants and Animals: Numerous contemporary medications come from natural sources, such as bacteria, fungi, plants, and animals. A famous example is the development of aspirin from willow tree bark or the cancer drug paclitaxel, which originates from the Pacific yew tree. Potential new medications might never be found when species become extinct or dwindle.

1. **Disruption of Ecosystem Services**: Healthy ecosystems provide a wide range of services, such as purifying air and water, regulating climate, and controlling diseases. Disruptions to biodiversity can affect these services, which may indirectly impact the production of medicines, particularly those that rely on certain ecological functions.
2. **Loss of Genetic Resources**: Genetic diversity within species is critical for developing disease-resistant crops, livestock, and even human treatments. Biodiversity loss reduces this genetic pool, which can limit the development of new therapies and vaccines, especially in response to emerging diseases.
3. **The Emergence of New Diseases**: When ecosystems are disrupted, new pathogens (like viruses or bacteria) can emerge and spread more easily. Loss of biodiversity can upset the balance of species, potentially leading to more frequent zoonotic diseases (diseases that jump from animals to humans). This creates a need for new drugs and vaccines, but reducing biodiversity makes it harder to find those solutions.
4. **Traditional Medicine**: Many Indigenous and local communities rely on biodiversity for their traditional medicinal practices. The decline in biodiversity could erode this knowledge, which has been passed down for generations and has often provided valuable insights for modern drug discovery (Heinrich *et al.*, 2021).

Consequences of Decline of Biodiversity for Future Drug Development

The decline of biodiversity can have significant consequences for future drug development. Many pharmaceutical drugs are derived from natural sources, such as plants, fungi, bacteria, and marine organisms. These organisms often contain unique compounds with medicinal properties that have led to groundbreaking treatments. If biodiversity continues to decline, we could face several negative outcomes for drug development:

Loss of Novel Drug Candidates: Antibiotics, anticancer medications, and painkillers are just a few of the modern medicines that have their roots in nature. One example is the paclitaxel (Taxol), a cancer medication that was first made from Pacific yew bark. We risk losing untapped natural resources that may have produced useful new medications if species become extinct.

Reduction in Chemical Diversity: A vast variety of chemical substances may be found in biodiversity. A species' potential pool of unique compounds that might be used as templates for creating novel medications increases with species diversity. This variety is diminished when species are lost, and the potential for finding novel medicinal chemicals is thus constrained.

Disruption of Ecosystems and Traditional Knowledge: Traditional treatments have been developed by many indigenous cultures based on the biodiversity of the region. These traditions are impacted by biodiversity loss, and invaluable ethnobotanical information that has been passed down through the centuries may be lost. Moreover, the loss of ecosystems might disturb the symbiotic relationships between species that could promote the synthesis of medicinal compounds.

1. **Impairment of Medical Research** Studying organisms in their natural environments leads to the discovery of many medications. Less time is available for bioprospecting and studying new species as a result of habitat degradation. It will be more difficult for researchers to find novel medications without access to varied habitats.
2. **Increased Resistance and Reduced Effectiveness of Existing Drugs**: The loss of biodiversity can also negatively impact the development of treatments for emerging diseases. For example, the decline of insect diversity may reduce the effectiveness of certain treatments for insect-borne diseases, as the interactions between species may influence how diseases spread or how effectively treatments work (Ferreira et al., 2023).

Importance of Conservation of Biodiversity for Drug Development

The conservation of biodiversity is crucial for drug development for several reasons:

1. **Source of New Medicines**: Many of the drugs we rely on today come from natural sources like plants, animals, fungi, and microorganisms. For example, compounds derived from the bark of the *Taxus* tree have been used to develop the chemotherapy drug paclitaxel. If species that produce these compounds become extinct or endangered, we lose a potential source of life-saving drugs.
2. **Untapped Potential**: Countless species in the world have yet to be studied or even discovered. These organisms may hold unique biochemical properties that could lead to breakthroughs in treatments for diseases that currently have no cure, such as cancer, HIV, or rare genetic disorders. Biodiversity is a treasure trove of untapped potential for pharmaceutical development.

Ecological Balance: The biodiversity of ecosystems supports processes like pollination, soil health, and water purification. Nutritious ecosystems sustain the plants and animals we use to make novel medications. Ecosystems may collapse due to biodiversity loss, endangering these functions and potentially affecting the amount and quality of medicinal resources.

Traditional Medicine: For many years, many indigenous groups have employed local plants and animals as remedies. By preserving these species, vital insights into potential treatments can be gained from the traditional wisdom that has been passed down through the ages.

Ecosystem Resilience: Biologically diverse ecosystems are more resilient to environmental changes. Since different organisms may thrive in different conditions, providing a broader diversity of resources, a varied range of species increases the probability of finding new chemicals with therapeutic potential (Linhares *et al.*, 2023).

Conclusion

In conclusion, nature is a vast and invaluable source of healing due to the range of plant, animal, and microbial resources present in its biodiversity. The world's many ecosystems have produced a large number of compounds with therapeutic potential, many of which have been used in traditional medicine for thousands of years and are now being researched for use in modern pharmaceutical applications. Conserving biodiversity is crucial to ensuring that these resources will be accessible for consumption by future generations as well as preserving environmental stability. By protecting ecosystems and promoting sustainable behaviors, we can improve our chances of discovering new therapeutic agents and deepening our understanding of medicine. Therefore, biodiversity is essential to ecological health, medical advancement, and human well-being.

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