

## Applications of Artificial Intelligence in Analyzing and Identifying Beneficial Bacteria and Their Role in Human Health and the Environment

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### Abstract

The application of artificial intelligence in the analysis and identification of beneficial bacteria is an advanced field that contributes greatly to improving human health and understanding their environmental impacts. Artificial intelligence techniques, such as machine learning and big data analysis, enable the classification of beneficial bacteria and the study of their interaction with the human microbiome. Research indicates that these bacteria play a vital role in enhancing the immune system, preventing digestive and immune diseases, and improving overall health balance. Moreover, recent studies have shown that artificial intelligence can help identify beneficial bacteria strains that may contribute to the treatment of chronic diseases such as diabetes and heart disease, in addition to providing personalized solutions for the treatment of some immune disorders, as complex medical and microbiological data are analyzed to provide accurate results related to the impact of the microbiome on health.

With regard to neurological diseases and cancer, artificial intelligence shows promising potential in determining how beneficial bacteria affect the growth of cancer cells as well as interacting with the nervous system in diseases such as Alzheimer's disease. The use of these techniques contributes to accelerating the discovery of microbial drugs and the development of new treatments.

Overall, it can be said that artificial intelligence represents a pivotal tool in enhancing a deep understanding of the health impact of beneficial bacteria, which contributes to the development of targeted and effective treatments, and opens new horizons in the medical and therapeutic field.

**Keywords:** Artificial Intelligence, Beneficial Bacteria, Human Microbiome, Public Health, Environmental Pollution

### تطبيقات الذكاء الاصطناعي في تحليل وتحديد البكتيريا النافعة ودورها في صحة الإنسان والبيئة

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### المستخلص

تُعد تطبيقات الذكاء الاصطناعي في تحليل وتحديد البكتيريا النافعة مجالاً متقدماً يساهم بشكل كبير في تحسين الصحة البشرية وفهم تأثيراتها البيئية. تمكّن تقنيات الذكاء الاصطناعي، مثل التعلم الآلي وتحليل البيانات الضخمة، من تصنيف البكتيريا النافعة ودراسة تفاعلها مع الميكروبيوم البشري. تشير الأبحاث إلى أن هذه البكتيريا تلعب دوراً حيوياً في تعزيز جهاز المناعة، الوقاية من الأمراض الهضمية والمناعية، وتحسين التوازن الصحي العام. إذ، أظهرت الدراسات الحديثة أن الذكاء الاصطناعي يمكن أن يساعد في تحديد سلالات البكتيريا النافعة التي قد تساهم في علاج الأمراض المزمنة مثل السكري وأمراض القلب، بالإضافة إلى تقديم حلول شخصية لعلاج بعض الاضطرابات المناعية، إذ يتم تحليل بيانات طبية وميكروبيولوجية معقدة لتوفير نتائج دقيقة تتعلق بتأثير الميكروبيوم على الصحة.

فيما يخص الأمراض العصبية والسرطان، يُظهر الذكاء الاصطناعي إمكانيات واعدة في تحديد كيفية تأثير البكتيريا النافعة على نمو الخلايا السرطانية وكذلك التفاعل مع الجهاز العصبي في الأمراض مثل مرض

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الزهايمر. يساهم استخدام هذه التقنيات في تسريع اكتشاف الأدوية الميكروبية وتطوير علاجات جديدة. بشكل عام، يمكن القول إن الذكاء الاصطناعي يمثل أداة محورية في تعزيز الفهم العميق للأثر الصحي للبكتيريا النافعة، مما يساهم في تطوير علاجات موجهة وفعالة، وفتح آفاق جديدة في المجال الطبي والعلاجي.

**الكلمات المفتاحية :** الذكاء الاصطناعي، البكتيريا المفيدة، بيولوجيا الإنسان، الصحة العامة، التلوث البيئي

## Introduction

Beneficial bacteria are an essential part of the human and environmental ecosystem, playing a major role in maintaining human health and enhancing immunity, and contributing to improving the environment in general [1]. With the advancement of computing science, it has become possible to use artificial intelligence to analyze and identify these bacteria more accurately and effectively [2]. In this context, artificial intelligence techniques, such as machine learning and neural networks, are employed to classify and understand the impact of beneficial bacteria on public health, including treating digestive and immune disorders [3]. These techniques also help study the relationship between the human microbiome and the surrounding environment, thus providing solutions to health and environmental problems [4].

By studying the impact of these beneficial bacteria on the environment, artificial intelligence techniques contribute to improving our understanding of how microbial interactions affect soil and water, which enhances environmental sustainability and reduces environmental pollution [5]. AI also helps in developing innovative treatments for chronic diseases, by identifying specific strains of bacteria that can contribute to prevention and treatment [6]. In addition, AI techniques contribute to accelerating the discovery

of new and specific drugs for chronic diseases [7]. Therefore, the aim of the current study is to review the applications of AI in the analysis and identification of beneficial bacteria, with a focus on their health and environmental effects. The study will seek to provide a comprehensive view of the growing role of these technologies in improving our understanding of beneficial bacteria and their use in innovative health and environmental applications.

## The role of artificial intelligence techniques in enhancing the understanding, classification and analysis of beneficial bacteria

Artificial intelligence techniques, such as machine learning and big data analysis, contribute to improving the process of classifying and analyzing beneficial bacteria that play a key role in maintaining public health. Using artificial intelligence models, beneficial bacteria can be identified and provide accurate insights into their environmental and health effects. Technologies such as deep neural networks and expert systems can help researchers predict the interactions of these bacteria in the body and analyze their microenvironments. This deep understanding enhances the ability to develop targeted treatments and improve prevention strategies for diseases associated with harmful bacteria, Figure 1 and 2 show a graphic of the role of artificial intelligence in promoting body health.



**Figure (1): The Role of Artificial Intelligence in Supporting Disease Diagnosis and Enhancing Healthcare**



**Figure (2): Utilizing Artificial Intelligence for Medical Data Analysis and Health Pattern Recognition**

### **1- Artificial Intelligence in Classification and Analysis of Beneficial Bacteria**

Recent years have witnessed a remarkable development in the use of artificial intelligence in the classification and analysis of beneficial bacteria, which contributed to improving the accuracy and speed in identifying their different strains. It began with studies that combined

artificial intelligence and genomics to discover and classify beneficial bacteria, as research results showed that integrative models contribute effectively to improving the process of identifying probiotic strains [8]. This was followed by a development in the use of support vector machines to classify probiotic bacteria strains with high accuracy based on their genetic and functional data

[9]. Big data analysis also contributed to improving the understanding of microbial communities and identifying the genetic patterns of beneficial bacteria, which led to expanding their biological applications [10].

Later, the focus began on improving the process of selecting probiotic strains using artificial intelligence, as studies emphasized the importance of employing machine learning techniques in developing more accurate strategies for selecting beneficial bacteria [11]. With the development of deep neural networks, these techniques have become more efficient in analyzing environmental samples and classifying beneficial microorganisms based on their genetic and functional characteristics [12]. AI capabilities in this field have also been enhanced by new applications in identifying and classifying probiotic bacteria using machine learning [13]. In recent studies, deep learning algorithms have helped improve the analysis of microbial genomes, increasing the accuracy of predicting the characteristics of beneficial bacteria and their health and environmental effects [14]. With this ongoing development, AI techniques are expected to continue to play a major role in improving our understanding of beneficial bacteria and their applications in various biological fields.

Finally, some recent studies have begun to use AI to analyze the effect of probiotics in cancer prevention, as probiotics can influence the growth of cancer cells through their immune and metabolic effects [15]. Other findings have shown that AI can help develop microbial therapies for neurological diseases such as Alzheimer's disease, by studying the interaction of probiotics with the nervous system ([16].

## 2- Artificial Intelligence in Studying the Effect of Beneficial Bacteria on Human Health

New studies have witnessed remarkable development in the use of artificial intelligence to analyze the effect of beneficial bacteria on human health, which has contributed to a deeper understanding of the relationships between the human microbiome and public health. Initially, artificial intelligence techniques, such as machine learning, were employed to extract patterns of interactions between beneficial bacteria and the digestive system, which demonstrated their effective role in promoting gut health [17]. Later, genetic analyses supported by artificial intelligence contributed to identifying strains of beneficial bacteria that can improve immune system responses and reduce chronic inflammation [18].

With the advancement of big data analysis technologies, it has become possible to predict the effect of the human microbiome on certain disease conditions, such as inflammatory bowel diseases, through artificial intelligence-based computational models [19]. These techniques have also helped identify the relationship between gastrointestinal disorders and changes in the composition of beneficial bacteria, paving the way for the development of personalized probiotic treatments for patients based on their personal microbial profiles ([20].

In recent years, deep neural networks have shown great ability to analyze the impact of the human microbiome on neurological health, as some bacterial species have been linked to improved brain function and reduced risk of neurological disorders, such as Parkinson's disease [21]. In addition, artificial intelligence has played an important role in the development of personalized probiotic treatment strategies, which has helped improve patients' health through accurate data-

based recommendations [22]. Finally, recent research has confirmed that the use of artificial intelligence techniques to study the complex interactions between beneficial bacteria and the human body contributes to the development of new diagnostic and therapeutic methods, which enhances public health [23].

### **3- Artificial Intelligence in Studying the Role of Beneficial Bacteria in Treating Environmental Pollution**

Artificial intelligence is a powerful tool for analyzing the role of beneficial bacteria in treating environmental pollution, as techniques such as machine learning and big data analysis can be used to study the interactions between microorganisms and environmental pollutants. Initially, studies used machine learning techniques to identify bacterial strains that have the ability to break down chemical pollutants such as heavy metals in soil and water [24]. This research contributed to understanding how beneficial bacteria can be used to remove pollution from the environment in more efficient and less costly ways compared to traditional methods [25].

Over time, artificial intelligence has begun to play a role in improving environmental processes using bacteria, by developing models to predict the effectiveness of certain strains in removing pollution. For example, artificial intelligence has been used to identify the most effective bacteria in removing organic pollution in wastewater [26]. Studies have also shown that artificial intelligence helps improve the process of biological composting using beneficial bacteria to reduce polluting gas emissions [27]. In recent years, AI techniques have been applied to analyze the effects of beneficial bacteria in environmental cleanup operations, such as removing oil from polluted

water. Studies have shown that AI can more accurately predict the success of bacterial strains in cleaning up oil-polluted environments [28]. The use of AI has also evolved to increase the effectiveness of bacteria that degrade plastic waste in the environment, offering innovative solutions to the ongoing problem of plastic pollution [29]. Finally, deep neural networks have helped identify beneficial bacteria that can treat a wide range of environmental pollutants, enhancing the potential of using bacterial microbiomes in sustainable environmental solutions [30].

### **4- Artificial Intelligence in Studying the Effect of Beneficial Bacteria on the Agricultural Environment and Improving Productivity**

Artificial intelligence contributes greatly to studying the effect of beneficial bacteria on the agricultural environment, as techniques such as machine learning and big data analysis are used to analyze the effect of these microorganisms in improving soil fertility and increasing agricultural productivity. Initially, artificial intelligence techniques were employed to analyze the effect of microbiome on plant growth, as studies have shown that beneficial bacteria can contribute to improving soil quality by fixing nitrogen and increasing the availability of nutrients to plants [31]. Research has also shown that artificial intelligence helps in identifying optimal bacterial strains that can be used to improve crop productivity [32].

On the other hand, advanced studies have shown that artificial intelligence can contribute to improving agricultural irrigation operations by analyzing the interaction of beneficial bacteria with soil and water, which contributes to reducing water consumption and increasing the efficiency of agricultural production [33]. Research has also

shown that AI technologies help improve the sustainable use of bacteria in the treatment of contaminated soil, as beneficial bacteria can be used to clean soil from toxins and improve its quality [34]. In recent years, AI technologies have been applied to analyze the role of beneficial bacteria in improving soil biodiversity and increasing resistance to plant diseases. For example, studies have shown that AI helps discover bacterial strains that can enhance crop resistance to fungal and viral diseases [35]. Other findings have shown that AI can improve the process of growing plants using biofertilizers containing beneficial bacteria, which reduces the need for chemical fertilizers and enhances environmental sustainability [36]. Finally, recent studies have shown that AI helps improve the use of beneficial bacteria in precision agriculture, where AI technologies are used to accurately analyze field data to determine crop needs and allocate fertilizers and pesticides accordingly, which contributes to increasing agricultural productivity and reducing the environmental impact [37]. It also enhances the process of managing farm animals in an excellent way [38].

## Conclusion

We conclude from this study that artificial intelligence applications provide advanced understanding in analyzing beneficial bacteria and studying their health effects on humans. Artificial intelligence can classify and study the interactions of these bacteria with the human microbiome, which contributes to improving immunity and preventing chronic diseases. It also contributes to developing targeted treatments for neurological diseases and cancer by identifying the role of beneficial bacteria. Therefore, artificial

intelligence enhances the opportunities for improving public health through innovative research.

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