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Review article

Therapeutic application of *Streptomyces*: A choice alternative to modern therapies

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ABSTRACT

Background: *Streptomyces*, a prolific genus of bacteria, has been a longstanding source of bioactive compounds with diverse therapeutic applications. This review explores the multifaceted therapeutic potential of *Streptomyces* and its derivatives as a compelling alternative to modern therapeutic approaches. The comprehensive analysis covers the biological diversity of *Streptomyces*, the intricate mechanisms of its secondary metabolites, and their impact on various medical domains. *Streptomyces*, boasting over 500 identified species, is renowned for its production of bioactive compounds with antibacterial, antifungal, antiviral, and anticancer properties. The primary focus is on the antibiotics, such as streptomycin and tetracycline, highlighting their significance in addressing bacterial infections, especially in the context of escalating antibiotic resistance. Additionally, the review delves into the antifungal activities exhibited by *Streptomyces* compounds, contributing to their role in combating mycotic diseases. Streptomyces-derived compounds have also shown promise in cancer therapeutics, with specific attention to Streptozotocin and its potential in treating pancreatic cancer. Beyond their direct antimicrobial and anticancer effects, *Streptomyces* compounds are recognized for their immunomodulatory properties, enhancing the body's ability to combat infections and manage inflammatory conditions. This review underscores the versatility of *Streptomyces* in therapeutic applications, ranging from its direct effects on pathogens to its potential in regulating immune responses. As research in this field advances, the ongoing exploration of *Streptomyces* and its bioactive compounds holds significant promise for the development of innovative and targeted therapeutic interventions, offering an appealing alternative to contemporary medical approaches.

Introduction

Streptomyces, a genus of Gram-positive bacteria, has garnered noteworthy attention in recent years due to its filamentous growth and capacity to synthesize a wide range of bioactive compounds, the spores are usually spiral, straight or in chains as represented in Figure 1. This paper aims to delve into the therapeutic applications of *Streptomyces*, emphasizing its emergence as a promising alternative to contemporary therapeutic approaches.

Streptomyces species are renowned for their biological diversity and have been a prolific source of secondary metabolites with diverse biological activities [1]. These bioactive compounds exhibit antibacterial, antifungal, antiviral, and anticancer properties, contributing to the growing interest in *Streptomyces* as a valuable therapeutic resource [1].

The antibacterial potential of *Streptomyces* has been exemplified by the discovery of antibiotics

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like streptomycin, tetracycline, and erythromycin. Streptomycin, for instance, interferes with bacterial protein synthesis and has been widely used to combat bacterial infections [2]. In the context of increasing antibiotic resistance, Streptomyces-derived compounds represent a crucial alternative to traditional antibiotics.

Streptomyces has also demonstrated efficacy in addressing fungal infections through the production of antifungal agents such as nystatin and amphotericin B. These compounds target specific components of fungal cells, showcasing the potential of *Streptomyces* as a source of antifungal therapies [3].

In the realm of cancer therapeutics, Streptomyces-derived compounds have shown promise. Streptozotocin, a compound produced by *Streptomyces* achromogenes, has been investigated for its ability to induce pancreatic beta-cell apoptosis and is employed in the treatment of pancreatic cancer [4]. This underscores the potential of *Streptomyces* as a source of anticancer agents, offering novel avenues for drug development [5].

Moreover, beyond direct antimicrobial and anticancer effects, *Streptomyces* has exhibited immunomodulatory properties. These compounds can modulate the immune response, enhancing the body's ability to combat infections and manage inflammatory conditions [5].

Streptomyces, with its diverse bioactive compounds, stands out as a promising alternative to modern therapeutic approaches. From antibacterial and antifungal activities to anticancer potential and immunomodulatory effects, *Streptomyces* holds the key to innovative and sustainable solutions in drug development [5].

Streptomyces Biological Diversity and Secondary Metabolites in Therapeutic Applications

Streptomyces has captured considerable scientific interest due to its remarkable biological diversity and the ability of its various species to produce a plethora of secondary metabolites. Details of *Streptomyces*' biological diversity and the therapeutic potential derived from its diverse secondary metabolites, emphasizing their applications in modern drug development is considered imperative [7].

Biological Diversity:

Streptomyces stands out for its extensive biological diversity, boasting over 500 identified species [7]. Each of these species exhibits unique characteristics, contributing to the genus's versatility. The filamentous growth pattern of *Streptomyces* further adds to its distinctive features, creating an environment conducive to the production of an extensive array of secondary metabolites [8].

Secondary Metabolites and Their Bioactivities:

The exceptional biological diversity of *Streptomyces* has positioned it as a prolific source of secondary metabolites, each displaying a spectrum of bioactivities. This section scrutinizes the hallmark feature of *Streptomyces*—its capacity to generate secondary metabolites—and delves into their diverse bioactivities, emphasizing their crucial role in contemporary drug discovery and development, the structure of some active enzymes recovered from *Streptomyces* are represented in Figure 2. The bioactive activity of some of the *Streptomyces* are also presented in Table 1.

Generation of Secondary Metabolites:

Streptomyces, a genus renowned for its filamentous growth, harnesses intricate biochemical pathways to produce a vast array of secondary metabolites [8]. These secondary metabolites, distinct from primary metabolites essential for growth and development, serve various ecological functions and have garnered substantial attention for their therapeutic potential.

Diverse Bioactivities:

The secondary metabolites produced by *Streptomyces* exhibit a myriad of bioactivities, making them invaluable in addressing various health challenges [7]. Antibacterial properties are evident in compounds such as streptomycin, tetracycline, and erythromycin, which interfere with bacterial processes, contributing to their status as essential antibiotics in clinical practice [10]. Streptomyces-derived secondary metabolites also manifest potent antifungal activities, with nystatin and amphotericin B being exemplary agents employed in the treatment of fungal infections [8].

Moreover, *Streptomyces* compounds showcase antiviral properties, contributing to the ongoing efforts in antiviral drug development. The diverse range of bioactive compounds produced by *Streptomyces* extends to anticancer agents like streptozotocin, demonstrating its potential as a valuable source for novel cancer therapeutics [11].

Significance in Drug Discovery:

The bioactive compounds derived from *Streptomyces* hold a pivotal role in drug discovery

and development. Streptomyces-derived secondary metabolites have become a focal point in the pursuit of novel drugs, owing to their unique structures and diverse pharmacological activities [1]. As a result, researchers are increasingly exploring these compounds for their potential in developing next-generation therapeutics.

Streptomyces stands out as a treasure trove of secondary metabolites with diverse bioactivities, making it a focal point in contemporary drug discovery and development [4]. From antibacterial and antifungal properties to antiviral and anticancer potential, Streptomyces-derived secondary metabolites offer a rich source of bioactive compounds with significant therapeutic implications [8]. As research in this field advances, the exploration of *Streptomyces* continues to unveil new and promising avenues for the development of innovative drugs.

Antibacterial Potential:

The rise of antibiotic-resistant strains has underscored the need for alternative therapeutic approaches in combating bacterial infections. *Streptomyces*, a genus of Gram-positive bacteria, has been at the forefront of this quest, providing a rich source of antibiotics that have played a pivotal role in addressing bacterial infections [11,12].

Mechanisms of Action:

Streptomyces-derived antibiotics, including streptomycin, tetracycline, and erythromycin, exhibit diverse mechanisms of action that target essential bacterial processes. Streptomycin, for example, interferes with bacterial protein synthesis by binding to the 30S ribosomal subunit [12]. Tetracycline acts by inhibiting protein synthesis through binding to the 30S ribosomal subunit as well, while erythromycin disrupts bacterial protein synthesis by binding to the 50S ribosomal subunit [12]. These distinct mechanisms collectively contribute to the efficacy of Streptomyces-derived antibiotics against a broad spectrum of bacteria. The summary of the mechanism of action of *Streptomyces* is illustrated in Figure 3.

Broad-Spectrum Activity:

One of the remarkable features of Streptomyces-derived antibiotics is their ability to target a wide range of bacterial species. The interference with fundamental processes like protein synthesis, DNA replication, or cell wall formation renders these antibiotics effective against Gram-positive and Gram-negative bacteria alike. This broad-spectrum activity enhances their versatility and applicability in diverse clinical settings[1].

Significance in the Face of Antibiotic Resistance:

The escalating prevalence of antibiotic-resistant strains poses a significant challenge to traditional antibacterial therapies. *Streptomyces* compounds, with their unique mechanisms of action, offer a valuable alternative to conventional antibiotics. By targeting distinct bacterial processes, these compounds may overcome resistance mechanisms, providing a renewed hope in the battle against antibiotic-resistant infections [1].

The antibacterial properties of Streptomyces-derived antibiotics have been well-documented[12]. Streptomycin, tetracycline, and erythromycin, among others, exert their effects through interference with bacterial protein synthesis, DNA replication, or cell wall formation[12].The broad-spectrum activity of these antibiotics makes them effective against a diverse array of bacterial species[13].

The antibacterial properties of Streptomyces-derived antibiotics, characterized by their diverse mechanisms of action and broad-spectrum activity, hold significant promise in addressing bacterial infections, particularly in the face of antibiotic-resistant strains. As research continues, the exploration and optimization of *Streptomyces* compounds may pave the way for innovative antibacterial therapies, providing a valuable arsenal against evolving challenges in infectious disease management [11,13].

Antifungal Activities:

The antifungal activities of *Streptomyces* compounds represent a significant facet of their therapeutic potential, with notable agents like nystatin and amphotericin B widely employed in the clinical management of fungal infections. This section explores the specific antifungal mechanisms of these compounds and underscores the potential of Streptomyces-derived metabolites in combating mycotic diseases [14].

Antifungal Agents and Their Application:

Streptomyces-derived compounds, such as nystatin and amphotericin B, have gained prominence as effective antifungal agents [3]. These compounds have been extensively utilized in clinical settings to treat a range of fungal infections, including those caused by Candida and Aspergillus species [6].

Mechanisms of Action:

Nystatin and amphotericin B exert their antifungal effects by targeting specific components of fungal cells. Nystatin, a polyene antifungal antibiotic, binds to ergosterol, a key component of fungal cell membranes, leading to the formation of pores and subsequent disruption of membrane integrity [5], as illustrated in Figure 4. This disruption compromises the structural integrity of the fungal cell, ultimately leading to cell death.

Amphotericin B, another polyene antifungal agent, also interacts with ergosterol in the fungal cell membrane. This interaction forms transmembrane channels that increase membrane permeability, disrupting cellular functions and contributing to fungal cell death [3,13].

Clinical Significance:

The clinical use of Streptomyces-derived antifungal agents has been pivotal in the treatment of various mycotic diseases. Nystatin, for instance, is commonly employed to treat oral and gastrointestinal candidiasis, while amphotericin B is used for systemic fungal infections, particularly those affecting immunocompromised individuals [14].

Despite their efficacy, challenges such as toxicity and the emergence of resistant strains highlight the need for ongoing research and innovation in antifungal drug development. *Streptomyces* compounds, with their diverse secondary metabolites, offer a valuable resource for discovering novel antifungal agents with improved safety profiles and reduced resistance issues [10], [14].

The antifungal activities of *Streptomyces* compounds, exemplified by agents like nystatin and amphotericin B [3], underscore the genus's potential in addressing mycotic diseases. Understanding the mechanisms by which these compounds target fungal cells provides insights into their clinical efficacy and informs future drug development efforts. As research continues, Streptomyces-derived metabolites remain a promising source for the discovery of innovative antifungal therapies [14].

Antibacterial Properties:

Streptomyces-derivedantibiotics, including streptomycin, tetracycline, and erythromycin, have been pivotal in the battle against bacterial infections, exerting their antimicrobial effects through interference with bacterial protein synthesis, DNA replication, or cell wall formation [15,16].Streptomycin, for instance, inhibits protein synthesis by binding to the 30S ribosomal subunit in bacteria [17]. Tetracycline acts by inhibiting the binding of aminoacyl-tRNA to the mRNA-ribosome complex [18], while erythromycin disrupts protein synthesis by binding to the 50S ribosomal subunit [19].

The versatility of Streptomyces-derived antibiotics lies in their effectiveness against a broad spectrum of bacteria, making them valuable tools in the treatment of various infections [1]. This broad-spectrum activity is particularly advantageous in clinical settings where the causative agent may not be immediately identified [19].

In the face of the growing threat of antibiotic-resistant bacterial strains, *Streptomyces* compounds present a promising alternative to traditional antibiotics [20]. The ability of Streptomyces-derived antibiotics to target multiple bacterial pathways makes it challenging for bacteria to develop resistance against them [21]. This characteristic is crucial in addressing the global concern of antibiotic resistance, where the overuse and misuse of antibiotics have led to the emergence of resistant strains [22].

Streptomyces-derived antibiotics have made significant contributions to the field of medicine by providing effective treatments against bacterial infections [22]. Their multifaceted mechanisms of action and broad-spectrum activity highlight their importance in the context of increasing antibiotic resistance. As research continues to explore new avenues for antibiotic development, *Streptomyces* compounds remain a valuable resource in the ongoing fight against bacterial infections [22,24].

Anticancer Potential:

The anticancer potential of Streptomyces-derived compounds has emerged as a promising area of research, offering novel avenues for the development of targeted therapies with potentially fewer side effects than traditional chemotherapeutic agents [23].

Streptozotocin, a compound produced by *Streptomyces* achromogenes, exemplifies the genus's anticancer properties. This compound has been extensively studied for its ability to induce apoptosis in pancreatic beta-cells, making it a valuable agent in the treatment of pancreatic cancer [23]. Streptozotocin's mechanism of action involves

the disruption of DNA synthesis, particularly in rapidly dividing cells, leading to cell death and inhibition of tumor growth.

The use of Streptozotocin in pancreatic cancer treatment highlights the potential of Streptomyces-derived compounds to serve as targeted therapies. Compared to traditional chemotherapeutic agents that often lack specificity, compounds like Streptozotocin offer the advantage of selectively targeting cancer cells while minimizing damage to healthy tissues [24].

The cytotoxic effects of Streptomyces-derived compounds extend beyond Streptozotocin. Many compounds from this genus have demonstrated direct cytotoxicity against cancer cells, making them attractive candidates for further investigation in cancer therapy [25].

The pursuit of Streptomyces-derived anticancer agents aligns with the ongoing efforts to develop more effective and targeted treatments. This approach holds particular promise in addressing the limitations and adverse effects associated with conventional chemotherapeutic agents [26].

Moreover, the diversity of secondary metabolites produced by *Streptomyces* offers a broad spectrum of potential anticancer compounds. These bioactive molecules have the capacity to interfere with various cellular processes involved in cancer development, providing researchers with a rich source of candidates for drug discovery [27].

The anticancer potential of Streptomyces-derived compounds, exemplified by Streptozotocin, signifies a significant stride in the quest for targeted and effective cancer therapies. The unique mechanisms of action and the potential for reduced side effects make *Streptomyces* compounds promising candidates for further exploration and development in the field of oncology [27]. One of the anticancer compound recovered from *Streptomyces* is illustrated in Figure 5.

Immunomodulatory Effects:

Beyond its established antimicrobial and anticancer properties, *Streptomyces* has gained recognition as a significant contributor to immunomodulation. This segment explores the immunomodulatory characteristics of compounds derived from *Streptomyces*, uncovering their capacity to boost the immune response within the body and address conditions characterized by immune dysregulation [26].

Immunomodulatory Mechanisms:

Compounds derived from *Streptomyces* exhibit a range of immunomodulatory effects, influencing the activity and responsiveness of the immune system. These effects are crucial in fine-tuning the immune response, enabling the body to combat infections and manage inflammatory conditions more efficiently [27]. The intricate mechanisms underlying *Streptomyces* immunomodulation involve the interaction between secondary metabolites produced by *Streptomyces* bacteria and the host immune system. Several studies have shed light on these mechanisms, providing insights into the immunomodulatory effects of Streptomyces-derived compounds [28].

One key aspect of *Streptomyces* immunomodulation lies in the ability of its secondary metabolites to influence the expression of cytokine genes in immune cells. For example, a study by Mahmoudi *etal*., [27] demonstrated that secondary metabolites from *Streptomyces* calvus enhanced the expression of pro-inflammatory cytokines, such as interleukin-2 and interferon-γ, in human peripheral blood mononuclear cells (PBMCs). This upregulation of pro-inflammatory cytokines suggests a potential activation of the immune response by *Streptomyces* compounds [27].

Furthermore, the same study revealed a reduction in the levels of the immunosuppressive cytokine interleukin-10 in PBMCs treated with *Streptomyces* calvus secondary metabolites. This finding indicates a dual impact on the immune system, promoting pro-inflammatory responses while mitigating immunosuppressive signals, which could contribute to a balanced and controlled immune modulation [27,28].

The observed concentration-dependent increase in PBMC proliferation in response to *Streptomyces* metabolite treatment also adds another layer to the immunomodulatory mechanisms. This suggests that *Streptomyces* compounds may not only influence cytokine expression but also actively participate in the regulation of immune cell proliferation [27].

While the exact molecular pathways involved in *Streptomyces* immunomodulation are still a subject of ongoing research, these findings collectively highlight the complex and multifaceted nature of Streptomyces-derived compounds in modulating the immune response. The ability of *Streptomyces* to both enhance pro-inflammatory signals and reduce immunosuppressive cues

showcases its potential as a source of robust immunomodulators, offering promising avenues for the development of novel therapeutic strategies [27]. Figure 6 illustrate the potentials of *Streptomyces* genus as a source of probiotics.

Enhanced Immune Response:

Streptomyces-derived immunomodulatory compounds have been found to enhance the body's innate and adaptive immune responses. By modulating the activity of immune cells such as macrophages, dendritic cells, and T lymphocytes, these compounds contribute to an augmented defense against pathogens [29]. This enhanced immune response is particularly valuable in scenarios where the immune system requires reinforcement.

Management of Inflammatory Conditions:

The immunomodulatory potential of *Streptomyces* extends to the management of inflammatory conditions. In diseases characterized by excessive inflammation, such as autoimmune disorders, compounds derived from *Streptomyces* play a role in dampening the inflammatory response. This anti-inflammatory action is pivotal in preventing tissue damage and alleviating symptoms associated with dysregulated immune responses [30].

Versatility in Disease Management:

The immunomodulatory properties of *Streptomyces* position it as a versatile tool in addressing a spectrum of diseases marked by dysregulated immune responses. Conditions such as rheumatoid arthritis, inflammatory bowel diseases, and certain allergic disorders may benefit from interventions involving Streptomyces-derived compounds [30]. This versatility opens up new avenues for therapeutic strategies that target the underlying immune dysregulation in diverse clinical scenarios.

Limitations of *Streptomyces* and its bioactive compounds as a therapeutic agent

The inconsistency in the synthesis of secondary metabolites among various strains and under varying environmental circumstances is a major drawback of *Streptomyces*, despite its tremendous potential in medicinal applications due to its bioactive chemicals. Significant genetic variety among *Streptomyces* species results in variations in the kinds and amounts of bioactive chemicals that they produce. This fluctuation can make it difficult to standardise medicinal formulations and guarantee that products made from *Streptomyces* will always be efficacious in different batches. Further impeding efforts to optimise and scale up production for commercial application are the intricate regulatory processes governing the biosynthesis of secondary metabolites in *Streptomyces*, which are not well understood. These restrictions show that to fully utilise *Streptomyces* and its bioactive chemicals for therapeutic purposes, more investigation and development are required. This includes tackling issues of variability and scalability in drug production.

Table 1. List of antibiotics produced by different Actinobacteria and their applications. Source: Mohammed et al. [9].

Antibiotic compound	***Streptomyces* species**	**Application**
1,4-Dihydroxy-2-(3-hydroxybutyl)-9,10-anthraquinone 9,10 anthrac	*Streptomyces* sp. RAUACT-1	Antibacterial
1,8-Dihydroxy-2-ethyl-3-methylanthraquinone	*Streptomyces* sp.	Antitumor
2-Allyloxyphenol	*Streptomyces* sp.	Antimicrobial; food preservative; oral disinfectant
Anthracyclines	*S. galileus*	Antitumor
Arenimycin	*S. arenicola*	Antibacterial; anticancer
Avermectin	*S. avermitilis*	Antiparasitic
Bafilomycin	*S. griseus, S. halstedii*	ATPase; inhibitor of microorganisms, plant and animal cells
Bisanthraquinone	*Streptomyces* sp.	Antibacterial
Carboxamycin	*Streptomyces* sp.	Antibacterial; anticancer
Chinikomycin	*Streptomyces* sp.	Anticancer
Chloramphenicol	*S. venezuelae*	Antibacterial; inhibitor of protein biosynthesis
Chromomycin B, A2, A3	*S. coelicolor*	Antitumor
Daryamides	*Streptomyces* sp.	Antifungal; anticancer
Elaiomycins B and C	*Streptomyces* sp. BK 190	Antitumor
Frigocyclinone	*S. griseus*	Antibacterial
Glaciapyrroles	*Streptomyces* sp.	Antibacterial
Hygromycin	*S. hygroscopicus*	Antimicrobial; immunosuppressive
Lajollamycin	*S. nodosus*	Antibacterial
Lincomycin	*S. lincolnensis*	Antibacterial; inhibitor of protein biosynthesis
Mitomycin C	*S. lavendulae*	Antitumor; binds to double-stranded DNA
Pacificanones A and B	*S. pacifica*	Antibacterial
Piericidins	*Streptomyces* sp.	Antitumor
Proximicins	*Verrucosispora* sp.	Antibacterial; anticancer
Pristinamycine	*S. pristinaespiralis*	Antibacterial
Rapamycin	*S. hygroscopicus*	Immunosuppressive; antifungal
Resistoflavin methyl ether	*Streptomyces* sp.	Antibacterial; antioxidative
Saliniketal	*S. arenicola*	Cancer; chemoprevention
Salinispyrone	*S. pacifica*	Unknown
Salinispyrone A and B	*S. pacifica*	Mild cytotoxicity
Salinosporamide A	*Salinispora tropica*	Anticancer; antimalarial
Salinosporamide B and C	*S. tropica*	Cytotoxicity
Sesquiterpene	*Streptomyces* sp.	Unknown
Staurosporinone	*Streptomyces* sp.	Antitumor; phycotoxicity
Streptokordin	*Streptomyces* sp.	Antitumor
Streptomycin	*S. griseus*	Antimicrobial
Streptozotocin	*S. achromogenes*	Diabetogenic
Tetracyclines	*Streptomyces achromogenes*; *S. rimosus*	Antimicrobial
Tirandamycins	*Streptomyces* sp.	Antibacterial
Valinomycin	*S. griseus*	Ionophor; toxic for prokarotes, eukaryotes

Figure 1. Light Microscopy images of *Streptomyces* species. Source Rengasamy and Ushadevi [6].

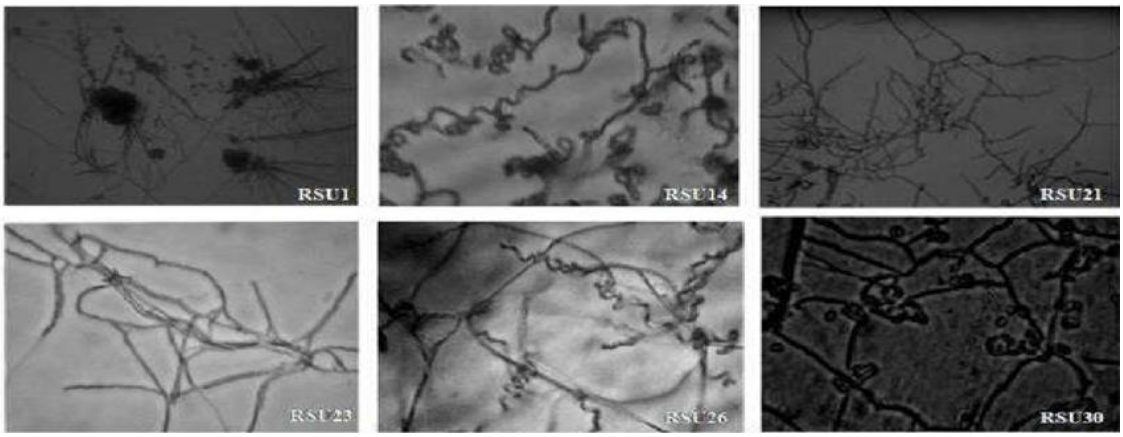


Figure 2. Structure of a modular type I PKS. Note: KS, ketosynthase; AT, acyl transferase; KR, ketoreductase; ACP, acyl carrier protein; TE, Thioesterase; DH, dehydrate [12].

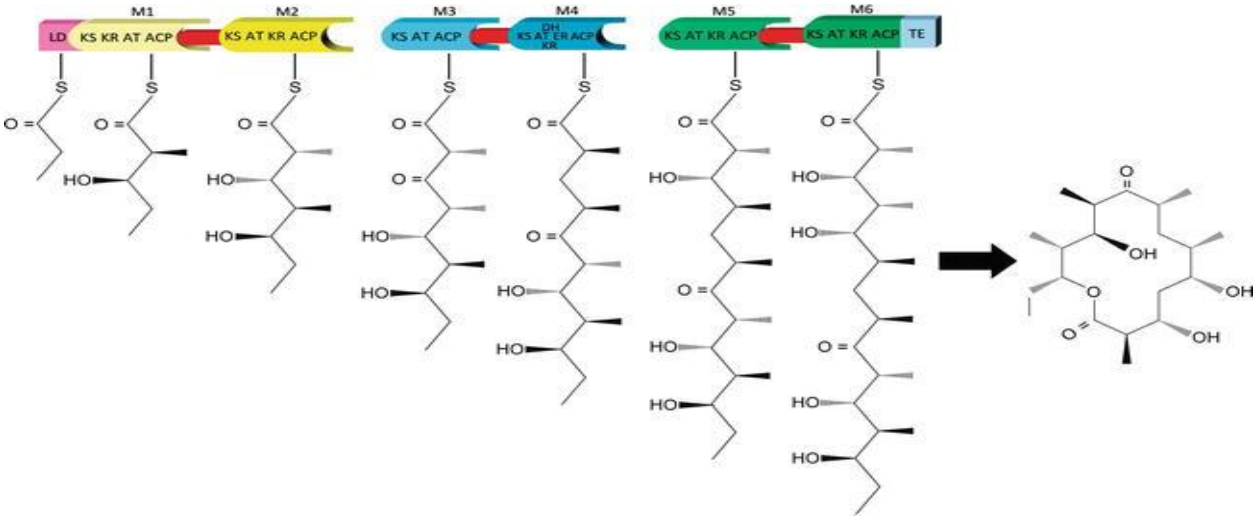
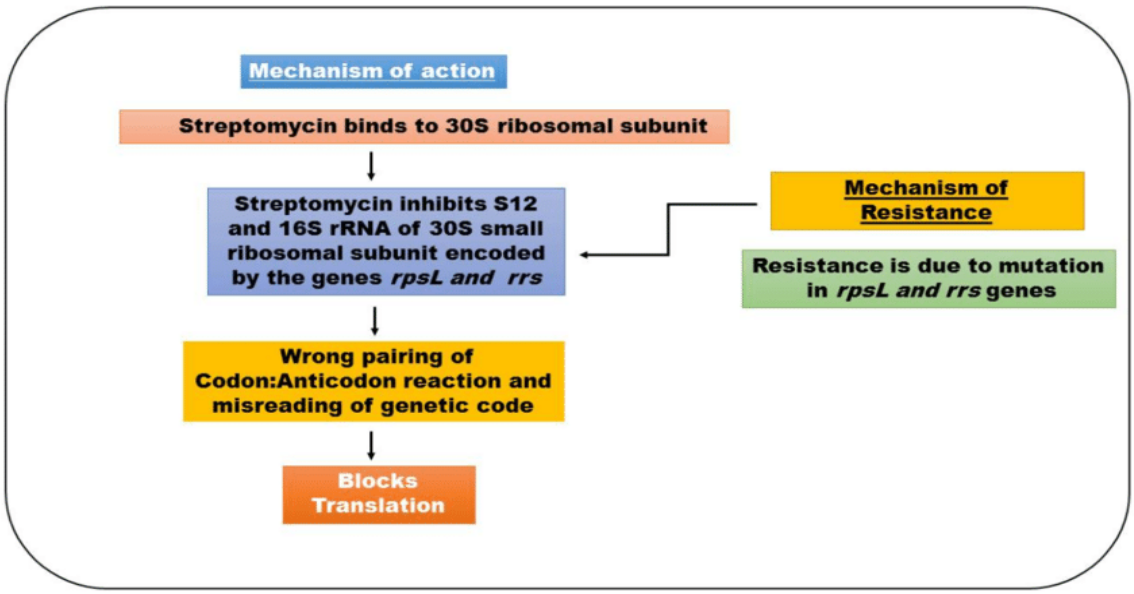
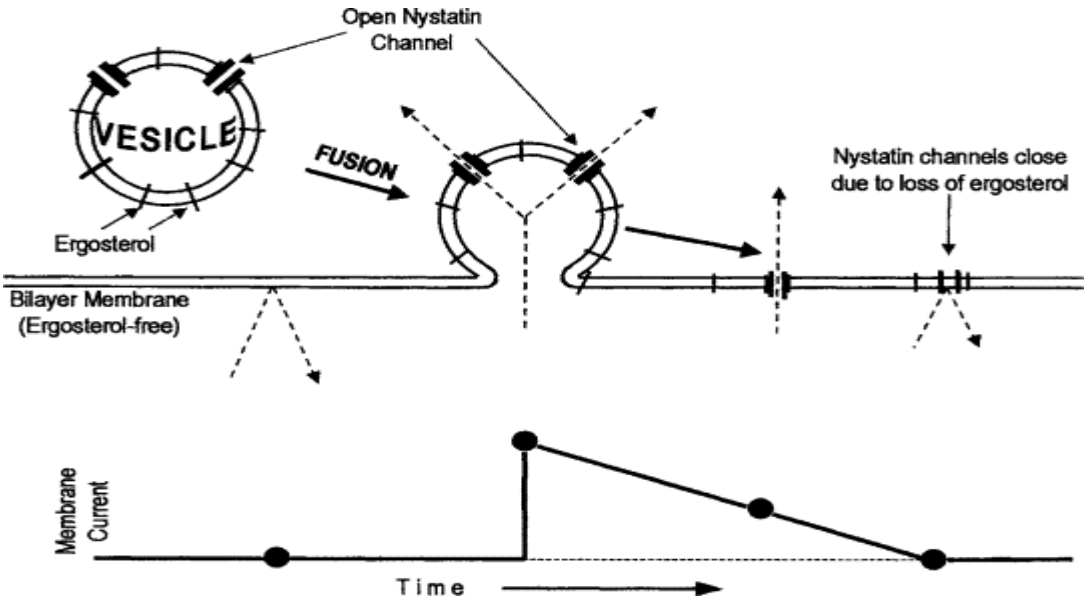


Figure 3. Mechanism of Action of streptomycin and mechanism of resistance associated with it.



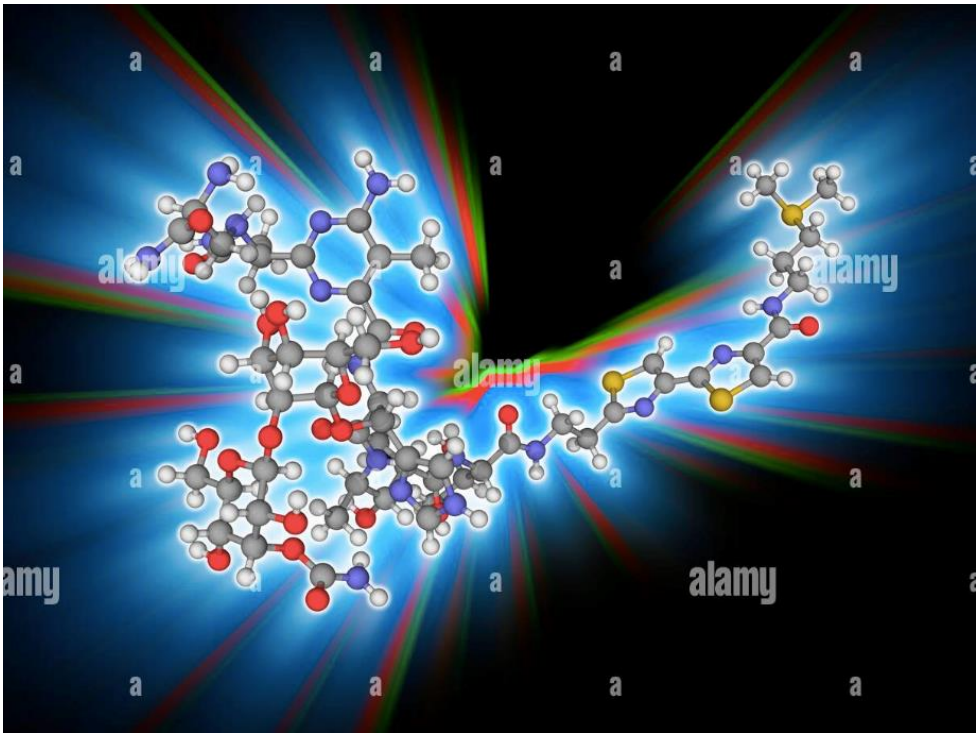
Source: Bashir *et al.* [13].

Figure 4. Nystatin - an overview



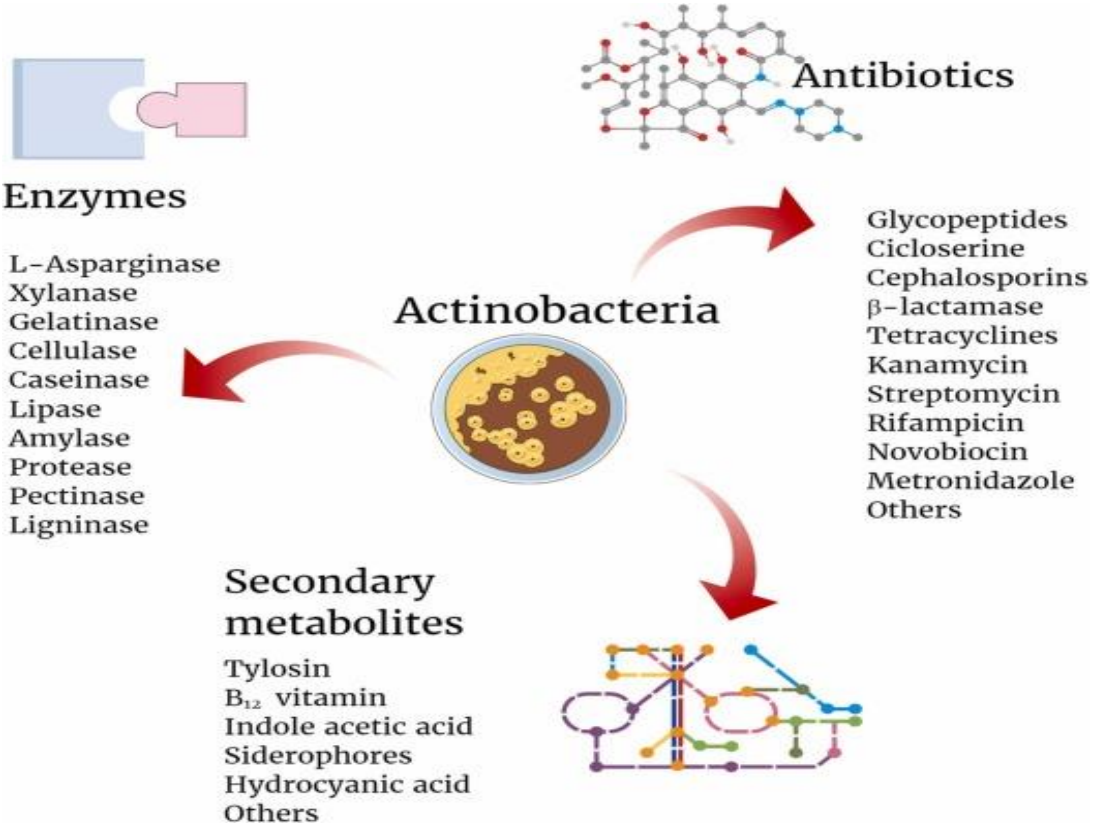
Source: Christine [14].

Figure 5. Bleomycin. Molecular model of the anti-cancer drug bleomycin (C55.H84.N17.O21.S3), a glycopeptide antibiotic produced by the bacterium *Streptomycesverticillus.*



Adapted from Science Photo Library(https://www.alamy.com/stock-photo-bleomycin-molecular-model-of-the-anti-cancer-drug-bleomycin-c55h84n17o21s3-126899813.html)

Figure 6. *Streptomyces* genus as a source of probiotics and its potential for its use in health.



Source: Cuozzo*et al.* [28].

Conclusion:

In conclusion, *Streptomyces* manifests not only considerable antimicrobial and anticancer potential but also a noteworthy capacity for immunomodulation. The modulation of immune responses by compounds derived from *Streptomyces* offers a promising avenue for therapeutic development. As research in this field advances, the immunomodulatory effects of *Streptomyces* are poised to be more comprehensively elucidated, paving the way for innovative and precisely targeted interventions in the management of diseases characterized by immune dysregulation.

This comprehensive review has delved into the multifaceted therapeutic potential of *Streptomyces*, focusing on its biological diversity, secondary metabolites, and immunomodulatory effects. With over 500 identified species, *Streptomyces* has emerged as a prolific source of bioactive compounds, exemplifying antibacterial, antifungal, antiviral, and anticancer properties. The primary mechanism driving *Streptomyces*' therapeutic efficacy resides in the production of secondary metabolites, harnessed for the development of novel drugs.

The antibacterial potential of *Streptomyces*, illustrated by antibiotics such as streptomycin and tetracycline, underscores its significance in addressing bacterial infections, particularly in the era of escalating antibiotic resistance. Additionally, *Streptomyces* compounds have demonstrated notable antifungal activities, contributing to their role in the treatment of mycotic diseases.

Furthermore, Streptomyces-derived compounds exhibit promise in cancer therapeutics, as evidenced by Streptozotocin's ability to induce apoptosis in pancreatic beta-cells, rendering it a valuable asset in the treatment of pancreatic cancer.

Beyond its direct antimicrobial and anticancer effects, *Streptomyces* has garnered recognition for its immunomodulatory properties. Compounds derived from *Streptomyces* modulate the immune response, augmenting the body's ability to combat infections and manage inflammatory conditions.

This review accentuates the versatility of *Streptomyces* in therapeutic applications, encompassing its direct antimicrobial and anticancer effects to its immunomodulatory potential. Streptomyces-derived compounds present a rich source for drug discovery, opening new avenues for addressing diseases characterized by dysregulated immune responses.

Looking forward, ongoing research in this field is poised to unveil additional bioactive compounds and further elucidate the mechanisms underpinning *Streptomyces*' therapeutic effects. This exploration holds promise for the development of innovative and precisely targeted therapeutic interventions, potentially revolutionizing the landscape of modern medicine.

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