

immunology topics for research

immunology topics for research represent a critical area of study in understanding the body's defense mechanisms against disease. As the immune system plays a vital role in health and disease prevention, exploring various immunology topics for research can lead to breakthroughs in vaccine development, autoimmune disorder treatments, and cancer immunotherapy. Researchers focus on diverse aspects such as cellular immunity, molecular pathways, and immunogenetics, which contribute to the evolving landscape of immunological science. In this article, several key immunology topics for research will be examined, highlighting current trends and emerging areas of interest. These topics are essential for advancing medical science and improving patient outcomes. The following sections will delve into fundamental themes, innovative technologies, and clinical applications within immunology. This comprehensive overview aims to guide researchers in selecting pertinent areas for investigation and inspire further scientific inquiry.

- Fundamental Immunology Research Areas
- Immunotherapy and Cancer Research
- Autoimmune Diseases and Immunology
- Infectious Diseases and Immune Response
- Emerging Technologies in Immunology Research

Fundamental Immunology Research Areas

Understanding the basic principles of the immune system is foundational to advancing immunology topics for research. Fundamental immunology explores the cellular and molecular mechanisms that govern immune responses. This area includes studying innate and adaptive immunity, antigen recognition, and immune cell signaling pathways. Insights from fundamental research provide the basis for developing new therapies and vaccines.

Innate Immunity and Pattern Recognition

Innate immunity represents the body's first line of defense against pathogens. Research in this area focuses on pattern recognition receptors (PRRs) such as Toll-like receptors (TLRs), which detect microbial components. Investigating how innate immune cells recognize and respond to infections informs the development of immunomodulatory treatments.

Adaptive Immunity and Antigen Presentation

The adaptive immune system provides specificity and memory in immune responses. Studies on antigen-presenting cells (APCs), T lymphocytes, and B lymphocytes elucidate how the immune system adapts to target specific pathogens. Research on the major histocompatibility complex (MHC) and T-cell receptor diversity remains a pivotal topic in immunology.

Cytokines and Immune Cell Communication

Cytokines are signaling molecules that facilitate communication among immune cells. Understanding cytokine networks and their regulatory roles is essential for comprehending immune responses. Research into cytokine storms, immunosuppression, and inflammatory processes offers critical insights into disease pathology.

Immunotherapy and Cancer Research

Immunotherapy has revolutionized cancer treatment by harnessing the immune system to target tumor cells. Immunology topics for research in this field focus on developing novel therapeutic strategies, understanding tumor-immune interactions, and overcoming resistance mechanisms.

Checkpoint Inhibitors and Immune Modulation

Checkpoint inhibitors such as PD-1/PD-L1 and CTLA-4 blockers restore T-cell activity against cancer cells. Research aims to optimize these treatments, identify biomarkers of response, and understand adverse effects. This remains a rapidly evolving area of immunology research with significant clinical implications.

CAR-T Cell Therapy

Chimeric antigen receptor T-cell (CAR-T) therapy involves genetically engineering T cells to recognize and attack cancer cells. Investigating the design and efficacy of CAR-T cells, as well as managing associated toxicities, is a prominent immunology topic for research.

Tumor Microenvironment and Immune Evasion

The tumor microenvironment (TME) plays a crucial role in cancer progression and immune evasion. Studies focus on how tumors manipulate immune cells, secrete immunosuppressive factors, and create physical barriers. Targeting the TME is a promising strategy in cancer immunotherapy research.

Autoimmune Diseases and Immunology

Autoimmune diseases result from aberrant immune responses against self-antigens. Research into the mechanisms driving autoimmunity is a vital immunology topic for research, with the goal of developing targeted therapies that restore immune tolerance.

Pathogenesis of Autoimmune Disorders

Understanding the genetic, environmental, and immunological factors contributing to autoimmune diseases is essential. Studies focus on molecular pathways leading to loss of self-tolerance, autoreactive lymphocytes, and chronic inflammation.

Biomarkers and Diagnostic Tools

Identifying reliable biomarkers enables earlier diagnosis and improved disease monitoring. Research efforts include discovering autoantibodies, cytokine profiles, and genetic markers associated with autoimmune conditions such as rheumatoid arthritis, lupus, and multiple sclerosis.

Novel Therapeutic Approaches

Developing targeted immunotherapies, including biologics and small molecules, aims to modulate immune responses without compromising overall immunity. Advances in immunology research continue to expand treatment options for autoimmune diseases.

Infectious Diseases and Immune Response

Investigating the immune system's response to infectious agents is a major focus within immunology topics for research. This area addresses host-pathogen interactions, vaccine development, and immune evasion strategies employed by microbes.

Vaccine Development and Immunogenicity

Research focuses on designing safe and effective vaccines that elicit robust and long-lasting immunity. Novel platforms such as mRNA vaccines and viral vectors have transformed vaccine science, creating new research opportunities.

Immune Evasion by Pathogens

Pathogens have evolved mechanisms to evade immune detection and destruction. Understanding these strategies, including antigenic variation and immune suppression, informs therapeutic approaches and vaccine design.

Role of the Microbiome in Immunity

The human microbiome significantly influences immune system development and function. Research explores how microbial communities modulate immune responses and contribute to susceptibility or resistance to infectious diseases.

Emerging Technologies in Immunology Research

Technological advances continue to propel immunology topics for research forward by providing innovative tools for analysis and experimentation. These emerging methodologies enable detailed understanding of immune processes at cellular and molecular levels.

Single-Cell Sequencing and Immune Profiling

Single-cell RNA sequencing allows researchers to analyze gene expression in individual immune cells, revealing cellular heterogeneity and functional states. This technology is revolutionizing immunology research by providing unprecedented resolution of immune responses.

CRISPR and Gene Editing in Immunology

CRISPR-Cas9 gene-editing technology is utilized to manipulate immune-related genes, study gene function, and develop gene therapies. It offers potential for correcting genetic defects causing immune disorders and enhancing immunotherapies.

Computational Immunology and Systems Biology

Computational approaches integrate large datasets to model immune system dynamics and predict responses to therapies. Systems biology techniques facilitate the identification of novel targets and the design of personalized immunotherapies.

- Advanced imaging techniques for immune cell tracking

- High-throughput screening of immune modulators
- Development of organ-on-a-chip models for immunological studies

Frequently Asked Questions

What are the latest advancements in cancer immunotherapy research?

Recent advancements in cancer immunotherapy include the development of personalized neoantigen vaccines, CAR-T cell therapies targeting solid tumors, and combination therapies that enhance immune checkpoint inhibitors' efficacy.

How is the gut microbiome influencing immune system research?

The gut microbiome plays a crucial role in shaping the immune system by modulating immune cell development and function, influencing responses to infections, and impacting autoimmune and inflammatory diseases, making it a significant focus in immunology research.

What novel biomarkers are being explored for autoimmune disease diagnosis?

Researchers are investigating novel biomarkers such as specific autoantibodies, cytokine profiles, and gene expression patterns to improve early diagnosis and prognosis of autoimmune diseases like rheumatoid arthritis and lupus.

How are single-cell technologies advancing immunology research?

Single-cell technologies, including single-cell RNA sequencing and mass cytometry, allow detailed analysis of immune cell heterogeneity, revealing new cell subsets, pathways, and mechanisms involved in health and disease.

What role do innate lymphoid cells (ILCs) play in immune regulation?

ILCs are critical in maintaining tissue homeostasis, responding to infections, and contributing to inflammatory and autoimmune diseases, making them important targets for immunological research and therapeutic interventions.

How is immunology research addressing vaccine development for emerging infectious diseases?

Immunology research focuses on understanding immune responses to pathogens, optimizing antigen design, adjuvants, and delivery systems, and employing mRNA and vector-based platforms to accelerate vaccine development against emerging infectious diseases.

What are the challenges in developing effective immunotherapies for autoimmune diseases?

Challenges include achieving targeted immune modulation without broad immunosuppression, understanding disease heterogeneity, identifying reliable biomarkers, and minimizing adverse effects while restoring immune tolerance.

How is CRISPR technology being utilized in immunology research?

CRISPR technology is used to edit immune cell genomes for functional studies, develop engineered immune cells such as CAR-T cells, and create disease models to better understand immune mechanisms and develop novel therapies.

Additional Resources

1. Janeway's Immunobiology

This comprehensive textbook covers the fundamental concepts of immunology, blending molecular and cellular perspectives. It is widely regarded as an essential resource for students and researchers alike, providing detailed explanations of immune system components and their functions. The book also explores the latest advances in immunological research and clinical applications.

2. Fundamental Immunology

Edited by William E. Paul, this book offers an in-depth exploration of the mechanisms underlying immune responses. It is designed for graduate students and researchers, featuring contributions from leading immunologists. The text covers both innate and adaptive immunity, with an emphasis on molecular and cellular pathways.

3. Cellular and Molecular Immunology

This text provides a clear and concise overview of the immune system at the cellular and molecular levels. It integrates recent discoveries with classical immunology topics, making it suitable for both newcomers and experienced researchers. The book also discusses immunological techniques and their applications in research.

4. Immunology: A Short Course

Ideal for a quick yet thorough introduction to immunology, this book distills

complex concepts into accessible language. It covers essential topics such as antigen recognition, immune regulation, and immunological memory. The text is supported by illustrative figures and clinical case studies, aiding comprehension and application.

5. *The Immune System*

Authored by Peter Parham, this book emphasizes the biological basis of immunity and its role in health and disease. It balances fundamental science with clinical relevance, making it a valuable resource for researchers in immunology and related biomedical fields. The latest edition includes updates on immunotherapy and vaccine development.

6. *Immunotherapy of Cancer*

Focusing on the rapidly evolving field of cancer immunotherapy, this book details the mechanisms by which the immune system can be harnessed to fight malignancies. It covers checkpoint inhibitors, adoptive cell transfer, and vaccine strategies. The text serves as a guide for researchers developing new immunotherapeutic approaches.

7. *Mucosal Immunology*

This specialized book explores the immune responses that occur at mucosal surfaces, such as the respiratory, gastrointestinal, and urogenital tracts. It discusses the unique challenges and mechanisms of mucosal immunity, including tolerance and inflammation. Researchers interested in infectious diseases and vaccine design will find this resource invaluable.

8. *Autoimmunity: From Bench to Bedside*

This volume addresses the pathogenesis, diagnosis, and treatment of autoimmune diseases through a translational research lens. It integrates basic immunological research with clinical findings, highlighting the interplay between genetics, environment, and immune dysregulation. The book is essential for scientists and clinicians studying autoimmune disorders.

9. *Immunological Methods*

A practical guide for researchers, this book details experimental techniques used in immunology, including flow cytometry, ELISA, and immunohistochemistry. It emphasizes protocol optimization and troubleshooting to ensure reliable results. Both beginners and experienced immunologists will benefit from its comprehensive methodological coverage.

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immunology topics for research: Ongoing Research in Jawed Fish Immunity: Structural and Functional Studies at the Protein and Cellular Levels Monica Imarai, Brian Dixon, 2020-06-04 Knowledge of jawed fish immune systems obtained in the last 15 years has been mostly obtained through the sequencing of genomes of different fish species and from the use of high-throughput techniques such as transcriptomic analysis and RNA sequencing, which has allowed characterization of immune gene responses at the transcriptomic level. Although these have been important tools for exploring the complexities of the immune responses of fish species, the next generation of knowledge requires the use of new tools and methods capable of unveiling the diversity of immune cells and molecules in jawed fish, the network of interactions and responses, and the mechanisms leading to immune protection against pathogens. For more than 10 years, many laboratories have been engaged in developing antibodies against key molecules of jawed fish immune systems in several different species because the lack of sequence conservation of most immune genes makes it impossible to use the large panel of antibodies against mammalian molecules for recognition of fish molecules. The numerous genes encoding cytokines and receptors have now been used to make recombinant proteins available, allowing studies of the complex network of cytokine and receptor functions central to fish immune responses. From many laboratories, new and interesting knowledge about immune cells, their functions and interactions can be studied with the availability of new tools and methods have begun to provide a clear understanding fish immunity at the protein and cellular levels. This Research Topic gives a comprehensive overview of the current knowledge of jawed fish immune responses with a particular emphasis on structural and functional studies at the protein and cellular levels.

immunology topics for research: Immunological Aspects of Emerging and Re-emerging Zoonoses Wei Wang, Jingxin Li, Yuejin Liang, Wenping Gong, 2024-03-20 Zoonosis is an infectious disease that has jumped from non-human animals to humans. To date, more than 200 known types of zoonoses have been identified, and 60% of emerging infectious diseases are zoonotic. It is estimated that zoonoses are responsible for 2.5 billion cases of human illness and 2.7 million human deaths worldwide each year, and 50-60% of the global population (5-6 billion) are projected to be at risk of zoonotic infections. Emerging and re-emerging zoonoses, such as monkeypox, Ebola, SARS, MERS, Zika, Rickettsia, and Mycobacteria, pose an immense and growing threat to global health, economy, and safety. As of September 26, 2022, there have been more than 600 million cases confirmed with COVID-19, and 6,514,397 deaths occurred due to this highly communicable disease. Identification of the immunological aspects of emerging and re-emerging zoonoses may facilitate the diagnosis, vaccine, and therapeutics development of emerging and re-emerging zoonoses.

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Alcohol use disorder (AUD) is a significant global health burden. Globally alcohol misuse is the fifth leading risk factor for premature death and disability, and accounts for ~3.3 million deaths annually. Chronic alcohol use deleteriously affects both normal behavior (e.g., depression, anxiety, and alcohol craving) and physiology (e.g., oxidative stress, intestinal hyperpermeability, immune dysfunction, and organ damage). Both heavy and binge drinking patterns alter immune frequencies, compromise immune cell function, resulting in increased morbidity and mortality. Alcohol misuse can damage barrier functions in vital organs such as the lungs, gut, increase susceptibility to both bacterial and viral infections but delay wound healing. Chronic alcoholics are also at a greater risk of developing Acute respiratory distress syndrome (ARDS), alcoholic liver disease (ALD), and certain cancers. A lot of progress has been made in elucidating the relationship between alcohol consumption and immune function and how it affects human health. However, the mechanisms by which alcohol and its metabolites interacts with peripheral and tissue-resident immune systems remain poorly defined. Defining specific systemic adaptations and molecular mechanisms is important for understanding the long-term consequences of chronic alcohol use. These studies will help devise new interventions or refine existing ones to target the immune system in mitigating alcohol-related diseases. The aim of this Research Topic is to bring together new research in the alcohol field exploring the broad molecular and cellular adaptations of binge and heavy drinking on peripheral and tissue immunity. Studies would ideally include a combination of in vitro cell line models and in vivo animal models, and/or human studies of alcohol-induced end-organ damage mediated by dysregulated immune responses. Papers in this Research Topic could be used to identify complementary mechanisms and pathways that may be the focus of future therapeutic strategies. We encourage the submission of Original Research articles, as well as Reviews, Mini-Reviews, and Perspectives covering the following or related topics: 1. Innate and adaptive immune adaptations with moderate and heavy drinking. 2. Transcriptional and epigenetic mechanisms of alcohol-associated immune dysfunction 3. Alcohol-microbiome cross-talk and its role on immune function. 4. Alcohol and tissue immunity - impact on barrier function, immune-stromal cell crosstalk. 5. Alcohol and immune responses to vaccines and infections. 6. Impact of alcohol on immune metabolism and mitochondrial dysfunction 7. Sex differences in the impact of heavy drinking on immune responses. 8. Organ-organ interactions and immunity o Gut-Lung-Liver axis o Gut-brain axis o Liver-brain axis

immunology topics for research: *Immunomodulatory effect of Nutrients on intestinal disorders and immunity* Yaozhong Hu, Benoit Stijlemans, Jin Wang, 2025-02-13

There are so many different types of food with divergent nutrient formulations, and these can exhibit different effects on our health. For example, it is believed that eating certain types of food, such as honey, garlic, or nuts, can enhance our immunity. The mechanism mainly relies on the ingestion of nutrients such as carbohydrates, fat, and protein, which are classified as macro-nutrients, to participate in important biological processes like cell metabolism, tissue repair, and immunity maintenance. Whereas, micronutrients like vitamins and microelements also play vital roles in guaranteeing internal homeostasis. The other dietary fractions, like plant-derived compounds, including flavonoid compounds and polyphenols, as well as prebiotics and probiotics, also play important roles in modulating our health as well as interfering with our immunity. It is considered that food nutrients are critical modulators of health and disease. Furthermore, the appropriate ingestion of these compounds is critical to maintaining homeostasis, while excess rather breaks the balance and can affect health negatively. It's easy to understand that food nutrients will play different roles under different conditions of health or disease. Thus, if certain nutrients possess immunomodulatory functions, they could either benefit certain diseases or cause disease progression, whereas they

could possibly be used to modulate the immune response to alter disease progression or cure the disease. Thus, it is important to explore the effect of nutrients on our internal immune balance.

immunology topics for research: Interaction between the Gut Flora and Immunity in Intestinal Diseases Yating Li, Silvia Turrone, Lan Gong, Ding Shi, 2024-08-20 The composition of gut microbiota plays a critical role in maintaining the host's health, particularly in regulating immune homeostasis and the intestinal immune response. A massive effort has pointed to the importance of these interactions in various intestinal diseases like colorectal cancer (CRC), irritable bowel syndrome (IBS), and inflammatory bowel disease (IBD). Microbiome influences the formation of key components of both the innate and adaptive immune systems, while the immune system is responsible for regulating and maintaining the symbiotic relationship between the host and microbes. Currently, the crosstalk between gut flora and host immunity is not fully revealed in both homeostasis maintenance and disease development. Hence detailed mechanistic studies are needed to further explore the microbial manipulation on host immunity as well as the immune response to microbiome dysbiosis in intestinal diseases. Current evidence indicates a strong bidirectional interaction between microbiome perturbation and immune dysregulation. The aim of this Research Topic is to create a platform for the advancement of research on the causal relationship between the microbiome and immunity. Besides, we would like to define the core microbiota responsible for the initiation and progression of intestinal diseases, the molecular mechanisms of host immune-microbiome interactions, and novel gut-targeted pharmacological interventions to achieve a positive impact on intestinal disease.

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immunology topics for research: Balancing Alloantigen-Induced Immune Responses and Anti-tumor Immunity in Transplantation Rita Maccario, Luigi Nespoli, Marcello Maestri, 2025-09-12 Transplantation, encompassing both hematopoietic stem cell and solid organ transplants, is a critical medical intervention for treating various life-threatening conditions. However, it is often complicated by alloantigen-induced immune activation, a response triggered by the donor's immune system against recipient antigens and/or the recipient's immune system against donor antigens. This immune activation can arise from prior sensitization events such as blood transfusions, previous transplants, or fetal-maternal interactions. While alloantigen-induced immune responses can be beneficial, as seen in the Graft vs. Leukemia (GvL) or Graft vs. Tumor (GvT) effects, they can also lead to adverse outcomes like Graft vs. Host Disease (GvHD) and graft rejection. Several studies have highlighted the complex interactions between immune cell populations in these processes, emphasizing the need for therapeutic strategies that balance long-term donor-recipient tolerance with the preservation of anti-tumor immunity and protection against opportunistic infections. Despite advancements, there remains a significant gap in understanding the molecular and cellular dynamics of alloantigen-induced immune activation, necessitating further research to develop more effective and tailored therapeutic approaches. This research topic aims to explore and delineate both molecular and cell-based therapeutic strategies designed to control the adverse effects of alloantigen-specific immune responses while maintaining anti-tumor immunity and protection against opportunistic infections in transplant recipients. It encompasses a critical review of existing therapeutic modalities, evaluates the latest advancements, and highlights ongoing research focused on refining these strategies. The objective is to foster a comprehensive understanding of the immune mechanisms at play and to identify innovative approaches that can enhance transplant outcomes.

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diabetes patients, thus significantly reducing hyperglycemia and improving HbA1c, and has become one of the ideal options for the treatment of type 1 diabetes patients. However, despite great progress, current islet transplantation is still limited by the isolation process, the culture period, and the rapid decline in islet functional activity after transplantation. Long-term survival and function of islet grafts are affected by non-immune and immune-related factors. To overcome these obstacles, various strategies, including stem cell combination transplantation, have been used for islet transplantation. Stem cells can promote vascular regeneration of islets and reduce inflammation and innate immune damage in the early stage of islet transplantation through potential immunomodulatory and anti-inflammatory effects. Therefore, combined transplantation of islets and stem cells can improve the survival rate of islets. In view of this, we are very honored and pleased to have some of the leading research groups in diabetes research contribute to the topic of islet transplantation. This special issue of the current landscape is dedicated to summarizing the latest advancements in allogenic and xenogenic islet transplantation and strategies to overcome its current limitations. Diversified topics related to islet isolation, islet transplantation, stem cells, immune regulation, angiogenesis, and strategies overcoming immune responses are welcome.

immunology topics for research: *Community Series in Novel Biomarkers in Tumor Immunity and Immunotherapy, volume II* Eyad Elkord, Takaji Matsutani, 2025-05-15 This Research Topic is the second volume of the “Novel Biomarkers in Tumor Immunity and Immunotherapy” Community Series. Please see Volume I here. Immune checkpoint inhibitors (ICIs) such as anti-PD-1 and anti-PD-L1 antibodies are highly effective against many types of cancer, yet durable responses are limited to a subset of patients highlighting the need for the development of effective biomarkers to predict prognosis and efficacy. Currently, PD-L1 expression in tumors, microsatellite instability (MSI) or mismatch repair deficiency (dMMR), and tumor mutation burden (TMB) are known as biomarkers for cancer immunotherapy but are not sufficient. Combination therapy with immune checkpoint inhibitors and chemotherapy or radiation therapy, as well as diverse therapies targeting intra-tumoral regulatory T cells have been described, but there are currently no unifying biomarkers that are applicable to clinically, a simple, fast, non-invasive method that can yield biomarkers of disease with a minimal adverse effect on patients is desirable. Recent findings suggest that the balancing of effector T cells and regulatory cells in the tumor microenvironment is associated with cancer progression and prognosis. Cells and molecules involved in the control of cancer are complex, and a better understanding of the tumor immune environment will lead to the development of truly effective biomarkers. This research topic will focus on novel biomarkers that predict efficacy, prognosis, or the development of adverse events in various cancer immunotherapies, and extensive basic research leading to the development of biomarkers. We expect a wide range of research, not only in serology, genetics, and immunocytochemistry but also in bacterial flora. Research on the development of novel assays and bioinformatics methods is also welcome: • Non-invasive biomarkers for cancer immunotherapy. • Bulk RNA-seq, scRNA-seq, or Rep-seq methods. • Correlation of tumor immune cells with gut microbiota in tumor immunotherapy. • Impact of Teff and Treg balance in the tumor microenvironment on tumor prognosis. • Inflammatory and immune signatures associated with drug response versus resistance in cancer. Please note that Topic Editor Dr. Takaji Matsutani is employed by Maruho Co., Ltd. The other Topic Editors declare no competing interests with regard to the Research Topic subject. Please also note that manuscripts consisting solely of bioinformatics or computational analysis of public genomic or transcriptomic databases which are not accompanied by robust and relevant validation (clinical cohort or biological validation in vitro or in vivo) are out of scope for this topic.

immunology topics for research: RNA Modifications in Cancer: Unraveling Roles and Therapeutic Potential in Immunity and Immunotherapy Zhihao Wang, Wanhong Liu, Haojie Dong, Xin He, 2025-10-06 RNA modification mechanisms and their related machineries are pivotal in determining cellular fate, dynamically regulating nearly every aspect of RNA functionality. A growing body of evidence suggests that variations in RNA modifications are implicated in a wide spectrum of physiological and pathological states, with cancer being of notable concern. These

modifications selectively influence the translation of transcripts that can either promote or suppress tumor development, thereby playing a critical role in cancer progression. Consequently, the machinery responsible for RNA modification—specifically writers, readers, and erasers—has garnered significant interest for their therapeutic potential in disease management. The primary objective of this research topic is to investigate the influence of RNA modifications, such as N 6-methyladenosine (m 6A), N 1-methyladenosine (m 1A), 5-methylcytosine (m 5C), N 7-methylguanosine (m 7G), N 4-acetylcytosine (ac 4C), pseudouridine (Ψ), and uridylation, on cancer immunity and the effectiveness of immunotherapies. This initiative aims to critically assess how these RNA modifications affect cancer development and to explore the possibility of targeting these modifications to improve the outcomes of cancer immunotherapy. By establishing a comprehensive research platform, this effort seeks to propel forward the development of more precise and potent cancer treatments through the innovative targeting of RNA modifications.

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