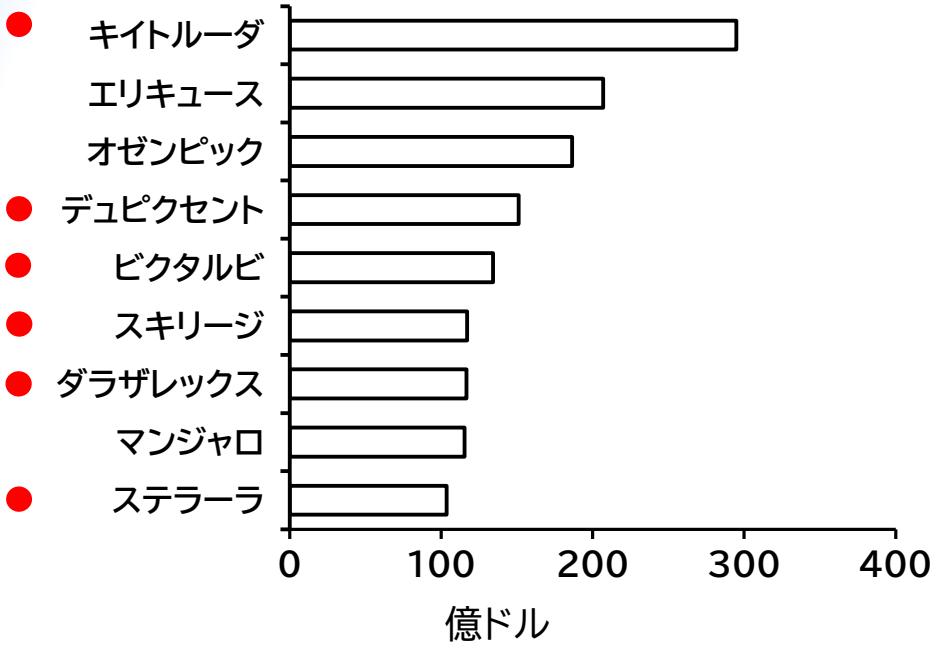
「我が国の勝ち筋」としての免疫研究
現在世界のお薬の売り上げの５～６割は抗体医薬を中心とする
免疫調整薬・がん免疫治療薬が席捲

世界医薬品売上ランキング



● 免疫調節薬

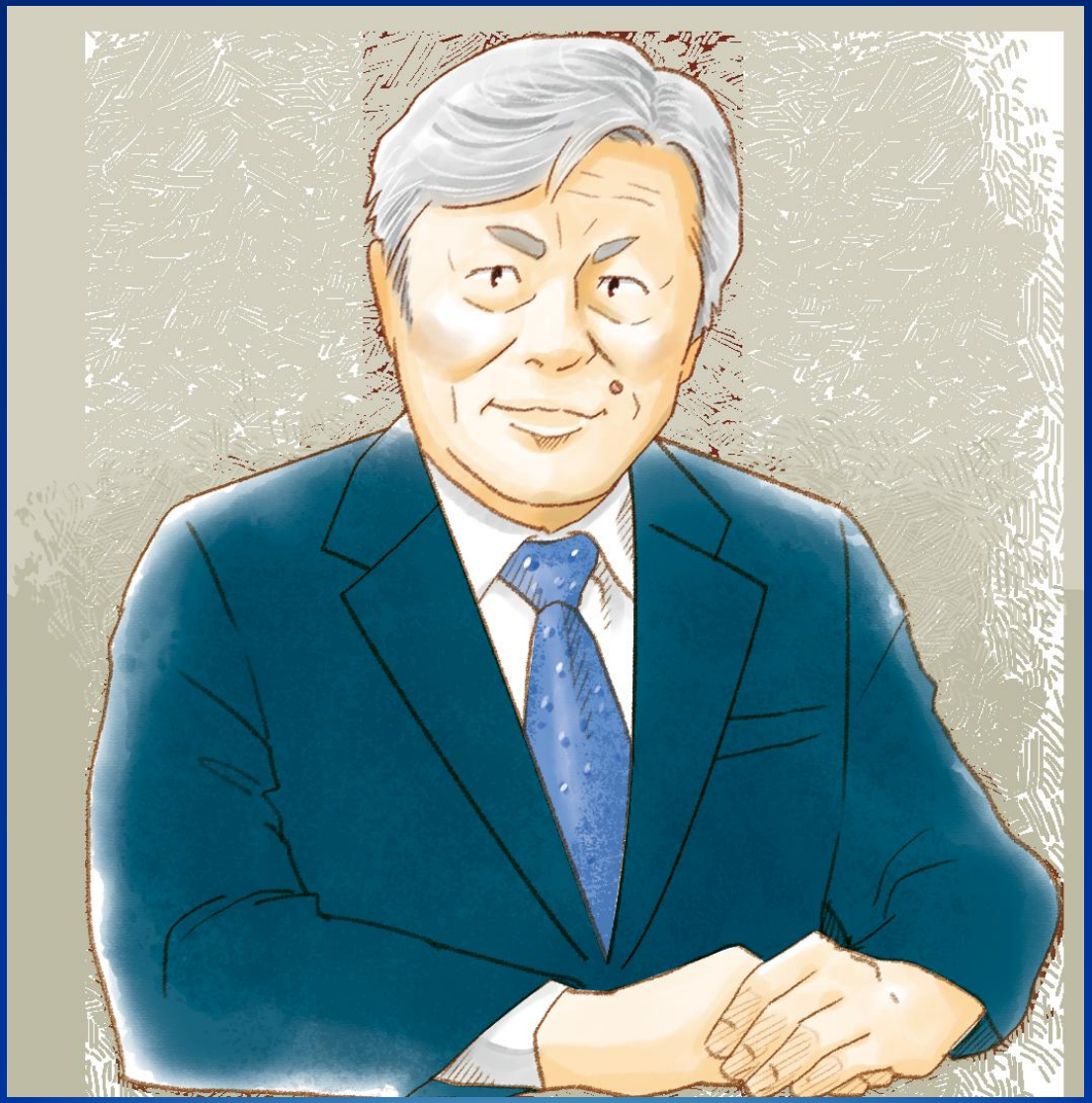
キイトルーダ：ヒト化抗ヒトPD-1モノクローナル抗体
エリキュース：経口FXa阻害剤
オゼンピック：持続性GLP-1受容体作動薬（2型糖尿病）
デュピクセント：ヒト型抗ヒトIL-4/13受容体モノクローナル抗体（アトピー性皮膚炎等）
ビクタルビ：抗ウイルス化学療法剤（HIV-1感染症）
スキリージ：ヒト化抗ヒトIL-23p19モノクローナル抗体（乾癬・クローン病等）
ダラザレックス：ヒト型抗ヒトCD38モノクローナル抗体（多発性骨髄腫）
マンジャロ：持続性GIP/GLP-1受容体作動薬（2型糖尿病）
ステラーラ：ヒト型抗ヒトIL-12/23p40モノクローナル抗体（潰瘍性大腸炎等）

GEN参照し図を作成
Top 10 Best-Selling Drugs

- **COVID-19を含む新興感染症制御の必要性**
- **アルツハイマーの疾患感受性遺伝子多型の７割は免疫関連**
- **がん免疫療法の有効性の向上、ロングサバイバーの増加**

抗体の遺伝子構造・多様性の解明

→抗体のエンジニアリングが可能に！



利根川進先生

The Nobel Prize in Physiology or Medicine 1987

岸本忠三先生
平野俊夫先生

The Crafoord Prize 2009

The Royal Swedish Academy of Sciences has decided to award the Crafoord Prize in Polyarthritis 2009 jointly to Charles Dinarello, University of Colorado School of Medicine, Denver, USA, Tadamitsu Kishimoto, Graduate School of Frontier Biosciences, Osaka University, Japan and Toshio Hirano, Graduate School of Medicine, Osaka University, Japan,
“for their pioneering work to isolate interleukins, determine their properties and explore their role in the onset of inflammatory diseases".

抗体を作らせるホルモン様物質（サイトカイン）IL-６の発見

我が国で初の抗体医薬の開発

→世界で累計６兆円（国内５０００億円）の売り上げ！

IL-6受容体 を標的とした薬剤	適応承認疾患
   抗IL-6受容体抗体 トシリズマブ	• キャッスルマン病、関節リウマチ • 全身型、多関節炎型の若年性特発性関節炎、**成人発症スチル病** • 高安動脈炎、巨細胞性動脈炎（皮下注のみ） • **CAR-T細胞治療時のCRS防止** • **COVID-19の重症化阻止としても！**

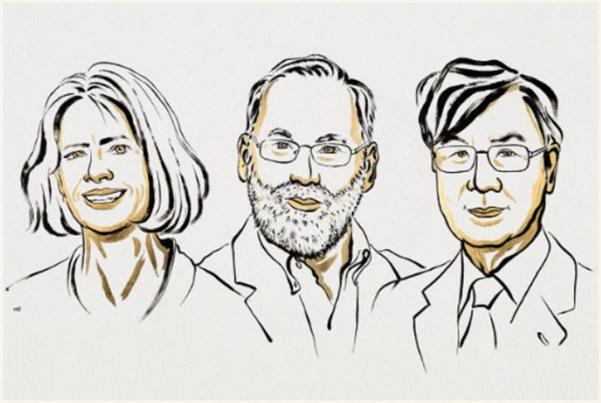
ノーベル生理学・医学賞：制御性T細胞の発見

免疫学フロンティア研究センター・坂口　志文 特任教授が 2025年ノーベル生理学・医学賞を受賞

The 2025 medicine laureates

The Nobel Assembly at the Karolinska Institutet has decided to award the 2025 Nobel Prize in Physiology or Medicine to Mary E. Brunkow, Fred Ramsdell and Shimon Sakaguchi "for their discoveries concerning peripheral immune tolerance."

They identified the immune system's security guards, regulatory T cells, thus laying the foundation for a new field of research. The discoveries have also led to the development of potential medical treatments that are now being evaluated in clinical trials. The hope is to be able to treat or cure autoimmune diseases, provide more effective cancer treatments and prevent serious complications after stem cell transplants.



Ill. Niklas Elmehed © Nobel Prize Outreach

坂口特任教授の研究成果

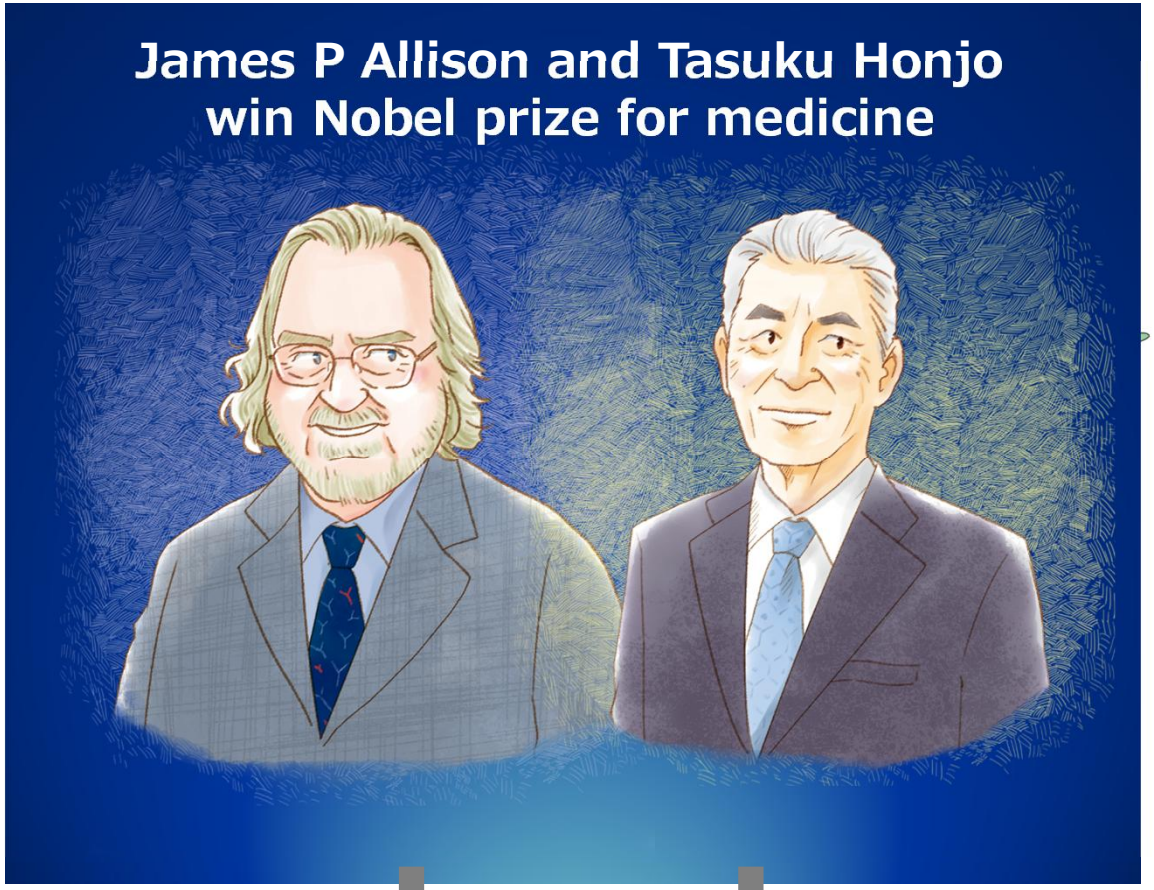
- **免疫自己寛容（自己に対する異常な免疫反応を抑える）、免疫恒常性（アレルギーなどの過剰な免疫反応を抑える）に必須な制御性T細胞(Regulatory T cell)の発見。**
- **制御性T細胞の異常としての自己免疫病、アレルギーなどの原因・発症機構の解明、および制御性T細胞を標的とした免疫病の治療法・予防法、がん細胞に対する免疫応答惹起法、さらに移植臓器に対する免疫寛容誘導法の開発。**

功績

1979年 制御性T細胞に関する研究を開始。
1995年 特異的分子マーカーによる制御性T細胞の同定に成功。
⇒制御性T細胞の存在とその免疫学的重要性を世界で初めて証明。
2003年 制御性T細胞特異的転写因子Foxp3の発見。

今後、ヒトの免疫病の治療・予防、がん免疫療法、移植臓器に対する免疫寛容誘導など医療への応用が期待される。

免疫チェックポイント分子の阻害によるがん免疫療法



化学療法 ＋ ＋ 放射線療法

がん免疫療法

がん免疫療法 ＋ ＋ 分子標的療法

2026 Japan Prize（日本国際賞）
核酸（mRNA, DNA）認識機構の解明

審良静男先生

授賞対象分野：生命科学

授賞業績

「自然免疫システムによる核酸認識メカニズムの解明」

これまでも自然免疫の研究で
ロベルト・コッホ賞
ガードナー国際賞など受賞

mRNAワクチン、核酸医薬品の登場
がん免疫療法の普及により注目！

2024年 米国ラスカー賞受賞の
ジージャン・チェン博士と共同受賞

薬の開発は縦糸（標的分子）と横糸（モダリティ）

〇新しい創薬モダリティ（従来は飲み薬、低分子化合物）

1．抗体： ナノボディ、バイスペシフィック抗体, ADC →免疫、がん治療

2．タンパク質・ペプチド： ターゲティングアゴニスト（GLP-1など）→内分泌、免疫学、血液学

3．細胞療法： CAR―T →がん、自己免疫疾患
T 細胞受容体療法 (TCR-T) →固形がん

4．遺伝子治療： 遺伝子増強、ゲノム編集 →希少疾患、特に血液、中枢神経系
腫瘍溶解性ウイルス →がん

5．核酸'（RNA創薬）： mRNA ワクチン →感染症、がんワクチン
mRNA医薬 →タンパク欠損症、がん、生活習慣病
アンチセンス →希少疾患、肝、筋、中枢神経系
RNAi →肝、腎、心筋、中枢神経系

6．その他： マイクロバイオーム →がん、免疫調節
プロタック（Proteolysis Targeting Chimera）→がん、神経、炎症性疾患
中分子（中外製薬）、中分子環状ペプチド

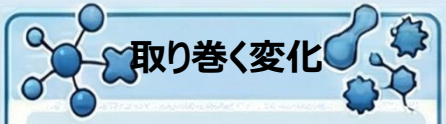
「勝ち筋となる分野」について「新技術立国」を目指す

現状

日本の強み

・アカデミア発の優れたシーズ
・医薬品売上の6割以上を免疫調節薬が占める中、特に、免疫分野に強み

取り巻く変化



モダリティの多様化

AI技術の進展

水平分業化の進展
科学とﾋﾞｼﾞﾈｽの近接化

喫緊に強化が必要な取組

科学とビジネスの近接化の強化

（研究開発税制等含めた企業側へのインセンティブ）

喫緊に強化が必要な取組

AI創薬への対応の強化

（AI活用による創薬プロセスの効率化を巡る国際競争が激化しているが日本はデータや計算資源の整備も含めて出遅れ）

継続的な基盤の強化

免疫研究やiPS細胞研究などの日本の強みを活かした基盤研究の充実や実用化への橋渡し機能の強化

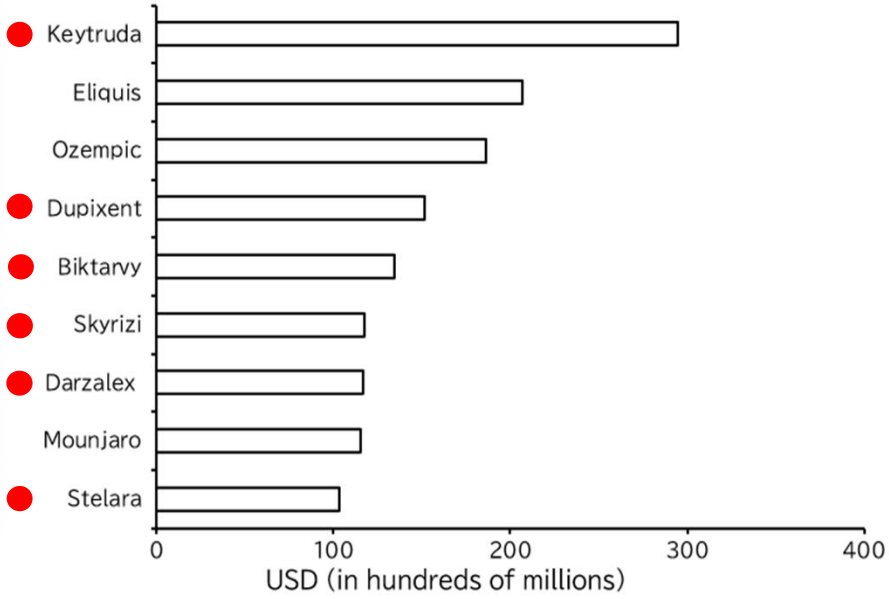
勝ち筋の創出

ファーストインクラス・ベストインクラスにつながる創薬シーズの継続的な創出

Japan's winning strategy: immunology research

-antibody-based therapeutics, immunomodulatory drugs, and cancer immunotherapies dominate 50–60% of global pharmaceutical sales-

Global pharmaceutical sales ranking



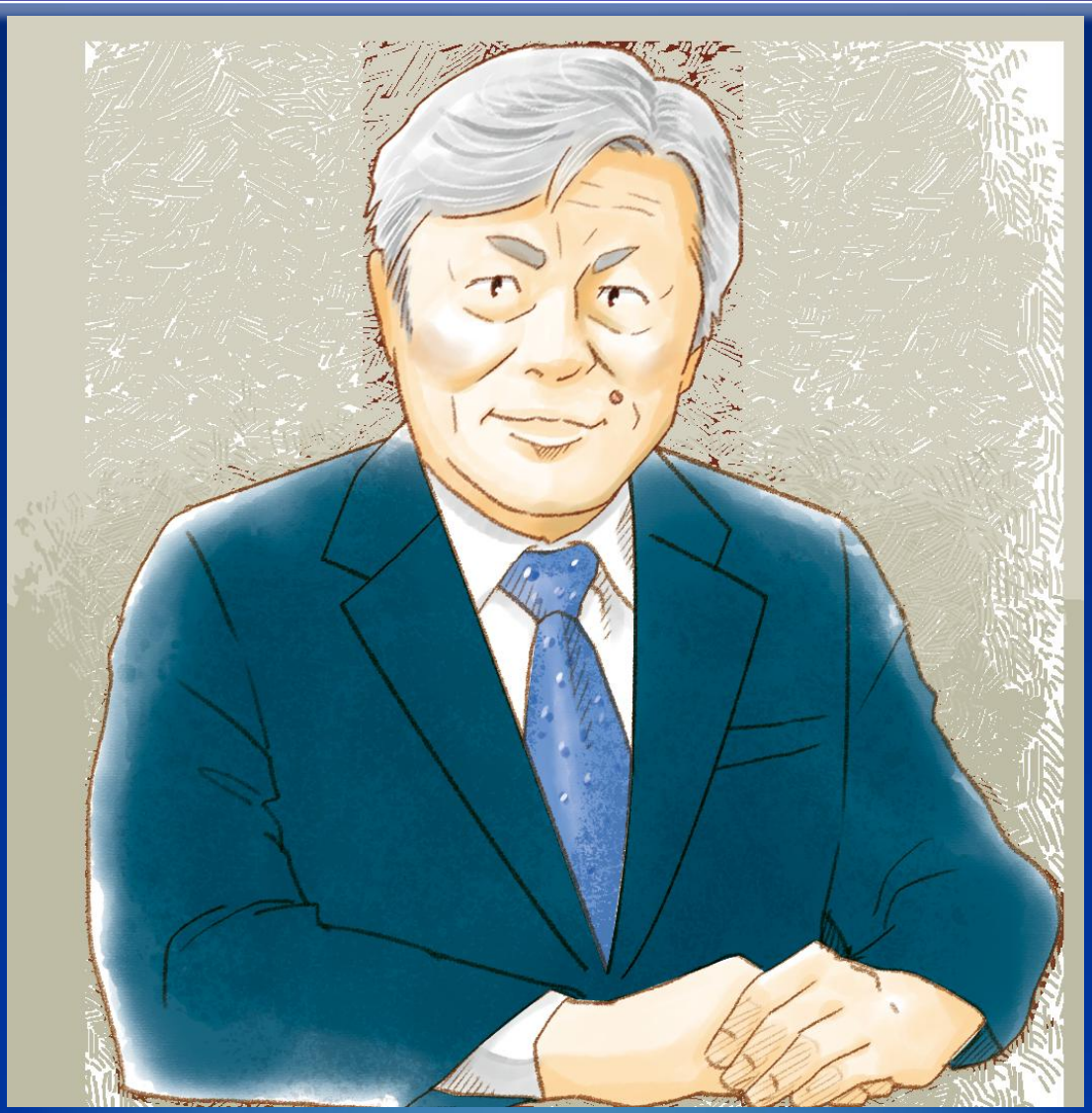
● **Immunomodulators**

Keytruda: humanized anti-PD-1 monoclonal antibody
Eliquis: oral factor Xa inhibitor
Ozempic: long-acting GLP-1 receptor agonist (type 2 diabetes)
Dupixent: fully human monoclonal antibody against IL-4 receptor α (IL-4Rα) (atopic dermatitis, etc.)
Biktarvy: combination antiretroviral therapy (HIV-1)
Skyrizi: humanized anti-IL-23 p19 monoclonal antibody (psoriasis, Crohn's disease, etc.)
Darzalex: fully human anti-CD38 monoclonal antibody (multiple myeloma)
Mounjaro: long-acting dual GIP/GLP-1 receptor agonist (type 2 diabetes)
Stelara: fully human anti-IL-12/23 p40 monoclonal antibody (ulcerative colitis, etc.)

Fig.1 (left) Philippidis, "Top 10 Best-Selling Drugs"
GEN Genetic Engineering & Biotechnology News, July 7, 2025

- **Controlling emerging infectious diseases (incl. COVID-19) is necessary**
- **70% of genetic risk variants in Alzheimer's are related to the immune system**
- **Advances in cancer immunotherapy efficacy contribute to an increase in long-term survivors**

Awarded the Nobel Prize in Physiology or Medicine (1987)



Prof.
Susumu
Tonegawa

…for his work in the elucidation of antibody gene structure and diversity, which made antibody engineering possible

THE Crafoord PRIZE

Prof. Tadamitsu Kishimoto
Prof. Toshio Hirano

The Crafoord Prize 2009

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**At the time of the award, The University of Osaka was known as Osaka University.*

For the discovery of IL-6 (cytokine), which induces the production of antibodies

The first antibody therapeutic developed in Japan

*Cumulative global sales of JPY 6 trillion** (JPY 500 billion in Japan***)!

**USD 37.53 billion ***USD 3.13 billion

Drug targeting the IL-6 receptor:	Approved use:
   Anti–IL-6 receptor antibody: Tocilizumab	• Castleman disease; rheumatoid arthritis • Systemic and polyarticular juvenile idiopathic arthritis (JIA); adult-onset Still's disease (AOSD) • Takayasu arteritis; giant cell arteritis (subcutaneous injection only) • Prevention of cytokine release syndrome (CRS) associated with CAR-T cell therapy • Also used to prevent severe COVID-19!

2025 Nobel Prize in Physiology or Medicine for the discovery of regulatory T cells (Tregs)

Distinguished Honorary Professor Shimon Sakaguchi, Immunology Frontier Research Center

The 2025 medicine laureates

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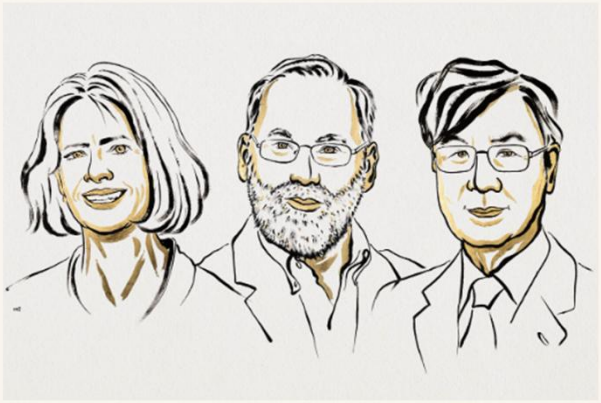

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Major Contributions

- **Discovery of regulatory T cells essential for immunological self-tolerance (control of autoreactive immune responses) and immune homeostasis (control of excessive responses, such as allergies).**
- **Elucidation of autoimmune and allergic disease mechanisms caused by regulatory T cell dysfunction; development of Treg-targeted therapies and prevention, cancer immune activation, and induction of transplant tolerance.**

Key Achievements

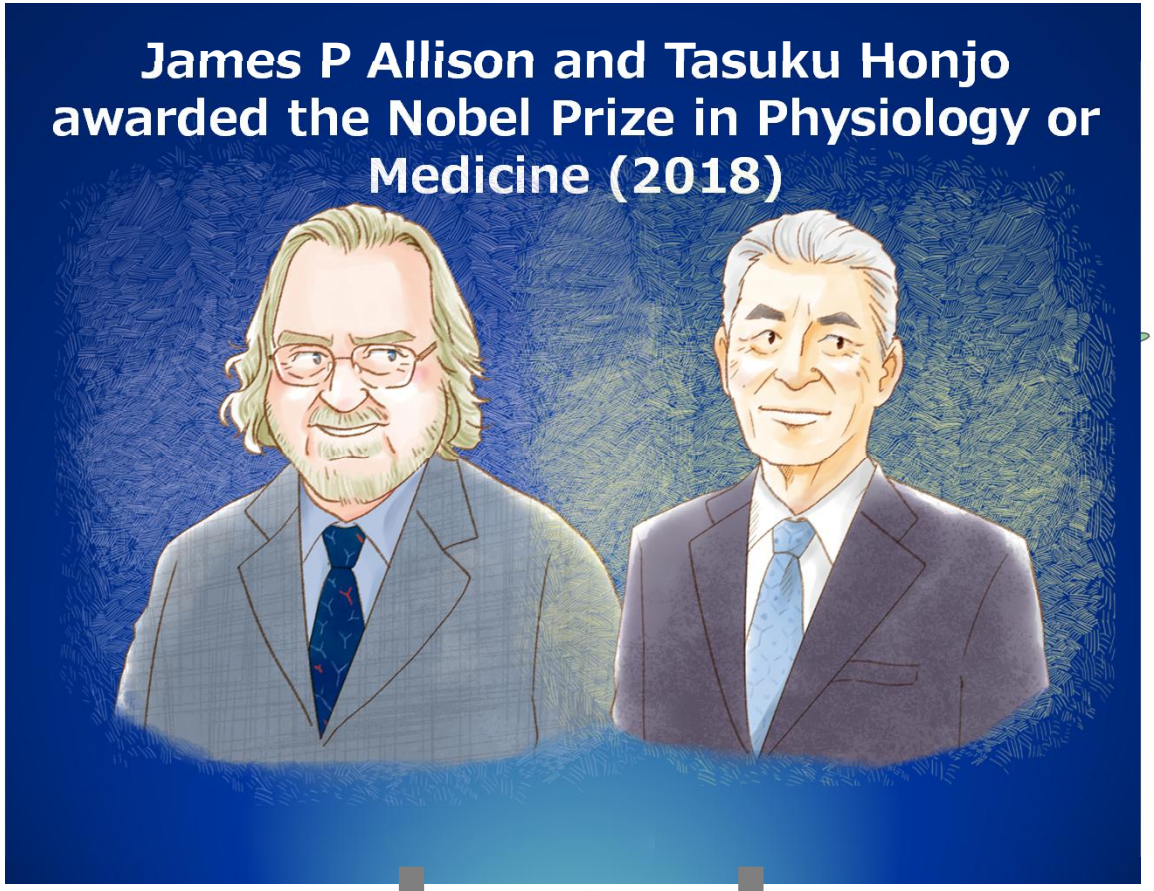
1979 Initiated research on regulatory T cells

1995 Identification of regulatory T cells using specific molecular markers
→ First demonstration of their existence and immunological importance

2003 Discovery of the Treg-specific transcription factor Foxp3

In the future, clinical applications in human immune disease treatment and prevention, cancer immunotherapy, and induction of transplant tolerance are expected.

Cancer immunotherapy through the inhibition of co-inhibitory checkpoint molecules



chemotherapy + + radiotherapy

cancer immuno-therapy

cancer immunotherapy + + Molecular targeted therapy

Recipient of the 2026 Japan Prize for elucidating the mechanisms of nucleic acid (mRNA, DNA) recognition

Specially Appointed Professor
Shizuo Akira

Award Field: Life Science*

Citation:

"Elucidation of the mechanisms of nucleic acid recognition by the innate immune system"

Also received international awards for his work in natural immunity:
-Robert Koch Prize
-Gairdner Award

Gaining attention for mRNA vaccines, nucleic-acid therapeutics, and cancer immunotherapy!

*Jointly awarded with the recipient of the 2024 Lasker Award, Dr. Zhijian J. Chen

Drug development involves vertical (target molecules) and horizontal axes (modalities)

★New drug modalities (traditionally oral drugs/low-molecular-weight compounds)

1. **Antibodies:**
   - **nanobodies, bispecific antibodies, and antibody–drug conjugates (ADCs)** for immunology and cancer therapies
2. **Proteins/peptides:**
   - **targeted agonists (e.g., GLP-1)** for endocrinology, immunology, hematology
3. **Cell therapy:**
   - **CAR-T** for cancer, autoimmune diseases
   - **T cell receptor therapy (TCR-T)** for solid tumors
4. **Gene therapy:**
   - **gene augmentation and genome editing** for rare diseases, especially hematologic/central nervous system disorders
   - **Oncolytic viruses** for cancer therapies
5. **Nucleic acids (RNA therapeutics):**
   - **mRNA vaccines** for infectious diseases; cancer vaccines
   - **mRNA therapeutics** for protein-deficiency disorders; cancer; metabolic diseases

   Antisense oligonucleotides (ASOs) for rare diseases; liver; muscle; central nervous system

   RNA interference (RNAi) for liver; kidney; heart; central nervous system
6. **Others:**

   Microbiomes for cancer/immune modulation

   PROTACs (Proteolysis Targeting Chimera) for cancer; neurological and inflammatory diseases

   Mid-sized molecules (Chugai Pharmaceutical), including cyclic mid-sized peptides

Becoming a nation of technological innovation by prioritizing strategic fields