Nobelförsamlingen
The Nobel Assembly at Karolinska Institutet

PRESS RELEASE
6 October 2025

The Nobel Prize in Physiology or Medicine 2025

The Nobel Assembly at Karolinska Institutet has decided to award the Nobel Prize in Physiology or Medicine 2025 to:

Mary E. Brunkow
Institute for Systems Biology,
Seattle, USA

Fred Ramsdell
Sonoma Biotherapeutics,
San Francisco, USA

Shimon Sakaguchi
Osaka University,
Osaka, Japan

"for their discoveries concerning peripheral immune tolerance"

They discovered how the immune system is kept in check

The body's powerful immune system must be regulated, or it may attack our own organs. Mary E. Brunkow, Fred Ramsdell and Shimon Sakaguchi are awarded the Nobel Prize in Physiology or Medicine 2025 for their groundbreaking discoveries concerning peripheral immune tolerance that prevents the immune system from harming the body.

Every day, our immune system protects us from thousands of different microbes trying to invade our bodies. These all have different appearances, and many have developed similarities with human cells as a form of camouflage. So how does the immune system determine what it should a>ack and what it should defend?

Mary Brunkow, Fred Ramsdell and Shimon Sakaguchi are awarded the Nobel Prize in Physiology or Medicine 2025 for their fundamental discoveries relating to peripheral immune tolerance. The laureates identified the immune system's security guards, *regulatory T cells*, which prevent immune cells from a>acking our own body.

"Their discoveries have been decisive for our understanding of how the immune system functions and why we do not all develop serious autoimmune diseases," says Olle Kämpe, chair of the Nobel Committee.

Shimon Sakaguchi was swimming against the tide in 1995, when he made the first key discovery. At the time, many researchers were convinced that immune tolerance only developed due to potentially harmful immune cells being eliminated in the thymus, through a process called *central tolerance*. Sakaguchi showed that the immune system is more complex and discovered a previously unknown class of immune cells, which protect the body from autoimmune diseases.

Mary Brunkow and Fred Ramsdell made the other key discovery in 2001, when they presented the explanation for why a specific mouse strain was particularly vulnerable to autoimmune diseases. They had discovered that the mice have a mutation in a gene that they named *Foxp3*. They also showed that mutations in the human equivalent of this gene cause a serious autoimmune disease, IPEX.

Two years after this, Shimon Sakaguchi was able to link these discoveries. He proved that the *Foxp3* gene governs the development of the cells he identified in 1995. These cells, now known as regulatory T cells, monitor other immune cells and ensure that our immune system tolerates our own tissues.

The laureates' discoveries launched the field of peripheral tolerance, spurring the development of medical treatments for cancer and autoimmune diseases. This may also lead to more successful transplantations. Several of these treatments are now undergoing clinical trials.

Mary E. Brunkow, born 1961. Ph.D. from Princeton University, Princeton, USA. Senior Program Manager at the Institute for Systems Biology, Seattle, USA.

Fred Ramsdell, born 1960. Ph.D. 1987 from the University of California, Los Angeles, USA. Scientific Advisor, Sonoma Biotherapeutics, San Francisco, USA.

Shimon Sakaguchi, born 1951. M.D. 1976 and Ph.D. 1983 from Kyoto University, Japan. Distinguished Professor at the Immunology Frontier Research Center, Osaka University, Japan.

Prize amount: 11 million Swedish kronor, to be shared equally between the laureates.
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What is Peripheral Immune Tolerance?

Imagine your immune system as a city's security force. Its mission is to spot and stop threats—viruses, bacteria, cancer cells—without hassling peaceful citizens like your own tissues, the food you eat, or the friendly bacteria living in your gut. Peripheral immune tolerance is the set of "common-sense rules" that guides this security team out on the streets, after officers have graduated from the academy. Without these rules, the team would overreact, arrest the wrong people, and the city would constantly be in chaos. With them, life runs smoothly.

One rule is called anergy, which you can think of as a "do-not-chase" list. If a security officer meets someone who looks a little unusual but there's no real sign of danger—no yelling, no broken windows, no alarm going off—the officer learns not to chase that person next time. Immune cells do the same thing: when they encounter a harmless molecule, especially one from your own body, without the chemical "alarm bells" that signal an infection, they become unresponsive to it. The cell isn't dead; it just won't make a fuss about that thing again. This stops a lot of false alarms before they start.

A second rule involves peacekeepers, known in biology as regulatory T cells (Tregs). These are the calm mediators who show up when a scuffle starts and tell everyone to take a breath. Tregs release soothing signals that make other immune cells less jumpy and also coach local "neighborhood watch" cells to present information more calmly. In everyday life, this matters after you eat: Tregs help your body stay chill about food proteins like peanut or wheat—substances that are foreign but not dangerous—so you don't get unnecessary inflammation every time you have a snack.

The third rule is deletion, which is like dismissing a hot-headed officer who keeps escalating small issues into big ones. When an immune cell repeatedly targets something it shouldn't—say, proteins in your joints—it can be instructed to self-destruct. That might sound drastic, but it protects the city from chronic trouble like autoimmune arthritis. Removing the few troublemakers keeps the whole force trustworthy.

Some parts of the city are designated quiet zones: the eyes, brain, and testes are examples of "immune-privileged" areas. Here, the rules are extra strict: fewer patrols, more caution, special signals that discourage aggressive responses. It's like posting signs that say "Silence, please—research in progress." Inflammation in these places can cause lasting damage, so the system errs on the side of calm. If a minor disturbance happens, the local rules help resolve it without turning it into a riot.

Finally, every officer has built-in brakes—checkpoint molecules like PD-1 and CTLA-4. During a long or intense pursuit, these brakes make sure the chase doesn't become reckless. They're essential for preventing friendly fire: too much enthusiasm can damage the city itself. Doctors even use medicines that release these brakes to help the immune system attack cancers more strongly, which shows how powerful the braking system normally is.

Why does all this matter? First, peripheral tolerance prevents autoimmunity—your immune system mistaking you for an invader. Without it, everyday activities would be risky: sun exposure might trigger skin attacks, a sore throat could spiral into heart inflammation, or a sandwich could start a battle in your gut. Second, tolerance lets you live peacefully with beneficial microbes and routine foods, saving energy for real threats. Third, it keeps responses proportional: enough to clear infections, not so much that the cleanup crew wrecks the neighborhood.

Of course, balance is everything. If tolerance is too weak, you get autoimmune diseases—guards arresting citizens. If it's too strong, tumors or chronic infections may slip by—guards waving through real criminals. Health depends on keeping these dials tuned just right.

Mary E. Brunkow

Fred Ramsdell

Shimon Sakaguchi

The Nobel Prize in Physics 2025

PRESS RELEASE

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Physics 2025 to

John Clarke
University of California, Berkeley, USA

Michel H. Devoret
Yale University, New Haven, CT and
University of California, Santa Barbara, USA

John M. Martinis
University of California, Santa Barbara, USA

"for the discovery of macroscopic quantum mechanical tunnelling and energy quantisation in an electric circuit"

Their experiments on a chip revealed quantum physics in action

A major question in physics is the maximum size of a system that can demonstrate quantum mechanical effects. This year's Nobel Prize Laureates conducted experiments with an electrical circuit in which they demonstrated both quantum mechanical tunnelling and quantised energy levels in a system big enough to be held in the hand.

Quantum mechanics allows a particle to move straight through a barrier, using a process called tunnelling. As soon as large numbers of particles are involved, quantum mechanical effects usually become insignificant. The laureates' experiments demonstrated that quantum mechanical properties can be made concrete on a macroscopic scale.

In 1984 and 1985, **John Clarke, Michel H. Devoret and John M. Martinis** conducted a series of experiments with an electronic circuit built of superconductors, components that can conduct a current with no electrical resistance. In the circuit, the superconducting components were separated by a thin layer of non-conductive material, a setup known as a Josephson junction. By refining and measuring all the various properties of their circuit, they were able to control and explore the phenomena that arose when they passed a current through it. Together, the charged particles moving through the superconductor comprised a system that behaved as if they were a single particle that filled the entire circuit. This macroscopic particle-like system is initially in a state in which current flows without any voltage. The system is trapped in this state, as if behind a barrier that it cannot cross. In the experiment the system shows its quantum character by managing to escape the zero- voltage state through tunnelling. The system's changed state is detected through the appearance of a voltage.The laureates could also demonstrate that the system behaves in the manner predicted by quantum mechanics - it is quantised, meaning that it only absorbs or emits specific amounts of energy.

"It is wonderful to be able to celebrate the way that century-old quantum mechanics continually offers new surprises. It is also enormously useful, as quantum mechanics is the foundation of all digital technology," says Olle Eriksson, Chair of the Nobel Committee for Physics. The transistors in computer microchips are one example of the established quantum technology that surrounds us. This year's Nobel Prize in Physics has provided opportunities for developing the next generation of quantum technology, including quantum cryptography, quantum computers, and quantum sensors.

John Clarke, born 1942 in Cambridge, UK. PhD 1968 from the University of Cambridge, UK. Professor at University of California, Berkeley, USA.

Michel H. Devoret, born 1953 in Paris, France. PhD 1982 from the Paris-Sud University, France. Professor at Yale University, New Haven, CT and University of California, Santa Barbara, USA.

John M. Martinis, born 1958. PhD 1987 from the University of California, Berkeley, USA. Professor at the University of California, Santa Barbara, USA.

Prize amount: 11 million Swedish kronor, to be shared equally between the laureates. Further information: www.kva.se and www.nobelprize.org Press contact: Eva Nevelius, Press Secretary, +46 70 878 67 63, eva.nevelius@kva.se Experts: Göran Johansson, +46 31 772 32 37, goran.l.johansson@chalmers.se and Eva Lindroth, +46 8 553 786 16, lindroth@fysik.su.se, members of the Nobel Committee for Physics.

The Royal Swedish Academy of Sciences, founded in 1739, is an independent organisation whose overall objective is to promote the sciences and strengthen their influence in society. The Academy takes special responsibility for the natural sciences and mathematics, but endeavours to promote the exchange of ideas between various disciplines.

KUNGL. VETENSKAPS-AKADEMIEN
THE ROYAL SWEDISH ACADEMY OF SCIENCES

Quantum Tunneling, Made Simple

For a long time, people thought the strange rules of quantum physics only applied to tiny things like atoms and electrons. In the 1980s, three scientists—John Clarke, Michel Devoret, and John Martinis—showed that this isn't true. They built special, super-cold electrical circuits where billions of electrons moved together like one object and followed quantum rules. In 2025, they received the Nobel Prize in Physics for this work. Their message was clear: quantum effects can be built, controlled, and used at a scale we can engineer.

The key idea is quantum tunneling. Imagine throwing a ball at a wall. In normal life, the ball bounces back. In the quantum world, there is a tiny chance it appears on the other side without breaking the wall. The scientists created a device called a Josephson junction—two superconductors with a very thin insulator in between. In this device, paired electrons can sometimes "tunnel" through the thin barrier even when they don't have enough energy to go over it. They also found that the circuit's energy comes in fixed steps, not a smooth range—like a staircase, not a ramp. Because of this, the circuit behaves like an "artificial atom": it only absorbs certain microwave frequencies and ignores the rest.

This may sound like lab magic, but it leads to real tools we use every day. Your phone's flash memory depends on tunneling. Data is stored by trapping or releasing electrons in tiny "floating gates." The insulating wall around each gate is so thin that, with the right voltage, electrons can tunnel in or out. Trillions of these small events let your photos and messages stay saved even when the power is off.

Hospitals use quantum effects too. SQUIDs (Superconducting QUantum Interference Devices) are the most sensitive magnetic sensors we have. They are made from superconducting loops with a Josephson junction. Tiny changes in magnetic fields—like those from brain activity—slightly change how electrons tunnel in the device. Doctors use this in magnetoencephalography (MEG) to map brain signals and plan treatments, especially for epilepsy. Quantum rules also lie behind MRI machines, whose strong superconducting magnets and precise signals come from a deep understanding of how atoms behave.

Accurate timing is another gift of quantum physics. Atomic clocks keep time by using fixed energy jumps inside atoms—the same idea as the "energy steps" in the artificial atom. These clocks are so steady that they keep GPS working. If the timing drifted even a tiny bit, your map would show you far from your real location. The stability and precision we rely on for navigation, internet time, and communications come from quantum behavior.

Looking ahead, quantum computers use circuits very similar to those in the Nobel-winning work. Their basic units, qubits, can be in a mix of 0 and 1 at the same time. Many of the best qubits today are built from superconducting circuits with Josephson junctions. Engineers control their energy steps and tunneling to set and read quantum states. These machines won't replace your laptop, but they can attack special problems—like designing new drugs and materials or improving complex schedules—that overwhelm normal computers.

If tunneling is real, why can't you walk through a wall? Because everyday barriers are thick and messy, and your body has an unimaginable number of particles. Getting them all to tunnel together is practically impossible. In the lab, scientists also cool their circuits to near absolute zero so thermal noise doesn't drown out quantum effects. Nature allows tunneling, but the conditions have to be just right.

In short, Clarke, Devoret, and Martinis showed that quantum rules can guide big, human-made systems, not just tiny particles. That changed quantum physics from a curiosity into a toolbox. It's why your phone stores so much data so reliably. It's how doctors read faint magnetic signals from the brain. It keeps GPS accurate. And it's powering new kinds of computers. Quantum physics may sound strange, but thanks to careful experiments, it now shapes everyday technology in simple, practical ways.

John Clarke

Michel H. Devoret

John M. Martinis

The Nobel Prize in Chemistry 2025 PRESS RELEASE

TheRoyalSwedishAcademyofScienceshasdecidedtoawardtheNobelPrizeinChemistry 2025 to

Susumu Kitagawa
KyotoUniversity,Japan

Richard Robson
University of Melbourne, Australia

Omar M. Yaghi
UniversityofCalifornajBerkeley, USA

"for the development of metal–organic frameworks"

Their molecular architecture contains rooms for chemistry

The Nobel Prize Laureates in Chemistry 2025 have created molecular constructions with large spaces through which gases and other chemicals can flow. These constructions, ***metal-organic frameworks***, can be used to harvest water from desert air, capture carbon dioxide, store toxic gases or catalyse chemical reactions. **Susumu Kitagawa**, **Richard Robson** and **Omar Yaghi** are awarded the Nobel Prize in Chemistry 2025. They have developed a new form of molecular architecture. In their constructions, metal ions function as corner-stones that are linked by long organic (carbon-based) molecules. Together, the metal ions and molecules are organised to form crystals that contain large cavities. These porous materials are called metal-organic fram- eworks (MOF). By varying the building blocks used in the MOFs, chemists can design them to capture and store specific substances. MOFs can also drive chemi- cal reactions or conduct electricity.

"Metal-organic frameworks have enormous potential, bringing previously unforeseen opportunities for custom-made materials with new functions," says Heiner Linke, Chair of the Nobel Committee for Chemistry.

It all started in 1989, when Richard Robson tested utilising the inherent properties of atoms in a new way. He combined positively charged copper ions with a four-armed molecule; this had a chemical group that was attracted to copper ions at the end of each arm. When they were combined, they bonded to form a well-ordered, spacious crystal. It was like a diamond filled with innumerable cavities. Robson immediately recognised the potential of his molecular construction, but it was unstable and collapsed easily. However, Susumu Kitagawa and Omar Yaghi provided this building method with a firm foundation; between 1992 and 2003 they made, separately, a series of revolutionary discoveries. Kitagawa showed that gases can flow in and out of the constructions and predicted that MOFs could be made flexible. Yaghi created a very stable MOF and showed that it can be modified using rational design, giving it new and desirable properties.

Following the laureates' groundbreaking discoveries, chemists have built tens of thousands of different MOFs. Some of these may contribute to solving some of humankind's greatest challenges, with applications that include separating PFAS from water, breaking down traces of pharmaceuticals in the environment, capturing carbon dioxide or harvesting water from desert air.

Susumu Kitagawa, born 1951 in Kyoto, Japan. PhD 1979 from the Kyoto University, Japan. Professor at Kyoto University, Japan.

Richard Robson, born 1937 in Glusburn, UK. PhD 1962 from University of Oxford, UK. Professor at University of Melbourne, Australia.

Omar M. Yaghi, Born 1965 in Amman, Jordan. PhD 1990 from University of Illinois Urbana-Champaign, USA. Professor at University of California, Berkeley, USA.

Prize amount: 11 million Swedish kronor to be shared equally between the laureates Further information: www.kva.se and www.nobelprize.org Press contact: Eva Nevelius, Press Secretary, +46 70 878 67 63, eva.nevelius@kva.se Expert: Olof Ramström, +46 70 433 42 60, ramstrom@protonmail.com, member of the Nobel Committee for Chemistry

What are Metal-organic frameworks (MOFs)?

These are crystalline, porous materials made from metal ions or clusters joined by organic molecules called linkers. Imagine a precise 3D scaffold where metal "nodes" and organic "struts" assemble into a lattice with enormous internal surface area—often thousands of square meters per gram—and up to ~90% empty space. Because chemists can choose the metal, the linker length, and functional groups, they can tune pore size, shape, and chemistry almost like molecular LEGO, yielding predictable, tailor-made crystals rather than random foams.

MOFs typically form by self-assembly: solutions of metal salts and linkers are heated or solvothermally treated so the parts snap into place. Small changes in temperature, solvent, pH, or additives steer outcomes—larger or smaller pores, greater stability, or specific chemical groups lining channels. Post-synthetic modification can further decorate the pores, and the vast menu of metals and linkers means a near-limitless design space.

These features make MOFs powerful wherever interactions with small molecules matter. In environmental uses, their adjustable pores and surface chemistry allow high-density gas storage and sharp separations. MOFs can pack hydrogen for cleaner fuels and selectively capture carbon dioxide from mixed gas streams, aiding industrial emissions control and direct-air capture. Water-stable MOFs shaped into membranes or powders filter heavy metals, organic dyes, pesticides, and even radioactive iodine, improving water quality. Many frameworks act as catalysts because reactants flow through channels to meet active metal sites across a gigantic surface. Others are engineered to change their glow in the presence of target molecules, enabling sensitive chemical sensors for explosives, pollutants, or humidity.

Energy technologies also benefit. In batteries and supercapacitors, MOFs' open networks provide short pathways for ions like Li^+ and abundant sites to host charge, potentially boosting capacity and charging speed. Although pristine MOFs are usually not very conductive, they can be converted into porous carbons or metal oxides that preserve the original architecture while adding electron pathways. As electrocatalysts and catalyst precursors, MOF-based materials help drive oxygen reduction and evolution reactions in fuel cells and metal-air batteries. Some MOFs absorb light like semiconductors and, with the right design, photocatalyze water splitting to produce hydrogen or reduce CO_2 into useful chemicals.

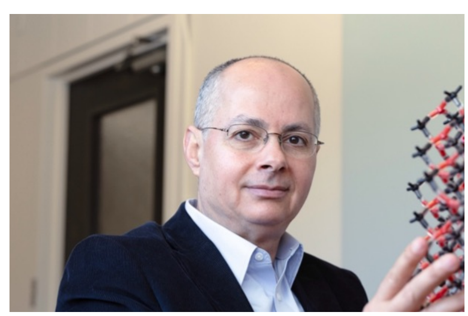
Biomedical research leverages the same tunability. Nano-MOFs can load high amounts of therapeutic cargo in their pores and release it steadily or in response to triggers such as pH or enzymes, potentially lowering doses and side effects. Biocompatible frameworks can carry imaging agents for MRI or act as biosensors. Enzymes immobilized inside a MOF are shielded from harsh conditions yet remain active, extending their usefulness in diagnostics and green chemistry.

Challenges remain. Early MOFs sometimes degraded in heat or humidity, but newer families—especially those with strong metal-oxygen bonds such as zirconium-based frameworks—exhibit excellent thermal and water stability. Limited conductivity is addressed with conductive MOFs and MOF-derived carbons/oxides. Scaling from grams to tons requires greener solvents, simpler linkers, and continuous production—areas now seeing rapid progress. For medical uses, rigorous evaluation of safety, biodegradation, and clearance is essential.

The appeal of MOFs is their combination of huge surface area and atom-level precision. You can design a pore to welcome one molecule, reject another, speed a reaction, or carry a drug—and then build that design as a solid crystal. As stability improves and manufacturing scales, expect MOFs in carbon-capture modules, hydrogen storage, smart separation membranes, high-performance electrodes and catalysts, targeted delivery systems, and ultrasensitive sensors. They are designer sponges for the atomic world, enabling us to store, sort, sense, and transform molecules with unprecedented control.

Susumu Kitagawa

Richard Robson



Omar M Yaghi

The Prize in Economic Sciences 2025

The Royal Swedish Academy of Sciences has decided to award the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2025 to Joel Mokyr, Philippe Aghion and Peter Howitt

"for having explained innovation-driven economic growth"

with one half to

Joel Mokyr

Northwestern University, Evanston, IL, USA

"for having identified the prerequisites for sustained growth through technological progress"

and the other half jointly to

Philippe Aghion

Collège de France and INSEAD, Paris, France, The London School of Economics and Political Science, UK

Peter Howitt

Brown University, Providence, RI, USA

"for the theory of sustained growth through creative destruction"

They show how new technology can drive sustained growth

Over the last two centuries, for the first time in history, the world has seen sustained economic growth. This has lifted vast numbers of people out of poverty and laid the foundation of our prosperity. This year's laureates in the Economic Sciences, Joel Mokyr, Philippe Aghion and Peter Howitt, explain how innovation provides the impetus for further progress.

Technology advances rapidly and affects us all, with new products and production methods replacing old ones in a never-ending cycle. This is the basis for sustained economic growth, which results in a better standard of living, health and quality of life for people around the globe.

However, this was not always the case. Quite the opposite – stagnation was the norm throughout most of human history. Despite important discoveries now and again, which sometimes led to improved living conditions and higher incomes, growth always eventually levelled off.

Joel Mokyr used historical sources as one means to uncover the causes of sustained growth becoming the new normal. He demonstrated that if innovations are to succeed one another in a self-generating process, we not only need to know *that* something works, but we also need to have scientific explanations for *why*. The latter was often lacking prior to the industrial revolution, which made it difficult to build upon new discoveries and inventions. He also emphasised the importance of society being open to new ideas and allowing change.

Philippe Aghion and **Peter Howitt** also studied the mechanisms behind sustained growth. In an article from 1992, they constructed a mathematical model for what is called *creative destruction*: when a new and better product enters the market, the companies selling the older products lose out. The innovation represents something new and is thus creative. However, it is also destructive, as the company whose technology becomes passé is outcompeted.

In different ways, the laureates show how creative destruction creates conflicts that must be managed in a constructive manner. Otherwise, innovation will be blocked by established companies and interest groups that risk being put at a disadvantage.

"The laureates' work shows that economic growth cannot be taken for granted. We must uphold the mechanisms that underly creative destruction, so that we do not fall back into stagnation," says John Hassler, Chair of the Committee for the Prize in Economic Sciences.

Joel Mokyr, born 1946 in Leiden, the Netherlands. PhD 1974 from Yale University, New Haven, CT, USA. Professor at Northwestern University, Evanston, IL, USA.

Philippe Aghion, born 1956 in Paris, France. PhD 1987 from Harvard University, Cambridge, MA, USA. Professor at Collège de France and INSEAD, Paris, France and The London School of Economics and Political Science, UK.

Peter Howitt, born 1946 in Canada. PhD 1973 from Northwestern University, Evanston, IL, USA. Professor at Brown University, Providence RI, USA.

Prize amount: 11 million Swedish kronor, with one half to Joel Mokyr and the other half jointly to Philippe Aghion and Peter Howitt.
Further information: www.kva.se och www.nobelprize.org
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What is innovation-driven economic growth?

The 2025 Nobel laureates—Joel Mokyr, Philippe Aghion, and Peter Howitt—collectively argue that prosperity isn't a passive inheritance; it's produced by a system that continuously discovers, tests, and diffuses new ideas. Mokyr pinpoints the fuel: "useful knowledge." Economies grow faster when they expand both propositional knowledge (theories, principles, models) and prescriptive knowledge (methods, blueprints, routines). His historical lens shows why some eras ignite growth while others stall: open scientific norms, merit-based universities, reliable property rights, and free inquiry convert curiosity into cumulative technological progress. Where censorship, rent-seeking, or closed guilds dominate, experimentation slows, diffusion falters, and living standards stagnate. Aghion and Howitt formalize the engine: "creative destruction." In their model, productivity rises as new technologies displace old ones—an inherently disruptive but necessary process. Competition keeps the cycle alive: incumbents must innovate to survive, entrants challenge entrenched firms, and capital shifts toward higher-value uses. When monopoly power hardens or rivalry is dulled—through excessive barriers to entry, lock-in, or weak antitrust—the innovation treadmill slows and the economy drifts toward stagnation. Policy flows directly from this synthesis. To sustain innovation-led growth, governments should:

- Invest in the idea pipeline: fund basic and mission-driven R&D; strengthen STEM and translational pathways; support open science where it accelerates spillovers and targeted IP where it catalyzes commercialization.
- Keep markets contestable: agile competition policy, interoperability and open standards, data portability, and deep capital markets that finance startups and scale-ups—not just incumbents.
- Regulate for learning: experimentation-friendly rules (regulatory sandboxes), outcome-based standards, and public procurement that pulls new technologies into real use.
- Build adaptive institutions: technology transfer offices that measure impact, not just counts; city-level clusters linking universities, labs, and industry; and immigration policies that attract global talent.
- Pair innovation with inclusion: protect workers, not specific jobs—portable benefits, rapid reskilling and apprenticeships, wage insurance, and place-based revitalization to maintain social consent for change.

Joel Mokyr

Philippe Aghion

Peter Howitt