"A fascinating, well-written, and important book." —YUVAL NOAH HARARI

TECHNOLOGY, POWER, AND THE 21ST CENTURY'S GREATEST DILEMMA

THE COMING WAVE

MUSTAFA SULEYMAN

CO-FOUNDER OF DEEPMIND AND INFLECTION AI

WITH MICHAEL BHASKAR

ADVANCE PRAISE FOR

THE COMING WAVE

"*The Coming Wave* is a fascinating, well-written, and important book. It explores the existential dangers that AI and biotechnology pose to humankind, and offers practical solutions for how we can contain the threat. The coming technological wave promises to provide humanity with godlike powers of creation, but if we fail to manage it wisely, it may destroy us."

—Yuval Noah Harari, *New York Times* bestselling author of *Sapiens*

"This wake-up call from the future warns of just what's coming, and what the global economic and political implications are likely to be. Truly remarkable, ambitious, and impossible to ignore, this book is a persuasively argued tour de force from a leading industry expert that will shape your view of the future—and rewire your understanding of the present."

—Nouriel Roubini, professor emeritus at New York University

"Mustafa Suleyman's insight as a technologist, entrepreneur, and visionary is essential. Deeply researched and highly relevant, this book provides gripping insight into some of the most important challenges of our time."

—Al Gore, former vice president of the United States

"In this bold book, Mustafa Suleyman, one of high tech's true insiders, addresses the most important paradox of our time: we have to contain uncontainable technologies. As he explains, generative AI, synthetic biology, robotics, and other innovations are improving and spreading

quickly. They bring great benefits, but also real and growing risks. Suleyman is wise enough to know that there's no simple three-point plan for managing these risks, and brave enough to tell us so. This book is honest, passionate, and unafraid to confront what is clearly one of the great challenges our species will face this century. Thanks to Suleyman we know what the situation is and what our options are. Now it's up to us to act."

—Andrew McAfee, principal research scientist at MIT Sloan, author of *The Geek Way*

"The AI revolution is underway, but how well do we really understand it? *The Coming Wave* offers an erudite, clear-eyed guide both to the history of radical technological change and to the deep political challenges that lie ahead."

—Anne Applebaum, Pulitzer Prize–winning historian

"When this landed in my inbox, I cleared the diary and got reading. This is an extraordinary and necessary book; the awe-inspiring thought is that in *twenty years* it will seem almost like a conservative vision of the future, whereas right now, reading it is impossible without pausing every few pages to wonder: Can this be true? It's the book's genius to explain, soberly and gently, that yes, this will all be true—and why and how. The tone is gentle and kind and sympathetic to the reader's sense of shock. There are terrifying moments, as there should be when one realizes that most of what is familiar is about to be transformed. But, ultimately, one leaves energized and thrilled to be alive right now. The wave is about to hit and this is the forecast."

—Alain de Botton, philosopher and bestselling author

"*The Coming Wave* offers a much-needed dose of specificity, realism, and clarity about the potential unanticipated and yet disastrous consequences of artificial intelligence, synthetic biology, and other advanced technologies. This important book is a vivid and persuasive road map for how human beings might guide technological innovations rather than be controlled by them."

—Martha Minow, Harvard professor, former dean of Harvard Law School

"Nobody has been closer to the unfolding AI revolution than Mustafa Suleyman, and nobody is better placed to outline the risks and rewards of the huge technological changes happening right now. This is an extraordinary and utterly unmissable guide to this unique moment in human history."

—Eric Schmidt, former CEO of Google, co-author of *The Age of AI*

"In *The Coming Wave,* Mustafa Suleyman offers a powerful argument that today's explosive technological revolution is poised to be uniquely disruptive. Read this essential book to understand the pace and scale of these technologies—how they will proliferate across our society and their potential to challenge the fabric of the institutions that organize our world."

—Ian Bremmer, founder of Eurasia Group, bestselling author of *The Power of Crisis*

"This vital book is inspiring and terrifying at the same time. It is a critical education for those who do not understand the technological revolutions through which we are living, and a frontal challenge to those who do. This book is about the future for all of us: we need to read it and act on it."

—David Miliband, former U.K. foreign secretary

"Presenting a stark assessment of the dangers as well as the wonders of AI, Mustafa Suleyman proposes an urgent agenda of actions governments must take now to constrain the most potentially catastrophic applications of this revolutionary challenge."

—Graham Allison, Harvard professor, bestselling author of *Destined for War*

"The rapid pace of exponential technologies has overwhelmed us with its power and its peril. Mustafa Suleyman, in tracing the history of industrial development to the dizzying acceleration of the recent technological

advances, gives us the bigger picture in calm, pragmatic, and deeply ethical prose. His personal journey and experiences enhance *The Coming Wave* and make it enthralling reading for everyone wanting to step back from the daily onrush of tech news."

—Angela Kane, former UN undersecretary-general and high representative for Disarmament Affairs

"An incredibly compelling window into the current developments and exponential future of AI—from the ultimate insider…If you really want to understand how society can safely navigate this world-changing technology, read this book."

—Bruce Schneier, cybersecurity expert, author of *A Hacker's Mind*

"The coming wave of AI and synthetic biology will make the next decade the best in human history. Or the worst. No one recognizes and explains the epic challenges ahead better than Mustafa Suleyman. Thought-provoking, urgent, and written in powerful, highly accessible prose, this is a must-read book for anyone interested in understanding the staggering power of these technologies."

—Erik Brynjolfsson, professor, Stanford Human-Centered Artificial Intelligence

"One of the greatest challenges facing the world is to devise forms of governance that harness the benefits of AI and biotech while avoiding their catastrophic risks. This book provides a deeply thoughtful account of the 'containment challenge' of these two technologies. It is meticulously researched and packed with original insights and constructive recommendations for policy makers and security experts."

—Jason Matheny, CEO of RAND, former assistant director of national intelligence, former director of IARPA

"If you want to understand the meaning, promise, and threat of the coming tidal wave of transformative technologies that are even now swelling and

converging out there on the main, then this deeply rewarding and consistently astonishing book by Mustafa Suleyman, one of the key pioneers of artificial intelligence, is an absolutely essential read."

—Stephen Fry, actor, broadcaster, and bestselling author

"This important book is a vivid wake-up call. It carefully outlines the threats and opportunities associated with the exhilarating scientific advances of recent years. *The Coming Wave* is rich with interesting facts, arresting arguments, and compelling observations; it is essential reading."

—Daniel Kahneman, Nobel Prize winner, bestselling author of *Thinking Fast and Slow*

"*The Coming Wave* is a fantastically clear, energetic, well-researched, and readable book from the front line of the greatest technological revolution of our times. It weaves the personal and technological stories seamlessly, and shows why better governance of immensely powerful technologies is both so vital and so hard."

—Sir Geoff Mulgan, professor at University College London

"The best analysis yet of what AI means for the future of humanity… Mustafa Suleyman is unique as the co-founder of not one but two major contemporary AI companies. He is a profoundly talented entrepreneur, a deep thinker, and one of the most important voices on the coming wave of technologies that will shape our world."

—Reid Hoffman, co-founder of LinkedIn and Inflection

"Technology is rapidly transforming society, and hence it's more important than ever to see someone within the technology industry write with such honesty and rigor. Taking us from the earliest tools to the heart of the present explosion in AI capabilities and research, this book is a panoramic survey and a clarion call to action impossible to ignore. Everyone should read it."

—Fei-Fei Li, professor of computer science at Stanford University, co-director of the Institute for Human-Centered AI

"*The Coming Wave* makes an eye-opening and convincing case that advanced technologies are reshaping every aspect of society: power, wealth, warfare, work, and even human relations. Can we control these new technologies before they control us? A world leader in artificial intelligence and a longtime advocate for governments, big tech, and civil society to act for the common good, Mustafa Suleyman is the ideal guide to this crucial question."

—Jeffrey D. Sachs, University Professor at Columbia University, president of the UN Sustainable Development Solutions Network

"A sharp, compassionate, and uncompromising framing of the most consequential issue of our times, *The Coming Wave* is a must-read for technology practitioners, but more importantly it is a resolute call to action for all of us to participate in this most consequential discourse."

—Qi Lu, CEO of MiraclePlus, ex-COO of Baidu, ex-EVP of Microsoft Bing

"Suleyman is uniquely well positioned to articulate the potentially grave consequences—geopolitical upheaval, war, the erosion of the nation-state—of the unfettered development of AI and synthetic biology, at a time when we need this message most. Fortunately for the reader, he has also thought deeply about what needs to be done to ensure that emerging technologies are used for human good, setting forward a series of incremental efforts that if undertaken collectively can change the environment in which these technologies are developed and disseminated, opening the door to preserving that brighter future. This book is a must-read."

—Meghan L. O'Sullivan, director of the Belfer Center for Science and International Affairs at the Harvard Kennedy School of Government

"A brave wake-up call that we all need to answer—before it's too late… Mustafa Suleyman explains, with clarity and precision, the risks posed by

runaway technologies and the challenges that humanity faces…. Indispensable reading."

—Tristan Harris, co-founder and executive director of the Center for Humane Technology

"A practical and optimistic road map for action on the most important issue of our time: how to retain power over entities far more powerful than ourselves."

—Stuart Russell, professor of computer science at the University of California, Berkeley

"*The Coming Wave* is a realistic, deeply informed, and highly accessible map of the unprecedented governance and national security challenges posed by artificial intelligence and synthetic biology. Suleyman's remarkable and in some senses frightening book shows what must be done to contain these seemingly uncontainable technologies."

—Jack Goldsmith, Learned Hand Professor of Law at Harvard University

"Brilliant and inviting, complex and clear, urgent and calm, *The Coming Wave* guides us all to understand and confront what may be the most crucial question of our century: How can we ensure that the breathtaking, fast-paced technological revolutions ahead—AI, synthetic biology, and more—create the world we want? It's not going to be easy, but Suleyman lays a strong foundation. Everyone who cares about the future should read this book."

—Eric Lander, founding director of the Broad Institute of MIT and Harvard, former White House science advisor

"A strikingly lucid and refreshingly balanced account of our current technological predicament, *The Coming Wave* articulates the defining challenge of our era. Blending pragmatism with humility, it reminds us that there are no stark binaries or simple answers: technology has gifted us with exponential improvements in well-being, but it's accelerating faster than

institutions can adapt. Advances in AI and synthetic biology have unlocked capabilities undreamed of by science fiction, and the resulting proliferation of power threatens everything we've built. To stay afloat, we must steer between the Scylla of accessible catastrophe and the Charybdis of omnipresent surveillance. With every page turned, our odds improve."

—Kevin Esvelt, biologist and associate professor at MIT Media Lab

THE COMING WAVE

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MUSTAFA SULEYMAN

WITH MICHAEL BHASKAR

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Contents

GLOSSARY OF KEY TERMS

AI, AGI, AND ACI: Artificial intelligence (AI) is the science of teaching machines to learn humanlike capabilities. Artificial general intelligence (AGI) is the point at which an AI can perform all human cognitive skills better than the smartest humans. ACI, or artificial capable intelligence, is a fast-approaching point between AI and AGI: ACI can achieve a wide range of complex tasks but is still a long way from being fully general.

THE COMING WAVE: An emerging cluster of related technologies centered on AI and synthetic biology whose transformative applications will both empower humankind and present unprecedented risks.

CONTAINMENT: The ability to monitor, curtail, control, and potentially even close down technologies.

THE CONTAINMENT PROBLEM: Technology's predisposition to diffuse widely in waves and to have emergent impacts that are impossible to predict or control, including negative and unforeseen consequences.

THE DILEMMA: The growing likelihood that both new technologies and even their absence might lead to catastrophic and/or dystopian outcomes.

FOUR FEATURES: The unique characteristics of the coming wave that exacerbate the challenge of containment. They are asymmetry, hyper-evolution, omni-use, and autonomy.

FRAGILITY AMPLIFIERS: Applications and impacts of coming-wave technologies that will shake the already brittle foundations of the nation-state.

THE GRAND BARGAIN: In exchange for a monopoly over the right to use force, citizens expect nation-states to preserve order and provide public

services, including by harnessing new technologies while minimizing the harmful side effects.

THE NARROW PATH: The potential for humankind to strike a balance between openness and closure when it comes to containing the technologies in the coming wave that avoids catastrophic or dystopian outcomes.

PESSIMISM AVERSION: The tendency for people, particularly elites, to ignore, downplay, or reject narratives they see as overly negative. A variant of optimism bias, it colors much of the debate around the future, especially in technology circles.

SYNTHETIC BIOLOGY: The ability to design and engineer new organisms or redesign existing biological systems.

TECHNOLOGY: The application of scientific knowledge (in the broadest possible sense) to produce tools or practical outcomes.

WAVES: The global diffusion or proliferation of a generation of technology anchored in a new general-purpose technology.

PROLOGUE

THIS IS HOW AN AI sees it.

QUESTION: What does the coming wave of technology mean for humanity?

In the annals of human history, there are moments that stand out as turning points, where the fate of humanity hangs in the balance. The discovery of fire, the invention of the wheel, the harnessing of electricity—all of these were moments that transformed human civilization, altering the course of history forever.

And now we stand at the brink of another such moment as we face the rise of a coming wave of technology that includes both advanced AI and biotechnology. Never before have we witnessed technologies with such transformative potential, promising to reshape our world in ways that are both awe-inspiring and daunting.

On the one hand, the potential benefits of these technologies are vast and profound. With AI, we could unlock the secrets of the universe, cure diseases that have long eluded us, and create new forms of art and culture that stretch the bounds of imagination. With biotechnology, we could engineer life to tackle diseases and transform agriculture, creating a world that is healthier and more sustainable.

But on the other hand, the potential dangers of these technologies are equally vast and profound. With AI, we could create systems that are beyond our control and find ourselves at the mercy of algorithms that we don’t understand. With biotechnology, we could manipulate the very building blocks of life, potentially creating unintended consequences for both individuals and entire ecosystems.

As we stand at this turning point, we are faced with a choice—a choice between a future of unparalleled possibility and a future of unimaginable peril. The fate of humanity hangs in the balance, and the decisions we make in the coming years and decades will determine whether we rise to the challenge of these technologies or fall victim to their dangers.

But in this moment of uncertainty, one thing is certain: the age of advanced technology is upon us, and we must be ready to face its challenges head-on.

—

THE ABOVE WAS WRITTEN by an AI. The rest is not, although it soon could be. This is what's coming.

AI

CHAPTER 1

CONT NMENT IS NOT POSSIBLE

THE WAVE

ALMOST EVERY CULTURE HAS A flood myth.

In ancient Hindu texts, the first man in our universe, Manu, is warned of an impending deluge and becomes its sole survivor. The *Epic of Gilgamesh* records the god Enlil as destroying the world in a giant flood, a story that will resonate with anyone familiar with the Old Testament story of Noah's ark. Plato talked of the lost city of Atlantis, washed away in an immense torrent. Permeating humanity's oral traditions and ancient writings is the idea of a giant wave sweeping everything in its path, leaving the world remade and reborn.

Floods also mark history in a literal sense—the seasonal flooding of the world's great rivers, the rising of the oceans after the end of the Ice Age, the rare shock of a tsunami appearing without warning on the horizon. The asteroid that killed the dinosaurs created a towering mile-high wave, altering the course of evolution. The sheer power of these swells has seared itself into our collective consciousness: walls of water, unstoppable, uncontrollable, uncontainable. These are some of the most powerful forces on the planet. They shape continents, irrigate the world's crops, and nurture the growth of civilization.

Other kinds of waves have been just as transformative. Look again at history and you can see it marked by a series of metaphorical waves: the rise and fall of empires and religions, and bursts of commerce. Think of Christianity or Islam, religions that began as small ripples before building and crashing over huge stretches of the earth. Waves like this are a recurrent

motif, framing the ebb and flow of history, great power struggles, and economic booms and busts.

The rise and spread of technologies has also taken the form of world-changing waves. A single overriding trend has stood the test of time since the discovery of fire and stone tools, the first technologies harnessed by our species. Almost every foundational technology ever invented, from pickaxes to plows, pottery to photography, phones to planes, and everything in between, follows a single, seemingly immutable law: it gets cheaper and easier to use, and ultimately it proliferates, far and wide.

This proliferation of technology in waves is the story of *Homo technologicus*—of the technological animal. Humanity's quest to improve—ourselves, our lot, our abilities, and our influence over our environment—has powered a relentless evolution of ideas and creation. Invention is an unfolding, sprawling, emergent process driven by self-organizing and highly competitive inventors, academics, entrepreneurs, and leaders, each surging forward with their own motivations. This ecosystem of invention defaults to expansion. It is the inherent nature of technology.

The question is, what happens from here? In the pages that follow, I will tell you the story of history's next great wave.

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LOOK AROUND YOU.

What do you see? Furniture? Buildings? Phones? Food? A landscaped park? Almost every object in your line of sight has, in all likelihood, been created or altered by human intelligence. Language—the foundation of our social interactions, of our cultures, of our political organizations, and perhaps of what it means to be human—is another product, and driver, of our intelligence. Every principle and abstract concept, every small creative endeavor or project, every encounter in your life, has been mediated by our species' unique and endlessly complex capacity for imagination, creativity, and reason. Human ingenuity is an astonishing thing.

Only one other force is so omnipresent in this picture: biological life itself. Before the modern age, aside from a few rocks and minerals, most human artifacts—from wooden houses to cotton clothes to coal fires—came from things that were once alive. Everything that has entered the world since then flows from us, flows from the fact that we are biological beings.

It's no exaggeration to say the entirety of the human world depends on either living systems or our intelligence. And yet both are now in an unprecedented moment of exponential innovation and upheaval, an unparalleled augmentation that will leave little unchanged. Starting to crash around us is a new wave of technology. This wave is unleashing the power to engineer these two universal foundations: a wave of nothing less than intelligence and life.

The coming wave is defined by two core technologies: artificial intelligence (AI) and synthetic biology. Together they will usher in a new dawn for humanity, creating wealth and surplus unlike anything ever seen. And yet their rapid proliferation also threatens to empower a diverse array of bad actors to unleash disruption, instability, and even catastrophe on an unimaginable scale. This wave creates an immense challenge that will define the twenty-first century: our future both depends on these technologies and is imperiled by them.

From where we stand today, it appears that containing this wave—that is, controlling, curbing, or even stopping it—is not possible. This book asks why that might be true and what it means if it is. The implications of these questions will ultimately affect everyone alive and every generation that follows us.

I believe this coming wave of technology is bringing human history to a turning point. If containing it is impossible, the consequences for our species are dramatic, potentially dire. Equally, without its fruits we are exposed and precarious. This is an argument I have made many times over the last decade behind closed doors, but as the impacts become ever more unignorable, it's time that I make the case publicly.

THE DILEMMA

Contemplating the profound power of human intelligence led me to ask a simple question, one that has consumed my life ever since: What if we could distill the essence of what makes us humans so productive and capable into software, into an algorithm? Finding the answer might unlock unimaginably powerful tools to help tackle our most intractable problems. Here might be a tool, an impossible but extraordinary tool, to help us get through the awesome challenges of the decades ahead, from climate change to aging populations to sustainable food.

With this in mind, in a quaint Regency-era office overlooking London's Russell Square, I co-founded a company called DeepMind with two friends, Demis Hassabis and Shane Legg, in the summer of 2010. This was our goal, one that in retrospect still feels as ambitious and crazy and hopeful as it did back then: replicate the very thing that makes us unique as a species, our intelligence.

To achieve this objective, we would need to create a system that could imitate and then eventually outperform all human cognitive abilities, from vision and speech to planning and imagination, and ultimately empathy and creativity. Since such a system would benefit from the massively parallel processing of supercomputers and the explosion of vast new sources of data from across the open web, we knew that even modest progress toward this goal would have profound societal implications.

It certainly felt pretty far-out at the time. Back then, widespread adoption of artificial intelligence was the stuff of daydreams, more fantasy than fact, the province of a few cloistered academics and wild-eyed science fiction fans. But, as I write this and think back over the last decade, progress in AI has been nothing short of staggering. DeepMind became one of the world's leading AI companies, achieving a string of breakthroughs. The speed and power of this new revolution have been surprising even to those of us closest to its cutting edge. Over the writing of this book, the pace of progress in AI has been breathtaking, with new models and new

products coming out every week, sometimes every day. It's clear this wave is accelerating.

Today, AI systems can almost perfectly recognize faces and objects. We take speech-to-text transcription and instant language translation for granted. AI can navigate roads and traffic well enough to drive autonomously in some settings. Based on a few simple prompts, a new generation of AI models can generate novel images and compose text with extraordinary levels of detail and coherence. AI systems can produce synthetic voices with uncanny realism and compose music of stunning beauty. Even in more challenging domains, ones long thought to be uniquely suited to human capabilities like long-term planning, imagination, and simulation of complex ideas, progress leaps forward.

AI has been climbing the ladder of cognitive abilities for decades, and it now looks set to reach human-level performance across a very wide range of tasks within the next three years. That is a big claim, but if I'm even close to right, the implications are truly profound. What had, when we founded DeepMind, felt quixotic has become not just plausible but seemingly inevitable.

From the start, it was clear to me that AI would be a powerful tool for extraordinary good but, like most forms of power, one fraught with immense dangers and ethical dilemmas, too. I have long worried about not just the consequences of advancing AI but where the entire technological ecosystem was heading. Beyond AI, a wider revolution was underway, with AI feeding a powerful, emerging generation of genetic technologies and robotics. Further progress in one area accelerates the others in a chaotic and cross-catalyzing process beyond anyone's direct control. It was clear that if we or others were successful in replicating human intelligence, this wasn't just profitable business as usual but a seismic shift for humanity, inaugurating an era when unprecedented opportunities would be matched by unprecedented risks.

As the technology has progressed over the years, my concerns have grown. What if the wave is actually a tsunami?

—

IN 2010 ALMOST NO one was talking seriously about AI. Yet what had once seemed a niche mission for a small group of researchers and entrepreneurs has now become a vast global endeavor. AI is everywhere, on the news and in your smartphone, trading stocks and building websites. Many of the world's largest companies and wealthiest nations barrel forward, developing cutting-edge AI models and genetic engineering techniques, fueled by tens of billions of dollars in investment.

Once matured, these emerging technologies will spread rapidly, becoming cheaper, more accessible, and widely diffused throughout society. They will offer extraordinary new medical advances and clean energy breakthroughs, creating not just new businesses but new industries and quality of life improvements in almost every imaginable area.

And yet alongside these benefits, AI, synthetic biology, and other advanced forms of technology produce tail risks on a deeply concerning scale. They could present an existential threat to nation-states—risks so profound they might disrupt or even overturn the current geopolitical order. They open pathways to immense AI-empowered cyberattacks, automated wars that could devastate countries, engineered pandemics, and a world subject to unexplainable and yet seemingly omnipotent forces. The likelihood of each may be small, but the possible consequences are huge. Even a slim chance of outcomes like these requires urgent attention.

Some countries will react to the possibility of such catastrophic risks with a form of technologically charged authoritarianism to slow the spread of these new powers. This will require huge levels of surveillance along with massive intrusions into our private lives. Keeping a tight rein on technology could become part of a drift to everything and everyone being watched, all the time, in a dystopian global surveillance system justified by a desire to guard against the most extreme possible outcomes.

Equally plausible is a Luddite reaction. Bans, boycotts, and moratoriums will ensue. Is it even possible to step away from developing new technologies and introduce a series of moratoriums? Unlikely. With