

How could science be different?

There are many ways in which science could be different, depending on the context and the specific aspects of science that we are referring to. Here are some examples: Biases and fallacies: The biggest obstacle in searching for truth is not lack of technology or knowledge but biases and fallacies that we have in our mind. Individuals create their own "subjective reality" from their perception of the data and input. An individual's construction of reality, not the objective input, may dictate their behavior in the world. A fallacy is the use of invalid or otherwise faulty reasoning or irrational thinking. But why we have cognitive biases and fallacies; because of beauty. We find pleasure and satisfaction at a cognitive level. One example is cherry picking by scientists (finding data in order to prove hypothesis). So here we see beauty is barrier in the search for truth. Funding: Science is heavily reliant on funding from government agencies, private foundations, and other sources. The amount and type of funding available can significantly impact the direction of scientific research and the types of questions that are explored. If funding priorities were different, science could focus on different areas and produce different types of knowledge. Education: The way that science is taught and learned can also have a significant impact on the field. If science education were more accessible, inclusive, and engaging, it could attract a more diverse group of students and lead to more innovative ideas and approaches. Communication: The way that scientific findings are communicated to the public and to other scientists can also affect the field. If there were better communication channels and methods, scientific discoveries could be disseminated more quickly and effectively, leading to faster progress and more collaboration. Ethics: The ethical considerations that guide scientific research can also have a major impact on the field. If there were different ethical guidelines or principles in place, science could focus on different types of research questions or use different methods. Collaboration: Science is often a collaborative endeavor, and the way that collaborations are structured and supported can affect the quality and impact of scientific research. If collaboration were more widespread and better supported, it could lead to more breakthrough discoveries and innovations. Overall, there are many factors that could impact the field of science and the types of knowledge that are produced. By considering these different factors and working to improve them, we can help to shape the future of science and make it more effective, inclusive, and impactful.

To what degree does (or must) math come before physics versus being created to address questions in physics? Could we have had centuries of advanced mathematics before physics came to be? Or is the opposite possible

Scientists think that physical laws have mathematical beauty. That is they find unreasonable effectiveness of mathematical beauty in natural science. But some thinks that there is no link between the two since only small amount of specific mathematics (very special cases) is involved in science. And another group of scientists thinks that it's very reasonable to have this strong relationship between the two because at the end scientists and philosophers don't live in

black box. They live and interact with nature so their thinking (mathematics and logic) has some connections (metaphor and analogies) with nature (truth). The relationship between math and physics is complex and intertwined, and it's difficult to say which one came first or which one is more fundamental. However, generally speaking, mathematics is seen as a fundamental tool for physics, rather than a prerequisite. Mathematics provides a language for expressing physical theories, and it allows physicists to make precise predictions and calculations. In this sense, mathematics is created and developed to address questions in physics, and it evolves alongside physics. However, it's also true that mathematics has a long history that predates the development of physics. Mathematics has been studied for thousands of years, and many of the concepts and tools that are used in physics were developed by mathematicians long before physics existed as a distinct field. For example, the ancient Greeks developed geometry as a purely abstract mathematical discipline, but it later became an essential tool for describing physical space. So while it's possible to imagine a world in which advanced mathematics existed without physics, it's likely that the two fields would have evolved in tandem regardless. The development of physics has driven many advances in mathematics, and vice versa, and the two fields continue to be closely intertwined today.

Could there be very different sets of mathematics—potentially based on different axiom choices—that support science comparable in power to the way it is now?

It is possible that there could be different sets of mathematics based on different axiom choices that support science comparable in power to the way it is now. In fact, there are many different branches of mathematics that use different sets of axioms and produce different results, yet all of them have found applications in science. For example, Euclidean geometry and non-Euclidean geometries use different axioms, but both have applications in physics and engineering. Similarly, there are different branches of mathematics, such as algebraic geometry, topology, and number theory, which use different sets of axioms and have found applications in science. However, it's worth noting that the choice of axioms can have significant consequences for the types of results that are derived from them. Some sets of axioms are more restrictive than others, and some may be better suited for describing certain phenomena or systems than others. In this sense, the choice of axioms can shape the direction of mathematical research and the types of questions that are explored. Overall, while different sets of axioms can produce different branches of mathematics with different applications, the underlying principles of mathematics and its relationship to science are likely to remain consistent. Mathematics provides a way to describe and understand the natural world, and the tools and concepts that are developed through mathematics will continue to be essential for scientific progress.

Could scientific modeling be done on a basis other than mathematics, such as clockwork constructions or other analog models?

Yes, scientific modeling can be done using other methods besides mathematics, such as clockwork constructions or other analog models. In fact, before the advent of modern mathematical notation and computers, scientists often used physical models and analog devices to simulate and understand physical phenomena. Clockwork constructions, for example, were used to simulate the motion of planets and other celestial bodies before the development of modern mathematical models of celestial mechanics. Similarly, physical models such as wind tunnels and wave tanks are used to simulate fluid flow and wave propagation in engineering and physics. Analog models, which use physical systems that are similar in some way to the system being studied, can also be used to simulate and understand complex phenomena. For example, electrical circuits can be used to model the behavior of biological systems or economic markets. However, it's worth noting that mathematical models have several advantages over analog models. Mathematical models can be more precise and flexible, allowing for more accurate predictions and simulations of complex systems. They also allow scientists to test hypotheses and explore scenarios that may not be possible with physical models. Nevertheless, physical models and analog devices can still be valuable tools for understanding and visualizing complex systems, and they continue to be used in many areas of science and engineering.

What would it be like if science were fundamentally based on discrete computation, cellular automata, and the like, rather than differential questions?

If science were fundamentally based on discrete computation, cellular automata, and similar approaches, rather than differential equations, it would likely have a different character and focus than it does today. Differential equations are a powerful tool for modeling continuous systems, such as the behavior of fluids, heat transfer, and electromagnetic fields. They allow scientists to make predictions about how a system will evolve over time based on its initial conditions and governing equations. However, differential equations are not always suitable for modeling discrete or non-continuous systems. In contrast, discrete computation and cellular automata are well-suited for modeling discrete systems, such as the behavior of digital circuits, social networks, and biological systems. These approaches allow scientists to model complex systems as discrete entities that interact with one another in discrete steps, rather than as continuous functions that change smoothly over time. One potential advantage of using discrete computation and cellular automata for modeling is that they can capture more complex and realistic interactions between discrete entities. For example, cellular automata models can capture emergent behaviors that arise from the interactions between many discrete entities, such as the flocking behavior of birds or the patterns that form in snowflakes. However, there are also limitations to using discrete computation and cellular automata for modeling. For example, they may not be as well-suited for modeling continuous phenomena or systems with a large number of interacting variables. Additionally, discrete models may require more computational resources and be more difficult to solve than differential equation-based models. Overall, if science were fundamentally based on discrete computation, cellular automata, and similar approaches, it

would likely lead to new insights and approaches for modeling complex systems, but it would also require a shift in the way scientists approach modeling and the tools they use to do so.

If we meet technologically advanced aliens, how similar is their physics (or mathematics) likely to be? How different could it be?

If we were to meet technologically advanced aliens, it is difficult to predict how similar their physics and mathematics would be to ours. It is possible that they would have a very different understanding of the universe and the laws that govern it, or they may have developed similar scientific knowledge through convergent evolution or other similar reasons. One argument for the possibility of convergent evolution of scientific knowledge is that the physical laws that govern the universe may be universal and invariant, regardless of the observer. This means that the same physical laws should apply to any civilization that has evolved under similar physical conditions. Therefore, it is possible that they would have developed a similar understanding of physics and mathematics, even if their methods and notation differ. On the other hand, it is also possible that they could have developed a radically different understanding of the universe, based on different assumptions or observations. For example, they may have a different concept of space-time, or they may have discovered different fundamental particles or forces that we are not aware of. In this case, their physics and mathematics could be very different from ours. Ultimately, the answer to this question is purely speculative and depends on a wide range of factors, including the aliens' evolutionary history, environment, and technological development. The only way to know for sure would be to encounter technologically advanced aliens and study their scientific knowledge directly.

Is it possible to have technology comparable to current human technology without scientific reasoning of a type we would recognize? E.g., could an incredibly powerful artificial or biological neural network predict or design elements of reality “unconsciously” without models, theories, and mathematical reasoning of the type we do? (We can note that nature has solved many problems by trial and error rather than understanding and design.)

It is possible to have technology comparable to current human technology without scientific reasoning of a type we would recognize. In fact, some technological advancements, particularly those in the field of artificial intelligence and machine learning, have been achieved without explicit scientific reasoning. Machine learning, for example, is a process by which a computer system can learn from data and improve its performance on a specific task without being explicitly programmed to do so. This is achieved through the use of artificial neural networks, which are modeled after the biological neural networks found in the human brain. These networks can be trained to recognize patterns in data and make predictions or decisions based on that data, without relying on explicit models, theories, or mathematical reasoning. In a similar vein, it is possible that an incredibly powerful artificial or biological neural network could predict or design elements of reality "unconsciously" without explicit models, theories, or

mathematical reasoning of the type we do. This would be achieved through trial and error, as the system learns from its interactions with the environment and improves its performance over time. Nature has also solved many problems through trial and error rather than understanding and design, as you noted. Evolution, for example, is a process by which organisms adapt to their environment through natural selection, without requiring a conscious understanding of the underlying physical laws. However, it is worth noting that while machine learning and trial-and-error approaches can lead to technological advancements, they may not be as efficient or reliable as scientific reasoning and design. In many cases, understanding the underlying physical laws and using mathematical models to predict and design technology can lead to more efficient and effective solutions.

Could different branches of science have evolved at different rates? In such a case, what would have happened if e.g., biology had advanced rapidly before the development of physics?

It is possible for different branches of science to have evolved at different rates, and in fact, this is exactly what has happened throughout history. Different fields of science have developed at different rates, depending on a variety of factors such as available resources, technological advancements, and cultural and societal values. If, for example, biology had advanced rapidly before the development of physics, it is likely that our understanding of biology would be much more advanced than our understanding of physics. This could have had significant implications for our understanding of the natural world and the way we interact with it. For example, our understanding of genetics and evolution could have developed much earlier and at a more rapid pace, potentially leading to advancements in genetic engineering and biotechnology. On the other hand, without a deep understanding of physics, we may have lacked the ability to explain some of the fundamental processes that underlie biological phenomena, such as the molecular and cellular mechanisms that drive life. It's also worth noting that the advancement of one field of science can often have significant implications for other fields. For example, advancements in physics have led to the development of technologies such as MRI machines, which have revolutionized our understanding of the human body and led to significant advancements in the field of medicine. In the end, it's difficult to predict exactly what would have happened if different branches of science had evolved at different rates, as there are so many interconnected factors at play. However, it's clear that the advancement of one field can have significant implications for others, and that the overall pace of scientific progress is shaped by a complex web of social, economic, and cultural factors.

In another historical timeline, or in a fully egalitarian culture without prejudice and bigotry, how could it have been different? How would one make it different now?

In an alternative historical timeline or a fully egalitarian culture without prejudice and bigotry, it's possible that scientific progress could have been different in a number of ways. Here are a few examples: Increased diversity in scientific fields: In a culture without prejudice and bigotry, individuals from all backgrounds would have equal access to education and scientific careers.

This could have led to increased diversity in scientific fields, with a wider range of perspectives and experiences informing scientific research and development. Collaboration across cultures: Without prejudice and bigotry, scientists from different cultures and backgrounds would be more likely to collaborate and share ideas. This could have led to the development of new scientific theories and advancements that draw on a wide range of perspectives. Greater emphasis on social and environmental impact: In a culture without prejudice and bigotry, scientific research and development could be driven by a greater emphasis on social and environmental impact. Scientists could prioritize addressing social and environmental challenges, such as inequality, poverty, climate change, and environmental degradation. In order to make these changes now, we need to address the systems of prejudice and bigotry that have historically limited access to education and scientific careers for individuals from certain backgrounds. This could involve increasing funding and support for diversity and inclusion initiatives in STEM fields, promoting mentorship and networking opportunities for underrepresented groups, and addressing implicit bias in hiring and promotion processes. We can also prioritize research that addresses social and environmental challenges, and encourage collaboration across cultures and disciplines. By doing so, we can create a more diverse and inclusive scientific community that is better equipped to address the challenges facing our world.

How could science be better?

Science, like any human endeavor, is not perfect and can always be improved. Here are a few ways in which science could be better: **Trans-disciplinary** approach involving a level of abstraction above the level of disciplines, cutting across disciplinary boundaries. Chemical change is a concept that is internal to chemistry, physical change is internal to physics, cultural change is internal to anthropology, linguistic change is internal to linguistics, and historical change is internal to history, but the concept of CHANGE itself is trans-disciplinary. Likewise, the structure of the atom is specific to physics, the structure of molecule is specific to chemistry, the structure of a crystal is back in physics, the structure of words and structure of sentences are internal to linguistics, the structure of a dance composition is specific to the study of dance, the structure of a planetary system is specific to astronomy, but the concept of STRUCTURE is a trans-disciplinary concept.

Promoting diversity and inclusivity: Science could benefit from greater diversity and inclusivity in terms of gender, race, ethnicity, socioeconomic status, and other factors. This can help to bring different perspectives and approaches to scientific research and ensure that science is conducted in a fair and equitable manner. Encouraging interdisciplinary research: Many of the challenges facing our world today are complex and multifaceted, and require an interdisciplinary approach to solve. Science could be better by encouraging more collaboration across different fields of study, allowing for a more holistic and comprehensive approach to problem-solving. Improving research transparency and reproducibility: Science could be improved by increasing transparency and reproducibility in research. This means making data and methods openly available, conducting pre-registration of studies, and publishing negative or inconclusive results, among

other practices. Addressing systemic issues: Science is not immune to the societal issues that affect us all. Science could be better by addressing systemic issues such as racism, sexism, and bias, and taking steps to make science more equitable and accessible for all. Communicating science effectively: Science could be better by improving the way that scientific information is communicated to the public. This includes making scientific findings more accessible and understandable, as well as engaging with the public in a two-way dialogue to better understand their concerns and values. There are many other ways in which science could be better, and it's important to continue to strive for improvement in all aspects of scientific research and practice.

How and why are scientific theories guided by data, simulation, prediction, consistency, beauty, simplicity, breadth, and so on? What are essential, and what are distractions?

Scientific theories are guided by a variety of factors, including data, simulation, prediction, consistency, beauty, simplicity, and breadth. Here is an overview of each of these factors and how they guide scientific theories:

Data: Scientific theories are generally based on empirical data. This means that theories are developed and refined based on observations, experiments, and other forms of empirical evidence. Data serves as a crucial guide for scientific theories, helping scientists to determine what is and is not supported by the available evidence.

Simulation: Simulation can be used to test and refine scientific theories. Scientists can create simulations of complex systems and test how different variables interact with one another. Simulation can also be used to test the predictions of a theory, allowing scientists to refine and improve the theory over time.

Prediction: Scientific theories are often judged based on their ability to make accurate predictions about future observations or experiments. The ability of a theory to make accurate predictions is a key factor in determining its validity and usefulness.

Consistency: Scientific theories should be internally consistent, meaning that they should not contain logical contradictions or inconsistencies. A theory that is internally inconsistent is unlikely to be valid or useful.

Beauty: Beauty or elegance is a subjective factor that can guide scientific theories. Scientists are often drawn to theories that are aesthetically pleasing or elegant in their simplicity. While beauty is not an essential factor in guiding scientific theories, it can be a helpful guide in some cases.

Simplicity: Occam's Razor states that, all things being equal, the simplest explanation is often the best. Scientists often prefer theories that are simple and parsimonious, as they are easier to understand and test. However, simplicity should not be prioritized at the expense of accuracy or explanatory power.

Breadth: Scientific theories should be able to explain a wide range of phenomena and observations, rather than being limited in scope. The ability of a theory to explain a broad range of observations is a key factor in determining its validity and usefulness.

While each of these factors can be important in guiding scientific theories, it is essential to prioritize those that are essential for scientific progress and avoid distractions. Scientific theories must be based on data and empirical evidence, internally consistent, and capable of making accurate predictions. Beauty, simplicity, and breadth can be helpful guides in some cases, but should not be prioritized at the expense of accuracy or explanatory power.

Are there significant elements that the current practice of science is missing that would make it much more effective, or perhaps as effective but very different?

The current practice of science is constantly evolving and improving, but there are some potential areas for improvement that could make it even more effective. Here are a few possibilities:

- Interdisciplinary collaboration:** While many scientific fields are already interdisciplinary, there is still room for improvement in terms of collaboration between different disciplines. For example, bringing together experts in different fields to tackle complex problems could lead to new insights and breakthroughs.
- Open science:** Greater transparency and openness in scientific research could make it more effective by allowing others to scrutinize and build upon research findings. This could include open data sharing, pre-registration of studies, and open access publication of research.
- Addressing systemic biases:** The scientific community could benefit from greater efforts to address systemic biases, such as gender, racial, and ethnic biases. This could involve measures such as diversity and inclusion initiatives, implicit bias training, and blind review processes.
- Emphasis on replication and robustness:** While replication is a cornerstone of scientific research, there is room for greater emphasis on replication and robustness in scientific practice. This could involve more rigorous statistical methods, larger sample sizes, and greater attention to experimental design and control.
- Incorporating indigenous knowledge:** Incorporating indigenous knowledge and perspectives could enrich scientific understanding of the natural world and help to address issues such as climate change and biodiversity loss.

These are just a few possibilities for how the current practice of science could be improved. While the scientific community is already making strides in these areas, there is always room for continued progress and innovation.

Are there significant changes to the institutions and ways of learning, journals, and other way of communicating, etc., that would make science more effective and equitable?

Yes, there are several changes to the institutions and ways of learning, journals, and other ways of communicating that could make science more effective and equitable. Here are a few examples:

- Open access publishing:** Many scientific journals are behind paywalls, which can limit access to important research findings. Open access publishing, in which research articles are made freely available online, could help to make scientific knowledge more accessible and equitable.
- Diversity and inclusion initiatives:** Science could benefit from greater diversity and inclusion, as this can help to bring different perspectives and approaches to scientific research. Initiatives such as scholarships, mentorship programs, and hiring practices that prioritize diversity and inclusion could help to achieve this.
- Alternative ways of communicating:** Traditional scientific communication methods, such as journal articles and conference presentations, may not be accessible or effective for all audiences. Alternative ways of communicating, such as social media, podcasts, and video-based content, could help to broaden the reach and impact of scientific knowledge.
- Collaborative learning:** Science education could benefit from more collaborative learning approaches, such as group projects and problem-based

learning. This could help to build teamwork and collaboration skills, which are important for scientific research. Improving the peer review process: The peer review process, which is used to evaluate the quality of scientific research, could be improved to reduce bias and improve rigor. This could involve measures such as blind review processes, post-publication peer review, and greater transparency in the review process. These are just a few examples of changes that could make science more effective and equitable. Continued innovation and evolution in the ways in which scientific research is communicated and conducted could help to make science more accessible and impactful for everyone.

Suppose science were different—and better—decades from now. How? In such a future, how does publication (if it happens) work? How do universities (or their replacements) work?

It's difficult to predict exactly how science will be different and better decades from now, but here are a few possibilities: Greater collaboration: In the future, scientific research may be more collaborative, with researchers from different fields and locations working together to solve complex problems. This could lead to more innovative and effective solutions, as well as greater sharing of knowledge and resources. Increased use of technology: Technology is already playing a significant role in scientific research, but in the future, it could become even more central. Advances in fields such as artificial intelligence, machine learning, and data analytics could help to uncover new insights and make scientific research faster and more efficient. More emphasis on reproducibility and open science: In recent years, there has been growing concern about the reproducibility of scientific research. In the future, there may be a greater emphasis on open science, with researchers sharing data, methods, and results more freely to ensure that findings are reproducible and trustworthy. More diverse and inclusive: As society becomes more diverse, it is likely that scientific research will become more diverse and inclusive as well. This could help to bring different perspectives and approaches to scientific research, and could lead to greater understanding of complex issues. In such a future, publication and universities (or their replacements) may look quite different. Publication may be more open and accessible, with greater use of online platforms and tools to share research findings. Universities may become more collaborative, with researchers from different institutions and fields working together to solve complex problems. They may also place a greater emphasis on interdisciplinary research, as well as on diversity, inclusion, and social responsibility. Overall, the focus may shift from individual achievement to collective impact, with a greater emphasis on addressing pressing societal issues through scientific research.